Charting the course:

Strategies for ports to supply zero-emission fuels

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RMI

ENERGY. TRANSFORMED.

Today's speaker

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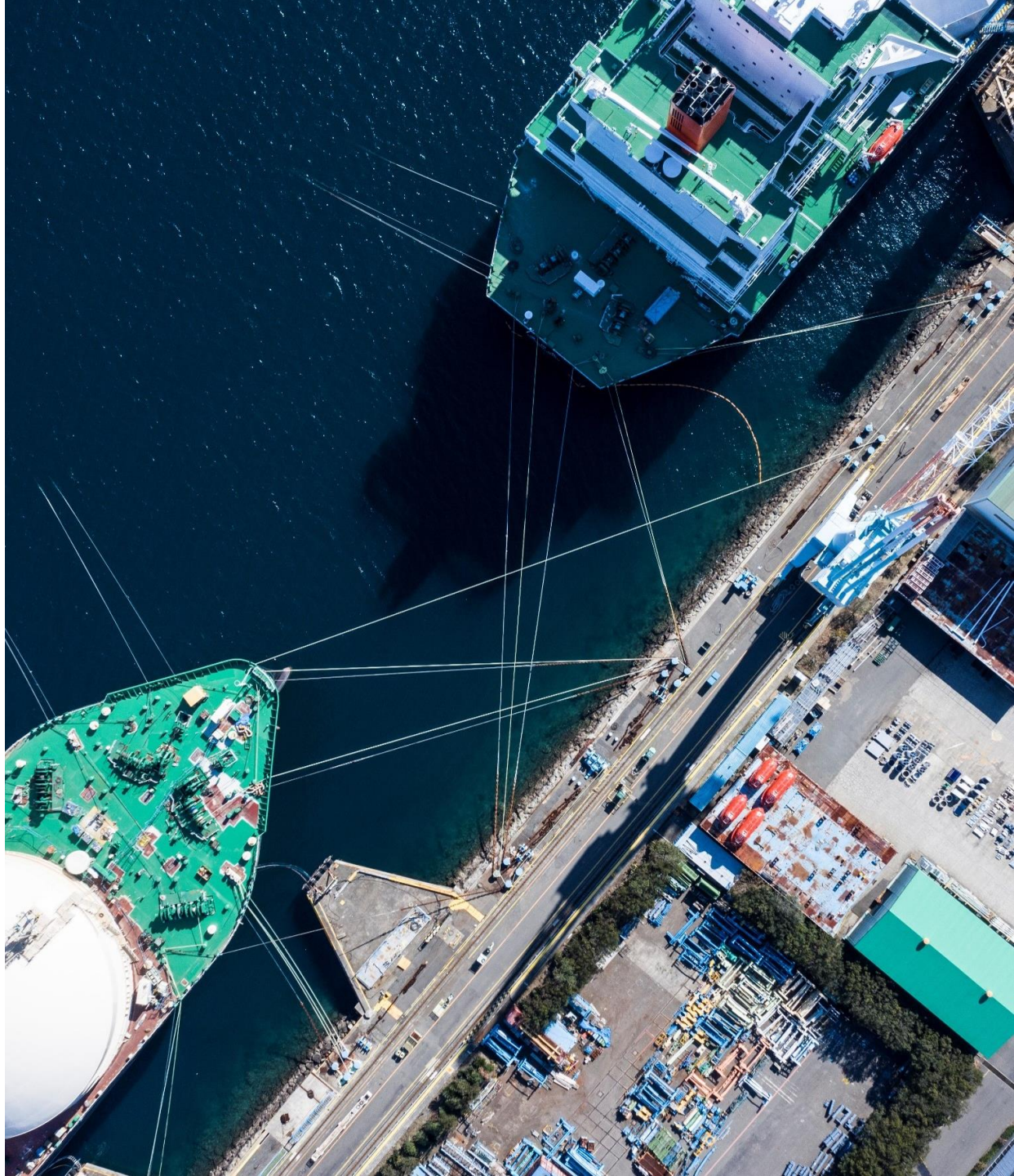
Agenda

1. Overview on relevant maritime policies and renewable shipping fuels
2. Intro to and key findings from the Oceans of Opportunity (OOO) report
3. A deeper dive into the Global South opportunity

Overview on relevant maritime policies and renewable shipping fuels



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Shipping is a global industry with emissions expected to significantly increase assuming current growth rates continue

~80%
of world trade today[1]

~3%
of current global emissions[2]

>¾
of goods movements by 2050[3]

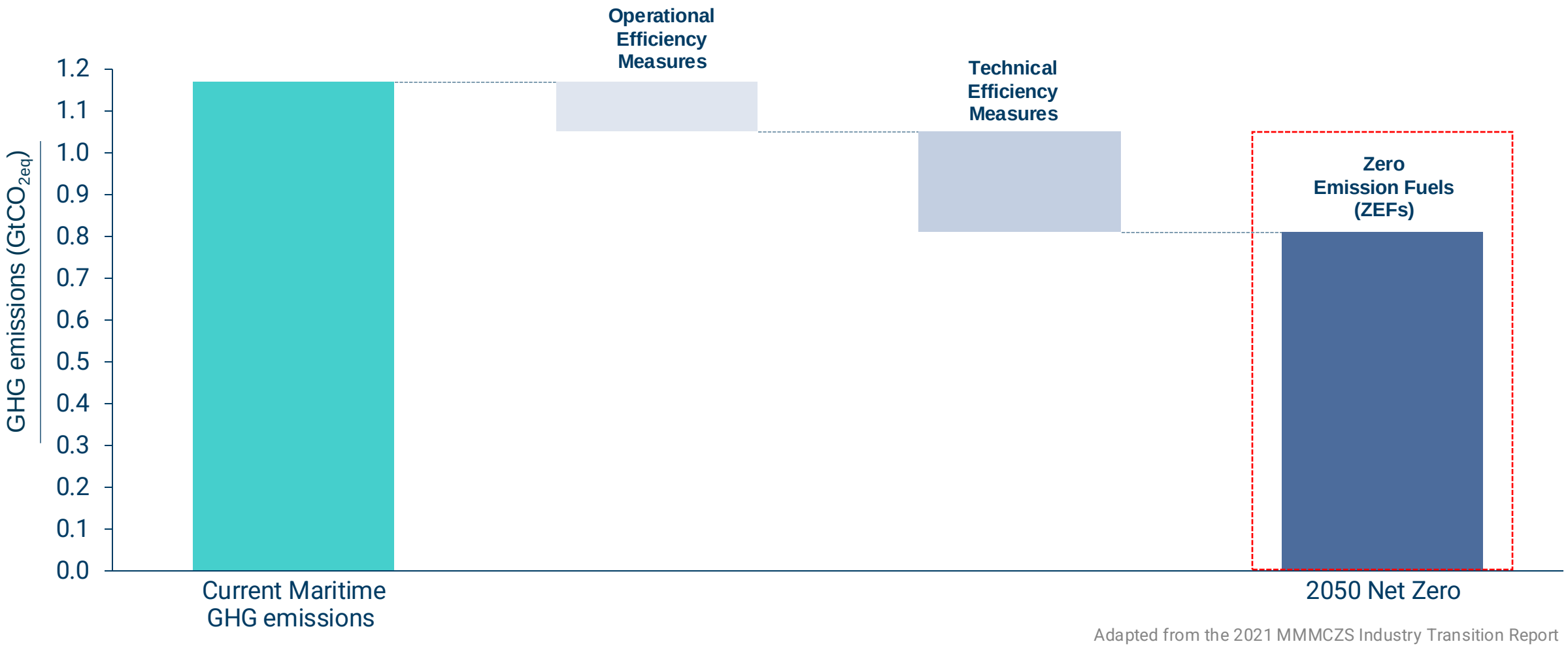
+ 50%
emissions without collective efforts by 2050[4]

