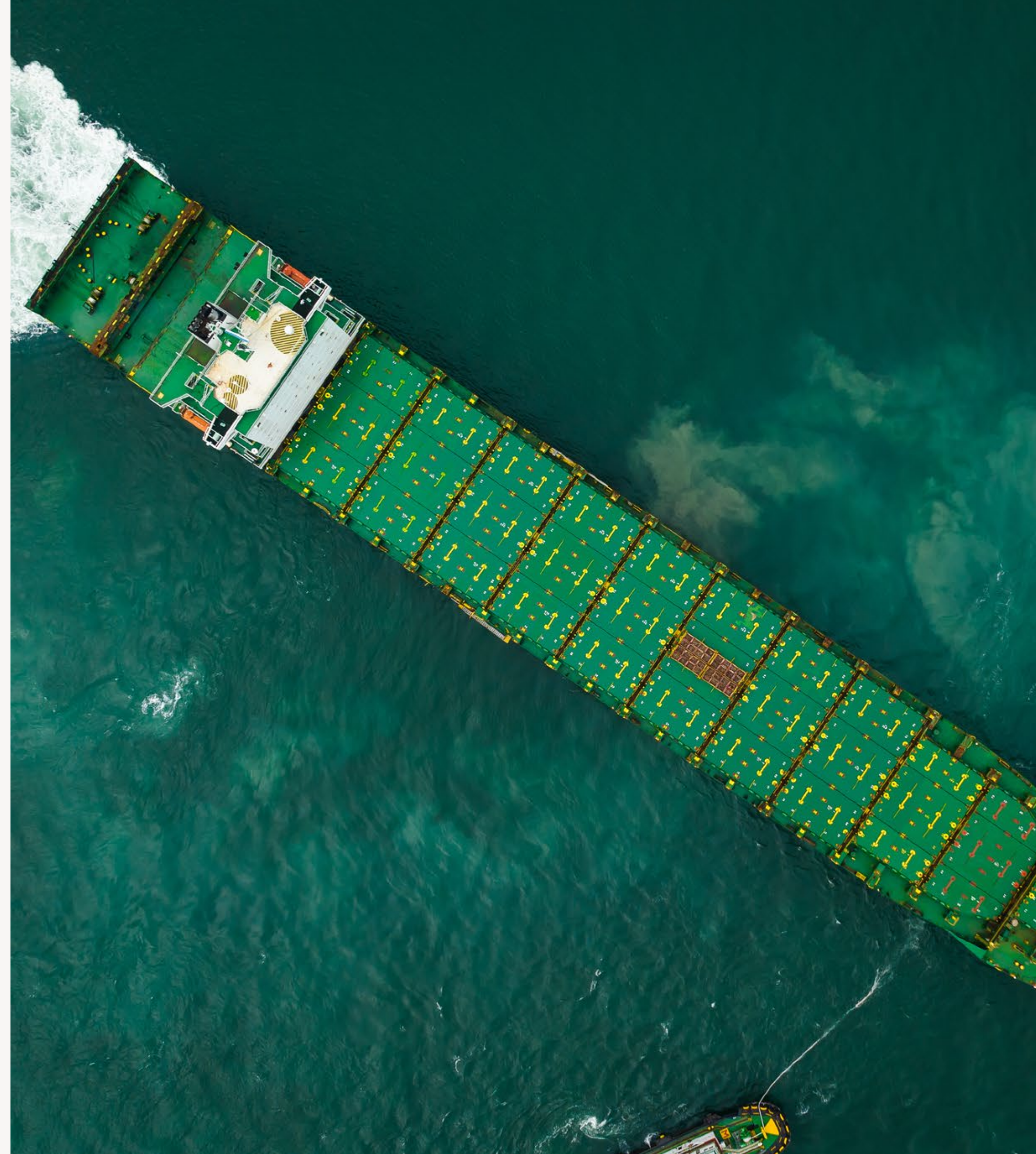


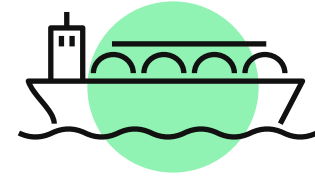


What's Next for Decarbonization in Shipping

OCTOBER 2025



The International Maritime Organization's new Net-Zero Framework establishes the first global carbon pricing mechanism for international shipping

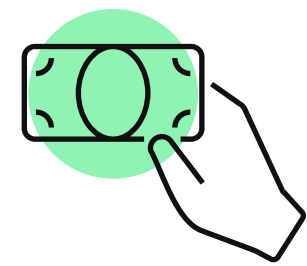


All ships must report their GHG Fuel Intensity (GFI) annually.



Each ship's GFI is compared against a two-tiered compliance system based on the 2008 baseline GFI of 93 grams of CO₂e per megajoule.

