

Prospects brief

Leveraging Book & Claim to decarbonize hard-to-abate industry



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

 **Smart Freight
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Summary

Scaling low-emission fuel production requires creditworthy, long-lived offtake. Shipping may have the purchasing power to provide it, but is not yet exercising it.

The core problem is structural: the addressable market of customers willing to pay a modest per-unit premium on any single route is generally too small to justify committing to alternative-fuel offtake, let alone the complementary investments needed in dual-fuel vessels and associated infrastructure.

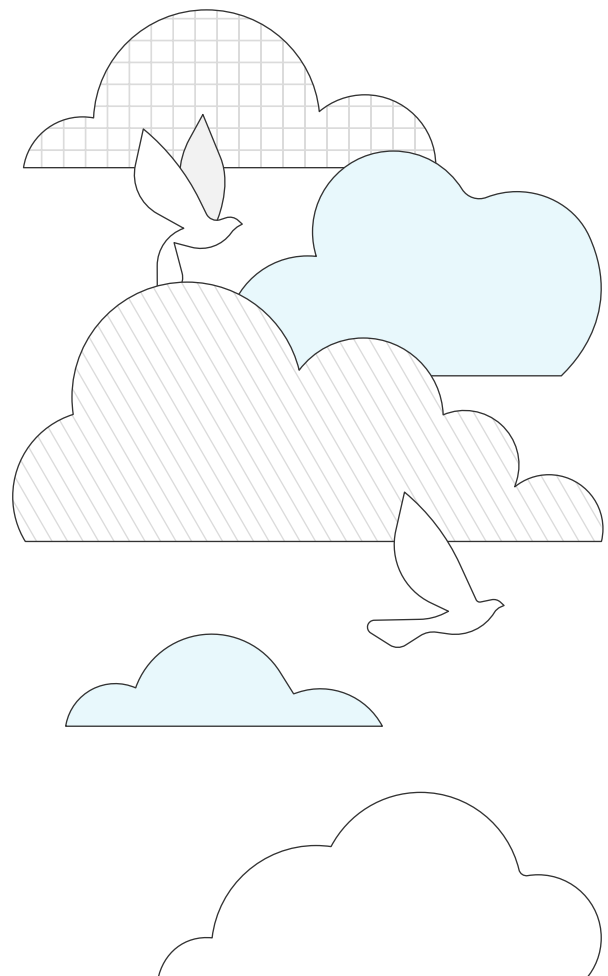
This paper proposes a solution. We argue that Book & Claim registries can help resolve this by decoupling the environmental value of a low-emission fuel from the physical (power generation) value of the fuel used to transport cargo. This transforms verified low-emission fuel consumption into tradeable environmental attributes. Once the environmental value of a voyage is expressed as a standardized unit, it can be sold to any organization with Scope 3 decarbonization commitments for shipping—regardless of whether they had cargo on board—immediately expanding the addressable market for low-emission fuel beyond the physical route.

Standardization and separating environmental attributes from low-emission fuel enable a second, more structural lever: the injection of subsidy capital through mechanisms that are fast being established, including double-sided auction mechanisms. By running competitive auctions on both the supply side (securing long-term agreements with fuel producers) and the demand side (matching carriers on shorter procurement cycles), a trading intermediary could bridge the gap between production cost and willingness to pay using governmental or multilateral subsidy streams.

Environmental attributes are what make this credible: registry-verified, traceable attributes satisfy the additionality requirements that financiers and public fund providers demand before committing capital.

Together with demand aggregation and the price transparency that standardized attributes progressively generate, these instruments form a commercial stack that can increase the likelihood that shipping emerges as a competitive end use market for low-emission fuel production.

Book & Claim is not a complete solution - it does not close the fuel cost gap alone, and governmental intervention through instruments such as FuelEU Maritime, the European Union Emissions Trading System (EU ETS), and an International Maritime Organization global framework like the Net-Zero Framework (IMO NZF) remains essential. But for some routes or operators for which the economics are closest to viability, this may provide enabling infrastructure built on existing, proven solutions.





