



GREEN MARITIME TECHNOLOGY

ECOSPRAY®
technologies for the planet

CARBON CAPTURE & STORAGE PROJECT

NEWCASTLE-MAX SERIES OF VESSELS



SEPTEMBER 2023



CONTENTS



VESSEL'S DETAILS



CARBON CAPTURE SYSTEM TARGET



GENERAL DESCRIPTION OF CCS



ONBOARD INSTALLATION



CONCLUSIONS

CARBON CAPTURE & STORAGE PROJECT



VESSEL'S DETAILS

Vessel's Particulars

Flag	Liberia
Class	BV
Vessel Type	Newcastlemax Bulk Carrier
DWT	207,812 mt
Scrubber Fitted	Yes
LOA	299.88 m
Breadth Moulded	50.00 m
GT	108,237 mt



CARBON CAPTURE & STORAGE PROJECT



VESSEL'S DETAILS

Engine Data

Main engine maker

MAN

Engine Type

6G70ME-C

Number of main engines

1

Power @ SMCR

17,494 kW @ 78.7rpm

Exhaust gas flow @ SMCR

89,200 kg/h

Exhaust gas temperature @ SMCR

~ 270 °C

Number of main engines connected to the scrubber

1



CARBON CAPTURE & STORAGE PROJECT



VESSEL'S DETAILS

Engine Data

Auxiliary engine maker

YANMAR

Engine Type

6EY22ALW

Number of main engines

3

Power @ SMCR

970 kW @ 900rpm

Exhaust gas flow @ SMCR

7,900 kg/h

Exhaust gas temperature @ SMCR

~ 350 °C

Number of main engines connected
to the scrubber

2



CARBON CAPTURE & STORAGE PROJECT



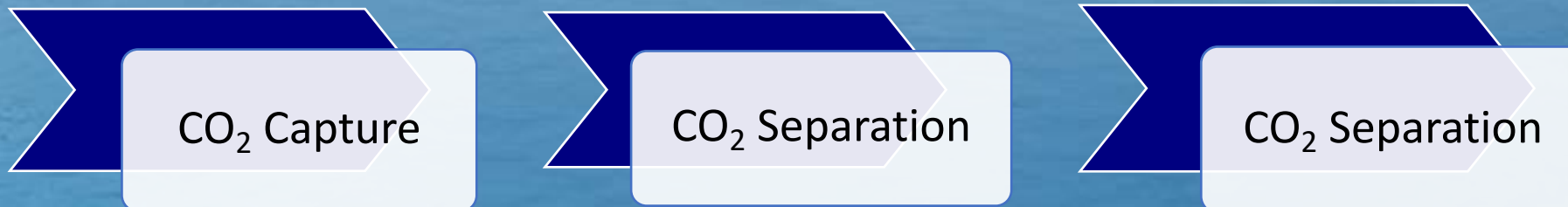
CARBON CAPTURE SYSTEM TARGET

CCS STANDARD OPERATION

CO ₂ capture system design data	
ME daily FOC (avg. value)	44 t/day
AE daily FOC	3,7 t/day
Total daily FOC [Q_{fuel}]	47,7 t/day
Tot. daily CO ₂ emission (HFO Cf = 3,114)	148,5 t/day
NET CO ₂ capture rate	20%
GROSS CO ₂ capture rate	28%
NET daily CO ₂ captured	29,71 t/day
Daily additional CO ₂ caused by CCS	16,63 t/day
GLOBAL daily CO ₂ captured [$Q_{\text{CO2 Captured}}$]	46,34 t/day
Liq. CO ₂ Storage capacity for 25 days	1050 m ³
Liq. CO ₂ Storage capacity for 40 days	1680 m ³

Amine-based carbon capture

- Amine-based carbon capture is a regenerative process using an amine solvent to remove CO₂ from flue gas.
- Reversing the reaction releases pure CO₂ for capture and frees up the solvent for re-use.
- This technology, based on amine chemical absorption, is conceived for CCS in marine onboard application.
- Considering the power consumption, another particular focus is the process optimization, using the thermal energy available on board.
- CO₂ is absorbed by the amine solution and during the process, the amine solution is regenerated by stripping the CO₂ out of it. Once separated, the CO₂ is then liquefied and stored in specific cryogenic tanks onboard.





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Challenges of CCS installation

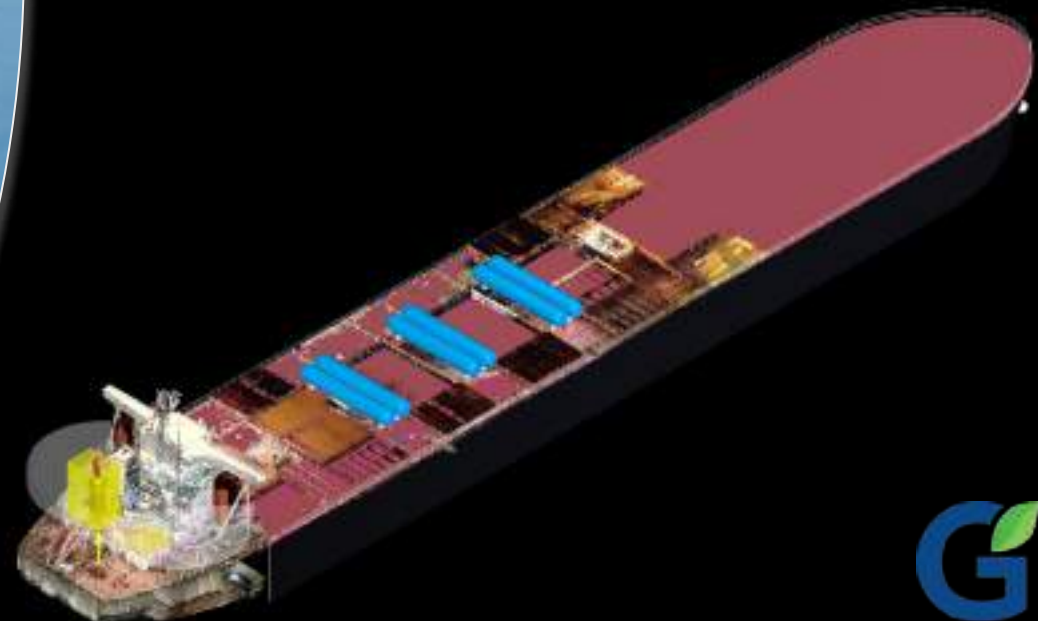
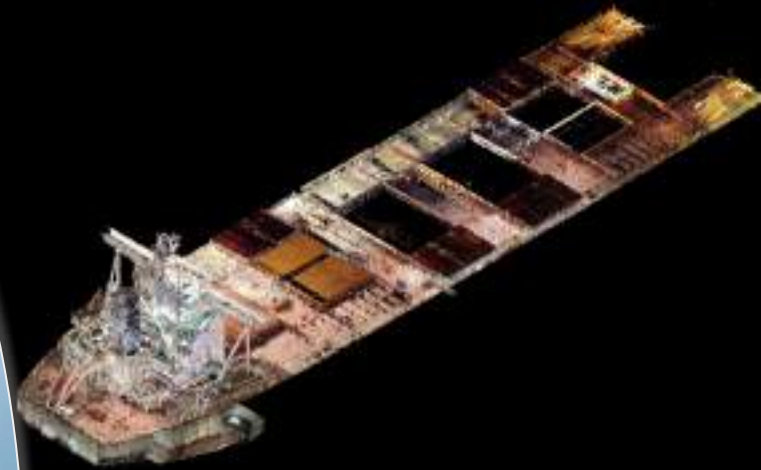
- System's significant footprint
- LCO₂ tanks possible installation area
- Space/vessel limitations (e.g., cranes, mooring and freefall operation)
- System's operational limitations
- Minimization of the new required materials of the on-board installation



Main areas of installation

- ✓ Upper deck, cross decks
- ✓ Below Bridge wings
- ✓ New constructed Backpack, Poop deck area
- ✓ New constructed technical space (other machinery space), for the new amine process tank, B deck
- ✓ Steering Gear Room 2nd deck
- ✓ Engine Room 2nd deck

CARBON CAPTURE & STORAGE PROJECT





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Challenges of CCS installation

