3

Shipping industry net-zero tracker

Despite the rise in emissions, a more ambitious IMO strategy and industry actions towards technology adoption positions shipping on a positive track for a net-zero pathway.

Key emissions data[68, 69, 70, 71]

2%
Contribution to global GHG emissions

0.76 $gtCO_2e$
International shipping GHG emissions (2018)

11.7 $gtCO_2e$
Emissions intensity (emitted per tonne nautical miles, 2018)

99%
Fossil fuels in the fuel mix (2021)

2 times
Expected demand increase by 2050

Readiness key takeaways

Technology

Transitioning to clean, hydrogen-based, zero-emission fuels (ZEF) like methanol and ammonia, could nearly eliminate shipping emissions. However, uptake faces costs and infrastructure challenges.

Infrastructure

Currently less than 1% of the necessary infrastructure exists, requiring about $0.4-0.6 trillion investment to support the development and scaling of shipping technology by 2050.[72]

Demand

Growing demand for low-carbon shipping faces uncertainty as B2B green premium of 30-80% remains mostly untested at scale.[73]

Policy

To meet IMO targets, policies should encourage low-emission fuels and operational efficiency through measures like carbon pricing, fuel standards and incentives for infrastructure.

Capital

Adopting ZEF propulsion for ships by 2050 requires up to $450 billion investment,[76] adding 47% to annual fleet owner costs, which are currently around $36 billion.[77]

Stated energy transition goals

- United Nations (UN) specialized agency IMO aims for at least 20%, striving for a 30% reduction in absolute emissions by 2030 (vs 2008) and net-zero emissions by or around 2050.[74]
- 51% of large publicly traded shipping companies consider climate change in their decision-making processes.[75]

Emission focus areas for tracker

Shipping emissions can be divided into two main categories considering well-to-wake:

1. **Operational emissions are** primarily due to the combustion of fossil fuels during maritime operations.
2. **Fuel value chain emissions** are mainly upstream emissions from the production and distribution of fossil fuels.

Sector priorities

Existing transport

Reduce near-term emissions intensity by:

- Accelerating design and efficiency improvements aligned with IMO guidelines
- Increasing share of fleet capable of running on alternate fuels supported by technology standards
- Explore feasibility of complementary solutions in the interim (e.g. wind-assisted propulsion).

Next generation transport

Accelerate clean hydrogen-based fuels development, to reduce absolute emissions by:

- Investing in next generation fuels and propulsion technology R&D
- Ramping up the required clean hydrogen-based fuels production capacity
- Developing the required bunkering capacity, with storage and refuelling infrastructure.

Ecosystem

De-risk capital investment to scale infrastructure capacity by:

- Implementing green corridors in major routes supported by clean hydrogen hubs
- Bridging the cost gap between ZEFs and conventional fuels through increased number of projects
- Implementing a blend of policies, primarily carbon pricing and fuel standards.

