

Ammonia as a future marine fuel - bunkering

*The 2nd Ammonia = Hydrogen 2.0
Virtual Conference*

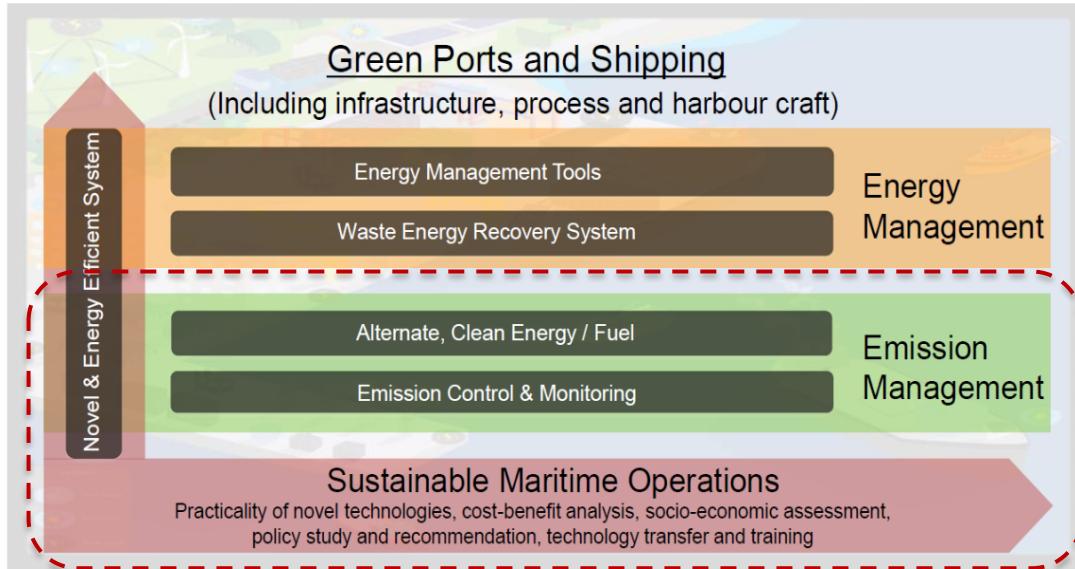
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Maritime Energy & Sustainable Development (MESD)
Centre of Excellence

28 August 2020



R&D Focus



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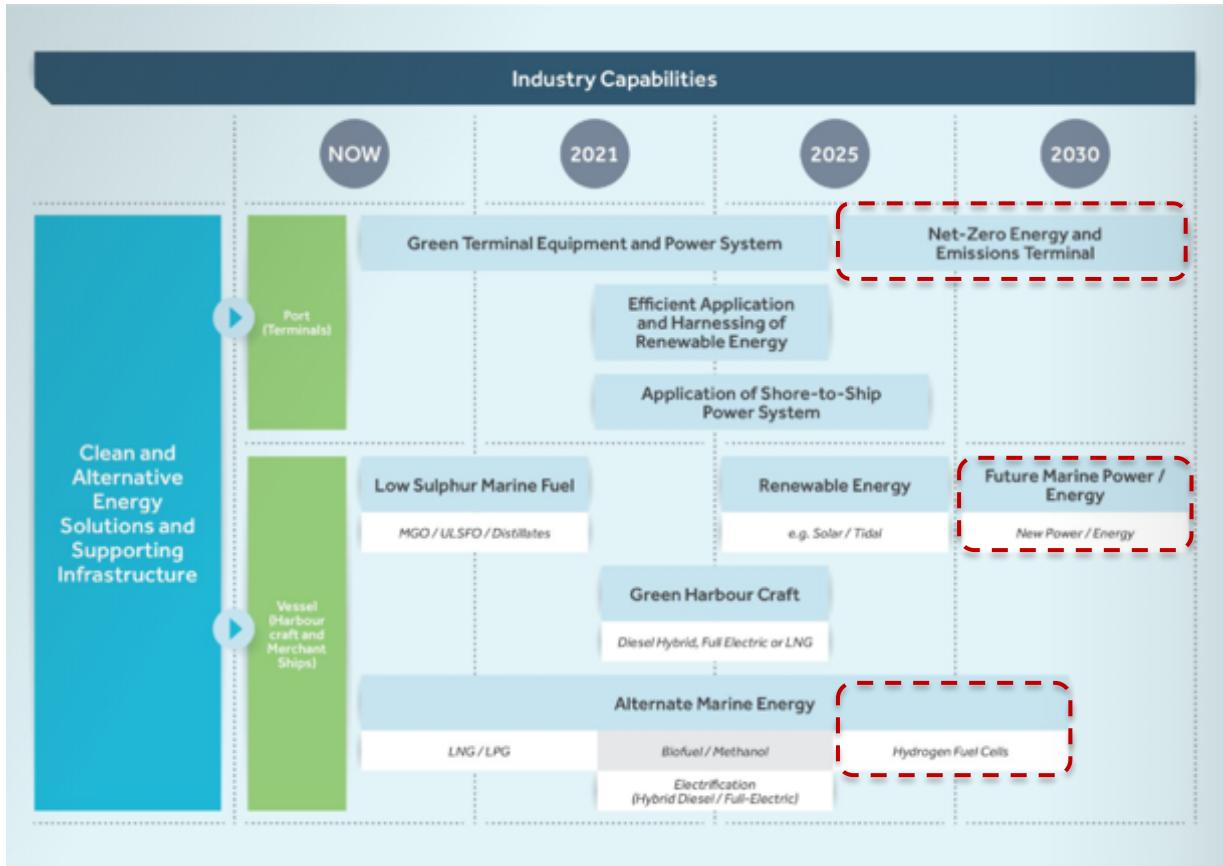


