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Economic benefits of building zero-emission capable vessels in East Asia

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SUMMARY

Achieving net-zero greenhouse gas (GHG) emissions from international shipping by or around 2050 will require zero-emission capable vessels (ZECVs). Most of these vessels would likely be built in China, Republic of Korea, and Japan, which collectively dominate the shipbuilding industry, especially for large cargo ships. Because ZECVs are more expensive than conventional vessels, this presents an economic opportunity for shipbuilders and shipbuilding countries, especially for first movers that gain a competitive advantage in the marketplace. In this paper, we provide an overview of the shipbuilding market and existing government support measures for the industry in China, Republic of Korea, and Japan. We then estimate the additional revenues these countries could earn by building ZECVs instead of conventional vessels.

We estimate that, if all newbuild bulk carriers, chemical tankers, container ships, oil tankers, and liquefied gas tankers produced in 2030 were to be zero-emission capable instead of running on conventional fossil fuels, the additional revenues would range from $6.9 billion to $36.0 billion globally. Building ZECVs could thus increase shipbuilder revenue from propulsion systems by 86% to 452%. Given each country's current shipbuilding market shares, China would see additional revenues of $3.1–$15.9 billion (98% to 510% above the Baseline scenario), Republic of Korea would gain an additional $1.5–$6.2 billion (60% to 253% above the Baseline), and Japan would gain an additional $2.1–$12.5 billion (97% to 583% above the Baseline).

If ZECV uptake grows at a constant rate between 2026 and 2030, the additional revenues in these countries would range from $14.2 billion to $77.4 billion, 85% to 463% more than building conventional propulsion systems. A first mover in ZECV

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shipbuilding could potentially demonstrate technological leadership and earn buyer loyalty, thereby capturing more of these additional revenues.

INTRODUCTION

In 2023, the International Maritime Organization (IMO) adopted a revised strategy that aims to reduce greenhouse gas (GHG) emissions from international shipping to net zero by or around 2050. An interim target calls for at least 5%—aiming for 10%—of the energy used by international shipping in 2030 to come from zero or near-zero GHG emission technologies or fuels (IMO, 2023). Achieving this target will require ships able to run on fuels with near-zero GHG emissions on a well-to-wake basis, hereafter referred to as zero-emission capable vessels (ZECVs).[1] Ships have lifetimes of about 25 years (Stopford, 2009) and the global fleet is growing by less than 5% each year in terms of deadweight tonnage (DWT; Case & Woyda, 2024). This means it is important to rapidly scale up production of ZECVs to support the IMO's climate ambitions.

Building ZECVs and operating them with zero-emission fuels will be costly. A 2020 analysis by University Maritime Advisory Services and the Energy Transitions Commission estimated that an ammonia-dominant scenario to decarbonize shipping by 2050 would cost $1.2 trillion to $1.6 trillion, or $60 billion to $80 billion invested annually between 2030 and 2050. Of these investments, 87% would be spent on fuel production, storage, and distribution, while 13% would be spent on engines, storage systems, and energy-efficiency systems on ships (Krantz et al., 2020). In 2021, Maersk, one of the world's largest shipping companies, ordered container ships that could run on both methanol and conventional fuel oil and estimated the additional capital expenditure (CapEx) to be 10%–15% of the total ship price (Frangoul, 2021).

While the additional CapEx might be a burden for shipowners, it would translate to additional revenues for shipbuilders and shipbuilding nations. The majority of ZECVs will likely be built in China, Republic of Korea, and Japan, given their current dominance in the shipbuilding industry. In 2022, China built 46.6% of ships in terms of gross tonnage (GT), Republic of Korea built 29.2%, and Japan built 17.2% (United Nations Conference on Trade and Development, 2023).

In this paper, we estimate the additional revenues that these three shipbuilding powerhouses could generate by building ZECVs instead of vessels running on conventional fuels. We first describe the current state of the global shipbuilding market and how governments in China, Republic of Korea, and Japan provide financial support to the shipbuilding industry. We then explain how we modeled the number of newbuild ZECVs using the ICCT's Polaris model and the additional revenues from building ZECVs using the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping's Total Cost of Ownership (TCO) Model. We estimate the extra revenues for each country in 2030 given their current market shares along with additional revenues between 2026 and 2030 based on the projected increase in ZECV uptake. We conclude with a discussion of the potential benefits of being a first mover in ZECV shipbuilding.

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[1] The life cycle of a marine fuel can be divided into well-to-tank (WTT) and tank-to-wake (TTW) phases. The WTT phase accounts for upstream fuel production activities ranging from feedstock extraction to fuel distribution, while the TTW phase comprises the fuel use in a vessel. Well-to-wake emissions refer to the sum of emissions from both stages (Carvalho et al., 2023). Whether a ship is truly a zero-emission vessel depends on the fuels it uses, how the fuels are produced, and any remaining direct emissions from the ship. Therefore, we use the term zero-emission capable vessel instead of zero-emission vessel.

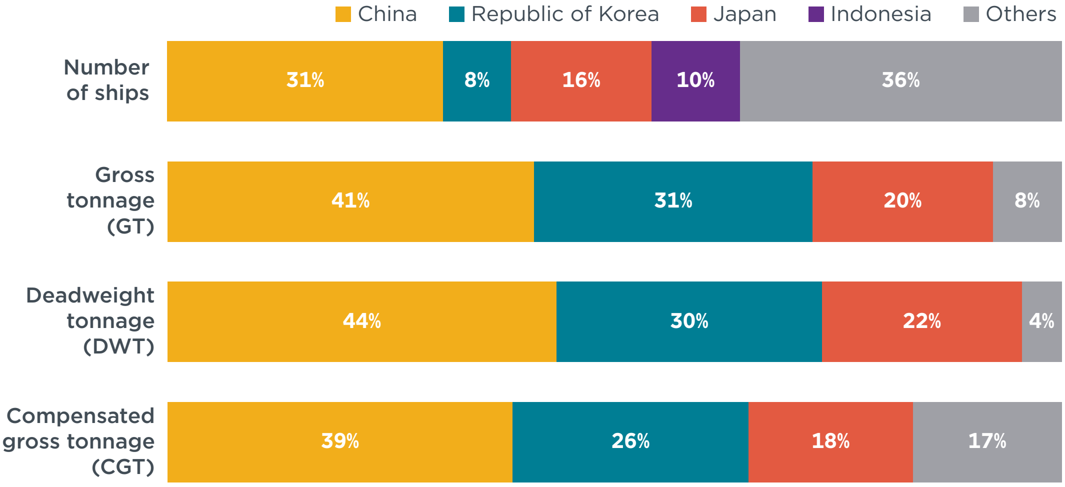
OVERVIEW OF THE SHIPBUILDING MARKET

To analyze the current state of shipbuilding, we examined 12,371 ships that were built between 2019 and 2022 according to records in the S&P Global database.[2] We assessed average production over 4 years to adjust for the unevenness of completion in a single year (Gourdon et al., 2023) and the impact of Covid-19 on production and newbuild orders.

Figure 1 shows shipbuilding market shares by country by different metrics. GT measures the volume of all enclosed spaces of a ship while DWT measures the maximum weight a ship can carry, including cargo, fuel, passengers, and crew. Compensated gross tonnage (CGT) is a measure of shipbuilding output that takes into account the production complexities of different ship types (Stopford, 2009).[3] While China, Republic of Korea, and Japan built 55% of the total number of ships in the database, their collective market shares by other measurements are much higher: 92% of GT, 96% of DWT, and 83% of CGT. This reflects the fact that these three countries mainly build large cargo ships. The market share as measured by CGT is slightly lower than for GT and DWT because cruise ships—which are complex to build and have a high CGT for their size—are mostly built in European countries.

Figure 1

Market shares for newbuild ships by country, 2019–2022



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Market shares vary widely across ship types, as shown in Figure 2. As noted above, China, Republic of Korea, and Japan dominate the cargo ship segment. Within this segment, China built the most bulk carriers, general cargo ships, vehicle carriers, and roll-on/roll-off (Ro-Ro) ships. Republic of Korea built the most container ships, oil tankers, liquefied gas tankers, and chemical tankers, while Japan built the most refrigerated bulk carriers. China also has significant market shares in other non-cargo and non-passenger segments, reflecting its large domestic fleet, which is not the case for Republic of Korea and Japan. The two ship types that the three countries do not build are cruise ships and yachts; these are mainly built in European countries such as Italy, Germany, France, and Finland. More detailed market shares by ship type and size are shown in Appendix A.

