WHEN TRUST MATTERS

GCMD Ammonia Bunkering Safety Study

Ammonia Energy Association

Dr Imran Ibrahim

24 May 2022

Background

- A detailed technical evaluation to define the safety and operational envelopes for ammonia bunkering in Singapore
- To advance the deployment of green ammonia as a marine fuel
- Expected outcomes of the evaluation will support the establishment of a regulatory sandbox for pilots and demonstration projects
- The whole study is split into 2 workstreams
  - Workstream 1 will focus on demand forecast, site selection, QRA, HAZID/HAZOP study, general CAPEX model
  - Workstream 2 will focus on the development of a technical, procedural, and competency guideline for ammonia transfer and bunkering and validation

Consortium Partners

Global Centre for MARITIME DECARBONISATION

DNV

SURBANA JURONG

SMA Singapore Maritime Academy SINGAPORE POLYTECHNIC

DNV

Overview of Workstreams 1 and 2

Workstream 1

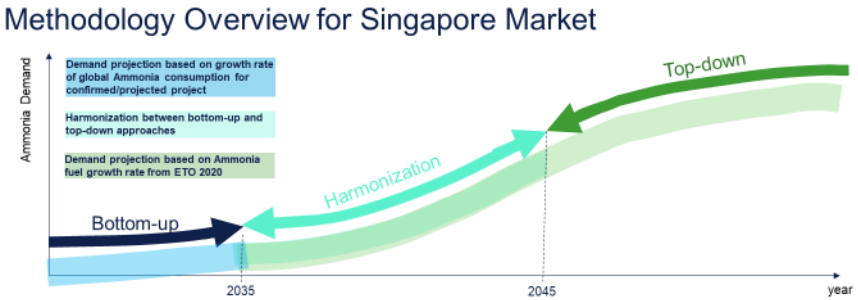
- 1.1 Bunkering Demand Forecast
- 1.2 Conceptual Design
- 1.3 Site Selection
- 1.4 Safety Studies
- 1.5 Capex model

Workstream 2

- Part 1: General Introduction
- Part 2: Custody Transfer
- Part 4: Training and Competency Requirements
- Part 3: Bunkering and Safety Procedures

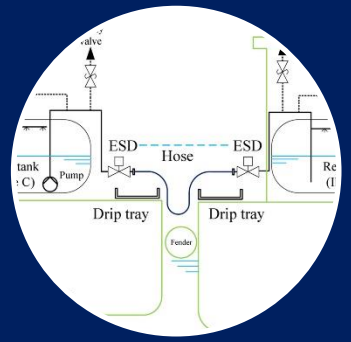
1.1 Ammonia Bunker Demand Forecast

- Developing Ammonia demand forecast model using bottom-up and top-down approaches leveraging on DNV in-house datasets, including but not limited to:
  - DNV AIS datasets
  - DNV ETO datasets
- Conducting workshops with stakeholders
  - Methodology presentation
  - Project demonstration
  - Clarifications
- Projecting the annual ammonia demand towards 2050.
- Estimate the vessel size and ammonia tank range for major ship segments (ie, container, tanker, bulker etc.)



- The above graph illustrates the methodology for ammonia bunker demand forecast in Singapore towards 2050.
- Bottom-up and top-down approaches will be applied and then harmonized in between.
- There will be three cases to be projected, which consist of:
  - Optimistic
  - Basic
  - Pessimistic

1.2 Conceptual Design



Establish Design Basis

- Establish Assumptions for the study
- Bunkering Capacity based on demand analysis by DNV
- Bunkering rates
- SIMOPS requirements

Bunkering Infrastructure Design

- Estimate preliminary topside infrastructure requirements Landside utility and fire fighting requirements
- Landside electrical connectivity adequacy check/new substation
- Perform Process Design (PFD, HMB, Line sizing, Equipment sizing, P&ID etc), bunkering truck specs

