mates

Maritime Alliance for fostering the European Blue Economy through a Marine Technology Skilling Strategy

Co-funded by the Erasmus+ Programme of the European Union

1.2 State of the Art Compilation

August 2019

About this Report

This document was developed within the framework of the **MATES project – Maritime Alliance for Fostering the European Blue Economy through a Marine Technology Skilling Strategy.** The objective of the project is to develop a skills strategy that addresses the main drivers of change to the maritime industry, in particular shipbuilding and offshore renewable energy. Both sectors are strongly linked and require new capacities to succeed in an increasingly digital, green and knowledge-driven economy.

Project duration: 2018–2021
www.projectmates.eu

Document information	
Short description	This document, (MATES "State of the Art Report") describes the situation of the shipbuilding and offshore renewable energy sectors in Europe. The report summarises the main relevant documents for MATES project purposes which are included in a repository of relevant information.
Next steps	This document will serve as the basis to analyse the present skills needs in shipbuilding and offshore renewables value chains, which will be presented in a baseline report.
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Lead authors	Pablo Fidalgo (ASIME)
Contributors	Néstor Martín (ASIME), Lucía Fraga (CETMAR), Rosa Fernández (CETMAR)
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Glossary

The glossary does not provide official definitions but explanations based on recognized information sources

CONCEPTS	DEFINITION
3D printing	Refers to a group of technologies where a three-dimensional object is created through the superposition of layers of material. This technology allows an optimisation of offshore construction logistics. It is already used in manufacturing and fabrication of offshore renewables components and moulds for testing procedures.
Additive manufacturing	Refers to a group of technologies where a three-dimensional object is created through the superposition of layers of material. This technology allows an optimisation of offshore construction logistics. It is already used in manufacturing and fabrication of offshore renewables components and moulds for testing procedures.
Big data & data analytics	Big data analytics is a complex process of examining large and varied data sets to reveal information, including hidden patterns, unknown correlations and trends.
Blue Growth	Europe's long-term strategy to support sustainable growth in the marine and maritime sectors as a whole. Seas and oceans are drivers for the European economy and have great potential for innovation and growth.
Capacity building	Long-term, ongoing process, in which all stakeholders participate (ministries, local authorities, non-governmental organisations and water user groups, professional associations, academics and others). In 1991 it was defined as a) the creation of an enabling environment with appropriate policy and legal frameworks; b) institutional development, including community participation (of women in particular); and c) human resources development and strengthening of managerial systems.
Cyber-security	The practice of protecting systems, networks, and programs from digital attacks
Cloud computing	Cloud computing, often referred to as simply "the cloud," is the delivery of on-demand computing resources (everything from applications to data centres) over the internet on a pay-per-use basis.
Composite materials	Materials made from two or more constituent elements, each with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. In the shipbuilding industry, three elements are used to create composite materials: fibres, core materials and resins.
Digitalisation	The use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business.

Energy storage	Set of methods and technologies used to store various forms of energy. The implementation of energy storage can provide further benefits to the offshore renewables sector. It can ensure the development and improvement of grid integration, as well as the integration of offshore renewables in energy network infrastructures. Besides, it supports the sector's growth by facilitating widespread installation of large-scale offshore facilities contributing to a reduction of their operating costs.
Exploitation of alternative fuels and renewable energy sources	Alternative fuels are all different substances which may be used as replacements for conventional fossil fuels that currently serve as the main power source for propulsion and power generation in shipping. The most relevant currently is liquefied natural gas (LNG), which has the widest applicability. In addition to this there are also other vessels using other sources for energy, such as electrification, which has attracted increased interest with significant projects being implemented.
Gender balance	This term refers to the equal participation of women and men in all areas of work, projects or programmes.
Ocean literacy	The understanding of the ocean's influence on you and your influence on the ocean.
Offshore renewable energy (ORE)	This term includes offshore wind, wave and tidal energy, osmotic and OTEC (ocean thermal energy conversion). Generally used to refer to offshore wind energy, MATES uses this term to refer to ocean renewable energy as well, which includes four different energy segments: wave and tidal, usually known as marine renewable energy (MRE), plus osmotic and OTEC, and even offshore solar energy.
Offshore wind jacket structure	Foundations with a lattice framework that feature three or four sea bed anchoring points, which increases safety levels when anchoring the towers. The top of the jacket features a transition piece that is connected to the turbine shaft, while the legs (three or four, according to the engineering design) are anchored to the sea bed with piles.
Shipbuilding	Building of ships and floating structures, including pleasure and sporting boats, repair and maintenance of ships and boats, and manufacture of marine equipment and marine machinery.
Virtual reality	A realistic (yet completely virtual) simulation of an environment that is created with a mixture of interactive hardware and software, and presented to the user in such a way that the user suspends disbelief and accepts it as a real environment.

List of Abbreviations

BGV	Badische Versicherungen
CGT	Compensated Gross Tonnage
EC	European Commission
EFFRA	European Factories of the Future Research Association
EMEC	European Marine Energy Centre
EU	European Union
GPD	Gross Domestic Product
GWEC	Global Wind Energy Council
ICT	Information and Communications Technology
ILO	International Labour Organization
IMF	International Monetary Fund
IMO	International Maritime Organization
IoT	Internet of Things
IRENA	International Renewable Energy Agency
JRC	Joint Research Centre
KETs	Key Enabling Technologies
LNG	Liquefied Natural Gas
MARPOL	International Convention for the Prevention of Pollution from Ships
MATES	Maritime Alliance for Fostering the European Blue Economy through a Marine Technology Skilling Strategy
NYK	Nippon Yusen Kaisha
OECD	Organisation for Economic Co-operation and Development
OPERA	Open Sea Operating Experience to Reduce Wave Energy Cost
OWC	Oscillating Water Column
PhD	Doctor of Philosophy
PwC	PricewaterhouseCoopers
PYMAR	Small and Medium Shipyards Society of Reconversion, S.A.
REF	Reference
R&D	Research and Development
R&I	Research and Innovation
RAMLAB	Rotterdam Additive Manufacturing LAB
SET-Plan	European Strategic Energy Technology Plan
US	United States
WSE	Wave Swell Energy
WTO	World Trade Organization

Executive Summary

The present report is framed within the MATES Blueprint project for Maritime Technologies granted EU funding under ERASMUS+ Sector Skills Alliances.

The present report was developed within the framework of the MATES project – Maritime Alliance for Fostering the European Blue Economy through a Marine Technology Skilling Strategy. The objective of the project is to develop a skills strategy that addresses the main drivers of change to the maritime industry, in particular shipbuilding and offshore renewable energy. Both sectors are strongly linked and require new capacities to succeed in an increasingly digital, green and knowledge-driven economy. This will be implemented from 2018 to 2021.

This document describes the **current situation and future prospects of the shipbuilding and offshore renewable energy sectors**, as well as the challenges that must be addressed in the coming years. It establishes a vision of the different drivers that will affect the transformation and evolution of the sectors, and finally a perspective on the socio-demographic situation.
In order to prepare this deliverable, the project partners, experts and stakeholders who have been mobilised to contribute to the MATES activities[1] have compiled a repository of relevant information with more than 390 publications and 150 projects. **A mixed research methodology was applied, including bibliographic reviews and a series of workshops** held between April and May 2018 in Greece, Portugal, the Netherlands, the United Kingdom and Spain.

Shipbuilding is one of the six sectors that has traditionally contributed to the Blue Economy[2]. It includes both shipyards (companies involved in shipbuilding, ship repair and conversion of commercial and military ships), as well as the auxiliary industry (companies that provide equipment and associated services). The sector **is characterised by manufacturing a unique, non-serial, high unit value product** (which usually exceeds the financial capacity of the shipbuilding companies in question), with lengthy manufacturing periods. This industry is sensitive to global economic trends, and there has been a sharp recession in recent years, which slumped to a record low in 2008. From that moment onwards, markets have been recovering and presenting constant and sustained growth over time and in forecasts for the following years.

The EU scenario has changed drastically in recent decades. Global competition has increased, especially in Asia, where countries with lower workforce wages have taken over the construction of the most common types of vessels as well as the manufacture of many components. However, the European Union has managed to maintain a leadership position in highly specialised vessels and in quality excellence. **The European shipbuilding industry is renowned throughout the world for its ability to develop and offer new high-tech solutions and innovative production processes** for both existing and traditional markets and for new market niches that comply with the most demanding requirements of international technical and safety standards.

According to the Transport White Paper published by the European Commission in 2011[3], the EU's first objective is to reduce CO_2 emissions from boilers by 40% by 2050, and its third

[1] 176 experts and stakeholders contributed at various stages of the project to ensure maximum uptake and impact of the MATES strategy: http://whowhomates.com

[2] EU Blue Economy Report 2019, Directorate-General for Maritime Affairs and Fisheries, https://publications.europa.eu/en/publication-detail/-/publication/676bbd4a-7dd9-11e9-9f05-01aa75ed71a1/language-en/format-PDF/source-98228766

[3] https://ec.europa.eu/transport/themes/strategies/2011_white_paper_en

objective is to transfer 50% of transport using other modes to rail and maritime transport. Building on this and the LeaderShip 2020[4] initiative, there are a number of challenges in different areas within the shipbuilding and ship repair industry in order to maintain and improve the competitiveness of the industry:

- **Employment and skills**. Improve the image of the marine industries as a sector of the future with a view to making it attractive in the labour market. It also proposes mobility promotion and harmonisation of the different systems and professional accreditation levels.
- **Improvement of access to markets and fair market conditions**, by regulating trade negotiating practices in the OECD, the WTO and the ILO, with clearer rules, in order to promote competition and better access to markets.
- **Access to funding**. This is a determining factor in the competition for shipbuilding contracts, and can be achieved by financially promoting technologies that improve environmental management and those designed to promote sector diversification, for example offshore renewable energies or the technological upgrading of existing facilities. Towards that end, also envisaged is the creation of a specific Development Fund for activities supporting innovation processes.
- **Research, development and innovation**, promoted through public-private cooperation, a zero-emissions policy and energy efficiency in vessels, increasing the safety of on-board operations and exploring new market opportunities, with an emphasis on the development of renewable marine energies.

The **offshore renewable energy sector** comprises different technologies at different stages of development: offshore wind energy has the most advanced technology in bottom-fixed structures, and ocean energy itself consists of a set of emerging technologies, such as wave and tidal, osmotic and OTEC (ocean thermal energy conversion), or even offshore solar energy. It is one of the five **emerging and innovative sectors of the Blue Economy, which constitutes a clean and inexhaustible source of energy**, capable of reducing greenhouse gas emissions and preserving the environment.

The current situation of offshore wind energy presents a constant growing number of installed capacities. In **2017 a record capacity of more than 4 GW was installed**, and in 2018 this figure was maintained and consolidated. In addition, future prospects are promising based on a series of factors as indicated below:

a) **Different markets that are expanding very rapidly**, such as Australia, Brazil and Turkey, as well as the emergence of countries in this sector. China installed 1.8 GW in the past year for the first time.
b) Technological improvements that improve electricity costs, such as the appearance of increasingly large **turbines that reach powers of up to 9.5 MW**.
c) The development of **innovative projects**, such as a plan to build a number of artificial islands for offshore wind energy generation with more than double the current installed offshore wind power capacity in Europe, promoted by the operators Tennet in the Netherlands and Germany and Energinet in Denmark, for installation in the North Sea. These can generate around 30 GW.

4 https://ec.europa.eu/growth/sectors/maritime/shipbuilding/ec-support_en

In addition to offshore wind energy there are other **marine energies** that play an essential role in the reduction of manmade CO_2 emissions, in the form of systems that obtain energy from the seas and oceans by harnessing energy from waves (**wave energy**) and energy from tides (**tidal power**). Moreover, we must mention other energy sources associated with the sea, such as temperature and salinity gradients.
Energy from tides, waves and oceans currently contribute very little to electricity production in EU countries and around the world. In 2016, this energy source represented **0.02% of the total electricity generated from renewable energy** sources in the EU-28.

According to the 2016 JRC report[5] on the status of ocean energy, Europe is the world leader in the development of ocean energy technologies and accounts for most of the developers in the world (52% for tidal currents and 60% for wave energy). However, the installation of ocean energy devices is slower than expected, there being only 14 MW of installed ocean energy capacity at the end of 2016, instead of the 641 MW declared by the EU Member States in their national action plans for renewable energy.

The main challenges within the marine energy industry, and particularly in offshore wind energy, are first and foremost to further **reduce the cost of electricity** through technological improvements in both turbines and other elements. The second of the most relevant challenges is to **increase the useful life of offshore wind farms**, as well as to improve their availability through the introduction of predictive systems and the optimisation of power generation in the machinery. Much of renewable energy R&D focuses on **improving energy storage technologies**, as storage systems seek to resolve the major challenges facing the development of renewable energy. Finally, the trend that offshore wind farms are increasingly being installed in deeper waters is resulting in the modification of **technologies used in the construction of the foundations**, where monopile foundation systems are losing out to jacket foundation systems.

The so-called Industry 4.0, a term first used in Germany, describes the organisation of production processes based on technologies and devices that communicate with each other autonomously through the value chain.
The main characteristics that this industry offers to the entities are:

- Interoperability
- Virtualisation
- Decentralisation
- Real-time capability
- Service orientation
- Modularity

It is estimated that supply chains based on data can accelerate a manufacturing process by 120%, while if we consider the time needed to deliver orders, the time to bring products to market can be reduced by 70%. Within the shipbuilding industry the trend is to reach **Shipyard 4.0**, which has all of its processes digitised, right from ship design through to production, allowing for their vertical integration into management systems. For example, construction plans are now hardly used, having been replaced by virtual simulations of the shipbuilding processes, which permit early optimisation of the ship and its systems, as well as simulation of the processes required for their production. This results in substantial improvements for the safety of people, the protection of the environment and the optimisation of energy consumption.

[5] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/jrc-ocean-energy-status-report-2016-edition

The report also analyses the **demographic situation**. The continuing decline in birth rates and the increase in life expectancy have transformed the shape of the age pyramid of the EU-28; probably the most important change will be a sharp transition to a much older population structure (already apparent in certain EU Member States). It should be noted that while in 2008 the average age of people in the EU-28 countries was 40.4, in 2017 average age had risen to 42.8, and the forecast for the next few years is that this trend will continue.

The ageing of the workforce in Europe presents a huge challenge and even though the total population of the EU-28 will only decline slightly from now until 2050, Eurostat forecasts that the age structure will dramatically change.

In the shipbuilding industry, according to the 2008 study carried out by the European Social Dialogue Committee, 53% of the workforce was aged 40+ years; since then the situation has worsened due in large measure to the recession previously referred to. Generational change continues to be a major challenge in an industry that in 2010 and according to the OECD study "The Ocean Economy in 2030" was responsible for **2 million direct jobs**.

Finally, it should be noted that another of the issues highlighted in MATES is gender balance. In the shipbuilding industry, the proportion of women in the workforce remains low. According to the annual report (2017) of the Navantia[6] shipyard, women make up only **10.1% of the workforce**, with quite a few in administrative and management positions.

According to the latest report of the International Renewable Energy Agency, hereinafter IRENA[7], the wind energy industry employed more than a million people around the world in 2017, more precisely, **1,148,000 direct jobs**. According to the macroeconomic scenarios of the report made by Wind Europe, in reaching an installed capacity of 323 GW in offshore wind, it is estimated that **569,000 direct jobs** will be needed in this industry in Europe. In contrast, the wave, tidal and marine energy industry created **1,057 direct jobs**.

Finally, according to She Figures 2018, gender balance is being achieved among doctoral students. Overall, by 2016, women accounted for 47.9% of doctoral candidates at EU level, while in two thirds of EU Member States the proportion of women doctoral candidates ranged from 45% to 55%. It is important to note that the proportion of women doctoral candidates continues to vary between different fields of education. In 2016, **female doctoral candidates** at EU level were over-represented in education (68%), but **under-represented in information and communication technologies (21%) as well as in engineering, manufacturing and construction (29%).**

[6] https://www.navantia.es/wp-content/uploads/2018/06/Memoria_2017.pdf
[7] https://www.irena.org/publications/2019/Jun/Renewable-Energy-and-Jobs-Annual-Review-2019

Introduction

Industry 4.0 promises a new revolution that combines advanced production and operational techniques with smart technologies for implementation within organisations, people and assets. This revolution is marked by the appearance of new technologies such as robotics, analytics, artificial intelligence, cognitive technologies, nanotechnology and the Internet of Things (IoT), among others. Organisations need to identify the technologies that best suit their needs in order to invest in them. If companies do not understand the changes and opportunities that Industry 4.0 offers, they run the risk of losing significant market share.

These new features of industry will have a crucial impact on people because such changes involve modifications to the way they currently work, which will in turn impose a need to adapt to the said new technologies, as well as a need for new qualified employees joining the different organisations having already acquired the future required skills.

The present report is framed within the MATES project – Maritime Alliance for Fostering the European Blue Economy through a Marine Technology Skilling Strategy, whose objective is to analyse the evolution of maritime technologies in Europe, in order to develop a strategic plan to improve the competitiveness of the industry through an adaptation of the existing training courses. The project consists of eight work packages to be implemented from 2018 to 2021.
The completion of the first planned stage of the project has resulted in this initial document which looks at current and future prospects and the challenges facing the activities which are the subject of this project, namely shipbuilding and the marine energy industries. The purpose of this initial document is firstly to explain the current situation of these activities in Europe and the technologies and projects that are being implemented at present or planned to be introduced in the near future. Lastly, it is to provide an introduction to the situation of workers, as well as the skills they need to have.

Different publications and projects compiled both by the consortium responsible for project implementation, as well as by experts actively collaborating in it, have been taken into account while preparing this document. In addition to this information, the document builds on the conclusions drawn by the five working groups during April and May, wherein consortium members were able to discuss the current and future prospects and training needs of people with the different Industry 4.0 experts from the relevant sectors.
This document, therefore, provides the basic information to be taken into account during subsequent analysis of the various existing training programmes in Europe associated with these productive sectors, and also to generate discussions with the thematic expert groups in relation to the future of the industry.

The document is structured into three parts: a) overall situation, b) key enabling technologies, and c) demographic situation and the required skills. The objective of the first part is to explain the current status of the activities covered by the study and the prospects and challenges in the future. The second part outlines the existing key enabling technologies in relation to Industry 4.0 and the projects that are underway in response to the challenges posed. Lastly, and based on the preceding sections, the demographic changes in recent years and the skills that will be required of the people concerned are presented.

Aims and Objectives

This document describes and summarises the information gathered in different publications and existing projects in order to set out the current framework and future perspectives of the sectors of activity that form the subject of this project: shipbuilding and ship repair, and marine renewable energy.

Methodology

To prepare this deliverable, the project partners, experts and stakeholders who were mobilised to contribute to the MATES activities[8] have compiled a total of 390 publications and 153 projects. A mixed research methodology was applied which included the following:

- Reviewing local and international literature on maritime technologies
- Participating in European events and including the relevant documents announced or cited there
- Examining the latest publications by relevant stakeholders
- Consulting administrative and statistical databases
- Key elements of the repository construction approach involved a survey answered by a wide range of stakeholders who selected three publications and projects of importance in their domain (industry, academia, research).

The information has been reviewed, analysed, summarised and classified into seven themes (digitalisation, open science, green technologies, ocean literacy, social changes, blue economy and other) and five sectors of activity: shipbuilding and ship repair, offshore value chain, marine energies, education and training, and European policies. Figure 1 presents the results of this classification.

