Confidential

Independent Market Research on Global and China Marine Ship and Maritime Environmental Protection Equipment and System Industries

For ContiOcean

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Signature: _____

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Agenda

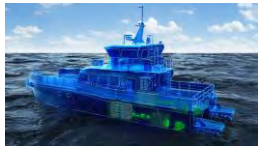
Overview of Global Marine Ship Market

Definition and Classification

- The global marine ship market is a diverse industry encompassing the design, manufacturing, operation, maintenance, and marine conservation of various types of ships for commercial and other purposes. It plays a crucial role in supporting logistics, energy transportation, manufacturing, and tourism. Recognizing its importance, countries worldwide are implementing policies and regulations to promote technological upgrades and environmentally-friendly transformations in marine ship manufacturing. The goal is to establish a modern shipping system that fosters sustainable development by balancing economic growth with ecological and environmental protection. The global marine ship industry can be categorized into coastal ships, sea-going ships, and ocean-going ships. Coastal ships are designed for operation within coastal waters, typically with a travel range of less than 200 nautical miles. Sea-going ships operate in both coastal and open sea areas, with a travel range of 200 to 500 nautical miles, including fishing boats, cargo ships, and cruise ships. Compared to ocean-going ships, coastal and sea-going ships are often smaller and more maneuverable, whereas ocean-going ships are built to withstand harsh conditions far from the coast, with a travel range exceeding 500 nautical miles. In the global marine ship market, commercial ships primarily include container ships, bulk carriers, and tankers. Container ships are designed to carry containerized cargo, bulk carriers transport bulk goods such as grains, coal, ore, and cement, and tankers are built to transport liquids or gases in bulk, such as oil. These ships are also integral to the downstream sector of the global maritime environmental protection equipment and system industry market.

Classification of Global Marine Ship Market

Global Marine Ship Market

Coastal Ship		Small size with shallow draft and travel range less than 200 nautical miles, mainly for transportation, offshore support operations, fishing industry, tourism and recreation etc.
Sea-going Ship		Small size with shallow draft and travel range from 200 to 500 nautical miles, mainly for transportation, etc.
Ocean-going Ship		Larger size with deeper draft and travel range more than 500 nautical miles, mainly for cargo use, military operations, exploration, etc. in open ocean.

Classification of Commercial Ships

Commercial Ship

Container Ship		Container ship refers to ships designed or equipped for carrying containerized cargo
Bulk Carrier		Bulk carrier refers to ships designed to transport bulk cargo, such as grains, coal, ore, and cement in its cargo holds
Tanker		Tanker refers to ships designed to transport liquids or gases in bulk, such as oil.

Source: IMO, Frost & Sullivan

Overview of Global Marine Ship Market

Development History

- The origins of the global ship market date back to ancient times, with coastal navigation being the primary mode of transport. Over time, technological advancements transformed ships, making steamboats a mainstream of the global marine ship market in the Industrial Revolution. Today, the market is driven by oil tankers, bulk carriers, container ships and other ships, which have revolutionized trade and transport worldwide.

Global

Before Christ	7th-16th Century	17th-19th Century	20th Century	21th Century
Early Stage	Large-scale Application	Technological Development	Industrial Modernization	Compliance Period

- Around 4,000 BCE, **Sailing ships** were in use in ancient Egypt.
- Around 3,000 BCE, **significant trade routes** had emerged between present-day India and Pakistan along the Arabian Sea.
- The Romans were **developing fleets that could cross the Mediterranean Sea.**

- During the 7th –14th centuries, the Arab Empire began developing **trade routes through Asia, Africa, and Europe**.
- During the 15th–19th centuries, advances in **navigation and shipbuilding allowed Europeans to voyage across the Atlantic**.

- Between 18th-19th century, The ship design began to modernize, leading to the emergence of **multi-masted sailing ships**.
- During the 19th century, the Suez Canal opened shipping between Europe and Asia without going around Africa.

- The two World Wars spurred rapid development in the shipbuilding industry, including the design and construction of cargo ships, tankers, and container ships. At the same time, the **establishment of the International Maritime Organization (IMO)** promoted the unification of global maritime regulations and standards.

- As the global marine ship industry advances with cutting-edge technology, it's undergoing a transformation towards **greater sustainability and eco-friendliness.**

China

Before Christ	3th-10th Century	10th-19th Century	20th Century	21th Century

- The maritime activities, **mainly coastal navigation** happened in Spring and Autumn period.
- **Official maritime expedition** started in Qin Dynasty.
- Zhang Qian's mission to the Western Regions marked the **opening of the Maritime Silk Road.**

- Zhang Qian's journey initiated the Maritime Silk Road.
- The Wei, Jin, and Northern and Southern Dynasties were marked by maritime trade.
- The Sui and Tang Dynasties saw the **Maritime Silk Road as a global trade hub.**

- Advancements like **compass use and watertight compartments** revolutionized navigation in Song and Yuan periods.
- During the Ming Dynasty, Zheng He's voyages to the Western Seas marked the zenith of maritime exploration.

- **Maritime prohibition policies** implemented in Qing Dynasty.
- Since the 1978 reform and opening up, **China's shipbuilding industry has flourished.** Deng Xiaoping's 1977 strategy to adopt foreign technology and enter global ship markets launched this industry's revival.

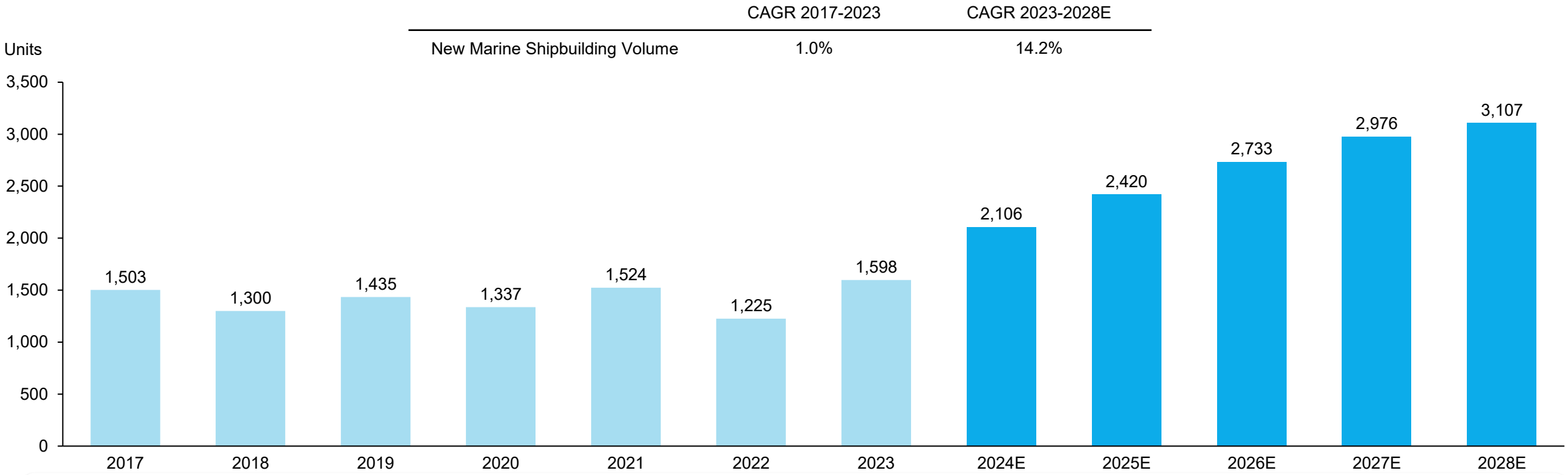
- After China joined the World Trade Organization (WTO), the Chinese marine ship market continued to develop and eventually became the **world's largest shipbuilding nation.**
- China is implementing a series of policies to support the **reduction of sulfur and carbon emissions.**

Source: IMO, Frost & Sullivan

Overview of Global Marine Ship Market

Global New Marine Shipbuilding Volume

New Marine Shipbuilding Volume (Global), 2017-2028E



- From 2017 to 2023, global new marine shipbuilding volume exhibited a slightly fluctuating upward trend. Between 2017 and 2019, stricter environmental regulations and previous fleet expansions contributed to fluctuations in demand for new marine shipbuilding. From 2020 to 2022, the recurring waves of COVID-19 led to intermittent shutdowns and production halts in various countries, causing fluctuations in the volume of new shipbuilding during this period. However, from 2023 to 2028, the global new shipbuilding volume is projected to recover and grow significantly from 1,598 units to 3,107 units at a CAGR of 14.2%. This growth is driven by the post-pandemic recovery, rising global trade demand, technological advancements in shipbuilding, and increased investments in ships with environmental protection equipment and systems to meet regulatory and efficiency standards.

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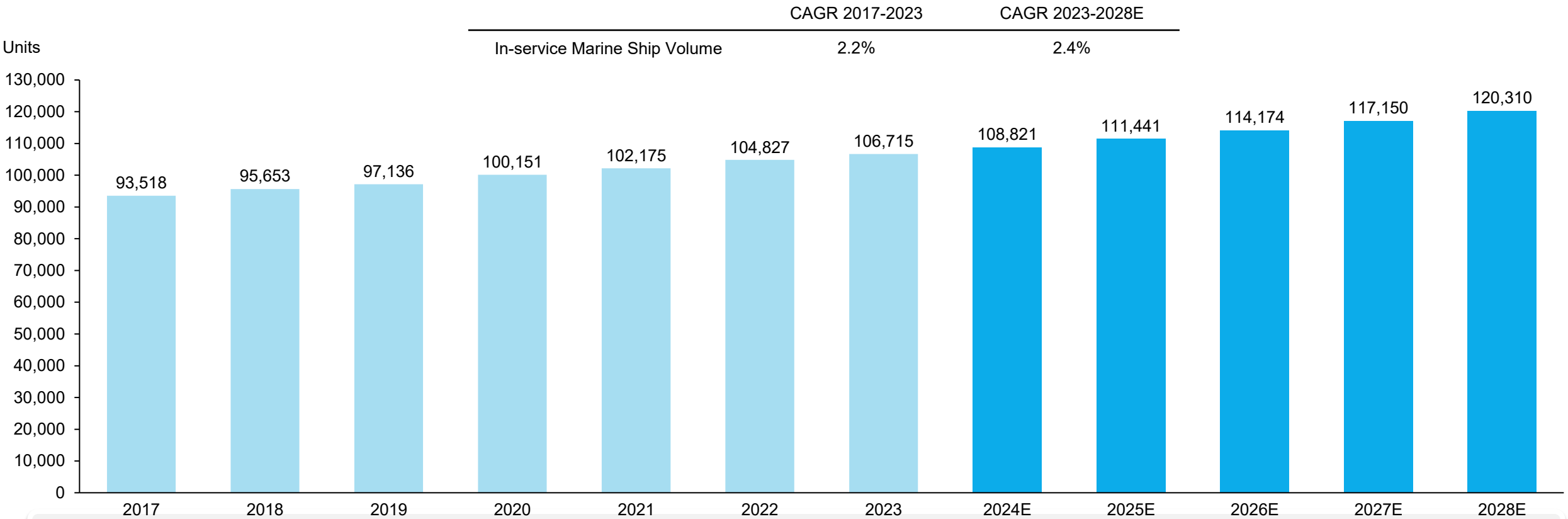
Source: Frost & Sullivan Report, China Association of the National Shipbuilding Industry, Lloyd's Register of Shipping, Clarkson, China Shipbuilding Industry Yearbook

Overview of Global Marine Ship Market

Global In-service Marine Ship Volume

In-service Marine Ship Volume (Global), 2017-2028E



- Maritime transport is the most important downstream application of marine ships and the primary mode of transportation in international logistics. In 2023, maritime transport accounted for more than 80% of the total volume of goods transported in international trade. Due to stable growth in shipping capacity and international trade demand, the total volume of global in-service marine ship volume increased steadily from 93,518 units in 2017 to 106,715 units in 2023, achieving a CAGR of 2.2%. Looking forward, this upward trend is expected to accelerate from 2023 to 2028, with the total volume of global in-service marine ship volume projected to reach 120,310 units in 2028, at a CAGR of 2.4%.

Note: The number of in-service marine ship volume is based on the number of total ships in operation during the year.

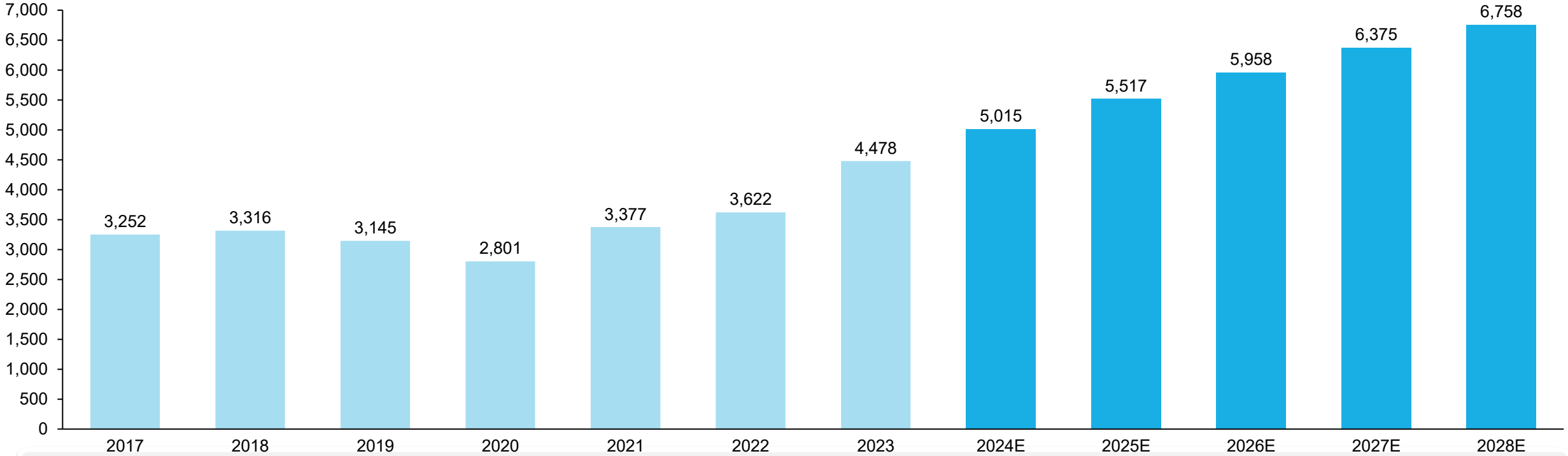
Source: Frost & Sullivan Report, China Association of the National Shipbuilding Industry, Lloyd's Register of Shipping, Clarkson, China Shipbuilding Industry Yearbook

Overview of Global Marine Ship Market

Global Marine Ship On-hand Order Volume

Marine Ship On-hand Order Volume (Global), 2017-2028E

	CAGR 2017-2023	CAGR 2023-2028E
Marine Ship On-hand Order Volume	5.5%	8.6%



- From 2017 to 2023, the global marine ship order volume displayed a fluctuating upward trend. In 2020, the COVID-19 pandemic caused intermittent shutdowns and production halts in various countries, disrupting the ocean freight supply chain and leading to a decline in new shipbuilding orders. However, these supply chain disruptions resulted in higher ocean freight rates and a shortage of shipping capacity. Consequently, many shipyards capitalized on these higher rates and subsequently placed new orders. From 2023 to 2028, the global marine ship order volume is projected to grow steadily from 4,478 units to 6,758 units, with a CAGR of 8.6%. This growth is driven by the post-pandemic recovery, rising global trade demand, technological advancements in shipbuilding, and increased investments in ships with clean-energy systems to meet regulatory and efficiency standards.

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Source: Frost & Sullivan Report, China Association of the National Shipbuilding Industry, Lloyd's Register of Shipping, Clarkson, China Shipbuilding Industry Yearbook

Overview of Global Marine Ship Market

Market Drives and Trends

Global Economy Growth

- Global economic growth significantly drives the marine ship market by increasing trade volumes, leading to higher demand for shipping services and fleet expansion. As economies grow, consumer spending and industrial production rise, boosting the need for ocean freight transportation. This demand fuels investments in new shipbuilding and fleet modernization. Technological advancements in fuel efficiency and environmental compliance are adopted to meet stricter regulations, enhancing competitiveness. Additionally, the improved and expansion of global supply chains led by the growth of the global economy further stimulate shipping activity, solidifying the marine ship market's growth and modernization.

Tightening of Environmental Protection Requirements

- The global marine ship market is increasingly influenced by stringent environmental protection requirements, driven notably by regulations from the International Maritime Organization (IMO), various countries and regional governments. These regulations mandate substantial reductions in sulfur oxide and greenhouse gas (GHG) emissions, leading to the adoption of maritime environmental protection equipment and systems such as marine exhaust gas cleaning systems, energy-saving device and carbon reduction systems, or the reconstruction of ships' power systems to use alternative fuels like LNG, LPG, methanol and ammonia. Furthermore, the industry is embracing digitalization for enhanced emissions monitoring and reporting, with collaboration among stakeholders playing a crucial role in developing and implementing effective environmental protection equipment and systems.

Technology Advancement

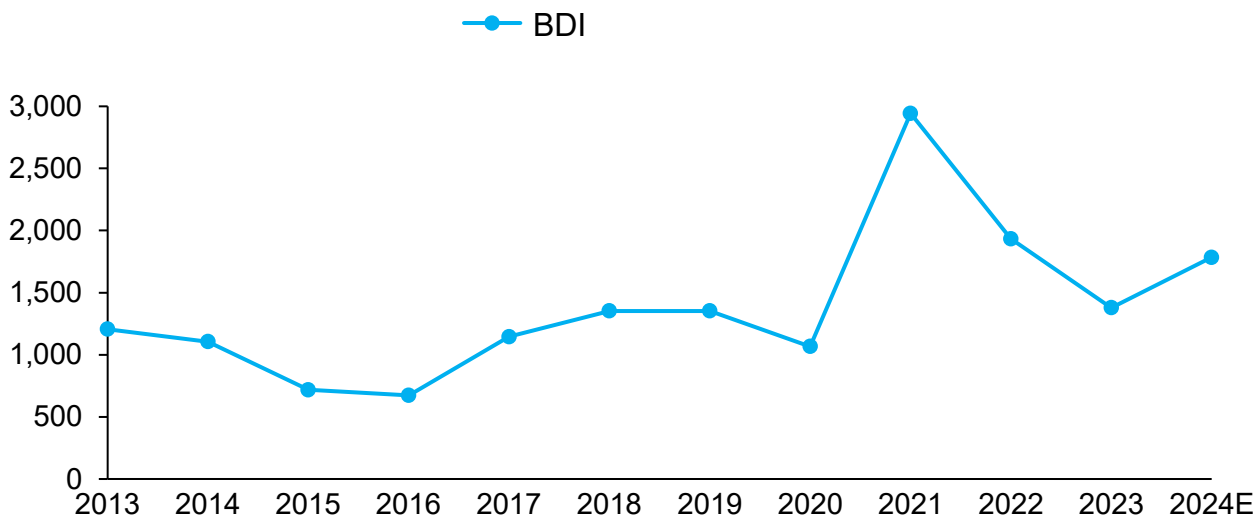
- Technological advancements in the marine ship industry are transforming ship operations by enhancing efficiency, reducing environmental impact, and improving safety. Marine exhaust gas cleaning technologies and energy saving device and carbon reduction systems further enhance efficiency and mitigate exhaust emissions, ensuring compliance with stringent environmental regulations. Propulsion systems have evolved with the adoption of alternative fuels, offering cleaner energy options compared to traditional fossil fuels. Automation and digitalization also play pivotal roles, enabling the development of smart ships equipped with advanced intelligent management systems and real-time performance detection systems. These technologies optimize fuel consumption, lower emissions, and enhance operational reliability, underscoring a shift towards sustainable and efficient maritime operations driven by innovation and environmental responsibility.

Source: Frost & Sullivan

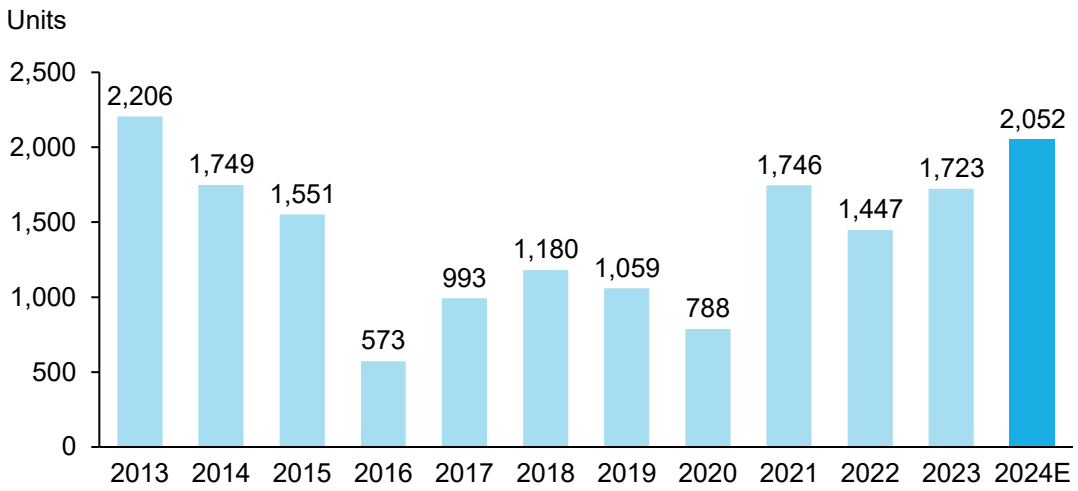
Overview of Global Marine Ship Market

Analysis of Relationship Between Freight Rates and Global Newly Added Marine Shipbuilding Order Volume

Average Baltic Dry Index , 2013-2024E



Newly added marine ship on-hand order volume (global), 2013-2024E



- The Baltic Dry Index (BDI) serves as a key indicator of global shipping prices, reflecting the cost of transporting goods and closely tied to the demand for shipping services. Generally, there is a positive correlation between the BDI and new shipbuilding orders. A rising BDI indicates strong demand for shipping, often driven by increased global trade or supply chain pressures, prompting shipowners to order new vessels to expand fleets and capitalize on favorable market conditions. During the COVID-19 pandemic, global maritime logistics faced severe disruptions, causing shipping prices to surge dramatically. From the second half of 2020 through 2021, the BDI rose to 2–3 times its 2013–2019 levels. However, operational halts at shipyards and component manufacturers, along with fully booked shipping capacities, limited some shipowners' ability to place new orders. As the pandemic was effectively controlled and operations resumed, the demand for new shipbuilding began to be gradually released starting in 2021. As a result, the volume of newly added marine ship on-hand orders in 2023 continued to show an upward trend, remaining significantly higher compared to the 2016–2020 period. This trend is expected to persist, driven by sustained demand for maritime shipping and fleet modernization. By 2022, as the pandemic's impact lessened and shipping prices stabilized, the BDI began to decline but stayed above pre-pandemic levels. A subsequent spike in 2023, driven by factors like the Red Sea Crisis, occurred. Revenue growth and long-term demand for new ships remain strong as shipowners, learning from pandemic challenges and other uncertainties, prioritize stability and capacity in their shipping supply chains. In the following years, new shipbuilding orders are forecast to rise steadily, supported by growing global trade, stricter environmental regulations, and the need for fleet modernization. This sustained demand, coupled with elevated shipping rates, is poised to drive continuous growth in newly added shipbuilding orders.

Source: Frost & Sullivan Report, China Association of the National Shipbuilding Industry, Lloyd's Register of Shipping, Clarkson, China Shipbuilding Industry Yearbook

Agenda

Overview of Global Maritime Environmental Protection Equipment and System Market

Analysis of the Impact of the Shipping Industry on our Group's Business

- The development of our Group's business is closely tied to the trends and drivers of the global shipping industry, including but not limited to the following:
- Global Economic Growth

Our Group's business benefits from global economic growth, as increased trade volumes and fleet expansion drive demand for its innovative maritime environmental protection equipment and systems and technologies. Rising shipping activity stimulates investment in new shipbuilding and fleet modernization, creating a strong market for our Group's products and service such as EGCS and energy-saving devices. The industry's growing focus on efficient and sustainable operations aligns with our Group's portfolio, establishing it as a key enabler of fleet upgrades and an integral part of the global shipping industry's evolution.

- Tightening Environmental Protection Requirements

Stricter environmental regulations significantly boost the adoption of our Group's products and technologies. Its EGCSs assist ship operators in meeting IMO sulfur emission limits, while its energy-saving devices and clean-energy supply systems provide forward-thinking options for meeting decarbonization goals. The regulatory push for alternative fuels and emissions monitoring further increases demand for our Group's advanced systems, ensuring strong growth prospects as shipowners prioritize compliance and sustainability in their operations.

Technological Advancements

Our Group's commitment to innovation positions it at the forefront of the global shipping industry's transition towards advanced technologies. Its development of marine service, marine energy-saving devices, and clean-energy supply systems aligns with the increasing demand for smarter and more sustainable maritime operations. As environmental protection and digitalization continue to reshape the industry, our Group's products and service offer significant opportunities to enhance operational reliability, reduce fuel consumption, and meet evolving market needs. This technological progression strengthens our Group's competitive edge and reinforces its relevance in the global shipping industry.

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Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Development Background Analysis

Background Analysis

- ***Environmental Concerns:*** Ships significantly contribute to air pollution due to the use of traditional fuels high in harmful substances. This creates a pressing need to address sulfur oxides, nitrogen oxides, and particulate matter emissions. Quantified data on these emissions highlights the extent of the problem and underscores the necessity for stringent regulations and innovative solutions.
- ***Regulatory Pressure:*** The international and domestic tightening of environmental standards reflects the global commitment to combating pollution and promoting sustainability. The shipping industry must adapt to these higher standards, indicating a growing market for maritime environmental protection equipment and systems that comply with new regulations.
- ***Demand for Comprehensive Environmental Protection Ship Technology：*** The need for comprehensive environmental protection technology stems from the urgent environmental and regulatory pressures on shipbuilders and retrofitters. Customers require efficient, all-encompassing services that can deliver rapid, high-quality modifications to meet strict emission standards. This drives innovation and efficiency within the industry, providing a competitive edge to those who can offer such technology and solutions.
- ***Technological Advancements:*** The swift development of comprehensive environmental protection technology, including energy-efficient propulsion systems, eco-friendly materials, and advanced emission control systems, indicates a robust market for these innovations. These technologies not only comply with regulatory demands but also enhance the overall sustainability and competitiveness of the shipping industry. The shift towards clean energy and improved operational efficiency aligns with global trends and consumer demand for environmentally responsible practices.

