

PEER REVIEW OF THE DANISH SHIPBUILDING INDUSTRY

Q1 2024



Foreword

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1. Executive summary

Denmark has a long history in marine industry and used to be one of the leading shipbuilding economies in the world. However, the Danish shipbuilding industry has witnessed a decline in orders for new ships since the late 1970s, notably in the context of the expansion of the shipbuilding activities in Asian countries. Major shipyards began to close in the 1980s, with the largest shipyard located in Odense closing in 2012.

Although newbuilding activity has decreased significantly, based on its long history and well-established expertise within the industry, Denmark continues to have a strong maritime value chain including marine equipment, ship design, ship repair and finance. Moreover, Denmark's shipping industry is also one of the largest in the world with companies such as Maersk. Danish shipowners order ships mainly at foreign yards, notably in Korea, People's Republic of China (hereafter China) and Japan.

Shipbuilding in Denmark focuses on the construction of specialised small and medium-sized vessels, especially fishing vessels. After the closure of shipyards, the facilities have been used by other industries with often a high level of innovation. The premises of former newbuilding yards have been transformed into industrial sites including Northern Europe's largest ship repair yard, wind turbine construction facilities and other activities including a robotic centre.

Danish Maritime Authority (DMA) is a governmental entity in charge of the regulation of Danish maritime activities and is part of the Ministry of Industry, Business and Financial Affairs. Public subsidies specific to the shipbuilding and maritime equipment industry in Denmark, were phased out by the end of 2012. On the other hand, the REACT EU funding instruments – both via the European Social Fund (ESF) and the European Regional Development Fund (ERDF) – support innovative industries and are expected to benefit marine equipment companies as well as other industries.

According to the DMA, the last of the government subsidies specifically supporting the domestic construction of ships were phased out by the end of 2012. The authority also mentioned that such public financing schemes do not currently exist for the shipbuilding industry in Denmark. Instead, the Danish government focusses on the support for technology development and demonstration through partnerships rather than subsidies.

Denmark has traditionally been a country with strong partnerships between the government and the private sector, which involve the government, private companies and universities, to support entrepreneurship and innovation, notably in the maritime sector. There can be government funding for some partnerships aimed at the creation of business cluster, or partnerships without government funding. For example, several partnerships support decarbonisation in the maritime sector, notably the “Green Ship of the Future” which focuses on exploring new technologies for zero-emission maritime transport and involve many partners from the maritime industry.

As in many other economies, securing workforce for the maritime industry has become one of the main challenges in Denmark. Companies in the maritime sector compete with other industries in the context of the increasing average age of employees in the maritime industry and increasing difficulty in recruiting younger workers. To attract young talents, maritime companies and associations in Denmark develop industry-university cooperation such as private-funded research projects and internship programs. The twin – green and digital – transition creates opportunities to attract new talents in Denmark's maritime sector. In addition, the maritime industry as a whole is focussed on curbing the women underrepresentation in the industry.

Drawing from the analysis, the Danish maritime industry's competitiveness is shaped by its historically strong value chain including marine equipment industry and its several public-private partnerships that contribute to innovation. Denmark must keep pace with new market trends shaped by the green and digital revolutions and may leverage on the increased demand for low-emissions ships and the growing conversion market. It is already doing so as Danish companies are leading the research on low-carbon

technology development future fuels and low-carbon strategy through an international public-private partnership. Accordingly, it should secure talented young generation as they are the key to making progress in the global maritime industry.

2. Introduction

In 2012, the OECD's Council Working Party on Shipbuilding (WP6), which became on the 1st of January 2024 the OECD Shipbuilding Committee, introduced a peer review process focused on support measures provided by governments to their shipbuilding sectors. Under this process, each economy participating in the Shipbuilding Committee undergoes an in-depth study of its shipbuilding industry and related government measures. Non-Shipbuilding Committee economies may also join the process and be the subject of a Shipbuilding Committee review.

The main goal of the peer review process is to strengthen the identification of government policies, practices and measures affecting the shipbuilding sector and to support the discussion of these measures within the Shipbuilding Committee. The analysis of the support measures is accompanied by contextual details of the industry to provide a rich discussion of shipbuilding policies and their impact. A key element of the process is the active debate and discussion of peer review drafts by Shipbuilding Committee participants, with a view to promoting transparency and sharing experiences.

Denmark, together with Croatia, Italy, Poland and Romania, is subject to a Shipbuilding Committee peer review in 2023, following the reviews of Japan (2012), Portugal (2013), Korea (2014), Germany (2015), Norway (2016), Finland (2017), the Netherlands (2019) and Republic of Türkiye (2021). In 2018, the Shipbuilding Committee decided to conduct an ad hoc review of the shipbuilding sectors in selected non-Shipbuilding Committee members, including China, Indonesia, Malaysia, the Philippines, Singapore, Chinese Taipei and Viet Nam. In 2020, the Secretariat also prepared a report on China's shipbuilding industry and policies affecting it.

The information in this report is based on publicly available information, statistical series available to the Secretariat, Denmark's response to the peer review questionnaire, and discussions with government officials and stakeholders during the Secretariat's mission to Denmark (18-19 April 2023). The Secretariat expresses its special gratitude to the government and industry stakeholders who participated in the review and especially the successful mission to Denmark.

The analysis focuses on the shipbuilding and marine equipment industry, but also provides information on the repair and conversion facilities. The report includes three substantive parts: global perspective, the structure and characteristics of the Danish shipbuilding and marine equipment industry and finally policies affecting the shipbuilding and marine equipment industry.

3. Global perspective

3.1. The Danish shipbuilding industry

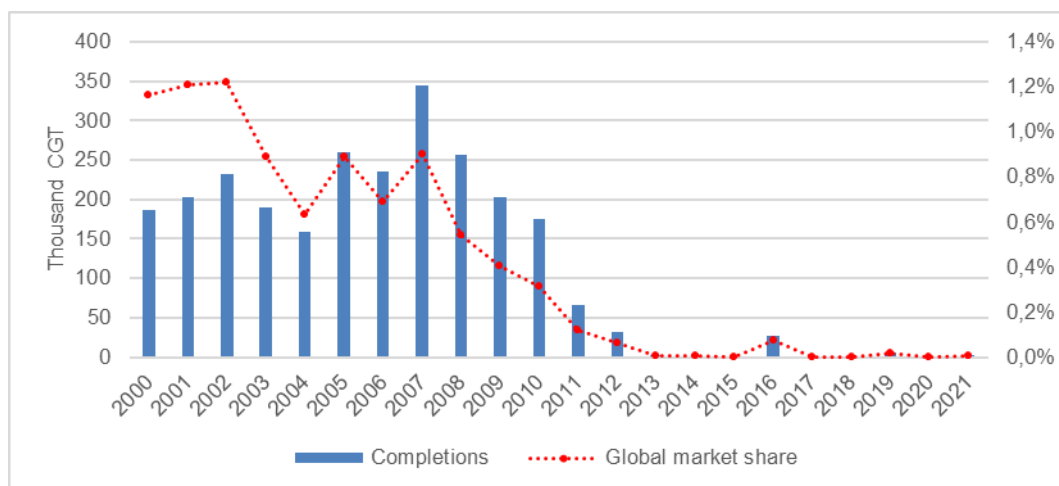
Denmark has a long history as a maritime nation surrounded by the sea. Denmark's geographic location has played a strong influential factor in the country's development into one of the world's leading maritime nations. Maritime transport has been a vital source of income in Denmark and the history and tradition of shipping have laid the foundation of a well-established expertise within the industry. Danish maritime know-how is ranging from development and production of equipment to the operation of a wide range of maritime activities, which creates spill-over effects among the different segments of the industry. The Danish shipbuilding and maritime equipment industry is known for its high quality, energy efficiency and innovative technology.

From the mid-1980s, the Danish shipbuilding industry changed significantly. While the large newbuilding yards gradually moved to Asia, Danish shipbuilding focused more on maritime equipment and the construction of small and medium size specialised vessels. The spirit and entrepreneurship of the large Danish shipyards is still alive in today's advanced equipment providers, and more specialised shipbuilding, and ship repair, that is taking place at the remaining shipyards.