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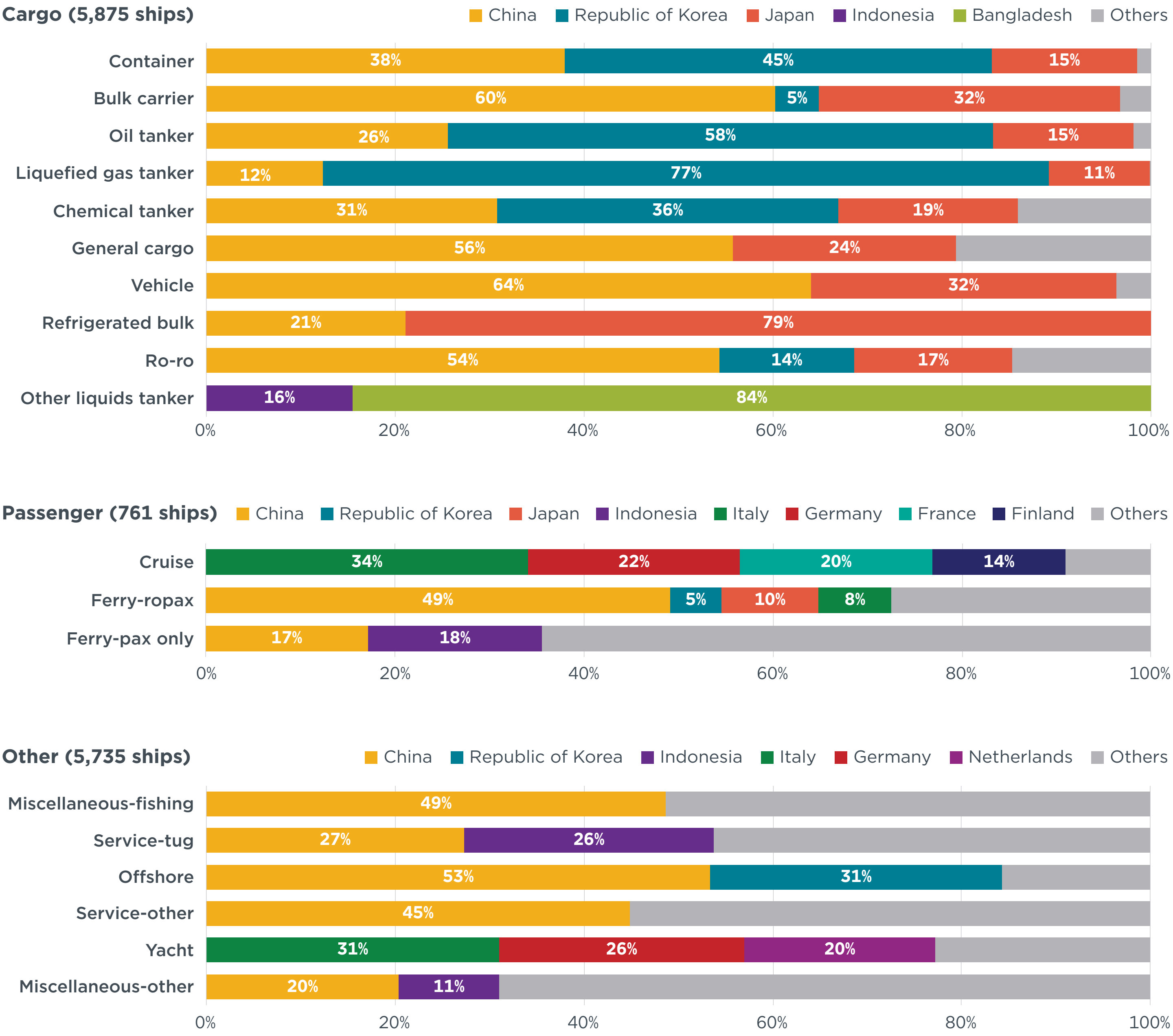
[2] Maritime information services provider IHS Markit was acquired by S&P Global in 2022.

[3] CGT is not included in the database purchased from S&P Global. We estimated CGT using GT and the formula and coefficients determined by the Organisation for Economic Co-operation and Development (OECD, 2006).

Figure 2

Market shares for newbuild ships by segment and type, 2019–2022



Cargo (5,875 ships)

Passenger (761 ships)

Other (5,735 ships)

Note: Market shares were calculated based on the units used to determine capacity in the *Fourth IMO Greenhouse Gas Study* (Faber et al., 2020), such as twenty-foot equivalent unit (TEU) for container ships and DWT for bulk carriers. Ropax ferries carry wheeled cargo as well as passengers, while pax only ferries carry only passengers.

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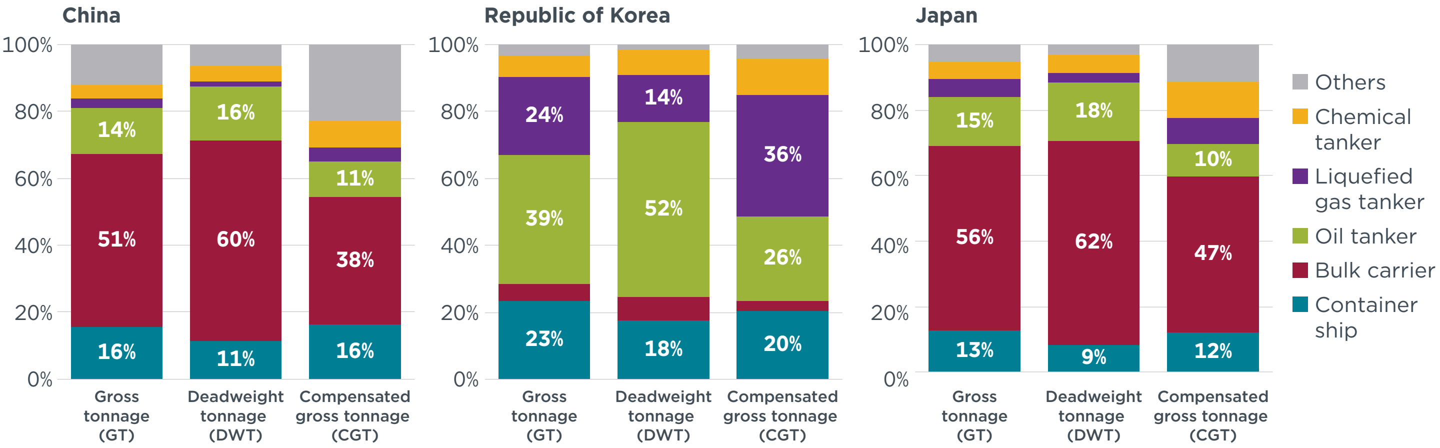
Figure 3 summarizes the shipbuilding portfolio in each of the three countries. Container ships, bulk carriers, oil tankers, liquefied gas tankers, and chemical tankers accounted for the lion's share of shipbuilding output in all three countries. China and Japan have similar shipbuilding portfolios, mainly building bulk carriers, container ships, and oil tankers. Republic of Korea mainly builds liquefied gas tankers, oil tankers, and container ships.

Figure 3

Shipbuilding portfolios for China, Republic of Korea, and Japan, 2019–2022



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GOVERNMENT MEASURES SUPPORTING THE SHIPBUILDING INDUSTRY IN CHINA, REPUBLIC OF KOREA, AND JAPAN

Following the Organisation for Economic Co-operation and Development's (2015) classification of policy support for fossil fuels, we define support measures for the shipbuilding industry to include budgetary transfers and tax expenditures made by governments—or bodies acting on behalf of governments—that provide a benefit for ship production or purchase. These measures can be broadly categorized based on their direct beneficiaries or transfer mechanisms. In terms of beneficiaries, a government can provide a subsidy to shipbuilders, shipowners, or other entities to provide infrastructure or support research and development (R&D). Transfer mechanisms include providing direct subsidies such as grants; reducing taxes or other payments to the government; shifting financial risk to the government; and induced transfers, such as price differences resulting from constraints on competition (e.g., domestic content requirements; International Transport Forum, 2019).

All three governments have provided support measures using various transfer mechanisms. State ownership of shipbuilding and shipping companies is prevalent in China and Republic of Korea. The largest shipbuilding and shipping companies in China—China State Shipbuilding Corporation (CSSC), COSCO Shipping Heavy Industry, COSCO Shipping, and China Merchants Group—are state-owned. Sixty-seven percent of all ships built in China (in CGT) in 2021 were built in shipyards owned by national or local governments (China Association of the National Shipbuilding Industry, 2022). State-owned financial institutions in Republic of Korea were major shareholders, as of 2023, of one of the country's largest shipbuilders, Hanwha Ocean, and one of its largest shipping companies, HMM (Hanwha Ocean, 2023; HMM, 2023).

Grants to buy new ships, such as those provided in China's "scrap and build" program (European Commission, 2023), are often tied to better environmental performance and domestic content requirements. Governments also assume financial risks by providing export credits, which can take the form of loans, insurance, or guarantees to foreign shipping companies purchasing domestically built ships. These export credit agencies include the Export-Import Bank of China, China Export & Credit Insurance Corporation, the Export-Import Bank of Korea, Korea Trade Insurance Corporation, the Japan Bank for International Cooperation, and Nippon Export and Investment Insurance. The export credit agencies also provide technical guarantees, working capital loans, and investment loans for shipbuilders. After the 2008 global financial crisis, China's leasing companies—some of which are state-owned (e.g., ICBC Leasing and BOCOM Leasing)—emerged as major financiers for global shipping companies (Daniel & Yildiran, 2019).

On top of general support for the industry, the three governments have implemented measures focusing on "green" ships in recent years, as detailed in the following section.

CHINA'S SUPPORT FOR NEW AND CLEAN ENERGY SHIPS

China has accelerated efforts to decarbonize shipping since the government announced carbon peaking and neutrality goals in 2021 ("China maps path," 2021). The action plan that followed the announcement provided high-level guidance to all industries and set a target of fueling about 40% of new vehicles, including ships, with new and clean energy by 2030 (National Development and Reform Commission [NDRC], 2021). The government defines new and clean energy ships to exclude vessels running on conventional fuels like heavy fuel oil, marine gas oil, and fossil diesel but include those powered by liquefied natural gas (LNG) and liquefied petroleum gas (LPG) despite their fossil origins and concerns about methane emissions from LNG-fueled ships (Pavlenko et al., 2020; Comer et al., 2024).

A series of policies and plans related to shipping decarbonization followed, led by multiple government entities, including the NDRC, Ministry of Industry and Information Technology (MIIT), Ministry of Transport (MOT), Ministry of Finance, and Ministry of Ecology and Environment. The policies and plans aim to promote the deployment of new and clean energy ships using LNG, battery electric, methanol, hydrogen, and other energy sources, and to develop related industries like shipbuilding, fuel storage and bunkering infrastructure, and intelligent operations (MIIT et al., 2022, 2023; MOT, 2022). Published at the end of 2023, the *Action Plan for Green Development in the Shipbuilding Industry (2024–2030)* set a goal of achieving at least a 50% market share in green energy shipbuilding, including LNG- and methanol-fueled ships, by 2025 (MIIT et al., 2023). In May 2024, the government issued the *Action Plan for Large-scale Transportation Equipment Renewal* to scale up domestic demand for new and clean energy transportation equipment (MOT et al., 2024). The 2024 plan called for accelerating the scrappage of old ships, supporting the development of new and clean energy technologies (e.g., engines and batteries), implementing pilot projects and demonstration zones to showcase new and clean energy ships, and improving the fueling, battery-charging, and battery-swapping infrastructure for such ships.