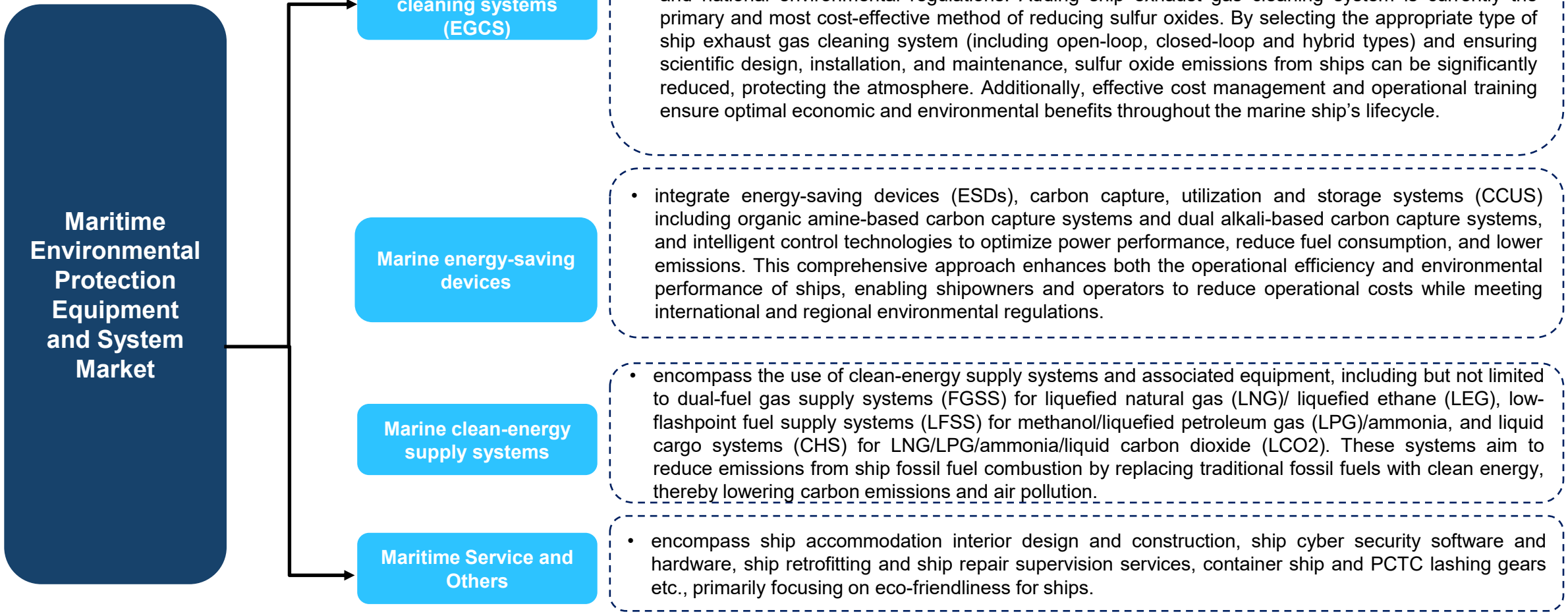
Definition

- International shipping, which transports over 80% of global trade, is facing increasing environmental challenges. Traditional fossil fuels emit harmful substances like sulfur oxides, nitrogen oxides, and particulate matter, significantly affecting air quality and human health. In response, the international communities and countries have imposed stricter environmental conventions and standards, raising emissions requirements for the shipping industry. For instance, the IMO's stringent requirements have increased the environmental and time pressures on shipbuilding and retrofitting industries, leading to a higher demand for maritime environmental protection equipment and systems. The maritime environmental protection equipment and systems effectively meet customers' needs through rapid response, comprehensive services, and innovative technologies, thereby improving the efficiency and quality of ships.
- Simultaneously, ship-related environmental technologies are advancing rapidly, with new generations of energy-saving, emission-reducing, and highly efficient equipment and systems continuously emerging. By optimizing ship design, retrofitting energy and power systems, implementing intelligent ship operation management systems, and utilizing clean energy, these innovations enhance the sustainable development and competitiveness of the marine shipping industry. Maritime environmental protection equipment and systems focus on advanced technology and environmentally friendly transformations throughout a ship's lifecycle — from design and manufacturing to operation and recycling. These equipment and systems economically fulfill their intended functions and performance, improve energy efficiency, reduce or eliminate environmental pollution, and provide excellent protection for operators and users, steering the industry towards more sustainable development.

Source: IMO, Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Definitions and Classifications



Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Development Background Analysis

Year	IMO Policy Background	Key Equipment and Systems to Achieve the Target	Feature
Since 2016	The global sulfur oxide emission limitation proposed by the IMO in 2016 marked the beginning of the development for the marine ship desulfurization industry. In 2020, the IMO further reduced the upper limit of sulfur oxide content in ships' fuel oil from 3.5% to 0.5%, serving as a critical catalyst that accelerated industry activities and drove significant growth. Consequently, the desulfurization of marine ships experienced rapid expansion to meet regulatory demands, positioning itself as a vital component of the marine ship industry's efforts to reduce sulfur oxide emissions and improve environmental compliance.	Marine exhaust gas cleaning systems	Effectively reduce sulfur oxide emissions with high cost-effectiveness
2021-2050 **Phase 1：2021-2030**	In addition to the established regulations that have been released, the IMO's "GHG Strategy" in 2021 aimed to reduce GHG emissions per transport work by at least 40% by 2030 compared to 2008 levels. This period is critical for transitioning from the initial introduction of GHG reduction policies to their comprehensive adoption and enforcement across the marine ship industry. This phase is expected to drive significant advancements in GHG reduction technologies and strategies, promoting more sustainable practices. The timeline reflects a gradual scaling up of efforts and investments in cleaner technologies, energy efficiency improvements, and alternative fuels, aiming for substantial reductions in GHG emissions by 2030. This period is essential for establishing long-term environmental compliance and sustainability in the marine ship industry.	Marine exhaust gas cleaning systems; Marine energy-saving devices;	Effectively reduce sulfur oxide emissions with high cost-effectiveness; Effectively reduce GHG emissions, but unable to achieve net zero GHG emissions
Phase 2: **2031-2050**	The IMO's "GHG Strategy" aims to peak and then achieve net-zero GHG emissions from international shipping by around 2050. This long-term goal signifies a transformative shift in the marine ship industry, necessitating substantial advancements in green ship technologies and sustainable practices. Achieving net-zero emissions involves extensive R&D and deployment of alternative fuels, such as LNG, LPG, methanol and ammonia, which have lower or no carbon footprints compared to traditional fossil fuels. Additionally, improvements in energy efficiency, through the optimization of ship design and operational practices, will be critical. By targeting net-zero emissions, the IMO strategy not only aims to mitigate the environmental impact of shipping but also to align the industry with global climate goals, ensuring its sustainability and resilience in the face of climate change.	Marine clean-energy supply systems	Aim to achieve net zero GHG emissions
Long-term Continuing	Continuing trend in the global shipping industry to pursue environmental sustainability, operational efficiency, social engagement, among others.	Maritime service and others	Realize the healthy and environmental sustainability development of the industry

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Source: Frost & Sullivan Report, IMO, Clarkson, China Association of the National Shipbuilding Industry, Lloyd's Register of Shipping, China Shipbuilding Industry Yearbook

Overview of Global Maritime Environmental Protection Equipment and System Market

Guidance of Sustainable Maritime Transportation Technology

- Current international sustainable maritime transportation standards are built upon and developed from the International Convention for the Prevention of Pollution from Ships (MARPOL). MARPOL addresses the prevention of marine pollution by ships from both operational and accidental causes. Specifically, Annex VI of MARPOL, titled "Prevention of Air Pollution from Ships," sets limits on sulfur oxide (SOx) and nitrogen oxide (NOx) emissions from ship exhausts and prohibits the deliberate release of ozone-depleting substances. Additionally, designated emission control areas (ECAs) enforce stricter standards for SOx, NOx, and particulate matter. Recent updates to MARPOL include mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships.To echo the MARPOL convention, countries such as Norway, Japan, the U.K., and China have set out different guidance and definitions of sustainable maritime transportation technology as listed below:

Guidance & Definitions of Sustainable Maritime Transportation Technology by Major Countries Around the World

Norway

Norway aims to reduce carbon emissions from domestic shipping and fishing ships by 50% by 2030. Key measures include legislative planning, financial support, public-private partnerships, a quota system, green public procurement, and registration incentives. The “Ship Safety and Control Act” and the “Pollution Control Act” enforce environmental requirements. Public procurement promotes zero and low-emission technologies, while subsidies and tax incentives support environmentally friendly ships. Norway also focuses on biofuels, with mandatory biofuel quotas proposed to meet emission reduction goals.

Japan

Japan targets ultra-low or zero-emission ships by 2030, aiming for a 90% reduction in greenhouse gas emissions from 2008 levels. Efforts include research, development, and demonstration of new technologies, with a focus on LNG as a transitional fuel and hydrogen and ammonia as long-term solutions. Strategies involve dual-fuel engines, CO2 capture systems, and improved battery efficiency. Conceptual designs for hydrogen and ammonia-fueled ships and CO2 capture ships are being explored to enhance green performance.

U.K.

The U.K. considers 2020-2030 crucial for developing zero-emission ship technologies to achieve IMO's 2050 zero-emission goal. Policies support cost-effective carbon reduction, stringent zero-emission standards, and collaborations with energy developers and fuel technology companies. Meanwhile, Lloyd's Register assesses alternative fuels' maturity and proposes solutions for technical challenges. Despite cost challenges, ongoing R&D investments aim to make zero-emission ships economically viable.

China

Driven by the international shipping industry's energy-saving and emission reduction goals, China has introduced policies to guide the development and construction of green ships. In 2013, the Ministry of Transport issued the "Guiding Opinions on Promoting the Application of Liquefied Natural Gas in the Water Transport Industry," advocating for LNG as fuel. In 2017, the Ministry of Science and Technology and the Ministry of Transport released the "13th Five-Year Plan for Technological Innovation in the Transport Sector," prioritizing advanced propulsion technology and green ship design. In August 2020, the Ministry of Transport issued the "Guiding Opinions on Promoting New Infrastructure Construction in the Transport Sector," encouraging the use of LNG and other clean energy sources. Domestic enterprises and research institutions are increasingly focusing on green standards in ship R&D and construction, achieving significant progress in building green ships, greening equipment, developing emission reduction technologies, and recycling ship materials.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Implementation Pathways for Global Maritime Environmental Protection Equipment and System Industry

Emission Reduction

Emission reduction primarily focuses on strengthening exhaust gas cleaning management to mitigate or eliminate environmental pollution caused by the maritime shipping industry. The key technological route currently in use aims to reduce sulfur oxides (SOx) and other gaseous pollutants emitted by ships, thereby significantly enhancing their environmental performance. This effort is driven by stringent international regulations such as the IMO's MARPOL Annex VI, which mandates a global sulfur cap of 0.50% m/m (mass by mass) for marine fuels, down from the previous 3.50% m/m. To comply with these regulations, many ships have adopted exhaust gas cleaning systems, which can remove up to 98% of SOx emissions. Additionally, the shift towards low-sulfur fuels and alternative energy sources such as liquefied natural gas (LNG) is gaining traction. LNG can reduce SOx emissions by nearly 100% and nitrogen oxides (NOx) by up to 85%, as well as lower CO2 emissions by 20-30%. Furthermore, policies such as the European Union's Green Deal and the U.S. Clean Air Act support the adoption of these technologies by providing regulatory frameworks and financial incentives. These measures not only comply with international standards but also promote sustainable practices within the maritime industry, ultimately contributing to global efforts to combat climate change and protect marine ecosystems.

Energy Efficiency

- Energy efficiency involves optimizing the overall design of ships and adopting energy-saving devices and systems to maximize energy utilization and reduce energy consumption. This approach is supported by various international regulations and initiatives aimed at improving the energy efficiency of maritime ships. For instance, the International Maritime Organization (IMO) has introduced the Energy Efficiency Design Index (EEDI), which sets mandatory energy efficiency standards for new ships, requiring them to become progressively more energy-efficient. Data from the IMO indicates that the implementation of EEDI is expected to reduce CO2 emissions by up to 30% by 2030 compared to 2008 levels.
- Innovations in ship design, such as more hydrodynamic hull forms, air lubrication systems, and advanced propeller designs, contribute significantly to reducing drag and improving fuel efficiency. Additionally, energy-saving devices like pre-swirl stators, energy-saving ducts, and high-efficiency rudders are being increasingly integrated into ship designs. The use of hybrid power systems and the integration of renewable energy sources, such as solar panels and wind-assisted propulsion systems, further enhance energy efficiency. Policies like the European Union's Horizon 2020 program provide funding and support for research and development in green ship technologies, encouraging the adoption of energy-efficient practices. Through these combined efforts, the maritime industry aims to achieve significant reductions in energy consumption, aligning with global sustainability goals and contributing to the overall reduction of greenhouse gas emissions.

Other Strategies

- Another key realization path for the global maritime environmental protection equipment and system market includes a variety of innovative approaches aimed at enhancing environmental sustainability and operational efficiency. This encompasses the use of eco-friendly materials and design principles for hull modifications, the adoption of advanced ship network solutions, and the implementation of energy management systems. By integrating sustainable materials and eco-design into shipbuilding and retrofitting, the industry can significantly reduce the environmental impact and improve the longevity and performance of ships. For example, lightweight and recyclable materials are increasingly used to lower fuel consumption and emissions. Additionally, high-efficiency network solutions, such as integrated maritime communication systems, enhance operational efficiency by optimizing route planning and reducing unnecessary fuel usage. Modern energy management systems, which monitor and control energy consumption in real-time, help to further reduce resource consumption and operational costs.
- Supportive policies and initiatives, such as the European Union's Green Deal and the International Maritime Organization's (IMO) guidelines on ship energy efficiency management plans (SEEMP), promote these technologies and practices. According to the IMO, the adoption of SEEMP can lead to significant fuel savings, contributing to the overall reduction of greenhouse gas emissions. By improving living conditions for crew members and increasing operational efficiency, these advancements not only contribute to the green and sustainable development of the maritime industry but also enhance the overall competitiveness and resilience of the sector.

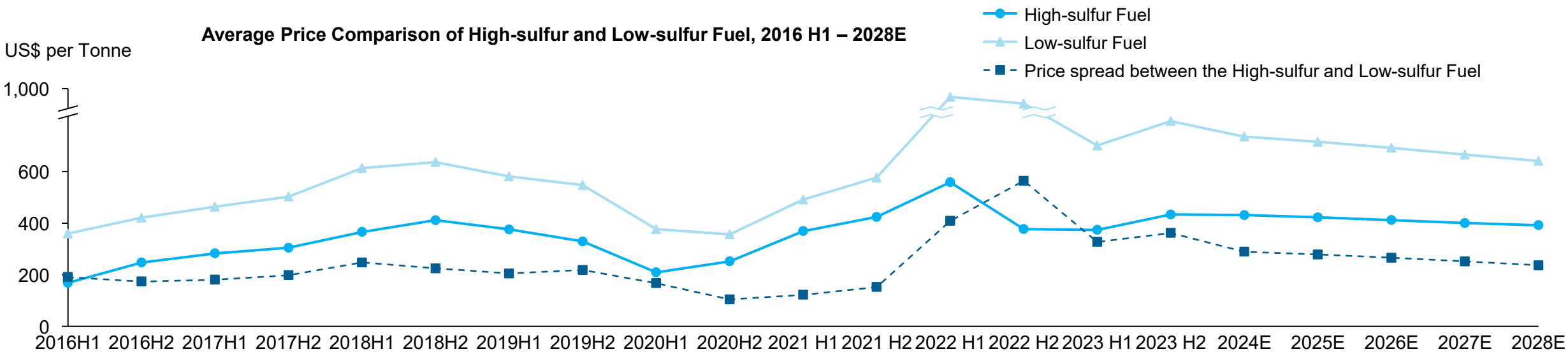
Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Cost Analysis of Marine Exhaust Gas Cleaning Systems

- Since the initial proposal of the global sulfur oxide emission limitation by the IMO in 2016, marine exhaust gas cleaning systems have dominated the global maritime environmental protection equipment and system market, comprising around 50% of the industry in 2023. To address the IMO's sulfur oxides emission limits, three strategies can be employed: 1) using low-sulfur fuel; 2) adopting ship exhaust gas cleaning systems; and 3) installing marine clean-energy supply systems, such as FGSS and LFSS. Although the transition to low-sulfur fuel offers a quick and straightforward approach to compliance, unstandardized mix during oil production may cause a relatively higher level of damage to a ship's engine during sailing. In addition, low-sulfur fuel is generally more expensive than high-sulfur fuel used with ship exhaust gas cleaning systems. Also, in general, the price of low-sulfur fuel was higher than that of high-sulfur fuel from 2016 to 2023, and this price spread is expected to be maintained from 2024 to 2028 due to several key factors, including but not limited to the following reasons that (i) the global sulfur oxide emission limitations first introduced by the IMO in 2016 spurred a rise in demand for low-sulfur fuel. As environmental awareness has grown, many countries and regions have implemented stringent regulations mandating the use of low-sulfur fuel or EGCS in response to the sulfur oxide emission limitations of IMO. This surge in demand, coupled with a relatively limited supply, has driven up prices of low-sulfur fuel; and (ii) the production cost of low-sulfur fuel is higher than that of high-sulfur fuel. Producing low-sulfur fuel requires advanced technologies, specialized equipment, and more stringent refining processes to reduce sulfur content. These additional costs are reflected in the higher price of low-sulfur fuel, making it more expensive compared to high-sulfur fuel, which requires simpler refining methods. In 2023, the global average price gap between high-sulfur and low-sulfur fuel was approximately US$340–350 per tonne. The average payback period for installing ship exhaust gas cleaning systems ranges from 6 months to 15 months, while the lifespan of ship exhaust gas cleaning systems can reach 5–10 years. After reaching the break-even point, the advantages of adopting ship exhaust gas cleaning systems become more significant.The global sulfur oxide emission limitations first proposed by the IMO in 2016 initiated the growth of the marine ship desulfurization industry. Since then, the rapid increase in demand for low-sulfur fuel has resulted in a significant price differential between high- and low-sulfur fuel, maintaining an elevated spread of around US$200 per tonne from 2016 to 2020. Due to the impacts of COVID-19 on global economy, the imbalance in the supply of high- and low- sulfur fuel has led to a narrowing of the price gap between the two. As a result, the price spread between high- and low-sulfur fuel fell to a low point of approximately US$105 per tonne in 2020. Following the implementation of sulfur oxide emission limitation in 2020 and the impacts of COVID-19 on the global economy starting to subside, this price spread quickly recovered in 2021 and widened further to approximately US$350 per tonne in 2023, prompting many shipowners to invest heavily in exhaust gas cleaning systems to continue using cheaper high-sulfur fuel while adhering to environmental standards. However, the rise in low-sulfur fuel production and enhanced refining efficiency have stabilized the supply of low-sulfur fuel.
- Looking ahead to 2024–2028, the price spread is expected to remain relatively stable. As more refineries come online and ramp up low-sulfur fuel production, the supply-demand balance should stabilize. If external factors, such as political and macroeconomic conditions, remain stable, the price spread is likely to remain stable or reduce gradually, particularly if high-sulfur fuel prices remain steady. However, the price spread between high-sulfur and low-sulfur fuel is expected to remain around US$240 per tonne through 2028, which is still relatively higher compared to 2016 levels. This sustained price spread makes the use of exhaust gas cleaning systems economically advantageous, allowing shipowners to continue using high-sulfur fuel while complying with environmental regulations.
- Furthermore, installing marine clean-energy supply systems incurs significant costs due to necessary modifications to the ship's power and fuel supply systems, such as converting diesel engines to dual-fuel engines and updating the energy supply systems, with the current cost six to eight times higher than implementing ship exhaust gas cleaning systems. Consequently, the cost advantage of adopting ship exhaust gas cleaning systems is more pronounced at this stage.

Average Price Comparison of High-sulfur and Low-sulfur Fuel, 2016 H1 – 2028E



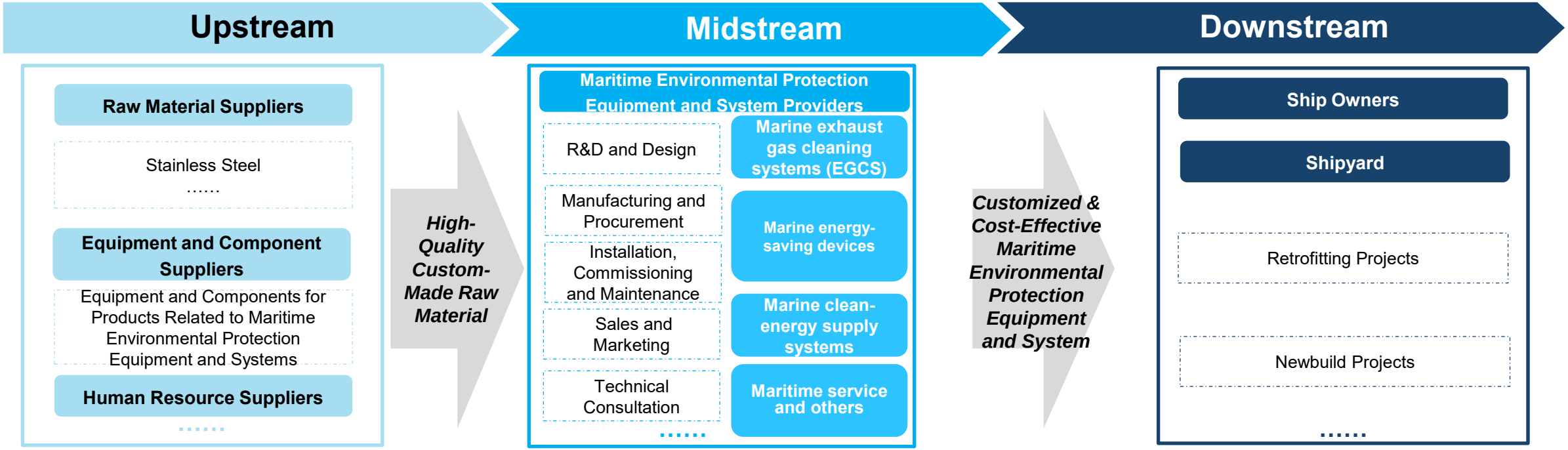
Note: Frost & Sullivan used the same calculation method to determine the average prices of high-sulfur and low-sulfur fuel above. The average price of high-sulfur fuel is derived from the average FOB spot prices of High Sulfur Fuel for the corresponding half-year periods in Singapore and Rotterdam. Meanwhile, the average price of low-sulfur fuel is calculated from the average FOB spot prices of VLSFO (Very Low Sulfur Fuel) for the same corresponding half-year periods in Singapore and Rotterdam.

The above data forecasts are based on the assumption of a stable global economy and industry supply and demand, without the influence of unpredictable external uncertainties.

Source: Frost & Sullivan Report, Organization of the Petroleum Exporting Countries, Clarkson, Platts, Bloomberg

Overview of Global Maritime Environmental Protection Equipment and System Market

Value Chain Analysis(1/2)



- The maritime environmental protection equipment and system industry is a comprehensive and integrated supply chain which spans multiple stages and participants focused on developing and implementing environmentally friendly maritime technologies. The upstream of the industry relies on raw material suppliers providing essential components such as stainless steel, and key equipment and component suppliers producing products related to maritime environmental protection equipment and systems such as scrubbers, carbon capture devices, fuel supply devices, fuel pipeline, etc.. In the midstream of the industry, maritime environmental protection equipment and system providers offer a range of products and services including R&D and design, manufacturing and procurement, installation, commissioning and maintenance, sales and marketing, and technical consultation, etc. In the maritime environmental protection equipment and system industry, it is an industry norm to engage sales agents in addition to the in-house sales and marketing teams as the maritime environmental protection equipment and system providers can gain timely insights into market needs and expedite the contract signing process. Furthermore, sales agents in general have stronger relationships with shipowners or ship builders, therefore, they can help in penetrating certain markets or networks of shipowners or ship builders where the providers do not have established relationships. In the downstream of the industry, shipowners and shipyards cooperate with maritime environmental protection equipment and system providers to integrate these customized and cost-effective equipment and systems to new ships or retrofit existing ships to meet environmental standards and improve efficiency.

Source: Frost & Sullivan

Global Marine Exhaust Gas Cleaning System Industry

Overview Global Marine Exhaust Gas Cleaning System Industry

Definition and Classification

Definition of Global Marine EGCS Industry

- Marine exhaust gas cleaning systems primarily refer to the installation of key environmental protection equipment on ships to treat diesel engine exhaust gas harmlessly, preventing air pollution caused by uncontrolled emissions and effectively helping shipowners and operators comply with International Maritime Organization (IMO) and various national environmental regulations. Currently, the main marine exhaust gas cleaning system is the marine ship exhaust gas cleaning system system, reducing environmental pollution by absorbing and decomposing sulfides in flue gas, such as sulfur dioxide. By selecting the appropriate ship exhaust gas cleaning system system type and conducting scientific design, installation, and maintenance, sulfur oxide emissions from ships can be significantly reduced, protecting the atmospheric environment. At the same time, effective cost management and operational training ensure that the system achieves optimal economic and environmental benefits throughout the ship's life cycle.

Classifications of EGCS

- Marine ship exhaust gas cleaning system is a system installed on ships, designed to clean the exhaust gas from main and auxiliary engines and remove sulfur oxides and particulate matter, offering economic benefits, simple installation, and a relatively short return on investment. Installment of ship exhaust gas cleaning system avoids the risks and higher costs associated with using low-sulfur fuels, and eliminates the need for expensive ship modifications required for using natural gas or other clean energy as fuel.
- According to their working principles, marine ship exhaust gas cleaning system can be divided into two main categories: dry ship exhaust gas cleaning system and wet ship exhaust gas cleaning system. Based on specific design differences on the discharging methods of washing water, wet ship exhaust gas cleaning systems can be further classified into three subcategories including open-loop ship exhaust gas cleaning system, close-loop ship exhaust gas cleaning system, and hybrid ship exhaust gas cleaning system.

