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Global Green Shipping Development Report



Shanghai International Shipping Institute (SISI)
World Maritime University (WMU)

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Working Group for "Global Green Shipping Development Report (2025-2026)"

This report was jointly prepared by World Maritime University and the Shanghai International Shipping Institute.

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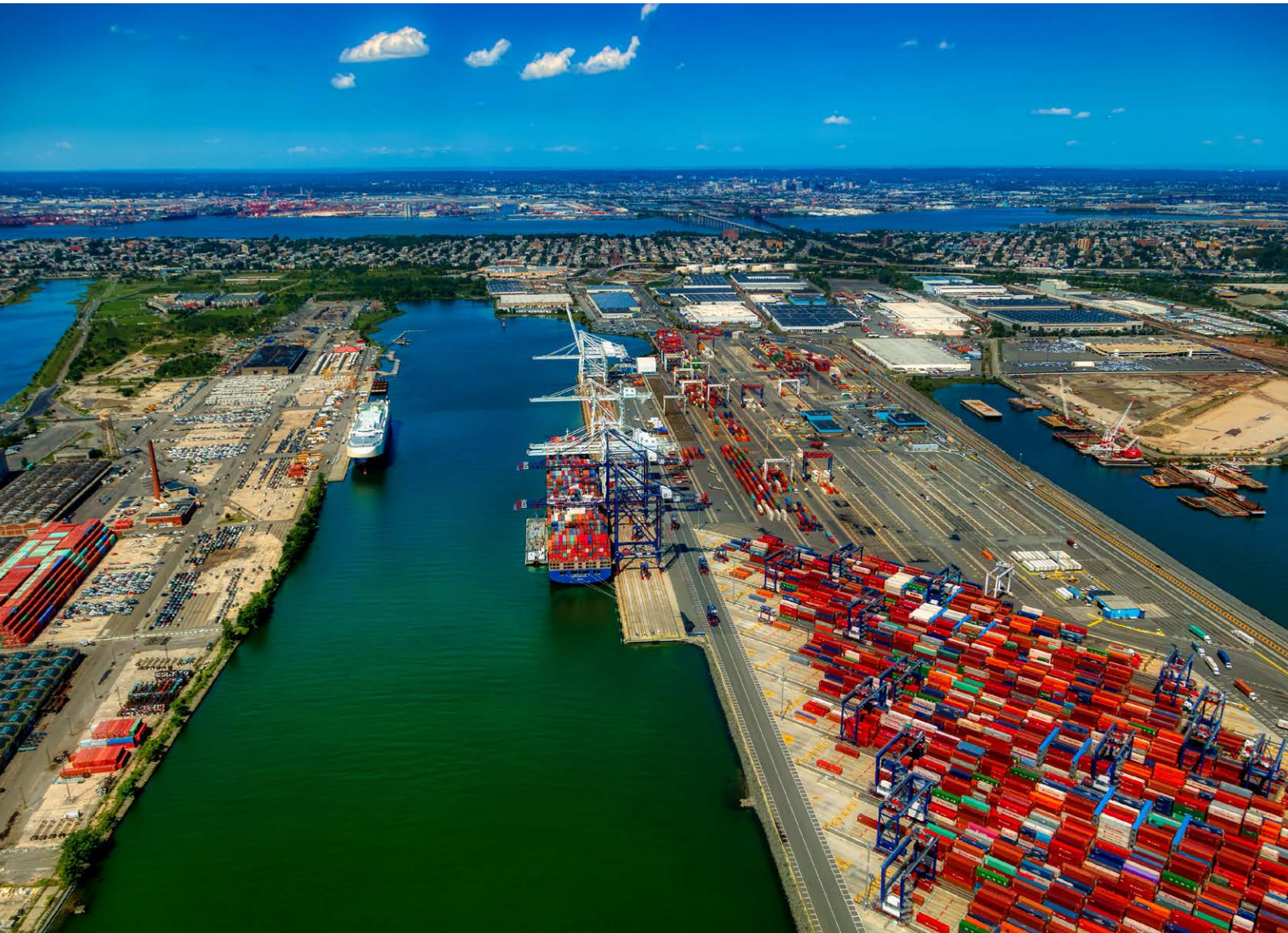
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PREFACE

In 2025–2026, the global green transition of shipping was characterized by the accelerated implementation of emissions reduction requirements alongside continued uncertainty over transition pathways. Compliance requirements for shipping under the EU Emissions Trading System (EU ETS) continued to advance, while FuelEU Maritime has been implemented since 2025. The impacts of factors such as carbon emission costs and the greenhouse gas intensity of energy used on board ships on the operations of shipping companies have become increasingly apparent. At the same time, the International Maritime Organization (IMO) Net-Zero Framework has not yet been formally adopted, and the relevant mechanisms and implementation arrangements remain under discussion. As rules are implemented at an accelerating pace while fuels, technologies, and markets continue to evolve rapidly, investment and operational decisions for shipping companies have become increasingly complex. Given the long service life of vessels, newbuilds, vessel retrofits, and fuel choices will have long-term impacts on fleet operating costs and compliance capabilities. Green fuels have yet to reach full maturity in terms of supply scale, pricing, and infrastructure, while different technological pathways have different conditions of applicability. For shipping companies, the green transition has gradually shifted from the question of "whether to reduce emissions" to how to plan fleet renewal, select energy sources and technological pathways, and control long-term investment risks while meeting current compliance requirements. The interactions among policy, energy, technology, and the market have also resulted in increasingly diverse pathways for advancing the global green shipping transition.





The Global Green Shipping Development Report (2025–2026) continues to be jointly compiled by the Shanghai International Shipping Institute and the World Maritime University, and mainly reflects developments in global green shipping from October 2025 to September 2026. The report continues its annual tracking of policies and regulations, market mechanisms, alternative energy sources, ship energy-saving and emission-reduction technologies, and industry practices. It focuses on changes in green shipping policies and regulations at the International Maritime Organization (IMO), in the European Union (EU), and in China; developments in market mechanisms such as carbon trading, industry initiatives, standards, and certification; progress in alternative marine energy sources, including LNG, methanol, hydrogen, ammonia, battery power, and biofuels, as well as related infrastructure; and actions taken by major countries, shipping companies, and ports to advance the green transition. Through continuous observation of developments across these areas, the report seeks to reflect changes at this stage of global green shipping development and their impacts on the industry.

This report is primarily based on policy documents, research findings, and related information publicly released by international organizations, government departments, industry bodies, research institutions, and companies, and draws on the views of industry experts in its analysis and assessment. It seeks to provide industry stakeholders with a reference for understanding global green shipping policies and regulations and trends in energy technologies and markets. The preparation of this report benefited from the support of relevant experts and industry colleagues, to whom we would like to express our gratitude. Due to limitations in the availability of information and the timing of the research, the report may contain omissions. Comments and corrections are welcome.

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Chapter 1

Green Shipping Policies

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1.1 IMO Regulatory update

Since the previous issue of this report in 2025, the latest significant IMO GHG regulatory developments come from three Intersessional Working Group on Reduction of Greenhouse Gas Emissions from Ships (ISWG-GHG 20, 21 & 22) in October 2025, April 2026, and September 2026 respectively, as well as the 84th session of the Marine Environment Protection Committee (MEPC), held in late April and early May 2026.

After approval of the historic IMO Net-Zero Framework (NZF) at MEPC 83 (7 to 11 April 2025), it was expected that the NZF be adopted during the second Extraordinary Session of the MEPC (MEPC ES.2) in October 2025 to mark a pivotal moment in international climate governance. The approved NZF is including new requirements on greenhouse gas (GHG) fuel intensity, in combination with a pricing and reward mechanism. Adoption requires acceptance by two-thirds of the parties to MARPOL Annex VI representing at least 50% of the gross tonnage of the world's merchant fleet. The regulatory content of the approved NZF apply to all ships above 5,000 GT, except ships trading solely domestically and platforms including FPSOs, FSUs and drilling rigs, and semi-submersible vessels.

1.1.1 ISWG-GHG 20

At ISWG-GHG 20, member states were unable to reach agreement on several key implementation issues related to the IMO NZF. As a result, the adoption of the NZF adjourned and the unresolved items were deferred for further negotiation over the coming year rather than being finalized at that session. The issues that remained unresolved included:

- The detailed design and governance of the IMO Net-Zero Fund.
- Rules for disbursement of revenues, including support for developing countries and the maritime energy transition.
- Certain aspects of the Global Fuel Standard (GFS) implementation, including compliance mechanisms and administrative details.
- Governance arrangements and legal text associated with the new measures.
- This postponement does not delay the overall target of bringing the IMO Net-Zero Framework into force (subject to formal adoption and ratification processes), but it does postpone agreement on the detailed implementation rules that industry will need for compliance.

1.1.2 ISWG-GHG 21

At ISWG-GHG 21, work was undertaken to develop guidelines necessary for the implementation of the current draft mid-term measures, as follows:

- Draft guidelines for calculation of attained annual GHG fuel intensity (GFI)
- Draft guidelines for rewards for ships used zero or near-zero fuels/technologies
- Wind Propulsion System guidance
- Draft governance provisions of the IMO Net-Zero Fund
- Draft guidelines on fuel certification scheme
- LCA (Life Cycle Assessment) guidelines

1.1.3 ISWG-GHG 22

ISWG-GHG 22 served as a critical stepping stone to refine the proposed IMO Net-Zero Framework (NZF) ahead of major decision-making windows at ISWG-GHG 23 and MEPC 85 later in the year. While the meeting concluded without an agreed final legal text, several key conclusions and takeaways emerged for the shipping industry:

1. No Appetite to Abandon the Net-Zero Framework

The NZF remains the definitive path forward. Though member states presented alternative proposals, none attracted enough traction to replace the core framework. The conversation has definitively shifted from whether the framework should exist to how it will be refined.

2. Strong Majority Support for Carbon Pricing

A clear majority of participating member states (approximately two-thirds) expressed continued backing for a centralized revenue-collection system tied to a global greenhouse gas price. This carbon-pricing mechanism is intended to penalize fossil-fuel reliance and use accumulated funds to reward early adopters of zero-emission tech, ensuring a just and equitable transition. A smaller contingent of states closely aligned with fossil-fuel interests argued for technical-only solutions.

3. Debate Over a "Softer Start, Harder Finish"

One of the most active debates surrounded the trajectory of reducing Greenhouse Gas Fuel Intensity (GFI). Several member states (including a prominent proposal from Brazil) argued for a more relaxed initial emissions-reduction curve to alleviate immediate compliance pressures and accommodate current limits in alternative fuel availability. However, other delegations warned that a softer start could delay crucial early-stage infrastructure investments.

4. Technical Rules Over Headline Targets

The session highlighted that the eventual commercial value of alternative fuels (like e-LNG or ammonia) will not be determined solely by high-level emissions targets. Instead, the intricate technical guidelines will dictate market value. Industry observers noted that final rules surrounding fuel certification, mass balancing, methane slip, and well-to-wake lifecycle assessments are what will ultimately determine how different fuel pathways are rewarded.

5. Timelines Are Compressed and Unresolved

Because a final consensus on the legal text was not achieved, the working group deferred deep consideration of specific implementation guidelines and the Life Cycle GHG Assessment (LCA) framework. These elements have been pushed to ISWG-GHG 23 in late November 2026, leaving a very tight window before the Extraordinary Session of MEPC in December 2026, where a finalized package is highly anticipated.

1.1.4 MEPC 84

At the MEPC 84, member states failed to reach a final agreement on the debated NZF mid-term measures, and the discussions are supposed to continue on both the regulatory framework and on supporting guidelines at two intersessional working groups on GHG (22 & 23) ahead of MEPC 85 in December 2026. on the positive side, a clear commitment of member states to the IMO GHG strategy 2023, to achieve net zero by or around 2050, and the establishment of a global IMO mechanism could be observed in MEPC 84. However, many also believe in the amendment of the NZF to find consensus, and to consider market readiness and commercial availability of alternative fuels suitable to comply with GHG intensity reduction targets in this amendment.

1.1.5 GHG Fuel Standard (GFS) and GHG Fuel Intensity (GFI)

As approved in MEPC 83, it is supposed that the NZF forms a new Chapter 5 of the revised Annex VI of the MARPOL. It comprises a set of international regulations aimed at reducing GHG emissions from ships, in line with IMO's 2023 strategy for reduction of GHG emissions from ships. It includes two key elements: a global fuel standard and global GHG emissions pricing mechanism.

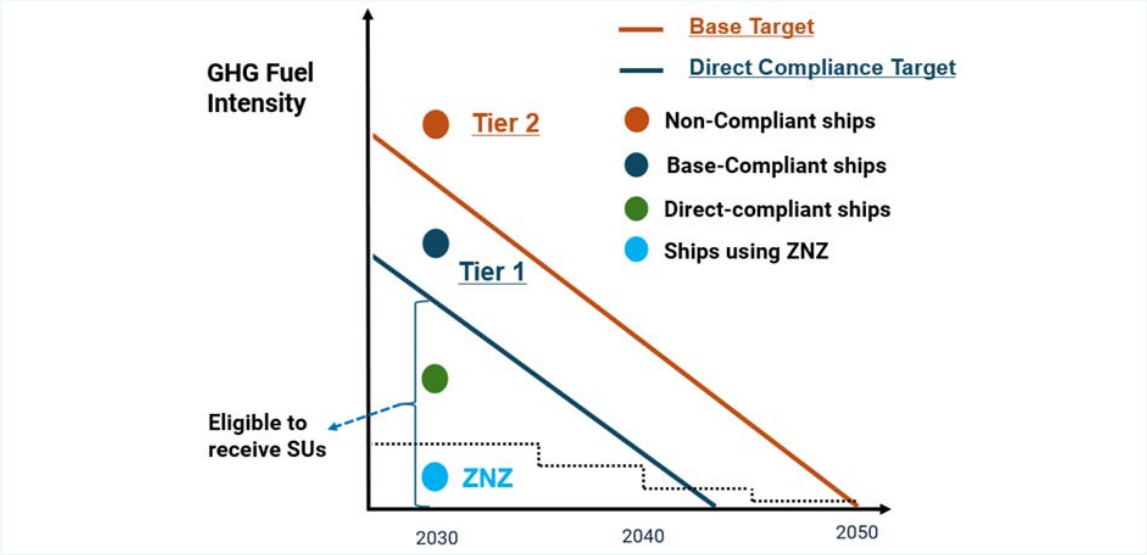
The requirements are based on a GHG fuel intensity (GFI) metric, which is the well-to-wake GHG emissions per unit of energy used on board a ship (shown in below formula). This also includes electricity delivered to the ship, wind propulsion and solar power. The attained GFI is to be reported annually by the ship as part of the DCS.

$$GFI_{attained} = \frac{\sum_{j=1}^{J} EI_j * Energy_j}{Energy_{total}}$$

where:

- j is the fuel or energy source type;
- J is the total number of fuels or energy sources used during the reporting period, as reported to the IMO Ship Fuel Oil Consumption Database;
- EI_j, expressed in g CO_2eq/MJ, is the GHG intensity, expressed on a well-to-wake basis, of fuel or energy source type j, calculated in accordance with the 2024 Guidelines on Lifecycle GHG intensity of marine fuels52;
- $Energy_j$, expressed in MJ, is the amount of energy used from energy source type j. For fuel oil, this shall be based on the Lower Calorific Value of fuel oil type (in MJ/tonne) multiplied by the amount of fuel oil (in tonnes) consumed by the ship. For electricity, it shall be the amount of electrical energy (in MJ) used by the ship. For zero-emission energy sources, such as wind and solar, it shall be the amount of effective energy (in MJ) delivered to the ship; and
- $Energy_{total}$ is the total amount of energy used by the ship, including, in particular, fuel oil, electricity delivered from the shore, and zero-emission energy sources.

The tiered Global Fuel Standard (GFS) establishes two annual compliance thresholds for the attained Greenhouse Gas Fuel Intensity (GFI) over the period 2028–2035, with indicative targets extending to 2040. These thresholds comprise a "Base" target and a more stringent "Direct Compliance" target. All ships are required to comply with the Direct Compliance target (see below diagram).



Source: KOREAN REGISTER: IMO News Flash MEPC 83

• Figure 1-1 The tiered Global Fuel Standard (GFS)

Ships achieving a GFI below the Direct Compliance target generate Surplus Units (SUs), reflecting emissions performance that exceeds the regulatory requirement. Conversely, ships with a GFI above the Direct Compliance target incur a compliance deficit, which is classified into two tiers depending on the magnitude of the exceedance.

A Tier 1 compliance deficit is generated when a ship's GFI exceeds the Direct Compliance target but remains below the Base Target. If the attained GFI exceeds the Base target, the ship incurs both a Tier 1 compliance deficit, corresponding to emissions between the Direct Compliance and Base targets, and a Tier 2 compliance deficit, representing emissions above the Base target. Ships holding compliance surpluses may transfer SUs to ships with compliance deficits or bank them for use during next two calendar years. A Tier 2 compliance deficit may be addressed through the acquisition of SUs from other ships or by purchasing Remedial Units (RUs) from the IMO Net-Zero Fund. In contrast, Tier 1 compliance deficits may only be compensated through the purchase of Tier 1 RUs. The initial prices for Remedial Units are established as follows:

Tier 1 RU rate: **US$ 100** per tonne of CO_2-equivalent

Tier 2 RU rate: **US$ 380** per tonne of CO_2-equivalent

The compliance mechanism is designed to incentivize the uptake of low-greenhouse-gas (GHG) fuels while ensuring a minimum level of financial contributions to the IMO Net-Zero Fund. In practice, most ships are expected to reduce their GFI sufficiently to meet the Base Target and subsequently purchase Tier 1 RUs to achieve compliance with the Direct Compliance Target. Alternatively, operators may acquire SUs to offset Tier 2 compliance deficits before purchasing Tier 1 RUs. This framework ensures that the fleet achieves at least the Base Target while generating revenue to support the Fund's disbursement mechanisms. Below table shows GFI reduction factors and targets over the period 2028–2035 (ICCT, 2026).

• Table 1-1 GFI reduction factors

Year	Base target		Direct Compliance target	
	GFI reduction factor (%)	GFI (g CO_2e/MJ)	GFI reduction factor (%)	GFI (g CO_2e/MJ)
2028	4.0%	89.57	17.0%	77.44
2029	6.0%	87.70	19.0%	75.57
2030	8.0%	85.84	21.0%	73.71
2031	12.4%	81.73	25.4%	69.60
2032	16.8%	77.63	29.8%	65.50
2033	21.2%	73.52	34.2%	61.39
2034	25.6%	69.42	38.6%	57.29
2035	30.0%	65.31	43.0%	53.18

Monitoring and reporting of GFI will be integrated into the existing IMO Data Collection System (DCS). Accordingly, each ship will be required to develop or update its Ship Energy Efficiency Management Plan (SEEMP Part II) to incorporate the data collection and reporting procedures necessary for calculating GHG fuel intensity. The revised plan must be verified and retained on board, together with a Confirmation of Compliance, prior to the commencement of the first reporting period on 1 January 2028.

Within the IMO Net-Zero Framework, Zero and Near-Zero (ZNZ) fuels are defined as fuels with a GFI below 19 gCO_2e/MJ, with the threshold becoming more stringent and decreasing to 14 gCO_2e/MJ by 2035. The IMO NZF has established a baseline of 93.3 gCO_2eq/MJ, reflecting the WtW GHG intensity of international shipping in 2008 (KR, 2026).

1.2 IMO STCW and HTW update

The 1978 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention) provides the global framework for training and certifying seafarers. Its core aim is to ensure worldwide, uniform, and consistent training so that all seafarers can operate ships safely and efficiently, recognizing that people are at the heart of maritime safety. Since its inception, it has evolved to meet changing operational, technological, and regulatory needs, with notable revisions including the 1995 amendments introducing the STCW Code and the 2010 Manila amendments.

1.2.1 STCW revision

Seafarers' competencies are changing as a result of advances in digitization, automation, and emerging technologies. Training and certification frameworks must remain relevant and effective as technology advances. To ensure safe, sustainable, and human-centered maritime operations, IMO initiated a comprehensive review of the STCW Convention in 2024. STCW's current comprehensive review is one of the most ambitious projects in its history. With more than 400 identified gaps1, the scope of the review is unprecedented. In light of the profound changes in the maritime sector, the current STCW revision extends beyond updating individual provisions and instead examines whether the Convention is still fit for purpose. In 2026, more than 160 documents have been submitted by Member States and international organizations. As compared to previous reviews, the volume and breadth of input from Member States and stakeholders have increased significantly. There were a large number of submissions, reflecting both the complexity of the issues and the community's strong engagement with this revision2.

Through this review, the STCW Convention and Code will be modernized to reflect technological advances, evolving social standards, and keep the human element at the core of maritime safety. A two-phase methodology has been employed for the comprehensive review of the STCW Convention and Code. Phase 1, review/identification of gaps, is about reviewing the Convention and Code based on two criteria: 1. Issues resulting from external factors including trends and new developments, and 2. Issues resulting from existing provisions based on implementation. Phase 2, revision, is about developing amendments to address gaps identified under phase 1 experiences. Amendments in this phase is based on submitted documents including: provisions and gaps identified in phase 1, proposed amendment, and explanation3. Phase 1 was completed in February 2025, and the target completion date of the review has been advanced to 2029–2030, from the initially planned 2031–2032.

1.2.2 Review of HTW sessions

Due to a very high workload on STCW revision, a subcommittee called Human Element, Training and Watchkeeping (HTW) was established and started to work on 2014, and thereafter, regular HTW sessions have been conducted annually. HTW deals with the human side of shipping, including training and certification, and the review, updating and revision of IMO model courses. This report, by reviewing the HTW sessions, tries to highlight activities relevant to the decarbonization, renewable and fuel technologies, and alternative fuels to reflect the IMO efforts in upskilling/reskilling seafarers. Below table is an abstract of the HTW sessions' activities with a lens of decarbonization and energy efficiency.

• Table 1-2 HTW sessions and main activities

HTW session	Date	Activity
HTW 1	2014	Guidance for training on board ships using gases or low flash-point fuel endorsed The Sub-Committee endorsed interim guidance on training for seafarers on board ships using gases or other low flashpoint fuels, for approval by the MSC. The guidance is intended as interim, pending the entry into force of the International Code of Safety for ships using gases or low-flashpoint fuels (IGF Code).
HTW 2	2015	No explicit mention of alternative fuels, renewable energy sources, or decarbonization.
HTW 3	2016	Model course activity The Sub-Committee agreed terms of reference to develop 2 model courses in relation to IGF Code: Basic training for ships subject to the IGF Code Advanced training for ships subject to the IGF Code
HTW 4	2017	No explicit mention of alternative fuels, renewable energy sources, or decarbonization.
HTW 5	2018	No explicit mention of alternative fuels, renewable energy sources, or decarbonization.
HTW 6	2019	New IMO model courses on IGF Code training validated Two new model courses were validated by the Sub-Committee: Advanced training for masters, officers, ratings and other personnel on ships subject to the IGF Code Basic training for masters, officers, ratings and other personnel on ships subject to the IGF Code.

• Continued

HTW session	Date	Activity
HTW 7	2021	No explicit mention of alternative fuels, renewable energy sources, or decarbonization.
HTW 8	2022	No explicit mention of alternative fuels, renewable energy sources, or decarbonization.
HTW 9	2023	Review of training provisions in draft guidelines on mitigation measures to reduce risks of the use and carriage for use of heavy fuel oil (HFO) as fuel by ships in Arctic waters.
HTW 10	2024	**Training for seafarers on ships using alternative fuels** The Sub-Committee discussed the development of training provisions for seafarers on ships using alternative fuels. The Sub-Committee agreed that the existing output of MSC on "Development of a safety regulatory framework to support the reduction of GHG emissions from ships using new technologies and alternative fuels" could be utilized to develop relevant training provisions for seafarers.
HTW 11	2025	See 1.2.2.1
HTW 12	2026	See 1.2.2.2

1.2.2.1 HTW 11 (2025)

In this session of the HTW the following items were discussed and agreed:

❖ Draft interim guidelines on training for seafarers on ships using alternative fuels and new technologies agreed (which was submitted to MSC 110)

The Sub-Committee recognized the maritime industry's need for technical and detailed guidance on training of seafarers on ships using alternative fuels and new technologies, including the addressing of different risk profiles. It was agreed that such guidance should be provided by means of both:

- Generic interim guidelines applicable across the whole industry and relevant to all alternative fuels and new technologies; and
- Individual sets of fuel/technology-specific interim guidelines, closely aligned with safety provisions developed by other IMO bodies.

- The Sub-Committee established the Correspondence Group on the Development of Training Provisions for Seafarers on Ships using Alternative Fuels and New Technologies to continue the work intersessionally.
- The Correspondence Group was instructed to develop interim guidelines for training of seafarers, including individual sets of guidelines, addressing:
- The use of methyl/ethyl alcohol as fuel, taking into account MSC.1/Circ.1621 on Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel;
- The use of ammonia as fuel, taking into account MSC.1/Circ.1687 on Interim guidelines for the safety of ships using ammonia as fuel;
- The use of LPG as fuel, taking into account MSC.1/Circ.1666 on Interim guidelines for the safety of ships using LPG as fuel;
- The use of hydrogen as fuel;
- Hydrogen fuel cell powered ships, taking into account MSC.1/Circ.1647 on Interim guidelines for the safety of ships using fuel cell power installations; and
- Battery powered ships.

1.2.2.2 HTW 12 (2026)

In this session of the HTW the following items were discussed and agreed:

- Two sets of draft interim guidelines for seafarer training were finalised

  The draft interim guidelines on training of seafarers using methyl/ethyl alcohols as fuel and the draft interim guidelines on training of seafarers using ammonia as fuel were finalised. These have been approved under STCW.7/Circ.26 (methyl/ethyl alcohol) and STCW.7/Circ.27 (ammonia).

- A workplan through to 2029 was agreed for the development of training requirements for seafarers using the following fuels/technologies in the priority order stated below:

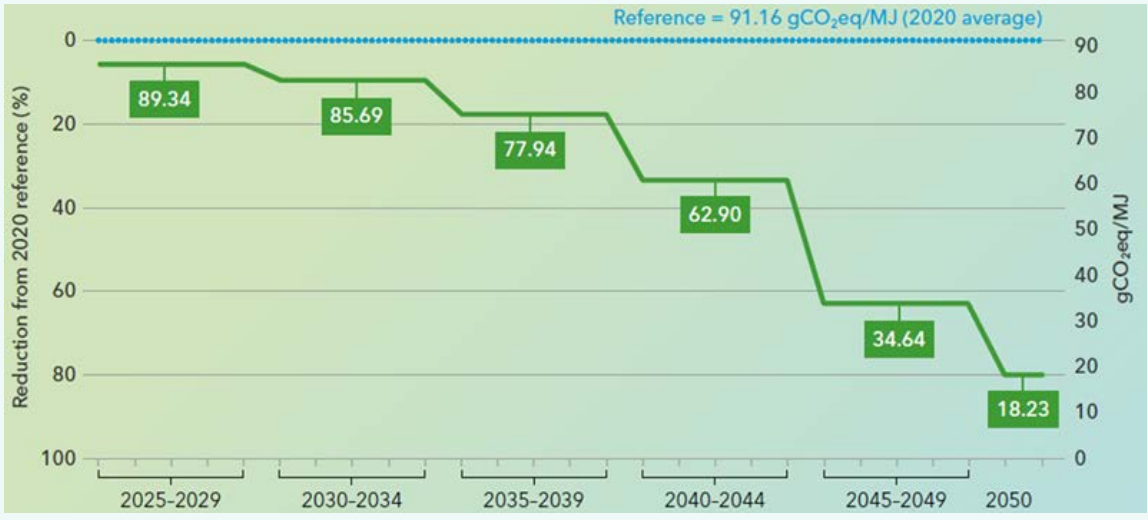
1.Hydrogen fuel cell
2.LPG
3.Hydrogen
4.Battery power
5.Wind propulsion systems and wind-assisted power

1.3 EU Regulatory update

The European Green Deal is the EU's overarching strategy to become the first climate-neutral continent by 2050, combining legislation with investment to cut emissions, restore nature, and modernize the economy. "Fit for 55" is the concrete legislative package designed to deliver these goals, aiming to reduce greenhouse gas emissions by at least 55% by 2030 (compared to 1990 levels). In comparison, while the European Green Deal is an ambitious strategy, "Fit for 55" is a set of concrete actions and legally binding tools to deliver that ambition. As part of the "Fit for 55" package, shipping was included in the EU Emission Trading System (ETS) in 2024, and in 2025 the FuelEU Maritime regulation entered into force. Ship operators for vessels—both cargo and passenger—with a gross tonnage equal to or greater than 5,000 GT must report their emissions and allocate allowances for each ton of CO_2 generated. Shippers operating in EU waters, regardless of their origin, will be subject to the requirements of the ETS.

1.3.1 FuelEU standard

FuelEU standard entered into force from 1 January 2025 and establishes stringent GHG emission intensity (gCO_2eq/MJ) requirements for ships over 5,000 GT transporting cargo or passengers for commercial purposes in the EU/EEA. It adopts a well-to-wake approach and sets a GHG intensity limit that decreases every five years. Each year, the actual GHG intensity is measured and compared to the regulatory limit. As shown in below diagram, the requirements start with a 2% reduction in GHG intensity from 2025 to 2029, relative to the average GHG intensity in 2020 (91.16 gCO_2eq per megajoule (MJ)). This reduction target then increases to 6% from 2030 to 2034, and further accelerates from 2035 to ultimately achieve an 80% reduction by 2050.



Source: DNV

Figure 1-2 FuelEU Maritime GHG intensity requirements 2025–2050

In compliance with FuelEU standard, shipowners can either pay a penalty cost, or use fuels/energy with lower well-to-wake GHG intensity, or use FuelEU flexibility mechanisms. The penalty amount is calculated using a regulatory formula. If a vessel is penalized for two or more consecutive years, an additional 10% escalation applies annually. FuelEU flexibility mechanisms are including banking, borrowing, and pooling:

ⓐ **Banking:** A vessel with a positive compliance balance in a reporting period can bank its surplus for subsequent reporting periods. The banked surplus does not expire; in case of a change of responsible company, the banked surplus follows the ship.

ⓑ **Borrowing:** A vessel with a negative compliance balance in a reporting period can borrow an advance compliance surplus from the following year. The borrowed amount plus an additional 10% is deducted from the following period's compliance balance. Borrowing cannot be done in two consecutive reporting periods, and the amount cannot exceed more than 2% of the required GHG intensity multiplied by the annual energy consumption of the ship.

ⓒ **Pooling:** Pools can be organized within a single company or between multiple companies. Two or more ships, including from different companies, can join a compliance pool and re-allocate compliance balance between the individual ships. This means that the ships with a negative compliance balance can rely on other ships with positive compliance balance to achieve a combined GHG intensity level meeting the GHG intensity requirement. New digital platforms enable firms to form and participate in multiple pools, thereby increasing flexibility in the sharing of compliance balances. Pooling rules are as follows:

- The total compliance balance of all ships is positive.
- Ships which had a compliance deficit do not have a higher compliance deficit after the reallocation of the compliance balance.
- Ships which had a compliance surplus do not have a compliance deficit after the reallocation of the compliance balance.
- Vessels entering the pool with a surplus must retain that surplus, and no vessel may participate in more than one pool.

GHG intensity in FuelEU standard is calculated based on Formula (1). This formula has considered RewardRFNBO, an additional energy credit for using Renewable Fuels of Non-Biological Origin (RFNBO). Likewise, RewardWind is a multiplicative adjustment factor that rewards the use of wind-assisted propulsion by reducing the calculated GHG intensity.

$$\text{GHG intensity}\left[\frac{gCO_2eq}{MJ}\right] = \frac{\text{Total GHG emissions}\left[tCO_2eq\right]}{\text{Total energy from fuels}\left[TJ\right] + \text{Total shore power}\left[TJ\right] + \text{Reward}_{RFNBO}\left[TJ\right]} \times \text{Reward}_{wind} \quad (1)$$

As shown in formula (2):

If Actual GHG intensity < Required GHG intensity, the compliance balance is positive, indicating the ship has over-complied and earns Surplus Units (SUs).