Provincial and local governments provide financial support based on the central government's high-level guidance. For example, Shanghai is offering subsidies of up to CN ¥400,000 ($57,000) for an LNG-fueled ship and up to CN ¥5 million ($714,000) for an electric ship until May 2026 (Shanghai Municipal Transport Commission, 2022).[4] From 2023 to 2025, Fujian Province is subsidizing demonstration projects of battery electric or hydrogen fuel cell ships by up to CN ¥10 million

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[4] Subsidy amounts in yuan were converted to U.S. dollars using the International Monetary Fund's average exchange rate for 2023 rounded to the nearest whole number ($1 = CN ¥7).

($1.4 million) per ship (Fujian Provincial Department of Industry and Information Technology, 2023); relevant charging infrastructure is also eligible for CN ¥0.2–CN ¥0.5 million ($29,000–$71,000) depending on the charging power. Shenzhen, meanwhile, has established a special fund of up to CN ¥133 million ($19 million) for 2023–2025 to subsidize the adoption of ships using clean fuel—including battery electric, hydrogen fuel cell, and LNG- and methanol-powered vessels—based on the engine power (Shenzhen Municipal Transportation Bureau, 2023).

REPUBLIC OF KOREA'S SUPPORT FOR GREEN SHIPS

Republic of Korea's shipping decarbonization efforts build on the Act on the Promotion of the Development and Distribution of Environment-Friendly Ships (2020), commonly known as the Green Ship Act, and are led by the Ministry of Oceans and Fisheries (MOF) and the Ministry of Trade, Industry, and Energy (MOTIE). The act defines green ships as those running on fossil fuels such as LNG, compressed natural gas (CNG), and LPG, in addition to ammonia, hydrogen, methanol, and electricity.

The act directs the two ministries to establish 5-year basic plans and annual action plans for the development and distribution of green ships. The plans advanced by MOTIE focus on the development of green ships, including R&D projects and projects to establish testing standards and facilities. Plans formulated by MOF, which focus on the distribution of such vessels, aim to build bunkering infrastructure for alternative fuels and provide financial support—such as subsidies or exemptions from fees and taxes—to public and private shipowners switching to green ships.

In addition to these plans, the government announced three strategies in 2023 focused on promoting the transition of the shipbuilding and shipping industries to green ships. The *Strategy for Decarbonization of International Shipping* is aimed at encouraging Korean shipping companies to transition to green vessels. The government committed to creating a public fund of ₩4.5 trillion ($3.4 billion) and a separate fund of ₩1 trillion ($766 million) specifically for small- and medium-sized shipping companies to subsidize the purchase of green ships (MOF, 2023a).[5] The *K-Shipbuilding Strategy for Next-Generation Market Dominance*, meanwhile, set a goal of capturing at least 80% of the next-generation shipbuilding market and targeted spending ₩710 billion ($544 million) by 2028 to support R&D on LNG ($31 million), ammonia ($31 million), hydrogen ($92 million), autonomous ships ($123 million), and marine equipment ($153 million), as well as shipyard digitalization ($115 million) and training programs (MOTIE, 2023). Finally, the *Plan for Establishing Green Marine Fuel Supply Chain* is focused on supporting LNG, methanol, and ammonia bunkering infrastructure by providing shipowners with subsidies for bunkering ships and creating a public–private fund of ₩1 trillion ($766 million) for bunkering infrastructure investment (MOF, 2023b).

JAPAN'S SUPPORT FOR NEXT-GENERATION SHIPS

In Japan, the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) is responsible for supporting the shipbuilding and shipping industries. Two recent initiatives underpin its support for shipbuilding in general and the transition to next-generation ships in particular: the Maritime Industry Strengthening Act and the Green Innovation Fund.

The Maritime Industry Strengthening Act was passed in 2021 with the aim of achieving a shipbuilding output of 18 million GT and improving the industry's productivity by 20% by 2025, as compared with 2019. Pursuant to the act, the Japanese government provides tax breaks and long-term, low-interest loans to Japanese shipbuilders and

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[5] Subsidy amounts in won were converted to U.S. dollars using the International Monetary Fund's average exchange rate for 2023 rounded to the nearest whole number ($1 = ₩1,306).

marine equipment manufacturers that receive approval for their "Business Foundation Strengthening Plans." These plans should entail the development and production of new vessels or services or introduce new production methods that increase efficiency or use of new materials. Beneficiary companies are expected to show improvement in business performance metrics. Japan also offers tax breaks and loans to shipping companies when they order ships from approved shipbuilders in accordance with "Specific Ship Introduction Plans," which should indicate how a ship would showcase improved energy efficiency measures that reduce air pollution, comply with safety regulations, and be equipped with advanced systems that reduce labor (MLIT, 2024).

In 2020, Japan's Ministry of Economy, Trade, and Industry (METI) established a JP ¥2 trillion ($14.2 billion) Green Innovation Fund as part of efforts to achieve economy-wide carbon neutrality by 2050 (New Energy and Industrial Technology Development Organization, 2023).[6] Up to JP ¥35 billion ($248 million) from the fund is expected to be spent by 2030 for next-generation ship development as outlined by MLIT (2023). According to MLIT's plan, up to JP ¥21 billion ($149 million) will be directed toward the development of hydrogen-fueled engines, fuel tanks, fuel supply systems, and a demonstration of hydrogen-fueled ships by 2030; up to JP ¥13.4 billion ($95 million) will go toward the development of ammonia-fueled engines, fuel tanks, supply systems, and the development of bunkering ships; and up to JP ¥600 million ($4.3 million) will target reducing methane slip on LNG-fueled vessels by 60% by 2026 (MLIT, 2023). Between 2021 and 2023, the Green Innovation Fund invested JP ¥250 million ($1.8 million) in technology development for automated vessels, zero-emission ships, and modernization of coastal shipping and JP ¥1.8 billion ($12.8 million) in innovative energy-saving technologies for coastal shipping; by 2025, it is expected to invest JP ¥600 million ($4.3 million) to subsidize the cost of introducing LNG fuel systems and CO_2 reduction equipment for use in combination with LNG fuel systems (MLIT, 2023).

The three countries' recent actions show that they view the transition to green ships as an opportunity for their shipbuilding industries to seize technological leadership and higher market share. Yet their definitions of green ships are broad. As a result, these policies continue to support building, purchasing, and operating LNG-fueled ships.

POTENTIAL FUEL AND PROPULSION PATHWAYS FOR ZECVS

For this paper, consistent with Meng & Rutherford (2024), we considered three fuels and two power options for ZECVs, resulting in three pathways: ammonia used as fuel in an internal combustion engine (ICE), methanol used in an ICE, and hydrogen used with fuel cells. Importantly, ammonia and methanol will still release air pollutant emissions when used in an ICE; combustion of ammonia can also lead to emissions of nitrous oxide (N_2O). Hydrogen fuel cells release no direct emissions. However, the actual life-cycle emissions of ZECVs would depend on zero-emission fuel costs and the stringency of environmental regulations. Ammonia, hydrogen, and methanol must be produced using 100% additional renewable electricity via electrolysis—or from biogas made from wastes and residues—to have lower life-cycle GHG emissions than using marine gas oil as fuel (U.S. Department of Transportation, Maritime Administration [MARAD], 2024). The characteristics and life-cycle emissions of each pathway are described in further detail in Meng & Rutherford (2024) and MARAD (2024).

To assess the uptake of these pathways by ship type and shipbuilding country, we examined ships built or expected to be built between 2023 and 2026 from the Clarksons

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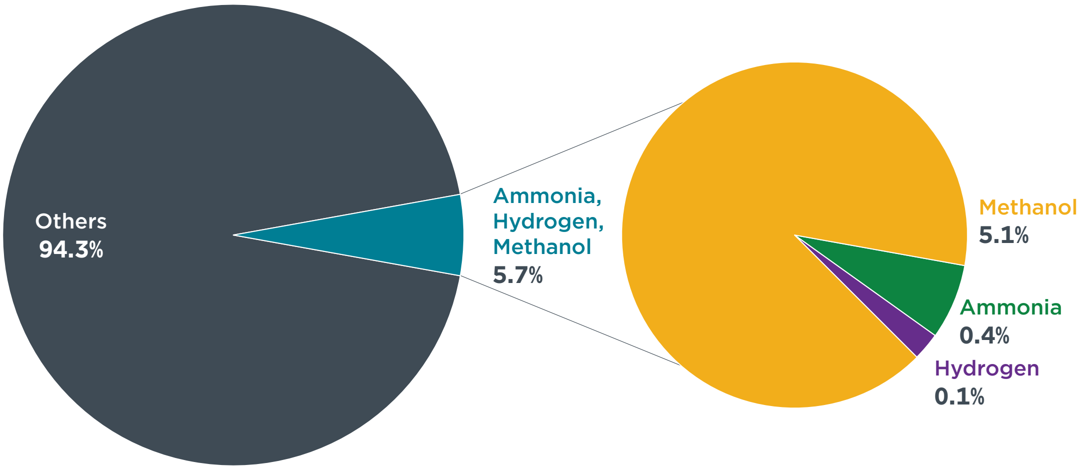
[6] Subsidy amounts in yen were converted to U.S. dollars using the International Monetary Fund's average exchange rate for 2023 rounded to the nearest whole number ($1 = JP ¥141).

Research World Fleet Register (WFR) database as of April 30, 2024 (Clarksons Research, n.d.-a). Of the 8,684 ships in the dataset, only 223 (5.7% by GT) were shown to be powered in some way by methanol, ammonia, or hydrogen (Figure 4).

Figure 4

Percentage of newbuild ships, by gross tonnage, capable of using hydrogen, ammonia, or methanol, 2023–2026



Note: Numbers in the right-hand chart do not sum up to 5.7% due to rounding.

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As shown in Figure 5, the uptake of methanol is driven by container ships. Liner companies like Maersk, CMA CGM, and HMM have started ordering methanol-powered container ships and increasing the number of deliveries each year. According to the WFR dataset, close to 11 million GT (13.2%) of container ships built between 2023 and 2026 will run on dual-fuel engines that can be powered with methanol or diesel. This is followed by bulk carriers at 1.1 million GT (1.5% of bulk carriers) and oil tankers at 0.6 million GT (1.7%). Bulk carriers are leading the uptake of ammonia at 1 million GT (1.4%), followed by liquefied gas tankers at 79,000 GT (0.2%). All these ships' main engines are dual-fuel, capable of switching fuel types depending on fuel prices and local environmental regulations.