[1] UNCTAD (2020)
[2] ETC (2020)
[3] OECD (2019)
[4] ETC (2019)

Efficiency measures can help but for true decarbonization the shipping industry will require a revolution in fuels and propulsion technologies

Emission reduction measures for maritime decarbonization

Illustrative



Adapted from the 2021 MMMCZS Industry Transition Report

The International Maritime Organization (IMO)'s GHG Strategy sets a pathway to reach net zero and calls for uptake of ZEFs by 2030

The use of ZEFs are essential if the maritime sector wants to reach net zero by 2050

IMO 2023 GHG strategy

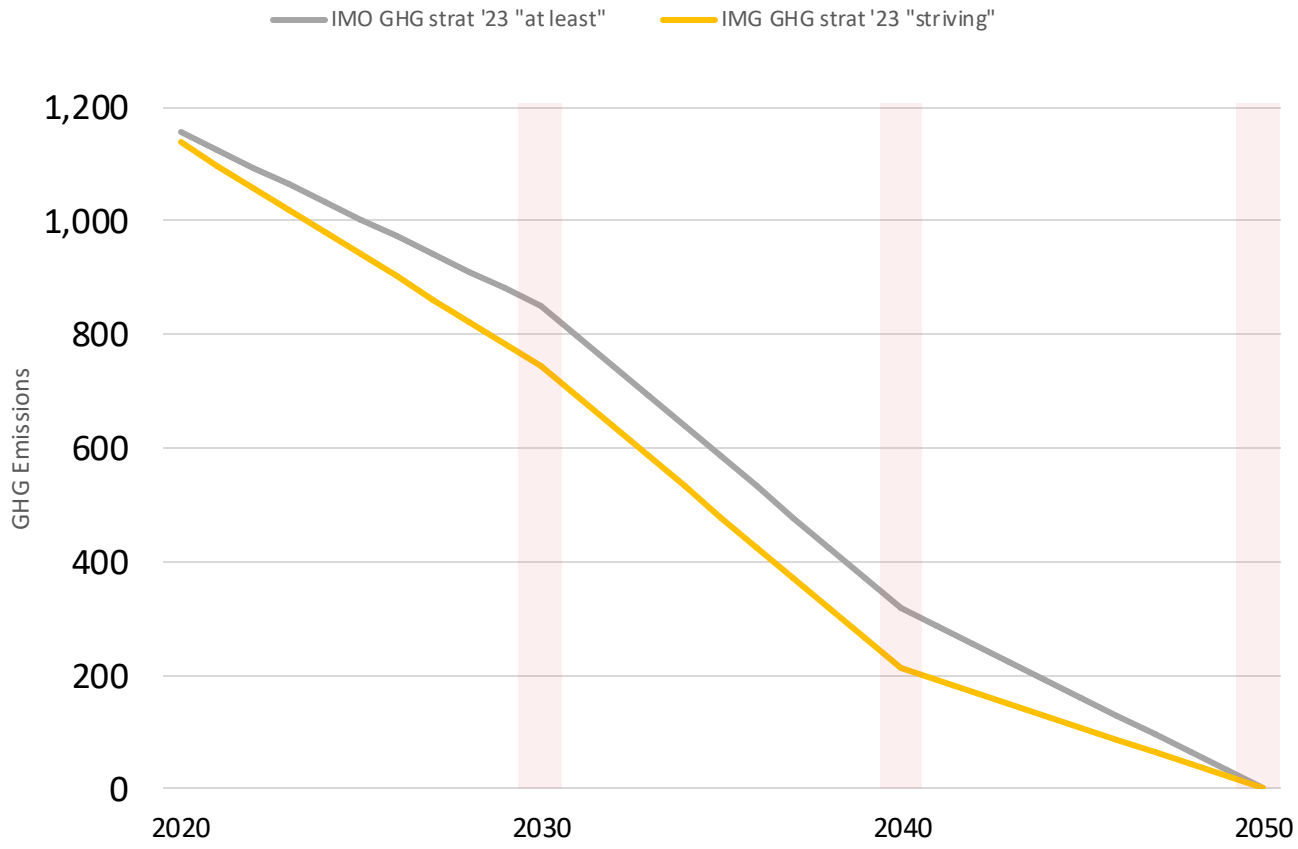
2030
Reduce international maritime GHG emissions by at least 20%, striving for 30%[1]

Uptake goal for zero or near-zero emission fuels to represent **at least 5% of shipping's energy use, striving for 10%**

2040
Reduce international maritime GHG emissions by at least 70&, striving for 80%[1]

2050
Net-zero GHG emissions

Emission goals set by IMO 2023 GHG strategy[2]



1. Relative to 2008 levels
2. GHG emissions based on IMO's Fourth GHG Study

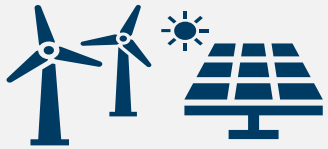
Two promising ZEFs for oceangoing vessels includes green methanol and green ammonia

Methanol is ready now, but has scalability challenges; ammonia could be ready within 5 years with high scalable potential

Feedstocks required

Green methanol (CH_3OH)

E-methanol



H2 from renewably powered electrolyzers

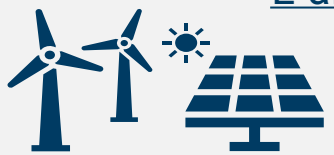
Biogenic carbon*

Bio-methanol

Biomass

Green ammonia (NH_3)

E-ammonia



H2 from renewably powered electrolyzers

Nitrogen from air separation unit

Progress in fuel deployment[1]