The Danish shipbuilding industry has witnessed a decline in orders for new ships in the late 1990s. During the 2000s, Denmark's seagoing vessel completions amounted to around 200,000 compensated gross tonnes (CGT) per year. Over the last twenty years, Denmark's global market share in terms of seagoing vessel completions peaked at 1.2% in 2002 (Figure 1). But it decreased sharply in the early 2010s, notably in the context of the expansion of Asian shipbuilding industries.

In regional perspective, Denmark represented about 0.28% and 0.14% of the EU's CGT production in 2021 and 2019 respectively. The EU shipbuilding industry was greatly affected by COVID-19, and the completion rate in 2020 decreased by 27% compared to 2019. However, it has been showing an upward trend since 2020, recording 6.3% of the world's CGT of selected vessels, 7% in 2021 and 9% in 2022. But Danish ship completions remained marginal.

Figure 1. Completions in CGT and global market shares by Denmark, 2000-2021



Note: This Figure includes all seagoing vessels from 100 GT.

Source: OECD calculations based on Clarkson Research Services Limited (January 2023), *World Fleet Register*, <https://www.clarksons.net/wfr>.

Although the number of ocean-going ships built in Denmark has decreased significantly, Denmark has a strong maritime value chain including equipment, design, repair and finance. Firstly, Denmark is a strong

marine equipment economy. Given the transition of many large Danish shipyards towards equipment manufacturing, it nowadays exceeds traditional shipbuilding in terms of both gross value added and number of employees. Secondly, the Danish maritime industry includes several of the world's leading ship design and ship interior companies. Thirdly, many of Denmark's shipyards use most of their capacities for repair and conversion activities. Furthermore, Denmark also hosts marine service companies.

The shift towards zero- and low-carbon ships has a big impact on Danish maritime value chain notably regarding ship retrofitting and ship finance. For example, ship conversion is expected to be a growing market since a share of the existing world fleet will be first retrofitted before being replaced. Due to its strength in the delivery of innovative green technology, the Danish equipment manufacturing sector is expected to be especially impacted by this. Moreover, the financing of the new zero- and low-carbon ships, and onshore bunkering infrastructure, will require massive investments and will be a significant issue in the shipbuilding sector.

Furthermore, Denmark hosts a sizeable offshore industry, which encompasses both traditional oil and gas exploration as well as a world-leading offshore wind sector. The strength of the marine equipment industry has greatly contributed to the development of other clean energy industries such as wind generation. Several suppliers to the maritime industry also provide their products or slightly revised versions of these to the offshore sector. While the Danish wind industry started onshore, there is no doubt that one of the reasons it could develop speedily at sea was the sound know-how available in Denmark when it comes to what it takes to place and make things last in a tough offshore environment at sea.

3.2. The Danish shipping industry

Denmark is a shipping powerhouse with some of the world's largest shipping companies such as Maersk, TORM and DFDS. Clarkson's World Fleet Monitor (June 2023) shows that Denmark ranked as the 11th largest owner country (Table 1). Denmark is having activities in almost all shipping segments, including container freight, tanker, bulker, and offshore-related activities notably offshore wind. Maersk is one of the largest container shipping companies globally, with more than 700 ships and 100,000 customers in the world¹.

Table 1. Owned fleets by country

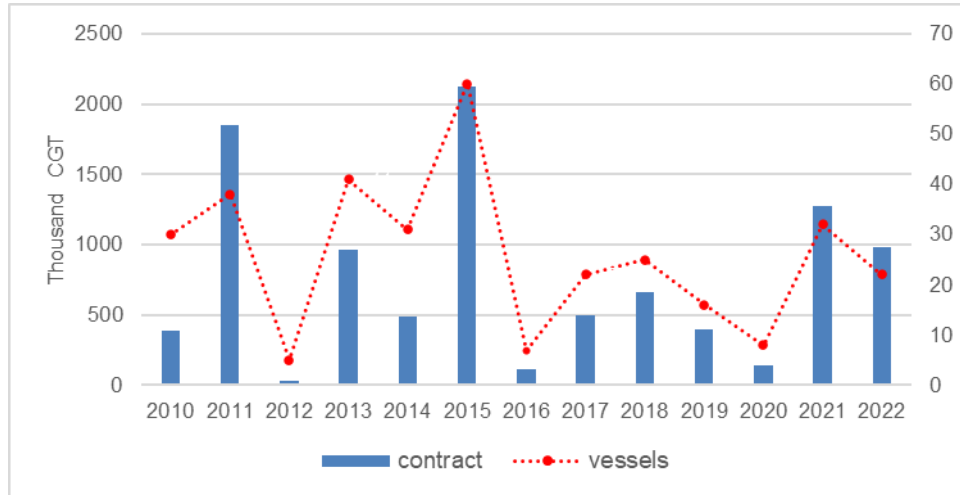
	Country	Number of current fleets	million GT
1	Greece	5 848	248.2
2	China	12 415	244.6
3	Japan	8 695	179.2
4	United States	4 988	65.9
5	South Korea	3 049	65.7
6	Norway	2 811	62.3
7	Germany	2 697	58.6
8	Italy	2 071	53.4
9	Singapore	3 571	49.8
10	Chinese Taipei	1 381	40.6
11	Denmark	1 348	36.9

Source: Clarkson Research Services Limited, *World Fleet Monitor* (June 2023), <https://www.clarksons.net/wfr>.

As an owner country, Denmark has been ordering ships every year for the past twenty years. Between 2010 and 2015, there were on average 30 contracted vessels each year, but in 2016, the number of ordered vessels declined sharply due to the crisis in the shipping industry. However, it began to recover in the late

2010s, and after a sharp decline in 2020 driven by the effect of the COVID-19 pandemic, it rebounded in 2021 and 2022. (Figure 2)

Figure 2. New contracts as an owner country, 2010-2022

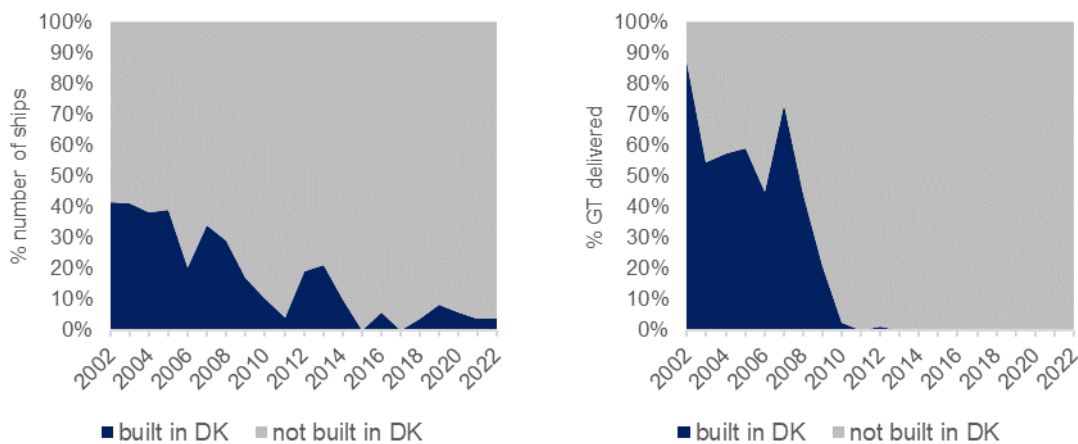


Note: This Figure includes all seagoing vessels from 100 GT.

Source: OECD calculations based on Clarkson Research Services Limited (January 2023), *World Fleet Register*, <https://www.clarksons.net/wfr>.

Since the Odense Steel Shipyard, the last large shipyard in Denmark, was closed in 2012, most of new vessel orders have been placed at foreign yards. Over the last twenty years, the share of ships built in Denmark delivered to Danish ship owners has been decreasing in terms of number and tonnage (Figure 3).

