Building a Business Case for Green Shipping Corridors

February 2025

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Executive summary

Green shipping corridors—first mover initiatives that seek to advance high-ambition solutions for zero emission shipping on dedicated trade routes—face significant commercial challenges. In the absence of regulation or direct support from governments, the private sector currently lacks either the ability or appetite to bridge the cost gap. However, this is changing. The EU's 'Fitfor55' package and IMO's upcoming mid-term measures will mandate and incentivise shipping's energy transition. Government funding for low emission fuel projects has started to flow and a need for demand-side support has been acknowledged. Across shipping's sub-sectors, a combination of such measures could crystallise the business case for a green shipping corridor.

Key findings: Current and anticipated policies reduce, but do not eliminate, the cost gap for corridors

This is the first study of its kind to assess the commercial viability of green shipping corridors using e-fuels under the combined effects of the IMO's mid-term measures, the EU ETS and the US IRA—and to offer insight into the factors which may direct stakeholders in the value chain to invest in such projects. The baseline TCO analysis applies a conservative assumption about future IMO policy by modelling a global fuel standard with a flexibility mechanism which allows for the internal pooling or external trading of overcompliance. However, even with the effects of the EU ETS and US IRA applied—and with the assumption that biofuel costs will trend towards the high penalty cost of non-compliance with FuelEU Maritime by 2030—the cost gap persists in the near term, and so further supportive measures to encourage the early adoption of e-fuels, such as pooling multipliers and CfDs, have also been explored.

The IMO's global fuel standard combined with only a flexibility mechanism is unlikely to lead to green shipping corridors before 2040

Green shipping corridor projects currently represent high-ambition, first mover initiatives. When the IMO introduces its mid-term measures, the business case for such projects—which aim to deliver 'above compliance' action by running entirely on e-fuels from the outset—will gradually improve as regulation steadily raises the cost of compliance. The cost gap will eventually close during the 2040's when the stringency of the IMO's fuel standard will compel the use of e-fuels. Initially, however, such projects will require significant levels of support.

A global fuel standard with a flexibility mechanism (which allows for overcompliance by one ship to offset undercompliance by others) could allow for another type of green shipping corridor to emerge. Physical 'compliance-driven' green shipping corridors could form where the use of e-fuels is concentrated on dedicated ships / routes which are then used as a means of attaining compliance for a wider pool of ships. In this scenario, there is still a premium associated with using e-fuels (compared with alternative low emission fuels which are cheaper) to meet compliance, but it is far lower than in an 'above compliance' corridor. However, the TCO analysis indicates that even in this scenario, although ammonia dual fuel ships deliver the lowest cost of compliance option by the early 2030s, blue ammonia continues to out-compete e-ammonia until the early 2040s.

Even when an IMO fuel standard is combined with the EU ETS and US IRA, compliance-driven green shipping corridors are unlikely to form

The EU ETS narrows the cost gap between an 'above compliance' green shipping corridor running entirely on e-fuels and the cheapest compliance option but it does not fully bridge the higher cost of e-fuels. The picture is more complex for 'compliance-driven' corridors where there could be an opportunity to comply with the IMO's fuel standard while minimising exposure to the EU ETS. For such corridors, the optimal solution is to maximise operation into or within the EU (where the full use of e-fuels will minimise ETS costs) and then to apply the overcompliance to non-compliant ships that do not trade into or within the EU. As alternative (cheaper) low emission fuels could also be utilised to deliver this strategy, the EU ETS does not offer a relative cost advantage to 'compliance-driven' corridors using e-fuels.

The US IRA subsidies for e-fuels narrows the cost premium for both types of corridors. However, the subsidies for blue ammonia could also extend the competitiveness of this fuel (over e-ammonia) into the mid-to-late 2040s. In combination with the IMO's fuel standard, the US IRA looks unlikely to enable green shipping corridors before that date.

Remaining cost gap could feasibly be closed through support for e-fuels and business models that account for escalating compliance

The TCO analysis in each sector indicates that a cost gap persists between both the above compliance and compliance-driven green shipping corridors, versus the lowest cost compliance options. From a policy standpoint, the solutions explored for bridging this gap included the introduction of a pooling multiplier on the number of ships offset by overcompliance through e-fuels and supportive measures such as CfDs and e-fuel auctions. The cost gap could also be closed through the use of a 'reward' or other direct subsidy on the use of e-fuel, which could be generated from GHG pricing.

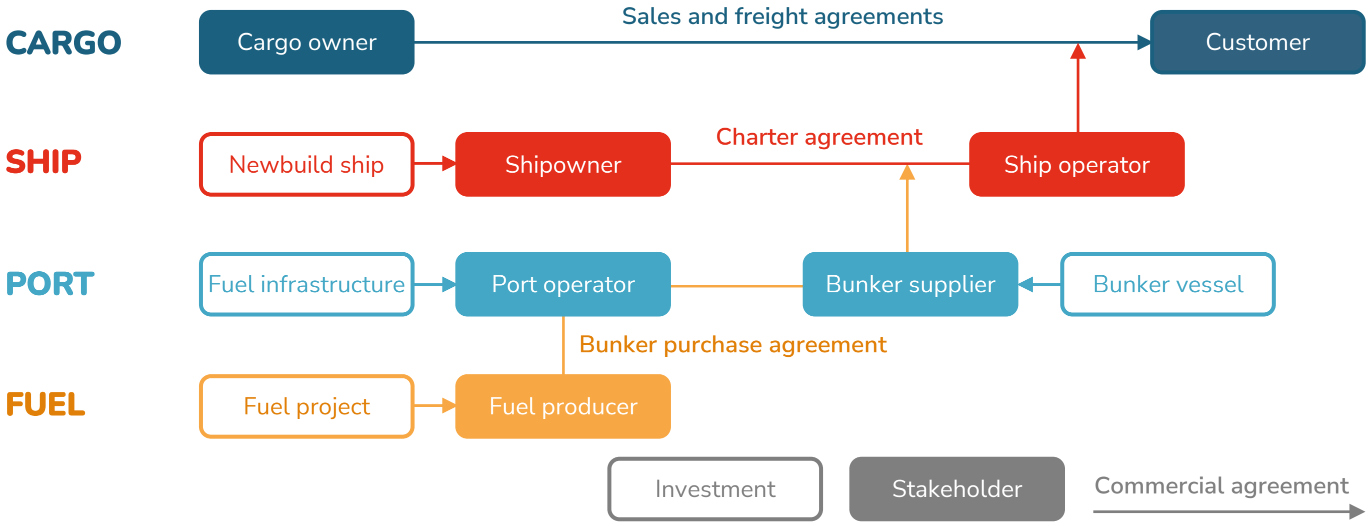
From the industry's perspective, the required level of customer willingness to pay for an e-fuel premium over and above the cost of compliance was assessed, along with reasons as to why shipowners might order dual fuel ships, and why operators and cargo owners might commit to e-fuel offtake over the near term as part of their bunkering strategies. While the business case for green shipping corridors will remain challenging, the analysis highlights that targeting additional support at e-fuels and recognising the implications of tightening compliance and an evolving fuel landscape within the business model can result in a cost gap that may be more surmountable than is often characterised or perceived.

Building a green shipping corridor business case: Why might actors from across the value chain participate?

Green shipping corridor projects typically necessitate collaboration among key stakeholders across the value chain and each party will need to manage their respective commercial risks while facilitating the investment required by such projects. In each value chain, the primary actors and types of agreements involved vary, shaped by the dynamics of the cargo market and shipping sector, but there are typically four common building blocks: fuel, port, ship and cargo.

For green shipping corridors to form, the contractual agreements currently in place along the value chain will need to adapt. However, when building the business case for a corridor project, each stakeholder should frame their investment decisions against a backdrop of accelerating regulation and the alternative pathways to compliance.

Figure 1: Key commercial agreements that span the four building blocks of a generic maritime value chain



FUEL: To secure fuel for a green shipping corridor project, an entity from the value chain will need to have the capability and resources to underwrite an offtake agreement with an e-fuel producer. For this stakeholder, an early commitment to offtake e-fuels could be an initial step in developing a long-term bunkering strategy focused on building a diverse portfolio of offtake agreements (potentially covering a range of fuel types, sources, and durations) through which to manage future compliance and fuel price risk exposure as regulation tightens.

PORT: Stakeholders involved in fuel storage and bunker provision at ports rely on customer demand to raise utilisation to a level that ensures a sufficient return on investment in related infrastructure and assets. These 'last mile' costs for the storage and supply of bunker fuels are highly sensitive to demand. Green shipping corridor projects can facilitate such investments by providing firmer commitments and potentially greater levels of demand, enabling economies of scale to be reached more swiftly.

SHIP: Shipowners that have invested in ships capable of running on alternative fuels may find it challenging to pass those higher capital costs on through the value chain—whether through direct operations or via chartering agreements. Operators will need to develop their fleet management or chartering strategies in tandem with their bunkering strategies and this could trigger a degree of risk sharing in charter agreements through a balance of premium and tenor.

CARGO: A green shipping corridor could form around a long-term sales agreement for a cargo, particularly if the customer is willing to pay a premium for a decarbonised supply chain. This may be more likely to occur where the cost of shipping is low relative to the value of the cargo, and so where higher costs could potentially be more easily absorbed.

Case studies: Exploring how corridors could form in different sectors through public and private action

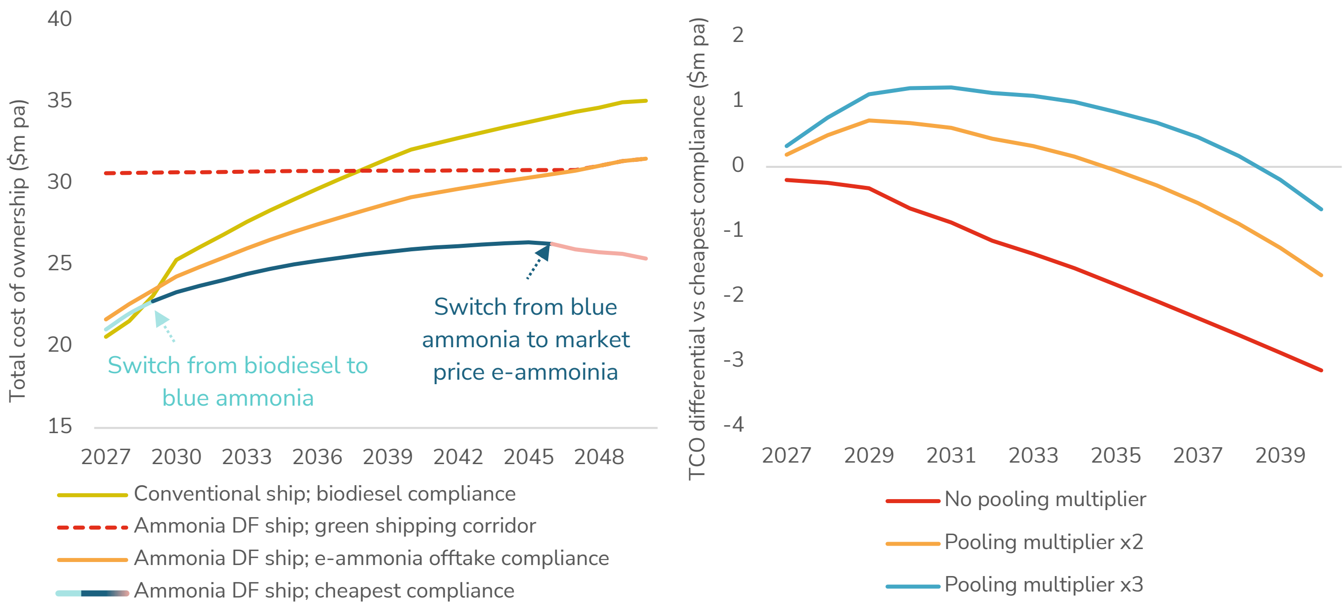
A conservative policy scenario that applies a global fuel standard from the IMO and (where applicable) leverages existing support measures (EU ETS and US IRA) is modelled across three different sectors that have promising potential for green shipping corridor projects. Each case study highlights the steps that could be taken—in terms of both supportive policies and through industry action—to maximise the opportunity for early adopter projects to be realised.

Gas carriers offer an ideal opportunity for green shipping corridor projects to form around an emergent trade in e-ammonia

This sector offers low-barrier opportunities for green shipping corridor projects to form around an emergent trade in e-ammonia. Building a corridor around a cargo circumvents some of the logistical (e-fuel transport) and port infrastructure (storage and bunkering facilities) hurdles associated with corridor projects. The large proportion of dual fuel gas carriers currently on order indicates the willingness of shipowners to build ships designed to run on cargo. An out-of-sector customer may also have access to more favourable terms than an offtaker from within the shipping industry due to higher volumes, longer-term commitments, and/or better credit quality. However, a portion of the cargo will need to be diverted for use as bunker fuel and the motivation to do so will vary depending on which entity in the value chain acts as the charterer and thus bears responsibility for bunkering decisions and costs.

If the e-ammonia producer is the charterer, the decision to use e-ammonia as a bunker fuel could be driven by a strategy to either meet compliance or to monetise overcompliance. The latter could provide the e-ammonia producer an alternative route to market, allowing them to indirectly sell uncontracted volumes into the shipping industry over the near term. A flexibility mechanism with a pooling multiplier supporting overcompliance through e-fuel bunkers would enhance and extend the viability of this opportunity.

Figure 2: TCOs for green shipping corridor and compliance options with US IRA subsidies and EU ETS applied (left) and illustration of impact of pooling multiplier on relative profitability of monetisation of overcompliance (right)



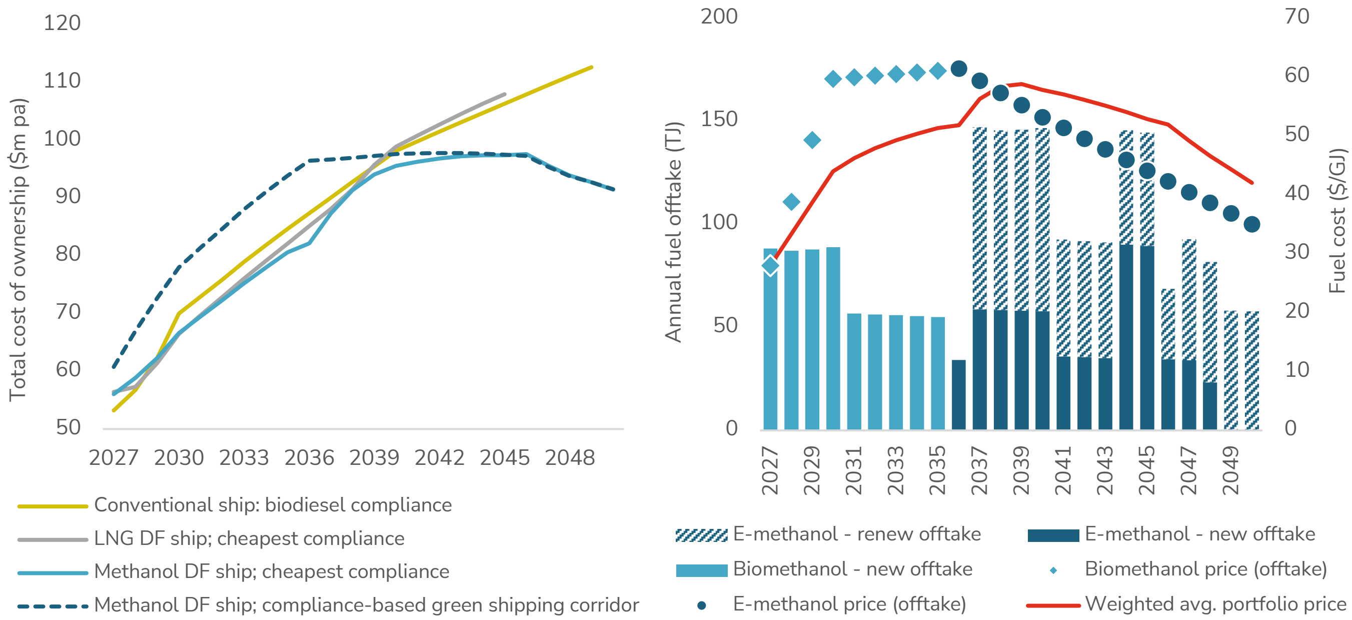
Note: *Based on a 45,000 cbm gas carrier using approx. 8,000 tonnes of LSFO equivalent annually (cost assumptions stated in Appendix).*

If the e-ammonia customer is the charterer, then the decision to use e-ammonia as a bunker fuel may align with a commitment to fully decarbonise their supply chain, beyond regulatory compliance. The high value of the cargo may bring the relative cost premium within range of the customer's willingness to pay. Customers could also potentially benefit from demand-side support not available to the wider shipping industry, such as a Contract for Difference (CfD) that subsidises the cost premium over fossil fuel-derived ammonia (or natural gas). However, it is likely the customer will find it more beneficial (in terms of the amount of CO_2 abated and the cost of that abatement) to use the e-ammonia to replace fossil fuel-derived ammonia in its existing supply chain rather than use as bunker fuel.

Compliance-driven corridors could provide liner companies with the opportunity to build offtake portfolios to manage future fuel price risk

The container shipping sector has several characteristics supportive of green shipping corridor projects. Large liner companies possess the internal resources and capabilities to negotiate and manage offtake agreements. Their control over large fleets, operating on fixed routes under regular schedules, simplifies the logistics of establishing such corridors. Regulation could act as a key catalyst for the creation of green shipping corridors in this sector—a fuel standard with a flexibility mechanism could lead to the emergence of compliance-driven green shipping corridors, but only if liner companies opt to use scalable e-fuels over lower-cost alternatives.

Figure 3: TCOs for compliance-driven e-methanol green shipping corridor versus cheapest compliance (left) and example of fuel offtake portfolio for cheapest compliance (right)



Note: *Based on 24,000 teu containership sailing between East Asia to Europe consuming approximately 30,000 tonnes LSFO equivalent per annum. Cost assumptions are detailed in the Appendix.*

Liner companies may choose to do so for a number of reasons. Accessing willingness to pay for green shipping is likely to be more challenging in a compliance regime. Customers who are willing to pay a premium for green shipping may be less inclined to do so if their goods are transported on an over-complying ship which is then used to offset a pool of non-compliant ships. To attract a premium for green shipping, liner companies could demonstrate that they have reduced emissions in excess of the level required by compliance, but a stronger claim could potentially be made through the use of e-fuels (even if at a scale that attains, rather than exceeds, compliance) compared to a greater use of less sustainable low emission fuels.

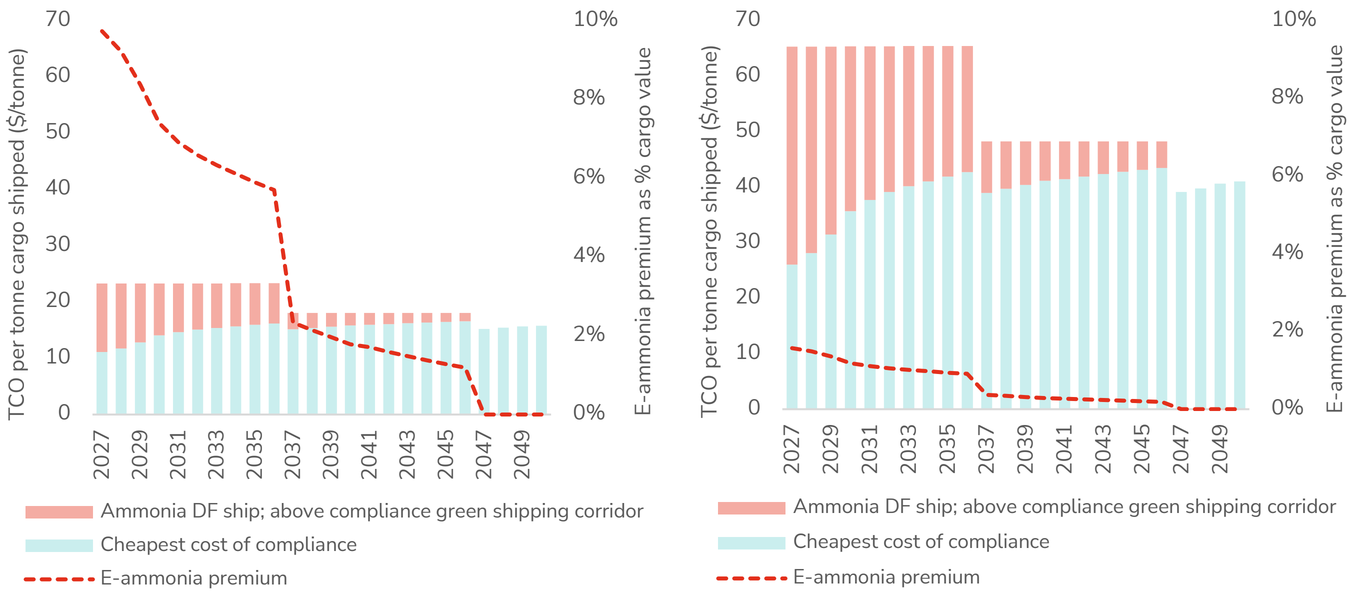
Alternatively, the decision could be triggered by a bunkering strategy intended to build a portfolio of offtake agreements to diversify the type, cost and source of bunker fuels over time as a means to managing future compliance as the regulation tightens and as a way to mitigate exposure to price spreads. However, this decision is made more difficult in the near term by a potential trade-off between securing low-cost, non-scalable fuels from biogenic sources before growing demand raises prices, and securing high-cost scalable e-fuels before increased supply drives prices down. Access to government auctions that resell e-fuels could bridge the cost gap between e-fuels and biogenic-derived alternatives over the medium term, helping to ensure that the weighted average cost of the fuel portfolio tracks falling e-fuel production costs. However, it may also expose the portfolio to renewal risks over the longer term.

Opportunities for compliance-driven and above compliance green shipping corridors reside within parts of the bulk carrier sector

The bulk carrier sector offers fewer opportunities to form green shipping corridors. Much of the fleet (particularly the smaller dry bulk carriers) trades in a random and wide-ranging manner, under short-term charters, and carrying low-value cargoes. The substantial trade in iron ore—which is shipped on the largest bulk carriers on relatively few routes—presents one opportunity for establishing compliance-driven green shipping corridors. A large mining company could potentially underwrite an e-fuel offtake agreement and offer long-term charters to shipowners for dual fuel bulk carriers in order to manage compliance with an IMO fuel standard across its fleet. Again, the challenge will be the cost of using e-fuels compared to cheaper compliance options.

There could also be demand for the immediate decarbonisation of a supply chain beyond (or rather, ahead of) regulatory requirements—particularly in a high-value trade where a green premium is available. The trade in copper concentrate between Chile and East Asia on smaller bulk carriers could offer one such opportunity. Although the additional cost (over the lowest cost of compliance) of switching over to run entirely on e-ammonia is far greater per tonne of cargo on smaller bulk carriers compared with the far larger iron ore carriers, the premium as a proportion of cargo value is far lower.

Figure 4: Indicative premium for e-ammonia use as % of cargo value for iron ore (left) and copper concentrate (right) for an above compliance green shipping corridor



Note: *Chart on left based on 210,000 dwt Capesize bulk carrier sailing between Australia and East Asia consuming approximately 9,100 tonnes LSFO equivalent per annum; assumes iron ore price of $125/tonne. Chart on right based on 64,000 dwt Handymax bulk carrier sailing between Chile and East Asia consuming approximately 6,500 tonnes LSFO equivalent per annum; assumes copper concentrate price of $2,500/tonne. Other cost assumptions detailed are detailed in the Appendix.*

This type of above compliance green shipping corridor would come at significantly higher cost compared to a compliance-driven corridor, as a larger quantity of e-fuels would need to be sourced from the outset. Moreover, without incremental offtake to create a weighted average cost portfolio and mitigate exposure to fuel price fluctuations, this type of supply chain would be more vulnerable to offtake renewal risk. Demand-side support measures, such as Contracts for Difference (CfDs), could help bridge the cost gap between e-fuels and fossil fuel bunkers, making these corridors more feasible. These measures could also be structured to adjust as the level of compliance set by regulation tightens.

Introduction

Green shipping corridors are first mover initiatives seeking to advance high-ambition solutions for zero emission shipping on dedicated trade routes. To unlock the required investment in zero emission fuels, ships and associated infrastructure, key actors across the maritime value chain must overcome significant commercial challenges. This report explores the barriers to investment and evaluates the steps that could be taken to build a business case for green shipping corridors.

Green Shipping Corridors face significant commercial challenges on path to execution

Green shipping corridors are first mover initiatives seeking to advance high-ambition solutions for zero emission shipping on dedicated trade routes. These early projects can help catalyse the decarbonisation of the wider maritime industry by testing the feasibility of zero emission technologies and fuels—particularly scalable e-fuels derived from hydrogen produced by renewable energy—whilst also spurring the formation of new supply chains and investment in associated infrastructure.

Over 60 corridors have been announced so far, bringing together collaborators from across the value chain (and beyond) to tackle the challenges specific to each route[1]. These initiatives are at varying stages of maturity, but the final steps towards implementation will invariably culminate in the commercial decisions that will drive investment in the requisite elements of a green shipping corridor—zero emission ships and fuels, and associated landside storage and bunkering infrastructure.

The key commercial challenge for green shipping corridor projects is that these ships, e-fuels, and infrastructure come at a greater cost than conventional shipping running on fossil fuels. Without a considerable level of willingness to pay for green shipping from customers, or regulations and measures that either oblige or support early mover adoption of zero emission fuels, this cost gap presents the most critical obstacle to the execution of these projects.

Efforts made to bridge this cost gap must account for the nuanced complexities of how discrete investment decisions are made and the commercial arrangements by which those costs are passed through the value chain. Across the different shipping sectors, value chains and stakeholder groups, green shipping corridor projects will require a shift away from current business practices and the manner in which responsibilities, risks and costs are typically shared. Investment decisions will also need to take account of future regulation.

Agreement and action by entities within the value chain can help overcome some of the commercial hurdles, but still may not fully bridge the cost gap—particularly for early projects targeting high-ambition high-cost e-fuels. The business case for these projects may then rely on targeted support.

[1] GMF: Annual Progress on Green Shipping Corridors 2024

Forming a framework to evaluate the business case for green shipping corridor projects

This report aims to identify where and why green shipping corridor projects present commercial challenges to the current modus operandi across the typical maritime value chains seen in different shipping sectors, and what steps could be taken to help overcome these challenges.

The first section introduces a generic value chain to illustrate the commercial drivers of key stakeholder groups, highlight where and how investment decisions are made, and indicate the types of agreements that then enable the associated costs to pass through the chain. The commercial implications of forming a green shipping corridor around this value chain are then assessed.

The second section summarises the current and anticipated policy landscape and describes how it informs the framework within which the analysis in this report was undertaken. Measures that currently affect the shipping industry, such as the European Union's Emissions Trading Scheme (EU ETS) and FuelEU Maritime policies, and the US Inflation Reduction Act (which subsidises the production of e-fuels from renewable energy and blue ammonia from natural gas), feed directly into the cost assumptions used in the analysis. Meanwhile, forthcoming regulation from the International Maritime Organization (IMO)—the shipping industry's global regulator—will shape future compliance and thus the baseline against which green shipping corridors should be assessed. The chapter also suggests possible policies and measures that could be supportive of the business case for a corridor project.

Subsequent sections examine the business case for green shipping corridor projects in the gas carrier, container and dry bulk sectors using illustrative ship sizes and routes. Each case study evaluates the capital cost of conventional ships and those with dual fuel (LNG, methanol and ammonia) capability. Alternative fuel scenarios are analysed using total cost of ownership (TCO) modelling to estimate 1) the cost of a green shipping corridor that uses scalable e-fuels (i.e. derived from hydrogen produced by renewable energy); and 2) the lowest cost option for meeting future compliance based on a projection of the IMOs upcoming regulation. This then forms the basis for the assessment of the cost differential attributable to green shipping corridors. Potential solutions for bridging that cost, particularly over the near term, are then explored.

This report does not aim to accurately model the business case of specific green shipping corridors. Instead, the intention is to illustrate an approach that could be used for such an assessment and to highlight indicative findings that flow from the framework used and assumptions applied. There are two critical assumptions that underpin the analysis in this report. The first is that the IMO will adopt a global fuel standard in 2027 to meet its stated decarbonisation ambition. This measure has been modelled in alignment with the IMOs minimum 2030 and 2040 targets which delivers a steep emissions intensity reduction trajectory over the near term.

The second key assumption is that this analysis has been framed against a backdrop of constrained biofuel supply. Prices for all fuels sourced from biogenic feedstock are assumed to increase to the level of FuelEU Maritime's penalty cost for non-compliance by 2030 and remain there from that point onwards. This sets an upper boundary for biofuels such as biodiesel, biomethane and biomethanol, beneath which the relative competitiveness of low and zero emission fuels produced by alternative pathways can be evaluated. More detail on the cost assumptions used in the analysis can be found in the Appendix.

Building blocks of a green shipping corridor business case

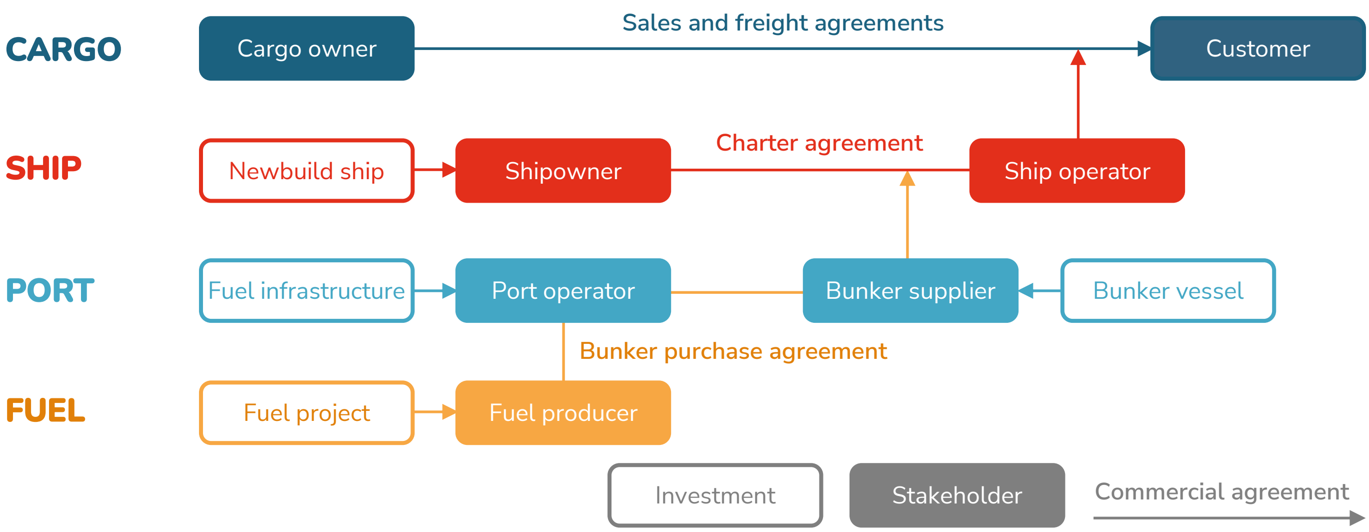
Green shipping corridors form across value chains that encompass actors, assets and commercial agreements. These components establish where the responsibility for investment decisions sit and how associated costs are passed through the chain. There are four building blocks in a green shipping corridor project—fuel, port, ship and cargo—and the business case hinges on long-term commitment, but this must be assessed against the trajectory of future regulation.

Mapping the key commercial agreements across the building blocks of a generic value chain

A maritime value chain consists of actors, assets and agreements which together facilitate the shipment of cargo across the world. The components and configuration of these value chains vary, shaped by the dynamics of the underlying cargo market and related shipping sector, but they do tend to have common elements. Principal actors typically include entities such as cargo owners, customers, ship operators and owners, ports, and bunker fuel providers. The contractual agreements that link these parties establish where responsibility (and associated risks) for different functions lie and dictate how costs are passed along the value chain to the customer. These costs reflect the provision of services and investments made in assets such as ships, port infrastructure and bunker fuel production facilities.

The key commercial agreements between the stakeholders responsible for discrete investment decisions can be mapped across a generic value chain to illustrate how the business case for a green shipping corridor project splits across four primary building blocks: fuel, port, ship and cargo.

