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Future Shipping Fuel Demand Outlook

Assessing Alternative Marine Fuel Supply and Demand

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Supply and Demand for Alternative Marine Fuels

- ✓ Tightening draft IMO NZF targets point to rising zero/near-zero (ZNZ) fuel demand
- ✓ Yet four barriers—resources, competition, cost, infrastructure—constrain supply

Demand: Policy-Driven

NZF targets **tighten yearly** → p.3

~10 EJ* of **ZNZ fuel demand** in 2050 → p.4

Multiple fuels likely to coexist → pp.3–6

*MMMCZCS scenario estimate

Gap

Supply: Four Barriers

① Resource limits → p.5

Capped by sustainable biomass and renewable hydrogen supply

② Sector competition → p.5

Road, aviation, chemicals and power vie for the same resources

③ Cost → p.5

Production costs far exceed those of fossil fuels

④ Infrastructure → p.6

High investment needs and a “chicken-and-egg” problem

Keys to closing the gap **IMO NZF pricing (RU/SU) → p.3 + Cost-sharing that includes cargo owners → p.7**

- **RU (Remedial Unit): unit acquired to cover a compliance deficit**
- **SU (Surplus Unit): unit earned when a ship’s GHG intensity is below the direct compliance target**

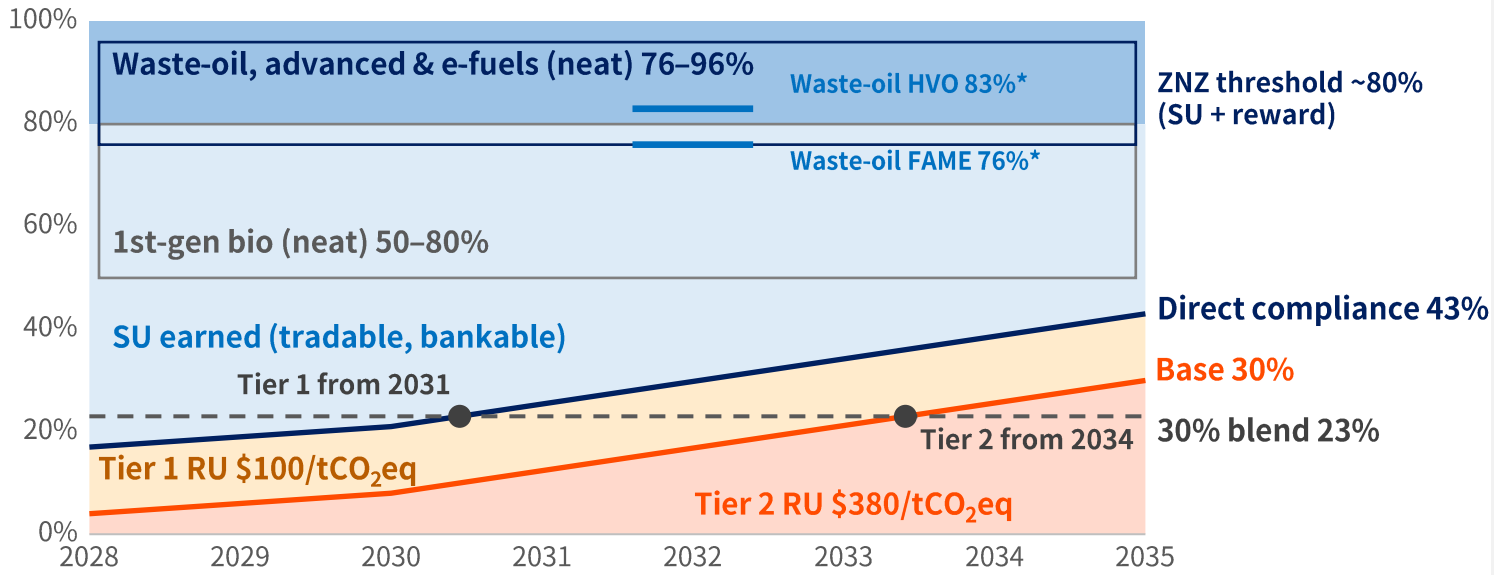
Source: Draft approved at IMO MEPC 83 in Apr 2025, not yet adopted (session resumes Dec 4, 2026, subject to MEPC 85); MMMCZCS (2023)
*SU/RU, fund, reward and target design are still under negotiation, with amendments proposed by several countries incl. Japan

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Draft IMO NZF: Stepwise Tightening and RU/SU

- ✓ Annual tightening can turn the same fuel and blend from SU earner to RU buyer
- ✓ Lower GHG intensity earns more SUs; ZNZ rewards add a further incentive to invest

Draft NZF GHG-Intensity Targets (Reduction vs. 2008)



SU = (Direct compliance GFI target − attained GFI) × energy used
→ Deeper cuts earn more SUs, making it easier to stay in surplus as targets tighten

*At 100% use; blends pro rata (dashed line = 30% waste-oil FAME blend, energy basis). Waste-oil FAME/HVO: IMO 2024 LCA Guidelines App. 2 defaults (2nd-gen feedstock); others: IEA. GFI: GHG fuel intensity (2008 ref. 93.3 g/MJ)

