CO_2 Shipping Interoperability Industry Group (CSIIG)

2nd CSIIG Workshop – 20 September 2023

EverLoNG project, WP2

The EverLoNG project is funded through the ACT programme (Accelerating CCS Technologies, Horizon2020 Project No 691712). Financial contributions have been made by the Ministry of Economic Affairs and Climate Policy, the Netherlands; The Federal Ministry for Economic Affairs and Climate Action, Germany; the Research Council of Norway; the Department for Business, Energy & Industrial Strategy, UK; and the U.S. Department of Energy. All funders are gratefully acknowledged.

Agenda (all times approx. BST / CEST)

The EverLoNG project & full CCUS chain overview (1000-1015 / 1100-1115)

1. Welcome & project overview: Richard L Stevenson, Project & Research Analyst, SCCS/The University of Edinburgh
2. WP2: Ship-based carbon capture in the full CCUS chain overview: Ragnhild Skagestad, Senior Research Scientist, SINTEF

Port perspective (1015-1035 / 1115-1135)

3. Port of Antwerp & Bruges: Arne Strybos, Program Manager Fuel Transition
4. Port of Rotterdam: Françoise Van den Brink, Senior Advisor Energy Transition

Shipping/CO2 handling perspective (1035-1055 / 1135-1155)

5. Moss Maritime: Tor Skogan, Vice President Gas
6. Altera Infrastructure: Frank Wettland, Project Manager - New Venture CCS

Interactive discussion (1055-1130 / 1155-1230)

7. All participants

EverLoNG & CSIIG overview

2^{nd} CSIIG Workshop – 20 September 2023

Richard Lindsay Stevenson, Project & Research & Analyst,
SCCS/The University of Edinburgh

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Objectives

The objectives of EverLoNG are to accelerate the implementation of Ship-based Carbon Capture (SBCC) technology by:

I. Demonstrating SBNCC on-board of LNG-fuelled ships

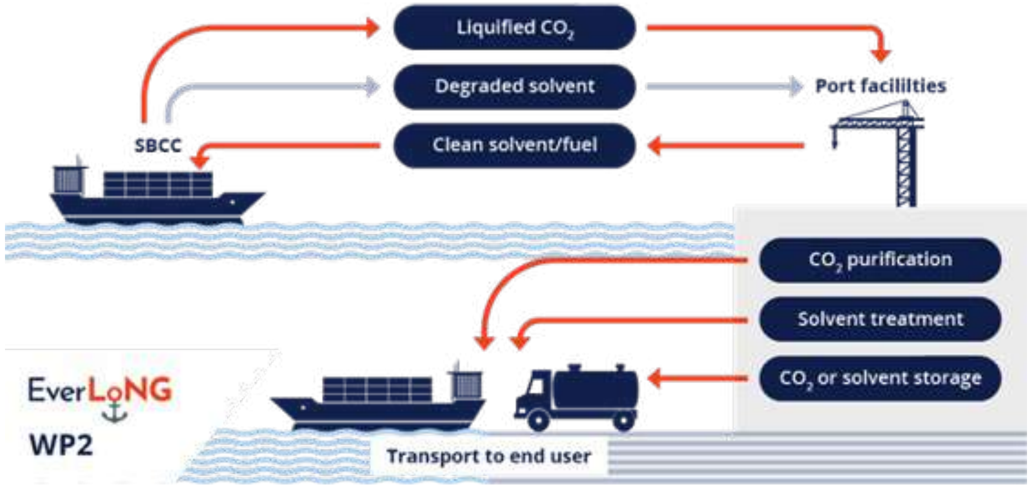
II. Optimising SBCC integration to the existing ship infrastructure

III. Facilitating the development of SBCC-based full CCUS chains

IV. Facilitating the regulatory framework for the technology

Facilitating the development of SBCC-based full CCUS chains

- Develop offloading strategies and establish guidelines for CO_2 shipping interoperability, port readiness, port infrastructure and CO_2 specifications; also solvent handling
- To this purpose a CO_2 Shipping Interoperability Industry Group (CSIIG) has been established
- Use of captured and liquified CO_2 will prove the CO_2 quality produced, which is critical for the development of CCUS chains.



- CCU: synthetic fuel production at RWE Niederaussem, greenhouses in NL
- CCS: Northern Lights, Porthos, Acorn

CSIIG#1 (Nov 2022)

- Summary of ZEP CO2 Shipping Guidance - Alistair Tucker (Shell)
- Update on progress towards development of ISO Standard for shipping – Erik Mathias Sørhaug (DNV)
- CO_2 Shipping Interoperability discussion – Philippa Parmiter (SCCS)

- Feedback
  - International shipping of CO2
  - Financing and availability of ships
  - CO2 handling infrastructure at port

CSIIG#2 (Sep 2023)

- Quayside requirements for CO_2 upload/offload
  - What's happening now?
  - What's in the pipeline?
  - Technical and non-technical aspects

- International shipping of CO_2
  - What's happening now?
  - What's in the pipeline?
  - Financing and availability of ships

Port of Antwerp Bruges

Port of Rotterdam

mossmaritime

altera INFRASTRUCTURE

Demonstration of ship-based carbon capture on LNG fuelled ships

CSIIG Workshop 2

Ragnhild Skagestad, WP 2 lead, Senior researcher at SINTEF AS, Norway

Ragnhild.Skagestad@sintef.no

20.09.2023

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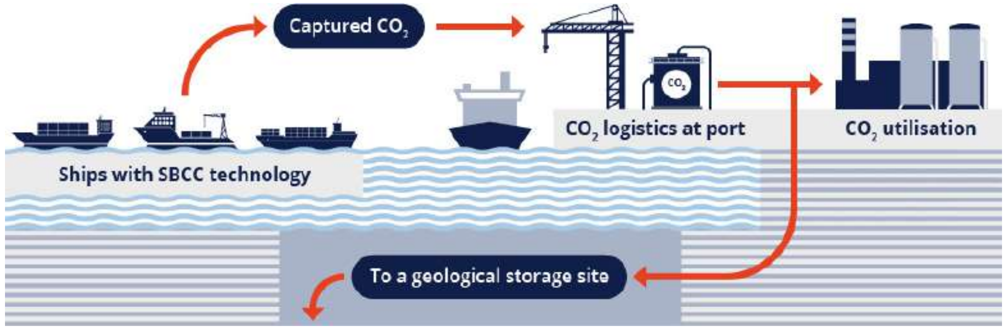
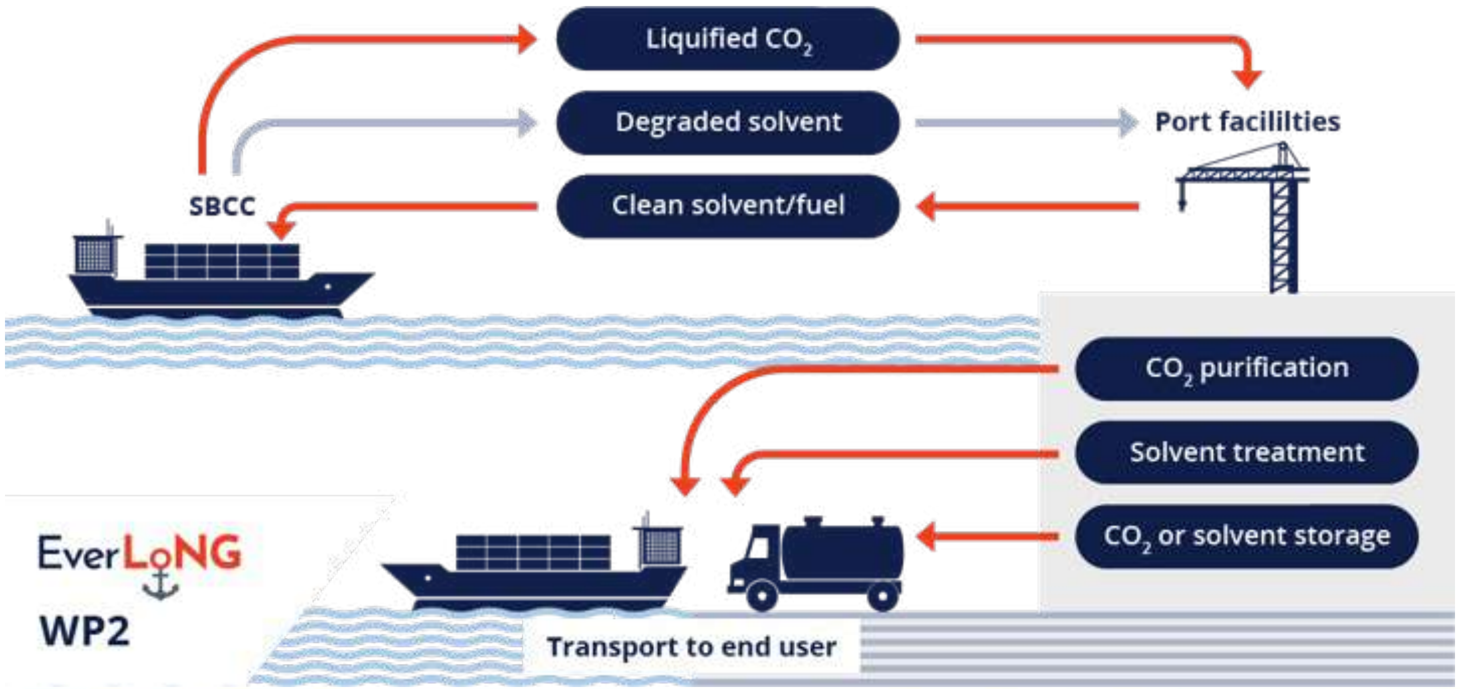
EverLoNG - CO_2 handling infrastructure

- After all the effort of capturing the CO2 onboard the vessel - it is paramount that the CO2 remains captured
- To enable this, a CO2 handling infrastructure needs to be in place that can receive this CO2 in such a way that it has little impact on the normal operation of the vessel
- Identified challenges are;
  - Limited CO2 infrastructure in place today
    - Both portside and in a wider perspective
  - The flexibility of the portside CO2 receival facility
    - Condition and quality of CO2
    - How is the CO2 unloaded (pumped to shore or container swap)
  - The CO2 volumes expected at each port
    - How does it impact on the established port operation
  - Unloading frequency
    - Trade-off between onboard storage capacity and unloading ports
  - +++

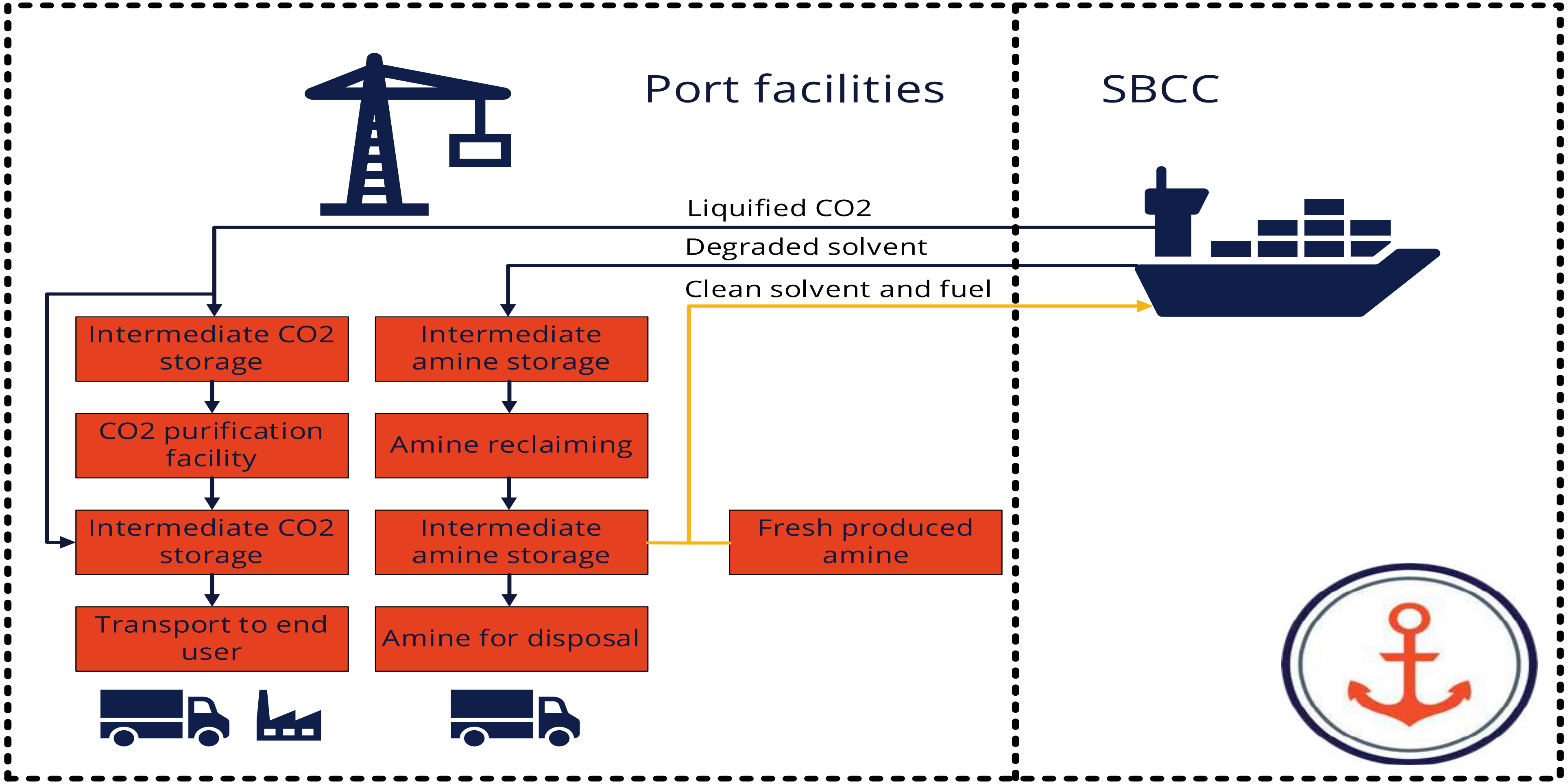


Objectives

The main objectives of WP2 are to develop offloading strategies, and establish guidelines for CO2 shipping interoperability, port readiness and CO2 specifications, to be compiled in a roadmap towards a European off-loading network.



Ports



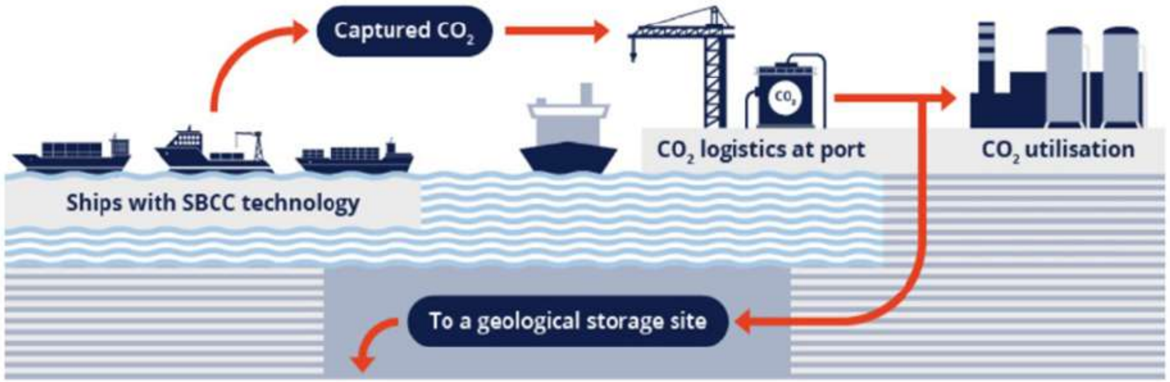
Port facilities
SBCC
Liquified CO2
Degraded solvent
Clean solvent and fuel
Intermediate CO2 storage
CO2 purification facility
Intermediate CO2 storage
Transport to end user
Intermediate amine storage
Amine reclaiming
Intermediate amine storage
Amine for disposal
Fresh produced amine

Criteria for port selection

Port selection for CO_2 receival, processing and transport to end customer should be based upon several criteria as

- geographical location,
- ship travel routes,
- existing pipelines in the area which can be used for CO_2 transport and vicinity to permanent storage and/or CO_2 utilization customers.