Figure 5: Key commercial agreements that span the four building blocks of a generic maritime value chain



In practice, some value chains will be simpler. For instance, a single entity could straddle multiple functions, such as a ship operator owning rather than chartering a ship. Often, however, a value chain will be more complex; contractual agreements may be nested (for example, ships can be sublet by their charterers) or may span different durations. This can make the distribution of risk and reward over a given period more difficult to judge. Nonetheless, a generic value chain offers a reasonable basis to discuss how the business case for a green shipping corridor project affects stakeholders and the commercial agreements that link them.

Commitment, cost and **fuel** choice will shape bunkering strategy in corridor projects

Currently, commercial shipping almost entirely runs on oil products, although there are now over 1,200 ships that are also able to use liquified natural gas (LNG) as an alternative fuel (not including LNG carriers)[2]. The fossil fuel bunker industry largely functions on the basis of commoditised products and liquid markets. There is global availability of standardised fuels such as high sulphur fuel oil (HSFO), low sulphur fuel oil (LSFO), and marine gas oil (MGO). Pricing is transparent and linked crude oil prices, albeit with regional variation. At present, the majority of bunkers are bought spot, i.e. for prompt delivery of fuel at current market prices[3].

A green shipping corridor project seeking to secure a scalable zero emission bunker fuel (such as e-ammonia or e-methanol) will require a bunkering strategy that veers sharply from the spot purchase approach typically employed at present. The key differentiators of that strategy are the commitment to offtake, the cost and the wider considerations associated with the choice of e-fuel.

Commitment to a fuel offtake agreement is the crucial catalyst for a green shipping corridor project

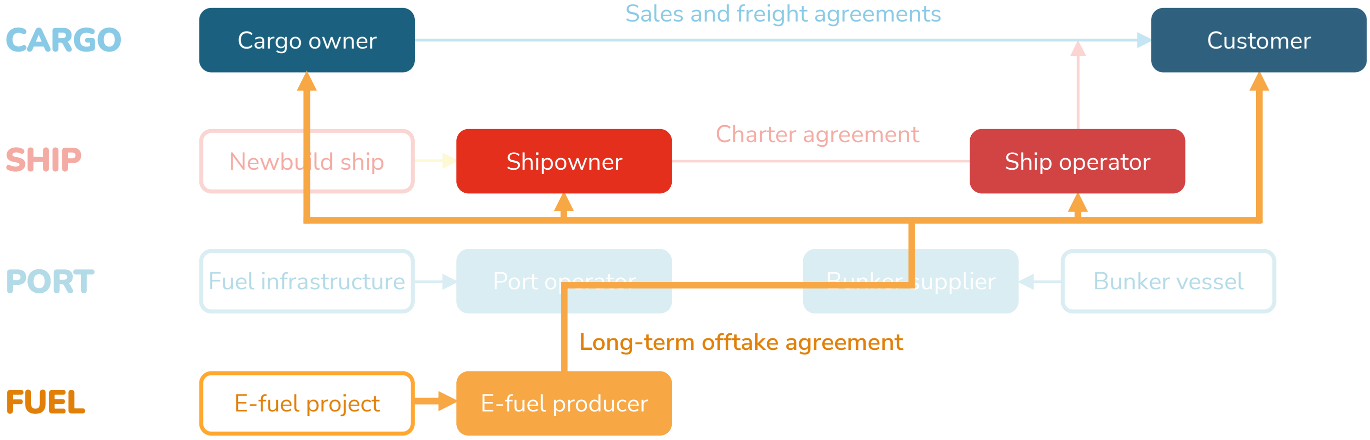
Projects that produce hydrogen (and derivative e-fuels) from renewable energy require substantial upfront capital investment, particularly those involving dedicated renewable energy generation (such as solar and/or wind power). For fuel producers to attract low-cost project financing, they will need to secure long-term (at least 10 years is likely) sales agreements for guaranteed offtake volumes from counterparties that are of sufficient credit quality (such as large corporate companies or state-backed enterprises).

For a green shipping corridor project that aims to deploy ships running on e-fuels, it is highly probable that a stakeholder from within the value chain will need to commit to an offtake agreement. This commitment could be linked to other long-term agreements that underpin the value chain (such as those related to the cargo or ship charter). Or, the role of offtaker may be adopted by the party responsible for fuel costs, whether shipowner, operator, cargo owner or customer. Alternatively, the degree of control over the shipping component of the value chain may determine which entity takes responsibility, or the choice may be obliged by the relative size and/or credit quality of the stakeholders that form the value chain.

[2] Clarksons SIN: Shipping Review and Outlook September 2024

[3] Ship & Bunker: Is It Better to Buy Bunkers Spot or on Contract?

Figure 6: Commitment to long-term offtake agreement for e-fuel could rest with one of several stakeholders



Most bunkers are currently acquired on a spot basis, but there are pockets of longer-term commitment. These are primarily driven by bunkering strategies that seek to manage fuel price volatility and/or benefit from bulk purchase discounts. Companies of sufficient scale and credit quality are able to negotiate bunker supply contracts which lock in forward volumes at fixed (and potentially discounted) prices. Large ship operators have secured long-term (5-10 years) supply contracts both for oil products and LNG bunkers[4]. Such agreements have been most common in the cruise and container shipping sectors as these ships sail on fixed routes which means that future fuel demand can be more accurately estimated and bunker stops planned.

Securing offtake agreements for e-fuels presents additional challenges. The cross-value chain collaboration gained in green shipping corridor initiatives can aggregate e-fuel demand, but even so, initial volumes sought may be lower than the minimum level accepted by large low-cost e-fuel production projects. The terms of offtake agreements are typically inflexible (take or pay), which means that early adopters will need to ensure that ships capable of running on the e-fuel are delivered on time.

It may prove more challenging to form green shipping corridors across value chains that currently operate via spot bunker purchases and in which the stakeholders involved have no experience of negotiating bunker supply agreements or weighing the wider ramifications of a commitment to volume and price over a period of time. However, even in value chains where stakeholders have sufficient internal capability to develop more sophisticated bunkering strategies, there will be uncertainty over how bunker fuel prices and availability will evolve, especially in a multi-fuel future.

E-fuel production costs are expected to fall but there is uncertainty over how the market for different fuels will evolve

In recent years, the number of projects announced intending to produce hydrogen from renewable energy sources has scaled rapidly. The International Energy Agency tracks thousands of hydrogen projects and estimates that just 4% of the capacity proposed to come online by 2030 has passed final investment decision[5]. Bloomberg New Energy Finance estimates that only 2% of project capacity planned by 2030 has signed, or has a solid chance of signing, binding offtake agreements[6].

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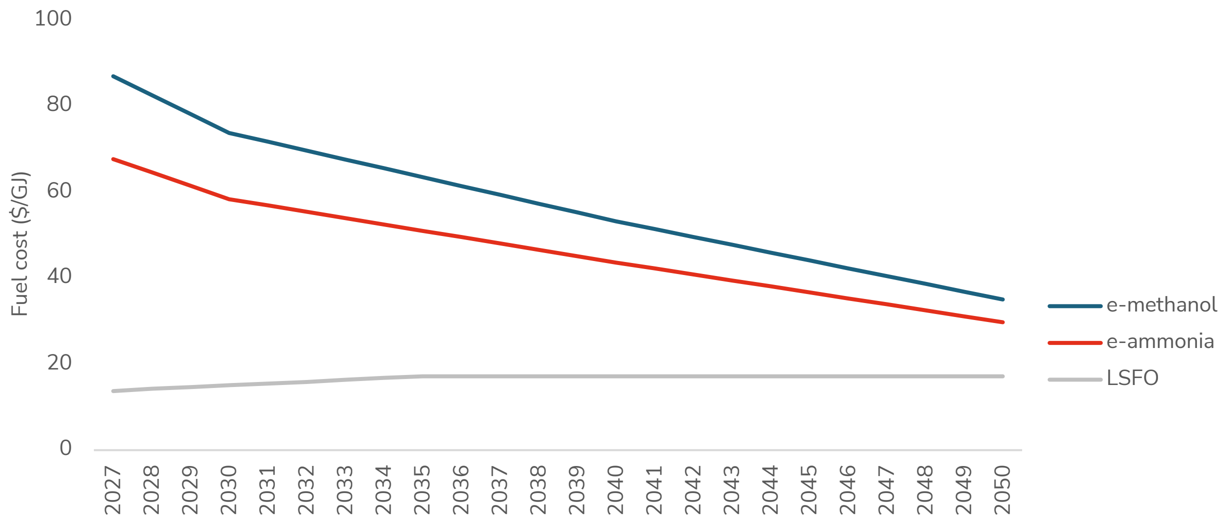
[4] HFW: LNG Bunkering – Long-term Contracts for a Transitional Fuel

[5] IEA: Global Hydrogen Review 2023

[6] Bloomberg NEF: Hydrogen offtake is tiny but growing

There is clear reluctance from the wider market to commit to long-term offtake agreements for volumes of hydrogen (and its derivatives) produced from renewable energy. This is largely down to cost. For industries that use hydrogen or ammonia derived from fossil fuels (primarily natural gas) as a feedstock, replacing this with cleaner alternatives produced from renewable energy will be approximately three times as expensive[7]. The multiple is even higher for sectors like the shipping industry which are seeking to replace cheaper oil products with e-fuels. While production costs are widely projected to fall as electrolyser technologies improve, supply chains form and economies of scale grow, this will be contingent on initial high-cost projects instigating this process.

Figure 7: Fuel cost projections for LSFO, e-ammonia and e-methanol used in analysis



Note: *Publicly quoted estimates of e-fuel production costs tend to vary by country or region—a reflection of the variation in capacity factors and cost of capital that renewable energy projects in different regions can benefit from. For simplicity, the analysis in this study is based on a global estimate for e-ammonia and e-methanol production costs and a market price for LSFO that reverts to a long-term average value.*

Projected production cost curves of e-fuels do not reflect how the future pricing might evolve over time. Strong demand signals could encourage intermediaries (such as traders) to step in as offtakers and take market risk by reselling volumes over shorter periods to customers. This could enable a sufficiently liquid market to emerge where supply and demand dynamics would then set the price.

Until this occurs, a 'cost-plus' approach could be a suitable pricing mechanism for these agreements to adopt. This price would reflect the cost of production and supply, plus the margins required by each entity in the fuel value chain, less any subsidies granted. Alternatively, offtake may be priced against a bilaterally agreed benchmark. This reference could be based on an input (for example, the wholesale electricity prices in country of production) or a substitution (such as LSFO plus a carbon price). However, if this reference is volatile, fuel producers could face market risk which would then impact their ability to raise finance (unless there was a subsidy regime in place to mitigate this exposure).

Through fixed price long-term offtake agreements, early offtakers for green shipping corridor projects could be locked into to high-cost sources of e-fuels as production costs fall. However, these initial commitments could be framed within the context of building a diverse portfolio of offtake agreements over time through which future compliance would be managed as regulation tightens.

[7] Bloomberg NEF: Green Hydrogen to Undercut Gray Sibling by End of Decade

Green shipping corridor projects offer ship operators an opportunity to initiate a diverse fuel offtake portfolio to meet future compliance

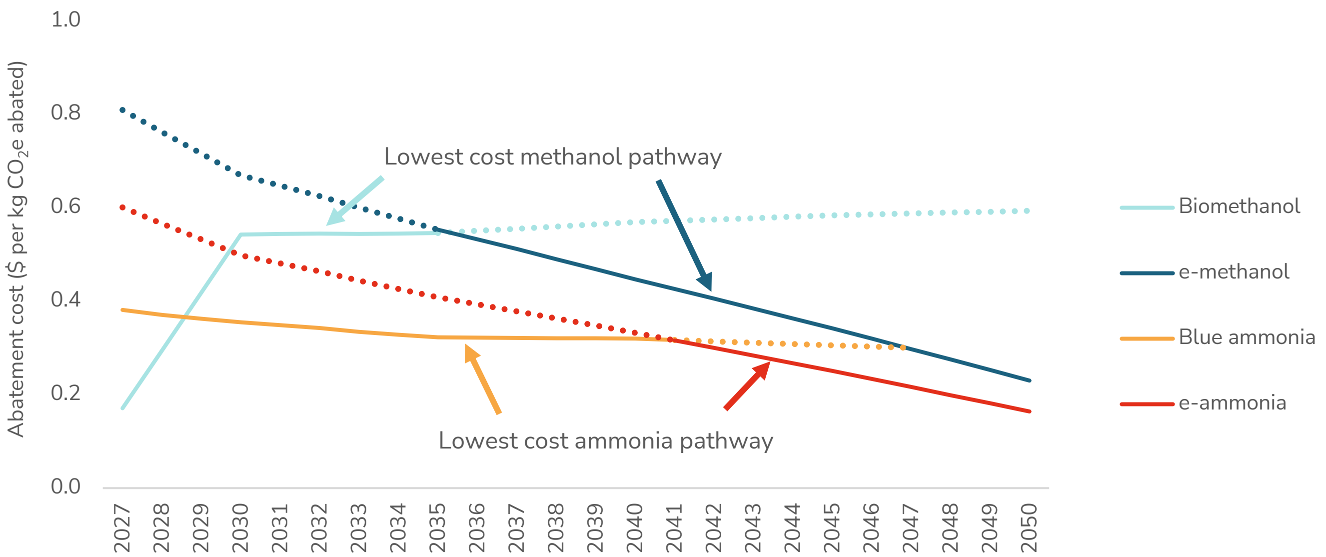
Thus far, the offtake of e-fuels for use by the shipping industry has been limited. Instead, there has been greater focus on securing agreements for alternative fuels produced from biogenic feedstocks (such as biomethanol and biomethane). The cost of production for these is lower than that of e-fuels and, given the finite supply of feedstock and competing demand from other sectors (such as aviation), the price of these biofuels is expected to increase markedly in future.

There are also biofuel bunkers that are currently available to purchase on a spot basis and which require no significant modification to a ship's engine. The feedstocks used to produce these biofuels are also limited and so the price of these fuels is also expected to climb, particularly as demand from ships without dual fuel capability increases as regulation tightens. The analysis undertaken in this report assumes that the cost of all fuels derived from biogenic sources is high from 2030 onwards due to high demand.

In addition to biofuels, 'blue' fuels are another low emission alternative. These are sourced from fossil fuels but utilise carbon capture and storage (CCS) technologies to remove a portion of the carbon dioxide emitted during production. Facilities that currently manufacture ammonia from fossil fuels—whether natural gas or coal—can be retrofitted to produce blue ammonia, but a carbon storage supply chain must be established to close the loop. Although blue fuels may be sold under offtake agreement initially, given the fossil fuel industry is integral to production, a commoditised market may emerge relatively quickly should demand materialise.

The plurality of fuel options, each with different production pathways, and thus costs and potential routes to market, suggests that the bunker ecosystem may evolve away from its current homogeneity. Bunkering strategies will need to become more sophisticated, assessing the relative spreads in price and emissions intensity between different fuel types, whilst also accounting for ship-related costs (i.e. dual fuel capability). Regulation adds another layer of complexity, shifting the focus to the spreads in the marginal cost of abatement. These costs will need to be assessed both within and across different fuel options linked to technology choices.

Figure 8: Cost of abatement ($ per kg of CO_2e abated) for ammonia and methanol options versus LFSO



Note: *Outputs reflect scenario where carbon price is set to zero and no subsidies have been applied.*

In a multi-fuel landscape, bunkering strategies will need to manage volatility across different fuel sources and types—for instance, blue ammonia prices may fluctuate in tandem with those of its primary feedstock, natural gas. Exposure to potential increases in biofuel prices may also need to be managed. The optionality offered by ships with dual fuel capability is one tool that can be leveraged, but a diversified portfolio of offtake agreements built over time will also help mitigate exposure to fuel price spreads. A green shipping corridor project offers an opportunity to start building that portfolio and provides a potential channel to access supportive measures that will be available early in the transition.

Clear demand signals from green shipping corridors can help unlock investment at **port**

As points of access to bunker fuels, ports are integral to green shipping corridors. Investment in infrastructure and assets dedicated to non-fossil fuel bunkering will be reliant on clear demand signals for these fuels, but the business case may benefit from an aggregation of demand across fuels of differing emissions intensity. For instance, investments made in ammonia storage and bunkering infrastructure can be utilised for both blue and e-ammonia. Green shipping corridor projects that have secured offtake agreements for e-fuels can deliver firm projections of demand and this can help stakeholders in the bunkering ecosystem plan investments.

Many ports are taking a proactive approach to facilitating the supply of low and zero emission bunker fuels

Ports are highly diverse—as well as varying in terms of size, types of shipping and cargoes handled, and their ownership and operating structure, individual ports can be subject to distinct constraints. For instance, a lack of physical space may impede the construction of new fuel storage facilities. Many ports function as nodes that enable trade and/or passenger transport on a local or regional basis. Some ports serve as large transhipment hubs, particularly for containerised cargo. There are also ports that function as gateways for key commodity exports or imports, built to facilitate trade from large centres of production (such as mines) to large centres of industry (such as steel mills).

Many ports are taking active steps to prepare for the upcoming shift away from fossil fuel bunkers, including direct participation in green shipping corridor projects. More than a fifth of the initiatives announced thus far are led by ports[8]. These ports are scrutinising safety standards for the storage and bunkering of new fuels (particularly ammonia which is toxic), determining where facilities could be placed, and assessing the business case for the investment require to supply alternative fuels—whether based on projections of demand from the shipowners and operators that currently call at the port, or through attracting a wider range of bunkering customers.

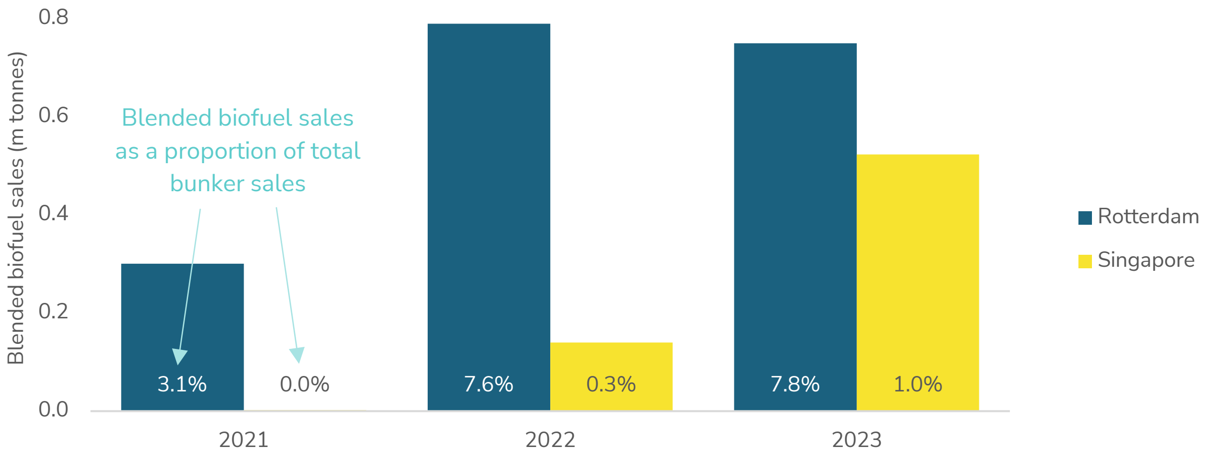
Some ports have started offering favourable terms (such as reduced port fees) for visiting ships that use low emission fuels and, in conjunction, have been increasing the supply of lower emission fuels. Sales of blended biofuels have grown in the last few years and LNG bunkering has expanded to 197 ports around the world[9].

[8] GMF: Annual Progress Report on Green Shipping Corridors 2024

[9] Clarksons SIN: Market Updates: Fuelling Transition November 2024

The two largest bunkering hubs—Singapore and Rotterdam—have been actively seeking to expand access to alternative fuels. Singapore's MPA has issued an expression of interest for a project to develop a low or zero emission ammonia bunkering (and for power generation too)[10]. A biomethanol producer is currently building a facility at the Port of Rotterdam, which is already a large (fossil fuel derived) methanol hub[11].

Figure 9: Sales of blended biofuel bunkers at Singapore and Rotterdam



Note: *Total bunker sales exclude LNG and methanol volumes. The ratio of biofuels in the blend is not explicitly stated in port sales data but other sources indicate that blends of 30% and 24% are common in Rotterdam and Singapore respectively*[12].
Source: *Port of Rotterdam; Maritime and Port Authority of Singapore (MPA)*

Ports that wish to secure access to low and zero emission bunker fuels will need to attract either parties that are willing to take market risk by supplying bunker fuels directly to customers on an ad hoc basis, or entities that already have an offtake agreement in place and simply require the infrastructure to store and supply the bunker fuel. The latter scenario offers the port and bunkering supplier greater certainty of future demand and utilisation, and thus provides a firmer business case for these stakeholders to invest in appropriately sized infrastructure and assets.

Firm e-fuel demand projections from green shipping corridors can help the business case for bunkering-related investments

Bunker fuels can be delivered from truck tankers, shoreside storage, fixed pontoons or via ship-to-ship transfers from bunker vessels. This service is typically offered by a bunker supplier and these companies range in size and types of activity, which can include bunker trading and broking, as well as the physical supply of fuels[13]. A bunker company will be exposed to operational risk when supplying the fuel and will take credit quality and liquidity risk if credit terms are offered to customers. Ownership of the infrastructure and assets connected with bunkering operations (storage facilities, bunker vessels, etc.) may lie with the port owner or operator, the bunker company, or a third party (such as an oil major or trader which sits upstream in the bunker supply value chain). These parties will rely on customer demand to raise utilisation to a level that ensures a sufficient return on investment.

[10] MPA: FAQs on EOI to develop end-to-end Low or Zero Carbon Ammonia Power Generation and Bunkering Solution in Singapore

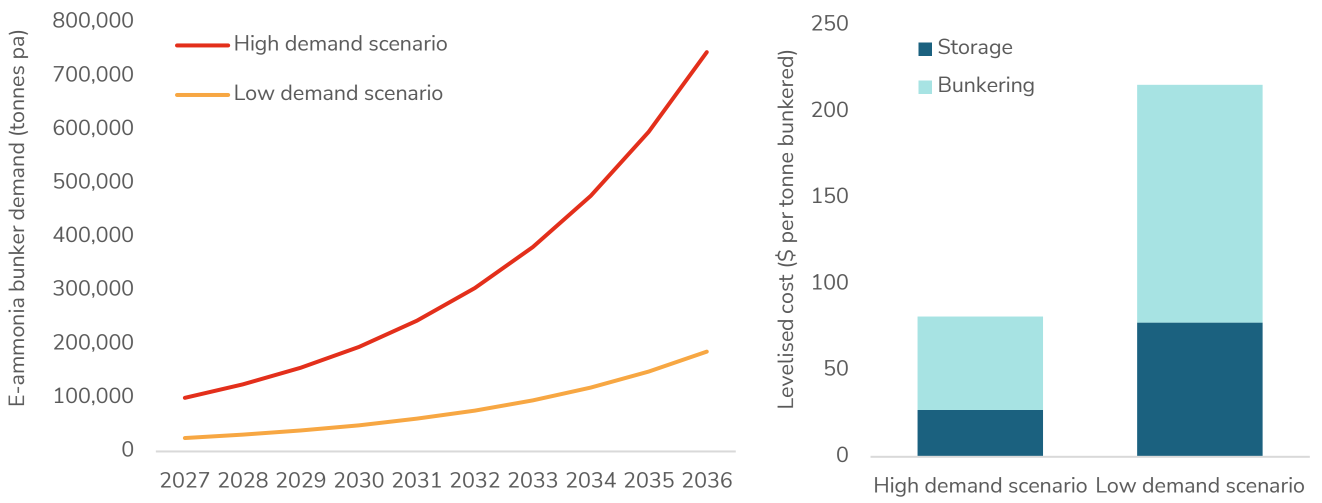
[11] GIDARA Energy: Press release on announcement of advanced methanol facility in the Port of Rotterdam

[12] Ship & Bunker: Biofuel Blend Premiums

[13] Ship & Bunker: Top 10 Bunkering Companies for 2024

These 'last mile' costs for the storage and supply of bunker fuels are highly sensitive to demand, particularly as the capital required will not scale linearly. Some elements of the investment (such as piping and equipment) may be fixed and independent of volume; other elements (such as the storage tanks and bunker vessels) will be built to a size that optimises the projected demand against economies of scale.

Figure 10: Indicative last mile costs for ammonia storage and bunkering in high and low demand scenarios

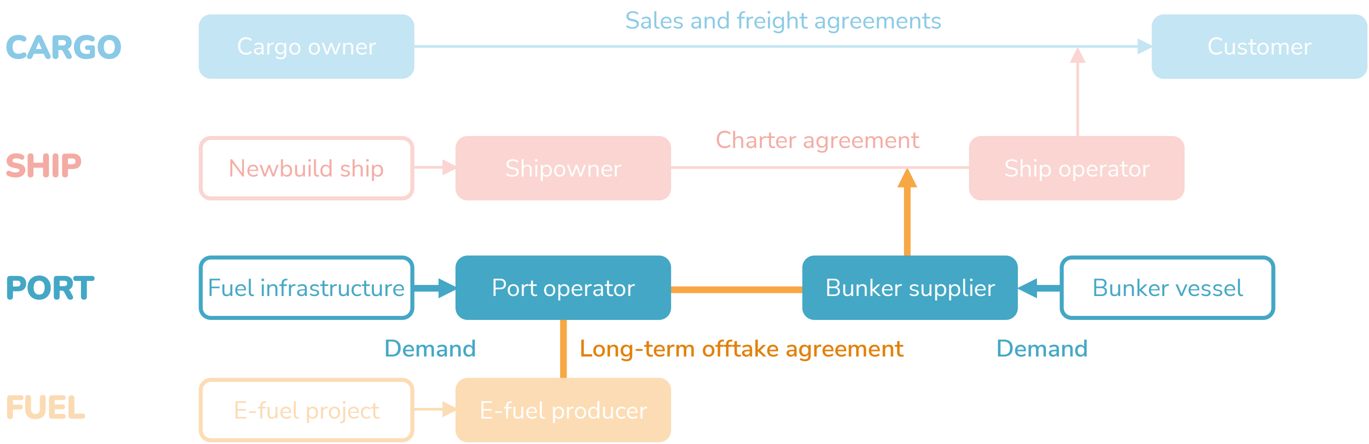


***Note:** Levelised costs for storage and bunkering are calculated over a 10-year period using a discount rate of 8%. The high and low demand scenarios are based on 30,000 cbm versus 15,000 cbm storage tanks and 22,000 cbm versus 5,000 cbm bunkering vessels respectively.*

The business cases for storage and bunkering investments may not necessarily be linked. For example, the port may function as a large import hub for the fuel which is then utilised by local industries. In this case, the investment in port storage will be assessed against a larger demand base while the business case for bunkering provision will depend on the utilisation offered solely by shipping demand.

Green shipping corridors can help reduce last mile costs. Given the commitment to offtake volumes, corridor projects offer greater certainty around future demand for e-fuels and thus provide a firmer business case for investment in appropriately sized infrastructure and assets by stakeholders within the port ecosystem. Such projects could also function as a platform through which demand from multiple stakeholders or shipping sectors could be aggregated. Corridors can also assist by coalescing demand around a single fuel type.

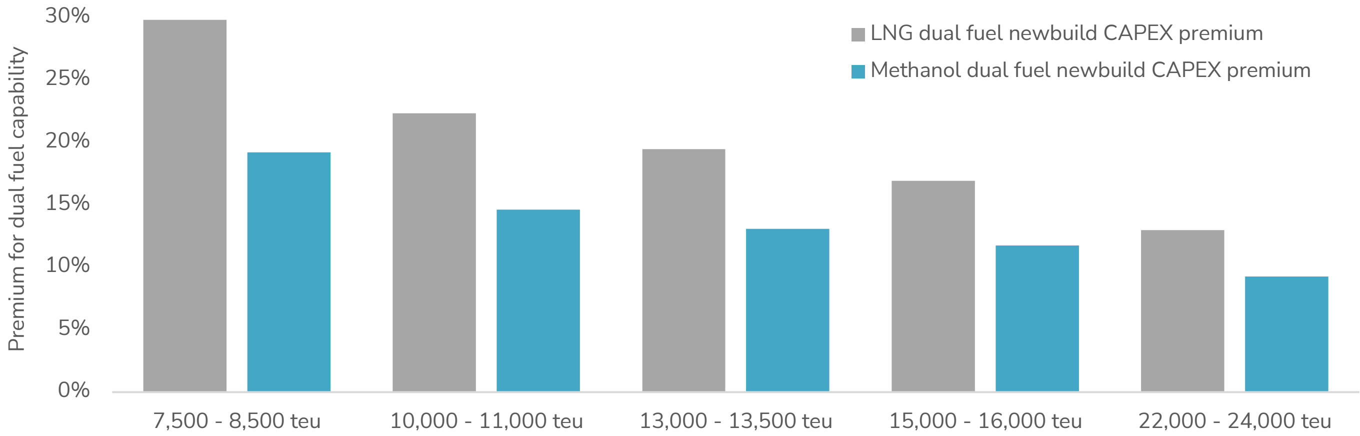
Figure 11: Investments at port could be facilitated by demand signals delivered through an offtake agreement



Dual fuel **ship** investments could be triggered by charters that balance premiums and risk sharing

A green shipping corridor will need ships capable of running on alternative fuels like e-ammonia and e-methanol. Early in the transition, such ships are likely to be built or retrofitted with dual fuel capability, granting the flexibility to continue to use conventional bunker fuels. The process of designing and installing a more complex engine and additional fuel storage means that dual fuel ships cost more than conventional versions. Shipowners may find it challenging to pass those higher capital costs on through the value chain, particularly for smaller ships where the premium is likely to be proportionally greater relative to cargo capacity.

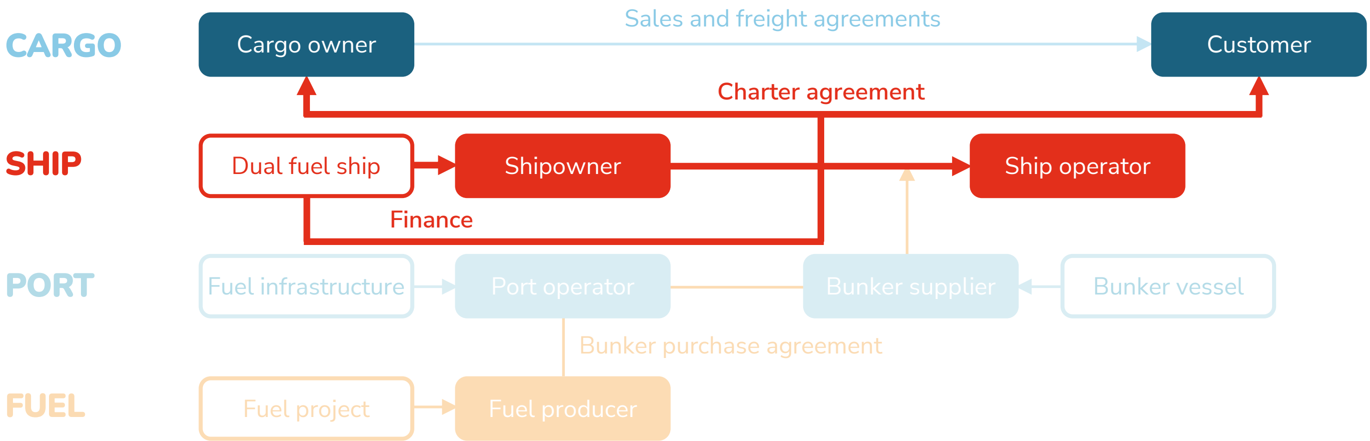
Figure 12: Newbuild cost premium for dual fuel capability over conventional container ship cost across different sizes



Source: *Clarksons SIN as of October 2024*

In value chains where the ship operator owns and operates the ship directly (as in the containership sector), it would endeavour to recover this additional capital outlay through normal business channels while allocating any willingness to pay for green shipping from customers. In value chains where the ship is chartered, the shipowner will seek to recoup at least a portion of the additional investment through the chartering agreement. The terms agreed between shipowner and charterer will be influenced by multiple factors and the charter agreement can, in turn, influence the type and terms of debt financing available to the shipowner.

Figure 13: A charter agreement can exist between a shipowner and a ship operator, cargo owner or customer



The charter premium agreed for dual fuel ships should reflect the trajectory of future regulation

A chartering strategy can serve a variety of goals. It may be driven by an ambition to profit from shipping market dynamics. Typically, the longer a charter period, the lower the charter rate (relative to current market levels) required to secure tonnage. In cyclical shipping markets, charterers aim to lock in tonnage for longer periods during low markets or preceding an anticipated tightening of the market.