- **Base compliance:** GFI reduction of 4% by 2028 and 17% by 2035
 - **Direct compliance:** GFI reduction of 30% by 2028 and 43% by 2035
-



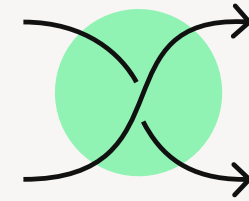
The penalty for non-compliance differs by tier.

- **Tier 1 non-compliance:** Ships with GFI between the base compliance and direct compliance targets pay \$100/ton of CO₂e.
 - **Tier 2 non-compliance:** Ships with GFI above the base compliance target pay \$380/ton of CO₂e.
-

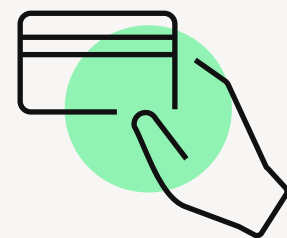


Ships with a GFI lower than the direct compliance target receive surplus units (SUs) that can be traded against the compliance targets of other ships or banked for up to two years.

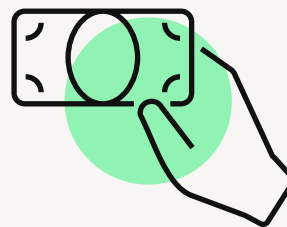
Carbon penalties are expected to begin in 2028, leaving shippers with three options



Switch conventional fuels to green fuels to avoid \$380/ton carbon penalty—and **potentially earn credits**. Only fuels with abatement costs below \$380/ton will be economically feasible.¹



Purchase carbon credits from third parties—or use previously earned credits² to avoid paying penalty.



Pay carbon penalty of \$100 (below direct compliance) and \$380 (below base compliance)

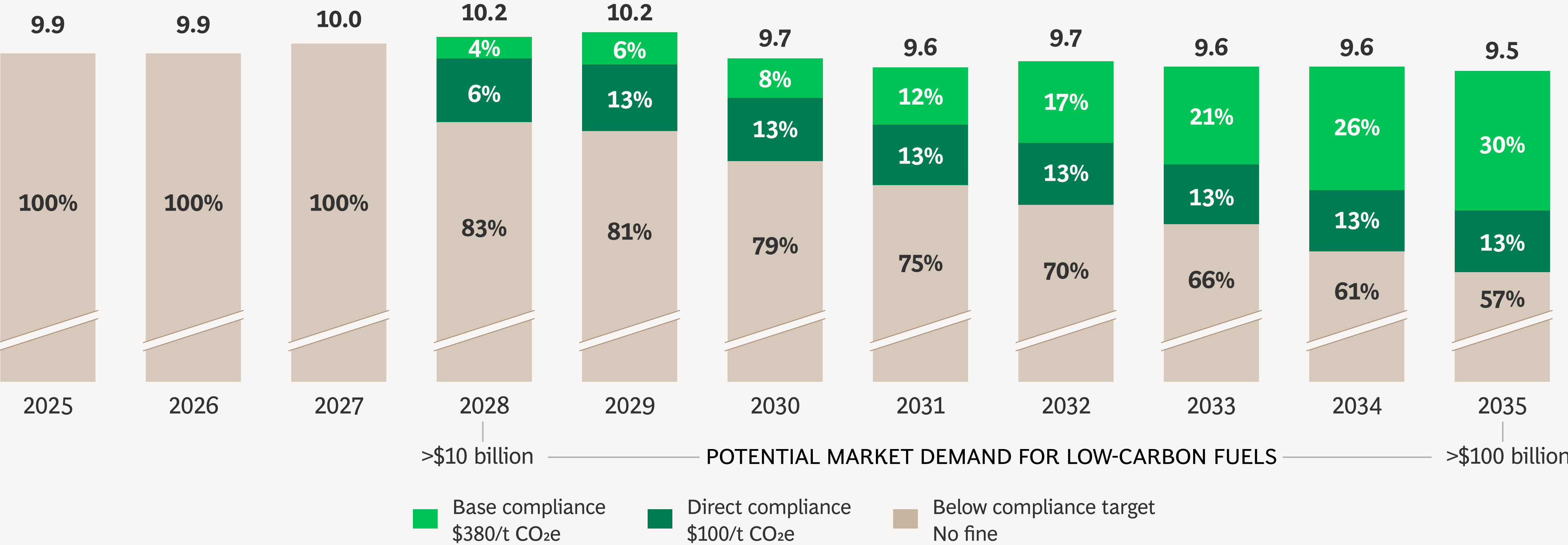
Sources: International Maritime Organization; BCG analysis.

¹Not including any potential positive impact of increased revenue from cargo owners' willingness to pay a premium for green shipping and other financial incentives such as port fees.

