Maritime Bunkering Options for Decarbonisation

Transport Events, Maritime Week – Port Réunion

Dr Jonathan Beard
Asia-Pacific Infrastructure Advisory Partner
EY Strategy & Transactions

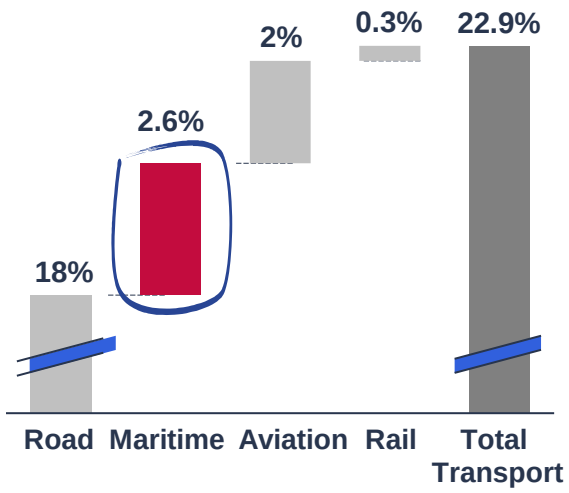
20th September 2023 v2

EY Parthenon

Current state of global emissions in the shipping industry

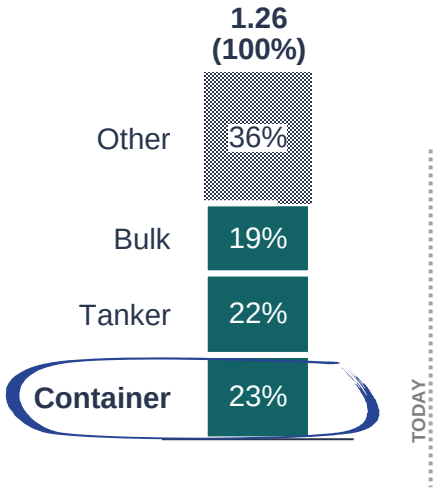
The shipping industry faces significant pressure to pursue a collective climate change response.

The maritime sector comprised ~3% of global emissions in 2020



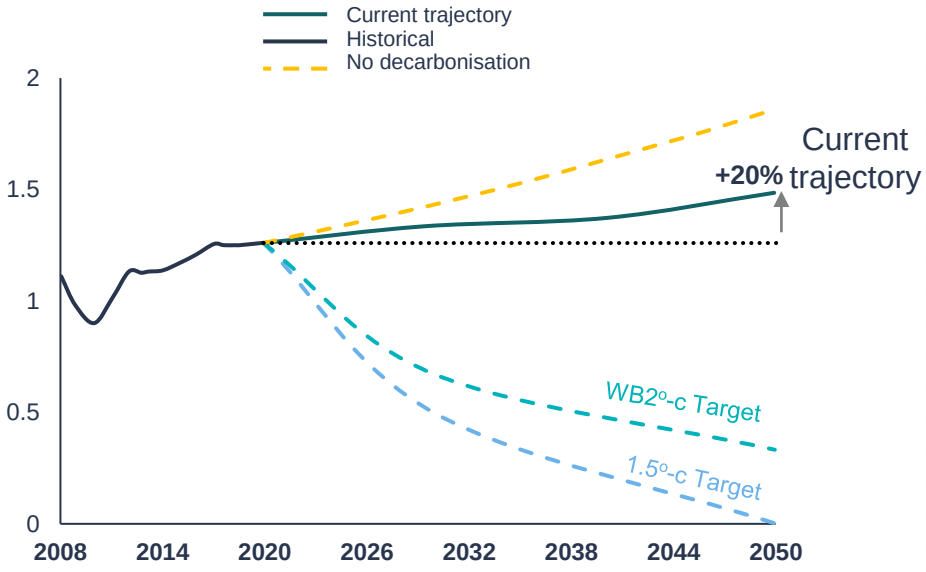
% of global emissions

Container ships are currently the highest annual emitters compared to other shipping vessels



% of emissions

Today, the path we are on may lead to +20% more emissions by 2050 in the maritime sector



WTW maritime emissions pathways Gt CO_2-e/yr (1)

Sources: (1) chart contains approximate values from IMO, IEA, Clarksons and Techno-economic model MMM Centre for Zero Carbon Shipping (2021)

EY Parthenon

Various fuels are being considered to reduce emissions

Each fuel variant has pros and cons for refuelling and storage, engine development and on-board safety.