If Actual GHG intensity > Required GHG intensity, the compliance balance is negative, indicating a compliance deficit that must be addressed through remedial measures such as Remedial Units (RUs), pooling, or other mechanisms under the EU ETS framework.

$$\text{Compliance balance}\left[tCO_2eq\right] = \left(\text{Required GHG intensity}\left[\frac{gCO_2eq}{MJ}\right] - \text{Actual GHG intensity}\left[\frac{gCO_2eq}{MJ}\right]\right) \times \sum \text{Energy}\left[TJ\right] \quad (2)$$

1.3.2 Latest update

No major legislative amendments have been made to FuelEU Maritime since it entered into force on 1 January 2025. However, the European Commission, in a proposal on July 2026 (European Commission, 2026), is going to revise the EU ETS as part of its pathway toward the EU's 2040 climate target. For shipping, the proposal aims to strengthen the maritime ETS by:

- reducing opportunities for carbon leakage and avoidance,
- updating the Maritime MRV framework,
- reinforcing incentives for investments in low-carbon shipping technologies, and
- aligning the maritime ETS with broader industrial decarbonization measures.

Currently, the EU shipping industry is arguing about redistributing carbon revenue. Under the current maritime ETS system, ECSA estimates revenues of € 7.65bn, assuming a carbon price of € 85 a tonne of CO_2 emitted, or € 9bn if costs reach € 100 a tonne. It has been argued by shipowners that more of the ETS revenue should be returned to the industry as subsidies to promote the use of green fuels. ECSA estimates that only 5% of ETS revenues will be returned to the maritime sector for decarbonization (ECSA, 2026).

1.4 China's Green Shipping Policy

1.4.1 Central Level

At the central government level, green shipping policies are becoming more systematic and standardized. Since October 2025, building on existing initiatives such as the promotion of new energy vessels and the renewal of aging vessels, relevant policies have further strengthened institutional arrangements for shipping carbon emissions management, green fuel supply, technical standards, and safety oversight. They have also improved relevant standards and requirements for new technologies such as battery power and hydrogen fuels, while promoting demonstration applications and the development of supporting infrastructure. The scope of these policies has gradually expanded from vessel renewal and technology application to multiple areas, including carbon governance, energy supply, technical standards, and market mechanisms.

● Table 1-3 Green Shipping Policies at National and Ministerial Level

Policy and Key Provisions	
17 July 2026	**The Ministry of Transport and three other departments jointly issued the 15th Five-Year Plan for the Development of Integrated Transport Services.** ● By 2030, a modern integrated transport service system will be basically established. By 2035, the modern integrated transport service system will be further improved. ● **Further optimize and adjust the transport structure.** Accelerate the shift of key commodities along major transport corridors from road to rail and from road to waterway, and increase the share of clean transport in key regions and sectors. ● **Promote the application of green facilities and equipment.** Develop demonstration road and waterway sections of zero-carbon transport corridors, as well as zero-carbon transport hubs, terminals, and service areas; promote new-energy and clean-energy vehicles and vessels, together with loading and unloading, transfer, and operational equipment; and retire and replace aging commercial vehicles and vessels with high energy consumption and emissions.

• Continued

30 June 2026

The Ministry of Transport and the National Development and Reform Commission jointly issued the Opinions on Deepening Reform of the Integrated Transport System.

- **Promote the green and low-carbon transition of transport.** Advance the shift of bulk cargo and medium- and long-distance freight from road to rail and from road to waterway. Promote large-scale equipment renewal in the transport sector and accelerate the adoption of new-energy transport equipment. Strengthen green and low-carbon monitoring, evaluation, and early warning in the transport sector, and improve the carbon emissions statistics and accounting system. Study measures to **promote the participation of green and low-carbon transport projects in voluntary greenhouse gas emissions reduction trading.**
- Promote high-level international cooperation in transport. **Establish standards and a certification system for green marine fuels.**

11 June 2026

The Ministry of Transport and nine other departments jointly issued the Guiding Opinions on Improving the Integrated Transport System for Modern Metropolitan Areas.

- Promote the green upgrading and renovation of transport infrastructure in metropolitan areas. **Develop demonstration road and waterway sections of zero-carbon transport corridors**, as well as zero-carbon transport hubs, terminals, and service areas. Ensure that port shore power facilities in riverine and coastal metropolitan areas are built wherever required and fully utilized.
- **Accelerate electrification and the application of green-fuel vehicles and vessels.** Accelerate the application of battery power technologies in small and medium-sized vessels, and promote LNG- and methanol-powered technologies in medium and large vessels.
- Optimize the transport structure of metropolitan areas. Develop multimodal transport based on major freight nodes and **increase the share of bulk cargo transported by rail and waterway.**

9 April 2026

The Maritime Safety Administration of the Ministry of Transport issued the Opinions on Promoting the Green and Low-Carbon Transition of Shipping.

- By 2030, China will fully establish **a comprehensive technical standards system for new-energy and clean-energy ships**, a safety regulatory system, a management system for seafarer training, examination, and certification, and a system of safety regulations and standards for green fuel bunkering. **A monitoring, reporting, and verification (MRV) system for carbon emissions from shipping suited to China's national conditions will also be fully established. The carbon intensity of ships engaged on international voyages will be reduced by at least 15% from the 2025 level.**

• Continued

Technical Standards and Safety Safeguards

19 June 2026

Construction of Shore-Based Charging Facilities for Electric Ships.

- The specification covers technical requirements for shore-based charging facilities for electric ships, testing and inspection, and related areas. **It fills a gap in China's technical standards for the construction of shore-based charging facilities for electric ships**, addressing issues including non-uniform interfaces among different vessel types, ports, and charging equipment, inconsistent construction standards, and unclear safety management requirements.

3 April 2026

The Maritime Safety Administration of the Ministry of Transport issued the Action Plan for Accelerating the Development of a Technical Standards System for Green and Intelligent Ships (2026–2030).

- By 2030, a comprehensive technical standards system for green ships will be established, while the technical standards system for intelligent ships will be largely complete, providing effective support for the development of China's green and intelligent shipping industry.
- Focusing on new-energy and clean-energy ships powered by batteries, methanol, LNG, ammonia, and hydrogen, as well as areas such as intelligent navigation, remote operation and control, inspection, and testing, the Action Plan advances the formulation and improvement of relevant technical standards to support the application of green and intelligent ship technologies and industrial development.

4 January 2026

The Maritime Safety Administration of the People's Republic of China issued the Interim Rules for Technology and Survey of Ammonia-Fueled Ships (2026).

- **The Rules establish technical requirements for the design, construction, operation, and survey of ammonia-fueled ships.** By specifying requirements for fuel storage and supply, ventilation, fire protection, leakage detection, and personnel protection, the Rules help reduce risks associated with ammonia toxicity, corrosiveness, and fire and explosion hazards, while improving consistency in ship design review and survey.

Vessel Renewal and Expansion of Application Scenarios

6 March 2026

The Ministry of Industry and Information Technology and two other departments issued the Notice on Carrying Out Pilot Programs for Integrated Hydrogen Energy Applications.

- Through city-cluster pilot programs, hydrogen application scenarios will be expanded from fuel cell vehicles to transport, industry, and other suitable fields. By 2030, large-scale application of hydrogen across diverse fields will be promoted in participating city clusters.
- Green ammonia and methanol. With a focus on improving the techno-economic performance of green ammonia and methanol and expanding downstream demand, the policy promotes innovation in production technologies and processes and advances their large-scale production and application. Stable downstream offtake channels will be established for products such as green synthetic ammonia and green methanol.
- Innovative application scenarios. Promote innovative applications of hydrogen in locomotives, **ships**, mining trucks, forklifts, aircraft, and other scenarios.

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6 March 2026

The Ministry of Transport and the National Development and Reform Commission issued the Implementation Rules for Subsidies for the Scrapping and Renewal of Aging Commercial Vessels (Revised Version).

- The Rules specify the scope and standards of subsidies for the scrapping and renewal of aging commercial vessels. **LNG single-fuel, methanol single-fuel, hydrogen-fueled, ammonia-fueled, and fully battery-powered vessels**, as well as **LNG/oil and methanol/oil dual-fuel** vessels meeting prescribed fuel substitution rates, are included within the scope of subsidies for new-energy and clean-energy vessels. Differentiated subsidies are provided according to vessel type, vessel age, propulsion type of newly built vessels, and other factors, encouraging the retirement of aging capacity and the green transition of vessel propulsion.

• Continued

Green Fuel Supply and Market Development

30 December 2025

The Ministry of Transport and nine other departments jointly issued the Implementation Plan for Supporting the Development of Shanghai's International Shipping Green Fuel Bunkering and Trading Centers.

- By 2030, Shanghai will have initially established **international green fuel bunkering and trading centers**. Bonded LNG bunkering capacity at the Port of Shanghai will reach the million-cubic-metre scale in liquid volume, while bunkering capacity for methanol, biofuels, and other fuels will reach the million-tonne scale.
- **Enhance green fuel supply security**. Support Shanghai in establishing cross-provincial cooperation mechanisms for green fuels with resource-rich regions such as Northeast China and eastern Inner Mongolia; support a special Transport Powerhouse pilot for the "green fuel transport corridor and international bunkering project"; explore diversified modes of transport; and establish stable, full-chain green fuel supply channels covering production, storage, transportation, and bunkering.
- **Improve the green fuel trading service platform with integrated industrial links and comprehensive functions**. Support Shanghai in conducting international shipping green fuel trading through institutions such as the Shanghai Shipping Exchange, and explore closed-loop services covering the certification, registration, trading, settlement, and cancellation of green fuel attributes.

30 October 2025

The Ministry of Commerce issued the Implementation Opinions on Expanding Green Trade.

- **Accelerate the green and low-carbon development of logistics**. Promote the shift of bulk foreign-trade cargo and long-distance container transport from road to rail and from road to waterway. **Support shipping companies in developing green and low-carbon systems**, and promote greener practices throughout the entire process of ship design, construction, and operation. Promote the use of transport vehicles and ships powered by clean energy sources such as renewable synthetic fuels in foreign-trade cargo transportation. **Support the blending of domestically produced biodiesel and marine fuel oil in comprehensive bonded zones**. Support eligible regions in **providing bonded bunkering services for international-voyage ships using LNG, biodiesel, green methanol, green ammonia, and other fuels.**

Source: China Government Website, compiled by the Shanghai International Shipping Institute

1.4.2 At the local level

Local green shipping policies showed pronounced regional differentiation. From October 2025 to September 2026, different regions further refined their green shipping policy arrangements in light of their respective shipping foundations, industrial conditions, and application scenarios. Leveraging its development as an international shipping center, Shanghai focused on advancing green fuel bunkering, trading, certification, and related infrastructure development; the Yangtze River Delta accelerated the green transition of inland waterway vessels and the development of cross-regional energy supply and replenishment networks; while Hubei, Fujian, and other regions placed greater emphasis on green and intelligent shipbuilding, key technology research and development, and industrialization. At the same time, the scope of local policy support gradually expanded from vessel renewal and demonstration applications to multiple areas, including green fuels, energy supply and replenishment facilities, industrial development, and fiscal and financial support.

● Table 1-4 Regional Green Shipping Policy Framework

Shanghai	
20 July 2026	**Shanghai Municipal People's Government: 'Shanghai's 15th Five-Year Plan for Accelerating the Development of the International Shipping Centre'** ● Support pilot schemes for green-powered vessels using hydrogen, ammonia, electricity and dimethyl ether; enhance LNG, methanol and biofuel bunkering capacity; promote battery-powered and methanol-fueled vessels, as well as charging and battery-swapping facilities, on inland waterways; establish **a green fuel bunkering and trading centre**; advance the expansion of LNG stations and pipelines, the production of green methanol, and the development of a fuel price index.
17 November 2025	**General Office of the Shanghai Municipal People's Government: 'Shanghai Marine Industry Development Plan (2026–2035)'** ● Establish a highly developed modern shipping service system. Construct **an international shipping green fuel bunkering** centre to provide internationally competitive 'one-stop' services for the procurement, bunkering, trading and certification of green fuels. ● Accelerate the construction of maritime infrastructure projects. Deepen the digital, smart and **green transformation of** the Port of Shanghai; build a smart, green hub port; and improve **the infrastructure for green shipping fuels.**

• Continued

4 November 2025

Shanghai Municipal Commission of Transport and Shanghai Municipal Commission of Development and Reform: 'Shanghai Action Plan for Reducing Costs, Improving Quality and Enhancing Efficiency in Transport and Logistics'

- Promote the routine use of shore power by vessels while berthed; support pilot schemes for vessels using new fuels such as methanol; and construct a diversified network for the supply of new fuels in phases.

21 July 2026

General Office of the Shanghai Municipal People's Government: 'Shanghai's 15th Five-Year Plan for the Development of Modern Logistics'

- **Establish a full-cycle green and low-carbon logistics system.** Continuously improve refuelling facilities for liquefied natural gas (LNG) and methanol used in shipping, and enhance the capacity for refuelling vessels with green fuels. Promote the full coverage and routine use of standardised shore power facilities at commercial berths in ports.

30 June 2026

General Office of the Shanghai Municipal People's Government: 'Implementation Plan for Shanghai's Construction of a Pilot Zone for High-Quality Development of Inland Waterway Transport in the Yangtze River Delta and the Inland Waterway Transport System Interconnection Project (2026–2030)'

- **Develop new energy and clean energy vessels.** Expand the scale of battery-powered applications in small and medium-sized vessels and for medium- and short-haul transport; construct charging and battery-swapping facilities; and explore pilot schemes for methanol-powered inland waterway vessels.

Zhejiang

10 October 2025

Standing Committee of the Huzhou Municipal People's Congress: 'Huzhou Municipal Regulations on Green Shipping'

- Establish industrial funds, provide interest subsidies on loans and insurance premium subsidies; build a green and smart vessel manufacturing base; promote the clustering of energy storage, electronic control and charging/battery-swapping industries; and promote the adoption of green and smart vessels.

16 September 2025

Hangzhou Municipal People's Government: 'Implementation Opinions of the Hangzhou Municipal People's Government on Implementing the High-Level Development of "Shipping Zhejiang"'

- Accelerate the upgrading of inland waterway vessels, promote electric vessels, and advance the research and development of methanol- and hydrogen-powered vessels; construct green shipping corridors, launch zero-carbon routes, and deploy charging and battery-swapping facilities.

Jiangsu

20 January 2026

Office of the Taizhou Municipal People's Government: 'Implementation Opinions on Accelerating the High-Quality Development of Taizhou's Modern Shipping Services Sector'

- Build a green and smart shipping base, with the carrying capacity of new energy vessels exceeding 10,000 deadweight tonnes by 2030; promote the conversion of vessels of 2,000 tonnes and above to LNG, and encourage the construction of all-electric transport vessels.

Yangtze River Delta

21 January 2026

Transport authorities of Shanghai, Jiangsu, Zhejiang and Anhui: 'Cooperation Agreement on the Planning and Construction of the Development and Recharging Network for New and Clean Energy Inland Waterway Vessels in the Yangtze River Delta (2026–2028)'

- Jointly promote the large-scale application of new energy and clean energy vessels on inland waterways and the construction of an inter-provincial energy-supply network; plans are in place to establish 31 charging and battery-swapping stations along major inland waterway routes, 22 of which will be newly built.

Hubei

13 July 2026

Hubei Provincial Office of National Defence Science and Technology Industry, Hubei Provincial Department of Economy and Information Technology, Hubei Provincial Department of Transport: 'Several Measures for Cultivating and Strengthening the Green and Intelligent Shipping Industry in Hubei Province'

- Conduct research and development into key technologies such as methanol and hydrogen internal combustion engines, fuel cells, hydrogen storage and 6G smart vessels; provide funding of up to 10 million yuan for major projects and up to 20 million yuan for the research and development of relevant vessel types; support technical upgrades and digital transformation in shipbuilding enterprises, with a maximum of 10 million yuan per project; offer a grant of 1.5 million yuan for the transfer of intellectual property rights for standard vessel types; and implement the 'Thousand Sails Plan' and incentives for green and smart vessel transport capacity.

• Continued

14 November 2025

General Office of the People's Government of Hubei Province: 'Work Plan for Promoting the Transformation, Upgrading and High-Quality Development of the Inland Waterway Vessel Industry in Hubei Province'

- Focusing on "energy diversification and electrification of propulsion", the plan aims to tackle key challenges in all-electric vessel range and battery-swapping, methanol, hydrogen fuel cell, ammonia-powered and hybrid technologies; to develop lightweight, energy-efficient and environmentally friendly technologies; and to foster demonstration scenarios for battery-swapping freight transport, methanol/LNG river-to-sea direct transport, and electric sightseeing vessels. It also seeks to improve the standardisation system for green vessels—including batteries, LNG, methanol, hydrogen and ammonia—and to promote the upgrading of Hubei standards to national and industry standards.

Chongqing

29 July 2026

Chongqing Municipal People's Government: 'Chongqing's 15th Five-Year Plan for the Development of a Modern Integrated Transport System and Logistics (2026–2030)'

- Promote the application of new energy and clean energy vessels, such as electric, liquefied natural gas (LNG) and methanol-powered vessels; build a 'Thousand-Li Light Vessel' new energy fleet; and improve the layout of energy-replenishment facilities.



Fujian

28 February 2026

Fujian Provincial Department of Industry and Information Technology and four other departments: 'Fujian Provincial Action Plan for the Development of the Electric Vessel Industry (2026–2028)'

- Promote the widespread application of electric vessels in shipping, ports, cultural tourism, fisheries, and other sectors. By 2028, Fujian aims to establish a product portfolio covering multiple types and specifications of electric vessels, achieve an annual manufacturing capacity of 50 electric vessels, and bring a cumulative total of 150 electric vessels into operation, including 20 vessels deployed outside Fujian Province and overseas. Core equipment products are expected to be used on more than 1,500 electric vessels in China and overseas, while the scale of the entire electric vessel industry chain will reach RMB 5 billion.

23 January 2026

General Office of the Fuzhou Municipal People's Government: 'Fuzhou Municipal Measures for Incentives to Promote the Development of the Shipping Industry (2026–2028)'

- Newly built inland waterway container vessels and new-energy cargo vessels are eligible for a subsidy of RMB 500 per deadweight tonne, while new-energy passenger vessels are eligible for RMB 3,000 per passenger seat. Freight enterprises will receive RMB 100,000 when the capacity of their self-owned new-energy vessel fleet first reaches 5,000 deadweight tonnes. Passenger transport enterprises will receive RMB 200,000 when their new-energy vessel fleet first reaches a passenger capacity of 500, with an additional RMB 100,000 for every subsequent increase of 100 passengers, up to a maximum of RMB 700,000.

• Continued

Anhui

5 January 2026

Office of the Huainan Municipal People's Government: 'Several Policies of Huainan City to Support the High-Quality Development of the Green and Smart Shipping Industry'

- A maximum subsidy of RMB 1 million per vessel is provided for the early scrapping of aging vessels; inland waterway vessels are exempt from lock passage fees, with priority given to vessel inspection and berthing services; support is provided for the overseas market expansion of green and intelligent vessels; enterprises in Huainan and centrally administered state-owned enterprises based in Huainan are encouraged to take the lead in using green and intelligent vessels; financial institutions are encouraged to develop dedicated financial products such as "Green Vessel Loans"; and the establishment of an industrial fund for green and intelligent vessel and equipment manufacturing is promoted.

Guangzhou

2 December 2025

Guangzhou Municipal People's Government: 'Outline Plan for the Construction of a Beautiful Guangzhou (2025–2035)'

- Promote the low-carbon transition of transport equipment and infrastructure. Promote the green and low-carbon transition of vessels, with a focus on Pearl River cruise services, advance the orderly application of electric vessels, and give priority to developing demonstration routes for electric vessels. Promote the application of hydrogen, natural gas, advanced liquid biofuels, and other energy sources in the transport sector. By 2035, the proportion of green development in transport infrastructure construction will reach 95%.

Shenzhen

23 June 2026

Shenzhen Municipal Transport Bureau: 'Implementation Rules for the Shenzhen Transport Special Fund: Green Transport Construction Sector (Ports and Shipping) Grant Scheme'

- Five categories of funded projects are established, including shore power retrofits, clean-energy-powered vessels, electric port machinery, and clean-energy bunkering, with total annual funding capped at RMB 75 million. Vessels powered by LNG, electricity, hydrogen, methanol, and liquid ammonia are eligible for support for up to five consecutive years. Green methanol bunkering is subsidized at RMB 300 per tonne based on the actual bunkering volume.

Source: Provincial and municipal government websites; compiled by the Shanghai International Shipping Institute

Chapter 2

Green Shipping Mechanisms

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2.3 Cross-sectoral Market Adjustment Mechanisms /34
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2.1 Carbon Trading Markets

The scope of global emissions trading schemes has expanded further. As of February 2026, there were 41 emissions trading schemes (ETSs) in operation worldwide, an increase of three from the previous year, namely the national-level ETSs in Japan, India and Vietnam. The proportion of greenhouse gas emissions covered by global ETSs rose further from 23 per cent in 2025 to 26 per cent; jurisdictions with ETSs in place collectively accounted for 63 per cent of global GDP and covered more than half of the world's population, with 14 G20 members having established ETSs.

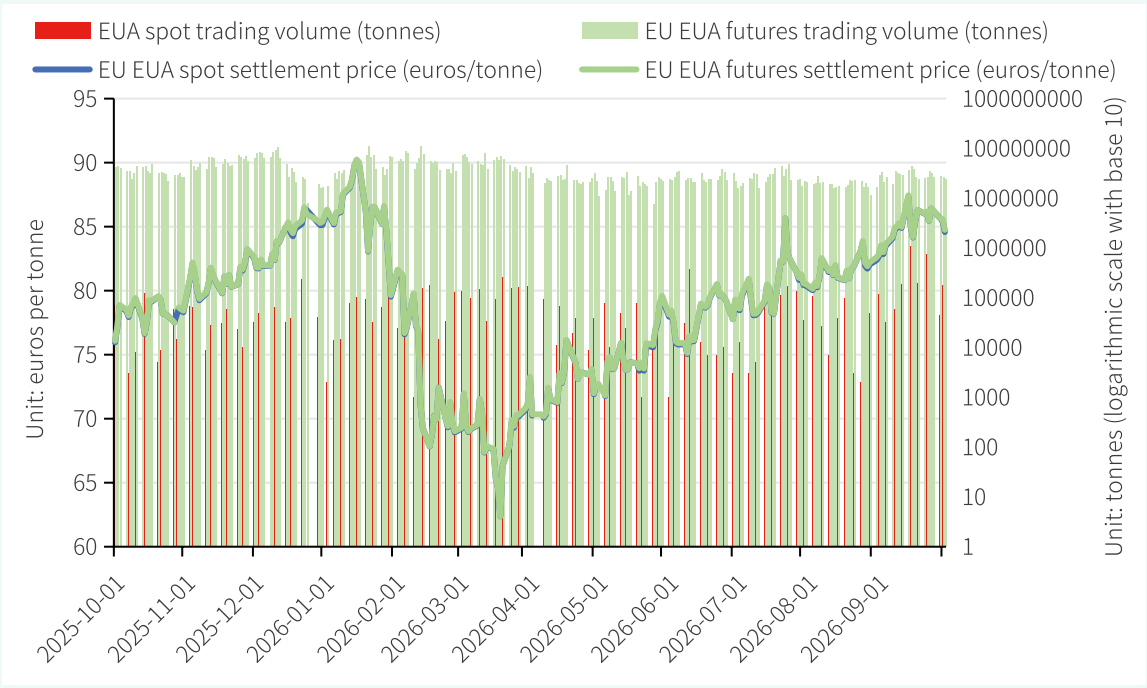
International cooperation mechanisms for compliance-based carbon markets were established at an accelerated pace. During COP30 in 2025, the Open Coalition on Compliance Carbon Markets, jointly promoted by China, Brazil, the European Union and others, gained the support of many countries. In May 2026, the Coalition was formally launched, with Brazil as Chair and China and the European Commission as Co-Chairs; in September, the Coalition held a high-level meeting in Wuhan, at which the Work Plan and the Secretariat Working Rules were adopted, further improving its institutional framework. The Coalition focuses its cooperation on carbon pricing, monitoring, reporting and verification (MRV), carbon accounting and high-quality carbon credit offsetting, and is gradually exploring coordination, linkage and mutual recognition among different carbon market mechanisms.

2.1.1 The European Union Emissions Trading Scheme (EU ETS)

The shipping industry achieved a high compliance rate in its first year of participation in the EU carbon market. According to the EU's 2025 Carbon Market Report, in 2024, 3,313 shipping companies reported MRV-compliant carbon emissions of 89.8 million tonnes from 13,627 vessels. During the transition period, 40 per cent of emissions—corresponding to 35.6 million allowances—were required to be surrendered, with a compliance rate exceeding 99 per cent by the end of September 2025.

The EU carbon market has established a stable market price signal. Between October 2025 and September 2026, the trading volumes of EUA futures and spot products stood at 9.38 billion tonnes and 22.118 million tonnes respectively; EUA futures accounted for approximately 99.8 per cent of the total trading volume, with prices fluctuating between 63.65 and 92.24 euros per tonne of CO_2 equivalent, and spot and futures prices moving largely in tandem throughout the year.





Source: EEX, ICE; compiled by the Shanghai International Shipping Institute

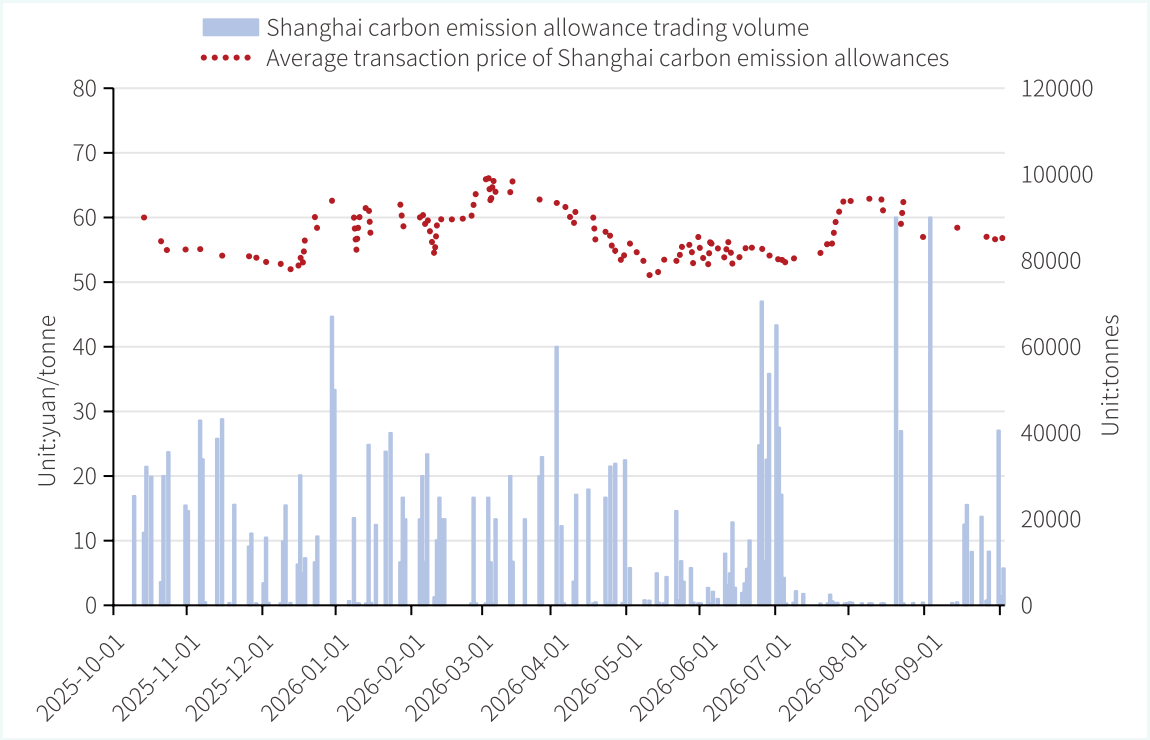
● Figure 2-1 Trends in the EU carbon market from October 2025 to September 2026

2.1.2 China's Carbon Trading Market

In 2021 and 2024, China successively launched the National Carbon Emissions Trading Market (mandatory carbon market) and the National Voluntary Greenhouse Gas Emissions Reduction Trading Market (voluntary carbon market), which together form the national carbon market system.

1. Mandatory Carbon Allowance Market

The scope of coverage of local carbon markets for port and shipping enterprises has been further expanded. As of September 2026, the carbon markets of Shanghai, Guangdong and Tianjin have included port and shipping enterprises in their pilots. The Guangdong carbon market and the Shenzhen carbon market have designated 10 and 5 port enterprises respectively as key emitting units. The 'List of Greenhouse Gas Emission Units of the Tianjin Carbon Market (2025)' published by Tianjin in March 2026 includes 4 port enterprises and 15 waterborne freight transport enterprises. A total of 17 waterborne transport enterprises and 7 port enterprises in Shanghai have been included in the Shanghai local carbon market, of which one waterborne transport enterprise participated in trading, with a trading volume of 10,500 tonnes and a transaction value of 722,400 yuan. In addition, from October 2025 to the end of September 2026, the Shanghai carbon market recorded a total transaction value of 140 million yuan and a trading volume of approximately 2.5238 million tonnes, up 26.8 per cent and 55.2 per cent year on year respectively; the average daily trading volume on trading days was 15,900 tonnes, up 29.8 per cent year on year; and the average transaction price was 57.4 yuan per tonne, down 15.4 per cent year on year.



Source: Shanghai Environment and Energy Exchange; compiled by the Shanghai International Shipping Institute

• Figure 2-2 Trends in the Shanghai carbon emission allowance market from October 2025 to September 2026

2. Voluntary Carbon Emissions Reduction Market

The process of integrating the shipping industry with the national voluntary emissions reduction market is accelerating. In August 2025, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council issued the 'Opinions on Promoting Green and Low-Carbon Transition and Strengthening the Development of the National Carbon Market', proposing that by 2027, the national voluntary greenhouse gas emissions reduction trading market should achieve full coverage of key sectors, while accelerating the development of methodologies for voluntary emissions reduction projects in these key sectors, thereby providing the institutional framework for emissions reduction projects from more industries to enter the national voluntary emissions reduction market.

Research into shipping emissions reduction methodologies continues to advance. In December 2025, the 'Methodology for Voluntary Greenhouse Gas Emissions Reduction Projects: LNG Fuel Substitution for Inland Waterway Freight Vessels', compiled under the leadership of the Wuhan Branch of the China Classification Society, passed the project acceptance review.Based on operational data from the inland waterway freight fleet, this methodology examines the methodology for calculating emission reductions resulting from the substitution of traditional marine fuels with LNG, providing a technical reference for the quantitative evaluation of emission reduction projects involving fuel substitution on

inland waterway vessels.In June 2026, the Ministry of Transport and the National Development and Reform Commission issued the 'Opinions on Deepening the Reform of the Integrated Transport System', proposing to explore ways to facilitate the participation of green and low-carbon projects in the transport sector in voluntary greenhouse gas emissions trading schemes, thereby providing a policy direction for exploring market-based incentives for emissions reduction projects in the shipping sector.

2.1.3 Carbon Trading Markets in Other Regions

The UK has formally incorporated domestic shipping into its carbon emissions trading scheme. From July 2026, the UK ETS has regulated greenhouse gas emissions from vessels of 5,000 gross tonnes or more operating on domestic UK routes and within UK ports; offshore vessels will be included from 1 January 2027. The UK is currently consulting on a policy proposal to include 50 per cent of emissions from international voyages under the scheme from 2028, although the proposal has not yet been implemented.

2.2 Industry Initiatives and Incentive Mechanisms

2.2.1 Industry Initiatives

The SBTi has further strengthened the implementation requirements for corporate net-zero targets. The Science Based Targets initiative (SBTi) is an international voluntary mechanism that provides enterprises and financial institutions with support for setting and verifying science-based carbon targets. In 2022, it published sector-specific guidelines for the maritime industry to assist shipping companies in formulating short- and long-term emission reduction plans aligned with the 1.5°C temperature control target.As of July 2026, over 11,000 organisations worldwide had achieved SBTi carbon target certification, including 41 shipping and port companies, of which 28 had finalised their targets and 13 were at the commitment stage.In June 2026, the SBTi published the 'Corporate Net-Zero Standard Version 2.0', shifting the focus from target setting to implementation and strengthening requirements for corporate governance, emissions reductions across the entire supply chain, and disclosure. Full implementation will commence in 2028, significantly raising the standards for emissions control and disclosure in shipping companies' fleet operations, fuel procurement and upstream and downstream supply chains.