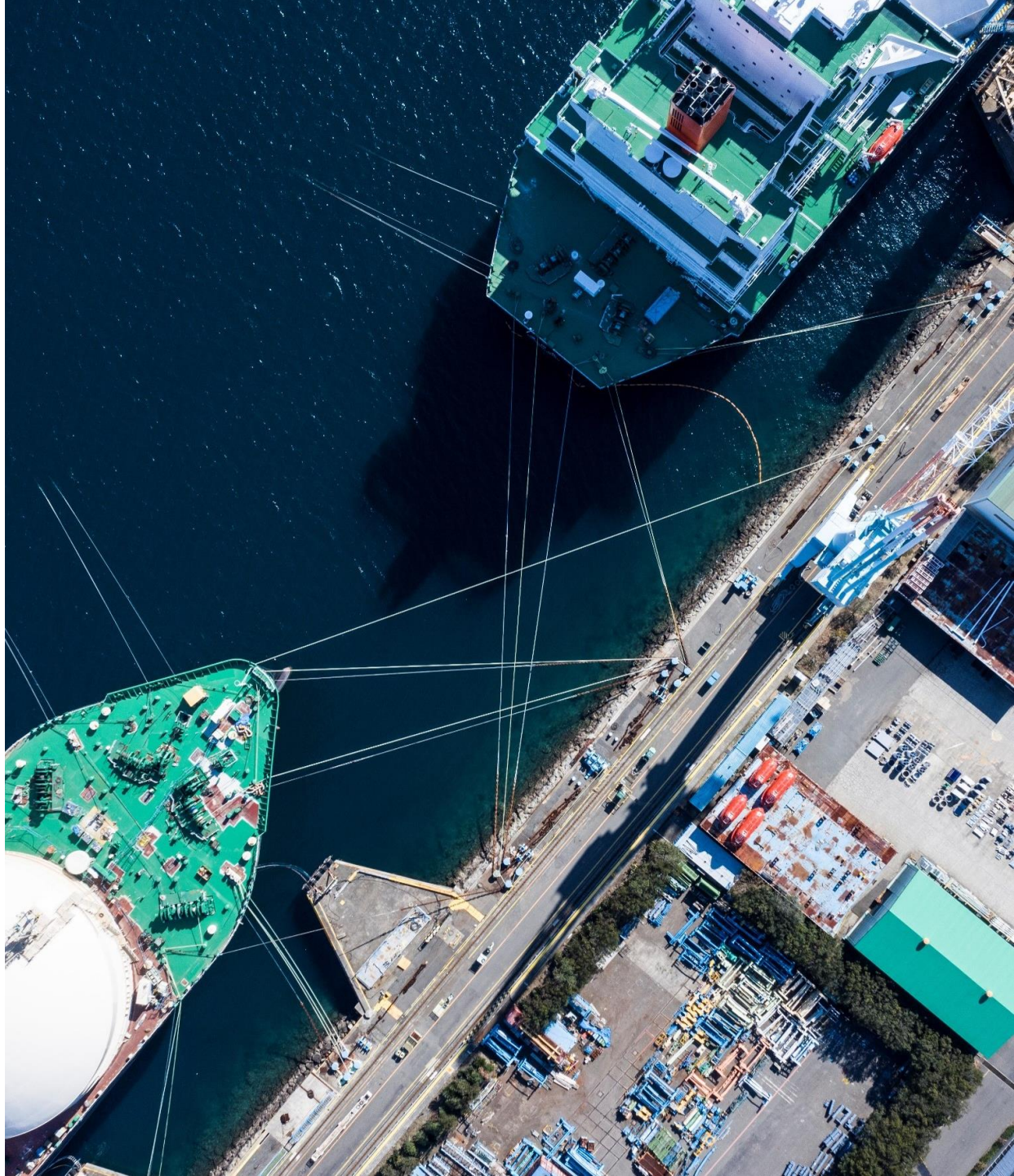
	TRL (Out of 9)
Dark green indicates high readiness	
Production	3.5
Bunkering & ports	6
Handling & storage	9
Engine	9

	TRL (Out of 9)
Dark green indicates high readiness	
Production	5
Bunkering & ports	5
Handling & storage	5
Engine	6

**E-methanol can also be made with carbon from direct air capture, but this likely won't be economically viable in the near-term*

1. Lloyd's Register Zero Carbon Fuel Monitor

Intro to and key findings from the Oceans of Opportunity (OOO) report



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The OOO report clarifies how ports and other maritime stakeholders can initiate green methanol and ammonia bunkering

The report's objective: To create clarity for ports, fuel producers, and investors on potential low-carbon fuel supply scenarios in 2030 and support competitive sourcing strategy development

To accomplish the objective, we leveraged **RMI's Port Fuel Supply techno-economic model** that estimates the total delivered cost of green ammonia or methanol to a vessel