Maturity / Performance
- Major challenges
- Emerging
- Mature
- In pilot

		Fuel properties (1)					Refuelling and storage		Engine development (2)		On-board safety considerations
		LHV (MJ/kg)	Volumetric Energy density (GJ/M3)	Storage Pressure (bar)	Storage temp (°C)	Emissions (Well-to-Wake) kgCO2-e/GJ	Refuelling in tandem with cargo operations	Fuel storage (compared to HFO) (2)			
FO	Bio/ e-diesel	28.9	19.2 (35-45 for standard HFO)	5	20	Mature	Mature	• Protocols exist which allow bunkering whilst simultaneously carrying out cargo operations	1x volume	Mature	• No change to existing vessel configuration	• Existing procedures
LNG	LNG	50	23.4	1	-162	Major challenges	Mature	• Protocols exist which allow bunkering whilst simultaneously carrying out cargo operations	2.5x volume	In pilot	• No change to existing vessel configuration • The conversion of existing vessels requires minor retrofits • Dual-fuel two-stroke and four-stroke LNG engines are commercially available	• Safety and all relevant operating procedures are already in place to deal with existing risks (e.g., explosions). • Initial training in crew competency is required, but otherwise there are limited safety considerations required
LNG	Bio-LNG (methane)					Emerging						
LNG	E-LNG (methane)					Mature						
Methanol	Bio-methanol	19.9	15.8	1	20	Mature	Emerging	• Protocols (in development) are expected to allow bunkering whilst simultaneously (un)loading cargo (e.g. Port of Gothenburg has released methanol bunkering regulations)	2.5x volume	Emerging	• Dual-fuel two-stroke and four-stroke methanol engines are commercially available • Methanol engines are being developed and commercialised for wider size ranges and are not expected to be size restricted	• Safety assessments are required due to low flashpoint of methanol, meaning that it can vaporize and mix with air to form a flammable mixture at a relatively low temperature • As methanol operates similar to other fuels, there are limited safety considerations required aside from initial training in crew competency.
Methanol	E-methanol					Mature						
Ammonia	Green / blue ammonia (pressurised)	18.6	12.7	8	20	Emerging	Major challenges	• Due to HSE considerations, it is not yet clear whether bunkering will be possible whilst (un)loading cargo • This may require vessels to make additional calls or increase time spent at a port	3.6x volume	In pilot	• Dual-fuel ammonia engines are being developed but are not finally proven or commercially available yet – delivery to yard in 2024 • Development of increased storage capacity, engine and fuel technologies is ongoing	• While ammonia is not flammable, it is highly toxic. • Rigorous risk assessments and design specifications are required to ensure onboard safety (inc. health and safety on board)
Ammonia	Green / blue ammonia (refrigerated)		11.3	1	-34	Mature						

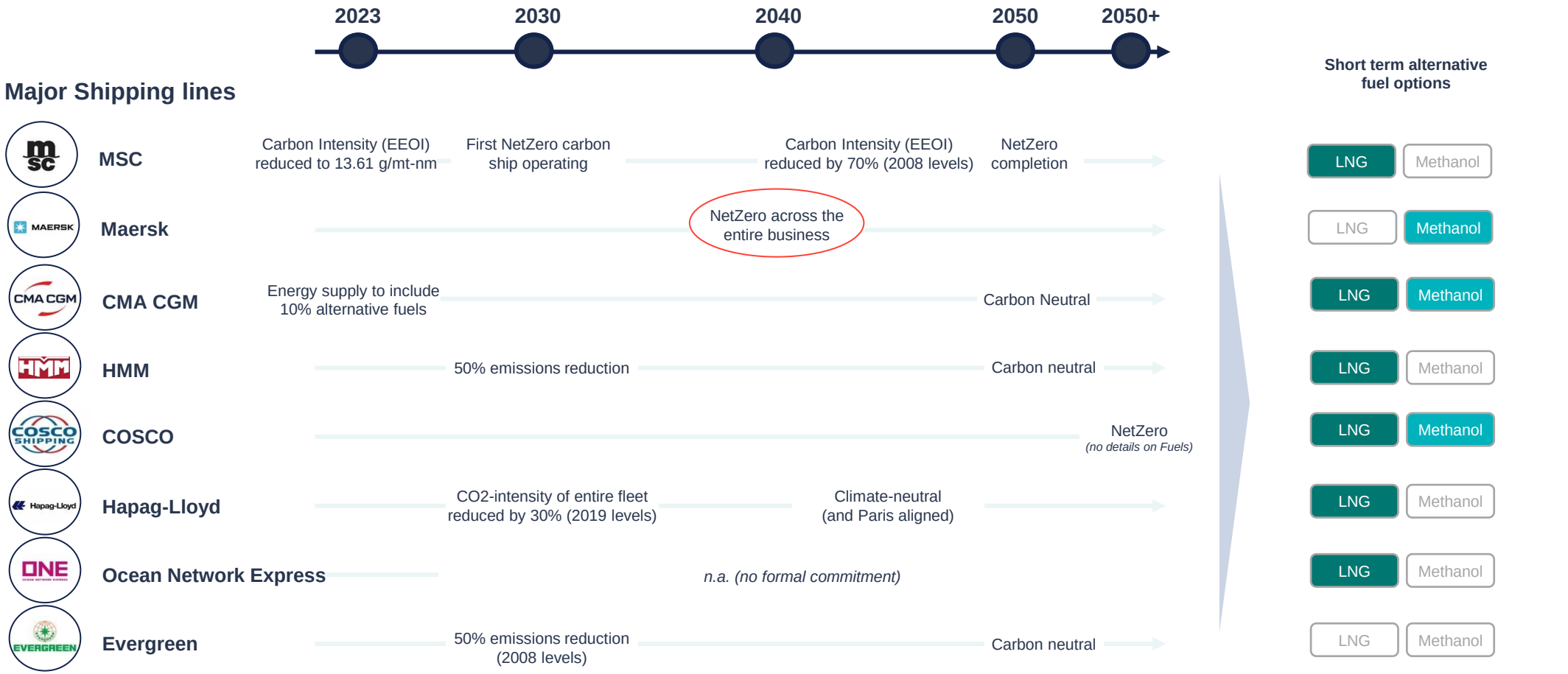
Sources: (1) IRENA 2019; (2) Zero carbon shipping