Other factors can also drive a long-term chartering strategy. For example, a charterer may value certainty in shipping costs or tonnage availability, particularly if linked to a long-term sales agreement. Alternatively, the charterer may require specialised ships that a shipowner would only consider building against a long-term commitment or may seek to establish an ongoing partnership with a ship operator.

Whilst a long-term charter provides the charterer with certainty and reduces its exposure to shipping market risk, the obligation will sit on its balance sheet (as both an asset and a liability) and so could affect its ability to rise further debt. Therefore, even where there is an underlying long-term sales agreement in place, the duration of the charter may not match that of the sales agreement. Instead, charterers may negotiate extension options to retain future access to tonnage without an upfront commitment. Consequently, short-term charters do not necessarily reflect the absence of a long-term relationship between charterers, operators and shipowners.

The shipowner will also weigh the rate and duration of a charter against an outlook on the shipping markets. This assessment will consider what the ship might earn over the period if it was not committed to the charter, alongside a projection of the shipowner's position at the end of the charter (known as residual value exposure—an estimate of what the ship could be worth or what it could earn after the charter).

In a green shipping corridor project, a shipowner will seek to recover a portion of the cost of the dual fuel capability from the charterer via a premium that is set by the charter rate and period (a shorter charter will require a higher rate). This premium will be estimated based on 1) the additional investment required; 2) the type, terms and level of financing available (which may be enhanced by the charter); 3) the operational costs, risks and cash flows involved; and 4) the shipowner's outlook on how the dual fuel capability will affect residual value at the end of the charter.

The premium indicates the speed at which the shipowner aims to depreciate the capital cost of the dual fuel capability and the degree to which it accepts exposure on that investment at the end of the charter. If the shipowner is confident that this capability will continue fetch a premium over non-capable ships after the charter, then a combination of charter rate and duration that does not fully depreciate the higher capital outlay may be accepted. If the risk that the dual fuel capability will prove a disadvantage in future is deemed to be high, then full depreciation over the period of the charter may be sought.

However, when making this assessment, the shipowner should recognise that this risk could be mitigated by the diversity in fuel production pathways (such as the option to use blue ammonia as a bunker fuel). The residual position should also be compared against the alternative options to meeting future compliance and not simply against the current status quo.

Charter agreements can be leveraged to access wider sources of finance and better debt terms

In shipping, debt is primarily raised (and secured via a mortgage) against the ship once it is built (although pre-delivery finance can be used to help fund shipyard instalments). The type and terms of ship finance available depends on factors such as the type, age and value of the ship, as well as the credit quality of the shipowner. Counterparties with strong credit quality will have access to wider sources of finance and will benefit from a lower cost of debt. If the charter period of a ship is commensurate with the tenor of a loan, and if the credit quality of the charterer exceeds that of the shipowner, then better terms may be offered to the shipowner.

Traditional banks have historically been the most common source of finance to the shipping industry, with loans sometimes arranged in conjunction with concessionary lending and/or guarantees from Export Credit Agencies (ECAs), although this entails a sizeable upfront premium. More recently, new types of lenders have emerged, such as leasing houses and alternative debt providers offering asset-based finance.

In the shipping sectors where ships typically trade spot or with short-term charters, the leverage offered for a newbuild ship could range between 50%-60%, with a loan tenor of up to 7 years, after which the ship will need to be refinanced (thus introducing refinancing risk). If a long-term charter with a high-quality counterparty has been secured, then the leverage could be increased (for example, to 75%-85%). For large deals, tranches of ECA-backed and commercial lending can be layered to graduate and extend the repayment profile up to 12 years.

Lease finance can offer even higher leverage and over longer tenors. Whilst the cost of debt is typically higher than that offered by banks, the uniform repayment profile of a lease can be easier to manage in terms of cash flow. Shipowners also value any optionality that is offered by the lessor (such as purchase options). Alternative debt providers are prepared to offer finance to customers across a broader spectrum of credit quality, albeit at a higher cost. In addition to catering to smaller shipowners, these providers also offer refinancing solutions for older ships with maturing loans.

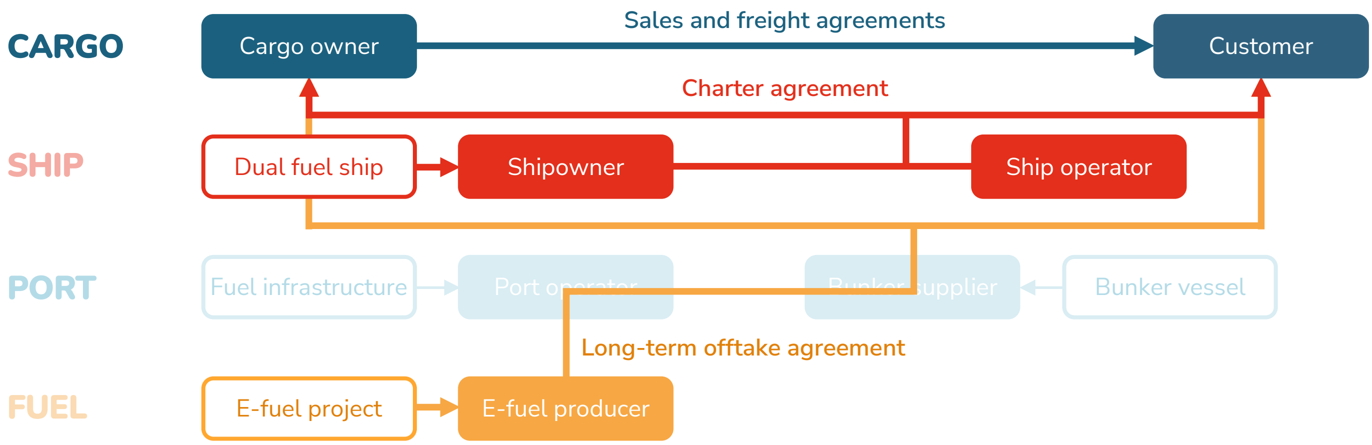
In a green shipping corridor, dual fuel ships could attract lower-cost sustainability-related finance. A charter agreement could also grant the shipowner access to wider sources of finance, higher leverage and more favourable terms. However, the loan amount will need to be balanced against the income generated by the charter as the cash flow required to service a larger loan, even at a lower cost of debt, may not be fully covered by the charter rate.

Long-term commitments across all the building blocks could cascade from the **cargo** agreement

A sales agreement that entails the transport of cargo from the seller to the buyer will define the terms under which this shipment will take place. These terms dictate which entity is responsible for the costs and risks associated with shipping (whether arranged directly between the two parties or via a third-party carrier) across each step of the logistics chain and the point at which ownership of the cargo (and thus responsibility for costs and risks) is transferred from the seller to the customer. In some value chains, the sales agreement can underpin the commitment required to form a green shipping corridor.

In value chains where either the cargo owner or customer is directly responsible for the charter of the ship and supply of bunker fuels (as in the dry bulk sector), one of these two parties could underwrite the long-term commitments required to secure dual fuel ships and e-fuel offtake and thus form a green shipping corridor. This decision could be made independently by either party or by mutual agreement—in which case, the sales agreement could form the principal commercial link from which these long-term commitments flow.

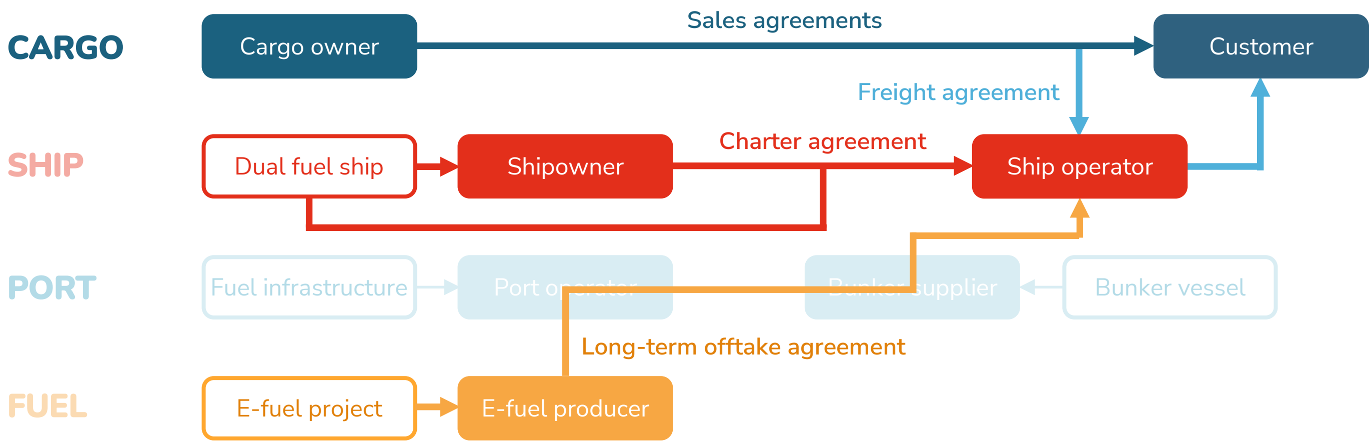
Figure 14: Long-term agreements could cascade from the commercial link between cargo owner and customer



A green shipping corridor could form around a long-term offtake agreement for the cargo, particularly if the customer is willing to pay a premium for a decarbonised supply chain. This may be more likely to occur where the cost of shipping is low relative to the value of the cargo, and so where higher costs could potentially be more easily absorbed.

If a third-party carrier is responsible for shipping, and particularly where the goods on board are aggregated from multiple owners and for multiple customers (as in the container sector), cargo owners and customers may be less involved in a green shipping corridor project. In this case, the ship operator may be the primary actor which underwrites the long-term offtake agreement for the e-fuel and, if the ship is not directly owned, the chartering agreement.

Figure 15: Ship operator may take role of underwriting long-term commitment across the value chain



Regulation and policy can help deliver the business case for corridors

The maritime industry stands at the cusp of profound change as governments and regulators assess and implement policies intended to reshape the energy and shipping landscapes. Actions taken at the national, regional and global level can support, but will ultimately oblige, maritime decarbonisation. Near-term measures can aid early mover projects, but the longer-term trajectory of regulation forms the backdrop against which today's investment decisions should be assessed.

Regulator and government policies can both compel and support maritime decarbonisation

Cost is the key challenge to maritime decarbonisation. The production of low and zero emission fuels, ships with dual fuel capability, and landside infrastructure—all these elements require investment, but all come at greater cost than the fossil fuel-based ecosystem currently in place. Voluntary action has been limited so far; the shift in business practices needed to materially reduce emissions across the sector will only be catalysed by regulation.

As a global industry with ships that sail across multiple jurisdictions, regulation can apply on a national, regional or international basis. The IMO, the industry's global regulator, revised its decarbonisation strategy in July 2023, setting clearer and more ambitious targets. The IMO's mid-term measures will not come into force until 2027, and although there is uncertainty over what form these will take, the ambition of the underlying trajectory is clear and so should inform the outlook against which today's investment decisions are framed. However, before the IMO's regulations come into effect, the maritime sector will face measures that have been introduced by the EU.

While regulation that obliges the shipping industry to reduce emissions delivers a blanket approach that maintains the level playing field under which the industry functions, supportive policies that help accelerate the adoption of specific fuels or technologies could be accessed by green shipping corridor projects. This support could be delivered through various channels, some of which may not directly target the shipping industry (for instance, subsidies for e-fuel production projects).

National governments or regional authorities may introduce supportive measures for a range of reasons—for example, to advance an industrial strategy, enhance energy security, or build competitive advantage in new technologies. Where governments view the maritime sector as strategically important (for example, shipbuilding and/or marine equipment manufacturing, or ports, or large domestic carriers), then targeted support measures may be developed. Otherwise, green shipping corridor projects may need to either take advantage of existing packages or lobby for specific support, with the former option likely to offer the faster route to execution.

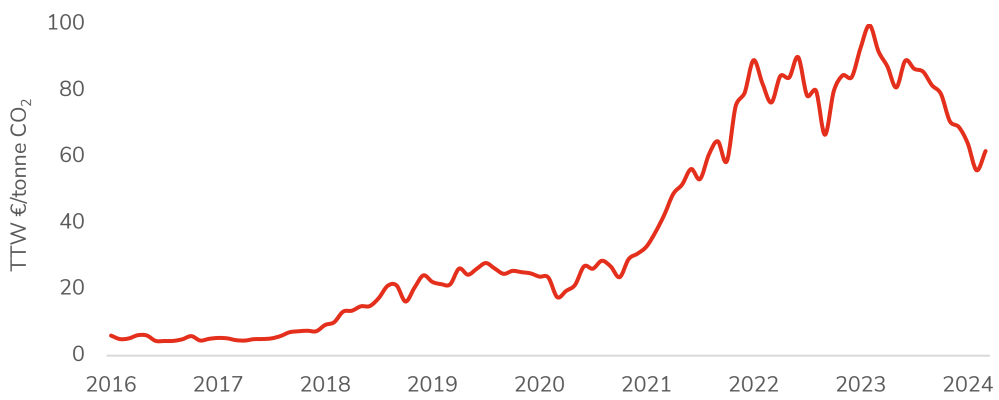
Regulation from the EU and the IMO may apply the same levers over different timeframes

As part of its 'Fit for 55' package, the EU has drawn the shipping industry into two measures—the Emissions Trading System (EU ETS)[14] and FuelEU Maritime (which obliges compliance with a fuel standard limiting the emissions intensity of the fuels used on EU voyages)[15]. These policies can have a direct and immediate impact on green shipping corridors that operate, even if only partially, within Europe. The IMO is currently finalising its mid-term measures and is also likely to combine technical and economic instruments. Once implemented in 2027, these measures will drive decarbonisation across all international shipping activity.

Shipping's first exposure to carbon pricing came in January 2024 with the industry's inclusion in the EU ETS

The EU ETS is a cap-and-trade scheme where the quantity of greenhouse gas emissions permitted each year is progressively reduced over time. EU ETS allowances (EUAs) for the right to pollute in a year are bought or traded at a price set by supply and demand in the market. The EU ETS was set up in 2005, but due to structural oversupply, the carbon price remained very low until 2018.

Figure 16: EU ETS allowance (EUA) futures price



Source: *ICE EUA Futures*

From January 2024 onwards, large (over 5,000 gross tonnes) cargo and passenger ships that sailed into, out from, or between EU or EEA (Norwegian and Icelandic) ports will have been captured within the EU ETS. All emissions from voyages between and whilst at EU/EEA ports and 50% of emissions from voyages that either start or end at EU/EEA ports are included. There is a phase-in period in 2024 and 2025 where 40% and 70% of emissions will be liable; this rises to 100% in 2026. The scheme is currently based on tank-to-wake (TTW) carbon dioxide emissions, but by 2026, other greenhouse gases (methane and nitrous oxide) will be included. Options to extend the scheme to cover different sectors, smaller ships, and well-to-tank (WTT) emissions, are being considered.

The EU ETS will raise the cost of shipping for the compliance-based scenarios that the green shipping corridor is compared against, which reduces the incremental cost of shipping using zero emission fuels. In this analysis. the EUA price is assumed to rise linearly to $300/tonne (approx. €280/tonne) by 2050.

[14] European Commission: Inclusion of Maritime Emissions in the EU ETS

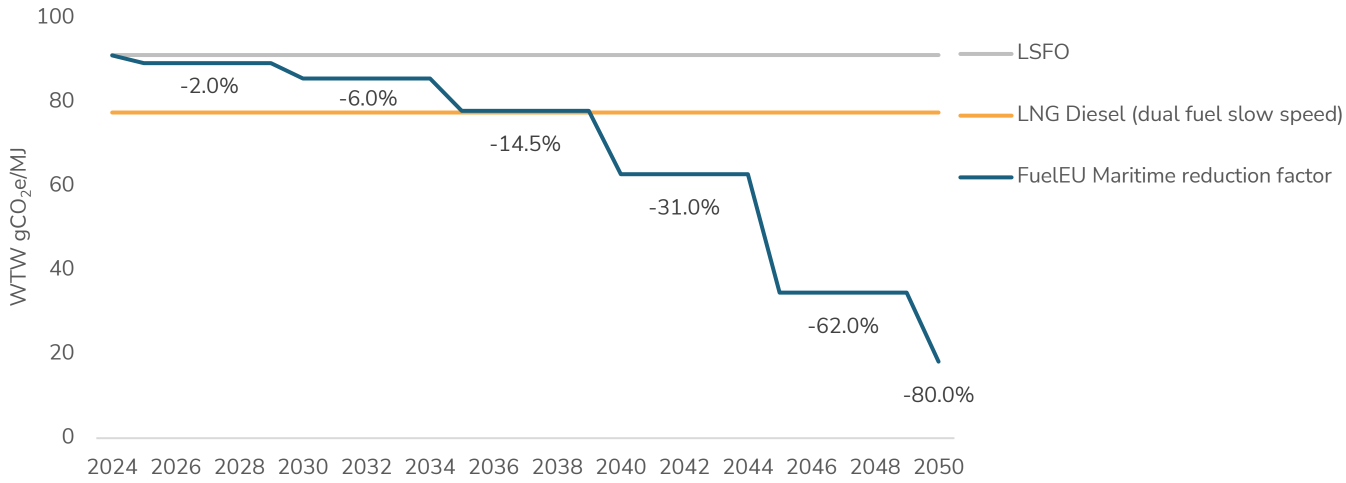
[15] European Commission: Decarbonising Maritime Transport – FuelEU Maritime

Responsibility for submission of the EUAs sit with the shipowner and so, for ships under charter, the EU ETS will be tiggering a widespread redrafting of contractual agreements between stakeholders to ensure that the cost of allowances is passed through the value chain. Charterers may pay the shipowner in cash or EUAs, but if the former, then the shipowner may choose to take on exposure to price risk as the window to submit allowances is up to 21 months. Therefore, in addition to the cost burden, the EU ETS is obliging shipowners, operators and charterers to become familiar with the costs, risks and processes involved in a carbon price regime.

FuelEU Maritime will come into effect from the start of 2025 and will be the industry's first exposure to a fuel standard

FuelEU Maritime is the second major measure introduced by the EU and will come into effect from the start of 2025. The regulation aims to promote the use of low and zero emission fuels through a fuel standard and encourage the use of on-shore power by ships at berth in EU/EEA ports. The fuel standard limits the emissions intensity of the energy used on board a ship arriving at, staying, or departing from an EU/EEA port. This is applied in the same proportions as the EU ETS; however, it is assessed on a well-to-wake (WTW) basis from the outset. There is a stepped reduction in the target level set with each stage spanning a five-year period.

Figure 17: Target emissions intensity from FuelEU Maritime compared with LSFO and LNG WTW figures



Source: *European Parliament – Regulation on the use of renewable and low-carbon fuels in maritime transport*

Compliance with FuelEU Maritime can be achieved on an individual ship basis by using sufficient volumes of low or zero emission fuels (or by adding wind power technologies) to reach the target emissions intensity. Alternatively, compliance can be attained via a pooling mechanism. This allows for overcompliance by one ship to offset undercompliance by other ships. This flexibility mechanism also allows for overcompliance to be banked and claimed in a subsequent period, and limited borrowing of future overcompliance is also permitted.

Pooling can drive ambitious efforts focused on fully decarbonising a single ship using dual fuel capability and zero emission fuels, rather than simply encouraging minimum compliance through the incremental use of blended biofuels. Credits for overcompliance can be shared within a single shipowner or ship operator's fleet, or across wider pools of ships at an agreed price. Therefore, the flexibility mechanism could offer these entities an opportunity to monetise overcompliance. However, the price that credits could fetch would be determined by the lowest cost solution to achieving compliance across the market.

During the initial phase of the policy when the target emissions intensity reduction is 2%, the price of overcompliance credits could be set by the price of blended biofuels or LNG (with a margin to account for the capital cost of dual fuel capability). As FuelEU Maritime's target reduction rises to 6% in 2030, annual demand for biofuel blends in Europe could increase to 6 million tonnes if other low emission fuels are not utilised[16]. If the supply of biofuel does not keep pace with this demand, the price for the biofuel portion of blended fuels could be driven towards FuelEU Maritime's noncompliance penalty (€2,400 or approx. $2,600 per tonne of LSFO equivalent).

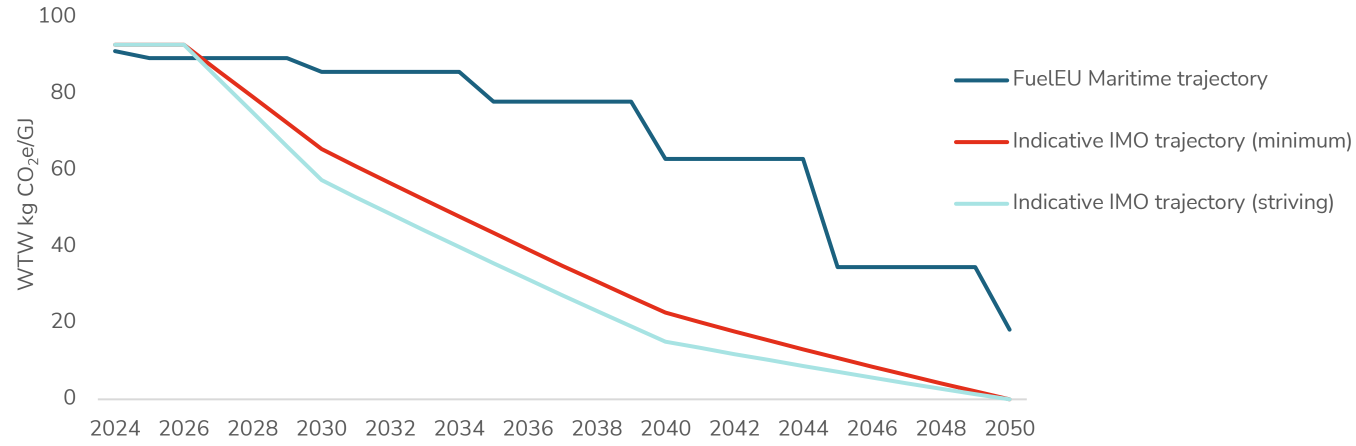
FuelEU Maritime may encourage the entities in the maritime value chain to consider more strategically how they will manage their fleet and fuels during the transition. It could also offer green shipping corridor participants an opportunity to generate revenue by selling overcompliance credits and thus reduce the cost gap compared to compliance scenarios. This analysis assumes that the EU's fuel standard will be superseded by a more stringent policy from the IMO, but FuelEU Maritime does influence the underlying assumption that demand for biofuels will exceed supply. From 2030 onwards, the global price of biodiesel has been set at FuelEU Maritime's penalty cost and the price of other fuels from biogenic sources have been set to match this on a cost of abatement basis.

IMO has signalled its ambition and its mid-term measures introduced in 2027 will likely involve a global fuel standard

The revised 2023 IMO GHG Strategy set a net zero target at or around 2050 and introduced indicative checkpoints for 2030 (reduce absolute emissions by at least 20%, striving for 30%, compared to 2008) and for 2040 (reduce absolute emissions by at least 70%, striving for 80%, compared to 2008). An aligned ambition was also stated: a minimum 5% (striving for 10%) uptake of low or zero emission fuels or energy sources by 2030[17].

The IMO is yet to finalise the basket of mid-term measures that will deliver these targets, but the adoption of a global fuel standard seems a near certainty at this stage. An economic measure (such as a levy on shipping emissions) is supported by a clear majority of Member States, but is still being debated. For this analysis, a global fuel standard trajectory which delivers the IMO's minimum 2030 and 2040 targets has been estimated and used to set the minimum level of compliance that will be required between 2027 and 2050.

Figure 18: Comparison of FuelEU Maritime versus indicative IMO global fuel standard targets



Note: *Estimate of 2008 WTW absolute emissions and projections of future energy demand based on IMO 3rd and 4th GHG Studies.*

[16] Based on 2022 EU MRV data; assumes 2022 levels of overcompliance is pooled and that blended biofuel ratio is 70% fossil fuel; 30% biofuel

[17] IMO: 2023 Revised Strategy on the Reduction of GHG Emissions from Ships

While there is current uncertainty over the types of the measures that the IMO will introduce, the overall ambition of the targets, and the decarbonisation trajectory these imply, should be factored into all near-term investment decisions around infrastructure and long-lived assets when assessing residual value exposure. Similarly, the business case for a green shipping corridor should be evaluated against a baseline which involves a minimum level of compliance with future regulation.

Current and emerging support measures could be leveraged in green shipping corridor projects

National governments or regional authorities have been putting packages of support in place for projects producing and utilising low and zero emission fuels and (less commonly) building ships capable of running on these fuels. Measures that aim to narrow the gap between fossil fuels and lower emission alternatives have been introduced across the world. Many are structured to subsidise, in various ways, the cost of producing these fuels. The need for demand-side support to encourage uptake has also been recognised, and measures are being considered. At a smaller scale, there are some packages of support being offered to help shipowners cover the capital cost associated with switching to alternative fuels[18].

The United States has delivered the world's most ambitious supply-side support package for clean hydrogen production

The US Inflation Reduction Act (IRA), signed in 2022, intends to direct almost $400 billion in federal funding towards clean energy projects this decade[19]. The level of support aimed at hydrogen projects makes this the world's most ambitious subsidy scheme to date. Support will be delivered primarily through corporate tax credits and its impact in the case studies has been modelled on the basis that the IRA will be implemented as originally conceived and will not be modified significantly by subsequent administrations.

Projects that produce hydrogen from electrolysis powered by renewable energy will be offered the most favourable credits. The tax credits can be applied to either the upfront capital investment in the project or the ongoing production of hydrogen, but not both. Which tax credit works out better depends on the capital cost of the project and the capacity factor of the renewable energy generation[20]. For most projects, the production tax credit delivers a greater benefit and equates to a subsidy of $3 per kilogram of hydrogen produced via electrolysis, which in turn, reduces the cost of derived e-fuels. Tax credits can be claimed by projects that begin construction before the end of 2032 and will be made available over a 10-year period. When levelised over a 30-year project lifespan, the subsidy will be approximately $18/GJ for e-ammonia and $20/GJ for e-methanol.

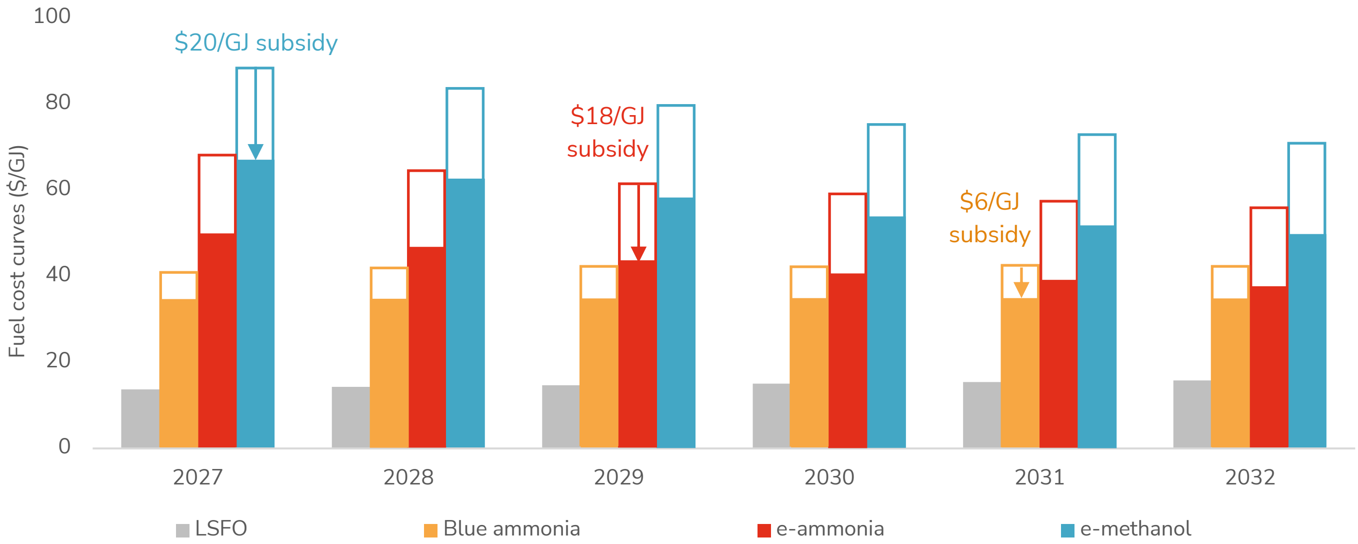
The US IRA also offers subsidies to blue ammonia production, applied to the CCS phase. These tax credits are less generous than those offered to projects producing hydrogen from renewable energy, reducing the cost of CCS by $85 per tonne of permanently sequestered carbon dioxide, but they are available for over 12-year period. This equates to a production subsidy for blue ammonia of roughly $6/GJ when levelised over a 30-year project lifespan.

[18] GMF: Insight Brief - National and Regional Policy for Green Shipping Corridors

[19] McKinsey: Update on the Inflation Reduction Act

[20] RFF: Incentives for Clean Hydrogen Production in the Inflation Reduction Act

Figure 19: Fuel cost projections with impact of US IRA tax credits on blue ammonia, e-ammonia and e-methanol costs



Note: *US IRA subsidies levelised over an assumed 30-year life from production facilities and using a discount factor of 8%*

Both of these subsidy schemes can affect green shipping corridor projects. The generous support available for hydrogen produced from renewable energy means that US-based e-fuel production will have an advantage over other projects in many parts of the world. Any corridor project which secures e-fuel offtake from a US producer receiving tax credits will benefit from lower e-fuel costs.

On the other hand, the CCS subsidies may lower blue ammonia production costs to the point where this fuel could displace other low-cost compliance options, such as biofuels (particularly post-2030) and LNG. The latter will be unsubsidised but will have correlated input costs to blue ammonia given both fuels use natural gas as a feedstock. Therefore, the US IRA subsidy of blue ammonia may factor into the cost of minimum compliance which functions as the basis of comparison for a green shipping corridor business case.

Demand-side support that complements fuel production subsidies can overcome cost and commitment hurdles

Schemes like the US IRA's production tax credits offer supply-side support—by subsidising the producers of hydrogen from renewable energy, the cost of low and zero emission fuels is reduced. However, this may not be sufficient to stimulate demand for these fuels, particularly if the subsidised cost still exceeds the level to which production costs are expected to fall over the period of an offtake agreement.

To encourage uptake, governments have been considering what types of demand-side measures could be offered. To complement its supply-side subsidies, the US has launched a Regional Clean Hydrogen Hubs program to deliver $7 billion in funding across seven regions to promote the uptake of hydrogen and its derivatives. Hubs in locations such as the US Gulf Coast, California, and the Pacific Northwest could promote investment in fuel distribution and infrastructure at ports, and could potentially support e-fuel offtake by domestic ship operators[21].

[21] US Department of Energy: Regional Clean Hydrogen Hubs Selections for Award Negotiations

Support schemes can take various forms and can be implemented in different ways. Some offer a fixed level of subsidy; others are structured to dynamically bridge some or all of the cost gap between a fossil fuel derived commodity and a low or zero emission alternative. Contracts for Difference (CfDs) are an example of the latter. These instruments can cover the difference in cost between an offtake agreement and the price of the fossil fuel commodity that the offtake is replacing.

For instance, a CfD that covers an e-ammonia offtake agreement could provide a subsidy so that the net cost to the offtaker is equivalent to the market price for fossil fuel derived ammonia. The offtaker will retain exposure to fossil fuel price volatility, but this will be in line with the wider market. From the offtaker's point of view, a CfD minimises the commercial risk associated with switching to lower emission, higher cost fuels and commodities, it allows the offtaker to remain competitive against its peers and enables it to sell products to its own customers without inflating prices.

In addition to addressing the cost gap between fossil fuels and low and zero emission alternatives, demand-side support can also assist companies that are unable or unwilling to commit to long-term offtake agreements. For instance, the government could step into the role of offtaker, and then resell subsidised volumes over shorter periods to customers through a competitive process like an auction. This approach can overcome the challenge associated with locking in a high-price offtake over the long term as production costs continue to fall.

Grants and soft loans can support decarbonisation-related capital investment in ships and at ports

National governments and regional authorities have also introduced measures that support R&D and investment linked to new technologies in the maritime industry. In recompense for shipping's inclusion in the EU ETS, the Europe Union is allocating 20 million EUAs to its Innovation Fund until 2030 to support the sector through capital grants in technologies such as energy efficiency, electrification, and zero-emission propulsion. The scheme will also support investment in landside infrastructure[22].