The challenge: a location mismatch



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Opportunities for cost-effective low-emission fuel production require a confluence of factors: abundant renewable energy (or relatively high wind and solar potentials), proximity to hydrogen or ammonia production, existing port infrastructure for fuel handling, including chemical terminals, supportive government policy such as national hydrogen strategies or public co-funding programs, and other features¹.

These are the right places to produce low-emission fuel, not necessarily the places where enough purchasing power exists to sell it. This underlies the challenge facing low-emission fuel production: scaling up production requires a liquid market and, particularly in early stages, long-lived, creditworthy offtake agreements².

Shipping offers a potentially compelling end use market for low-emission fuel based transport services.

First, as a hard-to-abate industry, a significant portion of the sector's energy demand requirements cannot feasibly be met through direct electrification, requiring low-emission fuels.

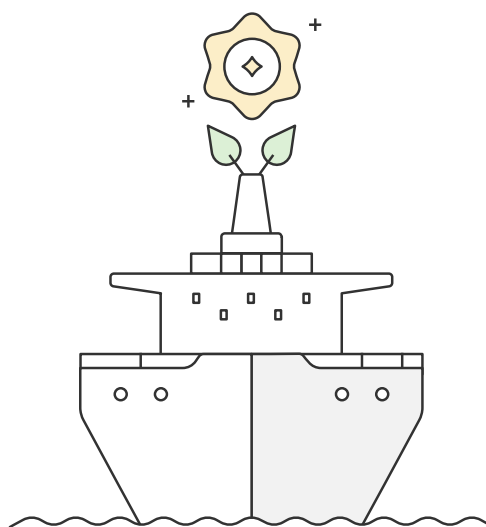
Second, because shipping's cost per unit of work (traditionally, cost per tonne nautical mile) is low compared to other transport modes, the per-unit cost of using low-emission fuels is limited, spreading the higher cost of this relatively expensive energy over many units of work.

One representative study, for example, models the per-freight-unit increase from using low-emission fuels compared to fossil fuels for transpacific container freight (from Shanghai to the West Coast of the United States)³. The upper end of their assumed cost of low-emission energy in 2030 is ~3,250 United States dollars (USD) per tonne, compared to ~600 USD per tonne for a benchmark fossil fuel like marine diesel oil (MDO), on an energy-equivalent basis. This difference in assumed energy costs results in a modeled increase per-twenty-foot equivalent unit (TEU) freight cost of ~460 USD, above the level used in the study (of ~870 USD, drawn from historical data). Put differently, an increase of more than 440% in (assumed) energy costs leads to an approximately 50% increase in (modeled) freight costs. Large differences in energy costs have muted effects on freight costs, and lower cost alternative energy would compress this cost gap.

Some recent estimates of, for example, low-emission ammonia indicate costs on the order of US\$1,500 — 2,000 USD⁴ (in energy-equivalent terms to a tonne of MDO).

Although the cost increase per container is smaller than the cost increase from switching to low-emission energy to move the container, very few low-emission transport services are currently on offer. For most shipping operators, the addressable market of customers willing to pay a premium on any single route is too small to justify committing to alternative-fuel offtake, let alone investing in dual-fuel vessels and other requisite infrastructure. As a result, the sector is not exercising its full purchasing power, and is not yet pulling investment into alternative-fuel production at meaningful scale.

Extensive work to investigate the feasibility of green shipping corridors has explored this challenge in detail. A green shipping corridor is a designated shipping route on which commercial vessels operate entirely on alternative, low-emission fuels. It serves as a proving ground where novel fuels, the bunkering infrastructure required to handle them, and new commercial models can be tested together within a defined scope⁵. At the 26th United Nations Climate Change Conference of the Parties (COP26), 22 governments signed the Clydebank Declaration, committing to support the development of green shipping corridors⁶. Organizations, including the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS), have since been working to translate that political commitment into operational reality.