EY Parthenon

Demand Signals

First movers in the maritime industry have clearly demonstrated their willingness to go green

Decarbonisation pledges and commitments (1)



Sources: (1) Company websites & interviews

EY Parthenon

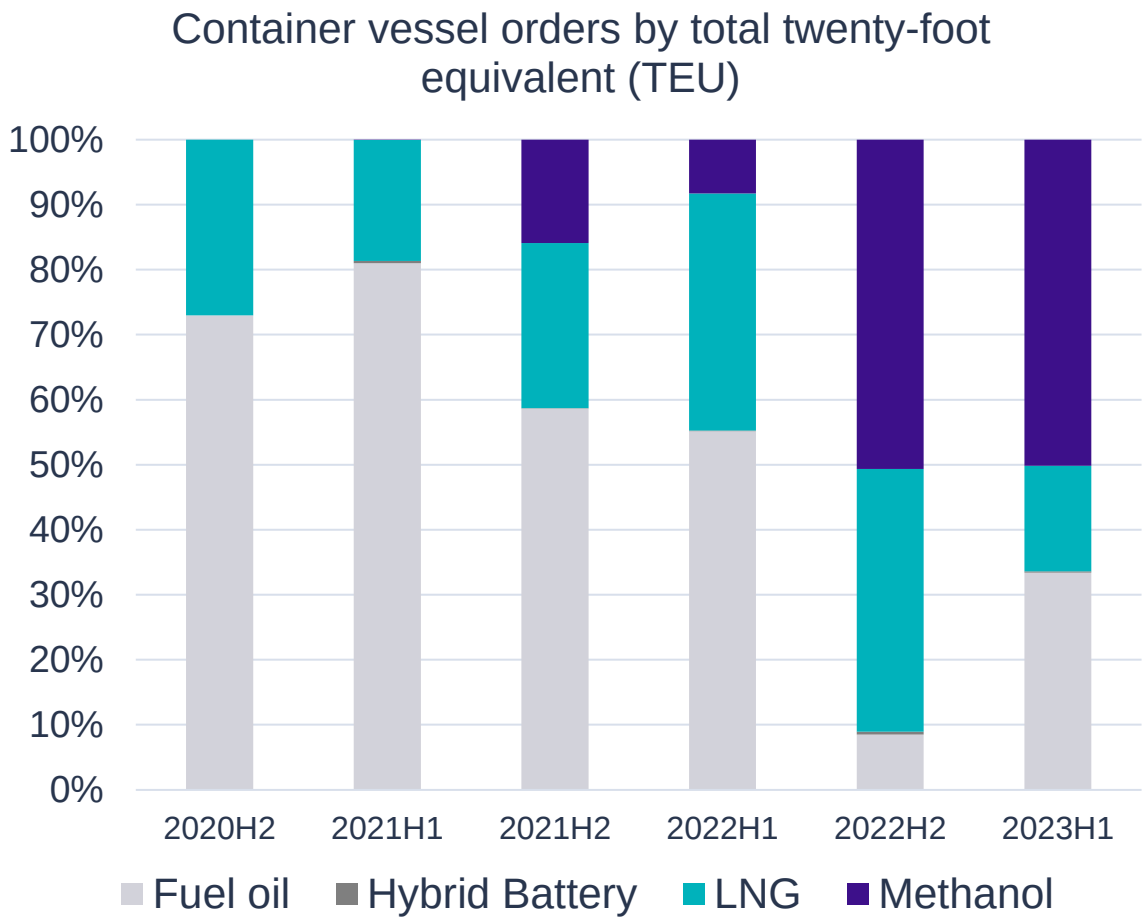
Future bunker requirements from lines?