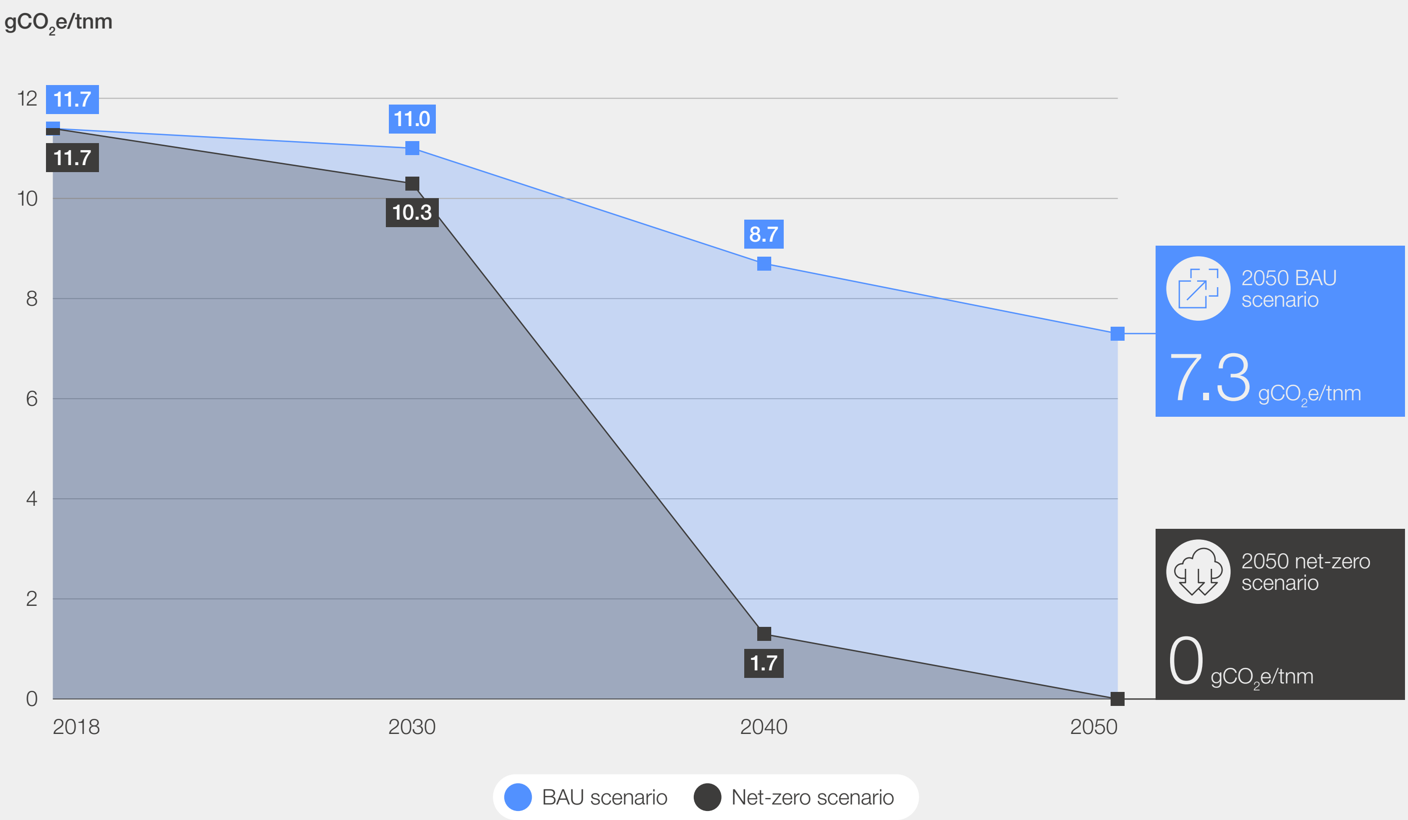
Performance

Emissions profile

Fuel combustion in maritime operations accounts for over 80% of the total shipping life cycle emissions, primarily due to the current reliance on fossil fuels.[78] Bulk carriers, oil tankers and container ships are responsible for 65% of these emissions.[79] As per IMO targets, absolute emissions need to be reduced by at least 20% by 2030 and at least 70% by 2040 compared to 2008.[80] As past trends show, shipping emissions continue to exceed the 2008 benchmark.[81]

Shipping emissions intensity varies based on factors such as fossil fuel use, vessel load use, size, speed and route characteristics. For example, in the case of container ships, the South-East Asia to/from North-East Asia shipping lane has the highest emission intensity among the top 10 trade lanes by activity, 35% above the average emission intensity levels.[82] To meet the IMO targets, carbon intensity trajectory has been considered (see Figure 20). This trajectory requires a 40% reduction in intensity levels (vs 2008) and near-zero intensity levels in 2050.[83]

FIGURE 20 **Emissions intensity trajectory, net-zero vs BAU scenario. Possible net-zero trajectory as per IMO targets**