Vision

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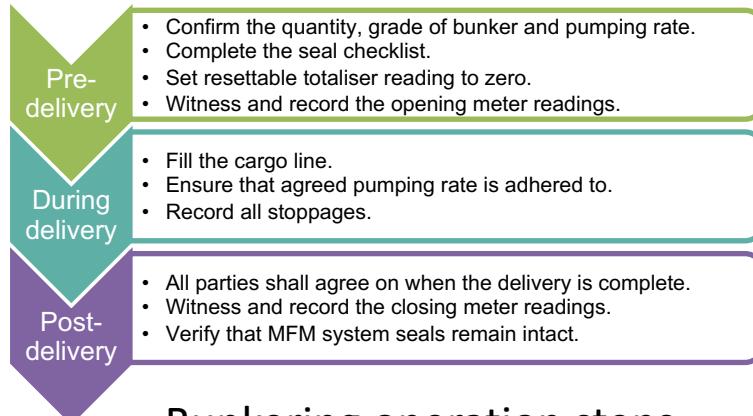
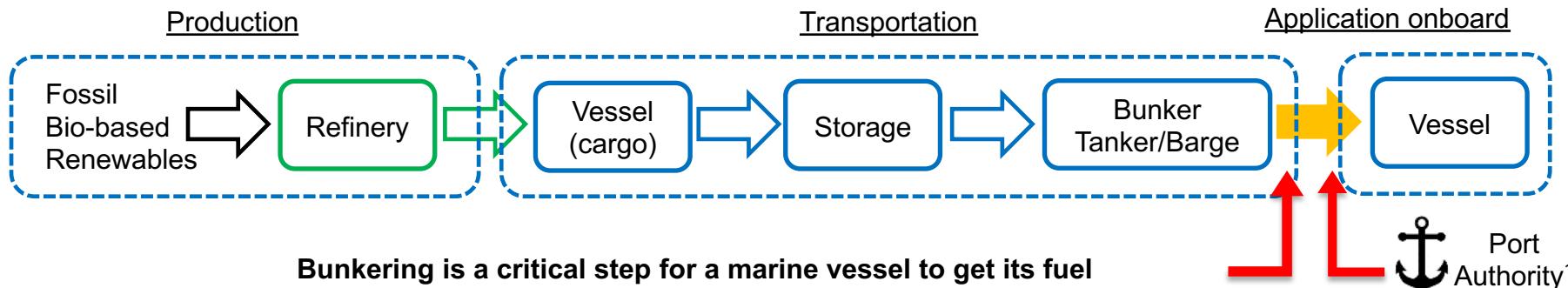
RESEARCH THRUST 5 | MARITIME ENERGY

Launched in SMTC 2019

Source:
<https://www.maritimeinstitute.sg/roadmap2030/>

Marine Fuel Bunkering - Overview

Marine fuel supply



Bunkering operation steps

- ❑ Similarly the ammonia bunkering is expected to follow the steps of marine fuel oil.
- ❑ No ammonia as a marine fuel bunkering procedure, guideline and standard is established.