- Maersk have stated its position on avoiding fossil fuels in its transition to NetZero(1). As such, Maersk have not considered LNG an option due to its relatively high lifecycle emissions and instead begun developing methanol fuel ships
- LNG is the preferred alternative fuel choice amongst other major shipping lines – particularly for MSC who expressed major interest in using bio-LNG (bio-methane)
- Methanol is an emergent fuel with announced fleet developments from Maersk initially, then CMA.
- June 2023 COSCO signed an order for a methanol fuel supply system for four 16,000-TEU containerships with COSCO Shipping Heavy Industry (Yangzhou).
- The majority of the shipping lines have 2050 NetZero targets versus 2040 for Maersk.

- The first of Maersk's orderbook of methanol dual fuel vessels during fit-out in April 2023.
- 2,100-TEU feeder ship to be deployed in Baltic Sea.
- Summer 2023, maiden voyage from South Korea to North Europe via Suez canal, **including pilot bunkering with green methanol at Singapore & Rotterdam**
- OCI Global will provide green methanol (from North America)

Sources: (1) Maersk website and Interview with Maersk Head of Fuel Innovation; (2) Company websites;

Future requirements from lines - recent increase in orders for methanol vessels



- Other methanol vessel types on order:
  - oil/chemical tanker 3 (& 23 in operation)
  - Tug 1
  - Bulk carriers (3 in operation)
  - Cruise 1
  - RoPax (1 in operation)
  - Other offshore vessels 4

Source: Alphaliner; DNV; Maersk

EY Parthenon

Alternative Fuels - Summary

LNG and Methanol as Near-term Bunkering Options

LNG

- Continued **demand** for new **LNG vessels**, albeit growth may be slowing
- Well established **supply/infrastructure value chains**
- **Lower emissions** than fuel oil
- Bio/ e-LNG can be dropped in to **further reduce emissions**
- **Flammable** and requires vapor handling systems
- **Requires specialist tanks** low temperature and pressure (expensive to build, maintain and operate)

Methanol

- **Emerging** fuel alternative
- Consistent growth in orderbooks from **most major shipping lines**
- Established **supply and infrastructure**
- Bio/e methanol is **ultra low carbon**
- Toxic but **water soluble and biodegradable**
- **Many ports have existing methanol storage** and it is possible to store in modified fuel oil tanks at ambient temperature
- Bunker barges and procedures for **simultaneous bunkering and cargo operations** being trialed

Ammonia

- 3-5 years away from ammonia ready engines / vessels
- viability of use in the shipping industry currently uncertain.

Hydrogen

- Technical challenges - need to handle & store at high pressures, low temperatures