Plot Space Adequacy Assessment

- Preliminary Plot Plan
- Preliminary Layout with required safety distances

Leveraging on previous studies done in the Port of Amsterdam and Oslo

- External safety study - bunkering of alternative marine fuel for seagoing vessels
  - Hydrogen
  - Ammonia
  - LNG
  - Methanol
- Determination of the location-specific individual risk/external safety distances
- Focus areas
  - Fire
  - Explosion
  - Toxic

- Ammonia Bunkering of Passenger Vessel - Concept Quantitative Risk Assessment
- Concept 1A: Transfer of pressurized ammonia from a truck to a pressurized storage tank on the quay and further to the passenger ship.
- Concept 1B: Transfer of refrigerated ammonia from a bunker ship to a pressurized storage tank on the quay and further to the passenger ship.
- Concept 2: Transfer of refrigerated ammonia from a bunker ship on the seaside of the passenger ship directly to the passenger ship.

1.3 Site Selection Methodology

Workshop-1 with Agencies

- Identify up to 4 Possible Sites

Criteria for Screening:

General characteristics of Singapore's Shoreline

- Site availability (land and sea space for deployment);
- Operational considerations (based on water depths and site access); and
- Other considerations (e.g. navigation/aerodrome restrictions, proximity to sensitive environmental receptors).

Evaluation Methodology Criteria

- Marine
- Land
- Layout
- HSE & Demography
- Accessibility
- Constructability

The Ranking scoring assessment will be conducted by a group of technical specialists.