²Credits can be banked up to two years.

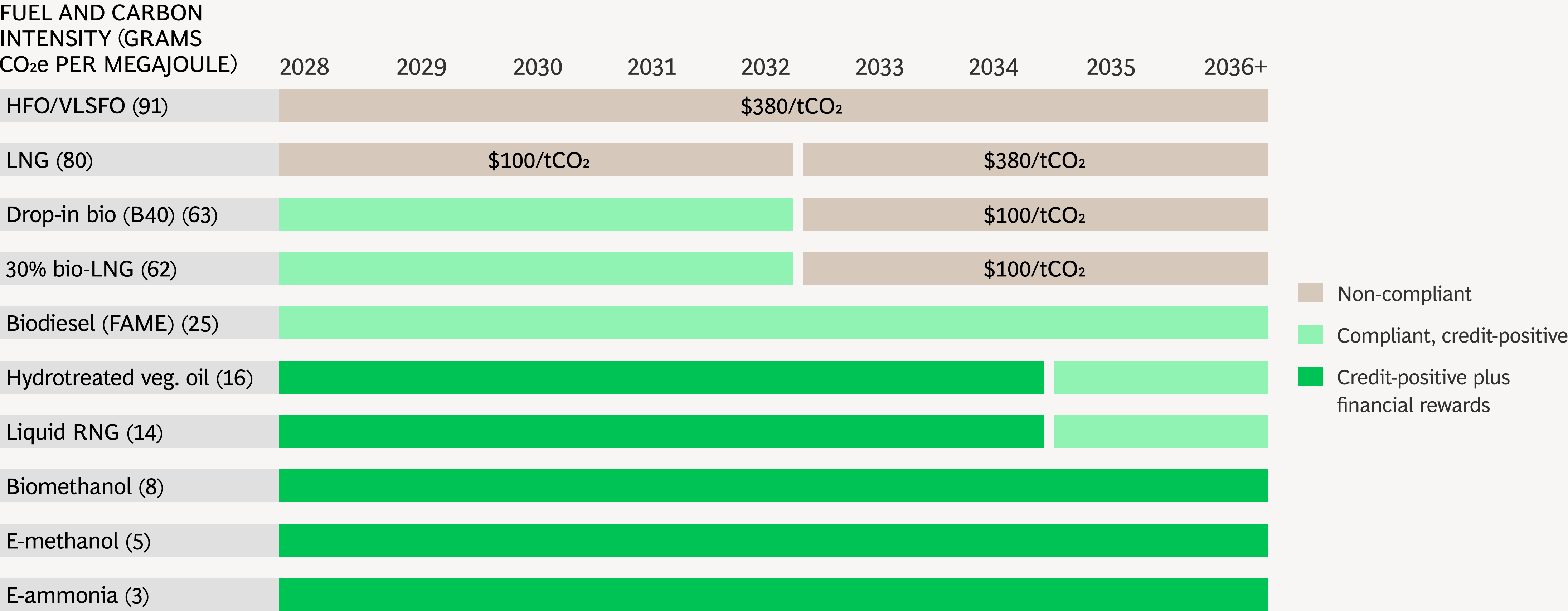
Rising demand for low-carbon fuel will create risks and opportunities for shippers—and a multibillion-dollar market for fuel producers

SHIPPING ENERGY DEMAND BY COMPLIANCE TARGET 2025–2035 (EXAJOULES)



Sources: Maersk Mc-Kinney Møller Center for Zero Carbon Shipping Industry Transition Strategy, October 2021; International Maritime Organization; BCG analysis.
Note: Demand expected to start before 2028 due to preparation of fleet and supply for when targets apply in 2028.

High-carbon fuels will begin to fall out of compliance in 2028 and become increasingly penalized in following years