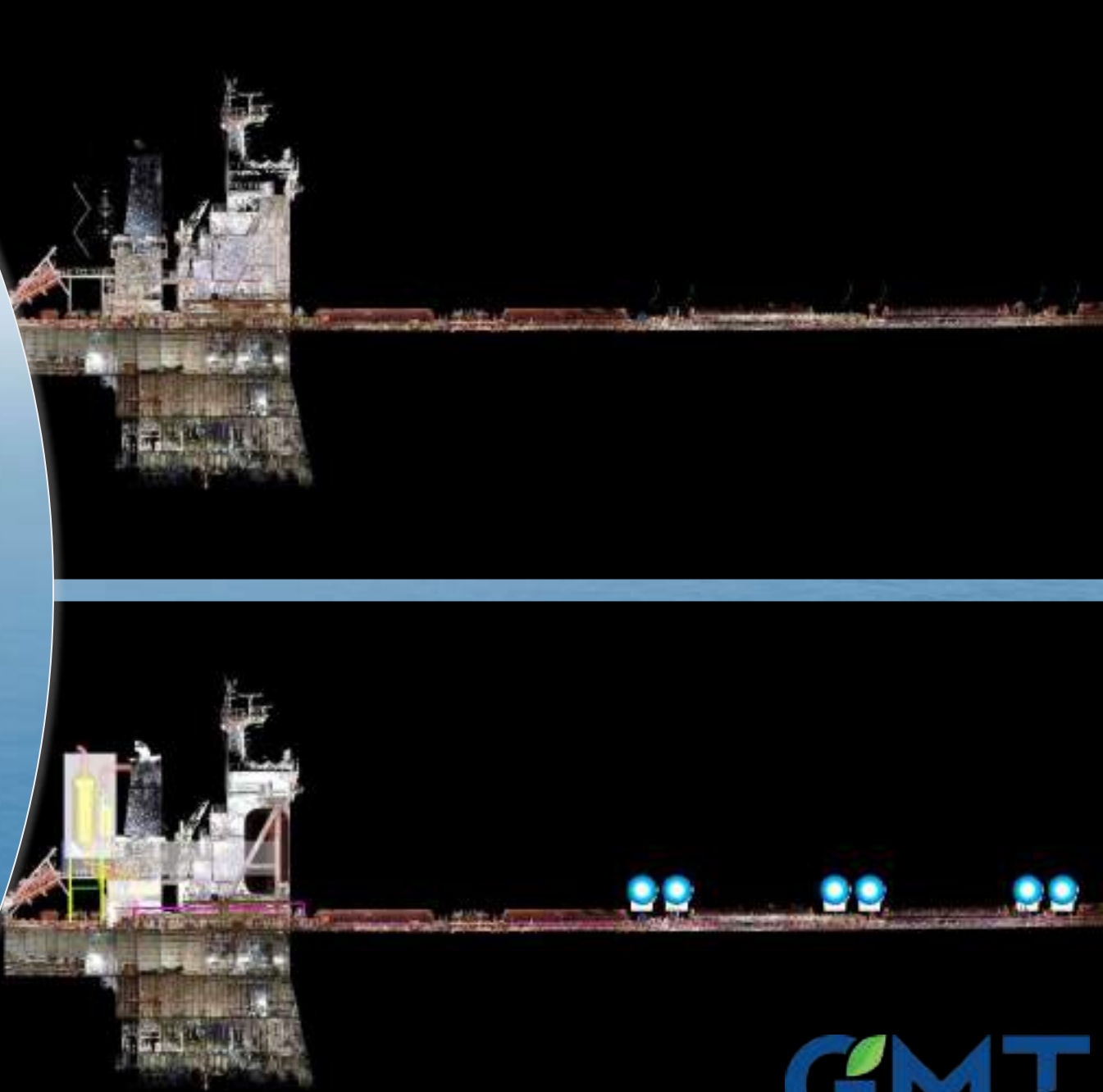
- System's significant footprint
- LCO₂ tanks possible installation area
- Space/vessel limitations (e.g., cranes, mooring and freefall operation)
- System's operational limitations
- Minimization of the new required materials of the on-board installation



Main areas of installation

- ✓ Upper deck, cross decks
- ✓ Below Bridge wings
- ✓ New constructed Backpack, Poop deck area
- ✓ New constructed technical space (other machinery space), for the new amine process tank, B deck
- ✓ Steering Gear Room 2nd deck
- ✓ Engine Room 2nd deck

CARBON CAPTURE & STORAGE PROJECT





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Challenges of CCS installation

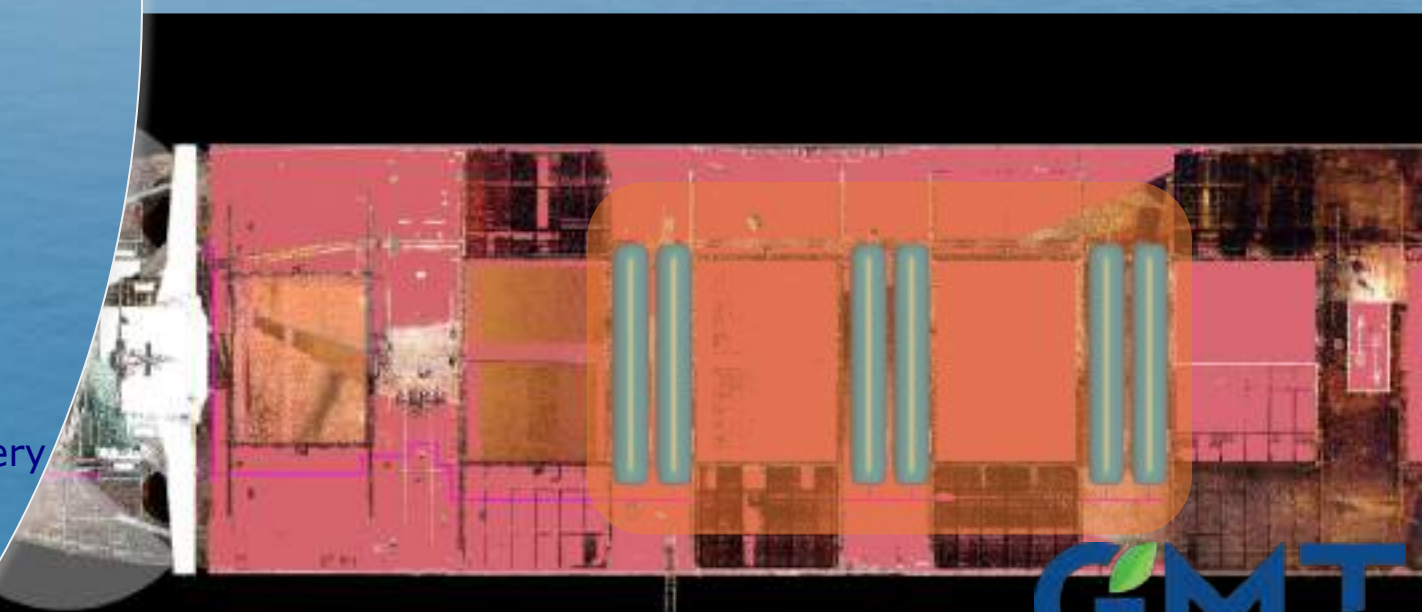
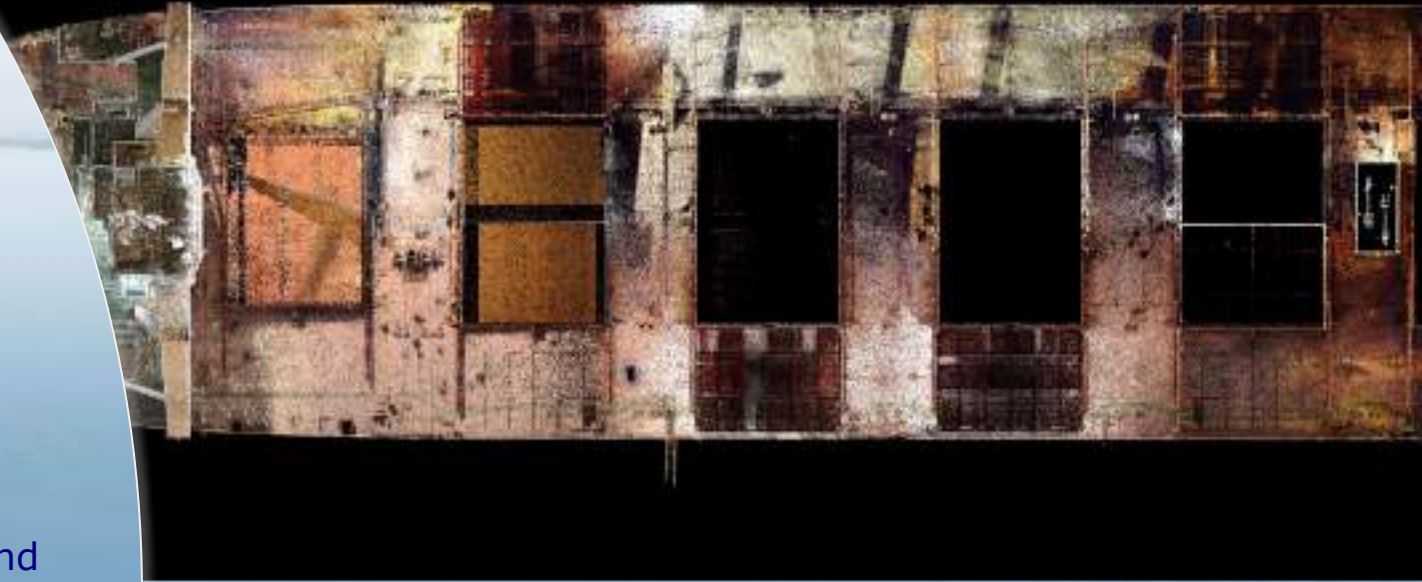
- System's significant footprint
- LCO₂ tanks possible installation area
- Space/vessel limitations (e.g., cranes, mooring and freefall operation)
- System's operational limitations
- Minimization of the new required materials of the on-board installation