Source: Frost & Sullivan

Overview Global Marine Exhaust Gas Cleaning System Industry

Comparisons of Different EGCS

Comparisons Between Different Types of Ship Exhaust Gas Cleaning System

Dry Ship Exhaust Gas Cleaning System

- Dry ship exhaust gas cleaning system do not use any liquids in the exhaust gas treatment process. Instead, quicklime particles react with sulfur oxides in the exhaust gas to form calcium sulfate, transferring sulfur atoms from gas molecules to solid molecules. At present, few ships use dry ship exhaust gas cleaning system.

Open-loop Ship Exhaust Gas Cleaning System

- The open-loop mode of the hybrid system will be enabled when the ship is sailing in a non-emission control area, and the corresponding system operation can refer to the above-mentioned ‘‘open-loop type.’’ Additionally, the hybrid system will switch to closed-loop mode when the ship is sailing in an emission control area or other restricted areas; it utilizes a mixed alkaline solution as its washing medium. An alkaline solution is used as an absorbent. This absorbent neutralizes the sulfides present in the flue gas, reacting to form sulfate and water. After the desulfurization process, the cleaned flue gas is released into the atmosphere. The resulting washing waste liquid is stored in the ship’s holding tank.

Close-loop Ship Exhaust Gas Cleaning System

- Unlike open-loop ship exhaust gas cleaning systems, which rely on seawater to treat exhaust gases, close-loop ship exhaust gas cleaning systems use freshwater mixed with alkaline substances like caustic soda (sodium hydroxide) to neutralize sulfur oxides in the exhaust gas, thereby achieving desulfurization. The recycling process is not 100% repetitive, and a small amount of scrubbing water is discharged into the sea after sewage treatment. The lost portion is replenished by adding fresh water and alkaline reagents. Therefore, close-loop ship exhaust gas cleaning systems are not entirely "zero wastewater discharge," but the amount of scrubbing water discharged is much less than that of open-loop systems. Close-loop ship exhaust gas cleaning systems can store scrubbing water in tanks to achieve "zero discharge" for a certain period.

Hybrid Ship Exhaust Gas Cleaning System

- Hybrid ship exhaust gas cleaning systems are combined systems that offer both open-loop and close-loop modes, allowing shipowners to switch between the two depending on environmental requirements. However, in some cases, hybrid ship exhaust gas cleaning system can also refer to open-loop systems that add caustic soda (to enhance sulfur removal), depending on the specific supplier's product naming conventions.

Comparisons Between Open-loop, Close-loop and Hybrid Ship Exhaust Gas Cleaning Systems

Categories	Price Range	Level of System Complexity	Construction and Maintenance Costs	Energy Consumption	Environmental Requirements for Marine Areas	Alkalinity Requirements	Scope of application
Open-loop Ship Exhaust Gas Cleaning System	Low	Simple	Low	High	High	High	Relatively Narrow
Close-loop Ship Exhaust Gas Cleaning System	High	Relatively Complicated	High	Low	Low	Low	Relatively Wide
Hybrid Ship Exhaust Gas Cleaning System	Relatively High	Complicated	Relatively High	Low (depending on mode)	Low	Low	Wide

Source: Frost & Sullivan

Overview Global Marine Exhaust Gas Cleaning System Industry

Development Background and Drivers of EGCS (1/2)

Global

After 2015:

- Annex VI of the MARPOL Convention aims for a reduction in sulphur oxide emissions from ships. The limits applicable at sea in Emission Control Areas (ECAs) were reduced from 1.5% m/m (mass by mass) to 1% m/m in 2010 and are planned to be further reduced to 0.1%, effective from 1 January 2015.

After 2020:

- In October 2016, the 70th session of the IMO Marine Environment Protection Committee (MEPC) adopted amendments to the MARPOL. The amendments focused on revising Annex VI, and decided to implement a global limit of 0.5% m/m for sulfur content in marine fuels from January 1, 2020.

Further, Annex VI provides two categories of measures and regulations for achieving emission compliance:

1. Direct use of marine fuel oil with a sulfur content not exceeding 0.5% m/m;
2. Allowing the use of alternative fuels or measures, such as LNG and marine diesel oil, or the continued use of high-sulfur marine fuel oil with EGCS, provided that the exhaust gas emissions are equivalent to those achieved with low-sulfur marine fuel oil.

China

Policy Engagement:

- Building upon the IMO's sulfur cap regulations, China has taken further steps to implement more stringent and specific regulations on ship pollutant emissions. These regulations not only align with the IMO's global standards but also address China's environmental concerns and maritime traffic conditions.

After 2019:

- According to the "Implementation Plan for Ship Air Pollutant Emission Control Areas" issued by the Ministry of Transport of the PRC, from January 1, 2019, marine ships entering the Emission Control Areas (ECAs) should use marine fuel oil with a sulfur content not exceeding 0.5% m/m. Large inland river ships and river-sea direct ships should use fuel oil that meets the requirements of the newly revised national standards for marine fuel oil. Other inland river ships should use diesel fuel that meets national standards.

After 2020:

- From January 1st, 2020, marine ships entering inland river control areas should use marine fuel oil with a sulfur content not exceeding 0.1% m/m.
- From March 1st, 2020, ships without alternative measures such as sulfur oxides and particulate matter pollution control devices entering the ECAs can only carry and use marine fuel oil as required by this plan.

After 2022:

- From January 1, 2022, marine ships entering the coastal control area of Hainan shall use marine fuel oil with a sulfur content not exceeding 0.1% m/m. The feasibility of using marine fuel oil with a sulfur content not exceeding 0.1% m/m will be assessed in whether to require seagoing ships entering coastal control areas to use marine fuel oil with a sulfur content not exceeding 0.1% m/m from January 1, 2025.

Policies Related to EGCS from Other Countries / Regions

South Korea:

- From September 1, 2020, to December 31, 2021, ships entering ECA in South Korea were mandated to use fuel oil with a sulfur content not exceeding 0.1% during the following periods while at berth (berthed or anchored). Starting from January 1, 2022, ships entering ECAs are mandated to use fuel oil with a sulfur content not exceeding 0.1% throughout their entire duration within the ECA. Alternatively, equivalent alternative methods can be used, such as ship exhaust gas cleaning systems.

European Union:

- Starting from January 1, 2010, ships berthed (docked or anchored) in ports of EU member states for more than 2 hours are required to use low-sulfur fuel oil with a sulfur content not exceeding 0.1% within 1 hour after arrival and 1 hour before departure.

Source: IMO, Frost & Sullivan

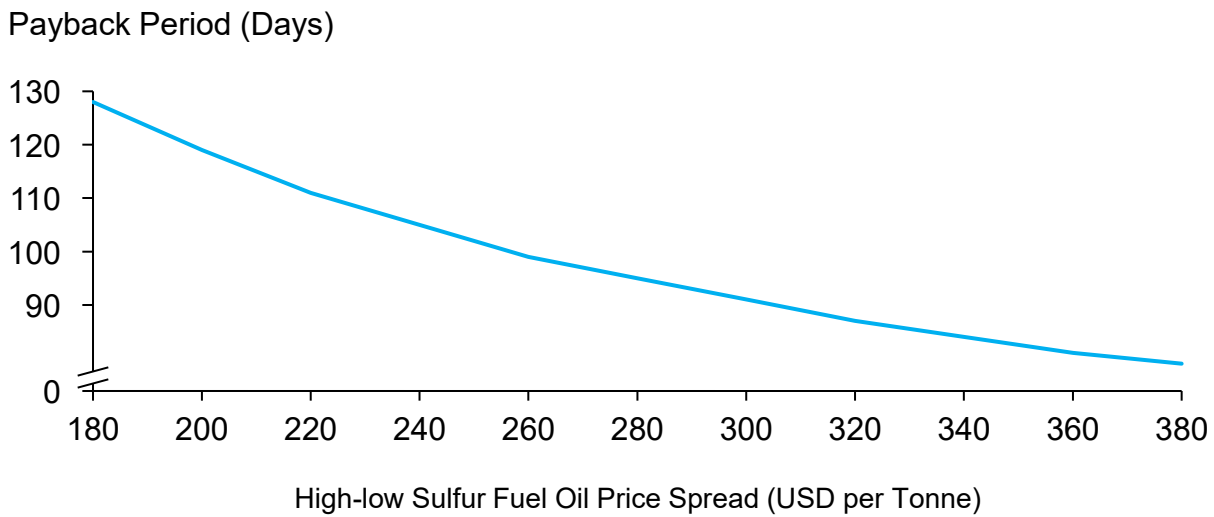
Overview Global Marine Exhaust Gas Cleaning System Industry

Development Background and Drivers of EGCS (2/2)

Significant Economic Benefits of EGCS

- The profitability and economic benefits of ship exhaust gas cleaning systems depends on the price difference between high-sulfur fuel oil (HSFO) and low-sulfur fuel oil (LSFO), as well as the fuel consumption of the ship. The costs involved include:
- 1. Initial capital expenditure for purchasing, installing, or retrofitting ship exhaust gas cleaning systems, which varies depending on the type of ship, trade routes, vessel age and type of ship exhaust gas cleaning system; Larger ships, with higher fuel consumption and longer voyages, stand to gain the most from marine exhaust gas cleaning system, as the savings from using HSFO are more substantial.
- 2. Operational costs incurred due to the use of ship exhaust gas cleaning systems, including additional electricity costs, water fees, and chemical expenses.
- Therefore, below shows the graphs for economic viability of ship exhaust gas cleaning systems and the price comparison of high-sulfur and low-sulfur fuel oil:

Economic Viability of Ship Exhaust Gas Cleaning Systems



- Economic viability of ship exhaust gas cleaning systems is calculated based on the average ship exhaust gas cleaning system cost or retrofitting compensation. Payback period decreases while the high-low sulfur fuel oil price spread increases. The payback period reaches to less than three months while the high-low sulfur fuel oil price spread increases to USD380 per ton. Although the future trend of the price difference between high-sulfur and low-sulfur fuel oil is relatively uncertain, in general, the higher the price difference, the better the economic viability of ship exhaust gas cleaning systems, and shipowners will tend to install more ship exhaust gas cleaning systems. At present, the price gap between high-sulfur and low-sulfur fuel oil remains high mainly due to the continued tightness of low-sulfur fuel supply and the increasing pressure on high-sulfur fuel supply.

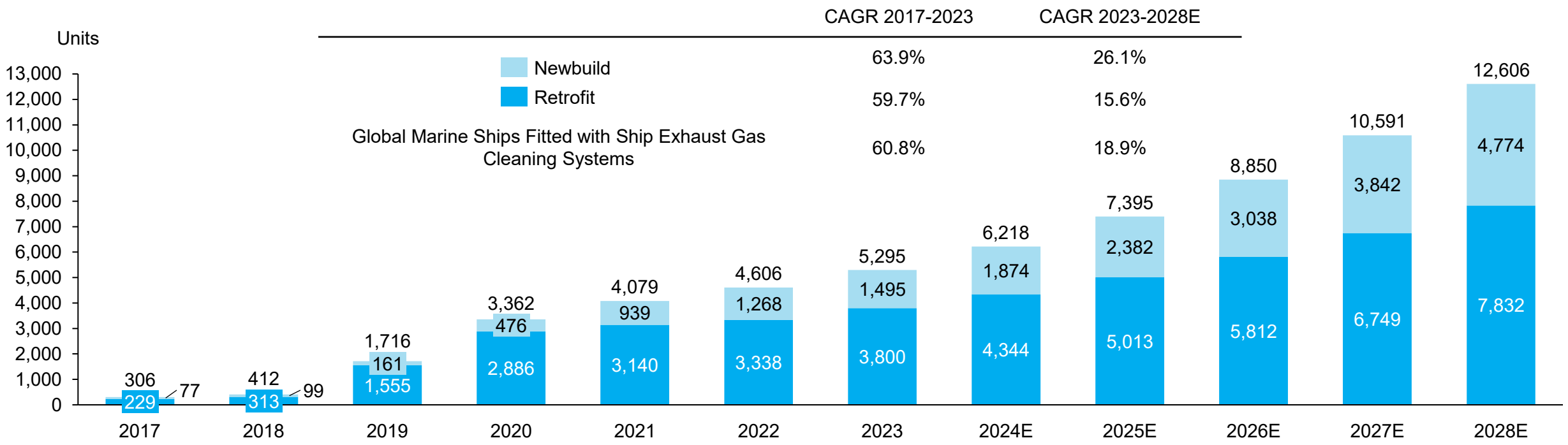
Notes: High-sulfur fuel oil price is based on the average FOB spot price of the corresponding half year of Singapore Fuel Oil (High Sulfur 180); low-sulfur fuel oil price is based on the average FOB spot price of the corresponding half year of Rotterdam Gasoil (0.1%).

Source: Wind, Frost & Sullivan

Overview Global Marine Exhaust Gas Cleaning System Industry

Cumulative Volume of Marine Ships Fitted with Exhaust Gas Cleaning Systems

Cumulative Volume of Marine Ships Fitted with Exhaust Gas Cleaning Systems (Global), 2017-2028E



- Ship exhaust gas cleaning systems serve as a crucial means to comply with IMO and regional regulations on sulfur oxide emissions from ships, offering stable economic benefits, straightforward installation, and a relatively short payback period compared to the volatile price gap between high and low-sulfur fuel oils. Consequently, the cumulative volume of global marine ships equipped with ship exhaust gas cleaning systems has grown explosively since the initial proposal of the global sulfur oxide emission limitation by IMO in 2016. As a result, the cumulative number of marine ships fitted with ship exhaust gas cleaning systems increased from 306 units in 2017 to 5,295 units in 2023, at a remarkable CAGR of 60.8%. Looking ahead, with ongoing tightening of IMO and regional regulations, more existing ships are expected to undergo ship exhaust gas cleaning system retrofits, while demand for ship exhaust gas cleaning systems in newbuilding ships will continue to grow, ensuring steady market expansion. The cumulative volume of global marine ships equipped with ship exhaust gas cleaning systems is forecasted to reach 12,606 units in 2028, reflecting a CAGR of 18.9% from 2023, thereby advancing industrial upgrades and promoting the desulfurization development of traditional shipping practices.

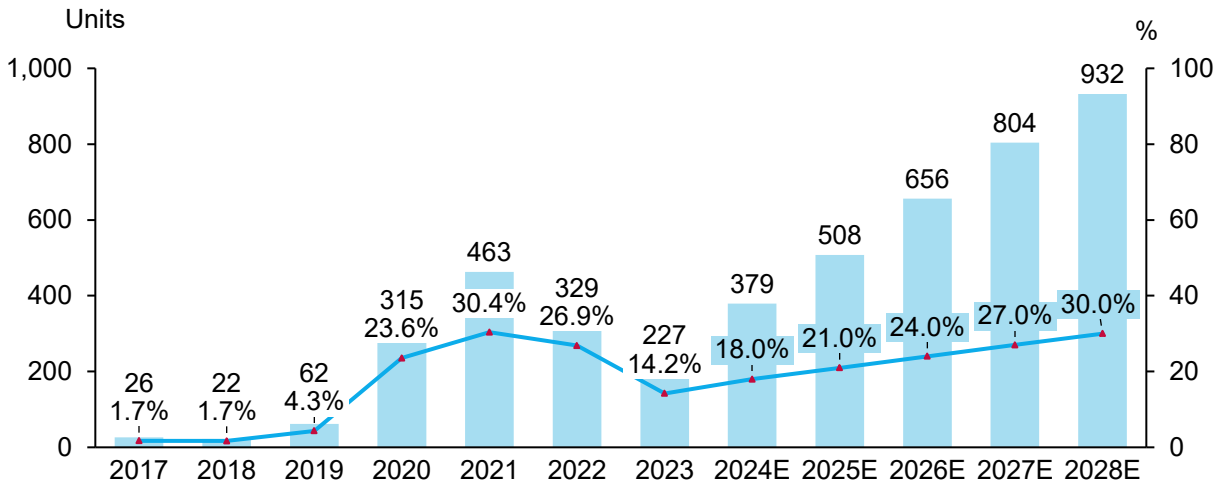
Source: IMO, Clarkson, Frost & Sullivan

Overview Global Marine Exhaust Gas Cleaning System Industry

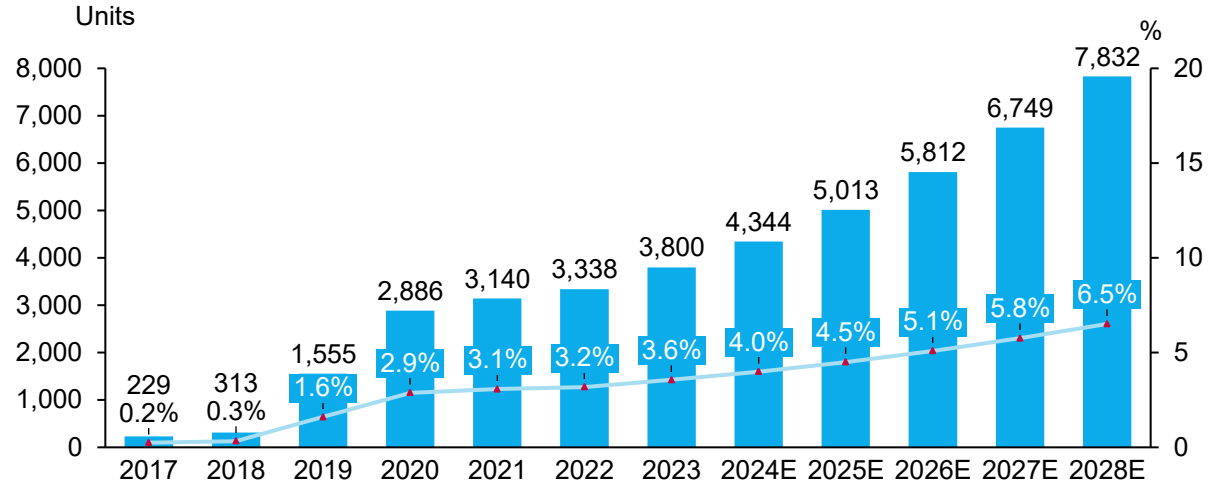
Added Volume of Marine Ships Fitted with Exhaust Gas Cleaning Systems

Newbuild and Accumulated Retrofit Volume of Marine Ships Fitted with Exhaust Gas Cleaning Systems (Global), 2017-2028E

	CAGR 2017-2023	CAGR 2023-2028E
Newbuild	43.5%	32.6%



	CAGR 2017-2023	CAGR 2023-2028E
Retrofit	59.7%	15.6%



Newbuild Marine Ships Fitted with EGCS as percentage of Global New Marine Shipbuilding Volume

Accumulated Retrofit Marine Ships Fitted with EGCS as percentage of Global In-service Marine Ship Volume

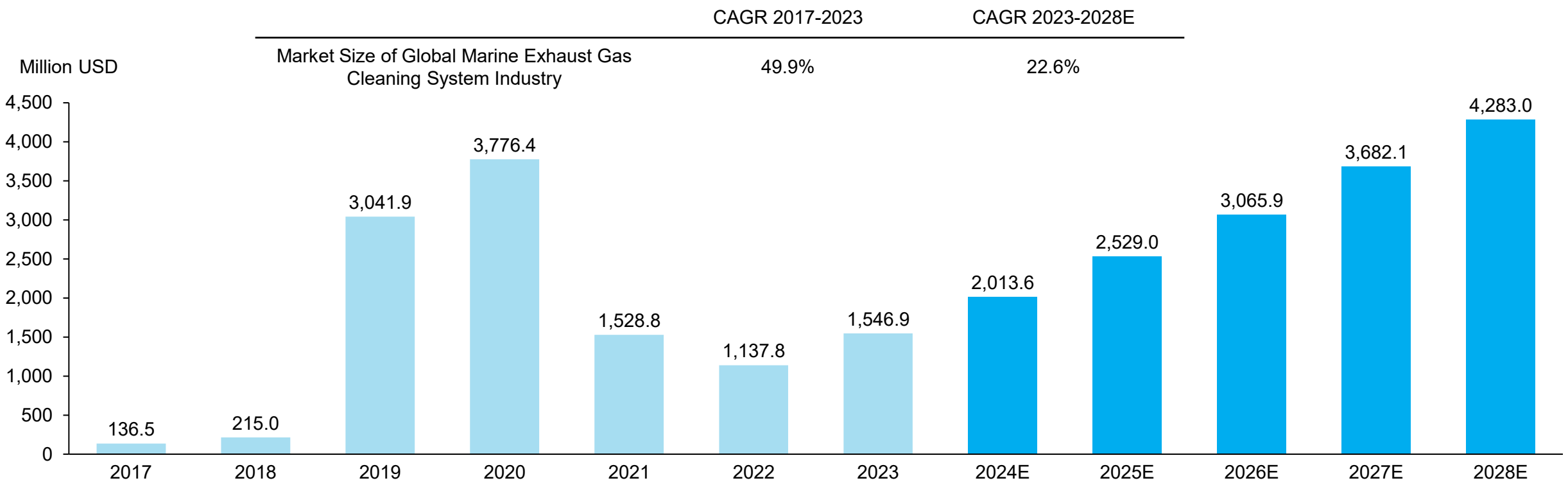
- Ship exhaust gas cleaning systems serve as a crucial means to comply with IMO and regional regulations on sulfur oxide emissions from ships, offering stable economic benefits, straightforward installation, and a relatively short payback period compared to the volatile price gap between high and low-sulfur fuel oils. Consequently, the volume of global marine ships equipped with ship exhaust gas cleaning systems has grown significantly since the initial proposal of the global sulfur oxide emission limitation by IMO in 2016. The total number of marine ships installed with EGCS consists of two parts: (i) the number of newbuild marine ships equipped with EGCS, and (ii) the number of in-service marine ships retrofitted with EGCS. Together, these two factors drive the growth in market demand for EGCS.
- The global added volume of newbuild marine ships fitted with EGCS increased from 26 units in 2017 to 227 units in 2023, at a remarkable CAGR of 43.5%. Looking ahead, in the newbuild segment, the global shift toward greener shipping practices has made it more common for ship builders to include exhaust gas cleaning systems in ship designs from the outset. With the IMO sulfur oxide emission limits and further regulations anticipated, shipowners are incentivized to address this issue early on when ordering new-buildings, resulting in steady demand for exhaust gas cleaning systems installations in newbuild ships.
- In the retrofit market, the growth of the cumulative volume of retrofit marine ship fitted with EGCS is primarily driven by two factors: the significant fuel cost and increasingly stringent environmental regulations. The sustained price spread of high-sulfur and low-sulfur fuel oil makes the use of exhaust gas cleaning systems economically advantageous. Furthermore, by 2022, as the pandemic's impact lessened and shipping prices stabilized, freight rates began to decline but remained above pre-pandemic levels, and shipping capacity was no longer in extreme shortage. However, in 2023, freight rates experienced a subsequent increase, driven by factors such as the Red Sea Crisis. Many shipowners, having accumulated funds during the high freight rates since 2020, are now focusing on upgrading their fleets to comply with tightening environmental regulations. As a result, the number of retrofit marine ship fitted with EGCS is expected to rise, driven by the need to meet stricter emissions standards while managing fuel costs. Moreover, in light of the accumulated wealth, shipowners would continue to place new shipbuilding orders for catering the demand in the next cycle.
- As a result, the global added volume of newbuild and accumulated retrofit marine ships fitted with ship exhaust gas cleaning systems is forecasted to reach 932 and 7,832 units in 2028, reflecting a CAGR of 32.6% and 15.6% from 2023, respectively, thereby advancing industrial upgrades and promoting the desulfurization development of traditional shipping practices.

Source: Frost & Sullivan Report, IMO, Clarkson, China Association of the National Shipbuilding Industry, Lloyd's Register of Shipping, China Shipbuilding Industry

Overview Global Marine Exhaust Gas Cleaning System Industry

Market Size of Global Marine Exhaust Gas Cleaning System Industry

Market Size of Global Marine Exhaust Gas Cleaning System Industry by Value, 2017-2028E



- Due to the amendment of a global limit of 0.5% m/m for sulfur content in marine fuels from January 1, 2020, many shipowners, especially for ships like large container ships, very large crude carrier (VLCC), etc., chose to focus on retrofitting ship exhaust gas cleaning systems in 2019 and 2020 to meet the IMO standards. Thus, the market size of global EGCS industry surge from 2018, with the CAGR of 2017 to 2020 reaching 202.4%. After 2021, the market has been gradually back from the outbreak and returned to a stable development trend. In the future, the tight supply of low-sulfur fuel oil may result in a relatively large high-low sulfur fuel oil price spread, incentivizing more shipowners to install ship exhaust gas cleaning systems. It is expected that the market size of global exhaust gas cleaning system (EGCS) industry by value will increase steadily from USD1,546.9 million in 2023 to USD4,283.0 million in 2028, at a CAGR of 22.6%.

Source: Frost & Sullivan Report, interviews with industry experts, IMO, Clarkson

Global Marine Energy-saving Device Industry

Overview of Global Marine Energy-saving Device Industry

Development Background Analysis(1/3）

IMO's GHG Strategy

2018

Initial Strategy

In 2018 (MEPC 73), IMO adopted an initial strategy on the reduction of GHG emissions from ships, setting out a vision which confirms IMO's commitment to reducing GHG emissions from international shipping and to phasing them out as soon as possible.

The initial GHG Strategy's ambition levels include reducing the carbon intensity of ships through further phases of the Energy Efficiency Design Index (EEDI) and strengthening design requirements. It aims to cut CO2 emissions per transport work by at least 40% by 2030, with efforts towards a 70% reduction by 2050, compared to 2008 levels. Additionally, it seeks to peak and then decline GHG emissions from international shipping, reducing total annual emissions by at least 50% by 2050 while pursuing efforts to phase them out, aligning with the Paris Agreement temperature goals.

2019

Amendments

The MEPC 74 session in May 2019 approved, for adoption at the next session, amendments to MARPOL Annex VI to significantly strengthen the EEDI "phase 3" requirements. The draft amendments bring forward the entry into effect date of phase 3 to 2022, from 2025, for several ship types, including gas carriers, general cargo ships and LNG carriers. **This means that new ships built from that date must be significantly more energy efficient than the baseline.**

MEPC 74 approved the "Procedure for Assessing Impacts on States" of candidate measures for reduction of GHG emissions from ships.