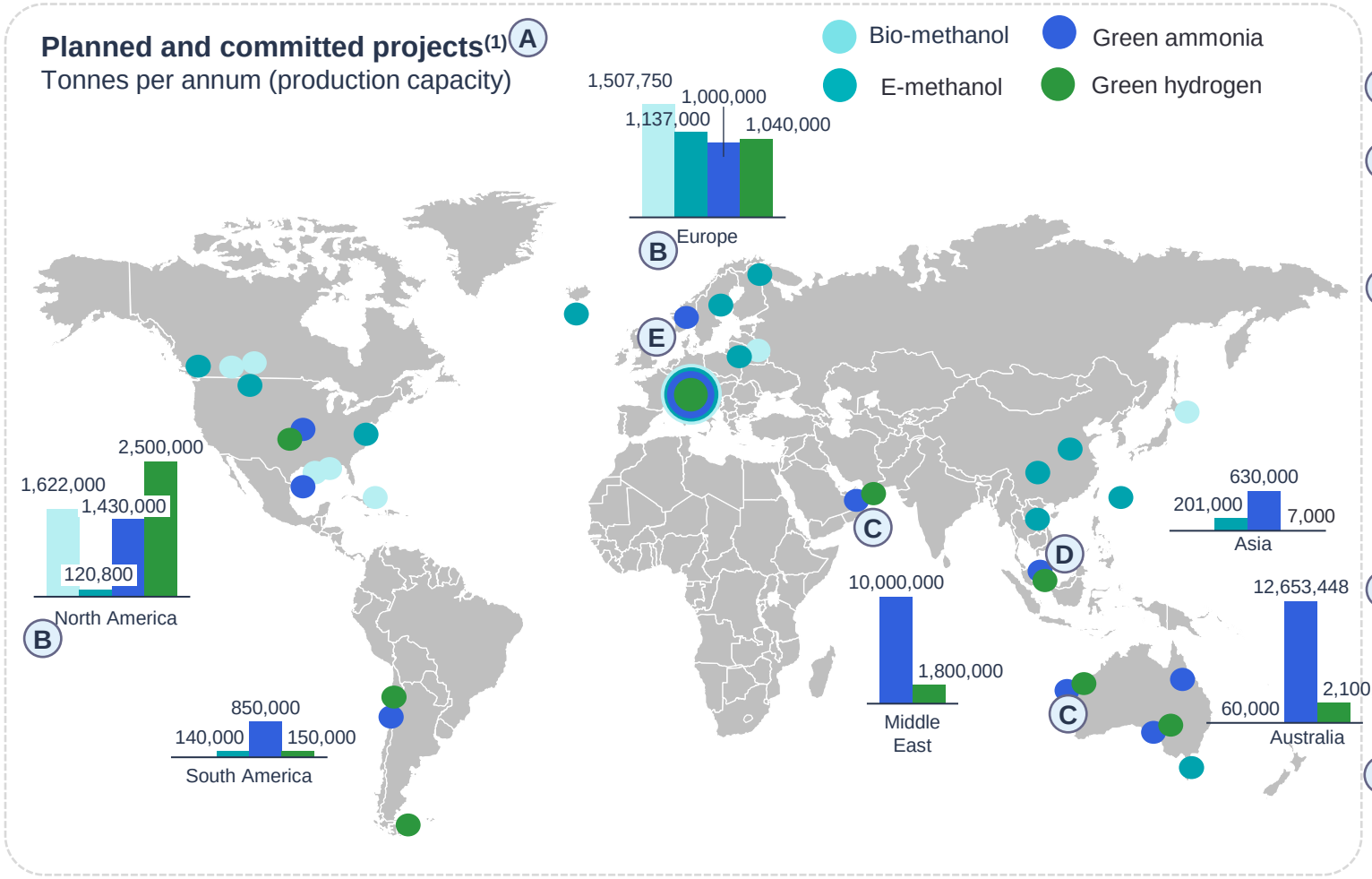
Bio/e-diesel

- “Drop in” fuel that burns in existing engines, can provide 50-90% decarbonization compared with M/HFO, etc. (depending on feedstock & production);
- faces bio-feedstock constraints; & limited cost-reduction potential (mature production processes).
- e-diesel has potential to significantly reduce emissions with existing engine designs, but early in its tech. cycle

Nuclear

- Closest to current zero-carbon shipping (navies and ice-breaking vessels), but still needs to overcome environmental, regulatory, economic, and societal acceptance issues

A significant number of planned or committed projects for alternative fuels across the globe are emerging, with planned production dates ranging between 2024 up to 2030



Comments

A The majority of projects have **production start dates between 2024-2027**

B The production of **e-methanol and bio-methanol is highest across North America and Europe**. Data from the methanol institute found that whilst 48 projects were planned or committed, only eight were considered operational(1)

C Green ammonia projects are featured across all key regions, although the emergence of two 'super' developments by **InterContinental Energy in Oman and Western Australia** are of particular note. These projects have proposed costs upwards of ~US$36billion and will use ~27GW upstream wind and solar to produce ~1.8million tons of green hydrogen and ~10million tons of green ammonia by 2027, far more than any other project announced to date(2). Singapore's sovereign wealth fund GIC has an equity investment in these projects(3).

D Sarawak Economic Development Corporation (SEDC) has announced the development of a **green hydrogen & ammonia project in Bintulu, eastern Malaysia**. Bintulu is already home to significant petrochemical infrastructure, including Petronas' LNG complex (one of the largest LNG production facilities in the world).