Governments have also taken steps to decarbonise domestic shipping. For example, Norway drove a large-scale switch to electrification in its domestic ferry fleet with a combination of its public procurement process and by using its innovation funding agency (Enova) to support investment in battery-electric systems and shore side infrastructure[23]. Enova also offers Norwegian shipowners funding for investment in ships that will utilise hydrogen or ammonia[24]. Other countries, such as Germany and the Netherlands, also offer grants to support the construction of zero emission ships. While nations with large shipbuilding sectors, such as South Korea and Japan, are supporting those sectors to deliver zero emission ships[25].

A shipowner or port involved in a green shipping corridor may be able to access funding for capital investment if the project aligns with the broader interests of one of the countries involved, such as support for domestic shipbuilding or a national carrier. Alternatively, if there is bilateral agreement between two nations to form a green shipping corridor, a package of measures that includes specific support for ship and/or port investments can be agreed by both governments.

[22] European Commission: Launch of the Innovation Fund 2023 Call for Projects

[23] Enova: Battery in zero emission ships

[24] Enova: Support services for maritime transport

[25] GMF: Insight Brief - National and Regional Policy for Green Shipping Corridors

Gas carriers: Building a green shipping corridor around a cargo

This case study examines how an emergent trade in e-ammonia could form a relatively simple value chain where elements supportive of a green shipping corridor are already in place. The commitment to establish a corridor could then be driven by opportunities to leverage supply and/or demand-side support directed at the cargo rather than the shipping industry.

E-ammonia trade projected to grow as existing users of ammonia decarbonise supply chains

Ammonia is a vital global commodity. Of the circa 180 million tonnes produced each year, 70%-85% is directed towards the manufacture of nitrogen fertilisers, with the remainder absorbed by heavy industry and chemical sector[26]. Ammonia is widely produced and less than 10% (15-16 million tonnes) is currently shipped around the world on gas carriers[27].

The production of ammonia is emissions intensive—a function of both the energy required to run the high pressure, high temperature process and the hydrogen feedstock used, which is derived from fossil fuels (either natural gas or coal). To cut ammonia's carbon footprint, both inputs must be tackled. Renewable electricity can reduce emissions during production, however, low and zero emission sources of hydrogen are also needed, either from the addition of CCS to existing fossil fuel-based supplies (blue ammonia) or from facilities that produce hydrogen via electrolysis using renewable energy (e-ammonia).

In the coming decades, as new supplies of low and zero emission ammonia replace current production streams, aggregate demand for the commodity is expected to grow, spurred by existing customers, new applications in industries such as marine fuels and power generation, and potentially as a method for transporting hydrogen. The production of e-ammonia will congregate around locations with high renewable energy resources and early projects are likely to be export-oriented, targeting customers who are either willing, obliged, or subsidised to purchase cleaner forms of ammonia. As a result, an increasing proportion of the ammonia produced (which will also be growing) would require shipping.

The degree and timing of this growth is uncertain, but over the near term, the higher cost of deriving ammonia from electrolysis compared with fossil fuels means that either direct support or regulation will be needed to ensure its adoption. The ships that will carry this commodity could also be fuelled by it; therefore, any support directed towards the cargo might also enable a green shipping corridor to form around the emergent trade in e-ammonia.

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[26] IRENA: Innovation Outlook – Renewable Ammonia

[27] Clarksons SIN: World Seaborne Ammonia Trade

Elements supportive of green shipping corridors will already be in place within the value chain

The value chain that will form around the shipping of e-ammonia cargoes will be underpinned by the offtake agreement between the cargo owner (the e-ammonia producer) and customer (the offtaker). These two entities will be the principal actors that will then sit at opposing ends of a relatively simple value chain and the offtake agreement will support the discrete components of investment required along that chain, i.e. the e-ammonia production facility, port infrastructure and ship capacity.

Table 1: Points of investment and cost passthrough mechanisms along the e-ammonia export value chain

Investment	Cost passthrough mechanisms
E-ammonia production facility	For an e-ammonia producer to raise project finance, it will need to sell a significant portion of its production volumes through offtake agreements with customers of high credit quality. The pricing mechanism will need to align with the risk tolerance of the project (and so may be influenced by any supply-side support measures in place), but will be either fixed or linked (either wholly or in part) to a variable reference such as the price of fossil fuel ammonia or its feedstock (most commonly natural gas), or an input into the e-ammonia process (such as electricity prices), or based on some other bilaterally agreed benchmark (for example, an inflation index).
Storage infrastructure at port	If the e-ammonia cargoes replace existing ammonia trade, then investment in onshore transport (plant to port) and storage (at port) infrastructure may be reduced or eliminated. Where new infrastructure is required, the investment may be made by the e-ammonia producer directly, or by the port owner/operator or a midstream intermediary—in which case some form of contractual or leasing agreement would be established. Similar arrangements may extend to the landside infrastructure on the importer's side, which may be funded directly or indirectly by the customer.
Gas carrier capacity	The cargo owner or customer will charter gas carriers, either directly with a shipowner or via an intermediary ship operator. The duration of the charter will depend on the chartering strategy adopted by the counterparty. If this is the customer, it may choose to lock in ships for the entirety of its offtake agreement, particularly if it is not already a buyer of ammonia. If the cargo owner is the charterer, it may elect to take exposure to shipping market risk. The charterer will also be responsible for fuel costs and must develop a bunkering strategy to meet (as a minimum) future compliance.

This value chain already has some of the key elements required for a green shipping corridor—access to e-ammonia and the associated supply and storage infrastructure is delivered through the offtake agreement. A further advantage over other green shipping corridors is that separate ammonia bunkering infrastructure (such as a bunker vessel) will not be needed. Only two additional commitments would be required:

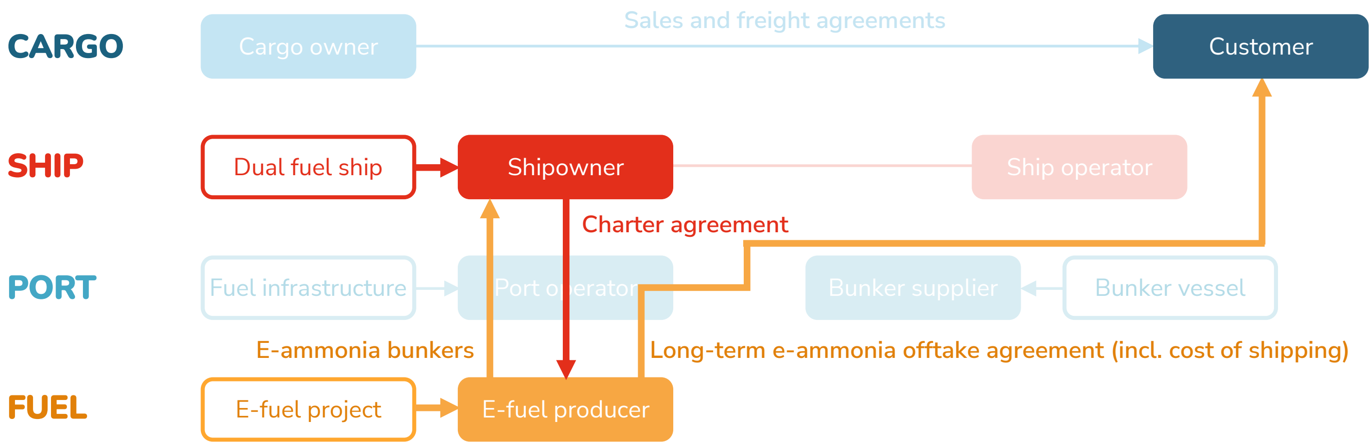
1. A chartering strategy that secures ships with dual fuel ammonia capability
2. A bunkering strategy that uses e-ammonia as fuel

The second commitment is contingent on the first, but the decision to charter a dual fuel gas carrier could also be driven by a strategy that intends to meet future compliance with a global fuel standard through the use of either e-ammonia or blue ammonia. A green shipping corridor would aim to use e-ammonia as a bunker fuel in greater volume than dictated by compliance, but the marginal cost associated with this—arising from the charter premium and the additional cost of e-ammonia bunkers—should be assessed against alternative pathways to achieving compliance.

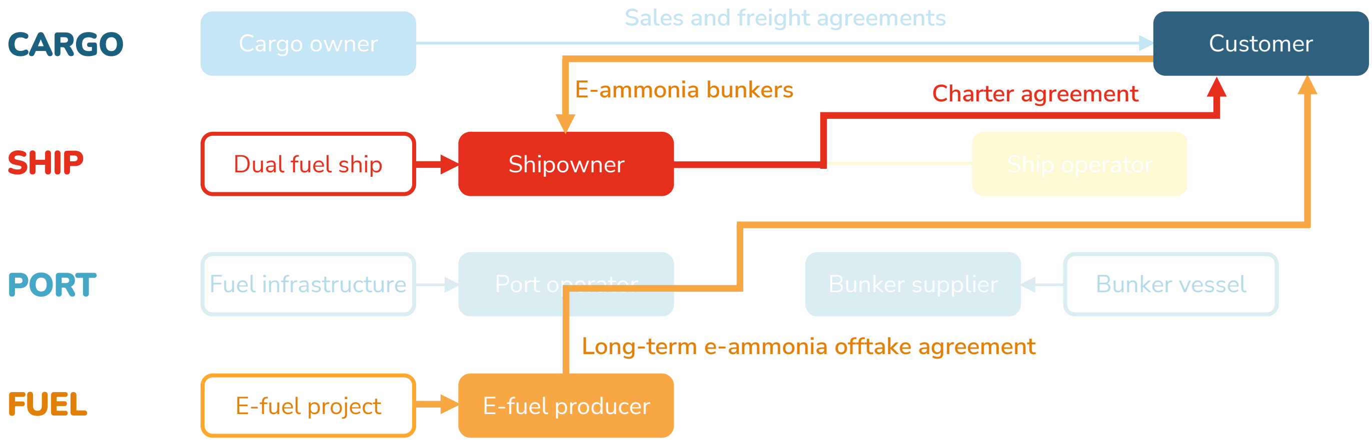
The strategy to meet, or the ambition to exceed, compliance could be driven by different motivations depending on which entity is charterer. Two green shipping corridor value chains have been defined to illustrate this. In the first, the e-ammonia producer adopts the role of charterer and so incorporates the cost of shipping into its offtake agreement. In the second, the customer acts as charterer and so directly pays the charter and bunker costs. For simplicity, both value chains reflect a direct relationship with the shipowner rather than via an intermediary ship operator.

Figure 20: Commercial agreements in the two scenarios of the gas carrier green shipping corridor value chain

Value chain 1: *E-ammonia producer charters dual fuel gas carrier and uses the e-ammonia it produces as bunkers*



Value chain 2: *Customer charters dual fuel gas carrier and directs portion of its offtake for use as fuel*



These scenarios are used to illustrate how different motivations, business cases and (potentially) channels of support could determine the basis on which a corridor is formed. In reality, the decision to establish a green shipping corridor will proceed with the assent of both the key actors and a degree of cost sharing may be agreed between them beforehand. However, within these binary value chains, the discrete drivers of investments and commitments can be assessed independently.

In the first value chain, the e-ammonia producer has autonomy over fuel choice. It charters a dual fuel gas carrier and uses its e-ammonia as bunkers, passing to the customer through the offtake agreement a cost of shipping that reflects a minimum level of compliance plus any additional willingness from that customer to pay for green shipping.

In the second value chain, the customer pays the charter rate premium for dual fuel capability and directs a portion of the e-ammonia volumes it has purchased to use as bunkers. One critical difference between the two value chains is the cost of the e-ammonia used to fuel the ship. In the first value chain, the e-ammonia producer would ascribe an internal cost for this fuel that would lie between the cost of production and the opportunity cost of forgone sales, depending on demand for offtake and other potential routes to market for its volumes. In the second value chain, the customer will sacrifice some of its cargo for use as bunker fuel and so the cost will be set by the price of offtake.

Dynamics of gas carrier market may offer option of a short or long-term chartering strategy

The chartering strategy adopted by the charterer (whether e-ammonia producer or customer) will focus on securing suitable tonnage, but the length of the commitment will depend on multiple factors. Long-term charters may be sought if the pool of ammonia carriers is small, if future tightness in the sector is anticipated, if certainty over shipping costs is important (for example, if the offtake agreement involves fixed pricing), or if the charterer wishes to establish a longstanding partnership with a gas carrier operator.

If the overall demand for ammonia increases as expected, additional capacity in the fleet will be needed. If the charterer has a long-term chartering strategy, the criteria for dual fuel capability may be added to a newbuild ship order with a minimum premium in the charter rate. However, even if the charterer wishes to engage tonnage over a shorter period than the length of the offtake agreement, the dynamics of the gas shipping market may provide shipowners with sufficient confidence to accept a degree of residual value exposure on the dual fuel element, particularly in light of tightening regulation.

A shorter-term chartering strategy could be enabled by the positive sentiment currently seen in the gas shipping market

The gas carrier sector can be split into two segments: a fleet of approximately 750 LNG carriers (large, specialised ships that carry liquified methane at very low temperatures) and a fleet of over 1,700 smaller gas carriers that transport a range of cargoes (mainly LPG, but also gases such as ethane, ethylene, and ammonia)[28]. The commercial traits of these two segments differ—a reflection of the dynamics in the underlying commodity markets. An emergent trade in e-ammonia could exhibit characteristics that are seen in both segments.

The LNG market was established in the 1980s through long-term sales agreements (at a price indexed to crude oil) between producers and state-backed utilities. This enabled the former to secure low-cost, high-leverage, long-tenor financing for expensive liquefaction projects and ensured security of supply for the latter. Specialised ships were needed to transport the LNG, and so long-term charters (though not necessarily equivalent to the duration of the offtake) were signed with shipowners off the back of these offtake agreements.

Over the last 15 years, a spot and short-term market for LNG cargoes has slowly developed and now accounts for 35%-40% of total LNG trade[29]. Increasing storage capacity, diversity of supply, and flexibility in contract terms enabled liquidity in gas markets to grow, alternative pricing mechanisms to emerge and intermediaries (energy companies and traders) to step in and buy long-term offtake to then sell into the market over shorter periods.

[28] Clarksons SIN: Gas carrier fleet vessel data

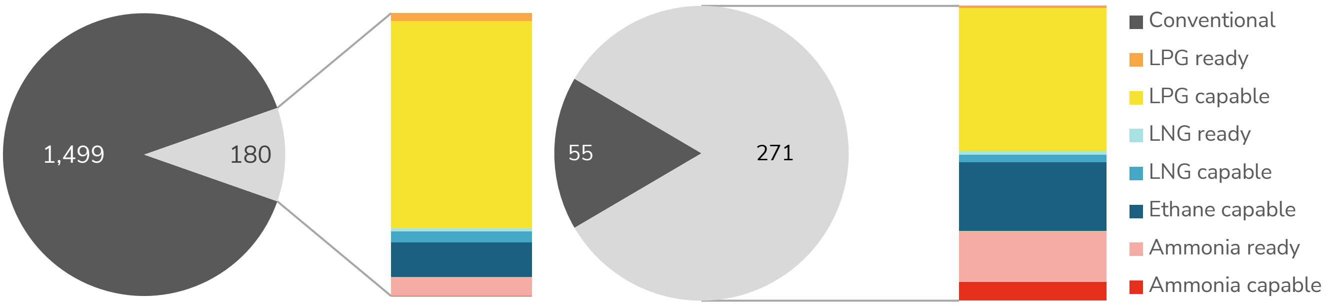
[29] GIIGNL: 2023 Annual Report

Similarly, as the size of the LNG fleet grew, and as older ships came off their original long-term charters, there was downward pressure on the length of charters and shorter fixtures became more common. Shipowners were obliged to incorporate increasing levels of market (in lieu of credit quality) risk into their investment decisions and charterers were correspondingly exposed to shipping market risk.

During its initial phase, the market for e-ammonia is likely to develop along similar lines to that of LNG. Producers will need to secure long-term offtake agreements with creditworthy counterparties to unlock the project financing required to build the renewable energy capacity, production facilities, and distribution and storage infrastructure. However, the market for e-ammonia shipping will be influenced by the dynamics found in the general gas carrier market which, like its underlying commodity market, is far more liquid. Trade and charter agreements range in duration, but the multitude and interoperability of ships across a variety of cargo types means that short-term fixtures are common, whether direct from shipowners or sublet by operators.

These gas carriers can be built to use their cargo as fuel and the segment has taken an unsurprising lead in ordering ships with dual fuel capability. Between 2021 and 2023, approximately half of the 200 or so ships delivered were built to run on alternative fuels[30]. Most were LPG capable, but some specialised ethane carriers were built to run on that cargo too. The current orderbook indicates an escalation of that trend with almost 80% of gas carriers being built with dual fuel capability or 'readiness' (building a ship that will be easier to retrofit to full capability in future). This includes nine mid-sized ammonia dual fuel gas carriers.

Figure 21: Dual fuel readiness and capability of (non-LNG) gas carrier fleet (left) and orderbook (right)



Source: *Clarksons SIN as of October 2024 for gas carrier fleet and orderbook of ships over 100 cbm.*

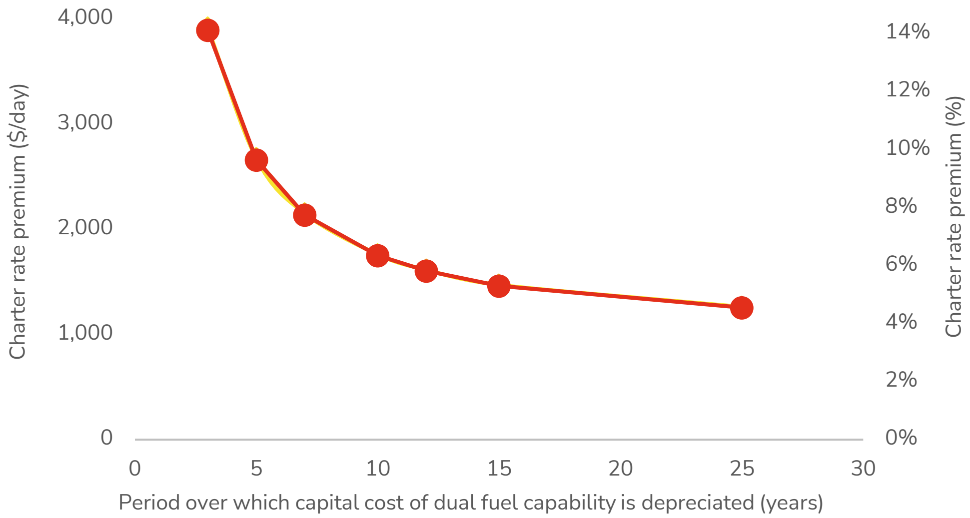
There has also been an uptick in orders for large gas carriers capable of transporting LPG or ammonia, possibly indicating a degree of speculative ordering based on the expectation that larger and longer distance ammonia trades will materialise. This reinforces the positive sentiment in the market.

The activity seen in the gas carrier market indicates that the shipowner may be willing to take residual value exposure on a newbuild gas carrier. This flexibility over the charter period would give the charterer the option of taking a degree of shipping market risk by not matching the duration of the charter with that of the e-ammonia offtake agreement. If the ship is built with dual fuel capability, the shipowner may be more cautious about residual value exposure.

[30] Shipping Intelligence Network (clarksons.net)

However, given the tendency of the sector to utilise lower emission cargoes as fuel and the potential for future trade in blue ammonia as well as e-ammonia, shipowners may feel more comfortable with residual value exposure and accept a premium that does not fully depreciate the capital cost associated with the dual fuel element over the charter period (for example, accepting a premium that reflects depreciation over 15 years on a 7 year charter).

Figure 22: Charter premium from fully depreciating the capital cost of dual fuel capability over a range of timescales



Note: *Modelled on publicly reported newbuild costs for 45,000 cbm dual fuel ammonia gas carrier using a discount rate of 8%.*
Source: *Clarksons SIN*

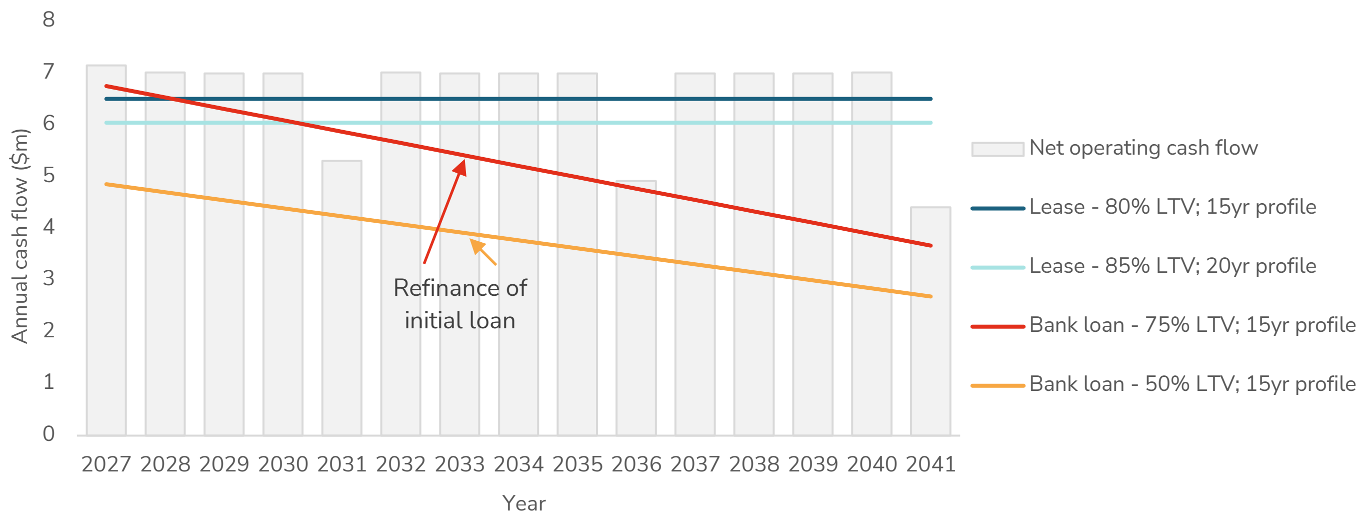
Shipowner could access higher leverage and more favourable financing terms with a longer-term chartering strategy

A shipowner may agree to a charter shorter than the length of the e-ammonia offtake agreement; however, the minimum charter period acceptable to the shipowner may also be influenced by the finance terms that lenders offer. A typical loan for a newbuild ship offered by a traditional bank would be along the lines of a 7-year tenor with a 15-year profile—i.e. for a $15m loan, $7m would be repaid over seven years (plus interest), and a balloon of $8m would need to be refinanced at the end of year 7. Without a charter secured over the 7-year loan tenor, the leverage (loan-to-value or LTV) offered would be low and the cost of debt contingent on the shipowner's credit quality.

If the ship is employed under longer-term charter, and particularly if the credit quality of the charterer exceeds that of the shipowner, wider sources of finance under more favourable terms could be available (although this may be contingent on the charterer offering a corporate guarantee). Traditional banks might be willing to offer a lower cost of debt and greater leverage (for example, increasing from 50% to 75%), albeit with the same amortisation profile.

Lease finance could also be accessed with the backing of a long-term charter. The tenor and (potentially) the amortisation profile of a lease could be longer the terms offered by banks, but the cost of debt will be higher. Lease finance can also offer greater leverage than bank facilities and the fixed lease payments make debt servicing easier to balance against the net operating cash flow of the ship. Lease finance can also offer far more flexibility than traditional banks. A lease can be structured with options for shipowners to repurchase the ship at a predefined price at set intervals (typically towards the end of lease period).

Figure 23: Indicative debt service (principal and interest) for bank loans and lease finance and net operating cash flows



***Note:** It is assumed that the bank loan has a 1% arrangement fee, 250 bps spread over a 15-year 1-month SOFR swap rate of 4.07%; the lease has 2% arrangement fee and 8% implicit interest rate. Net operating cash flow calculated on the basis of dual fuel capability depreciated over 15 years. Other assumptions are detailed in the Appendix.*

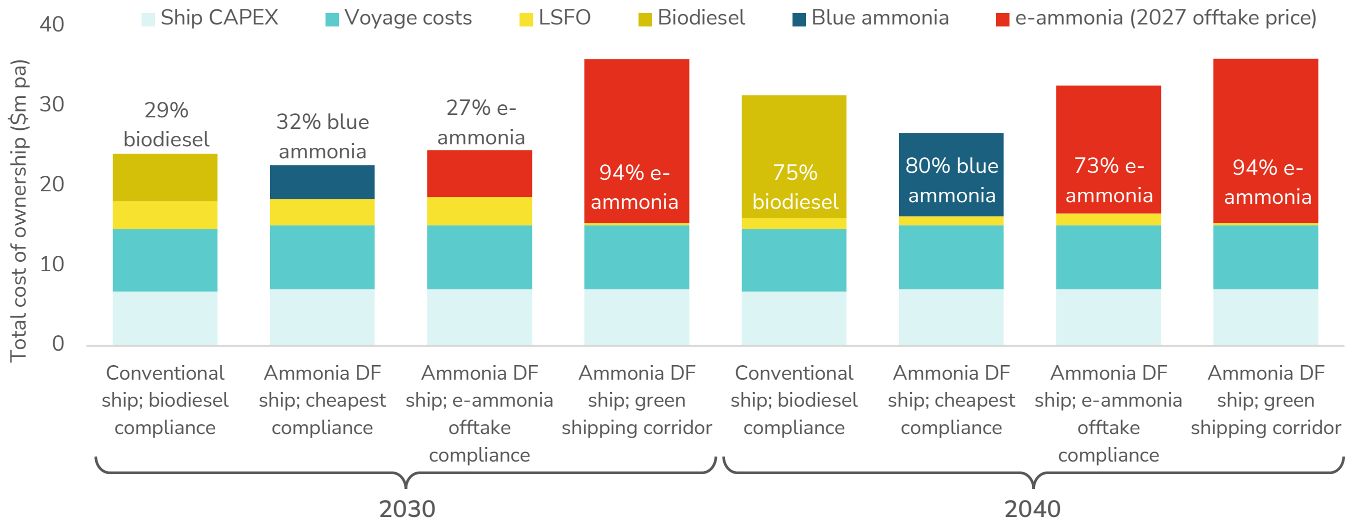
Comparing the cost of a green shipping corridor to alternate approaches for attaining compliance

The TCO calculation for a green shipping corridor combines the charter rate (which reflects the capital cost of the underlying ship as well as the dual fuel capability, plus ship-related voyage expenses such as crew costs), other voyage costs such as port and canal transit fees, and the cost of using the e-ammonia cargo as fuel. This aggregate cost is compared to three TCO calculations that deliver compliance with a global fuel standard through different approaches. The TCO scenarios modelled are:

1. **Conventional ship; biodiesel compliance:** A conventional gas carrier running on biodiesel blends to meet compliance.
2. **Ammonia dual fuel ship; cheapest compliance:** A dual fuel ammonia gas carrier which runs on the lowest cost fuel mix (from a choice of LSFO, biodiesel, blue ammonia and e-ammonia) to meet compliance.
3. **Ammonia dual fuel ship; e-ammonia offtake compliance:** A dual fuel ammonia gas carrier which runs on just enough e-ammonia cargo to meet compliance.
4. **Ammonia dual fuel ship; green shipping corridor:** A dual fuel ammonia gas carrier which runs entirely (less pilot fuel) on the e-ammonia cargo.

The second option uses an e-ammonia price that reflects expected falls in the cost curve over time; the third and fourth options use 2027 e-ammonia production costs to reflect a locked-in production cost for the exporter. The components of the TCO calculations highlight that the variance between the four options is overwhelmingly driven by the fuel cost. However, the difference between them does fall over time as compliance obliges greater volumes of low and zero emission fuels to be used.

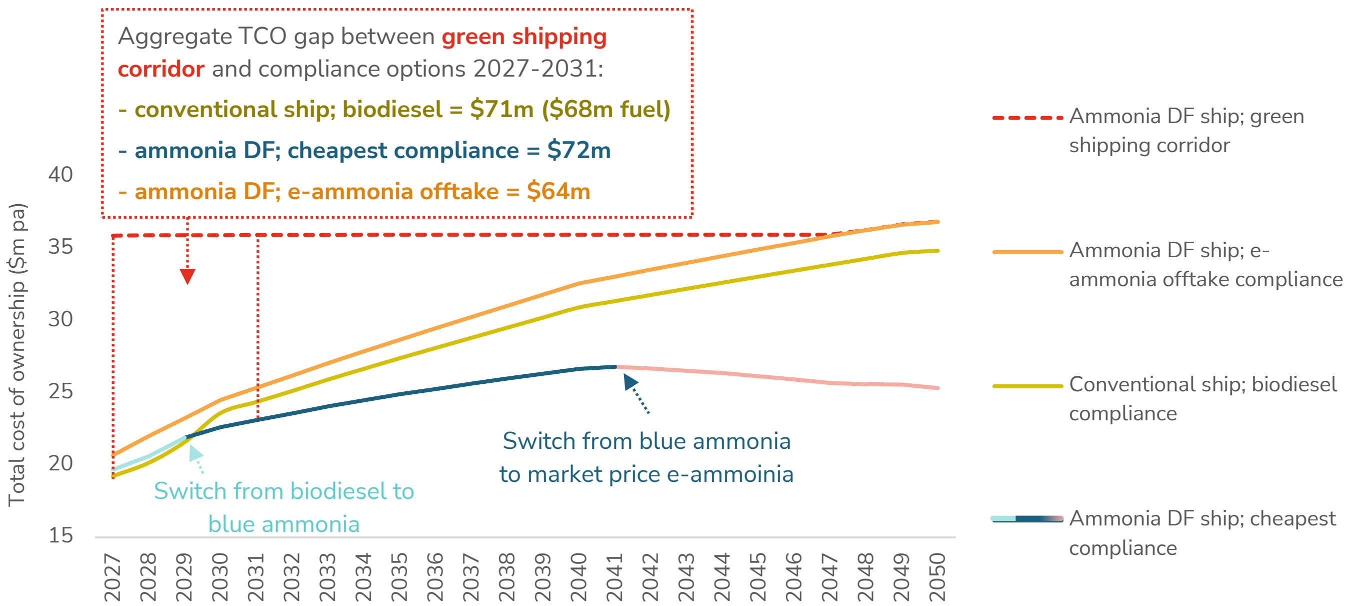
Figure 24: Breakdown of TCO in 2030 and 2040 with proportion of low emission fuel used shown as % of GJ



Note: *Based on a 45,000 cbm gas carrier using approx. 8,000 tonnes of LSFO equivalent annually (cost assumptions stated in Appendix).*

The TCO calculations indicate that the lower cost of blue ammonia bridges the capital cost of installing dual fuel ammonia capability by 2030. From the early 2040s, the production cost of e-ammonia is expected to fall below that of blue ammonia on a cost of abatement basis and so the cost of compliance falls, even as the stringency of the fuel standard rises.

Figure 25: TCOs for green shipping corridor and compliance options and aggregate cost gap over initial 5-year period



Note: *Based on a 45,000 cbm gas carrier using approx. 8,000 tonnes of LSFO equivalent annually (cost assumptions stated in Appendix).*

The compliance options modelled should not be viewed as mutually exclusive and, in the absence of explicit support to help bridge the fuel cost gap, multiple factors could influence which bunkering strategies are employed, and when, during the transition. Given the degree of convergence between these options initially, it is conceivable that in the near term, even without support or subsidy, compliance could be met through the use of e-ammonia, particularly as it would mean that alternative sources of ammonia bunkers would not need to be found. Then, as the volume required to meet compliance grows over time, impetus may build for a switch to blue ammonia, and then to market-sourced e-ammonia.

The TCO analysis does, however, highlight the magnitude of the challenge faced in committing to a green shipping corridor early in the transition, even on a route this accommodating. Business cases for such projects could be built by actors within the value chain but are likely to need support from governments or regulators over the near term.

Business case for e-ammonia producer: supply-side support and monetising overcompliance

If the e-ammonia producer is the charterer, and thus responsible for the bunkering strategy, then it can utilise supply-side support measures directed at the production of hydrogen or ammonia from renewable energy to help narrow the gap between the cost of a green shipping corridor and the compliance options. There could also be an opportunity for the e-ammonia producer to generate an alternative revenue stream by monetising overcompliance. This could enable the e-ammonia producer to indirectly sell volumes that are uncommitted to offtake agreements into the shipping industry.