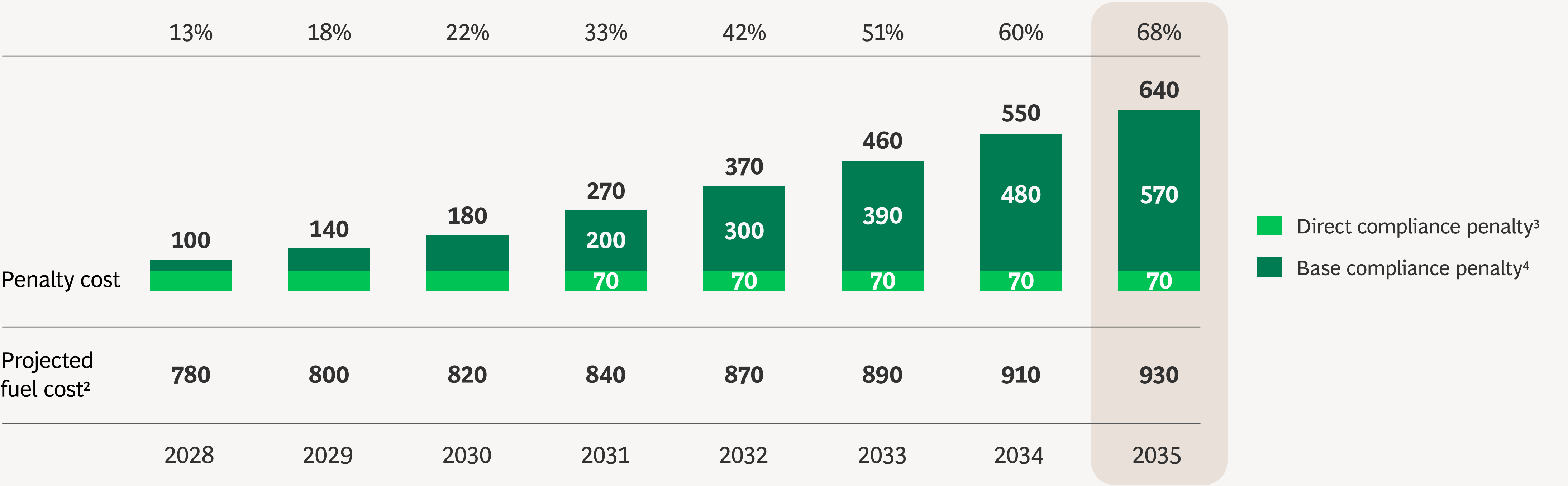


Sources: Maersk Mc-Kinney Møller Center for Zero Carbon Shipping; BCG analysis.
Notes: HFO/VLSFO = heavy fuel oil/very low sulphur fuel oil. LNG = liquid natural gas. RNG = renewable natural gas. FAME = fatty acid methyl ester. Carbon intensity scores vary based on specific pathway. Values used are exemplary.

The cost of non-compliance will mount quickly, rising toward 70% of total fuel cost

Annual compliance cost for example fleet¹ (\$millions)

% OF PROJECTED FUEL COSTS



Sources: Clarksons Research; Shipping Intelligence Network 2025; Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping; GFI Compliance Calculator; BCG analysis.

¹Illustrative example based on representative fleet of 125 vessels burning heavy fuel oil at GFI 91g CO₂e/megajoule, priced at \$554/ton.

²Estimated using fuel consumption data from IMO and fuel cost; growth in line with global inflation of 2% to 3%.

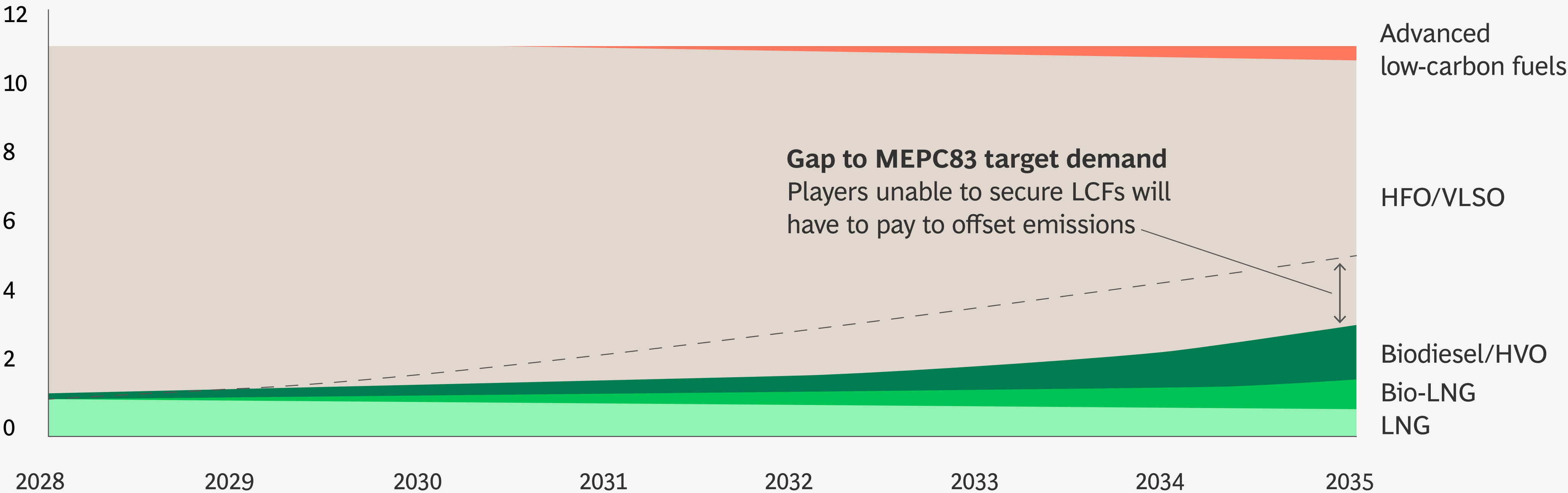
³Tier 1 non-compliance fee - \$100/ton CO₂e for excess emissions.