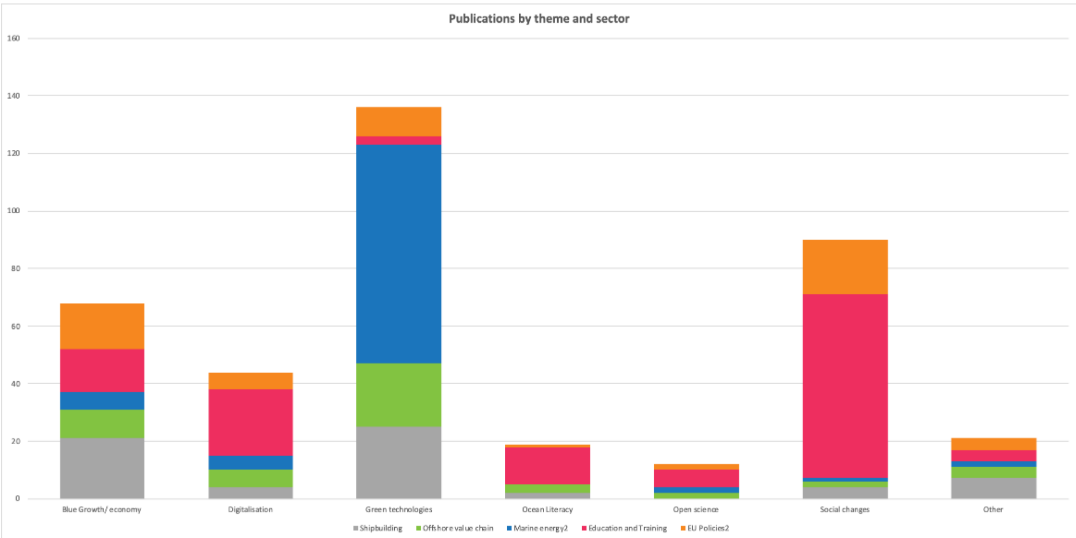

Figure 1: Publications analysed grouped by subject (bars) and sector (colours). Source: Asime

A shorter list was finally produced with the selection of the main classified and summarised references for the MATES project. It is available on the MATES website[9], including direct links to data sources. This selection was made by the leaders of the thematic groups, based on their experience and the nature, scale and importance of the information gathered so far.
The same classification was applied to those projects identified as relevant to MATES activity, as shown in Figure 2:

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[8] 176 experts and stakeholders contributed at various stages of the project to ensure maximum uptake and impact of the MATES strategy: http://whowhomates.com
[9] Digital repository of relevant documents for MATES https://www.projectmates.eu/references/

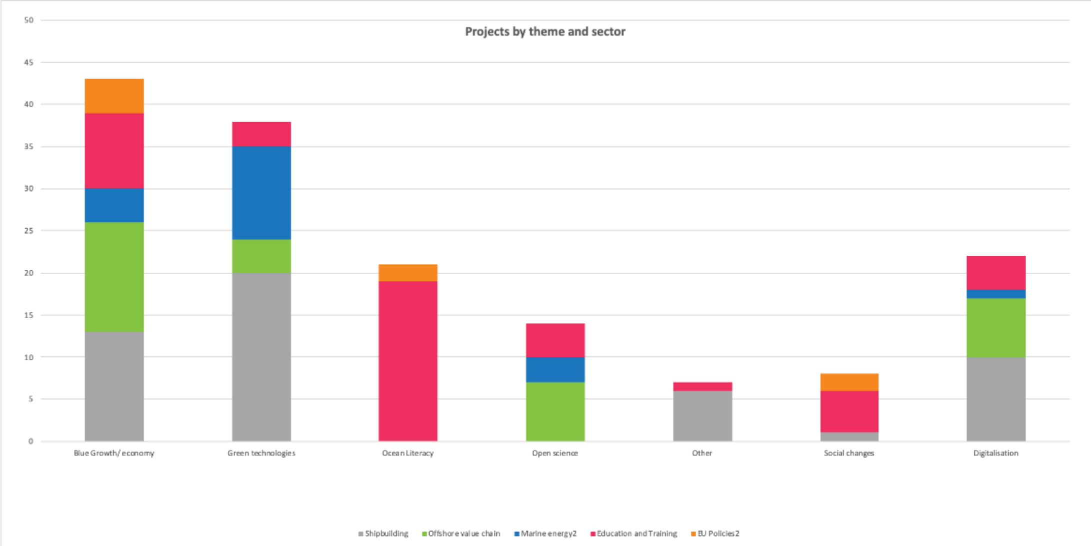


Figure 2: Projects analysed, grouped by subject (bars) and sector (colours). Source: Asime

To complete the bibliographic review, the report obtained information from a series of workshops held between April and May 2018 in Greece, Portugal, the Netherlands, the United Kingdom and Spain. They analysed how the MATES target sectors are being influenced by capacity needs related to digital skills, green technologies, and innovation management, and how ocean literacy can promote blue growth in the maritime industry. A total of 105 attendees participated, 28% of them women, offering their views on how the evolution of sectors and technologies influences the labour market and the need for new skills (or on new ways to deliver training and education). [REF. D1.3 Mobilisation WS reports[10]].

Based on the information gathered and analysed, the following chapters of this document will describe the current situation and future prospects of the sectors in question, as well as the challenges that must be addressed in the coming years. It will present a vision of the different drivers that will affect the transformation and evolution of the sectors and finally put forward a perspective on the socio-demographic situation.

[10] Reports of the five mobilisation workshops are available on the MATES website, section Deliverables 1.3, Mobilisation Workshops https://www.projectmates.eu/results/deliverables/

Overall Situation

Overall Situation of the Shipbuilding Industry

Introduction

The shipbuilding industry is defined as a synthesis industry that manufactures a unique, non-serial, high unit value product (which usually exceeds the financial capacity of the shipbuilding companies), with lengthy manufacturing periods. This industry is highly sensitive to economic cycles, has (an almost permanent) excess global capacity, and is subject to serious international competition.

The shipbuilding industry includes both shipyards (companies involved in shipbuilding, ship repair and conversion of commercial and military ships), as well as the auxiliary industry (companies that provide equipment and associated services). Thus, the sector has become a synthesis industry in which shipyards have specialised and have become assembly plants that build the hull, the basic structures and then integrate the components supplied by the auxiliary industry. The shipyard has progressively become the coordinator of a global project, responsible for planning and coordinating the activities of a large number of companies involved in the design, construction, repair and maintenance or transformation of a ship. Therefore, shipyards are also the driving force behind important auxiliary industries. It is important to note that the equipment installed (motors, water purification systems, electronic equipment, etc.) can account for up to 65% of the total value of the ship, while construction labour represents up to 35% of the productive effort.

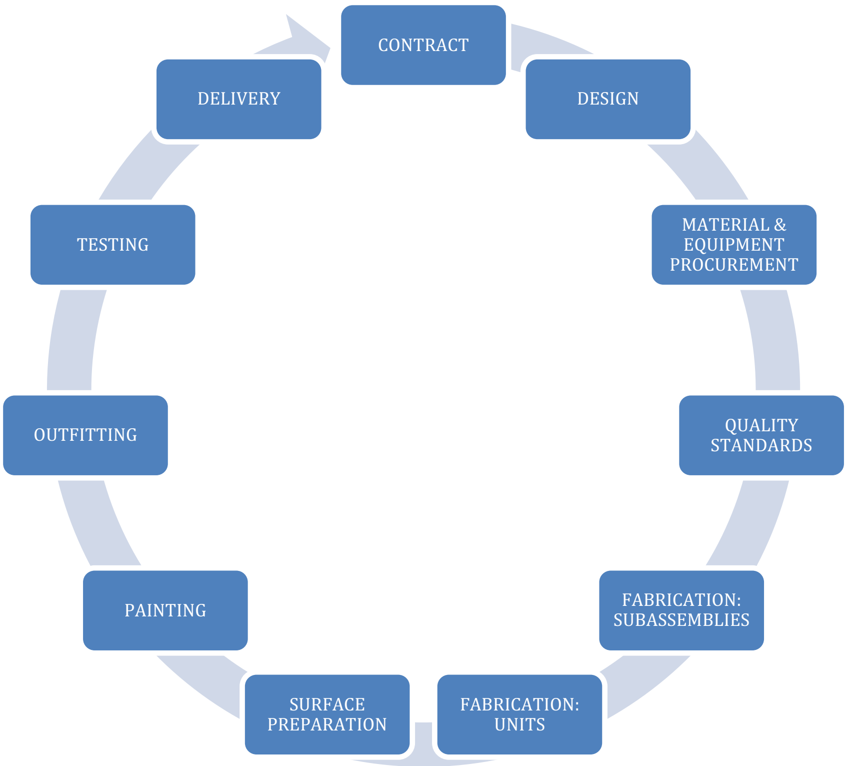


Figure 3: Construction process of the shipbuilding industry. Source: Asime

Economic Situation and Global Perspective

The shipbuilding industry is sensitive to global economic trends, and there has been a sharp recession in recent years, which reached its lowest point in 2008. Since the, markets have been recovering, showing constant and sustained growth over time and in forecasts for the future. The graph below (Figure 4) shows the percentage evolution of global growth for different groups of countries over the years.

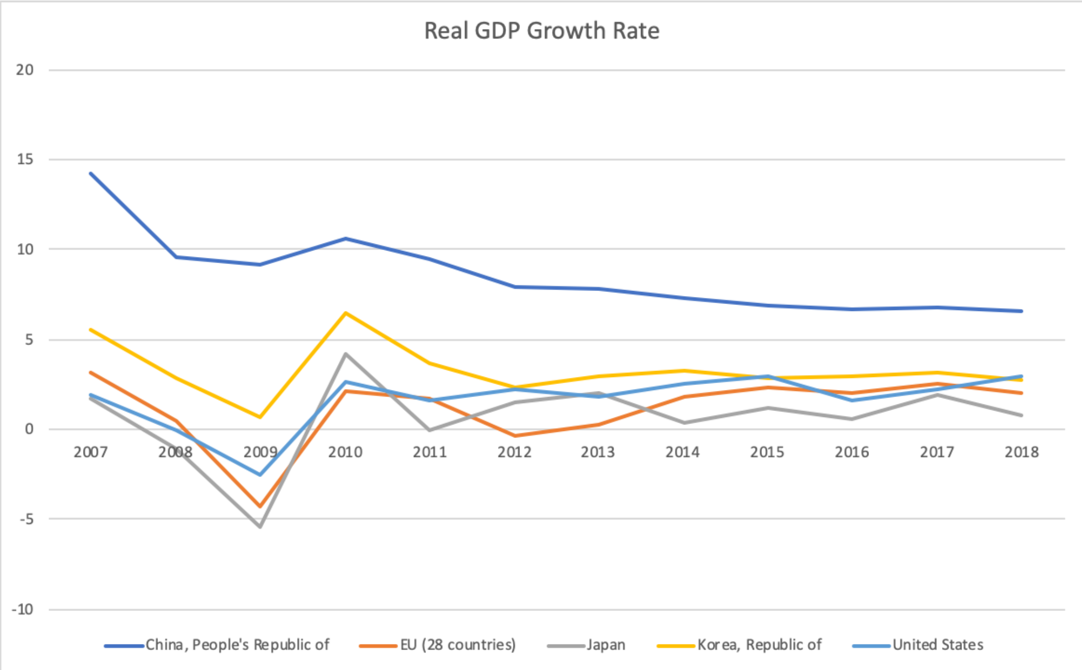


Figure 4: Real GPD growth. Source: Asime with published information from Eurostat and IMF

The global economic situation seriously affected new orders from 2008 to 2012 with workloads dropping year after year until they reached one of their worst episodes in 2012 with a workload of new orders measured in compensated gross tonnage (CGT) of 24.7 million.

As of March 2018, the global orderbook registered ships totalling approximately 78 million CGT, thus continuing to remain at historically very low levels. In year-on-year (YoY) terms this represents a decline of around 10%, and is almost 66% lower than in September 2008. The orderbook continuously declined after 2008 before stabilising in 2013 and remaining above 120 million CGT throughout 2014. With deliveries stable and new contracting at record lows, the orderbook again decreased substantially in 2016, declining by around a quarter from January 2016 to January 2018. During 2018, new orders picked up again from their lows, but declined once more in the first quarter of 2018.

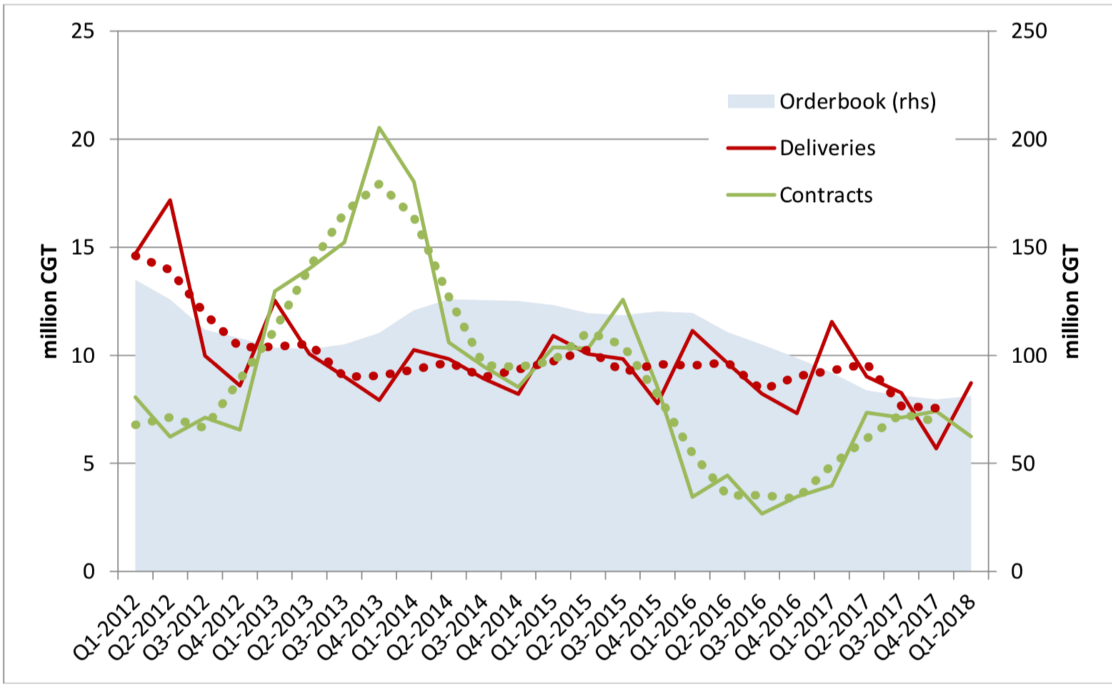


Figure 5: Orderbook, contracts and deliveries. Source: OECD representation based on Clarkson's World Fleet Register

According to the 2018 annual report published by PYMAR, at the close of fiscal year 2018, a total of 3,619 ships under construction equivalent to 70.6 million CGT were registered worldwide, with a combined value of close to US$230 billion. In CGT terms, these values showed a reduction in the global portfolio of 5.3% compared to the values reached the previous year, as well as a decrease of close to 40% compared to the average of the last 10 years.

China remained the world leader in shipbuilding with 1,089 units and 21.7 million CGT under construction, although its market share fell again to just two tenths above that of South Korea. South Korea experienced a strong increase in its domestic orderbook, after several years of a strong recession in which the three large South Korean shipyards (Samsung, Daewoo and Hyundai) laid off more than 20,000 workers and recorded losses of more than €6 billion in 2015. Although there has been a recovery in the last year in terms of new orders, they were still 34.5% below the average of the last ten years. Japan, for its part, continued to suffer a marked contraction in its orderbook, a situation that caused it to remain almost 50% below the average portfolio for last 10 years.

Analysing the orderbook by ship type reveals the extent to which each segment was affected by the overall decline. When compared to the levels of January 2015 (the middle of the period when the orderbook remained relatively stable), tankers have been least affected by the decline, with a decrease of 18% in terms of CGT. Containers registered a slightly larger decrease, with the current global orderbook 23% lower than two years ago. The drop in the orderbook for bulkers, however, was more severe, with a decline of 60%, resulting from the near disappearance of new bulker orders in the second half of 2016. Among the types of ships under construction, passenger ships (cruise ships and ferries) experienced the greatest increases in their orderbook. With 366 units equivalent to 11.8 million CGT, this type of ship reached its highest record in the entire historical series at the end of last year.

Considering classification by type of vessel, the global orderbook continued to be widely comprised of large transport vessels such as tankers, with 23.3% of the overall CGT orders; bulk carriers were at 19.3% CGT, and container ships were at 16.7% CGT. Cruise liners were the only type of ship that registered significant increases in orders, attaining more than 10% of the global shipbuilding CGT. This new shipbuilding market was concentrated almost entirely within the European continent.

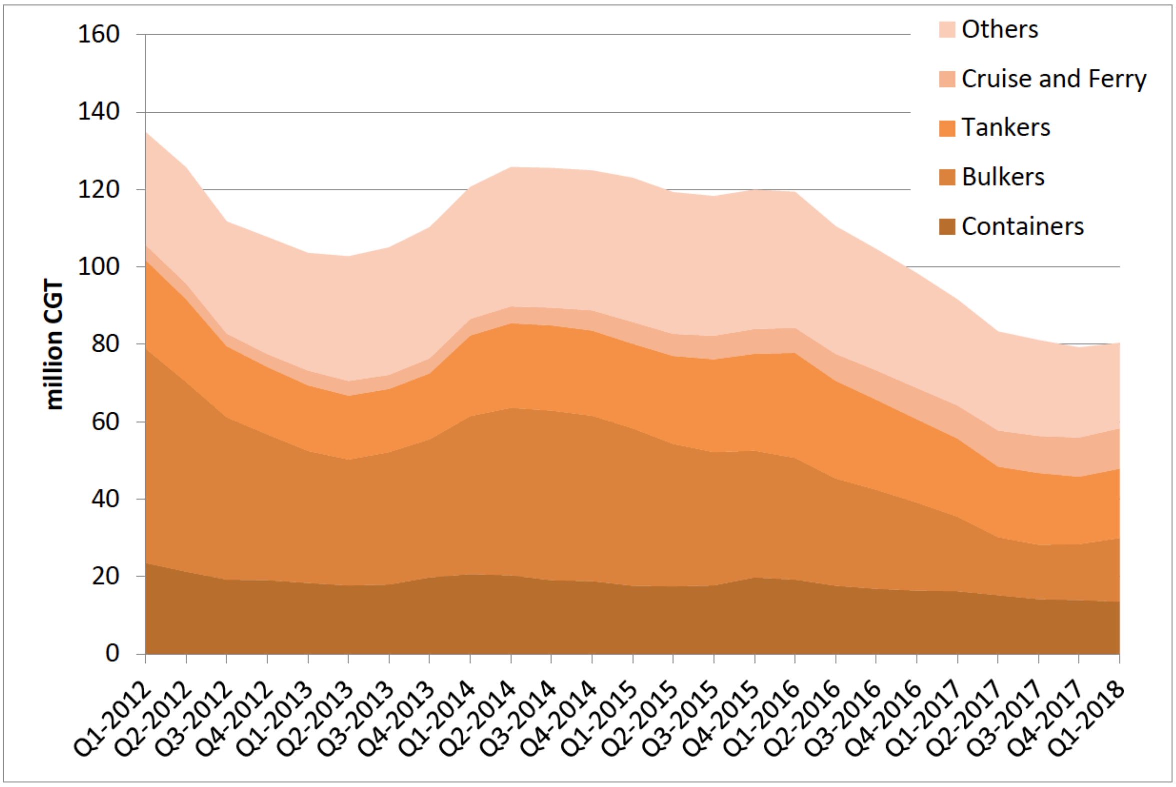


Figure 6: Orderbook by ship type. Source: OECD

The cyclicality of new ordering activity can easily be gauged by looking at Figure 7. New contracting reached approximately 63 million CGT in 2013 and dropped to 14 million CGT just three years later, representing a decline of 78%. Quarterly and monthly data similarly exhibit strong variability.

By ship type, the best performance was recorded in the gas tanker segment, mainly in methane tankers, where total investment in new construction in the latter segment exceeded US$12.5 billion divided among 67 new contracts. Similarly, cruise ships and ferries also recorded high levels of contracting, reaching 181 vessels with a global value that represented 23.3% of the total amount contracted during the year. In contrast, tankers suffered contracting figures significantly lower than the usual values within this segment of maritime transport. South Korea ranked as the country with the highest volume of contracting during 2018, with more than 40% of CGT contracted globally. These records allowed it to position itself almost 15 percentage points above China, its immediate competitor, which lost the global leadership in terms of contracting it had held since 2012. Japan, despite tripling the number of CGTs contracted compared to the previous year, barely reached 16.5% of the global market share.