Ship to ship



Shore to ship



¹ for Singapore context

Ammonia Bunkering – Relevance

Land Based Experience

Chemical Industry



Source: Pneumsys Advance Energy Solutions

Power Plant (SCR)



Source: Rocky Mountain Power, PacifiCorp

Fertilizer Industry



Source: Successful Farming

Refrigeration



Source: SubZero Constructors

Marine Experience

Ammonia Terminal



Source: Indonesia Ammonia Export Terminal - MDR

LNG Bunkering



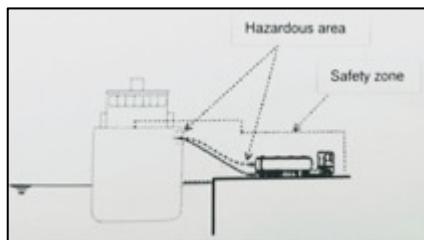
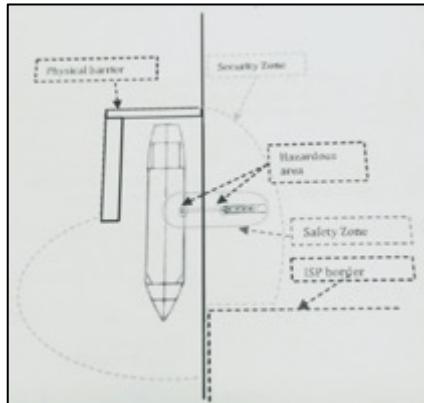
Source: Word Energy News, Amsterdam Port

Experience from chemical, fertilizer and relevant marine sectors serve as good reference to establish ammonia bunkering operation.

Ammonia Bunkering – Safety

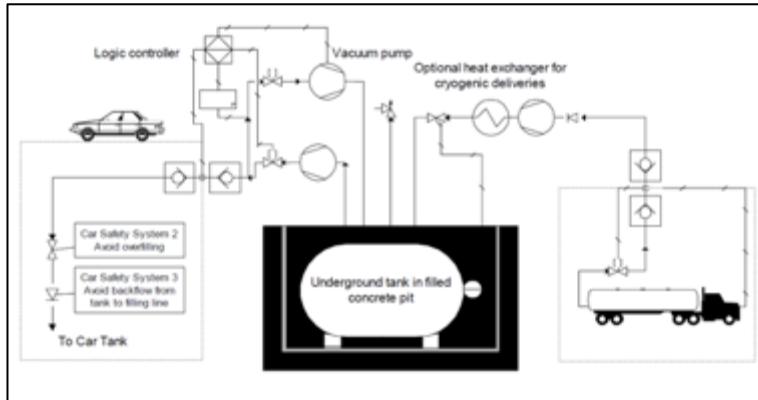
Safety Zone

LNG Bunkering



Source: TR 56 LNG Bunkering

Ammonia Refueling



Source: N. J. Duijm, F. Markert, and J. L. Paulsen, "Safety assessment of ammonia as a transport fuel," 2005.

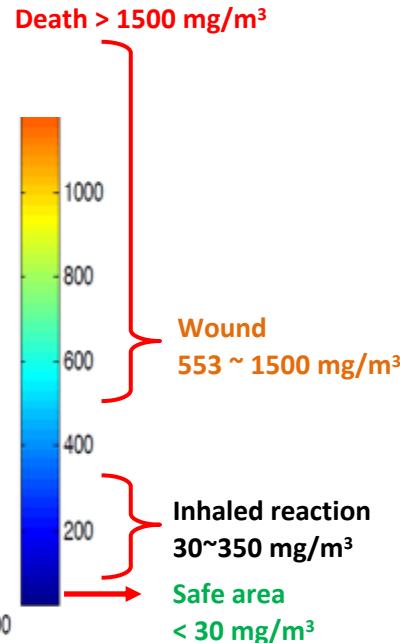
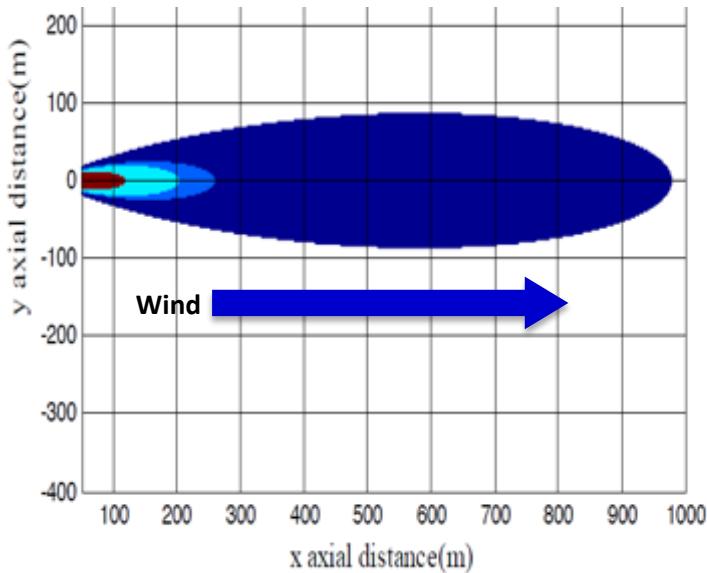
Ammonia Bunkering ?