Project initiators

ZERO-EMISSION SHIPPING MISSION

RMI

GLOBAL MARITIME FORUM

Sounding board group

Port of Rotterdam

Port of Seattle

PILBARA PORTS AUTHORITY

Port of Antwerp Bruges

MPA SINGAPORE

WorldKinect Energy Services

Bunker Holding Group

InterContinental Energy

YARA

Port of Amsterdam

U.S. DEPARTMENT OF ENERGY

UMAS

Forskningsrådet

Several key takeaways emerged from the report

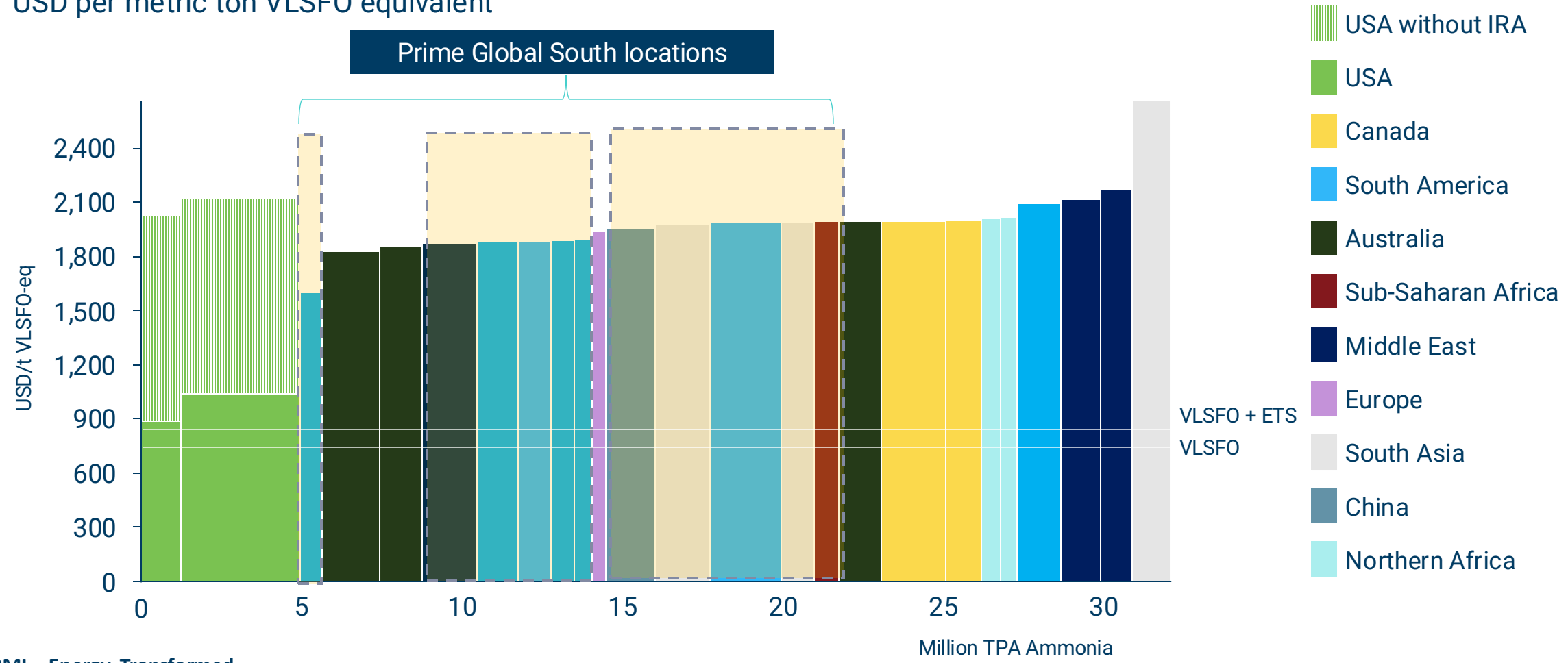
Fuel availability	Project announcements suggests there could be enough combined green methanol and ammonia to meet the IMO's target of 5% zero-emission fuel use by 2030
First mover advantage	Despite sufficient projected availability, only a few locations will have low-cost fuel; first-movers will have a significant advantage if they are aggressive in fuel procurement
Significant trade	Because global production costs of green methanol and ammonia are higher than fuel vessel transport costs, significant global fuel trade is likely
Four port archetypes	Different port “archetypes” will face different opportunities and risks in providing zero-emission fuels, and require different strategies to unlock their potential
Global South opportunity	There will be opportunities in many Global South countries for greater maritime fuel-related economic activities, due to lucrative solar and wind resources

Significant volumes of green ammonia could be available by 2030, including from production in the Global South

Green ammonia will most likely be produced from a wide variety of countries

Announced 2030 green ammonia capacity by region in order of cost

USD per metric ton VLSFO equivalent

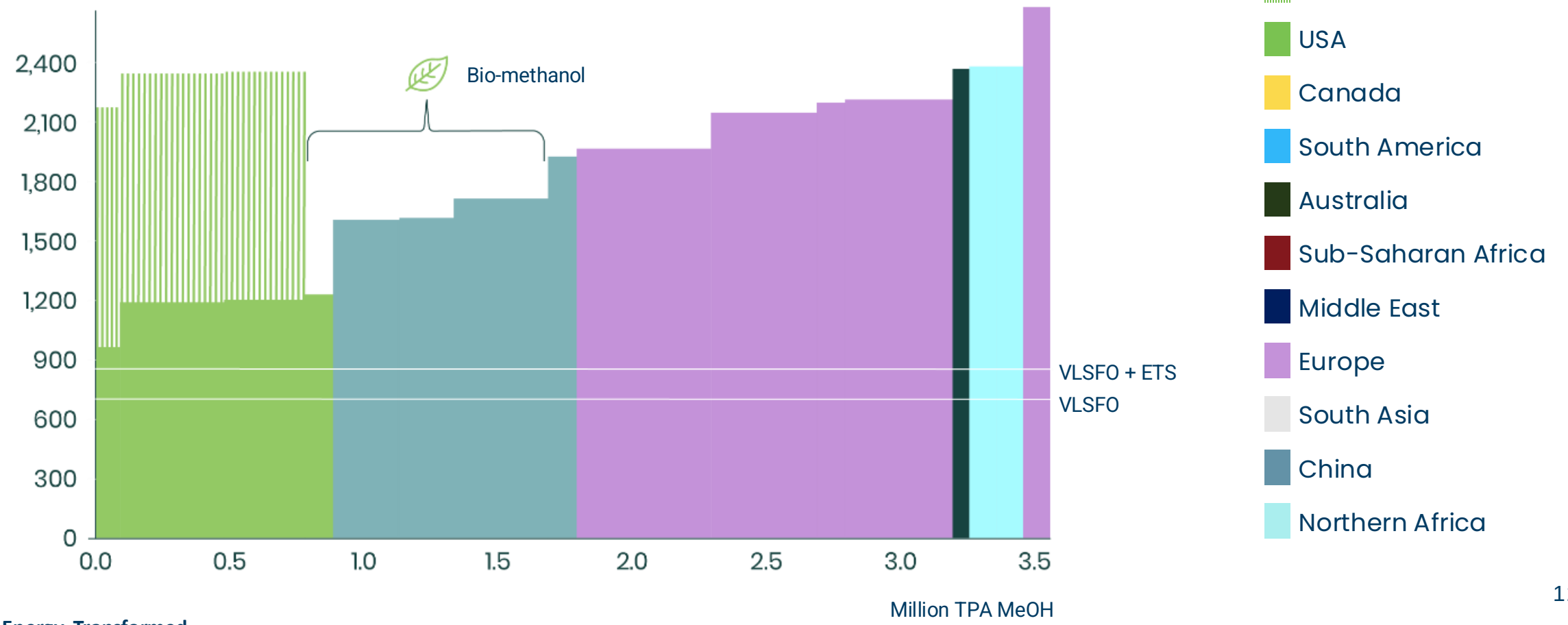


Less green methanol will be available due to limited sustainable carbon resources