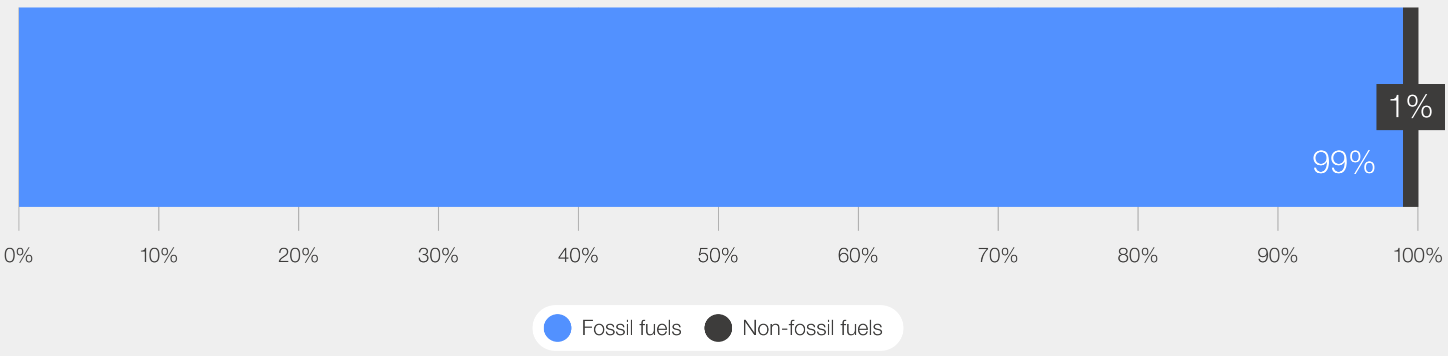


Source: Accenture analysis based on IEA and IMO data

Path forward

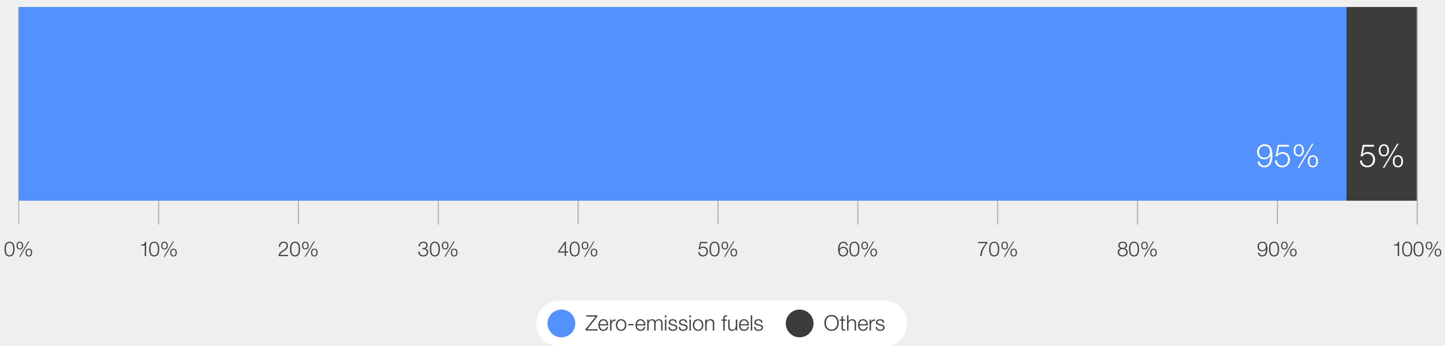
Meeting the IMO net-zero target by or around 2050 demands substantial collaboration from governments, industry stakeholders and research institutions. The industry's primary focus should centre on advancing clean hydrogen-based ZEFs and incentivizing their widespread adoption, to align with Global Maritime Forum (GMF) transition strategy. ZEFs are expected to occupy more than 90% of the 2050 energy mix, facilitating the achievement of net zero.[84] While these fuels develop, biofuels – and, to a limited extent, liquified natural gas (LNG) – will serve as transition fuels. In addition to fuel-switching, emissions can be further reduced through operational efficiency enhancements and design improvements, which are crucial for meeting the near-term 2030 IMO targets.

FIGURE 21 | **2021 fuel mix**[85]



Source: IMO

FIGURE 22 | **2050 net-zero scenario**



Source: GMF

3

SHIPPING

Technology

Up to
80%
increase in total ownership costs expected

Switching entirely to clean hydrogen-based ZEFs, such as methanol, ammonia and liquid hydrogen, holds the potential to achieve near-zero well-to-wake shipping emissions. While methanol-fuelled ships are available, they currently rely on natural gas-based feedstock. Commercial availability of ammonia and liquid hydrogen propulsion technology is expected by 2025. However, transitioning to these fuels may increase total ownership costs by 30-80%.[86] Key barriers to their adoption include higher vessel ownership costs, limitations in the fuel supply chain, the absence of global bunkering infrastructure, and the need for modifications in onboard storage configurations. The TRL of ZEFs can be considered in terms of the maturity of the fuel production process, the maturity of propulsion technologies and the readiness of bunkering technologies. Globally, there are over 200 R&D projects dedicated to advancing these fuels and related technologies.[87]

Production technologies

Currently, ammonia, methanol and hydrogen are derived from natural gas feedstocks. Clean hydrogen-based production for shipping applications is currently limited to demonstration projects. In addition to clean hydrogen, methanol production will require CO_2, which can be sourced from industrial point sources or via DAC technologies. Clean hydrogen production facilities and carbon capture technologies need to be sufficiently scaled at an industrial level to advance the production of ZEFs.