Experience from environmental assessment provide good reference for predicting the safety zone during ammonia bunkering.

Ammonia Bunkering – Safety

Simulation as a powerful tool



Human
Exposure
Inhale
Acute effect
Chronicle effect
Training
PPE...



Environment
Atmosphere
Waterbody
Eutrophication
Recovery...

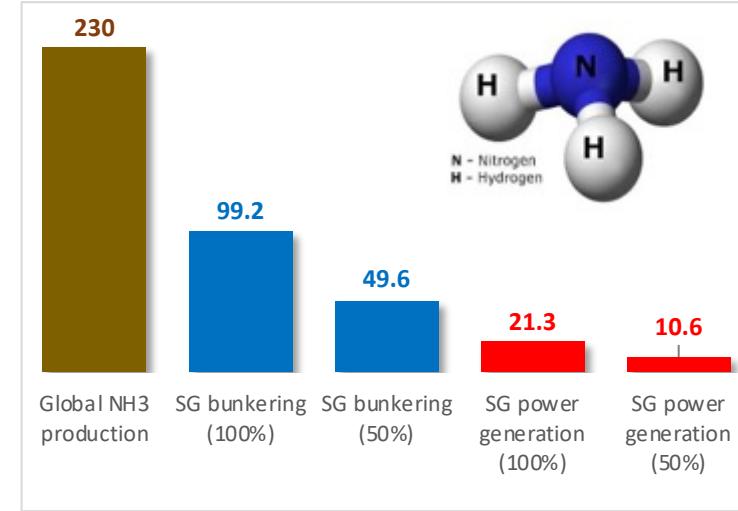
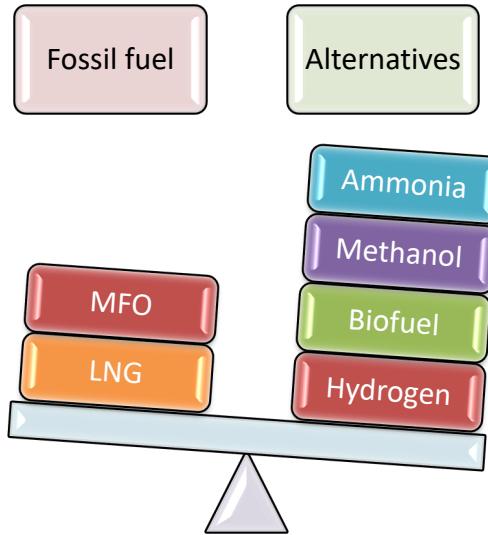


Machinery
Material integrity
Ventilation
Detection system
HAZOP...