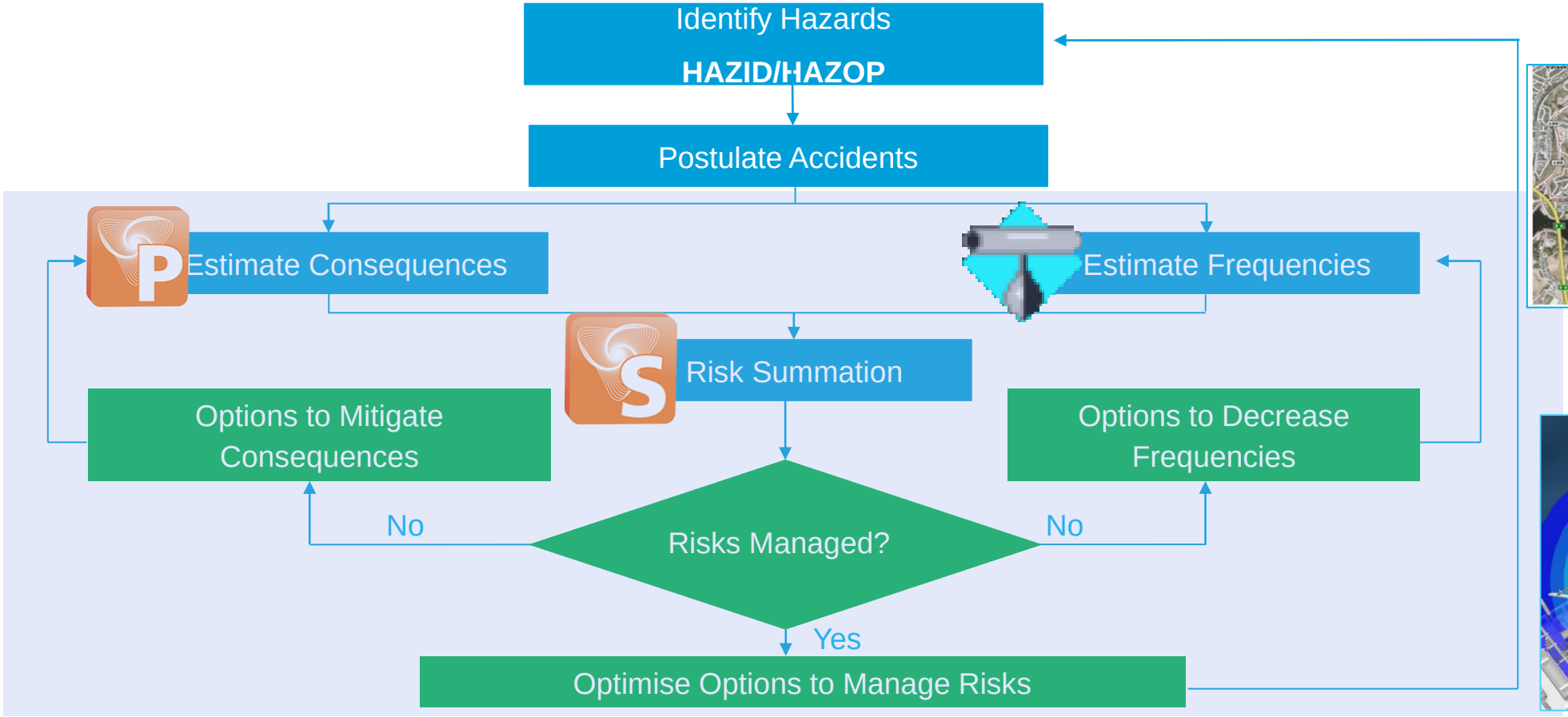
Workshop-2 with Agencies

Alignment with agencies and GCMD on ranking score, evaluation on agencies inputs and Shortlist 2 suitable sites

2 sites

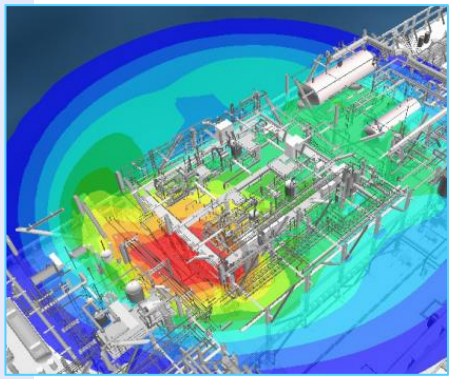
12 Agencies (URA, SLA, MPA, CAAS, MHD, SCDF, JTC, NEA, NParks, SFA. EDB, ESG) to be consulted at two inter-agency site selection workshops