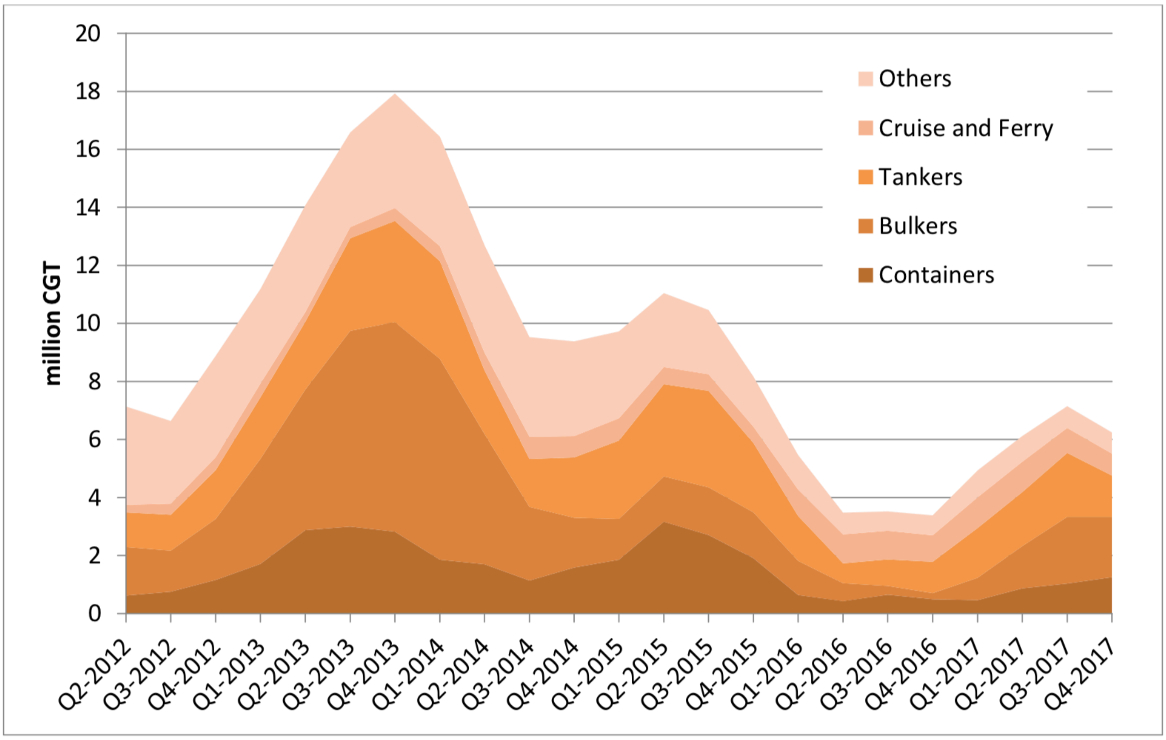


Figure 7: New contracts by ship type. Source: OECD

In the different documents that have been analysed there is little information related to the existing market of **military vessels** and above all aggregated data that show such information.
Being able to face the new technological challenges and to take advantage of their opportunities, conserving the necessary capacity to adapt, have made the naval industry an especially intensive sector in R&D activities. This aspect is also relevant in the military naval segment, where technological leadership is crucial for construction results.
By characterising the different ships that are built within the military sector, we can identify nine different types: battleships, hovercrafts, frigates, corvettes, cruisers, landing craft, aircraft carriers, assault boats and submarines.

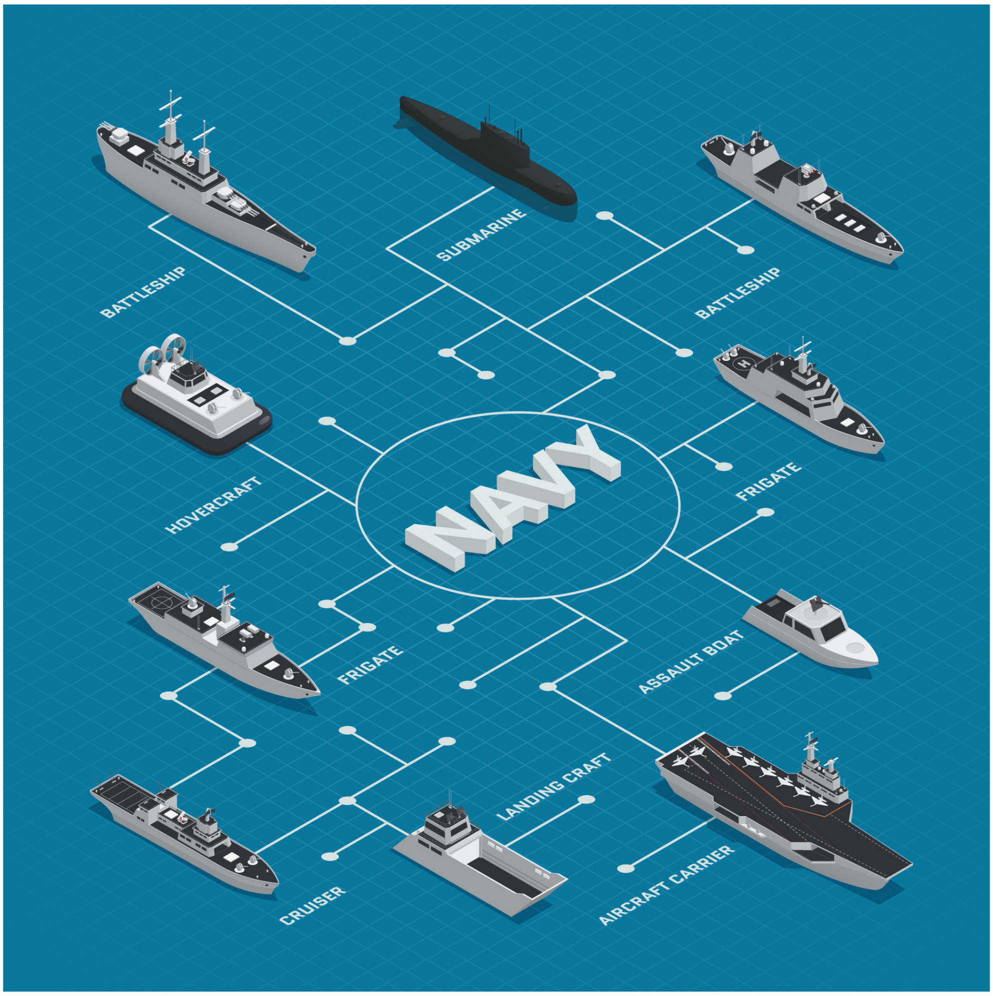


Figure 8: Types of military vessels. Source: Shutterstock[11]

According to the Ship and Offshore Repair Journal, the leading country in the export of military ships between 2005 and 2016 was Germany with US$9.639 billion, followed by Russia with US$7.925 billion, France with US$4.898 billion, Spain with US$4.032 billion and China with US$3.032 billion.

As shown by the export data, the military vessels segment is very relevant in Europe. In general, these segments are characterised by a high degree of specialisation and high-tech qualities, complex production processes, in combination with limited numbers of vessels of the same type that are to be built. As such Europe's position can be characterised as that of a specialised niche player.

By analysing the data on the activity registered in the Warships Global Market Report 2019, we can identify ten countries that represent a global sample of the current global state:

- **Australia**: Australia will acquire nine high quality anti-submarine frigates from the end of the next decade under an agreement with BAE Systems worth AU$35 billion (US$26 billion).
- **Brazil**: The Brazilian Navy's Naval Projects Centre developed the basic corvette design project with assistance from Fincantieri's VARD; it will be a versatile platform used for employment against air, surface and submarine threats.

[11] https://www.shutterstock.com/image-vector/military-boats-isometric-flowchart-composition-different-629681918

- **China**: According to a 2016 report, China is expected to have not only the world's largest fleet but also the second-most capable blue-water navy in the world by 2020. This includes a naval force of more than 270 ships in the next 3 years.
- **France**: The French navy is involved in the implementation of the so-called "Horizon Marine 2025" plan. FREMM (multi-mission frigate) 7 and 8 are expected to be built with a modified design optimised for air defence, thus replacing the anti-air warfare vessels in its navy.
- **Germany**: In September 2017 it announced a deal for US$2 billion from a consortium of domestic shipyards which will manufacture five new Braunschweig-class corvettes The new ships will be delivered to the German Navy in 2025.
- **Italy**: Its last two orders were in April 2016, when it ordered two Carlo Bergamini-class (FREMM) frigates. Ten frigates are currently on order to be delivered by 2021. Also, seven Pattugliatori Polivalenti d'Altura (PPA) frigates are on order for US$4.8 billion.
- **Russia**: It has been reported that there is a 12-ship programme for the Project 23560 Lider-class heavy destroyer, probably intended to replace the Udaloy- and Sovremenny-class destroyers and the Slava-class cruisers. The construction of the 15,000–18,000-ton destroyer is scheduled to commence after 2020 with construction to begin perhaps by 2025 and service entry slated for late 2020s.
- **Spain**: Spain has acquired five new F-110 frigates that are under design and will be built by Navantia. In addition, the U.S. State Department has approved a potential sale of five AEGIS ballistic missile defence systems.
- **United Kingdom**: Its production is focused on the construction of new frigates. The introduction of the "Type 26" frigate has been delayed to the mid-2020s. On the other hand, it has been announced that a class of smaller, cheaper light general-purpose frigates would sustain the fleet as Type 23 frigates are retired, called the General Purpose Frigate (GPFF) or Type 31.
- **United States:** It is focused on developing the new guided missile destroyer, the DDG 51, now in its final design phase. Also, it is looking for inputs from industry on a new multi-mission guided-missile frigate adapted from existing ship designs.

Economic Situation and the European Perspective

The EU shipbuilding industry scenario has changed drasticallyin recent decades. Global competition has increased, especially in Asia, where countries with lower wages have taken over the construction of the most common types of vessels and the manufacture of many components. However, the European Union has managed to maintain a leadership position in highly specialised vessels and in quality excellence. The European shipbuilding industry is renowned throughout the world for its ability to develop and offer new high-tech solutions and innovative production processes for both existing and traditional markets and for new market niches that comply with the most demanding requirements of international technical and safety standards. After several years of increasing demand (2004–2007) and with the recession overcome, Europe considers the gradual recovery both in terms of orders and new shipbuilding to be very positive. In general, the European continent continues to perform far better than the world average, accounting for 3.6 million CGT.

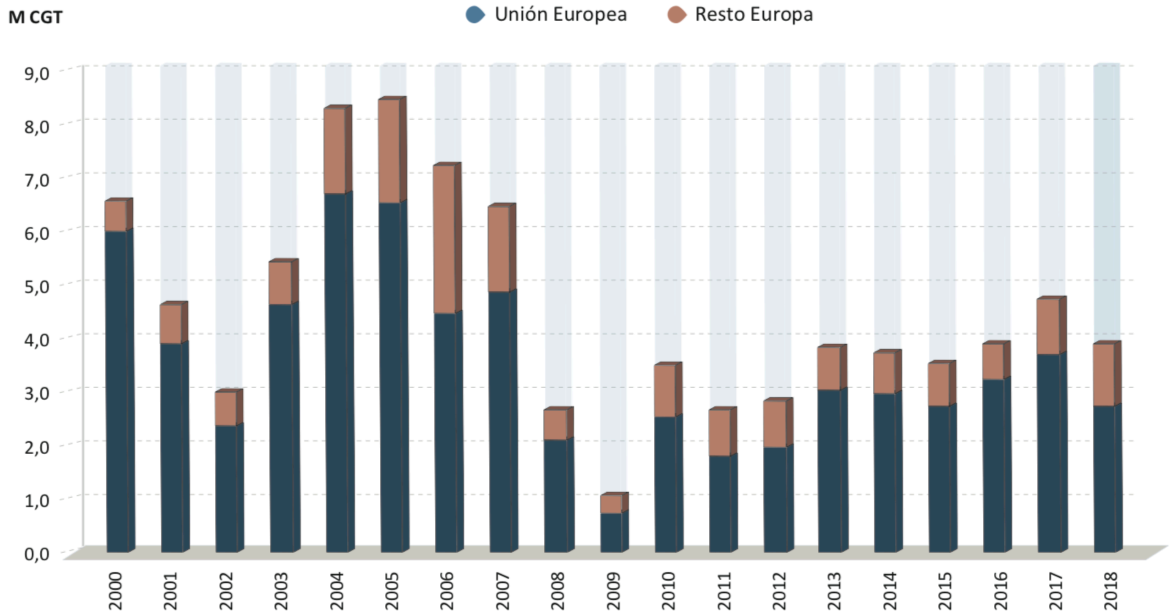


Figure 9: The evolution of recruitment in Europe. Source: PYMAR

During 2018, the number of deliveries registered on the European continent reached 410 vessels, equivalent to 2.9 million CGT and an estimated value of more than US$11 billion, the second highest value in the last seven years. The European Union, with 288 ships and 2.3 million CGT, accounted for about 80% of the total volume of deliveries recorded on the continent.
The number of European shipyards with at least one registered delivery during the year stood at 163 (only one less than those registered in 2017), of which 104 were located in countries belonging to the European Union.

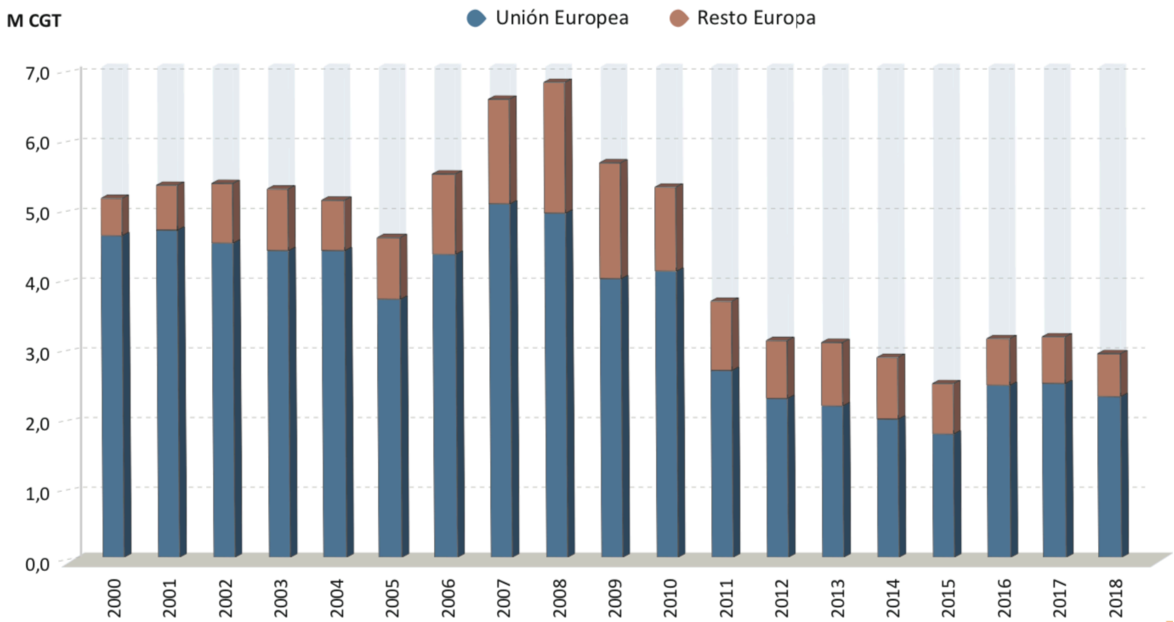


Figure 10: Evolution of deliveries in Europe. Source: PYMAR

Europe continued to concentrate a significant percentage of its deliveries in market segments with a high added value and technological component, such as cruise ships, where European shipyards accounted for 97.5% of the CGT delivered worldwide (19 units and 1.3 million CGT), dredgers with 54.2% (11 units and 90,198 CGT), and vessels for the fishing industry with 32.8% (87 units and 260,857 CGT).

For the sixth consecutive year, the European order book continued its path of growth and expansion, a trend that led it to reach a total of 821 ships under construction with an estimated value of US$68.6 billion (29.8% of the value of the global order book) and 12.8 million CGT, the highest value in the last decade and more than 30% above the average for the last 5 years. The European Union accounted for 80.0% of the total CGT under construction for the entire continent, a percentage close to the average recorded in recent years.
The ships under construction were distributed among a total of 187 shipyards, among which 28 are in Holland, 26 in Norway, 25 in Turkey, 20 in Russia and 16 in Spain.

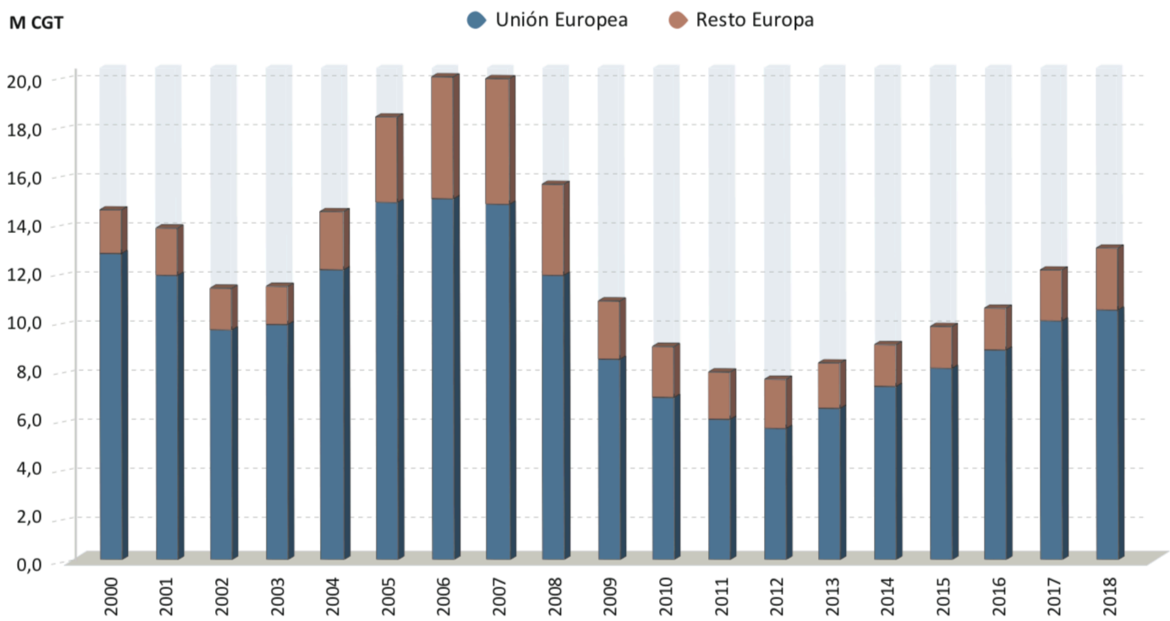


Figure 11: Evolution of orderbook in Europe. Source: PYMAR

The European Union continued to lead new orders in niche markets such as cruise liners with a global market share of 94.8%. The market share for mega yachts is 94%; for oceanographic vessels it is 44.1%; and for fishing industry vessels it is 30.7% of the worldwide contracted CGT.

The Netherlands was the country with the most units ordered, mainly tugs, while Spain was the second country in the European Union with most units ordered, mainly vessels for the fishing industry. Italy recorded greater CGT mainly for cruise ships.

	China	Japan	Korea	Rest of Asia	European Union	Rest of Europe	Rest of World
Tankers	29,70%	6,10%	47,40%	12,50%	1,00%	3,30%	0,00%
Bulk carriers	59,40%	14,30%	15,10%	11,20%	0,00%	0,00%	0,00%
Containerships	40,50%	6,10%	48,50%	1,80%	0,00%	0,00%	3,20%
Overall cargo	48,10%	16,20%	0,00%	34,60%	0,00%	1,10%	0,00%
Ro-Ro	28,70%	35,80%	25,00%	0,40%	10,10%	0,00%	0,00%
Offshore	28,30%	1,40%	49,60%	5,40%	5,30%	8,20%	1,80%
Fishing vessels	11,40%	4,60%	2,10%	4,30%	30,70%	46,50%	0,40%
LNG	25,60%	0,00%	72,40%	2,00%	0,00%	0,00%	0,00%
LPG	24,10%	13,10%	61,20%	1,60%	0,00%	0,00%	0,00%
Cruise ships	0,60%	0,00%	0,00%	0,60%	94,80%	3,50%	0,50%
Ferries	37,40%	16,40%	0,00%	3,80%	20,00%	17,70%	4,70%
Oceanographic vessels	9,10%	11,60%	0,00%	14,60%	44,10%	0,00%	20,60%
Tugs	16,80%	4,60%	0,90%	19,30%	28,50%	23,20%	6,60%
Dredgers	25,60%	0,00%	0,00%	30,30%	40,70%	3,40%	0,00%
Yachts	0,00%	0,00%	2,20%	0,00%	94,00%	3,80%	0,00%

Figure 12: Contracting quotas by type of vessel during 2017. Source: PYMAR

The European Union maintained leadership in orderbooks in the construction of cruise ships, with 94.8% of the total CGT; yachts were at 81.9%; dredgers at 63.8%; and oceanographic vessels at 41.0%. Most of these vessels are highly complex to build.