MEPC 74 also adopted "Resolution MEPC.323(74)" on Invitation to Member States to encourage voluntary cooperation between the port and shipping sectors to contribute to reducing GHG emissions from ships.

2021

Amendments

The MEPC 76 meeting adopted technical and operational measures to reduce the carbon intensity of international shipping, effective from 2023. **These measures include the Energy Efficiency Existing Ship Index (EEXI), the enhanced Ship Energy Efficiency Management Plan (SEEMP), and the Carbon Intensity Indicator (CII) rating scheme.**

Ships will implement a mandatory CII rating system to calculate and compare their carbon intensity performance with required standards, incentivizing effective operational measures for better ratings and competitive advantages. Ships with poor ratings must improve their energy efficiency management. The annual carbon intensity reduction factor will progressively raise CII standards, aiming to reduce the overall carbon intensity of the maritime fleet.

2023-Future

Adoption of Revised Strategy

Member States of IMO, meeting at the MEPC 80, have adopted the "2023 IMO Strategy on Reduction of GHG Emissions from Ships" in 2023, with enhanced targets to tackle harmful emissions.

The 2023 IMO GHG Strategy aims to reduce the carbon intensity of ships by improving energy efficiency and strengthening design requirements for new ships. It seeks to achieve net-zero greenhouse gas emissions around 2050 and establish "emission reduction milestones": 1) By 2030, achieve a 20% reduction in total greenhouse gas emissions compared to 2008 levels, aiming for a reduction of up to 30%. 2）By 2040, achieve a 70% reduction in total greenhouse gas emissions compared to 2008 levels, aiming for a reduction of up to 80%.

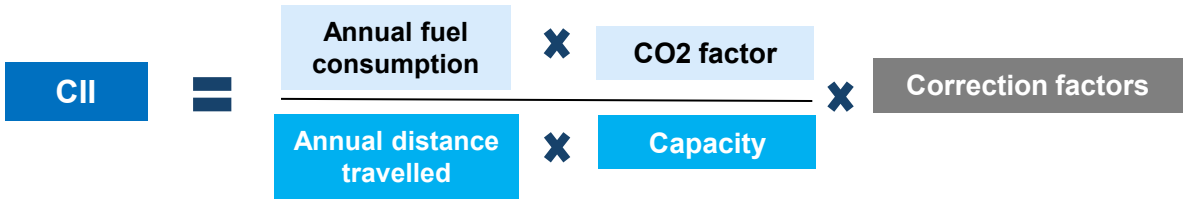
Source: IMO, Frost & Sullivan

Overview of Global Marine Energy-saving Device Industry

Development Background Analysis(2/3）

CII Rating System

- The Carbon Intensity Rating is for international sailing ships of 5,000 GT or more.
- Carbon intensity indicator (CII) means a value quantifying the efficiency of a ship based on ship operation data.
- Ratings from A to E are given according to the degree of improvement in the annual CII achievement compared to the annual CII requirement.



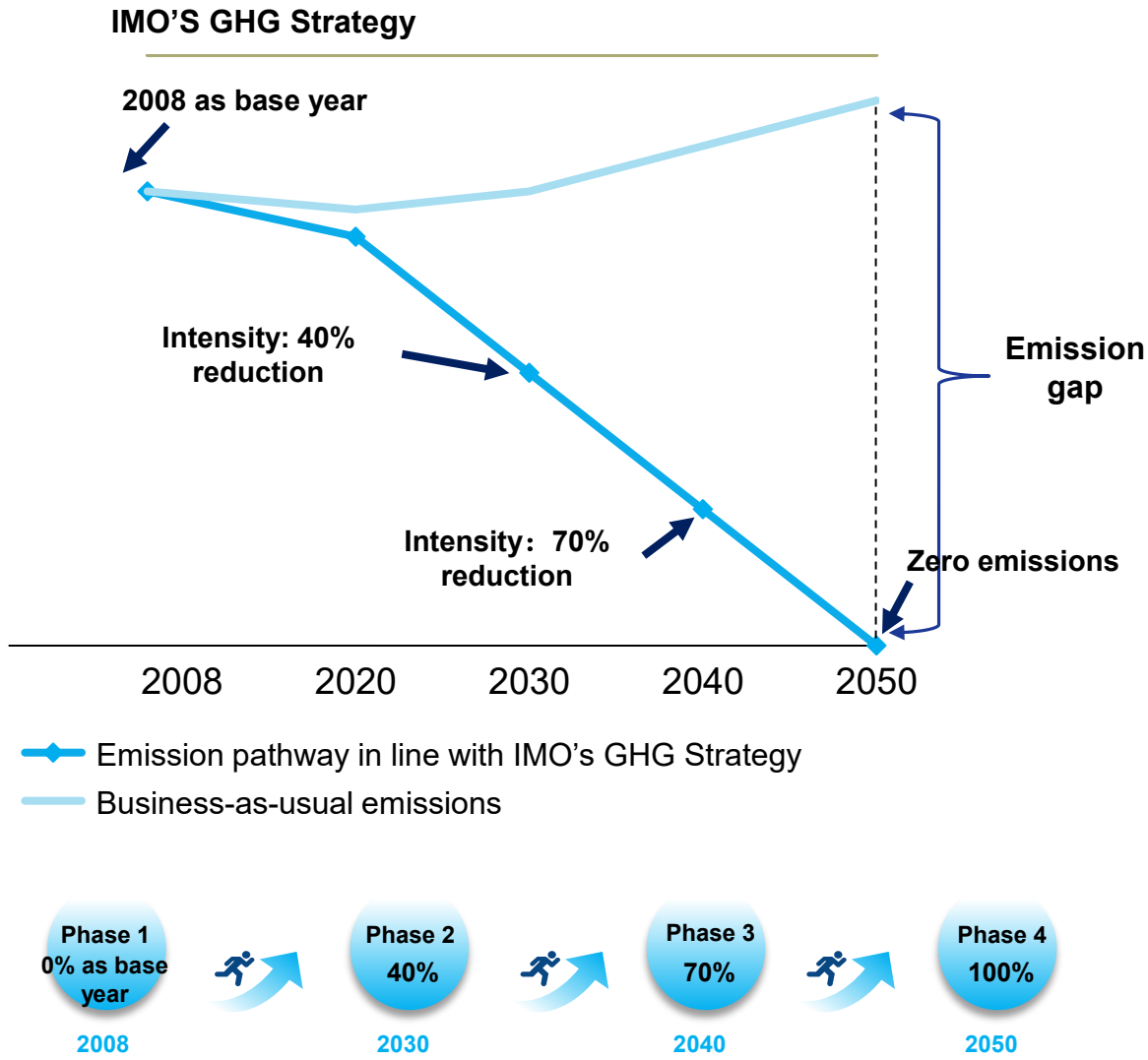
Ship EEDI

Target index to reduce CO2 emissions per average transport work by N% by N years compared to 2008

It refers to the amount of CO2 emitted when a ship transports 1 ton of cargo for 1 nautical mile.

When a ship is built, the EEDI must be calculated to meet the phase reduction rate for each year.

The 2023 IMO GHG Strategy aims to reduce the carbon intensity of ships by improving energy efficiency and strengthening design requirements for new ships. It seeks to achieve net-zero greenhouse gas emissions around 2050 and establish “emission reduction milestones“: 1) By 2030, achieve a 20% reduction in total greenhouse gas emissions compared to 2008 levels, aiming for a reduction of up to 30%. 2）By 2040, achieve a 70% reduction in total greenhouse gas emissions compared to 2008 levels, aiming for a reduction of up to 80%.



Source: IMO, Frost & Sullivan

Overview of Global Marine Energy-saving Device Industry

Development Background Analysis(3/3）

Market Demand for Marine Energy-saving Device Rises Significantly

- With the increasing global focus on environmental protection and sustainable development, as well as the IMO's future GHG emission reduction targets and EEDI emission reduction targets for new ships, the demand for low-emission and efficient operations from shipping companies and cargo owners is continuously growing. Further, the price of traditional marine fuels is highly volatile and has been on a long-term upward trend. Energy-saving technologies can reduce fuel consumption of ships, thereby lowering operating costs and improving the economic benefits of ship owners. Following with the goal of reducing greenhouse gas emissions from international shipping by more than 50% from 2008 levels by 2050, more ships and customers are inclined to choose environmentally friendly transportation methods. At the same time, in order to meet market demand, shipowners need to adopt energy-saving and carbon-reduction technologies to improve the environmental performance of ships and gain a competitive edge in the market. Energy-saving devices will become a crucial pathway to achieve green and low-carbon development in the shipping industry. Digital operation and maintenance of ships will be an essential means to verify the reliability and availability of systems and equipment, thus forming a comprehensive evaluation system for the contribution of energy-saving device.

Technological Advances Propel the Industry Growth

- Technological enhancement of energy saving devices (ESD) and ship carbon capture systems (CCS) accelerate the industrial development. Among the ship energy saving devices involve the innovations in various aspects, including hull form optimization, propeller optimization, propulsion system arrangement optimization, auxiliary equipment optimization, the installation of hydrodynamic energy-saving devices and the reserve and application of alternative energy and new energy technologies. For example, hydrodynamic energy-saving devices (HESDs) such as pre-swirl stator, vortex fins, rudder bulb, etc. have become one of the main choices for energy-saving retrofits of in-service ships due to their good energy-saving effects, simple structure, and low retrofitting costs. For the ship CCS, latest innovation such as the organic amine-based carbon capture system generates the high-efficiency energy-saving equipment which enables low terminal temperature difference, corrosion-resistant & high efficiency. This method can introduce high carbon capture efficiency implementing the high-performance tower in which achieves large-scale flow field optimization, ultra-low emissions, and high-performance packing. Consistent development and innovation of these ship energy-saving and emission-reduction technologies provide a practical and feasible path for the shipping industry to achieve its goals of desulfurization and carbon reduction, promoting the transformation of the shipping industry towards a cleaner and more sustainable future.

Source: Frost & Sullivan

Overview of Global Marine Energy-saving Device Industry

Definition and Classification

Definition of Global Marine Energy-saving Device Industry

- By comprehensively applying ship energy-saving devices, carbon reduction systems, and related energy management systems and intelligent control technologies that optimize power performance, reduce fuel consumption, and lower emissions, the operational efficiency and environmental performance of ships can be comprehensively improved. This not only helps shipowners and operators reduce operating costs but also meets international and regional environmental regulations, contributing to the development of sustainable marine operating. The global ship energy saving device and carbon reduction systems primarily consists of two parts: energy saving devices (ESD) and ship carbon capture systems (CCS).

Classifications of Global Marine Energy-saving Device

Marine Energy-saving Devices

Energy Saving Devices (ESD)

- Ship energy saving devices (ESDs) rely on both technological advancements and basic device or infrastructure management. Technological advancements involve utilizing energy-saving technologies to promote energy conservation in ships. For example, during the design of new ships, energy-saving optimization designs for hull, machinery, and propellers can be implemented, along with the rational configuration of propulsion diesel engines and power systems, to reduce ship resistance and improve propulsion efficiency. Basic device management include ship photovoltaic system, shore power system, sail, etc.

Ship Carbon Capture Systems (CCS)

- By decarbonisation process, CCS can be classified into dual alkali-based and organic amine-based.

- Dual Alkali-based Carbon Capture Systems
- Organic Amine-based Carbon Capture Systems

Source: Frost & Sullivan

Overview of Global Marine Energy-saving Device Industry

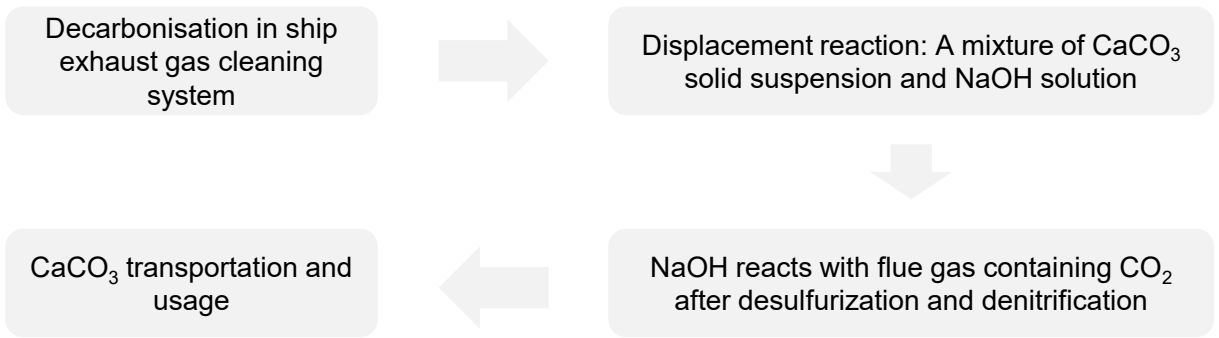
Technical Route Analysis of Ship Carbon Capture Systems (CCS)

Introduction of Technical Route of Ship Carbon Capture Systems (CCS)

- The primary step in the ship energy-saving device and carbon reduction system is the carbon capture process. Due to the unique characteristics of ship operations, such as being offshore, constantly moving, and operating under variable conditions, there are specific requirements for carbon capture on ships. Factors such as the space occupied, energy consumption, technological maturity, extent of ship modification, and investment costs of different carbon capture methods all constrain the choices of carbon capture methods for ships.
- Currently, post-combustion carbon capture technologies mainly include dual alkali-based, organic amine-based, etc. Both methods meet the technical standards for ship carbon reduction and can be combined with desulfurization systems to operate as a single system, achieving the dual goals of desulfurization and carbon reduction. The application of post-combustion carbon capture on ships must consider the unique characteristics of marine exhaust gas, and a suitable carbon capture method should be selected from the available post-combustion methods based on these specific characteristics. Below introduces the details among technical routes in the ship CCS:

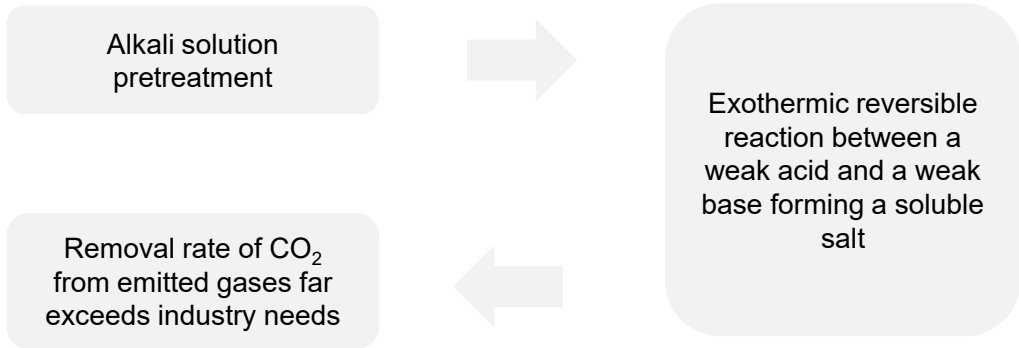
Dual Alkali-based Carbon Capture Systems

- Among this CCS, gas desulfurization is first carried out using sodium-based alkaline absorbent, and then the desulfurization solution is regenerated with lime powder. As the entire reaction process takes place between liquid and gas phases, system scaling is avoided. Additionally, the absorption rate is high, the liquid-to-gas ratio is low, the absorbent utilization rate is high, the investment cost is low, and the operating cost is low.



Organic Amine-based Carbon Capture Systems

- Organic amine-based carbon capture system is a carbon capture technology that utilizes amine-based chemical solvents. Due to their strong alkalinity, these solvents react rapidly with carbon dioxide, absorbing it from flue gas. The carbon dioxide is then separated through a reverse reaction and compressed for storage, while the chemical solvent can be reused.



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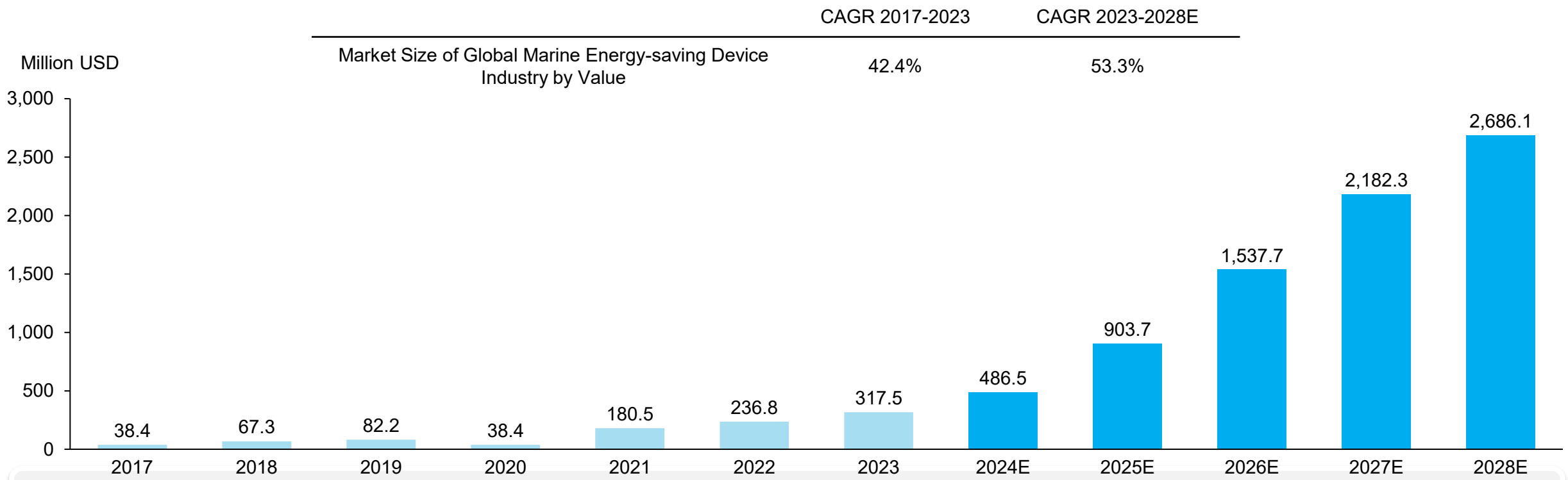
Source: Frost & Sullivan

Overview of Global Marine Energy-saving Device Industry

Market Size of Global Marine Energy-saving Device Industry

Market Size of Global Marine Energy-saving Industry by Value, 2017-2028E



- Due to the need for carbon reduction and the development of green shipping, the global ship energy saving device and carbon reduction systems industry will combine multiple measures to achieve carbon reduction targets to meet the existing Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) standards. For existing ships in particular, meeting EEXI requirements solely by reducing power may not be realistic, nor economically viable in terms of market operation. Therefore, it is necessary to improve ship energy efficiency through ship modification or the addition of energy-saving devices, thus achieving the decarbonisation. Therefore, the market size of global ship energy saving device and carbon reduction systems industry has increased from USD38.4 million in 2017 to USD317.5 million in 2023, at a CAGR of 42.4%. In the future, with the further implementation of goal for low-carbon emission in the marine industry, it is expected that the market size of global marine energy-saving devices industry will increase to USD2,686.1 million in 2028, at a CAGR of 53.3% from 2023.

Source: Frost & Sullivan Report, interviews with industry experts, IMO, Clarkson

Global Marine Clean-energy Supply System Industry

Overview of Global Marine Clean-energy Supply System Industry

Development Background Analysis(1/2)

Environmental Regulations and Policies

Many countries have established policies and subsidies aimed at reducing carbon emissions and advancing clean energy initiatives. For instance, the European Union's European Green Deal aspires to achieve carbon neutrality by 2050, while China's Carbon Peak Action Plan targets peak carbon emissions by 2030.On July 7, 2023, the International Maritime Organization (IMO) revised its greenhouse gas reduction strategy, setting ambitious goals. These include achieving net-zero greenhouse gas emissions around 2050 and establishing "reduction checkpoints" to decrease total greenhouse gas emissions by 20% by 2030 compared to 2008 levels, with an aim for a 30% reduction. By 2040, the targets are a 70% reduction, with an aspiration to reach an 80% reduction. Currently, ship desulfurization and carbon reduction systems are among the most effective and economically viable solutions for reducing carbon dioxide emissions. However, these systems do not eliminate exhaust pollution at its source. As environmental policies become increasingly stringent, the adoption of clean fuels such as methanol and ammonia is essential for the sustainable development of the shipping industry. Promoting the use of alternative fuels and developing a range of low-carbon technologies will enable the maritime industry to achieve more sustainable development and meet higher environmental standards and carbon reduction targets. The IMO has implemented several measures to encourage ship carbon reduction, including mandatory efficiency standards for new ships to reduce carbon dioxide emissions per unit of transport work. Starting in 2023, ship operators are required to report their annual carbon intensity and will be rated based on their performance, encouraging continuous improvement. Vessels operating in regions with strict emissions regulations or on routes with limited compliant fuel options also benefit from EGCS adoption.

The Maturity and Declining Costs of Clean Energy Technologies

Advanced sensors and data analytics play a crucial role in enabling real-time monitoring and optimization of energy efficiency. Smart ship systems can significantly reduce fuel consumption and emissions through data analysis and automated control, enhancing overall operational efficiency. Moreover, combining traditional fuels with battery storage technology allows for flexible energy source switching under different sailing conditions, optimizing energy use efficiency. This hybrid approach ensures that ships can utilize the most efficient energy source available at any given time, further reducing emissions and fuel consumption. With breakthroughs in technologies for new clean fuels such as methanol and ammonia, the application scope of clean marine fuels is continually expanding. These fuels not only reduce emissions but also possess high energy density and favorable storage and transportation characteristics. As a result, they are becoming increasingly attractive options for the maritime industry, contributing to its sustainable development and compliance with stringent environmental regulations. Overall, the advancements in clean energy technologies, coupled with their declining costs, are paving the way for a more sustainable and economically viable future for the maritime industry.

Source: Frost & Sullivan

Overview of Global Marine Clean-energy Supply System Industry

Development Background Analysis(2/2)

Economic Factors

The volatility of traditional fossil fuel costs, the long-term economic feasibility of clean energy systems, government regulations and incentives, and changes in market demand all provide strong momentum for the adoption of clean energy in the maritime sector. Traditional fossil fuel prices are heavily influenced by geopolitical factors and market demand, leading to significant instability. This volatility motivates shipowners to seek stable and economical alternative energy sources. For instance, according to the International Energy Agency (IEA), global oil prices experienced significant fluctuations in 2022 due to the Russia-Ukraine conflict, rising from USD70 per barrel at the beginning of the year to over USD120 mid-year. In contrast, the price volatility of alternative fuels such as LNG, methanol, and ammonia is relatively smaller, offering more stable fuel cost expectations. Despite the high initial investment in clean energy systems, their operational and maintenance costs are lower. For example, hybrid power systems reduce mechanical wear and increase efficiency, significantly lowering long-term operational costs. Furthermore, subsidies and incentives provided by governments and international organizations, such as tax breaks and carbon credit trading, further enhance the economic attractiveness of clean energy solutions. For instance, the United States' Inflation Reduction Act offers tax breaks for ships using clean fuels, and the European Union provides "green ship" subsidies to support the purchase and retrofitting of clean energy ships. Additionally, as consumers and cargo owners increasingly prioritize environmental sustainability, ships using clean energy have a competitive edge in the market, attracting more business and customers. This shift in market demand underscores the growing importance of environmental considerations in commercial decision-making, further driving the maritime industry's transition to clean energy.

Source: Frost & Sullivan

Overview of Global Marine Clean-energy Supply System Industry

Fuel cost overview

Production route	LNG	LPG	Ammonia	Methanol
Current production cost vs HFO market price	Approx.equivalent	Approx.equivalent	Additional 10% ~ 25%	Additional 1% ~ 10%
Potential for cost reduction vs current cost	Natural gas price	Crude oil and natural gas production	Natural gas price	Natural gas price
	High-cost uncertainty associated with CCS technology High cost of ship's fuel system reconstruction			

- Given that LNG and LPG have comparable costs to HFO and the other alternatives (ammonia and methanol) are more expensive, installing ship exhaust gas cleaning systems and continuing to use high-sulfur fuel oil (HFO) remains the most cost-effective solution. This method allows ships to meet regulatory requirements without the higher costs associated with the ship's fuel system reconstruction and adoption of alternative fuels or technologies.