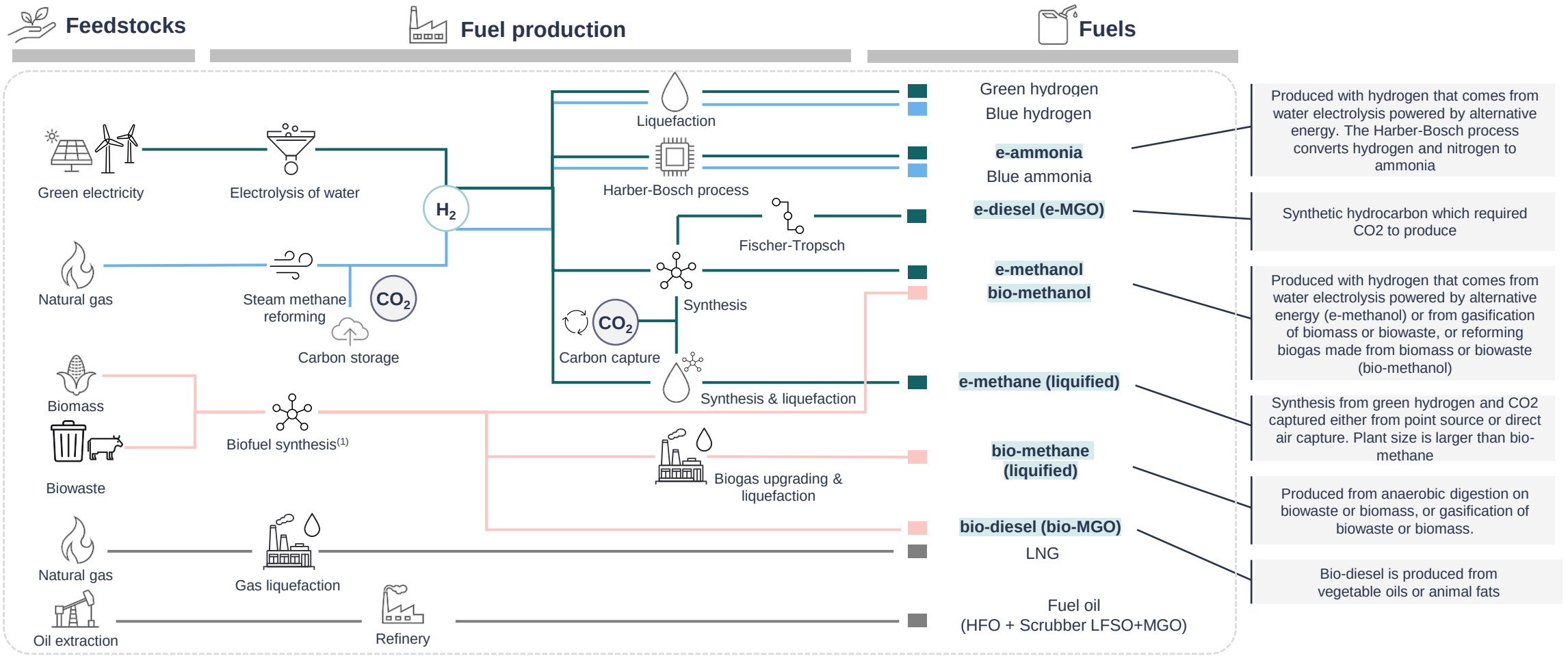
E Maersk in partnership with Copenhagen Infrastructure Partners have announced proposals for the development of the largest **green ammonia production facility** in Esbjerg on the west coast of **Denmark**.

Source: (1) All units displayed in tonnes per annum. Production capacity has been calculated for all projects operational, planned or committed using latest data from the Methanol Institute, and Ammonia Energy Association. Please note this snapshot may not represent the full pipeline of planned or committed projects around the globe; (2) InterContinental Energy; (3) Ammonia Energy Association article Feb 2, 2022.

EY Parthenon

Alternative fuel options – Supply

Fuel production will vary depending on locations, availability of feedstocks and technology cost curves.