	China	Japan	Korea	Rest of Asia	European Union	Rest of Europe	Rest of World
Tankers	33,10%	22,40%	32,50%	6,70%	2,90%	1,70%	0,70%
Bulk carriers	55,60%	33,20%	5,60%	5,20%	0,40%	0,00%	0,00%
Containerships	53,90%	19,20%	20,70%	4,30%	0,00%	0,00%	1,90%
Overall cargo	45,70%	16,90%	0,00%	21,50%	9,80%	3,50%	2,60%
Ro-Ro	24,60%	37,70%	23,70%	0,10%	13,90%	0,00%	0,00%
Offshore	56,60%	0,80%	17,10%	12,30%	3,50%	3,60%	6,10%
Fishing vessels	10,70%	2,90%	4,10%	2,30%	34,10%	43,00%	2,90%
LNG	10,00%	28,60%	60,90%	0,30%	0,30%	0,00%	0,00%
LPG	33,30%	24,30%	39,20%	3,20%	0,00%	0,00%	0,00%
Cruise ships	0,20%	0,00%	0,00%	0,20%	94,80%	4,40%	0,30%
Ferries	37,80%	13,10%	3,40%	5,90%	20,20%	13,60%	6,00%
Oceanographic vessels	26,30%	3,80%	0,00%	19,20%	41,00%	0,00%	9,60%
Tugs	14,20%	3,10%	0,30%	21,50%	27,90%	16,20%	16,80%
Dredgers	16,90%	0,00%	0,00%	17,40%	63,80%	1,90%	0,00%
Yachts	2,00%	0,00%	0,50%	1,50%	81,90%	12,70%	1,40%

Figure 13: Portfolio shares by type of vessel at 2017 close. Source: PYMAR

Major Challenges Ahead

The European Commission's **LeaderSHIP 2020**[12] initiative establishes the vision and strategy of the shipbuilding industry to ensure long-term prosperity in the market. It was adopted in 2013, in response to the effects of the economic crisis, and provides a number of short to medium-term technology recommendations for the European maritime sector in order to support high value sustainable growth and cope with the social challenges of Europe. Based on

[12] https://ec.europa.eu/growth/sectors/maritime/shipbuilding/ec-support_en

the strategic vision for 2020, the EC is striving to make the industry innovative, competitive and international, and the European maritime actors have identified four pillars of action for business success:

- **Employment and skills**. In anticipation of the short supply of qualified personnel in the sector, the strategy seeks to improve the image of the marine industries as a sector of the future with a view to making it more attractive in the labour market. It also proposes mobility promotion and harmonisation of the different systems and professional accreditation levels to meet market needs and improve employability, both in formal training (including graduate and post-graduate studies), as well as in non-formal training and experience.
- **Improvement of access to markets and fair market conditions**, by regulating trade negotiating practices in the OECD, the WTO and the ILO, for clearer rules, in order to promote competition and access to markets.
- **Access to funding**. This is a determining factor in the competition for shipbuilding contracts, and will be achieved by financially promoting technologies that improve environmental management and those designed to promote sector diversification, for example offshore renewable energies or the technological upgrading of existing facilities. Towards that end, also envisaged is the creation of a specific Development Fund for activities supporting innovation processes as well as industry attractiveness and the required staff training. The reason for creating this specific Fund resides in the nature of the activity wherein production is not serial, several of the processes are manual, and where years of crises have led to a decrease in funds for innovation and development.
- **Research, development and innovation**, promoted through public-private cooperation, a zero-emissions policy and energy efficiency in vessels, increasing the safety of on-board operations and exploring new market opportunities, with an emphasis on the development of renewable marine energies. The objectives set by the International Maritime Organisation aim to promote both the growth of transport in this medium, as well as a reduction of fuel consumption, and hence the need to support initiatives and explore new ways to achieve them, such as the introduction of composite materials to lighten the weight of ships whilst maintaining their properties, or the use of renewable energies.

LeaderSHIP 2020 allows the European maritime technology industry to continue placing a strong emphasis on innovation, the environment, and on the application of new technologies, as well as on diversification into new emerging markets, such as offshore wind power.
On the other hand, air pollution generated by the transport sector is and continues to be a reason for the implementation of many policies aimed at mitigating its negative impact on the environment and on the health of the population.
The **International Maritime Organisation** (IMO) is the United Nations agency in charge of maritime safety and prevention of pollution generated by ships in the marine environment. Since its entry into force on 19 May 2005, Annex VI to the MARPOL[13] Convention regulates the emission of the principal air pollutants contained in exhaust gases of ships' engines, such as SOx and NOx, as well as ozone-depleting substances.

The White Paper published by the European Commission in relation to the transportation roadmap has acted as a warrant for the need to adapt this industry, whose first objective is to reduce boiler fuel CO_2 emissions by about 40% in the maritime sector by the year 2050. Its third objective foresees the transfer of 50% of transportation that uses other modes to rail and maritime transport in 2050.

[13]http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-%28marpol%29.aspx

The barrier-free European maritime transport space should evolve to become a "blue belt" of free movement at sea in Europe and its surroundings, and furthermore exploit the full potential of maritime and river transport.

- Integrate the use of vigilance tools by all competent authorities, ensure full interoperability between information and communication technology (ICT) systems in the areas of maritime and river transport, ensure surveillance of vessels and their cargo ("blue belt") and establish adequate port facilities ("blue lanes").
- Establish a framework for granting certificates of exemption from pilotage services in EU ports.
- Review restrictions on the provision of port services.
- Increase port financing transparency by clarifying the destination of public subsidies with regard to the different port activities with a view to avoiding any distortion of competition.

Therefore, the medium to long-term trend in the shipbuilding industry indicates the construction of vessels using **alternative energies and fuels** such as LNG, wind, solar, hydrogen or biofuels. Likewise, also linked to a reduction in the weight of vessels is the possibility of incorporating **composite materials** or other materials that enable the weight of vessels to be lightened and thus leading to a reduction in fuel consumption. The third axis is to assess the incorporation of **modularisation** of vessels to lengthen lifespan and facilitate different uses from time to time.

According to the IRENA Renewable Energy Options for Shipping study[14], currently renewable energy (RE) options are being considered for the global shipping fleet at all levels and in varying magnitudes, including: international and domestic transport of goods, people and services; fishing; tourism and other maritime pursuits. Renewable options can be used in ships of all sizes to provide primary, hybrid and/or auxiliary propulsion, as well as on-board and shore-side energy use. These clean energy solutions are being integrated through retrofits to the existing fleet or are incorporated into new shipbuilding and design, with most applications deploying renewable energy as part of an integrated package of efficiency measures. The current focus of renewable energy application in shipping is on:

- Wind energy: for example, using: soft-sails, such as Greenheart's 75 dwt freighter, B9 Shipping's 3 000 dwt bulker and Dykstra/Fair Transport's 7 000 dwt Ecoliner; fixed-sails, such as in the UT Wind Challenger and the EffShip project; Flettner rotors, such as in the Alcyone and Enercon's 12,800 dwt E-Ship 1; kite sails, such as in the MS Beluga Skysails; and wind turbines (no successful prototypes to date).
- Solar photovoltaics (mainly in hybrid models with other energy sources on small ships, such as NYK's Auriga Leader and SolarSailor by Ocius Technology (formerly Solar Sailor Holdings Ltd).
- Biofuels, such as the Meri cargo ship which claims to be the first of its size to use 100% bio-oil.

Hydrogen fuel cells have also been used as a clean energy technology for shipping: for example, in the FCS Alsterwasser, a 100-pax fuel-cell-powered passenger vessel based in Hamburg Port (Germany), as well as a number of other small ferries and river boats. In 2012, as part of the FellowSHIP project, a 330 kW fuel cell was successfully tested on board the offshore supply vessel Viking Lady, operating for more than 7,000 hours. This was the first fuel cell unit to operate on a merchant ship, with the electrical efficiency estimated to be 44.5% (when internal

[14] https://www.irena.org/publications/2015/Feb/Renewable-Energy-Options-for-Shipping

consumption was taken into account), with no detectable NOx, SOx or particulate matter (PM) emissions.

Figure 14: Energy Observer. Source: Shutterstock15

The current industrial era faces the challenge of digital transformation without losing sight of the medium to long-term objectives. This new paradigm, based on technology, involves the integral evolution of manufacturing companies, regardless of the sector they belong to, toward a new way of understanding productive activity and relations with all value chain agents. This disruption is solidly based on the new opportunities offered by the integration of new digital technologies, but more so on the competitive disadvantage that will result for those who do not incorporate such technologies.

The new Industry 4.0 model promotes the use of tools that permit hybridisation of the physical world (materials, products, machinery and facilities) with digital systems, and thus progressing towards the concept of smart manufacturing.
In a market scenario characterised by production over-capacity and increasing pressure on margins, the reduction of "time-to-market", the optimisation in the use of resources and the incorporation of new customer services added to the product (known as "servitisation") are increasingly crucial factors in the competitiveness of shipyards.

The practical use of digital key enabling technologies (KETs) facilitates the achievement of these objectives. In its digital strategy, the industry places special emphasis on three of these: **collaborative platforms**, **embedded sensors and systems,** and **3D printing**.

[15] (https://www.shutterstock.com/es/image-photo/russia-stpetersburg-19-june-2019-french-1428881579?src=-1-1)

The first KET mentioned, collaborative platforms, enables simultaneous instant coordination of the many value chain agents that engage in vessel construction in a shipyard, as well as the integration of their management into the systems used to monitor work progress. The optimisation of planning and control of productive flows, facilitated through the use of these tools, offers the opportunity to shorten manufacturing times resulting in improved efficiency of production facilities.

Lastly, the incorporation of a higher degree of sensors and embedded systems (embedded devices in products to control one or more functions, acting as a data source), can facilitate the incorporation of new functionalities and ship services that provide greater added value. An example of this is the integration of component behaviour analysis systems, which offers ship owners a new predictive maintenance utility based on monitoring for prior detection of failure, thus avoiding early and/or unnecessary replacement or replacement only after it is too late.

The fundamental advantages in the case of 3D printing techniques for the manufacture of complex design components are the need for a small number of elements and less maintenance. Moreover, thanks to the possibility of local manufacturing, its use would minimise the logistics costs associated with their production.

These and many other possibilities that digitisation offers to the industrial sector to improve competitiveness have a common denominator: human capital. The results of a survey prepared by PwC [16]showed that more than 2,000 companies from 26 countries have benefited. The same study indicated major transformation barriers such as the lack of culture and digital training, as well as the lack of involvement of senior management in the process.

[16] https://www.pwc.com/gx/en/industries/industries-4.0/landing-page/industry-4.0-building-your-digital-enterprise-april-2016.pdf

Overall Situation of the Marine Energy Industry

Introduction

Marine energies play an essential role in the reduction of CO_2 emissions of human origin; hence their promotion and development are crucial for mitigating the effects caused by climate change. Currently, the technology with a higher level of development is **offshore wind power**. However, there are other systems that obtain energy from seas and oceans by harnessing energy from waves (**wave energy**) and energy from tides (**tidal power**). Moreover, we must mention other energy sources associated with the sea such as temperature and salinity gradients.

As mentioned earlier, wind energy is the most mature and developed of the renewable energies. It generates electricity through wind action by using the kinetic energy produced by air currents. This is a clean and inexhaustible source of energy, which reduces greenhouse gas emissions and preserves the environment.

Wind energy moves a propeller which through a mechanical system turns the rotor of a generator to produce electricity. Wind turbines are usually grouped together and called wind farms in order to make better use of the energy, which also reduces their environmental impact.

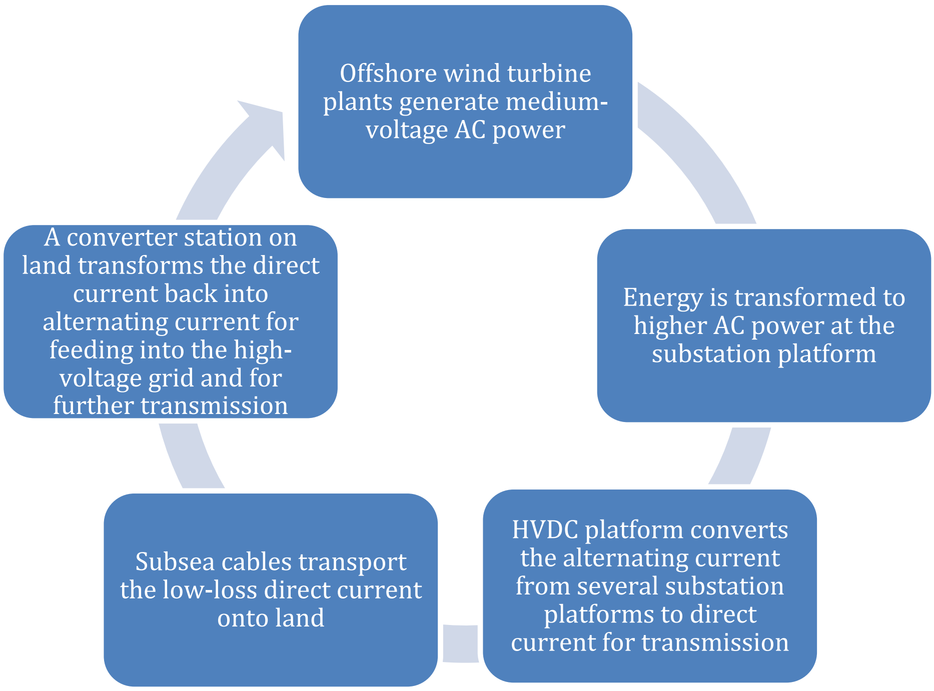


Figure 15: Process of obtaining wind energy power. Source: Asime

Figure 16: Offshore wind power plan. Source: Shutterstock[17]

It should be noted that 2020 is an important milestone for the European Union to the extent that Member States will be monitored in respect of to their **commitment to climate change and energy**. Wind energy will contribute significantly to the achievement of these commitments in the energy sector, allowing many Member States to attain their objectives in a cost-effective manner and continue with their power generation transformation process.

Power generation from ocean energy is an emerging sector. Several technologies are currently being developed, such as power generation from tides and waves, conversion of ocean thermal energy (taking advantage of the difference in temperature between cold deeper waters of the ocean and warmer surface waters of the tropics) or the salinity gradient (energy generation from salinity difference between sea water and river water). The various ocean energy technologies are at different stages of technical and commercial development.
Wave energy has the highest potential among marine energies, but this potential is not the same on all coasts of the world. Areas with the greatest potential must first be selected, in order to take maximum advantage of this resource. Moreover, choosing an area with great potential for wave energy is not the only factor that needs to be analysed, as there are many factors for harnessing waves and several classifications of energy converters. The choice of area and the technique used are closely linked to the cost of development and the environmental impact.

Wave energy is essentially a condensed form of solar power produced by the action of wind blowing on the ocean surface that can then be used as an energy source. When the intense rays of the sun hit the atmosphere, they heat it. The intensity of the sun's rays that strike the earth's atmosphere varies considerably in different parts of the world. This variation in atmospheric temperature throughout the world makes the air travel from warmer regions to colder ones giving rise to winds.

As the wind glides over the ocean surface, a fraction of the kinetic energy of the wind is conveyed to the water below, producing waves. In fact, the ocean could be viewed as a large collector and store of energy transported by the sun's rays to the oceans, where waves carry the kinetic energy transmitted through the ocean surface. With this in mind, we can safely conclude that waves are a form of energy and it is this energy, and not water, that slides over the ocean surface.
Waves can travel through large oceans without losing very much energy. However, when they arrive at the coast, where water depth decreases, their speed reduces and their size increases

[17] https://www.shutterstock.com/es/image-vector/vector-low-poly-wind-turbines-power-703729213?src=library

significantly. These waves finally crash on the shore, transferring large amounts of their kinetic energy.
It is important to indicate that one of the most relevant advantages with respect to other renewable energy sources is that the arrival pattern of waves is highly predictable. They arrive both during the day and at night and carry more energy than other renewable energy sources.
Tidal energy is defined as the energy obtained from tidal flows, generated by action of the gravitational and centrifugal forces between the earth, the moon and the sun. Tides result from the regular rise and fall of the ocean surface caused by the gravitational pull of the sun and the moon on the earth. The rotation of the earth and the moon produces the centrifugal force. The moon generates a gravitational force that is approximately 2.2 times greater than the gravitational force of the sun because the moon to earth distance is less than that of the sun. Gravity creates a tide with two "protuberances" on the earth's surface; one on the side of the earth facing the moon and the other on the opposite side. There is a maximum of two tides depending on the location relative to the earth's axis of rotation.

Power from tides can be generated using various technologies, the most important ones being tidal dams, tidal fences and tidal turbines.

Tidal dams are the most efficient sources of tidal energy. A tidal barrage is a dam that uses the potential energy generated by the change in height between high and low tides. This energy turns a turbine or compresses air, thereby generating electricity.

Tidal fences are turbines that operate as giant tourniquets, while tidal turbines are similar to wind turbines but under water. In both cases, electricity is generated when the mechanical energy from tidal currents is transferred to the turbines connected to a generator. Ocean currents generate relatively more energy than air currents because ocean water is 832 times denser than air and, therefore, applies a greater force to the turbines.

Economic Situation and Global Perspective

2017 has been a very favourable year of unprecedented growth for the offshore wind farm sector due to several factors, among which we can highlight a) the emergence of increasingly large turbines reaching powers of up to 9.5 MW,;b) a plan to build a number of artificial islands for offshore wind energy generation with more than double the current installed offshore wind power capacity in Europe, promoted by the operators Tennet in the Netherlands and Germany and Energinet in Denmark, for installation in the North Sea. These can generate around 30 GW, and c) the different markets that are expanding rapidly, such as Australia, Brazil and Turkey. The rapid development of technology has meant that offshore wind power is positioning itself as the main source of energy.

Figure 17: Artificial islands for offshore wind energy. Source: Tennet https://northseawindpowerhub.eu/tennet-presents-hub-and-spoke-concept/

According to GWEC's annual report in 2017, a historic record capacity of 4,334 MW of offshore wind energy was installed in nine markets worldwide in 2017 (the United Kingdom, Germany, Belgium, Finland, Japan, South Korea, Taiwan and France). This represents an increase of 95% over the 2016 market. In general, there is now 18,814 MW of offshore wind power capacity installed in 17 markets throughout the world. At the end of 2016, nearly 84% of all installations at sea were in waters off the coast of eleven European countries. The remaining 16% were mainly in China, followed by Vietnam, Japan, South Korea, the United States and Taiwan.
The United Kingdom is the world's largest offshore wind energy market and represents just over 36% of installed capacity, followed by Germany in second place at 28.5%. China occupies third place in the global offshore classification at slightly less than 15%. Denmark is now at 6.8%, the Netherlands at 5.9%, Belgium at 4.7% and Sweden at 1.1%. Other markets such as Vietnam, Finland, Japan, South Korea, the USA, Ireland, Taiwan, Spain, Norway and France make up the rest of the market.

The expansion of the offshore industry beyond the north of Europe to North America, East Asia, India and other places has now begun. The first US offshore wind farm began operations in 2016; Block Island Wind Farm has a capacity of 30 MW and is located off the coast of Rhode Island. China's offshore wind industry has taken off and Taiwan has an ambitious programme in the pipeline. The number of countries planning to start pilot projects or large-scale development of offshore wind farms on a commercial scale is growing rapidly; the latest newcomers who wish to enter the sector are Australia, Brazil and Turkey. In 2017, Turkey launched a tender for the construction of a 1,200 MW offshore wind energy plant, the largest in the world and the first in the country.

2018 was a pivotal year for the offshore wind industry:

- For the first time, China installed and connected more offshore capacity (1.8 GW) than any other country. The United Kingdom took second place with 1.3 GW and Germany third place with 0.9 GW.
- The second tender for offshore wind in Germany once again included a project bidding for 0.0 EUR/MWh support (repeating the zero-priced bids of the first round in 2017 and meaning that the project will only receive the wholesale price of electricity and no further support/payment). This proves how offshore costs have come down. It also proves how

the structuring of very capital-intensive offshore projects (e.g. excluding grid connection cost) can advance projects.

- Offshore activities in the US market are increasing. Leasing tenders have been executed (Massachusetts) and industry stakeholders have set up offices (MHI Vestas in Boston). The next stage will be the development of an offshore supply chain and projects advancing towards construction and execution timelines.
- Development in the Asian offshore markets were positive in 2018 – commitments to invest in projects and the supply chain have been made. Keeping up the momentum requires government commitment and viable levels of support to ensure the growth of the Asian offshore industry.
- India, as an example of an emerging offshore market, held a first Expression of Interest in 2018, and the first offshore tender is expected during 2019. Draft auction rules were released during January 2019.