Relevant regulative bodies should be involved in approval and standardization of both hardware and operational procedures for future CO_2 – storing, offloading and port processing.



Green corridors

- The EverLoNG project aims
  - at identifying infrastructure needs necessary to receive and handle CO_2 portside and
  - to propose a timeline for port implementation
- It is not likely that all ports can offer such an infrastructure and further, it might not be necessary

- An approach could be to focus on the busiest shipping lanes that could, if infrastructure is offered, have the grates impact on CO_2 emissions from the shipping industry
- These shipping lanes could become green corridors where selected ports can offer CO_2 handling infrastructure
- One such shipping lane could be Rotterdam – Singapore

Conclusion - SBCC

- Implementation of SBCC is a decarbonising measure that can be implemented today
- Still,
    - Shipboard integration challenges exists
        - Space, energy integration
        - The CO_2 capture and liquefaction capacities can vary greatly depending on fuel and engine type
    - Portside CO_2 handling infrastructure is not in place
        - One approach is to identify shipping lanes and ports that would have the greatest impact and develop a green corridors for these
            - E.g., Rotterdam and Singapore

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Thank you for listening

Ragnhild.Skagestad@sintef.no

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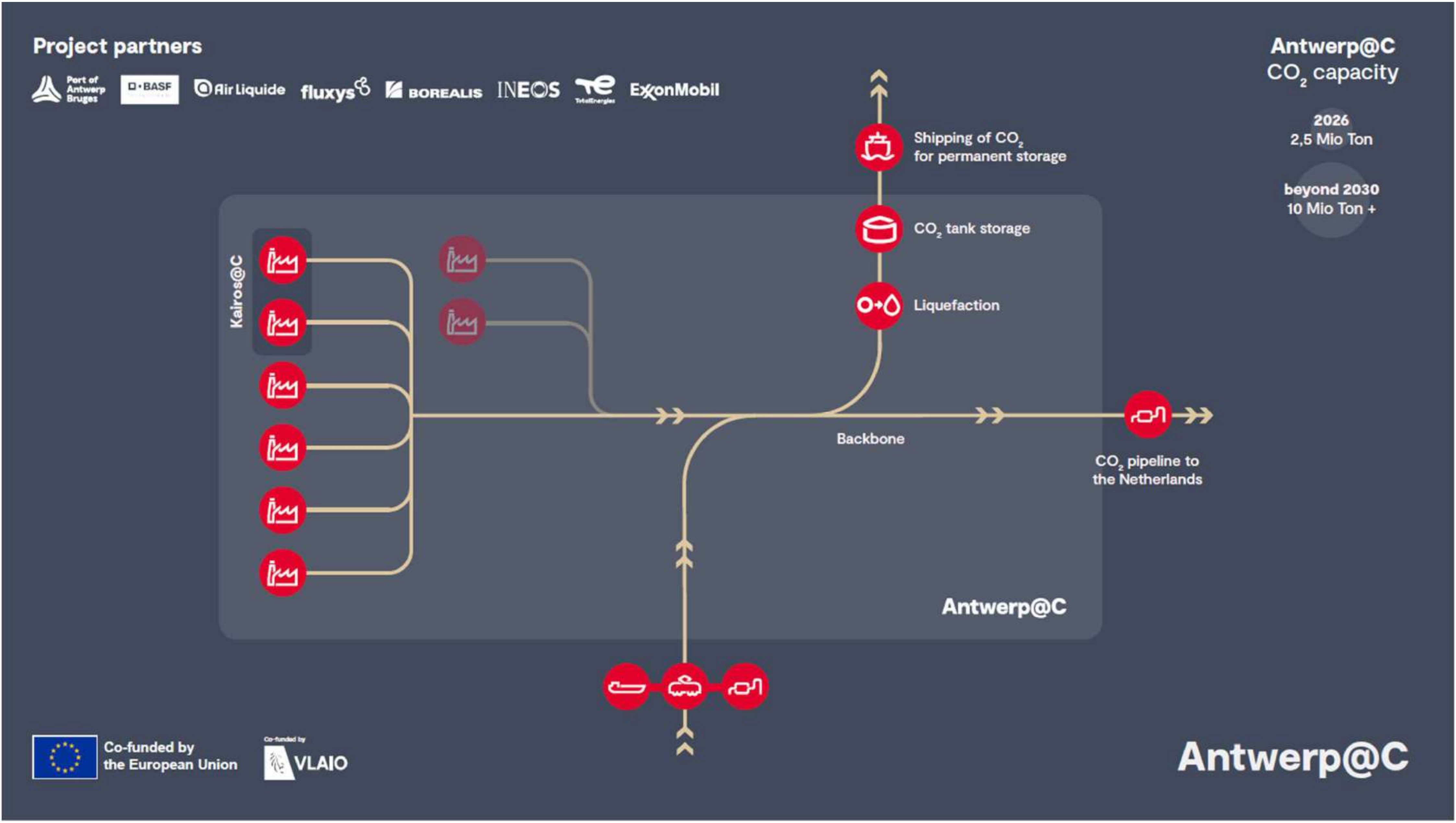
Project partners
Port of Antwerp Bruges
BASF
Air Liquide
fluxys
BOREALIS
INEOS
TotalEnergies
ExxonMobil
Antwerp@C
CO_2 capacity
2026
2,5 Mio Ton
beyond 2030
10 Mio Ton +
Shipping of CO_2 for permanent storage
CO_2 tank storage
Liquefaction
Kairos@C
Backbone
CO_2 pipeline to the Netherlands
Antwerp@C
Co-funded by the European Union
Co-funded by
VLAIO
Antwerp@C

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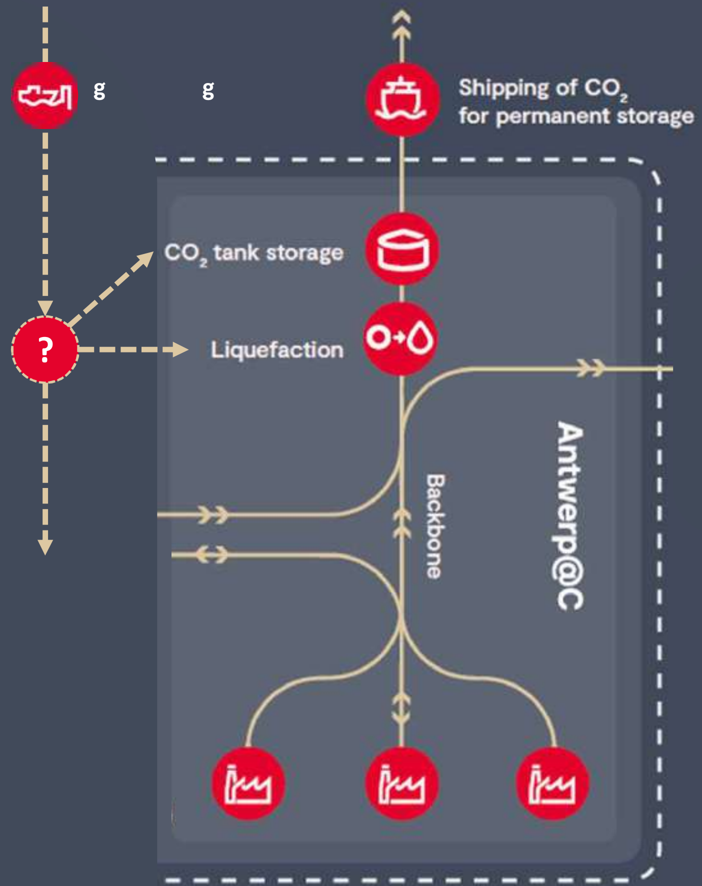
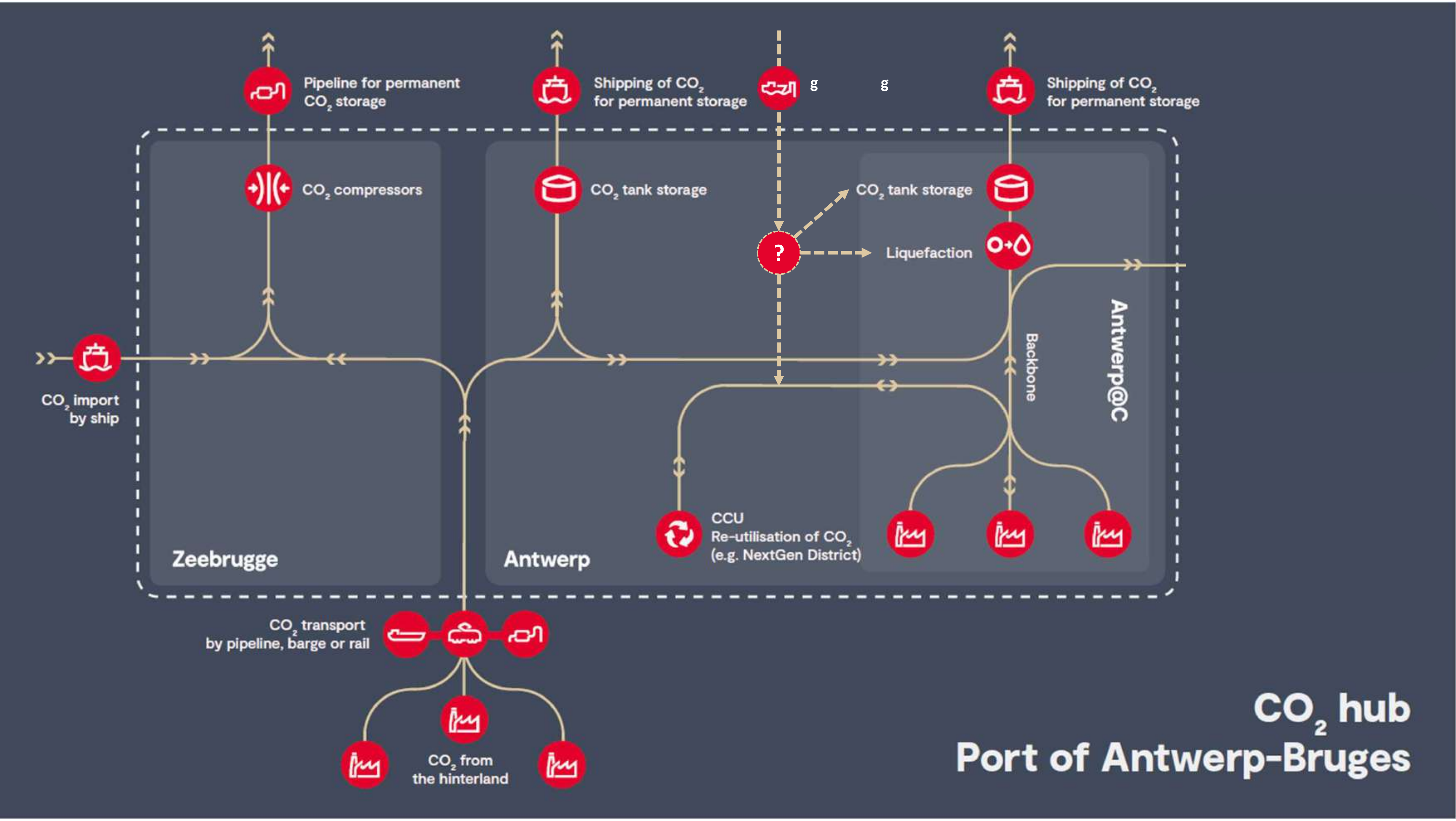
Port of Antwerp Bruges



CO_2 hub
Port of Antwerp-Bruges



Pipeline for permanent CO2 storage
Shipping of CO2 for permanent storage
g
g
Shipping of CO2 for permanent storage
CO2 compressors
CO2 tank storage
CO2 tank storage
?
Liquefaction
CO2 import by ship
Backbone
Antwerp@C
CCU
Re-utilisation of CO2
(e.g. NextGen District)
Zeebrugge
Antwerp
CO2 transport by pipeline, barge or rail
CO2 from the hinterland
CO2 hub
Port of Antwerp-Bruges

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1. Specifications of captured CO_2

- → What is the quality of onboard captured CO_2?
- → What are expected volumes of onboard captured CO_2?
- → What are existing technologies for shipbased carbon capture?
- → What CO_2 storage types and/or mediums exist and what are the associated products?

2. Port-related operations

- → What services are needed to get CO2 from ships to the quay?
- → If solvent is used: where/when should it be seperated from CO2? Which steps have to be taken?
- → Which (local) companies are interested in CO_2 handling and solvent separation?
- → Risk analysis needed for operations?

3. Connection to terminal infrastructure

- → Can expected volumes be interesting to add to existing infra?
- → Need for treatment of CO_2 (high grade expected @sinks)?
- → Conditions and required infra to make the connection?
- → Ownership of CO_2 molecule and associated risks?

4. CCUS application (?)

- → Hence volumes, quality, etc.: Might it be more interesting for shipping to look into solutions where CO2 is used and fixed in applications instead of carbon sinks (?)
- → NextGen (Demo) opportunities to set-up activities?

