Readying Ports for the Future: Ammonia as a Marine Fuel

Tan Wee Meng, Chief Projects Officer

TOC Asia

27 November 2024

Global Centre for MARITIME DECARBONISATION

Mission statement

Our mission is to help the maritime industry eliminate GHG emissions by **shaping** standards, **deploying** solutions, **financing** projects, and **fostering** collaboration across sectors.

Founders/ strategic partners

BHP, BW, DNV, Eastern Pacific Shipping, MPA Singapore, ONE Ocean Network Express, Seatrium, bp, Hapag-Lloyd, Hanwha Ocean, NYK Line Nippon Yusen Kaisha

Impact partners

BCG, Chevron the human energy company, gard, MOL Mitsui O.S.K. Lines, msc, Olympic Shipping and Management S.A.

Coalition partners

IBIA, International Chamber of Shipping Established 1921, IWSA International Windship Association, OGCI Oil and Gas Climate Initiative, SGMF the society for gas as a marine fuel, SSA Singapore Shipping Association

Knowledge partners

Global Maritime Forum, GSBN, KPLER, Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, SINTEF

Enabling partners

KIRI Capital

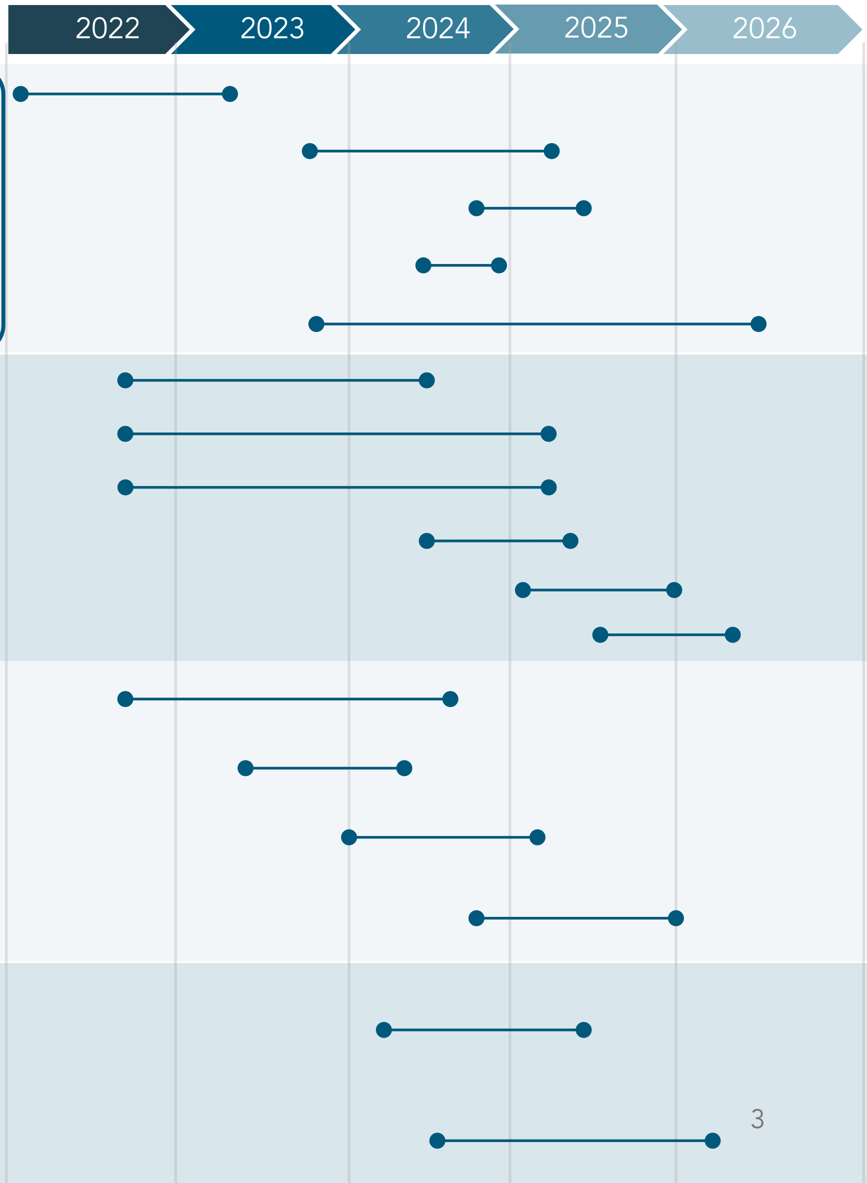
And > 100 project partners

Our initiatives roadmap

(as of 18 Oct 2024)