Business case for US-Europe e-ammonia trade can apply US IRA subsidies and EU ETS carbon price to narrow TCO gap

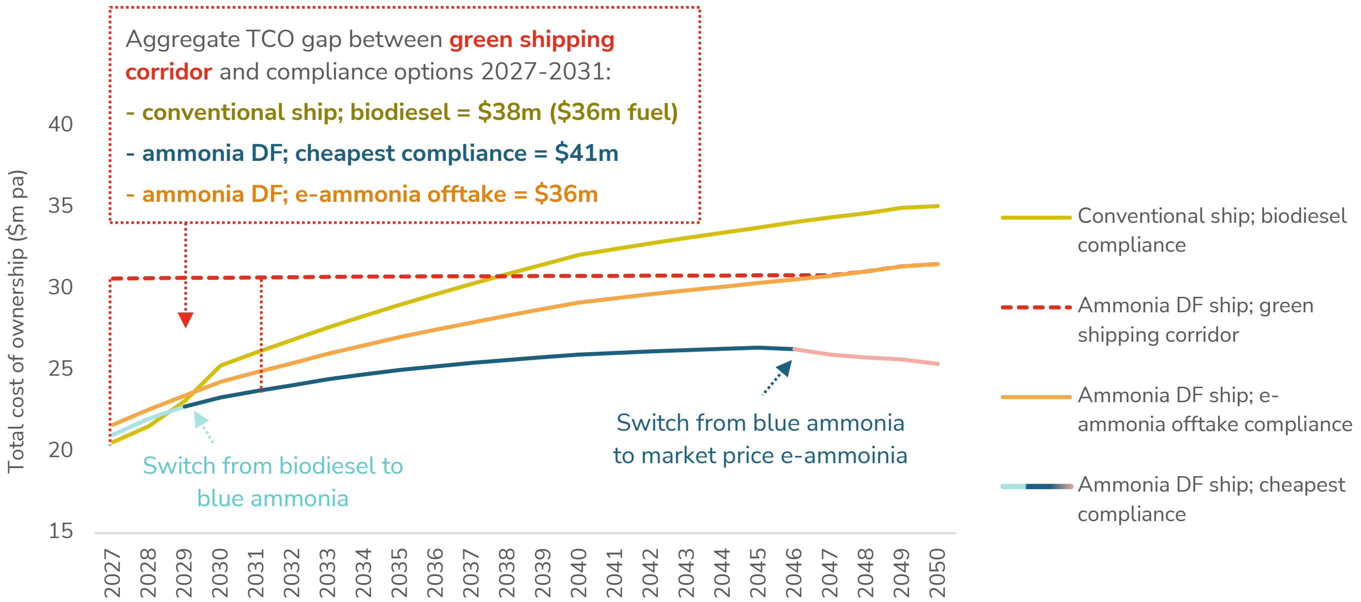
The US Gulf Coast is a major energy export hub. Shale oil and gas is piped to large refineries and ports along the coast, from where crude oil, oil products, LNG, and feedstocks for the petrochemical industry are shipped across the world. The region currently produces and exports fossil fuel-derived ammonia, and energy companies are looking at projects to build blue and e-ammonia production facilities utilising the support offered by the Inflation Reduction Act[31]. Export-oriented projects in the US Gulf Coast supplying international customers with lower cost e-ammonia offtake agreements could offer the earliest opportunities to form green shipping corridors.

Shipments of e-ammonia cargoes to customers in Europe would fall under the EU ETS and FuelEU Maritime measures (although only 50% of the fuel consumption on the voyage would be liable). The former increases the TCO in line with the emissions intensity of the bunker fuel and therefore has a greater impact on the compliance options. The latter could reduce the green shipping corridor TCO by presenting an opportunity to sell the credits attained through overcompliance to other shipping companies sailing to, between, and out of EEA ports. However, this analysis assumes that FuelEU Maritime is superseded by the IMO's global fuel standard.

The TCO analysis has been replicated with US IRA subsidies applied to e-ammonia and blue ammonia production. For the scenarios involving an offtake agreement with the fuel producer (the green shipping corridor and compliance through use of the offtake), the cost of the e-ammonia is fixed throughout the period at the 2027 production cost, less the value of the levelised subsidy. In the cheapest compliance scenario, the levelised subsidy has been applied to projected e-ammonia and blue ammonia production costs until 2032, and thereafter the lower of the 2032 US IRA-subsidised cost and the market cost has been used.

[31] McKinsey: Unlocking clean hydrogen in the US Gulf Coast

Figure 26: TCOs for green shipping corridor and compliance options applying US IRA subsidies and EU ETS carbon price



Note: *Based on a 45,000 cbm gas carrier using approx. 8,000 tonnes of LSFO equivalent annually (cost assumptions stated in Appendix).*

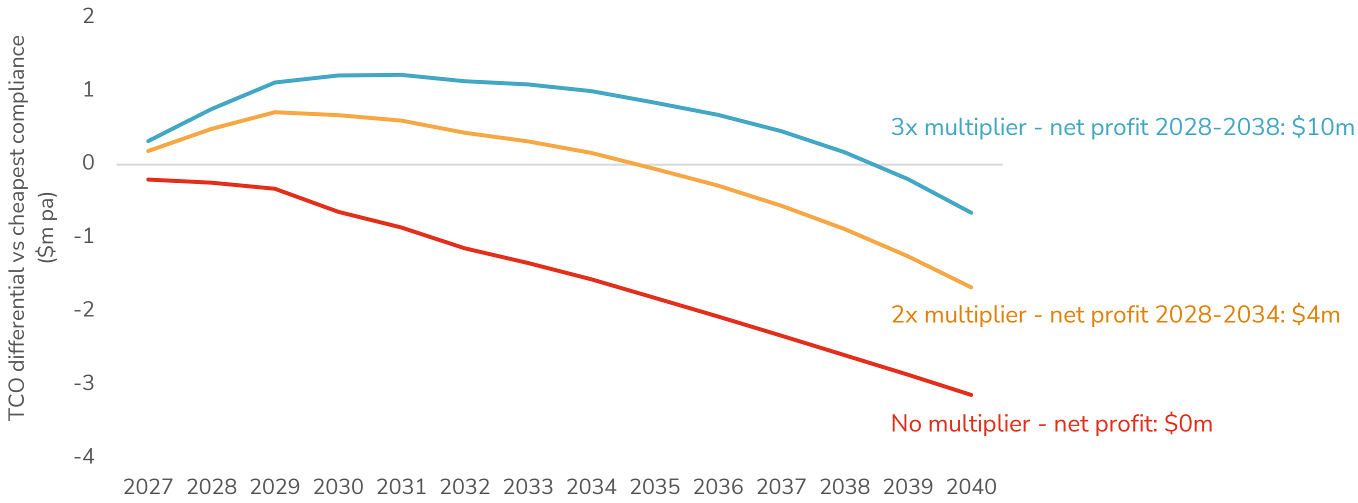
The combination of the US IRA subsidies and EU ETS carbon price makes meeting compliance with the e-ammonia offtake equivalent to doing so via biofuels over the initial 5-year period. However, subsidies for blue ammonia production deliver the cheapest route to compliance and extend the cost competitiveness of this fuel on a cost of abatement basis, meaning that US IRA-subsidised blue ammonia will continue to be lower in cost than declining global e-ammonia production costs until the mid-to-late 2040s.

A fuel standard with a flexibility mechanism and targeted multiplier could enable e-ammonia producers to monetise overcompliance

A global fuel standard with a flexible pooling mechanism could through the use of a targeted multiplier, give e-ammonia producers an opportunity to indirectly 'sell' e-ammonia volumes into the shipping market by using it to fuel the gas carriers that transport their cargoes and then selling the overcompliance credits to shipowners and operators. However, the window of opportunity for early projects to monetise pooling will be limited by competition from new, lower cost e-fuel projects. There is also uncertainty over the price that credits will fetch in future. Supply and demand for credits will be shaped by factors such as the lowest cost pathways to meeting compliance in each shipping sector (i.e. the cost of abatement on a TCO, rather than a fuel, basis) and the penalty for noncompliance with the global fuel standard.

Fuels made by pathways that do not use renewable energy (such as blue ammonia) will compete with higher cost e-fuels. A targeted multiplier that supports e-fuels over other low emission fuels could help even the playing field and boost the period and profitability of the pooling mechanism for e-fuel producers. Based on the very conservative assumption that overcompliance credits will fetch a price equivalent to the cheapest compliance TCO of the gas carrier, with US IRA subsidies applied to blue ammonia and e-ammonia (with the latter fixed at 2027 production cost), a direct multiplier on the number of credits earned by overcompliance through e-fuels could generate an opportunity to monetise overcompliance during the early 2030s.

Figure 27: Illustration of monetisation opportunity for overcompliance with US IRA subsidised e-ammonia



Note: *Based on a 45,000 cbm DF ammonia gas carrier using US IRA-subsidised e-ammonia. Cost assumptions are detailed in the Appendix.*

Business case for customer: willingness to pay and option to divert demand-side support

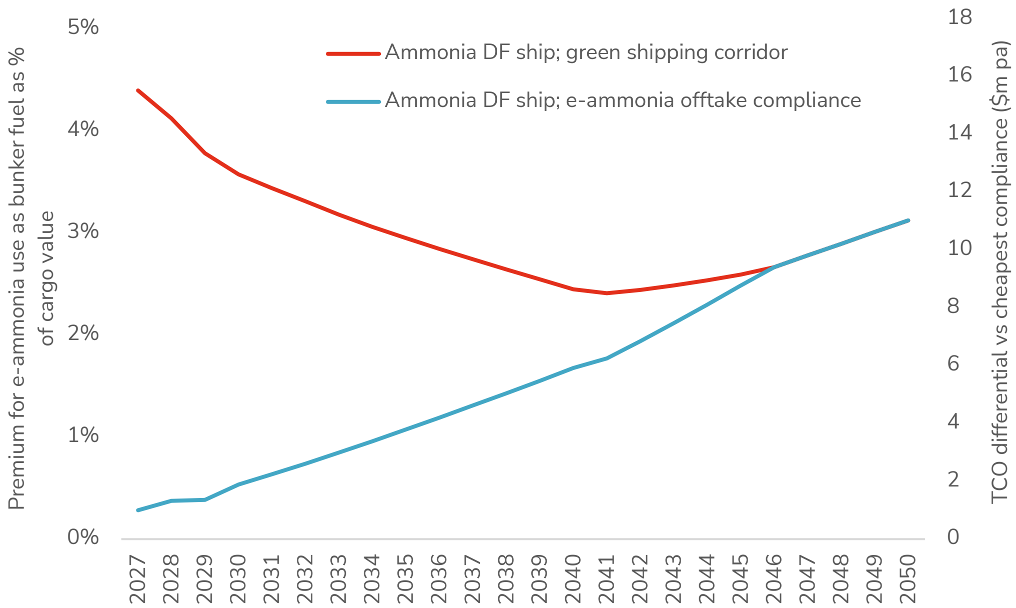
If the customer wishes to decarbonise the supply chain for the e-ammonia offtake, then this can provide the basis for forming a green shipping corridor. This will entail the customer allocating a portion of the offtake volumes it has secured for use as fuel in the gas carrier transporting the cargo. This cost premium could be bridged by the customer's willingness to pay and/or through supportive demand-side measures. However, the benefit of using the e-ammonia as bunker fuel must be weighed against the primary use for the cargo.

High value of e-ammonia could bring relative cost of green shipping within range of the customer's willingness to pay

A customer may be able to dictate the fuel choice for the gas carriers transporting its cargo, whether through a direct operational decision as charterer, or by agreement with the e-ammonia producer if it is the charterer. The bunkering strategy adopted by the customer could target compliance, or the full decarbonisation of its supply chain through use of its offtake volumes (potentially monetising overcompliance credits or using them for internal offsetting), or it may opt for something in between (for example, to meet specific emissions reduction targets).

One factor that could influence a commitment to a green shipping corridor is the high cost of e-ammonia. Each gas carrier will be transporting approximately $350m worth of cargo annually ($260m if subsidised by the US IRA). Compared to the value of the cargo, the cost of shipping is relatively low, averaging 7% on a lowest cost compliance basis and 10% when running fully on e-ammonia. The premium for the latter starts at 4.5% but over the near term, the cost of using offtake to meet compliance is marginal. The customer's willingness to pay for green shipping may fall somewhere between these two options.

Figure 28: Premium for green shipping (compared with cheapest cost of compliance) as proportion of cargo value



***Note:** Based on a 45,000 cbm DF ammonia gas using US IRA-subsidised e-ammonia. Cost assumptions are detailed in the Appendix.*

Demand-side subsidies aimed at the cargo could be directed towards using the e-ammonia as bunker fuel

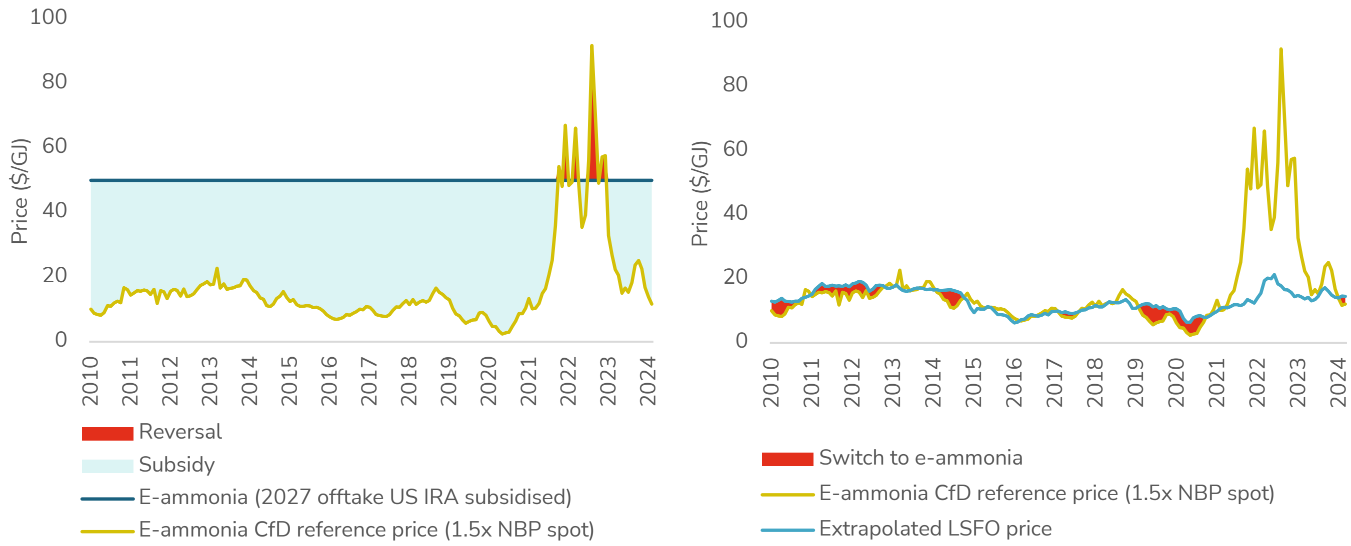
Global prices for fossil fuel-derived ammonia averaged $200-$300/tonne between 2017 and 2021. However, as gas prices rose, so did ammonia prices, peaking at $1,400/tonne in spring 2022. Prices have since fallen back and, as of the start of 2024, were approximately $300/tonne[32]. At this level, fossil fuel derived ammonia is roughly a quarter of e-ammonia production costs (or one third if including US IRA subsidies). This highlights how even generous supply-side subsidies do not fully bridge the cost gap and why it will be so challenging for existing users of ammonia to displace current sources with lower emission, higher cost alternatives.

A CfD is one demand-side support measure that may be available to the customer in a green shipping corridor. Through a CfD, the price of the e-ammonia offtake would move in tandem with the price of fossil fuel ammonia or natural gas. When the fixed offtake price exceeds the market price for the benchmark, the difference will be subsidised; should the price of ammonia or natural gas spike (as it did in 2022), then the subsidy could be reversed and the offtaker would then pay the excess over the offtake price.

The CfD would also have implications for the use of e-ammonia as a bunker fuel. The price of the offtake would track that of blue ammonia (which has the same production pathway as fossil fuel ammonia, but with CCS employed), and so may displace blue ammonia as the lowest cost option for compliance. Depending on the spread between crude oil and natural gas prices, it may even be possible for the subsidised e-ammonia to out compete LSFO.

[32] S&P Global Commodity Insights; quoted ammonia price is Middle East FOB

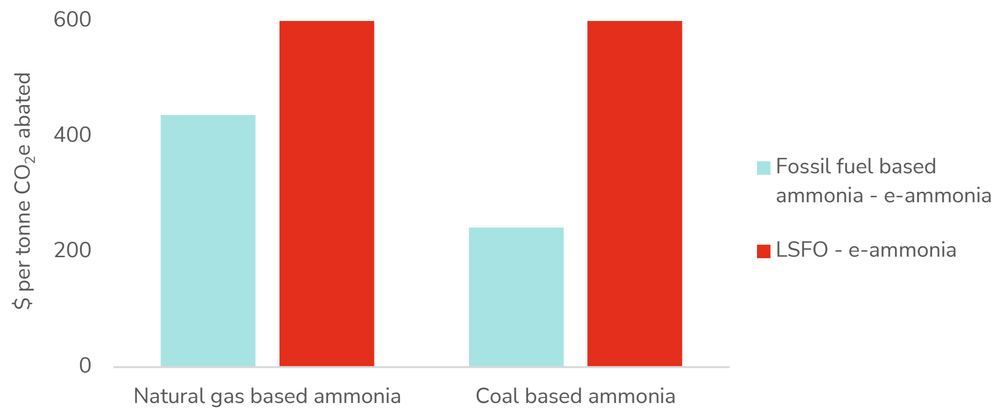
Figure 29: Illustrative e-ammonia CfD using historical gas prices (left) and spread versus LSFO (right)



Note: *Reference benchmark of 50% mark-up on NBP (UK National Balance Point) spot gas prices for illustrative purposes. Historical LSFO prices have been extrapolated from HSFO and MGO price timeseries.*
Source: *Clarksons SIN*

A decision to direct a portion of the offtake for use as bunkers needs to be balanced against the alternative uses of those volumes. The lifecycle emissions from the production of ammonia from natural gas (approx. 120 gCO_2e/MJ) or coal (approx. 215 gCO_2e/MJ) exceeds the WTW emissions for any fossil fuel used as bunkers (for example, LSFO is 91gCO_2e/MJ)[33]. Therefore, if the customer is replacing existing volumes of fossil fuel-derived ammonia from its supply chain, then on an emissions abatement basis, this would be a better use of the e-ammonia compared with using it to replace LSFO. Additionally, at current commodity prices, it would also be better on a cost basis. At a price of $300/tonne for fossil fuel ammonia, the cost of abating one tonne of CO_2e by replacing LSFO (priced at $566/tonne) with e-ammonia is almost 40% greater than using the e-ammonia to replace gas-derived ammonia and more than twice the cost of replacing coal-derived ammonia.

Figure 30: Cost of abatement for using of e-ammonia to replace fossil fuel ammonia versus replacing LSFO



Note: *Based on 2027 e-ammonia price without US IRA-subsidies or EU ETS applied. Cost assumptions are detailed in the Appendix.*

[33] IRENA: Innovation Outlook: Renewable Ammonia

Container ships: Seeding a portfolio with a green shipping corridor

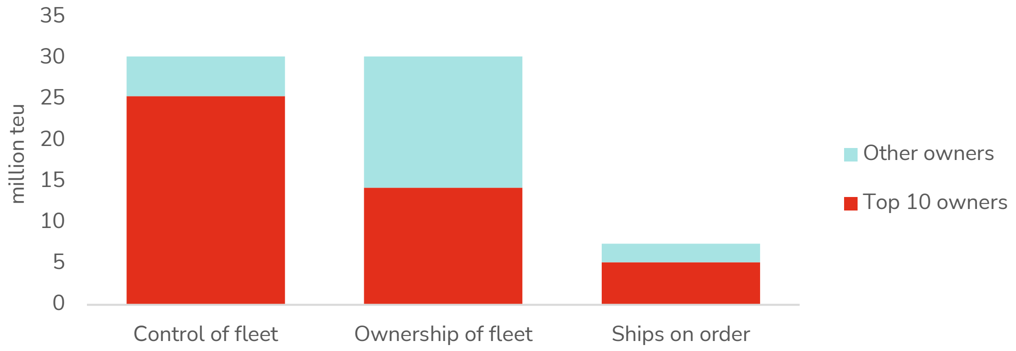
Liner companies will be the driving force behind green shipping corridors in the container shipping sector. Direct control over the fleet and fuel choices will enable these companies to build an internal business case for compliance-driven corridors where the critical hurdle revolves around selecting e-fuels over alternative low emission fuels. This choice could be triggered by a bunkering strategy which manages future exposure to fuel costs through a portfolio approach.

Sector dynamics will play a key role in the business case for a green shipping corridor

Over the last two decades, the containership sector has been shaped by competitive pressures brought about by overcapacity. Multiple bankruptcies in this period led to a highly concentrated market within which the surviving players grew in scale and built ever larger ships in a bid to lower transport costs on a per-container basis. This accelerated growth in shipping capacity which continued to supress profitability. Liner companies formed alliances to optimise the utilisation of these large ships, enhance operational efficiencies and expand geographical coverage. Diversification along the logistics chain or into other sectors was also sought. Until the surge in demand during the pandemic, however, margins in this sector were typically tight.

Smaller players survived this period by specialisation in regional trades, but overall, this sector's demographics—a small number of large liner companies in control of the majority of the fleet through direct ownership and chartering—is one of several features that differentiates container shipping from other sectors. Another is the regularity of voyage profiles, with ships sailing on fixed routes and schedules. A third is the diversified customer base, with ships transporting cargo destined for many customers. A fourth is the history of operational coordination between peers via alliances. The final differentiator is that this sector tends to be the 'public' face of shipping due to the size of liner companies, some of which are publicly listed.

Figure 31: Concentration of control of containership shipping capacity by top 10 liner companies



Source: *Clarksons SIN as of October 2024*

Given the central role that a liner company plays in the container shipping value chain, it will be the key actor in a green shipping corridor project and will need to underwrite the commitment to secure e-fuel offtake and build dual fuel ships. The business case for these actions will be influenced by the dynamics of the sector.

The sheer size of liner companies is a distinct advantage on several fronts. A large fleet makes it easier to plan for renewal and retrofits, and any risks associated with the adoption of dual fuel capability on few ships is reduced when diversified across the entire fleet. Liner companies are also more likely to have the internal capability and capacity to negotiate and manage fuel offtake agreements (especially those that have existing bunker supply contracts or fuel hedging instruments in place).

The operational profile of container shipping is also conducive to forming corridors. Scheduled sailings enable more accurate projections of future fuel demand and the coordination of zero emission fuel bunkering provision. Conversely, however, long voyage distances and multi-stop routes may complicate the bunkering solution.

Despite these advantages, the sector also faces headwinds. High earnings during the Covid period triggered an ordering spree and the orderbook peaked at 30% of fleet capacity in spring 2023. As the containership fleet absorbs this new tonnage over next few years, profitability in the sector is expected to fall, which may make liner companies hesitant to commit to a corridor project.

Unlike the bulk cargo sectors, a green shipping corridor cannot be initiated by a single customer's willingness to pay. A liner company can aggregate premiums from those of its customers prepared to pay extra for green shipping by using internal insetting solutions such as Book and Claim schemes which allow cargo owners or customers to purchase low or zero emission fuels for use in a ship that their cargo may not necessarily sail on[34]. However, in the absence of an initiative that can offer firm commitments over a period (such as ZEMBA[35]), the business case for a corridor faces uncertainty over future premiums, particularly as there could be a risk that willingness to pay will decrease as regulation tightens.

Ultimately, a liner company's decision to participate in a green shipping corridor project will be largely driven by internal considerations. It may be motivated by a desire to be seen as a leader on maritime decarbonisation. Or it could be impelled by a commercial strategy—for example, to manage compliance across the wider fleet by using the fuels secured under offtake agreements in dual fuel ships on the most economical and logistically optimal routes.

Liner companies can exploit the full control over fleet and fuel to form green shipping corridors

As the entity that straddles the fuel, ship and freight elements of the value chain, the liner company will be the driving force behind establishing a green shipping corridor in this sector. Despite uncertainty over the future premium that can be earned from customers, the business case for green shipping corridors is aided by the degree of control that liner companies have over the first two elements—fuel and fleet—which facilitates a coordinated approach to investment decision-making.

[34] GMF Insight Brief: A Book and Claim Chain of Custody System for the early transition to Zero-emission Fuels in Shipping

[35] Aspen Institute: ZEMBA Announces Completion of Inaugural Tender

Commitments to offtake and investment in ships will put liner companies at the centre of the green shipping corridor

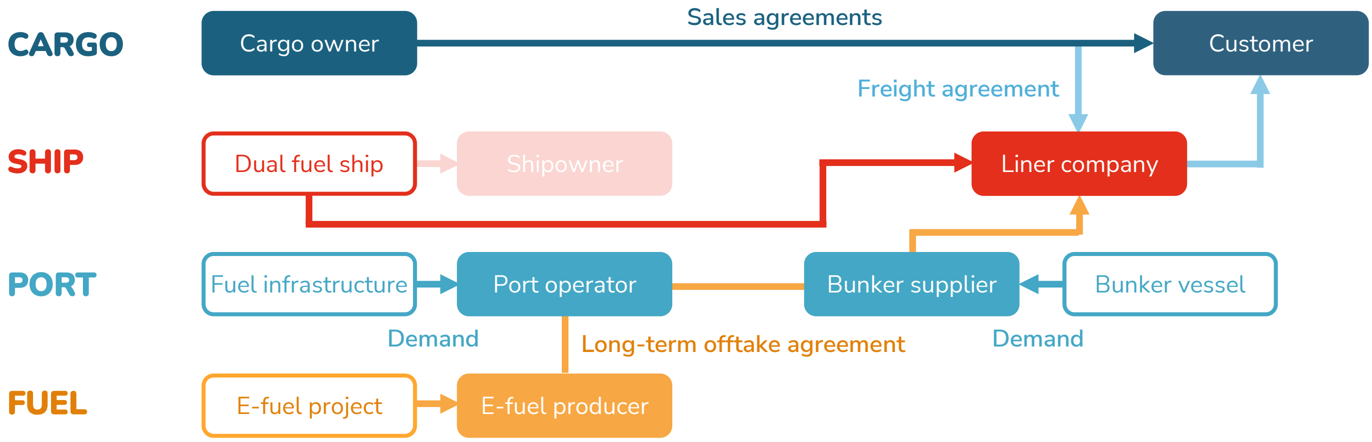
To form a green shipping corridor across this value chain, an offtake agreement for an e-fuel is required, along with dual fuel ships and bunkering infrastructure to supply the fuel. The first two commitments will lie with the liner company, but the last element will depend on the formation of a wider supply chain for that fuel. All costs associated with the corridor will ultimately pass through the liner company.

Table 2: Points of investment and cost passthrough mechanisms along the green shipping corridor value chain

Investment	Cost passthrough mechanisms
E-fuel offtake agreement	The liner company will be the entity that commits to an e-fuel offtake agreement. Currently, liner companies pass fuel costs on to customers either as part of the freight cost or through a more transparent surcharge that adjusts as fuel price changes. Customer willingness to pay for green shipping could be aggregated and channelled to offset corridor-related costs, but a liner company will likely need to construct an internal business case to justify this commitment.
Bunker fuel storage and supply at port	The utilisation of infrastructure and assets at ports will be critical to minimising the last mile costs for e-fuel bunkering. These costs will be passed on to the liner company through a margin on the delivered cost of fuel. The business case for storage facilities at port will be strengthened by any supplemental sources of demand (for example, for use by local industries), but that of the bunker supplier (which relies on the utilisation of its bunker vessel to recoup investment and operational costs) will be entirely dependent on demand from the shipping industry.
Dual fuel containerships	The capital cost of the containership is passed through to customers within the cost of freight. A liner company can directly own or charter in ships, giving it a degree of flexibility over exposure to dual fuel capability in its fleet. However, a liner company can depreciate the capital cost of the dual fuel capability over the life of the ship, while the rate for a chartered ship may include a premium that reflects the depreciation of the investment in dual capability over a shorter period. The current orderbook indicates that liner companies are directly investing in dual fuel ships.

The types of investments, commitments and commercial agreements required by a green shipping corridor have parallels to the sector's adoption of LNG bunkering—although the business case for the corridor will be compliance, rather than profit, driven. The evolution of the LNG bunkering ecosystem could off insights into the emergence of new low and zero emission fuels.

Figure 32: Commercial agreements in green shipping corridor value chain in the container shipping sector



A green shipping corridor project could have parallels to the sector's adoption of LNG bunkering

The container shipping sector has long utilised bunker supply contracts to secure volume discounts and fixed pricing[36]. Liner companies first began signing LNG offtake agreements in the second half of the 2010s, primarily driven by commercial factors (the opportunity to benefit from a spread in oil and gas prices), but also to comply with air pollution limits set in Emission Control Areas (ECAs). Dual fuel LNG containerships were built in conjunction with these offtake agreements and there are now almost 90 on the water.

However, it took over a decade for the LNG bunkering supply chain to mature to the point where liner companies began to participate. The initial small-scale projects in the early 2000s faced high last mile costs due to low utilisation. Only when the broader trade in LNG (i.e. as a way to transport natural gas) grew, underwriting the construction of large-scale storage infrastructure at export and import ports, did wider investment in bunkering assets and services start to flow[37].

This highlights the challenges faced in building the wider ecosystem required to deliver alternative bunker fuels to ships and indicates that, over the short term, green shipping corridors that span ports where other sources of demand are aggregating will have an advantage. Demand could come from within the sector (for example, through agreements with alliance members), the industry (for example, at large bunkering hubs where other corridors are forming), or linked to ports that are emerging as hubs for e-fuel trade.

As containerships sail on fixed routes and schedules, and typically bunker while loading or discharging, liner companies will need to balance the optimal location for bunkering facilities from an operational perspective, against the cost benefit of accessing e-fuel bunkers at ports with lower last mile costs.

The dual fuel capability of ships on the water and on order reflect the views on fuel pathway choices so far

Shipowners in the container shipping sector are divided into two groups—liner companies and non-operating owners. The former charters in tonnage from the latter for periods ranging from months to over 10 years. The proportion of owned versus chartered-in tonnage has varied over time; over the last decade, the liner-owned fleet has climbed from 50% to 60%. However, direct ownership and control is highly concentrated, with the top ten largest liner companies currently owning 47% of fleet capacity and controlling 84%[38].

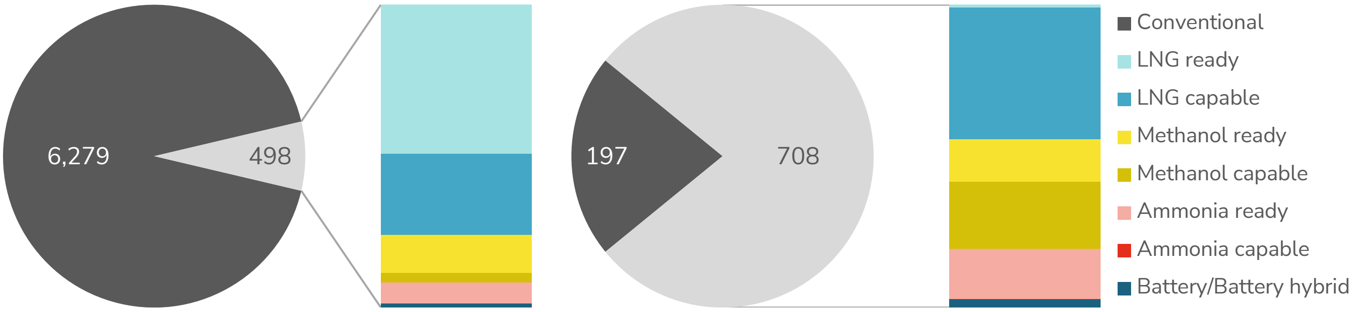
The current orderbook is filled with post-pandemic orders, largely from liner companies, and indicates a preference for direct ownership of dual fuel ships, at least in the near term. The increasing number of dual fuel ships being ordered, and the expanding range of capabilities and readiness being built into the fleet, indicates that the containership sector is grappling with decisions over which technology and fuel pathways offer the best opportunity through the transition.

[36] DTU: Bunker Purchasing with Contracts

[37] OIES: LNG Supply Chains and the Development of LNG as a Shipping Fuel in Northern Europe

[38] Clarksons SIN: Container Intelligence Monthly October 2024

Figure 33: Dual fuel readiness and capability of containership fleet (left) and orderbook (right)



Source: *Clarksons SIN as of October 2024 for containership fleet and orderbook of ships over 100 teu.*

A bunkering strategy focused on future compliance may employ a portfolio approach to fuel offtake agreements

Liner companies will be responsible for the fuel and fleet choices that will shape the decarbonisation of the container shipping sector. Navigating this transition will be challenging given the competitive nature of an industry striving to reduce the cost of transport on a per-container basis. To date, bunkering strategies have focused on gaining competitive advantage either by reducing operating costs through bunker supply contracts or by mitigating risks to those costs through hedging instruments.