An example of progress is Danish energy company Orsted's construction of Europe's largest clean methanol plant in North Sweden, set to commence operations by 2025. It is expected to supply 50,000 tonnes of clean methanol annually.[88]

Propulsion technologies

Methanol engines have been successfully demonstrated and are in the early adoption stage of development. Currently, there are around 30 vessels running on methanol.[89] In 2023, Maersk will start operating the world's first container ship powered by clean methanol, with further ships in the order book.[90] Ammonia and liquid hydrogen engines are still in development and are expected to mature after 2025.[91]

Bunkering and onboard storage technologies

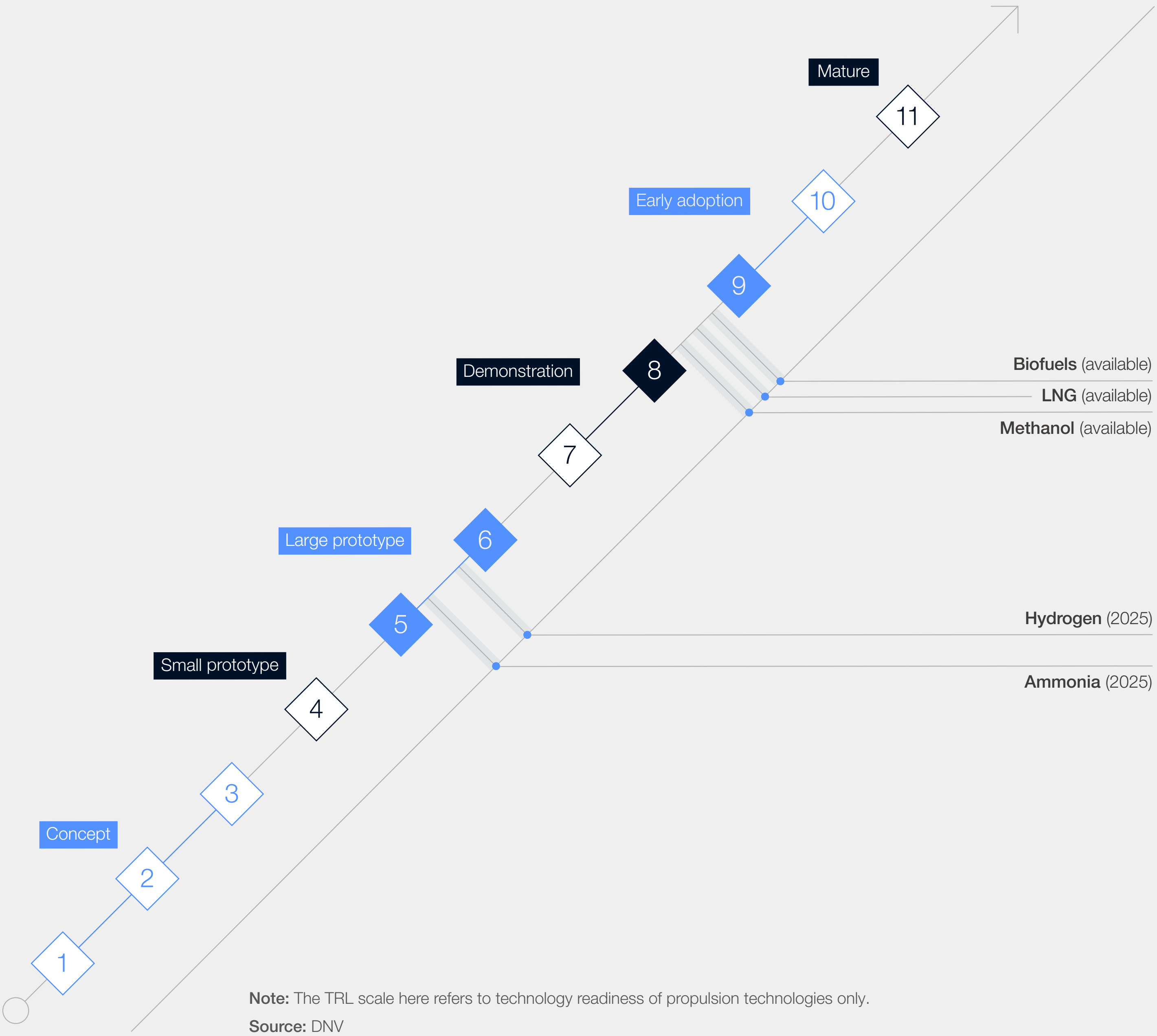
Methanol bunkering and onboard storage/handling technologies have been successfully demonstrated. For ammonia and liquid hydrogen, these technologies need to be progressed beyond the prototype stage.[92]

Other intermediate measures

Additional decarbonization pathways are essential to ensure that the shipping industry meets the near-term IMO targets for 2030. Transition fuels, such as biofuels, can be considered as potential options. Moreover, achieving decarbonization in shipping necessitates improvements in operational and technical efficiency. For instance, optimizing routes and enhancing vessel use can result in emission reductions of up to 10%.[93] Additionally, innovative systems, such as wind-assisted propulsion, are under investigation to further contribute to emissions reduction.

Technology pathways[94]

FIGURE 23 **Estimated TRL and year of availability for key technology pathways**



Note: The TRL scale here refers to technology readiness of propulsion technologies only.