RU/SU: Carrot and Stick

① Paying for deficits (stick)
Tier 1 deficit: buy Tier 1 RUs (US$100/t)
Tier 2 deficit: SUs or Tier 2 RUs (US$380/t)
*Prices set to 2030; later prices TBD

② Incentive (carrot)
Surpluses earn SUs (tradable; bankable up to 2 years)
Price set by the market

③ ZNZ reward
Fuels ≤19 gCO_2eq/MJ WtW (~80% cut) eligible; design under discussion
*From 2035: ≤14 gCO_2eq/MJ (~85% cut)

④ Stepwise tightening
2028→35: Base 4→30%,
Direct compliance 17→43% (2040: Base 65%)

→ Blends and low-cut options lose ground yearly; deep-cut ZNZ fuels gain over the long term

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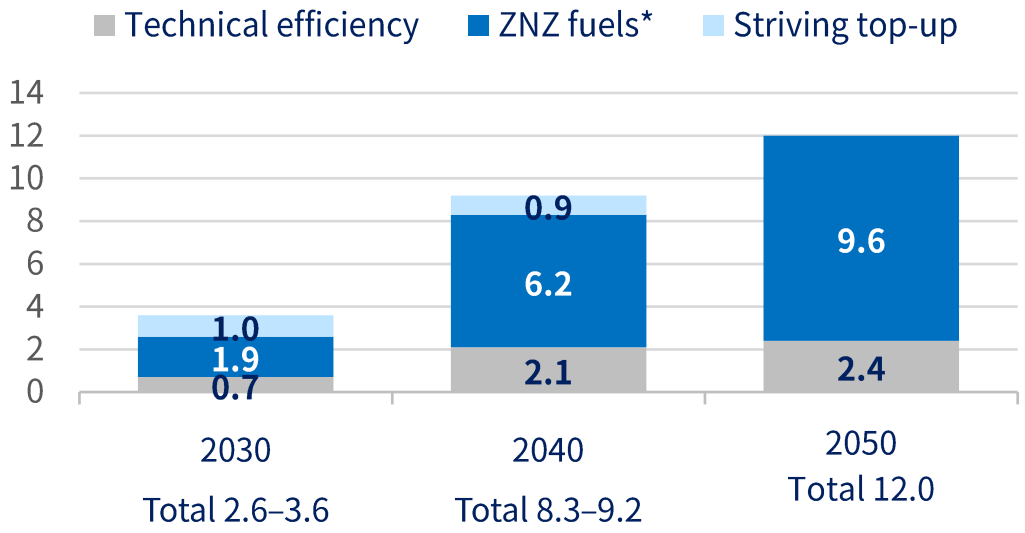
Source: Draft approved at IMO MEPC 83 (not yet adopted; subject to change), IMO 2024 LCA Guidelines, MMMCZCS “Breaking down the IMO NZF”

Shipping Fuel Demand: Volumes and Mix

- ✓ MMMCZCS estimates ~10 EJ of ZNZ fuel demand in 2050 on an IMO-aligned pathway
- ✓ The fuel mix hinges on biofuel availability; multiple fuels are likely to coexist

Estimated Volumes for IMO Targets

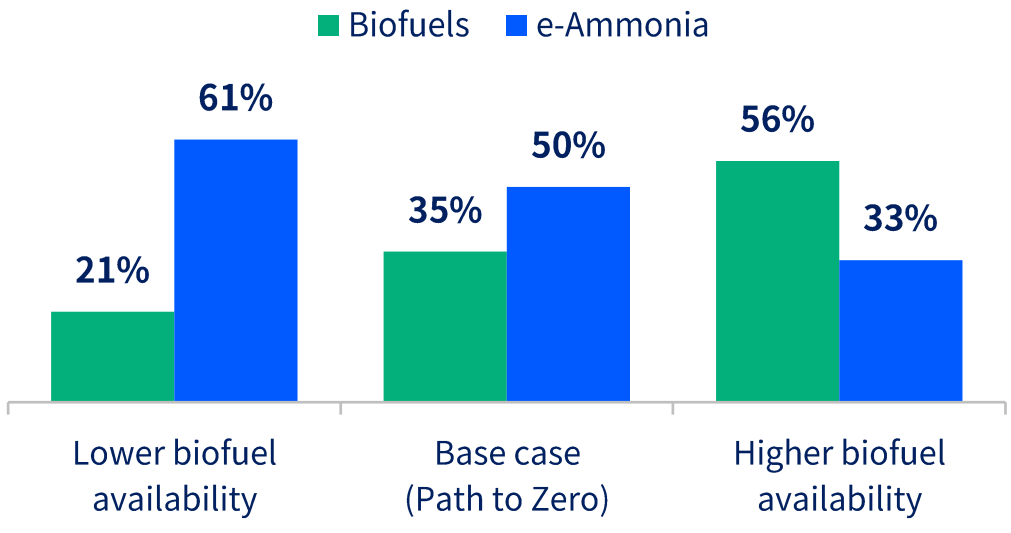
Fossil fuel use to be avoided (int'l shipping, VLSFO-equivalent, EJ)