1.4 Safety Studies **2** locations – **4** bunkering concepts

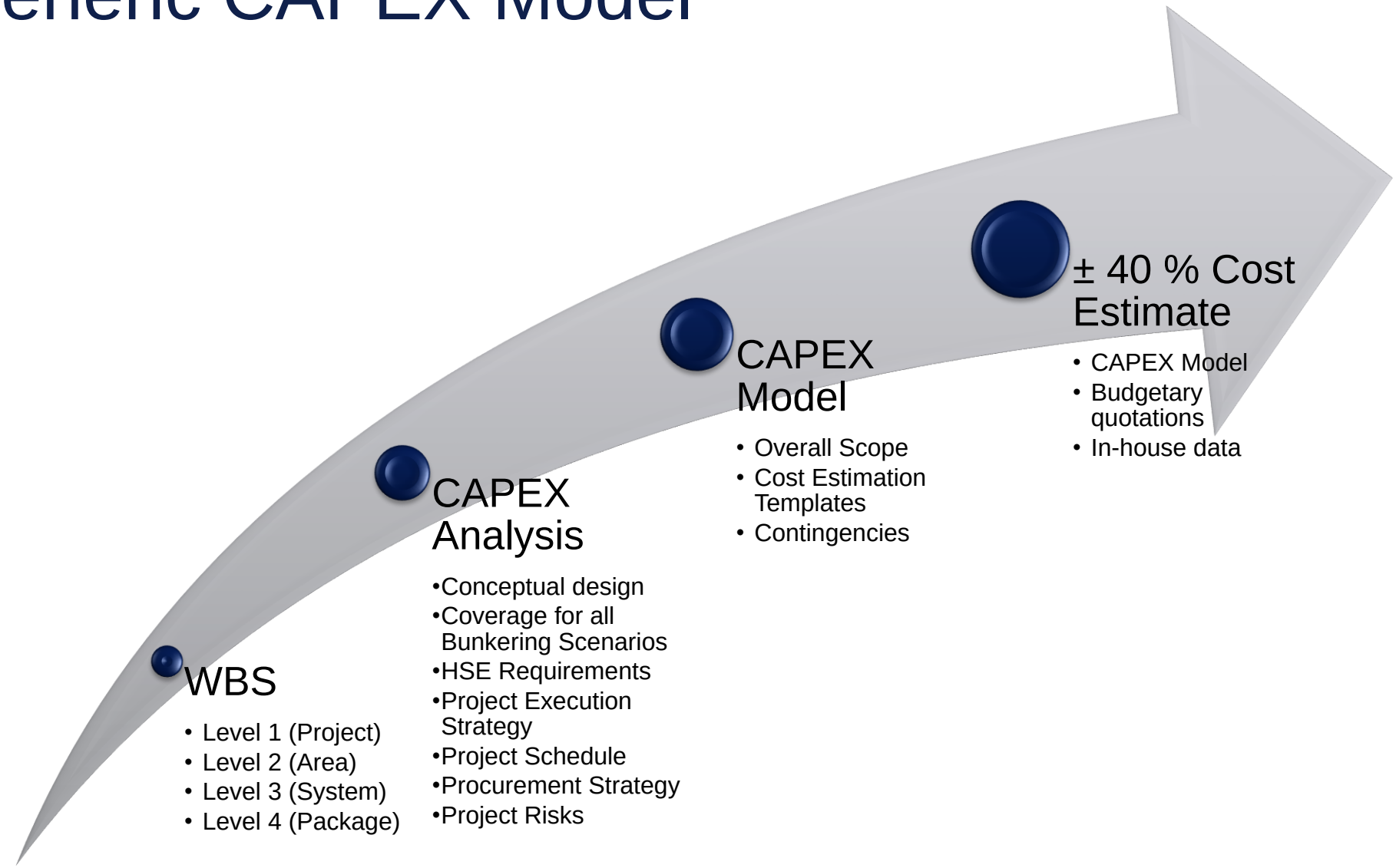


QRA

CFD KFX



1.5 Generic CAPEX Model



WBS

- Level 1 (Project)
- Level 2 (Area)
- Level 3 (System)
- Level 4 (Package)

CAPEX Analysis

- Conceptual design
- Coverage for all Bunkering Scenarios
- HSE Requirements
- Project Execution Strategy
- Project Schedule
- Procurement Strategy
- Project Risks

CAPEX Model

- Overall Scope
- Cost Estimation Templates
- Contingencies

± 40 % Cost Estimate

- CAPEX Model
- Budgetary quotations
- In-house data

2 Drafting of Technical, Procedural and Competency Guidelines

- The core objective of this scope is to develop an extensive guideline like Technical Reference (TR 56) for LNG bunkering.
- This section requires close collaboration with the committed study partners through meetings and workshops at several stages of the documentation, facilitated by DNV. We also intend to engage Singapore Standards Association in the discussions.
- The guideline will have 4 sub-parts as follows:

  Part 1: Ammonia as a marine fuel – Safety and Regulations
  Part 2: Custody transfer
  Part 3: Bunkering and Safety Procedures
  Part 4: Training and competency requirements

Contents

Overview of Workstreams 1 and 2

Workstream 1

- 1.1 Bunkering Demand Forecast
- 1.2 Conceptual Design
- 1.3 Site Selection
- 1.4 Safety Studies
- 1.5 Capex model

Workstream 2

- Part 1: General Introduction
- Part 2: Custody Transfer
- Part 4: Training and Competency Requirements
- Part 3: Bunkering and Safety Procedures