2.2.2 Incentive Mechanisms

Port green incentive schemes. Major ports worldwide are using measures such as shore power subsidies, port fee reductions and green fuel incentives to encourage vessels to reduce emissions while in port and accelerate the use of low-carbon fuels. Relevant policies have gradually shifted from single-facility subsidies to comprehensive incentive mechanisms linked to vessels' environmental ratings, zero-emission performance and the use of green fuels.

• Table 2-1 Green Incentive Policies at Major Ports

Port of Shanghai	Implementing Rules for the Management of Project Funds for the Adjustment and Optimisation of the Shipping and Logistics Structure in Shanghai	• For Yangtze River branch-line 'fixed-schedule liner' services, Yangtze River Delta inland river container services and river–sea through transport operated between 1 January 2026 and 31 December 2030 using pure battery-electric, LNG-only, methanol-only, hydrogen or ammonia-powered vessels, the support standard for waterway transport operators under the corresponding services will be raised by 30 per cent on top of the existing standard.
Port of Hong Kong	Green Marine Fuel Bunkering Incentive Scheme	• Priority support is given to LNG and green methanol. Enterprises that complete their first two refuelling operations within one year after conducting a risk assessment accepted or endorsed by the Marine Department will receive a reward of HK$500,000 per refuelling; each enterprise may claim this reward a maximum of twice per fuel type. The maximum reward for a single type of green fuel is HK$2 million, and rewards are allocated on a first-come, first-served basis.
	Maritime Fuel-Related Vessel Port Charge Incentive Scheme	• The policy is valid from 16 June 2026 to 15 June 2029. Ocean-going vessels carrying green fuels for discharge in Hong Kong or bunkering green fuels such as LNG, methanol, ammonia and hydrogen (other than biodiesel) in Hong Kong enjoy a 50 per cent port fee reduction; ocean-going vessels using such fuels as propulsion enjoy a 25 per cent reduction; vessels carrying or bunkering biodiesel (biofuel ratio ⩾ 20 per cent) enjoy a 25 per cent reduction.
	Green Vessel Registration Incentive Scheme	• Registration subsidies are provided for vessels using LNG, methanol, hydrogen or ammonia as their primary propulsion fuel, with a maximum of HK$60,000 per vessel per year and a cumulative maximum of HK$180,000 over three years.

• Continued

Port of Oslo

- From 2026, cargo ships using shore power will be eligible for a 20 per cent discount on quay dues; vessels achieving zero emissions throughout the entire process of entering, leaving and berthing at the port will be eligible for a 100 per cent discount on quay dues; vessels with an ESI score exceeding 30 points will receive a 10 per cent discount, and those exceeding 40 points will receive a 20 per cent discount. These discounts may be combined.

Port of Singapore

Maritime Singapore Green Initiative (MSGI):

- Until 31 December 2027, ocean-going vessels calling for no more than four days that use zero-emission fuels such as hydrogen and all-electric power, as well as compliant green methanol, B100 and ammonia fuel, will be exempt from all port charges; a 30 per cent discount applies to methanol meeting the applicable lower CF threshold, LNG with a methane slip rate of ⩽ 1 per cent, and B50–B99 biofuels; a 20 per cent discount applies to conventional LNG, B24–B49 and fuels meeting the carbon factor standard.

Port of Los Angeles

Voluntary Environmental Ship Index Programme (ESI Programme):

- ESI score incentives: ocean-going vessels scoring 40–49 points receive a reward of US$750 per port call; those scoring 50 points or above receive US$2,500 per port call; vessels fitted with IMO Tier III main engines receive US$5,000 per port call; and vessels participating in the port's Technology Advancement Program (TAP) receive US$750 per port call.

Port of Rotterdam

Green Award Incentives for Maritime Transport

- LNG carriers, chemical/gas carriers and product tankers that have been awarded the Port of Rotterdam Green Award certificate are eligible for a 70 per cent discount on the 'sustainability component' of port dues.

Green Award Incentives for Inland Waterway

- Motorised vessels that undergo verification across three areas—ship engines, on-board equipment and crew management—and are awarded a Green Award certificate will receive discounts on port charges based on their award tier: 15 per cent for Bronze and Silver awards, 30 per cent for Gold awards, and 100 per cent for Platinum awards.

Port of Yokohama

Port Incentive Scheme

- From 1 January 2026, the Port of Yokohama will waive entry fees for vessels fueled by methanol, as well as for vessels refuelling with 300 tonnes or more of blended fuel containing at least 24 per cent biofuel.

● Continued

Port of Vancouver

EcoAction Green Incentive Programme:

- From 2026, the Port of Vancouver grades port fee reductions into platinum, gold, silver and bronze tiers according to the clean fuels, emissions reduction technologies and environmental performance adopted by vessels, granting reductions of 60, 40, 30 and 20 per cent respectively. Among these, vessels using clean fuels such as LNG and hydrogen, adopting wind-assisted or battery-assisted emissions reduction technologies, or obtaining qualifying low-noise vessel certification may receive up to a 60 per cent port fee reduction; vessels actually using shore power while berthing receive a 40 per cent reduction. The incentive criteria also cover environmental performance including air emissions, greenhouse gas reduction and underwater noise.

Source: Official websites of respective port authorities; compiled by the Shanghai International Shipping Research Centre

2.3 Cross-sectoral Market Adjustment Mechanisms

The 'Book & Claim' mechanism is accelerating its transition towards standardised management. 'Book & Claim' is a management mechanism for low-carbon fuels that 'separates the right to use from the emission reduction attributes'; after a vessel has actually used low-carbon fuel, the verified emission reduction attributes can be transferred to shippers and logistics companies that have not used such fuel.Since 2025, this model has become increasingly standardised, with the introduction of system registration, third-party verification and the allocation of credits across different entities. The number of participating entities has continued to expand, and the mechanism has been actively aligned with shipping compliance requirements and IMO fuel certification rules.

● Table 2-2 Key developments in the shipping industry's Book & Claim mechanism from October 2025 to September 2026

October 2025

123Carbon, ZERO44

Mechanism type: Synergy between compliance management and the Book & Claim platform

Key developments: The partnership integrates CII, EU ETS and FuelEU Maritime compliance management with 123Carbon's carbon-insetting and Book & Claim functions, enabling shipping companies to coordinate mandatory compliance and voluntary emissions-reduction attribute management while reducing the risk of double counting.

• Continued

November 2025

RSB, DHL Global Forwarding

Mechanism type: Book & Claim pilot for maritime and air freight
Key developments: Launch of a Book & Claim pilot to test the RSB registration system, the allocation of emission reduction attributes across multiple clients, and traceable, verifiable emission reduction claims.

April 2026

Mitsui O.S.K. Lines, Shell, 123Carbon

Mechanism type: Allocation of third-party vessel emission reduction attributes
Key developments: Shell promoted the use of FAME biofuel on third-party vessels, entered the resulting Scope 3 emissions reduction value for shippers into the 123Carbon registration system and allocated it to Mitsui O.S.K. Lines, which, after verification, forms the corresponding emissions reduction certificates and provides them to its customers.

April 2026

Pacific International Lines, American Bureau of Shipping

Mechanism type: Independent verification of Book & Claim data
Key Development: American Bureau of Shipping (ABS) acts as an independent third party to verify Pacific International Lines' fuel consumption, transport activities and emissions data, supporting its participation in the Book & Claim registration system and enabling the generation of credible emissions reduction claims.

May 2026

Scan Global Logistics, Hapag-Lloyd

Mechanism type: maritime biofuel Book & Claim service
Key Development: The integration of Hapag-Lloyd's Ship Green biofuel service into SGL's emissions reduction portfolio, enabling customers to claim verified Scope 3 emissions reductions across their supply chains via the Book & Claim mechanism without altering their existing logistics operations.

July 2026

International Maritime Organisation (IMO)

Mechanism type: study of chain-of-custody models such as Book & Claim
Key developments: The IMO held an expert workshop to study chain-of-custody models such as physical segregation, mass balance and Book & Claim, and to explore their potential linkage with the IMO's life-cycle greenhouse gas assessment framework for marine fuels and its sustainable fuel certification system.

The forms of green finance support for shipping have become more diversified. Over the past year, financial instruments such as credit, bonds, financial leasing and export credit insurance have continued to be applied to the green transition of shipping, with support covering fields including green ship construction and renewal, power batteries, shore power and port infrastructure. Different financial instruments provide support such as long-term loans, equipment financing, credit enhancement and capital market financing according to project characteristics, offering diversified funding sources for the implementation of green shipping projects.

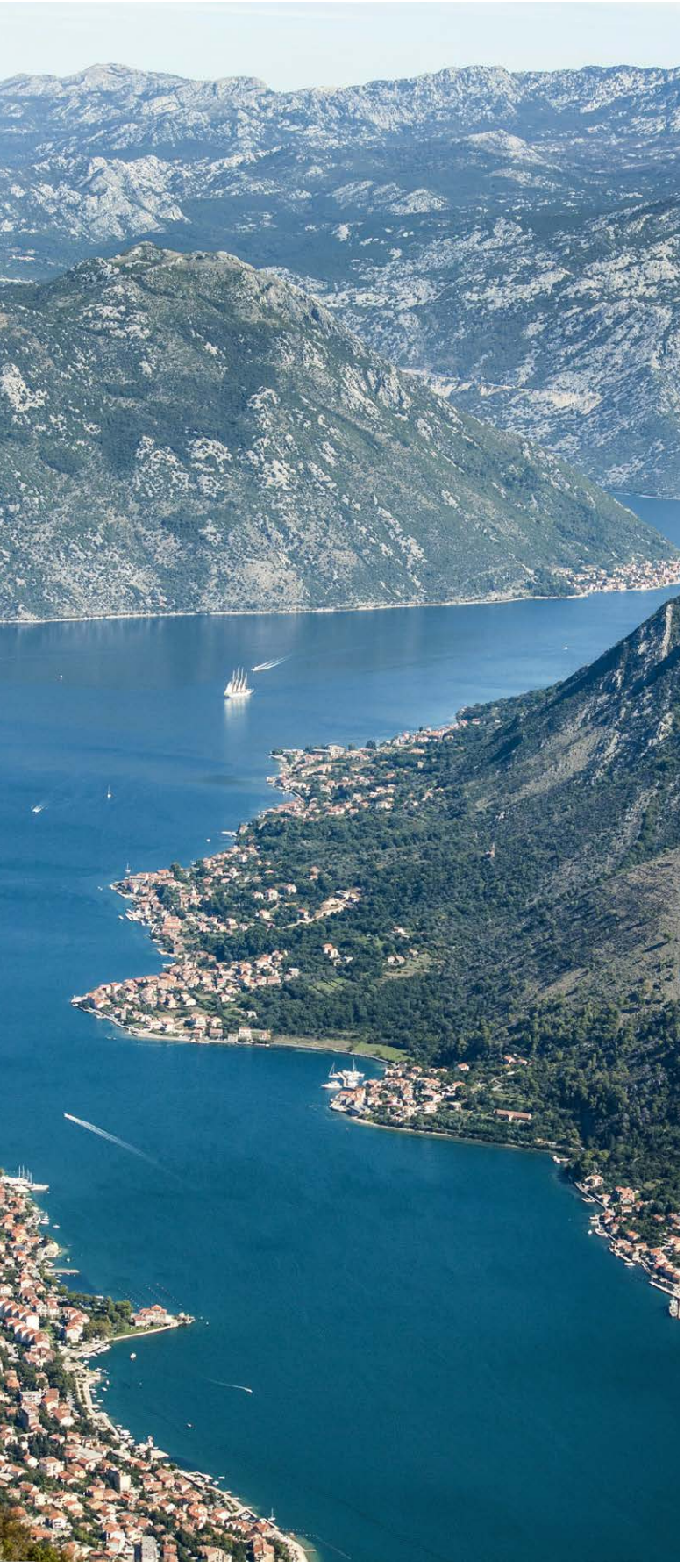
• Table 2-3 Typical Green Finance Case Studies in the Shipping Sector, 2025–2026

Date	Project Name	Type of Financing	Financing Institution	Purpose and Outcomes
December 2025	CMA CGM's methanol-dual-fuel container ship 'ANTIGONE'	French tax lease financing	Sinosure, the Export-Import Bank of China and dozens of domestic and foreign banks	Secured financing of approximately US$1.5 billion to support the delivery of CMA CGM's methanol dual-fuel vessel project, of which the ANTIGONE was delivered in December 2025.
December 2025	Skandia Gateway Expansion Project at the Port of Gothenburg	Long-term loan for port infrastructure	European Investment Bank (EIB)	Invested 850 million Swedish kronor (approximately 77.5 million euros) to carry out channel dredging and quay reinforcement works.
December 2025	Shandong Weiqiao Pioneering Group's New Energy Bulk Carriers	Finance Lease	China Resources Financial Leasing Co., Ltd.	Provided customised financial leasing services for the vessel's core power system — containerised lithium battery packs.
December 2025	Guangzhou Public Transport Group Passenger Ferry Company's All-Electric Passenger Vessel Project	Transition finance loan for inland waterway passenger vessels	Bank of Communications, Guangdong Branch	Disbursed a loan of 82.54 million yuan, with an initial disbursement of 10.54 million yuan, for the construction of all-electric passenger vessels.



Date	Project Name	Type of Financing	Financing Institution	Purpose and Outcomes
March 2026	Port of Rotterdam Deep-Water Container Terminal Shore Power Project	Project loan + EU grant	European Investment Bank (loan of 90 million euros); European Commission CEF-AFIF (grant of approximately 70 million euros)	Construction of 8 kilometres of quay and 35 shore power connection points for ocean-going container ships at three deep-water container terminals, with phased commissioning planned from the second half of 2028.
May 2026	Port of Klaipėda Green and Resilient Infrastructure Programme	Non-committed credit facility	Nordic Investment Bank (NIB)	€ 55.5 million to support a total investment of € 111 million, comprising shore power, Lithuania's first green hydrogen production and refuelling hub, and navigation facilities.
June 2026	Nippon Yusen's Sixth Series of Transition Bonds (Nos. 52 and 53)	Unsecured transition bonds (5-year + 10-year)	Nomura Securities, MUFG Morgan Stanley Securities, SMBC Nikko Securities, Daiwa Securities	Total issue amount of 33 billion yen; proceeds to be used for vessel fuel conversion projects, including LNG-powered vessels; the two bond issues mature in 2031 and 2036 respectively.

Source: Relevant company websites; compiled by the Shanghai International Shipping Institute



Shipper consortia are forming large-scale procurement demand. The Zero-Emission Maritime Buyers' Alliance (ZEMBA) brings together shippers' emissions reduction demands and releases demand signals to shipping companies and green fuel producers through joint tendering and multi-year procurement contracts. In December 2025, the second round of tendering selected two shipping companies, Hapag-Lloyd and North Sea Container Line, to deploy e-methanol and e-ammonia respectively. Current commitments cover approximately 20 billion tonne-miles of transport activity, to be implemented from 2027, with cumulative emissions reductions of at least approximately 120,000 tonnes of CO_2 equivalent expected; by August 2026, ZEMBA's two rounds of tendering had covered three ultra-low-carbon fuel pathways and produced nearly 40 multi-year contracts.

The German-led H2Global mechanism links the supply of and demand for clean fuels through two-way auctions and uses public funds to bridge the price gap between the two sides. In 2026, H2Global further explored applying the mechanism to the clean marine fuel market and co-initiated the e-Sustainable Marine Fuels Early Movers Initiative, promoting the establishment of a two-way auction mechanism for green shipping fuels. In August of the same year, H2Global and ZEMBA jointly proposed two conceptual models combining public funding support with voluntary shipper procurement, exploring the introduction of corporate demand for Scope 3 emissions reduction attributes into two-way auctions through the Book & Claim mechanism, thereby forming a new pathway in which public funds and voluntary corporate demand jointly support green fuel uptake.

2.4 Accounting, Standards and Certification Systems

The IMO continues to refine the life-cycle accounting rules for marine fuels. In May 2026, MEPC 84 continued its review of the life-cycle greenhouse gas emission factors of marine fuels and agreed to include the initial well-to-tank (WtT) default emission factor of 20.8 gCO_2e/MJ for a specific Brazilian second-crop corn ethanol pathway in a future revision of the LCA Guidelines. In June, the IMO issued the revised interim guidelines for biofuel DCS and CII, clarifying that from 2027 onwards, biofuels certified by a recognised international certification scheme as meeting sustainability requirements and achieving full life-cycle greenhouse gas emissions at least 65 per cent lower than those of fossil MGO may be assigned corresponding carbon emission conversion factors based on their certified actual emission intensity, effectively linking fuel emissions, certification and the assessment of ship carbon intensity.

The EU's green fuel accounting has further strengthened the integration of actual emissions with supply chain certification. FuelEU Maritime applies full life-cycle accounting to the greenhouse gas intensity of the energy used on board ships, and the recognition of the emissions reduction value of fuels such as biofuels and RFNBOs requires sustainability and greenhouse gas emissions reduction certification consistent with the requirements of the EU Renewable Energy Directive (RED). In October 2025, the EU published guidelines for the reporting and verification of actual methane slip emission factors for marine engines, allowing verified actual methane slip values that meet the prescribed conditions to replace default values, thereby improving the accuracy of greenhouse gas emissions accounting for LNG-powered ships.

China's standards relating to alternative marine fuels continue to be refined. In March 2026, the Standardisation Administration of China issued the formulation plan for the recommended national standard 'Marine Biofuel Oil'; GB/T 47317—2026 'Marine Methanol Fuel Engines' came into force on 1 July; and the mandatory national standard 'Safety Code for Methanol Fuel Bunkering Operations on Water' has entered the approval stage. The relevant standards progressively cover fuel products, power equipment and bunkering operations, providing technical specification support for the application of alternative marine fuels such as methanol and biofuels.



The verification mechanism for zero-carbon energy certificates is gradually being extended to the marine fuel sector. The Zero Carbon Energy Certification (ZCEC), spearheaded by the Biomass Energy Industry Branch of the China Industrial Development Promotion Association, addresses challenges relating to the certification, traceability and value quantification of green fuels. The platform issues certificates following multi-stage audits, has established a three-tiered set of rules, and has developed verification methods for green methanol. As of March 2026, 99 projects had been integrated into the system, 121,500 certificates had been issued, and 4,000 certificates had been traded, creating a closed-loop end-to-end process to support carbon accounting for marine fuels and international alignment.



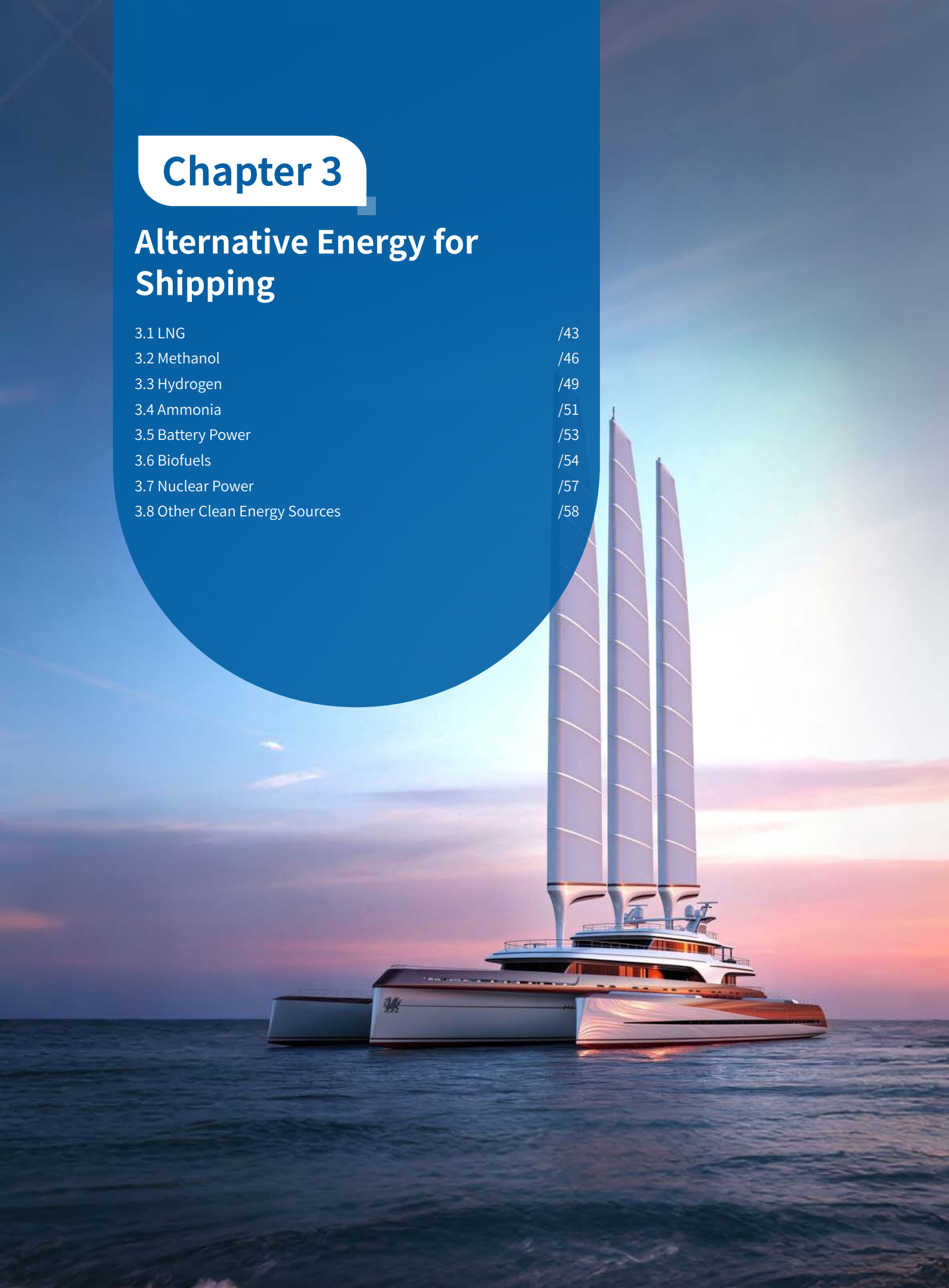
• Figure 2-3 Functions of the Voluntary Verification Platform for Zero Carbon Energy Certificates

The green marine fuel certification system has commenced demonstration applications. On 30 June 2026, the Green Marine Fuel International Certification System (GSTC), independently developed by China, was launched in Shanghai, and the GSTC Affairs Centre was established to explore related certification services, with the first group of market entities completing demonstration certification. On the same day, the Shanghai International Shipping Green Fuel Trading Platform started trial operation, piloting services including certification-based confirmation of rights, registration, trading, settlement and cancellation of green fuels. With the certification system and the trading platform advancing in step, a foundation has been laid for subsequently improving certification rules, developing market-based service capabilities and exploring international mutual recognition.

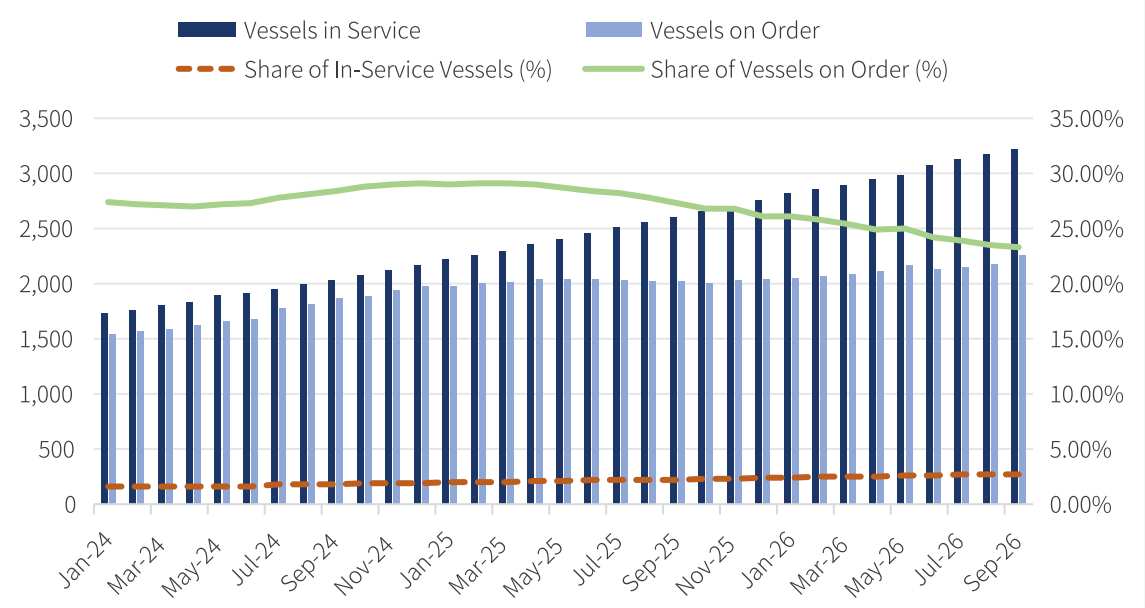
Chapter 3

Alternative Energy for Shipping

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From January 2024 to September 2026, the green transition of the existing fleet continued to advance. The share of alternative-fuel vessels in the gross tonnage of the global fleet increased steadily from 6.3% to 10.5%, while their share of the global orderbook by gross tonnage declined from 50.3% to 41.6%. Uncertainty surrounding the pace of policy implementation, the availability of green fuels and longer-term technology pathways has made shipowners increasingly cautious in making newbuilding investment decisions.

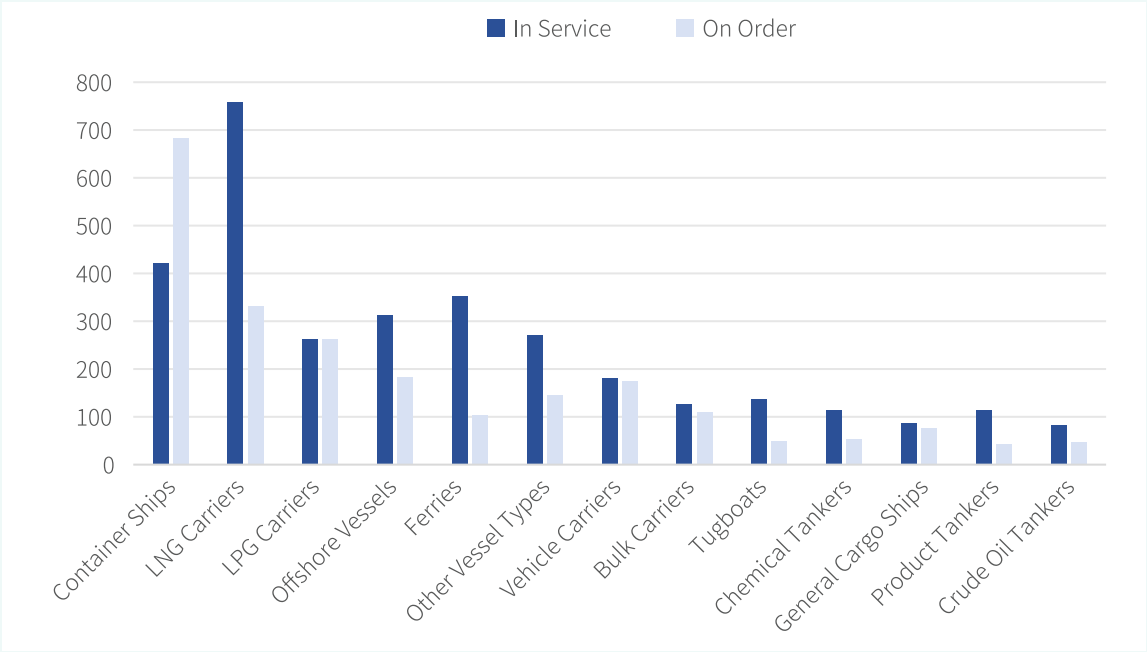


Source: Clarksons.

● **Figure 3-1 Trends in the Global Alternative-Energy Fleet and Orderbook as of September 2026**

As of September 2026, 3,218 alternative-fuel vessels were in service worldwide, with a combined gross tonnage of 188.9316 million GT, accounting for 2.7% of the global fleet by vessel count and 10.5% by gross tonnage. Of these, 1,729 were LNG-fueled vessels and 178 were methanol-fueled vessels. Over the same period, the global orderbook for alternative-fuel vessels stood at 2,262 vessels and 181.2969 million GT, representing 23.3% of the global orderbook by vessel count and 41.6% by gross tonnage. LNG-fueled and methanol-fueled vessels accounted for 1,195 and 283 vessels on order, respectively. A total of 507 alternative-fuel vessels entered service in 2025, while 576 new orders were placed. During the first three quarters of 2026, 418 alternative-fuel vessels entered service and 516 new orders were placed.





Source: Clarksons.

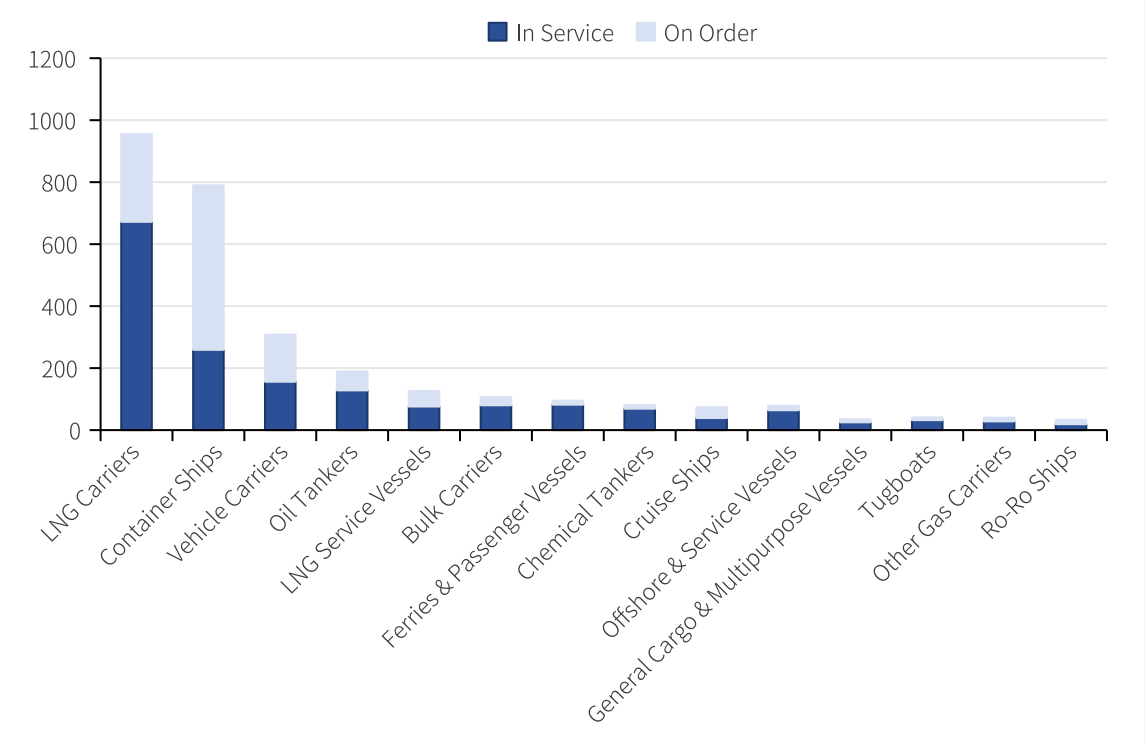
● Figure 3-2 Alternative-Fuel Vessels in Service and on Order, by Ship Type , as of September 2026

Container ships accounted for the largest share of alternative-fuel vessel orders by ship type. As of September 2026, the container ship orderbook stood at 1,913 vessels and 147.16 million GT. Of these, 683 vessels, totaling 95.9488 million GT, were designed to use alternative fuels, accounting for 35.7% of the container ship orderbook by vessel count and 65.0% by gross tonnage. They also represented 30.2% of all alternative-fuel vessels on order by vessel count and 52.9% by gross tonnage.



3.1 LNG

LNG remains the principal alternative marine fuel. As of September 30, 2026, 1,729 LNG-fueled vessels were in service worldwide, accounting for 53.7% of all alternative-fuel vessels in service and 78.4% of their combined gross tonnage. LNG carriers and container ships, numbering 757 and 259, respectively, were the principal ship types in the LNG-fueled fleet. A further 1,195 LNG-fueled vessels were on order, accounting for 52.8% of alternative-fuel vessel orders by count and 76.2% by gross tonnage.