Note: based on average HFO market price of 450 USD per tonne in 2023

Source: Frost & Sullivan

Overview of Global Marine Clean-energy Supply System Industry

Definition and Classification

- Marine clean energy supply systems encompass the use of clean-energy supply systems and associated equipment, including but not limited to dual-fuel gas supply systems (FGSS) for liquefied natural gas (LNG)/ liquefied ethane (LEG), low-flashpoint fuel supply systems (LFSS) for methanol/liquefied petroleum gas (LPG)/ammonia, and liquid cargo systems (CHS) for LNG/LPG/ammonia/liquid carbon dioxide (LCO2). These systems aim to reduce emissions from ship fossil fuel combustion by replacing traditional fossil fuels with clean energy, thereby lowering carbon emissions and air pollution

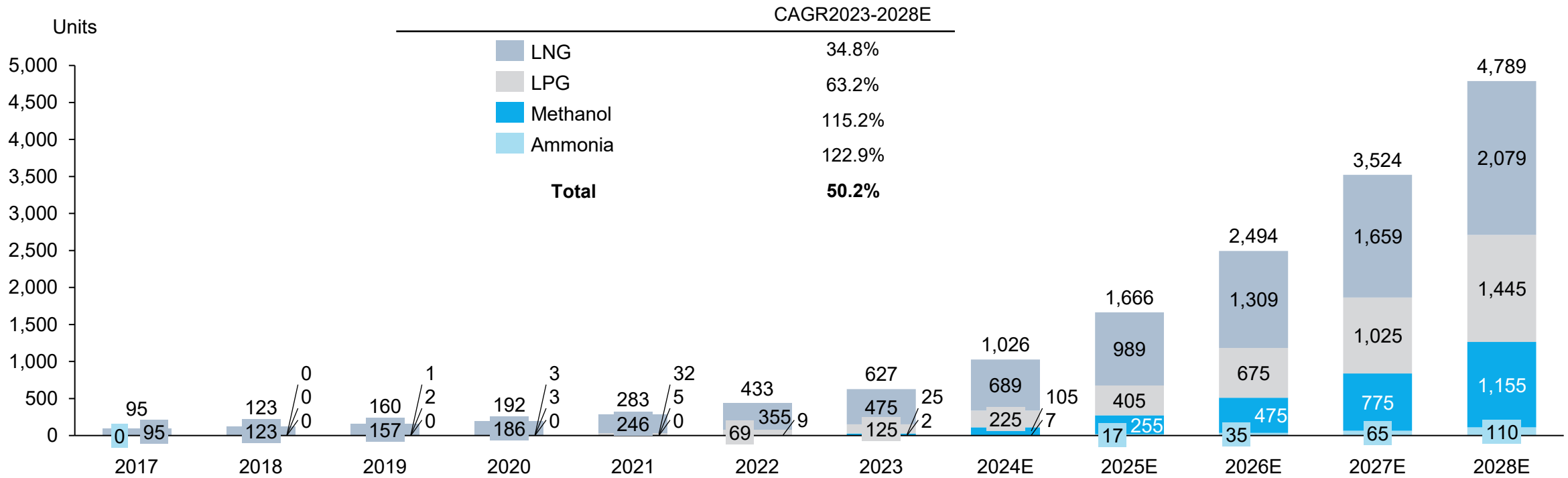
Name of the Core Systems	Introduction of Core Systems
Fuel Gas Supply System (FGSS)	• FGSS is designed to supply dual fuels, such as liquefied natural gas (LNG) and liquefied ethane gas (LEG), to marine engines. The main goal is to ensure the safe and efficient delivery of gaseous fuels to ship engines, thereby reducing reliance on conventional marine fuels and cutting down on emissions.
Low-Flashpoint Fuel Supply System (LFSS)	• LFSS focuses on supplying low flashpoint fuels such as methanol, liquefied petroleum gas (LPG), and ammonia. These systems are crucial for the safe and efficient handling and delivery of fuels with lower flashpoints, providing less polluting alternatives to traditional marine fuels.
Cargo Handling System (CHS)	• CHS is utilized for the handling and transport of liquid cargoes such as liquefied natural gas (LNG), liquefied petroleum gas (LPG), ammonia, and liquefied carbon dioxide (LCO_2). Its primary function is to manage and transport these liquid cargoes safely and efficiently, ensuring minimal environmental impact.
Other Core Systems	• Other core systems include the Cryogenic Piping System (Double Wall Pipe), Cryogenic Valves, Marine and Offshore Gas Skid & Module, Double-filters, and Urea Solution Production Plant, depending on the specific application.

Source: Frost & Sullivan

Overview of Global Marine Clean-energy Supply System Industry

Number of Ships Using Clean Energy by Fuel Type

Number of Ships Using Clean Energy by Fuel Type (Global), 2017-2028E



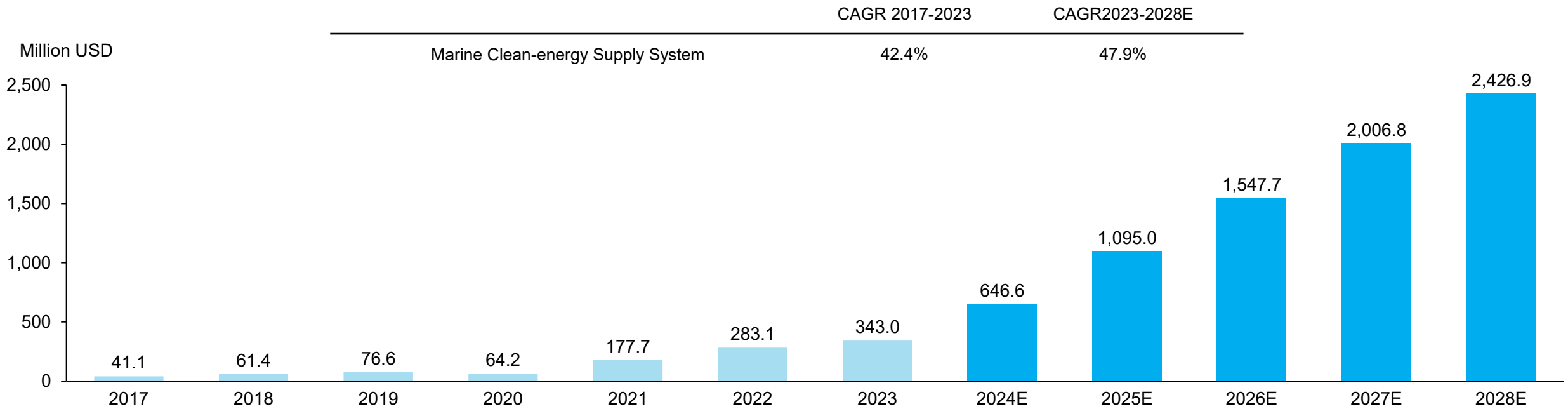
- With the continuous strengthening of global environmental awareness, the IMO has amended the GHG strategy, leading to an increase in the number of ships using clean energy since 2017. This trend has experienced explosive growth, from 95 ships in 2017 to 627 ships in 2023, with a CAGR of 37.0%. The majority of these clean energy ships are powered by LNG, with the number of new LNG-powered ships worldwide reaching 469 units by 2023. This is followed by LPG-powered ships, methanol-powered ships, and ammonia-powered ships, reflecting a significant shift towards more sustainable fuel sources in the maritime industry. The shift towards clean energy in the maritime industry is expected to accelerate as global environmental regulations become more stringent and technological advancements continue. The adoption of alternative fuels like methanol and ammonia is likely to grow, driven by their lower emissions and increasing availability. Investment in R&D for innovative propulsion technologies, such as hydrogen fuel cells and electric ships, will further diversify the clean energy options. Additionally, digitalization and automation in ship operations will enhance efficiency and sustainability. Collaboration among industry stakeholders, including shipbuilders, fuel suppliers, and regulatory bodies, will be crucial in overcoming challenges related to infrastructure and supply chains, ensuring a robust transition to a greener maritime future.

Source: DNV AFI, Clarkson, IMO, Frost & Sullivan

Overview of Global Marine Clean-energy Supply System Industry

Market Size of Marine Clean-energy Supply System Industry

Market Size of Marine Clean-energy Supply System Industry (Global), 2017-2028E



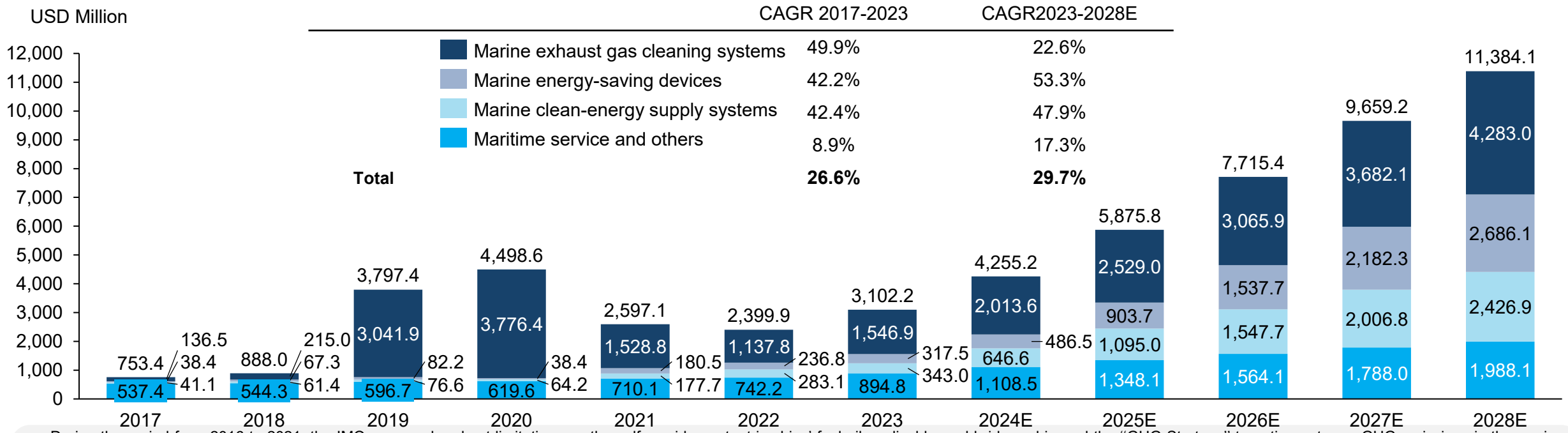
- Ship clean energy supply systems in shipping involve using alternative fuels to power ships, thereby reducing greenhouse gas emissions and environmental impact. With the increasing global emphasis on environmental protection, the IMO has implemented regulations limiting the green house gas emissions. This has driven the adoption of cleaner energy in the shipping industry. The market size of marine clean-energy supply system industry increased from USD41.1 million in 2017 to USD343.0 million in 2023, representing a CAGR of 42.4%.
- Looking forward, promoted by the stricter regulations, the technological upgrade of clean energy and lower costs, the demand for market size of marine clean-energy supply system will further increase. It is expected that the market size of marine clean-energy supply system industry will increase to USD2,426.9 million in 2028, representing a CAGR of 47.9%.

Source: IMO, Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Market Size of Global Maritime Environmental Protection Equipment and System Industry by Segment

Market Size of Global Maritime Environmental Protection Equipment and System Industry by Revenue by Segment, 2017-2028E



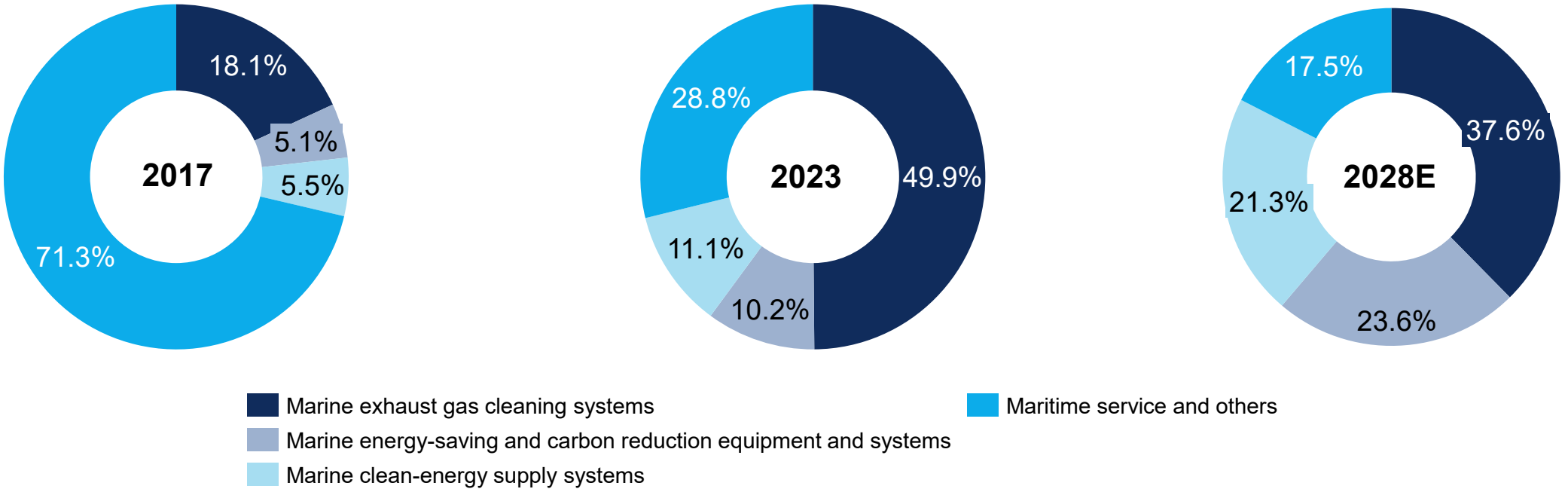
- During the period from 2016 to 2021, the IMO proposed and set limitations on the sulfur oxide content in ships' fuel oil applicable worldwide and issued the "GHG Strategy" targeting net-zero GHG emissions in the marine ship industry by around 2050. These measures served as critical catalysts, accelerating the development of the global green ship industry. As a major segment, the marine exhaust gas cleaning system market has dominated the global maritime environmental protection equipment and system market for the past five years, accounting for approximately 50% of the industry in 2023. It is expected to remain the largest segment from 2024 to 2028. Between 2017 to 2020, the primary drivers for the global marine exhaust gas cleaning system market were the IMO's desulfurization regulations announced in 2016 and effective from 2020, prompting many shipowners to install ship exhaust gas cleaning systems on both newbuild and retrofit ships. This led to a surge in demand for marine exhaust gas cleaning systems in this period, increasing the market size from US$136.5 million in 2017 to US$3,776.4 million in 2020, with its market share of the maritime environmental protection equipment and system industry rising from 18.1% to 81.6%. However, factors such as workforce reductions, container shortages, supply chain disruptions, and increased demand for goods caused by COVID-19 significantly increased ocean freight prices between 2021 and 2022, indirectly reducing the willingness of shipowners to stop operations and install ship exhaust gas cleaning systems. As a result, the market size of the marine exhaust gas cleaning system industry decreased to US$1,137.8 million in 2022, leading to a decline in the overall global maritime environmental protection equipment and system market. As the pandemic's impact subsides and the supply chain recovers, the market size is expected to rebound from 2023 onwards, reaching US$4,283.0 million in 2028, representing a CAGR of 22.6% between 2023 and 2028.
- Due to stricter international regulations and growing environmental concerns, the demand for marine energy-saving devices, along with marine clean-energy supply systems, is also set to rise substantially. Technological advancements, economic incentives, and financial support make these equipment and systems more attractive, prompting companies to invest in them to comply with regulations, reduce costs, and enhance their competitiveness. The marine energy saving device and carbon reduction systems and marine clean-energy supply systems segments are projected to reach US$2,686.1 million and US$2,426.9 million by 2028, respectively. Meanwhile, the market share of these segments is expected to increase from 10.2% and 11.1% in 2023 to 23.6% and 21.3% in 2028, respectively, providing strong support for the development of the maritime environmental protection equipment and system industry. Propelled by these factors, the global maritime environmental protection equipment and system industry is expected to reach US$11,384.1 million by 2028, representing a CAGR of 29.7% between 2023 and 2028.

Source: Frost & Sullivan Report, interviews with industry experts, IMO, Clarkson

Overview of Global Maritime Environmental Protection Equipment and System Market

Market Share of Global Maritime Environmental Protection Equipment and System Industry by Segment

Market Share of Global Maritime Environmental Protection Equipment and System Industry by Segment, 2017, 2023 & 2028E



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Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Drivers and Trends Analysis of Global Maritime Environmental Protection Equipment and System Market（1/3）

Strengthened Regulations and Standards

The increasing emphasis on environmental protection globally, is a significant driver for the maritime environmental protection equipment and system industry. Stricter environmental regulations and standards are being implemented, compelling the shipping industry to adopt cleaner energy products.

- **From the perspective of desulfurization of ship:**

The regulations and standards pertaining to ship desulfurization have undergone significant evolution driven by environmental concerns and regulatory frameworks. Since January 1, 2010, the EU has mandated that ships berthed in EU ports for over 2 hours use low-sulfur fuel oil with sulfur content not exceeding 0.1%, aimed at reducing sulfur oxides emissions in port areas. In October 2016, the IMO further decided that starting from 2020, a global sulfur oxides limit of 0.5% would apply to ships sailing outside sulfur oxides emission control areas (ECA). This regulation has spurred the adoption of low-sulfur fuels and desulfurization technologies like EGC systems across the marine ship industry, marking a significant shift towards maritime environmental protection equipment and systems to meet global environmental standards. Countries worldwide have responded actively to IMO requirements with their own measures, such as South Korea's "Special Act on Improvement of Air Quality in Port Areas, etc." effective from January 1, 2020, imposing a 0.1% sulfur oxides cap and voluntary speed reductions. China's Ministry of Transport also mandated ships in emission control areas to use fuel with sulfur oxides content not exceeding 0.5% from January 1, 2019, and 0.1% from January 1, 2020, with stricter controls in specific areas from January 1, 2022, potentially extending nationwide by January 1, 2025.

- **From the perspective of carbon reduction of ship:**

The MEPC 76 meeting in 2021 introduced technical and operational measures effective from 2023, aimed at reducing the carbon intensity of international shipping. These measures include implementing the Energy Efficiency Existing Ship Index (EEXI), enhancing Ship Energy Efficiency Management Plans (SEEMP), emphasizing Energy Efficiency Design Index (EEDI), and establishing a Carbon Intensity Indicator (CII) rating scheme. The CII system mandates ships to calculate and compare their carbon intensity performance against set standards, encouraging operational efficiencies and providing competitive advantages for higher-rated vessels. Ships with lower ratings must improve their energy management practices. The progressive annual increase in the carbon intensity reduction factor aims to significantly decrease the overall carbon intensity of the global maritime fleet. Additionally, the "IMO Strategy on Reduction of GHG Emissions from Ships" adopted in 2023 set ambitious targets, including a 40% reduction in greenhouse gas emissions by 2030 from the level of 2008 and achieving net-zero emissions by around 2050. Moreover, the EU Emissions Trading System (EU ETS) has been extended to include the shipping industry, starting January 2024, requiring companies operating within the EU to pay for their carbon emissions progressively, with full charges applicable by 2026. These regulatory advancements reflect a comprehensive effort to align the shipping sector with stringent environmental goals and global emission reduction strategies. These policies incentivize investments in desulfurization and carbon reduction of ships, encouraging ship owners to adopt maritime environmental protection equipment and systems and fostering a cleaner and more sustainable marine ship industry.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Drivers and Trends Analysis of Global Maritime Environmental Protection Equipment and System Market（2/3）

Improved Economic Benefits Along with Technology Innovations

To address the IMO’s sulfur oxides emission limits, installing the ship exhaust gas cleaning systems offers the most economic benefit due to cost control and the consideration of the ship's operating performance at present. As countries worldwide set double-carbon targets and the IMO introduced “GHG Strategy”, controlling sulfur oxide emissions from ships is no longer sufficient to meet current environmental requirements. The importance of ship carbon reduction is increasingly prominent. To comply with IMO’s GHG emission targets, ship owners can consider adopting ship energy-saving devices or marine clean-energy supply systems. These equipment and systems help reduce payments from carbon taxes and trading and align with the IMO’s GHG Emission Strategy in the long run, despite high installation costs at present.

Energy-saving and carbon-reduction technologies, such as propeller optimization systems, wind deflectors, and marine photovoltaic systems, provide multiple options for reducing energy consumption and emissions. Continuous advancements in these areas are driving the development of efficient equipment and systems, while carbon capture technologies are also being enhanced to effectively capture and store CO2. However, these measures alone are insufficient to meet the IMO's targets of net-zero emissions by 2050. Marine clean energy supply systems, which involve sustainable technologies like LNG, LPG, methanol, and clean energy for ammonia production, are currently less adopted due to high equipment and construction costs. Most ships focus on energy-saving measures for long-term carbon reduction. With stricter GHG emission regulations, advancements in clean energy technologies, and cost reductions, clean energy supply systems are expected to become the primary pathway for achieving maritime environmental protection equipment and systems in the future.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Drivers and Trends Analysis of Global Maritime Environmental Protection Equipment and System Market（3/3）

Substitution from Premium Domestic Chinese Products

In recent years, China has developed a comprehensive industrial value chain and demonstrated superior cost advantages compared to foreign competitors. Leading Chinese enterprises now exhibit strong and stable delivery and project management capabilities. As a result, their products are increasingly installed on a wider range of ships, with performance quickly verified and gaining customer trust. Turnkey engineering services also meet customers' one-stop service requirements, enabling these enterprises to establish a global service network. In 2023, three of the top five global maritime environmental protection equipment and system providers were Chinese enterprises. As Chinese companies deepen customized and integrated cooperation with various shipowners and the demand for marine carbon reduction continues to grow, premium domestic products are expected to expand their market share. With enhanced factors such as superior performance, energy-saving effects, comprehensive equipment and systems offerings, efficient construction cycles, longer service life, and higher overall project value, both product deliveries and new orders for premium domestic products are anticipated to rise continuously. This will accelerate the pace of domestic substitution, reinforcing the competitive edge of Chinese enterprises in the global market.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Entry Barrier Analysis (1/2)

1 Technological Barriers

- The technological barrier in the global maritime environmental protection equipment and system market is substantial, driven by the necessity for expertise across multiple fields, including engineering design, materials science, and environmental science. Companies that possess advanced technologies and specialized knowledge gain a significant competitive edge, creating a formidable challenge for new entrants. This barrier is further reinforced by stringent international regulations, such as the IMO mandates on sulphur content and carbon reduction targets, which impose high standards for emission reductions and energy efficiency. Compliance with these regulations requires sophisticated technologies and extensive R&D investments, elevating the entry threshold. Leading companies must integrate advanced clean energy technologies, specialized hardware, professional operational and maintenance skills to provide highly advanced products and services. This integration is critical to overcoming high initial investments, technical complexities, and market uncertainties, ultimately enabling suppliers to meet the diverse needs of shipping companies and maintain high-quality service delivery.

2 Regulation and Qualification Barrier

- Compliance with international conventions in the marine shipping industry is mandatory. Ship classification societies, such as Lloyd's Register (LR), Det Norske Veritas (DNV), American Bureau of Shipping (ABS) and Bureau Veritas (BV), set rigorous standards for environmental performance and safety that must be met for certification. Failing to meet ship classification society requirements can lead to non-certification, operational restrictions, insurance issues, legal and financial penalties, reputational damage, and costly operational interruptions. National environmental policies further complicate the regulatory landscape, requiring companies to navigate a complex web of legal requirements to operate legally. Companies failing to meet these standards face substantial fines, operational shutdowns, and loss of market credibility. Maritime environmental protection equipment and system market participants must invest substantial resources in understanding and adhering to these regulations to gain market access and operational legitimacy.

3 Customer Barrier

- One of the main challenges in the global maritime environmental protection equipment and system industry is overcoming the high expectations and strict requirements set by its primary customers—large shipping companies. These clients demand suppliers provide reliable, cost-effective, and highly efficient equipment and systems that align with their operational and environmental objectives. To meet these demands, industry participants need advanced technological capabilities, strong R&D, and proven performance records to gain the trust and business of these discerning customers. This high bar for quality and performance creates a challenging environment for new entrants or smaller firms lacking the necessary resources and expertise.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Entry Barrier Analysis (2/2)

4 Comprehensive and Customizable Product Offering Barrier

- The ability to deliver a comprehensive array of high-quality, customizable products is essential for maintaining a competitive edge. This capability demands substantial investment in R&D, manufacturing, and expertise, creating a formidable barrier for new entrants and smaller players. Leading industry participants must continuously adapt to policy changes, shifting market demands, and technological advancements to maintain a robust product portfolio. Moreover, the ability to foresee market trends and anticipate customer needs to develop the new products ahead of demand is also crucial. This forward-thinking approach is reflected in a company's R&D capabilities and its proactive engagement in numerous customer collaborations. These customers expect equipment and systems that not only meet stringent environmental regulations but also enhance operational efficiency and cost-effectiveness.

5 Production Barrier

- Customization and flexibility in production face significant barriers due to the need for advanced manufacturing technologies and versatile production setups capable of handling bespoke orders. Integrating rapid technological advancements, complying with diverse regulatory standards, and maintaining seamless supply chain coordination add layers of complexity. Effective cost management and a skilled workforce are crucial, as these factors directly impact the ability to produce tailored equipment and systems efficiently. Companies must invest in cutting-edge technologies, robust quality control, and continuous workforce training to overcome these challenges and leverage their integrated supply chains to meet specific customer demands. Owning factories becomes increasingly important, as it allows firms to directly control production processes, ensure higher quality standards, and respond swiftly to market changes and regulatory requirements. This ownership fosters innovation, enhances operational efficiency, and strengthens the ability to offer customized, sustainable solutions, positioning companies to better compete in the evolving maritime environmental protection equipment and system market landscape.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Opportunity and Challenge Analysis of Global Maritime Environmental Protection Equipment and System Market

Short-Term Analysis:

- Continued Role of Conventional Fuel-Powered Ships: In the short term, traditional fuel-powered ships will continue to play a significant role in maritime transportation. Fossil fuels remain the dominant energy source for ships, and the demand for exhaust gas cleaning systems will stay strong, especially given the widespread adoption of sulfur reduction systems to comply with current environmental regulations.
- Limitations of Electric-Powered Ships: Electric-powered ships present a cleaner alternative but currently face significant limitations that reduce their immediate impact on the exhaust gas cleaning system market. Technological constraints restrict their ability to handle long-distance and large-tonnage shipping demands, while the high costs associated with large-capacity electric ships hinder their competitiveness. Additionally, the infrastructure for charging electric ships is underdeveloped, with insufficient charging facilities at ports, which further limits their operational range. The lengthy charging times also pose a challenge, as they reduce overall efficiency, making electric ships less viable for time-sensitive shipping. As a result, electric-powered ships are primarily suited for short-range, nearshore routes and are unlikely to replace large-tonnage ships in long-distance shipping in the short term. Consequently, these limitations mean that electric ships do not pose a substantial risk to the demand for exhaust gas cleaning systems in the short term.
- Challenges from Other Alternative Fuels: Alternative fuels like green methanol and green ammonia are still in the early stages of development and adoption, with challenges in scaling production and establishing supply chains. Current estimates suggest that only 1–3% of demand can be met with these fuels, leaving fossil fuels as the dominant energy source for most ships. Furthermore, alternative fuels face significant hurdles compared to fossil fuels, such as lower energy conversion efficiency, meaning more fuel volume is needed to achieve the same power output. This limitation reduces the maximum range of ships.