Source: DNV

SHIPPING

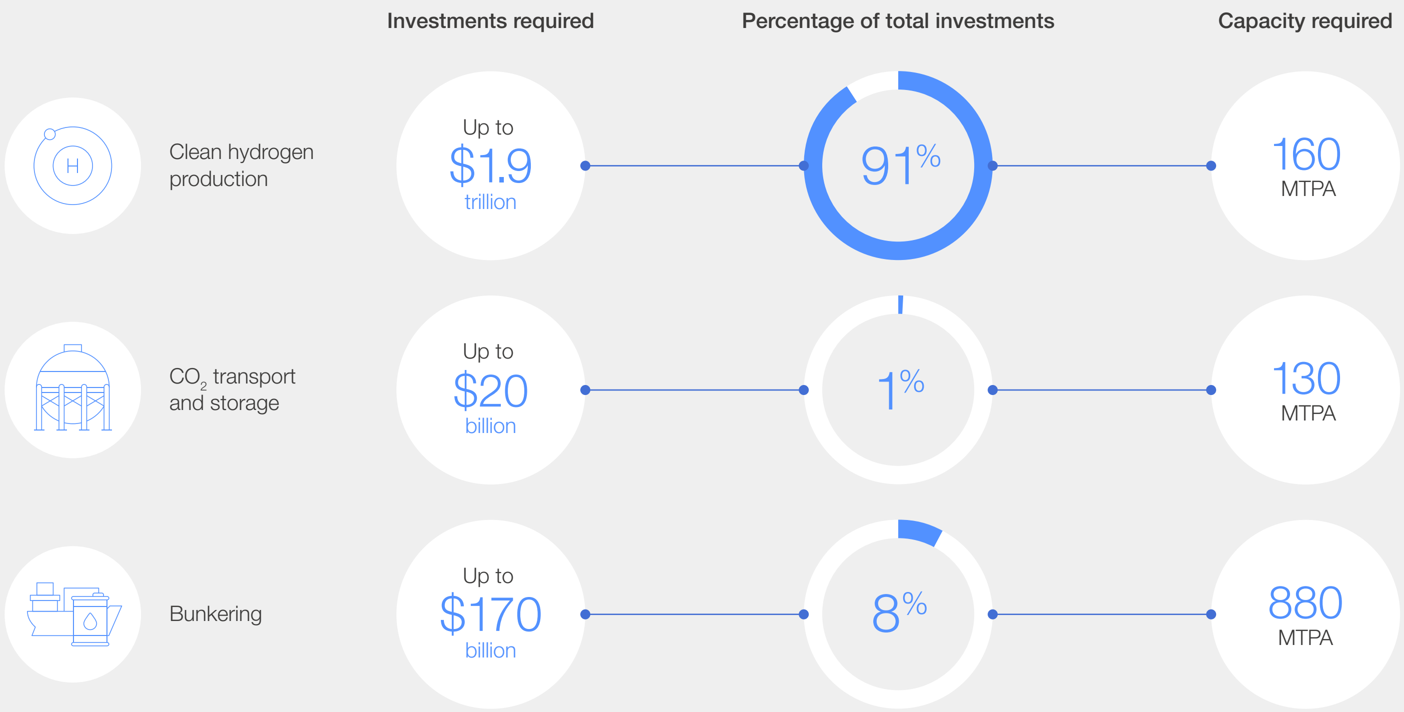
2 Infrastructure

Adopting ZEFs hinges on scaling clean hydrogen, CO_2 handling and bunkering infrastructure, however less than 1% currently exists.[95] Investments of up to $0.8-2.1 trillion will be needed by 2050,[96] mainly for clean hydrogen-based fuel infrastructure. To meet the 2050 net-zero scenario, clean hydrogen production capacity of 160 MTPA is required,[97] necessitating an investment of $0.6-1.9 trillion.

By 2050, up to 130 MTPA of CO_2 will be needed as a feedstock for producing ZEFs.[98] If the CO_2 is sourced from industrial point sources not co-located with the ZEF producing facility, adequate CO_2 transport infrastructure must be established. This is projected to require investments in the range of $10-23 billion.[99]

ZEFs need to be supported by bunkering infrastructure, which will require an additional $132-176 billion in investment.[100] Notable efforts include Yara International and Azane Fuel Solutions partnering to create a "zero-emission" ammonia fuel bunker network in Scandinavia, backed by around $9 million in public funding. This network will supply "zero-emission" ammonia to ships as early as 2024, expediting fuel adoption.[101] Also, Clean Energy Marine Hubs, a public-private platform between energy, maritime, shipping and finance stakeholders, has been recently launched to de-risk investment into the necessary ZEF infrastructure and accelerate pace of deployment.[102]

FIGURE 24 **2050 investment requirements**



Source: Accenture analysis based on multiple sources to include; GMF, GTZ and Global CCS institute

Demand

Demand for decarbonized shipping services is rising as nations and businesses pursue strict environmental, social and governance (ESG) goals. However, the feasibility of cargo owners absorbing the estimated green premium of 30-80% remains untested on a large scale.[103] As an industry working on narrow margins, passing the costs on to cargo owners will be challenging and hence, increased policy interventions may be necessary to reduce the green premium.