Source: Clarksons.

● Figure 3-3 Distribution of LNG-Fueled Vessels by Ship Type as of September 2026

LNG bunkering volumes continued to grow at major ports. In the first half of 2026, LNG bunkering volumes at the ports of Singapore, Rotterdam and Shanghai reached 318,300 tonnes, 237,600 tonnes and 174,900 tonnes, respectively, all exceeding the corresponding levels recorded in the first half of 2025. Singapore recorded the highest year-on-year growth rate, at 30.3%.

● Table 3-1 LNG Bunkering Volumes at Selected Ports, 2025 and First Half of 2026

Port	H1 2026 bunkering volume(10,000 tonnes)	Year-on-year growth(%)	2025 bunkering volume(10,000 tonnes)	Year-on-year growth(%)
Singapore	31.83	30.3	57.14	23.1
Rotterdam	23.76	11.5	45.48	7.0
Shanghai	17.49	1.4	32.04	54.1

Note: LNG volumes have been converted using a conversion factor of 1 m^3 of LNG = 0.45 tonnes.

Source: Official websites of the relevant port authorities; compiled by the Shanghai International Shipping Institute.

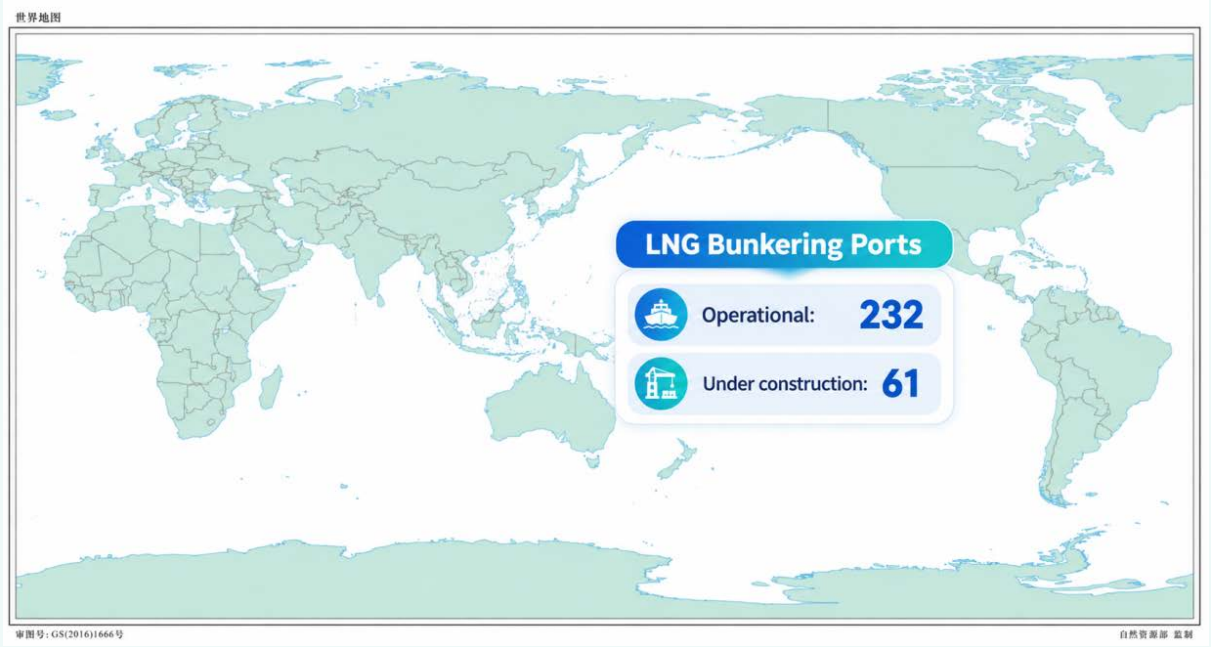
LNG bunker prices showed considerable volatility. LNG prices are affected by natural gas supply and demand, liquefaction costs, interregional transportation costs, port service charges and regional energy prices, and generally fluctuate more widely than very low-sulfur fuel oil (VLSFO) prices. From October 2025 to September 2026, LNG bunker prices in Rotterdam generally declined before rising. The lowest price was USD 610.5 per metric tonne during December 15–19, 2025, while the highest was USD 1,597 per metric tonne during September 14–18, 2026.



Source: Ship & Bunker.

● Figure 3-4 LNG and VLSFO Bunker Prices in Rotterdam, October 2025–September 2026

As of September 30, 2026, approximately 293 ports worldwide had LNG bunkering facilities in operation or under development, of which around 232 were already operational. LNG bunkering ports and supply capacity were concentrated primarily in Europe, Asia and North America, with particularly dense networks in Europe and across East and Southeast Asia.



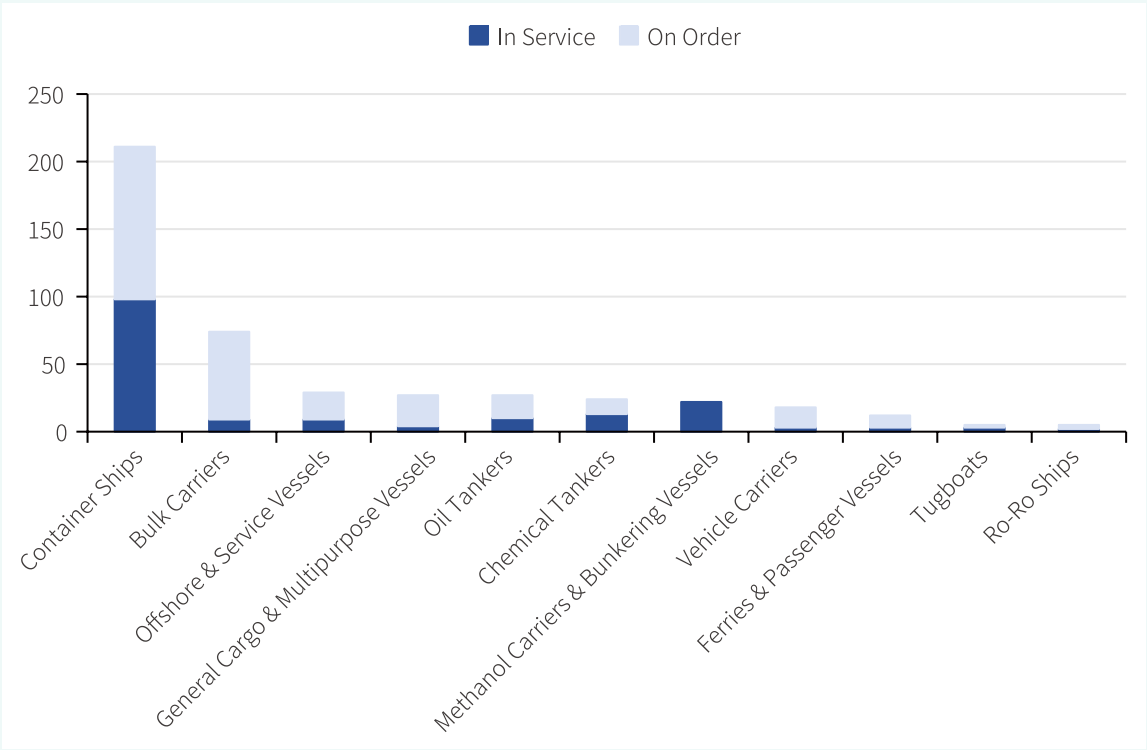
Sources: SEA−LNG and DNV.

● Figure 3-5 Global LNG Applications and Bunkering Infrastructure as of December 2025

The use of bio-LNG accelerated. Bio-LNG is generally produced by upgrading and purifying biogas derived from biomass feedstocks into biomethane, which is subsequently liquefied. Commercial supplies of bio-LNG have already been established at several European ports, with bunkering volumes continuing to increase. In the first half of 2026, bio-LNG bunkering volume at the Port of Rotterdam reached 22,766 m^3, exceeding the total volume recorded for the whole of 2025 and indicating that local marine demand for bio-LNG was expanding more rapidly.

3.2 Methanol

Methanol is being adopted across a broader range of ship types. As of September 30, 2026, 178 methanol-fueled vessels were in service worldwide and 283 were on order. Their respective shares of the gross tonnage of the alternative-fuel fleet in service and orderbook stood at 7.1% and 13.9%. The existing fleet consisted primarily of container ships, methanol carriers and chemical tankers, while the orderbook had expanded further into ocean-going segments such as bulk carriers, oil tankers and vehicle carriers.



Source: Clarksons.

● Figure 3-6 Methanol-Fueled Vessels in Service and on Order as of September 2026

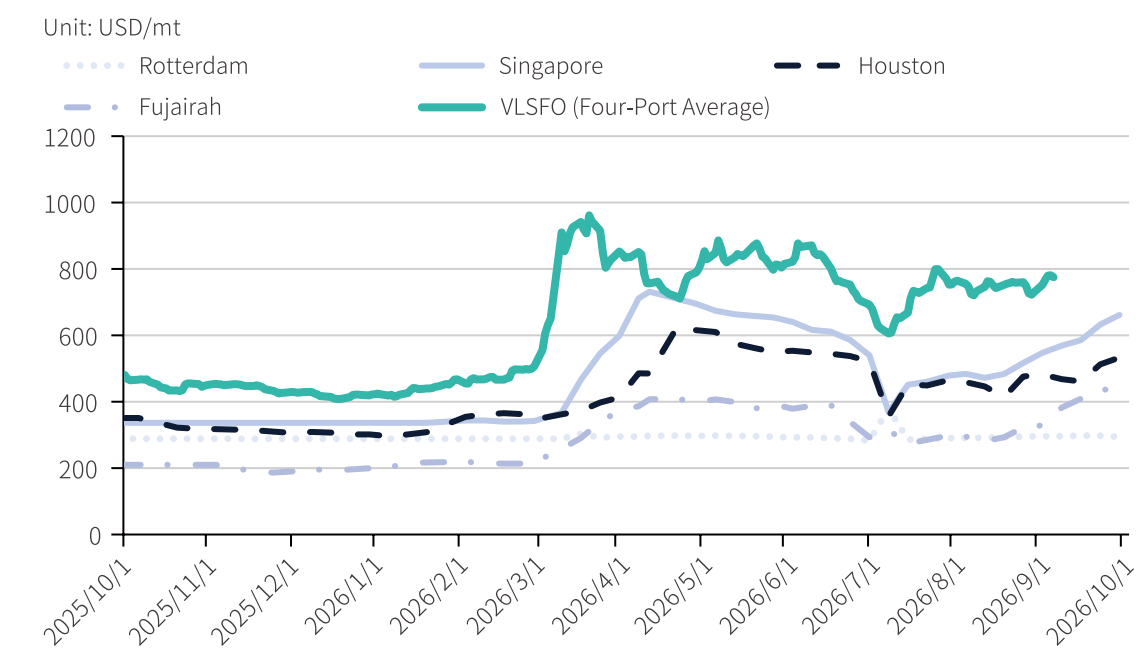
Methanol bunkering activity continued to expand rapidly. In the first half of 2026, methanol bunkering volume at the Port of Shanghai reached 51,200 tonnes, up 57.5% year on year. Of this total, 14,660 tonnes was domestically produced green methanol, representing a year-on-year increase of 144%. Methanol bunkering volume at the Port of Singapore reached approximately 6,310 tonnes, already exceeding its full-year 2025 level. Rotterdam recorded 3,841 tonnes of methanol bunkering, all of which was biomethanol, representing a year-on-year decline of 59.3%.

● Table 3-2 Methanol Bunkering Volumes at Selected Ports, 2025 and First Half of 2026

Port	H1 2026 bunkering volume (tonnes)	Year-on-year growth(%)	2025 bunkering volume (tonnes)	Year-on-year growth(%)
Singapore	6,310	/	3,010	85.1
Rotterdam	3,841	-59.3	11,819	199.5
Shanghai	51,200	57.5	62,500	12,301

Source: Official websites of the relevant port authorities.

Methanol bunker prices showed considerable volatility. From October 2025 to September 2026, conventional methanol bunker prices at major ports, including Rotterdam, Singapore, Houston and Fujairah, showed marked fluctuations but rose overall from their levels at the beginning of the period. The lowest price, at USD 186.5 per metric tonne, was recorded at Fujairah on November 24, 2025, while the highest, at USD 731.5 per metric tonne, was recorded at Singapore on April 10, 2026. Price differentials among ports were mainly attributable to regional supply and demand conditions, sources of supply, transport distances, port service charges and delivery terms. According to Argus, in early March 2026, RED-certified biomethanol was quoted at US$865 per tonne FOB northern China and US$920–950 per tonne for bunkering in eastern China (renamed the Shanghai bunkering price in May 2026). The bunkering transaction price for negative-carbon-intensity biomethanol at the Port of Shanghai exceeded US$1,000 per tonne.



Source: Ship & Bunker.

• Figure 3-7 Conventional Methanol Bunker Prices at Selected Ports, October 2025–September 2026

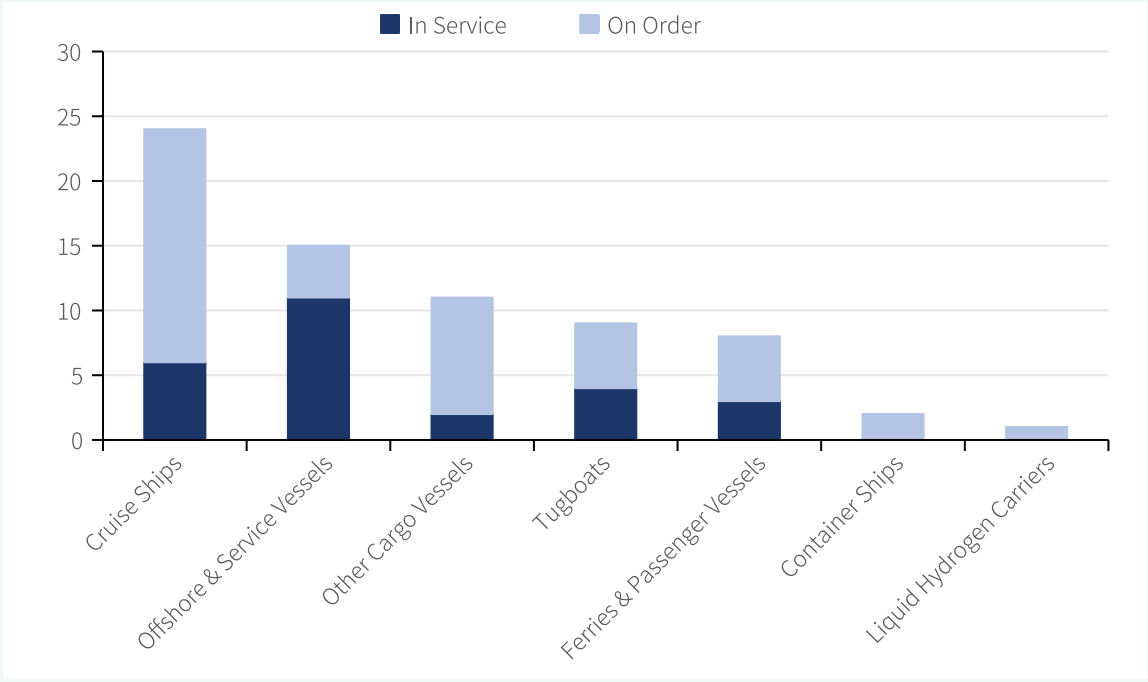
Methanol bunkering infrastructure continued to expand. As of September 30, 2026, 34 ports worldwide had established methanol bunkering capabilities, while another 32 ports had such facilities under development or construction. These ports were concentrated mainly in major shipping regions in East Asia, Southeast Asia and Northwestern Europe. Of these, 21 ports were capable of providing green methanol bunkering services, primarily in the Asia-Pacific region, Northwestern Europe and the United States. The global methanol bunkering network is expanding along major Asia–Europe shipping routes and around major container hub ports, gradually progressing from demonstration-scale operations toward routine supply.



Figure 3-8 Global Green Methanol Bunkering Ports as of September 2026

3.3 Hydrogen

Hydrogen-fueled vessels remain at the demonstration stage. Their applications are concentrated mainly in inland waterway transport, fixed-route passenger services, harbor operations and specialized operations, where voyage distances are relatively short and hydrogen supply and refueling conditions can be more readily managed. Overall deployment remains limited. As of September 30, 2026, 26 hydrogen-fueled vessels were in service worldwide and 44 were on order, accounting for 0.8% and 1.9% of alternative-fuel vessels in service and on order, respectively.



Source: Clarksons.

● Figure 3-9 Hydrogen-Fueled Vessels in Service and on Order, by Ship Type, September 2026

Hydrogen is developing along differentiated technological pathways. Its use as a marine energy source is advancing primarily through two technological routes: hydrogen fuel cells and hydrogen internal-combustion engines. Hydrogen fuel-cell systems have already entered operation on short-distance routes with fixed or relatively fixed operating patterns. In May 2026, China's hydrogen fuel-cell container ship Dongfang Hydrogen Harbor entered service. The vessel is equipped with two hydrogen fuel-cell systems, each rated at 240 kW, and has a hydrogen storage capacity of 550 kg and an operating range of approximately 380 km. Earlier, in December 2025, India's first domestically built hydrogen fuel-cell passenger vessel entered commercial service in Varanasi.

Such operating scenarios feature relatively stable voyage distances and berthing locations, making it easier to deploy centralized hydrogen-refueling infrastructure and undertake equipment maintenance. Consequently, hydrogen fuel-cell vessels currently in operation or under demonstration remain concentrated primarily on short-distance routes with fixed or relatively fixed operating patterns.

Hydrogen internal-combustion engines are progressing toward higher-power and ocean-going applications. Large marine hydrogen engines for ocean-going vessels remain primarily at the stages of full-scale main-engine testing and demonstration-vessel design and construction. Japan is developing a 17,500-dwt hydrogen-fueled multipurpose vessel equipped with a liquid-hydrogen fuel-supply system and a low-speed two-stroke hydrogen engine. In March 2026, its full-scale main engine achieved a hydrogen co-firing ratio of more than 95% at full load. Demonstration operations are scheduled to begin in fiscal year 2028 and continue for three years.

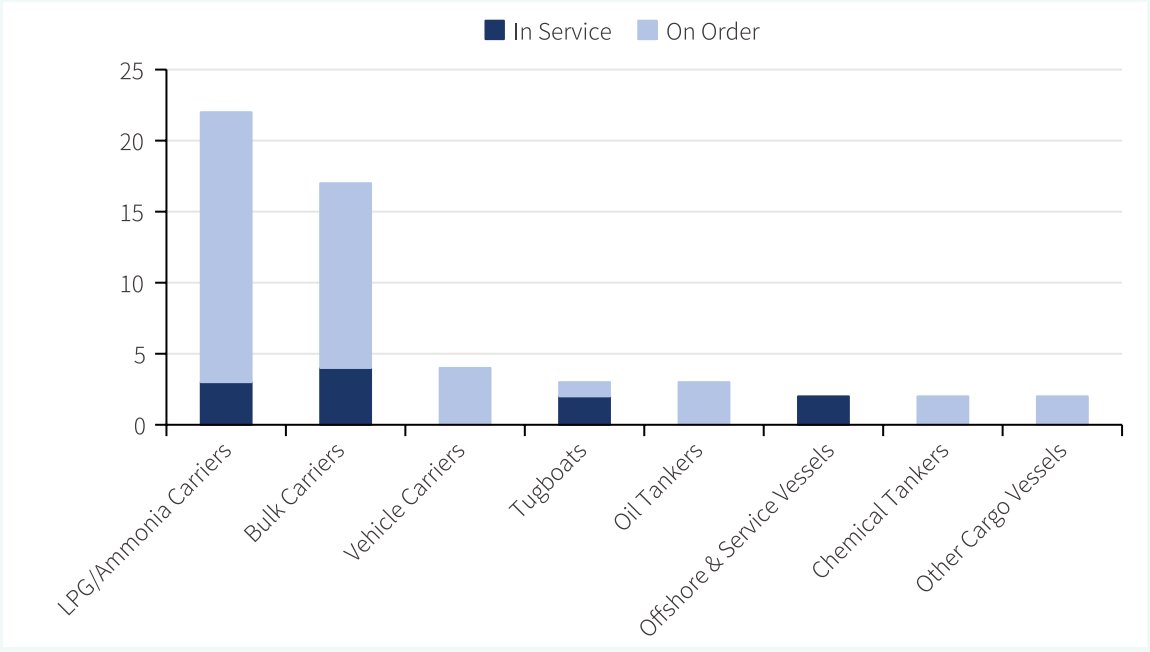
● Table 3-3 Principal Technology Pathways for Marine Hydrogen Applications

Technology pathway	System characteristics	Principal applications	Key technical requirements
Hydrogen fuel-cell electric propulsion	Hydrogen fuel cells generate electricity to drive an electric propulsion system, normally in combination with propulsion batteries and an energy-management system	Inland cargo vessels, passenger vessels, ferries, tugboats, harbor craft and offshore support vessels	Fuel-cell power output and durability, hydrogen storage and supply systems, battery integration, thermal management and shoreside hydrogen refueling
Hydrogen internal-combustion engines	Hydrogen is introduced into engine cylinders for combustion; current systems generally operate in dual-fuel mode or use a small quantity of pilot fuel for ignition	Tugboats, workboats, coastal vessels and large ocean-going cargo ships	Combustion stability, abnormal-combustion control, NOx emissions control, fuel injection and high-capacity hydrogen supply

Hydrogen storage and supply capabilities remain major constraints on large-scale deployment. The principal onboard hydrogen supply options include high-pressure compressed hydrogen, liquid hydrogen and onboard hydrogen production through processes such as methanol reforming or ammonia cracking. High-pressure compressed-hydrogen technology is relatively mature, but its comparatively low volumetric energy density means that it is mainly suited to short- and medium-range vessels. Liquid hydrogen can support longer voyages and higher power requirements, but imposes more stringent requirements for cryogenic storage, boil-off gas management and safety segregation. Onboard hydrogen production can reduce direct hydrogen-storage requirements, but results in greater system complexity and higher equipment-space requirements. Overall, the cost of low-carbon hydrogen supply, onboard hydrogen-storage space, liquid-hydrogen storage and transportation, port hydrogen-refueling infrastructure and safety management remain the principal constraints on the large-scale adoption of hydrogen-fueled vessels.

3.4 Ammonia

Ammonia-fueled vessels remain concentrated primarily in the orderbook. As of September 2026, 11 ammonia-fueled vessels were in service worldwide and 44 were on order, accounting for approximately 0.3% and 1.9% of alternative-fuel vessels in service and on order, respectively. Seven new orders were placed in 2025, compared with four during the first three quarters of 2026.



Source: Clarksons.

• Figure 3-10 Ammonia-Fueled Vessels in Service and on Order, by Ship Type, September 2026

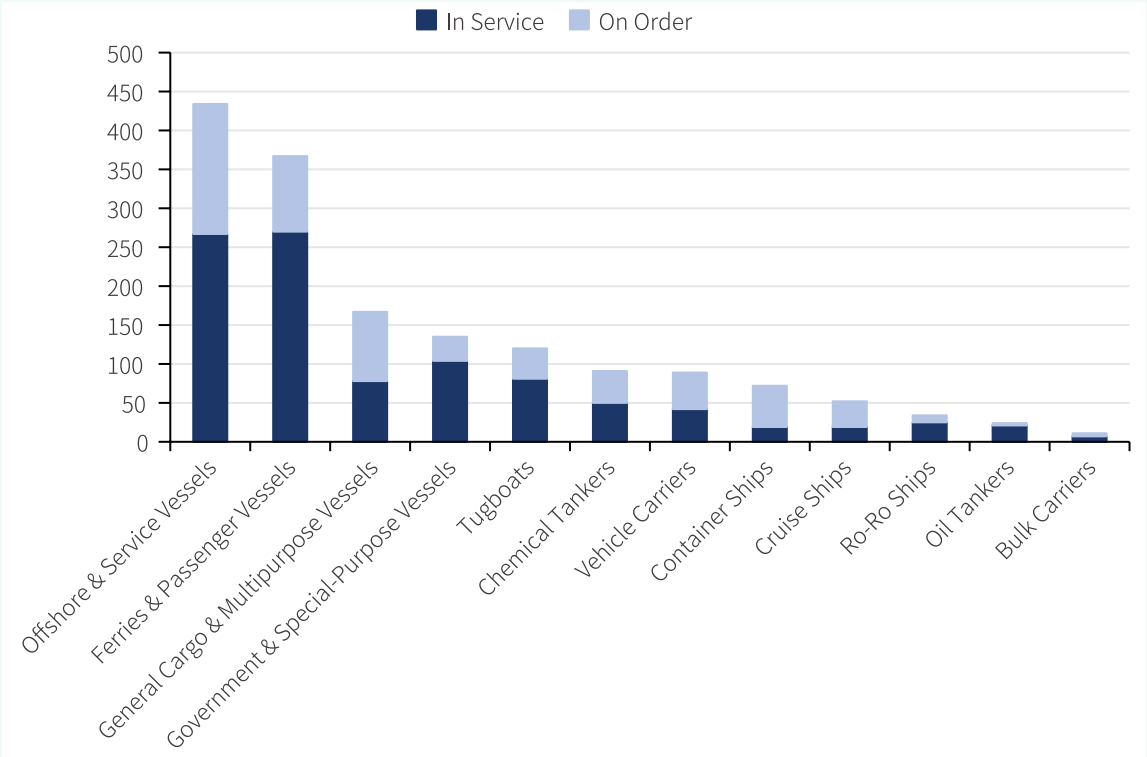
Ammonia-fueled shipping is progressing from technology validation toward shipboard application. Large ocean-going ammonia-powered vessels currently rely primarily on dual-fuel internal-combustion engines. In January 2026, WinGD's X52DF-A two-stroke ammonia-fueled engine completed Type Approval Testing (TAT) and Factory Acceptance Testing (FAT). In May, EXMAR's 46,000 m^3 midsize gas carrier ANTWERPEN, equipped with the engine, completed sea trials and was formally delivered in June. It became the world's first ocean-going vessel equipped with an ammonia dual-fuel engine, marking the transition of large ammonia dual-fuel engines from land-based testing to operation aboard an ocean-going vessel.

Safety requirements and supporting bunkering arrangements for ammonia are also being strengthened. In December 2024, the IMO approved the Interim Guidelines for the Safety of Ships Using Ammonia as Fuel. In May 2026, it further approved interim guidelines concerning the use of ammonia cargo as fuel and related seafarer training. Safety requirements are therefore extending beyond shipboard equipment and systems to cover cargo-as-fuel applications and personnel operations.

In April 2026, approximately 600 tonnes of ammonia fuel was supplied to ANTWERPEN at the Port of Ulsan in the Republic of Korea, completing the world's first commercial ammonia bunkering operation. During the same period, Singapore advanced technical standards for ammonia bunkering and ship-to-ship bunkering trials, while major European ports accelerated the development of safety requirements, approval procedures and supply networks. In July, ITOCHU Corporation and Peninsula established a specialized ammonia bunkering company, with plans to develop operations at ports including Algeciras, Rotterdam and Antwerp-Bruges. These developments indicate that ammonia fuel is gradually moving from technical demonstration toward commercial application.

3.5 Battery Power

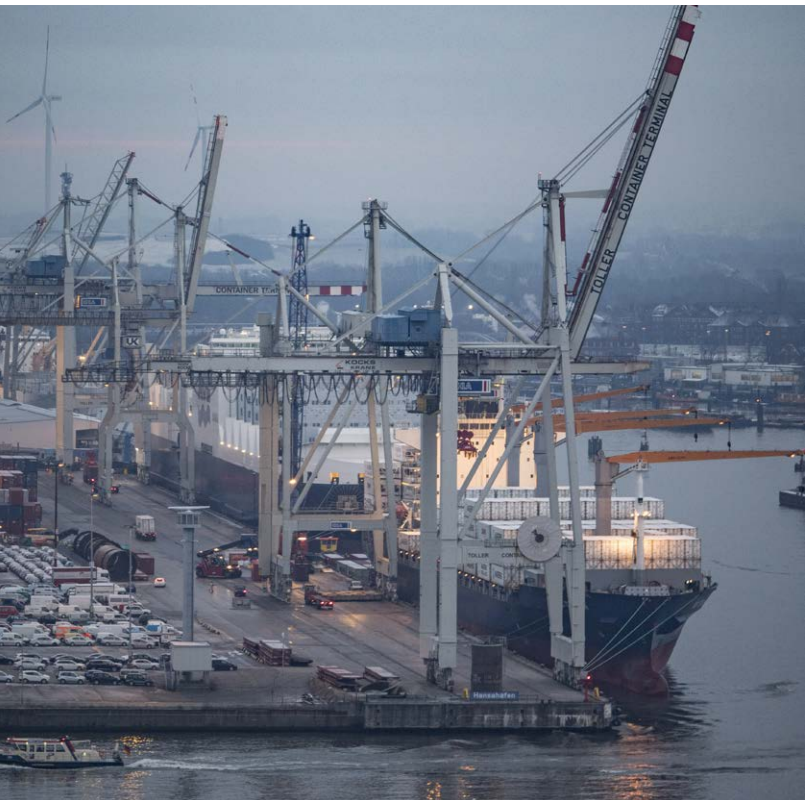
Battery-powered vessels remain predominantly hybrid. As of September 30, 2026, 983 battery-powered vessels, with an aggregate gross tonnage of approximately 9.7608 million GT, were in service worldwide and accounted for 30.6% of the alternative-fuel fleet by vessel count. Of these, 139 were fully battery-electric vessels and 844 were battery-hybrid vessels. A further 613 vessels, totaling approximately 11.428 million GT, were on order and accounted for 27.1% of the alternative-fuel vessel orderbook by vessel count. By ship type, battery-powered vessels in service were concentrated primarily in the offshore-vessel and ferry segments, with 281 and 270 vessels, respectively. The orderbook was increasingly expanding into larger merchant-ship segments, including 53 container ships and 47 vehicle carriers. A total of 227 new battery-powered vessels were ordered in 2025, compared with 116 during the first three quarters of 2026.



Source: Clarksons.

● Figure 3-11 Battery-Powered Vessels in Service and on Order, by Ship Type, September 2026

Charging and battery-swapping networks and related safety requirements are developing rapidly. During 2025–2026, as battery-powered vessels increasingly entered regular service on fixed routes, supporting infrastructure gradually evolved from individual charging facilities toward standardized and networked charging and battery-swapping systems. Zero Emission Services (ZES) in the Netherlands continued to expand its charging and battery-swapping network for inland vessels, with five sites in operation by 2026.