Growing the total addressable market by decoupling



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Expanding the addressable market of green shipping requires a way to separate, or decouple, the environmental value of a low-emission voyage from the physical cargo it carries.

Book & Claim, a chain-of-custody model already operational in the maritime industry, does exactly this⁷. When an operator runs a vessel on low-emission fuel, the resulting emission reductions are quantified, independently verified, and registered as an environmental attribute on a dedicated registry.

Book & Claim offers a way to expand that addressable market by allowing organizations beyond the physical route—those with decarbonization commitments—to procure the environmental value the green shipping corridor produces without having cargo on board.

These attributes represent the environmental value of using low-emission fuel and grant exclusive ownership of the emission reductions. To illustrate, combusting a tonne of a benchmark fossil fuel to power a vessel generates ~3.7 tonnes of greenhouse gases (GHGs), measured in tonnes of carbon dioxide equivalent (CO₂eq), on a “well-to-wake” basis that accounts for upstream emissions involved in extracting and processing the fuel. The same amount of energy generated using a low-emission fuel with an emissions intensity of, for example, 10 grams of CO₂eq per megajoule (MJ), generates 0.4 tonnes of CO₂eq. The difference (3.7–0.4), or 3.3 tonnes CO₂eq avoided, represents the emissions avoidance attributable to the low-emission fuel when generating the amount of energy embodied in a tonne of the traditional fossil fuel. Consequently, a transport service based on low emission fuel has a lower emissions intensity than a transport service based on traditional fossil fuel.

The shipping operator, green corridor consortium, or another entity to which the attributes of the low-emission fuel have been pledged can transfer these attributes to any buyer who wishes to claim low-emission transport in their Scope 3 reporting, regardless of whether that buyer had cargo on the vessel⁷.

In sum, Book & Claim provides the common

foundation on which four distinct levers operate, each increasing the likelihood of green transport services and thereby stimulating demand for alternative fuels. Once the environmental value of a low-emission voyage is decoupled from the physical cargo, this single building block makes it possible to expand the addressable market beyond the route, extend revenue certainty from short procurement cycles to investment-grade horizons, concentrate geographically dispersed demand into structured offtake, and lower transaction costs through comparable price data across corridors. Each of these four levers is discussed in turn in this article and summarized in the table below.

We summarize these enabling features in greater detail below and show how the solution stack outlined here acts as an enabler to overcome this barrier. The remainder of the paper explores each of these in turn.



	Challenge	What Book & Claim enables	Effect on fuel production
1	The addressable market is too small.	Decoupling environmental value into environmental attribute enables sales beyond a physical route, giving buyers a verified way to claim actions that reduce their maritime Scope 3 emissions.	Addressable market expands beyond the route.
2	Long-term investment needs do not match short-term procurement cycles.	Book & Claim transforms the environmental value of a low-emission transport service into a tradeable unit, enabling instruments such as double-sided auctions and forward purchase agreements.	Revenue certainty extends from one to three years to ten or more years.
3	Willing buyers are geographically scattered.	Environmental attributes provide a standardized unit around which geographically dispersed demand can be collected, enabling demand aggregators to form. Further, offtake portfolios across price points and time horizons can be structured to collect demand from buyers with different needs.	Dispersed demand becomes concentrated, structured offtake.
4	High transaction costs, including search costs, prevent buyers and sellers from finding each other.	Standardized environmental attributes enable comparable transactions, generating potential price data that reduces transaction costs as the market matures.	Each transaction that generates price data makes the next one easier to finance.



Enabler 1:

Expanding the buyer base beyond the route



From cargo owners to a wider buyer landscape

When the addressable market is limited to cargo owners on the route, many shipping operators or green shipping corridor consortia cannot generate sufficient revenue to justify the investment.