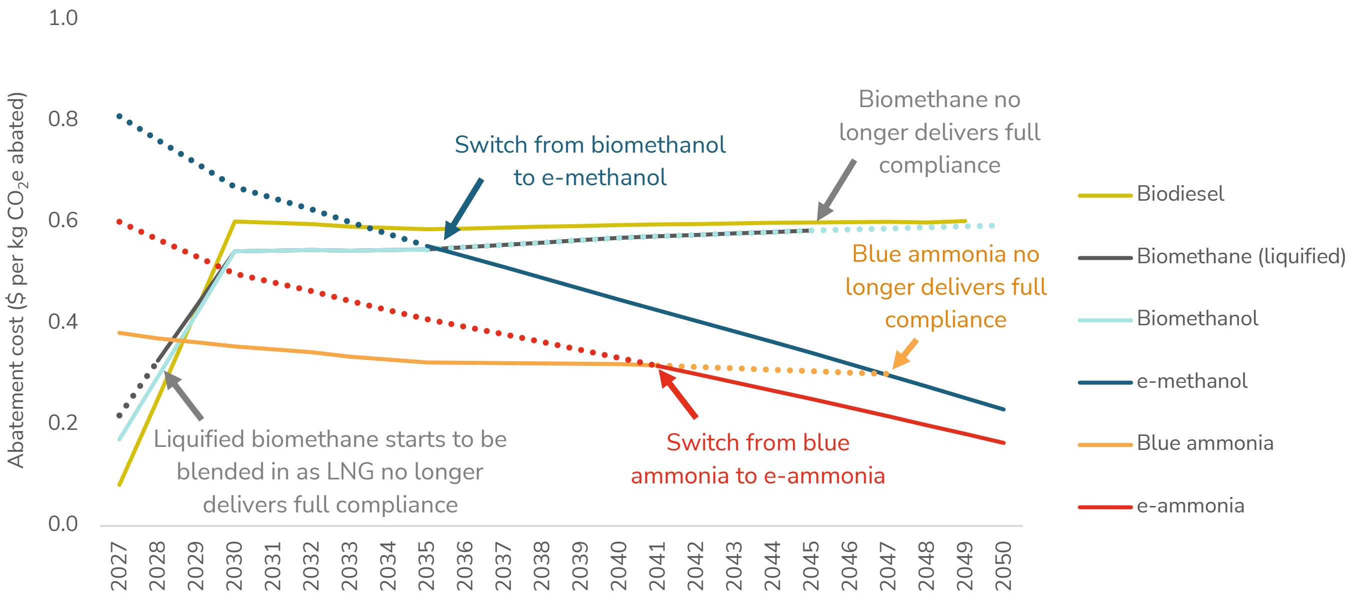
The IMO's ambition to reduce emissions underscores the importance of developing more sophisticated bunkering strategies in future, regardless of participation in a green shipping corridor. These strategies will need to focus on the cost of abatement and will need to assess potential exposure to future price risk between different fuel types (for example, LNG versus biomethanol) and across fuel variants (for example, biomethanol versus e-methanol). Strategies will also need to consider how the dual fuel capability locks in future fuel choices, assess the longevity of fuels with higher emissions intensity (such as LNG), and map which progressively lower emission fuel types linked to that capability could be available and at what price.

These assessments will be made far more complex by the uncertainty over how the markets for each fuel and fuel variant will develop—if and when fuels will shift from offtake agreement to spot availability, and how pricing on an offtake and spot basis will evolve. The lack of clarity means that the risks associated with limiting future fuel choices by locking in dual fuel capability can be difficult to judge. Diversification typically mitigates exposure to such risks; however, liner companies will need to balance the benefits of building a fleet that cover a range of dual fuel capabilities against the advantages of concentrating demand for a single fuel type/variant (such as driving volume discounts or building crew expertise in one fuel type).

Liner companies currently face weighing the certainty of an offtake agreement—locking in known volumes for a known duration at a known price (assuming the offtake agreement is based on fixed pricing rather than linked to a variable reference)—against an indeterminate future. One element of this uncertainty will resolve over the near term as the IMO's decisions regarding its mid-term measures become clearer. However, opportunities to secure fuel offtake may also shift over this timeframe. For instance, strong demand for fuels derived from biogenic sources may drive up the cost at which offtake can be secured.

The underlying premise of the analysis in this report is based on the assumption that limited biogenic feedstock will mean that growth in demand for biofuels will raise prices (whether on an offtake or spot basis) to the point where the economics of fuel choice broadens to cover other production pathways. This has been implemented through an assumption that the prices of biodiesel, biomethane and biomethanol will all rise towards the FuelEU Maritime penalty cost for noncompliance (on a cost of abatement basis) and then stay at this level from 2030 onwards, while the price of scalable e-fuels declines over time as supply chains mature.

Figure 34: Fuel cost and emissions intensity in terms of cost abatement ($ per kg of CO_2e abated per GJ) versus LFSO



Note: *Outputs reflect scenario where carbon price is set to zero and no subsidies have been applied.*

To manage future compliance, a liner company could employ a bunkering strategy that relies entirely on the low and zero emission fuels that will be available on a spot basis. This strategy may utilise drop-in biodiesel blends in conventional ships, or it may involve building dual fuel ship able to run on fuels that might be rapidly commoditised (for example, blue ammonia). This approach will result in exposure to fuel price (in terms of relative spread) risk.

Alternatively, a liner company may choose to develop a bunkering strategy that leverages a portfolio of offtake agreements structured to manage exposure to price risk. This portfolio may be sized to deliver some or all of the low or zero emission fuel required to cover future compliance and the approach would allow for greater optimisation of fleet planning, with dual fuel ships built to match offtake volumes. The portfolio could be built around a single fuel type or cover multiple fuels. The former may be more likely in the near term if volume aggregation helps to meet a required minimum level of offtake and/or if there is potential to benefit from economies of scale in delivering a bunkering solution.

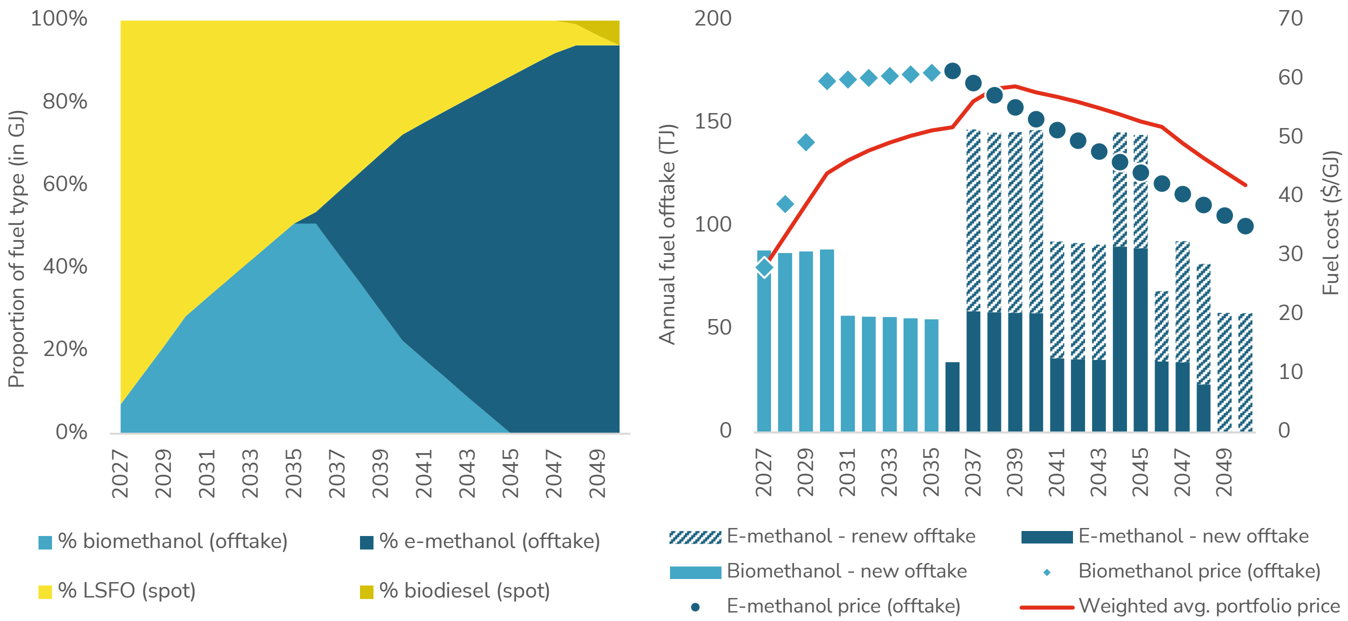
Some of the largest liner companies are already investing in sources of low and zero emission alternative fuels. Maersk has been the forerunner in this area. It has formed strategic partnerships with multiple suppliers over the last few years and at the end of 2023 secured the shipping industry's first large scale offtake agreement for 500,000 tonnes per annum of biomethanol and e-methanol[39].

[39] Maersk: Maersk signs landmark green methanol offtake agreement, significantly de-risking its low-emission operations in this decade

The challenge for green shipping corridor projects is the near-term trade off between securing offtake of low-cost non-scalable fuels from biogenic sources before growing demand drives prices up versus securing offtake of high-cost scalable e-fuels before growing supply drives prices down. However, the process of incrementally constructing a portfolio, where more offtake agreements are added each year to meet rising compliance, results in a weighted average fuel price that dilutes the impact of any single offtake agreement's price. Near-term commitments to fuel offtake need to be assessed against the backdrop of tightening regulation and the inevitable increase in the volumes of low and zero emission fuels required over the next 25 years.

To illustrate the effect of cost averaging in a fuel offtake portfolio, the charts below reflect a containership meeting compliance through the lowest cost combination of biomethanol and e-methanol. Assuming that LSFO and biodiesel are available on a spot basis, and that biomethanol and e-methanol volumes are secured through 10-year offtake agreements, then 1) the biomethanol remains part of the fuel mix even as the cost of e-methanol falls below that of biomethanol; and 2) the weighted average portfolio price of biomethanol and e-methanol offtakes lags and dampens exposure to the annual variation in offtake prices.

Figure 35: Fuel mix for lowest cost compliance in DF methanol ship (left) and annual offtake and costs in portfolio (right)



Note: *Based on 24,000 teu containership sailing between East Asia to Europe consuming approximately 30,000 tonnes LSFO per annum. Fuel cost assumptions detailed are in the Appendix.*

Scenarios to assess green shipping corridors against compliance across slate of fuel choices

For a global fuel standard with a flexibility mechanism, compliance could be met on a per ship basis (i.e. each ship using enough low or zero emission fuel to comply) or a number of dual fuel ships that run entirely on low or zero emission fuels could offset non-compliant ships which continue to run on LSFO. The overcompliance generated by the dual fuel ships could be pooled internally or traded externally. Although trading offers shipowners or operators a way to either buy compliance or sell overcompliance, the future price of credits will be uncertain.

In this sector, given the size of the fleets that the large liner companies control, a strategy of internal pooling of overcompliance by a subset of dual fuel ships to offset the residual fleet running on LSFO could offer the lowest cost and lowest risk approach to meeting compliance. The dual fuel ships that over-comply could run on the cheapest mix of fuels, but if e-fuels were used instead, then the over-complying ships would effectively form green shipping corridors. In other words, even though the compliance generated from the use of e-fuels will be spread across multiple ships, there will be a physical corridor on which ships will be running on e-fuels.

The simplest representation of the average TCO across a pool of ships amongst which over and under compliance is balanced, would be to use a single ship meeting compliance as a proxy. This will enable an assessment of the cost gap between a compliance-based green shipping corridor using e-fuels and the lowest cost of compliance alternative. However, this is only a rough estimate given it assumes that all ships in the pooled fleet 1) have the same energy demand; and 2) bear the same additional capital cost of the dual fuel capability that the over-complying ships do.

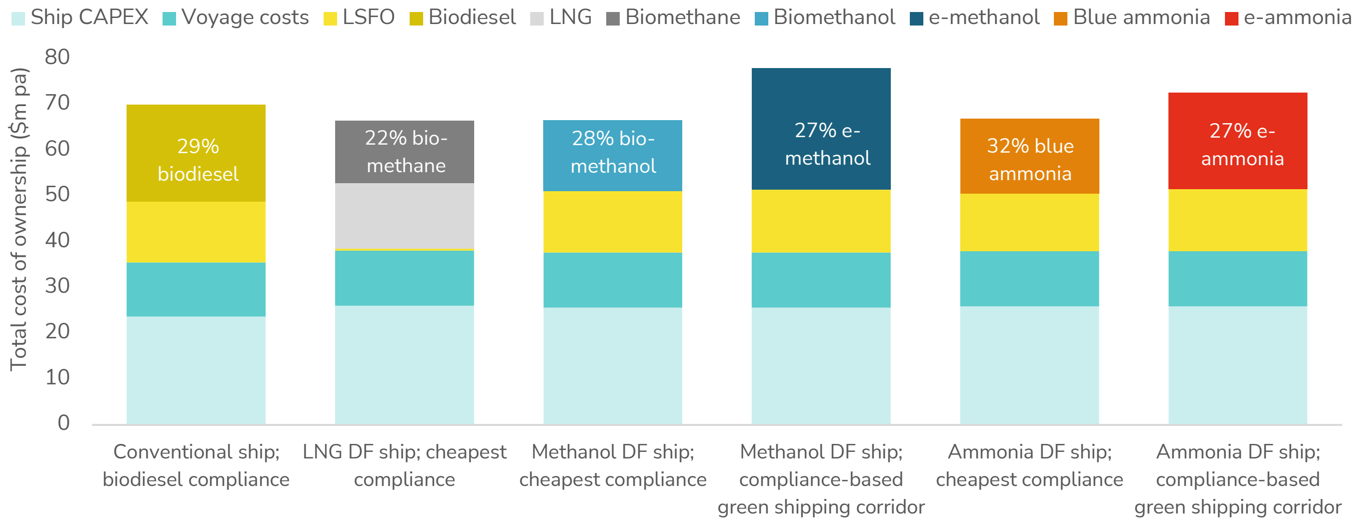
Scenarios have been formed for four types of 24,000 teu containership (conventional and dual fuel LNG, methanol and ammonia) using eight fuels (LSFO, biodiesel, LNG, liquified biomethane, biomethanol, e-methanol, blue ammonia and e-ammonia). The lowest cost combination of fuels to meet compliance has been calculated for each ship, along with the cost of complying through e-fuels (i.e. as a representation of a physical green shipping corridor) for the dual fuel methanol and ammonia ships:

1. **Conventional ship; biodiesel compliance:** A conventional containership running on biodiesel blends to meet compliance.
2. **LNG dual fuel ship; cheapest compliance:** A dual fuel LNG containership running on the lowest cost fuel mix (from a choice of LSFO, biodiesel, LNG and liquified biomethane) to meet compliance.
3. **Methanol dual fuel ship; cheapest compliance:** A dual fuel methanol containership running on the lowest cost fuel mix (from a choice of LSFO, biodiesel, biomethanol and e-methanol) to meet compliance.
4. **Methanol dual fuel ship; compliance-based green shipping corridor:** A dual fuel methanol containership running on e-methanol to meet compliance as a proxy for running entirely on e-methanol and pooling overcompliance.
5. **Ammonia dual fuel ship; cheapest compliance:** A dual fuel ammonia containership running on the lowest cost fuel mix (from a choice of LSFO, biodiesel, blue ammonia and e-ammonia) to meet compliance.
6. **Ammonia dual fuel ship; compliance-based green shipping corridor:** A dual fuel ammonia containership running on e-ammonia to meet compliance as a proxy for running entirely on e-ammonia and pooling overcompliance.

It has been assumed that LSFO, biodiesel, LNG and blue ammonia are available on a spot basis. Liquified biomethane, biomethanol, e-methanol and e-ammonia have been assessed on the basis that incremental volumes each year are secured through 10-year offtake agreements.

A breakdown of the TCO indicates that fuel is the largest cost component across all scenarios. The capital cost of the ship is also significant, but as the 24,000 teu is the largest containership, the relative cost of the dual fuel capability is minimised. Assuming that the additional investment required is depreciated over the economic life of the ship (25 years), this adds between 8% and 10% to the capital cost component of the TCO for dual fuel ships.

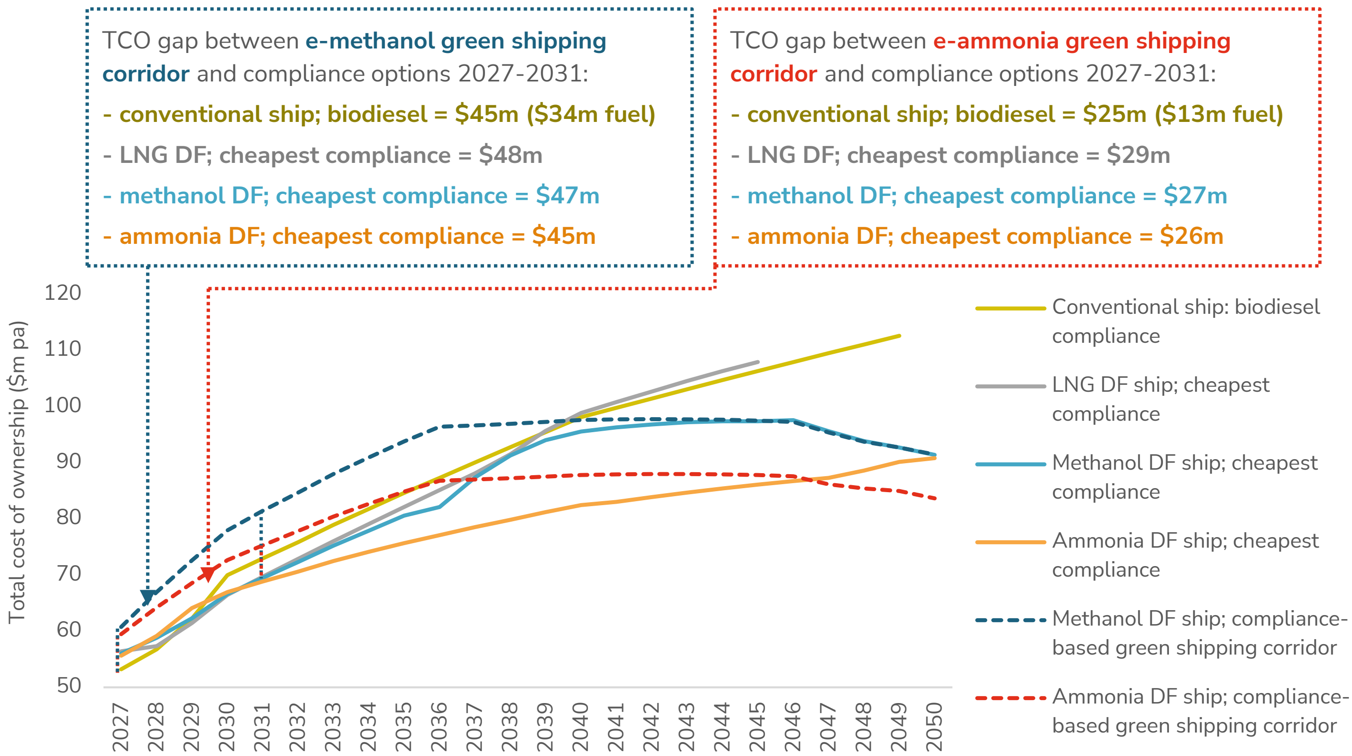
Figure 36: Breakdown of 2030 TCO with proportion of low emission fuel used shown as % of GJ



Note: *Based on 24,000 teu containership sailing between East Asia to Europe consuming approximately 30,000 tonnes LSFO equivalent per annum. Cost assumptions are detailed in the Appendix.*

By framing the view of the marginal cost of a green shipping corridor (where ships would run entirely on e-fuels) against routes on which ships would over comply by running only on alternative low emission fuels, the premium for the green shipping is far smaller than an assessment which compares a ship running only on e-fuels to a ship using low emission fuels to comply. However, given the competitive nature of the industry, it can still be a challenge to bridge the gap between e-fuels and lower cost alternatives and support may be needed to shift the business case in favour of the e-fuel option, and thus facilitate green shipping corridors to form in this sector.

Figure 37: TCOs for compliance-based corridors versus cheapest compliance and total cost gap over initial 5-year period



Note: *Based on 24,000 teu containership sailing between East Asia to Europe consuming approximately 30,000 tonnes LSFO equivalent per annum. Cost assumptions are detailed in the Appendix.*

Business case for compliance via e-fuel use can be triggered by private and public actions

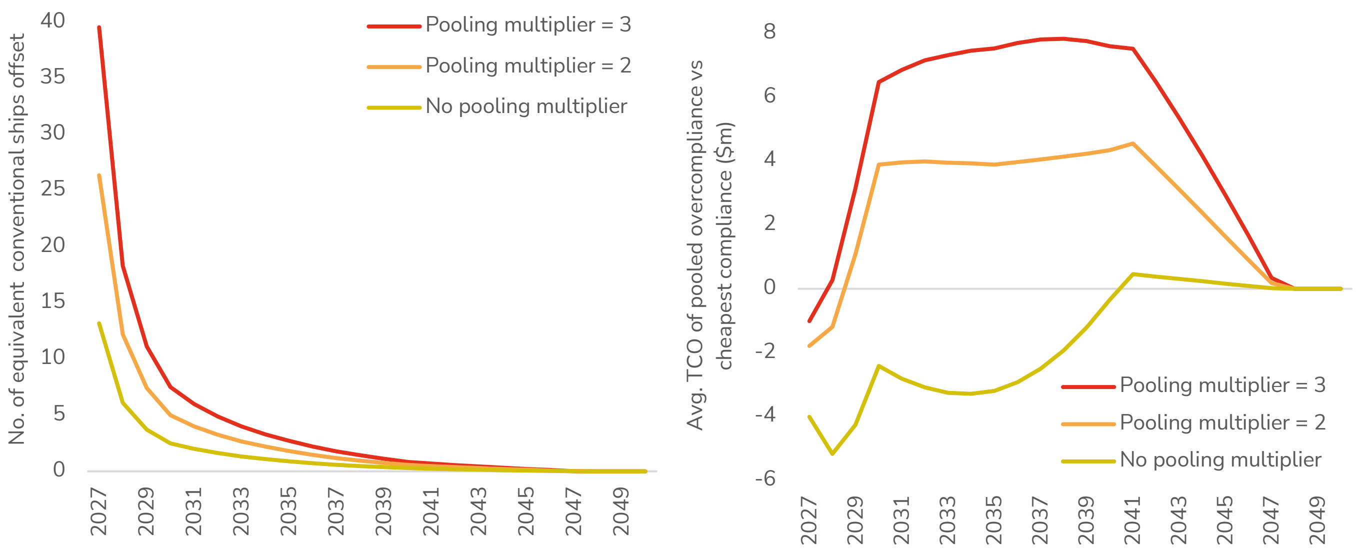
As in the gas carrier case study, supply-side support that subsidises fuel production (such as the US IRA) and can assist in narrowing the cost gap between e-fuels and other low emission fuels. However, the impact of the EU ETS will be marginal as the differential being assessed is between zero and low emission fuels. A multiplier directed at e-fuels would increase the viability of this option in a compliance-based green corridor business case. Alternatively, other avenues of support for green shipping corridors could flow from both the private and public spheres.

Direct multiplier applied to e-fuels could extend the window to replace or retrofit ships and bridge the TCO gap

As part of its 2030 ambition for a minimum of 5% (striving for 10%) uptake of low or zero emission fuels, the IMO could incentivise the shipping industry to use e-fuels by incorporating targeted support within a global fuel standard such as a multiplier on the number of credits earned by ships using e-fuels. This approach would have two effects. Firstly, it would increase the number of non-compliant ships offset by the dual fuel ship using e-fuels, and so lower the average TCO of the pool of ships across which compliance is balanced. This could potentially close the gap between a compliance-based greens shipping corridor and the lowest cost solution.

Secondly, the multiplier would extend the runway for building or retrofitting ships to run on alternative fuels. For a liner company, longer timescales for installing dual fuel capability would be an advantage from both a fleet management and a capital investment perspective. Based on the emissions intensity trajectory applied in this analysis, a ship running on e-ammonia in 2027 will offset just over 13 equivalent conventional ships with comparable energy demand running on LSFO. The number of ships offset decays exponentially and by 2035 falls below 1. A multiplier of x2 and x3 would extend this window by three and five years respectively, thus allowing more time for fleet adjustments to be made.

Figure 38: Effects of direct multiplier on e-ammonia—no. of ships offset (left) and TCO gap vs cheapest compliance (right)

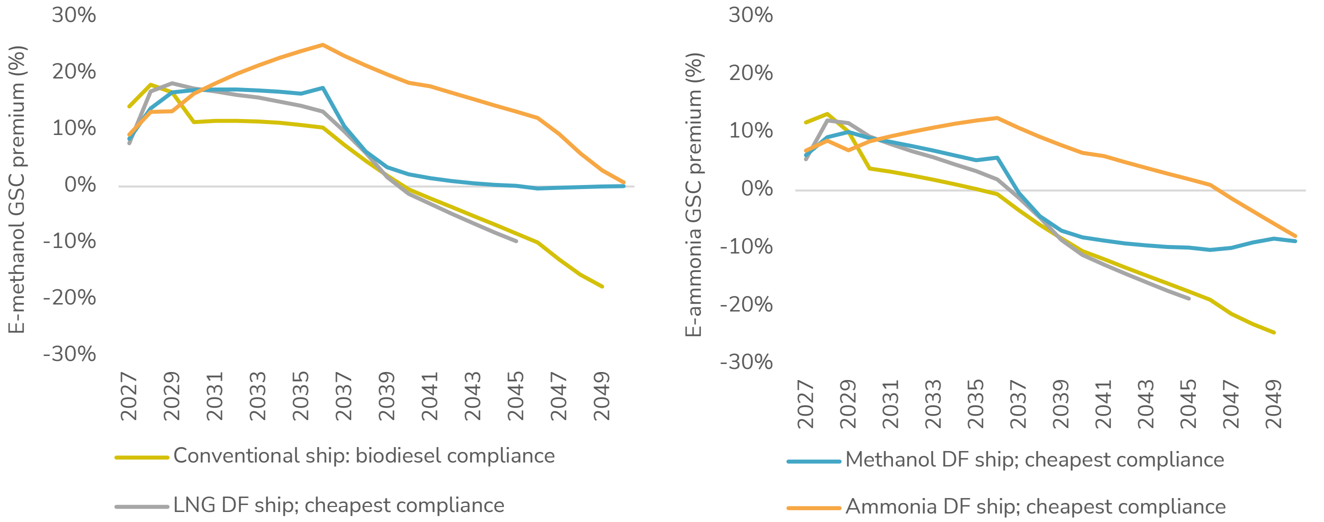


Note: *Based on 24,000 teu containership sailing between East Asia to Europe consuming approximately 30,000 tonnes LSFO equivalent per annum. Cost assumptions are detailed in the Appendix.*

Channelling customer willingness to pay to bridge the gap between cheapest compliance and green shipping corridor

Viewing the relative costs of TCOs for compliance via e-fuels versus other lower cost, higher emission fuels, illustrates the premium attributable to a green shipping corridor. Over time, the marginal cost of forming a green shipping corridor decreases as the cost of e-fuel offtake falls, with the premium switching to a discount in some cases. The higher projected cost of e-methanol compared with e-ammonia means that the marginal premium of the former remains above that of the latter.

Figure 39: Green shipping corridor premium over other compliance options for e-methanol (left) and e-ammonia (right)



Note: *Based on 24,000 teu containership sailing between East Asia to Europe consuming approximately 30,000 tonnes LSFO equivalent per annum. Cost assumptions are detailed in the Appendix.*

Once the IMO's regulations take effect, the costs associated with reducing emissions to meet compliance will be passed onto the customer. It is unclear how customers that are currently willing to pay for green shipping will respond to this and whether the existing appetite to voluntarily pay an excess will change once compliance complicates the accounting of a green premium. Where willingness to pay does persist, it is likely to come with a higher bar for the level of ambition it covers.

On this basis, a green shipping corridor project could provide a viable platform to attract willingness to pay from the market. Initiatives such as ZEMBA, which aggregate and commit willingness to pay from groups of customers, could target tenders towards corridors using high ambition e-fuels and undertake the accounting of the future marginal premium compared with a compliance baseline.

Demand-side support offered through government auctions for e-fuels could do more than close the fuel cost gap

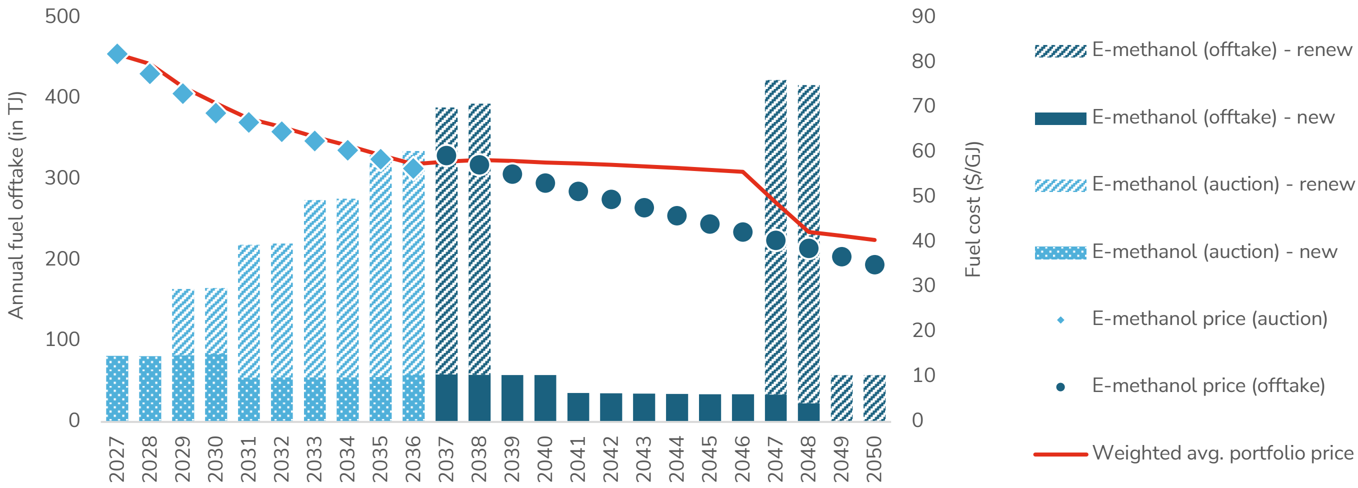
Companies which sign offtake agreements for e-fuels can benefit from both supply and demand-side support to help bridge the fuel cost gap. The former targets the suppliers of e-fuels to reduce production costs; the latter subsidises the company using the e-fuel. A mechanism that combines both forms of support could also address the current conflict facing green shipping corridors—the trade-off between locking in e-fuel offtake agreements when costs are high rather than securing offtake agreements for fuels made from biogenic sources while costs are still low.

Governments that step into the role of offtaker can channel supply-side support to e-fuel producers by agreeing a fixed price or variable premium, but they can also deliver demand-side support to the customer base by 1) reselling volumes at a discounted price (as determined by a competitive auction process); and 2) offering volumes over shorter durations that the offtake agreement.

The German government has launched this type of double-sided measure. It has backed an intermediary (HINT.CO) which will secure 10-year offtake agreements for hydrogen derivatives from around the world through an auction process. The competitive auction would then be switched to the demand-side, offering consumers the opportunity to bid for volumes over shorter periods[40].

This type of support would allow the liner company to build an e-fuel portfolio from the outset without the penalty of a high-cost lock-in. For example, assuming that over the course of 10 years, annual auctions were opened for bids for subsidised e-methanol volumes with a 2-year offtake commitment, and that bid prices secured a $5/GJ subsidy over the market price of e-methanol offtake (i.e. a quarter of the size of the US IRA subsidy), then the near-term weighted average portfolio cost would track the fall in e-methanol production costs. However, this would also come with renewal risk at the end of the 10-year period, when the required replacement of offtake volumes may lock in the price over a period during which e-methanol costs continue to fall. Therefore, exposure duration-related risks need to be considered when constructing an offtake portfolio.