While the increase in shipping costs is expected to have a minor impact on end-consumers, resulting in an approximate 1-2% green premium (see Figure 25), it's important to note that shipping costs represent only a small fraction of the final retail price of products.[104] Nonetheless, this premium can result in significant absolute cost increases for essential commodities like oil, grains and metals, particularly affecting emerging and developing economies.

FIGURE 25 **Estimated B2B and B2C green premium**

Source: Accenture analysis based on DNV and GMF data

The ability of shipping companies to pass on or profit from the green premium of decarbonized shipping services depends on the demand from industrial or consumer segments and the location. For instance, low-income countries that heavily rely on maritime trade for essential commodities may feel a more significant impact. As the market progresses, regulatory measures could help reduce green premiums and promote the adoption of decarbonized shipping services, thereby driving increased uptake of ZEFs.

The adoption of ZEFs may also need business model changes across the upstream shipping value chain. For example, existing ammonia producers should move beyond traditional demand applications and build supply capabilities to support the increasing need for ammonia from shipping. Similarly, shipbuilders will need to develop ships capable of running on ZEFs as part of their product portfolio. Stable and predictable policy frameworks will be required to create these new markets, build sustained demand and reduce the risk of stranded assets for early movers.

With growing customer emphasis on climate considerations, decarbonized shipping is gaining popularity as a viable alternative. Industry leaders are actively promoting their offerings to meet this demand. For instance, Maersk ECO Delivery, using fatty acid methyl ester (FAME) biofuels, provides CO_2-saving certificates.[105] Hapag-Lloyd's Ship Green enables "climate-friendly container shipping" to reduce ocean shipment emissions. The FMC shipping members have committed to ZEF targets by 2030,[106] with fleet operators pledging 5% of deep-sea shipping and cargo owners committing at least 10% of goods volume via ZEF-powered vessels.[107] These commitments across the value chain have the potential to drive global demand for decarbonized shipping.

To enhance consistency and comparability of GHG emissions data, the industry should adopt standardized quantification and reporting, exemplified by the introduction of ISO 14083 in March 2023.[108] Standardized reporting empowers industry players to strategically target GHG emissions collectively while also creating stricter policies to encourage low-emission fuel adoption, further boosting market demand. The implementation of IMO regulations, Energy Efficiency Design Index (EEXI) and Carbon Intensity Indicator (CII) is anticipated to improve vessel performance transparency and further stimulate the demand for decarbonized shipping.

> Low-income countries that heavily rely on maritime trade may feel more of the green premium impact.

SHIPPING

2 Policy

The global shipping industry operates under selected flag states subject to international regulations led by the IMO. These regulations are bolstered by supporting regional policies that regulate ships entering territorial waters.

To meet IMO targets, regional policies should incentivize ZEF adoption and improve operational efficiency. Key measures include carbon pricing, fuel standards, green corridors, fiscal incentives for low-emission fuel infrastructure, bunkering standards and performance standards.

Existing policy landscape

TABLE 6 **Policy summary**

Enabler	Policy type	Policy instruments	Key examples	Impact
Technology	Market-based	Carbon pricing	– EU-ETS[109] – US International Maritime Pollution Accountability Act: $150 per tonne of CO_2 emissions proposed[110] – IMO economic measure, 2023 strategy[111]	$2.2 billion under EU-ETS to fund shipping decarbonization innovation.[112] The proposed US carbon pricing is projected to bring in $250 billion in low-emission funding, over the next 10 years.[113] Carbon pricing under IMO is still under discussion and will not be in effect before 2027.
	Mandate-based	Performance standards and certification	– Energy Efficiency Design Index (EEXI)[114] – Carbon Intensity Indicator (CII)[115]	Mandatory standards that ships must comply with, driving continuous technical and operational improvements.
Infrastructure	Incentive-based	Taxes and subsidies	– IRA clean power and green hydrogen production tax credits[116]	50% reduction in green hydrogen production costs that can boost scaling of green hydrogen capacity required for low-emission fuels.[117] The feasibility of such subsidy-driven policies for developing economies is uncertain.
	Mandate-based	Direct regulation	– EU Alternative Fuels Infrastructure Regulation mandate for major EU ports to provide shore side electricity to vessels[118]	Reduces emissions at ports by providing cleaner electricity as an alternative with a specific timeline for ports to action upon (by 2030).[119]
Demand	Incentive-based	Green corridors	– Clydebank Declaration: 22 countries as signatories to create six green corridors by 2026[120] – Green corridor pledges at COP27 between the US, the UK, the Netherlands and Norway[121]	Reduces risks of adopting low-emission fuels by deploying at a local scale and mobilizing demand. 21 green corridor initiatives announced so far, involving over 100 stakeholders.[122]
	Mandate-based	Fuel standards	– FuelEU Maritime initiative[123] – US Clean Shipping Act[124] – IMO technical measure, 2023 strategy[125]	Provides predictable pathways for low-emission fuels that encourage adoption and drive demand.
Capital	Incentive-based	Direct funding	– Public funding for green shipping projects in India[126]	Funds 30% of costs of new "green" ships.[127]