Book & Claim could change this by allowing the environmental value of green shipping services to be sold as environmental attributes to buyers beyond the physical route, increasing the opportunity to establish a market willing to pay the incremental cost of low-carbon transportation. In practice, the infrastructure to enable this already exists. Under Science Based Targets initiative (SBTi) Corporate Net-Zero Standard Version 2.0 (CNZS 2.0), such mechanisms would likely operate primarily at the level of activity pools or sector-level actions, enabling demand for low-emission transport solutions where direct procurement is constrained by fuel availability,

infrastructure, or network realities.

The Smart Freight Centre's Voluntary Market Based Measures Framework for Logistics Emissions Accounting and Reporting provides the overarching methodological foundation, defining the rules for how environmental attributes are created, transacted, and reported across both the supply and demand sides⁸. The Katalist registry developed by the MMMCZCS and RMI, operationalizes these rules as the platform where green shipping corridor operators register verified emission attributes and buyers receive and retire the resulting environmental attribute certificates⁹.

Beyond the infrastructure, both buyers and operators face considerations that will define how this market develops. Frameworks such as the recently published SBTi CNZS 2.0 will shape how companies implement actions to reduce greenhouse gas emissions¹⁰. Operators need to consider regulations such as FuelEU Maritime and the sector's inclusion under the EU ETS and, any global IMO framework to ensure additionality and avoid double counting between compliance obligations and voluntary attribute certificate sales¹¹.



Enabler 2:

Creating long-term revenue from short-term demand

Bridging the gap between long-term investment and short-term demand

Time adds a further dimension to this challenge, and one that Book & Claim can also help address. Scaling low-emission fuel production or amortizing the cost of building a green shipping corridor both require long-term investment commitments, while cargo owners typically procure transport services on short-term cycles of one to a few years.

Book & Claim separates the additional cost of low-emission fuel from the underlying transport service, turning it into a tradable unit. Once tradeable, the risk associated with this premium can be distributed across multiple parties and time horizons through dedicated contract structures. Three contract structures illustrate how this can work in practice