Green methanol will be produced primarily from North America, China, and Europe

Announced 2030 green methanol capacity by region in order of cost

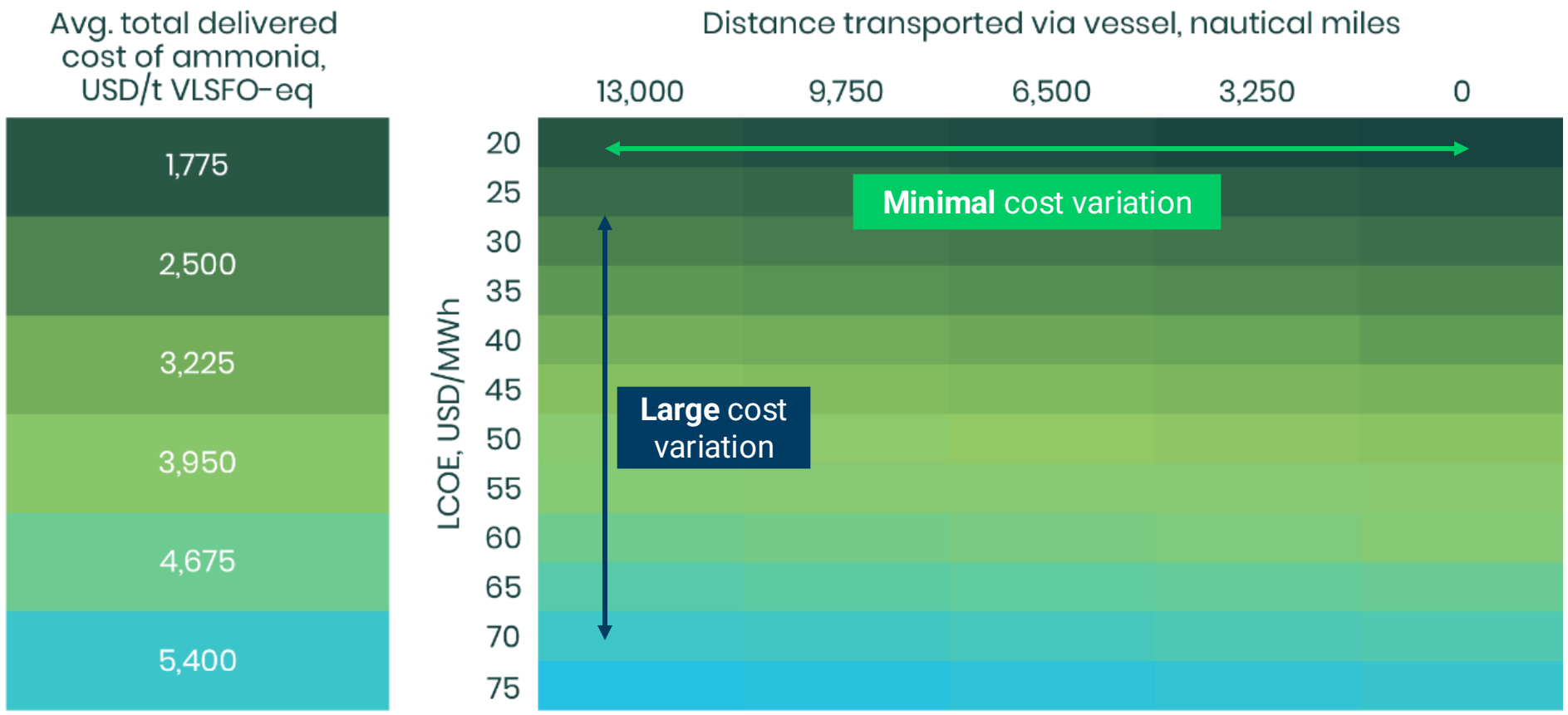
USD per metric ton VLSFO equivalent



Renewable capacity factors affect the total delivered cost of green fuel significantly more than ocean transport costs

Production conditions, especially LCOE, are by far the largest factor for the total delivered cost of fuel

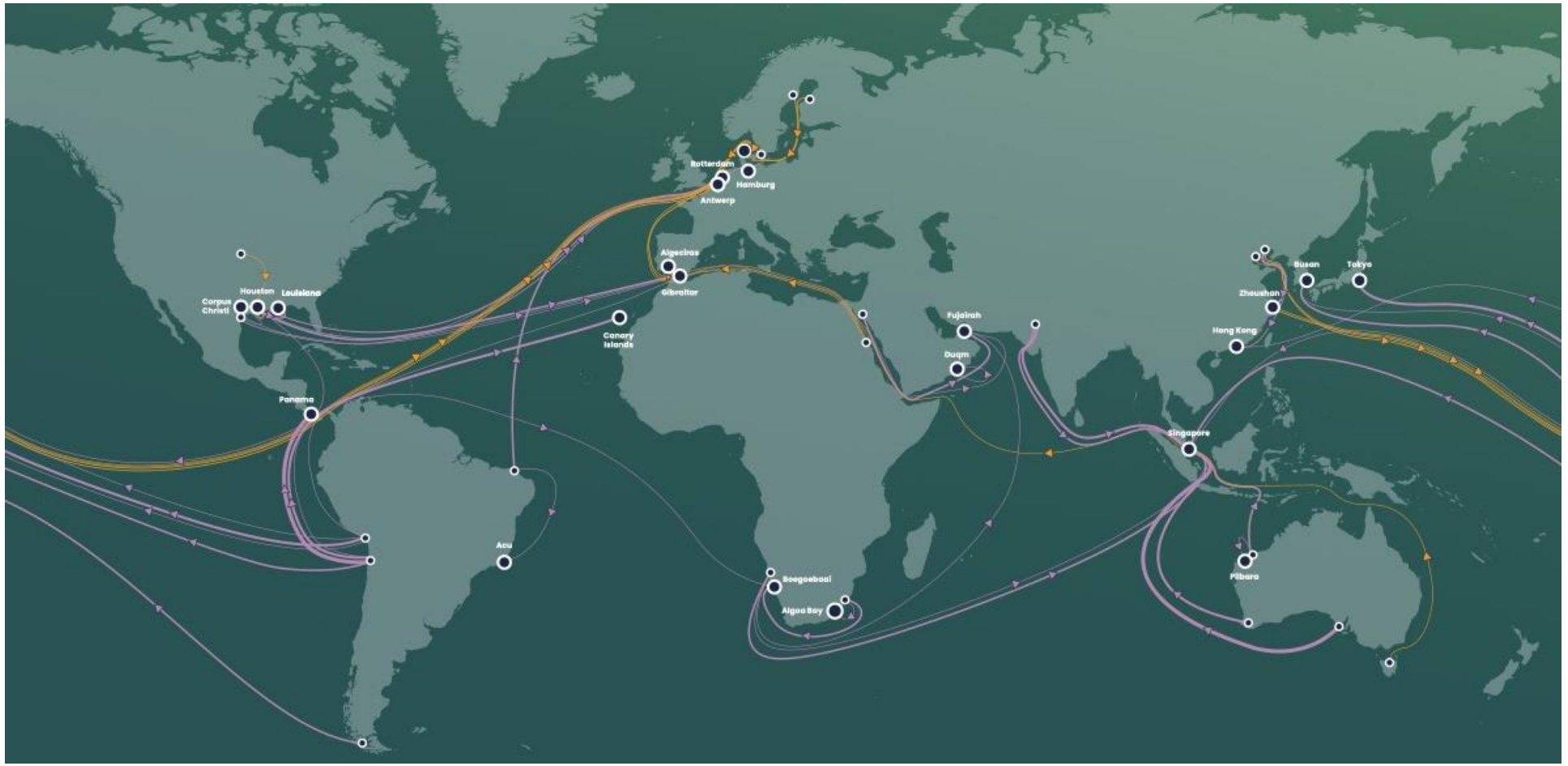
Relative impact on total delivered cost of green ammonia from levelized cost of renewable electricity compared to seaborne transport