● Completed ◐ In Progress ◌ Planning

Enabling ammonia as a marine fuel	Completed	Phase 1: Ammonia bunkering pilot safety study
	In Progress	Phase 2A (Singapore): Detailed operational risk assessment for ship-to-ship (STS) ammonia transfer
	In Progress	Phase 2B (Singapore): Plan and execute STS ammonia transfer pilot
	Completed	Detailed operational risk assessment and execution of STS ammonia transfer pilot in Pilbara
	In Progress	Enabling a network of ports for ammonia bunkering
Assuring the quality, quantity and emissions abatement of drop-in green fuels	Completed	Biofuels end-to-end supply chain pilots
	In Progress	Assurance framework for biofuels end-to-end supply chain
	In Progress	Crude algae oil as a drop-in green marine fuel
	In Progress	Project LOTUS: Long term impact of continuous use of biofuels on vessel operations
	Planning	E/ bio-methanol quality, quantity and abatement assurance (QQAA)
	Planning	BioLNG QQAA
Unlocking the carbon value chain	Completed	Project REMARCCABLE: Realising maritime carbon capture to demonstrate the ability to lower emissions
	Completed	Concept study to offload onboard captured CO_2
	In Progress	Project COLOSSUS: Carbon capture, offloading, onshore storage, utilisation and sequestration
	Planning	Project CAPTURED: Demonstrate the offloading, handling, utilisation and/ or sequestration of onboard captured CO_2
Scaling adoption of energy efficiency technologies	In Progress	Pay-As-You-Save (PAYS) 1: Establish binding commercial, data and technical agreements for retrofit installation + execution, data collection, validation and activation of contracts
	Planning	PAYS 2: Establish agreements for PAYS retrofit installations for a fleet of vessels + execute installation, data collection, validation and activation of contracts



Use of alternative fuels has many considerations

	Production		Distribution + Storage		Bunkering		Application	
	Sustainable feedstock availability	Fuel production scalability	Storage infrastructure	Handling safety	Volumetric Energy density	Regulations	Conversion technology	Cost drivers
Fossil fuels	No sustainable feedstock	Full scale	Developed infrastructure	Mature	~ 36 MJ/L depending on type of fossil fuel	Mature	Mature	Global market demand
Biofuels	Limited (high sectoral competition)	Feedstock dependent	Can leverage existing infrastructure	Mature	~33 MJ/L depending on feedstock	Mature	Available with long term tests ongoing	Dependent on feedstock + demand
Hydrogen	Unlimited (water)	Limited by electricity only	New dedicated infrastructure needed	Flammable + safe handling still being developed	4.5 MJ/L (compressed) – 8.0 MJ/L (Liquid)	Under development	R&D stages	Cost of H_2/ CCS + storage + handling
Methanol	Limited (carbon + water)	Limited by carbon (DAC, CCS) tech	More dedicated buildout needed	Mature	15.8 MJ/L	Mature	Available in early stages	Cost of H_2 + carbon + synthesis
Ammonia	Unlimited (air & water)	Limited by electricity only	More dedicated buildout needed	Toxic + safe handling still being developed	12.9 MJ/L	Under development	R&D stages	Cost of H_2 + synthesis