Figure 3. Ships delivered to Danish owners



Source: Danish Maritime provided the figure based on IHS

During the same period, the average share of orders placed by domestic companies in Denmark is 9.3% in CGT. 90.7% of orders are placed at foreign companies, first Korea (52.0%), followed by China (19.5%) and Japan (6.0%), in CGT terms (Table 2).

Table 2. Country of shipbuilding, 2002-2022

Country of build	Thousand CGT	Thousand CGT (%)
South Korea	9 486	52.0%
China	3 565	19.5%
Denmark	1 706	9.3%
Japan	1 101	6.0%
Germany	768	4.2%
Türkiye	379	2.1%
Norway	257	1.4%
Total	18 252	100.0%

Note: This Figure includes all seagoing vessels from 100 GT.

Source: OECD calculations based on Clarkson Research Services Limited (January 2023), *World Fleet Register*, <https://www.clarksons.net/wfr>.

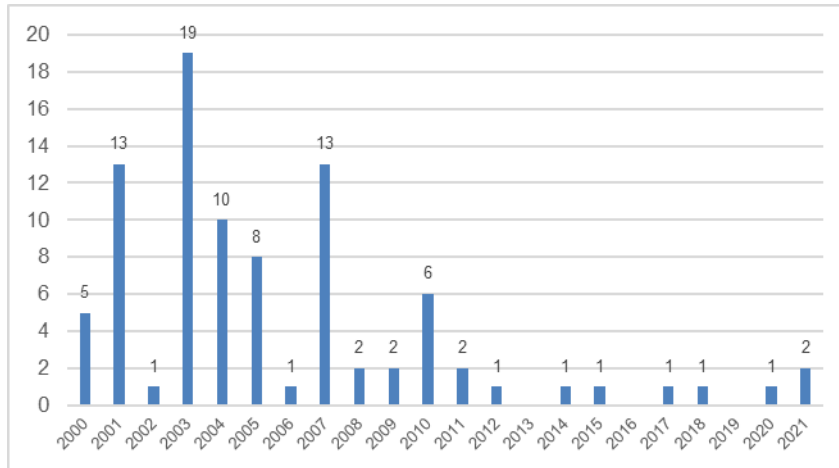
4. Structure and characteristics of the Danish marine industry

4.1. The shipbuilding and marine equipment industries

4.1.1. Recent market trends

Over the past twenty years, new orders at Danish shipyards have sharply decreased, starting in 2010 (Figure 4 and Figure 5). This is driven by the closure of major shipyards in Denmark in the early 2010s.

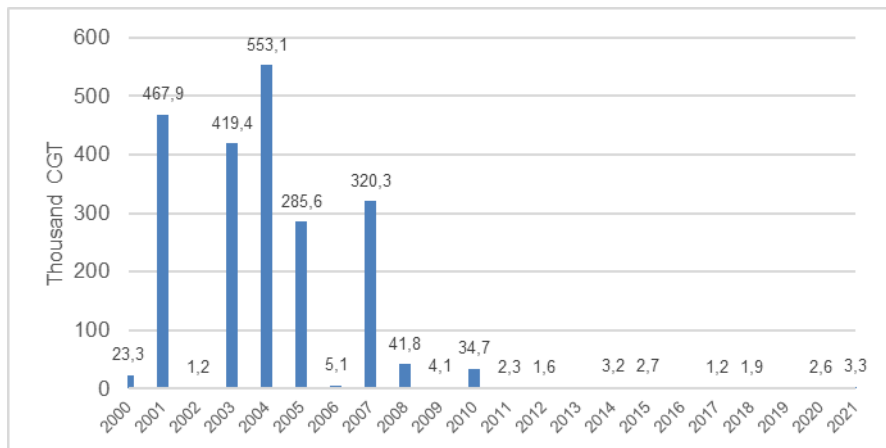
Figure 4. Number of new contracts in Denmark shipyards, 2010-2021



Note: This Figure includes all seagoing vessels from 100 GT.

Source: OECD calculations based on Clarkson Research Services Limited (January 2023), *World Fleet Register*, <https://www.clarksons.net/wfr>.

Figure 5. New contracts in terms of CGT, 2010-2021



Note: This Figure includes all seagoing vessels from 100 GT.

Source: Source: OECD calculations based on Clarkson Research Services Limited (January 2023), *World Fleet Register*, <https://www.clarksons.net/wfr>.

Danish shipyards have been producing a limited variety of sea-going vessel types over the last ten years, including fully cellular containers (FCC) and roll-on/roll-off (Ro-Ro). Between 2010 and 2021, Denmark accounted for 3.7% of the global production of FCC in CGT terms and 3% of the global production of Ro-Ro (Table 3).

Table 3. Completions of seagoing vessels by builder country and by ship type in the world and in Denmark, 2010-2021

Ship type	World	Denmark	
	CGT ('000)	CGT ('000)	Percentage (%) of Total
Tanker	101 198	-	-
Tug	11 584	-	-
Cruise	12 998	-	-
Ferries	10 727	46	0.4%
Other dry cargo	21 981	6	0.0%
Offshore	28 429	2	0.0%
Bulkers	160 862	125	0.1%
FCC	76 621	2844	3.7%
Gas carrier	43 794	-	-
Ro-ro	4 125	125	3.0%
Dredger	3 112	8	0.3%

Note: This Figure includes all seagoing vessels from 100 GT.

Source: OECD calculations based on Clarkson Research Services Limited (January 2023), *World Fleet Register*, <https://www.clarksons.net/wfr>.

However, if small and medium sized vessels under 100 GT are included in our analysis, the results are slightly different. According to the Danish Maritime based on IHS database², a large part of Danish newbuilding is focused on fishing vessels, with this ship type accounting for 35% of newly built ships from 2012 to 2022. Significant activities can also be seen in the building of Crew and Supply vessels for the offshore sector (25%) and RoPax ships (12%). The latter are typically smaller ferries that are used to connect Denmark's numerous small islands.

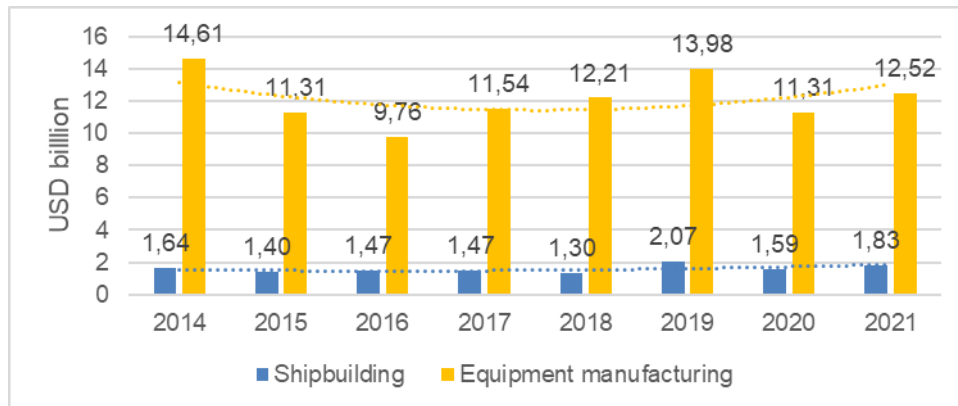
The shipbuilding industry's focus on the construction of specialised small and medium-sized vessels is also visible in the current orderbook of Danish shipyards. According to the Danish Maritime based on IHS database, as of January 2023, the reported orderbook contains 17 vessels of over 100 GT with a total gross tonnage of 44,891 GT, which are to be delivered from 2023 to 2025. Fishing vessels make up the majority of this, with 92% of the ships currently on order being of this ship type.

4.1.2. Production

From 2014 to 2021, the overall combined production in the shipbuilding and equipment manufacturing in Denmark has maintained its scale without significant differences (Figure 6). The marine equipment production has been fluctuated between about 7 to 9 times the size of the shipbuilding outcome.