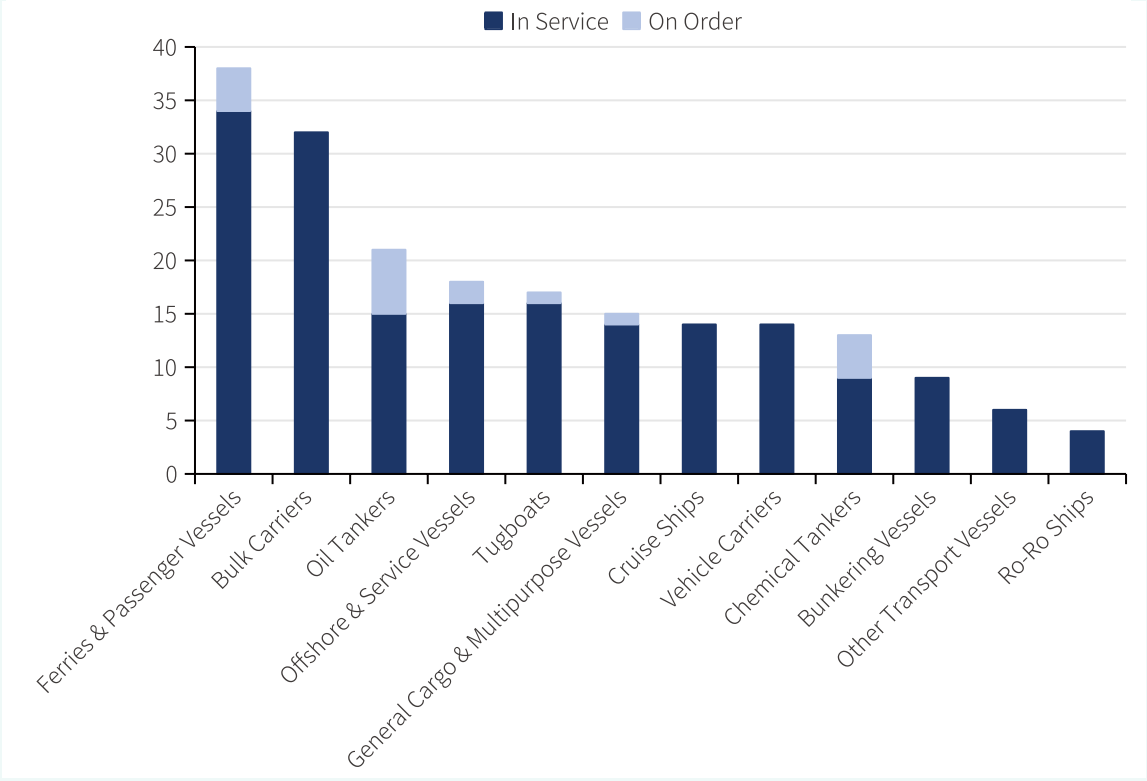


In China's Yangtze River Delta, Shanghai, Jiangsu, Zhejiang and Anhui jointly developed a network plan comprising 31 charging and battery-swapping stations for electric inland-waterway vessels. Nine stations had already been built, while a further 22 were planned. At the same time, the IMO initiated work to strengthen safety requirements for lithium-ion batteries and swappable containerized battery systems, including studies on amendments to SOLAS and the development of safety requirements for swappable battery containers. The revised China Classification Society rules governing the use of battery power aboard ships entered into force in January 2026, further strengthening requirements for shoreside monitoring, digital surveys and the management of containerized mobile power systems.

Fully battery-electric propulsion is expanding into larger cargo vessels. On 15 April 2026, China's first 10,000-ton-class fully battery-electric intelligent container ship, Ningyuan Diankun, entered service on the route between Ningbo-Zhoushan Port and Jiaxing Port. The vessel has a capacity of 742 TEU and can carry ten standardized containerized battery units, providing approximately 19,600 kWh of total energy-storage capacity and a range of around 90 nautical miles. It combines shoreside charging with containerized battery swapping, indicating that fully battery-electric propulsion is extending beyond small and medium-sized vessels and short-distance applications into larger coastal cargo shipping.

3.6 Biofuels

The biofuel vessel orderbook remains limited. As of September 30, 2026, 232 vessels recorded as using biofuels were in service worldwide and 18 were on order, accounting for 7.2% and 0.8% of alternative-fuel vessels in service and on order, respectively. Vessels in service included container ships, passenger vessels, oil tankers, bulk carriers, tugboats and vehicle carriers. Eight new orders were placed in 2025, compared with one during the first three quarters of 2026. Because biofuels can be blended with conventional fuels and used aboard existing vessels with compatible fuel systems without requiring large numbers of purpose-built vessels, the number of vessels recorded in shipping databases does not fully reflect the actual scale of marine biofuel use.

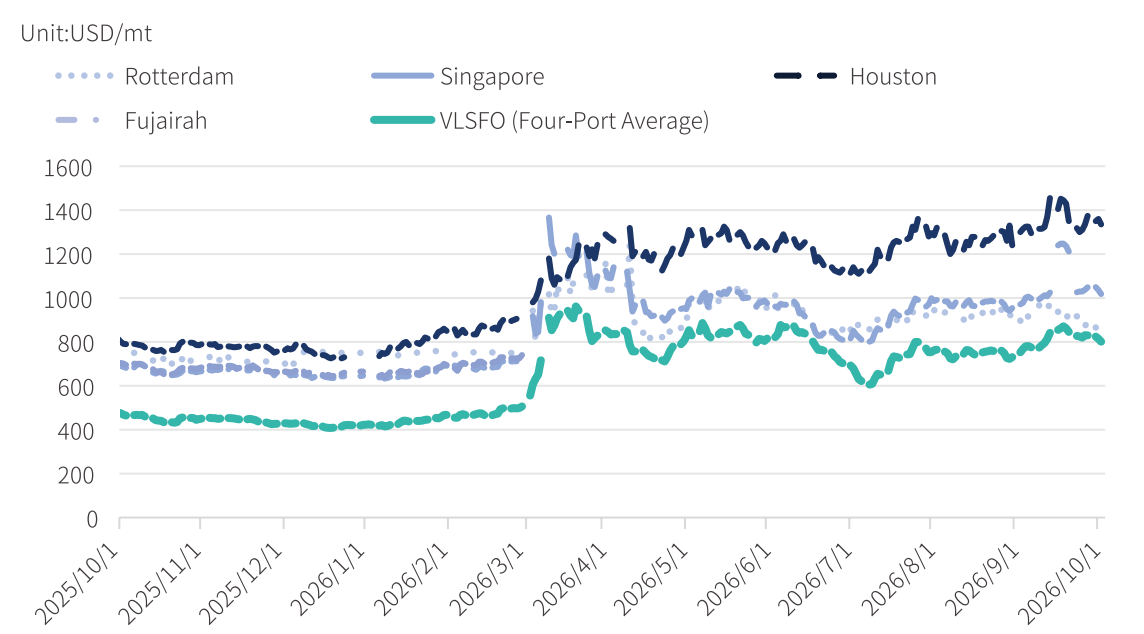


Source: Clarksons.

● Figure 3-12 Biofuel-Capable Vessels in Service and on Order, by Ship Type, September 2026

Biofuel bunker prices trended upward amid considerable volatility. From October 2025 to September 2026, the lowest biofuel bunker price recorded at major global ports was USD 633 per metric tonne at Singapore on January 7, 2026, while the highest was USD 1,455 per metric tonne at Houston on September 11, 2026.





Note: The biofuel products shown are blends with VLSFO. The product supplied in Singapore is B24, containing 24% biofuel, while those supplied in Rotterdam, Fujairah and Houston are B30 blends containing 30% biofuel.

Source: Ship & Bunker.

• Figure 3-13 Biofuel Bunker Prices at Selected Ports, October 2025–September 2026

Bunkering volumes at major ports showed divergent trends. In the first half of 2026, Singapore shifted from year-on-year growth to decline, while Rotterdam moved from decline to growth. Ningbo-Zhoushan Port continued to record relatively rapid growth. Market performance therefore varied markedly across the world's principal biofuel bunkering ports.

● Table 3-4 Biofuel Bunkering Volumes at Selected Ports, January 2025–June 2026

Port and product	H1 2026 bunkering volume (10,000 tonnes)	Year-on-year growth (%)	2025 bunkering volume (10,000 tonnes)	Year-on-year growth (%)
Singapore (B24)	41.8	-45.0	137.9	56.7
Rotterdam (B30)	34.6	23.6	64.9	-14.6
Ningbo-Zhoushan (B24)	10.74	203.4	12	/

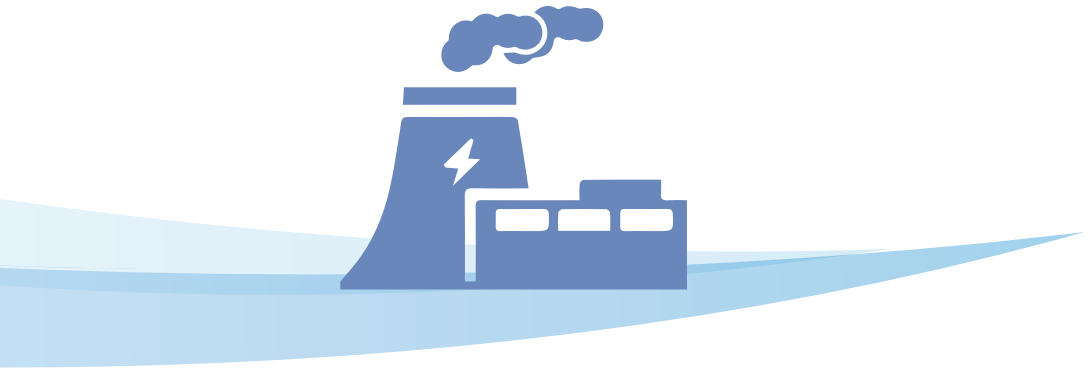
Notes: The figures for Zhoushan refer to bonded marine biofuel oil bunkering volumes at Zhoushan port.

Sources: Maritime and Port Authority of Singapore, Port of Rotterdam Authority and Zhejiang Seaport Group; compiled by the Shanghai International Shipping Institute.

China achieved a breakthrough in the domestic blending and supply of marine biofuel oil. In 2026, Zhoushan was authorized to conduct marine biofuel oil blending for export and completed China's first production and commercial bunker delivery of domestically blended B24 marine biofuel oil. This expanded China's marine biofuel supply model from reliance on imported finished products toward domestic blending.

3.7 Nuclear Power

Nuclear-powered vessels have not yet achieved large-scale commercial deployment. Existing civilian nuclear-powered vessels are concentrated primarily in specialized applications, particularly Russian polar icebreaking operations, while applications aboard conventional ocean-going merchant ships remain at the stages of conceptual design and technology research. As of September 30, 2026, there were 11 nuclear-powered vessels in the existing global fleet and 4 vessels on order, accounting for approximately 0.3% and 0.2% of the respective alternative-fuel fleet and orderbook by vessel count. Most existing vessels were nuclear-powered icebreakers, together with one barge carrier. Commercial application therefore remains at an early stage.



The regulatory framework for nuclear-powered merchant ships has begun to be updated. The existing SOLAS Chapter VIII and the 1981 Code of Safety for Nuclear Merchant Ships are no longer adequate to address the application of new-generation reactor technologies. In 2026, the IMO initiated a comprehensive revision process and plans to complete the revised code and associated SOLAS amendments by 2030.

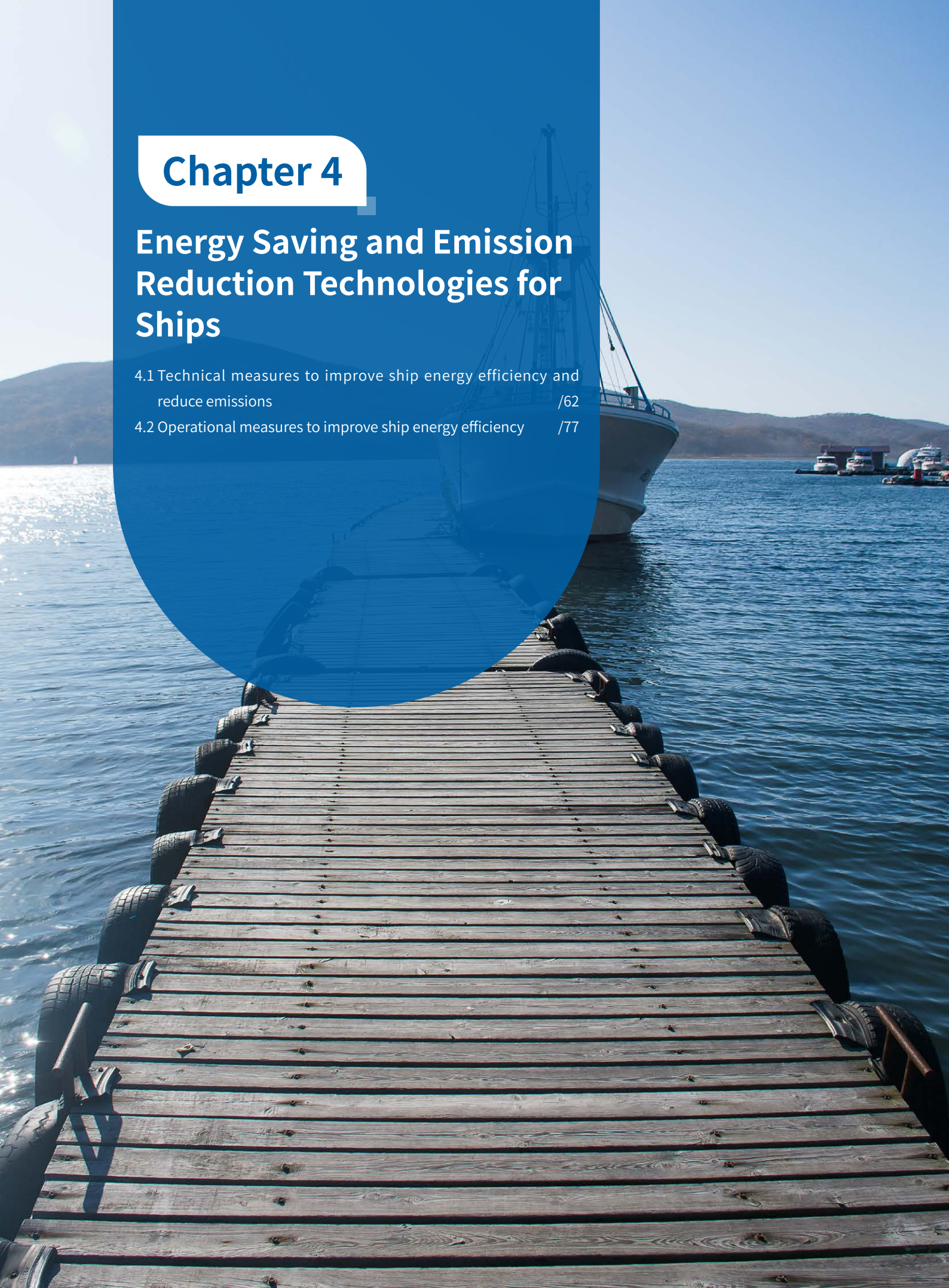
At the same time, regulatory research is extending from vessel design to port access. In June 2026, the Port of Rotterdam, Lloyd's Register, CORE POWER and Maersk completed a feasibility study on port calls by nuclear-powered merchant ships, focusing on safety regulation, emergency preparedness, liability and port operations.

3.8 Other Clean Energy Sources

The use of LPG and ethane as marine fuels remains concentrated in specialized gas carriers. Both fuels exhibit a pronounced cargo–fuel synergy, allowing gas carriers to use the cargo they carry directly as propulsion fuel. Relevant dual-fuel engines and fuel-supply systems have already reached commercial application. LPG is used primarily as a fuel aboard LPG carriers, while ethane is used mainly aboard large ethane carriers and other specialized gas carriers. Neither fuel has yet expanded significantly into the broader market for conventional ocean-going cargo vessels.

Ethanol is beginning to move from experimental validation toward application aboard ocean-going vessels. Ethanol and methanol share a relatively high degree of compatibility in terms of storage and handling systems and engine technologies. In May 2026, WinGD secured the world's first orders for ethanol-fueled main engines for ocean-going vessels. The engines will be installed on two 325,000-dwt ore carriers for Shandong Shipping Corporation. During the same year, ports including Rotterdam and Santos carried out bunkering operations involving ethanol and ethanol-blended marine fuels.

On the regulatory side, IMO MEPC 84 agreed to include an initial well-to-tank (WtT) default GHG emission factor of 20.8 gCO_2e/MJ for Brazilian second-crop corn ethanol in a future revision of the IMO LCA Guidelines. The technical, bunkering and regulatory foundations for the use of ethanol as an ocean-going marine fuel are therefore gradually taking shape.



Chapter 4

Energy Saving and Emission Reduction Technologies for Ships

4.1 Technical measures to improve ship energy efficiency and reduce emissions /62
4.2 Operational measures to improve ship energy efficiency /77

Introduction and technology-uptake snapshot

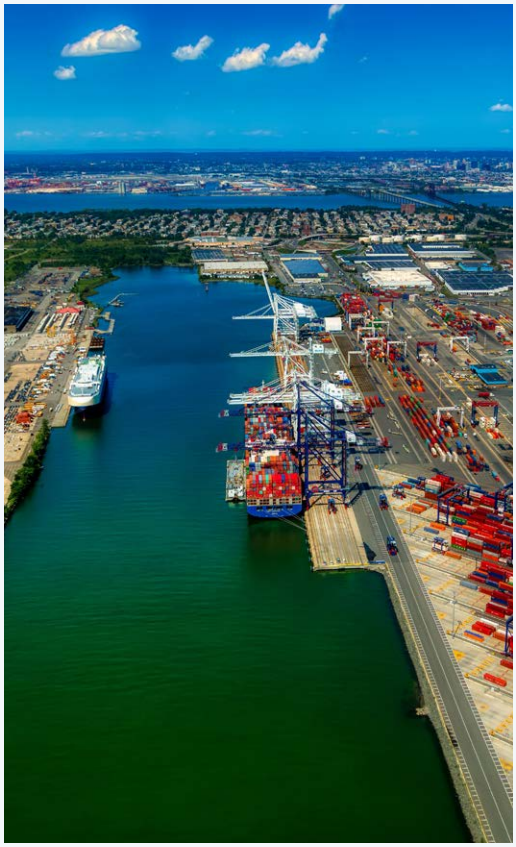
The regulation that pushes owners toward efficiency technology grew stronger over the reporting period. Shipping's coverage under the EU Emissions Trading System reached 100 percent of in-scope emissions from 2026, FuelEU Maritime started to apply on 1 January 2025, and MEPC 83 in April 2025 set a tighter Carbon Intensity Indicator (CII) path for the years 2027 to 2030 that aims for a 21.5 percent improvement in carbon intensity by 2030, or about 2.6 percent a year (Lloyd's Register, 2025a). Taken together these rules turn an efficiency upgrade from a nice-to-have into a compliance need, and they shorten the payback time on the hardware. That was the common thread running through the year's class-society analysis.

The Clarksons green-technology tracker that opened Chapter 4 in the 2024 to 2025 edition has now been refreshed to 1 October 2026, and the updated Table 4-1 is reproduced below (Clarksons Research, 2026). It shows the fleet still tilting green measure by measure. On a tonnage basis, 32 percent of the fleet now carries scrubbers, up from 30 percent a year earlier, 39 percent has a modern eco engine, up from 34 percent at the start of 2025 and 21 percent at the start of 2020, and 48 percent now carries at least one energy-saving technology, up from 35 percent five years ago, while Clarksons's alternative-fuel data shows 10 percent of the fleet is alternative-fuel capable and 42 percent of orderbook tonnage is set to use alternative fuels. (Clarksons Research, 2026). Lloyd's Register data adds that more than 10,000 ships, in service and on order, were built with a propulsion energy-saving device, and that at least 1,400 more existing ships have had one retrofitted since 2020, with the pace of retrofitting up almost fourfold (Lloyd's Register, 2025a).

• Table 4-1 Green technology uptake, fleet and orderbook (Clarksons Research, 1 October 2026)

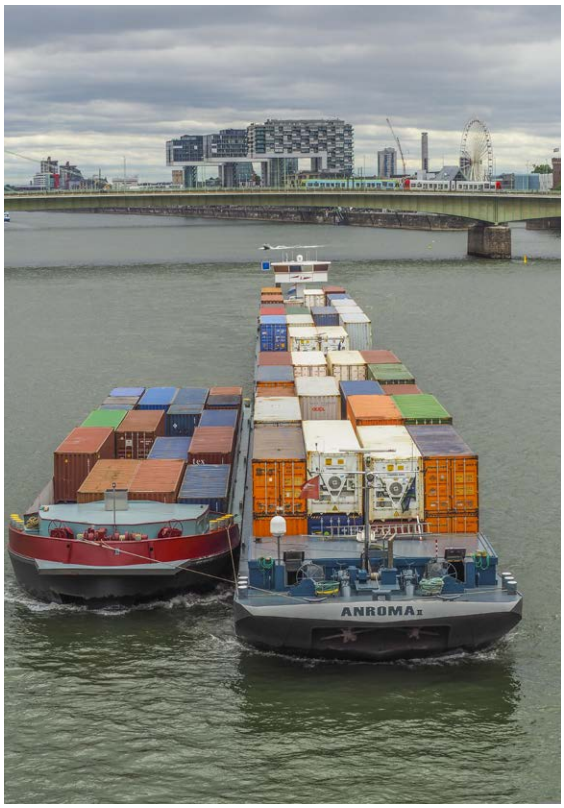
Equipment type	Fleet (No.)	Fleet (% GT)	Orderbook (No.)	Orderbook (% GT)
SOx scrubbers	7,540	32.0	1,942	36.4
Carbon capture system	58	0.1	4	0.2
NOx SCR / EGR	6,912	19.9	6,638	92.5
Wind propulsion	126	0.2	93	1.3
Air lubrication	442	2.9	212	6.1
Other ESTs	15,574	47.8	3,674	56.2
Shore power (HVSC)	4,746	13.0	2,024	31.8
Auxiliary batteries	118	0.2	64	0.6
Shaft generators	8,222	11.0	2,183	36.2
Eco engine (modern)	12,447	39.1	5,279	83.2

Source: Clarksons Research, World Fleet Register, as of 1 October 2026 (Clarksons Research, 2026). ESTs denotes vessels with at least one energy−saving technology onboard; reported−equipment basis may understate true uptake.



The class societies made the same point in their 2025 and 2026 work, and put a number on it. DNV's 2024 Maritime Forecast estimated that operational and technical efficiency measures can lower fleet fuel use by between 4% and 16% by 2030 (DNV, 2024), and its 2025 edition is framed around cutting energy losses as the cheapest lever available while low-carbon fuels are still scaling (DNV, 2025b). Its companion report on energy-efficiency measures (2025) catalogues more than 35 measures with their savings, cost and ship-type fit. It finds that uptake remains low largely because shipowners lack trust in the efficacy and business case of many measures, and it calls for greater independent, third-party verification of their performance. That lack of trusted, verified numbers is the recurring theme of this chapter. ABS added the wider context in its 2025 outlook, noting that total shipping emissions were still well above 2008 levels and warning that shipyard retrofit capacity is itself becoming a bottleneck (ABS, 2025a).

Behind those headline shares, Clarksons also tracks the individual technologies, and the device-level counts in Table 4-2 show where the market actually is. The most-fitted energy savers are all around the propeller and hull, with more than 8,200 rudder bulbs, 6,200 pre-swirl stators, 5,200 boss cap fins and 4,000 propeller ducts across fleet and orderbook, while the newer measures are smaller but growing fast, roughly 650 air-lubrication systems and around 220 wind installations counting rotors, wings and kites (Clarksons Research, 2026). The counter-note is capacity. ABS warns that global retrofit capacity could turn negative between 2028 and 2030, so the yards themselves, not the technology, may become the binding constraint this decade, a concern sharpened by Clarksons's finding that about 42% of tanker, bulker and container tonnage would be rated CII D or E by 2027 on the current fleet (ABS, 2025b; Clarksons Research, 2026).



• Table 4-2 Energy-saving technology examples, savings and uptake (Clarksons Research, 1 October 2026)

Group	Technology (example makers)	Fuel saving (maker claim)	Vessels (fleet + orderbook)
Engine room	Waste-heat recovery generator	3 to 8%	over 200
	Variable compression ratio	3 to 8%	over 130
	Fuel emulsifier	3 to 10%	over 188
Propeller	Propeller duct	3 to 8%	over 4,064
	Pre-swirl stator	4 to 6%	over 6,279
	Rudder bulb	3 to 5%	over 8,294
	Propeller boss cap fin	2 to 5%	over 5,259
	Wake-equalizing duct	6 to 10%	over 834
Wind	Flettner rotors	7 to 10%	over 95
	Suction wing	10 to 30%	over 65
	Rigid sail	8 to 30%	over 51
	Wind kite	up to 20%	over 7
Hull	Air lubrication	5 to 10%	over 654
	Bow enhancement / windshield	4 to 10%	over 6,534
	Hull fin	2 to 5%	over 2,204

Source: Clarksons Research, World Fleet Register, as of 1 October 2026 (Clarksons Research, 2026). Fuel−saving figures are technology−maker marketing claims, not independently verified; vessel counts combine fleet and orderbook.

4.1 Technical measures to improve ship energy efficiency and reduce emissions

Before going measure by measure, Table 4-3 sets out the whole toolbox at a glance, using DNV's 2025 assessment of more than 35 efficiency measures (DNV, 2025a). It gives the efficiency gain and the capital cost for each, grouped the way DNV groups them, from energy consumers through hull and propulsion to machinery and operations. Installation time, drydock needs and typical payback for the main device-level measures are added in Table 4-5. As every source in this chapter stresses, these figures are ranges, the real number depends on the ship and its route, and the gains do not simply add up when measures are combined.

● Table 4-3 Energy-efficiency measures at a glance, efficiency gain and capital cost (DNV, 2025)

Category	Measure	Efficiency gain (%)	CAPEX (kUSD)
Energy consumers	Auxiliary systems optimization	0.5 to 1.5	50 to 1,000
	Energy-efficient lighting	0.1 to 1	20 to 1,200
	Cargo-handling optimization	0.5 to 1	5 to 30
Energy harvesting	Solar panels	0 to 2	700 to 3,000
	Wind-assisted propulsion	5 to 40	500 to 3,000
Propulsion and hull	Air lubrication	0 to 8	500 to 3,500
	Bulbous-bow retrofit	2 to 15	500 to 1,500
	High-performance coatings	2 to 8	50 to 600
	High-efficiency rudder	2 to 4	500 to 1,500
	Hull and propeller cleaning	3 to 6	25 to 50
	Hull-form optimization	2 to 20	70 to 300
	ESDs aft of the propeller	0 to 3	25 to 120
	ESDs forward of the propeller	2 to 9	200 to 600
	Propeller measures	2 to 7	200 to 2,500
Machinery	Batteries	2.5 to 5	1,000 to 3,000
	Engine de-rating	5 to 15	50 to 1,000
	Shaft generator (PTO / PTI)	2 to 5	700 to 2,000
	Shore power	25 to 50 (of aux load)	20 to 1,000
	Variable-frequency drives	0.5 to 2	70 to 300
	Waste-heat recovery	5 to 12	1,500 to 9,000
Operational	Trim optimization	2 to 7	50 to 60
	Speed optimization	5 to 40	—
	Weather routing	3 to 10	Software-based

Source: DNV, Energy−efficiency measures and technologies (2025), summary metrics table, pp. 12 to 13 (DNV, 2025a). Abbreviated here; DNV's full list also gives operating cost and implementation time per measure.



4.1.1 Hull optimization

The basics have not changed. Parametric hull design gives roughly 3% to 6%, bulbous-bow optimization 2% to 5%, and slender hull forms add more, so the whole abatement range sits around 3% to 15% once you combine measures (SISI & WMU, 2025). In practice a bulbous-bow retrofit is about a two-week drydock job (ABS, 2025a). What moved this year is the design and manufacturing side. CFD and model testing still underpin any credible saving, but generative design paired with additive manufacturing is starting to produce complex, lightweight shapes that would have been hard to make before, including early class-qualification work on 3D-printed propellers. That points to faster and more ship-specific hull and appendage work in the years ahead (ABS, 2026a).

4.1.2 Air lubrication systems (ALS)

Air lubrication systems (ALS) continued to gain momentum recently as one of the more mature energy-saving technologies for ships. Its main role is to reduce the frictional resistance between the hull and seawater by creating a controlled layer of air bubbles or air film under the flat bottom of the vessel. The main recent development was a shift from individual demonstration projects towards wider newbuild integration, retrofit projects, and more attention to verified in-service performance.

Lloyd's Register reported in 2025 that Silverstream had more than 100 systems in operation, with strong uptake across cruise ships, LNG carriers, container ships, Ro-Ro vessels, PCTCs and bulk carriers. The same source also noted that the Northern Lights CO_2 carriers Northern Pioneer and Northern Pathfinder were the first ships with ALS reflected in their EEDI certificates[3].

In the cruise sector, Carnival Corporation has continued to expand the use of the Silverstream system, with recent newbuild installations planned for large LNG-powered Excel-class vessels. Reported net fuel and emissions savings for the system are typically in the range of 5–10%, depending on vessel type and operating profile, with independent verification involving organizations such as Lloyd's Register, HSVA, the University of Southampton, Carnival Corporation and Shell[4].

The retrofit market is also developing. A notable 2026 example is Vertom Group's decision to install the latest generation of Alfa Laval OceanGlide on the Vertom Joy. The project is relevant because it targets a short-sea vessel rather than only a large deep-sea ship. Alfa Laval highlights easier installation, no need for sea chests or major hull modifications, and the use of low-profile air distribution bands to create a controlled air layer[5].

Reported energy savings from ALS can vary significantly depending on hull form, speed, draft, weather, fouling condition, air distribution, compressor power demand and operational profile. For example, the Alfa Laval OceanGlide case on M/V Tharsis reported demonstrated net fuel savings of 7–10% through reduced propulsion power, based on real operation and test runs in both loaded and ballast conditions[6]. The main technical point is that ALS savings should always be reported as net savings, not only gross drag reduction. Compressor power, system control, maintenance and operating conditions can reduce the final benefit. A 2026 EMSA study describes hull air lubrication as an interesting but still maturing technology and notes that the industry still needs a clearer picture of system performance under real service conditions[7]. Table 4-4 present the recent development of this technology in shipping industry.

Table 4-4 Recent development of ALS

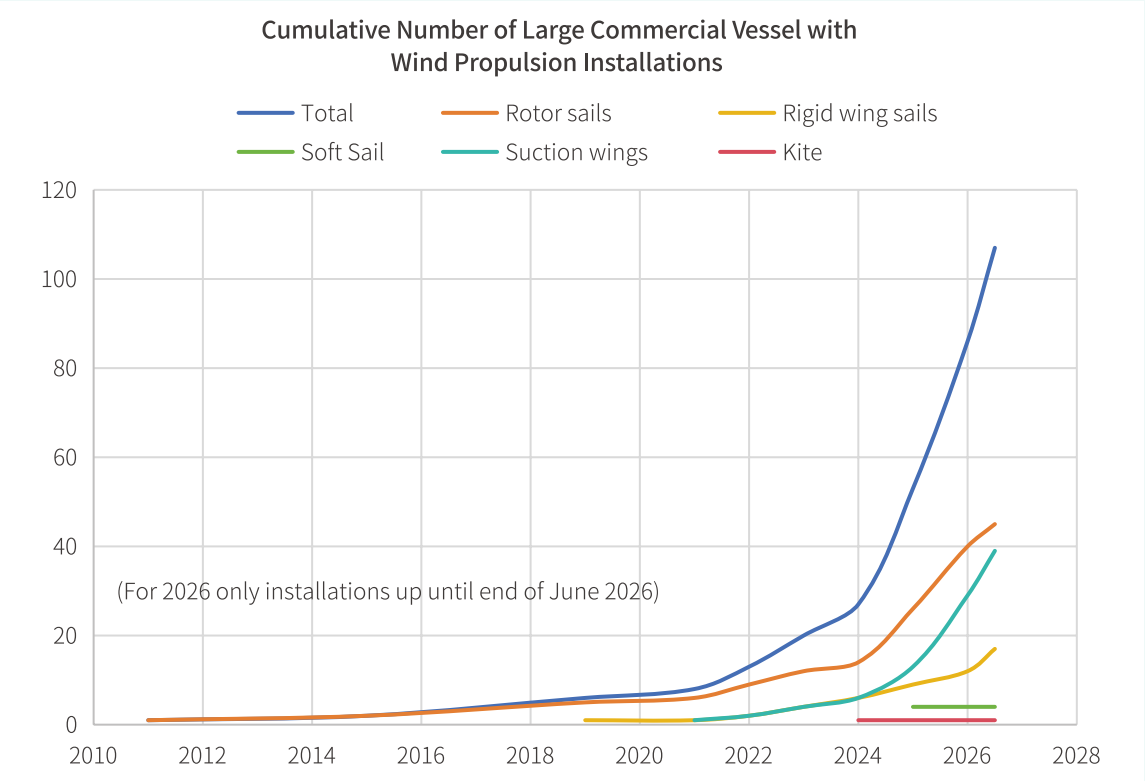
Development area	Recent signal	Relevance for green shipping
Newbuild uptake	ALS increasingly specified for large cruise ships, LNG carriers, CO_2 carriers and other large vessels	Shows growing confidence from shipowners and shipyards
Retrofit development	Newer systems are designed for easier installation with fewer hull modifications	Improves feasibility for existing ships
Verified savings	Reported net savings commonly around 5–10%, but strongly vessel-specific	Supports EEXI/CII and operational emission reduction
Regulatory relevance	ALS has been reflected in EEDI certification for selected newbuilds	Moves the technology closer to formal efficiency assessment
Remaining challenge	Need for more transparent in-service data and net saving verification	Avoids overclaiming and improves investment decisions

4.1.3 Wind-assisted propulsion

Wind-assisted propulsion, or wind propulsion, which hereafter shall be collectively referred to as wind propulsion, has seen an accelerating increase in installations over the past decade. At the shift of the millennium, the use of wind propulsion had essentially disappeared from commercial cargo vessels, but recent years have witnessed a renaissance of wind propulsion for commercial cargo vessels. The reasons are twofold. On one hand, wind propulsion systems allow avoiding the emission of greenhouse gases by omitting the need to burn conventional fossil marine fuels, and on the other hand they allow savings on purchasing expensive and scarcely available alternative fuels with low greenhouse gas emissions.