⁴Tier 2 noncompliance fee - \$380/ton CO₂e for excess emissions.

As the cost of non-compliance increases, supplies of unpenalized fuels will significantly lag demand

Marine energy supply 2025–2035, split by abatement cost of fuel (EJ)

EXAJOULES



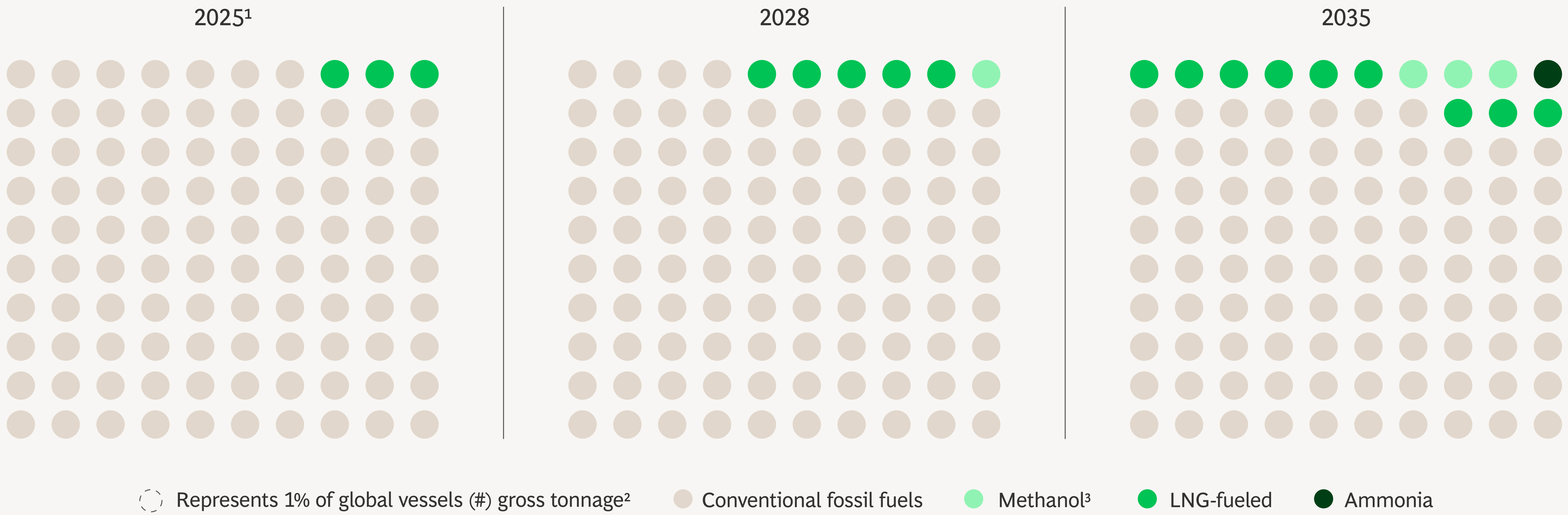
ABATEMENT COST: ■ >\$380/tCO₂e ■ HFO/VLSFO ■ \$201 to \$380/tCO₂e ■ \$100 to \$200/tCO₂e ■ Less than \$100/tCO₂e

Source: BCG analysis.

Note: MEPC = Marine Environment Protection Committee; LNG = liquid natural gas. HVO = hydrotreated vegetable oil.