Port of Antwerp Bruges

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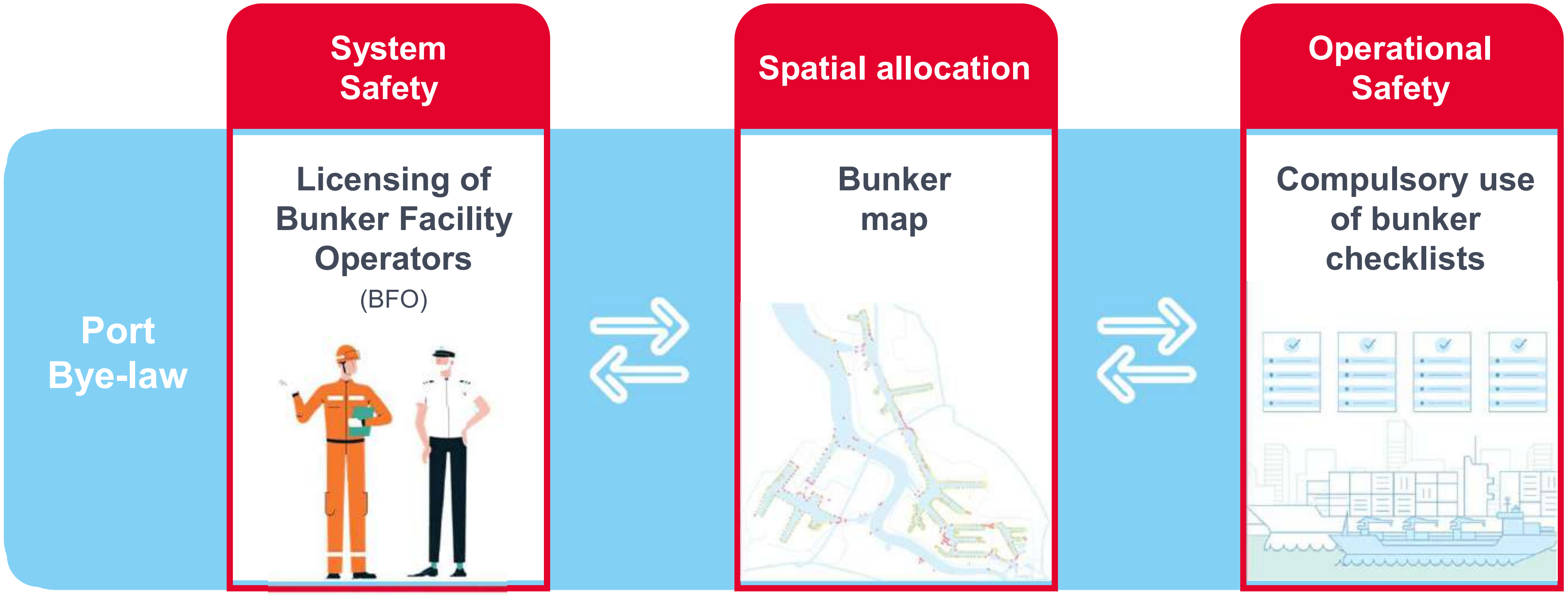
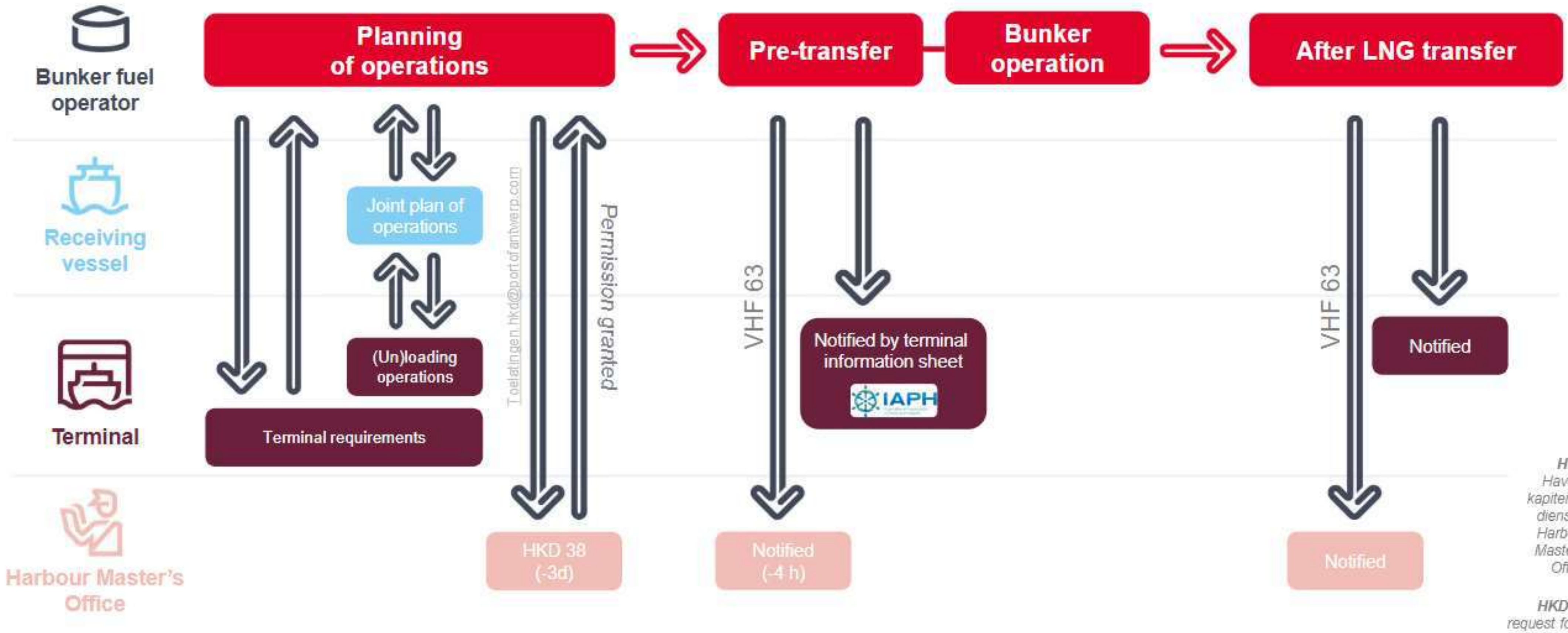


Port of Antwerp Bruges

Process of LNG bunker operations



HKD Haven-kapiteins-dienst = Harbour Master's Office

HKD 38 request form for LNG bunkering

Port of Antwerp Bruges

Port of Antwerp Bruges

Arne Strybos

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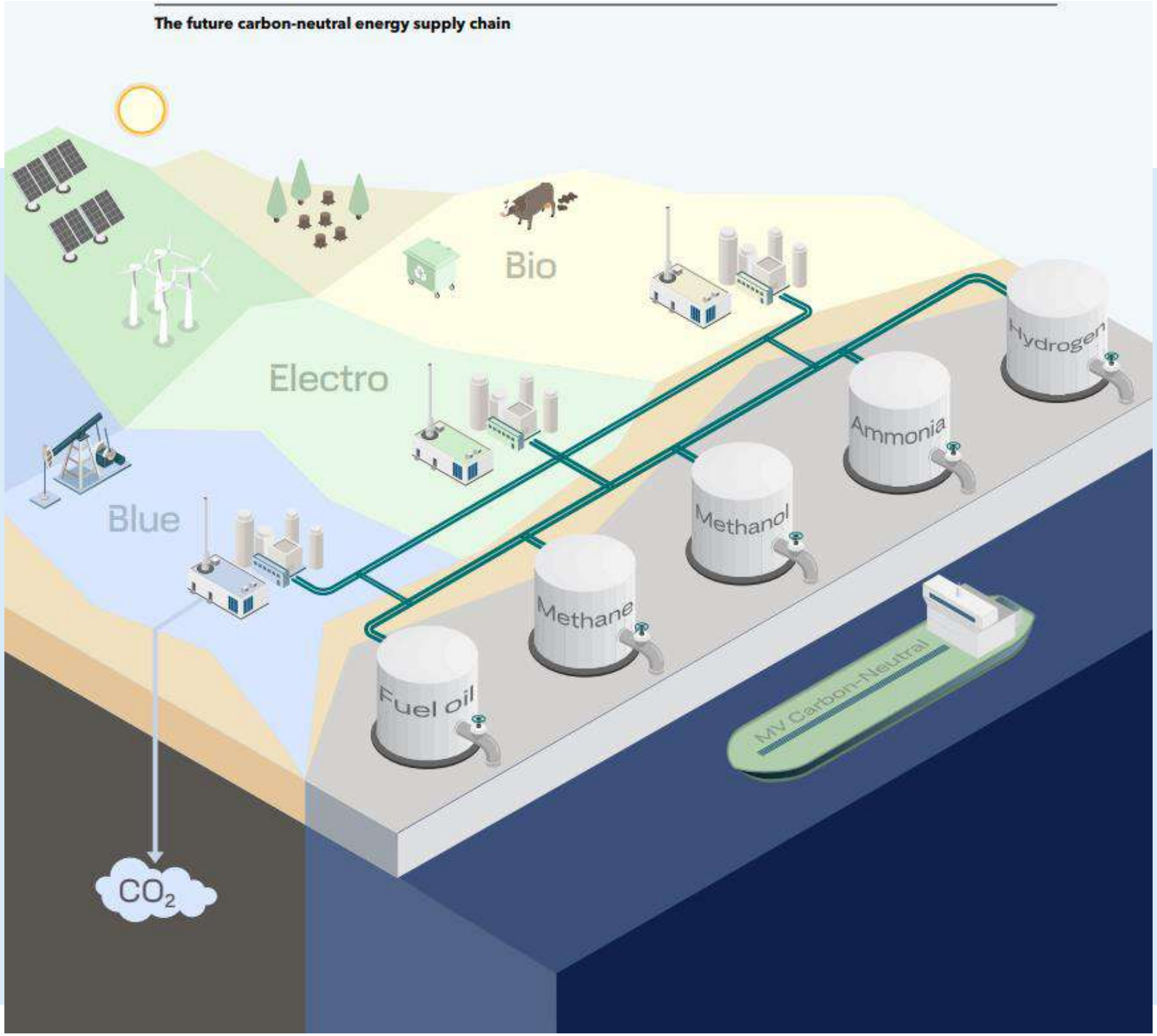
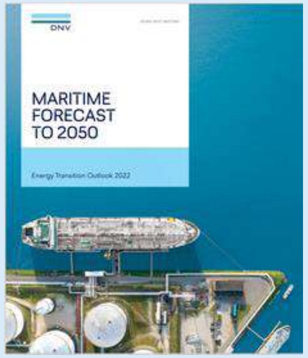
Françoise van den Brink
Port of Rotterdam Authority
Harbourmaster Division

EverLoNG SCCS 20230920

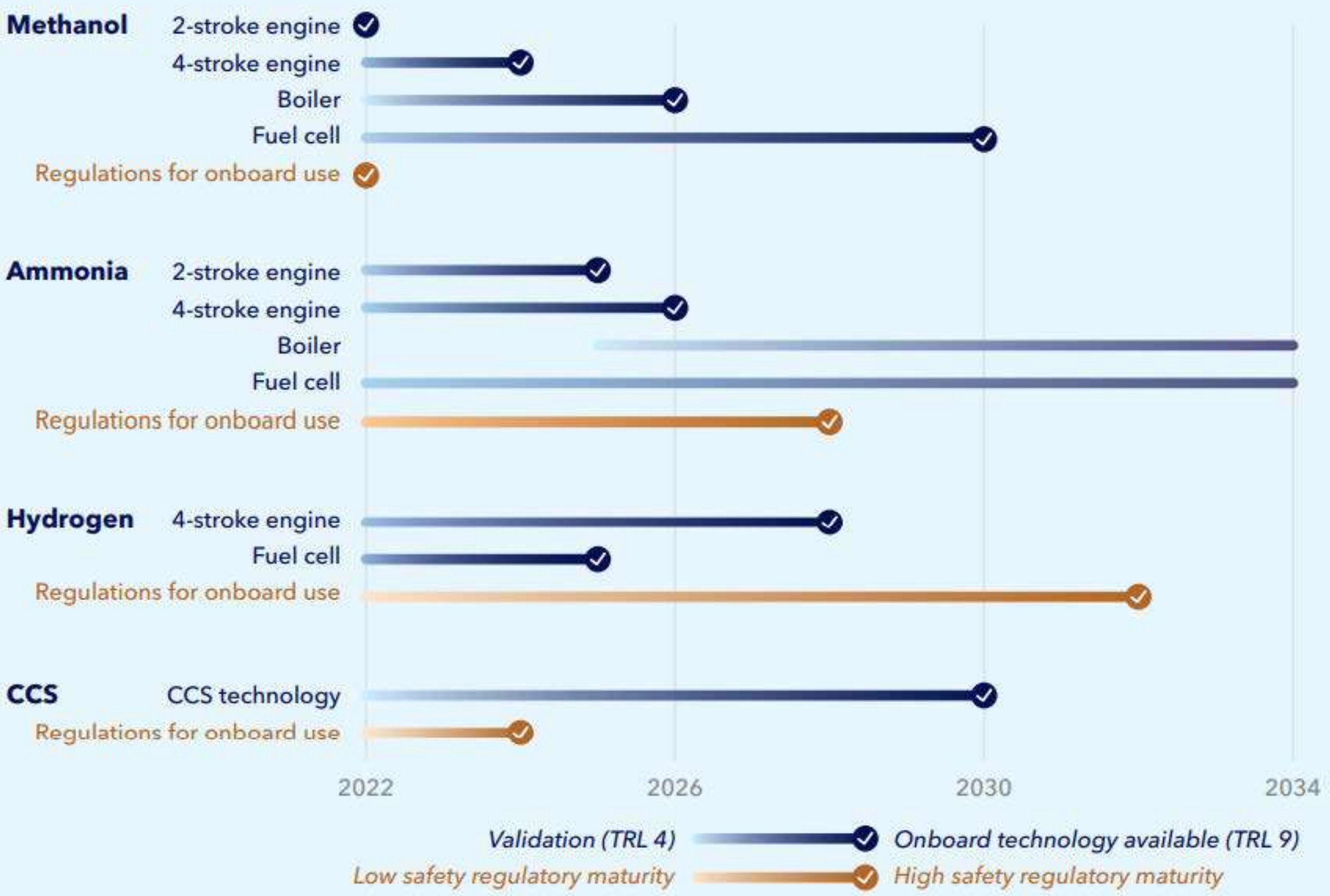
Port of Rotterdam

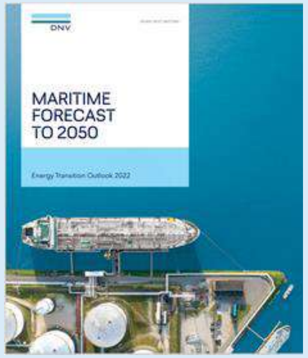




Port of Rotterdam

Estimated maturation timelines for energy converters, onboard CCS technologies, and corresponding safety regulations for onboard use

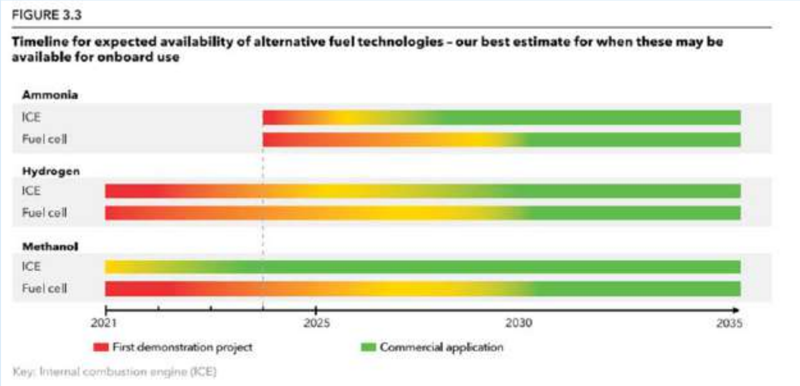




Port Readiness Level

We must be aware that "Ready" and the timeline will be different for every port:

- **Port** — Bunker port, Maintenance port, Port of call, Service Port, in-port or at Anchorage
- **Readiness** — What is your "Ready" ?
- **Level** — What is your present and future level of readiness for every new fuel?



Bunkering *or* *a call?*

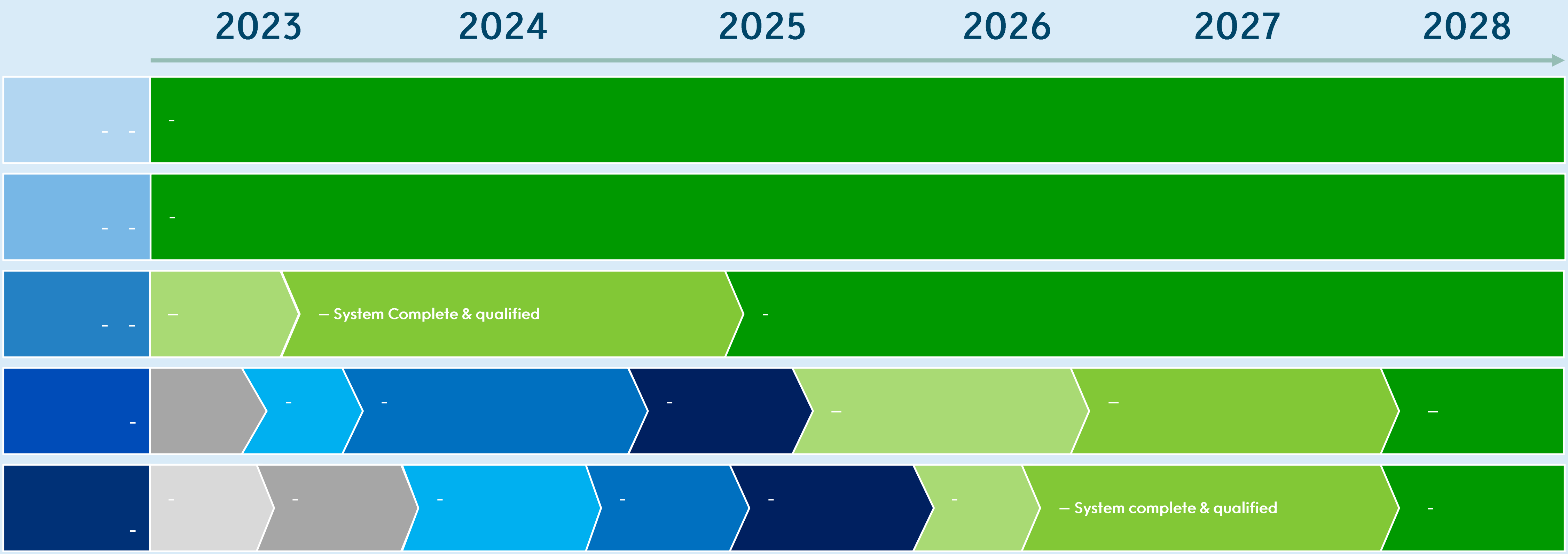
WPCAP

Port Readiness Level Indicator: Alternative Fueled Vessels

Port Readiness Level (PRL) for Alternative Fuels on vessels				
		Vessels carrying specific fuel as cargo	**Call specific fueled vessel**	**Bunkering specific fuel**
PRL 1	Research		Fuel relevance assessed	
PRL 2			Interest of port stakeholders determined	
PRL 3			Sufficient information gathered	
PRL 4	Development	Admission policy vessels with specific fuel as cargo decided, roadmap developed	Policy for call specific fueled vessel decided, roadmap developed	Policy for bunkering specific fuel decided, roadmap developed
PRL 5		Framework for vessels with specific fuel as cargo designed	Framework for call specific fueled vessel designed	Framework for bunkering and associated activities of a specific fuel designed
PRL6		Framework for vessels with specific fuel as cargo demonstrated in a protected environment	Framework for call specific fueled vessel demonstrated in a protected environment	Framework for bunkering specific fuel demonstrated in a protected environment
PRL7	Deployment	Calls of vessels with specific fuel as cargo established on a project base	Calls of specific fueled vessels established on a project base in an operating environment	Bunkering of specific fuel established on a project base in an operating environment
PRL8		System for calls of vessels with specific fuel as cargo complete and qualified	System for calls of specific fueled vessels complete and qualified	System for bunkering of specific fuel complete and qualified
PRL9		Calls of vessels with specific fuel as cargo integrated in regular port operations	Calls of specific fueled vessels integrated in regular port operations	Bunkering of specific fuel integrated in regular port operations
Specific fuels:		LNG ☐ BLG ☐ e-Methane ☐ LPG ☐ Methanol ☐ B-Methanol ☐ e-Methanol ☐ Ethanol ☐	Hydrogen (Liquid) ☐ Hydrogen (Pressurized) ☐ LOHC ☐ Ammonia (Liquid) ☐ Ammonia (Pressurized) ☐ Other........	☐ Swapping MECS ☐ Shore based Bunker facility ☐ Trucks ☐ Bunker Vessel