Figure 40: Weighted average cost of fuel with 2-year auctioned offtake until 2036 followed by 10-year market offtake



***Note:** Based on 24,000 teu containership sailing between East Asia to Europe consuming approximately 30,000 tonnes LSFO equivalent per annum. Fuel cost assumptions are detailed in the Appendix.*

With the assumptions and fuel costs used in this analysis, for the above measure to entirely close the gap between the cheapest cost of compliance (via a combination of 10-year biomethanol and methanol offtakes), the subsidy will need to be in the region of $15/GJ.

[40] BMWK: Federal Ministry for Economic Affairs and Climate Action launches first auction procedure for H2Global

Bulk carriers: Green shipping corridor delivered by compliance or cargo

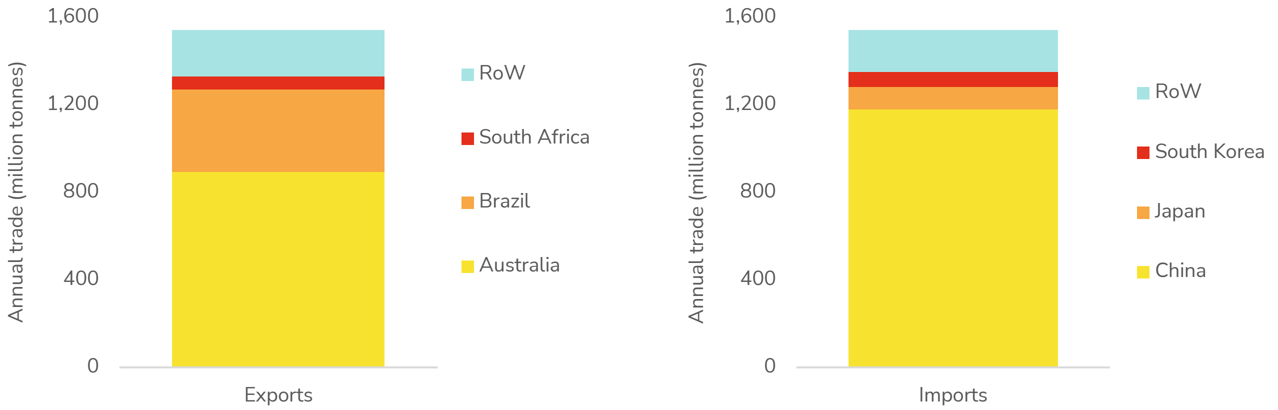
Dry bulk trade is typically fluid, but green shipping corridor projects are developing in pockets of opportunity in this sector. Such projects benefit from a simple value chain with a direct commercial link between cargo owner and customer, but the division of responsibility for the ship and fuel adds complexity to the business case. Large charterers could deliver compliance-driven green shipping corridors and projects that aim to immediately and entirely decarbonise a supply chain could form around a trade in high-value cargoes, potentially supported by a CfD mechanism.

Green shipping corridor projects are forming in the pockets of opportunity present in this sector

Bulk carriers transport a diverse set of commodities such as iron and other ores, coal, grains, fertiliser, steel, forestry products, and a host of other dry bulk cargoes. Some of this trade is seasonal (such as grains), but much is also widely dispersed—i.e. the same dry bulk commodities are produced in and exported from many parts of the world, and imported by and consumed in many parts of the world. The fluidity of trade means that most of the bulk carrier fleet undertakes 'tramp shipping'—sailing on a flexible and unscheduled basis all over the globe and potentially carrying a different cargo on each journey.

A green shipping corridor usually relies on persistent demand along a consistent trade route. This is less common in dry bulk shipping compared with other sectors. Fortunately, the trade in iron ore—the largest dry bulk trade by volume—offers one such opportunity. This commodity is mainly mined in Brazil and Australia, and China is by far the biggest importer. To take advantage of economies of scale, the cargo is shipped on large bulk carriers, the very largest of which are typically secured under long-term charters by iron ore mining companies.

Figure 41: Major iron ore exporting and importing nations



Source: *Clarksons SIN; 2023 trade figures*

Two green shipping corridor projects have formed around the iron ore trade to date: Australia to East Asia and South Africa to Europe. One challenge faced by the stakeholders of these projects is that iron ore is a relatively low value product (a challenge common to the many dry bulk commodities that are simply unrefined raw materials), although a higher value copper concentrate trade from Chile to Asia has formed the basis for another green shipping corridor project. These initiatives have convened participants from across the value chain.

The members of the Australia to East Asia iron ore corridor consortium are large-scale export-oriented mining companies and shipowners/operators, supported by a wider taskforce that include energy producers, classification societies and an Australian port authority[41]. The South Africa to Europe corridor seeks to tap into European demand for green steel by delivering zero emission shipments of iron ore. The consortium for this project includes a mining company, fuel producer, shipowner and port authority[42]. The Chile to Asia project is one in a network of green shipping corridor opportunities being assessed by the government of Chile—a country that has considerable potential to produce fuels from renewable energy[43].

In the dry bulk sector, there is the potential for green shipping corridors to form wherever the circumstances—practical and commercial—are conducive. As the current roster of projects indicates, corridors could be instigated by different parties to meet differing aims. For instance, a large-scale dry bulk exporter may form a green shipping corridor using a small portion of the fleet it controls to pool overcompliance across its whole shipping operation (in a similar approach to a liner company). Alternatively, a corridor may be driven by a customer's willingness to pay for green shipping, or it may be supported by a government to catalyse demand for domestic e-fuel projects. The primary objectives of a corridor can affect the manner in which its business case is assessed.

Division of responsibility for ship and fuel adds complexity to an otherwise simple value chain

The dry bulk value chain is underpinned by the sales agreement between a cargo owner (which could be a commodity producer or a trader) and a customer. This could take the form of a long-term offtake agreement (where prices could be negotiated quarterly or annually), a short-term contract (less than one year), or the spot sale of a single cargo. The terms of the sale agreement will stipulate which party is responsible for shipping.

If the corridor has been instigated by a customer's willingness to pay for green shipping, then if the cargo owner is responsible for shipping, the associated costs can be passed through to the customer via the sales agreement. However, the duration of that agreement will need to be sufficient (for example, commensurate with the length of the e-fuel offtake agreement). If there is little or no willingness to pay for green shipping from the customer, the corridor will need to rely on an internal business case or some form of external support.

[41] GMF: Western Australia and East Asia iron ore green shipping corridor feasibility assessment

[42] GMF: Maritime, mining, steel, and energy industry leaders join forces to develop green corridor between South Africa and Europe

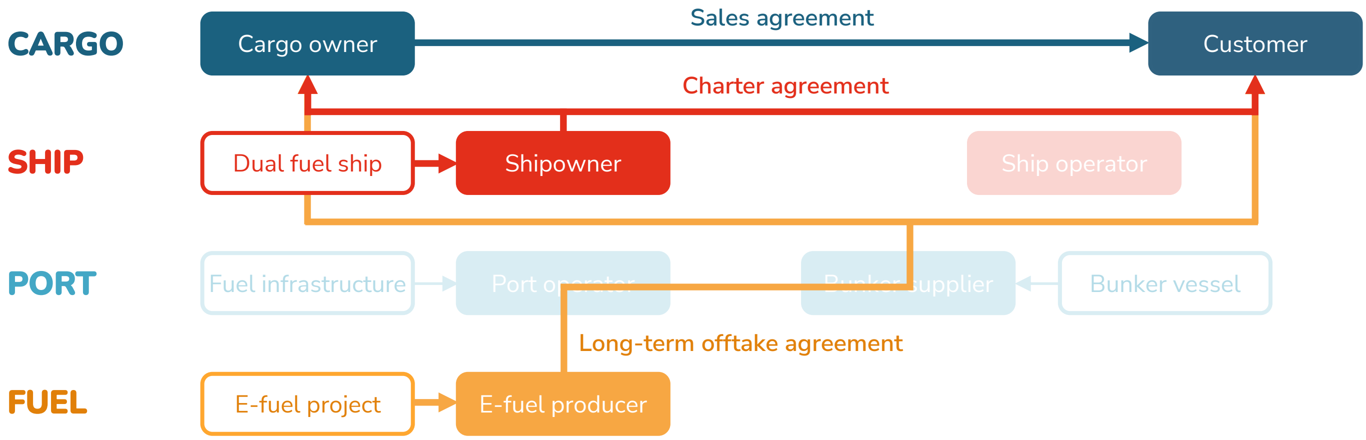
[43] MMMCZCS: The Chilean Green Corridors Network Pre-Feasibility Study Summary

Table 3: Points of investment and cost passthrough mechanisms along a dry bulk green shipping corridor value chain

Investment	Cost passthrough mechanisms
E-fuel offtake agreement	Under a ship charter agreement, the charterer is responsible for bunker fuel costs. This entity could be the cargo owner, the customer, or a ship operator. However, in the absence of supportive policies that can overcome the issue of credit quality (for example, some form of credit guarantee), the cargo owner or customer may more likely be in a position to commit to an e-fuel offtake agreement. The degree to which associated costs can be passed through the value chain depends upon the customer's willingness to pay for green shipping.
Bunker fuel storage and supply at port	Once again, the utilisation of infrastructure and assets at ports will be key to minimising last mile costs for e-fuel bunkering. One advantage in this sector is that bulk carriers spend more time at berth as it takes longer to load and discharge cargo that a containership for example. This could make bunkering services easier to manage efficiently. However, green shipping corridors in the dry bulk sector may more easily form in locations where bunkering solutions benefit from demand aggregation (for example, using bunker hubs linked to other corridors) or where e-fuel export or import infrastructure has been built at the port.
Dual fuel bulk carriers	Large entities such as major mining companies or agriproduct traders may own bulk carriers but will typically supplement capacity through charters. Where the ship is not directly owned, it will need to be chartered, either from a shipowner or via an intermediary ship operator. Depending on the terms of the sales agreement, the charterer may be the cargo owner or customer. Given the uncertainty around how widely available alternative fuels will be in the future, shipowners will be concerned about the residual value risk linked to the dual fuel capability and so will seek a charter of sufficient duration and premium to mitigate some of this exposure. Such agreement may be easier to reach on the trades and routes that already support long-term chartering and/or sales agreements.

The dry bulk value chain ensures a direct commercial link between the cargo owner, customer and a dedicated ship which transports the cargo. However, the delineation between the entities responsible for the investment in the ship (the shipowner) and the cost of the bunker fuel (the charterer), adds complexity to a green shipping corridor, particularly as the long-term commitments that would be required in such a project are uncommon in the bulk carrier sector. The commercial challenges faced in forming a green shipping corridor across this value chain will be similar whether the cargo owner or customer acts as charterer.

Figure 42: Indicative commercial agreements in green shipping corridor value chain in the dry bulk shipping sector



Chartering strategy will need to accommodate a long-term commitment and premium

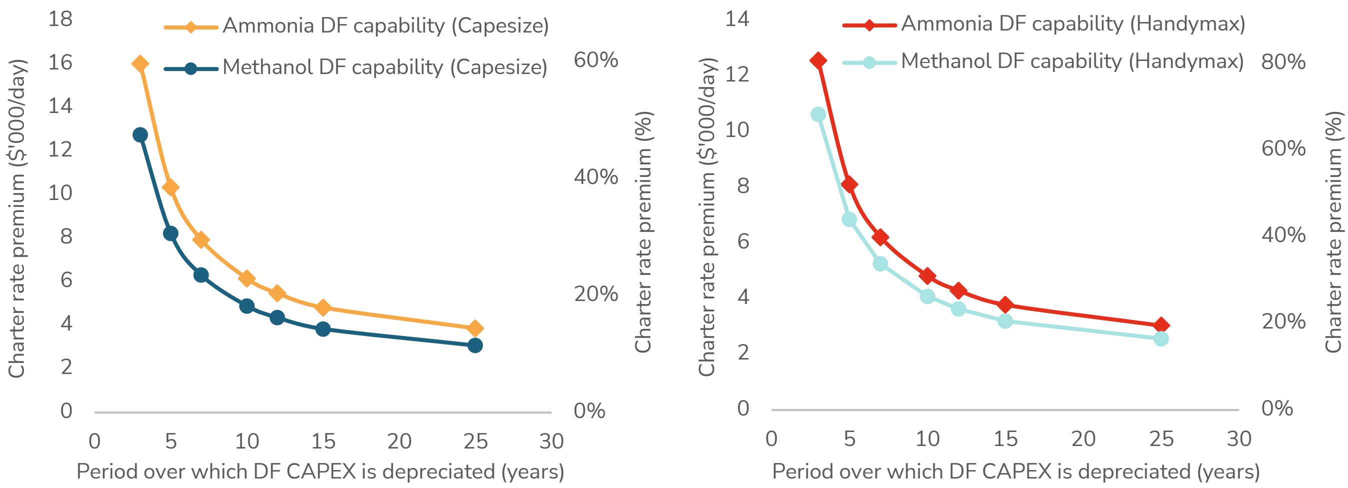
The bulk carrier fleet is largely standardised with discrete size bands that dictate the range of cargoes and types of ports that ships generally trade in. Large bulk carriers transport iron ore and sometimes coal between a limited number of ports; smaller ships carry more diverse cargoes and trade much more widely. Given the size of the fleet and generic design of bulk carriers, the charter market is liquid and long-term charters are uncommon, with the largest iron ore carriers being a notable exception. Other bulk carriers are chartered on periods that typically range from 2 to 24 months, or the ships can be operated on a voyage-by-voyage basis by shipowners.

The second-hand sales market for bulk carriers is also liquid, with ship prices linked to short-term charter rates. Therefore, when a shipowner assesses the terms under which it would be willing to supply a dual fuel ship, the charter rate and duration sought will 1) indicate proportion of the capital cost of the dual fuel capability depreciated over the charter period; and 2) reflect the shipowner's view of the relative worth of that capability at the end of the charter, i.e. the residual value.

As bulk carriers trade so widely, shipowners will be concerned about future access to suitable fuels. Although the ability to use a range of low emission fuels mitigates this risk, the shipowner may seek a longer charter (with a correspondingly smaller premium) to increase the likelihood that alternative fuels will be widely distributed at the end of the charter. This assessment may vary by ship size—large bulk carriers trade between ports that are big enough to accommodate them and such ports may gain access to alternative fuels before smaller ports.

Another drawback is that bulk carriers are simple ships that are relatively cheap to build. The current newbuild price of a Capesize bulk carrier (a large ship which carries iron ore) is about $75 million. The price of the largest containership, which can carry roughly the same weight of cargo as a Capesize bulk carrier, is currently just over $235 million. As a consequence, the premium required to depreciate the capital cost of the dual fuel capability is proportionally higher in the dry bulk sector. Smaller bulk carriers (such as the Handymax) will be further disadvantaged as dual fuel capital costs will not scale linearly with a ship's cargo carrying capacity.

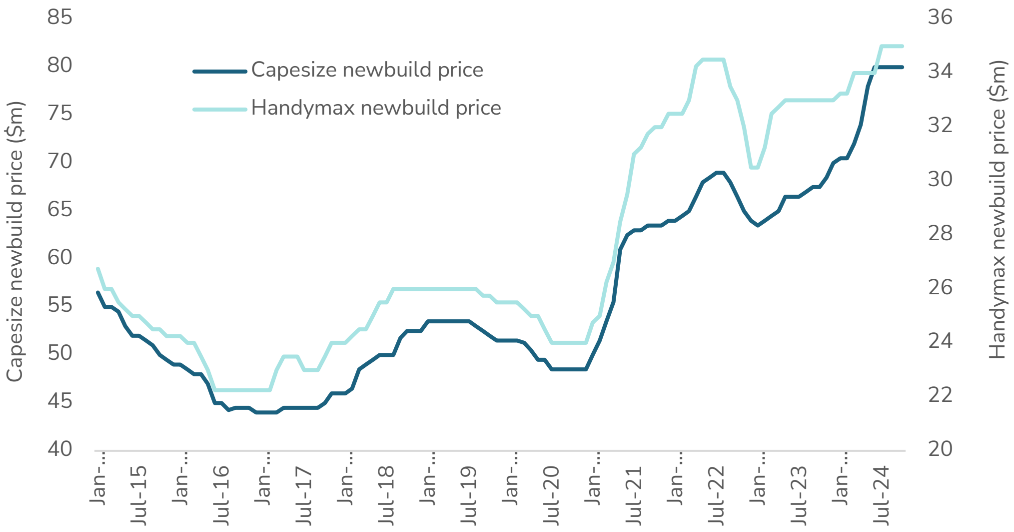
Figure 43: Indicative charter rate premium for capital cost of dual fuel capability depreciated over range of timescales



Note: *Based on newbuild price for 210,000 dwt Capesize and 64,000 dwt Handymax bulk carriers; indicative dual fuel capital costs derived from LNG dual fuel prices. Ship cost assumptions are detailed in the Appendix.*

An additional cost pressure is the price inflation for new ships seen over the last few years. This has resulted from rises in input (steel) and labour costs, as well as the increased pricing power of shipyards which have been filled with orders for new containerships and LNG carriers. Over the last four years, price of a new Capesize ship has grown by over 50% and by almost 40% for a Handymax ship.

Figure 44: Newbuild price for Capesize and Handymax conventional (non-dual fuel) bulk carriers



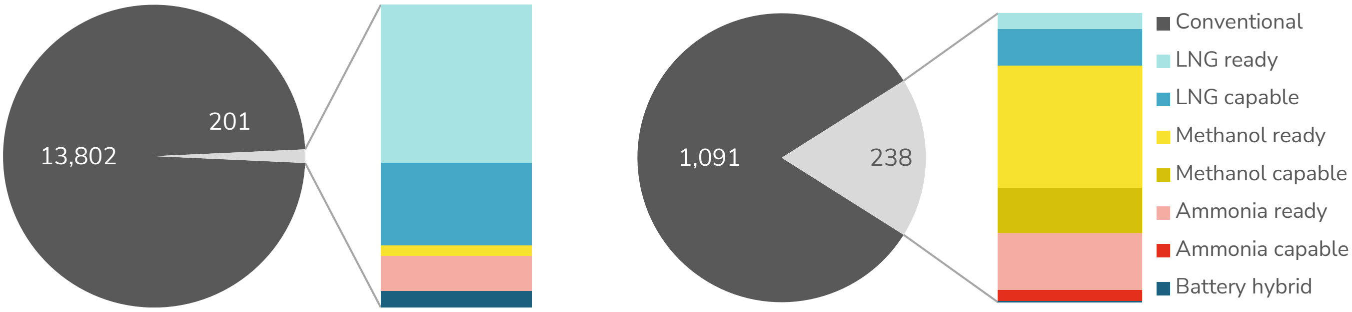
Source: *Clarksons SIN*

Supply and demand for shipping capacity sets the level for short-term charter rates in the market which, in turn, determines the value (adjusted for age) of existing ships. With both the earnings potential and value of a ship linked to the short-term charter market, a period of rapid inflation in the price of new ships can make near-term investment decisions more challenging, particularly as the supply-demand driven cyclicality of the market means that such inflationary effects are not smoothly absorbed into the market.

A new conventional ship ordered today will generate the same revenue as a slightly older peer which was considerably cheaper to build. Both ships will be valued on the same terms (albeit adjusted for age), meaning that the return on investment for the newer ship will be lower. However, building new ships with dual fuel capability could possibly begin to introduce a degree of differentiation into the charter markets that might provide shipowners with an opportunity to access a charter rate premium over conventional ships. With sufficient tightness in this new tier of the shipping market, charter rates could reflect the recent rises in the price of the underlying ship, as well as the cost of the dual fuel capability.

The more positive the outlook held by the shipowner on the future value of its dual fuel investment, the more prepared it will be to take residual value exposure at the end of an initial charter. Such charters have been thin on the ground, however, which means that the adoption of dual fuel capability has been minimal to date. Some dual fuel bulk carrier orders can be linked to charterers such as mining companies, steel producers and agriproduct traders, but greater emphasis has been (and is continuing to be) placed on the future optionality offered by dual fuel 'readiness' instead. With more than 85% of the orderbook filled with conventional ships, the indications are that early compliance in this sector will be largely met with drop-in blended biofuels or through the purchase of overcompliance credits (or internal pooling, potentially from other shipping sectors, if this is an option for the charterer or ship operator).

Figure 45: Fuel capability of bulk carrier fleet (left) and orderbook (right)



Source: *Clarksons SIN as of October 2024 for bulk carrier fleet and orderbook of ships over 10,000 dwt.*

Alternative approaches could be employed to build the business case for dry bulk corridors

The impetus behind a green shipping corridor could influence how the incremental costs associated with the commitment to run a shipping route entirely on e-fuels might be evaluated. For instance, in a similar manner to a liner company, the entity responsible for shipping in a dry bulk value chain may adopt a strategy to achieve compliance across all the ships it owns and/or operates by internally pooling overcompliance from a subset of this fleet. In this situation, as in the previous case study, a reasonable comparison would then be between a single ship complying by using e-fuels versus a ship meeting compliance through the lowest cost fuels (on a cost of abatement basis).

Alternatively, a green shipping corridor may be instigated by a purpose or aim that does not involve meeting compliance. For example, a project could be formed with the ambition to entirely decarbonise a specific shipping route (i.e. in excess of the emissions reduction required by regulation). In this case, the cost of a ship running entirely on e-fuels should be compared to that of a ship complying by using the lowest cost fuels.

In practice, the assessment of the business case for a green shipping corridor may fall somewhere in between these two approaches. A project may combine a degree of willingness to pay from a customer for green shipping with the opportunity to pool internal overcompliance but, for example, at a cost which exceeds the price at which external credits to meet compliance could be acquired. However, even where the ambition behind a green shipping corridor exceeds near-term compliance, the longer-term trajectory of regulation will need to be factored into any investment decision, given the long economic life of the infrastructure and ships involved.

To illustrate the two approaches to evaluating potential green shipping corridors in this sector, eight TCO scenarios have been modelled with two alternative green shipping corridor options for the ammonia and methanol dual fuel bulk carriers. The first represents a similar approach to that taken in the container shipping sector, i.e. compliance by a single ship using e-fuels has been used as a proxy for compliance across a fleet (achieved via overcompliance and pooling). The second option reflects the full cost of running a ship entirely on e-fuels, without leveraging the opportunity to internally pool or externally monetise overcompliance.

Two sizes of bulk carrier—Capesize (210,000 dwt) and Handymax (64,000 dwt)— with four fuel capabilities (conventional and dual fuel LNG, methanol and ammonia) using eight fuel options have been modelled. It has been assumed that LSFO, biodiesel, LNG and blue ammonia are available on a sport basis. Biomethane, biomethanol, e-methanol and e-ammonia have been assessed on the basis that incremental volumes each year are secured through 10-year offtake agreements.

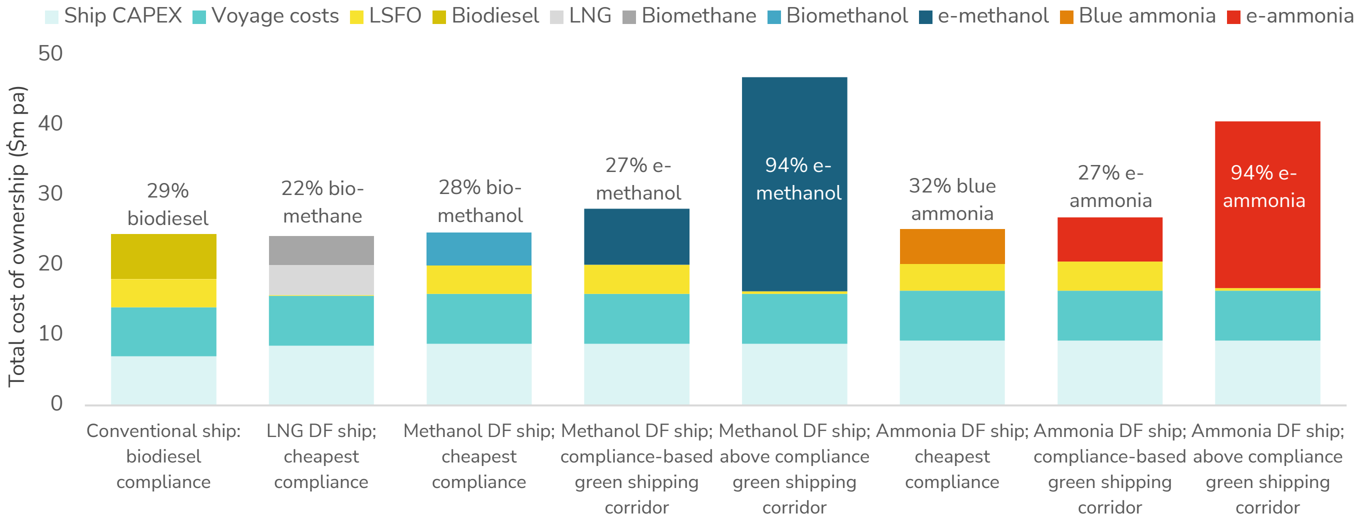
1. **Conventional ship; biodiesel compliance:** A conventional bulk carrier running on biodiesel blends to meet compliance.
2. **LNG dual fuel ship; cheapest compliance:** A dual fuel LNG bulk carrier running on the lowest cost fuel mix (from a choice of LSFO, biodiesel, LNG and liquified biomethane) to meet compliance.
3. **Methanol dual fuel ship; cheapest compliance:** A dual fuel methanol bulk carrier running on the lowest cost fuel mix (from a choice of LSFO, biodiesel, biomethanol and e-methanol) to meet compliance.
4. **Methanol dual fuel ship; compliance-based green shipping corridor:** A dual fuel methanol bulk carrier running on e-methanol to meet compliance as a proxy for running entirely on e-methanol and pooling overcompliance.
5. **Methanol dual fuel ship; above compliance green shipping corridor:** A dual fuel methanol bulk carrier running entirely on e-methanol.
6. **Ammonia dual fuel ship; cheapest compliance:** A dual fuel ammonia bulk carrier running on the lowest cost fuel mix (from a choice of LSFO, biodiesel, blue ammonia and e-ammonia) to meet compliance.
7. **Ammonia dual fuel ship; compliance-based green shipping corridor:** A dual fuel ammonia bulk carrier running on e-ammonia to meet compliance as a proxy for running entirely on e-ammonia and pooling overcompliance.
8. **Ammonia dual fuel ship; above compliance green shipping corridor:** A dual fuel ammonia bulk carrier running entirely on e-ammonia.

As bulk carriers are relatively cheap ships to build, the dual fuel capability forms a higher proportion of the overall cost. The impact of this additional capital cost is heightened if it is depreciated over a period shorter than the economic life of the ship. In the scenarios modelled, it has been assumed that charterer offers the shipowner a charter of 10 years (i.e. commensurate with the offtake agreement), and that the shipowner seeks to depreciate the dual fuel investment fully over that period. On this basis, during the initial charter period, dual fuel Capesize bulk carriers have an annualised capital cost that averages 30% higher than the cost of a conventional ship; for a Handymax bulk carrier it averages 50% higher.

The breakdown of the 2030 TCO for the Capesize bulk carrier illustrates the relative impact of the investment in dual fuel capability as a proportion of the capital cost of the ship and the overall TCO. This cost could be reduced through the charterer's commitment to a longer charter, which would allow the dual fuel investment to be depreciated over a long period, and thus result in a lower the charter rate premium.

The comparative TCOs also clearly highlights the near-term challenge for green shipping corridors that aim to use e-fuels to entirely decarbonise a specific route or supply chain without leveraging the opportunity to pool overcompliance across other ships. For above-compliance green shipping corridors, the fuel cost gap over the short-to-medium term presents a more significant hurdle than the capital cost of the dual fuel capability.

Figure 46: Breakdown of 2030 TCO for Capesize bulk carrier with proportion of low emission fuel used shown as % of GJ



Note: *Based on 210,000 dwt Capesize bulk carrier sailing between Australia and East Asia consuming approximately 9,100 tonnes LSFO equivalent per annum. Cost assumptions are detailed in the Appendix.*

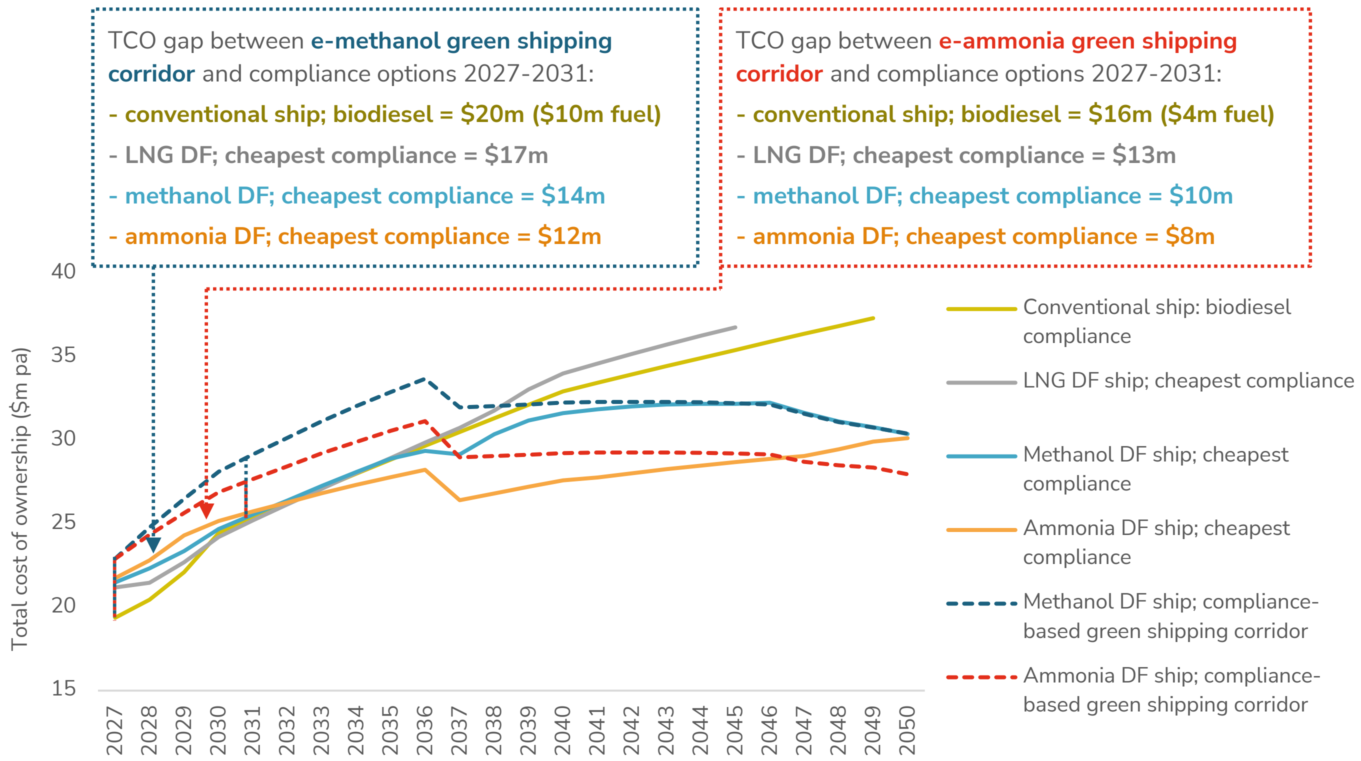
Compliance-based corridors in dry bulk sector would need to target large ships on long routes

A green shipping corridor in the bulk carrier sector could effectively be formed by a strategy to deliver fleet-wide compliance through the overcompliance of a small number of ships using e-fuels on a dedicated route. This could arise where the entity which acts as the charterer (or ship operator) in the value chain controls a fleet large enough to enact such a strategy. In this situation, the cost premium associated with the green shipping corridor would then be assessed in relation to cheaper modes of compliance.

For a charterer or ship operator wishing to adopt a strategy based on the internal pooling of overcompliance, as the capital cost of dual fuel capability is likely to be proportionally higher in smaller ships, the most optimal solution would be to introduce dual fuel capability onto the largest ships with the highest annual fuel consumption. This approach minimises the capital cost of the dual fuel capability (and thus the average cost of compliance) for each GJ of low or zero emission fuel used. In the dry bulk sector, large iron ore carriers are an obvious candidate. As these ships sail long distances between a large ports the logistical and last mile cost challenges associated with fuel provision could be mitigated by choosing to bunker at ports that benefit from aggregated sources of demand.

Over the initial five-year period, the TCO and fuel cost differentials between the Capesize bulk carrier running on e-fuels and the cheapest compliance option—a conventional ship using biodiesel to comply—indicates that the capital cost of the dual fuel capability is a near-term hurdle. However, this cost gap will be an overestimate as the approach of using compliance on a single ship basis as a proxy for the average TCO of the pool of ships across which overcompliance is balanced, assumes that all non-complying ships also bear the capital cost of dual fuel capability. This effect is heightened in the near term when the greatest number of ships are offset.