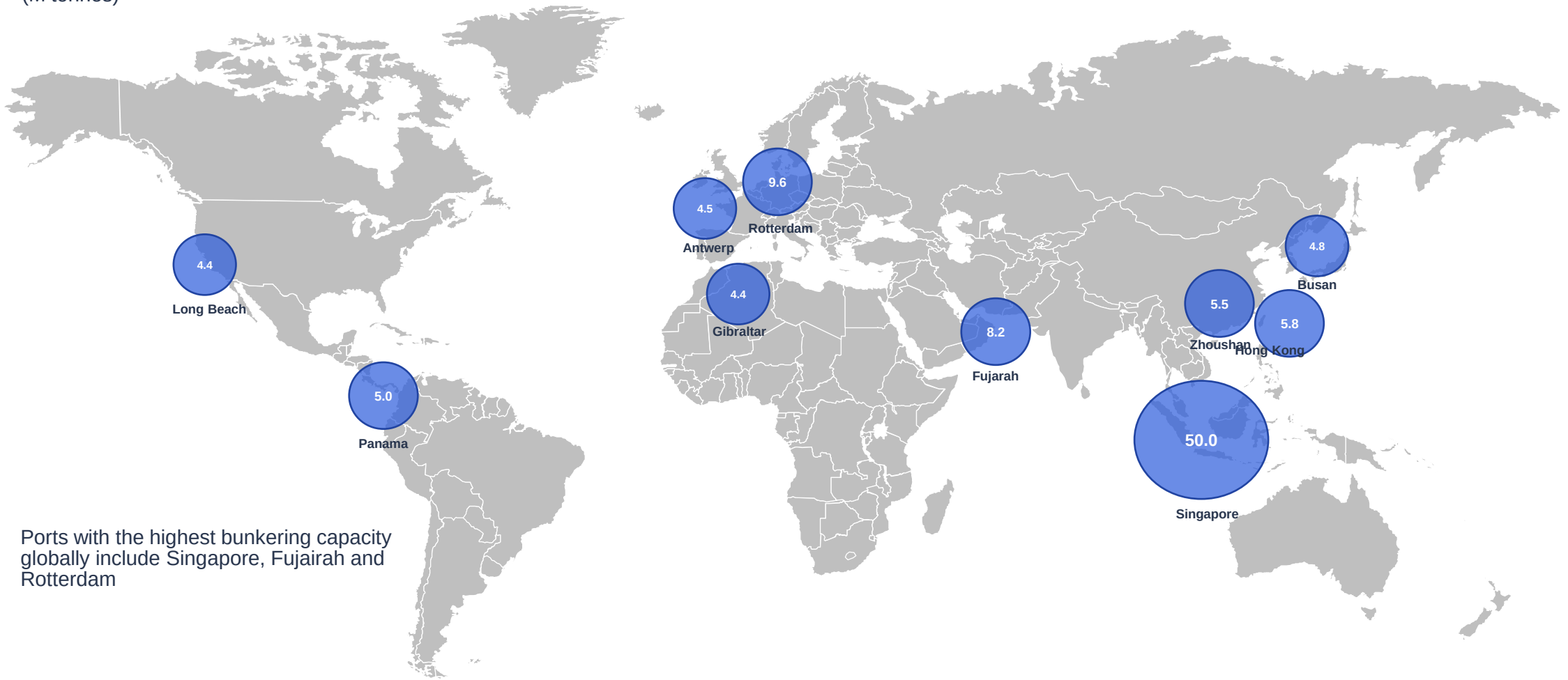
EY Parthenon

Top 10 bunkering ports globally - Singapore is by some margin the largest

Strategically located for ocean trade, **but does not have close / direct access to green fuels**

2021 Annual bunker sales of selected ports

(M tonnes)



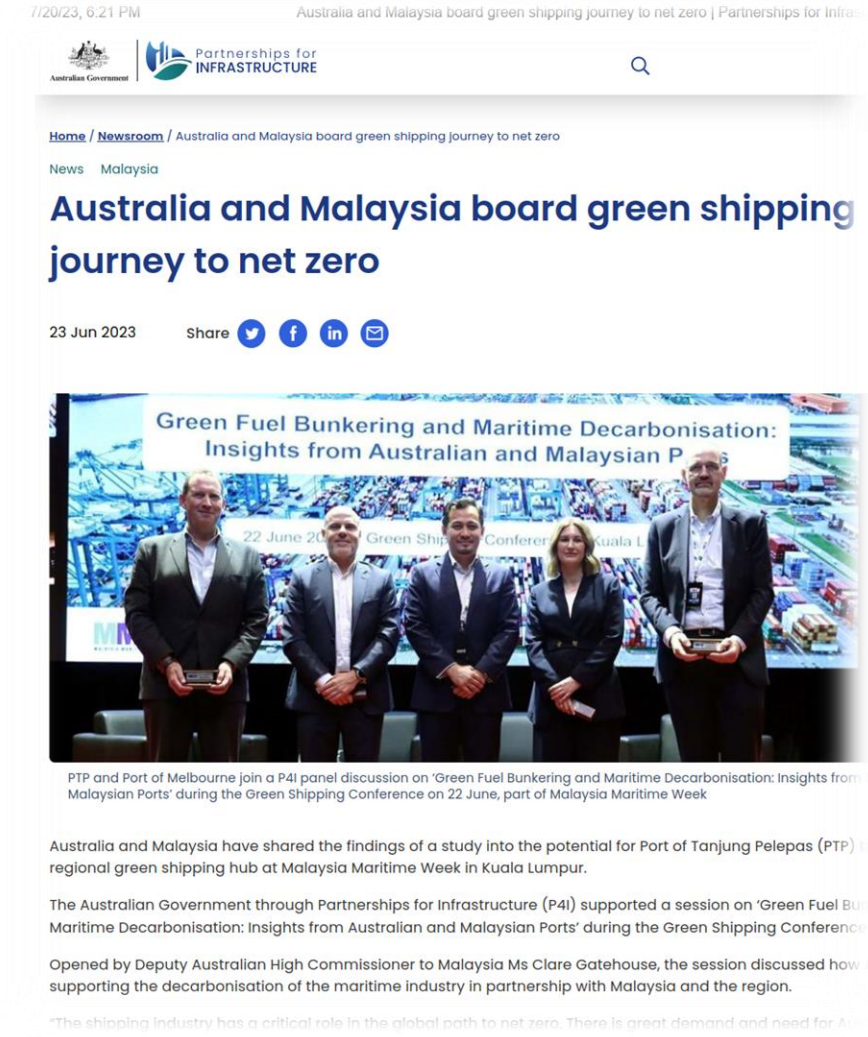
Ports with the highest bunkering capacity globally include Singapore, Fujairah and Rotterdam