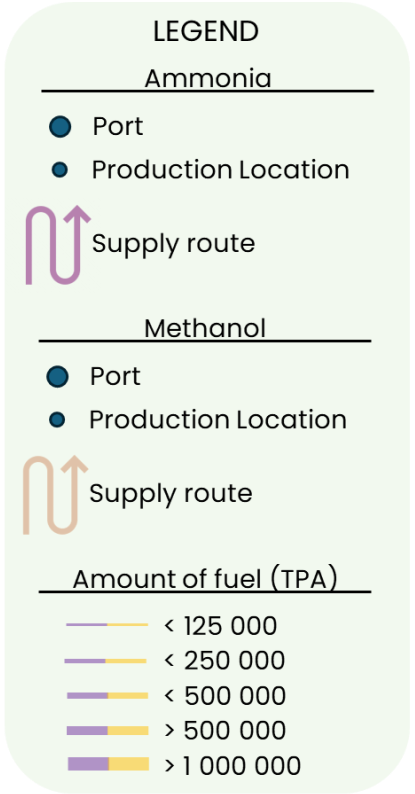


Relatively low ocean transportation costs and high variation in production costs will result in significant global martime fuel trade

Europe and Asia are likely to be leading demand centers for maritime ZEFs

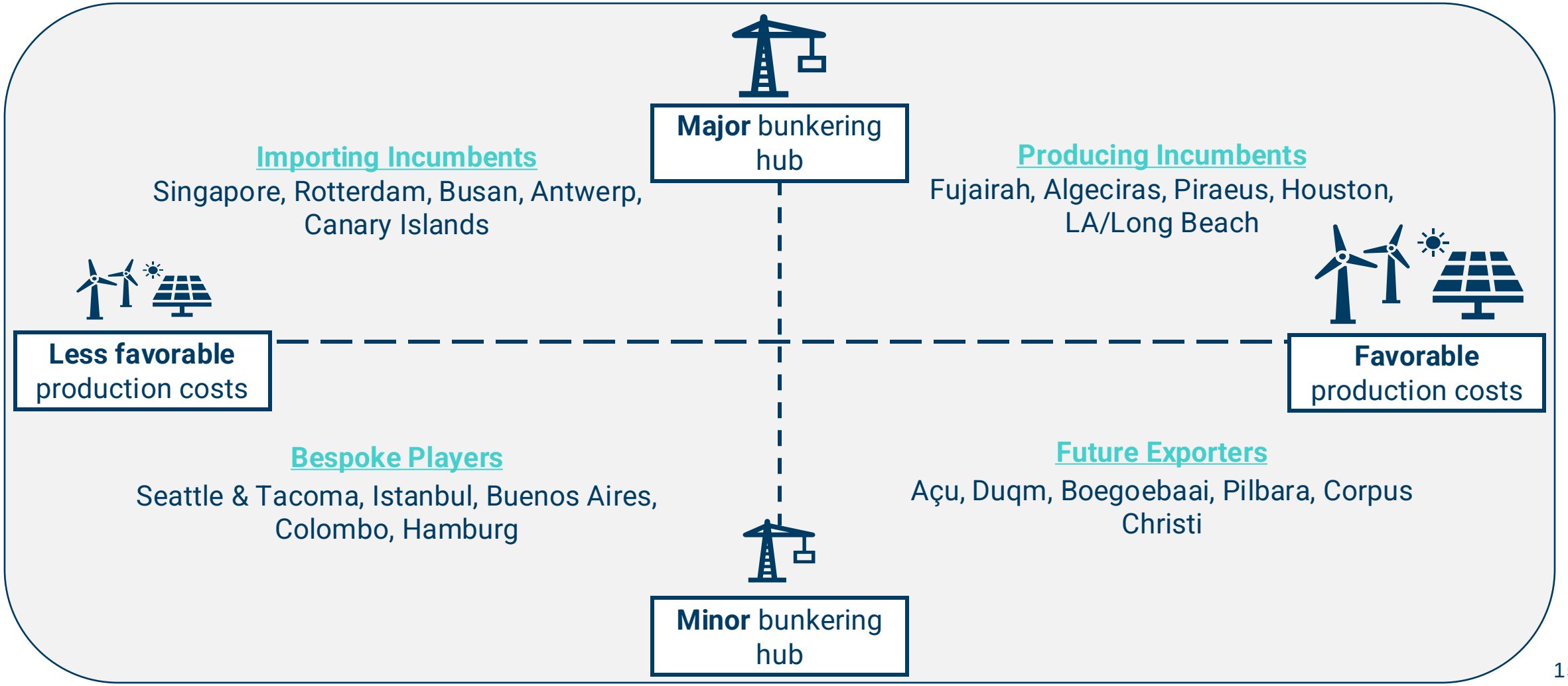
Potential green methanol and ammonia trade flows by 2030 if 20% of announced volume is realized





Fuel trade dynamics will likely result in the emergence of four distinct port ‘archetypes’

Archetypes are based on i) current size of bunkering operations and ii) favorability of local production conditions



Port archetype assignments are estimates based on current conditions. Ports placements are slightly subjective.

Based on their port archetype, ports can determine what strategies they can use to source green fuel and initiate green fuel bunkering demand