Thank You

24 May 2022

Global Centre for
MARITIME DECARBONISATION

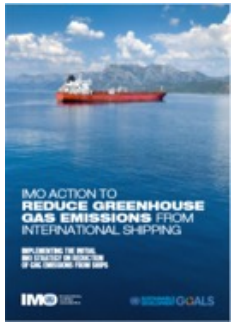
Lau Wei Jie

Director
Research and Projects

How we started

Global Centre for MARITIME DECARBONISATION

IMO 2050 target articulated, Apr 2018



First meeting of the International Advisory Panel (IAP) for Maritime Decarbonisation, Jul 2020

GCMD founded, Aug 2021

Founding partners

BHP · DNV · EASTERN PACIFIC SHIPPING · MPA SINGAPORE · ONE OCEAN NETWORK EXPRESS · sembcorp marine

2018 — 2019 — 2020 — 2021 — 2022

Singapore to set up a global maritime decarbonisation centre: Ong Ye Kung

TAY PECK GEK peckgek@sph.com.sg @PeckGekBT

IAP report published and Singapore announces plans to set up decarbonisation centre, Apr 2021

Singapore's new decarbonisation centre invites proposals for ammonia bunkering study

GCMD announced the Invitation for Proposal, Oct 2021

Ammonia bunkering safety study

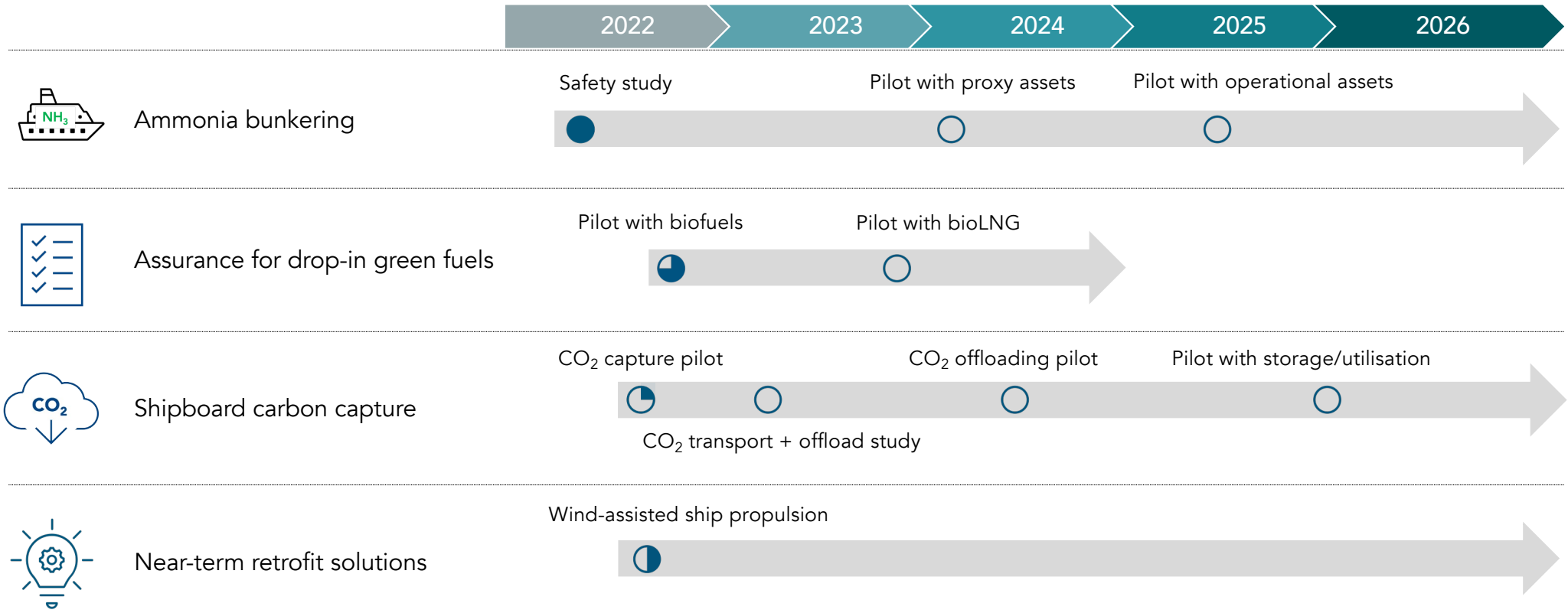
Defining the safety + operations envelopes to enable ammonia bunkering pilot + demonstration