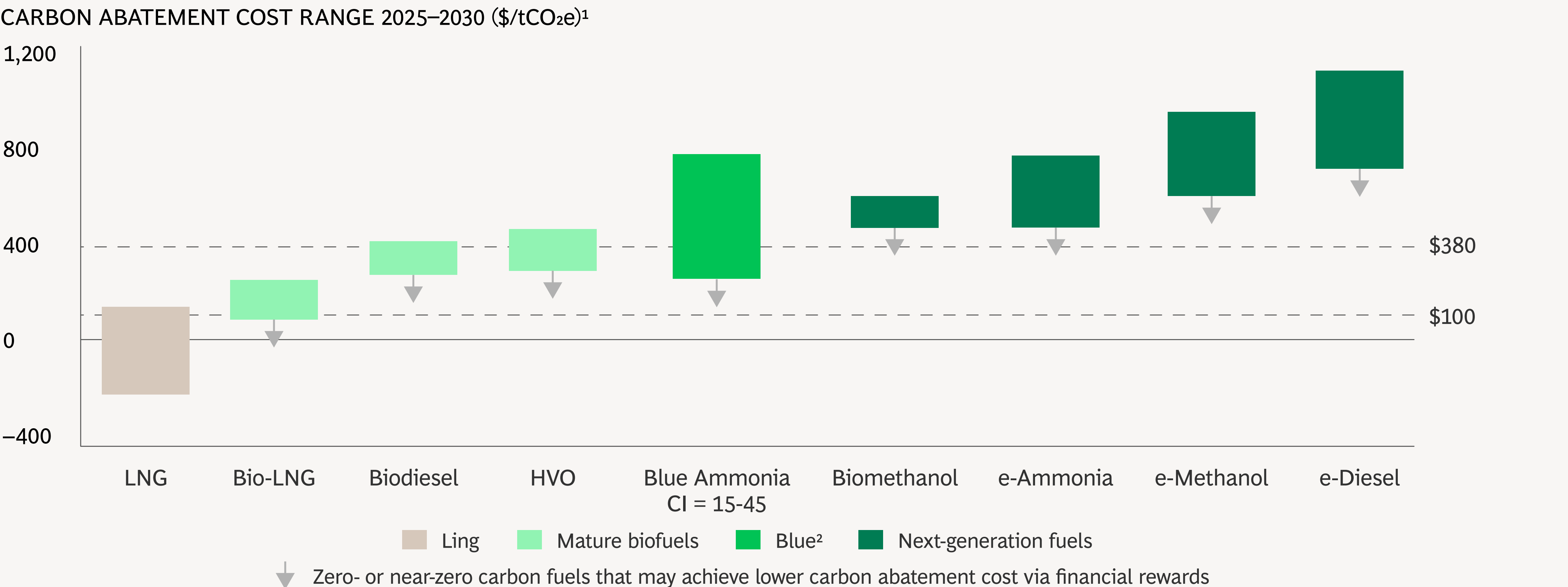
Less than 1% of the global fleet is green-fuel capable today, underscoring the importance of fuels compatible with existing engines

GLOBAL FLEET FORECAST (%)



Sources: Maritime Insights vessel forecast; BCG analysis.
¹Less than 1% vessel methanol- and ammonia-fueled.
²Includes dual-fuel engines capable of running LNG and conventional fuels.
³Dual-fuel engines capable of running on methanol.

Drop-in biofuels deliver the best abatement costs, while the financial viability of some low-carbon fuels is more uncertain



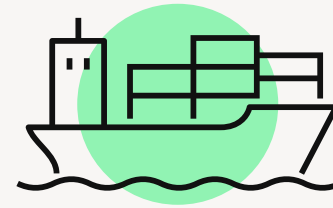
Sources: Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping; FuelEU Maritime Initiative; Argus; BCG analysis.

Note: Fuels shown are not exhaustive: emerging fuels (e.g., e-LNG, HTL, pyrolysis oil) have been excluded for clarity. LNG = liquid natural gas. HVO = hydrotreated vegetable oil. HTL = hydrothermal liquefaction.

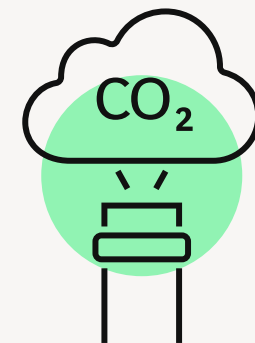
¹Carbon abatement cost of fuels; excludes infrastructure, vessel operation, penalties, etc.

²Price of \$600 to \$900/ton, carbon intensity score assumed from 15 to 45.

All three major industry players—ship owners, fuel developers, and investors—must devise a strategy to respond to the risks and opportunities of the shift to low-carbon fuels.



Shipping companies looking to convert their operations to LCFs must quickly settle on the strategy or combination of strategies that best suits their needs. Fuel sourcing and efficiency should be at the center.