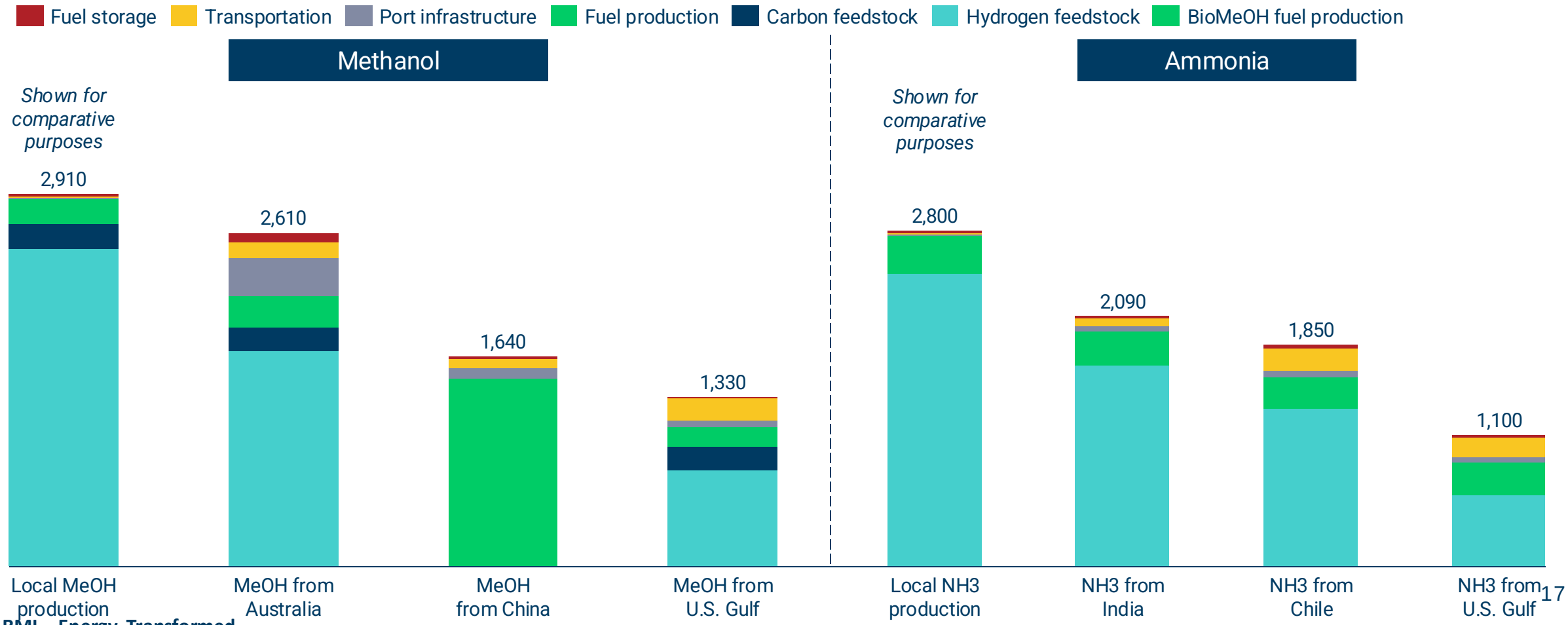
Recommended actions each port archetype should take to seize their green bunkering opportunity	Importing incumbents	Producing incumbents	Future Exporters	Bespoke Players
Establish partnerships with low-cost regions to earmark low-cost fuel volumes	■			■
Participate in **hydrogen import/export corridors**	■	■	■	■
Coordinate green methanol and ammonia bunkering standards with other ports	■	■		
Engage first mover customers within shipping to activate green methanol and ammonia fuel demand	■	■	■	■
Set up **export routes** for the supply of green methanol and ammonia to other ports to scale infrastructure and production		■	■	
Consider focusing efforts on **establishing bunkering one zero-emission fuel** in the near-term			■	■
Implement **incentives**, such as discounted harbor dues and preferential berthing**, for zero-emission ships**			■	■
Consider setting a **target of 10% zero-emission fuel sales** by 2030			■	■
Explore the availability of **capital grants** or **preferential loans for methanol and ammonia bunkering infrastructure**			■	■
Explore **collaborative offtake opportunities**			■	■

Large bunkering ports with limited renewable resources, like Singapore, will rely on multiple green fuel export hubs with low-cost production conditions

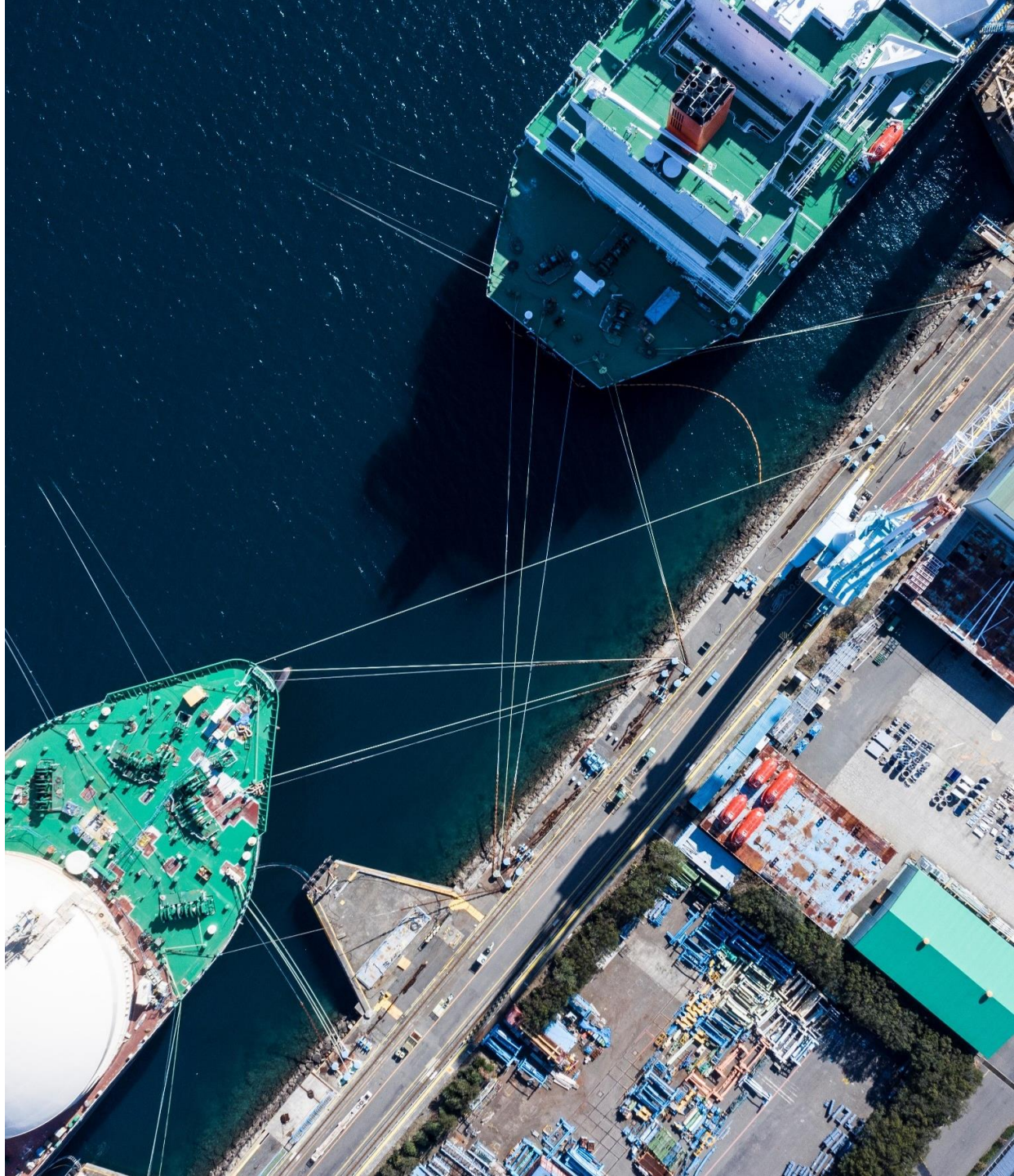
Singapore is the largest bunkering port globally, bunkering five times more than the next leading bunkering port