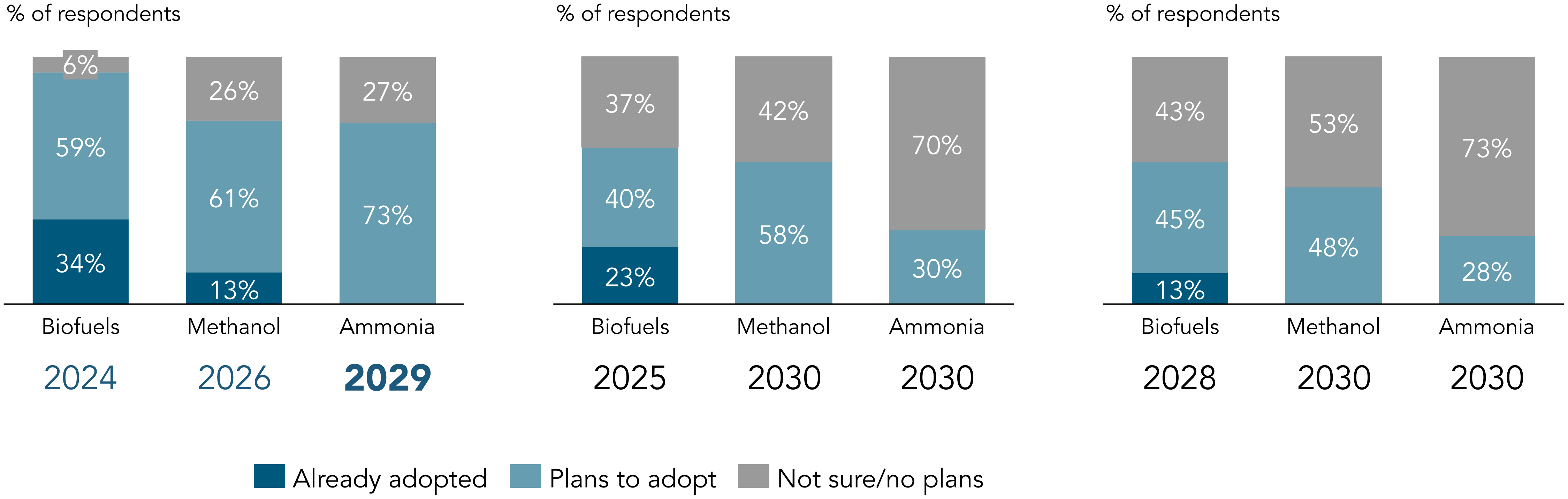
Respondents plan to adopt ammonia as early as **2029**

Current and planned adoption of future fuels

Frontrunners

Followers

Conservatives



Source: GCMD-BCG Industry Survey on Maritime Decarbonisation (N=128), BCG analysis

Switch to new fuels likely to impact bunkering patterns

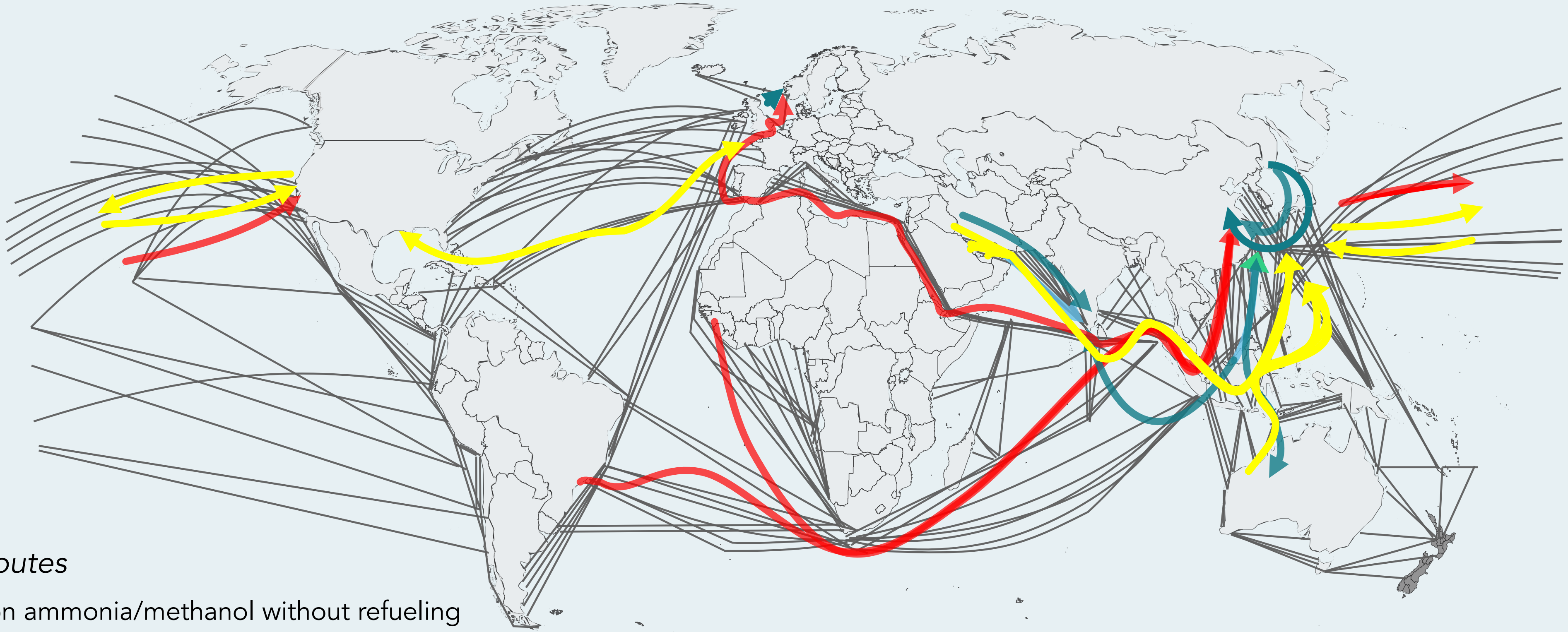
Wider network of infrastructure will be needed to support more frequent bunkering