Long-Term Outlook:

- Technological Advancements and Market Opportunities: In the long run, technological advancements will shape the demand for EGCS products. The industry is expected to see the rise of more diverse ship propulsion technologies, such as nuclear-powered, green methanol, green ammonia, electric, and hydrogen-powered ships. These developments pose both challenges and opportunities. Companies involved in EGCS will need to innovate and expand their offerings to include clean-energy systems to remain competitive. While the shift toward cleaner energy sources may reduce demand for traditional EGCS, it opens the door for companies to invest in diverse products.
- Clean Energy Competition: As clean energy technologies improve, the need for EGCS could decrease. Electric, nuclear-powered, green methanol, green ammonia, and hydrogen-powered ships, once they mature, may reduce the market size for EGCS. Companies in this space will face challenges in adapting their products to align with the changing energy landscape. Lower Price Spread between high and low-Sulfur Fuel: The price spread between high-sulfur and low-sulfur fuel may slump in the future, which creates more incentive for shipowners switching to low-sulfur fuels instead of installing scrubber. This unpredictability can influence demand for EGCS products. A larger spread allows shipowners to recoup their initial investment and operational costs more quickly, while also benefiting from long-term fuel savings. This dynamic shortens the payback period, making EGCS an increasingly attractive option. The spread is influenced by factors such as crude oil prices, refining capacity, geopolitical events, and natural disasters. However, the price spread between high-sulfur and low-sulfur fuel oil is expected to remain relatively stable from 2024 to 2028, hovering around US$250 per tonne, which continues to make exhaust gas cleaning systems economically advantageous for shipowners using high-sulfur fuels with EGCS.
- Evolving Global Regulations: Regulatory standards for emissions vary significantly across regions, creating complexity and uncertainty for industries like shipping. While shipowners typically adhere to the strictest regulations to avoid penalties, the evolving nature of these standards is critical. If emission regulations continue to tighten globally, demand for EGCS will remain strong as companies seek compliance. However, if regulations stop tightening or even begin to relax, the demand for EGCS could weaken considerably, as shipowners may opt for less advanced technologies or reduce reliance on these systems, complicating investment decisions and creating long-term uncertainty in the market.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Policy Analysis (1/5)

In recent decades, global governments are actively implementing a series polices and environmental regulations for the maritime industry to reduce its impact on the environment. These policies include restrictions on ship emissions, energy efficiency standards, and incentives for the use of clean energy, all aimed at fostering a green transformation in the global marine ship industry.

Laws and Regulations	Issue Year	Issue Dept.	Description
Action Outline for Green Development of the Shipbuilding Manufacturing Industry (2024-2030)	2023	China - Ministry of Industry and Information Technology (MIIT) and other four official departments	By 2025, the green development system of ship manufacturing industry will be initially constructed. The supply capacity of green ship products will be further enhanced, the application of alternative marine fuels and new energy technologies will be synchronized with international standards, and the international market share of liquefied natural gas (LNG), methanol and other green-powered ships will exceed 50%.
Fit for 55 in 2030	2023	European - Members of the European Parliament (MEP)	MEPs adopted new rules on cleaner maritime fuels. The ships will have to gradually reduce greenhouse gas (GHG) emissions by cutting the amount of GHG in the energy they use (below 2020 level) by 2% as of 2025 to 80% as of 2050. This would apply to ships above a gross tonnage of 5,000, which are in principle responsible for 90% of CO2 emissions, and to all energy used on board in or between EU ports, as well as to 50% of energy used on voyages where the departure or arrival port is outside of the EU or in EU outermost regions.
Norwegian Maritime Authority - West Norwegian Fjords	2023	Norwegian Maritime Authority	The regulation aims to limit greenhouse gas (GHG) emissions in the West Norwegian Fjords, a UNESCO World Heritage site known for its pristine natural environment. Starting in 2026, only zero-emission ships will be allowed to operate in the fjords. This regulation is part of Norway's broader commitment to environmental sustainability and climate action. It encourages the use of electric and hydrogen-powered ships, thereby protecting the fjords' delicate ecosystems and reducing local air pollution. This move will also drive technological advancements and investments in green maritime technology.
Fuel EU Maritime	2023	European Union (EU)	Fuel EU Maritime aims to accelerate the carbon reduction of maritime transport by incentivizing the use of low-carbon and renewable fuels. From 2025, ships over 5,000 gross tonnage (GT) operating in European territorial waters will be required to comply with increasingly stringent targets for reducing the carbon intensity of the energy used on board. This regulation is expected to drive demand for sustainable fuels, such as biofuels, hydrogen, and ammonia, thus stimulating market growth and technological innovation in fuel production and supply chains.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Policy Analysis (2/5)

Laws and Regulations	Issue Year	Issue Dept.	Description
EU ETS	2023	European Union (EU)	The EU ETS is one of the world's largest cap-and-trade systems designed to reduce greenhouse gas (GHG) emissions. Starting in 2024, the maritime sector will be included in this system, which sets a cap on total emissions allowed from covered entities. Companies receive or buy emission allowances (EUAs) which they can trade with one another. The inclusion of shipping means that ships operating within the EU will need to purchase allowances for their emissions, creating a financial incentive to reduce their carbon footprint. This move is expected to cover approximately 90 million tons of CO2 emissions annually, making it a significant step in the EU's climate strategy.
Us International Maritime Pollution Accountability Act of 2023 (Proposed)	2023	United States Congress	This proposed act seeks to impose a pollution fee on large marine ships unloading cargo at U.S. ports. The fee would be calculated based on the vessel's emissions, creating a direct economic incentive to reduce pollution. The revenue generated would be allocated to environmental initiatives aimed at mitigating the impacts of maritime pollution. This policy could significantly impact shipping costs and operational practices, encouraging investments in cleaner technologies.
US Clean Ship Act of 2023 (Proposed)	2023	United States Congress	The proposed US Clean Ship Act of 2023 aims to introduce progressively stricter standards for the carbon intensity of fuels used by ships, with the goal of reducing GHG emissions. The act would require ships calling at U.S. ports to use cleaner fuels and adopt energy efficiency measures. If enacted, this legislation would position the U.S. as a leader in maritime carbon reduction and could influence global shipping practices.
Strategies for Becoming a Shipping Powerhouse	2022	Korea - Ministry of Oceans and Fisheries	MOF will accelerate the shift into securing eco-friendly ships by setting a full cycle of the framework, starting from developing and demonstrating new technology to securing infrastructure for fuel supply to provision and expansion. First, MOF will help to develop technology with the goal of promoting the use of zero-carbon ships by 2050 (KRW 254 bil. from 2022 to 2031). Secondly, MOF will transform 528 ships into eco-friendly ships by providing tailored support for each ship type by 2030, increasing the share of eco-friendly ships up to 15% in Korea.
National Budget 2021- Support for Carbon Neutrality in the Maritime and Port Fields	2021	Japan	To achieve carbon neutrality by 2050, the Japanese government allocated JPY 800 million to develop low carbon technologies in the maritime sector.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Policy Analysis (3/5)

Laws and Regulations	Issue Year	Issue Dept.	Description
National ETS (Spending)	2021	China - National governments implementing ETS systems	Various countries have implemented national Emissions Trading Systems (ETS) to cap and reduce GHG emissions. The first phase typically targets the power sector, with plans to expand to other industries, including possibly shipping, by 2025. These systems work by setting a cap on emissions and allowing companies to buy and sell allowances. The inclusion of shipping in national ETSs would create a significant market for emission allowances, driving reductions in GHG emissions through market-based mechanisms.
Clydebank Declaration for green shipping corridors	2021	US,UK	This declaration aims to support the establishment of at least 6 green corridors by the middle of this decade, while aiming to scale activity up in the following years, by inter alia supporting the establishment of more routes, longer routes and/or having more ships on the same routes. To identify and explore actions to address barriers to the formation of green corridors. This could cover, for example, regulatory frameworks, incentives, information sharing or infrastructure.
California Air Resource Board At-Berth Regulation	2020	US - California Air Resources Board (CARB)	The At-Berth Regulation mandates that ocean-going ships (OGVs) reduce emissions while docked at Californian ports, targeting pollutants such as diesel particulate matter (PM) and nitrogen oxides (NOx). The regulation requires ships to either shut down auxiliary engines and connect to shore power or use alternative control technologies to achieve equivalent emission reductions. By 2023, it is expected that regulated ships will reduce their at-berth emissions by 80%, significantly improving air quality in port communities.
Clean Maritime Plan	2019	UK	The Clean Maritime Plan is part of the UK's Maritime 2050 strategy, which outlines a vision for the future of the UK's maritime sector. The plan emphasizes the development and deployment of new and improved port infrastructure to support alternative fuel bunkering and onshore power supply. It sets ambitious goals, such as achieving zero-emission domestic ferries by 2050 and supporting the transition to clean maritime technologies. The plan includes funding for research and development, pilot projects, and collaborations with industry stakeholders to accelerate the adoption of sustainable practices.
Maritime Singapore Green Initiative	2019	Singapore - Maritime and Port Authority of Singapore (MPA)	The Maritime Singapore Green Initiative seeks to reduce the environmental impact of shipping and related activities and to promote clean and green shipping in Singapore. In 2011, the Maritime and Port Authority of Singapore (MPA) pledged to invest up to S$100 million over 5 years in the Maritime Singapore Green Initiative. In 2019, the Initiative was further extended till 31 December 2024 and enhanced to promote carbon reduction of shipping.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Policy Analysis (4/5)

Laws and Regulations	Issue Year	Issue Dept.	Description
2023 IMO Strategy on Reduction of GHG Emissions from Ships	2023	International Maritime Organization	The 2023 IMO Strategy on Reduction of GHG Emissions from Ships is a continuation of the International Maritime Organization's (IMO) efforts to address greenhouse gas emissions from international shipping. The strategy is designed to realize a net-zero carbon footprint by 2050, with interim "emission reduction benchmarks" set as follows: 1) By 2030, it targets a minimum of 20% reduction in overall greenhouse gas emissions from 2008 levels, with a more aggressive goal of up to 30%. 2) By 2040, the aim is to achieve a 70% reduction in total emissions from the 2008 baseline, with an aspirational target of reaching an 80% decrease.
Marine Environment Protection Committee – MEPC 76.	2021	International Maritime Organization	MEPC 76 adopted amendments to MARPOL Annex VI to reflect the technical and operational measures to reduce the carbon intensity of international shipping. The revised Annex VI requires ships to calculate their Energy Efficiency Existing Ship Index (EEXI) and establish an annual operational carbon intensity indicator (CII) and rating. The amendments to MARPOL Annex VI are expected to enter into force on 1 November 2022, with the requirements for EEXI and CII certification coming into effect from 1 January 2023. This means that the first annual reporting will be completed in 2023, with the first rating given in 2024.
MARPOL Annex VI, Procedure for Assessing Impacts on States and Resolution MEPC.323(74)	2019	International Maritime Organization	The MEPC 74 session (13-17 May) approved amendments to strengthen existing mandatory requirements for new ships to be more energy efficient; initiated the Fourth IMO GHG Study; adopted a resolution encouraging cooperation with ports to reduce emission from shipping; approved a procedure for the impact assessment of new measures proposed; agreed to establish a multi-donor trust fund for GHG. The draft amendments bring forward the entry into effect date of phase 3 to 2022, from 2025, for several ship types, including gas carriers, general cargo ships and LNG carriers. This means that new ships built from that date must be significantly more energy efficient than the baseline.
Initial IMO GHG Strategy	2018	International Maritime Organization	The strategy encompasses a comprehensive approach to decarbonize international shipping by leveraging the Energy Efficiency Design Index (EEDI) to enhance the carbon efficiency of new ships, setting ambitious goals to decrease the carbon intensity by a minimum of 40% by 2030 and 70% by 2050, alongside halving the total annual greenhouse gas emissions by 2050 relative to 2008 levels. It also aligns with the Paris Agreement's temperature objectives by proposing a progressive pathway for CO2 emissions reduction and establishing quantifiable targets for GHG reductions extending to the year 2050.

Source: Frost & Sullivan

Overview of Global Maritime Environmental Protection Equipment and System Market

Policy Analysis (5/5)

Laws and Regulations	Issue Year	Issue Dept.	Description
IMO 2020 - cleaner shipping for cleaner air	2020	International Maritime Organization	From 1 January 2020 the global upper limit on the sulphur content of ships' fuel oil will be reduced to 0.50% (from 3.50%). Known as "IMO 2020", the reduced limit is mandatory for all ships operating outside certain designated Emission Control Areas*, where the limit is already 0.10%.The new limit will mean a 77% drop in overall SOx emissions from ships, equivalent to an annual reduction of approximately 8.5 million metric tonnes of SOx. Particulate matter - tiny harmful particles which form when fuel is burnt – will also be reduced.
RESOLUTION MEPC.320(74) - 2019 guidelines for consistent implementation of the 0.50% sulphur limit under MARPOL ANNEX VI	2019	International Maritime Organization	the Committee adopted, resolution MEPC.280(70), Effective date of implementation of the fuel oil standard in regulation 14.1.3 of MARPOL Annex VI, confirming "1 January 2020" as the effective date of implementation for ships to comply with global 0.50% m/m sulphur content of fuel oil requirement.
Guidance on the development of a ship implementation plan for the consistent implementation of the 0.50% Sulphur limit under MARPOL ANNEX VI. (MEPC.1/Circ.878)	2018	International Maritime Organization	MARPOL Annex VI mandates that ships must comply with a sulphur content limit of 0.50% in fuel oil by January 1, 2020. To achieve this, the MEPC 73 recommends that flag administrations encourage ships to develop implementation plans detailing steps to meet the sulphur limit. These plans should include an assessment of potential fuel-related safety risks, machinery system impacts, and necessary adjustments such as segregated fuel systems. Additionally, ships might need to clean fuel oil tanks regularly, considering timelines and procedures, to ensure compliance.
ANNEX 1 RESOLUTION MEPC.259(68) - 2015 Guidelines for Exhaust Gas Cleaning Systems	2015	International Maritime Organization	MEPC.259(68) establish a comprehensive framework for the regulation, testing, certification, and monitoring of exhaust gas cleaning systems on ships to ensure compliance with MARPOL Annex VI emission reduction requirements. The guidelines introduce the SO2(ppm)/CO2(%) ratio method for simplified SOX emission monitoring, outline two schemes for EGC system approval (Scheme A with parameter and emission checks, and Scheme B with continuous emission monitoring), emphasize safety considerations in handling exhaust gases, and set specific washwater discharge criteria, including pH levels, PAH, turbidity, and nitrate levels. Additionally, they mandate continuous monitoring and recording of emissions and washwater parameters, require ships to have an approved SOX Emissions Compliance Plan (SECP), and provide appendices for record-keeping and data collection to demonstrate ongoing compliance with the stringent sulfur emission standards set by the IMO.

Source: Frost & Sullivan

Agenda

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Top 10 Global Ship Exhaust Gas Cleaning System Designers

Top 10 Global Ship Exhaust Gas Cleaning System Providers as of June, 2024

Ranking	Company	Headquarter and Year of Established	Cumulative Number of Orders Completed and On-hand (Units)	Market Share (%)
1	Alfa Laval	1883 / Lund, Sweden	632	9.4%
2	Wartsila	1834 / Helsinki, Finland	531	7.9%
3	PANASIA	1989 / Busan, South Korea	520	7.7%
4	Zhejiang Energy Martime	2018 / Hangzhou, Zhejiang, China	370	5.5%
5	Qiyao Environ Tech	2015 / Shanghai, China	358	5.3%
6	Feen Marine Inc.	1997 / Singapore	343	5.1%
7	Ecospray	2005 / Alzano Scrivia, Italy	318	4.7%
8	Yara Marine Tech	1905 / Oslo, Norway	313	4.6%
9	HHI Power Systems	1972 / Gyeonggi-do, South Korea	257	3.8%
10	**ContiOcean**	**2017 / Shanghai China**	**167**	**2.5%**
11	Clean Marine	2004/Singapore	160	2.4%

Since 2019, the marine exhaust gas cleaning system market has been the largest segment of the global maritime environmental protection equipment and system market, accounting for nearly 50% in 2023. Consequently, the competition within the global maritime environmental protection equipment and system market primarily revolves around the marine exhaust gas cleaning system sector. At present, the global marine exhaust gas cleaning system market is highly fragmented, with around 60–70 companies worldwide capable of providing ship exhaust gas cleaning systems. Our Group stands out as one of the very few companies offering comprehensive, customized maritime environmental protection equipment and systems.

As of June 30, 2024, the global cumulative total of completed and on-hand orders for ship exhaust gas cleaning systems reached 6,753. The top 10 players collectively hold about 56.4% of the market share. Our Group has secured 167 orders, placing it tenth in the global maritime environmental protection equipment and system market, third among PRC-based providers, and first among PRC-based private ship exhaust gas cleaning system providers by cumulative completed and on-hand order volume for ship exhaust gas cleaning systems. From 2021 to 2023, our Group was the fastest-growing company in terms of completed ship exhaust gas cleaning system orders among the top ten players.

Note: It is an industry norm to rank EGCS providers based on the number of orders rather than revenue. This method is considered more equitable because pricing can vary significantly based on factors like ship type, tonnage, and specific customer requirements, making revenue-based comparisons less reliable. Each order usually represents one scrubber, and typically, a single scrubber is installed per ship. Thus, order quantity serves as a more consistent and clearer indicator of market activity and supplier performance.

Source: Frost & Sullivan Report, Clarkson, China Association of the National Shipbuilding Industry, interviews with industry experts

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Top 5 China-based Ship Exhaust Gas Cleaning System

Top 5 China-based Ship Exhaust Gas Cleaning System Providers in the World as of June, 2024

Ranking	Company	Headquarter and Year of Established	State-owned / Private Company	Cumulative Number of Orders Completed and On-hand (Units)	Market Share (%)
1	Zhejiang Energy Martime 浙能迈领	1985 / Hangzhou, Zhejiang, China	State-owned	370	5.5%
2	Qiyao Environ Tech 齐耀环保	1963 / Shanghai, China	State-owned	358	5.3%
3	**ContiOcean 汇舸**	**2017 / Shanghai China**	**Private**	**167**	**2.5%**
4	Pure Ocean Tech 佩森环科	2017 / Weihai, Shandong, China	Private	77	1.1%
5	SunRui 双瑞	1961 / Qingdao, China	State-owned	74	1.1%

Source: Frost & Sullivan Report, Clarkson, China Association of the National Shipbuilding Industry, interviews with industry experts

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Ranking

Ranking	Company	CAGR of Completed Ship Exhaust Gas Cleaning System Orders from 2021 to 2023 (%)
1	**ContiOcean**	**102.8%**
2	Zhejiang Energy Mar	100.0%
3	Qiyao Environ Tec	41.4%
4	Alfa Laval	-16.8%
5	HHI Power Systems	-20.2%
6	Wartsila Moss	-20.2%
7	PANASIA	-22.5%
8	Yara Marine Tech	-25.5%
9	Ecospray	-29.3%
10	Feen Marine Inc.	-34.5%

From 2021 to 2023, ContiOcean was the fastest-growing company in terms of completed ship exhaust gas cleaning system orders among the top ten players.

Source: Frost & Sullivan

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Top 10 Global Ship Exhaust Gas Cleaning System Designers

Top 10 Global Ship Exhaust Gas Cleaning System Providers as of June, 2024

Ranking	Company	Cumulative Number of Orders Completed and On-hand (Units)	Market Share (%)
1	Company A	632	9.4%
2	Company B	531	7.9%
3	Company C	520	7.7%
4	Company D	370	5.5%
5	Company E	358	5.3%
6	Company F	343	5.1%
7	Company G	318	4.7%
8	Company H	313	4.6%
9	Company I	257	3.8%
10	**Our Group**	**167**	**2.5%**
11	Company J	160	2.4%

Source: Frost & Sullivan, Clarkson

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Top 10 Global Ship Exhaust Gas Cleaning System Providers

Top 10 Global Ship Exhaust Gas Cleaning System Providers，2023

Ranking	Company	Cumulative Number of Orders Completed and On-hand (Units)	Market Share (%)
1	Company D	130	13.2%
2	Company E	85	8.6%
3	Company A	60	6.1%
4	**Our Group**	**57**	**5.8%**
5	Company B	50	5.1%
6	Company F	40	4.1%
7	Company C	35	3.6%
8	Company I	27	2.7%
9	Company H	18	1.8%
10	Company G	15	1.5%

During 2023, the global cumulative total of completed and on-hand orders for ship exhaust gas cleaning systems reached 985 with a market share of 5.8%. The top 10 players collectively hold about 52.5% of the market share. Our Group has secured 57 orders, placing it fourth in the global maritime environmental protection equipment and system market.

Source: Frost & Sullivan Report, Clarkson, China Association of the National Shipbuilding Industry, interviews with industry experts.

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Top 10 Global Ship Exhaust Gas Cleaning System Providers

Top 10 Global Ship Exhaust Gas Cleaning System Providers，2023

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2	Qiyao Environ Tech	85	8.6%
3	Alfa Laval	60	6.1%
4	**ContiOcean**	**57**	**5.8%**
5	Wartsila	50	5.1%
6	Feen Marine Inc.	40	4.1%
7	PANASIA	35	3.6%
8	HHI Power Systems	27	2.7%
9	Yara Marine Tech	18	1.8%
10	Ecospray	15	1.5%

Source: Frost & Sullivan Report, Clarkson, China Association of the National Shipbuilding Industry, interviews with industry experts.

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Top 10 Global Ship Exhaust Gas Cleaning System Providers

During 2023, the global cumulative total of completed and on-hand orders for ship exhaust gas cleaning systems reached 985 with a market share of 5.8%. The top 10 players collectively hold about 52.5% of the market share. ContiOcean has secured 57 orders, placing it fourth in the global maritime environmental protection equipment and system market.

Compared to overseas companies, Chinese enterprises have a shorter establishment history yet have quickly captured significant market share. This is attributed to several factors. As a leading global shipbuilding nation, China boasts a well-established industrial chain that enhances the efficient production of exhaust gas cleaning systems. Since 2019, China has been the largest shipbuilding market worldwide, with its industry accounting for over 65% of global new orders by tonnage in 2023. This strong supply chain enables Chinese companies to outperform their foreign competitors in production efficiency, pricing, and after-sale services. On average, an exhaust gas cleaning system from a Chinese company costs 20–30% less than that from foreign firms, with even larger price disparities for complex systems on large tonnage ships. Furthermore, Chinese companies excel in delivery speed, typically completing projects two months faster than international competitors, thanks to their well-equipped teams. Given these advantages above, the Group stands out in the global maritime environmental protection equipment and system market, particularly when compared to its peers. First, it is one of the very few companies in the world that focuses exclusively on maritime environmental protection equipment and systems, while most competitors treat this area as just one part of their broader product portfolios. This dedicated focus enables the Group to deliver more specialized, professional, and customized solutions tailored to specific customer needs. Second, the Group has expanded beyond its core business of maritime exhaust gas cleaning systems to include energy-saving device and carbon-reduction systems, clean-energy supply systems, and maritime services. This expansion aligns with both evolving customer demands and tightening global regulations, ensuring the Group remains relevant and competitive. In contrast, many competitors have been slower to adapt to these market shifts. Lastly, by building on its core maritime exhaust gas cleaning system business, the Group offers extended services, such as maritime maintenance, which strengthen customer loyalty. Given that shipowners typically limit their retrofitting vendors to 1–2 providers for cost efficiency, the Group's ability to offer comprehensive solutions gives it a substantial competitive advantage.

Given these advantages above, the Group stands out in the global maritime environmental protection equipment and system market, particularly when compared to its peers. First, it is one of the very few companies in the world that focuses exclusively on maritime environmental protection equipment and systems, while most competitors treat this area as just one part of their broader product portfolios. This dedicated focus enables the Group to deliver more specialized, professional, and customized solutions tailored to specific customer needs. Second, the Group has expanded beyond its core business of maritime exhaust gas cleaning systems to include energy-saving device and clean-energy supply systems. This expansion aligns with both evolving customer demands and tightening global regulations, ensuring the Group remains relevant and competitive. In contrast, many competitors have been slower to adapt to these market shifts. Lastly, by building on its core maritime environmental and protection equipment and system business, the Group offers extended services, such as maritime service, which strengthen customer loyalty and satisfaction. Given that shipowners typically limit their retrofitting vendors to 1–2 providers for cost efficiency and with a strong history of successful cooperation and high customer satisfaction, downstream clients are increasingly inclined to select the Group for additional maritime services. The Group's ability to offer comprehensive solutions gives it a substantial competitive advantage.

Source: Frost & Sullivan Report, Clarkson, China Association of the National Shipbuilding Industry, interviews with industry experts.

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Top 3 Maritime Service Providers in the Global Maritime Environmental Protection Equipment and System Market

Top 3 Maritime Service Providers in the Global Maritime Environmental Protection Equipment and System Market by Revenue, 2023

Ranking	Company	Revenue	Market share%	Major Maritime Service Provided
		（RMB Billion）	(%)	
1	Company A	2.0	31.7%	Ship retrofitting and ship repair supervision services, spare parts, technical support, etc.
2	Company B	1.5	23.8%	Crew training, ship retrofitting and ship repair supervision services, ship cyber security software and hardware, spare parts, technical support，etc.
3	**Our Group**	**0.1**	**1.7%**	**Ship accommodation interior design and construction, the provision of maritime equipment and spare parts，ship cyber security software and hardware, etc.**

The global maritime services market is highly fragmented, with thousands of players offering a wide array of services, making it difficult to establish clear competitive boundaries. Most players focus on delivering one or two specialized maritime services, resulting in a highly dispersed competitive landscape. In contrast, the maritime environmental protection equipment and systems market is relatively specialized, with only a small percentage of global suppliers capable of providing both the equipment and systems (such as EGCS, and clean-energy supply systems) as well as maritime services. Among the 90–100 companies offering environmental protection equipment and systems, only 30–35 are equipped to provide both, making this a more concentrated segment within the broader maritime services market. In 2023, our Group ranked as the third-largest maritime service provider among the 30–35 companies that offer both maritime environmental protection equipment and systems as well as maritime services in terms of revenue from maritime services for 2023. Our Group generated RMB0.1 billion in revenue from maritime services with a market share of 1.7% in 2023.

Note: The revenue above only includes the income generated from the group's maritime services segment.

Source: Frost & Sullivan Report, Clarkson, official websites and annual reports of comparable companies, interviews with industry experts

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Competitor Profile

Company A was founded in 1883 and is headquartered in Lund, Sweden. Its main business includes ship exhaust gas cleaning systems as well as clean-energy supply for the efficient purification, refining and recycling of natural resources. The company operates approximately 40 production sites and distribution centers across Europe, Asia, and the Americas. It is listed on the Stockholm Stock Exchange.