The direct production by the shipbuilding industry amounted to USD 1.26 billion in 2021, with another indirect production of USD 0.57 billion corresponding to shipbuilding-related activities. Direct and indirect shipbuilding production amounted to USD 1.85 billion, which accounted for 0.3% of total Danish GDP in 2021. In addition, direct marine equipment production amounted to USD 9.15 billion, with an addition of USD 3.37 billion considering indirect production related to the sector, thus accounting for 1.8% of overall Danish GDP in 2021. Thus, shipbuilding and equipment manufacturing together accounted for 2.1% of total Danish production in 2021.

Figure 6. Production in shipbuilding and equipment manufacturing in 2014-2021

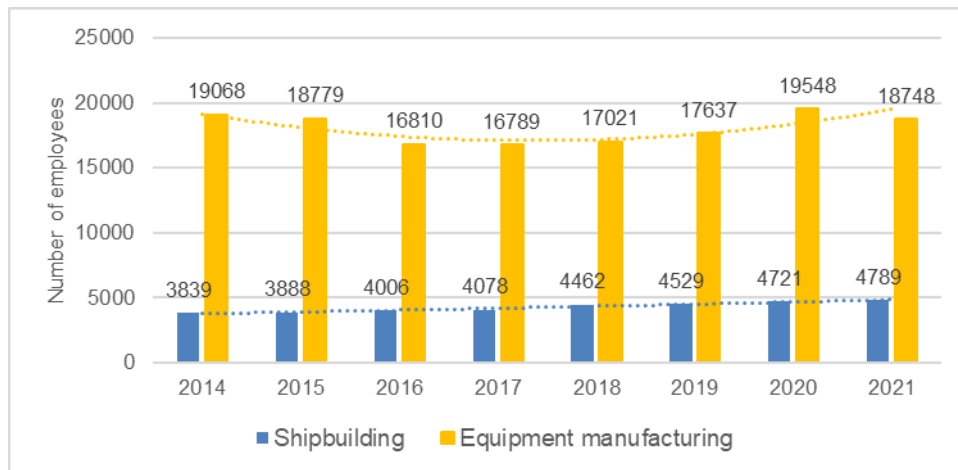


Source: Danish Maritime Authority, “Employment and production in Blue Denmark 2022”, prepared by COWI based on data from Danish Statistics

4.1.3. Employment

Shipbuilding and Equipment manufacturing still play an important role in the labour market in Denmark, directly employing around 24,000 people in 2021 thus accounting for about 0.8% of all employees in Denmark (Figure 7). Overall employment has not decreased during the COVID-19 pandemic. The total number of directly employed staff of the shipyards in Denmark is stable at around 4,500 persons over the period from 2018 to 2021 meaning the workforce capacity remained in the sector³.

Figure 7. Employees in shipbuilding and equipment manufacturing, 2014-2021



Source: Danish Maritime Authority, “Employment and production in Blue Denmark 2022”, prepared by COWI based on data from Danish Statistics

Education and training play a major and increasingly important role throughout the Danish maritime sector. The level of education in the Danish maritime industry is high and gradually rising. As an example, according to the DMA, in 2020 the number of employees having a Bachelor of Arts (BA) degree exceeds the number of employees having completed just primary school.

Both the shipbuilding and the equipment manufacturing industry are characterized by the fact that they employ large number of skilled workers. In 2021, data shows that the most common education in shipbuilding are smithing/welding, ship technician, and mechanics, whereas Industry and Computer

Numerical Control (CNC) technicians, mechanics and administrative education are most common in the equipment manufacturing sector. (Table 4, Table 5)

Table 4. Top 3 educations in shipbuilding in 2021

	Share of employees in the sector
Smithing/Welding	12.3%
Mechanics	5.7%
Ship technician	5.4%

Source: Danish Maritime Authority, “Employment and production in Blue Denmark 2022”, prepared by COWI based on data from Danish Statistics

Table 5. Top 3 educations in equipment manufacturing in 2021

	Share of employees in the sector
Industry and CNC technicians	8.0%
Mechanics	7.5%
Administrative educations	4.0%

Source: Danish Maritime Authority, “Employment and production in Blue Denmark 2022”, prepared by COWI based on data from Danish Statistics

Highly skilled workforce and continued inflow of qualified employees are important factors for the development of Danish maritime industry. However, in recent years, the maritime sector has been experiencing increasing difficulties in attracting youth cohorts. Therefore, workers’ recruitment and retention are a key issue for maritime companies.

4.1.4. Exports

In 2021, Danish ship exports amounted to USD 0.35 billion, corresponding to 0.2% of total Danish exports. Moreover, exports of the maritime equipment sector represented USD 5.20 billion in 2021 corresponding to 2.7% of total Danish exports. In total, the shipbuilding and marine equipment industries accounted for about 3% of Denmark's total exports in 2021.

Furthermore, Blue Denmark, the Danish maritime cluster including offshore companies that contribute by, for example, oil extraction and setting up wind turbines, shipping companies sailing with goods or passengers, Danish ports and freight terminals serving a regional catchment area, freight forwarders and shipbrokers represented in 2021 around 30% of Danish exports in 2021 and was one of Denmark’s largest export industries and plays an important role for Danish employment.

4.1.5. Shipyards

According to Danish Maritime, in 1972, before the start of the transformation towards repair and conversion and the rise of equipment manufacturing in Denmark, the eight largest Danish shipyards employed a total of 18,675 employees, providing a capacity of 66,000 dwt⁴ (Table 6). However, following the energy crisis in the 1970s, most major shipyards gradually moved into equipment manufacturing and subsequently closed their shipbuilding activities. Major shipyards began to close in the 1980s, with the largest shipyard in Odense closing in the early 2010s. Consequently, the figures provided are historical and do not resemble today’s capacity.

Table 6. The eight largest Danish shipyards in 1972

Shipyards Name	Employees	Capacity (Dwt)	Closed year
Odense Steel Shipyards	5 700	500 000	2011-2012
B&W Shipyards	3 500	90 000	1980 and 1996
Aalborg Shipyards	2 800	14 000	1987-1988
Helsingør Shipyards	2 500	14 000	1983
Nakskov Shipyards	2 000	27 000	1986-1987
Frederikshavn Shipyards and Floating dock / Danyard Frederikshavn	1 000	7 000	1999
Svendborg Shipyards	600	4 600	1999
Århus Floating dock	575	5 000	1999
Total	18 675	661 600	

Source: Olesen, T. R., 2016, "When the shipyards closed"; based on Jeppesen et al., 2001; Kamedula et al., 1987; Søndergaard et al., 2007

The shipyards are closed, but new innovations are successfully taking place in the same facilities. The closure of the Odense Steel Shipyards is an interesting case. The premises of the former yard have been transformed into an industrial site with numerous enterprises including Northern Europe's largest ship repair yard, wind turbine construction facilities and other activities including a Robotics centre for Large Structure Production in co-operation with the University of Southern Denmark.

Most Danish shipyards now use most of their capacities for repair and conversion activities. Therefore, it is difficult to correctly assess the current newbuilding capacity in Denmark. As of April 2023, the largest shipyards in Denmark are Fayard in Odense, Orskov Yard in Frederikshavn and Karstensens Shipyards in Skagen (Table 7).

Table 7. Main shipyards in Denmark

	Fayard	Orskov	Karstensens
Location	Odense	Frederikshavn	Skagen
Founded	1916	1958	1917
Main field of operation	Conversion Repair	Conversion Repair	New building Conversion Repair

Source: Danish Maritime Members brochure 2023

For new construction work, the yards specialized in fishing vessels have enjoyed healthy orderbooks. But also, in the repair and conversion sector, shipyards are doing well. For example, Orskov Yard in Frederikshavn has recently expanded by means of another floating dock. Small ferries of novel design with electric or other improved propulsion technology have also been built and delivered. For the yards as well as for the equipment manufacturers the high number of retrofit projects, conversions and upgrades have also stimulated the business.