Figure 5

Uptake of hydrogen, ammonia, and methanol in 2023–2026 by ship type and gross tonnage

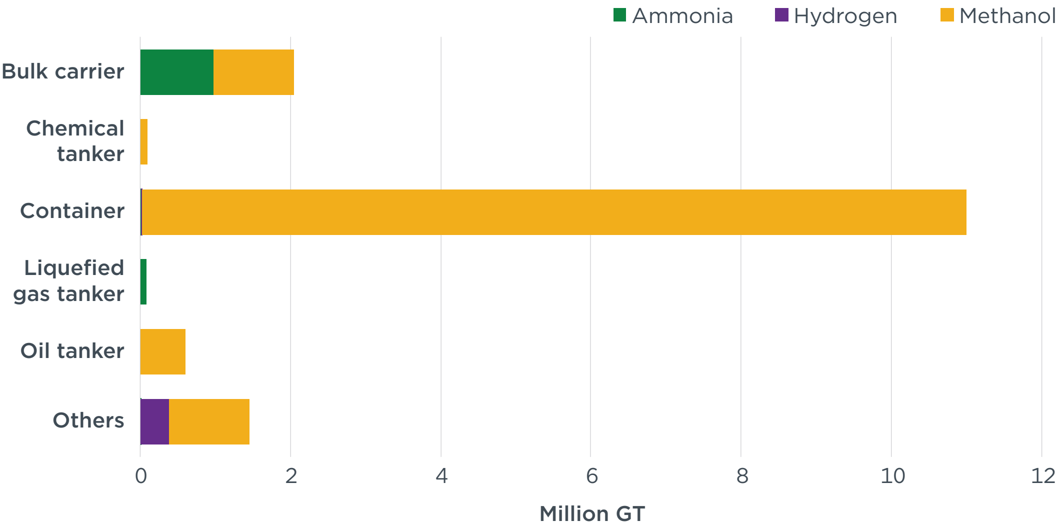
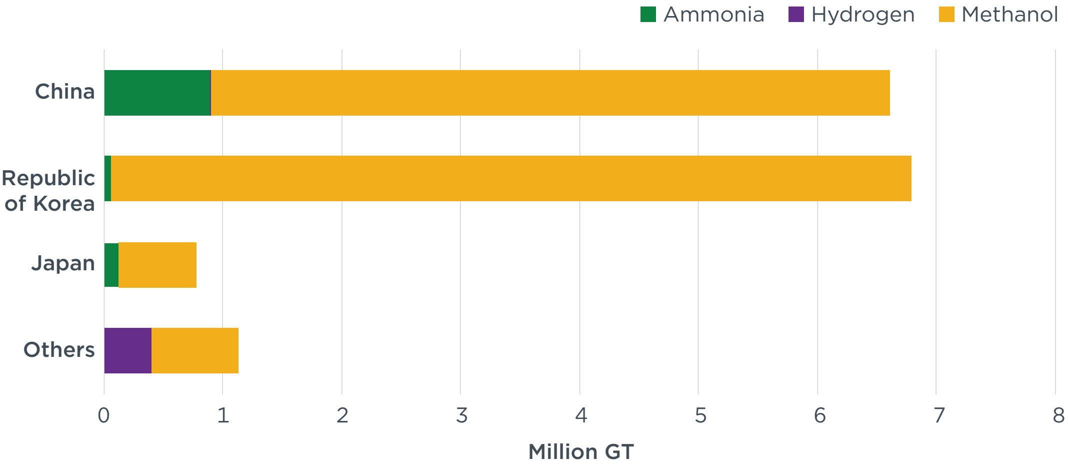


Figure 6 illustrates ZECV deliveries by shipbuilding country. China and Republic of Korea are leaders in building methanol-fueled ships, with methanol-capable ships accounting for 5.7 million GT (4%) of deliveries between 2023 and 2026 in China and 6.7 million GT (9%) in Republic of Korea. Ammonia orders pale in comparison to methanol, with 0.9 million GT (0.6%) of China's portfolio for these 4 years consisting of ammonia dual-fuel vessels. This share is even lower in Japan and Republic of Korea, at 0.4% and 0.07%, respectively.

The hydrogen fuel cell pathway is still in its infancy, with a single project in the dataset: a pilot of pure fuel cell propulsion technology in China. Outside of China, hydrogen projects consist of either hybrid vessels using batteries and fuel cells or a combination of diesel, batteries, and hydrogen fuel cells.

Figure 6

Uptake of hydrogen, ammonia, and methanol in 2023–2026 by shipbuilding country and gross tonnage



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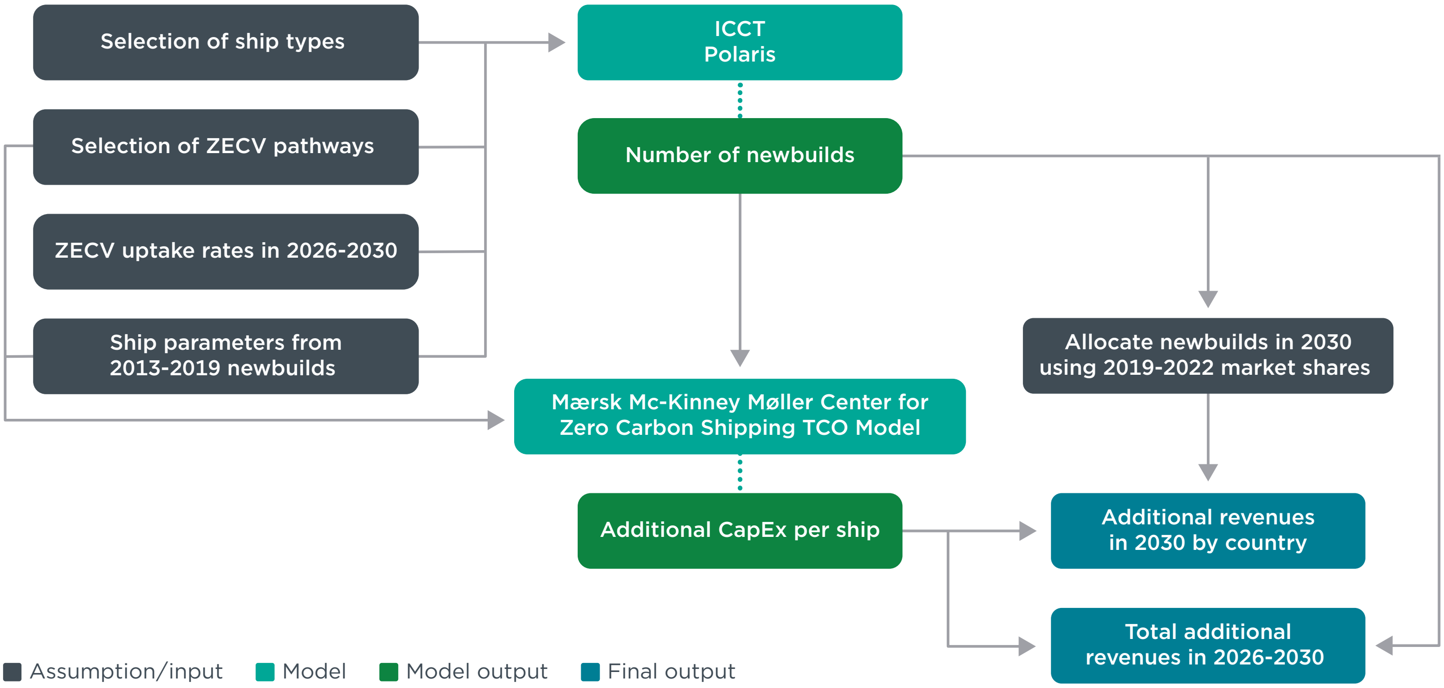
METHODS

The methodology of this paper is illustrated in Figure 7.

Figure 7
Study methodology



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SELECTION OF SHIP TYPES TO ANALYZE

We chose five ship types to estimate additional revenues from ZECV shipbuilding: container ships, bulk carriers, oil tankers, liquefied gas tankers, and chemical tankers. These vessels consume the most fuel (Faber et al., 2020) and accounted for 67% of GHG emissions from international shipping in 2022. They also represented 74.6% of global shipbuilding outputs in CGT between 2019 and 2022. Moreover, as discussed above (see Figure 3), most of the shipbuilding capacity in our three focus countries was used to build these ship types: 77% of total CGT in China, 96% in Republic of Korea, and 89% in Japan. As of April 25, 2024, Clarksons Research (n.d.-b) estimated the value of global deliveries of these five ship types to be $54 billion in 2023.

SELECTION OF ZECV PATHWAYS

We selected fuel and propulsion options for the five selected ship types to estimate the additional CapEx for ZECVs. We designed two scenarios to show the lower and upper bounds of additional revenues: Low CapEx, an ammonia-dominant scenario, and High CapEx, which includes higher-cost hydrogen fuel cell technology. The scenarios are similar to those in our previous work and, as in Meng & Rutherford (2024), should not be interpreted as actual technologies to be deployed on a given ship type or size. We compared these scenarios to a Baseline scenario, in which newbuild ships would run on conventional fuels.

We focused on ammonia and methanol in our Low and High CapEx scenarios as they are the options being considered and built in the near future. Hydrogen fuel cells are considered a potential option for ZECVs to produce no direct climate and air pollution, but the additional CapEx is significantly higher than other options (MARAD, 2024). We included this option in the High CapEx scenario for some segments, mainly small- and medium-sized ships, to get an upper range of the additional revenues to shipbuilders and shipbuilding countries. The details of the scenarios are shown in Table 2.