Company B was founded in 1834 and is headquartered in Helsinki, Finland. Its main business includes ship exhaust gas cleaning systems, marine ship engines, electrification and propulsion systems, as well as hybrid and propulsion systems. The company operates in 79 countries, contributing to global decarbonization effort. It is listed on the Helsinki Stock Exchange.

Company C was founded in 1989 and is an unlisted company headquartered in Busan, South Korea. Its main business includes exhaust gas cleaning systems and technology for ships, pan-cross filter systems, water level control measuring devices, as well as the core components of in-house production systems such as towers, gas monitoring systems and water treatment systems. The company operates local offices in European, China and Japan.

Company D was founded in 2018 and is an unlisted company headquartered in Zhejiang province, China. Its main business focus on ship exhaust gas cleaning systems, dual-fuel power supply systems and marine carbon capture systems. The company's business covers Europe, America, Asia and other countries and regions in the world.

Company E as founded in 2015 and is an unlisted company headquartered in Shanghai, China. Its main business includes ship exhaust gas cleaning systems, selective catalytic reduction systems, fuel gas supply systems, onboard carbon capture and storage systems, etc. The company operates two independent after-sales service centers in Shanghai and Singapore, and cooperates with domestic and overseas service providers, covering major ports and routes around the world.

Company F was founded in 1997 and is an unlisted company headquartered in Singapore. Its main business includes inert gas systems, ship exhaust gas cleaning systems, nitrogen generators, as well as parts and service for sailing ships. The company's management and services operate in Indonesia, Singapore, China, Japan, and Norway, etc.

Company G was founded in 2005 and is an unlisted company headquartered in Alzano Scrivia, Italy. Its main business includes ship exhaust gas cleaning systems, wet electrostatic precipitator, biomethane liquefaction, CO2 liquefaction system, and carbon capture and sequestration systems. The company's business covers Europe, America, China and other countries and regions in the world.

Company H was founded in 1905 and is an unlisted company headquartered in Oslo, Norway. Its main business includes exhaust gas cleaning systems, cleaner ammonia production, and marine battery technology. The company operates in approximately 60 countries.

Company I was founded in 1972 and is an unlisted company headquartered in Gyeonggi-do, South Korea. Its main business includes ship exhaust gas cleaning systems, heat recovery steam generators, etc. The company's business covers Asia, North America and other countries and regions in the world.

Company J was founded in 2004 and is headquartered in Singapore. Its main business includes exhaust gas cleaning systems as well as end-to-end services from product design and engineering to global aftersales support.

Source: Frost & Sullivan

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Key Success Factor Analysis(1/2)

Market Recognition and Brand Influence	• A strong brand instills confidence in customers and stakeholders, which is critical for securing long-term contracts and repeat business. With robust brand recognition, companies can penetrate new markets more easily, leveraging their reputation to overcome entry barriers. Additionally, positive customer feedback and a strong brand lead to higher customer retention rates, reducing the cost of acquiring new customers. This combination of trust, market penetration, and loyalty ensures sustained growth and competitive advantage in the global maritime environmental protection equipment and system market.
Market Sensitivity and Product Customization Ability	• Companies that can quickly adapt their products and services to meet changing customer demands can capitalize on emerging opportunities faster than competitors. Customized solutions increase customer satisfaction by addressing specific needs, leading to better customer relationships and higher sales. Staying ahead of market trends allows companies to position themselves as industry leaders and innovators, thereby enhancing their reputation and securing a competitive edge in the global maritime environmental protection equipment and system industry.
Technological Innovation and R&D Capability	• Cutting-edge technology differentiates a company from its competitors, making its products more attractive and providing a significant competitive advantage. Advanced R&D ensures that products meet stringent environmental regulations, avoiding penalties and enhancing the company's reputation. Additionally, innovation in eco-friendly technologies addresses the growing market demand for sustainable solutions, opening up new market segments and driving long-term growth in the global maritime environmental protection equipment and system industry.
Quick Response to Customer Needs	• Agile operations lead to faster turnaround times and more efficient use of resources, reducing costs and enhancing operational efficiency. Rapidly addressing customer needs and issues boosts customer satisfaction and loyalty, ensuring high customer retention. Additionally, the ability to quickly pivot in response to market changes keeps the company competitive and relevant, enabling it to capitalize on emerging opportunities and maintain a strong market presence in the global maritime environmental protection equipment and system industry.
Policy Support and Industry Collaboration	• Policy support and subsidies reduce operational costs and increase profitability, providing significant financial incentives. Strategic alliances foster collaborations that lead to shared resources, knowledge, and technology, driving innovation and market expansion. Aligning with government policies ensures compliance, enhances the company’s reputation, and positions it favorably for future regulatory changes, thereby strengthening its competitive edge in the global maritime environmental protection equipment and system industry.

Source: Frost & Sullivan

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Key Success Factor Analysis(2/2)

Legal Compliance and Standards Adherence

- Strict adherence to international and domestic environmental laws, regulations, and standards is critical for the success of maritime environmental protection equipment and system industry. By complying with these regulations, companies not only ensure legal conformity but also maintain a strong industry reputation. This adherence mitigates the risks associated with legal penalties and reputational damage that could arise from non-compliance. Moreover, it fosters trust among stakeholders, including customers, investors, and regulatory bodies, positioning the company as a responsible and sustainable player in the maritime industry. Companies that prioritize legal compliance and standards adherence are better equipped to navigate regulatory complexities, gain competitive advantages, and sustain long-term growth in the evolving landscape of maritime environmental protection equipment and systems.

Integrated Capability Across the Industry Chain

- The ability to integrate resources across multiple sectors, including shipbuilding, environmental technology, and maritime services, is a pivotal success factor in maritime environmental protection equipment and systems. Companies that excel in this integrated capability can achieve synergistic development across the entire industry chain. By effectively coordinating activities and sharing resources, they enhance efficiency and collaboration throughout various stages of production and service delivery. This integration not only optimizes operational processes but also fosters innovation and adaptation to market trends. Moreover, it strengthens core competitiveness by streamlining operations, reducing costs, and enhancing the overall value proposition for customers. Companies with a strong integrated capability are well-positioned to capitalize on opportunities in the growing market for sustainable shipping solutions, driving long-term success and leadership in the maritime environmental protection equipment and system industry.

Financial Strength

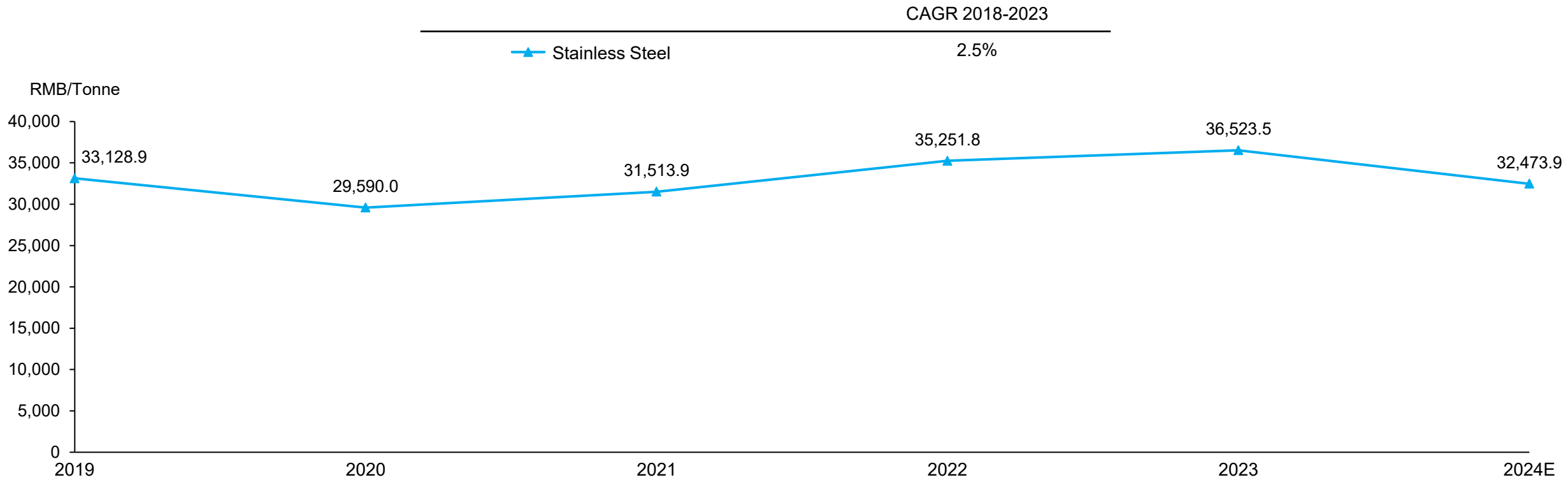
- Financial strength is a critical success factor in the development and deployment of maritime environmental protection equipment and systems. Companies with sufficient financial resources can make substantial investments in research and development (R&D), innovation, and advanced technologies aimed at enhancing environmental sustainability. This financial capability also supports robust marketing activities to promote green initiatives and attract environmentally conscious customers. Moreover, it enables companies to navigate market fluctuations, economic uncertainties, and competitive pressures effectively. By maintaining solid financial health, organizations can sustain long-term growth, expand their market presence, and seize opportunities in the evolving landscape of sustainable shipping. Overall, financial strength enhances resilience and positions companies to lead in the adoption of green technologies and practices within the maritime environmental protection equipment and system industry.

Source: Frost & Sullivan

Competitive Landscape of Global Maritime Environmental Protection Equipment and System Market

Raw Material Analysis

Average Price of Stainless Steel, 2019-2024E

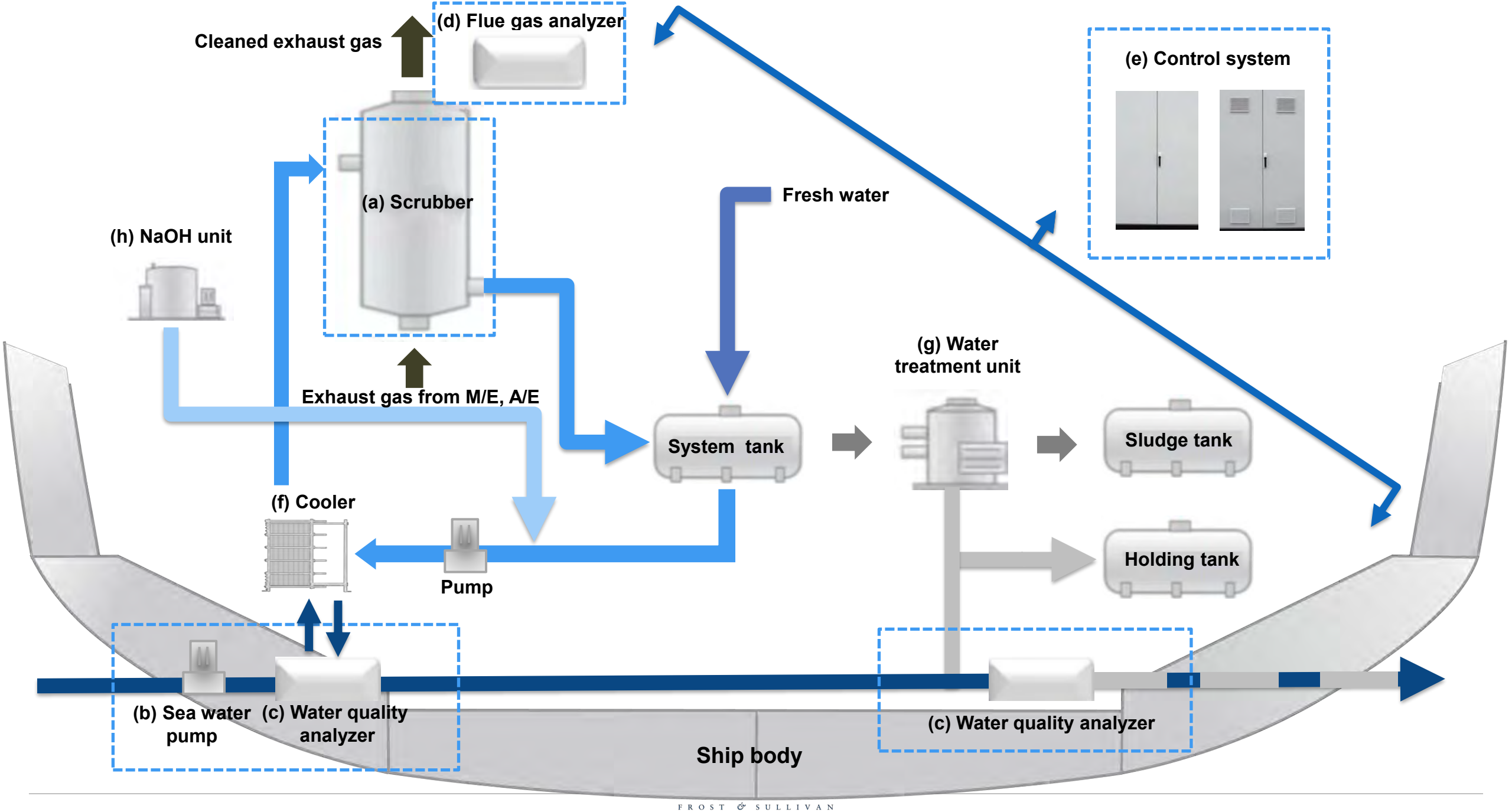


- Stainless steel is one of the primary raw materials for the global maritime environmental protection equipment and system industry. Prices for stainless steel have experienced a slightly fluctuating increase from RMB33,128.9 per tonne in 2019 to RMB36,523.5 per tonne in 2023, reflecting a CAGR of 2.5%. This increase has been largely driven by strong demand from key industries like construction and automotive, along with supply chain disruptions caused by the COVID-19 pandemic, which tightened supply conditions and pushed prices higher. Looking ahead, it is anticipated that the average stainless steel price will decline, driven by increased production efficiencies, technological innovations, and potentially lower raw material costs, further boosting the economic feasibility of maritime environmental protection equipment and systems.

Note: The average price of stainless steel is based on the average price of type 2205 6.0mm stainless steel, which is commonly used as raw material of ship exhaust gas cleaning systems in the industry.

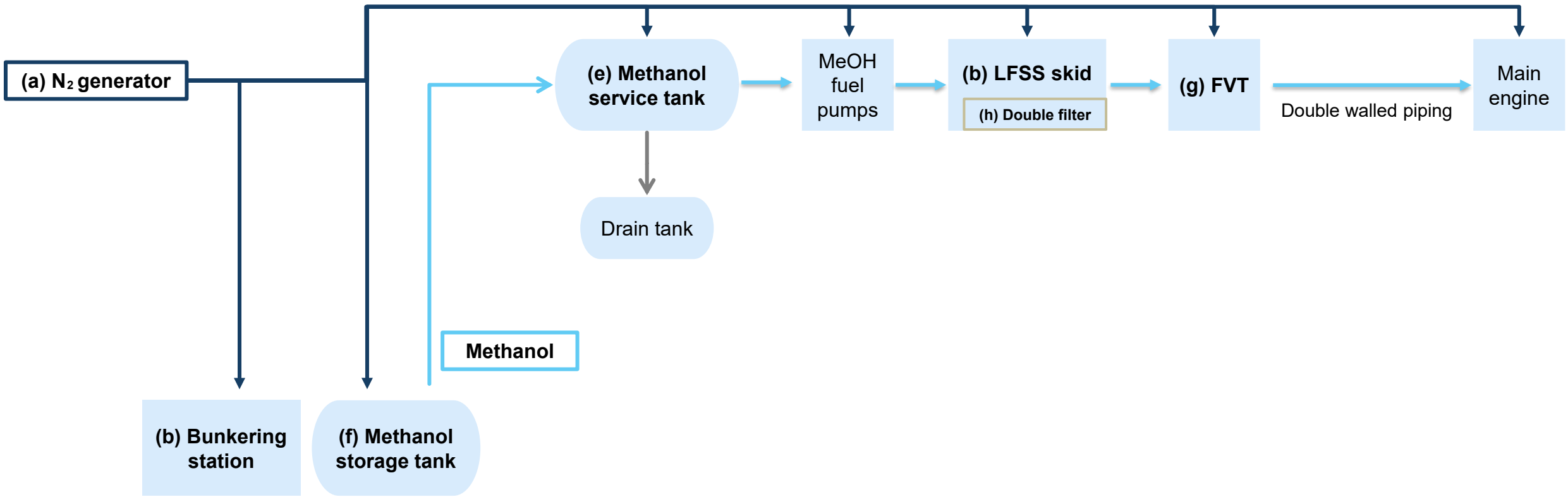
Source: Frost & Sullivan Report, China National Bureau of Statistics, BAIINFO

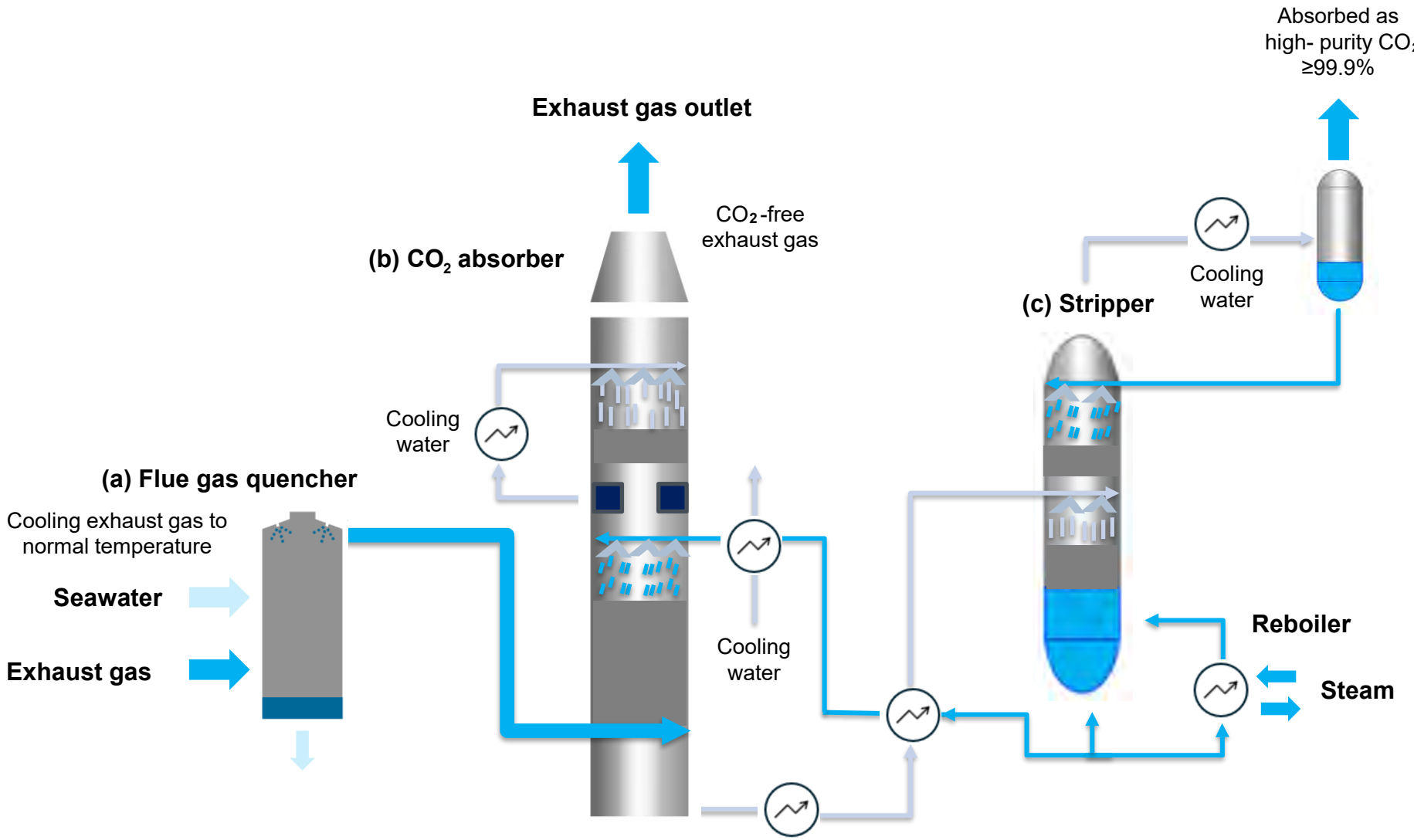
Agenda



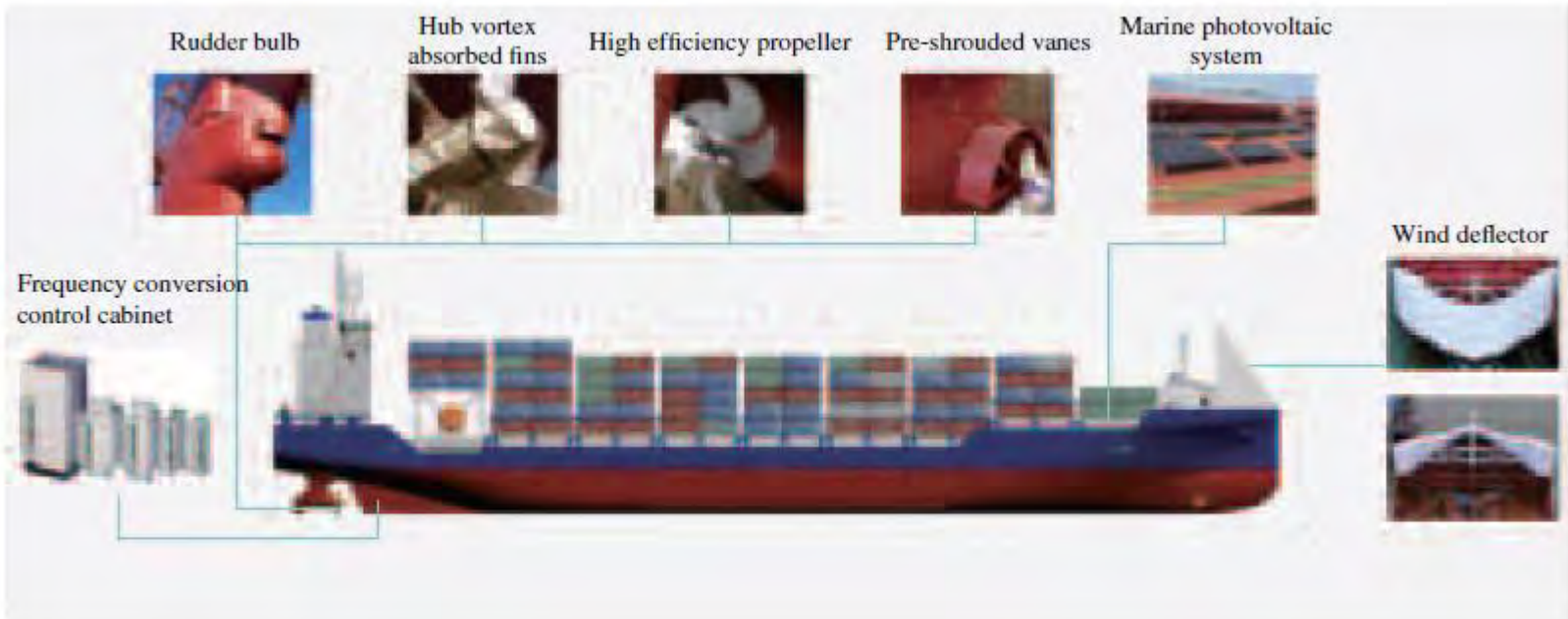
FROST & SULLIVAN 沙利文

Seawater | Closed loop / hybrid wash water | Treated wash water | Fresh water | Exhaust gas


(a) N_2 generator
(e) Methanol service tank
MeOH fuel pumps
(b) LFSS skid
(h) Double filter
(g) FVT
Double walled piping
Main engine
Drain tank
Methanol
(b) Bunkering station
(f) Methanol storage tank



Exhaust gases are introduced into a flue gas quencher (as illustrated in (a) in the diagram above) for desulfurization and cooling before entering a CO2 absorber (as illustrated in (b) in the diagram above), where the flue gas flows upward while an amine-based absorbent is sprayed downward from the top of the tower, facilitating a counter-current contact and reaction that adsorbs and removes a portion of the carbon content, with the treated flue gas then being discharged from the top of the tower. Once the CO2 is absorbed, the amine absorbent transitions from a "lean" to a "rich" solution and is conveyed to a stripper (as illustrated in (c) in the diagram above). Within the stripper, the rich solution is heated to a specific temperature to release CO2, which is expelled from the top of the tower and, after treatment, is compressed, liquefied, and stored, while the regenerated lean solution is cooled via a heat exchanger before being recirculated back to the CO2 absorber for continuous CO2 absorption.


Rudder bulb
Hub vortex absorbed fins
High efficiency propeller
Pre-shrouded vanes
Marine photovoltaic system
Wind deflector
Frequency conversion control cabinet

Appendix

- Tri-party business arrangements between (i) ship exhaust gas cleaning system providers, (ii) ship owner or ship operator, and (iii) single-ship company, which is an entity related to or ultimately controlled by the ship owner or operator and primarily hold the vessel, who was also the represented signing party of sales contract entered between ship exhaust gas cleaning system providers and the ship owner/operator for transactions. Tri-party business arrangement is an industry norm and is mainly to limit the financial and legal liability of the ship owner or operator in connection with uncertain adverse event, such as maritime accident caused by the vessel or its equipment which may result in significant compensation as requested by the victims. By establishing a separate entity for each ship, ship owners can isolate the risks associated with each vessels, which is a strategic approach commonly adopted in maritime asset management for better risk management and operational efficiency.
- The customer (i.e., ship owner or ship operator), which is also the beneficiary would request the supplier to compensate should the supplier default in providing its products or services. Accordingly, supplier would issue a bank letter of guarantee for certain customers based on their requests, in which the beneficiary was the ship owner or operator but not the single-ship company. In general, the bank letter of guarantee would be released following the completion of the first stage of the contract.
- It is the industry norm that the players in shipping industry is relatively concentrated rather than fragmented. Concentration in the customer base in the maritime environmental protection equipment and system industry is in line with the industry norm.
- The supplier normally secured customers through agents (who referred overseas shipping companies to the supplier for business with a commission fee charge), which is in line with the industry practice.
- Delivery of a new ship project is normally expected to be in 18-24 months, which is longer than operational ships in most cases.
- It is not uncommon a customer is also a supplier in the shipping and shipping related industry.
- ContiOcean's revenue increased from RMB140.5 million for the year ended December 31, 2021, to RMB510.3 million for the year ended December 31, 2023, representing a CAGR of 90.6%, which significantly outpaced the industry average CAGR of 9.3%.
- Engagement of sales agents in the maritime environmental protection equipment and system industry is in line with the industry norm.
- On the one hand, shipping companies benefited from a sharp increase in freight rates and achieved record-high performance, and they in turn expanded their capital expenditures, including those on procurement of newbuilding and our equipment and systems relating to newbuilding orders. On the other hand, many shipowners postponed the installation of equipment and systems of their ships in operation so as not to interrupt their shipping business' operations to benefit from the high ocean freight rates.
- Due to various quarantine measures in the Mainland China, ContiOcean's production, delivery of equipment and systems, installation and commissioning, and other daily operations were temporarily affected.
- Carbon Intensity Indicator (CII) is a measure of the carbon emission intensity in the process of shipping. It calculates a ship's carbon intensity by collecting data on its fuel consumption and distance travelled
- "Emission control areas" also known as "Sulphur emission control areas" (SECAs), are sea areas in which stricter controls were established to minimize airborne emissions from ships as a measure to protect human health and the environment. These emissions primarily include SOx, NOx, and other particulate matters.