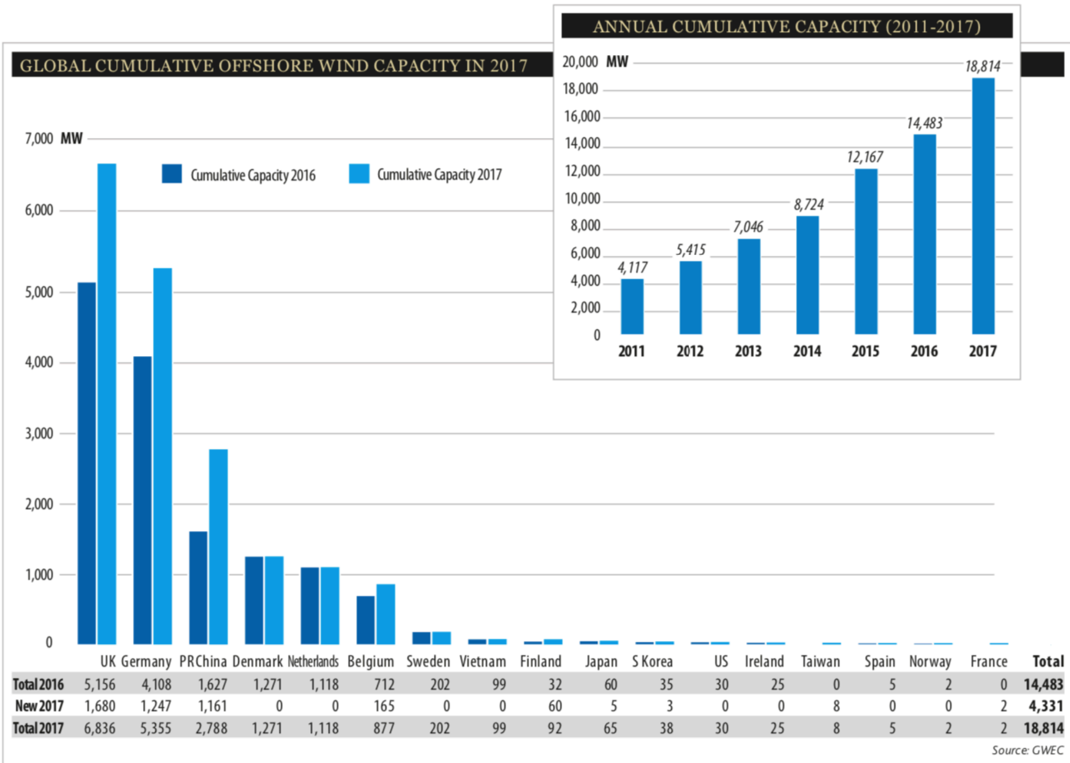


Figure 18: Global cumulative offshore wind capacity in 2017. Source: GWEC

According to BVG Associates, the forecasts for the year 2030 estimate a total installed capacity of 120 GW, and a rate of installation of more than 10 GW per year.

Much of this growth will be in Europe, based on the capacity to establish such technology and cost control, but there will also be a significant increase of installed power in countries like China and the United States and, to a lesser but also significant extent, in Japan, Taiwan and South Korea.

2017 witnessed the launch of the first **floating wind farm** in the world: Hywind Scotland, owned by Statoil, now Equinor. Conversion of strong winds off the coast into electricity requires defying the depth of the sea. According to the operator Equinor, about 80% of the possible offshore wind sites are in waters of > 60 m depth and floating wind structures facilitate the capture of energy in deep environments of up to 800 m depth. This wind farm has a capacity of 300 MW and in 2030 the costs of energy from the Hywind floating wind farm are expected to be reduced to €60/MW hour according to the company. During the first years of 2020, floating farms may continue to be a niche sector that will gain momentum towards the end of the decade.

Energy from tides, waves, and oceans is a different story since it currently contributes very little to electricity production in EU countries and worldwide. In 2016, this source of energy amounted to 0.02% of the total electricity generated from renewable energy sources in the EU-28.

The power rating of a wavefront is measured in energy density per metre of front and its value varies from one location to another. The potential depends on wave height which is attenuated by water depth as a result of friction of the wave with the sea bottom. This energy source has not been quantified with accuracy, and estimations range between 2,000 and 4,000 GW depending on the source. If we distribute these values over the 336,000 km of coastline in the world, we obtain an average wave energy density value per metre of coastline of 8.0 kW. However, this distribution is not equal since there are coastal areas in Australia or New Zealand where it can reach 100 kW/m, whilst in other places it is only 5 kW/m. In Europe this resource is found mostly on the Atlantic Coast and varies from 30 kW/m to 75 kW/m depending on location.

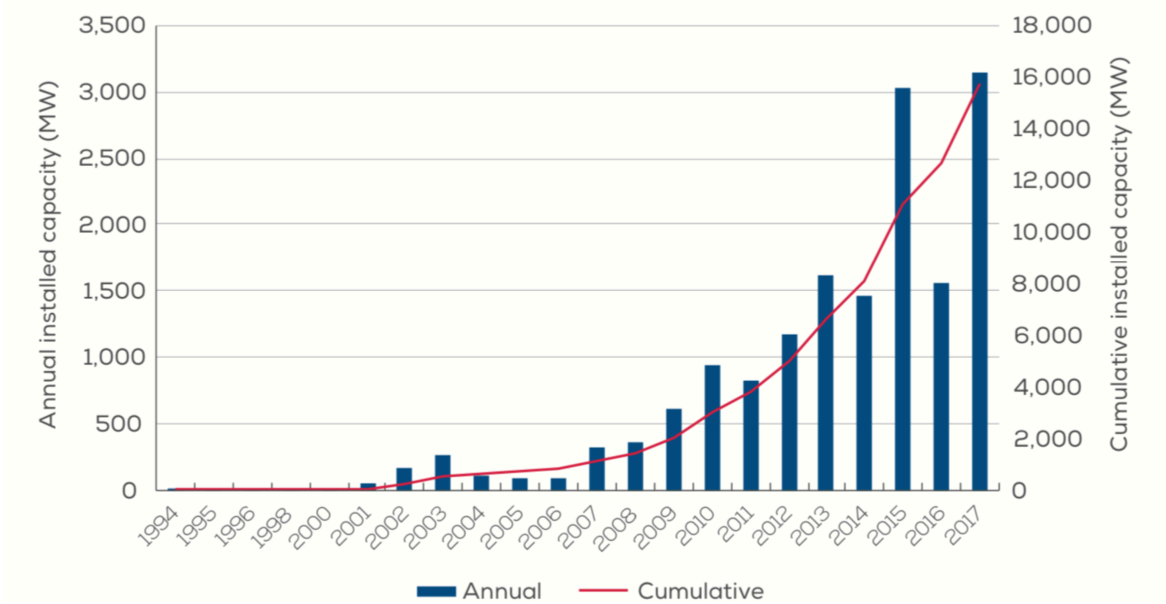
The potential for this type of available energy source is huge, even though the existing technological capacity does not permit the exploitation of more than 2% of the same. The estimated global potential is 2 TWh/year and the areas with the greatest potential per metre of coastline to use wave energy are the following: the European continent in the northwest area, especially in the North Sea; the north coast of the United Kingdom and the coasts of Ireland and Scotland; the North and South Pacific coasts in South America; the coasts of Japan and Asturias, and the coasts of Aysén and Magallanes in Chile.

Economic Situation and the European Perspective

The European offshore wind industry obtained a new annual record for installed capacity of 3,148 MW corresponding to 560 new turbines in wind farms. It represents double the installed capacity in 2016 and a 13% rise over that in 2015.

Slightly more than half of all capacity (53%) launched in 2017 was in the United Kingdom, including the launch of the first floating wind farm on the high seas: Hywind, in Scotland. The second most important market was Germany, with 40% of the EU's total capacity, thanks largely to the implementation of the Veja Mate and Wikinger projects.

In cumulative terms, Europe now has an installed offshore wind capacity of 15,780 MW, which corresponds to 4,149 wind turbines connected to the network in 11 countries.



Source: WindEurope

Figure 19: Cumulative and annual offshore wind energy installation in Europe. Source: WindEurope https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2017.pdf

The United Kingdom has the largest offshore wind capacity in Europe at 6,836 MW, followed by Germany with 5,355 MW and Denmark with 1,271 MW. The Netherlands occupies fourth place at 1,118 MW, and Belgium fifth place at 877 MW. Together, the five main countries of the EU represent 98% of all offshore wind energy installations connected to the network in Europe.

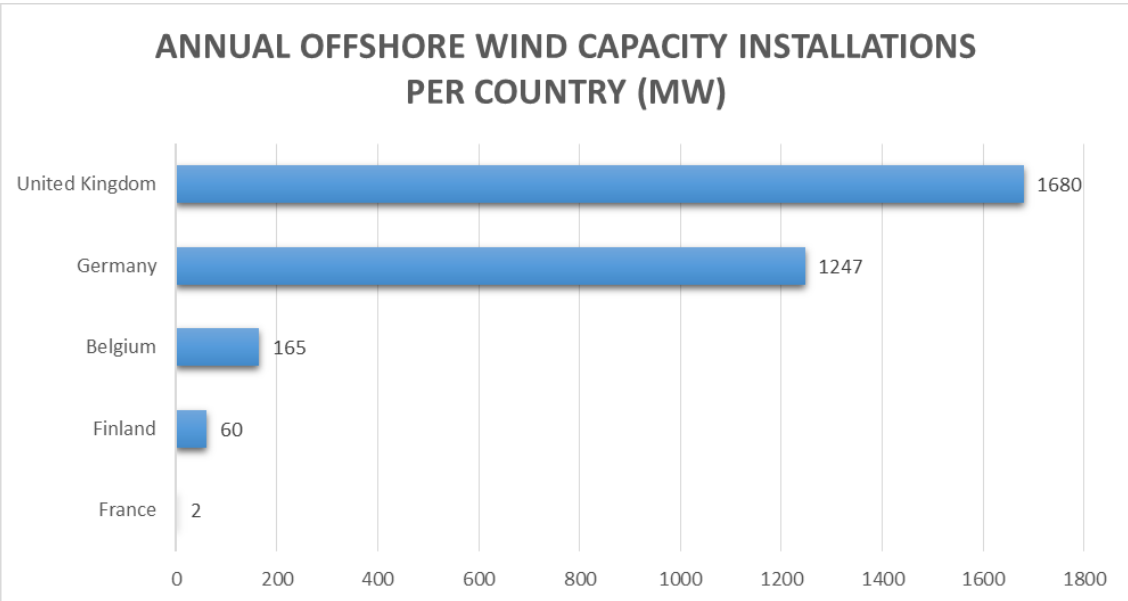


Figure 20: Annual offshore wind capacity installations per country. Source: WindEurope

Installations in the North Sea represent 71% of all offshore wind capacity in Europe. The Irish Sea has 16% of the installed capacity, which is followed by the Baltic Sea at 12%, and the Atlantic Ocean at 1.2%.

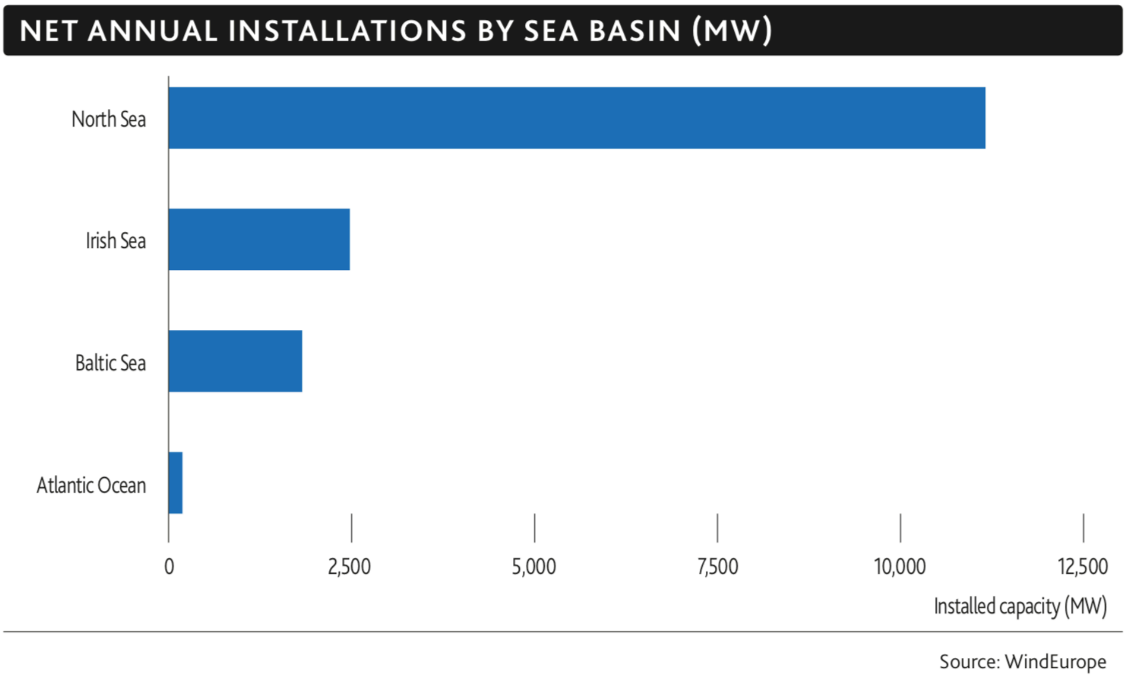


Figure 21: Net annual installations by sea basin. Source: WindEurope

During the 2014–16 period, the tidal energy sector made significant progress towards commercialisation culminating in the installation of the first tidal energy network in the Shetland Islands. This was followed by the four 1.5 MW turbines deployed as part of the Meygen project in Pentland Firth, in November 2016.

According to the 2016 JRC report[18] on the status of ocean energy, Europe is the world leader in the development of ocean energy technologies and accounts for most of the developers in the world (52% for tidal currents and 60% for wave energy). However, the installation of ocean energy devices is slower than expected, there being only 14 MW of installed ocean energy capacity at the end of 2016, instead of the 641 MW declared by the EU Member States in their national action plans for renewable energy.

From a technological point of view, there are different projects in the sector and their portfolio announced in Europe could reach 600 MW for tidal power and 65 MW for wave energy by 2020. In 2020, and taking into account only projects that have already obtained funding, the EU may have 71 MW of tidal power and 37 MW of wave energy.

The EU is strongly committed to supporting the development of ocean energy, by financing projects right from the research and development stage to the stage of demonstration plants and regional collaboration. The European Commission has reinforced its support for the development of ocean energy within the framework of its Strategic Energy Technology Plan[19]. Towards that end, objectives have been set for the cost of harnessing wave and tidal energy, in order to ensure adoption and long-term viability of both technologies.

Major Challenges Ahead

In Europe and the rest of the world, technological breakthroughs have contributed most to cost reduction and the consequent rise in the number of offshore wind projects. The technologies

[18] https://ec.europa.eu/jrc/en/publication/annual-reports/jrc-annual-report-2016
[19] https://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan

that have most encouraged progress are larger, more efficient turbines and improvements in the foundations of structures. Since wind turbines account for most of the capital and operating expenditures, it is likely that rotor size will continue to increase with a view to seeking economies of scale to reduce cost per MW, thereby improving performance and operation, and maintaining efficiency. This is why the main challenge within this industry is to continue reducing the **cost of electricity**. The said reduction in electricity cost is directly linked to decreasing uncertainty in terms of the costs associated with the strategies for optimal operation and maintenance. These activities are related to maritime transport and involve performance of corrective maintenance on the different turbines on the farms, which also depends on maritime navigation conditions.

Another challenge faced by the industry is increasing the **lifespan of wind farms,** as well as improving their availability through the introduction of predictive systems and optimisation of energy generation in the machinery. At this point, the digitalisation technologies used in the different farms are of great relevance when it comes to information removal and storage. This information may be processed using big data tools in order to finally establish such predictive systems. And lastly, this challenge is also related to the maintenance of facilities and hence to the costs incurred in operations and maintenance.
Much of the R&D in renewable energies is focused on improving **energy storage** technologies. Storage systems seek to resolve the major challenges faced by the development of renewable energies.

Likewise, it is important to highlight the trend that offshore wind farms are being increasingly installed in deeper waters. This results in the modification of the technologies used in the construction of **foundations**. Monopile foundation systems are losing out to jacket foundation systems. According to the National Renewable Energy Laboratory, it is expected that monopile structures will decrease from 80% to 59% between 2017 and 2022 as the preferred system used in structure foundations. Meanwhile, the reverse is true for jacket foundations, which have increased from 2% to 22%. Mention must be made at this point of the close relations that exist between the two industries (shipyards and wind energy) because the jacket foundations used in various wind farms are being built in different shipyards.

Very few doubt the potential of marine energy as a source of electricity generation: both wave movement and tidal displacement can generate huge amounts of almost limitless renewable energy. However, over the years neither of the two has progressed as expected. In Europe, these energies are in a position to make the most significant contribution to the European energy system in the short to medium term.

Significant reductions in technology costs will be instrumental in achieving the ambitious goals outlined in the European Strategic Energy Technology Plan (SET-Plan): the **technology cost** of tidal energy must be reduced by 75% and that of wave energy by 85%. Similarly, offshore wind farms should be planned, put in place and then deployed; such moves would undoubtedly attract the kind of investors and investment needed for developing the sector, which also needs public intervention to support and strengthen unique infrastructures and technologies.

A reduction of the considerable costs involved in such enterprises will be feasible if the R & D (research and development) arm has achieved its stated goals within a relatively short time scale. This could be accomplished by improving the design concepts and optimising engineering, by making use of economies of scale in production, construction, installation, operation and management. Long-term learning could also contribute to improve competitiveness on a commercial scale, because the theoretical cost of a wave power plant would be from around €3.9

to €6.7 million/MW. The hours of operation never coincide with the planned ones, which range from 2,200 to 3,100 hours/year, and these figures are never reached in actual performance of the prototypes. The investment and operating costs of these facilities will depend on their dimensions, capacity and location; that is to say, on the harvesting technology being used. By using many complex simulation tools, the operating cost is estimated to be between €30 million and €52 million/MW/year, three-quarters of which are destined for the costs of maintenance and repair.

In the case of the wave industry, the biggest challenges are posed by large waves directly hitting machines and damaging components and devices that are submerged in places difficult to access. The operation and maintenance of marine energy equipment has always been a challenge. According to a report from the European Union, the annual repair and maintenance costs can reach 5.8% of capital expenditure, compared to 3.7% for offshore wind power.

Projects such as the OPEN Sea Operating Experience to Reduce Wave Energy Cost (OPERA)[20] funded by Horizon 2020, or by the company Wave Swell Energy, have come to the conclusion that wave energy devices must move towards the oscillating water column concept, due to the minimum number of components, scalability, and low cost of power generation.

[20] http://opera-h2020.eu

Key Enabling Technologies

The term Industry 4.0 was first used by the German Government and describes the organisation of production processes based on technology and devices that communicate with each other autonomously throughout the value chain: a model of a “smart” factory of the future where computer systems monitor physical processes and create a virtual copy of the physical world, and where decisions are made in a decentralised manner based on self-organisation mechanisms. In this new stage, sensors, machines, components and systems would be connected along the value chain, beyond the limits of individual firms. These connected systems could interact with each other using standard internet protocols and analyse data to predict errors, have capacity for self-configuration and adapt to possible changes. In other words, digital technologies permit linking the physical world (devices, materials, products, machinery and equipment) with the digital one (systems). This connection enables devices and systems to collaborate with each other and with other systems to create a smart industry, with decentralised production that adapts to changes in real time. In this environment, the barriers between people and machines become blurred.