SETTING THE PACE & STANDARD FOR SHIP-TO-SHIP BUNKERING OF ALTERNATIVE FUELS

BUNKERING PROCEDURES **INFRASTRUCTURE PERSPECTIVE** **AVAILABILITY)**



. Level 9 Means business as

availability of

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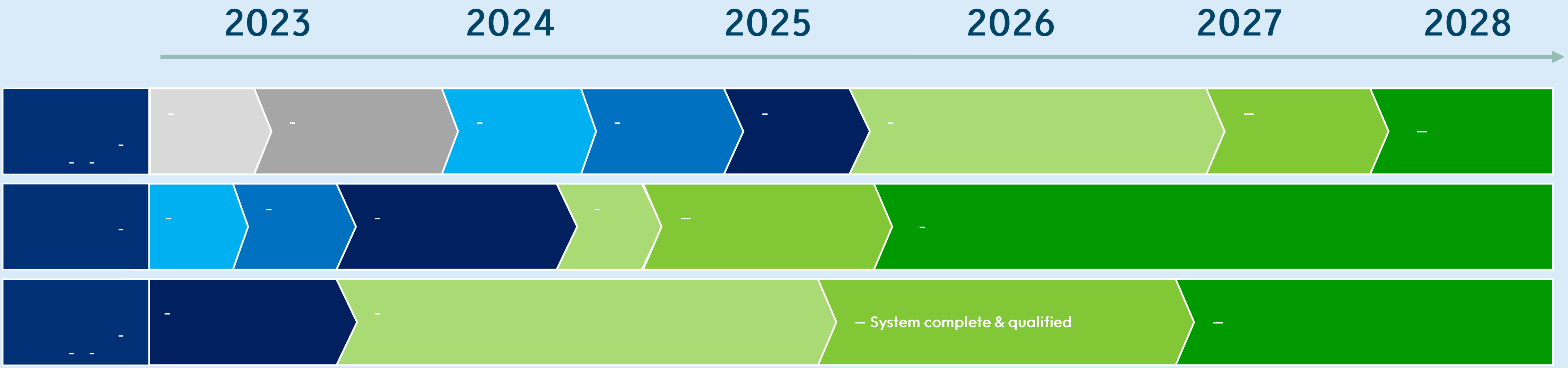
Port of Rotterdam

SETTING THE PACE & STANDARD FOR BUNKERING OF ALTERNATIVE FUELS (HYDROGEN SMALL SCALE)

BUNKERING PROCEDURES INFRASTRUCTURE PERSPECTIVE AVAILABILITY)

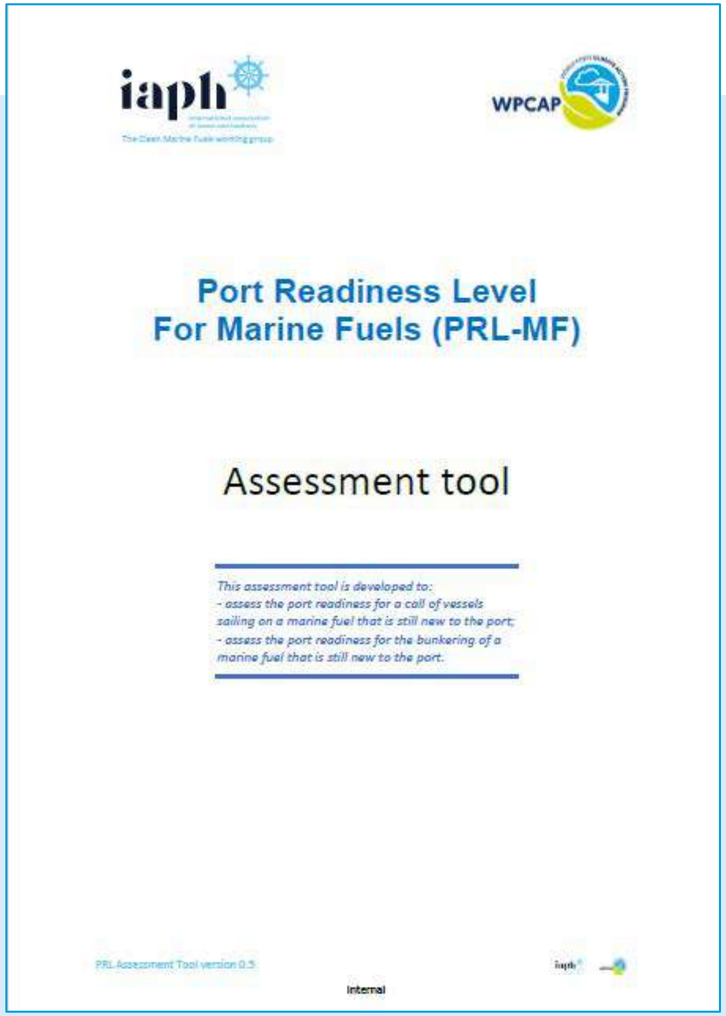


Port of Rotterdam

<table>
<tr><th>PRL: BUNKERING AF - seagoing vessels Rotterdam
Port Governance, Infrastructure, Safety</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026-2030</th><th>2031-2035</th><th>2036-2040</th><th>2041-2050</th></tr>
<tr><td>Swapping Mobile Energy Containment Systems</td><td>6</td><td>7</td><td>8</td><td colspan="5">9</td></tr>
<tr><td>Electric Energy OPS</td><td>6</td><td colspan="3">7</td><td>8</td><td colspan="3">9</td></tr>
<tr><td>Electric Energy Loading</td><td>1</td><td>2</td><td>4</td><td>5-6</td><td>7-8</td><td colspan="3">8</td></tr>
<tr><td>Hydrogen (Liquid)</td><td>2</td><td>3</td><td>4-5</td><td>6</td><td>7-8</td><td colspan="3">9</td></tr>
<tr><td>Hydrogen (Pressurized)</td><td>3</td><td>4</td><td>5-6</td><td>7</td><td>8</td><td colspan="3">9</td></tr>
<tr><td>LNG</td><td colspan="8">9</td></tr>
<tr><td>LPG</td><td>2</td><td>2</td><td>3</td><td>4-5</td><td>6-7</td><td colspan="3">8</td></tr>
<tr><td>Methanol</td><td>7</td><td>8</td><td colspan="6">9</td></tr>
<tr><td>Ammonia (Liquid)</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7-8</td><td colspan="3">9</td></tr>
<tr><td>Ammonia (Pressurized)</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8-9</td><td colspan="2">9</td></tr>
<tr><td>Nuclear</td><td>0</td><td>1</td><td>2</td><td>3</td><td colspan="4">4</td></tr>
<tr><td>Amine, for CCS with and without CO2</td><td>5</td><td>6</td><td>7</td><td>8</td><td colspan="4">9</td></tr>
</table>

1 2 3	Fuel relevance assessed Interest of port stakeholders determined Sufficient information gathered	4 5 6	Policy for bunkering specific fuel decided, roadmap developed Framework for bunkering and associated activities of a specific fuel designed Framework for bunkering specific fuel demonstrated in a protected environment	7 8 9	Bunkering of specific fuel established on a project base in an operating environment System for bunkering of specific fuel complete and qualified Bunkering of specific fuel integrated in regular port operations

PRL Assessment Tool Checklist

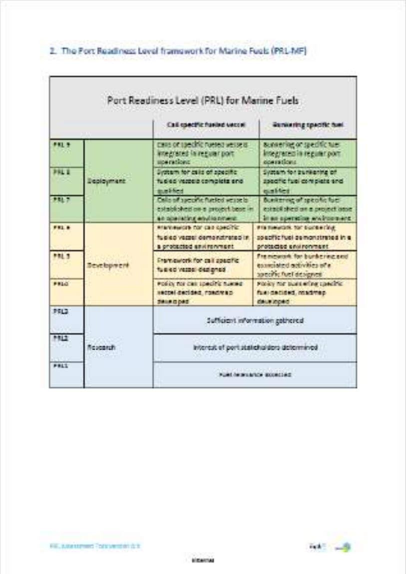

iaph
The Clean Marine Fuels working group
WPCAP

Port Readiness Level
For Marine Fuels (PRL-MF)

Assessment tool

This assessment tool is developed to:
- assess the port readiness for a call of vessels sailing on a marine fuel that is still new to the port;
- assess the port readiness for the bunkering of a marine fuel that is still new to the port.

PRL Assessment Tool version 0.5
Internal


2. The Port Readiness Level framework for Marine Fuels (PRL-MF)

Port Readiness Level (PRL) for Marine Fuels			
		Call specific fueled vessel	Bunkering specific fuel
PRL 9	Deployment	Calls of specific fueled vessels integrated in regular port operations	Bunkering of specific fuel integrated in regular port operations
PRL 8		System for calls of specific fueled vessels complete and qualified	System for bunkering of specific fuel complete and qualified
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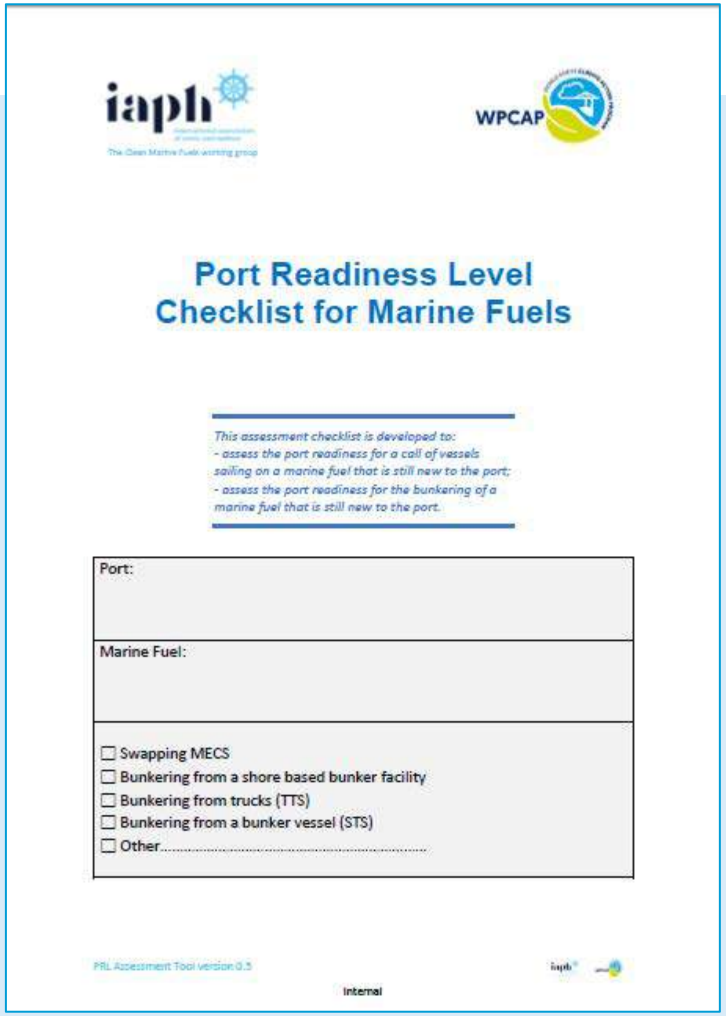
PRL4		Policy for call specific fueled vessel decided, roadmap developed	Policy for bunkering specific fuel decided, roadmap developed
PRL3	Research	Sufficient information gathered	
PRL2		Interest of port stakeholders determined	
PRL1		Fuel relevance assessed	

Internal


iaph
The Clean Marine Fuels working group
WPCAP

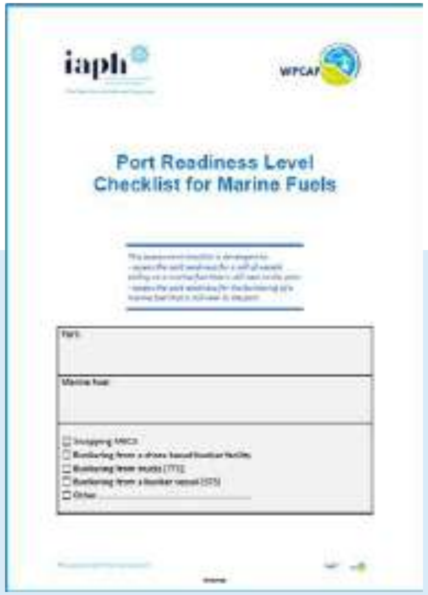
Port Readiness Level
Checklist for Marine Fuels

This assessment checklist is developed to:
- assess the port readiness for a call of vessels sailing on a marine fuel that is still new to the port;
- assess the port readiness for the bunkering of a marine fuel that is still new to the port.