Appendix

- Among the top ten market players in the global ship EGCS market, only two are listed company and only focus on providing maritime environmental protection equipment and systems. Also, out of the top 10 companies within the maritime environmental protection equipment and system sector, 4 of them has the term “tech” within their names.
- Forecasting the stainless steel prices is challenging due to the volatility of raw materials like nickel and chromium, global supply chain disruptions, and demand variability from key downstream industries of stainless steel such as construction and automotive. Currency fluctuations further complicate predictions, as stainless steel is traded internationally. Additionally, environmental regulations can unpredictably impact production costs, while technological advancements or the emergence of alternative materials may shift market dynamics. Due to the uncertainties mentioned above, it is difficult to provide an accurate quantitative forecast of the average price of stainless steel. However, assuming external market stability, the average price of stainless steel is expected to show a gradual downward trend in the coming years.
- The fluctuation of stainless steel prices can affect the Group’s final product pricing; however, it has a limited impact on the Group’s net profit. This is primarily because the Group's products are highly customized, and they utilize a cost-plus pricing strategy along with a “sales-oriented production” model. These approaches allow the Group to effectively incorporate the latest stainless steel prices when determining the final selling price of their products.
- Since 2021, the Group has adopted a strategy of locking in the procurement price of stainless steel with suppliers upon receiving an order. This approach ensures that any subsequent fluctuations in stainless steel prices do not impact the Group's final procurement cost. Meanwhile, the final selling price remains the same, as it utilized a cost-plus pricing strategy when the Group received the order, maintaining the Group's gross profit.
- The pricing of products provided by Jiangsu ContiOcean was not higher than that of similar products offered by the independent suppliers.
- The Group’s performance follows the market trend and the gross profit margin of the Group’s global maritime services is comparable with the industry range.
- The recent focus on improving ship crews 'onboard living conditions and the surge in container shipping freight rates resulting increased demand for our global maritime services.
- The utilization rate exceeding 100% in 2023 was in line with the industry practice because the COVID-19 pandemic caused severe container shortages and supply chain disruptions from 2021 to 2022, which led to soaring ocean freight rates. As a result, many shipowners postponed the installation of equipment and systems so as not to interrupt their shipping business’ operations to benefit from the high ocean freight rates. However, as the pandemic eased in 2023, the ocean freight rates declined, which increased shipowners’ willingness to install our equipment and systems.
- Energy Efficiency Existing Ship Index” or “EEXI” refers to the number of grams of carbon dioxide emitted per capacity tonmile under ship-specific reference conditions, a framework established by the IMO to assess the energy efficiency of existing ships and a part of a broader set of measures aimed at reducing GHG emissions from international shipping.
- High sulfur fuel is characterized by a higher sulfur content, often exceeding 2% by weight, which leads to greater emissions of sulfur dioxide when burned, contributing to air pollution and acid rain, and posing environmental and health challenges.
- International Maritime Organization, a specialized agency of the United Nations responsible for regulating shipping. Established in 1948 and headquartered in London, the IMO’s primary purpose is to develop and maintain a comprehensive regulatory framework for shipping, and its remit includes safety, environmental concerns, legal matters, technical cooperation, maritime security, and the efficiency of shipping.

Appendix

- There is no material differences in the works of sales agents or the delivery process between sales in PRC and overseas.
- Leading maritime environmental protection equipment and system providers capitalize on Europe's technologies in shipping, maritime affairs and environmental protection.
- ContiOcean capitalizes on local maritime expertise and the mature European maritime environmental protection equipment and system industry to lead in maritime technology innovations.
- Failure to adhere can result in significant penalties, including denial of docking privileges, which can have severe financial and operational repercussions for shipping companies.
- Besides, the cost-savings achieved from continuing use of the more economical high-sulfur fuel also far exceed the required upfront investment and future maintenance.
- However, as technology advances and regulations tighten, the long-term trend is expected to shift towards new energy sources.
- It is at the forefront of applying advanced technologies, leveraging the city's advantage as a global shipping, innovation, and manufacturing hub.
- It benefits from the Yangtze River Delta's collaborative environment and a strong supply chain, which together facilitate the quick transformation of scientific innovations into market-ready products.
- ContiOcean's Shanghai R&D team focuses on the development and implementation of advanced technologies, such as the N2 generator project, positioning it at the forefront of the industry.
- ContiOcean makes warranty provisions, which represent the management's best estimate of its liability under 12 to 60 months assurance-type warranty granted on products, based on prior experience and industry averages for defective products.
- There was a notable concentration in ContiOcean's customer base as large shipping companies have increasingly dominated in terms of number of ships, which has influenced its strategy to engage primarily with these major players due to their substantial market share.
- Additionally, the shipbuilding industry mirrors this pattern, where major ship builders are strengthening their order-taking capabilities, leading to a further concentration within the industry in 2023 compared to 2021.
- ContiOcean's insurance coverage arrangements are in line with the PRC's general practice in the industry in which it is engaged. The insurance coverage ContiOcean currently has is in line with relevant industry standards and is adequate to conduct normal business operations.
- The main and auxiliary engines of ships have back pressure limits, and the total back pressure of the devices, pipes, valves, etc. connected to them must not exceed the upper limit of the engine back pressure. Properly controlling and reducing the back pressure in the ship exhaust gas cleaning systems can help decrease resistance and energy loss in the system, improving engine performance and reducing power consumption.
- Shipping companies benefited from a sharp increase in freight rates and achieved record-high performance, and they in turn expanded their capital expenditures.
- The IMO and other global regulators play a pivotal role in shaping maritime ESG regulations, which most jurisdictions tend to adopt due to the international nature of shipping and the need for standardized practices.
- The installation of ship exhaust gas cleaning systems allows ships to continue using the more economical high-sulfur fuel by cleaning emissions before they are released into the atmosphere.
- Currently, shipowners and ship builders predominantly opt for installation of ship exhaust gas cleaning systems due to their cost-effectiveness and the ability to retrofit in-service ships, making it a more practical and efficient solution for the short to medium term.

Appendix

- Compared to overseas companies, Chinese maritime environmental protection equipment and system providers excel in delivery speed, typically completing projects two months faster than international competitors. In addition, ContiOcean is one of the very few companies in the world that focuses exclusively on maritime environmental protection equipment and systems, while most competitors treat this area as just one part of their broader product portfolios.
- Furthermore, compared to overseas companies, due to the lower costs of labor and raw materials, ContiOcean can offer more competitive pricing for our products.
- Compared to the domestic competitors, ContiOcean have expanded beyond our core business of maritime exhaust gas cleaning systems to include energy-saving devices and carbon-reduction systems and clean energy supply systems. This expansion aligns with both evolving customer demands and tightening global regulations, ensuring ContiOcean remains relevant and competitive. In contrast, many domestic competitors have been slower to adapt to these market shifts.
- Shipowners typically limit their retrofitting vendors to one to two service providers for cost efficiency. ContiOcean's strong history of successful cooperation and high customer satisfaction makes it a preferred choice for these services.
- Compared to state-owned enterprises, ContiOcean, as a private ship exhaust gas cleaning system provider, has more streamlined decision-making processes, allowing it to respond quickly to market changes and opportunities.
- Safety during transportation of new energy vehicles is crucial, as a fire can cause catastrophic damage to a ship. Therefore, shipping companies are highly concerned about PCTC vehicle fire monitoring.
- Additionally, geopolitical tensions such as the Russia-Ukraine conflict and the Red Sea crisis may significantly impact the supply, demand, cost, and operation of global and regional shipping industry and shipbuilding industry. These tensions can negatively affect shipping companies' ability to adapt to changes in the cost, availability of bunker fuel and their shipping routes, which may in turn influence their decisions to purchase new ships, ultimately affecting the shipbuilding industry.
- During the Track Record Period, the surge of newbuildings orders driven by a shortage of shipping capacity and higher ocean freight rates, necessitating more ship accommodation interior design and construction as well as lashing gears, and an increased emphasis by ship builders and shipowners on improving onboard living conditions to attract and retain crew members amidst a labor shortage.
- The global maritime industry is undergoing significant regulatory shifts to reduce sulfur oxide emissions, driven by the IMO and regional governments. The IMO introduced the concept of ‘‘emission control areas’’ with the goal of regulating ship emissions by establishing specific maritime zones. Currently, there are multiple emission control areas globally, including the Baltic Sea, North Sea, the coastal waters of the United States and Canada, and the Caribbean. These areas impose a strict sulfur oxide emission limit of 0.1% m/m. On January 1, 2020, the IMO further limited sulfur content in marine fuels to no more than 0.5% m/m worldwide, outside of the emission control areas. This regulatory shift aims to reduce pollution from maritime shipping and encourages the adoption of cleaner fuels and technologies, such as exhaust gas cleaning systems, to meet the stringent emission standards.
- There is a growing application of new energy sources. Specifically, there has been a significant rise in the demand for nitrogen from oil-chemical ships. The nitrogen requirements of oil-chemical ships are substantially higher than those of new energy ships, leading to a higher average selling price.
- Concentration in the customer base in the maritime environmental protection equipment and system industry is in line with the industry norm based on the interviews conducted with top 10 global market players and comprehensive primary research by interviewing experts form the China Association of the National Shipbuilding Industry, a leading organization in the shipbuilding industry, encompassing various related enterprises and institutions.
- Frost & Sullivan compared the ship exhaust gas cleaning systems provided by the top 10 global providers, revealing that most leading products in the industry currently achieve a desulfurization efficiency of 97%. Therefore, in terms of product performance, ContiOcean’s ship exhaust gas cleaning systems do not show significant differentiation from those of other comparable companies in the industry. Since a desulfurization efficiency of 97% already meets the strictest requirements in the industry, ContiOcean’s systems align with the established standards. There were a surge of newbuildings orders driven by a shortage of shipping capacity and higher ocean freight rates, largely attributable to the COVID-19 pandemic which resulted in more newbuilding orders in order to increase the shipping capacity.

Appendix

- Compared to overseas companies, Chinese maritime environmental protection equipment and system providers excel in delivery speed, typically completing projects two months faster than international competitors. In addition, we are one of the very few companies in the world that focuses exclusively on maritime environmental protection equipment and systems, while most competitors treat this area as just one part of their broader product portfolios.
- Shipowners typically limit their retrofitting vendors to one to two service providers for cost efficiency.
- The industry generally uses high-suffer fuel oil with a silver content of 2.5% to 3.5%.
- In terms of marine exhaust gas cleaning systems, for newbuildings, the process from signing agreements to final acceptance generally takes approximately 12–24 months. For retrofit in-service ships, the process from signing agreements to final acceptance and delivery generally takes approximately four to eight months, the above project timespan is generally in line with industry norm.
- In terms of marine energy-saving devices, for retrofit in-service ships and newbuildings, the process from signing agreements or confirming purchase orders to final acceptance generally takes approximately two to three months. According to Frost & Sullivan, the above project timespan is generally in line with industry norm.
- In terms of marine clean-energy supply systems, for retrofit in-service ships and newbuildings, the process from signing agreements to final acceptance generally takes approximately four to 24 months. For newbuildings, the process from design services to final acceptance generally takes approximately 11 to 18 months. According to Frost & Sullivan, the above project timespan is generally in line with industry norm.
- In terms of ship accommodation interior design and construction services, for retrofit in-service ships, the process from design services to final acceptance generally takes approximately three to six months. The above project timespan is generally in line with industry norm.
- In terms of container ship and PCTC lashing gears and related services, for retrofit in-service ships, the process from signing agreements to final acceptance and delivery generally takes approximately one to six months. According to Frost & Sullivan, the above project timespan is generally in line with industry norm.
- In terms of other marine services, for both newbuildings and retrofit in-service ships, the entire process generally takes approximately two weeks to three months. The above project timespan is generally in line with industry norm.
- Currently, marine carbon reduction systems are still in the development phase within the industry, with various market participants actively working on the development to meet regulatory requirements for ship carbon emissions. The carbon reduction systems and technologies provided by different industry players vary. For example, Shanghai Qiyao Environmental Technology Co., Ltd offers a decarbonization tower for carbon dioxide absorption, while Wärtsilä Corporation provides onboard carbon capture and storage systems.
- The carbon reduction systems offered by leading industry players primarily achieve an average carbon capture efficiency of 70–90% currently. In comparison, the carbon capture efficiency of ContiOcean's organic amine-based carbon capture system stands out as significantly higher, providing a clear competitive advantage in the market. It gives ContiOcean edge in addressing the growing market need for high-performance carbon capture systems in the industry.
- On the one hand, shipping companies benefited from a sharp increase in freight rates and achieved record-high performance, and they in turn expanded their capital expenditures, including those on procurement of newbuilding and ContiOcean's equipment and systems relating to newbuilding orders. On the other hand, many shipowners postponed the installation of equipment and systems of their ships in operations so as not to interrupt their shipping business' operations to benefit from the high ocean freight rates.
- The industry generally uses high-suffer fuel oil with a sulfur content of 3.5%.
- The "IMO Strategy on Reduction of GHG Emissions from Ships," adopted in 2023, outlines ambitious emissions reduction targets for the maritime industry, aiming for a 40% reduction in greenhouse gas emissions by 2030 and a 70% reduction by 2040, both compared to 2008 levels.

Appendix

- Timely and efficient customer service: By providing after-sales services to existing customers or pre-sales services to potential customers more promptly and efficiently. ContiOcean's engineers (as opposed to engineers from the service contractor) who have an in-depth understanding of its products and services can resolve issues on-site. This enhances customer satisfaction.
- Cultural and communication familiarity: Local employees are more familiar with the culture, habits, and communication styles of local customers or potential customers. This familiarity aids us in expanding ContiOcean's customer base.
- Showcasing products and services: Through the service center show rooms, potential customers can gain a direct understanding of all ContiOcean's products and services, thereby increasing their willingness to purchase new products and enhancing our brand image.
- Cost reduction and cultural diversification: Setting up service centers can reduce costs of providing pre-sales and after-sales services costs locally and foster a more diverse corporate culture. This aligns with ContiOcean's international positioning and can attract more talent to join it.
- The industry competition should not have material impact on the EGCS average selling price. Due to its highly customization factor, the ASP of an EGCS is more affected by the following key factors, (i) technical requirements depending on the type of ships (retrofit in-sell ships and newbuildings) ,(ii)diameters of scrubbers per customer's request, and (iii) scale of orders. As a result, a lower ASP of an EGCS may have higher gross profit margin.
- Ships that have installed ship exhaust gas cleaning systems using high-sulfur fuel can also use low-sulfur fuel.
- Newbuildings often came in series with similar design, as opposed to retrofit in-service ships, which may incur design costs such as those related to 3D scanning provided by external suppliers and modification designs.
- ContiOcean employs a ‘‘sales-oriented production’’ model, which is a demand-driven approach intended to align our production planning with sales order volumes and minimizes the risk of overproduction and excess inventory.
- A transition to alternative providers would incur switching costs. Using different equipment and systems will incur additional time and costs to train their personnel to become familiar with new equipment and systems.
- International Convention for the Prevention of Pollution from Ships’’ or ‘‘MARPOL’’ is a key international maritime convention designed to minimize pollution of the oceans and seas. It includes various measures aimed at preventing accidental and operational pollution from ships. Established by the IMO in 1973 and updated by the Protocol of 1978, MARPOL is one of the most important international marine environmental conventions. It has been ratified by the vast majority of countries involved in maritime shipping and covers not only accidental and operational oil pollution, but also pollution by chemicals, goods in packaged form, sewage, garbage, and air pollution from ships.
- Low-sulfur fuel’’ is a type of fuel that contains a reduced amount of sulfur, typically less than 0.5% by weight, which helps in minimizing sulfur dioxide emissions upon combustion, thereby reducing air pollution and mitigating the impact on the environment.
- A downturn in these industries could lead to reduced demand for new ships, which may adversely affect the demand for our equipment and systems. Conversely, when freight rates are relatively high, there is typically a surge in newbuilding orders. However, during such periods, shipowners may prefer not to suspend ship operations for the installation of ContiOcean's products, which can affect ContiOcean's business operations. Additionally, geopolitical tensions such as the Russia-Ukraine conflict and the Red Sea crisis may significantly impact the supply, demand, cost, and operation of global and regional shipping industry and shipbuilding industry. These tensions can negatively affect shipping companies' ability to adapt to changes in the cost, availability of bunker fuel and their shipping routes, which may in turn influence their decisions to purchase new ships, ultimately affecting the shipbuilding industry.
- The industries in which ContiOcean operate are characterized by high demand and intense competition for top talent. In recent years, the average labor cost, particularly for highly skilled and experienced personnel, has been rising steadily.

Appendix

- The IMO and other global regulators play a pivotal role in shaping maritime ESG regulations, which most jurisdictions tend to adopt due to the international nature of shipping and the need for standardized practices. Failure to adhere can result in significant penalties, including denial of docking privileges, which can have severe financial and operational repercussions for shipping companies.
- Currently, shipowners and ship builders predominantly opt for installation of ship exhaust gas cleaning systems due to their cost-effectiveness and the ability to retrofit in-service ships, making it a more practical and efficient system for the short to medium term.
- During the track record period, the historic surging container shipping freight rates and the corresponding rise in shipowners' investments in the container ships, leading to increased demand for ContiOcean's container ship and PCTC lashing gears.
- Ships that have installed ship exhaust gas cleaning systems using high-sulfur fuel can also use low-sulfur fuel.
- The open-loop type offers a cost-effective solution due to requiring fewer devices for installation and, subsequently, less device maintenance compared to the hybrid type system.
- Marine photovoltaic systems are commonly installed on the deck surfaces of bulk carriers and oil tankers.
- For newbuildings, the process from signing agreements to final acceptance and delivery generally takes approximately six to 12 months.
- Revenue from other maritime services is recognized upon final acceptance when the confirmation of receipt is signed.
- Given the complexity of ship exhaust gas cleaning systems, retrofitting an operational ship requires significant modifications to the ship's structure and its electrical and plumbing systems. Consequently, retrofit in-service ships must dock at shipyards for a certain period to undergo this retrofitting process.
- ContiOcean's competitors in the industry tend to have a relatively lower concentration risk in their customer base compared to us, primarily due to their longer operating history, larger business size and more diversified business operations.
- ContiOcean operate in a competitive industry. ContiOcean generally compete with global maritime environmental protection equipment and system providers. Competition largely focuses on advancement of technology, price of services, quality and variety of services provided, financial capacity and access to customers.

Appendix

- Contracting between maritime environmental protection equipment and system providers and ship-owning SPVs is in line with industry norm for shipowners' risk management purposes.

- The ship trading market is active.

- The global and China's maritime environmental protection equipment and system industry is highly fragmented and competitive.

- 船舶尾气净化系统业务属于船舶脱硫行业，主管部门为中华人民共和国工业和信息化部、国家发展和改革委员会及国家海事局负责具体相关工作。
- 船舶节能减碳系统及清洁能源供应系统的研发、生产、销售服务的产品属于绿色船舶行业，主要由中华人民共和国工业和信息化部、国家发展和改革委员会及国家海事局负责具体相关工作。
- 全球海事服务属于航运服务业，主要由中华人民共和国交通运输部、国家海事局负责具体相关工作。
- 船舶尾气净化系统、船舶节能减碳系统及清洁能源供应系统上游供应商属于钢铁和化工行业，主要由中华人民共和国工业和信息化部负责具体相关工作。下游客户属于船舶制造业，主要由中华人民共和国交通运输部、国家海事局负责具体相关工作。
- 工业和信息化部的职能包括：提出工业发展战略，拟订工业行业规划和产业政策并组织实施；指导工业行业技术法规和行业标准的拟订；按国务院规定权限，审批、核准国家规划内和年度计划规模内工业固定资产投资项目；工业日常运行监测以及工业的节能、资源综合利用和清洁生产促进工作等。
- 国家发展和改革委员会的职能包括：拟订并组织实施国民经济和社会发展战略、中长期规划和年度计划；统筹协调经济社会发展，研究分析国内外经济形势，提出国民经济发展、价格总水平调控和优化重大经济结构的目标、政策；提出综合运用各种经济手段和政策的建议；负责产业政策的研究制定、行业的管理与规划等。
- 国家海事局的职能包括：拟定和组织实施国家水上安全监督管理和防止船舶污染、船舶及海上设施检验、航海保障以及交通行业安全生产的方针政策和技术规范，负责管理船舶及海上设施法定检验、发证工作；负责通航秩序、通航环境以及航海安全保障等工作。
- 交通运输部的主要职责包括：制定并监督执行公路、水路交通行业的发展战略、方针政策和法规；拟定并实施发展规划和中长期计划，负责交通行业统计和信息引导；调控国家重点物资运输和紧急客货运输，组织实施重点交通工程建设；指导行业体制改革，维护公平竞争，引导结构优化和协调发展；组织建设和维护水运基础设施，监督水上交通安全，检验船舶及设施，防止污染，保障航海安全；制定科技政策和技术标准，推动技术进步，指导交通教育；指导港口、航运公安工作等。

Research Methodologies

- Frost & Sullivan is an independent global consulting firm, which was founded in 1961 in New York. It offers industry research and market strategies and provides growth consulting and corporate training. Its industry coverage includes automotive and transportation, chemicals, materials and food, commercial aviation, consumer products, energy and power systems, environment and building technologies, healthcare, industrial automation and electronics, industrial and machinery, and technology, media and telecom.
- The Frost & Sullivan's report includes information on global marine ship and maritime environmental protection equipment and system industries.
- Frost & Sullivan has conducted detailed primary research which involved discussing the status of the industry with certain leading industry participants and conducting interviews with relevant parties. Frost & Sullivan has also conducted secondary research which involved reviewing company reports, independent research reports and data based on its own research database. Frost & Sullivan has obtained the figures for the estimated total market size from historical data analysis plotted against macroeconomic data as well as considered the above-mentioned industry key drivers.
- Frost & Sullivan's Market Engineering Forecasting Methodology integrates several forecasting techniques with the Market Engineering Measurement-based System. It relies on the expertise of the analyst team in integrating the critical market elements investigated during the research phase of the project. These elements include:
  - ✓ Expert-opinion forecasting methodology
  - ✓ Integration of market drivers and restraints
  - ✓ Integration with the market challenges
  - ✓ Integration of the Market Engineering Measurement trends
  - ✓ Integration of econometric variables
- In compiling and preparing the Report, Frost & Sullivan has adopted the following assumptions:
  - ✓ The social, economic and political environment of the globe is likely to remain stable in the forecast period
  - ✓ Related industry key drivers are likely to drive the market in the forecast period

Source: Frost & Sullivan

Research Methodologies

- The methodologies used by Frost & Sullivan in identifying the overall market size of the industry in which the Company operates and the number of market players therein, identifying the top ten market players obtaining their background information and financial/operating data included both primary research and secondary research.
- Frost & Sullivan first commenced the research by conducting extensive secondary analysis, leveraging their internal database alongside reputable, publicly available sources. These included industry reports and data from key maritime organizations such as Clarkson, the China Association of National Shipbuilding Industry, Lloyd's Register of Shipping, and the China Shipbuilding Industry Yearbook. These insights provided a broad macro-level view of the market, covering critical aspects like market size, growth trends, major players, and historical rankings within the maritime environmental protection equipment and systems sector.
- To enhance this foundational research, Frost & Sullivan conducted interviews with experts from prominent shipbuilding enterprises like China State Shipbuilding Corporation (CSSC), Yangzijiang Shipbuilding, and South Korea's HD Hyundai. These downstream industry leaders provided valuable perspectives on the demand for maritime environmental protection equipment, highlighting factors such as operational efficiency, cost-effectiveness, and regulatory compliance. This allowed Frost & Sullivan to merge supply-side data with demand-side insights, resulting in a comprehensive understanding of market dynamics, current gaps, future trends, and opportunities driven by evolving customer demands and regulatory shifts.
- Then, Frost & Sullivan conducted granular primary research through interviews with key players in the maritime environmental protection equipment sector, such as Alfa Laval, Wartsila, Panasia, Zhejiang Energy Maritime, and Qiyao Environment Tech. These industry professionals provided detailed insights into critical areas like marine exhaust gas cleaning systems, energy-saving technologies, carbon reduction systems, and clean energy systems. For example, one expert, with over 20 years of experience at top environmental firms, shared valuable perspectives on market shifts, competitive strategies, and future industry positioning.
- After completing both the primary and secondary research phases, Frost & Sullivan applied a rigorous cross-verification process. This involved aligning data from primary interviews with corroborating insights from secondary sources to ensure the credibility and accuracy of their market size estimates and competitive landscape analysis.
- Finally, Frost & Sullivan synthesized these insights to develop well-grounded projections for future market growth. These projections were based on assumptions derived from both qualitative insights and quantitative data, combining expert interviews with macro-level trends. Through this comprehensive approach, Frost & Sullivan delivered a robust, multi-faceted analysis of the maritime environmental protection equipment market, offering reliable estimates of market size and competitive dynamics.
- By integrating these methodologies, Frost & Sullivan provided a nuanced and accurate analysis of the market, supporting their estimates with a well-rounded understanding of the industry.

Source: Frost & Sullivan