2.4-2.8x

Lower volumetric energy density vs fuel oil

~60%

Would **bunker more often** than use larger fuel tanks

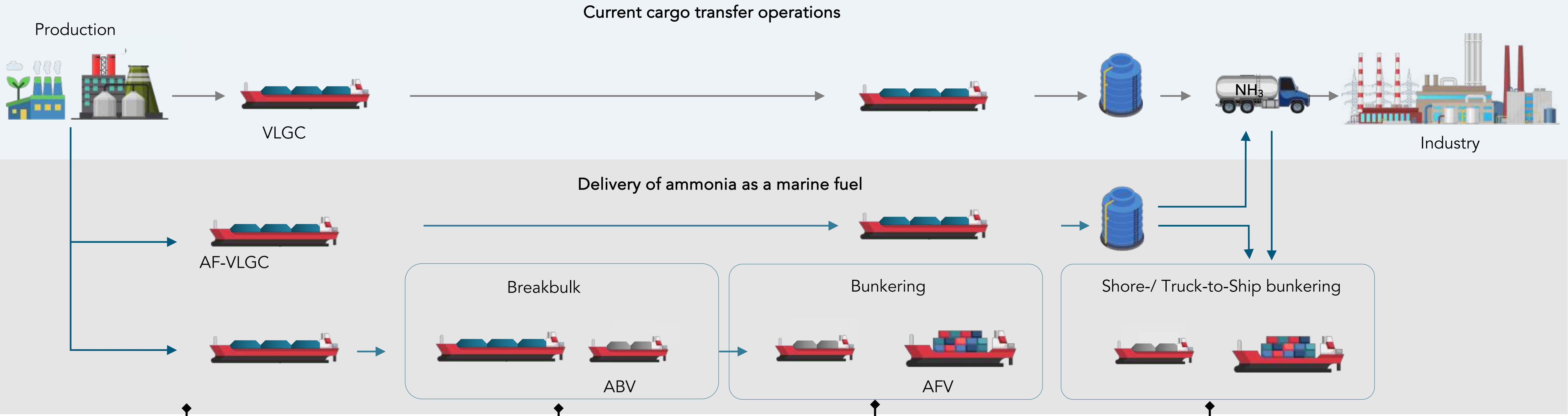


Selected major trade routes

- Round-trip possible on ammonia/methanol without refueling
- 1-way trip possible on ammonia/methanol without refueling
- Requires refueling enroute on ammonia/methanol

Source: GCMD-BCG Industry Survey on Maritime Decarbonisation (N=128), BCG analysis

Delivery of ammonia as a marine fuel will be more complex than current cargo transfer operations



- Existing cargo loading procedures can be used
- New AF-VLGC with NH_3 engines
- Engine room
  - New designs e.g., isolation/ segmentation of fuel preparation rooms
  - Additional safety designs & procedures, remote engine monitoring

- NH_3 transfer procedures do not exist
- New ABV designs with or without NH_3 engines with additional safety guidelines
- STS procedures between AF-VLGC and ABV to be established
- Emergency response plans to be developed and refined using STS cargo transfer as a proxy – interim step to build confidence in safety procedures

- NH_3 related bunkering procedures do not exist
- New AFV with NH_3 engines
- New AFV engine room with additional safety designs & procedures, remote engine monitoring
- Bunkering procedures and emergency response plans to be refined when vessels are available

- NH_3 related bunkering procedures do not exist
- Existing storage to truck procedures are applicable
- Bunkering procedures and emergency response plans to be refined when vessels are available

AF-VLGC - Ammonia-Fuelled Very Large Gas Carrier
VLGC - Very Large Gas Carrier
ABV - Ammonia Bunkering Vessel
AFV - Ammonia-Fuelled Vessel

Macro drivers of ammonia adoption

Global Centre for MARITIME DECARBONISATION

Potential for economic viability

- Scalability of current Haber-Bosch production plants
- New technologies to improve yield with lower energy demand
- Availability of existing fleet of gas carriers to facilitate adoption

Regulatory drivers

IMO GHG strategy

- Targets (from 2008 baseline)
  - 2030: Targeting for 20%, striving for 30% emissions reduction
  - 2040: Targeting for 70%, striving for 80% emissions reduction
  - Around 2050: Net Zero

Carbon pricing mechanisms

- Implementation of Emissions Trading Systems (ETS) and carbon taxes

Fuel transition policies

- National strategies, such as Singapore's EOI for ammonia bunkering and power generation, Japan's Green Growth Strategy and EU's "Fit for 55" package, actively promote ammonia as a marine fuel.