Source:

EY Parthenon

Summary & Key Takeaways

1. Variety of fuel types under consideration to deliver maritime decarbonisation
2. Landscape is evolving rapidly - some uncertainty about the ultimate and optimal 'solution'
3. However, over short to medium term key lines have opted for LNG (as a transitional fuel) and methanol, and are making investments accordingly
4. Other fuels, notably Ammonia, hydrogen and possibly nuclear are at an earlier stage of development (and / or acceptance), but may emerge as key solutions over the medium to longer-term
5. **Supply side** maturity is not adequate – must be a substantial ramp up in capacity to meet demand. In addition, other potential fuels (e.g. ammonia) have yet to develop the appropriate regulatory framework (HSE, etc.).
6. Will the new vessels lead to a **re-configuration of networks & hubs**, due to shorter vessel ranges (plus break-up of alliances, specifically the 2M)?
7. The green fuels will **raise costs for supply chains**, although as supply matures, prices may fall – which supply chain parties will bear the costs?
8. Or do established hubs, e.g. Rotterdam & Singapore retain their position?
9. For example, Singapore's economies of scale, established cluster of expertise and excellence, and ability to leverage a 'whole of government' approach for decarbonisation (beyond just maritime) are key advantages
10. But it does not have **ready access to green fuels – other locations do and those located on/close to key trade lanes may target the bunkering market**



7/20/23, 6:21 PM Australia and Malaysia board green shipping journey to net zero | Partnerships for Infras

Australian Government | Partnerships for INFRASTRUCTURE

Home / Newsroom / Australia and Malaysia board green shipping journey to net zero

News Malaysia

Australia and Malaysia board green shipping journey to net zero

23 Jun 2023 Share

PTP and Port of Melbourne join a P4I panel discussion on 'Green Fuel Bunkering and Maritime Decarbonisation: Insights from Malaysian Ports' during the Green Shipping Conference on 22 June, part of Malaysia Maritime Week

Australia and Malaysia have shared the findings of a study into the potential for Port of Tanjung Pelepas (PTP) to regional green shipping hub at Malaysia Maritime Week in Kuala Lumpur.

The Australian Government through Partnerships for Infrastructure (P4I) supported a session on 'Green Fuel Bu Maritime Decarbonisation: Insights from Australian and Malaysian Ports' during the Green Shipping Conferenc

Opened by Deputy Australian High Commissioner to Malaysia Ms Clare Gatehouse, the session discussed how supporting the decarbonisation of the maritime industry in partnership with Malaysia and the region.

"The shipping industry has a critical role in the global path to net zero. There is great demand and need for A

Thank you

Dr Jonathan Beard
Asia-Pacific Infrastructure Advisory Partner
EY Strategy & Transactions

- Based in Hong Kong and leads EY's maritime logistics work in Asia
- 25 years of experience and has advised on transportation policy and infrastructure development in over 25 countries
- Relevant expertise in:
  - Logistics & transportation infrastructure
  - Maritime sector, including decarbonization & digitalization
  - Forecasting & strategic planning
  - Policy & institutional advisory

jonathan.beard@hk.ey.com

EY | Assurance | Tax | Strategy and Transactions | Consulting

About EY
EY is a global leader in assurance, tax, transaction and advisory services. The insights and quality services we deliver help build trust and confidence in the capital markets and in economies the world over. We develop outstanding leaders who team to deliver on our promises to all of our stakeholders. In so doing, we play a critical role in building a better working world for our people, for our clients and for our communities.

EY refers to the global organization, and may refer to one or more, of the member firms of Ernst & Young Global Limited, each of which is a separate legal entity. Ernst & Young Global Limited, a UK company limited by guarantee, does not provide services to clients.

Information about how EY collects and uses personal data and a description of the rights individuals have under data protection legislation is available via ey.com/privacy. For more information about our organization, please visit ey.com.

ED None

UEN 201911025K

This material has been prepared for general informational purposes only and is not intended to be relied upon as accounting, tax or other professional advice. Please refer to your advisors for specific advice.

ey.com