The largest concentration of both newbuilding/repair and recycling yards are found in Jutland, with the majority in Northern Jutland, which include both Orskov Yard in Frederikshavn and Karstensens Shipyards in Skagen. The latter also has a hull-division in Gdansk, Poland and a repair/service yard in Nuuk, Greenland. Moreover, located in Jutland are also Thyboron Yard, Hvide Sande Shipyards, Steen & Service, Grenå Yard, Hirtshals Yard, North Sea Yard, Vestvaerftet, Esbjerg Yard, as well as Jobi Yard.

Jutland is also the location of recycling yard Fornæs in Grenaa and Smedegaarden in Esbjerg. Denmark's largest repair yard is Fayard located in Funen. In addition to this, Petersen & Sorensen Shipyard is found in Svendborg, Soby Yard in Aero, Faaborg Yard and Tuco Yard in Faaborg, Assens Shipyard in Assens, and Bredgaard Boats in Rodby. In the Faroe Islands in the North Atlantic the MEST Shipyard is found.

4.2. Ship design industry

The Danish maritime industry includes several of the world's leading ship design and ship interior companies including Knud E. Hansen, Odense Maritime Technology, OSK Shiptech as well as Hauschildt Marine. Together these companies possess strong competencies in the design of commercial, passenger, naval, offshore, wind and special vessels.

During the mission to Denmark in April 2023, the Secretariat had an opportunity to visit Knud E. Hansen in Helsingør. It is one of the world's leading ship design companies for both newbuild and conversion. Since it was founded in 1937, more than 800 vessels were built based on its designs and more than 400 conversions were successfully completed⁵. The Secretariat found out that the ship design plays an important role in experimenting and applying new and innovative technological possibilities for newbuild ships or the conversion of existing ships to greener ships.

Representatives from Knud E. Hansen mentioned that securing talent is a key factor in leading the design market and using the latest technologies. They have focused on attracting and retaining experienced and qualified maritime designers and engineers from around the globe. They are employing more than 90 naval architects and marine engineers in Denmark, Australia, the Faroe Islands, Spain, the United Kingdom and the U.S. The company mentioned the importance of illegal copying issues and that they filed lawsuits concerning the infringement of their intellectual property rights.

4.3. Ship repair/conversion/recycling industry

A well-implemented ship conversion can be a cost-effective method to extend the life and repurposing an existing vessel as well as meeting the recently strengthened environmental regulations. As for repair and conversion capacity, Denmark focused on repair and conversion of existing tonnage so that ships can become greener in their operation phase. Danish yards involved in this activity optimize the operation and propulsion systems to reduce the CO₂ emissions. In terms of capacity, Fayard is the largest repair yard in the Nordic countries.

Denmark also hosts several ship recycling yards and ship scrapping facilities. Fornæs in Grenaa, Smedegaard in Esbjerg and Fayard in Odense which have recycling and scrapping facilities are approved according to the EU Ship Recycling Regulation (EU SRR). Furthermore, Modern American Recycling Service (MARS) has chosen Frederikshavn for their operations, which recycles oil drilling and production platforms that are no longer needed at sea, for example, from various locations in the North Sea.

The green transition has been a driver of this trend, as exhaust gas cleaning systems, ballast water treatment plants, optimized propellers, energy-saving devices and other advanced technologies are installed into ships as environmental regulations drive the uptake of these technologies. Denmark is expected to benefit from this development, as it can leverage its strength in green technologies, and key skills that were developed thanks to the successful transition of former newbuilding yards into repair and conversion yards.

4.4. Ship finance

Ships are assets in which large amounts of capital are invested. Financial strategy is a key element for shipping companies, as they need capital to buy ships, and for shipping finance to cover their working capital requirements. The importance of ship finance is reinforced as ship costs and prices increase as vessels become more eco-friendly and larger.

The Secretariat met representatives from Danish Ship Finance (DSF) during its mission in Denmark. DSF has been established in 1961 and owns a portfolio of ship loans amounting approximately to USD 4.9 billion secured by first priority mortgages in 678 vessels. 50% of DSF's loans provided in 2023 are linked to the financing of green ships, with a target to have a credit portfolio fully green in 2025. Well-designed ship finance is a key success factor to the decarbonisation of the Danish maritime industry.

4.5. Competitiveness of Danish Shipbuilding and Marine Equipment Industry

Table 8 provides a SWOT analysis of selected strengths, opportunities, weaknesses and threats of the Danish shipbuilding industry, revealing insights into its competitiveness. It is based on data and analyses detailed in the previous sections of the report.

Table 8. SWOT analysis of the Danish Shipbuilding Industry

Strength	Weaknesses
<ul style="list-style-type: none"> • Strong maritime value chain including marine equipment, ship design, ship repair and finance • Strong position in green maritime technology, which is needed in the decarbonisation of shipping • Several public-private partnerships to support entrepreneurship and innovation 	<ul style="list-style-type: none"> • Significant decrease in newbuilding activities • Increasing age of employees in the maritime industry • Lower proportion of women in the maritime industry
Opportunities	Threats
<ul style="list-style-type: none"> • Increased demand for low-emissions/ zero-emissions ships • Growing ship conversion market 	<ul style="list-style-type: none"> • Difficulty to secure workforce for the maritime industry

The geographical location surrounded by the sea and long history of marine industry have been valuable assets for Denmark. Based on those, Denmark developed a strong maritime value chain including marine equipment, ship design, ship repair and ship finance. This strong value chain also extends to green technology, giving the Danish shipbuilding industry an especially strong position within this area. Also, several public-private partnerships between businesses and public institutions have contributed to the high level of innovation in the maritime industry. Furthermore, recent increased demand for low-emission and zero emissions ships and growing demand in the ship conversion market are opportunities for the Danish shipbuilding industry notably for shipyards already specialized in ship repair and conversion activities.

Despite these advantages, competitiveness is hampered by several factors. Newbuilding activity has decreased significantly since the late 1990s, which means Danish shipowners highly rely on overseas shipyards for ship production. Additionally, the average age of employees working in the shipbuilding industry is increasing and women's proportion is significantly lower than that of males in the industry. Threats to competitiveness include difficulties for securing workforce in the maritime industry.

In summary, the Danish maritime industry's competitiveness is shaped by its historically strong value chain including marine equipment industry and its several public-private partnerships that contribute for the development and innovation of the sector. Given mainly its labour issues as well as the significant decrease in newbuilding activities, securing talented young generation and seizing the new digital and

green revolutions will be the key to making progress in the Danish shipbuilding industry in the global maritime industry.

5. Challenges for the Danish maritime industry

5.1. Decarbonization of the maritime sector

5.1.1. Public and private sectors' initiatives to support decarbonisation

Denmark is at the forefront of global efforts to reduce greenhouse gas emissions. The Climate Act sets a legally binding objective of reducing domestic CO₂ emissions by 70% by 2030 from 1990. The target is one of the most ambitious among OECD countries and would put the country on track for carbon emissions neutrality by 2050 (OECD, 2021). The Ministry of Finance of Denmark mentioned that, in climate change, it is crucial for the government that Denmark takes the lead in the EU to raise the bar in the global climate fight and show the way to climate neutrality and faster phasing out of fossil fuels, especially in the transport sector⁶. Denmark directed 60% of its COVID-19 recovery spending towards environmental goals – a high share by international comparison (OECD, 2021)⁷.

Danish companies are also taking numerous actions to support decarbonization. The marine equipment industry already offers a broad range of solutions enabling the production and operation of zero- and low-carbon ships and continues to invest in the development of new technology. Competition from Asia will remain, but the solid maritime value chain in Denmark is an asset to seize the opportunity of decarbonization especially in terms of the high demand for retrofitting in the coming years.

In January 2023, the Danish government adopted a more ambitious climate strategy targeting to reach climate neutrality by 2045 instead of 2050 as well as reducing CO₂ emissions nationally by 110% - consequently reaching a negative level - in 2050 compared to 1990 levels⁸. After the Danish government announced the first version of the climate strategy in 2019, climate partnerships have been established for different sectors in 2021.