Main areas of installation

- ✓ Upper deck, cross decks
- ✓ Below Bridge wings
- ✓ New constructed Backpack, Poop deck area
- ✓ New constructed technical space (other machinery space), for the new amine process tank, B deck
- ✓ Steering Gear Room 2nd deck
- ✓ Engine Room 2nd deck

CARBON CAPTURE & STORAGE PROJECT





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Challenges of CCS installation

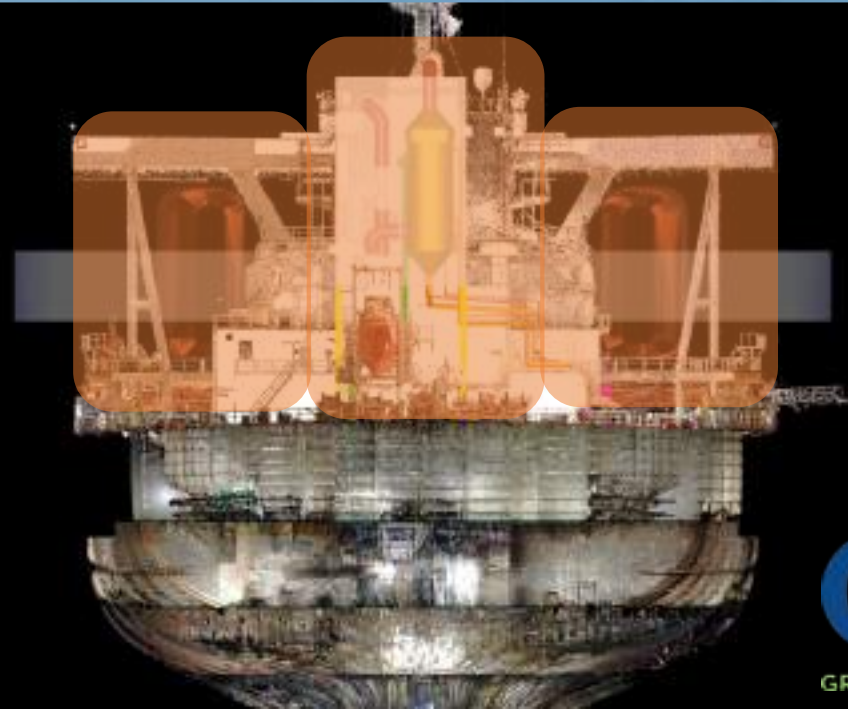
- System's significant footprint
- LCO₂ tanks possible installation area
- Space/vessel limitations (e.g., cranes, mooring and freefall operation)
- System's operational limitations
- Minimization of the new required materials of the on-board installation



Main areas of installation

- ✓ Upper deck, cross decks
- ✓ Below Bridge wings
- ✓ New constructed Backpack, Poop deck area
- ✓ New constructed technical space (other machinery space), for the new amine process tank, B deck
- ✓ Steering Gear Room 2nd deck
- ✓ Engine Room 2nd deck

CARBON CAPTURE & STORAGE PROJECT





MAIN AREAS OF CCS INSTALLATION & CHALLENGES

Challenges of CCS installation

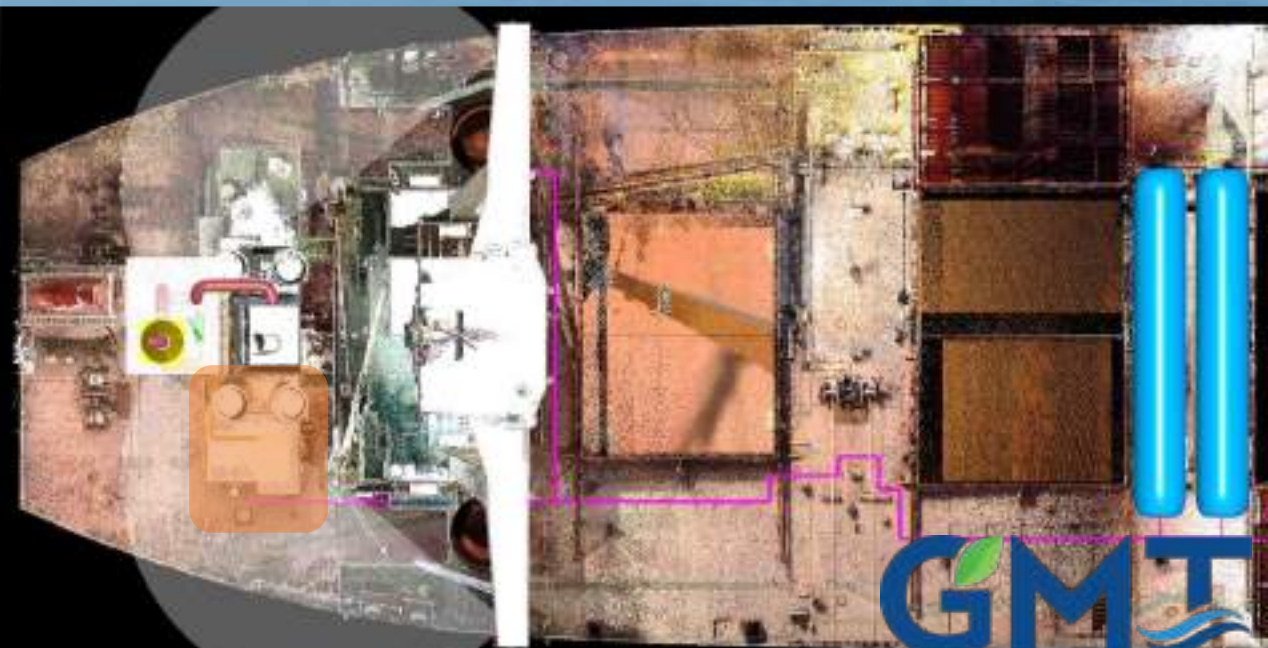
- System's significant footprint
- LCO₂ tanks possible installation area
- Space/vessel limitations (e.g., cranes, mooring and freefall operation)
- System's operational limitations
- Minimization of the new required materials of the on-board installation



Main areas of installation

- ✓ Upper deck, cross decks
- ✓ Below Bridge wings
- ✓ New constructed Backpack, Poop deck area
- ✓ New constructed technical space (other machinery space), for the new amine process tank, B deck
- ✓ Steering Gear Room 2nd deck
- ✓ Engine Room 2nd deck

CARBON CAPTURE & STORAGE PROJECT





MAIN AREAS OF CCS INSTALLATION & CHALLENGES

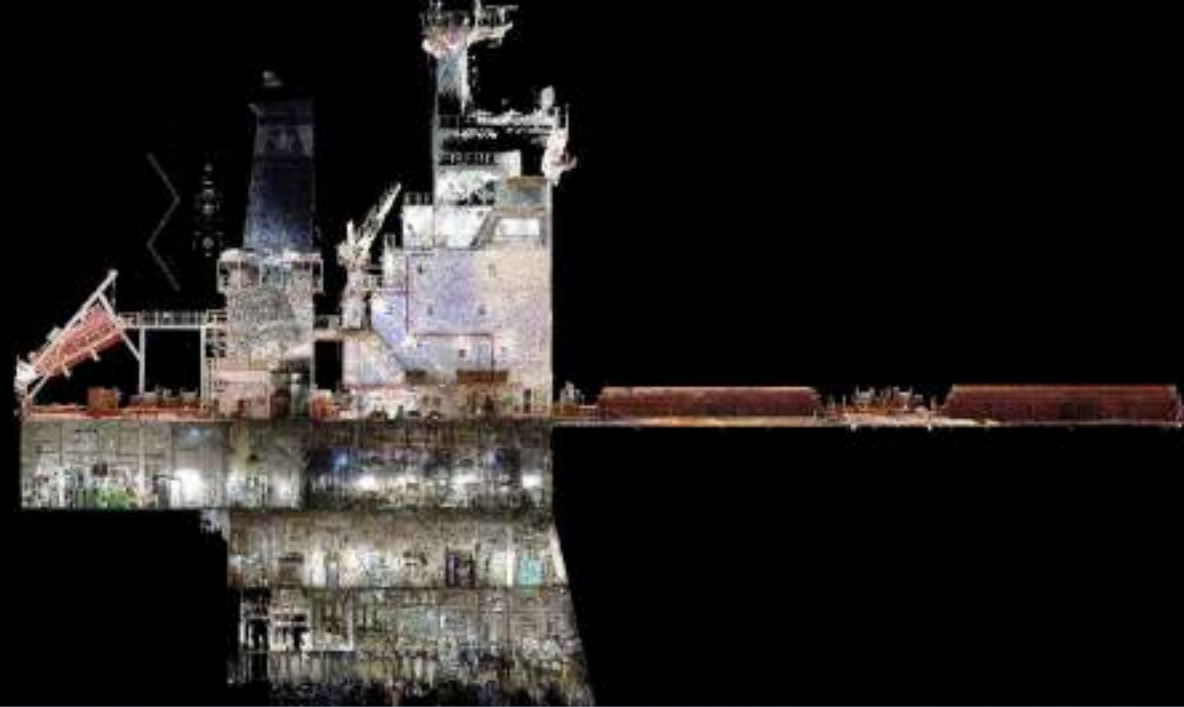
Challenges of CCS installation

- System's significant footprint
- LCO₂ tanks possible installation area
- Space/vessel limitations (e.g., cranes, mooring and freefall operation)
- System's operational limitations
- Minimization of the new required materials of the on-board installation