Geographical and trade route advantages

- Availability of existing production facilities in proximity to bulk ports/ specialised ports for early adoption
  - e.g., Australia, Pilbara Ports - Port Dampier/ Port Hedland
  - e.g., Norway, Kopervik (Kårstø) terminal / Fjord Base in Florø
- Ports at these locations are typically located in remote areas, minimising risks to populations.

Macro drivers of ammonia adoption

A multi-fuel future

- The shipping industry is evolving towards multiple fuel types, driven by vessel types and trade routes.

Ammonia adoption by segments

Ammonia-fuelled gas carriers

- Likely front runners due to their ability to use cargo as fuel
- Bunkering and associated infrastructure less of a concern

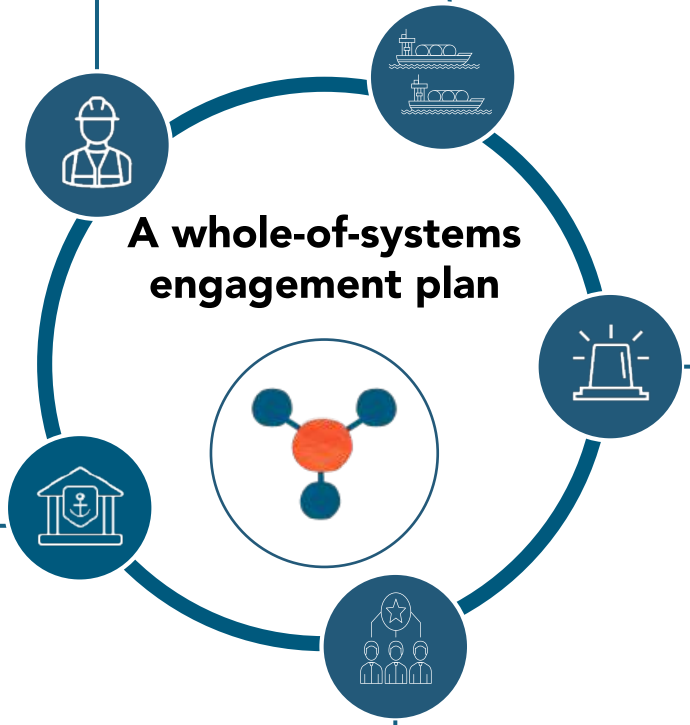
Bulk carriers

- Bulk cargo routes are typically plied by dedicated large bulkers with only one loading and one unloading port.
- Ports are typically located in remote areas, minimising risks to populated areas.
- Opportunity increases with nearby ammonia production (e.g., Australia's Pilbara region and China's Zhoushan and Rizhao region)

Container ships

- Faces additional safety challenges as container ports are typically located in closer proximity to populated areas.

Readying a future ammonia bunkering ecosystem



Safety studies

- Completed location-specific safety studies in partnership with **regulators and industry stakeholders**
- Initiated ship-to-ship ammonia transfer trials to establish baseline for bunkering

Bunkering trials

- Conducted ammonia transfer trials in port limits with **cargo and vessel owners** with plans for more trials to close gaps in ammonia bunkering at various ports
- Initiated conversations on bunkering pilots with **vessel owners and operators, fuel suppliers, storage terminal operators, port operators**

Safety standards and assessment

- Submitted guidelines to national and international **standards development organisations**
- Conducted detailed safety assessments with **class and engineering consultants**

Emergency response procedures

- Developed emergency response procedures with **emergency responders**

Engagement with regulators and port authorities

- Engaging with **regulators and port authorities** to secure sandbox for trial(s)

Pilbara – A potential ammonia bunkering hub?