Table 2

CapEx scenarios by ship type and capacity bin

Ship type	Capacity bin	ZECV pathway	
		Low CapEx scenario	High CapEx scenario
Bulk carrier	1, 2, 3	Ammonia ICE	Hydrogen fuel cell
	4	Methanol ICE	Ammonia ICE
	5, 6	Ammonia ICE	
Chemical tanker	1, 2, 3, 4, 5	Methanol ICE	Hydrogen fuel cell
Container ship	1, 2, 3, 4, 5, 6, 7	Ammonia ICE	Hydrogen fuel cell
	8, 9	Methanol ICE	Ammonia ICE
Oil tanker	1, 2, 3, 4, 5	Methanol ICE	Ammonia ICE
	6	Ammonia ICE	Hydrogen fuel cell
	7, 8	Ammonia ICE	
Liquefied gas tanker	1	Methanol ICE	Ammonia ICE
	2	Ammonia ICE	Hydrogen fuel cell
	3	Ammonia ICE	

Note: Capacity bins for categorizing ship size follow the definitions from the *Fourth IMO Greenhouse Gas Study* (Faber et al., 2020), with 1 being the smallest capacity for that type of ship.

ASSUMPTION OF ZECV UPTAKE RATES FROM 2026 TO 2030

We assumed a ZECV uptake rate of 13.4% for 2026, equivalent to the share (in GT) of alternative fuel-capable vessels in the orderbook to be delivered that year. This share includes battery electric and biofuel vessels in addition to those fueled by ammonia, hydrogen, or methanol; vessels running on fossil fuels (LNG, LPG, or ethane) were excluded. We then assumed a compound annual growth rate (CAGR) of 65.3%, so that the global newbuild ZECV share would reach 100% in 2030, as shown in Table 3.[7] ZECV shares were equally distributed across ship types and sizes. For example, any ship type of any capacity bin would have a ZECV share of 36.6% in 2028.

Table 3

Assumptions of global newbuild ZECV shares from 2026 to 2030

Year	2026	2027	2028	2029	2030
ZECV share (%)	13.4%	22.1%	36.6%	60.5%	100.0%

ESTIMATION OF NEWBUILD FLEET FROM 2026 TO 2030

We used the ICCT's Polaris model v1.0 (ICCT, 2022) to estimate the number of newbuild ships by ship type and capacity bin. Polaris starts with the 2019 fleet inventory of approximately 80,000 ships from the ICCT's Systematic Assessment of Vessel Emissions (SAVE) model and can project the evolution of the world fleet up to 2070.

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[7] CAGR is the average annual growth rate over a given time period when compounding is taken into account (Chan, 2009). For the initial share of 13.4% to grow to 100% in four years, the CAGR must be 65.3% ($13.4 \times 1.653^4 = 100$).

To calculate how many vessels will be built each year, Polaris first forecasts the demand for yearly transport work in cargo ton-nautical miles using United Nations Trade and Development (UNCTAD) data. After retiring ships based on historical survival curves by ship type, Polaris calculates how much transport work demand cannot be met with the remaining fleet and adds newbuild ships needed to fulfill this demand. The model assumes that each segment will retain its historical parameters (e.g., DWT, engine power, fuel tank size) as well as its historical share of total transport work. However, the model forces newbuild ships to comply with the IMO's Energy Efficiency Design Index (EEDI) by limiting the main engine power and maximum speed of noncompliant ships.

For our analysis, we used Polaris' newbuild estimates for selected ship types from 2026 to 2030. The newbuild ZECV shares (Table 3) were used as a scenario input. Additionally, we divided the number of newbuild liquefied gas tankers into LPG tankers and LNG tankers based on their historical shares within the segment. This step was necessary because most LNG tankers use LNG as fuel and, therefore, have higher CapEx than LPG tankers that mostly use conventional fuels.

ADDITIONAL CAPEX MODELING

We used the TCO Model v1.2 from the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (2021) to calculate the CapEx difference between a ZECV and a conventional vessel. In this model, the TCO consists of three cost categories:

- CapEx: including costs of ship hull, engines, battery or fuel cell system, fuel tank, fuel supply system, yard installation, and efficiency levers
- Operating expenses (OpEx): including fuel cost, port and canal fees, and maintenance cost
- Cost of capital: cost of debt and equity

For this analysis, we analyzed only CapEx, which represents costs from a shipowner's perspective but revenues from a shipbuilder or a shipbuilding nation's perspective. We did not consider the ship hull cost, which does not change with the fuel or propulsion pathway, or the cost of an energy-efficiency system, which would vary by technology and have a smaller impact on CapEx than on TCO.

The TCO Model estimated CapEx based on the ship parameters (e.g., engine power and fuel tank size) of the fleet built between 2013 and 2019 and the ZECV pathways presented in Table 2. The CapEx difference between a ZECV and a conventional vessel would be determined by the different unit costs of propulsion systems (in $/MW), fuel tanks (in $/m^3), and fuel supply systems (in $/vessel). These unit cost estimates are in constant 2020 U.S. dollars and the fuels are assumed to be stored onboard in liquid form. We assumed that all conventional vessels except for LNG tankers would run on very low sulfur fuel oil (VLSFO).[8] Conventional LNG tankers were assumed to run on LNG, consistent with typical LNG tanker fuel choices (Comer et al., 2024). The detailed assumptions and formulas of the TCO Model are not shown here, according to the model's terms of use. Detailed ship parameters by ship type and capacity bin are shown in Appendix B.

ADDITIONAL REVENUES IN 2030 GIVEN EXISTING MARKET SHARES

For the Low and High CapEx scenarios, we assumed that all newbuilds in 2030 would be ZECVs and assigned them to each shipbuilding country based on their market

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[8] As there is no separate VLSFO input in the TCO Model, we used the heavy fuel oil (HFO) input as a proxy for VLSFO. We do not expect the CapEx to differ between an HFO-fueled vessel and a VLSFO-fueled vessel.

shares in each segment from 2019 to 2022 as shown in Appendix A. For example, China is assumed to build 65% of the 19 bulk carriers in the Capacity Bin 1 size category, while Japan builds 18% of these ships. Using the per-ship additional CapEx for each ship type and capacity bin we estimated with the TCO Model, we calculated the additional revenues from building ZECVs in 2030 for each country.

ADDITIONAL REVENUES IN 2026–2030 GIVEN INCREASING ZECV UPTAKE

To explore the maximum potential revenues the three countries could collect by building ZECVs in the early stages, we estimated the total additional revenues from 2026 through 2030 using the newbuild estimates from the ICCT Polaris model and the assumptions about ZECV shares (Table 3). We assumed that the three countries would maintain their cumulative market shares in each segment during these 5 years.

RESULTS AND DISCUSSION

ADDITIONAL REVENUES FROM BUILDING ZECVS IN 2030

We estimated that 1,192 ships would be built globally in 2030 across the five ship types. If all of them were to be ZECVs, the additional CapEx—on top of the propulsion system CapEx of $8.0 billion in the Baseline scenario—would range from $6.9 billion to $36.0 billion. This means that building ZECVs could increase shipbuilder revenues from propulsion systems by 86% to 452%. As noted in the methodology, this CapEx does not include hull costs, which are identical for all scenarios. The number of newbuilds and ZECV pathways and propulsion system CapEx for each segment are summarized in Table 4.

For LNG tankers, the additional CapEx is estimated to be minimal or even negative. This is because we assumed LNG tankers to run on LNG in the Baseline scenario. The TCO Model estimates LNG fuel tanks to be more costly than ammonia or methanol fuel tanks, as LNG has a lower boiling point (at -162 °C) than ammonia (-33 °C) or methanol (which is liquid at ambient temperature; American Bureau of Shipping, 2021; MARAD, 2024).

Table 4

Total propulsion system CapEx in 2030 by ship type, size, and scenario in 2020 U.S. dollars

Ship type	Capacity bin	Number of newbuilds	Baseline scenario	Baseline CapEx (millions)	Low CapEx scenario	Low CapEx (millions)	High CapEx scenario	High CapEx (millions)
Bulk carrier	1	19	VLSFO	$23	Ammonia	$60	Hydrogen fuel cell	$199
	2	37	VLSFO	$103	Ammonia	$229	Hydrogen fuel cell	$948
	3	125	VLSFO	$422	Ammonia	$936	Hydrogen fuel cell	$4,015
	4	236	VLSFO	$958	Methanol	$1,819	Ammonia	$2,132
	5	38	VLSFO	$249	Ammonia	$551	Ammonia	$551
	6	40	VLSFO	$315	Ammonia	$697	Ammonia	$697
Chemical tanker	1	34	VLSFO	$27	Methanol	$67	Hydrogen fuel cell	$213
	2	16	VLSFO	$25	Methanol	$52	Hydrogen fuel cell	$209
	3	24	VLSFO	$57	Methanol	$111	Hydrogen fuel cell	$504
	4	24	VLSFO	$83	Methanol	$154	Hydrogen fuel cell	$746
	5	70	VLSFO	$277	Methanol	$508	Hydrogen fuel cell	$2,515
Container ship	1	21	VLSFO	$31	Ammonia	$80	Hydrogen fuel cell	$286
	2	48	VLSFO	$249	Ammonia	$499	Hydrogen fuel cell	$2,250
	3	27	VLSFO	$205	Ammonia	$398	Hydrogen fuel cell	$1,857
	4	23	VLSFO	$274	Ammonia	$535	Hydrogen fuel cell	$2,566
	5	9	VLSFO	$129	Ammonia	$253	Hydrogen fuel cell	$1,224
	6	48	VLSFO	$1,077	Ammonia	$2,076	Hydrogen fuel cell	$10,167
	7	23	VLSFO	$552	Ammonia	$1,092	Hydrogen fuel cell	$5,356
	8	19	VLSFO	$485	Methanol	$841	Ammonia	$967
	9	12	VLSFO	$334	Methanol	$577	Ammonia	$666
Oil tanker	1	57	VLSFO	$38	Methanol	$104	Ammonia	$127
	2	25	VLSFO	$34	Methanol	$74	Ammonia	$86
	3	9	VLSFO	$22	Methanol	$41	Ammonia	$46
	4	5	VLSFO	$24	Methanol	$45	Ammonia	$51
	5	9	VLSFO	$44	Methanol	$81	Ammonia	$93
	6	37	VLSFO	$206	Ammonia	$435	Hydrogen fuel cell	$1,983
	7	25	VLSFO	$190	Ammonia	$387	Ammonia	$387
	8	37	VLSFO	$390	Ammonia	$838	Ammonia	$838
LNG tanker	1	3	LNG	$18	Methanol	$16	Ammonia	$18
	3	27	LNG	$872	Ammonia	$784	Ammonia	$784
LPG tanker	1	44	VLSFO	$126	Methanol	$232	Ammonia	$263
	2	21	VLSFO	$125	Ammonia	$256	Hydrogen fuel cell	$1,171
Total		**1,192**		**$7,962**		**$14,829**		**$43,915**

Table 5 shows by how much the per-vessel propulsion system CapEx can vary depending on the ZECV pathway. A methanol-fueled ship would be cheaper than an ammonia-fueled one, and the propulsion system CapEx would be 10%–20% higher in the High CapEx scenario than in the Low CapEx scenario. If hydrogen fuel cells were chosen as a pathway, the propulsion system CapEx in the High CapEx scenario would be 3.2 to 4.9 times higher than in the Low CapEx scenario.