Main areas of installation

- ✓ Upper deck, cross decks
- ✓ Below Bridge wings
- ✓ New constructed Backpack, Poop deck area
- ✓ New constructed technical space (other machinery space), for the new amine process tank, B deck
- ✓ Steering Gear Room 2nd deck
- ✓ Engine Room 2nd deck

CARBON CAPTURE & STORAGE PROJECT





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Upper deck area, cross deck & Below Bridge wings

- Components: LCO₂ Storage Tanks
Vertical and Horizontal Type
- Total Volume: 1800m³~1840m³
- Challenges: Excessive Large size and weight
- Installation notes: new constructed foundation



OPTION 1

Location

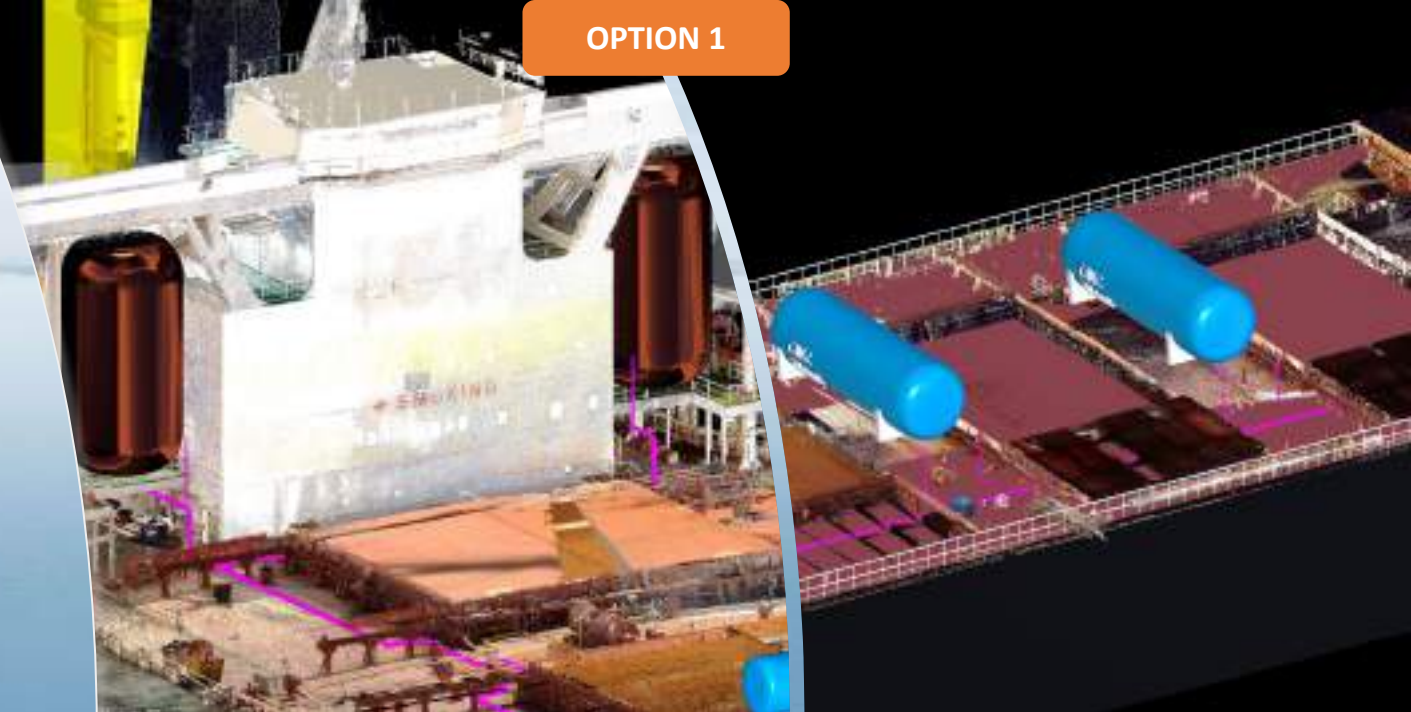
Upper deck area,
cross deck & Below
Bridge wings