A Potential Port for Ammonia

- **5%** of all tradeable ammonia are currently supplied through Dampier
- Start of the busiest iron ore route
- About **7,700** vessel calls in the Pilbara Ports for 2023
- Potential demand of **1-1.5** million tonnes of bunker by 2035

Source: Kpler, 11 Oct 2024
Vessel traffic for iron-ore carrying capesize and newcastle max bulk carriers

Ammonia transfers between the Green Pioneer and the Navigator Global in the anchorage of Port of Dampier

4000 cbm (2700 tonnes) of liquid ammonia was transferred at 700-800 cbm/h from the Green Pioneer to the Navigator Global and back

Goal of our pilot in Pilbara

To **showcase breakbulk** and **mimic bunkering operations** before ammonia-fuelled vessels are available

Four areas of focus:

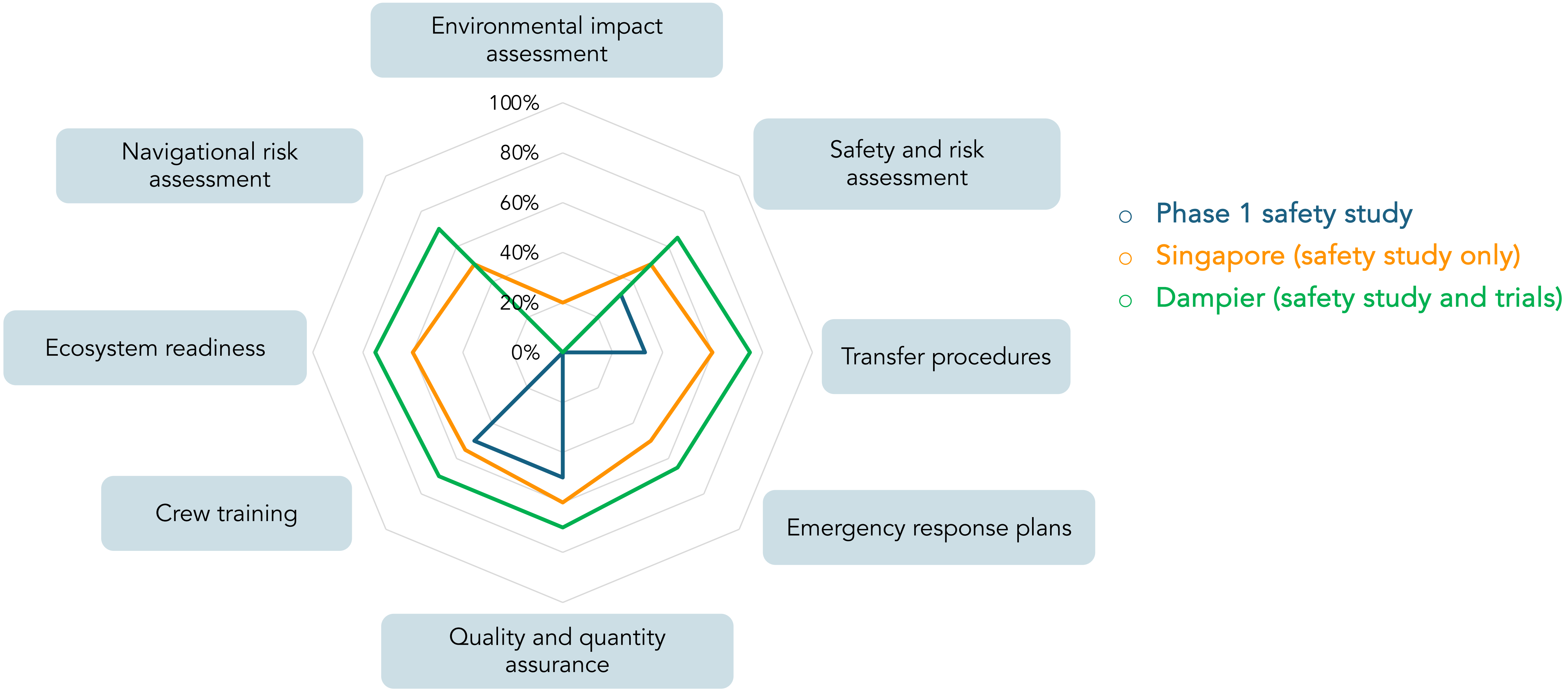
01 | Safety + risk assessments

02 | Operational procedures

03 | Safety protocols

04 | Emergency response protocols

Closing knowledge gaps progressively with each pilot



Thank you!

Scan the QR code to download
GCMD reports and papers

Global Centre for
MARITIME DECARBONISATION

8 Robinson Road #06-01 | Singapore 048544

www.gcformd.org

projects@gcformd.org

+65 6979 7660