The Danish maritime cluster has established a partnership to identify goals and initiatives to be taken by the maritime sector to reduce emissions⁹. Several public-private partnerships involving the Danish maritime cluster contribute significantly to achieving climate neutrality such as Green Ship of the Future (GSF).

Denmark is also a leading participant in some of the international partnerships in the shipping sector. Denmark (led by the DMA), the United States, Norway, Global Maritime Forum and Maersk Mc-Kinney Moller Centre for Zero Carbon Shipping have been implementing an international public-private partnership called 'Zero-Emission Shipping Mission' since June 2021¹⁰. The Shipping Mission focuses on the entire maritime value chain, and it aims to accelerate international public-private collaboration to scale and deploy new green maritime solutions, setting international shipping on an ambitious zero-emission course¹¹.

During the mission to Denmark in April 2023, the Secretariat had an opportunity to visit the Maersk Mc-Kinney Moller Centre (the Centre) in Copenhagen. The Centre is a good example of the dynamism of the Danish maritime cluster. It is a non-profit, independent research and development centre founded in 2012 aiming to accelerate the transition towards a net-zero future for the maritime industry. The centre was founded with a start-up donation of USD 61 million from the A.P. Moller Foundation. With around 50 partners, the centre drives and facilitates the development and implementation of new technologies for decarbonisation of ships. The Centre notably studies the pathways and newbuilding for the implementation of alternative marine fuels such as ammonia and methanol with increasing market for retrofit.

5.1.2. Innovation efforts on environmentally friendly technologies

Green solutions covering a wide range of technologies and systems have been drivers of commercial activity in the maritime industry. Investments in research and development (R&D) for greener technologies have been on top of the agenda in the Danish maritime industry already for quite some time.

Danish companies tend to both invest in their own companies' procedures and suppliers to be sure that they are working in a sustainable way.

For example, R&D in the field of onboard energy savings has driven equipment manufacturers to invent and deliver remarkable solutions. Substantial reductions in CO₂ can be obtained when investing in such technology. Resistance and propulsion of ships is another field where antifouling manufacturers have undertaken substantial research and where reductions in CO₂ can be achieved.

Engine manufacturers have invested in research aiming to reduce engines' specific fuel consumption across all fuel types. Increasing the uptake of new fuels and maximizing the efficiency of existing fuel types are essential. Danish companies do notably research on internal combustion engines and on many other energy converting systems.

During the mission to Denmark in April 2023, the Secretariat visited MAN Energy Solutions in Copenhagen. MAN Energy Solutions is a leading company in the global ship engine market. Around 50% of global freight is transported by a MAN Energy Solutions' engine. On their Future Fuel Outlook, they mentioned first that dual fuel engine technologies are required for retrofitting the existing fleet as well as for newbuilds when estimating the lifetime of a ship at approximately 25 years. Two stroke dual fuel engine contracting gained pace in 2021 and the trend is persistent. Second, by 2030 it is impossible to predict the winning fuel among LNG, LPG, Ethane, Methanol and Ammonia. It is highly dependent on future legislation and regulation and the selection of fuel will depend on vessel type, size, trading patterns and company strategy. Lastly, as an engine company, they mentioned that regulations are needed to drive the uptake of dual-fuel engines and in particular the production of green fuels.

Depending on the ship types, trade and other operational requirements new systems are being implemented. This also covers the use of battery technologies, fuel cells, and hydrogen in various configurations, all integrated and optimized for the specific purpose. For example, Denmark is active in building green ferries which are 100% battery operated as well as hybrid propulsion ferries. The use of artificial intelligence and autonomous systems technologies have been demonstrated with success on full scale although in a restricted environment.

For shipyards, the environmental awareness of Danish shipyards is constantly growing. The yards are keen to optimize the use of resources and reduce the burden on the environment through sound management, innovation and awareness. Yards have for example invested in wastewater treatment and discharge facilities, to ensure that the wastewater of docked ships is treated responsibly. Danish maritime equipment providers also contribute to better environmental performance and a safer working environment at shipyards¹³.

Welding robots for shipyards provided, for example, by Inrotech, a Danish automated robot company, can help in eliminating or reducing work which may be dangerous or potentially harmful to health, such as work carried out in ballast water tanks or other confined spaces. Inspections of tanks can increasingly be carried out by drones. Additionally, the inspection or cleaning of underwater hulls and even propellers can now often be done by Remotely Operated Vehicles (ROVs) – such services are for example provided by CLIIN or Blue Atlas Robotics, both are Danish robot companies. When it comes to the application of marine coating, providers like Hempel have developed technologies which significantly reduces the amount of organic volatile compounds released during the application, as well as the amount of biocide in new anti-fouling coatings, which at the same time significantly increases the energy efficiency of the ship.

During the mission to Denmark in April 2023, the Secretariat had an opportunity to visit Hempel A/S in Lyngby and learned how innovative coating technology contributes to the decarbonization of ships. The innovative coating can improve ships' energy efficiency by 20% (compared to the most basic bottom paints) and provide an out-of-dock fuel efficiency increase by 6%, which in turn contributes to a significant reduction in fuel consumption. Since ships need to be repainted every 5 years, it is necessary

to strip the old paint before applying new coating. Robotic laser surface treatment is being developed by Hempel as a new service allowing to recycle existing paint and to avoid large amounts of waste.

Furthermore, decarbonisation can lead to expand the scope of the marine equipment industry. Re-flow, a Danish maritime company based in Copenhagen is a good example of this trend. Re-flow, made a presentation at OECD Shipbuilding Committee meeting in May 2023 showing their Life Cycle Data Model for ship decarbonisation which assesses the carbon footprint in each ship's life cycle steps including Construction, Fuel, Maintenance and End-of-life.

5.2. Labour issues

5.2.1. Competition with other sectors

In recent years, attracting talents to the maritime industry has become a major challenge in most economies including Denmark, notably in the context of the competition with other sectors. Many companies the Secretariat met during the mission to Denmark, such as MAN Energy Solutions, Hempel A/S, and Knud E. Hansen, all mentioned difficulties in securing human resources. For example, Hempel A/S, mentioned that, as a chemical company, they are struggling to compete with pharmacy industries to secure qualified candidates.

This is related to the recent phenomenon in the marine industry, an increase in average age of employees. According to Blue Denmark (2022), 40% of maritime employment was 50 years or older in 2021, compared to 31% in 2011.

To address this challenge and to ensure a more appealing image of the industry, marine industry associations are actively promoting the maritime industry as an opportunity for young people to work with advanced technology and become a part of the green transition within the transportation and manufacturing sectors. To find young talents, many marine companies have partnerships with universities.

The Secretariat visited Denmark's Technical University (DTU) in Lyngby during the mission. DTU is a polytechnic university and school of engineering founded in 1829. Maritime DTU is one of the departments of DTU and is the point of contact for cross-cutting collaboration between universities, businesses, and authorities including government. It aims to strengthen the collaboration with the Danish maritime cluster, coordinate and facilitate business-oriented, interdisciplinary research, and ensure training of several maritime engineers with broad skill sets¹⁴.

DTU's most important responsibility is to attract and qualify students to work in the maritime industry. In the past, naval architecture was the main required competency, but recently, new competencies such as data science, Artificial Intelligence (AI) and machinery are more and more required as marine industries are in great need for highly qualified engineers with various skills. With strong collaborations with maritime companies, DTU trains students through private-funded research projects and internship programs.

5.2.2. Gender equity issues

According to the DMA, 2 out of 10 employees in the maritime industry are women. Further, according to the Danish Maritime, 17% of leaders in the maritime industry are women. Moreover, 58% of the employees in the maritime industry have a technical education. However, among the employees with a technical education, women only make up 7%. Women in the maritime industry have more frequently an education in social science rather than a technical education. Furthermore, 35% of female employees and 43% of male employees have a vocational education. In general, women have also more frequently administrative roles, while vocational workers as industrial technicians, electricians and ship fitters typically are male.