Table 5

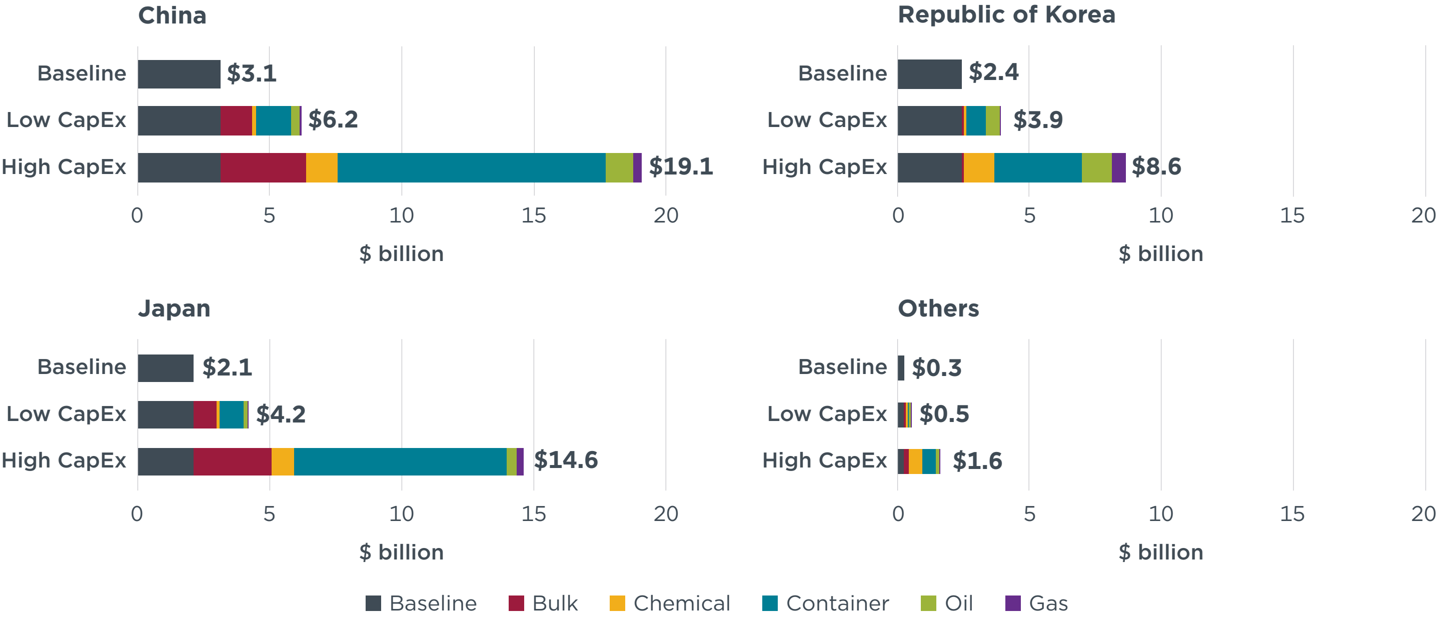
Per-vessel propulsion system CapEx in 2030 by ship type, size, and scenario in 2020 U.S. dollars

Ship type	Capacity bin	Baseline scenario	Baseline CapEx per vessel (millions)	Low CapEx scenario	Low CapEx per vessel (millions)	High CapEx scenario	High CapEx per vessel (millions)	High/Low CapEx ratio
Bulk carrier	1	VLSFO	$1.2	Ammonia	$3.2	Hydrogen fuel cell	$10.5	3.3
	2	VLSFO	$2.8	Ammonia	$6.2	Hydrogen fuel cell	$25.6	4.1
	3	VLSFO	$3.4	Ammonia	$7.5	Hydrogen fuel cell	$32.1	4.3
	4	VLSFO	$4.1	Methanol	$7.7	Ammonia	$9	1.2
	5	VLSFO	$6.5	Ammonia	$14.5	Ammonia	$14.5	1
	6	VLSFO	$7.9	Ammonia	$17.4	Ammonia	$17.4	1
Chemical tanker	1	VLSFO	$0.8	Methanol	$2	Hydrogen fuel cell	$6.3	3.2
	2	VLSFO	$1.5	Methanol	$3.2	Hydrogen fuel cell	$13.1	4
	3	VLSFO	$2.4	Methanol	$4.6	Hydrogen fuel cell	$21	4.5
	4	VLSFO	$3.5	Methanol	$6.4	Hydrogen fuel cell	$31.1	4.9
	5	VLSFO	$4	Methanol	$7.3	Hydrogen fuel cell	$35.9	4.9
Container ship	1	VLSFO	$1.5	Ammonia	$3.8	Hydrogen fuel cell	$13.6	3.6
	2	VLSFO	$5.2	Ammonia	$10.4	Hydrogen fuel cell	$46.9	4.5
	3	VLSFO	$7.6	Ammonia	$14.7	Hydrogen fuel cell	$68.8	4.7
	4	VLSFO	$11.9	Ammonia	$23.3	Hydrogen fuel cell	$111.6	4.8
	5	VLSFO	$14.3	Ammonia	$28.2	Hydrogen fuel cell	$136.1	4.8
	6	VLSFO	$22.4	Ammonia	$43.2	Hydrogen fuel cell	$211.8	4.9
	7	VLSFO	$24	Ammonia	$47.5	Hydrogen fuel cell	$232.9	4.9
	8	VLSFO	$25.5	Methanol	$44.3	Ammonia	$50.9	1.1
	9	VLSFO	$27.9	Methanol	$48.1	Ammonia	$55.5	1.2
Oil tanker	1	VLSFO	$0.7	Methanol	$1.8	Ammonia	$2.2	1.2
	2	VLSFO	$1.4	Methanol	$3	Ammonia	$3.4	1.2
	3	VLSFO	$2.4	Methanol	$4.5	Ammonia	$5.1	1.1
	4	VLSFO	$4.8	Methanol	$9	Ammonia	$10.1	1.1
	5	VLSFO	$4.9	Methanol	$9	Ammonia	$10.3	1.1
	6	VLSFO	$5.6	Ammonia	$11.8	Hydrogen fuel cell	$53.6	4.6
	7	VLSFO	$7.6	Ammonia	$15.5	Ammonia	$15.5	1
	8	VLSFO	$10.5	Ammonia	$22.6	Ammonia	$22.6	1
LNG tanker	1	LNG	$5.8	Methanol	$5.3	Ammonia	$6	1.1
	3	LNG	$32.3	Ammonia	$29	Ammonia	$29	1
LPG tanker	1	VLSFO	$2.9	Methanol	$5.3	Ammonia	$6	1.1
	2	VLSFO	$6	Ammonia	$12.2	Hydrogen fuel cell	$55.7	4.6

If we assigned these additional revenues to each shipbuilding country based on their current (2019–2022) market shares, Republic of Korea, which builds a large share of liquefied gas tankers, would have the lowest additional revenues among the three countries in both Low and High CapEx scenarios (Figure 8). Republic of Korea would also have the smallest relative difference between the Low and High CapEx scenarios, given that it focuses on building larger vessels for which we did not consider hydrogen fuel cells as a pathway. China would garner additional revenues of $3.1–$15.9 billion, an expected increase in CapEx revenue of 98% to 510% compared with the Baseline scenario of $3.1 billion. Republic of Korea would have additional revenues of $1.5–$6.2 billion, up 60% to 253% compared with the Baseline of $2.4 billion, and Japan would collect an additional $2.1–$12.5 billion in 2030, up 97% to 583% from the Baseline of $2.1 billion. Other countries building these five ship types would earn additional revenues of $0.3–$1.4 billion, up 103% to 540% from the Baseline of $250 million.

Figure 8

CapEx revenues from building ZECVs in 2030, by shipbuilding country, ship type, and scenario in billions of 2020 U.S. dollars