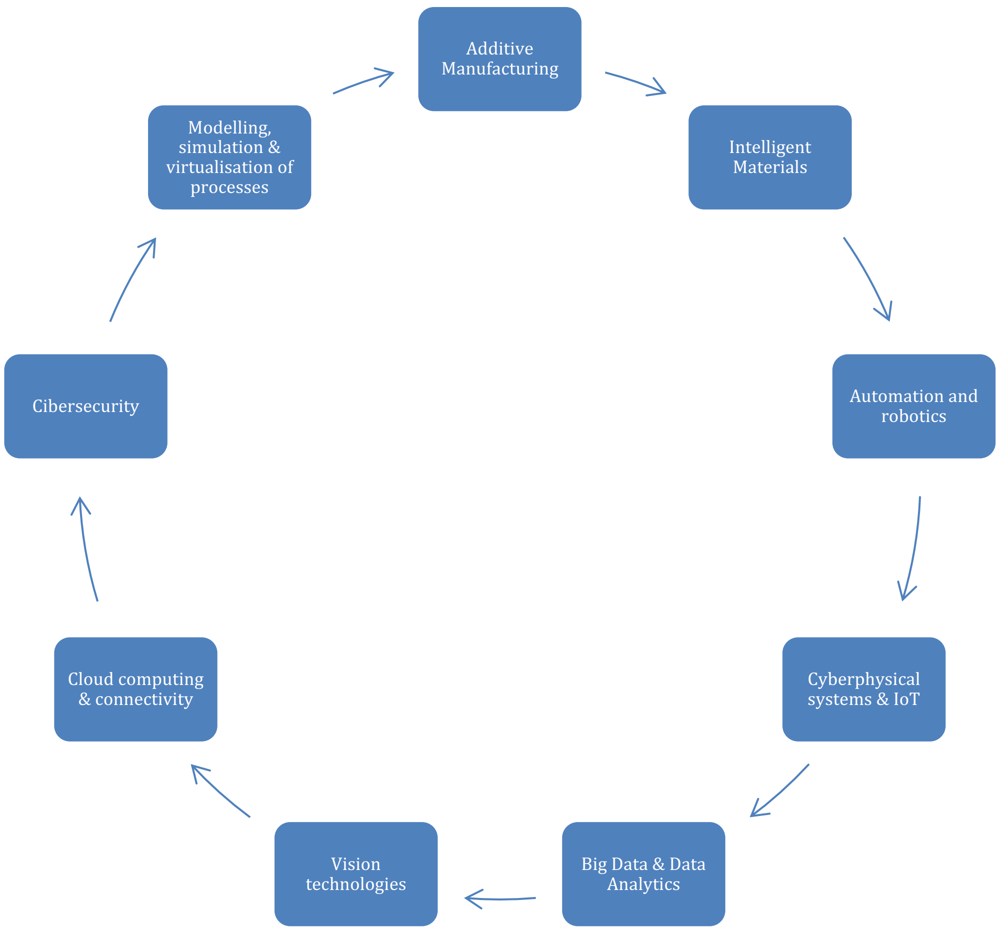


Figure 22: Technologies implemented in Industry 4.0. Source: Asime

The main **characteristics** of Industry 4.0, after taking the above into account, are:

- Interoperability: cyber-physical systems (carriers of working parts, assembly stations and products) allow humans and smart factories to connect and communicate with each other.
- Virtualisation: creates a virtual copy of the smart factory linking sensor data with virtual plant models and simulation models.

- Decentralisation: capacity of cyber-physical systems to make their own decisions and produce locally thanks to 3D printing technologies.
- Real-time capability: the ability to gather and analyse data and provide resulting information immediately.
- Service orientation.
- Modularity: flexible adaptation of smart factories to changing requirements by replacing or expanding individual modules.

Also, worth highlighting are the **technologies** associated with Industry 4.0 by the German Government:

- Application of information and communications technologies (ICTs) to digitise information and to integrate systems in all stages of product creation and use (including logistics and supply).
- Cyber-physical systems that use ICTs to monitor and control processes and physical systems. These may involve embedded sensors, smart robots that can be configured to suit the product in real time in line with the progress of additive manufacturing or creation.
- Network communications including wireless and internet technologies that are used for communication between devices (e.g. 3D printing).
- Simulation, modelling and virtualisation in the design of products and the plant, and with suppliers and distributors.
- Collection of large amounts of data and their analysis and exploitation.
- Greater support based on ICTs for workers, including robots, augmented reality, or through big data analyses and cloud computing.

Another approach to the **key enabling technologies of Industry 4.0** is the one provided by EFFRA[21] in its RoadMap:

- Advanced manufacturing processes: such as additive manufacturing, photonics, forming technologies, self-assembly, etc.
- Mechatronics for advanced manufacturing systems: control techniques, intelligence based on cognition in machinery and robotics, human-machine interaction, smart actuators, advanced materials, etc.
- Information and communications technologies: Connecting the physical world in production plants, data mining, modelling and simulation, etc.
- Manufacturing strategies: user-centred design, virtualisation, and digitisation, etc.
- Modelling, simulation and forecasting
- Knowledge and skills of workers.

Digitised manufacturing will give rise to a wide range of changes in manufacturing processes, results and business models.
Smart factories allow for greater flexibility in production. The automation of production processes, product data transmission during its passage through the manufacturing chain and the use of configurable robots mean that a variety of different products can be manufactured in the same production facility. This mass-customisation will allow production of increasingly smaller lots (even as small as unique ones) due to the ability to quickly configure machines to meet the needs of customers, and also due to additive manufacturing. This flexibility also encourages innovation, since prototypes and new products can be produced quickly, at a reduced cost, without the need for new production lines.

[21] https://www.effra.eu

The speed at which a product can be produced will also improve. Digital designs and virtual modelling of the manufacturing process can reduce the time between product design and its delivery. It is estimated that the supply chains based on data can accelerate a manufacturing process by 120%, while if we talk about the time needed to deliver orders, the time to bring products to the market can be reduced by 70%.

Integration of product development with digital technology and its physical production has been associated with major improvements in product quality and a significant reduction in error rates. Data collected through sensors can be used to monitor each piece produced instead of using sampling to detect errors, and hence correction of machinery errors can be done in real-time. These data can also be collected and analysed to use 'big data' techniques and to identify and resolve small incidents on the fly. Increase in quality plays an important role in reducing costs and, therefore, in increasing competitiveness: the top 100 European manufacturers could save around €160 billion in reprocessing costs of defective parts if all defects were eliminated.

Productivity can also be improved through various effects of Industry 4.0. By using advanced analytics in predictive maintenance programmes, manufacturing firms can avoid machine breakdowns in the production plant and reduce downtime by an estimated 50%, and increase production by about 20%. Some companies will create 'lights out' factories where automated robots continue to produce without light or heat after staff have gone home. Human workers can be used more effectively for tasks in which they are truly essential. For example, in the Netherlands, Philips produces electric razors in a "dark factory" using 128 robots and only nine workers, who perform quality control.

Customers will be able to participate more in the design process, even by providing their own designs which can then be produced quickly and cheaply. The location of some manufacturing operations can also be sited close to the client: if manufacturing is largely automated, there is no need to be "off-shore" or located in distant countries with low labour costs (but high transport costs). European companies can decide to bring plants back to Europe, i.e., "re-shore", or to establish new plants in Europe rather than abroad.

Industry 4.0 will also bring about changes in business models. Instead of competing solely on costs, European companies can compete on the basis of innovation (the ability to deliver a new product quickly), or the ability to produce customised designs (through configurable factories) or quality (the reduction of flaws due to automation and control). Some companies may take advantage of the data created as "smart" products and adopt business models based on the sale of services and not products.

This servitisation can help expand business opportunities and increase revenues.
In Europe we have examples of shipyards that are facing the transformation processes towards industry 4.0 such as **Meyer Werft**, **Damen** or **Fincantieri** among others.

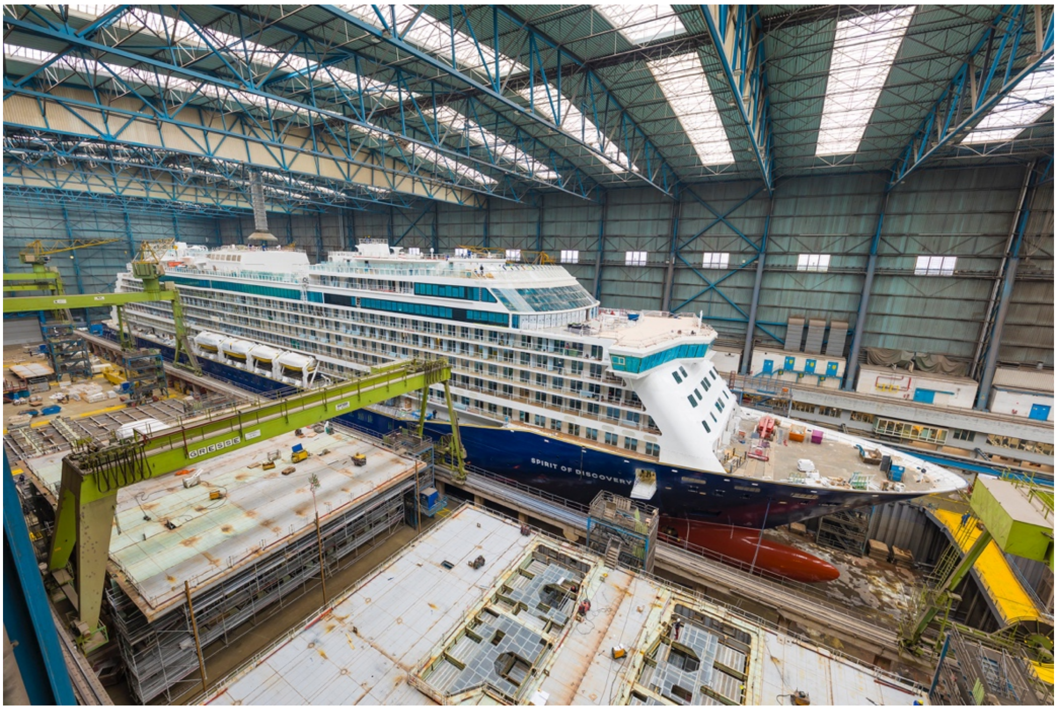


Figure 23: Meyer Werft. Source: Meyer press photos[22]

It is an Industry 4.0 shipyard, which has all of its processes digitised, right from ship design though to production, which allows for their vertical integration into management systems. For example, construction plans are hardly used, having been replaced by virtual simulations of the shipbuilding processes, which permit early optimisation of the ship and its systems, as well as simulation of the processes required for their production. This results in substantial improvements for the safety of people, the protection of the environment, and the optimisation of energy consumption.

Figure 24: Meyer Werft Plant. Source: Meyer press photos

[22] https://www.meyerwerft.de/de/meyerwerft_de/index.jsp

It is also important to highlight the effort and commitment of other shipyards, such as **Navantia** in Spain, which are implementing digital transformation plans to adapt to Industry 4.0.

Innovative Projects

Listed below are innovative projects related to the shipbuilding value chains and the marine energy sector that reflect some of the trends in these sectors for the coming years. In the projects described below we will review the implementation of key enabling technologies applied to processes, products and services.

RAMLAB PROJECT[23]

Industrial spare parts should always be available wherever and whenever they are needed. They must also meet or exceed end user's quality requirements and come at a competitive price. Additive manufacturing has the potential to facilitate the availability of certified large-scale metal parts upon demand. RAMLAB's mission is to accelerate the adoption of additive manufacturing technology, in order to provide partners with easy access to the entire value chain.

RAMLAB's 3D printing field laboratory (Rotterdam Additive Manufacturing LAB) is working with partners Damen Shipyards Group, Promarin, Autodesk and Bureau Veritas to develop the first 3D printed marine propeller in the world. A boat propeller was produced using a hybrid manufacturing process that combines additive wire and arc welding, using industrial robotic arms and subtractive machining and grinding techniques.

The Dutch port of Rotterdam is the largest port in Europe and is one of the major intersections for cargo flow in the world. It offers the best connections in the region to worldwide ports and handles more than 460 million tons of cargo/year, and hence the need for both installations and ships to operate without problems.

For example, if a ship currently arrives at port and sends a request for a spare propeller it can take weeks or months to order and get it delivered, which costs companies millions of dollars while they wait. Keeping a large stock of spares in stores around the world can also be quite expensive for companies.

To address this challenge, the port opened the innovative RAMLAB, an on-site installation, which has a pair of robotic arms with 6 axes that is also capable of producing large industrial metal parts. The RAMLAB team works with a dedicated network of hardware and software partners, academic and certification institutions, and end users, key to helping the port to stay on course and become the smartest port in the world.

[23] https://ramlab.com

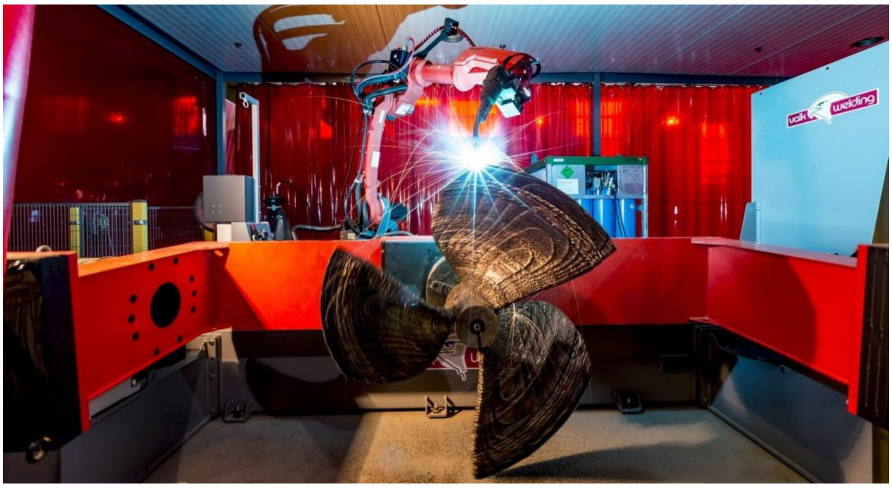


Figure 25: Ramlab propeller. Source: Ramlab

ENERGY OBSERVER[24]

This is an innovative project in which a catamaran is driven solely and exclusively with renewable energies. These include solar, wind and wave energy, as well as hydrogen generated from sea water.

This hydrogen-based energy technology is not new, since we have seen it in operations on land. In fact, Toyota uses this technology in its Mirai car and it has now been adapted to this vessel. This is the first time that it is being used in the marine field to produce hydrogen in a direct manner during navigation.

Although this sounds scarcely believable, the Energy Observer is not new; it was built in Canada in 1983 by the naval architect Nigel Irens with the intention of participating in maritime races. Its aim is not to gain a first record either, since in 1984, it became the first catamaran to sail more than 800 kilometres in just 24 hours.

For this new challenge, over time the Energy Observer has increased its length to 30.5 metres, while the width has stayed the same at 12.8 metres. Its weight is only 28 tonnes, which makes it lighter than vessels with battery storage systems.

The most interesting aspect lies in the interior, where we find a system that extracts hydrogen through demineralisation of sea water, and then separates oxygen and hydrogen by electrolysis. The hydrogen is compressed and then stored in tanks, ready to be used in the batteries whenever needed.

More than 30 people consisting of engineers and designers have worked on this project, in order to prepare it for an adventure that will last six years. During this time, the plan is to visit 50 countries and 101 ports, and in fact, the idea is to pass through Tokyo in 2020 for the Olympic Games.

During this long journey, a team will record content for a documentary focused on renewable energies, comprising eight episodes to be broadcast by the French channel Planète+. There will also be a series in web format, shared on social media networks over these six years, which will enable this journey to be followed closely.

[24] http://www.energy-observer.org/en/

Obviously, one of the goals of this project is to demonstrate the feasibility of using hydrogen-based energy and its practical applications, and furthermore it seeks to promote greater adoption of this technology.

Figure 26: Renewable energy catamaran. Source: ShutterStock[25]

ROBOTICS

Hyundai Heavy Industries Co. is using robots to build ships for the first time in order to improve efficiency and reduce costs.

One of the largest shipyards in the world, it is located in Ulsan, 414 kilometres south-east of Seoul. The shipyard has recently completed a year of testing on a robotic system which automatically shapes the three-dimensional curved surface of a vessel.

This unmanned system is based on the Internet of Things and automation technologies, and is equipped with a high frequency inductive heating system and a multi-articulating arm.

Hyundai Heavy Industries Co. plans to add artificial intelligence and more sophisticated technologies in the future.

[25] https://www.shutterstock.com/es/image-photo/fuel-cellpowered-ship-energy-observer-leaves-1458521018?src=library

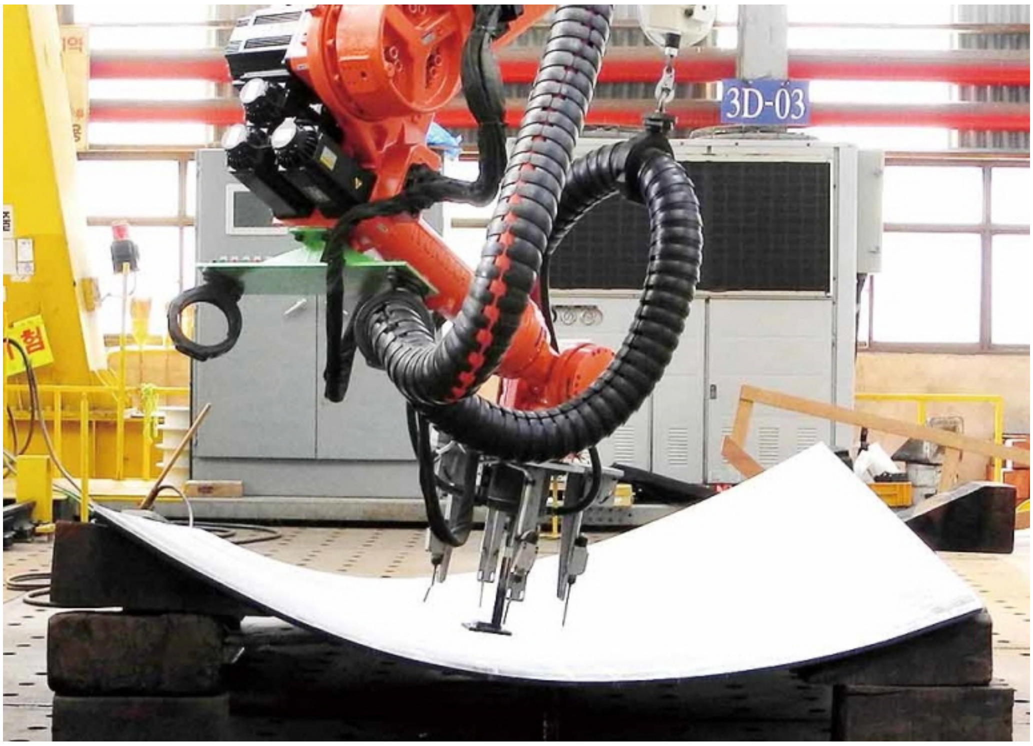


Figure 27: A robotic system works on a 3D curved surface of a ship part at Hyundai Heavy Industries Co.'s shipyard in Ulsan. Source: The Korea Bizwire26

The company claimed that the system will increase productivity threefold compared to the work done by humans, besides improving the quality of the final product. Hyundai Heavy Industries Co. expects the robot to save between KRW100 billion (US$92.3 million) and KRW200 billion over the next 10 to 20 years, depending on its useful life.

This Korean shipbuilder is one of the industry leaders in the adoption of robotics for efficiency, workplace safety and cost reduction.

Robots can replace skilled labour in welding, blasting, painting, lifting heavy loads and other tasks.

MAGALLANES PROJECT[27]

The Magallanes project started in 2007 in Redondela (Galicia, Spain) with the challenge of developing a technology capable of obtaining power from tidal currents. The project is in the final stage of assembly and construction of a full-scale 350 metric tons prototype. Sea trials were carried out towards the end of 2015 and early 2016.

After a research and development phase in 2014, Magallanes built and tested the first 1:10 scale model, which successfully concluded the official tests carried out at the European Marine Energy Centre (EMEC) in Orkney (Scotland). The system developed by Magallanes is based on building a floating platform (a steel trimaran) that includes a tube with a submerged part where hydrogenerators are installed.

The platform is anchored by two anchor lines at the fore and aft of the vessel. Being a floating platform, it does not involve any sea floor construction and thus can be installed in any part of

[26] http://koreabizwire.com/hyundai-heavy-industries-to-use-robots-in-shipbuilding/112775
[27] http://www.magallanesrenovables.com/en/proyecto

the world. It is also the system with the lowest maintenance cost, since it allows access by boat to the platform for checks, repairs or any other operation.

The objective of Magallanes is to develop and build the technology needed to win the tidal power race in Galicia, and promote patent filing, expert teams and an industry of electrical and naval components for floating platforms.

This is the first time that Galicia is contributing an electrical technology project to harness tidal energy in other parts of the world, which is not being used for the exploitation of natural resources in Galicia.

The project has the support of the Xunta de Galicia, through the Galician R&D Plan. Forty researchers from universities and technological centres are involved in the development of the model based on the latest third-generation technologies.

Magallanes is the only Spanish project which is at an advanced stage of development researching electricity generation from tides. It uses floating technology that does not need dams or barrages, or any structures or pillars on the sea floor.

Its greatest advantages are: low maintenance cost due to an easily accessible engine room, low installation costs, and greater efficiency. Being floating installations, they can be adapted to all marine areas, with low environmental impact.

WAVE SWELL ENERGY[28]

Wave Swell Energy technology is based on the well-established "oscillating water column" (OWC) concept. An OWC is actually an artificial breather. It is a large hollow concrete chamber, which is partially submerged and seated on the seabed, with an underwater vent to the ocean. The chamber also has a small opening above the water line to the atmosphere which houses an air turbine.