Assessed green methanol and ammonia supply pathways for Singapore in 2030

USD per metric ton VLSFO equivalent



A deeper dive into the Global South opportunity

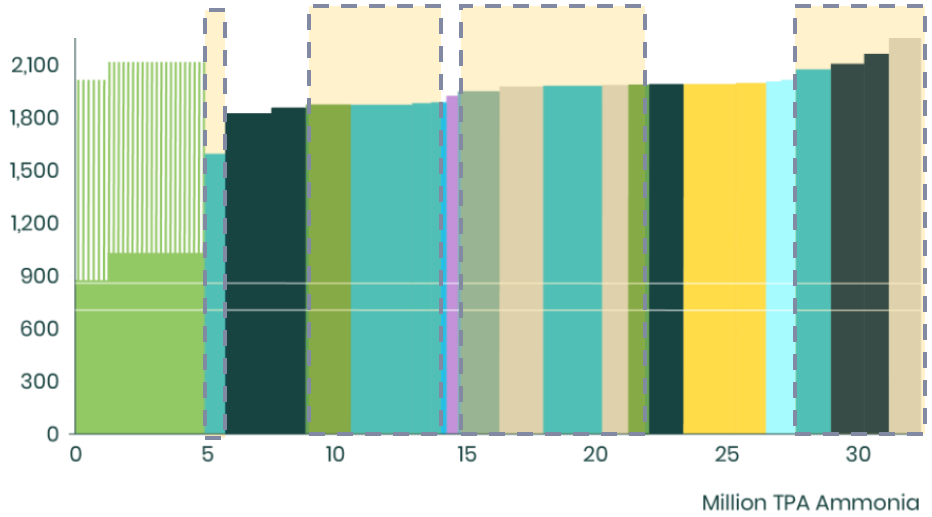


Significant volumes of maritime ZEF could come from Global South countries

Green ammonia

Many projects are planned in Global South regions like **South America, Northern Africa, Sub-Saharan Africa, South Asia, and East Asia**

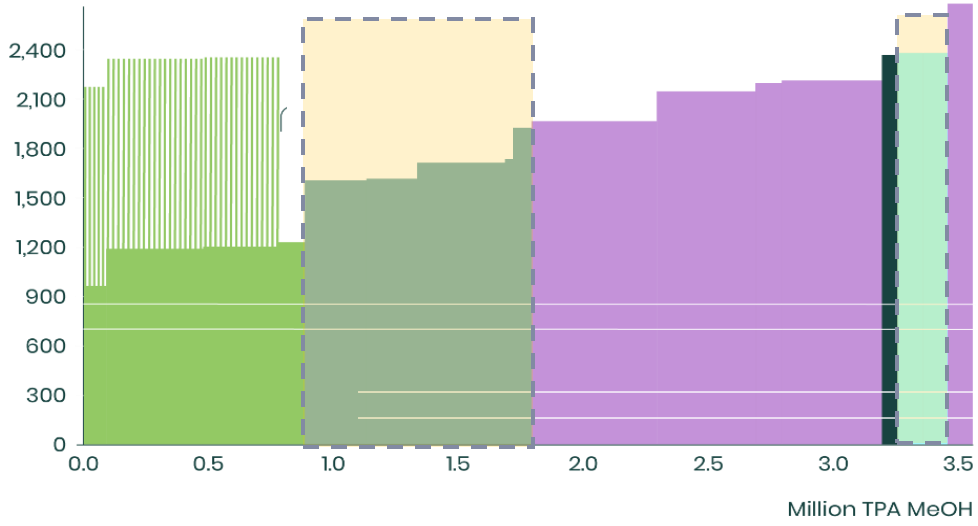
Global south locations



Green methanol

Despite the the merit order curve showing less green methanol emerging from the Global South, we still expect additional countries like **Brazil and India to be producers due to their sustainable carbon resources**

Global south locations



We initiated the Global South Export Hub workstream to support the scaling of ZEF production and advance Global South inclusion in the maritime sector

Objective

Support two high potential zero-emission maritime fuel export hubs in the Global South

Theory of Change

Bolster the supply of accessible ZEF at 'Importing Incumbents' by 2030

Highlight how 'Future Exporters' in developing countries can benefit from the maritime energy transition

Deliverables

A regulatory, economic, technical and stakeholder feasibility assessment to guide the port's development

The convening of supply and demand actors for maritime ZEFs, with the potential to catalyze ZEF exports through a green corridor

We are completing the four frameworks to analyze a port's feasibility and advance their agenda of being a ZEF export hub

Regulatory framework

Assess existing or needed regulatory mechanisms to enable ZEF exports

Technical framework

Assess physical attributes that could enable or delay ZEF exports

Economic framework

Assess ZEF competitiveness and export strategies

Stakeholder framework

Assess stakeholders for enabling ZEF exports

Countries that aim to be maritime ZEF exporters can implement policy to lower fuel costs, increase investability and maximize local benefits

1 LOWER FUEL COST	**Lower CAPEX**	**Lower OPEX**
	• Grants • Electrolyzer tax credits or subsidies	• Renewable energy tax credits or subsidies • Grid transmission cost waivers if grid-connected • Grid- firming services
2 INCREASE INVESTABILITY	**Lower interest rates**	**Become marketable globally**
	• Guarantees • Soft loans	• Interoperable renewable fuel certifications • Green corridors • Fuel off-take contracts with importers
3 MAXIMIZE LOCAL BENEFITS	**Create long-term jobs**	**Prioritize safety**
	• Local training programs for renewable energy and H2 related jobs • Incentivize local GH2 demand in applicable hard-to-abate sectors	• Adopt ISO safety standards • Fuel pilots • Bunkering regulations • Emergency response planning • Dispersion testing

India released their ambitious National Green Hydrogen Mission last year, which has galvanized their green hydrogen economy

1 LOWER FUEL COST

- Subsidies for domestic electrolyzer manufacturing
- Grid transmission cost waivers
- Subsidies for green H2 projects via auctions

2 INCREASE INVESTABILITY

- Indian gov't drafted the Green H2 Certification scheme
  - *Gov't should ensure Green H2 certification scheme aligns with international certifications*

3 MAXIMIZE LOCAL BENEFITS

- 600,000 new green jobs by 2030
- Indian gov't to set min. GH2 use by specified domestic sectors
- *GH2 transport related safety standards should be adopted*

Areas of improvement are italicized

Thank you for your attention

Please feel free to reach out
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