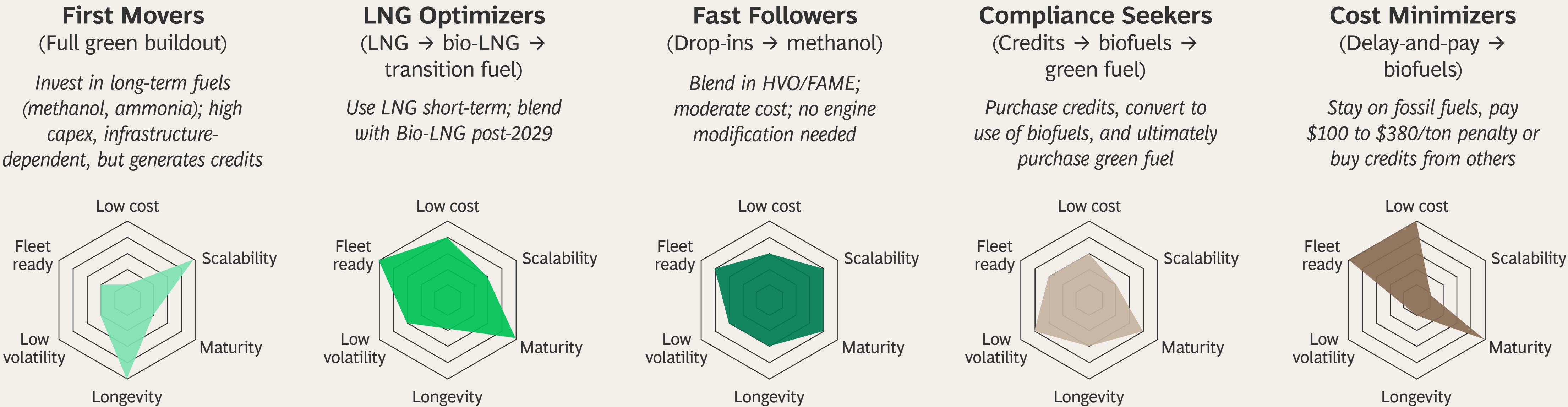


Developers of LCFs must choose which fuel type to focus on—based on when they expect a pay-off—and the best opportunities available.



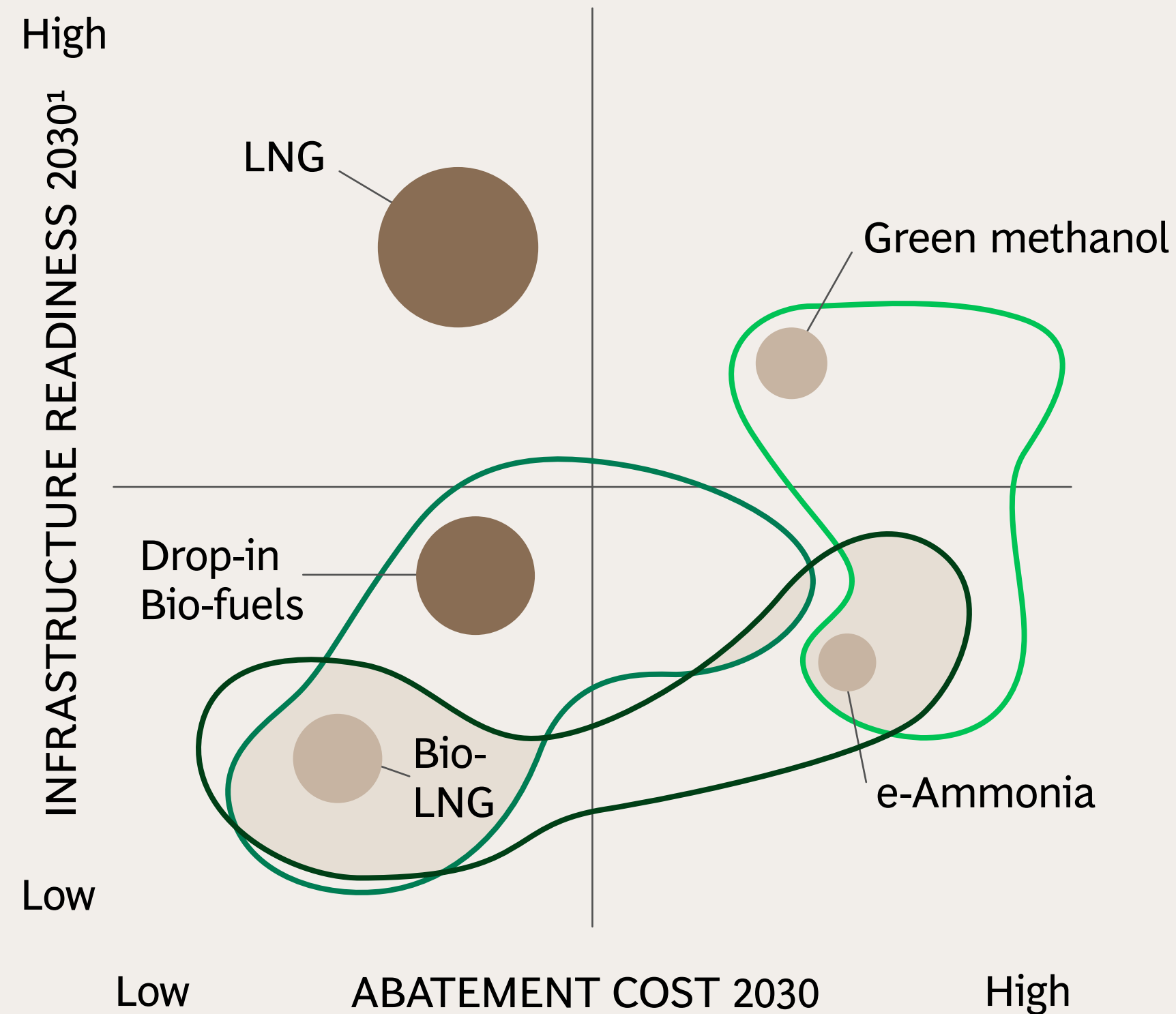
Investors must determine the best pathway to returns as the value chain for LCFs grows.