OPTION 2

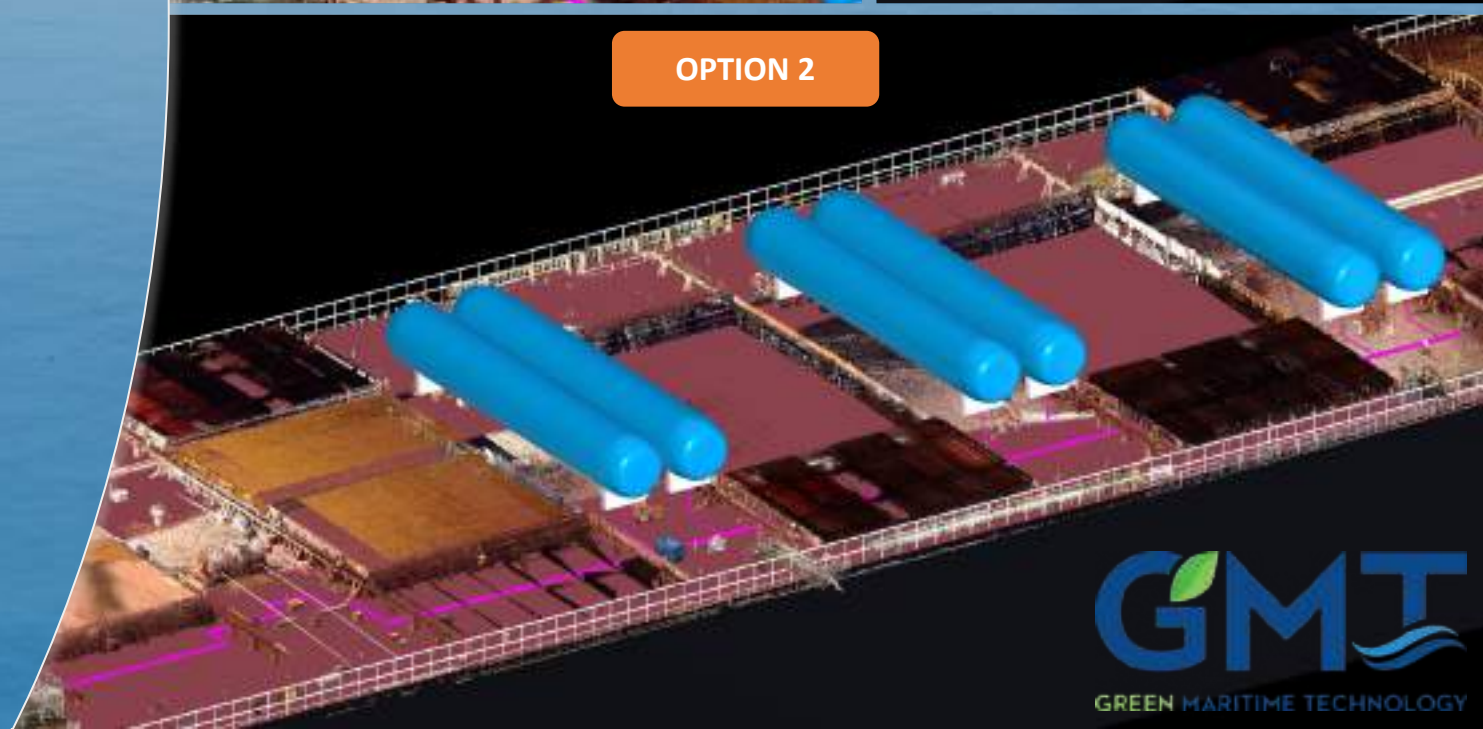
Location

Upper deck area,
cross deck

OPTION 1



OPTION 2





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



OPTION 1

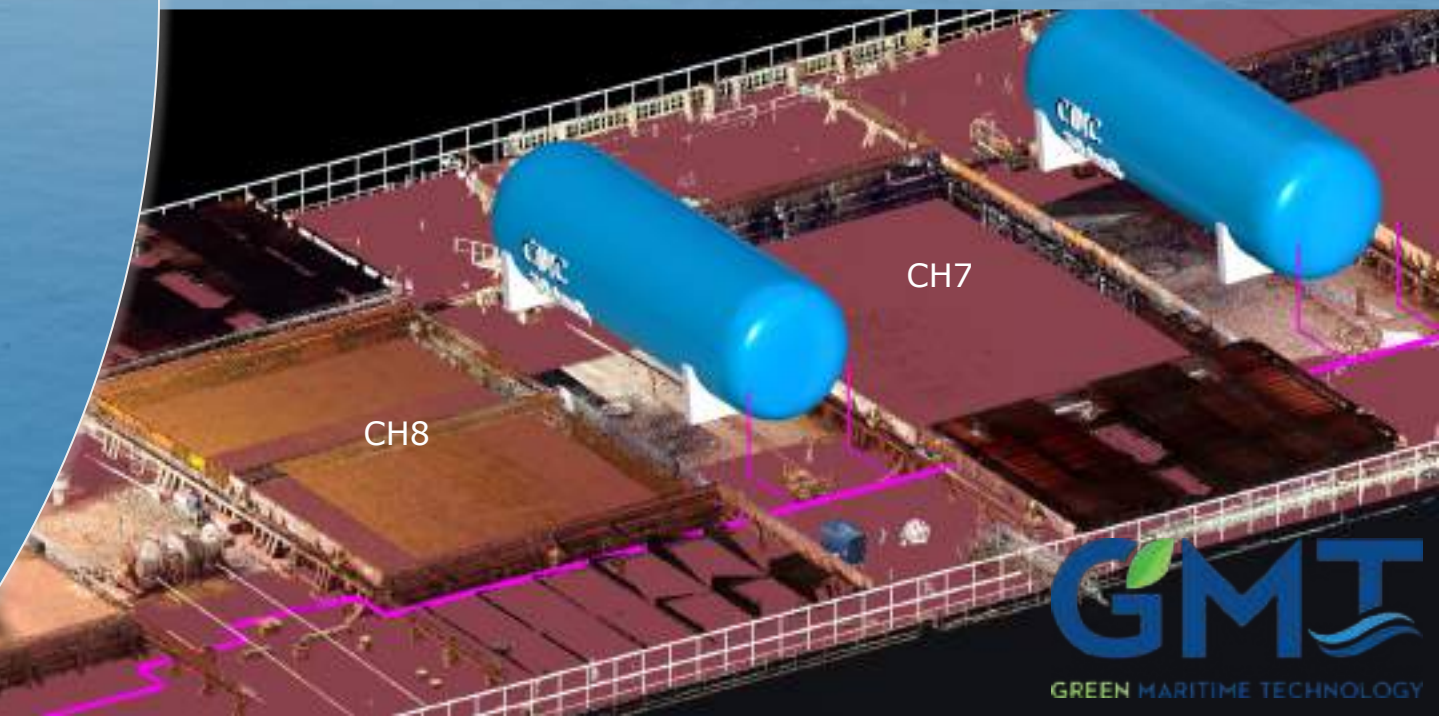
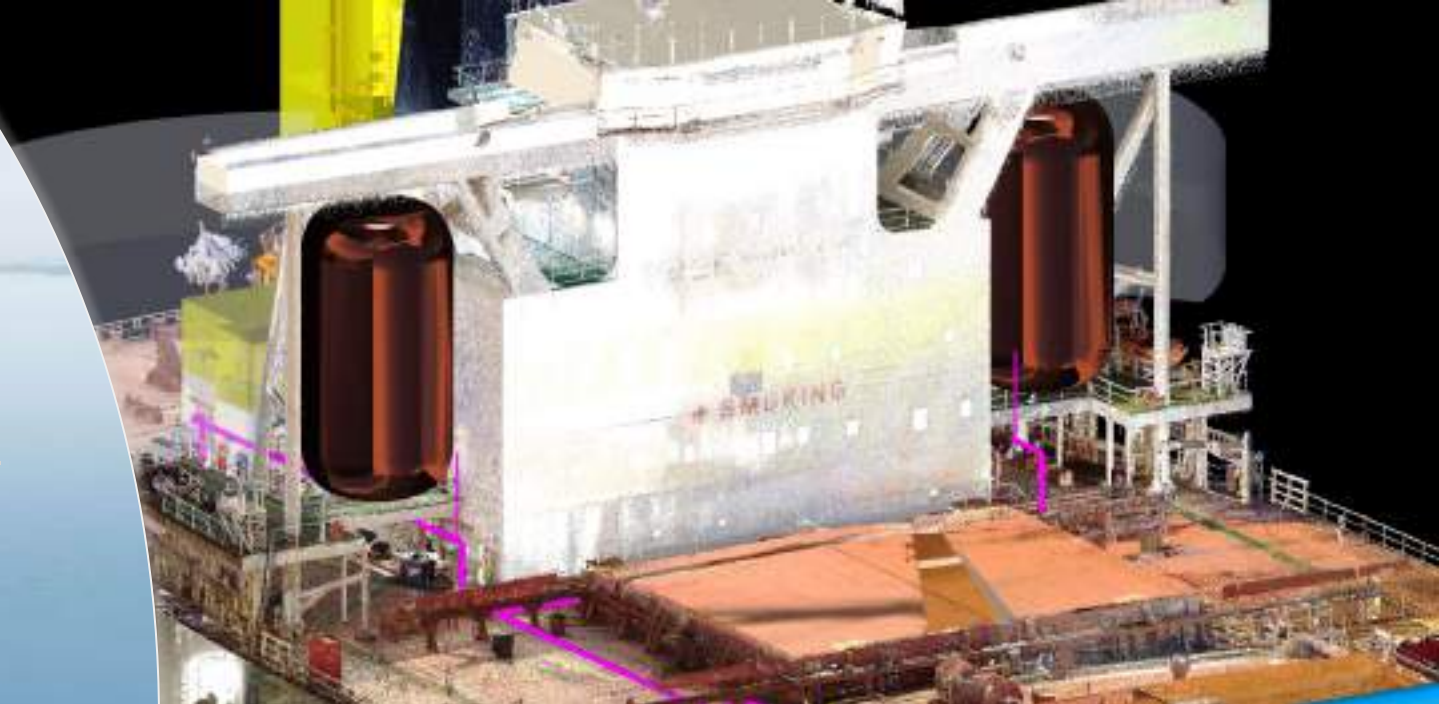
Upper deck area, cross deck & Below Bridge wings

- Components: LCO₂ Storage Tanks
Vertical and Horizontal Type
- Total Volume: ~1840m³
- Challenges: Excessive Large size and weight

LCO₂ Storage Tanks

Type	Vertical	Horizontal
Number tanks	2	2
Dimensions	Ø=6.3m, L=12.50m	Ø=6.00m, L=20.20m
Volume per tank	~350m ³	~570m ³
Total Volume	~700m ³	~1140m ³
Installation area	Below Bridge wings	Upper dk-cross deck