Wind propulsion directly converts wind power into propulsive power for the ship. It is thus not an energy efficiency measure as such, but a source of primary energy, and likely the most energy-efficient means of converting primary energy into propulsive power for ships. Taking a full holistic well-to-wake assessment approach, wind propulsion applied directly to ships avoids energy losses otherwise associated with the use of wind turbines, electrical generators, chemical synthesis of electrofuels, and subsequent conversion back into useful rotary power in an engine or using fuel cells and electric motors. Even assessed solely from tank-to-wake, wind systems are more efficient than electric propulsion systems, because they also avoid the hydrodynamic losses associated with a propeller.

At the end of the first half of 2026, the International Windship Association reported that 107 large vessels using wind or wind-assisted propulsion were in operation worldwide, corresponding to around 6 million deadweight tons.[8] Many of these ships had more than one wind-propulsion unit installed, so that the number of wind-propulsion rigs or systems installed amounted to approximately 220 units. It is important to note that five of the installed vessels are actually primary wind ships, which highlights that if owners and operators can be sufficiently flexible in their business model and operational routines, wind propulsion can provide the main source of energy for vessels. In addition to these existing installations, conservatively estimated, another 16 vessels in the global fleet are considered to be wind-assisted ready by the end of the first half of 2026.



Source: International Windship Association (IWSA, 2026) https://www.wind-ship.org/market-intelligence/

• Figure 4-1 Large Commercial Vessel with Wind Propulsion Installations

Figure 4-1 shows that the wind-propulsion market has seen a strongly positive development in the last three years, and that development is not dominated by a single type of technology but by five main families, which may be loosely defined as rotor sails, rigid wing sails, soft sails, suction sails and kites. This diversity suggests that the optimum choice of technology may strongly depend on the specific type of vessel, its speed and routes, and other commercial and technical factors such as available space and whether the installation is a retrofit or a newbuild. The majority of applications consisted of rotor sails up until around 2019, with subsequent years seeing suction wings and rigid wing sails also entering the market significantly. The years 2025 and 2026 in particular witnessed a strong uptake of suction wings. Rotor sails, in terms of number of units, remained the most frequently deployed technology by the end of the second quarter of 2026. Suction wings are typically installed on smaller vessels, but have recently also been deployed to larger ships.

Looking beyond the first half of 2026 provides an even more exciting picture. Clarksons Research reported in its Shipping Review & Outlook for July 2026 that 118 vessels in the global fleet are fitted with wind propulsion technologies.[9]

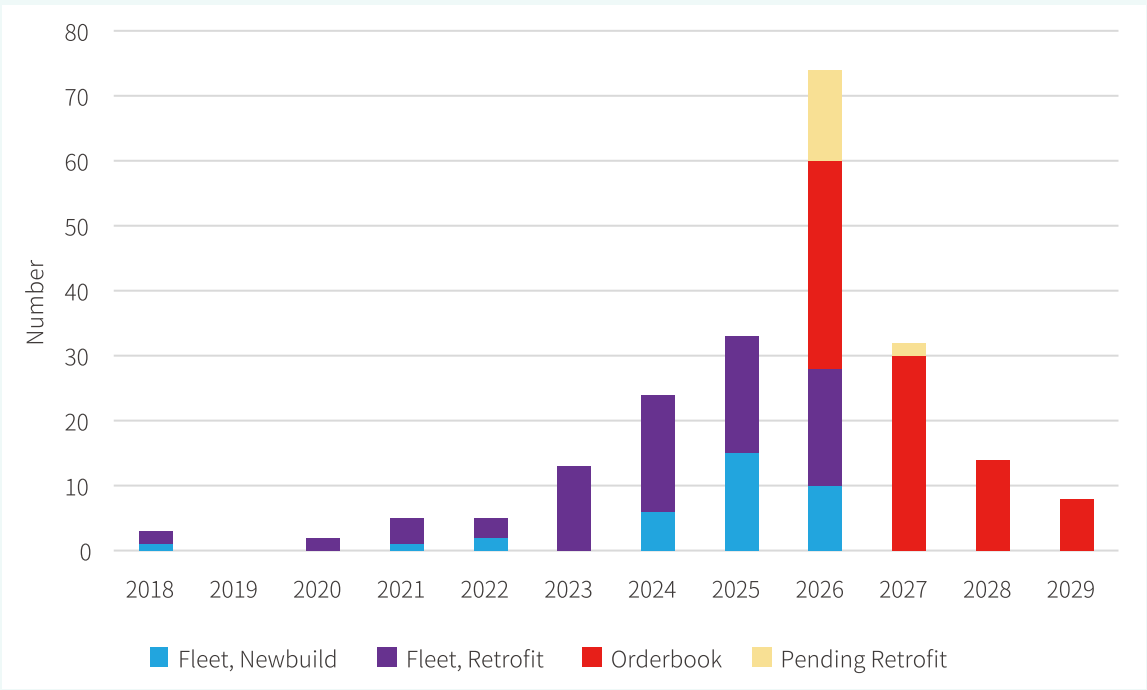


Figure 4-2 Wind Propulsion Technologies by installed number in terms of retrofit and newbuilds, as well as pending retrofits and orderbook.

Clarksons Research further provides useful information on the orderbook for the coming three years, indicating that more than 30 installations are already planned for 2027 and that 2026 is expected to see more than 70 wind propulsion installations onboard vessels by the end of the year. This means we can expect around 156 wind-assisted or wind-propelled ships in the global fleet by the end of 2026. As the data suggests, wind propulsion appears to be one of the most promising technologies for reducing greenhouse gas emissions from ships, and it is in an exciting development phase, with several established and newer providers successfully installing systems and several technical innovations being implemented.



• **Figure 4-3 Pyxis Ocean Wing sails and Oceanbird wing-sail on test stand.**

Wind propulsion systems will undoubtedly make a key contribution to the decarbonisation of the maritime industry, and we are currently witnessing the rise of the first technology able to provide deep greenhouse gas reductions being deployed at a significant scale.

On performance, reported fuel savings cluster around 5% to 20%, and DNV has independently verified peaks near 30% reduction in energy per nautical mile in favourable conditions (DNV, 2025b). On economics, ABS puts a typical wind package at roughly 3 to 5 million US dollars in capital cost for a 10% to 20% emissions reduction, with a breakeven of about seven to eight years, improving beyond 20% where control algorithms optimise routing (ABS, 2025b). On regulation, the business case is set to strengthen further because wind will count in the fuel-intensity calculation of the IMO Net-Zero Framework (DNV, 2025b).



4.1.4 Solar (photovoltaic) for auxiliary power

Solar stays a supporting measure rather than a main one. Limited deck area and low power density hold the efficiency gain to about 0 to 2 percent (SISI & WMU, 2025). Interest continued in hybrid setups, most visibly the combined wind-and-solar sail concepts and PV paired with battery storage, which make more sense on coastal, short-sea and inland ships that work in sunny regions (IEEE Spectrum, n.d.). There is fresh field activity too. MarineSolar ran an at-sea pilot of its NanoDeck photovoltaic system on the RTM Cook in mid-2026, though quantified fuel figures were not yet published at the time of September 2026. In August 2026 MarineSolar also began work with SU|MO on high-frequency energy monitoring for NanoDeck, so it is one to watch rather than to bank on (MarineSolar, 2026).

4.1.5 Propeller efficiency enhancement

Propeller and energy-saving-device retrofits were the busiest technical area over the period, and the 2025 Lloyd's Register retrofit study gives the clearest read on the market so far (Lloyd's Register, 2025a). Uptake is still low next to the potential. The most popular device, the rudder bulb, is fitted at newbuild on only about 1.7% of the global fleet. The orderbook share is several times higher at around 8.4%, and in the fuel-hungry bulk carrier, tanker and container segments it is higher again, with rudder bulbs on roughly 6.7% of ships in service against 16.9% of the orderbook. Retrofit demand has grown almost fourfold since 2020, and the ships being converted are getting younger. More than a third of the 2024 retrofits were on ships ten years old or less, compared with 16% in 2020.

The study also spells out why the rules make these devices pay. Under CII, the share of the world bulk-carrier fleet sitting in bands A to C is expected to slip from 58% to 35% between 2022 and 2026 if nothing is done, which is about 3,000 ships that need to improve (Lloyd's Register, 2025a). Updated EEXI rules now let a propeller designed for a set maximum speed count as a permanent power limitation, which feeds 75% of MCR into the calculation instead of 83% (Lloyd's Register, 2025a). Table 4-5 below lists the published saving and cost ranges. The savings do not simply add up, because the devices affect the same flow around the hull and propeller and have to be designed together.



Table 4-5 Propeller and ESD fuel savings, unit cost, installation and payback

Energy-saving device	Published fuel saving	Unit cost (US$ '000)	Install time / drydock	Typical payback
High-efficiency propeller	3 to 10%	vessel-specific	days to 2 weeks, drydock	case-specific
Pre-swirl stator fin	about 3.5%, up to 6%	250 to 400	4 to 9 days, drydock	~3 years
Post-swirl stator fin	about 4%	100 to 400	several days, drydock	1 to 5 years
Propeller duct	about 5%	220 to 575	~4 days, drydock	1 to 5 years
Wake-equalizing duct	about 2.5%	300 to 600	~4 days, drydock	1 to 5 years
Propeller boss cap fin (PBCF)	about 1.5%, fitted on 3,000+ ships	65 to 350	short, drydock	1 to 5 years
Rudder bulb	about 3.5%	250 to 300	~5 days, drydock	1 to 5 years
Gate rudder	about 6%	project-specific	newbuild	case-specific

Source: Fuel saving and unit cost from Lloyd's Register, Figure 6 (Lloyd's Register, 2025a); installation time and drydock from the ABS technology matrix (ABS, 2025a); payback from Lloyd's Register (propeller devices) and the ABS 2025 outlook (ABS, 2025b).

ABS put comparable numbers on individual devices in its November 2025 technology catalogue, which is a useful cross-check on the Lloyd's Register figures. It reports wake-equalizing ducts at 4 to 8% with a payback of around four months, Mewis-type ducts at 3 to 8%, pre-swirl and post-swirl stators up to 5%, propeller boss cap fins at 2% to 7%, contra-rotating propellers up to 9%, Kappel propellers at 4% to 6%, and gate rudders across a wide 3% to 14% depending on the ship (ABS, 2025a). The two catalogues line up well, which gives more confidence in the ranges than any single vendor claim would.

On cost and payback, the ABS 2025 outlook is the clearest source. It groups the common devices, propeller ducts, boss cap fins and rudder bulbs, at savings of the order of 1% to 10% with a short payback of one to five years in most cases, which is why these are the measures owners reach for first (ABS, 2025b). The Clarksons August 2026 tracker (Table 4-2) confirms these are the most widely fitted energy savers of all, with rudder bulbs, pre-swirl stators, boss cap fins and propeller ducts each on several thousand ships across fleet and orderbook, well ahead of any other category, so the direction of travel is clearly upward (Clarksons Research, 2026).





Three points carry into the 2026 chapter. First, verification is the weak spot. Many retrofits fall short of the promise because the before and after measurement is unreliable, the trials run in uncontrolled conditions, or the device was not designed for the ship's full operating profile, so savings need independent checking, ideally with CFD and model testing together (Lloyd's Register, 2025a). Second, a retrofit changes the mechanics, so torsional vibration, shaft alignment and underwater radiated noise all have to be looked at next to the fuel saving. Third, fouling on the propeller and the devices can wipe out the gain, which ties this section straight to hull-fouling management in 4.1.9.

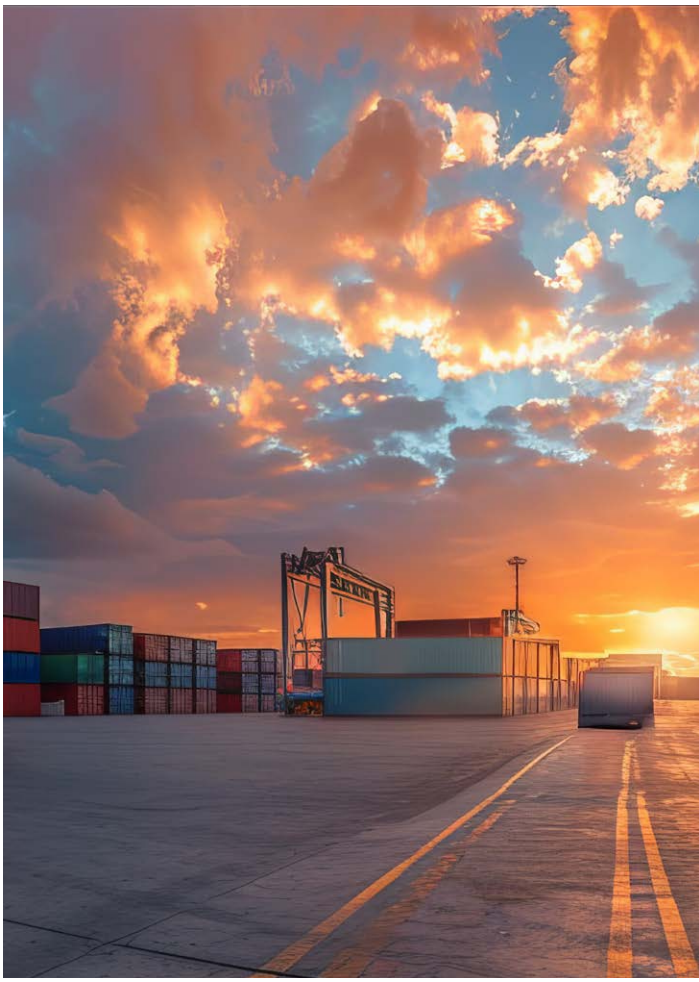
4.1.6 Energy-efficient light sources (LED)

There is no major update this cycle. LED lighting is a settled, low-risk measure. It cuts lighting energy by up to about 85% and takes roughly 1% to 3% off vessel CO2 and auxiliary fuel, with a fast payback and long life, exactly as the 2024 to 2025 edition described (SISI & WMU, 2025).

4.1.7 Electrification of auxiliary equipment

Auxiliary electrification moved forward on several fronts. The main options and their rough savings are the same as before, with shore power at 5% to 10%, shaft generators and PTO at 3% to 5%, variable-speed drives on pumps and fans at 20% to 30% on the systems they suit, and battery hybrids at 10% to 40% in the right profile (SISI & WMU, 2025). The fresh developments are in the enabling technology. Battery storage is now built into new designs, and all-electric operation is normal in tugs, ferries and offshore support vessels. Newer chemistries such as sodium-ion and solid-state, along with standard swappable containerised batteries, promise better safety and quicker turnaround. Direct-current and medium-voltage DC layouts are coming back for their compactness, and a class-qualified breakerless Medium-Voltage Direct Current (MVDC) propulsion system was one of the year's milestones (ABS, 2026a). The two barriers people are working on are standard shore-side charging and lithium-ion fire safety, where immersion cooling is one answer to thermal runaway.

The class societies gave this area a lot of attention over the period. Bureau Veritas published a maritime electrification report in April 2026 that sizes the market, counting 252 full-battery ships in service with 59 on order and 1,105 hybrid-propulsion ships in service with 453 on order, and noting that more than 50 ports now offer onshore power, while a large cruise ship can draw up to 20 MVA at berth (Bureau Veritas, 2026). Korean Register put numbers on the electric-propulsion case in its July 2026 magazine, reporting that variable-speed generation saves roughly 9% to 23% of fuel in the low-load range against fixed-speed gensets, and that medium-voltage DC can improve overall power-integration efficiency by up to 20% on large vessels (Korean Register, 2026). ABS quantifies the building blocks at up to about 5% each for DC bus systems, variable-speed generators and variable-frequency drives on shaft generators, and it published a second volume on emerging battery chemistries focused on thermal-runaway safety (ABS, 2025a). Lloyd's Register completed the first shore-power compatibility assessment for a tanker in early 2025, extending cold ironing beyond the ferry and cruise segments where it started (Lloyd's Register, 2025d).



DNV's 2026 shore-power white paper is worth drawing on directly, because it sizes both the prize and the gap. It finds that shore power could cut global fuel-oil demand for ships above 5,000 gross tonnes by about 3.5%, which is roughly 9.2 million tonnes of oil equivalent and 29 million tonnes of CO_2 a year, and that this is before boilers, which can be up to 40% of port fuel use and are harder to electrify (DNV, 2026). Uptake is still thin. Only about 4% of the world fleet has a high-voltage shore connection, led by cruise at 29% and container at 20% but only 7% for dry bulk and 1% for tankers, and just about 3% of ports offer it, mostly in Europe, China and the US. The EU rules will move this, since around 300 core and comprehensive TEN-T ports must provide shore power by 2030 (DNV, 2026). The World Bank puts a concrete figure on the local benefit, reporting that at Kaohsiung each plugged-in cruise ship avoids around one tonne of SOx and more than 20 tonnes of CO_2 per call, while making the important caveat that the climate benefit depends on the carbon intensity of the local grid, so shore power can shift emissions upstream rather than remove them if the grid is dirty (World Bank, 2026).

On the battery side, ABS published a second volume on emerging chemistries during the period. Lithium-ion in its Lithium Iron Phosphate (LFP) and other forms remains the maritime workhorse, while sodium-ion at roughly 75 to 200 watt-hours per kilogram, solid-state, silicon-anode and flow batteries are the ones to watch, and the report's main focus is the safety envelope around thermal runaway and gas generation that will govern how fast they can be adopted (ABS, 2025c).



4.1.8 Lightweight materials for ship construction

The baseline holds. Selective use of high-tensile steel, aluminium and fibre-reinforced polymer composites cuts structural weight, and a typical 5% weight saving gives around 2% to 5% fuel savings (SISI & WMU, 2025). The update is in the materials themselves. High-manganese steel has come through as a lower-cost option for the cryogenic tanks on the growing fleet of gas and CO_2 carriers, Fibre-Reinforced Polymer (FRP) composites are spreading into superstructures and gas-storage tanks, and generative design with additive manufacturing is making lighter parts and on-demand spares possible (ABS, 2026a). Two EU projects give a sense of the ceiling. RAMSSES showed composite hull structures more than 24% lighter than steel with about a quarter less operational footprint, and FIBRESHIP demonstrated full-composite designs that added 17% cargo capacity on a container concept and cut total weight by 36% on a research vessel, with much higher end-of-life recyclability than steel (European Commission, n.d.).

4.1.9 Hull fouling and prevention

Fouling on the hull and propeller is still one of the biggest and cheapest efficiency levers. A thin slime layer alone can add more than 15% to fuel use, and regular cleaning can take around 9% off, or 17% in dry dock (SISI & WMU, 2025). The shift is toward proactive, condition-based management rather than cleaning on a fixed calendar. Foul-release and smart coatings are maturing, robotic and Remotely Operated Vehicle (ROV) in-water cleaning and propeller polishing are becoming routine, and hull-performance monitoring built on ISO 19030 and helped by AI image recognition lets crews act before losses build up (SISI & WMU, 2025; ABS, 2025a). On the governance side the IMO 2023 biofouling guidelines, a proper Biofouling Management Plan and Record Book, and class notations such as Lloyd's Register CleanHull now set the standard, and they matter for protecting the gains from the propeller and Energy-Saving Device (ESD) retrofits in 4.1.5 (Lloyd's Register, 2025a).

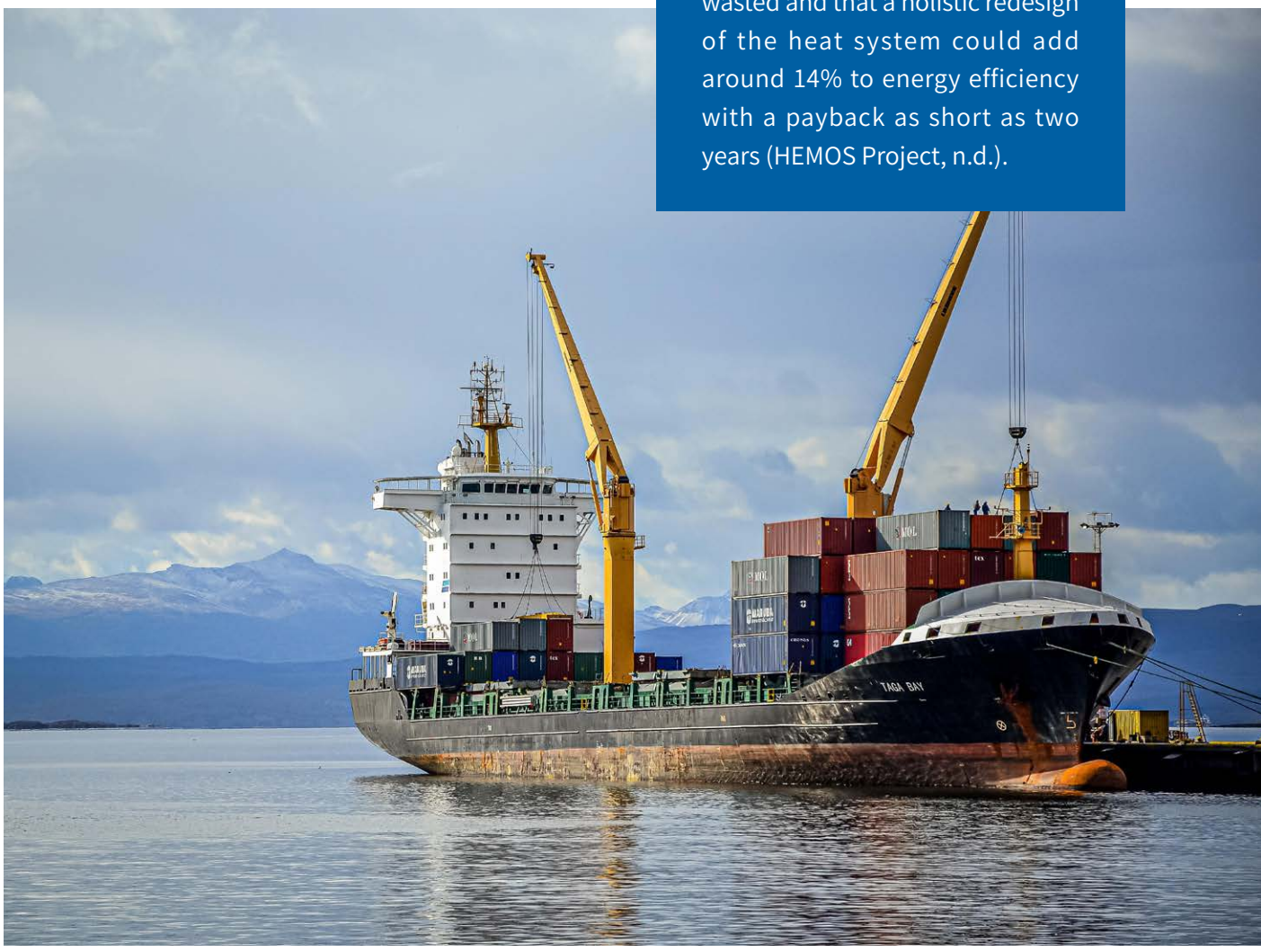
Coatings saw the clearest movement this cycle. Lloyd's Register approved Graphite Innovation and Technologies (GIT) Coatings' graphene-based XGIT-FORCE hard foul-release coating in March 2026, with up to 10% fuel savings claimed and first deployments on gas, bulk and container ships, and it began an independent ISO 19030 performance study of Nippon Paint Marine's coatings across several ship types in late 2025 (Lloyd's Register, 2026). ABS puts anti-fouling coatings at roughly 1% to 7%, nanocoatings up to 8%, hull cleaning up to 5% and propeller polishing up to 6%, and the coatings go on during a normal three-to-eight-day docking, so the coating-plus-cleaning package is one of the better-value combinations on the table (ABS, 2025a). Class certification of coatings is maturing alongside the products, with Lloyd's Register running a coating-certification scheme that recognises anti-fouling paints against the IMO International Convention on the Control of Harmful Anti-Fouling Systems on Ships and certifies ballast-tank and cargo-tank coatings under the IMO performance standards, which gives owners an independent check on the performance claims (Lloyd's Register, n.d.).

Robotic cleaning is turning into a real market rather than a pilot. NYK signed a memorandum with Neptune Robotics in September 2025 to scale robotic hull cleaning across its fleet, with the partners citing large fuel and emission reductions relative to the cost of cleaning, and ABS signed its own memorandum with Fleet Robotics in April 2026 to work on class standards for autonomous in-water cleaning and inspection (NYK & Neptune Robotics, 2025; ABS, 2026b). The direction is toward frequent, gentle, condition-based cleaning that keeps the hull and propeller close to their design state rather than letting fouling build up between dry dockings.

4.1.10 Waste heat recovery (WHR)

The technical case has not changed. About half the fuel energy leaves as heat, and a good WHR plant on the main engine can recover roughly 10% at MCR, which is about a 5% gain in total efficiency (SISI & WMU, 2025). Most of the recent activity is around Organic Rankine Cycle systems, which work at lower temperatures and are now being proposed for generator heat as well as main-engine exhaust, so they suit more than just the largest ships. WHR still fits newbuilds best, since a retrofit integration runs on the order of eighteen months, and it interacts with other measures, because both slow steaming and air lubrication reduce the exhaust heat available, so it is worth judging at the whole-ship level (Ship Universe, 2026).

ABS gives current figures for the different routes, putting whole WHR and Organic Rankine Cycle (ORC) systems at 3% to 8%, with commercial examples such as a 5% saving from one ORC unit and 9% to 18% thermal recovery from another, and two-stage turbocharging at 6% to 7% (ABS, 2025a). The EU HEMOS project frames the size of the prize well, pointing out that 40% to 50% of a ship's heat energy is currently wasted and that a holistic redesign of the heat system could add around 14% to energy efficiency with a payback as short as two years (HEMOS Project, n.d.).



4.1.11 Onboard carbon capture and storage (OCCS)

Onboard Carbon Capture and Storage (OCCS) is transitioning from experimental trials to early commercial deployment, with over 50 vessels globally now equipped or retrofitted. However, there is still lack of formal IMO recognition, with no EEDI, EEXI or CII credit yet, and the shortage of port CO_2 reception stayed the real limits (gCaptain, 2026). The wider CCUS chain is scaling up, with the Global CCS Institute counting 77 operational land facilities at about 64 million tonnes per annum (Mtpa) and a pipeline above 400 Mtpa in 2025, and liquefied-CO2 carriers adapted from LPG designs are starting to link capture with offshore storage (Global CCS Institute, 2025).

DNV's 2025 Maritime Forecast models the ceiling for the largest ships and finds it is real but tied to port infrastructure. Using CO2 tanks the size of existing LNG tanks, most bulk carriers could capture 10% to 50% of their emissions, most container ships 25% to 60%, and most tankers above 60%, at an assumed 30% fuel penalty for full capture (DNV, 2025b). Scale then depends on offloading ports. DNV finds that fitting the 20 busiest ports with CO_2 offloading could remove more than 75 million tonnes a year, about 9% of world fleet emissions, and that raising this to 200 ports could almost halve emissions from the ships studied, roughly a fifth of all shipping emissions. The regulatory gap remains the limiter, with the IMO framework due in 2028, the EU ETS already giving an incentive, and FuelEU Maritime not yet doing so pending its 2027 review (DNV, 2025b). ABS puts the cost of a shipboard system at roughly 2.5 to 9 million US dollars with a payback of five to seventeen years, which explains why, for now, it pencils only on the ship types with the space, the heat and the routes to justify it (ABS, 2025b).

During MEPC 84, the IMO made key strides in developing a regulatory framework for Onboard Carbon Capture and Storage (OCCS). The committee progressed draft guidelines for the testing, approval, survey, and certification of OCCS systems, ensuring a technology-neutral and step-wise approach. Methodological treatments for carbon capture technologies were integrated into ongoing LCA framework updates, including emission factors and provisions that cover the entire value chain, laying the groundwork for how captured carbon will be calculated under emissions standards. The IMO also gave vital in-principle support to recognizing carbon mineralisation as permanent CO_2 storage.

The CO_2 captured onboard has been formally recognised for compliance under the European Union Emissions Trading System (EU ETS). This means the verified tonnage of captured CO_2 can be deducted from emissions requiring the surrender of EU Allowances (EUAs).

4.2 Operational measures to improve ship energy efficiency

There is no real technological update for these measures. The operational measures set out in the 2024 to 2025 edition still stand as written. Weather routing, trim optimization, speed optimization and slow steaming, autopilot upgrades and the Planned Maintenance System, all sitting under SEEMP Parts I to III and the CII, have not changed in kind, and neither has the software behind them (SISI & WMU, 2025). What has changed is the pressure to use them. The tighter 2027 to 2030 CII path from MEPC 83, FuelEU Maritime from 2025, and full EU ETS coverage from 2026 all sharpen the case for careful voyage planning (Lloyd's Register, 2025a). So, the measures are reported here by reference, with their potential kept as a quick reminder in Table 4-6. The real limits are still data quality, crew buy-in and the split incentive between charterer and owner, not the technology. It is worth noting that the biggest recent gains come from combining these measures rather than running them alone. The EU CHEK project bundled route optimization with air lubrication, wing sails and waste-heat recovery and reported up to 99% GHG reduction and at least 50% energy savings in its demonstrator designs, and the new FIT-HORIZONS project, launched in June 2026 with SINTEF Ocean and 19 partners, is building an AI platform to design exactly these combined retrofits (CHEK Project, 2024; FIT-HORIZONS, 2026).



Two other sources add useful numbers here. The DNV and WMMF Net-Zero Guide reports that trim optimization and weather routing together deliver about 1.5 to 3% in practice, and that a full package of operational measures can reach up to 12%, with trim and draft optimization alone worth up to 10% on the right ship (DNV & WMMF, 2025). The World Bank's 2026 regional report highlights the port interface, finding that big-data dynamic routing and just-in-time speed adjustment have cut fuel use by up to 8% on trans-Pacific routes, that ships in the East Asia and Pacific region still spend 4% to 6% of their operating time waiting at anchor, and that optimized arrival planning could cut the associated emissions by up to 25%. This is the same just-in-time gain that the charterer-owner split incentive keeps holding back (World Bank, 2026).

• Table 4-6 Operational measures, potential and quick reminder (baseline unchanged)

Operational measure	Reported saving potential	Quick reminder and status
Weather routing	0.1% to 1%	Mature and software-based. Biggest gains on long ocean legs and larger ships.
Trim optimization	1.5% tankers and bulkers, up to 4% container and Ro-Ro	Cheapest and easiest measure. Software about US$25k. No update.
Speed optimization and slow steaming	up to about 25%, route and market dependent	Power rises with the cube of speed. Watch the trade-offs on schedule, engine, WHR and coatings.
Autopilot upgrade	small and vessel-specific	Adaptive economy and precision modes cut rudder drag. No update.
Planned Maintenance System (PMS)	indirect, through reliability and efficiency	More AI, IoT and digital-twin enabled. Required under ISM. No update.

Note: DNV's Table 4−3 gives wider ranges for some of these operational measures (for example weather routing 3% to 10% versus 0.1% to 1% here, and speed optimization 5% to 40% versus up to about 25%). The differences reflect the different source methodologies and vessel samples of DNV (2025a) and the SISI and WMU baseline rather than a contradiction.

Source: Saving ranges from SISI and WMU, Global Green Shipping Development Report (2024 to 2025), Chapter 4 (SISI & WMU, 2025)

Chapter 5

Special Report

5.1 National Action Plans: from IMO ambition to national implementation /80
5.2 The Green Transition of Major Global Liner Shipping Companies /83
5.3 Green Transition of Ports /93



5.1 National Action Plans: from IMO ambition to national implementation

National Action Plans (NAPs) are voluntary national roadmaps for reducing greenhouse gas (GHG) emissions from ships. They translate IMO-level objectives into actions that can be implemented through national legislation, institutions, ports, shipping companies, fuel suppliers, research organizations and financial actors. IMO resolution MEPC.367(79) encourages Member States to develop and submit NAPs. It identifies possible areas of action, including stronger institutional and legal arrangements, ship energy efficiency, low- and zero-carbon fuels, port emission reduction, capacity-building, green infrastructure and cooperation across the maritime value chain .