Shipping companies can combine five strategic archetypes to build their fleets, based on current vessel portfolio and future orders



Source: BCG analysis.
Note: LNG = liquid natural gas. HVO = hydrotreated vegetable oil. FAME = fatty acid methyl ester.

Fuel developers have several plays to choose from, depending on the fuel's cost and infrastructure readiness



Balanced play

- Combine credits from low-cost fuels early with higher-cost, longer-term options to balance exposure
- Example combination: Bio-LNG plus e-ammonia

High-yield play

- Focus on fuels that deliver big compliance credits now
- Example combination: Drop-in Bio (B20/40) plus Bio-LNG

Long-term play

- Invest early in fuels that align with long-term regulations to secure scale and pricing later
- Example combination: Green methanol plus e-ammonia

Size = supply potential for maritime use

Compliant 2030

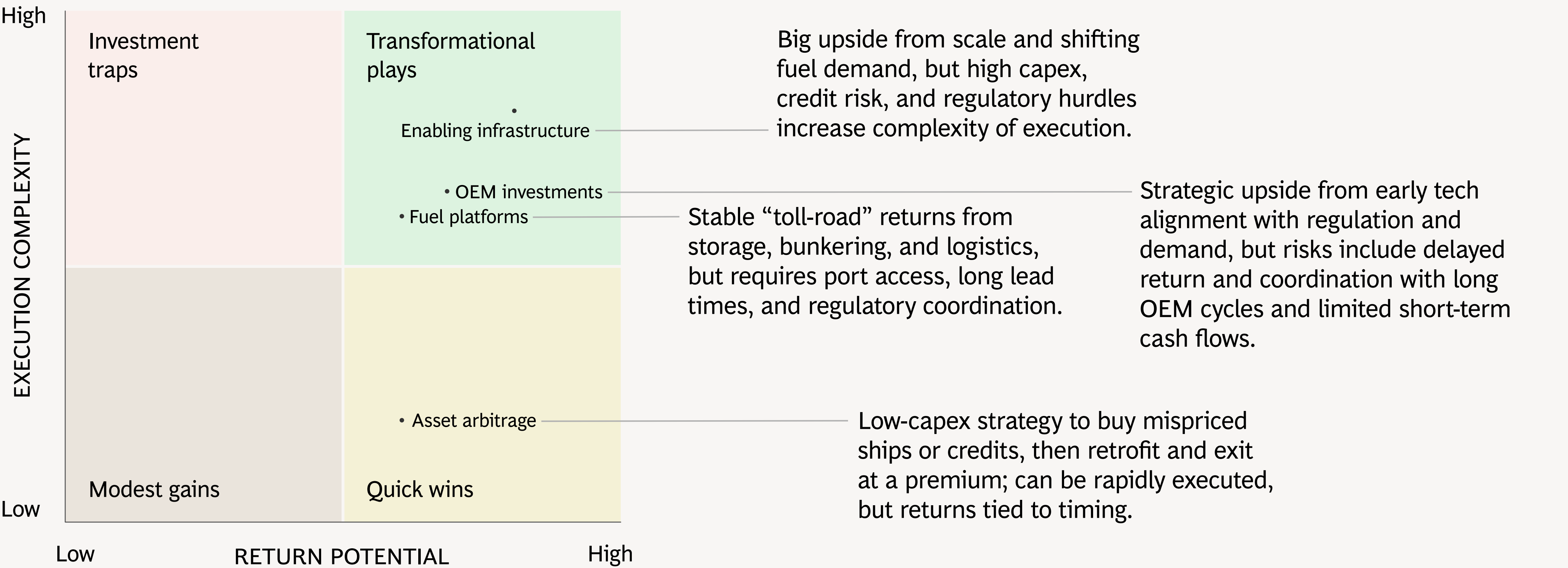
Credit-positive 2030

Source: BCG analysis

Note: LNG = liquid natural gas

¹Infrastructure readiness in 2030 based on current outlook and not representative of potential by 2035.

Investors in new ships, fuels, and infrastructure must time strategies carefully based on risk tolerance and future expectations



Source: BCG analysis.