CARBON CAPTURE & STORAGE PROJECT





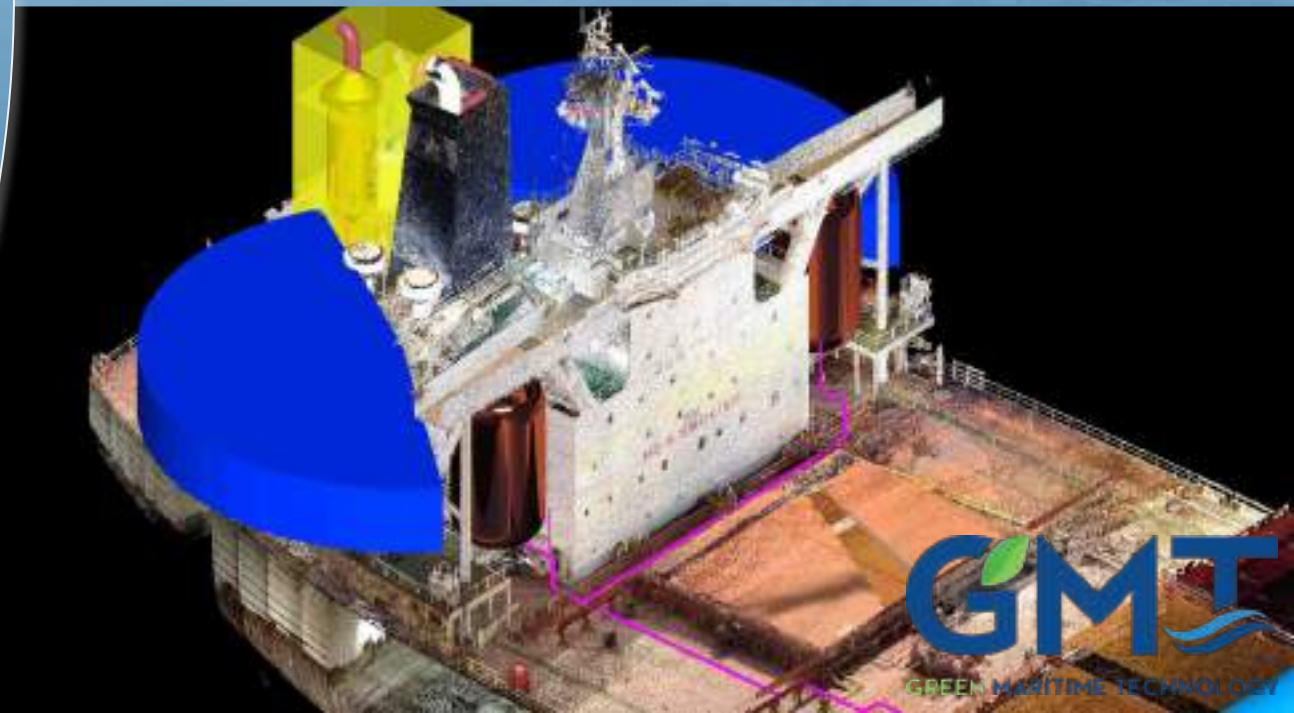
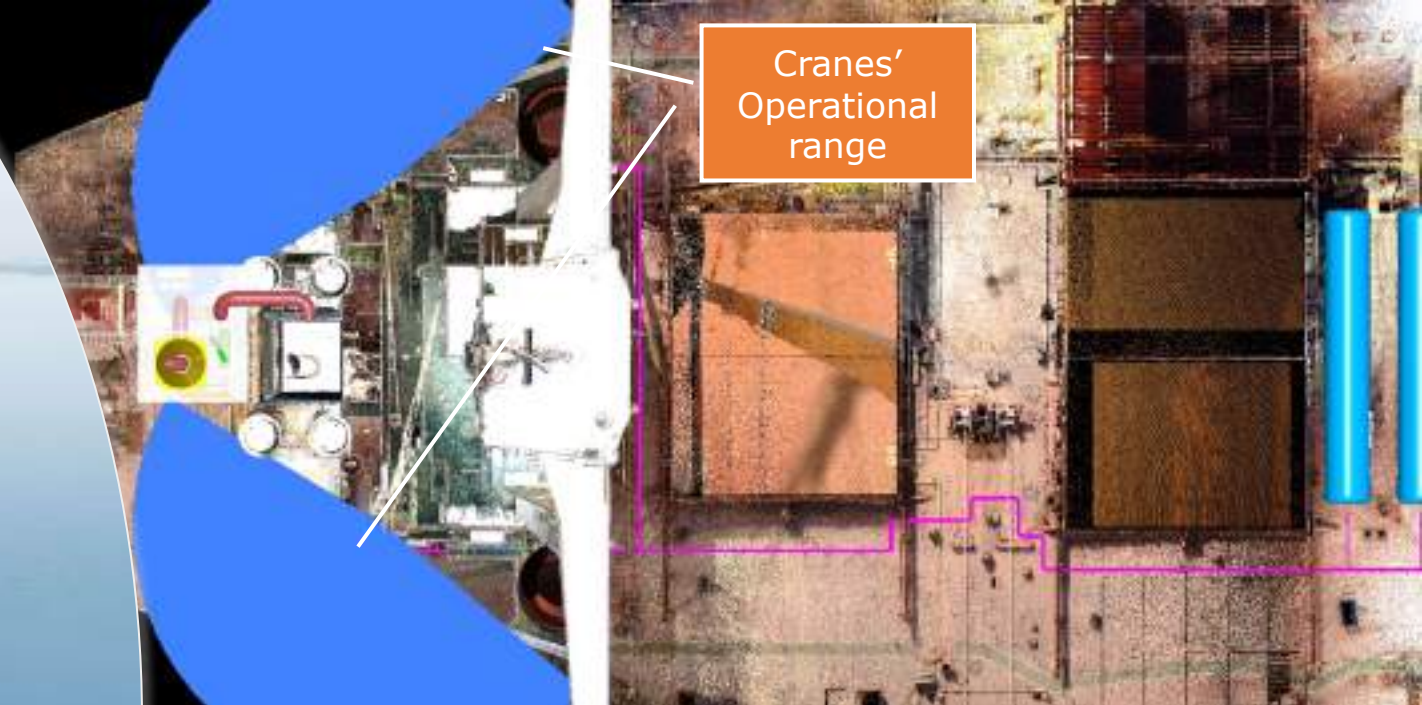
MAIN AREAS OF CCS INSTALLATION & CHALLENGES



OPTION 1

Upper deck area, cross deck & **Below Bridge wings**

- Components: LCO₂ Storage Tanks
Vertical and Horizontal Type
- Total Volume: ~1840m³
- Challenges: Excessive Large size and weight
- **Installation notes:** The position of the Horizontal tanks has been chosen, in order to retain both cranes' normal operation





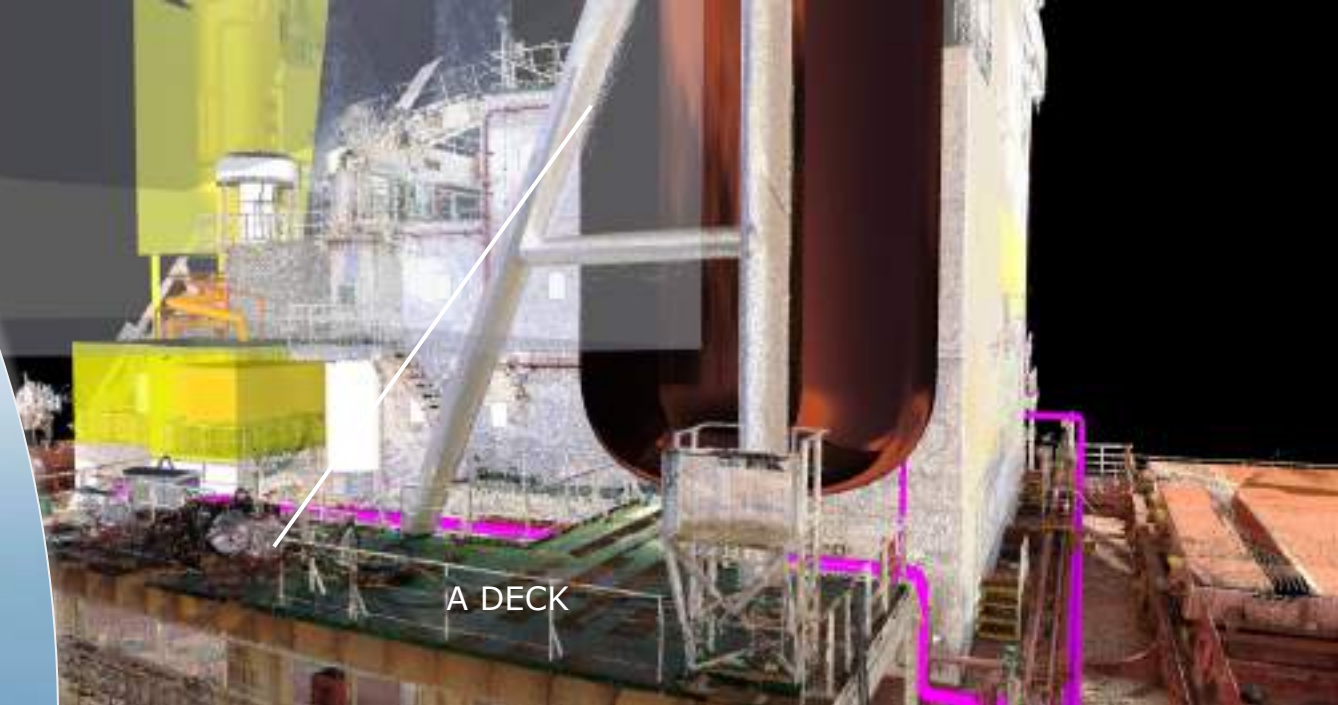
MAIN AREAS OF CCS INSTALLATION & CHALLENGES



OPTION 1

Upper deck area, cross deck & Below Bridge wings

- Components: LCO₂ Storage Tanks
Vertical and Horizontal Type
- Total Volume: ~1840m³
- Challenges: Excessive Large size and weight
- **Installation notes:** Possible re-arrangement of passageway at A deck's outboard platform (P & S) will be required.