The importance of NAPs has increased following the adoption of the 2023 IMO Strategy on Reduction of GHG Emissions from Ships. The Strategy sets a common ambition to reach net-zero GHG emissions from international shipping by or around 2050, with indicative checkpoints for 2030 and 2040. These global goals require preparation at the national level. Countries need to understand their emissions, identify suitable technologies and fuels, prepare ports and infrastructure, build skills and establish policies that can mobilize public and private investment . As of 30 September 2026, the IMO repository lists 10 Member States that have formally submitted relevant national action plans or strategies (Table 5-1).



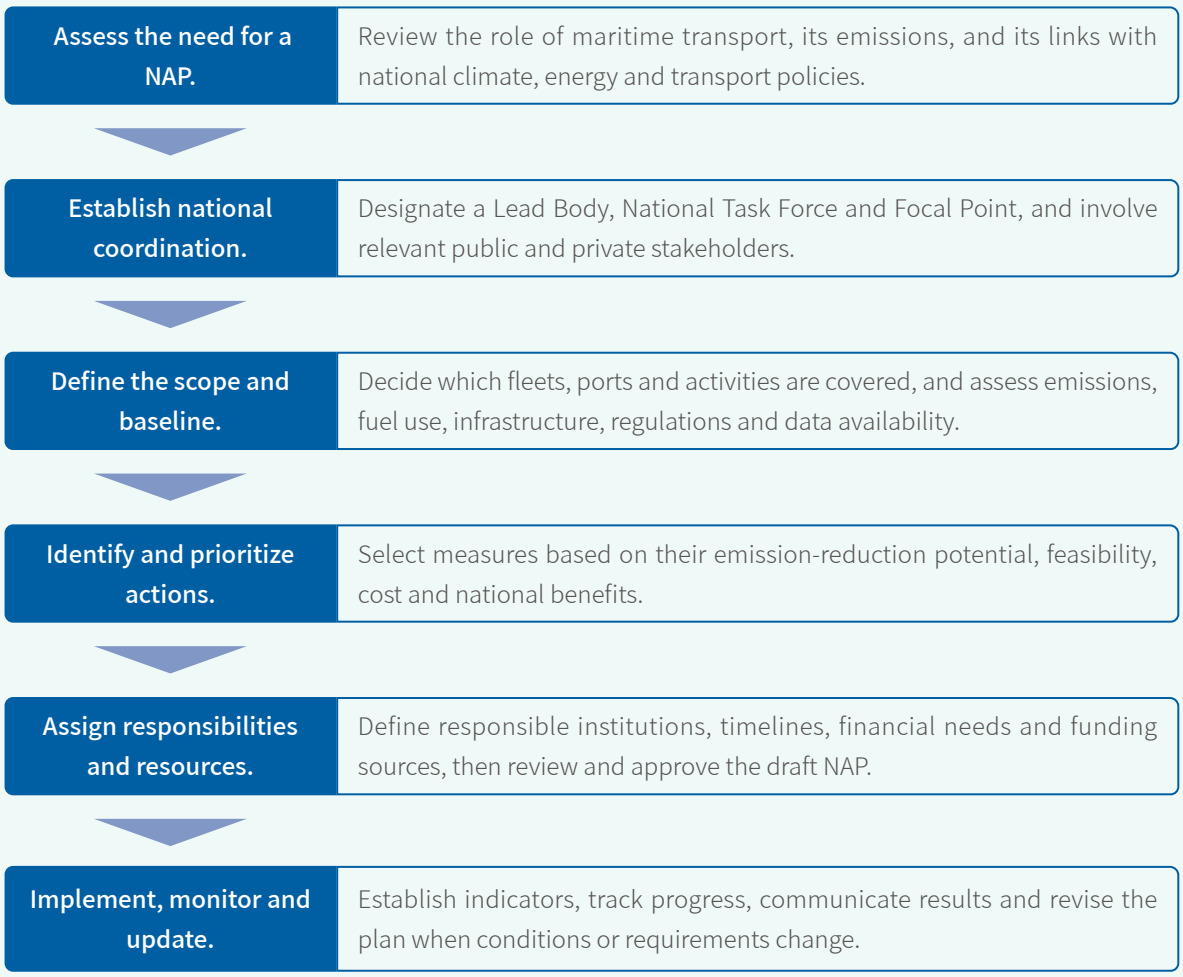
Table 5-1 National action plans and strategies submitted to IMO

Member State	Title of National Action Plan	Year
Finland	Government resolution on reducing greenhouse gas emissions from maritime and inland waterway transport	2021
France	Roadmap for decarbonization of the maritime sector	2025
India	Maritime India vision 2030	2021
Japan	Roadmap to zero emission from international shipping	2020
Marshall Islands	Rebbelib 2050: A Catalyst for Change - Marshall Islands national transport decarbonisation framework	2022
Norway	The Government's action plan for green shipping	2021
Republic of Korea	Toward Green Shipping by 2050	2023
Singapore	Maritime Singapore Decarbonisation blueprint: Working towards 2050	2022
Solomon Islands	Solomon Islands Plan for a Sustainable Maritime Future	2025
United Kingdom	Maritime Decarbonisation Strategy	2025



Recent work under IMO's GreenVoyage2050 Programme shows growing momentum, particularly among developing countries and Small Island Developing States. In 2025, Bangladesh, Egypt, Ghana, Mexico and Nigeria were selected for support to develop NAPs. India, Indonesia, Türkiye, Philippines and Viet Nam received separate support for feasibility studies of pilot projects. In 2026, Colombia, Senegal and South Africa joined the programme as partner countries for NAP development. The assistance includes technical guidance, data analysis, stakeholder engagement, capacity-building and national coordination .

Recently, Bangladesh has involved ports, shipyards, vessel operators, training institutions and the ship-recycling sector to identify practical measures and investment needs. Egypt has assessed major ports and their potential roles in the future production, storage and bunkering of alternative marine fuels. Nigeria and Senegal have started baseline and stakeholder processes covering governance, finance, port infrastructure, alternative fuels and capacity-building . The Solomon Islands launched a NAP in December 2025, while the Cook Islands approved a plan with actions extending from 2025 to 2029 and beyond. These island plans connect emission reduction with fleet renewal, port modernization, transport reliability, climate resilience and access to finance . In 2026, Viet Nam and the Philippines advanced NAP preparation under the SMART-C GHG Project through national workshops, stakeholder coordination and the development of maritime GHG emissions baselines . Overall, a practical process for developing a NAP can be organized into six main steps as shown in Figure 5-1.



• Figure 5-1 Key steps in developing, approving and implementing a National Action Plan for maritime decarbonization.

It should be noted that NAP is an implementation framework that connects climate ambition with institutions, projects and investment. For ports and shipping companies, it can provide clearer signals on future fuel supply, infrastructure, incentives, pilot projects and regulatory readiness. Its effectiveness will depend less on the number of measures included than on whether responsibilities, financing, timelines and monitoring arrangements are clearly defined.

5.2 The Green Transition of Major Global Liner Shipping Companies

Over the past year, the vote on the International Maritime Organisation (IMO)'s net-zero framework was postponed by one year; the EU Emissions Trading System raised the allowance surrender rate for shipping to 100%, incorporating methane and nitrous oxide into compliance requirements for the first time; and FuelEU Maritime entered its first full compliance cycle. Global carbon reduction regulations for shipping have thus exhibited a trend characterised by 'uncertainty at the global level and continued tightening at the regional level'. Against this backdrop, major shipping companies have not slowed their green investments; the industry's transition has shifted from pioneering trials to large-scale implementation, with the green transition now adopting a 'portfolio approach' to hedge against the dual uncertainties of regulation and fuel supply. This special feature compiles the green transition measures and actions taken by the top 10 liner companies by capacity over the past year, analysing the characteristics of the green transition during this period from the following perspectives.

5.2.1 Net-Zero Targets: From Announcement Race to Credibility Checks

The net-zero targets of major shipping companies remain unchanged: Maersk maintains its 2040 target; Hapag-Lloyd and HMM have set their targets for 2045; MSC, CMA CGM, Evergreen and ONE maintain their 2050 targets; and COSCO SHIPPING Holdings retains its target of 'net-zero for vessels around 2050'. Key developments include Maersk becoming the first liner shipping company in the industry to be verified by the Science Based Targets initiative (SBTi) and publicly endorsing the updated Corporate Net-Zero Standards in August 2026; ONE disclosed that its Scope 1 emissions intensity has fallen by 65% compared to 2008 and has extended the scope of external assurance to Scope 3 Category 4 (upstream transport and distribution); Hapag-Lloyd joined the United Nations Global Compact in 2025; the four members of the Ocean Alliance reaffirmed their 2050 net-zero commitments during the launch of their 'Day 10' product, marking the emergence of collective endorsement at alliance level. 'Verified' targets are replacing 'self-declared' targets as the new benchmark for credibility. Whether net-zero targets genuinely influence companies' current investment decisions remains to be seen.

● Table 5-2 Greenhouse gas reduction targets of major liner shipping companies

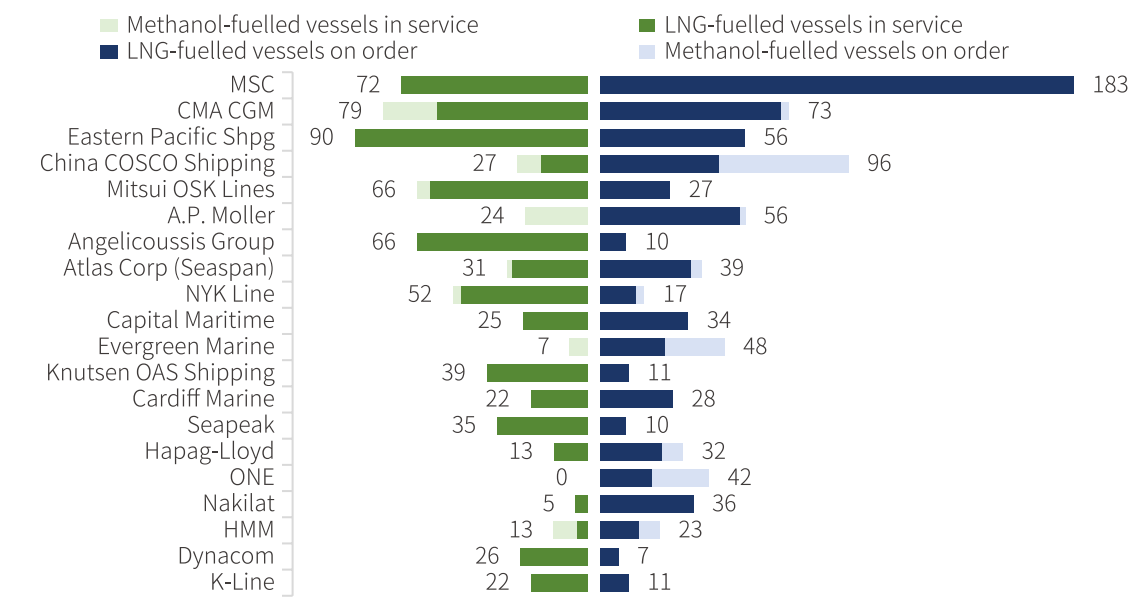
Company	2030 and Mid-Term Targets	Long-term Targets	Nature of the Target
MSC	A 9% reduction in absolute greenhouse gas emissions from shipping operations by 2030 compared with 2022; a 68% reduction by 2040.	Achieve net-zero emissions from shipping operations by 2050	Absolute emission reduction targets are adopted, based on a reduction model established by the company itself that is compatible with the 1.5° C pathway.
Maersk	By 2030, Scope 1 absolute greenhouse gas emissions will be reduced by 34.7% compared to 2022, and Scope 3 emissions by 21.9%.	Achieve net-zero greenhouse gas emissions across the entire value chain by 2040	Absolute emission reduction targets are adopted, covering maritime transport and the Group's value chain; these targets have been validated by the SBTi.
CMA CGM	By 2030, WtW greenhouse gas emissions from the maritime business will be reduced by 30% compared to 2008; by 2040, they will be reduced by 80%.	Achieve net-zero carbon emissions across all Group operations by 2050	Absolute emission reduction targets are adopted, with the 2030 and 2040 targets applying to the maritime business, whilst the 2050 net-zero target covers all Group operations.
COSCO SHIPPING Holdings	By 2030, greenhouse gas emission intensity for the container shipping business will be reduced by 12% compared with 2019; greenhouse gas emission intensity at controlled terminals will be reduced by 20% compared with 2020.	Strive to achieve the shipping industry's net-zero target around 2050; achieve carbon neutrality by 2060 at the latest	The 2030 targets are based on emission intensity targets.
Hapag-Lloyd	By 2030, the fleet's absolute WtW greenhouse gas emissions will be reduced by approximately one-third compared to 2022, falling to 10 million metric tonnes of CO_2e; the fleet's average AER will be reduced by approximately 53%, from approximately 9.1 to 4.3 $gCO_2e/dwt \cdot nm$.	Achieve net-zero emissions from fleet operations by 2045	Absolute emission reduction targets and emission intensity targets have been set for 2030; DNV has independently assessed their consistency with the 1.5° C goal.

Company	2030 and Mid-Term Targets	Long-term Targets	Nature of the Target
ONE	By 2030, Scope 1 greenhouse gas emissions intensity will be reduced by 70% compared with the 2008 baseline levels, measured in emissions per TEU-km.	Achieve net-zero greenhouse gas emissions, including Scope 2 and 3, by 2050	By 2030, adopt an emissions intensity target per unit of container transport turnover, measured by Scope 1 greenhouse gas emissions per TEU · km.
Evergreen Marine	Reduce the fleet's CO_2 emission intensity by 70% by 2030 compared with the 2008 baseline.	Achieve net-zero emissions by 2050	Adopt an emissions intensity target per unit of container transport turnover by 2030, measured by CO_2 emissions per TEU · km.
HMM	By 2030, absolute greenhouse gas emissions from maritime operations will be reduced by 7% compared to 2021, with emissions from container operations falling by 26%; simultaneously, fleet emission intensity will be reduced by 50% compared to 2008, and that of the container fleet by 70%.	Achieve net-zero greenhouse gas emissions for Scopes 1, 2 and 3 by 2045	Set both absolute emission reduction targets and emission intensity targets for 2030; a roadmap to net-zero by 2045 has been drawn up.
Yang Ming Marine Transport	By 2030, Scope 1 emissions intensity will be reduced by 10% compared with 2024; Scope 2 absolute emissions will be reduced by 20%.	Achieve net-zero emissions by 2050	By 2030, adopt an emissions intensity target for Scope 1 emissions per unit of container transport turnover, measured in g/TEU · km; for Scope 2, adopt an absolute emissions reduction target, measured by total emissions.
ZIM	By 2030, Scope 1 greenhouse gas emission intensity for the operating fleet will be reduced by 40% compared to 2021; by 2040, it will be reduced by 60%.	Achieve net-zero Scope 1 greenhouse gas emissions for the operational fleet by 2050	Both 2030 and 2040 targets are based on emission intensity per unit of container transport turnover, measured by Scope 1 CO_2 emissions per TEU · km.

Source: Shipping companies' official websites; compiled by the Shanghai International Shipping Research Centre

5.2.2 Fuel strategies shift from single-bet strategy to a diversified portfolio

Major liner companies are not converging on a single alternative fuel strategy, but are instead further strengthening their multi-fuel portfolios. Although LNG and methanol are the main alternative fuels, new orders indicate that LNG currently holds a temporary lead in alternative fuel orders for container ships, whilst methanol-powered vessels are gradually entering mass delivery and actual operation.As at 30 September 2026, the world's top 20 shipping companies had a combined fleet of 714 LNG and methanol-powered vessels in service and a total of 839 vessels on order, accounting for 37.4 % and 56.8% of the global total respectively, with MSC, CMA CGM, Eastern Pacific Shipping (EPS), COSCO Shipping and Mitsui OSK Lines (MOL) continuing to rank in the top five.



• **Figure 5-2: Top 20 Shipping Companies by LNG and Methanol-Fueled Vessel Deployment and Order Volumes, September 2026**

Maersk is continuing to expand its use of methanol whilst conducting trials on ethanol co-firing. In February 2026, it placed new orders for eight 18,600 TEU LNG dual-fuel container ships, and in September 2026 confirmed orders for 26 large LNG container ships; simultaneously, it has signed a Bio-LNG supply agreement and is considering fuels such as ammonia as long-term potential options;CMA CGM is simultaneously advancing LNG and methanol initiatives, whilst conducting bioethanol trials on actual vessels; Evergreen has significantly increased its orders for LNG dual-fuel vessels on top of its existing methanol dual-fuel vessel orders, establishing a parallel strategy for methanol and LNG; ONE, meanwhile, is reserving flexibility for future fuel conversion through methanol dual-fuel vessels and 'methanol and ammonia-ready' designs.The fuel choices of leading companies reflect a desire to retain flexibility between technological maturity, fuel availability and long-term emissions reduction requirements, rather than committing in advance to a single definitive path.

● Table 5-3 Changes in alternative-fuel vessels among major shipping companies from October 2025 to September 2026

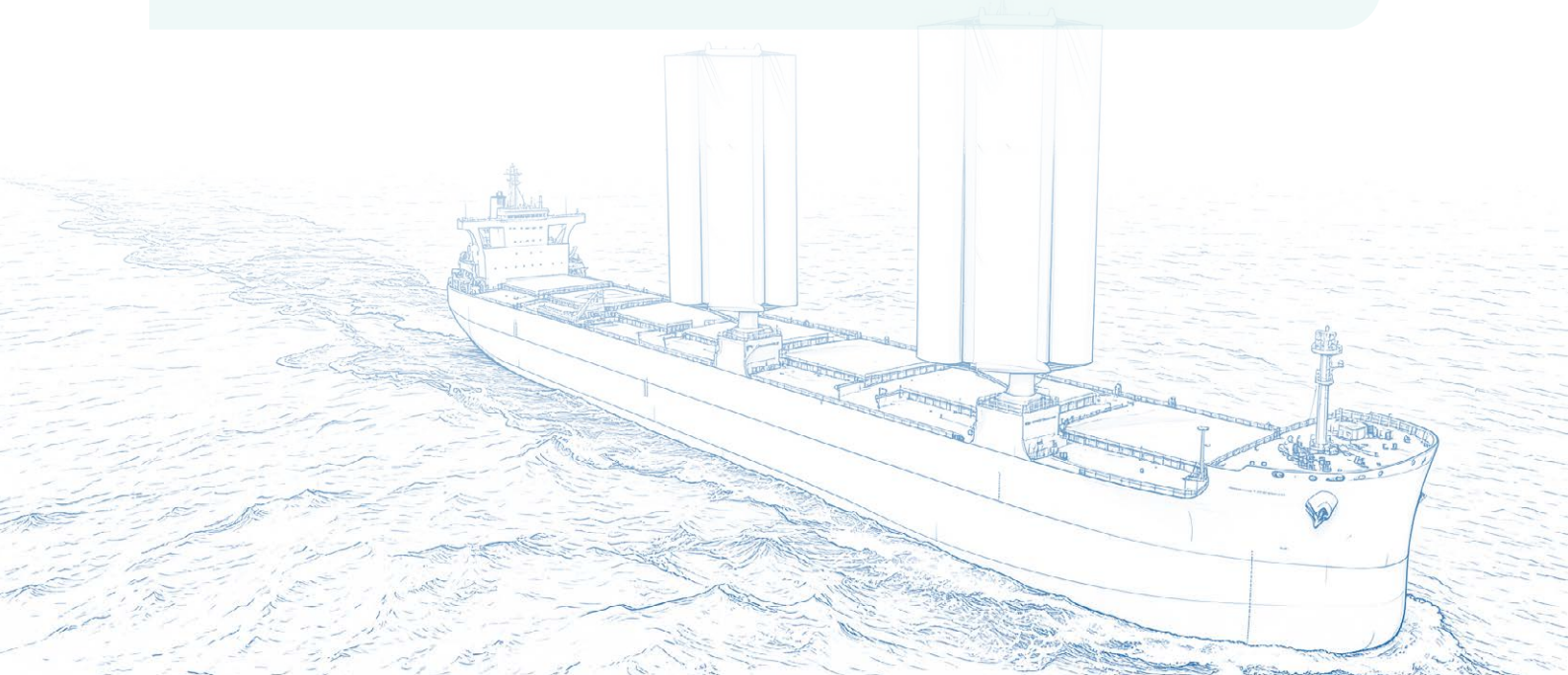
Company Name	Fuel Type (Union of orders and vessels in service)	New Additions in the Year		
		New Fuel Types	Newly Commissioned Vessels (vessels)	New Vessel Orders (vessels)
MSC	LNG, biofuels, hydrogen, battery/hybrid, fuel cells	New battery/ hybrid orders: 16 vessels	28	56
Eastern Pacific Shipping	LNG, LPG, ethane, battery/ hybrid, ammonia	2 new orders for ammonia-fuelled vessels	18	-4
CMA CGM	LNG, methanol, biofuels, ethanol, battery/hybrid	One vessel added to the fleet running on ethanol	21	1
China COSCO Shipping	LNG, LPG, methanol, biofuels, battery/hybrid, ammonia	2 new orders for ammonia-fuelled vessels	13	40
Mitsui OSK Lines	LNG, LPG, methanol, ethane, biofuels, battery/hybrid, hydrogen	/	13	–15
NYK Line	LNG, LPG, methanol, biofuels, ammonia, battery/hybrid, hydrogen, fuel cells	1 new hydrogen-fuelled vessel order, 1 new fuel cell vessel order	10	-3
Capital Maritime	LNG, LPG, battery/hybrid, ammonia	/	11	-6
A.P. Moller	Methanol, biofuels, ethanol, LNG	Two ethanol-fuelled vessels newly entered service	8	27
Atlas Corp (Seaspan)	LNG, methanol, biofuel, ethane	Five new ethane-fuelled vessels ordered	4	1
Angelicoussis Group	LNG, battery/hybrid	/	-7	-9

• Continued

Company Name	Fuel Type (Union of orders and vessels in service)	New Additions in the Year		
		New Fuel Types	Newly Commissioned Vessels (vessels)	New Vessel Orders (vessels)
Cardiff Marine	LNG, LPG	/	6	10
BW Group	LNG, LPG	/	-3	10
Hapag-Lloyd	LNG, biofuels, methanol	Eight new orders for methanol-fuelled vessels	0	8
Evergreen Marine	Methanol, biofuels, LNG	/	7	7
Fjord1 AS	LNG, biofuels, battery/hybrid	/	0	0
Knutsen OAS Shipping	LNG	/	6	3
Seapeak	LNG, ethane	/	-1	5
Nakilat	LNG, LPG	/	0	0
Petronas	LNG, ethane, ammonia, battery/hybrid	1 new battery/ hybrid order	-5	9
ONE	LNG, methanol	/	0	6

Note: The top 20 shipping companies were selected based on the sum of the number of alternative-fuel vessels in service and the number of orders on hand as at the end of September 2026; both the number of new orders and the number of new vessels entering service represent net changes, as some orders have been delivered and subsequently put into service.

Source: Clarksons, compiled by the Shanghai International Shipping Research Centre



5.2.3 The application of green fuels is shifting from procurement planning towards actual vessel operation

Leading liner companies are shifting their green fuel strategies from long-term off-take agreements and supply partnerships towards actual bunkering and vessel operations. Maersk continues to expand its fuel options beyond its methanol-powered fleet, having successively completed trials of ethanol–methanol blended fuel and 100% ethanol on actual vessels, and in September 2026 carried out commercial bunkering of 100% ethanol on a deep-sea container ship in the United States;CMA CGM, meanwhile, has successively carried out bunkering operations using bio-methanol, Bio-LNG and bio-ethanol; notably, the CMA CGM OSMIUM completed the company's first bio-methanol bunkering in Shanghai, whilst CMA CGM IRON used bioethanol on board in Brazil; COSCO Shipping's methanol dual-fuel vessels have also conducted green methanol bunkering operations at ports such as Yantian and Nansha. At the same time, shipping companies continue to strengthen their future fuel security capabilities through long-term agreements and project collaborations.X-Press Feeders has signed a letter of intent with PuriFire to procure bio-methanol produced by a planned project.Overall, the focus of leading shipping companies on green fuels is shifting from 'whether fuel can be obtained' to 'whether it can be used continuously on actual routes', whilst fuel strategies are gradually expanding from the procurement of a single fuel type to the operational validation of various low-carbon fuels. However, at this stage, the application of most green fuels remains concentrated on certain vessels and routes, and there is still some way to go before large-scale, routine use is achieved.

● Table 5-4 Comparison of Low-Carbon Fuel Supply Chain Strategies Among Major Shipping Companies

Company	Key Fuels	Supply Assurance Methods	Representative Advances in Applications	Strategic Features
Maersk	Green methanol, biomethane, ethanol	Long-term off-take agreements + cross-regional procurement + port bunkering	Signed a 500,000 metric tonnes per annum green methanol off-take agreement with Goldwind; conducted trials of ethanol-blended fuel and 100% ethanol on actual vessels	Expansion from single-fuel methanol to multi-fuel supply
CMA CGM	Green methanol, biofuels, etc.	Fuel projects + port bunkering synergy	Establishing a green methanol supply chain linking Taonan, Jilin, and the Port of Shanghai; conducting real-ship applications of bio-methanol and bio-ethanol in Shanghai and Brazil	Linking fuel production, supply at hub ports and vessel application

• Continued

Company	Key Fuels	Supply Assurance Methods	Representative Advances in Applications	Strategic Features
COSCO Shipping	Green methanol	Domestic Projects + Overseas Resource Development + Port Bunkering	Advancing cooperation on domestic green methanol supply; carrying out methanol bunkering at multiple domestic ports including Shanghai, Shenzhen and Hong Kong	Gradually building a green methanol supply network by leveraging the Group's and port resources
MSC	LNG, Bio-LNG	Low-carbon upgrade of existing LNG systems	Continuously expanding the LNG dual-fuel fleet; advancing alternative fuel cooperation with Singapore's MPA	Progressively transitioning through existing LNG assets
X-Press Feeders	Green methanol and ethanol	Upstream production capacity collaboration + port synergies	90% bio-methanol + 10 % ethanol in actual vessel operations	Focusing on short-haul feeder routes in Europe, whilst extending into upstream production capacity and multi-fuel applications

5.2.4 Accelerated retrofitting of existing vessels; green fleet development proceeds through a dual approach of 'newbuilds and retrofits'

Whilst continuing to invest in new vessels powered by alternative fuels, leading liner companies are further intensifying their efforts to retrofit existing vessels, with the scope of retrofitting extending from traditional energy-saving equipment upgrades to alternative-fuel propulsion systems.In June 2026, Seaspan's 10,100 TEU vessel 'Seaspan Yangtze' completed its methanol dual-fuel retrofit and was returned to service with Hapag-Lloyd. The project team estimates that, by using low-carbon methanol, each retrofitted vessel will reduce CO_2e emissions by approximately 30,000–50,000 tonnes per year on a Well-to-Wake (WtW) basis. Conventional energy efficiency retrofits are also continuing.Hapag-Lloyd is continuing to advance its Fleet Upgrade Programme, with related measures expected to achieve an energy efficiency improvement of approximately 9%; Maersk implemented large-scale energy-saving retrofits on 230 owned vessels and 150 time-chartered vessels in 2025, resulting in a decline in the EEOI of its maritime operations for the third consecutive year; and Yang Ming Marine Transport's CO_2 emission intensity for vessels in operation in 2025 fell by 63.32% compared with the 2008 baseline.Overall, the development of green fleets by leading liner companies is shifting from a reliance on new vessel replacements towards a parallel approach involving the construction of new vessels powered by alternative fuels, retrofitting existing vessels with alternative propulsion systems, and energy efficiency upgrades.

5.2.5 Carbon management has evolved from a reporting function to an operational function

Internal carbon pricing is gradually being integrated into operational decision-making. ONE continues to utilise its internal carbon price in investment decisions; SITC International, meanwhile, links its internal carbon price to EU ETS prices and compliance rates. In 2025, the internal carbon price rose from the previous year's US$28.03/$tCO_2e$ to US$60.34/$tCO_2e$, and energy-saving and emissions-reduction targets have been incorporated into the performance appraisals of branch managers and other staff.In Maersk's 2025 long-term incentive scheme, ESG indicators account for 20%, including decarbonisation targets; however, the company has decided to exclude ESG indicators from this scheme from 2026 onwards. Carbon compliance costs are also being incorporated more directly into freight quotations.Maersk adjusts its emissions surcharge quarterly in line with EUA prices, whilst MSC lists the relevant carbon surcharge separately in its Asia–Europe route quotations; as the EU ETS enters its 100% compliance phase in 2026, Hapag-Lloyd anticipates that the relevant emissions surcharge will increase by approximately 45%.Meanwhile, emissions reduction capabilities are being further translated into customer products: Hapag-Lloyd's 'Ship Green' programme recorded sales of over 380,000 TEU in 2025, serving more than 750 customers; Yang Ming and PSA have begun jointly developing a digital 'Book & Claim' system and integrated sea-land emissions reduction solutions, whilst PIL has engaged ABS to carry out third-party assurance of emissions reductions from alternative fuels.

● Table 5-5 Carbon Management and Green Transport Products of Selected Shipping Companies

Company	Carbon Compliance/ Management	Green Transport Products	Key Mechanisms	Typical Clients or Applications
MSC	Introduce an EU ETS surcharge, adjusting the fee in 2026 as the compliance rate rises to 100%, and dynamically adjusting it in line with carbon allowance prices	Biofuel Solution, etc.	Biofuel Emissions Reduction Services	Global customers can access biofuel emission reductions through Biofuel Solution
Maersk	Has introduced an Emissions Surcharge to cover compliance costs under the EU ETS, FuelEU and other schemes; the surcharge is adjusted quarterly in line with the price of EUAs	ECO Delivery	Low-carbon fuels, mass balance, etc.	Inditex, Grundfos, etc.

• Continued

Company	Carbon Compliance/ Management	Green Transport Products	Key Mechanisms	Typical Clients or Applications
Hapag-Lloyd	Recovers EU ETS and FuelEU costs through the emissions surcharge, whilst linking this to green transport products	Ship Green	Book & Claim	DHL, DSV, Kuehne+Nagel
ONE	Internal carbon pricing is used for investment decisions; the Europe Environment Surcharge is adjusted quarterly and covers costs related to the EU ETS, FuelEU and the UK ETS	ONE LEAF+	Book & Claim, UCOME second-generation biofuels, third-party assurance	Nike, Yusen Logistics, etc.
Yang Ming Marine Transport	Developed an online carbon emissions calculator and engaged third parties to verify emissions reduction data for alternative fuels	YM EcoSea+	ISCC-certified biofuels, Book & Claim, carbon reduction tokens and certificates	Joint development with PSA of a digital Book & Claim system and integrated sea–land carbon-insetting solutions
PIL	Incorporate climate risks and opportunities into corporate risk management, and strengthen capacity building for carbon emissions MRV	PIL–PSA Land-Sea Green Transport Services	Land-sea coordinated emissions reduction, Book & Claim, third-party assurance	Launching integrated land-sea green transport services with PSA and DNV; ABS provides verification of emissions reduction data
SITC International	Establishing an internal carbon pricing system, using the average EU ETS price and the shipping industry's compliance rate to derive a shadow carbon price, and integrating this with internal cost structures, compensation schemes and performance incentive mechanisms	Carbon Emissions Calculator	Calculation of carbon emissions based on route distance and cargo volume	The internal carbon price is used for investment, operations and performance appraisal, and a tool for calculating route-specific carbon emissions is provided to customers

5.2.6 Decarbonisation collaboration is expanding from individual partnerships to a networked approach.

Decarbonisation partnerships among leading liner companies are evolving from individual inter-company collaborations towards collaborative networks spanning multiple stakeholders and regions. Green shipping corridors are attracting more shipping lines to participate; MSC has joined the Ningbo-Zhoushan–Valencia Green Shipping Corridor, whilst CMA CGM is participating in the development of the Ningbo-Zhoushan–HAROPA Green Shipping Corridor. Joint procurement by shippers has also developed further: Hapag-Lloyd and North Sea Container Line were awarded the contract for the second round of ZEMBA's e-fuel tender, whilst shippers such as Amazon, IKEA and Nike have pooled their demand to jointly procure low-emission maritime transport services.In September 2026, the International Green Shipping Corridors Alliance was formally established, with its inaugural members comprising 45 organisations across 12 countries, including shipping companies such as COSCO Shipping and CMA CGM, alongside ports and energy enterprises. Overall, decarbonisation cooperation among shipping enterprises is gradually shifting from individual projects and bilateral cooperation towards networked collaboration spanning multiple enterprises, ports and industrial chains.