Port:
Marine Fuel:
☐ Swapping MECS ☐ Bunkering from a shore based bunker facility ☐ Bunkering from trucks (TTS) ☐ Bunkering from a bunker vessel (STS) ☐ Other…………………………………………

PRL Assessment Tool version 0.5
Internal


Contents



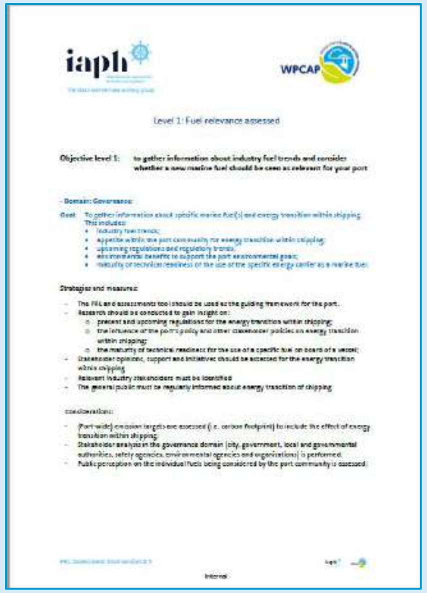
For every new fuel or energy carrier:

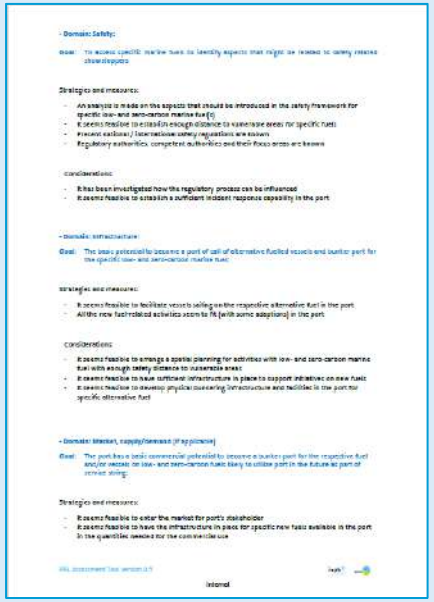
Domains:

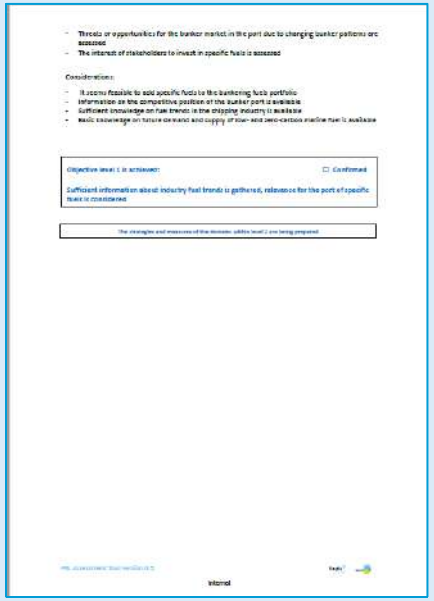
- Governance
- Safety
- Infrastructure
- Market and supply/demand

For every domain:

- Goal
- Strategies and measures
- Considerations







Port of Rotterdam

Port Readiness Level (PRL) for Marine Fuels			
		Call specific fueled vessel	**Bunkering specific fuel**
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PRL3	Research	Sufficient information gathered	
PRL2		Interest of port stakeholders determined	
PRL1		Fuel relevance assessed	

Project MAGPIE Demo Ammonia Bunkering HAZID Report
March 2023

For the demo:

Unmitigated risks:

1 : Extreme
After recommendations in the mitigated risk only 2 High risk remaining

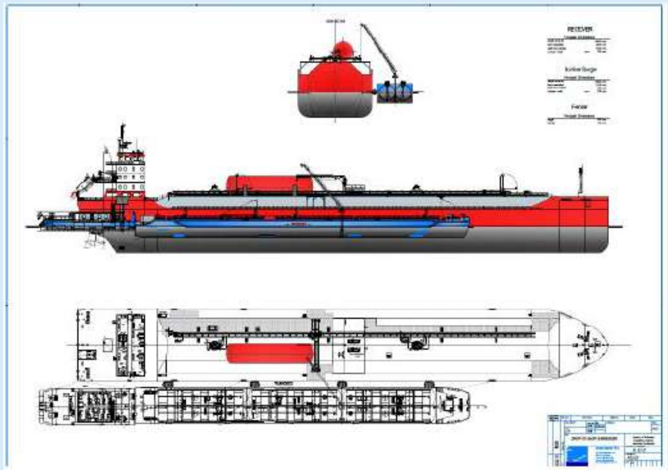
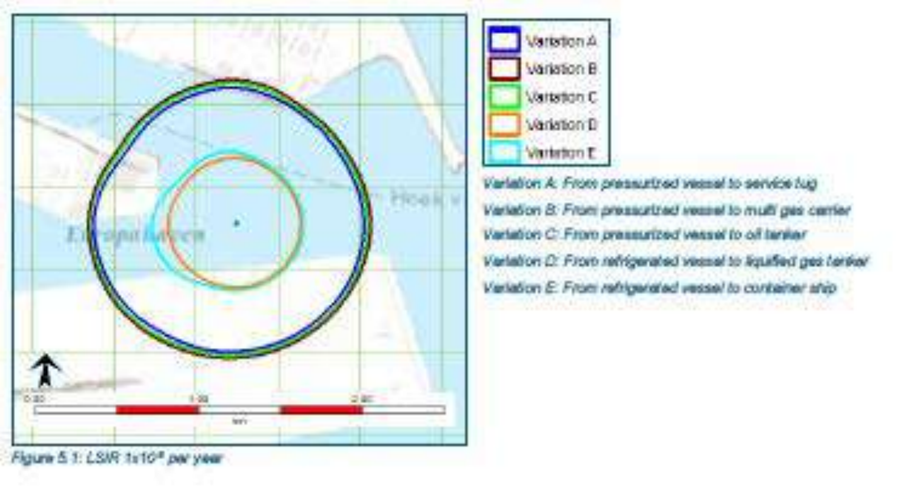


Figure 2: Bunker Barge and Receiver Vessel General Arrangement

Table 4: HAZID Risk Ranking Summary

Node #	Key system level HAZID nodes	Unmitigated Risk Ranking				Mitigated Risk Ranking			
		L	M	H	E	L	M	H	E
1	Shore to Ship Transfer	3	4			4	3	-	-
2	Voyage from Terminal to Bunkering Pier	-	-	-	-	-	-	-	-
3	Bunkering Phase 1 - Berthing Preparation	3	1	-	-	4	-	-	-
4	Bunkering Phase 2 - Mooring & Coming-along-side	-	7	-	-	4	3	-	-
5	Bunkering Phase 3 - Pre-Meeting	-	2		-	1	1	-	-
6	Bunkering Phase 4 - Hose Connection	1	2	1	-	3	1	-	-
7	Bunkering Phase 5 - Hose Purging and Leak Testing	-		2	-	2	-	-	-
8	Bunkering Phase 6 - Measurement	-	-	-	-	-	-	-	-
9	Bunkering Phase 7 - ESD system functional test at ambient temperature (hot condition)	-	-	-	-	-	-	-	-
10	Bunkering Phase 8 - Line cooldown in case of ammonia bunker in refrigerated state	-	-	-	-	-	-	-	-
11	Bunkering Phase 9 - ESD system function test at low temperature	-	-	-	-	-	-	-	-
12	Bunkering Phase 10 - Start Bunker Transfer-	-	5	5		2	8	-	-
13	Bunkering Phase 11 - Steady State Bunker Transfer	-	-	24		4	20	-	-
14	Bunkering Phase 12 - Bunker Transfer Completion	-	-	-	-	-	-	-	-
15	Bunkering Phase 13 - Drain and Liquid Purging	-	-	-	1		1	-	-
16	Bunkering Phase 14 - Measurement	-	-	-	-	-	-	-	-
17	Bunkering Phase 15 - Vapor Purging	-	-	-	-	-	-	-	-
18	Bunkering Phase 16 - Hose Disconnection	-	5	-		5	-	-	-
19	Bunkering Phase 17 - Meeting After Completion of Bunker Transfer	-	-	-	-	-	-	-	-
20	Bunkering Phase 18 - Vessel Departure	-	1	-	-	-	1	-	-
21	Demo - Vessel General Arrangements	-	-	-	-	-	-	-	-
22	Demo - Manifold and Piping Arrangement	-	-	-	-	-	-	-	-
23	Demo - Safety Systems	-	1	1	-	1	1	-	-
24	Demo - Operational Safety	-	-	-	-	-	-	-	-
25	Nearby vessels at the port	-	2	2	-	-	2	2	-
	Total	7	30	35	1	30	41	2	0

(1): L=Low, M= Medium, H = High and E = Extreme




REPORT

Location-specific individual risk contours for the bunkering of ammonia

Client: TNO Innovation for life

Reference: BH4271BRP001F01
Status: Final/01
Date: 20 September 2022

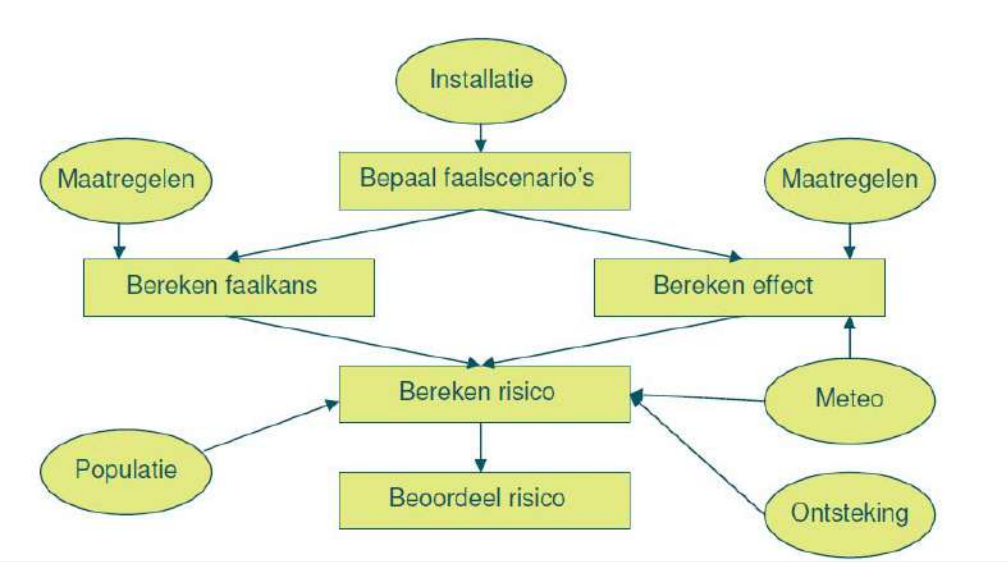
Royal HaskoningDHV
Enhancing Society Together

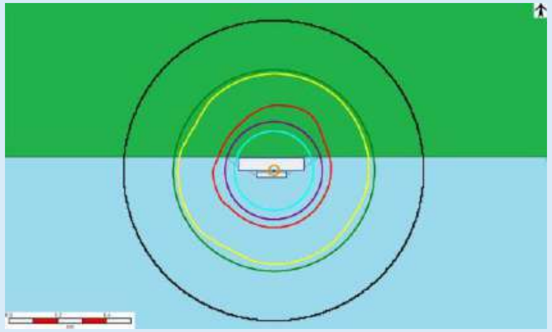

PEUTZ

External safety in relation to the bunkering of ammonia

Quantitative Risk Analysis (QRA)

EV





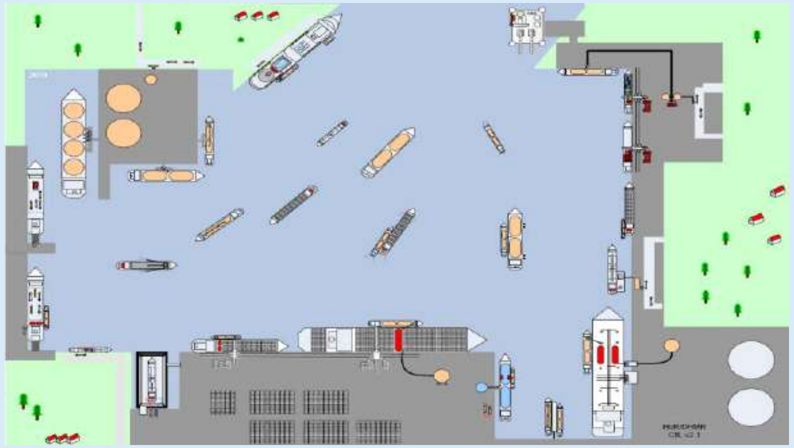
Tabel 0-1: Externe veiligheidsafstanden (afstand tot 10-6 per jaar PR-contour)

Bunkerscenario	Laag debiet (400 m³/u)[1]	Hoog debiet (1000 m³/u)[1]
	PR Afstand (m)	PR Afstand (m)
LNG (-146 °C)	321	- [2]
LNG (-159 °C)	231	344
Methanol	68	98
Ammoniak (gekoeld)	255	427
Ammoniak (onder druk)	793	973
Waterstof (vloeibaar)	214	273
Waterstof (gasvormig) – (3 t/u)	87	- [2]
Waterstof (gasvormig) – 700 bar (60 g/s)	- [2]	- [2]
Waterstof (gasvormig) – 1000 bar (60 g/s)	- [2]	- [2]

[1] Bunkerdebieten gelden voor de vloeibare brandstoffen. Het debiet voor de gasvormige brandstoffen is weergegeven in de scenarionaam
[2] Uitleg bij de tabel is te vinden onder Tabel 7-1 in paragraaf 7.1

Scenario	Description	External safety distance [m]*	
		The Netherlands	Germany
1a	Swapping containers with pressurized hydrogen (300 bar) at container terminals (start-up case) – no storage in stack	39	182
1b	Swapping containers with pressurized hydrogen (500 bar) at container terminals (future case) – storage in stack	129	230
2a	Truck-to-ship bunkering of gaseous hydrogen via hose to fixed tanks on board (start-up case)	37	96
2b	Bunker station to ship, bunkering of gaseous hydrogen via hose to fixed tanks on board (future case)	106	96
3	Truck-to-ship bunkering of liquid hydrogen	82	70
4a	Truck-to-ship bunkering of refrigerated liquid ammonia	175	205
4b	Truck-to-ship bunkering of pressurized liquid ammonia	543	395
5	Truck-to-ship bunkering of methanol	79	67

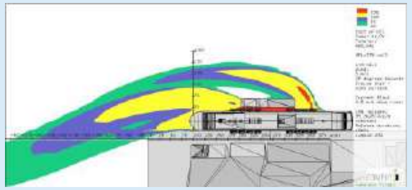
* Reference is made to Table 4 for an explanation from where these distances should be measured.



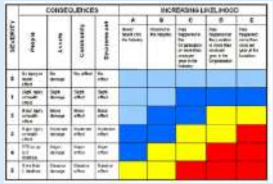

Wilhelminakade
Otto Reuchlinweg

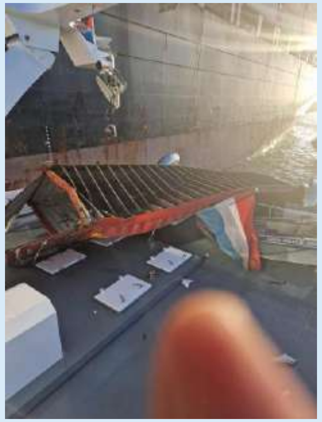

Port of Rotterdam

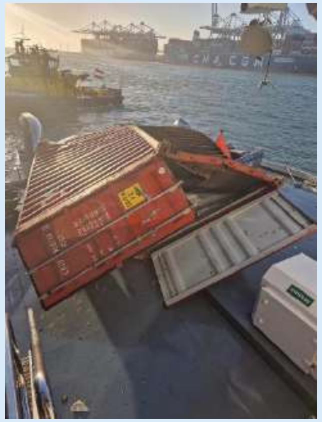
SIMOPS

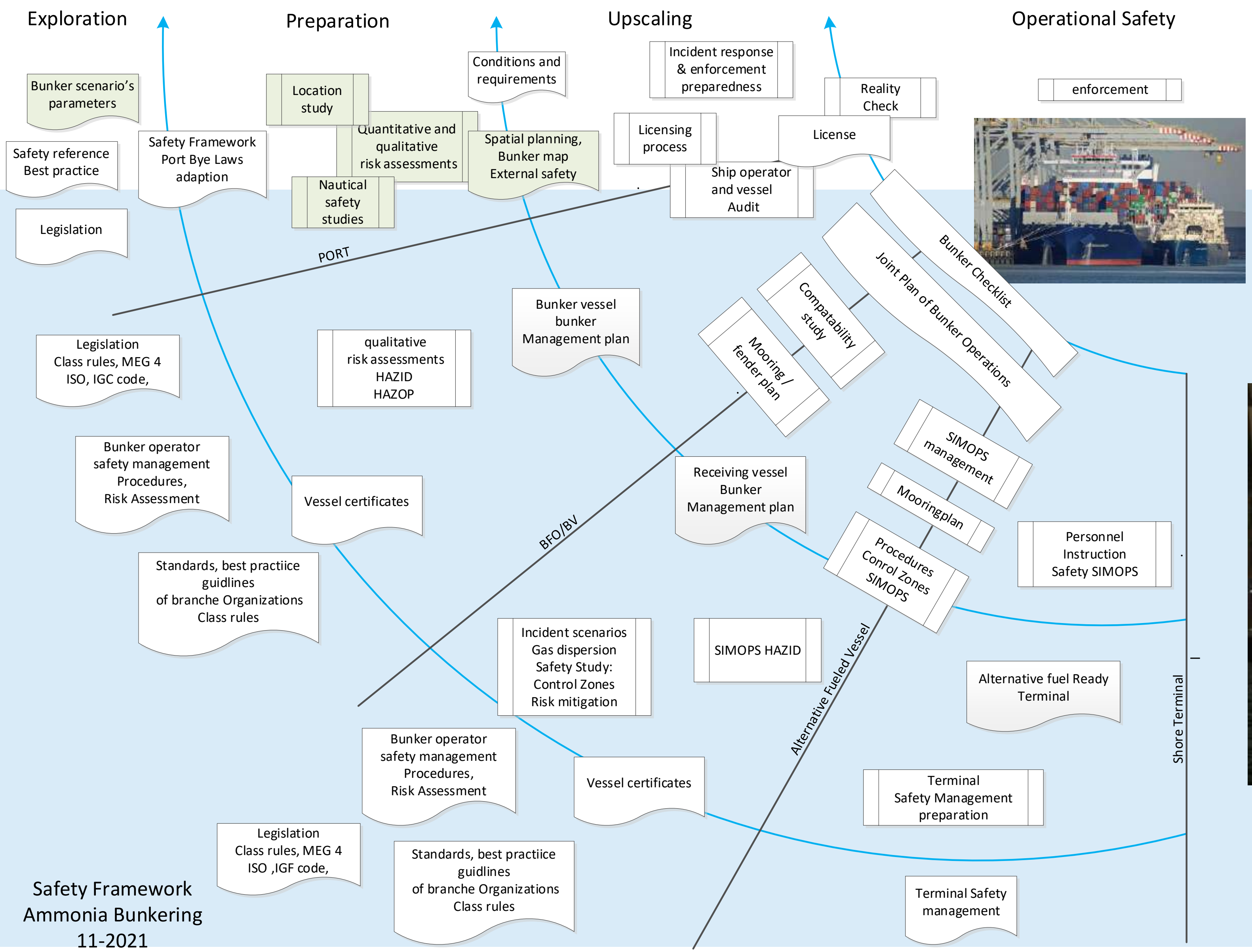


Gas dispersion study or BASIL
→









Safety Framework
Ammonia Bunkering
11-2021

QUESTIONS?