A DECK



Re-arrangement
of passageway



MAIN AREAS OF CCS INSTALLATION & CHALLENGES



OPTION 2

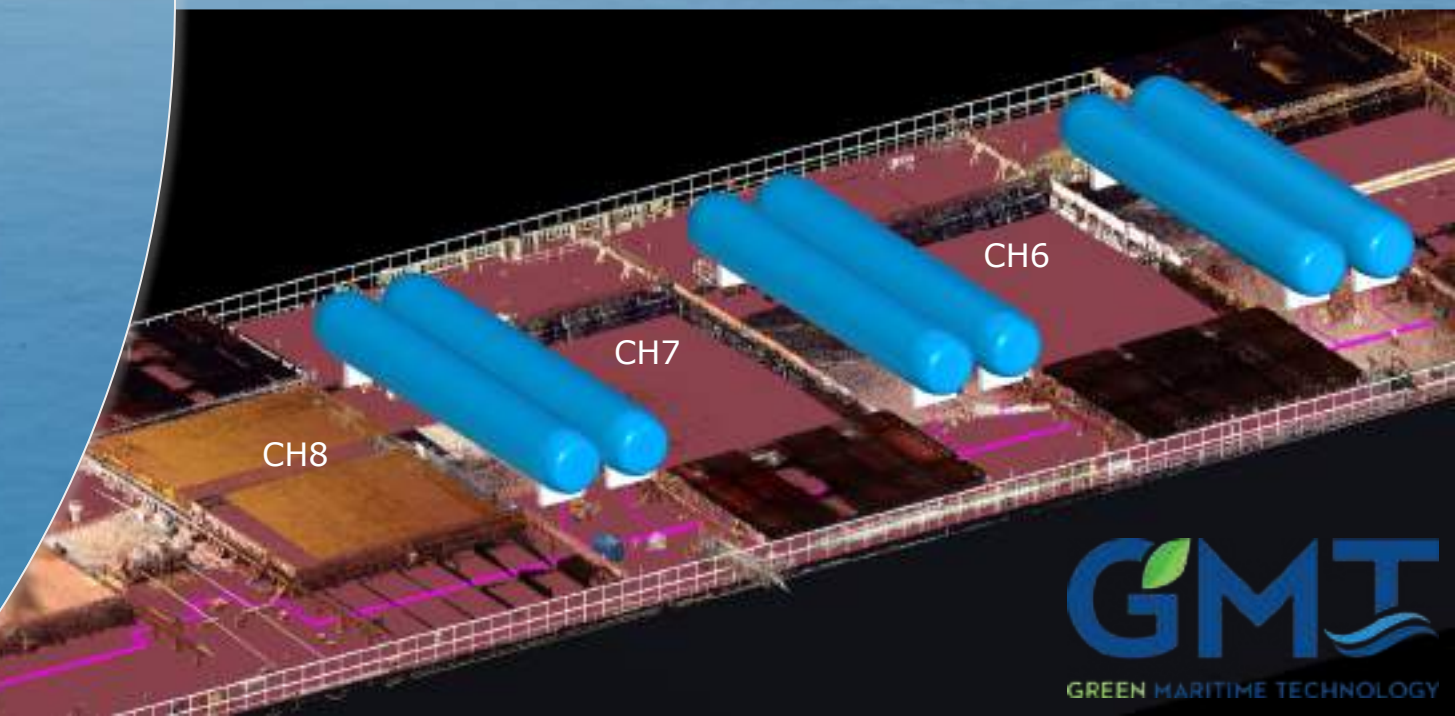
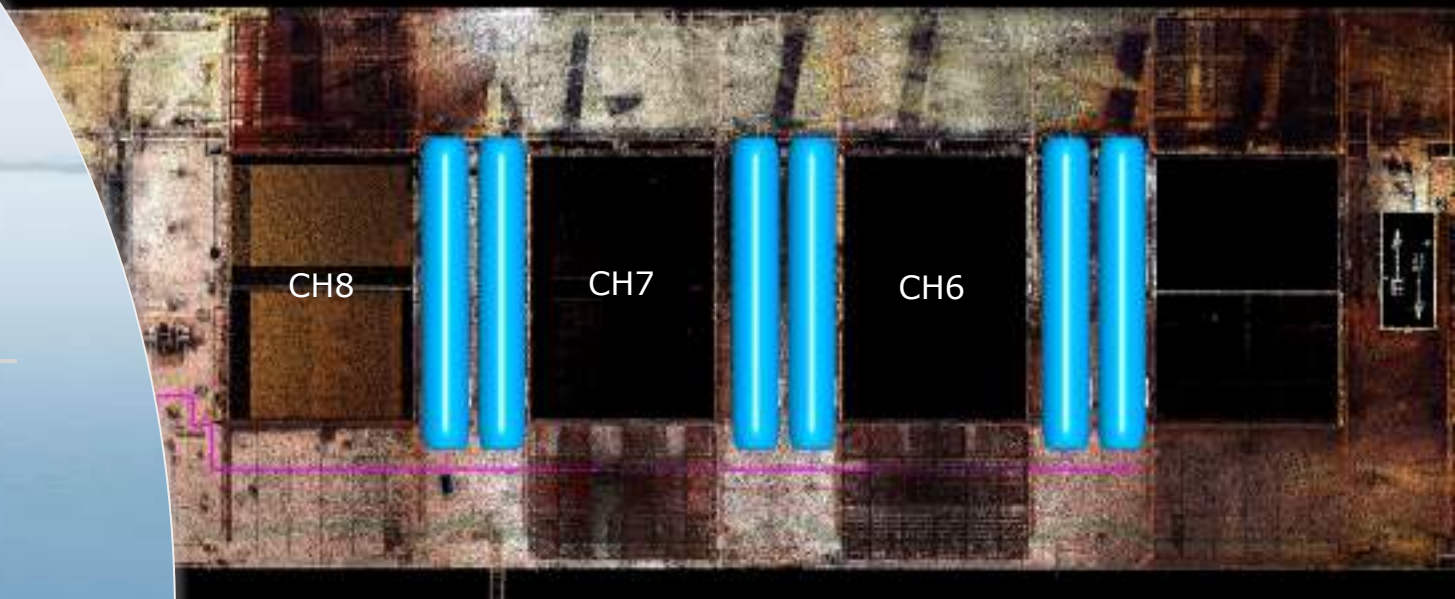
Upper deck area, cross deck

- Components: LCO₂ Storage Tanks
Horizontal Type
- Total Volume: ~1800m³
- Challenges: Excessive Large size and weight

LCO₂ Storage Tanks

Type	Horizontal
Number tanks	6
Dimensions	Ø=4.3m, L=28.0m
Volume per tank	~300m ³
Total Volume	~1800m ³
Installation area	Upper dk-cross deck

CARBON CAPTURE & STORAGE PROJECT





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Upper deck area

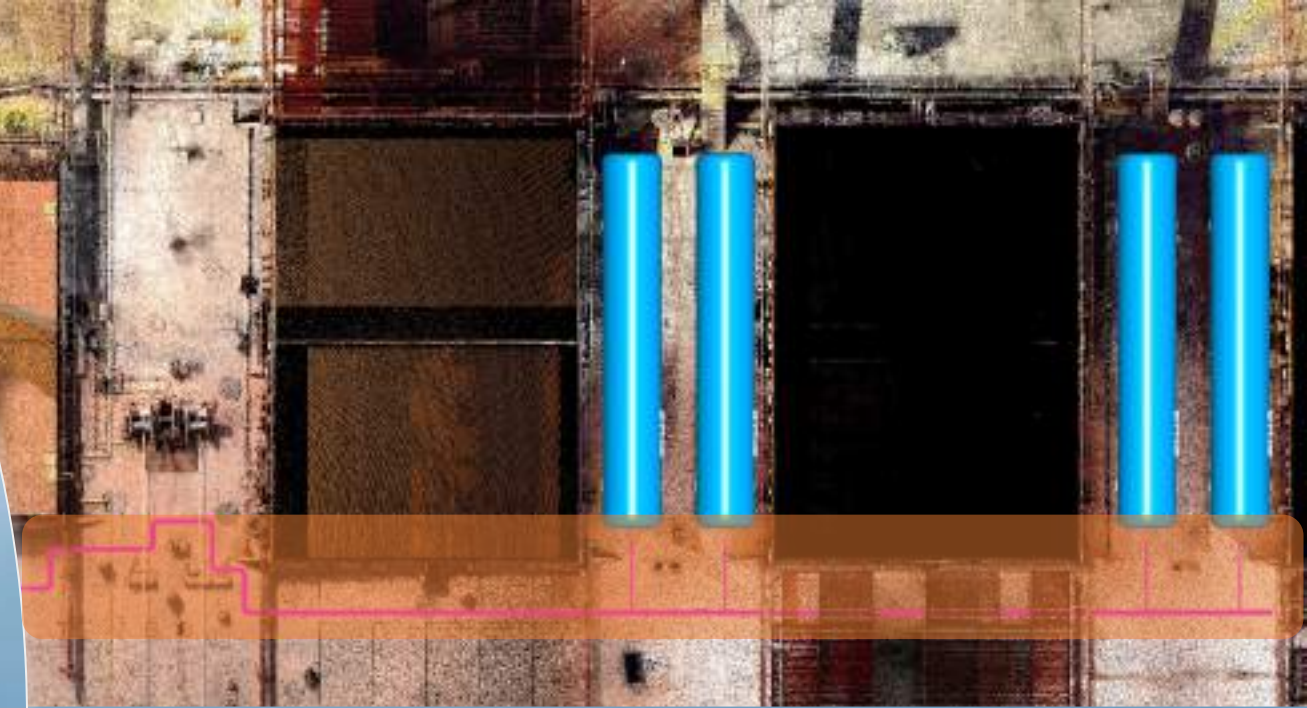
➤ LCO₂ Storage Tanks Pipeline

OPTION 1

OPTION 2

➤ Installation notes:

- Piping insulation
- Manifolds
- And bunkering connection for CO₂ utilization offshore





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



New constructed Backpack, Poop deck area

- Components: Absorption tower and Regeneration tower
 - Dimensions: 9.4mx7.8mx15.0m (approx.)
 - Challenges: Excessive Large size and weight
-
- **Installation notes:**
 - Attached structurally with vessel existing structure, and proper under deck reinforcement
 - Independent structure with no common boundaries with ship's enclose spaces.
 - Backpack's breadth is less than B/4 in order to avoid any changes at vessel's Equipment Number (EN).