Study consultant: DNV Singapore Pte Ltd

Partners: Surbana Jurong, Singapore Maritime Academy

+ Start date: Feb 2022
+ Project duration: 10 to 12 months

5-year projects outlook



List is not exhaustive; current as of May 2022.

The fuels of tomorrow will be largely different from today

Global Centre for MARITIME DECARBONISATION

	Conventional/ fossil fuels	Lower carbon fuels available today		Low-/zero-carbon fuels		
Characteristics	MGO/HFO/LSFO	Biodiesel	LNG	Ammonia	Hydrogen	Methanol
Boiling point @1 atm	-	-	-160°C	-33°C	-253°C	65°C
Energy Density (MJ/L)	36.6-38.2	35-37	20.8 (liquefied)	12.8 (liquefied)	8.49 (liquefied)	15.8
Fuel tank size relative to MGO	-	-	1.7	2.8	4.2	2.4
Toxicity	Non-toxic	Non-toxic	Non-toxic	Highly-toxic	Non-toxic	Low acute toxicity

Sources:
1. Alternative fuels for international shipping, NTU MESD
2. MAN B&W two-stroke engine operating on ammonia, MAN ES
3. Comparison of Alternative Marine Fuels, SEA\LNG

Ammonia as cargo versus bunker

	Ammonia as cargo	Ammonia as bunker
State of matter during transport and storage	Pressurised liquid at room temperature or refrigerated liquid	**Needs to be specified per transfer and storage modes**
Quality / grade	Chemical grade	**Does fuel grade need to be as high as chemical grade?**
Capacity	20-60,000 cbm for tankers; 5-7,000 cbm for Panamax container ships; approx. 10,000 cbm stored in Singapore	On average 3,600 cbm per bunker call assuming the endurance of fuel oil; much smaller quantities for trucks, etc.
Transfer frequency	Low (<< 1 delivery/day depending on consumption volume and rate)	Very high (for reference: about 110 bunker call/day in Singapore) **Specs needed to ensure safe operations**
Operation experience	Limited to industrial processes	**Does not exist today**
Transfer process	Established (fully-refrigerated; semi-refrigerated; not refrigerated)	**Not established; needs to be customised for bunkering operations**
Dispersion study on ammonia release	Limited to industrial sites	**More expansive scope needed to cover potential release on land and in water**
Guidelines for transfer and storage	In place	**Not established**

Information from MESD, NTU
For further details, please see Dr. Liu Ming's presentation at SMI Forum on October 14, 2021 (https://www.youtube.com/watch?v=0MnBCPS3TsA).