Moss Maritime & LCO_2

Our history

A brief summary

Moss Maritime has its roots from the former Moss Rosenberg Shipyard in the city of Moss.

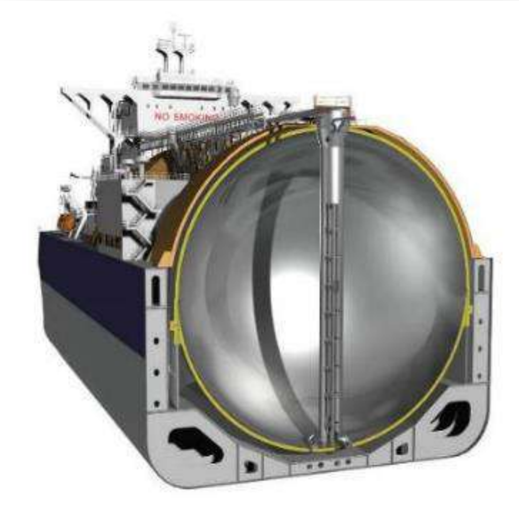
After the close-down of the shipyard in the 1980s the company has had many shapes and forms until we were included into the Saipem umbrella in 2001.

SAIPEM

The company name is closely associated with a trademark on one of the most recognized products in the LNG industry;

The Moss™ LNG Carrier

- robust and high performing technology
- 145 ships built



Moss CS™- series of drilling semis

Some of the largest and most advanced semi-submersible drilling platforms are designed & engineered by Moss Maritime

The moss CS-series of semi-submersible catamaran platforms is one of the world's most field proven and successful platforms designs for harsh environment.

- harsh environment units with better operability than the competition
- 30 units built

mossmaritime

Moss Maritime today : 4 business lines


Clean Energy Solutions

ECO Drilling Floaters


Ocean Technology & Infrastructure


Gas Technologies

MOSS semi-submersible platform designs

Key Features

- ✓ Proven and robust design
- ✓ Unmatched track record in harsh environments
- ✓ Excellent operability confirmed by operators

From one-of-a kind projects to the world's first pure dynamic positioning drilling semi-submersible, Moss Maritime has brought creative solutions to offshore platforms built for the O&G industry

Moss CS *Eco-X*™

- ✓ Latest/future Rig Technology
- ✓ Minimum manning
- ✓ Plug-in hybrid
- ✓ Green Fuels

mossmaritime

Moss semi-submersible platforms

Reference list

- Bingo class (5), (2 of them on the NCS)
- Ocean Yatzy
- West Alpha
- Veslefrikk B
- *Scarabeo 5**
- Petrobras 26
- Noble Clyde Boudreaux
- SeaLaunch
- Moss CS50 West Venture
- Moss CS30 Stena Don
- Moss CS50 SBX-1
- Moss CS50 MkII West Phoenix
- Moss CS50 MkII West Eminence
- *Moss CS50 MkII Scarabeo 8**
- Moss CS50 MkII West Leo
- Moss CS50 MkII West Pegasus
- Moss CS50 ARCTIC Polyarnaya Zvezda (Gazflot)
- Moss CS50 ARCTIC Severnoye Siyaniye (Gazflot)
- Moss CS60 West Mira (HSHI
- Moss CS60 Transocean Norge (Jurong)
- Moss CS60 E West Bollsta (HHI)
- Moss CS60 E Ocean GreatWhite (HHI)
- Moss CS60 E Deepsea Nordkapp (SHI)
- Moss CS60Eco MW (KFELS), 2 conf. + 2 options






mossmaritime

* Owned & operated by SAIPEM

Gas Technology

50 years of liquefied gas competences

Floating LNG terminals

LNG FSRU/FSU, FLNG

- Pioneering design & engineering of floating LNG terminals
  - *First FSRU conversion 2008 - Golar Spirit (Brazil/Petrobras)*
  - *First FLNG conversion 2018 - Golar Hilli (Cameroon/Perenco)*
  - *Moss designs and patents*
  - *25+ FSRU/FSU/FLNG projects completed so far*
- Multi-discipline engineering competence; clients: Shipowners, shipyards, charterers
  - concept → basic/FEED → detail engineering
  - all typical disciplines covered
    - ✓ *Process*
    - ✓ *Utility & marine systems*
    - ✓ *EIT*
    - ✓ *Safety*
    - ✓ *Piping & layout*
    - ✓ *Naval/mooring & hydrodynamics*
    - ✓ *Structures*
    - ✓ *Project management*


FSU Malta (Bumi Armada)


FLNG Cameroon (Golar LNG)


El Salvador FSRU (BW LNG)


FSRU Indonesia (Golar LNG)


FSRU Toscana (OLT)


FSRU Golar Spirit

mossmaritime

Floating LNG terminals

Moss LNG regasification systems

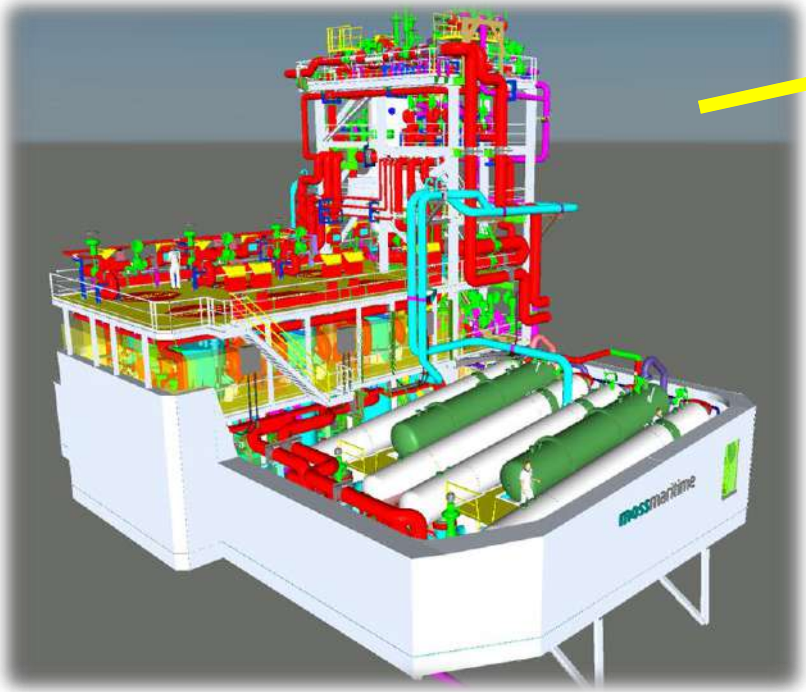
- First system (3 MMTPA) designed & built 2008
- Builder: Keppel Shipyard, Singapore
- Operated by Golar LNG in Brazil for Petrobras; 2008-2018

mossmaritime

Floating LNG terminals

Moss LNG regasification systems

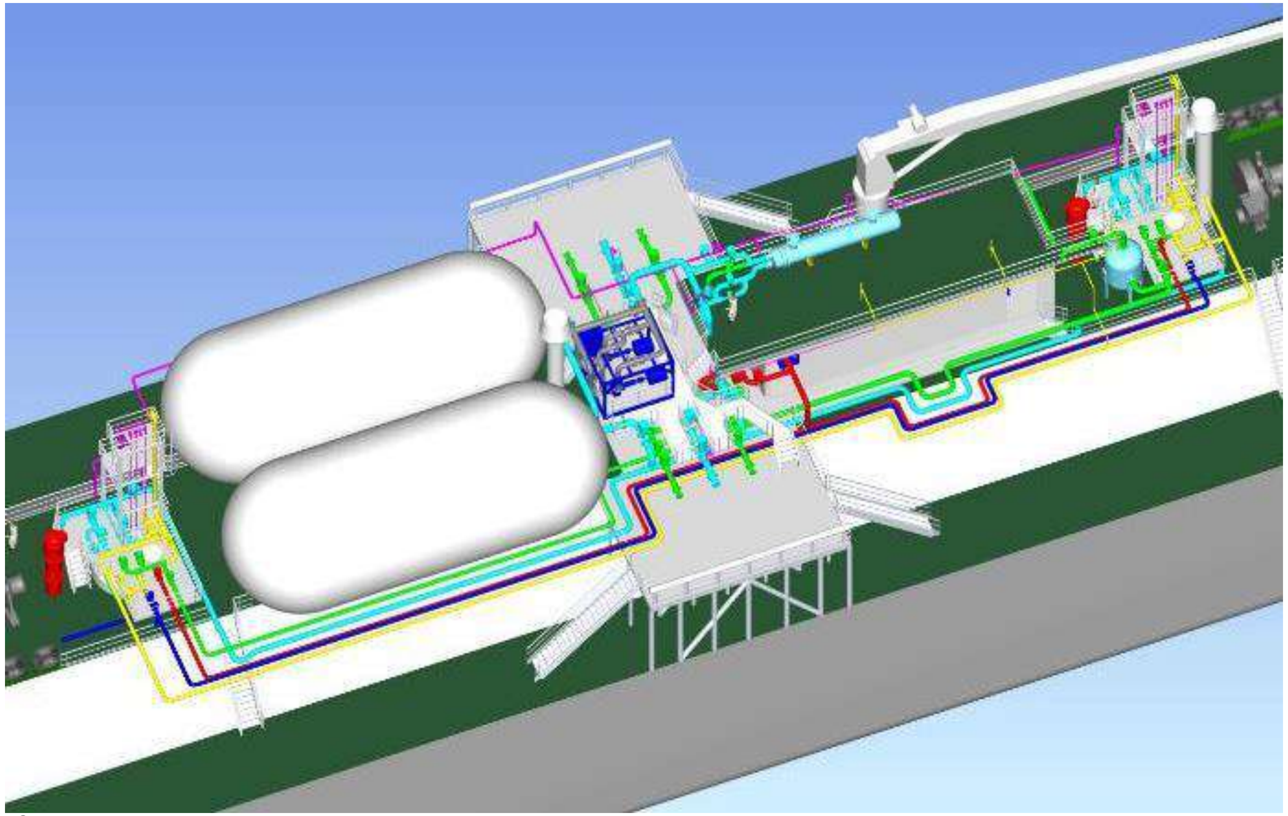
- New system (7 MMTPA) under construction
- Builder: Seatrium, Singapore
- Open & closed loop regas capacity 7 MMTPA
- To be operated by Gaslog in Greece from 1Q2024



LCO2 references

Northern Lights project

- 2019: FEED for cargo handling system for 7 500 m^3 **medium pressure** LCO2/LPG ships
- Experience from LNG & LPG carriers being key to understand and design similar systems for LCO2



mossmaritime

ACCSESS

- 50.000 tonnes LCO2 carrier
- LOA=227.0m, B=40.7m, T=11.6m
- LNG or NH3 as fuel

Read more:
www.projectaccsess.eu

mossmaritime | SAIPEM

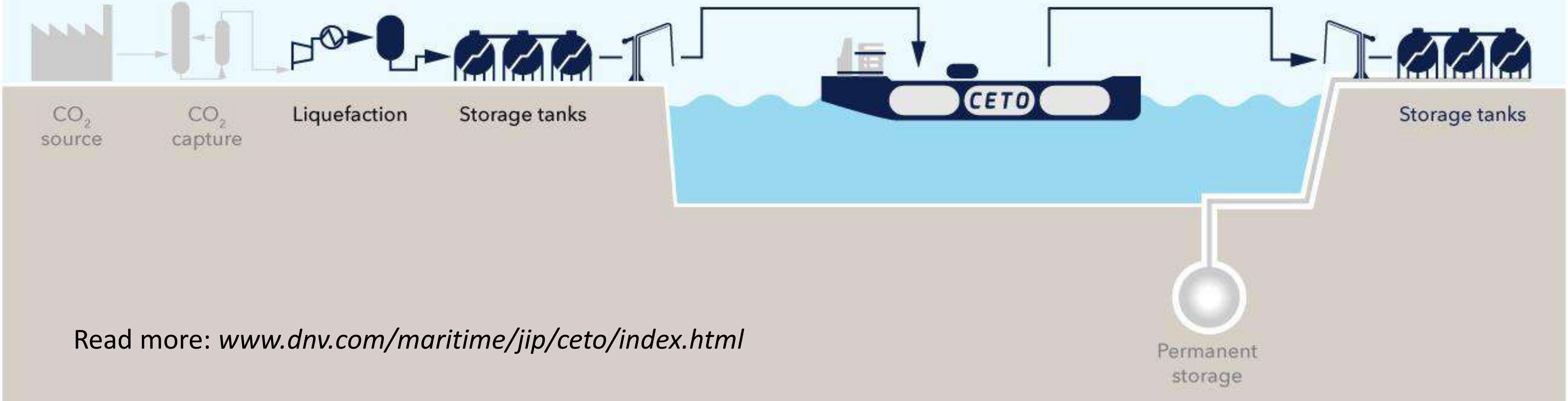
Providing access to cost-efficient, replicable, safe and flexible CCUS

CETO

CO_2 Efficient Transport via Ocean

Technology Qualification low-pressure CO_2 ship transport

- JIP managed by DNV on behalf of energy majors
- Goal: Reduce risks and uncertainties for LP CO_2 ship transport chain
- Moss scope: Basic design of 30 000 m^3 LCO2 carrier