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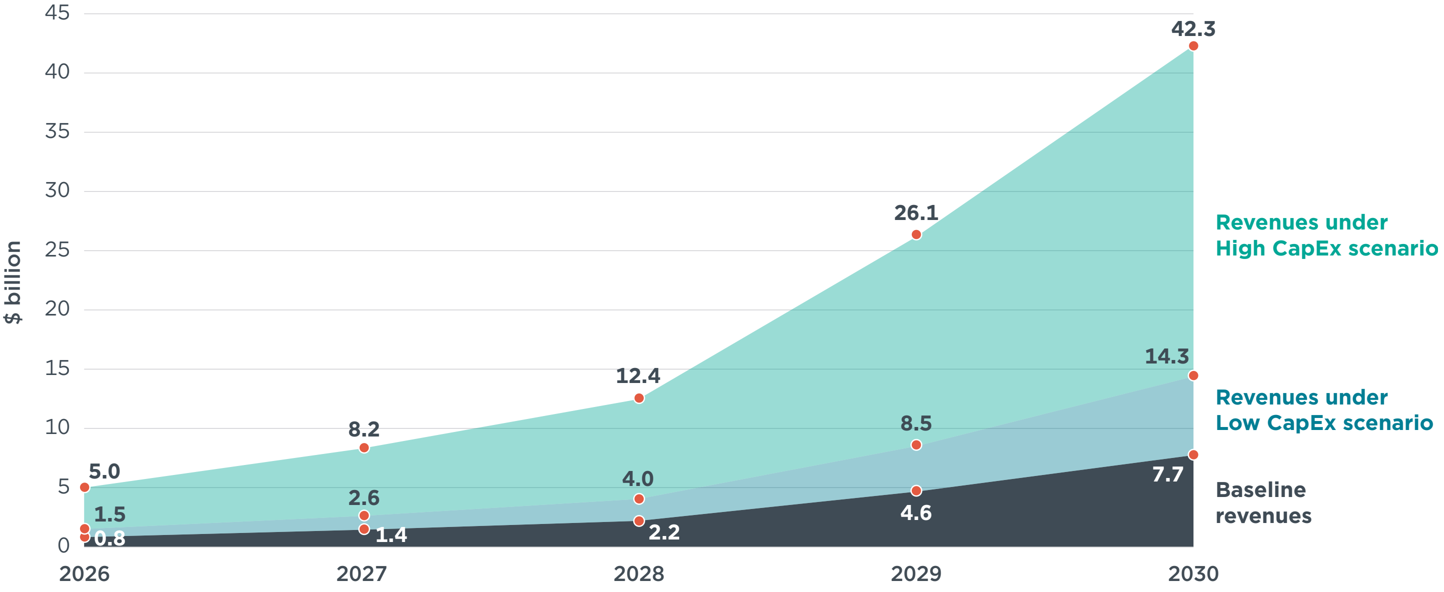
By assuming that all ships, other than LNG tankers, would run on VLSFO in the Baseline, we may be overestimating the additional revenues, given that other ship types have been (and are being) built to run on LNG. As of April 2024, in terms of GT, 5.6% of the entire existing fleet and 32% of ships on order were LNG-capable; among LNG-capable ships on order, 30% were container ships and 15% were oil tankers (Clarksons Research, n.d.-c). As with LNG tankers, the additional revenues for an ammonia- or methanol-fueled container ship or oil tanker would be minimal or negative compared with the revenue of building a ship fueled by LNG. At the same time, from the shipowner's perspective, the increasing uptake of LNG-capable ships implies that the additional CapEx of methanol- or ammonia-fueled vessels would be a less significant barrier to the adoption of ZECVs than the cost of zero-emission fuel (Velandia Perico et al., 2023).

ADDITIONAL REVENUES IN 2026–2030 AND POTENTIAL FIRST-MOVER ADVANTAGES

Given our assumptions on ZECV uptake rates (Table 3), we estimated the global CapEx from ZECV shipbuilding from 2026 through 2030 to be $14.7 billion in the Low CapEx scenario and $80.5 billion in the High CapEx scenario, in addition to $17.3 billion in revenues from the propulsion system in the Baseline scenario. If China, Republic of Korea, and Japan were to maintain their aggregate shipbuilding market shares from 2019–2022, they would capture the great majority of this additional revenue, with a collective $14.2 billion in the Low CapEx case and $77.4 billion in the High CapEx case—up 85% to 463% from the Baseline revenue of $16.7 billion (see Figure 9). For the year 2030 alone, total revenue—including Baseline revenue—would be $42.3 billion for the High CapEx scenario and $14.3 billion for the Low CapEx scenario.

Figure 9

Range of additional CapEx from building ZECVs in China, Republic of Korea, and Japan in 2026–2030, in billions of 2020 U.S. dollars



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As ZECVs are a new product category equipped with different propulsion and fuel storage technologies, there is potential for a first-mover advantage in the ZECV market. A first-mover advantage refers to a firm's ability to be better off than its competitors as a result of being the first to enter a market. Lieberman & Montgomery (1988) discussed three primary sources of the first-mover advantage: (1) technological leadership, (2) preemption of assets, and (3) buyer switching costs and buyer choice under uncertainty.

For the shipbuilding industry, technological leadership derived from the learning curve and success in R&D and patent races would be most relevant. Empirical data show that the workload, expressed in the number of person-hours, declines as a shipyard builds a specific ship design in series (OECD, 2006). A first mover in ZECV shipbuilding could gain from lower production costs, especially during the transition period, and by protecting or licensing its R&D outputs in the longer term. For instance, while it is not a shipbuilder, France's Gaztransport & Technigaz has rights to the original technology for a specific type of LNG cargo tank that is the de facto standard for LNG tankers and receives royalties for every LNG tanker built using its technology (Hellenic Shipping News, 2023).

A first mover also benefits when buyers find it inconvenient to switch to a later entrant's product because of initial transaction costs, supplier-specific learning, or extra market research on product quality. Although this type of brand loyalty has a greater effect for consumer goods than for industrial goods (Lieberman & Montgomery, 1988), it could exist in the ZECV market as well. Negotiation and contractual processes are time-consuming and can be even more so with a new shipbuilder or for a new ship design (Stopford, 2009). Until technologies mature and shipowners become more aware of competing products, shipowners might want to stick with shipbuilders with proven track records. A first mover could thus be more selective in their choice of ships to build and choose to build high-value ships in their limited number of berths.

It is important to note that this analysis did not consider the following factors, which could have implications for shipbuilders' decisions and economic outcomes:

- Reductions in CapEx as ZECV technology develops: The TCO Model assumes no unit cost changes for propulsion or fuel-storage technologies except for hydrogen fuel cells and hydrogen fuel tanks. Costs could go down as the technology evolves and is deployed on more ships, leading to lower per-vessel CapEx, especially in the long term beyond 2030.
- Baseline vessel prices: We focused on the price difference between a ZECV and a vessel running on VLSFO (or LNG in the case of LNG tankers). However, shipbuilders deciding what to build may focus on total price, including the hull cost, especially during the early transition period. For example, the additional CapEx for an average Capacity Bin 8 (14,500–19,999 TEU) container ship ranges from $19–$25 million. According to Clarksons Research's (2024) World Shipyard Monitor, average prices for a 15,500-TEU container ship and a 23,000-TEU container ship were $169 million and $236 million, respectively, at the end of 2023. A shipbuilder might therefore be better off building a conventional Capacity Bin 9 (greater than 20,000 TEU) container ship than a Capacity Bin 8 zero-emission capable container ship.
- Energy-efficiency system costs: Systems such as air lubrication to reduce hull friction or wind-assist technologies to aid propulsion were not considered. ZECVs may be equipped with such systems given the high cost of zero-emission fuels (Sturrup & Stolz, 2023), which would increase CapEx but reduce OpEx.
- Domestic versus imported supply chain for inputs: Although we allocated all of the additional revenues from building ZECVs to the shipbuilding countries, their actual revenues might be lower or higher depending on whether they import or export intermediate inputs. Gourdon & Steidl (2019) estimated that the share of domestic value added (i.e., contributions of domestic production to the final product value) in the shipbuilding industry varied across major shipbuilding countries in 2015, with the Republic of Korea having the lowest share at 65% and China the highest share at 89%. A first mover with technological leadership in ZECV shipbuilding could potentially enjoy a higher share of additional domestic value and capture more additional revenues by exporting intermediate inputs to other countries.
- Loss of cargo space in ZECVs: Because ammonia, hydrogen, and methanol have lower energy densities than VLSFO, ZECVs might require more space onboard for fuel storage at the expense of cargo space. As a result, shipowners may decide to operate their vessels at higher speeds or more ships could be built to meet the demand for transport work.
- Different ZECV uptake rates across ship types: To estimate additional revenues from 2026 to 2030, we assumed an identical ZECV uptake rate regardless of ship type and size. As shown in Figure 5, some segments might have higher ZECV uptake rates than others.

- Potential ZECV pathways other than ammonia, methanol, and hydrogen fuel cell: In line with Meng & Rutherford (2024), we did not consider two other potential options—electrification (using batteries) and biofuels. Electrification is challenging for deep-sea shipping and implies high CapEx from battery costs. Drop-in biofuels would have little impact on CapEx but result in higher OpEx; the supply of sustainable biofuel is also limited. We also did not consider hydrogen ICE; this pathway was not included as an option in the TCO Model and it is not as efficient as hydrogen fuel cell technology (McKinlay et al., 2021).

FINDINGS AND CONCLUSIONS

This paper surveyed the shipbuilding market and government measures supporting the industry in three major shipbuilding countries: China, Republic of Korea, and Japan. It then estimated the additional revenues these countries could earn by building ZECVs instead of conventional vessels. We found that:

- Between 2019 and 2022, China, Republic of Korea, and Japan mainly built cargo ships, with the market shares for each country varying by ship type and size. China and Japan had similar shipbuilding portfolios, primarily building bulk carriers, container ships, and oil tankers. The Republic of Korea mainly built liquefied gas tankers, oil tankers, and container ships.
- All three countries have recently implemented policies to support "new and clean energy," "green," or "next-generation" shipbuilding. However, these initiatives all include support measures for ships fueled by LNG, which is a fossil fuel that can result in higher GHG emissions than conventional marine fuels.
- We estimated that 1,192 ships would be built in 2030 across five ship types: bulk carriers, chemical tankers, container ships, oil tankers, and liquefied gas tankers. Building these ships to run on VLSFO (or LNG in the case of LNG tankers) would cost $8 billion for the propulsion systems. Building all these ships as ZECVs would result in projected additional CapEx ranging from $6.9 billion to $36.0 billion. This means that building ZECVs could increase shipbuilder revenues related to the propulsion system by 86% to 452%. Based on these estimates, given each country's current market shares, China would reap additional revenues of $3.1–$15.9 billion (98% to 510% above the Baseline), Republic of Korea would collect an additional $1.5–$6.2 billion (60% to 253% above Baseline), and Japan would collect an additional $2.1–$12.5 billion (97% to 583% above Baseline).
- Additional CapEx would be lowest for methanol-fueled ships, followed by ships using ammonia and hydrogen fuel cells. The additional CapEx for an LNG-fueled ship switching to methanol or ammonia is estimated to be minimal or even negative due to high LNG fuel tank costs.
- Assuming a CAGR of 65.3% in ZECV uptake, the additional revenues from ZECV shipbuilding in these countries from 2026 through 2030 would range from $14.2 to $77.4 billion, up 85% to 463% compared with building conventional propulsion systems.