Figure 47: TCOs for compliance-based corridors versus cheapest compliance and total cost gap over initial 5-year period



Note: *Based on 210,000 dwt Capesize bulk carrier sailing between Australia and East Asia consuming approximately 9,100 tonnes LSFO equivalent per annum. Cost assumptions are detailed in the Appendix.*

A global fuel standard that targets support at e-fuels through a multiplier could help bridge the overall TCO gap and thus offer support for the investment in the dual fuel capability, as well as closing the fuel cost differential. Over the first five years, the premium for using e-fuels versus the lowest cost option averages 16% for e-methanol and 13% for e-ammonia. A multiplier of x2.0 would bring e-methanol to parity with the lowest cost alternative over this period; a multiplier of x1.5 would be sufficient for e-ammonia.

Green shipping corridors motivated by ambition to exceed compliance will come at a higher cost

In green shipping corridor projects that are motivated by an ambition that exceeds the level of emissions reduction enforced by regulation, the largest factor driving the cost gap (versus the cheapest form of compliance) will arise from not utilising the subsequent overcompliance to offset non-complying ships (whether through internal pooling or external trading). However, if this trade route or supply chain is completely decarbonised from the outset, this cost gap will also be compounded by the initial commitment to an e-fuel offtake agreement that is not subsequently diluted by adding further volumes at lower cost over time (i.e. the type of incremental portfolio that would be adopted under a compliance-based strategy).

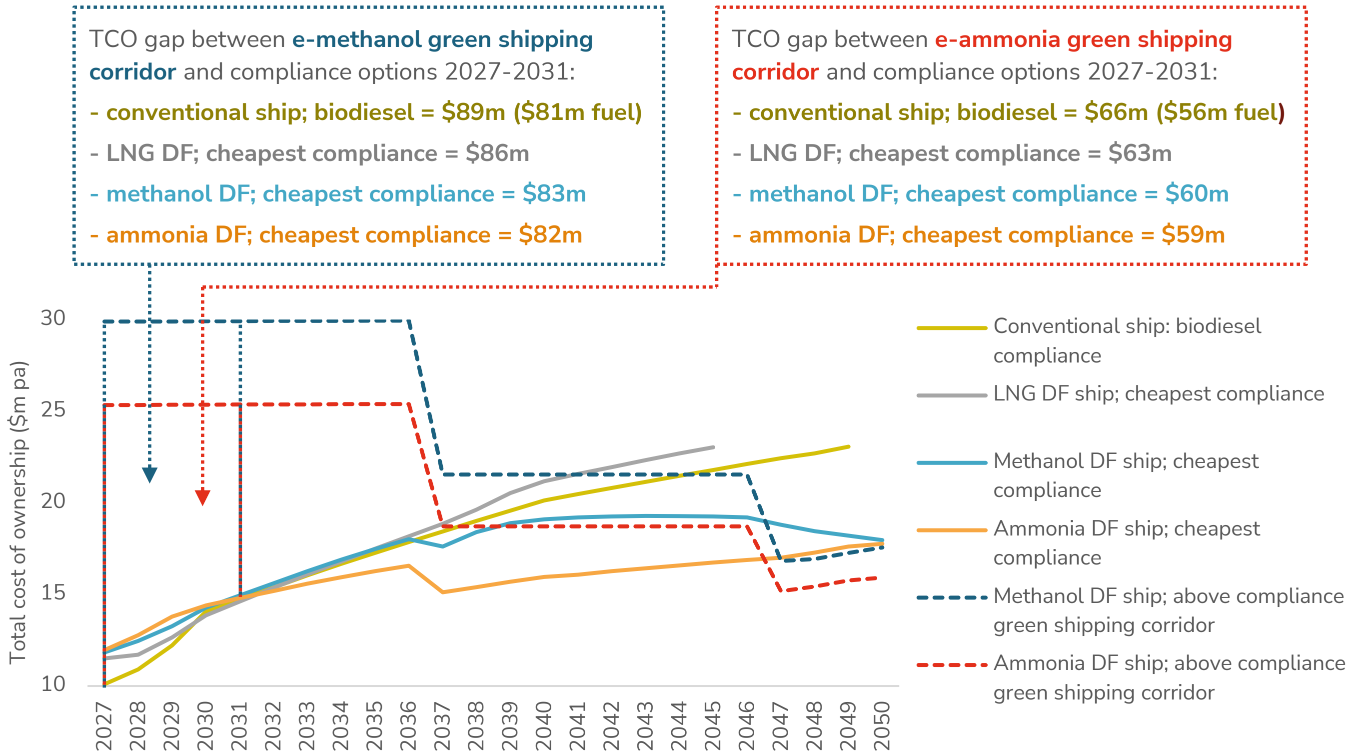
Such projects can still be viable opportunities if customer willingness to pay or forms of external support can be leveraged, though this may occur in more niche trades or to deliver specific objectives.

Projects that aim to entirely and immediately decarbonise a supply chain could form in high-value trades

Given the scale of the iron ore trade, the types of entities involved, and the size of the fleet under their control, green shipping corridors involving Capesize bulk carriers are more likely to emerge from compliance-based strategies. Projects that aim to entirely and immediately decarbonise a specific supply chain may instead develop in smaller niche trades, particularly if related to cargoes of high value and/or able to attract a green premium (such as an input into green steel manufacturing).

The proposed green shipping corridor based on the trade in copper concentrate—a high value cargo—transported by smaller Handymax bulk carriers between Chile and East Asia offers one such opportunity. The TCO calculations below reflect the indicative cost of fully decarbonising just one ship in that trade, but the spread between the green shipping corridor and compliance options effectively represents the relative cost of entirely decarbonising the whole supply chain in 2027, i.e. the highest possible cost gap for this corridor.

Figure 48: TCOs for above-compliance corridors versus cheapest compliance and total cost gap over initial 5-year period

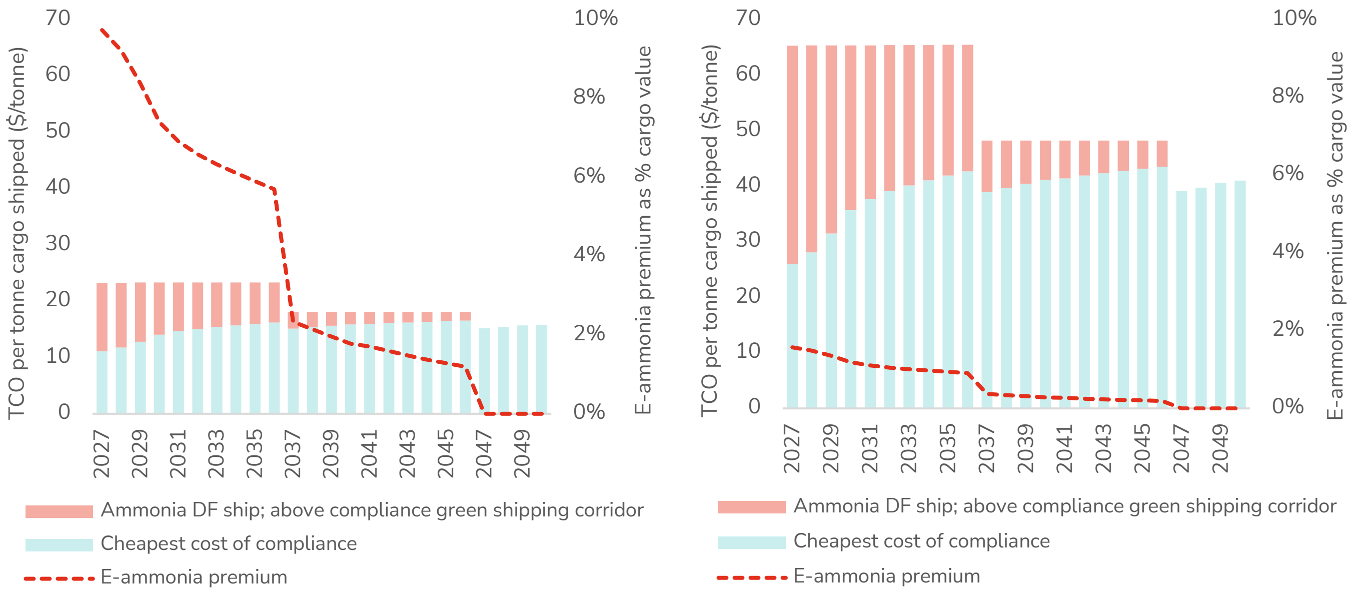


***Note:** Based on 64,000 dwt Handymax bulk carrier sailing between Chile and East Asia consuming approximately 6,500 tonnes LSFO equivalent per annum. Cost assumptions are detailed in the Appendix.*

The high fuel costs locked in by the initial 10-year e-fuel offtake agreements are only marginally offset as compliance increases over this period. Only after the first offtake agreement is renewed, do the green shipping corridor TCOs start to align with compliance costs. This emphasises the challenge for a green shipping corridor business case that does not involve any ratcheting up of demand for e-fuels over time and instead relies on a single offtake agreement that is renewed every ten years or so. In practice, even in small-scale green shipping corridor projects, a ramp up of demand for e-fuels may be possible, which will allow them to derive some benefit from a weighted average fuel cost.

The advantage of the trade in copper concentrate is that it is a high value cargo and an essential commodity within the context of the energy transition. The price spread between copper concentrate and iron ore will depend on the grades of the ores and current market prices, but the former is roughly twenty times the value of the latter on a per tonne basis. This means that although the smaller Handymax bulk carriers have a higher cost of shipping on a per tonne of cargo basis when compared with the Capesize bulk carriers, the additional cost associated with switching to e-fuels over the lowest cost of compliance, is far less as a proportion of the cargo value and so customers may be willing to pay this premium.

Figure 49: Indicative premium for e-ammonia use as % of cargo value for iron ore (left) and copper concentrate (right)



__Note:__ Chart on left based on 210,000 dwt Capesize bulk carrier sailing between Australia and East Asia consuming approximately 9,100 tonnes LSFO equivalent per annum; assumes iron ore price of $125/tonne. Chart on right based on 64,000 dwt Handymax bulk carrier sailing between Chile and East Asia consuming approximately 6,500 tonnes LSFO equivalent per annum; assumes copper concentrate price of $2,500/tonne. Other cost assumptions detailed are detailed in the Appendix.

Potential application of a targeted demand-side CfD for e-fuels that adjusts to match compliance

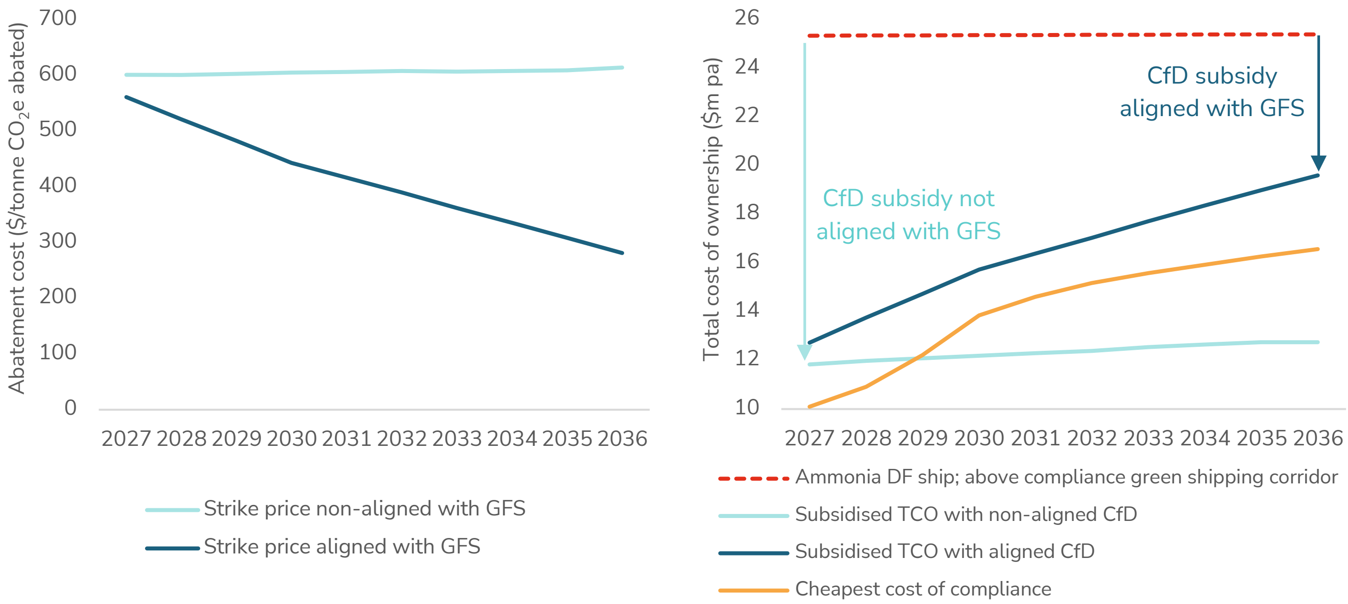
High-ambition green shipping corridors could potentially lobby governments for targeted demand-side support. There could be several reasons why such support may be extended—for example, governments may wish to build a demand base for the domestic production e-fuels, secure strategic trade links, or advance innovation in the domestic maritime sector. The supportive measure could take the form of a fixed or variable subsidy, with a CfD mechanism possibly used for the latter.

A fixed subsidy is a form of support that will be more viable for a green shipping corridor business case that does not have exposure to competitors operating at a compliance-level cost basis. For example, it could be offered to ship operators that provide dedicated cargo shipping or passenger services on specific routes. Where the corridor functions within a competitive market, a CfD that is (for example) referenced against the price of LSFO, would not only bridge the fuel cost gap (either entirely or in part), but it would also ensure that the subsidised cost would fluctuate in tandem with the fuel price experienced by the rest of the market, thereby keeping the playing field level.

However, any CfD offered to the shipping industry will need to incorporate the impact of increasing compliance and reflect that LSFO will account for a decreasing proportion of the fuel mix of those competitors. One way to do this would be to apply the strike price on a cost of abatement basis and then align it with the reduction in emissions intensity stipulated by the fuel standard. This would convert the CfD into a mechanism that resembles a carbon contract for difference (CCfD), except the reference would continue to be the price of LSFO rather than a carbon price.

As an example, based on the fuel cost estimates used in this report, the cost of abatement for using e-ammonia (at the 2027 offtake price) versus LSFO is approximately $600/tonne of CO_2e abated. A CfD which fully subsidises the fuel cost gap between the price of e-ammonia and LSFO over the initial 10-year offtake agreement requires a subsidy of $130 million and, as it does not account for the increasingly stringent emissions intensity limit, the CfD reduces the TCO below that of the lowest cost of compliance from 2029 onwards. On the other hand, a CfD that is aligned with a global fuel standard will entail a subsidy of $89 million.

Figure 50: Example of a compliance-aligned CfD mechanism—strike prices (left) and impact on TCO (right)



Note: *Strike price based on 2027 e-ammonia offtake cost. Cost and emissions intensity assumptions are detailed in the Appendix.*

Both forms of the CfD mechanism expose the charterer to LSFO price risk, although the relative exposure falls over time in a CfD aligned with a global fuel standard. If the price of LSFO remains below that of alternative low and zero emission fuels, an aligned CFD would effectively bring the cost of an above-compliance green shipping corridor (i.e. one running entirely on e-ammonia) down to the level of a compliance-based corridor (i.e. one that meets compliance using e-ammonia), with a similar premium over the lowest cost compliance option. With a higher LSFO price, the subsidy received from both forms of the CFD will decrease. If the price of LSFO rises above that of a viable alternative fuel (for example, blue ammonia), then the lowest cost option will benefit from a switch away from LSFO, reducing this TCO relative to that of the aligned and non-aligned CFDs.

Conclusion

Green shipping corridors face significant commercial challenges. In the absence of regulation or support by governments, the burden of investment has fallen on a private sector that, under current business models, does not have sufficient ability or appetite to meet. However, this is changing. The EU's 'Fitfor55' package and the IMO's upcoming mid-term measures will mandate and incentivise shipping's energy transition. Government funding for low emission fuel projects—most notably through the US Inflation Reduction Act—has started to flow, along with a growing recognition of the need for demand-side support. In combination, such measures could help crystallise the business case for green shipping corridors.

Cost gap faced by green shipping corridors is reduced but not eliminated by current and anticipated policies

This is the first study of its kind to assess the commercial viability of green shipping corridors using e-fuels under the combined effects of the IMO's mid-term measures, the EU ETS and the US IRA—and to offer insight into the factors which may direct stakeholders in the value chain to invest in such projects. The baseline TCO analysis applies a conservative assumption about future IMO policy by modelling a global fuel standard with a flexibility mechanism which allows for the internal pooling or external trading of overcompliance. However, even with the effects of the EU ETS and US IRA applied—and with the assumption that biofuel costs will trend towards the high penalty cost of non-compliance with FuelEU Maritime by 2030—the cost gap persists in the near term, and so further supportive measures to encourage the early adoption of e-fuels, such as pooling multipliers and CfDs, have also been explored.

The IMO's fuel standard combined with only a flexibility mechanism is unlikely to lead to green shipping corridors before 2040

The IMO's global fuel standard will set a minimum level of compliance that can only be met through the use of lower emission fuels. Accordingly, the business case for 'above compliance' green shipping corridors (i.e. those running entirely on e-fuels) will improve under this policy but will rely on additional support to bridge the significant remaining cost gap compared with the lowest cost of compliance. However, this premium decreases over time as the compliance requirements increase and should eventually close during the 2040's when the fuel standard stringency approaches the emissions intensity of e-fuels.

If the fuel standard includes a flexibility mechanism that allows for overcompliance by one ship to offset non-compliance by others, then 'compliance-driven' green shipping corridors could emerge with ships running entirely on e-fuels offsetting non-compliant ships. In this scenario, there is still a premium associated with the green shipping corridor, but it is far lower—it is the difference between the average cost across the pooled ships of meeting compliance using e-fuels versus the cheapest compliance solution. However, the TCO analysis indicates that in this scenario, while ammonia dual fuel ships deliver the lowest cost of compliance option by the early 2030s, blue ammonia continues to out-compete e-ammonia until the early 2040s.

Even when an IMO fuel standard is combined with the EU ETS and US IRA, compliance-driven green shipping corridors are unlikely to form

The EU ETS narrows the cost gap between an above compliance green shipping corridor running entirely on e-fuels and the cheapest compliance solution by increasing the cost of the fossil fuels used in the latter option. However, the incentive does not fully cover the higher cost of e-fuels. For compliance-driven corridors, the ETS has zero impact if the ships offset have the same proportion of EU trading as the emissions from compliant ships—whether pooled or not—is the same, regardless of the type of low emission fuel used. Only if the offset ships do not trade within the EU, will there be a marginal cost saving secured by the over-complying ship. This could lead to a concentration of low emission fuel use in Europe as a way to maintain compliance with the IMO fuel standard while minimising exposure to the EU ETS.

The US IRA subsidies for e-fuels narrows the cost premium for both types of corridors. However, the subsidies for blue ammonia could also extend the competitiveness of this fuel (over e-ammonia) into the mid-to-late 2040s. In combination with the IMO's fuel standard, the US IRA looks unlikely to enable green shipping corridors before that date.

Remaining cost gap could feasibly be closed through support for e-fuels and business models that account for escalating compliance

The TCO analysis in each sector indicates that a cost gap persists between both the above compliance and compliance-driven green shipping corridors, versus the lowest cost compliance options. From a policy standpoint, the solutions explored for bridging this gap included the introduction of a pooling multiplier on the number of ships offset by overcompliance through e-fuels and supportive measures such as CfDs and e-fuel auctions. The cost gap could also be closed through the use of a 'reward' or other direct subsidy on the use of e-fuel, which could be generated from GHG pricing.

From the industry's perspective, the required level of customer willingness to pay for an e-fuel premium over and above the cost of compliance was assessed, along with reasons as to why shipowners might order dual fuel ships, and why operators and cargo owners might commit to e-fuel offtake over the near term as part of their bunkering strategies. While the business case for green shipping corridors will remain challenging, the analysis highlights that targeting additional support at e-fuels and recognising the implications of tightening compliance and an evolving fuel landscape within the business model can result in a cost gap that may be more surmountable than is often characterised or perceived.

Cases studies explore how green shipping corridors could be realised through public and private action

A conservative policy scenario that applies a global fuel standard from the IMO and (where applicable) leverages existing support measures (EU ETS and US IRA) is modelled across three different sectors that have promising potential for green shipping corridor projects. Each case study highlights the steps that could be taken—in terms of both supportive policies and through industry action—to maximise the opportunity for early adopter projects to be realised.

Gas carriers offer an ideal opportunity for green shipping corridor projects to form around an emergent trade in e-ammonia

The trade in e-ammonia cargoes presents a low-barrier opportunity for green shipping corridor projects to form. Key elements supporting the business case include:

1. No requirement for a separate bunker offtake agreement
2. The terms of the offtake agreement may be more favourable due to higher volumes or better credit quality
3. Supply and port storage infrastructure investment is underwritten by the e-fuel production and export project
4. No requirement for dedicated bunkering infrastructure

For a green shipping corridor to form, a portion of the cargo will need to be diverted for use as bunker fuel. The motivation to do so will vary depending on which entity in the value chain acts as the charterer and thus bears responsibility for bunkering costs.

If the e-ammonia producer is the charterer, the decision to use e-ammonia as a bunker fuel could be driven by a strategy to either meet compliance or to monetise overcompliance. The latter could provide the e-ammonia producer an alternative route to market, allowing them to indirectly sell uncontracted volumes into the shipping industry over the near term. A flexibility mechanism with a pooling multiplier supporting overcompliance through e-fuel bunkers would enhance and extend the viability of this opportunity.

If the e-ammonia customer is the charterer, then the decision to use e-ammonia as a bunker fuel may align with a commitment to fully decarbonise their supply chain, beyond regulatory compliance. The high value of the cargo may bring the relative cost premium within range of the customer's willingness to pay. Customers could also potentially benefit from demand-side support not available to the wider shipping industry, such as a Contract for Difference (CfD) that subsidises the cost premium over fossil fuel-derived ammonia (or natural gas). However, it is likely the customer will find it more beneficial (in terms of the amount of CO_2 abated and the cost of that abatement) to use the e-ammonia to replace fossil fuel-derived ammonia in its existing supply chain rather than use as bunker fuel.

Compliance-driven corridors could provide liner companies with the opportunity to build offtake portfolios to manage future fuel price risk

The container shipping sector has several characteristics supportive of green shipping corridor projects. Large liner companies possess the internal resources and capabilities to negotiate and manage offtake agreements. Their control over large fleets, operating on fixed routes under regular schedules, simplifies the logistics of establishing such corridors. Regulation could act as a key catalyst for the creation of green shipping corridors in this sector—a fuel standard with a flexibility mechanism could lead to the emergence of compliance-driven green shipping corridors, but only if liner companies opt to use scalable e-fuels over lower-cost alternatives.

Liner companies may choose to do so for a number of reasons. Accessing willingness to pay for green shipping is likely to be more challenging in a compliance regime. Customers who are willing to pay a premium for green shipping may be less inclined to do so if their goods are transported on an over-complying ship which is then used to offset a pool of non-compliant ships. To attract a premium for green shipping, liner companies could demonstrate that they have reduced emissions in excess of the level required by compliance, but a stronger claim could potentially be made through the use of e-fuels (even if at a scale that attains, rather than exceeds, compliance) compared to a greater use of less sustainable low emission fuels.

Alternatively, the decision could be triggered by a bunkering strategy intended to build a portfolio of offtake agreements to diversify the type, cost and source of bunker fuels over time as a means to managing future compliance as the regulation tightens and as a way to mitigate exposure to price spreads. However, this decision is made more difficult in the near term by a potential trade-off between securing low-cost, non-scalable fuels from biogenic sources before growing demand raises prices, and securing high-cost scalable e-fuels before increased supply drives prices down. Access to government auctions that resell e-fuels could bridge the cost gap between e-fuels and biogenic-derived alternatives over the medium term, helping to ensure that the weighted average cost of the fuel portfolio tracks falling e-fuel production costs. However, it may also expose the portfolio to renewal risks over the longer term.

Opportunities for compliance-driven and full green shipping corridors reside within portions of the bulk carrier sector

The bulk carrier sector offers fewer opportunities to form green shipping corridors. Much of the fleet (particularly the smaller dry bulk carriers) trades in a random and wide-ranging manner, under short-term charters, and carrying low-value cargoes. The substantial trade in iron ore—which is shipped on the largest bulk carriers on relatively few routes—presents one opportunity for establishing compliance-driven green shipping corridors. A large mining company could potentially underwrite an e-fuel offtake agreement and offer long-term charters to shipowners for dual fuel bulk carriers in order to manage compliance with an IMO fuel standard across its fleet. Again, the challenge will be the cost of using e-fuels compared to cheaper compliance options.

There could also be demand for the immediate decarbonisation of a supply chain beyond (or rather, ahead of) regulatory requirements—particularly in a high-value trade where a green premium is available. The trade in copper concentrate between Chile and East Asia on smaller bulk carriers could offer one such opportunity. Although the additional cost (over the lowest cost of compliance) of switching over to run entirely on e-ammonia is far greater per tonne of cargo on smaller bulk carriers compared with the far larger iron ore carriers, the premium as a proportion of cargo value is far lower.

This type of above compliance green shipping corridor would come at significantly higher cost compared to a compliance-driven corridor, as a larger quantity of e-fuels would need to be sourced from the outset. Moreover, without incremental offtake to create a weighted average cost portfolio and mitigate exposure to fuel price fluctuations, this type of supply chain would be more vulnerable to offtake renewal risk. Demand-side support measures, such as Contracts for Difference (CfDs), could help bridge the cost gap between e-fuels and fossil fuel bunkers, making these corridors more feasible. These measures could also be structured to adjust as the level of compliance set by regulation tightens.

Appendix: TCO model assumptions and variables

Fuel cost and emissions intensity and EU ETS allowance price assumptions

Figure 51: Fuel cost (left) and emissions intensity (right) curves

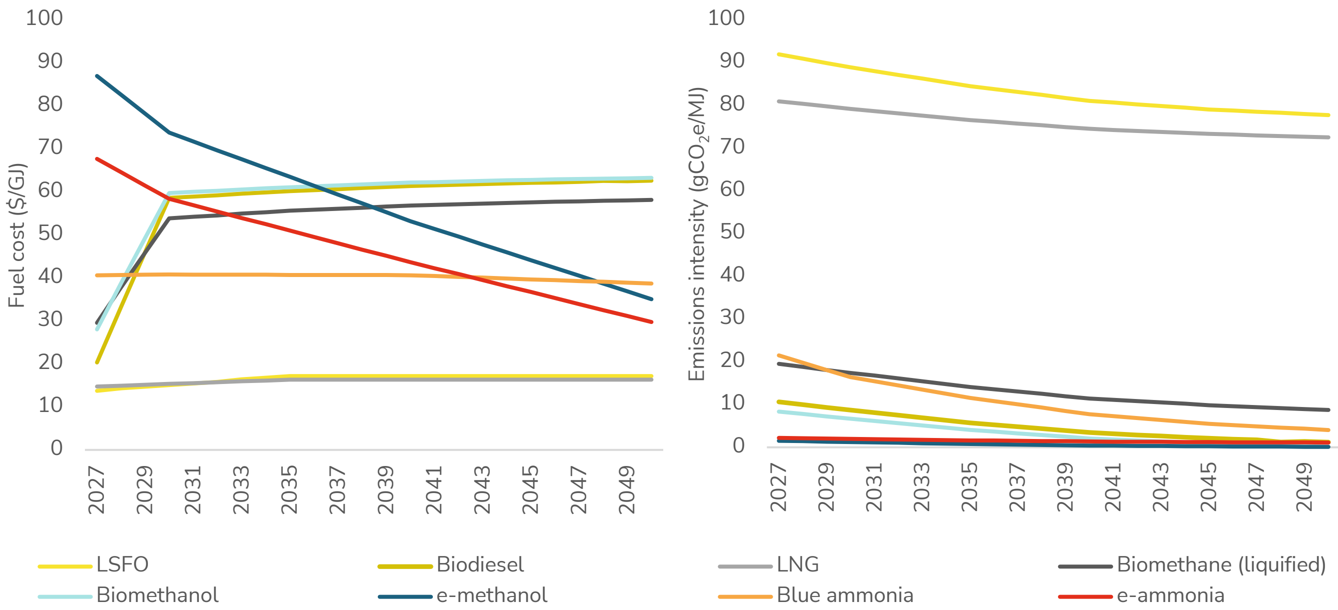
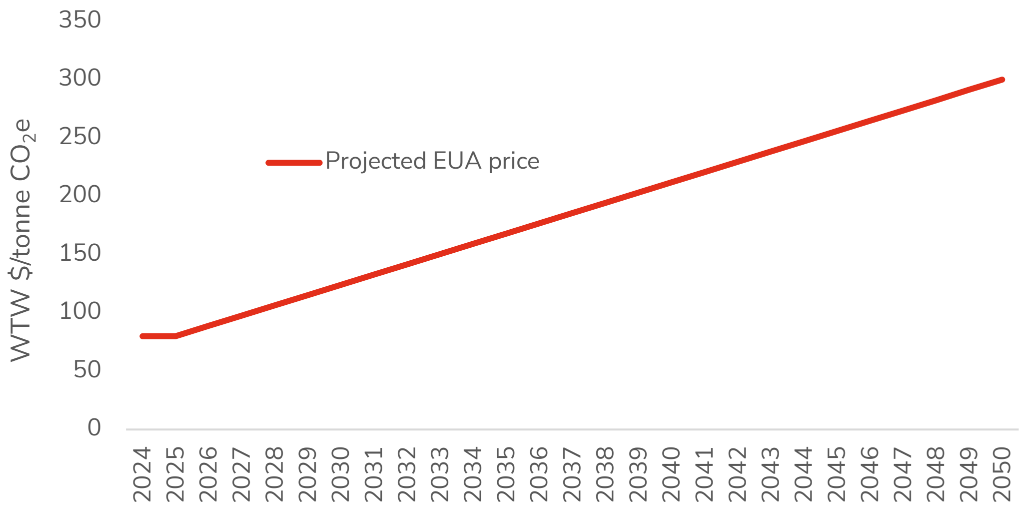


Figure 52: EU ETS allowance cost assumptions



Ship and voyage assumptions

Table 4: Ship and voyage assumptions underpinning TCO model

Variable	Unit	Case study 1	Case study 2	Case study 3a	Case study 3b
Vessel type		Gas carrier	Containership	Bulkcarrier	Bulkcarrier
Vessel size		45,000	24,000	210,000	64,000
Size unit		cbm	teu	dwt	dwt
Route		US-EUR	CHINA-EUR	AUS-CHINA	CHILE-JAPAN
No. of port calls per round trip	#	2	16	2	2
Avg. distance per round trip	miles	10,000	24,000	7,000	19,000
Avg. speed	knots	13.5	15.1	10.9	10.0
Days at sea per round trip	days	31	66	27	79
Days at port per round trip	days	6	24	14	10
Days per round trip	days	37	90	41	89
No. round trips per year	#	9.6	3.9	8.7	4.0
Cargo carried per round trip	teu/tonnes/cbm	29,181	185,000	199,500	60,800
LSFO consumption at sea	tonnes/day	25	108	37	20
LSFO consumption at port	tonnes/day	7	21	4	4
Fuel consumption at sea	GJ/round trip	31,847	294,952	40,632	65,233
Fuel consumption at port	GJ/round trip	1,730	20,765	2,307	1,648
Fuel consumption per round trip	GJ/round trip	33,578	315,717	42,939	66,881
EU fuel consumption per round trip	GJ/round trip	16,789	157,858	0	0
Ship newbuild cost	$m	67.5	236.5	70.5	34.0
Shipowner WACC	%	8%	8%	8%	8%
Economic life	years	25	25	25	25
Scrap value	$m	5.6	23.9	9.5	4.1
Assumed charter tenor	years	25	25	10	10
Pilot fuel (LNG)	%	2%	2%	2%	2%
Pilot fuel (ammonia/methanol)	%	6%	6%	6%	6%
LNG DF premium	$m	N/A	25.5	16.0	12.5
Methanol DF premium	$m	N/A	21.0	12.0	10.0
Ammonia DF premium	$m	3.2	23.8	15.1	11.8
Days offhire per year	days	10	10	10	10
OPEX	$/day	8,370	10,995	7,212	5,775
DF OPEX premium	%	5.0%	5.0%	5.0%	5.0%
Port fees (round trip)	$m	0.5	0.5	0.5	0.2
Canal fees (round trip)	$m	0.0	1.5	0.0	0.0