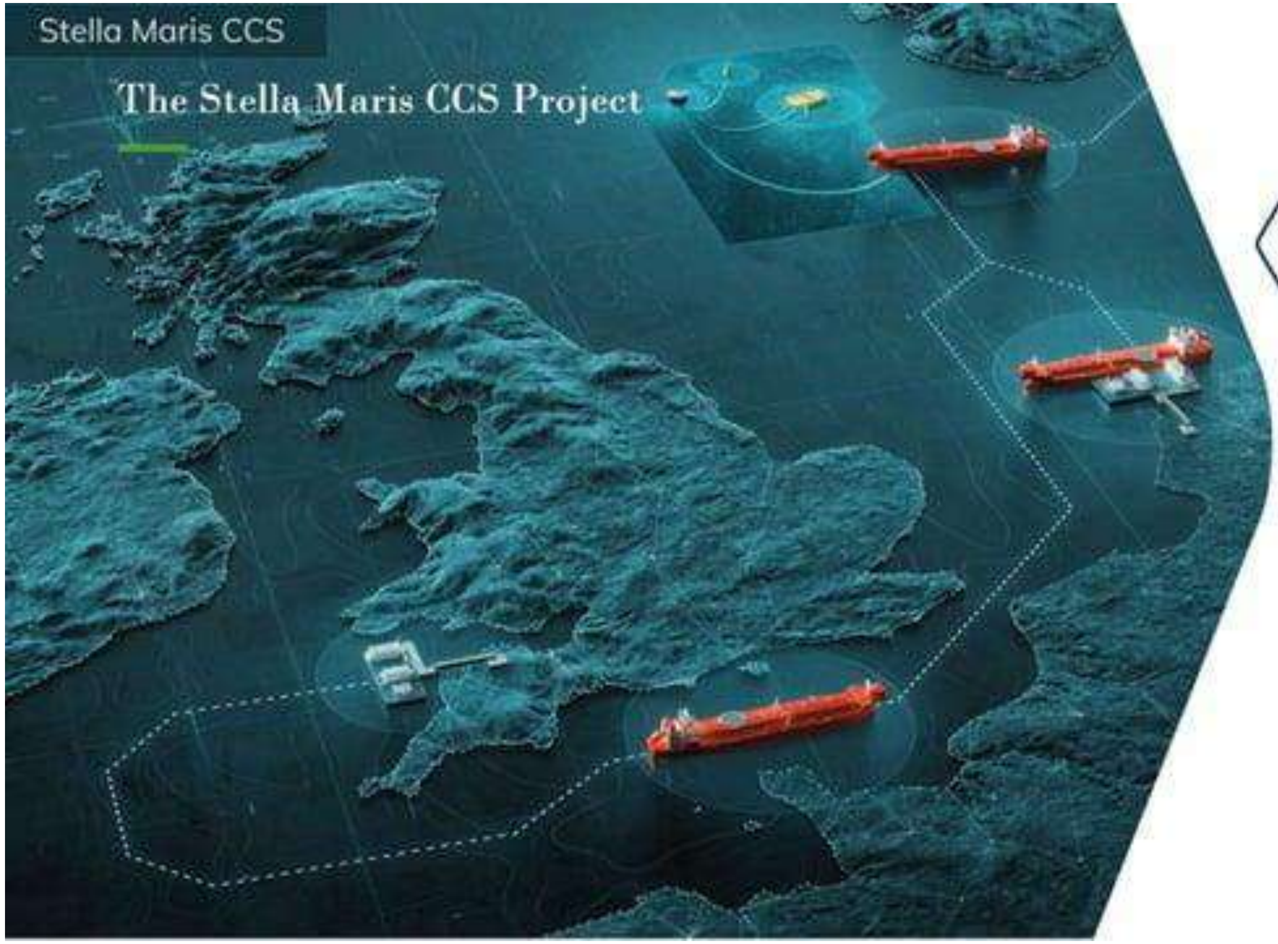
Read more: *www.dnv.com/maritime/jip/ceto/index.html*

Stella Maris CCS

By Altera Infrastructure. Transport & offshore direct LCO2 injection Storage

Moss scope:

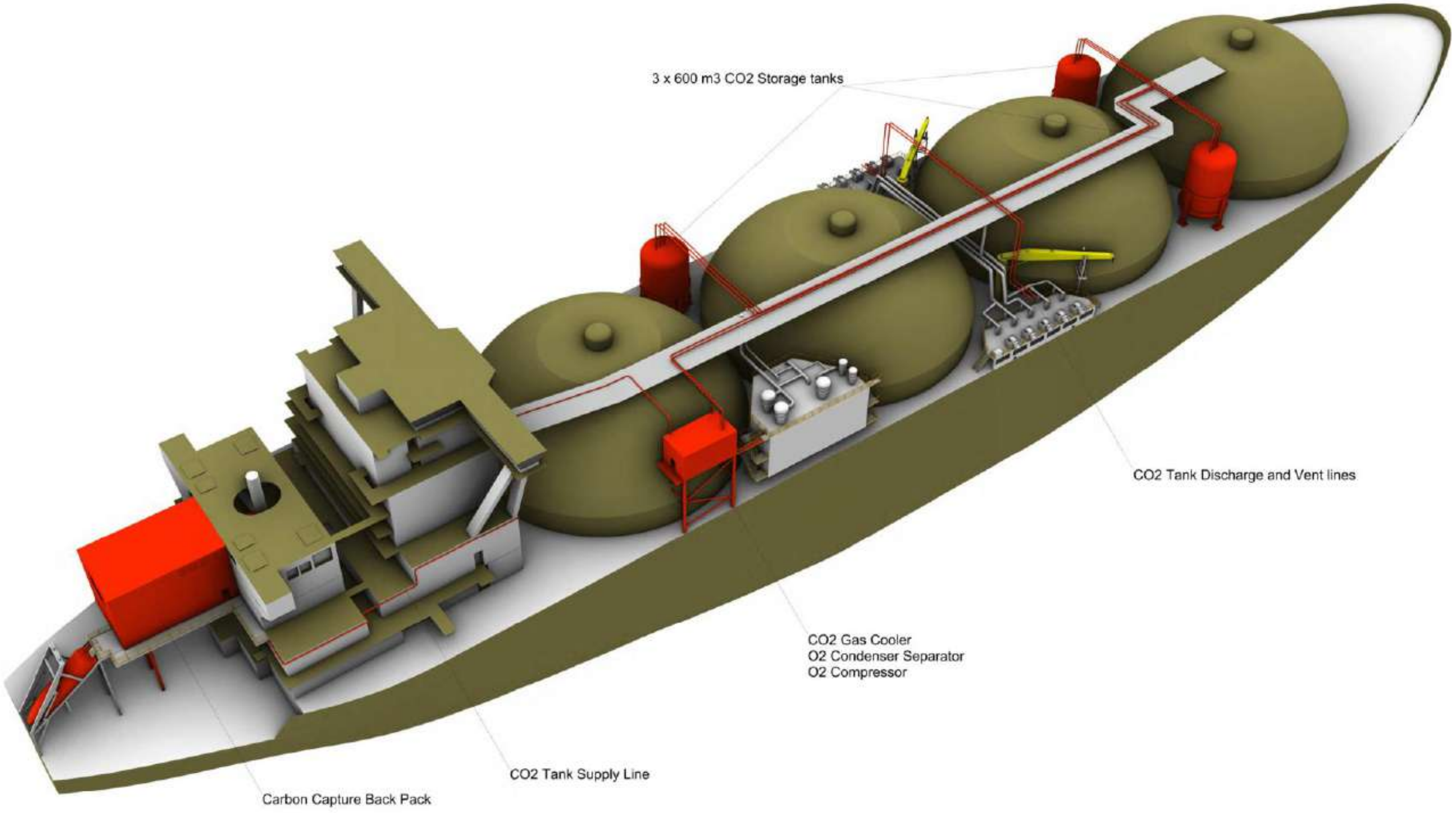
- Overall process flow simulations (ship transport to injection) incl. dynamic process simulations
- Design of cargo handling system for LCO_2 carriers
- Design of CO_2 conditioning & injection process system for the Floating Injection Unit (FIU)
- Design of the floating injection unit
- Feasibility study, concept selection study, and concept definition study completed



altera

Onboard carbon capture

- Moss cooperation with carbon capture designer Ionada
- A joint feasibility study was performed for an energy major (capture of CO_2 from steam boiler exhaust of LNGC)
- Study soon to be commenced for major LNGC owner



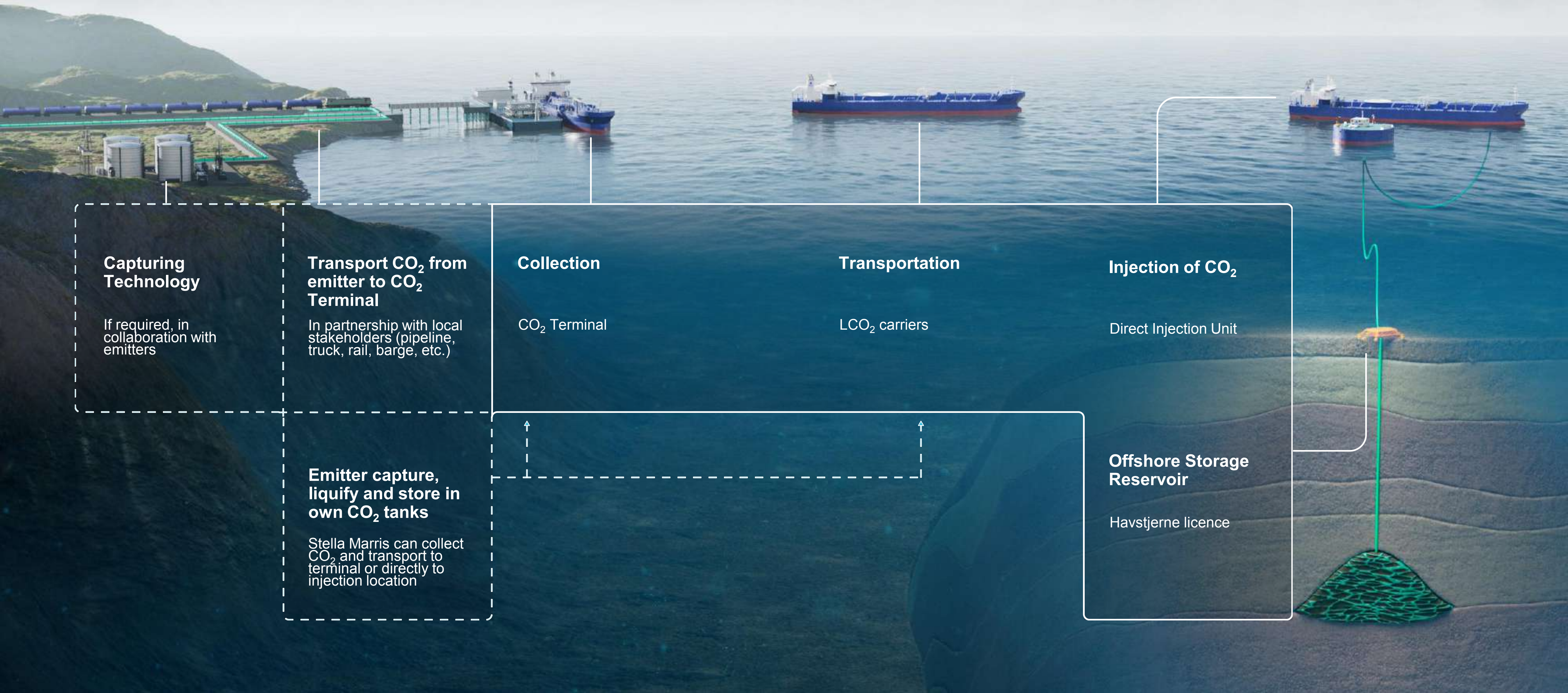
Thank you!

mossmaritime

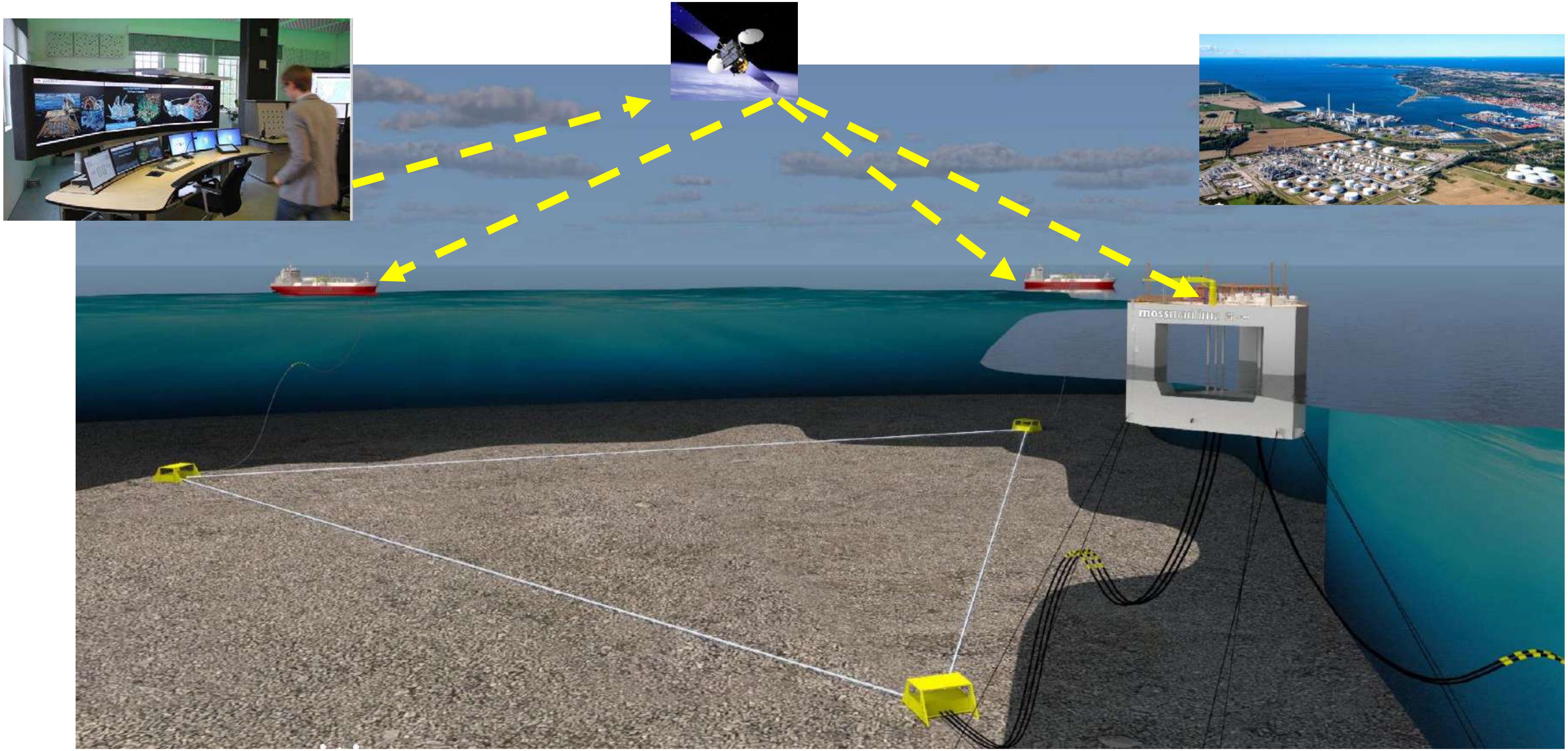
Stella Maris CCS

Stella Maris – from terminal to storage

A single Stella Maris project will have the capacity to store 10 Mt CO_2/year



Stella Maris CCS – Remote Operation



On-board CCS pilot study – June 2023- June 2024

Green Shipping Programme

Develop an onboard CCS retrofit case based on E-Shuttle, but scalable for the Altera Stella Maris CO_2 carriers

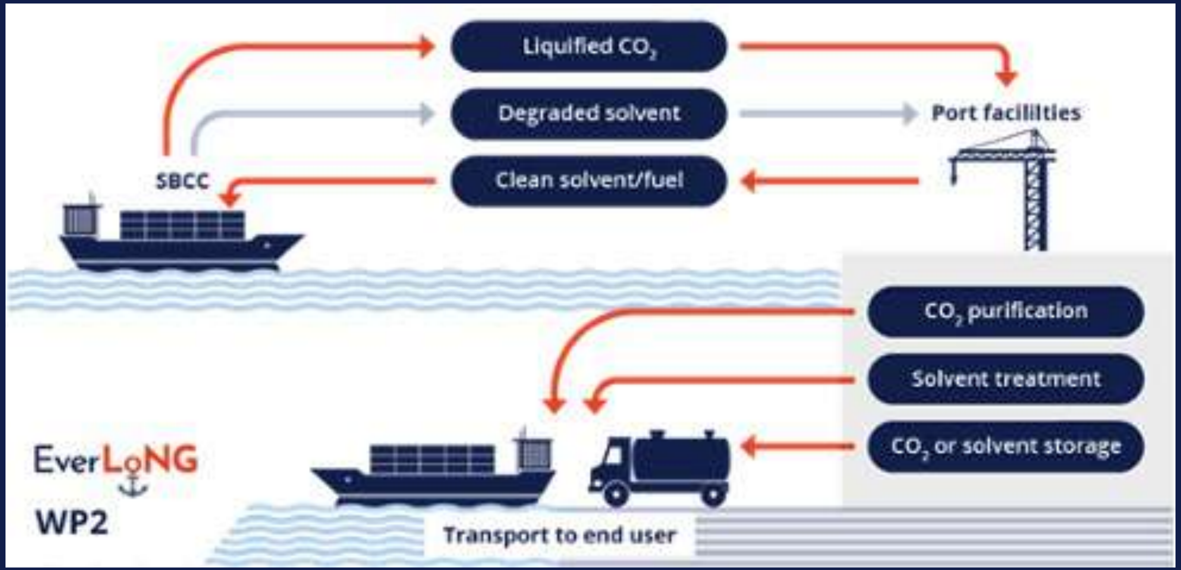
altera INFRASTRUCTURE · equinor · The Stella Maris CCS Project · Miljø-direktoratet · DNV·GL · Sjøfartsdirektoratet Norwegian Maritime Authority · WÄRTSILÄ · ionada · WE Tech CREATING SAVINGS · NorSeaGroup · Topeka · DNB · SKULD

Industry partners in the study representing the full value chain

Operations, Chartering	Rules, Regs	Technology Suppliers	Engineering	Downstream CO2 Logistics	Finance/ Insurance
altera INFRASTRUCTURE	DNV·GL	ionada	BREVIK engineering	The Stella Maris CCS Project	DNB
equinor	Miljø-direktoratet	WE Tech CREATING SAVINGS		NorSeaGroup	SKULD
	Sjøfartsdirektoratet Norwegian Maritime Authority	WÄRTSILÄ		Topeka	

Outcome: business case with a Techno-Economic evaluation of a potential pilot installation.