According to these estimates, the additional revenues from ZECV shipbuilding could be substantial. A first mover with technological leadership in building ZECVs could potentially capture a greater share of the market and generate even more revenue by exporting intermediate inputs to other countries. China, Republic of Korea, and Japan—three countries that have invested in strategies to grow their domestic shipbuilding industries—are well-positioned to realize first-mover advantages by focusing their resources on developing and promoting ZECVs.

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APPENDIX A
MARKET SHARES BY SHIPBUILDING COUNTRY, SHIP TYPE, AND SHIP SIZE

The size units and ranges used to allocate capacity bins follow the *Fourth IMO Greenhouse Gas Study* (Faber et al., 2020) and are shown in Appendix B. Information on market shares and top shipbuilders is sourced from S&P Global.

Table A1

Market shares for bulk carriers built in 2019–2022 and top shipbuilders by capacity bin

Capacity bin	China	Republic of Korea	Japan	Others	Top 3 shipbuilder groups
1	64.6%	0.0%	17.6%	17.7%	Huanghai Shipbuilding, Penglai Jinglu Shipyard, Miura Zosensho
2	68.4%	1.3%	28.7%	1.7%	Namura Zosensho, Shin Kurushima Group, Yangzijiang Holdings
3	41.6%	0.0%	56.4%	2.0%	Imabari Shipbuilding, Oshima Shipbuilding, Shin Kurushima Group
4	56.6%	0.0%	37.6%	5.8%	COSCO Shipping Heavy Industry, Tsuneishi Holdings, China State Shipbuilding Corp. (CSSC)
5	45.2%	4.3%	50.6%	0.0%	CSSC, Imabari Shipbuilding, Japan Marine United
6	72.0%	11.4%	15.1%	1.5%	CSSC, New Century Shipbuilding Group, COSCO Shipping Heavy Industry

Table A2

Market shares for chemical tankers built in 2019–2022 and top shipbuilders by capacity bin

Capacity bin	China	Republic of Korea	Japan	Others	Top 3 shipbuilder groups
1	35.2%	2.5%	21.0%	41.2%	Rhine-Danube d.o.o., GS Yard B.V., Jiangsu Haitong Offshore Engineering Equipment
2	44.4%	5.3%	13.4%	36.9%	China Merchants Group, Partner Stocznia, Jiangsu Haitong Offshore Engineering Equipment
3	42.2%	1.9%	51.3%	4.7%	Fukuoka Shipbuilding, Asakawa Shipbuilding, China Merchants
4	40.9%	10.9%	45.5%	2.7%	Shin Kurushima Group, Fujian Shipbuilding, HD Korea Shipbuilding & Offshore Engineering
5	26.5%	48.0%	10.5%	15.0%	HD Korea Shipbuilding & Offshore Engineering, CSSC, New Century Shipbuilding

Table A3
Market shares for container ships built in 2019–2022 and top shipbuilders by capacity bin

Capacity bin	China	Republic of Korea	Japan	Others	Top 3 shipbuilder groups
1	78.1%	7.6%	2.7%	11.6%	Ningbo Boda Shipbuilding, Huanghai Shipbuilding, Haidong Shipyard
2	61.1%	21.7%	13.0%	4.3%	HD Korea Shipbuilding & Offshore Engineering, Yangzijiang Holdings, CSSC
3	74.2%	3.7%	12.8%	9.3%	CSSC, Yangzijiang Holdings, Imabari Shipbuilding
4	51.6%	0.0%	38.7%	9.7%	Japan Marine United, Yangzijiang Holdings, COSCO Shipping Heavy Industry
5	100.0%	0.0%	0.0%	0.0%	New Changjiang Group
6	37.1%	0.0%	62.9%	0.0%	Imabari Shipbuilding, Yangzijiang Holdings
7	34.0%	46.4%	19.6%	0.0%	Samsung Heavy Industries, HD Korea Shipbuilding & Offshore Engineering, Yangzijiang Holdings
8	20.5%	79.5%	0.0%	0.0%	HD Korea Shipbuilding & Offshore Engineering, CSSC, Daewoo Shipbuilding & Marine Engineering (DSME)[9]
9	32.2%	59.1%	8.7%	0.0%	DSME, CSSC, Samsung Heavy Industries

Table A4
Market shares for oil tankers built in 2019–2022 and top shipbuilders by capacity bin

Capacity bin	China	Republic of Korea	Japan	Others	Top 3 shipbuilder groups
1	42.3%	5.0%	15.9%	36.8%	Zhoushan Hetai Shipbuilding, Bashundhara Group, Usda Seroja Jaya
2	78.9%	1.1%	5.6%	14.4%	Qidong Jisheng Shipbuilding, Linhai Huajie Shipbuilding, Dayang Offshore Equipment
3	86.6%	0.0%	2.4%	10.9%	Haitong Offshore Engineering Equipment, Qidong Jisheng Shipbuilding, Fujian Shipbuilding
4	61.9%	31.2%	0.0%	6.9%	CSSC, HD Korea Shipbuilding & Offshore Engineering, COSCO Shipping Heavy Industry
5	63.5%	0.0%	18.8%	17.7%	CSSC, Onomichi Dockyard, Jiangsu Hantong Group
6	40.6%	38.5%	16.0%	5.0%	CSSC, Daehan Shipbuilding, Samsung Heavy Industries
7	30.6%	62.7%	5.0%	1.6%	HD Korea Shipbuilding & Offshore Engineering, Samsung Heavy Industries, New Century Shipbuilding Group
8	16.1%	65.6%	18.3%	0.0%	HD Korea Shipbuilding & Offshore Engineering, DSME, CSSC

Table A5
Market shares for liquefied gas tankers built in 2019–2022 and top shipbuilders by capacity bin

Capacity bin	China	Republic of Korea	Japan	Others	Top 3 shipbuilder groups
1	29.7%	45.6%	20.9%	3.8%	HD Korea Shipbuilding & Offshore Engineering, CIMC, CSSC
2	29.1%	50.6%	20.4%	0.0%	HD Korea Shipbuilding & Offshore Engineering, CSSC, Kawasaki Heavy Industries
3	6.0%	86.9%	7.1%	0.0%	HD Korea Shipbuilding & Offshore Engineering, DSME, Samsung Heavy Industries

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[9] In 2023, DSME was renamed Hanwha Ocean after its acquisition by Hanwha Group.

APPENDIX B

Table B1

Parameters of newbuild ships

Ship type (Size unit)	Capacity bin	Capacity range	Gross tonnage (GT)	Main engine power (MW)	Auxiliary engine power (MW)	Fuel tank size (m^3)
Bulk carrier (DWT)	1	0–9,999	3,220	1.86	1.01	795
	2	10,000–34,999	18,624	5.63	1.94	1,305
	3	35,000–59,999	27,186	7.34	2.02	1,751
	4	60,000–99,999	40,435	9.27	2.08	2,416
	5	100,000–199,999	89,875	15.94	2.61	4,663
	6	200,000+	129,187	18.97	3.17	6,123
Chemical tanker (DWT)	1	0–4,999	1,610	1.28	0.60	259
	2	5,000–9,999	4,997	2.86	1.25	370
	3	10,000–19,999	10,504	4.64	1.90	703
	4	20,000–39,999	20,714	6.77	2.76	1,220
	5	40,000+	30,112	8.00	2.99	1,431
Container ship (TEU)	1	0–999	5,370	2.89	0.97	857
	2	1,000–1,999	15,405	10.33	4.14	1,756
	3	2,000–2,999	28,694	14.78	6.35	2,760
	4	3,000–4,999	43,026	25.56	8.42	4,617
	5	5,000–7,999	61,480	31.41	9.58	6,093
	6	8,000–11,999	102,097	48.07	15.94	9,403
	7	12,000–14,499	145,554	54.74	14.54	11,257
	8	14,500–19,999	177,590	57.66	15.27	13,594
	9	20,000+	211,398	61.65	17.29	15,803
Oil tanker (DWT)	1	0–4,999	1,802	1.22	0.33	402
	2	5,000–9,999	4,957	2.61	0.98	507
	3	10,000–19,999	11,306	4.09	2.26	764
	4	20,000–59,999	31,022	11.29	2.73	1,564
	5	60,000–79,999	43,238	10.96	2.94	2,057
	6	80,000–119,999	62,738	12.54	3.26	2,727
	7	120,000–199,999	82,470	16.43	4.97	3,654
	8	200,000+	160,269	26.02	4.27	6,974
LNG tanker (m^3)	1	0–49,999	11,602	4.98	2.65	932
	3	100,000–199,999	116,006	34.83	10.03	3,512
LPG tanker (m^3)	1	0–49,999	11,602	4.98	2.65	932
	2	50,000–99,999	47,755	12.62	4.14	2,540

APPENDIX C

Table C1

Estimated number of newbuild ships by type and size, 2026 to 2030

Ship type	Capacity bin	Number of newbuilds				
		2026	2027	2028	2029	2030
Bulk carrier	1	14	16	14	19	19
	2	27	29	30	33	37
	3	96	103	97	113	125
	4	179	193	188	212	236
	5	28	30	30	33	38
	6	31	33	32	36	40
Chemical tanker	1	31	33	34	40	34
	2	16	15	15	19	16
	3	23	24	23	27	24
	4	22	24	24	28	24
	5	62	68	66	78	70
Container ship	1	15	18	15	21	21
	2	36	38	34	49	48
	3	21	22	19	27	27
	4	17	18	16	23	23
	5	7	6	6	8	9
	6	36	37	33	48	48
	7	17	18	16	22	23
	8	14	15	13	18	19
	9	8	9	8	11	12
Oil tanker	1	43	46	43	56	57
	2	20	20	19	25	25
	3	7	8	7	8	9
	4	3	4	4	5	5
	5	7	8	7	8	9
	6	30	31	29	36	37
	7	20	21	19	25	25
	8	29	31	28	35	37
LNG tanker	1	3	3	3	4	3
	3	23	24	25	32	27
LPG tanker	1	39	42	41	55	44
	2	19	20	20	26	21
Total		**943**	**1,007**	**958**	**1,180**	**1,192**

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