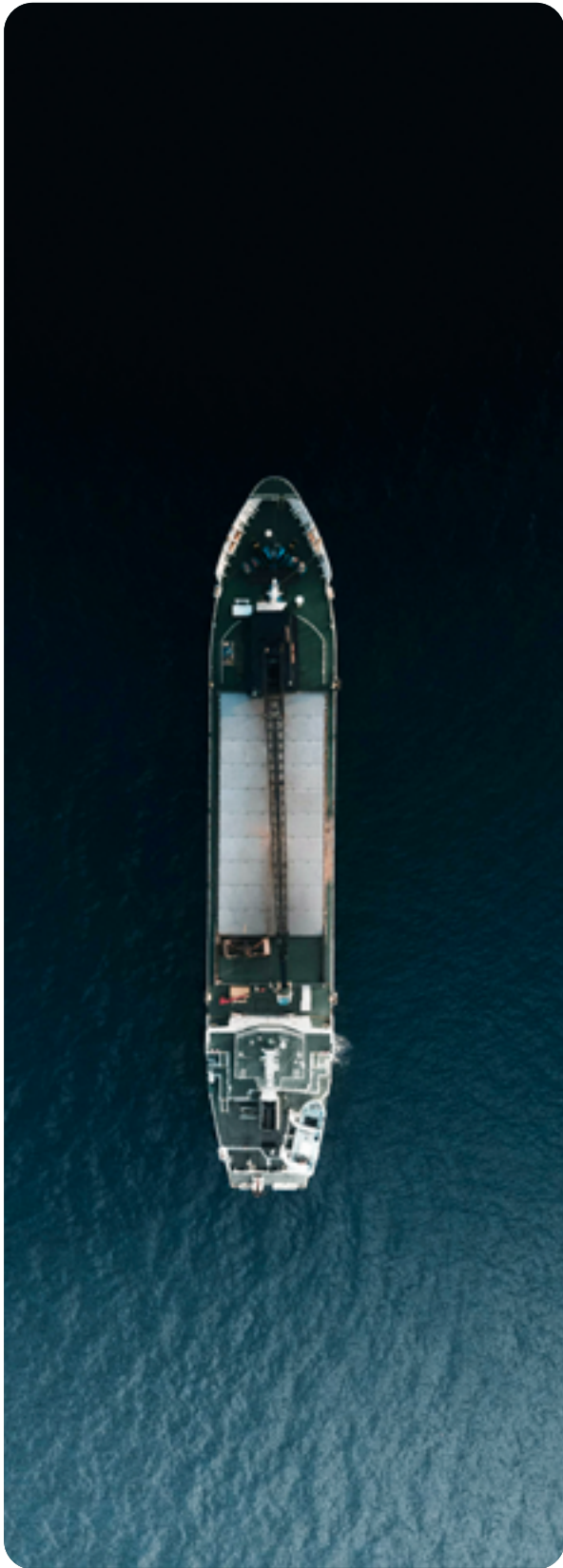
Forward purchase agreements

In the simplest approach, environmental attributes are created after low-emission fuel has been consumed on a voyage, but the right to these environmental attributes can be contracted in advance through forward purchase agreements. This allows a buyer to secure low-emission transport services based on a committed volume for future delivery at an agreed price, which is particularly relevant when demand is known and the buyer wishes to lock in low-emission transport services at a beneficial rate. At the same time, the sellers' position becomes more bankable as future cash flows are contractually secured. Registries provide the standardized units of value that both parties can reference and stipulate in a forward contract.

Double-sided auctions and related subsidy instruments

Double-sided auctions can connect the long-term supply side with the short-term demand side of a low-emission shipping service. On the long-term side, energy and fuel providers need offtake security to justify their investment in low-emission fuel production. On the short-term side, carriers offering low-emission services procure fuel on shorter cycles and cannot commit to the same time horizons. A trading intermediary runs competitive auctions on each side: a supply-side auction to secure long-term agreements with fuel providers and a demand-side auction to match carriers on shorter terms.





The intermediary also bridges the price gap between the production price and the willingness to pay of offtakers through public capital, e.g., from governments or international fund providers. H2Global, the developer of the concept of the double-sided auction mechanism for low-emission fuels, is already implementing such auctions through the market intermediary Hintco, a subsidiary of the H2Global Foundation).

Registries such as Katalist, developed by MMHCZCS, could make double-sided auctions more impactful because traceability via the registry builds trust with the financiers funding the subsidy stream or purchasing attributes, as this confirms the attributes are linked to genuine, credible emissions reductions and satisfy additionality requirements. Standardized units in the form of environmental attributes provide a common trading unit that connects both sides of the auction.

Innovative configurations of producers and consumers for environmental attributes

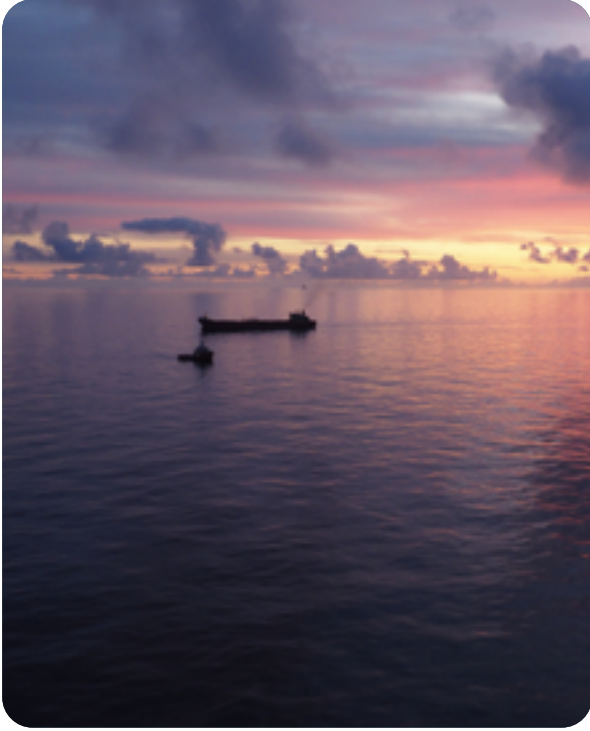
Using two-sided auctions to help “demand meet supply” is congruent with several different configurations in which companies produce environmental attributes and other companies are willing to purchase them. Fuel producers could generate the attributes directly, selling their molecules as energy and monetizing the emission savings they generate separately.