Interactive discussion



What regulatory hurdles do you see for realising Carbon Capture as a solution for the decarbonisation of shipping?

26 responses

Don't know

no clea view on what CO_2 is waste or product

define the status of CO_2 (waste, product ?)

Which regulation is applicable at what point in the infrastructure chain

cross-bondary transport of CO_2 must become legal. Today the London Protocol dictates this, and bi-lateral agreements are required between nations in order to open up for this. Since shipping is intern

Transferring CO_2 between ountries.

CCS fits within regulation, postponi g decisions is yhe largest threat

Handling facilities along trading route and unified requirements to CO_2 captured

Certification of captured/stored CO_2, ownership ow CO_2

What regulatory hurdles do you see for realising Carbon Capture as a solution for the decarbonisation of shipping?

26 responses

CO2 infrastructure

How is CO2 considered, waste, ...?

Bringing Port facilities and capturing onboard CO2

Onboard Carbon Capture must be given the necessary credit in the various decarbonization regulations facing the shipping industry. This includes IMO which regulates world wide shipping, but also the E

Accounting between countries

Planning and regulatory timelines.

Standarisation is important

CC(U)S not yet defined as a decarbonisation measure by the IMO.

Carbon accounting and emission reduction validation

What regulatory hurdles do you see for realising Carbon Capture as a solution for the decarbonisation of shipping?

26 responses

Cross border transportation of CO_2 (waste)

CO_2 cspture is within Fit55

integrating modular (ISO) tank regulation (IMDG) with IGC

how to account for emmision (reduction) under ETS directive

The availability of large quantities

The ability to retrofit not only the capture but also the liquefaction and storage. facilities.Perhaps other

Yes

no

What limitations / restrictions are there to the carriage of large quantities of CO_2 onboard?

20 responses

Space limitations onboard

Space

Cargo tank size.

A new media for the crew to handle. New safety risks.

Look into risks and mitigation

Availibilty of CO2 handling plants, either re-use as feedstock or storage

there should not be as long as it is compliant with the IGC

Space and weight footprint

The limitations are set by where you can discharge the CO2, This transcribes to an issue of chemical composition and unified requirements thereto

What limitations / restrictions are there to the carriage of large quantities of CO_2 onboard?

20 responses

Crew training

restriction in the text ship stability

Impact on crew

Volume and weight of captured CO2 means less cargo can be transported

Safety aspects

CO2 can also be captured using solid bed absorbant

Transporting CO2 is just like a LNG carrier, that's not the challenge.

Simply the impact on the ability to maximise carrying capacity

Space and weight are mainly important for retrofits, less so for newbuilds

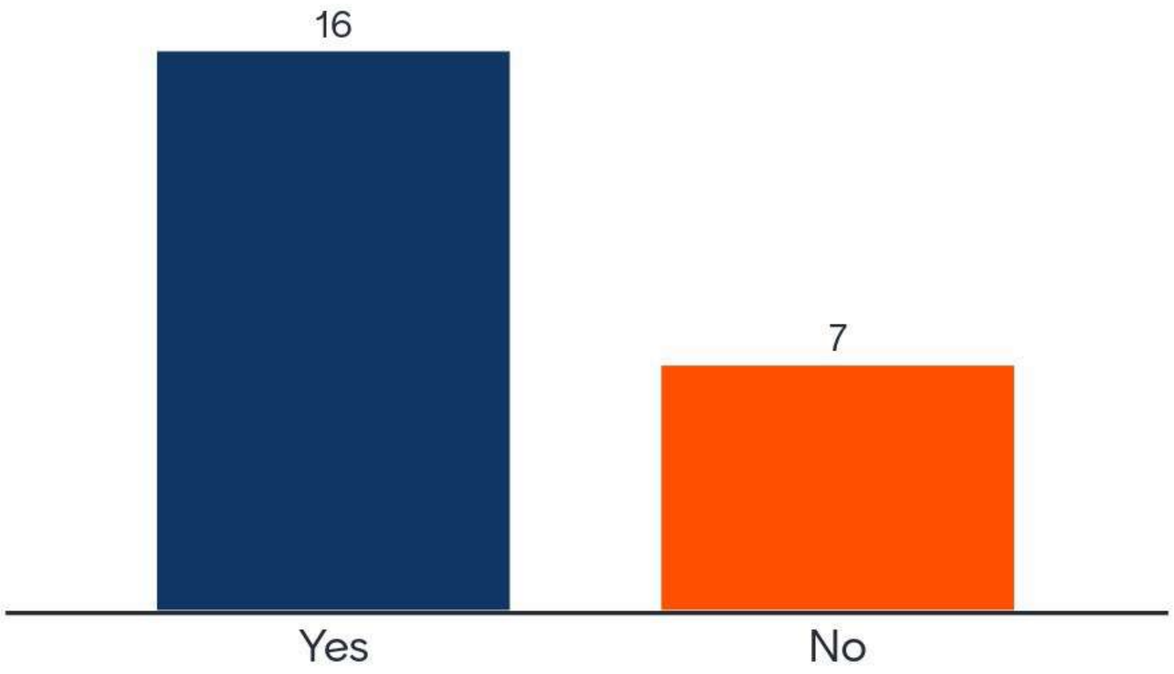
What limitations / restrictions are there to the carriage of large quantities of CO_2 onboard?

20 responses

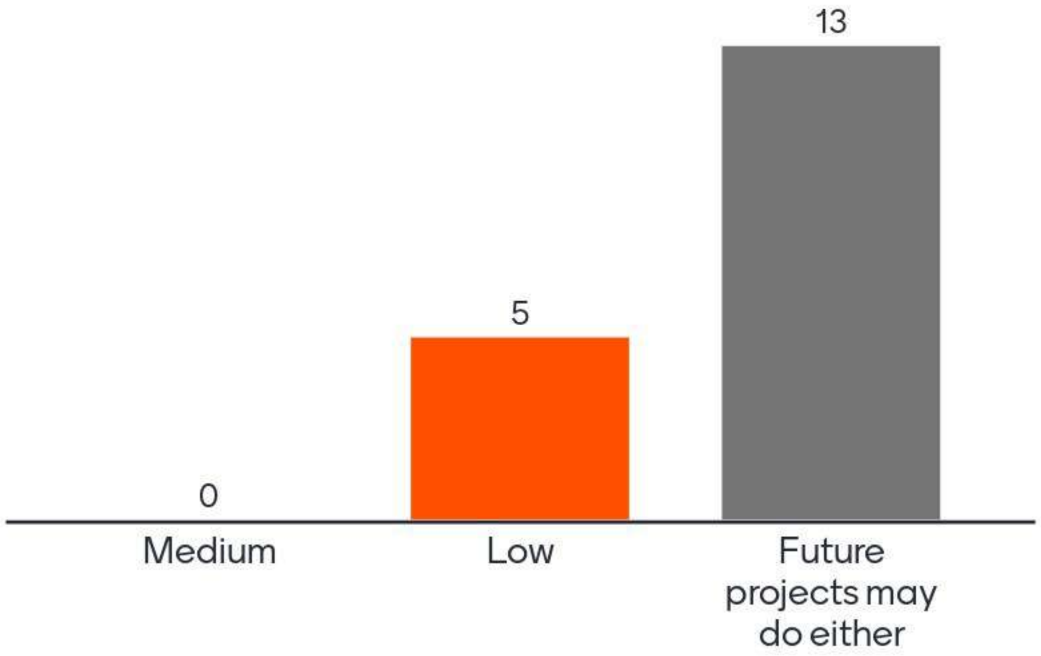
Power requirement should

The IGC is not updated for co2

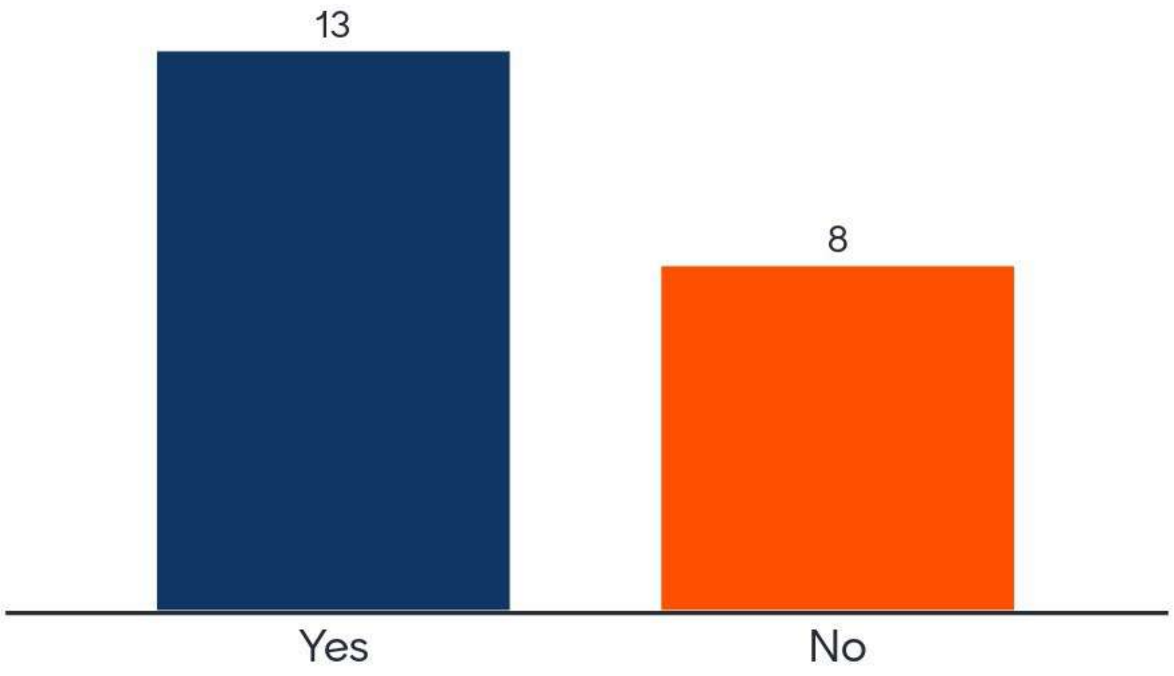
Can we standardise CO_2 offloading across the globe? i.e. storage pressures and temperatures



The Northern Lights project chose to transport LCO_2 at medium pressure. What transport pressure do you think future projects will employ?

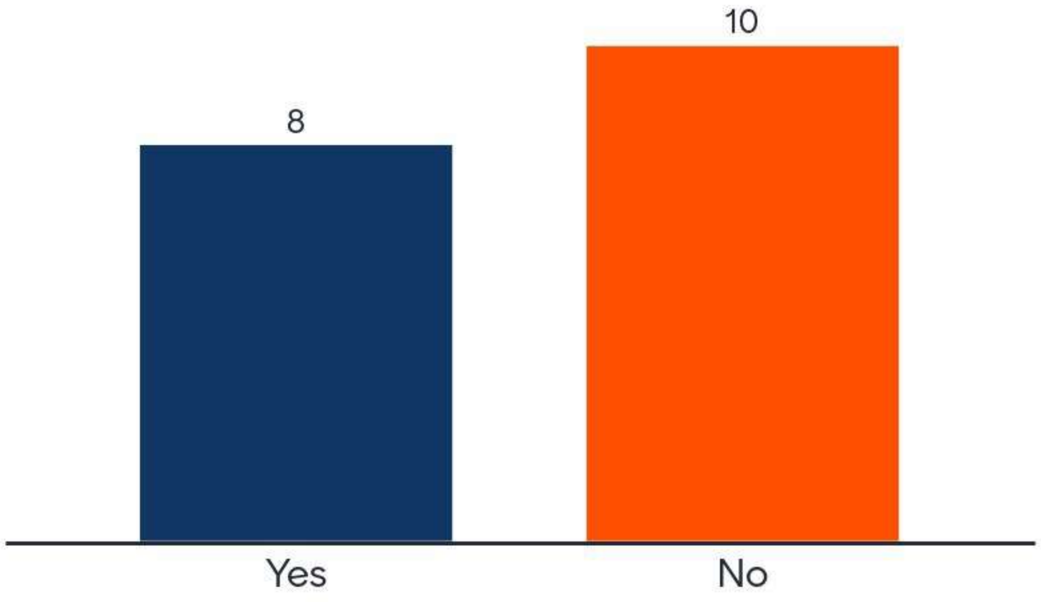


The Northern Lights project chose LCO_2 with very low impurities. Is that an example to follow?



www.everlongccus.eu

Do you think ship-based carbon capture should look into solutions where CO_2 is used & fixed in applications, instead of geological storage?



18

What services are needed to get CO_2 from ships to landside?

Waiting for responses ...

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1

EverLoNG

How do you account for risks and associated liability of CO_2 ownership, loss (leakage), across the full value chain?

15 responses

Insurance

In the same way as waste and slops are treated

Contracts

CO2 ownership change at the delivery point

Insurance

There is a difference between ownership of the CO2 and the custodian of the CO2

Good question. Rules and reulatuins and custody transfer need to be discussed and developed

Agreements

volumes should be auditable in the same manner as cargoes in general

13

How do you account for risks and associated liability of CO_2 ownership, loss (leakage), across the full value chain?

15 responses

accountability where leakage occurs

Leakage is the responsibility of the custodian and financially liable to the owner

Pre-agreed margin to be added equally to all stakeholders

Measure landed CO2 by weight

Shipowners only accountale for CO2 landed ashore.Reception facility accountable for further handling

Responsabiliteit changes in the value chain, defilé who is accountable where

13

Thank you for listening

If you want to be part of this CO_2 Shipping Interoperability Industry Group (CSIIG) please put in Chat or contact:

Richard L Stevenson richard.stevenson@sccs.org.uk

Erika Palfi erika.palfi@sccs.org.uk

Acknowledgements

The EverLoNG project is funded through the ACT programme (Accelerating CCS Technologies, Horizon2020 Project No 691712). Financial contributions have been made by the Ministry of Economic Affairs and Climate Policy, the Netherlands; The Federal Ministry for Economic Affairs and Climate Action, Germany; the Research Council of Norway; the Department for Business, Energy & Industrial Strategy, UK; and the U.S. Department of Energy. All funders are gratefully acknowledged.