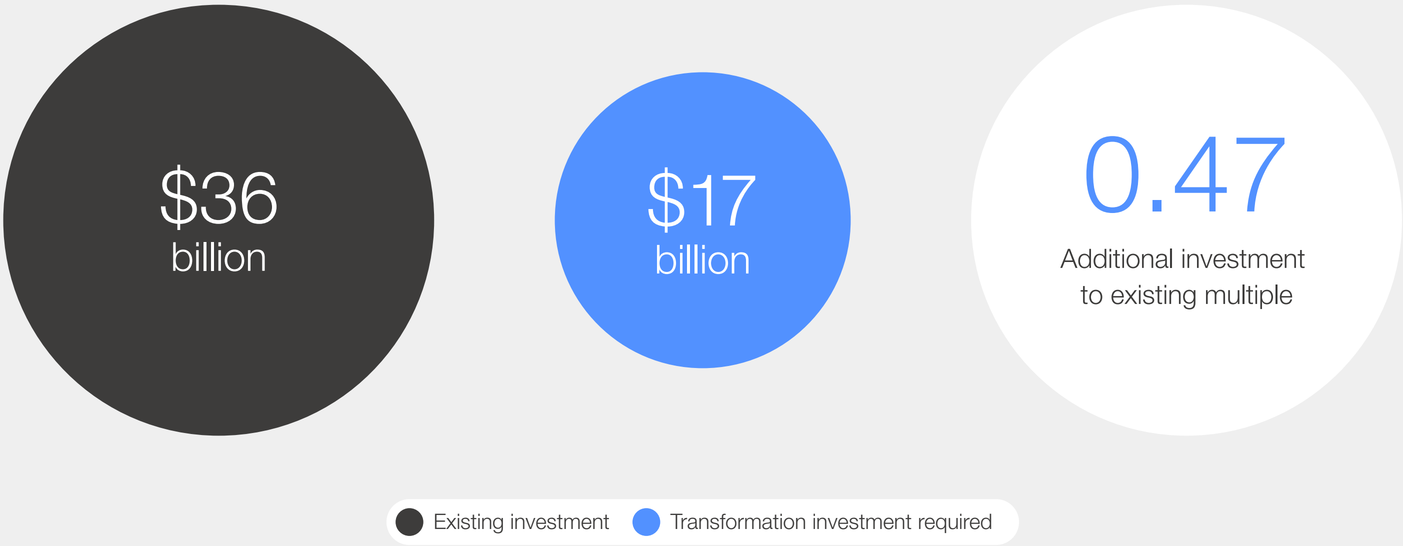
SHIPPING

1 Capital

In the shipping industry, retrofitting the current fleet and upcoming ships orders with ZEF propulsion technology necessitates an estimated $450 billion in investment by 2050.[128] This breaks down to an annual extra cost of $17 billion for fleet owners.[129] Given the current annual CapEx for shipping firms, which stands at approximately $36 billion, this represents an added 47% investment load annually.[130]

Recent data suggests the business case for zero-emission shipping investment remains weak due to high costs and uncertain returns. Current industry profit margins of around 32%[131] and WACC of 8-10%[132] suggest the industry is not positioned to absorb additional costs and generate sufficient returns solely from internal cash flows.[133] Fortunately, with the expansion of technology and the realization of economies of scale, it is anticipated that the financial demands for investment will diminish.