Source: MMMCZCS (2023), Setting Sail on a Sustainable Course
*Total ranges from minimum to striving levels (2030: 20–30% cut; 2040: 70–80% cut)
*ZNZ fuels: sustainable fuels covering the gap after technical (non-operational) measures

2050 Fuel Mix by Biofuel Availability

Share of shipping energy demand (%); remainder: other ZNZ fuels



Source: MMMCZCS (2021), Position Paper: Fuel Option Scenarios
*2021 scenarios predating the 2023 IMO GHG Strategy, shown to illustrate sensitivity

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Supply Limits: Resources and Competition

- ✓ Upstream resources cap supply—and road, aviation and shipping compete for them
- ✓ ZNZ fuels currently cost far more to produce than conventional fossil fuels

Category	Main fuels / feedstocks ( ) = supply constraint	Main end uses Dark = primary, light = partial	GHG reduction (indicative)	Cost and scale-up
1st-gen biofuels	**Crop-based FAME, ethanol** Rapeseed, soy, etc. (food vs. fuel) ***Counted as fossil under FuelEU**	Road Air Ship Chem Power	~50–80% cut (varies by feedstock/origin) Benefit may shrink once ILUC is counted NZF: crop-based fuels in scope (LUC TBD)	Varies by production region
Waste-oil biofuels	**UCO-FAME, HVO/HEFA** UCO, tallow (finite supply)	Road Air Ship Chem Power	IMO default values (→ p.3) FAME 76%, HVO 83% (only HVO ≤19 g)	Scale-up is challenging Feedstock limits may raise prices
Advanced (2nd-gen)	**Bio-methanol, bio-LNG, etc.** Residues, waste (collection limits)	Road Air Ship Chem Power	Bio-LNG can benefit under FuelEU, but depends on methane slip	Feedstock limits; large offtakes hard to secure (bio-LNG contested); scale may cut costs
e-fuels	**e-SAF, e-methanol, e-ammonia, etc.** Renewable H2 (electrolyzer limits)	Road Air Ship Chem Power	Requires renewable power (plus a sustainable CO2 source for carbon-based e-fuels)	Costs could fall with large-scale output as uses beyond shipping (power, H2 carriers) grow

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Source: IEEJ assessment based on IEA Delivering Sustainable Fuels (2025), IMO 2024 LCA Guidelines, etc.

Beyond Production: Infrastructure Gaps

- ✓ Investment in supply infrastructure often hinges on medium- to long-term offtake contracts
- ✓ Regulatory uncertainty makes shipping companies and cargo owners wary of long-term deals
- ✓ Demand is still very limited; supply alone is unlikely to break the chicken-and-egg cycle

Production → **Transport** → **Storage** → **Bunkering** → **Onboard use**

Infrastructure Requirements by Fuel

Fuel	Storage conditions	Existing infrastructure	Common supply challenges	Other challenges
Biodiesel	Liquid at ambient temperature	Replacing current fuels at scale requires new or expanded storage tanks, bunker vessels, etc.	Ports worldwide need infrastructure matched to bunker demand: • Onshore (or floating) storage • Bunker vessels (where needed) • Loading facilities (jetties, etc.) • Fuel suppliers • Port permits and approvals	Quality loss in long-term storage Blending facilities for fuel oil Blend stability with fuel oil
Methanol / ethanol				Safety measures for low-flashpoint fuels
Ammonia	−33°C (atmospheric) or pressurized			Toxicity-related safety requirements
Bio-/e-LNG	Cryogenic (−162°C, near-atmospheric)	LNG bunkering network usable, though limited		Existing industrial facilities may need retrofits or new capacity

Source: IEEJ

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Conclusions: Challenges and Outlook

Answer to the Key Question	**Demand:** ~10 EJ of ZNZ fuel demand in 2050 on an IMO-aligned pathway (MMMCZCS) **Supply:** Four barriers (resources, competition, cost, infrastructure) may open a gap

- ✓ **Every alternative fuel faces cost, infrastructure and scale-up hurdles as a ZNZ fuel**
  - Methanol/ethanol and ammonia need major marine-fuel infrastructure, from low-GHG production to bunkering; scaling biofuels also requires securing sites and repurposing or building infrastructure
- ✓ **ZNZ fuel demand remains limited, so supply-led investment is hard to justify**
  - Dispersed bunkering demand from shipping alone can hardly justify new infrastructure; without visible, sustained demand, investing across the value chain—from production to global supply—is difficult
- ✓ **Few cargo owners pay a green premium; fuel switching has recently lost momentum**
  - Some estimates suggest a limited premium per container or vehicle, yet cargo-owner buy-in is hard to win and shipping companies cannot bear the cost alone; cost-sharing that includes cargo owners is needed
- ✓ **If adopted, the IMO NZF (RU/SU) could be a game-changer**
  - A pricing mechanism with incentives and penalties would improve demand visibility and support investment from production to supply—though adoption timing and design remain under negotiation

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Source: IEEJ, based on MMMCZCS, draft approved at IMO MEPC 83, DNV Alternative Fuels Insight, etc.