The lower proportion of women vs men in the most frequently requested educations in the maritime industry explain the underrepresentation of women in the sector. In addition to that, the talent pool of

technically trained women could also work more frequently in the maritime industry. The marine industry is very focused on moving in the right direction, and many initiatives within the industry are aiming at increasing the number of women in it.

6. Policies affecting the shipbuilding and marine equipment industry

6.1. Government Policy

6.1.1. Government structure

From 1988, the regulation of the Danish maritime industry falls under the responsibility of the DMA. The Authority is a part of the Ministry of Industry, Business and Financial Affairs¹⁵. The DMA aims to create safety at sea and growth in the Danish maritime industry with the main task to maintain and develop Denmark's position as a leading maritime nation. From the onset, it has performed tasks such as ship survey and certification. Over the years, more tasks have been added, including assistance to the minister and legislation and, later, after the merger with the Danish Maritime Safety Administration in 2011, also aids to navigation, navigational information and navigation warnings. The DMA consists of approximately 300 employees.

6.1.2. Industry associations

The industry association Danish Maritime represents the Danish shipbuilding, marine equipment, maritime design and maritime service providers, whereas Danish Shipping represents the shipowners. Danish Port and Shipping Companies¹⁶ unite the companies with activities in or between ports, while the Association of Danish Ports forms the industry association of commercial seaports. Together these organisations form the informal Blue Denmark network, an initiative also supported by the DMA.

Furthermore, the industry association Danish Maritime is an active member of the Shipyards' & Maritime Equipment Association of Europe (SEA Europe).

6.1.3. Shipbuilding strategy

According to the DMA, the last of the government subsidies specifically supporting the domestic construction of ships were phased out by the end of 2012. The authority also mentioned that such public financing schemes do not currently exist for the shipbuilding industry in Denmark and in recent years Denmark has generally supported the removal of public financing schemes and related policies limiting equal access to the global shipbuilding market.

The Danish government has initiated several public-private partnerships which consist of a range of different initiatives to support entrepreneurship and innovation across all industries. There can be governmental funding for some partnerships aimed at the creation of business cluster that are described in the following section on support measures. The Danish government also participates in public-private partnerships without governmental funding.

Following the withdrawal of the UK from the EU, companies could however apply for partial compensation if they were able to proof actual losses connected to Brexit. More details are provided in the following section on support measures.

6.2. Support measures¹⁷

6.2.1. The EU measures

As a Member of the European Union (EU) since 1973, Denmark abides by the common and general regulations, policies, and strategies that are established under the functioning framework of the EU, and that fall within its exclusive competence.

In accordance with Article 3 of the Treaty on the Functioning of the European Union, and considering all possible exceptions, the EU exercises exclusive competence in regulating a number of areas that are relevant but not limited to industry such as (a) common commercial policy; (b) the establishing of the competition rules necessary for the functioning of the internal markets; (c) customs tariffs and duties

which shall cover all trade in goods; (d) the conservation of marine biological resources under the common fisheries policy, and (e) the exclusive competence for the conclusion of international agreements when its conclusion may affect common rules or alter their scope, among others.

In what pertains to the areas that fall within the exclusive competence of the EU, Denmark, as an EU Member State, shall legislate or adopt legally binding acts only if so empowered by the EU or for the implementation of EU acts. While the areas that refer to EU common and general regulations, policies, and strategies interact with a broader range of industries, they influence Danish shipbuilding industry.

Subsection 2 of Article 2, and Articles 4 and 6 of the Treaty on the Functioning of the European Union, confer a shared competence between the EU and Member States in certain areas where Member States might be able to legislate or adopt legally binding acts to the extent that the EU would not or has not yet exercised its competence, and also to coordinate, support or supplement regulations and policies that are already in place.

Areas of shared competence between the EU and the Member States can cover, for instance, social and employment policy, environmental and industry transition policy, internal market policy, consumer protection policy, and transport policy, among other policy areas, including policies related to specific common safety concerns on security issues and public health matters.

Considering the above-mentioned, the Danish shipbuilding industry has been shaped around the EU functioning framework. Furthermore, the sector has been influenced by Denmark's membership to International Intergovernmental Organizations (IGOs) such as the World Trade Organization (WTO), where WTO standards, agreements and global rules for international trade have been incorporated and enforced.

Beyond its impact in international trade, Danish membership to the WTO has extended its effects in Denmark's social and labour standards. This, through the alignment of WTO Member States with international core labour principles outlined by the International Labour Organization (ILO) on areas including freedom of association and no discrimination at work. Moreover, Denmark has adopted the Agreement of Government Procurement (GPA) to regulate public procurement of good and services based on principles of transparency, openness, and non-discrimination.

It is relevant to mention that, within the framework of the functioning of the EU, and in accordance with what is stipulated in subsection 5 of Article 168 and subsection 4 of Article 2 of the Treaty on the Functioning of the European Union, a number of temporary measures and incentives were deployed to address the exceptional challenges pertaining the Covid-19 pandemic and Russia's war of aggression against Ukraine.

Some of the temporary measures and incentives put in place to tackle the challenges arising from the COVID-19 pandemic and Russia's war of aggression against Ukraine continue in effect and may impact, among others, Danish shipbuilding industry.

For instance, strategies such as NextGenerationEU, operating through the Recovery and Resilience Facility (RRF) and within the framework of the EU's post-COVID-19 recovery plan, have set the ambitious goal of making Europe climate-neutral by 2050 by, inter alia, investing in environmentally friendly technologies, which is expected to push forward Danish shipbuilding industry transition toward decarbonisation.

EU State Aid Temporary Framework has also given Denmark a tool to support the economy in the face of the above-mentioned crises by allowing the country to implement support measures that are not specifically directed to the shipbuilding industry but applicable to various sectors. It is important to note that the EU State Aid Temporary Framework expired in June 2022, except in the areas of investment and solvency support, which remain in effect until December 2023.

As previously mentioned, the EU has established a set of common general regulations, policies, and strategies that influence industry in general and that affect or are foreseen to affect the Danish

shipbuilding industry. Nonetheless, in addition to the common general regulation, the EU has also issued common specific regulations that exclusively affect the Member States shipbuilding industry.

The common specific regulation on shipbuilding that the EU has put in place and that affects EU Member states including Denmark is the following: i) EU Regulation 1257/2013 on ship recycling, which aims at enhancing the protection of human health and the EU marine environment, particularly regarding the proper management of hazardous materials on ships; ii) EU Regulation 2016/1013 on protection against injurious pricing of vessels, which punishes shipbuilders engaged in unfair pricing; iii) EU Directive 2009/21/EC, which aims to enhance safety and prevent pollution from ships flying the flag of a Member State; iv) EU Directive 2014/90/EU on Marine Equipment, which aims to increase marine safety and reduce the risk of marine pollution, and v) the International Convention for the Safety of Life at the Sea (SOLAS), which was ratified by all EU Member States.

Furthermore, as an EU member state, Denmark is expected to implement EU regulations to encourage the decarbonisation of maritime transport. Starting January 2024, the EU Emissions Trading System (EU ETS) will include maritime CO₂ emissions from all large ships entering EU ports, irrespective of their flag. Additionally, the EU FuelEU Maritime regulation is set to be effective from January 2025

It is important to mention that international maritime standards are developed by the International Maritime Organization (IMO), a United Nations (UN) specialized agency responsible for providing the regulatory framework for the shipbuilding industry.

6.2.2. Danish Individual Measures

Public-Private Partnerships with governmental funding

Public-private partnerships consist of a large range of different activities and, according to the DMA, only a small proportion of the activities are related to maritime activities. The Danish Business Authority (DBA) is responsible for this type of partnership. Recently, the Recovery assistance for cohesion and the territories of Europe¹⁸ (REACT-EU) have contributed by DKK 108.5 million (approximately USD 15.3 million) to the public-private partnerships at Funen, which creates, tests and produces new digital, robotic and autonomous solutions for use on land, water and in the air. It is unknown by the Secretariat how much funds for maritime projects were distributed, but marine equipment companies in the region are expected to participate and benefit. The funds will go towards investing in test equipment and establishing the infrastructure for a test and development centre at the Port of Odense, where robots and drones will automate testing and production of large structures, for example, building parts, ship parts or wind turbines¹⁹.