FIGURE 26 **Additional investment required to existing investment ratio**



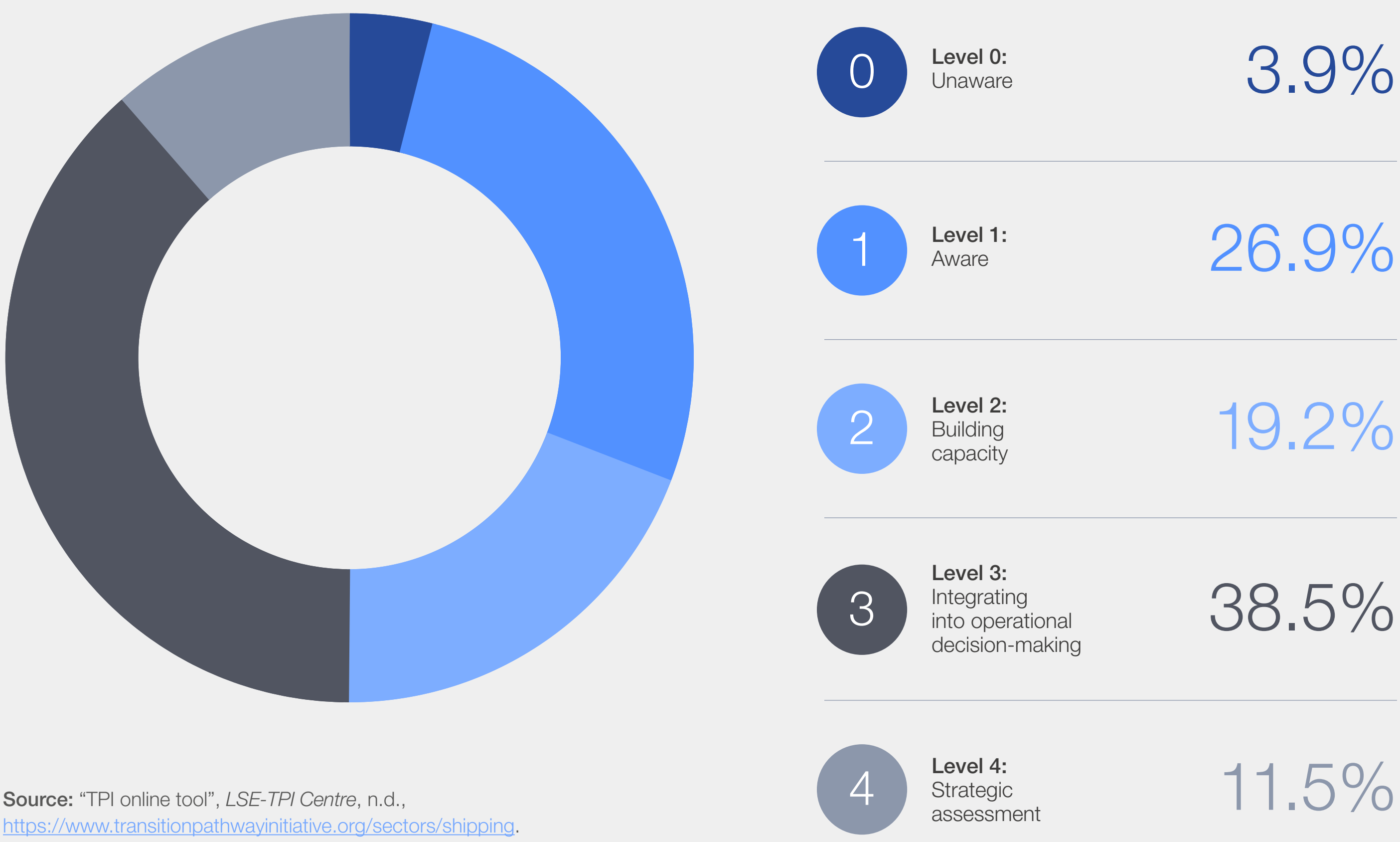
Source: Accenture analysis based on multiple sources, to include EMSA, DNV and UNCTAD

Historically, commercial bank loans have served as the primary source of financing for the shipping industry. Nevertheless, for the sector to achieve its net-zero objectives, there is a growing need for increased involvement from the public sector. This involvement can take the form of direct subsidies or blended finance mechanisms, both of which are designed to incentivize private sector engagement in sustainable shipping initiatives. The International Chamber of Shipping (ICS) set out a Fund and Reward proposal to the IMO for shipowners to make mandatory contributions per tonne of CO_2 emitted to create a new IMO fund to be established by 2024, which will reward uptake of low and zero-carbon fuels and provide billions of dollars of funding annually for alternative fuel production and bunkering infrastructure in developing countries.[134]

Approximately 50% of large publicly traded shipping companies consider climate change as a key consideration for their strategic assessment and integrate it into their operational decision-making.[135] Meanwhile, 19% of companies are building basic emissions management systems and process capabilities. Finally, 27% of companies acknowledge climate change as a business issue.[136]

FIGURE 27

Distribution of companies in the shipping sector according to the management of their GHG emissions and of risks and opportunities related to the low-carbon transition



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