Example: simulated ammonia leakage at 5 kg/s with wind speed of 4.5 m/s

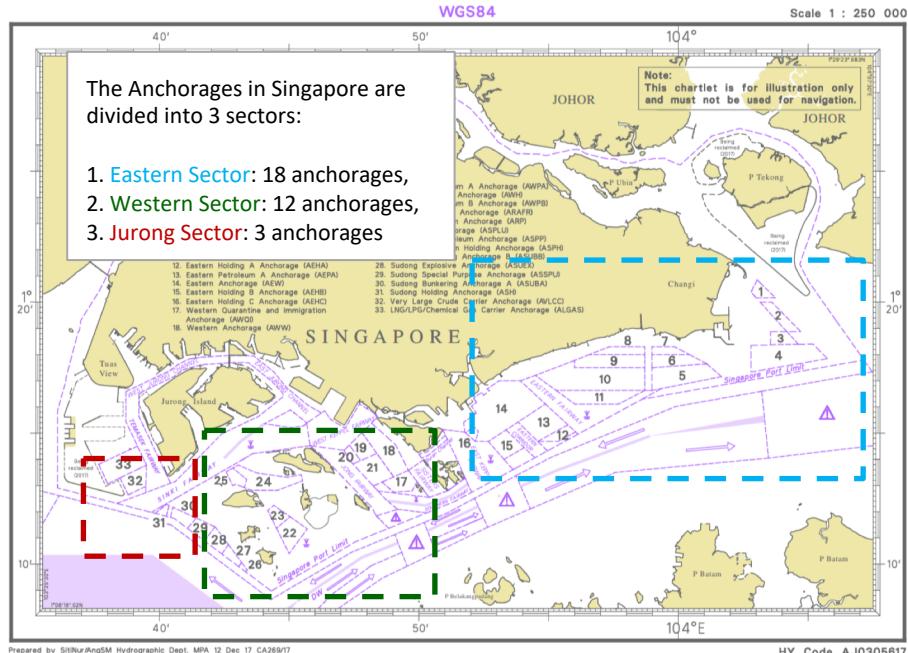
Source: J. Jie, C. Xiaoxia, and H. Xuefeng, "Rapid simulation and visualization analysis of liquid ammonia tank leakage risk," *Procedia Engineering*, vol. 84, pp. 682-688, 2014.

Singapore Context

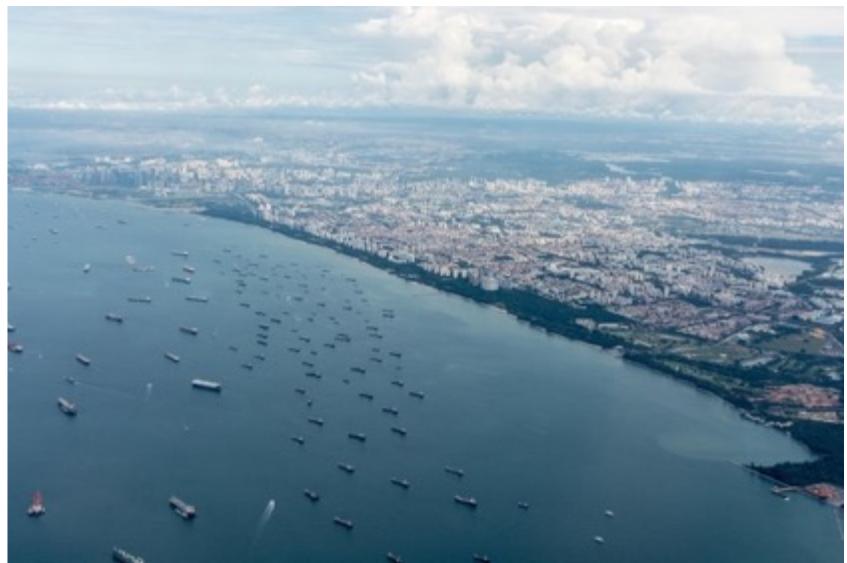


- ❑ Singapore is one of the largest world bunkering hub with options of future alternative bunker fuels.
- ❑ Singapore will play a critical role as a strategic location to receive, store, consume or bunker ammonia.
- ❑ The potential demand of ammonia as an alternative fuel in Singapore is huge, either for power generation or bunkering purpose.

Anchorages



Aerial View



Source: https://www.reddit.com/r/singapore/comments/68rgot/birds_eye_view_of_singapore/

Bunkering activities are concentrated around designated anchorages and terminals.

Ammonia Bunkering – Further Considerations

Bunkering procedure, guideline and standard

- MFM Metering
- Safety and risk analysis
- Crew training
- ...

Fuel Supply System

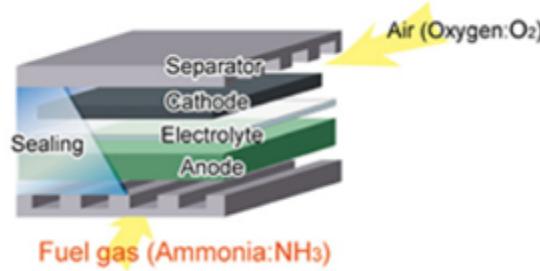
- Fuel storage
- ICE or FC?
- ...

Vessel Design

- Crew Safety
- Retrofit or new build
- ...



Ammonia ?



Ammonia SOFC
Source: Noritake



Ammonia carrier fuelled by its own cargo
Source: Maritime Executive, 2019

Thank you

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