Support measures to address adverse effects of the COVID-19 pandemic and the Brexit

After lockdowns and operational disruptions during the COVID-19 pandemic, funds were made available for a wide range of businesses in Denmark as a part of the economic relief efforts by the government. Beneficiaries included businesses in the shipbuilding sector and maritime equipment industry. Funds were made available for businesses in the maritime sector to cover a proven loss due to Brexit. These funds following Brexit were temporary and managed by the DBA and DMA.

It was expected that the UK's decision to leave the single EU market would have had consequences for Danish maritime companies since Danish shipping exports approximately DKK 12 billion (USD 1.9 billion) in 2019 to the UK. Moreover, the UK is an important market for Danish shipping companies²⁰. In addition, offshore companies, manufacturers of maritime equipment and service providers in the maritime area have significant activities in the UK. To mitigate the negative consequences of Brexit and support maritime companies in their transition to new markets, the Danish government and a broad majority of the parties in the Danish Parliament agreed to create a maritime transition pool under the Brexit adjustment reserve where the funds for the transition pool were EU sponsored. The DMA opened

a conversion pool for Danish companies in the maritime sector (excluding the fisheries sector). Maritime companies that have lost revenues because of Brexit have been able to apply for compensation of up to DKK 250,000 (USD 35,300). The pool was DKK 100 million (approximately USD 14.1 million) and was divided into two rounds: one in autumn 2022 and one in summer 2023²¹. The pool was closed in summer of 2023 due to a lack of potential applicants. The total amount of compensation paid to Danish companies amounted to less than DKK 500,000 (USD 70,600) whereby only a minor part of the pool was actually distributed.

6.3. Public-Private Partnerships

In Denmark, the high level of innovation within the maritime industry is, besides development and innovation from private businesses, also a result of the fruitful cooperation between national research institutions, research partners from abroad and cooperation between businesses and public institutions. Among the various partnerships, three examples are given below.

First, Green Ship of the Future (GSF) was founded to build an open collaboration and cooperation with all stakeholders in the maritime industry. The GSF initiative was initially founded in 2008 by the four leading Danish maritime companies, Aalborg Industries, A.P. Moller-Maersk, MAN Diesel and Odense Steel Shipyard together with the DMA in recognition of the ecological responsibility of the maritime industry²². The public partners do not finance or direct the project, but they remain involved. The private companies pool knowledge but each bears its own costs²³. The members explore the road to emissions free maritime transport and a more environmental and financial sustainable maritime industry, through three core areas: Future fuels, Increased appliance of energy efficient technology and de-carbonization through digitization. One of the recent projects is the Retrofit Series project. Launched in 2019, GSF and 20 partners examine the potential for optimizing energy in existing vessels, and thereby reducing their fuel consumption and CO₂ emissions²⁴. Based on the case studies of three different vessels from two tankers from Hafia and Maersk and a RO-PAX ferry from DFDS, they showed large energy saving potential by applying actual data from the vessels and their operational profile. It could bring concrete saving potentials and inspire others to optimize their vessels before the new technology such a new fuel is scaled.

Second, ShippingLab was established in 2019 to provide a neutral platform for development of technology and technical solutions for stakeholders in Blue Denmark²⁵. More than 30 partners including companies, universities, schools, government-approved research and technology organizations, authorities and associations work together for digital and sustainable shipping in Denmark. The goal of ShippingLab is to create Denmark's first autonomous, environmentally friendly ship through a number of projects within 3 work packages of digital ship operation, autonomy and decarbonisation. The ShippingLab is supported by Innovation Fund Denmark, the Danish Maritime Fund, Orient's Fund and Lauritzen Fonden²⁶. Moreover, the project partners provide self-financing²⁷.

Third, a new partnership between the DMA and Maersk McKinney Møller Institute for Zero Carbon Shipping was announced in April, 2022²⁸. The two organizations co-lead the Zero Emission Shipping Mission under Mission Innovation along with the Governments of the US and Norway and the Global Maritime Forum. As part of this effort, the two partners have committed to extensive knowledge sharing as they work to accelerate the development and implementation of the future fuels and solutions needed to decarbonize shipping. As technology develops, new standards, policies and regulations are in need in the same pace. The partnership is expected to build bridges between industry developments and regulation.

Fourth, universities also participate in these kinds of partnerships. For example, University of Southern Denmark (SDU) has in collaboration with Odense Steel Shipyard developed a ground-breaking robotics solution to problems often found in shipbuilding. They challenged the emerging robot industry by combining automation technology and manufacturing know-how accumulated derived from shipbuilding industry. As part of the Maersk McKinney Møller Institute at SDU, the Large Structure Production (LSP)

center develops robotics technology to address pressing issues in the maritime, construction and energy sectors. Unlike typical robotics research, the LSP center is creating novel robotics solutions for large structure production, rather than simple small-scale robotics for the factory floor. By collaborating with diverse partners, from Danish labor unions to private companies like Danfoss and Maersk, to the local robotics community in Odense, the program is creating novel solutions that help businesses, workers, and the environment.

7. Conclusions

Danish marine industry has a long and successful history. Through the peer review, the industrial characteristics and policies of the Danish shipbuilding and marine equipment industry were studied. The main contents and implications of the report are described below.

First, in Denmark, the share of the ship and marine equipment industry has remained around 2% of total GDP between 2014 and 2021. The employment has also been relatively stable at the level of 23,000 workers without significant change during the same period. The marine equipment production has fluctuated between about 7 to 9 times the size of the shipbuilding outcome.

Second, many ships are owned by Danish shipping companies including global enterprises such as Maersk, DFDS, TORM, Norden and Lauritzen Bulkers. Although Denmark is not a major shipbuilding country, it is influencing the ship market as a major customer of ships. It also has a big impact on the green transition, and Danish companies are especially leading the research on low-carbon technology development, future fuels, and low-carbon strategy with the Zero Shipping initiative. Additionally, the McKinney Centre is a global thinktank specialized in research on maritime decarbonisation.

Third, Danish shipbuilding industry itself is small, but the shipyards have been often transformed into innovative sites without shutting down industrial operations. After the shipbuilding market moved to Asia, Danish shipyards mainly focused their newbuilding activities on fishing vessels and other small vessels. Denmark is also active in building green ferries which are 100% battery operated as well as hybrid propulsion ferries. With the growth of related industries such as wind power and the robot industry, Danish shipyards have been successfully transformed into places where innovation continues to happen, notably on digital technology. In addition, job losses that would be caused by the full shutdown of the shipyard have been at least partly avoided, and there were incentives to retain related workforce. The experience of such a successful conversion of yards that became not competitive enough in the global shipbuilding market is very interesting. Moreover, Denmark developed new strengths in the conversion of existing vessels into low-carbon ships.

Fourth, Denmark is a country with a strong shipbuilding value chain. It includes design, equipment, repair, conversion and ship finance. A strong value chain can serve as a hub for decarbonization. Marine equipment companies also continue to host global R&D activities in Copenhagen, although actual production is performed by licensees in various parts of the world.

Fifth, Denmark has traditionally been a country with strong and fruitful partnerships between the government and the private sector. Government policies focus on the support of technology development and demonstration through partnerships rather than government subsidies. Industrial projects are carried out based on long-term partnerships, and cooperation such as developing better technologies becomes easier through exchanges and communication between public and private stakeholders. The government participates in establishing domestic systems and international rules in cooperation with the private sector. In addition, efforts to secure labour force were made through partnerships including universities.

As the shipbuilding industry is more and more shaped by the digital and green revolutions, new opportunities are opening not only in current major shipbuilding countries but also in smaller but very agile maritime countries, notably Denmark. The successful influx of new young talents in the maritime industry and the persistence of good cooperation with various participating companies, institutions and government would allow Denmark's position in the global maritime industry to rise further based on the harmony of maritime tradition and innovation on frontier technologies.

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