As wave crests and troughs pass through the OWC, water enters and exits the chamber through its submerged vent. This water travels up and down inside the chamber, causing the pressure of the air trapped above to oscillate between positive and negative pressures. Such pressure fluctuations force air to pass through a turbine located at the top of the chamber, thereby generating electricity.

The fundamental difference between Wave Swell Energy OWC technology and that of other companies is that, through an ingenious conceptual difference, patented by the company, the WSE turbine is exposed to air flow from just one direction. This provides a much simpler and more robust turbine design that is also more reliable and provides greater energy conversion efficiency.

The only moving parts of the entire technology are in the turbine and some simple valves, all of which are situated far above the water line. There are no moving parts within or underwater. This means that maintenance is only required in areas with easy access located well above the ocean.

This design reduces maintenance and directly contributes to cost reduction and greater viability of the project.

[28] https://www.waveswell.com

Demographic Situation and Skill Requirements

The continuing decline in birth rates and the increase in life expectancy are transforming the shape of the age pyramid of the EU-28; and probably the most important change will be the sharp transition to a much older population structure, which is already apparent in several EU Member States.

Therefore, the proportion of working-age people in the EU-28 is declining, while the relative number of retired persons is increasing. The percentage of elderly persons in relation to the total population will increase significantly over the coming decades, when a large part of the post-war "baby boom" generation reaches retirement age. This, in turn, implies an increase in the social spending burden of the working-age population to deal with the needs of an ageing one.

According to Eurostat data[29], the population of the EU-28 on 1 January 2016 was approximately 510.3 million. Youth (0 to 14 years of age) accounted for 15.6% of the EU-28 population, while persons considered to be of working age (15 to 64 years of age) accounted for 65.3% of the population. The elderly (65 years or more) accounted for 19.2% (an increase of 0.3% compared to the previous year, and an increase of 2.4% in relation to ten years earlier). The average age of the population in 2017 was 42.8 years, while in 2010 it was 41.0 years.

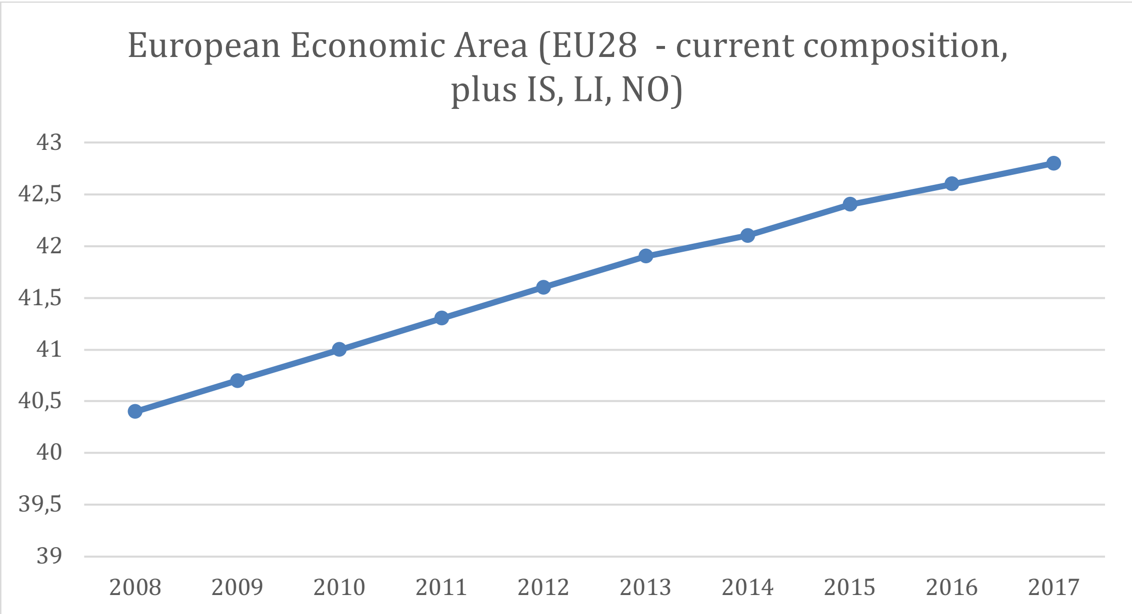


Figure 28: European Economic Area (EU28 - current composition, plus IS, LI, NO). Source: Asime based on Eurostat data

The average age in all EU Member States ranged between 36.9 years (Ireland) and 45.9 (Germany), which shows that population structures are relatively young and relatively old in these two Member States.

In all EU Member States, the proportion of youth in the total population in 2016 was highest in Ireland (21.9%) and lowest in Germany (13.2%). In relation to the proportion of people ≥ 65 years of age in the total population, Italy (22.0%), Greece (21.3%) and Germany (21.1%) showed the highest percentages, while Ireland recorded the lowest proportion (13.2%).

[29] https://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing

The ageing of the workforce in Europe is a huge challenge and even though the total population of the EU-28 will decline only slightly from now until 2050, Eurostat forecasts[30] that the age structure will change dramatically as shown in the graph below (Figure 29).

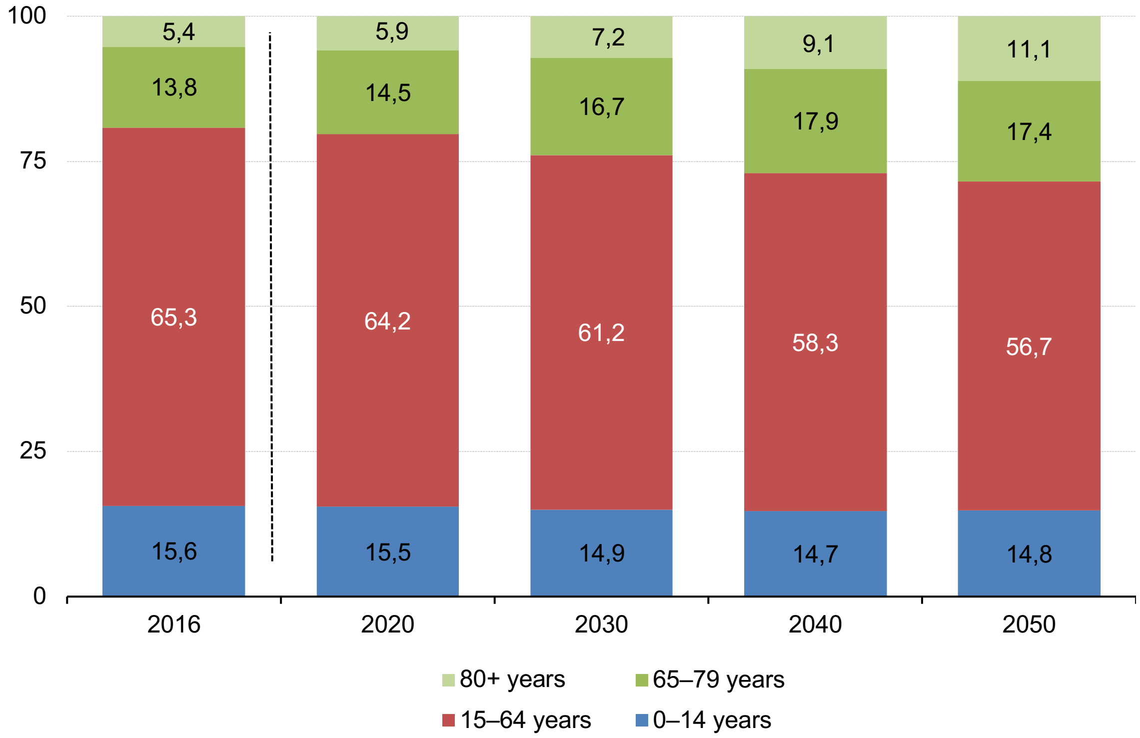


Figure 29: EU-28 age structure. Source: Asime based on Eurostat data

This existing demographic trend is a crucial aspect of the shipbuilding industry where the average age of workers may be as high as 53 years. This warrants the development of a necessary and useful strategy to facilitate the renewal of existing staff prior to retirement and early retirement in the coming years, in order to ensure that expert knowledge is transferred from older to younger staff.

This generational change should stem from an improvement in the maritime industry's image in general and the activity of the shipbuilding industry in particular. We should be able to attract young people with talent to lead and manage the evolution of Industry 4.0, based on knowledge of all processes currently used in the industry.

Finally, in this Industry 4.0 demographic and paradigm change, we should also take into account an ideal methodology based on the age bracket of each worker.

The shipbuilding study carried out by the European Social Dialogue Committee shows a comparison of the age distribution in the shipbuilding industry for the EU-14 countries against the rest of the European workforce (Figure 30).

[30] https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=File:Population_structure_by_major_age_groups,_EU-28,_2017-80_(%25_of_total_population).png

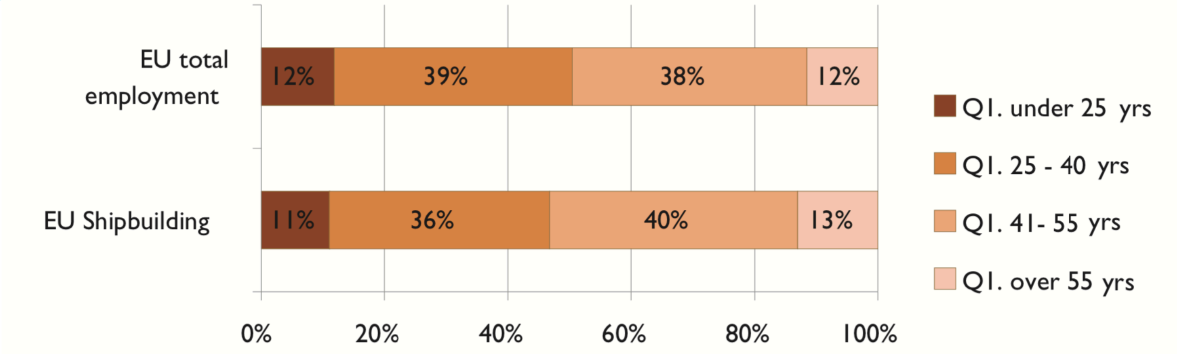


Figure 30: Comparison of the age distribution in the shipbuilding industry for the EU-14. Source: Demographic Change & Skills Requirements in the European Shipbuilding & Ship Repair Industry

In 2008, 53% of workers in the industry were aged 40+ years; since then the situation has worsened due in large measure to the recession previously referred to. This situation, when viewed by country, shows a great deal of variation between them.

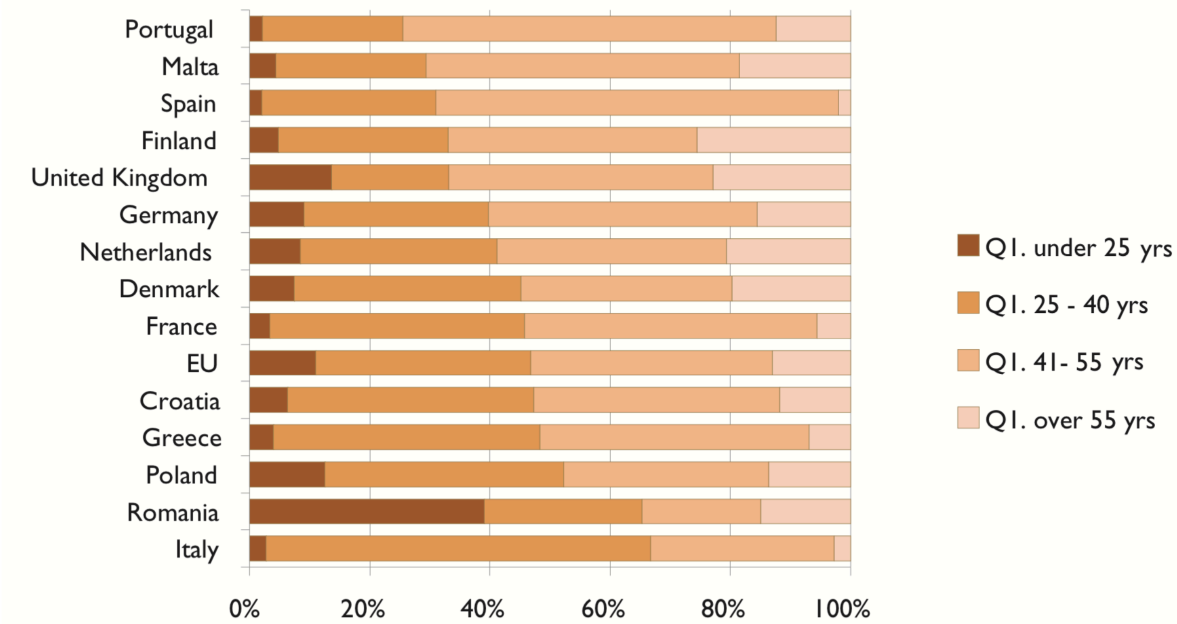


Figure 31: Comparison of the age distribution in the shipbuilding industry for the EU-14 by country. Source: Demographic Change & Skills Requirements in the European Shipbuilding & Ship Repair Industry

Countries such as Portugal, Malta, Spain, Finland, the United Kingdom and Germany had more than 60% of staff aged 40+ years, while the situation is completely different in countries such as Italy and Romania, where more than 60% of staff are aged < 40 years.

Sector specialisation means that access to skilled labour has become important for both European shipyards and suppliers of marine equipment. Below is a graph (Figure 32) showing the educational level of the workforce in the shipbuilding industry.

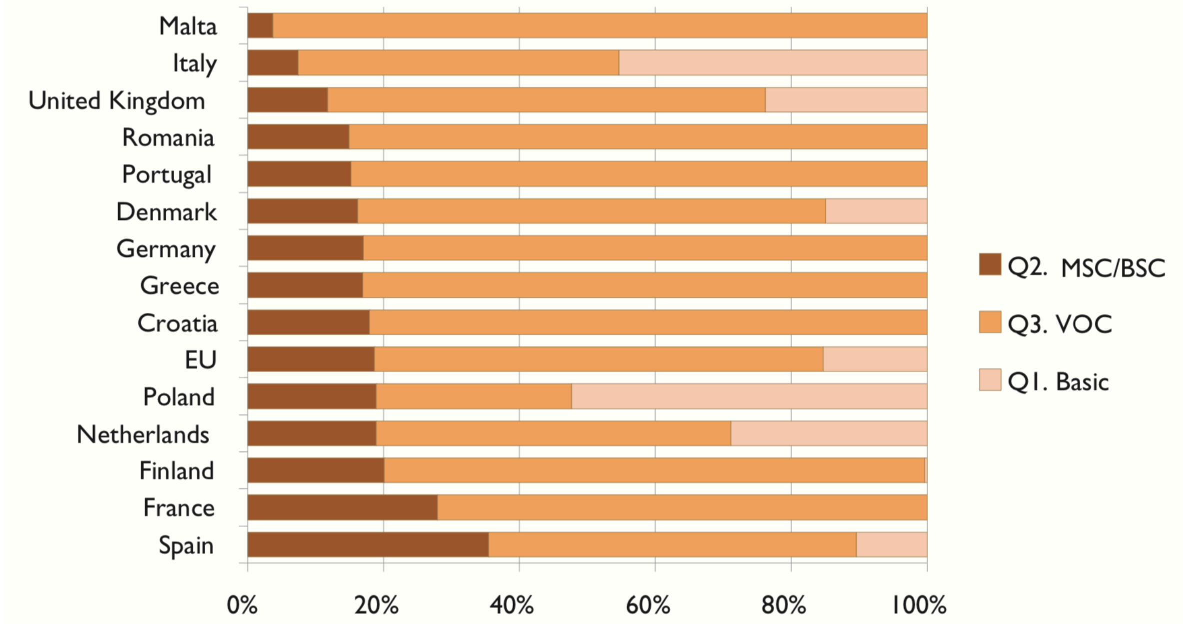


Figure 32: Educational level of the workforce in the shipbuilding industry. Source: Demographic Change & Skills Requirements in the European Shipbuilding & Ship Repair Industry:

The trend here shows that there is an increasing need for workers with a high educational level and that workers with only a basic education are gradually disappearing. This is closely related to the shipbuilding industry becoming more specialised and more knowledge -ntensive. It is also in line with the expected increase in demand for sales staff (from 2 - 3%) and design and engineering staff (from 12% - 17%).

Education Level	2004	2010-2015
MSc/BSc level	19%	25%
Vocational level	66%	74%
Basic level	15%	<1%
Total	**100%**	**100%**

Figure 33: Percentage of workers by educational level. Source: Study on the Competitiveness of the European Shipbuilding Industry-2009

According to the OECD report "The Ocean Economy in 2030"[31], in 2010, the shipbuilding and ship repair industry employed almost 2 million direct employees, as can be seen in Figure 34. The ocean-based industries have contributed some 31 million direct full-time jobs since 2010, around 1% of the global workforce. The largest employers were industrial capture fisheries (36%) and maritime and coastal tourism (23%). The remaining industries accounted for shares of between less than 1% and 8%.

[31] *http://dx.doi.org/10.1787/9789264251724-en*

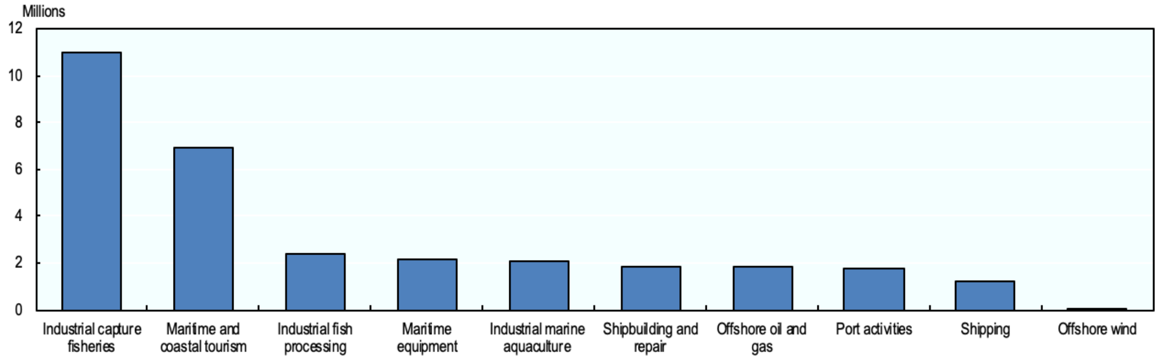


Figure 34: Employment in ocean-based industries. Source: OECD STAN, UNIDO INDSTAT, UNSD

It is expected that the growth of almost 30% of employment in ocean-based industries during the 20 year period will exceed that of the global workforce (around 19%). The table below (Figure 35) presents a sector-by-sector comparison of the results of the projections until 2030 for the average annual growth rates of value added and employment for the ocean economy.

Industry	Compound annual growth rate for GVA between 2010 and 2030	Total change in GVA between 2010 and 2030	Total change in employment between 2010 and 2030
Industrial marine aquaculture	5.69%	303%	152%
Industrial capture fisheries	4.10%	223%	94%
Fish processing	6.26%	337%	206%
Maritime and coastal tourism	3.51%	199%	122%
Offshore oil and gas	1.17%	126%	126%
Offshore wind	24.52%	8 037%	1 257%
Port activities	4.58%	245%	245%
Shipbuilding and repair	2.93%	178%	124%
Maritime equipment	2.93%	178%	124%
Shipping	1.80%	143%	130%
Average of the total ocean-based industries	3.45%	197%	130%
Global economy between 2010 and 2030	3.64%	204%	120%[1]

1. Based on projections of the global workforce, extrapolated with the UN medium fertility rate.

Figure 35: Overview of estimates of industry-specific growth rates in value added and employment between 2010 and 2030, Source: OECD STAN, UNIDO INDSTAT

From the data shown in the previous table (Figure 35), the offshore wind industry stands out, as far as changes in employment are concerned

One of the relevant topics of the MATES Project is the issue of equality between men and women. At the time of writing, it is quite complicated to find aggregated data at European level on women's participation in the shipbuilding industry. The perception of the different stakeholders who have been consulted is that the proportion of women in shipbuilding remains low. To give some relevant factual information in support of these perceptions, the largest Spanish shipyard, Navantia[32], with a workforce of 5,172 workers in 2017 according to the information contained in its 2017 annual report, reported only 10.1% women in its workforce. This company has a plan for corporate social responsibility and equality which aims to reduce this gap and improve the conditions for family reconciliation, among other challenges.