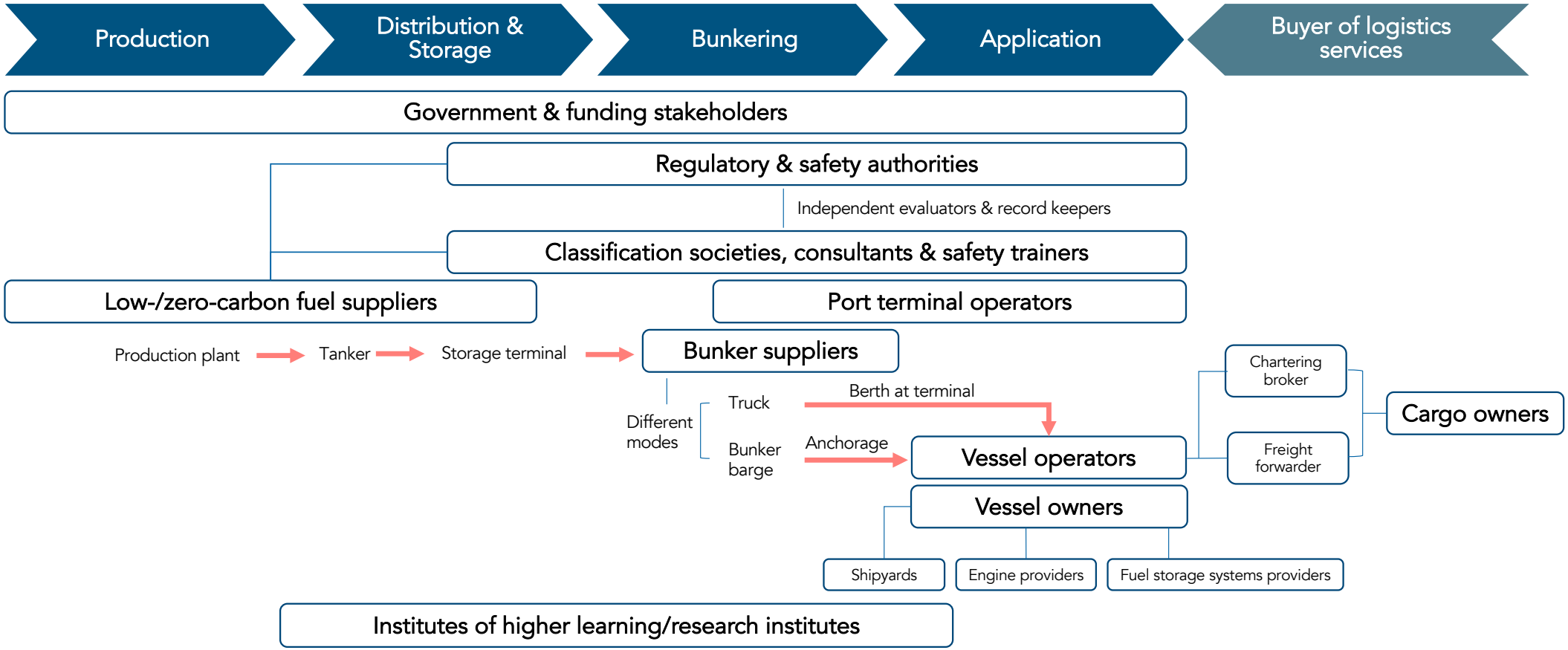
Scope + outcomes

Global Centre for MARITIME DECARBONISATION

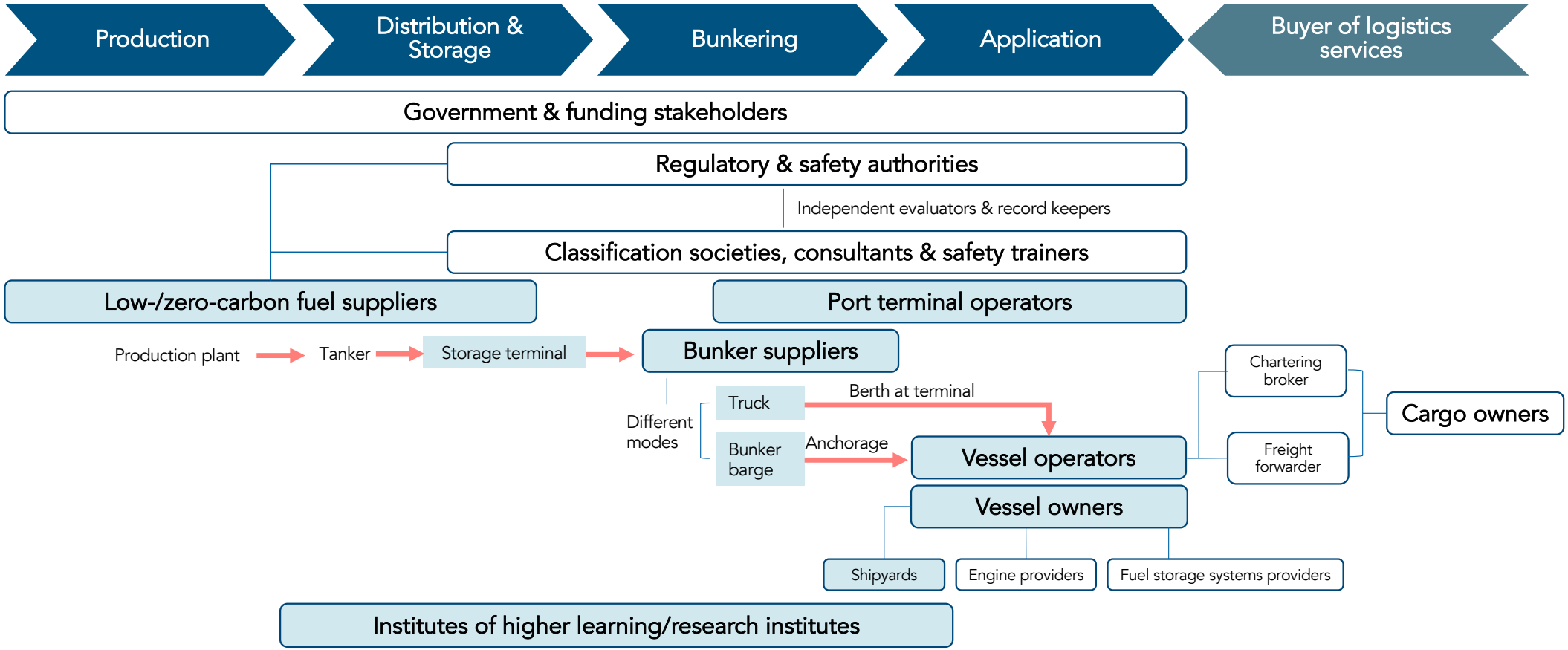
01	02	03	04	05	06
Identify & make recommendations to address regulatory gaps	Recommend up to two sites for ammonia bunkering	Draft Technical Guidelines and Procedures	Generate CAPEX model for ammonia bunkering infrastructure	Develop competency standards for bunkering operations	Validate & finalise findings with industry stakeholders

The expected outcomes will support the establishment of regulatory sandbox for pilots and demonstration projects

Study focuses on transfer of ammonia



Committed industry partners



Study partners

Global Centre for MARITIME DECARBONISATION

Fuel producers	Fuel storage terminal operators	Bunker suppliers + barge operators	Port terminal operators	Vessel owners + operators	Shipyards	Fuel (quality + quantity) testing service providers
+ Yara	+ Oiltanking + Vopak Terminals	+ Fratelli Cosulich + Hong Lam + Kenoil + Pavilion Energy	+ Jurong Port + PSA	+ Asiatic Lloyd + EPS + MOL + Navigator Gas/BW + NYK + ONE + PIL	+ Keppel + Sembcorp Marine	+ National Metrology Centre + Viswa Lab + VPS

Welcoming your participation

GCMD has set up an Industry Consultation and Alignment Panel (iCAP) to provide input to the recommendations of this study before the report is finalised.

Register your interest via:

Link: iCAP registration

QR code:

Global Centre for
MARITIME DECARBONISATION

10 Pasir Panjang Road #17-02 Mapletree Business City | Singapore 117438

www.gcformd.org

projects@gcformd.org

+65 6979 7660