More creatively, shipping companies themselves could be on the bid side of these auctions, procuring fuel and providing shipping services while monetizing the environmental attributes through auctions. Because the demand for the attributes is highly credit rated, the shipping companies could themselves support the long-term offtake agreements required by fuel producers.



Enabler 3:

Channeling dispersed demand



How decoupling enables demand aggregators to channel dispersed buyers and structure layered offtake toward specific corridors

Book & Claim expands the total addressable market for green shipping corridors. Two instruments may be particularly relevant for aggregating the resulting dispersed (but larger) market:

Demand aggregators: concentrating dispersed buyers toward a single attribute generator, a pool of attribute generators, or a single green corridor.

Demand for low-emission transport services is geographically scattered, and under conventional models it remains tied mainly to cargo owners paying for transport on a route. A demand aggregator can collect and channel purchase commitments from cargo owners in different regions, using registries such as Katalist as the practical tool to consolidate buyers and direct their combined offtake toward a green shipping corridor. Far from being theoretical, this model is already emerging in the maritime sector, where buyer alliances pool commitments from their members and contract with carriers operating on low-emission fuels¹².

Building an offtake portfolio across price points and time horizons. Once demand is aggregated, it can also be structured. Within a pool of buyers, individual cargo owners will have different willingness to pay and different commitment lengths. One may prefer a shorter-term agreement at a higher price, while another may commit for a longer term at a lower rate. An intermediary can structure these into a layered offtake, combining multiple commitments at different prices and tenors to build a diversified and resilient customer base. This is an elaboration of the approach underlying current design work already undertaken by H2Global, and similar offtake portfolio constructs can be reviewed in the electricity market, where Guarantees of Origin and Power Purchase Agreement structures are used to build diversified customer bases for renewable energy assets^{13,14,15}.

The common feature of both these approaches is to coordinate dispersed demand for environmental attributes (in one case, across space, in the other, over time horizons).



Enabler 4:

Reducing transaction costs between buyers and sellers

The first three enablers address the direct commercial challenges of providing low-emission shipping services or building the business case for a particular green corridor. This fourth enabler is different in nature. It tackles the high transaction costs that make it hard for buyers and sellers to find each other and agree on a price.

Today, pricing for low-emission maritime transport via environmental attributes is almost entirely opaque. Transactions are bilateral and confidential, and a proliferation of attribute certificate types with different scopes, verification methods, and fuel pathways adds confusion rather than clarity. The result of this asymmetric information is high transaction costs for any single deal: non-standard contracts, proprietary trading units, and significant search costs all slow the development of a liquid market. Participants lack reference points for prices and must spend time and money simply to assess, negotiate, and execute each transaction. Without reference prices, a willing buyer cannot judge whether an offer is fair, and a seller cannot confidently price its environmental attributes. This friction slows every deal and raises the cost of participation on both sides.