[32] https://www.navantia.es/wp-content/uploads/2018/06/Memoria_2017.pdf

She Figures 2018[33] investigates the level of progress made towards gender equality in research & innovation (R&I) in Europe. It is the main source of pan-European, comparable statistics on the representation of women and men amongst PhD graduates, researchers and academic decision-makers. The data also shed light on differences in the experiences of women and men working in research, such as relative pay, working conditions and success in obtaining research funds. They also present the situation of women and men in respect of scientific publications and inventor-ships for the first time, as well as the inclusion of the gender dimension in scientific articles.

The EU is approaching gender balance among doctoral students. Overall, in 2016, women made up 47.9% of doctoral graduates at the EU level, while in two thirds of EU Member States the proportion of women among doctoral graduates ranged between 45% and 55%. While the overall number of both women and men doctoral graduates increased between 2007 and 2016, in most of the countries that She Figures covered, the number of women doctoral graduates increased at a faster rate than for men. The proportion of women among doctoral graduates still varies among the different fields of education; in 2016, women doctoral graduates at EU level were over-represented in education (68%), but under-represented in the field of information and communications technologies (21%) and the fields of engineering, manufacturing and construction (29%).

Tertiary-educated women make up a majority of ‘professionals and technicians’ in the EU-28. More specifically, in 2017 at the EU level, women represented 53.1% of tertiary-educated people employed as professionals or technicians. In contrast, in science and engineering, women in the EU-28 were still a minority as they made up only 40.8% of people employed as scientists or engineers. However, between 2013 and 2017, in both science and engineering and professional and technical occupations, the number of women grew on average by 2.9% per year between 2013 and 2017. In total employment, women continue to hold lower shares than men, and even when they achieved tertiary education level, women are more likely than men to be unemployed. In the EU-28 in 2017, the unemployment rate for women with tertiary education was 3.8%, while for men the same rate was 2.9%.

Gender imbalance amongst researchers still remains, as in 2015 only one third of the EU’s researchers were women. However, during the 2008–2015 period, the number of women researchers in the EU-28 increased at a slightly higher rate on average than men (3.8% for women and 3.4% for men). Women researchers’ presence in 2015 was strongest in the government sector (where 42.5% of researchers are women) and in the higher education sector (42.1%), resulting in a more gender-balanced population of researchers at the EU level. On the contrary, in the business enterprise sector, women are still severely under-represented as they only represent 20.2% of the total number of researchers.

Differences between women and men can also be observed in their working conditions as researchers. At the EU level, the proportion of women researchers working part-time was higher than that of men; 13% of female researchers and 8% of male researchers were working part-time in 2016. Furthermore, 8.1% of female and 5.2% of male researchers worked under contract arrangements considered as ‘precarious employment’. In terms of equal pay, there is still a considerable gender pay gap in scientific R&D occupations. Across the EU-28, women in R&D earned on average 17% less than their male colleagues in 2014, and the gender pay gap was found to widen with age. Moreover, the presence of women researchers seems to have an inverse

[33] https://publications.europa.eu/en/publication-detail/-/publication/9540ffa1-4478-11e9-a8ed-01aa75ed71a1/language-en

relationship with the R&D expenditure per researcher; most of the countries that spent more per researcher had some of the lowest shares of women researchers.

Moving up the academic ladder, fewer women are represented. In the EU-28 in 2016, women represented 48% of doctoral students and graduates, 46% of grade C academic positions, 40% of grade B and 24% of grade A academic positions. The gap between women and men was wider in STEM (science, technology, engineering and mathematics); while women made up 37% of doctoral students and 39% of doctoral graduates, they held only 15% of grade A academic positions. In the EU-28, the proportion of women among heads of institutions in the higher education sector increased from 20% in 2014 to 22% in 2017. Furthermore, in 2017, women made up 27% of the members of boards of research organisations, while when focusing on board leaders alone, the proportion of women decreased to 20%.

In the EU-28, women were still under-represented in the publication of scientific papers. Between 2013 and 2017, the ratio of women to men among authors of scientific publications in the EU was on average one to two. However, this ratio is slowly improving and it has been increasing by almost 4% per year since 2008. The highest women to men ratio of authorship was observed in the fields of medical and agricultural sciences, where a little over eight women authors corresponded to 10 men authors. Moreover, women are still strongly under-represented among patent inventors; between 2013 and 2017 in the EU, the women to men ratio of patent inventors was on average just over one to three. A strong gender gap in the composition of the inventors' teams was also observed in the EU-28, where the most frequent composition of the teams was all men (47%), followed by those with just one male inventor (33%). A final overall observation for EU countries was a slight gender gap in receiving research grants. The funding success rate was higher for male team leaders than female team leaders by 3.0 percentage points.

Country	2012		2013		2014		2015		2016	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
EU-28	57 646	64 080	:	:	62 117	67 978	62 199	68 559	61 683	67 104
BE	1 036	1 332	1 054	1 410	1 137	1 444	1 214	1 586	1 353	1 537
BG	506	473	616	586	719	644	719	723	773	691
CZ	1 112	1 571	1 040	1 393	1 062	1 422	1 070	1 370	1 015	1 364
DK	703	849	852	1 036	1 002	1 124	1 054	1 122	1 065	1 133
DE	12 179	14 628	12 256	15 451	12 798	15 349	13 052	16 166	13 248	16 055
EE	96	94	139	94	113	100	107	101	130	109
IE	747	785	862	876	898	851	683	746	:	:
EL	761	973	691	836	784	817	849	945	986	1 017
ES	4 604	4 879	5 237	5 267	5 361	5 528	5 667	5 649	7 463	7 231
FR	5 761	7 517	6 088	7 802	6 003	7 362	6 054	7 720	5 797	7 219
HR	730	608	454	376	450	405	497	381	355	291
IT	6 099	5 359	5 557	5 130	5 588	5 090	5 409	5 076	5 077	4 726
CY	24	24	26	26	33	27	42	35	54	36
LV	160	107	181	134	159	105	141	114	114	83
LT	227	171	260	181	243	168	248	169	187	137
LU	29	28	25	39	31	51	48	59	43	64
HU	577	665	495	574	553	601	559	647	589	666
MT	6	7	12	12	6	16	16	14	15	22
NL	1 815	2 225	1 997	2 324	2 142	2 386	2 290	2 373	:	:
AT	1 009	1 403	974	1 254	924	1 283	954	1 236	947	1 292
PL	1 911	1 679	2 051	1 668	1 798	1 578	2 078	1 709	2 030	1 734
PT	1 637	1 272	1 355	1 108	1 347	1 156	1 259	1 092	1 289	1 055
RO	2 851	2 307	2 808	2 562	1 932	1 845	2 082	1 910	1 238	1 022
SI	287	282	626	540	562	441	568	432	2 308	1 455
SK	1 063	1 118	1 091	1 028	1 082	1 100	953	961	928	843
FI	944	890	961	938	1 061	952	1 052	948	1 036	973
SE	1 541	1 802	1 542	1 803	1 665	1 919	1 661	1 986	1 598	1 935
UK	9 415	11 023	12 033	13 863	11 757	13 263	12 507	14 129	12 647	14 719
IS	21	19	29	26	53	35	35	32	46	26
NO	677	731	741	808	712	730	731	676	686	682
CH	1 571	2 067	1 589	2 042	1 664	2 183	1 727	2 127	1 743	2 192
ME	:	:	:	:	:	:	:	:	19	9
MK	71	75	119	100	106	100	143	103	111	86
AL	69	48	114	95	27	30	314	206	364	291
RS	:	:	:	:	356	385	574	515	585	481
TR	2 096	2 410	:	:	2 155	2 361	2 394	2 798	2 803	3 249
BA	75	114	88	122	31	50	116	185	128	157
AM	116	264	106	271	74	173	116	210	125	212
GE	172	98	218	188	265	185	216	133	210	159
IL	823	763	804	737	769	777	804	813	:	:
MD	241	164	295	193	232	176	256	193	254	191
TN	:	:	337	284	468	357	824	501	700	755
UA	5 162	4 086	5 059	3 864	5 127	3 954	4 789	3 481	4 651	3 557

Figure 36: Number of doctoral (ISCED level 8) graduates by sex, 2012–2016. Source: SHE FIGURES 2018, European Commision

	2008						2015					
	Natural sciences	Engineering and technology	Medical and health sciences	Agricultural sciences	Social sciences	Humanities	Natural sciences	Engineering and technology	Medical and health sciences	Agricultural sciences	Social sciences	Humanities
BE	23	30	41	40	28	45	34	27	65	49	48	56
BG	53	37	56	60	61	66	50	41	81	63	64	66
CZ	33	26	55	49	48	45	33	26	56	48	47	42
DK	26	27	33	67 (2/3)	43	44	31	0 (0/1)	54	-	53	51
DE	28	23	48	40	44	49	34	23	51	44	52	52
EE	33	35	76	70	81	71	29	53	85	71	67	67
IE	32	28	76	34	51	-	30	29	88	39	53	-
EL	30	34	52	32	63	67	41	29	40	34	54	56
ES	42	37	52	50	47	45	44	33	57	50	49	44
HR	49	29	49	42	53	57	52	38	52	48	57	55
IT	35	31	55	40	51	52	41	39	55	48	54	58
CY	60	20 (1/5)	38	17	47	61	63	33 (1/3)	29 (2/7)	28	74	74
LV	49	33	72	50	72	71	59	21	78	65	79	65
LT	49	34	68	67	65	68	43	26	58	62	64	65
LU	42	29	50 (1/2)	25 (4/16)	40	20 (2/10)	47	24	72	-	40	58 (7/12)
HU	29	34	57	41	40	49	34	26	52	50	46	50
MT	71 (5/7)	67 (4/6)	50 (1/2)	43 (3/7)	59 (10/17)	0 (0/1)	100 (1/1)	-	60 (6/10)	9	-	0 (0/1)
NL	31	22	44	33	48	37	31	24	53	37	57	54
AT	28	38	53	27	52	52	37	41	40	38	54	53
PL	41	24	60	47	46	57	39	28	: c	54	46	57
PT	61	43	64	59	68	65	61	42	61	67	53	59
RO	51	46	72	65	55	53	44	47	70	60	55	50
SI	38	33	53	45	56	51	41	31	71	41	65	53
SK	41	31	60	46	57	52	44	28	58	54	60	56
FI	38	31	:	49	56	68	41	30	65	51	57	66
SE	42	23	47	100 (1/1)	48	49	43	28	51	-	43	57
UK	27	16	45	39	59	46	34	17	43	43	55	58
IS	:	:	:	:	:	:	42	33	36 (5/14)	11 (2/19)	50 (5/10)	65
NO	32	20	52	40	47	52	37	27	57	42	52	57
ME	70	46 (6/13)	58	-	-	26 (5/19)	54	50 (10/20)	57	0 (0/1)	60 (3/5)	19 (3/16)
MK	49	49	61	48	41	57	41	-	53	:	65	49
RS	57	45	74	50	57	45	62	46	58	73	48	56
TR	27	28	50	29	46	35	31	24	27	37	43	32
BA	48	-	0 (0/1)	-	-	11	48	44	76	-	-	19
AM	:	:	:	:	:	:	51	35	54	54	53	57
GE	:	:	:	:	:	:	73	33	64	30	59	77
MD	:	:	:	:	:	:	52	27	55	55	59	54
UA	:	:	:	:	:	:	42	39	65	57	63	68

Figure 37: Evolution of proportion (%) of women among researchers in the higher education sector, by field of research and development, 2008–2015. Source: SHE FIGURES 2018, European Commision

There are several reasons why enterprises are having difficulties in recruiting suitable staff, two of the main ones being education and attractiveness of the industry. The low number of entities and qualified staff to train specific personnel for the shipbuilding industry is the principal reason for the problem of staff recruitment. The other main factor is the declining appeal of the industry as compared to other types of activities. There is therefore a need to create specialised training in shipbuilding and to improve working conditions, since they are key factors to address the challenges associated with the workforce.

According to the latest report of the International Renewable Energy Agency, hereinafter IRENA[34], the wind energy industry employed more than a million people around the world in 2017; more precisely, 1,148,000 direct jobs. The countries that generate the most jobs in the world are China, Germany, the United States, India and the United Kingdom respectively. Wind energy is the fourth type of renewable energy that has generated most direct jobs and is preceded only by photovoltaic/solar energy, biofuels and hydraulic power stations. According to the macroeconomic scenarios of the report made by Wind Europe, in the case of reaching an installed capacity of 323 GW in offshore wind, it is estimated that 569,000 direct jobs are needed in this industry in Europe. In contrast, the wave, tidal and marine energy industry created only 1,057 direct jobs. As described above, this type of industry is still in a pre-commercial stage and therefore the number of jobs created at the moment is low as compared to other technologies.

[34] https://www.irena.org/publications/2019/Jun/Renewable-Energy-and-Jobs-Annual-Review-2019

Moreover, the various workshops held in the first half of 2018 identified the need to develop specific training programmes to address the training needs demanded by the marine industry value chain companies. There are several professional activities, such as painter and sheet-metal workers, that do not have formal training systems, making it difficult for the educational system to provide workers needed in the shipbuilding industry. Furthermore, not only do we need to address the skills needed to perform the job, but also to provide basic training in the prevention of occupational risks.

Lastly, not only do we need to identify and schedule workers' current needs, but also to outline the future skills required of them.

Conclusions

After several years of a major economic crisis, which has led to the disappearance of companies and the destruction of jobs around the world in different sectors of activity, we find ourselves at a time when current and future employment prospects are more positive and are generating moderate optimism in society. Forecasts indicate that stable jobs will be created in the coming years not only in strong sectors in Europe, such as shipbuilding and the offshore wind industry, but also in other areas, such as the marine energy industry (mainly wave and tidal), which have experienced a high degree of development and application in Europe. This is mainly due to the favourable conditions on our continent or activities related to information technology and Industry 4.0.

The shipbuilding industry is cyclical in nature, largely influenced by global economic cycles. This characteristic influences the programming and planning of activities in the industry in the medium and long term to generate stability in terms of human capital and when making investments to improve productive capacities. Likewise, the level of specialisation of the naval industry in Europe makes us world leaders in certain types of ships, such as cruise ships, yachts, dredgers and fishing boats. Some of these have a high technological level, which allows European shipyards to be optimally positioned in the construction of military vessels. This high competitive level in terms of the technology implemented in the ships represents a strategic competitive advantage over the world's main shipyards located in China, South Korea and Japan. However, in order to maintain the identified strengths and mitigate certain existing weaknesses or barriers, it is vital to focus on human capital and innovation and development. As far as human capital is concerned, the ageing of the population together with the average age of the industry's workers suggest that one of the most important challenges is generational change and the transfer of information and experience. To this end, improving the image of the sector in order to attract workers to it or the greater participation of women in this industry is essential to maintain competitiveness, as well as labour mobility between regions. However, it is not only important to attract human capital, but also to achieve a high level of training and acquisition of skills to improve the productive capacity of enterprises and promote the implementation of technological solutions. It is therefore crucial to adapt existing training in this field and to allow access for skilled workers in the workplace.

Furthermore, the strategy set out by the European Commission to reduce CO_2 emissions and increase the transport of both goods and maritime passengers by 2050 gives rise to a series of challenges that must be taken into account in the medium and long term. These include the use of alternative energies and fuels (examples of which are the use of LNG or renewable energies, such as the Energy Observer project), the use of composite materials or the modularisation of ships.

As far as marine energies are concerned, the challenges are different, also due to the different degree of technological development presented by each of them, with the offshore wind industry leading the energy generation technologies. The evolution of offshore wind energy is constant growing, which, added to the improvement of technologies, mainly in the field of turbines, foundation structures and improvements in terms of maintenance of the useful life of windfarms, offers a glimpse of a decade of important developments. Projects such as North Sea Wind Power are new and of great relevance to the sector. Several countries are engaged in the installation of offshore windfarms and others plan to begin construction in the coming years. For example, China has implemented 1.8 GW in the last year. If the expectations for this decade are maintained, more than 500,000 new direct jobs will be created, which is a challenge when it comes to finding the new workers that will be needed.

As far as marine energies related to wave, tidal and gradient energy are concerned, their level of technological development is inferior to that of offshore wind energy, so in the coming years it will be very important to continue improving the technology in order to improve the competitiveness of electricity generation and generate economies of scale in the future. Due to the existing geographical characteristics in Europe, the development and implementation of these energies will be of great importance when it comes to generating electricity and reducing the impact of CO2 emissions into the atmosphere. Projects such as Magallanes or Wave Swell Energy are models to be highlighted and followed, as well as encouraged to achieve the desired objectives.

Following this first report in which the situation of both sectors is presented along with the challenges that each of them will have to face in the short, medium and long term, the next step that will be taken in the MATES project will be to analyse the existing capacities for both sectors in Europe, as well as the competences and abilities that must be instilled in the training centres for the development of human capital. As has been previously described, being able to homogenise and develop training courses in the field of shipbuilding and marine energies, which will enable a high level of human capital in these sectors, is one of the great challenges to be overcome in the near future and is crucial when facing the challenges posed, such as the implementation of key enabling technologies in the production processes of industries or in the development of innovative and disruptive projects that allow us to lead these sectors at a global level.

List of Institutions

Organisations participating in the workshops held between the months of April and May 2018 in Greece, Portugal, Netherlands, United Kingdom and Spain. The attendees analysed how the MATES target sectors are being influenced by capacities needs related to digital skills, green technologies, and innovation management, and how ocean literacy can promote blue growth in the maritime industry. [REF. D1.3 Mobilisation WS reports][35]

Institutions	Country
Aceuve	Spain
Afavias Açores	Portugal
Aimen	Spain
American Bureau of Shipping (ABS)	Greece
Asociación de Industriales Metalúrgicos de Galicia (ASIME)	Spain
Associação Comercial e Industrial da Ilha do Pico	Portugal
Associação das Indústrias Navais	Portugal
Associação de Armadores de Pesca Artesanal do Pico	Portugal
Atlanticoline SA	Portugal
Balance Consulting	Germany
Bivara	Spain
Câmara do Comércio e Indústria da Horta	Portugal
Centro de I&D Okeanos	Portugal
CERTH-HIT	Greece
CETMAR	Spain
CIFP Someso	Spain
Clube Naval da Horta	Portugal
Coterena	Spain
CT Ingenieros	Spain
Denmark Technology University	Denmark
Digital Enterprise	Spain
Direção Regional das Pescas	Portugal
Direção Regional dos Assuntos do Mar	Portugal
Escola Básica e Integrada da Horta	Portugal
Escola Profissional da Horta	Portugal
Escola Secundária Manuel de Arriaga	Portugal
Extrusionados Galicia S.A.U.	Spain
Flying Sharks – Consultoria e Inovação Lda	Portugal
Fórum Oceano – Associação da Economia do Mar	Portugal
Fundação Rebikoff-Niegeler	Portugal
Fundación Empresa-Universidad Gallega (Feuga)	Spain
Fundo Regional para a Ciência e Tecnologia	Portugal
Galventus Servicios Eólicos	Spain
Gdansk University of Technology	Poland
Gesdim Ingenieros	Spain

[35] Reports of the five mobilisation workshops are available at MATES website, section Deliverables 1.3, Mobilisation Workshops https://www.projectmates.eu/results/deliverables/

Ghent University	Belgium
Gradiant	Spain
Hellenic Centre for Marine Research, HCMR, Institute of Oceanography	Greece
Hellenic Institute of Marine Technology & Hellenic Shot sea Ship-owners Association	Greece
Iberdrola	Spain
Indigo-Med	Greece
Industrias Ferri	Spain
Innovation Quarter	The Netherlands
Instra Ingenieros	Spain
Istanbul Technical University	Turkey
Ledisson AIT	Spain
Logistics S.A. (Transport and Goods Management Company)	Greece
Montajes Cancelas S.L.	Spain
Moreira Facturing S.L.	Spain
National Technical University of Athens/Dept of Naval Architecture & Marine Engineering	Greece
Navantia	Spain
Nervion Industries	Spain
NTUA	Greece
Observatório do Mar dos Açores	Portugal
Piraeus Chamber of Commerce & Industry	Greece
Portos dos Açores SA	Portugal
Rysia	Spain
seaExpert, Fisheries Services and Consultancy, Ltd	Portugal
Secondary Education Environmental Education Responsible, Attiki Region	Greece
Ship repair Services Company of Piraeus Port Authority	Greece
Southampton University	UK
Technical University of Delft	The Netherlands
Universidad de A Coruña	Spain
Universidade de Vigo	Spain
Universidade dos Açores	Portugal
University College London	UK
University of Amsterdam	The Netherlands
Vigo Marine Services	Spain
WavEC – Offshore Renewables	Portugal
Wegemt	The Netherlands

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