5.3 Green Transition of Ports

From 2025 to 2026, the green transition of major ports has expanded from standalone measures such as energy-saving equipment deployment and clean-energy substitution to multiple fields including low-carbon por-tarea operation, clean-energy utilization, digital management and green evaluation. The application of shore-side electricity, green power, hydrogen energy and new-energy port machinery keeps advancing. Digital tools such as smart dispatching and energy-carbon management are being rapidly integrated into port operations. Evaluation and certification mechanisms for zero-carbon ports have gradually improved. Green shipping corridors drive ports to strengthen cross-port collaboration in fuel supply, shore-side electricity, data and emission-reduction rules. The green transition of ports covers an increasing number of links and features more prominent coordinated advancement.

5.3.1 Port Green Evaluation System

Port green evaluation systems have been continuously refined. From 2025 to 2026, green evaluation and certification mechanisms for ports at home and abroad have been further detailed. Building on the star-rating evaluation for green ports in China, the Technical Specification for Zero-Carbon Port Evaluation was released in July 2025, and the Trial Measures for the Administration of Zero-Carbon Port Accreditation was issued in April 2026. Evaluation practices have gradually moved from technical standards toward formal accreditation implementation. Japan has steadily advanced the graded CNP (Carbon Neutral Port) certification; it completed the first-batch certification in September 2025, and revised the guidelines to expand its scope of application in 2026. Established evaluation frameworks including Europe's EcoPorts PERS and North America's Green Marine continue to conduct ongoing assessments of port environmental performance through regular reassessment and third-party verification.

• Table 5-6 Comparison of Major Global Port Green Evaluation and Certification Systems

Region	Evaluation System	Implementation Timeline & System Positioning	Major Evaluation Contents	Evaluation Approaches
China	Guidelines for Green Port Grade Evaluation(JTS/T 105-4-2020)	Implemented July 2020; comprehensive evaluation for port green development	Comprehensive assessment covering green philosophy, practical actions, management and outcomes; including resource conservation, energy-saving and low-carbon development, with performance metrics on energy consumption and carbon emissions per unit throughput.	Ratings of 3-star, 4-star and 5-star (5-star being the highest). Procedures include self-assessment, document review and on-site inspection.
China	Technical Specification for Zero-Carbon Port Evaluation(T/CCTAS 220-2025)	Implemented July 2025; specialized evaluation of port carbon emissions	Focuses on port carbon emissions, clarifies evaluation boundaries, and specifically assesses carbon monitoring, accounting, governance and zero-carbon outcomes. Applicable to single terminals or port zones composed of multiple terminals.	Accreditation against zero-carbon port technical standards, with key verification of whether carbon-emission accounting and governance satisfy zero-carbon indicators.

• Continued

Region	Evaluation System	Implementation Timeline & System Positioning	Major Evaluation Contents	Evaluation Approaches
Japan	CNP Certification (Carbon Neutral Port Certification)	Launched June 2025; graded evaluation of decarbonization levels for container terminals	Evaluates implementation of terminal decarbonization plans, including zero-carbon conversion of port-handling equipment, clean-energy adoption, shore-side electricity access and supply of zero-carbon fuels.	Grades from Level 1 to Level 5. Additional "+"labels recognize extra decarbonization initiatives.
Europe	EcoPorts PERS(Port Environmental Review System)	Incorporated into ESPO in 2011; certification for port environmental-manag ement systems	Evaluates completeness and practical performance of port environmental-management systems across environmental policy, energy-resource management, pollution prevention & control, monitoring and organizational accountability.	Ports complete PERS environmental review and submit documentation; third-party audit for certification with periodic reassessment; no star-based grading.
North America	Green Marine	Launched 2007; graded environmental-perfor mance evaluation for port-shipping enterprises	Covers greenhouse-gas & air-pollutant emissions, water environment, waste management, biodiversity and community impacts. Higher tiers require emission inventories, quantified emission-reduction targets and sustained emission-reduction performance.	Annual assessment of each environmental indicator at Level 1–5, with regular independent third-party verification. Higher grades impose stricter requirements for environmental management and practical performance.

5.3.2 Progress in Low-Carbon Port-Area Operation

Low-carbon port-area operation keeps advancing. From 2025 to 2026, major global ports continued to cut carbon emissions from port-area operations via two dimensions: energy supply and operational equipment. The adoption of clean energy such as green-power procurement and distributed photovoltaics keeps expanding. Some ports have simultaneously deployed hydrogen-energy infrastructure for a more diversified port-area energy mix. Equipment including electric yard cranes and AGVs has been deployed at an accelerated pace, raising the electrification and automation level of port machinery. Meanwhile, several ports have begun to coordinate clean-energy production, storage-transportation and industrial energy consumption within port zones. Low-carbon port-area operation is characterized by coordinated advancement of energy infrastructure and operational systems.

● Table 5-7 Progress in Low-Carbon Operation of Major Global Ports

Port	Key Low-carbon Priorities	Key Practices in 2025-2026
Port of Rotterdam	Port-area hydrogen-energy infrastructure	In May 2026, the first segment of the Dutch national hydrogen network went into official operation at the Port of Rotterdam. A 32-km hydrogen pipeline connecting Maasvlakte and Pernis links hydrogen-production facilities at Maasvlakte with industrial end-users inside the port zone.
Port of Singapore	Electrification of port-handling equipment	In March 2026, the Maritime and Port Authority of Singapore announced four new berths to be built at Tuas Port in 2026. The Tuas Living Lab within these berths will verify new technologies such as autonomous driving. Existing operational systems at Tuas Port adopt electric automated yard cranes, battery-powered AGVs and smart-grid technologies. Electric AGVs can deliver approximately 50% lower carbon emissions compared with conventional diesel tractors.
Port of Valencia	Application of hydrogen-fueled port machinery	In December 2025, the H2PORTS project completed demonstration validation. Hydrogen-fuel-cell-powered container reach stackers, 4×4 terminal tractors and mobile hydrogen-refueling facilities were deployed under real-world port-operation conditions. This is the world's first port zone that routinely uses pure-hydrogen-powered container reach stackers and terminal tractors.
Port of Tianjin	Green-power substitution in port areas	In January 2026, Tianjin Port Group achieved full green-power coverage for all production-related electricity-consumption scenarios across the entire port. New installed capacity of renewable energy reached 37.5 MW in 2025, bringing cumulative installed capacity to 152 MW.

5.3.3 Progress in Green-Energy Adoption for Ships at Berth

Green-energy adoption for ships at berth continues to move forward. From 2025 to 2026, major ports further improved shore-side-electricity facilities and alternative-fuel supply systems.

• Table 5-8 Progress in ShoreSideElectricity and AlternativeFuel Application at Major Global Ports

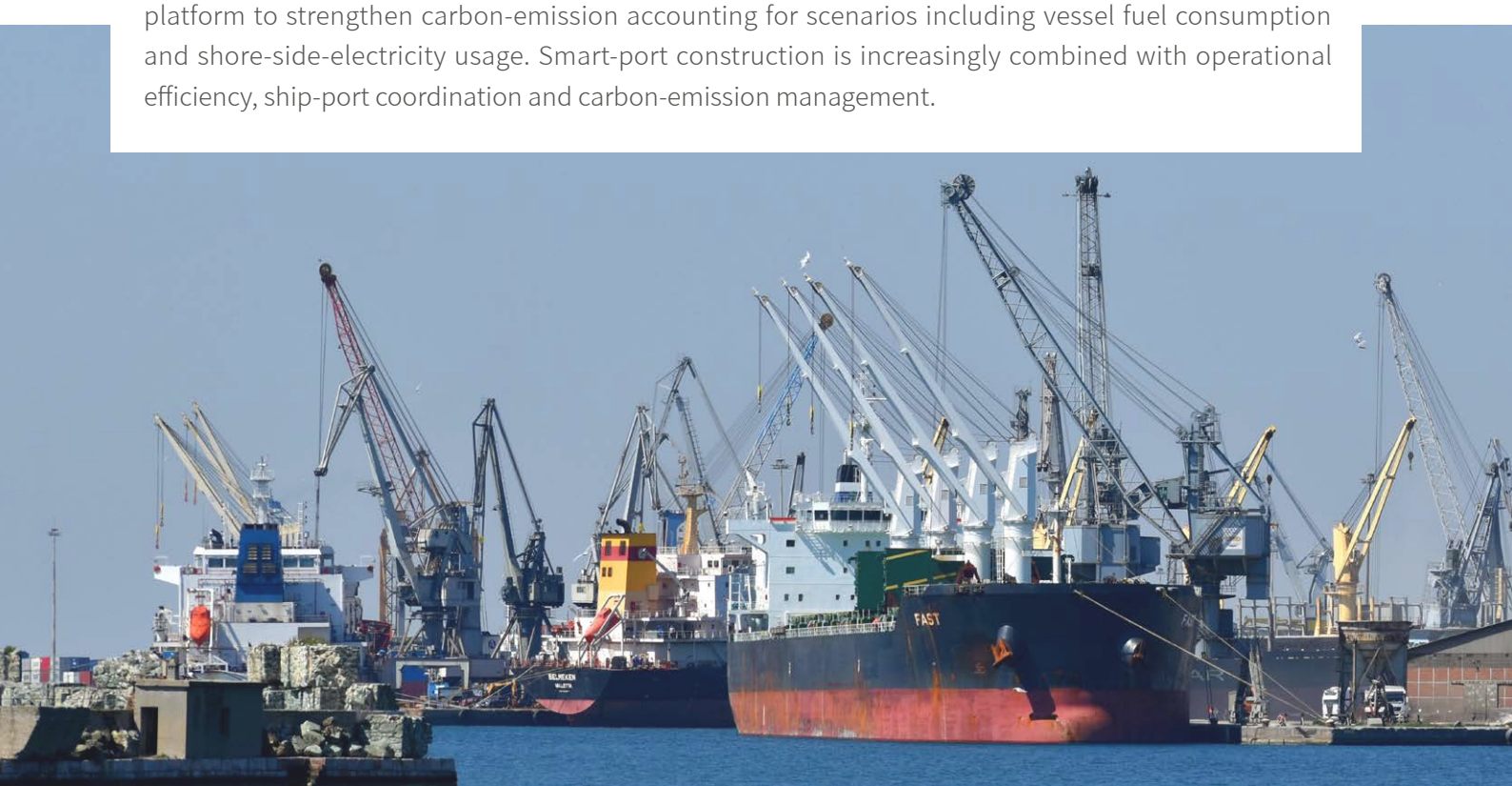
Port	Shore-Side-Electricity Deployment	Alternative-Fuel Application & Layout
Port of Singapore	Large-scale shore-side-electricity application has not yet been achieved. The port's vessel-energy transition currently focuses more on alternative fuels and electrification of port craft.	Fuel portfolios expand from LNG and biofuels toward methanol. Three marine methanol-bunkering supply licences were issued for the first time in November 2025. Front-end engineering design for ammonia-fuel-power generation and bunkering is underway, alongside continuous improvement of the low-carbon LNG supply system.
Port of Rotterdam	Shore-side-electricity coverage expands from inland-waterway vessels and cruise ships to large deep-sea container vessels. The Shore-Side-Electricity Strategy 2025-2035 was released in 2025. In 2026, shore-power projects for three deep-water container terminals are being advanced, with plans to build 35 shore-power connection points for deep-sea container ships along an 8-kilometre shoreline.	A multi-fuel supply system covering LNG, biofuels and methanol is already in place, and new fuels are being further explored. In March 2026, projects for an additional 67 500 cubic metres of (bio-)methanol and (bio-)ethanol storage capacity were initiated. The port completed its first marine-vessel ethanol bunkering operation in May 2026.
Port of Shanghai	Shore-side-electricity has entered the large-scale application phase. By the end of 2025, shore-power-facility coverage among normally-operating port enterprises reached 99.8%. In 2025, shore-side-electricity was used for 158,500 vessel-calls with total consumption of 72.4019 GWh, representing a year-on-year increase of 31%.	Ship-to-ship bunkering systems for LNG and green methanol are operational. In 2026, green-methanol application scenarios were further expanded. The first anchorage-based ship-to-ship green-methanol bunkering was completed. Efforts are being made to normalize and popularize green-fuel bunkering across the whole port, while low-carbon fuels such as bio-fuels are being deployed.

• Continued

Port	Shore-Side-Electricity Deployment	Alternative-Fuel Application & Layout
Port of Ningbo-Zhoushan	Focus of shore-side-electricity development shifts from facility construction toward regular practical utilization. By 2025, shore-side-electricity facilities covered all coastal berths above 1 000 dwt and inland-waterway berths. Shore-power consumption totalled 19.2 GWh in the first 11 months of 2025, up 32% year-on-year.	Application scenarios for green methanol keep expanding. Following Zhejiang's first terminal-side green-methanol bunkering in September 2025, Zhejiang's first ship-to-ship green-methanol bunkering was accomplished in April 2026, marking the transition from terminal-side supply to ship-to-ship supply mode.

5.3.4 Smart Operation and Energy-Efficiency Improvement

Integration between smart technologies and low-carbon port operation is accelerating. From 2025 to 2026, on the basis of equipment automation, major ports have further strengthened the application of artificial intelligence, data collaboration and digital management in production and operation. Singapore optimizes vessel arrival through real-time coordination of vessel schedules and port services, while new-generation automated terminals continue to be developed. Ports including Shanghai and Ningbo-Zhoushan apply AI to production planning, vessel stowage and equipment dispatching to improve terminal operational efficiency. Qingdao leverages its digital energy-carbon-management platform to strengthen carbon-emission accounting for scenarios including vessel fuel consumption and shore-side-electricity usage. Smart-port construction is increasingly combined with operational efficiency, ship-port coordination and carbon-emission management.



● Table 5-9 Progress of Smart-Operation Empowered Decarbonization at Major Global Ports

Port	Smart-Technology Deployment	Key Progress (Oct 2025-Aug 2026)
Port of Singapore	Intelligent vessel-arrival coordination and automated port-zone operation	In 2026, Singapore's JIT (Just-in-Time) planning and coordination platform covered more than 150 port users and service providers. Real-time coordination of vessel schedules, berths and port-service resources helps vessels optimize arrival time and sailing speed and reduces anchorage waiting time; platform coverage is further extended to oil-tanker scenarios. Automation construction proceeds at Tuas Port. The Tuas Living Lab within newly-added berths carries out real-world-scenario tests for next-generation automated-port technologies such as unmanned operations.
Port of Shanghai	Terminal operating system and AI-driven intelligent decision-making	SIPG's self-developed Terminal Operating System (TOS) has been deployed across 69 terminals at home and overseas. In July 2026, the AI-native Terminal Operating System AITOS was released. Artificial intelligence is embedded throughout production planning, dispatching and execution workflows. Terminal operations are advanced from automated execution toward AI-assisted decision-making and agent-driven execution, further optimizing operational organization and energy-utilization efficiency.
Port of Ningbo-Zhoushan	AI-powered intelligent stowage planning and automated-operation coordination	In 2026, the self-developed n-TOS system trains AI models based on long-term accumulated terminal-operation data, cutting vessel-stowage-planning duration from three hours to 20 minutes. Synergy between the n-TOS and iECS systems enables remote quay-crane control, autonomous task assignment for unmanned container trucks, optimal-route planning and anomaly early warning, improving collaboration efficiency for terminal equipment and transport resources.
Port of Qingdao	Digitalized energy and carbon-emission management	In May 2026, the digital energy-carbon-management platform went online. Centered on carbon-emission control, it covers scenarios including accounting for emissions from vessel fuels, emission-reduction calculation for shore-side-electricity at berth, and carbon-emission comparison for container modal shift from road to waterborne transport. It realizes digital accounting and management of energy consumption and carbon emissions within the port-shipping sector.

5.3.5 Green Shipping Corridors and Inter-Port Collaboration

Green shipping corridors are evolving from conceptual advocacy toward network-based practical implementation. According to the 2025 Green Shipping Corridors Annual Progress Report released by the Global Maritime Forum in November 2025, the number of ongoing global green-shipping-corridor projects rose from 62 in 2024 to 84, representing a 35% year-on-year increase. More than one-third of projects have delivered substantial cross-regional progress, and new projects are mainly concentrated in emerging markets such as India, China, Brazil and Chile.

Fuel-technology pathways for green shipping corridors show a diversified evolutionary trend. Methanol and ammonia remain mainstream marine fuels. Their market roll-out requires full-industrial-chain collaboration, which aligns with the multi-stakeholder-engagement philosophy of green shipping corridors. Biomethane, e-methane and hydrogen energy have attracted growing attention. Biomethane has achieved commercial application on short-haul Nordic routes including Stockholm-Turku and Vaasa-Umeå. Battery power is mostly deployed for short-sea ro-ro vessels and ferries in Europe. In 2025, the United States and the United Kingdom jointly built the world’s first nuclear-fuel-powered shipping corridor. Nuclear energy has been added to fuel options for shipping corridors, further diversifying relevant technical pathways.



● Figure 5-3 Geographical Distribution of Global Green Shipping Corridors in 2025

Stakeholders participating in corridors have gradually expanded from port-management authorities to industrial-chain participants including shipping companies, terminal operators, fuel suppliers, cargo owners and research institutions. Green shipping corridors are evolving from inter-port cooperation frameworks toward cross-value-chain collaborative emission-reduction mechanisms.

● Table 5-10 Progress of Typical Green Shipping Corridors and Inter-Port Collaboration

Green Shipping Corridor	Participating Ports (Regions)	Key Progress	Collaboration Priorities
Shanghai-Los Angeles/ Long Beach Green Shipping Corridor	Port of Shanghai; Port of Los Angeles; Port of Long Beach	From 2025 to 2026, the corridor completed Phase-1 targets. It promoted shore-side-electricity usage for berthed vessels, low-carbon-vessel deployment and preliminary preparation for low-carbon marine-fuel bunkering. Cooperation has shifted gradually from implementation plans toward concrete emission-reduction actions.	Shore-side-electricity application, low-carbon-vessel deployment, green-fuel bunkering
Singapore-Los Angeles/ Long Beach Green and Digital Shipping Corridor	Port of Singapore; Port of Los Angeles; Port of Long Beach	In April 2026, the three parties renewed the Memorandum of Understanding for the Green and Digital Shipping Corridor for another three years. Building on existing baseline studies, pilot initiatives on alternative fuels, digitalization and energy efficiency keep moving forward.	Alternative fuels, digital collaboration, energy efficiency
Rotterdam-Singapore Green and Digital Shipping Corridor	Port of Rotterdam; Port of Singapore	In February 2026, the corridor published research outcomes on sustainable marine-fuel investment. Investment barriers for fuel projects were systematically sorted out. Proposals were put forward to strengthen coordination among policy-making, finance, fuel-production and fuel-procurement stakeholders, so as to develop investable business models for green-fuel projects.	Green-fuel investment, risk sharing, demand-side coordination

• Continued

Green Shipping Corridor	Participating Ports (Regions)	Key Progress	Collaboration Priorities
Singapore-Republic of Korea Green and Digital Shipping Corridor	Port of Singapore; relevant ports and competent authorities of the Republic of Korea	In November 2025, Singapore and the Republic of Korea signed a Memorandum of Understanding for the Green and Digital Shipping Corridor. The two sides plan to cooperate on the application of zero- or near-zero-GHG-emission fuels, digital solutions and relevant demonstration pilots.	Zero-/ near-zero-emission fuels, digitalization, demonstration projects

China has become a vital node within the global green-shipping-corridor network. As of July 2026, China has participated in the construction of 16 green shipping corridors, covering five major hub ports: Port of Shanghai, Port of Ningbo-Zhoushan, Port of Qingdao, Port of Tianjin and Port of Guangzhou.

• Table 5-11 Status of China's Green Shipping-Corridor Construction (as of September 2026)

Chinese Port	Major Corridors	Construction Status
Port of Shanghai	① Shanghai-Los Angeles / Long Beach ② Shanghai-Hamburg ③ Shanghai-Melbourne ④ Shanghai-Barcelona Digital-Green Ro-Ro Shipping Corridor ⑤ Shanghai-Antwerp-Bruges Green Ro-Ro Shipping Corridor	The Shanghai-Los Angeles / Long Beach corridor has completed Phase-1 targets, delivering enhanced shore-power capacity, low-carbon-vessel deployment and green-fuel exploration. It has entered the phase of emission-reduction quantification and fuel certification. Corridors linking Shanghai with European and Australian ports are in the phase of deepened cooperation and scheme formulation.

• Continued

Chinese Port	Major Corridors	Construction Status
Port of Ningbo-Zhoushan	① Ningbo-Zhoushan-Hamburg ② Ningbo-Zhoushan-Wilhelmshaven ③ Ningbo-Zhoushan-Valencia ④ Ningbo-Zhoushan-HAROPA Port Alliance ⑤ Ningbo-Zhoushan-Abu Dhabi ⑥ Ningbo-Zhoushan-Algeciras ⑦ Ningbo-Zhoushan-Felixstowe	Cooperation with three major European ports was launched in 2025. Three new corridors covering Abu Dhabi, Algeciras and Felixstowe were added in 2026, with shipping carriers including MSC and CMA CGM engaged. Shore-side-electricity coverage is achieved (except for liquid-chemical berths). LNG and bio-fuel application capabilities are available, and development is underway toward a diversified-fuel system centred on green methanol.
Port of Qingdao	① Qingdao-Hamburg ② Qingdao-Wilhelmshaven	Initiated at the 2025 North Bund International Shipping Forum. Cooperation focuses on green fuels, shore-side-electricity and smart ports. As of August 2026, projects are in the phase of cooperation-mechanism establishment and implementation-plan formulation.
Port of Tianjin	Tianjin-Singapore Green Shipping Corridor	Launched in 2023. Cooperation focuses on green-fuel supply, vessel-emission-reduction technologies and smart-port collaboration.
Port of Guangzhou	Guangzhou-Singapore Green Shipping Corridor	Cooperation covers green fuels, port-energy transition and low-carbon-shipping technologies.

Chapter 6

Review of Green Shipping Development

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6.1 The process of harmonising global rules has slowed, whilst the implementation of regional rules has accelerated

In 2026, the global economy will continue to grow, but a slowdown in trade growth, geopolitical conflicts and energy price volatility will heighten uncertainty in the external environment. The International Monetary Fund (IMF) forecasts global economic growth of 3.0% in 2026; the World Trade Organisation (WTO) projects that the growth rate of global merchandise trade volume will fall from 4.6% in 2025 to 1.9% in 2026. Against a backdrop of economic and trade pressures, shipping emissions reduction regulations are increasingly influenced by factors such as transition costs, energy security and industrial competitiveness. Progress towards globally harmonised emissions reduction regulations has slowed somewhat. In October 2025, the IMO's Net-Zero Framework failed to be formally adopted as originally planned; in 2026, parties continued to negotiate issues such as fuel greenhouse gas intensity standards, greenhouse gas pricing and implementation arrangements. Meanwhile, supporting regulations on life-cycle greenhouse gas accounting, the use of biofuels and crew training are still being advanced, and the development of global emissions reduction systems has not stalled. At the regional level, the transition to the practical implementation phase has accelerated. The share of shipping emissions subject to allowance surrender under the EU ETS continues to increase, with methane and nitrous oxide included in accounting from 2026; FuelEU Maritime has entered the implementation phase, and greenhouse gas intensity requirements for ship energy are beginning to directly influence fuel selection and operational management; the UK also incorporated eligible domestic shipping activities into the UK ETS in July 2026.

The coexistence of a slowdown in the advancement of global harmonised rules and the accelerated implementation of regional regulations has placed shipping companies in a more complex, multi-layered compliance environment. In the short term, companies need to prioritise compliance with regional regulations that have already come into force, whilst retaining flexibility to adapt to future global mechanisms under the IMO. Should global mechanisms continue to be delayed, whilst long-term net-zero targets remain unchanged, the subsequent time window for fleet renewal, the expansion of green fuel production and infrastructure development may narrow further.



6.2 Accelerated development of green shipping market mechanisms

According to the International Carbon Action Partnership (ICAP) 2026 Annual Report, 41 carbon emissions trading schemes are currently operational worldwide, covering approximately 26% of global greenhouse gas emissions, with the relevant economies accounting for around 63% of global GDP. As the share of shipping emissions subject to allowance surrender under the EU ETS increases and regions such as the UK expand the coverage of their shipping carbon markets, carbon costs are becoming a more direct factor in shipping companies' operational decision-making. In addition to carbon markets, mechanisms such as preferential port charges, green finance, joint procurement by shippers, two-way auctions and 'Book & Claim' continue to play a role. Ports are reducing the operating costs of green vessels through preferential rates, whilst tools such as loans, bonds, finance leases and export credit insurance provide financial support for green vessels and supporting infrastructure; ZEMBA aggregates shippers' demand for low-carbon transport through joint procurement, and H2Global and ZEMBA are further exploring ways to combine public funds with voluntary payments from shippers to jointly share the cost of green fuel premiums. Meanwhile, 'Book & Claim' separates emission reduction attributes from the physical use of fuel, offering shippers a more flexible means of participating in supply chain emissions reduction.

Overall, mechanisms such as carbon pricing, cost-sharing, demand aggregation and the transfer of emission reduction value are forming a more closely integrated framework. Whether the demand-payment relationship between fuel producers, shipping companies and shippers can be further streamlined in the future will directly impact the large-scale implementation of green fuel projects.



6.3 Alternative-fuel fleets continue to expand, whilst new investment becomes more cautious

The global alternative-fuel fleet continues to expand, but new investment is becoming more cautious. As of early 2026, approximately 47% of the tonnage in the global order book was capable of running on alternative fuels; in 2025, 576 new orders for alternative-fuel vessels were placed, a year-on-year decrease of 27%, yet in terms of gross tonnage, these still accounted for approximately 37% of global newbuilding orders. The decline in orders reflects, to a greater extent, a cooling of the overall newbuilding market and an adjustment in the pace of investment, rather than a reversal in the direction of the green transition. The pace of development across different fuel pathways has diverged further. LNG remains a key choice for new alternative-fuel vessels; the methanol-powered fleet continues to grow, though new orders have slowed significantly; ammonia-fuelled vessels are progressing from engine validation to full-scale ship demonstrations; hydrogen fuel has established two technical pathways—fuel cells and internal combustion engines; and the scope of battery-powered applications is also expanding. Meanwhile, the scale of fuel supply, prices, infrastructure and life-cycle emissions reduction levels are having an increasingly significant impact on shipowners' choices.

DNV forecasts that the shipping industry's demand for low-greenhouse-gas fuels will be approximately 4 million to 22 million metric tonnes of oil equivalent in 2030, and may rise to 33 million to 185 million metric tonnes of oil equivalent by 2050. In the future, marine energy will continue to follow a multi-path parallel development pattern. Shipowners will place greater emphasis on the suitability of vessel types and routes, fuel availability and total cost of ownership, whilst maintaining flexibility in fleet composition and fuel selection to address long-term uncertainties.



6.4 Energy efficiency technologies: a certain choice in an uncertain environment

Whilst significant uncertainty remains regarding alternative fuel pathways, improving vessel energy efficiency can directly reduce fuel consumption, carbon emissions and compliance costs, making it a universally applicable emissions-reduction measure for shipowners. In the first half of 2026, approximately 48% of the global fleet tonnage had already been fitted with at least one energy-saving technology, with the application of technologies such as hull optimisation, propulsion system retrofits, air lubrication, wind-assisted propulsion and digitalised operations continuing to increase. The economic value of improved energy efficiency will become even more pronounced as the use of low-greenhouse-gas fuels expands. Fuels such as green methanol and green ammonia are expected to command a green premium for the foreseeable future; reducing energy consumption therefore means lowering both fuel costs and carbon costs. Research by DNV shows that energy efficiency measures offer both emission reduction and economic benefits across various regulatory scenarios.

In the future, energy efficiency in the shipping sector will place greater emphasis on technology portfolios and actual operational outcomes. Shipowners need to coordinate technical retrofits, digital operations and speed management, taking into account the vessel's age, type, route and operating conditions, whilst verifying energy-saving effects and return on investment through actual operational data.

6.5 Green competition places greater emphasis on comprehensive capabilities

The transition to green shipping is taking shape as a collaborative effort involving multiple stakeholders, including nations, companies, ports and cargo owners. At the national level, an increasing number of economies are advancing the development of green fuels, vessel energy efficiency and infrastructure through shipping decarbonisation strategies and action plans; ports, meanwhile, are continuously improving their shore power, green energy and alternative fuel bunkering capabilities, whilst strengthening cross-port collaboration through green shipping corridors. The green transition of shipping companies is no longer limited to ordering alternative-fuel vessels. Whilst renewing their fleets, leading shipping companies are beginning to strengthen their green fuel procurement, vessel energy efficiency management, carbon cost management and low-carbon transport services for shippers. They are mitigating transition risks and responding to clients' emission-reduction demands through long-term fuel procurement, carbon data management and 'Book & Claim' schemes.

In future, green competition amongst shipping companies will increasingly manifest as comprehensive capabilities in green fuel procurement, low-carbon fleet configuration, energy efficiency management, carbon cost management and low-carbon services for clients. The ability to maintain flexible allocation across regulatory changes, fuel supply, asset renewal and client demands will become a key capability for companies in navigating the uncertainties of the green transition.



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Abbreviations

ABS:	American Bureau of Shipping
AFIR:	Alternative Fuels Infrastructure Regulation
ALS:	Air Lubrication System
CB:	Compliance Balance
CCUS:	Carbon Capture, Utilization and Storage
CII:	Carbon Intensity Indicator
DCS:	Data Collection System
ECSA:	European Shipowners
EEA:	European Economic Area
EEDI:	Energy Efficiency Design Index
EEX:	European Energy Exchange
EEXI:	Energy Efficiency Existing Ship Index
EGR:	Exhaust Gas Recirculation
ESD:	Energy-Saving Device
ESI:	Environmental Ship Index
ETS:	Emissions Trading System
EU ETS:	European Union Emissions Trading System
FRP:	Fibre-Reinforced Polymer
GFI:	GHG Fuel Intensity

GFS: Global Fuel Standard

GHG: Greenhouse Gas

HFO: Heavy Fuel Oil

HTW: Sub-Committee on Human Element, Training and Watchkeeping

ICE: Intercontinental Exchange

IGF Code: International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels

IMO: International Maritime Organization

IMO DCS: IMO Ship Fuel Oil Consumption Database/Data Collection System

IMO NZF: IMO Net-Zero Framework

ISWG-GHG: Intersessional Working Group on Reduction of GHG Emissions from Ships

LCA: Life Cycle Assessment

LED: Light-Emitting Diode

LNG: Liquefied Natural Gas

LPG: Liquefied Petroleum Gas

LR: Lloyd's Register

MEPC: Marine Environment Protection Committee

MRV: Monitoring, Reporting and Verification

MSC: Maritime Safety Committee

MVDC: Medium-Voltage Direct Current

NAP: National Action Plan

OCCS: Onboard Carbon Capture and Storage

ORC: Organic Rankine Cycle

PBCF: Propeller Boss Cap Fin

PTI: Power Take-In

PTO: Power Take-Off

RFNBO: Renewable Fuels of Non-Biological Origin

ROV: Remotely Operated Vehicle

RSB: Roundtable on Sustainable Biomaterials

SCR: Selective Catalytic Reduction

SEEMP: Ship Energy Efficiency Management Plan

SHEA: Shanghai Emission Allowance

STCW: International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

VLSFO: Very Low Sulphur Fuel Oil

WHR: Waste Heat Recovery

WtT: Well-to-Tank

WtW: Well-to-Wake

ZEMBA: Zero Emission Maritime Buyers Alliance

ZNZ: Zero or Near-Zero GHG Emission Technologies, Fuels and/or Energy Sources

SBTi: Science Based Targets initiative



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