Book & Claim registries such as Katalist can be the nucleus from which a liquid market evolves once these hurdles are removed. Standardized, verifiable environmental attributes produce clean, comparable data, turning low-emission shipping from a bespoke product to a commodity. This commoditization can be taken advantage of through the publication of appropriately aggregated, anonymized, and historic transaction data, subject to applicable competition law requirements, that can enable market transparency, giving both buyers and sellers the information they



need to transact with confidence and at lower cost. As this market deepens, green corridors emerge as a result rather than a precondition, and their formation feeds back positively, generating richer data and further accelerating the move toward a liquid, transparent market.

This effect compounds, but only if the underlying environmental attributes are sufficiently standardized. Without common definitions of what an environmental attribute represents, each transaction refers to something different and price data becomes non-comparable. Standardized trading units are therefore a precondition for meaningful benchmarks, and the registry can only become that nucleus once this standardization is in place.



A reality check

Book & Claim cannot eliminate the underlying fuel cost differential; it is an enabler, not a complete solution. It does not produce low-emission fuel, build bunkering infrastructure, or create regulatory mandates. In many cases, the cost premium of low-emission energy carriers is so large that even a dramatically expanded buyer base, at any plausible near-term attribute price, cannot close the gap alone.

The enablers described in this paper, unsurprisingly, have the highest probability of impact where the fuel cost premium is moderate and the environmental attributes are recognized under buyer-side frameworks such as SBTi. The crucial factor required to move low-emission shipping and green corridor models from feasibility into operation remains governmental intervention and support, building on existing regulatory frameworks, whether regional or global, such as FuelEU Maritime, the EU Emissions Trading

System and any future IMO Net-Zero Framework^{16,17}. Book & Claim and Green Corridor initiatives can complement these regulatory measures by enabling action at the level of activity pools and ultimately at sector level. This creates the potential to aggregate demand beyond individual shipping routes or customer relationships, helping to establish a broader market willing to pay the incremental cost of low-emission shipping. It increases the probability that shipping operators use low-emission energy by expanding and structuring the revenue base. For corridors where the economics are closest to viable, it may be the piece that tips the balance. For others, it is one necessary layer alongside policy intervention and continued cost reduction. Book & Claim, attribute-based market expansion, the injection of subsidies, and resolving price opacity make low-emission fuel contracting for shipping more likely. They cannot individually or jointly make it certain.





Looking ahead

The four enablers described in this paper are foundational instruments that are operational or in advanced development.

To mature the market, this paper outlines areas where further work is needed: standardized trading units and contract structures that allow environmental attribute transactions to scale; demand aggregation and intermediary models that can collect and channel early demand toward specific corridors; marketplace functionality built on existing registry infrastructure that connects dispersed buyers with corridor supply; and the reference prices and benchmarks needed to reduce search costs for both sides.

The toolkit outlined here can raise the likelihood that shipping emerges as a customer for low-emission fuel production. Doing so would enable the world to scale low-emission energy, working alongside other sectors to diversify and decarbonize our energy system. This paper outlines a small, tractable set of innovations that will help shipping do its part.



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Expanding the addressable market for low-emission transport

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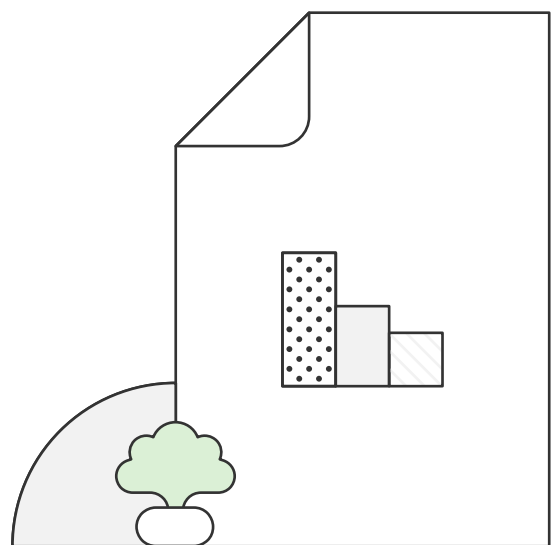
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