New
constructed
Backpack



MAIN AREAS OF CCS INSTALLATION & CHALLENGES

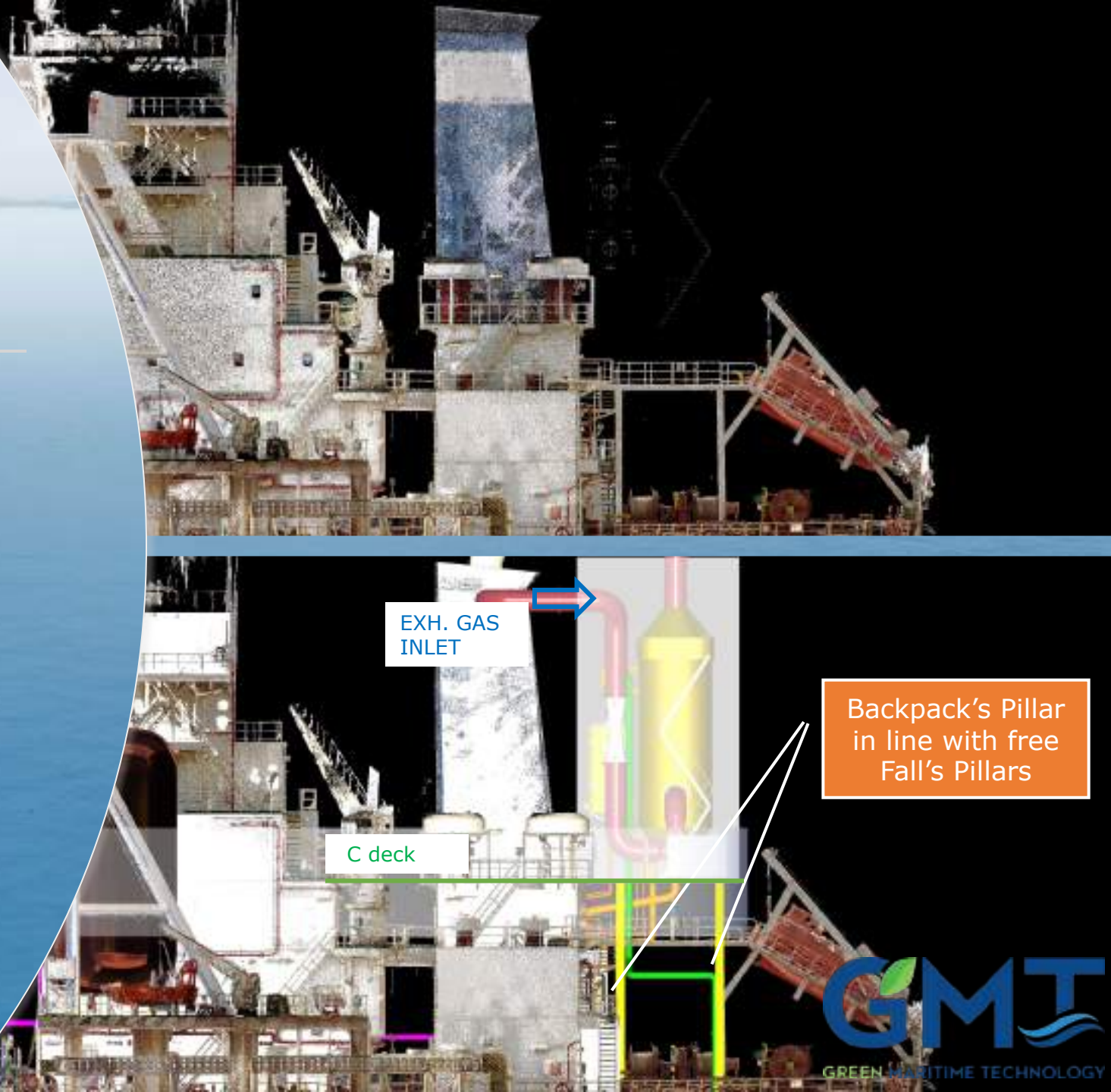


New constructed Backpack, Poop deck area

- Components: Absorption tower and Regeneration tower
- Dimensions: 9.4mx7.8mx15.0m (approx.)
- Challenges: Excessive Large size and weight

➤ Installation notes:

- Backpack's supporting pillars will be in line with Free Fall's Pillars on X-axis. with ship's enclose spaces.



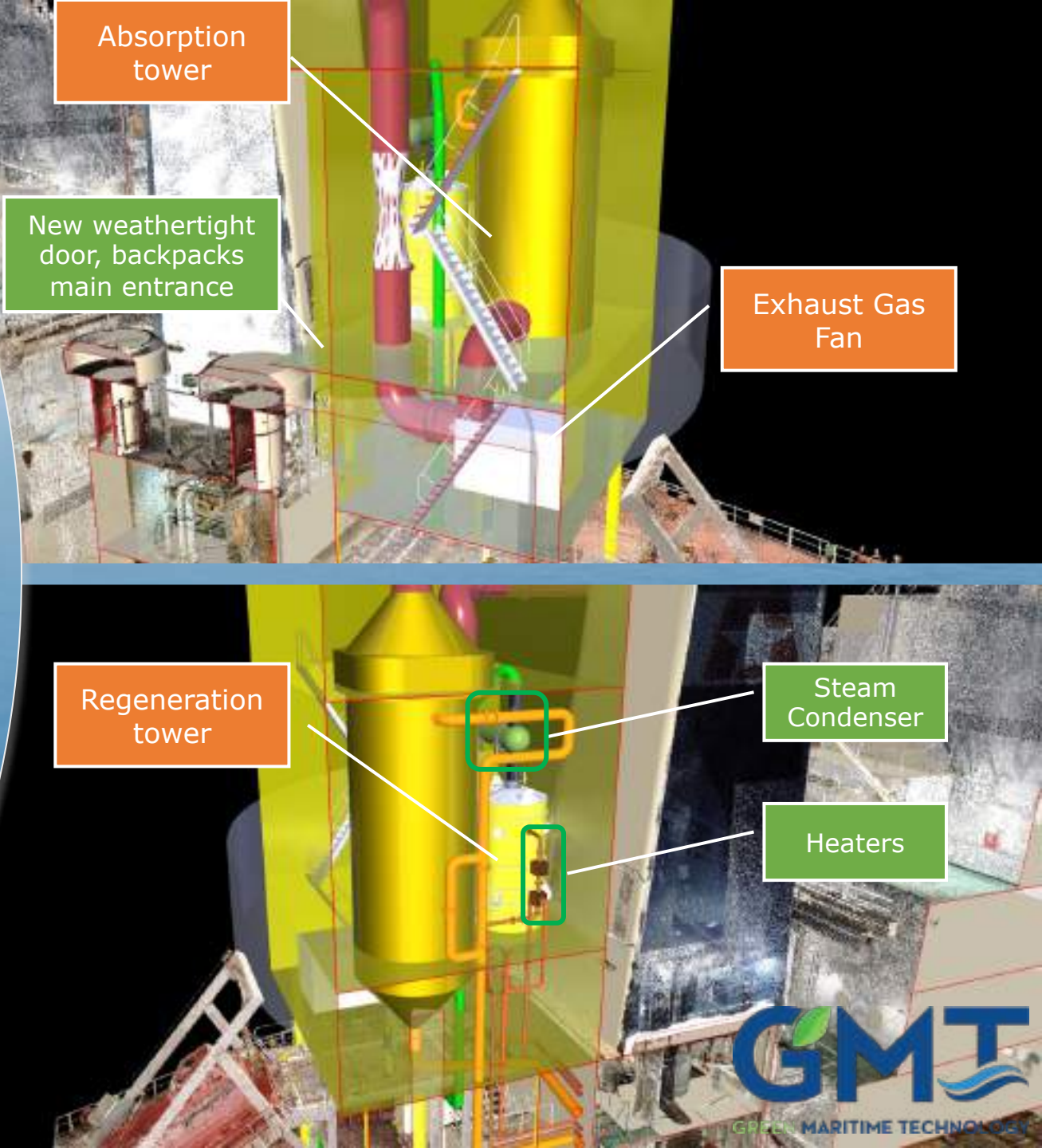


MAIN AREAS OF CCS INSTALLATION & CHALLENGES



New constructed Backpack, Poop deck area

- Components: Absorption tower and Regeneration tower
 - Dimensions: 9.4mx7.8mx15.0m (approx.)
 - Challenges: Excessive Large size and weight
-
- **Installation notes:**
 - Additional ECOSPRAY components: Steam Condenser, Filters and Heaters.
 - Backpack's Categorization is category 7, other machinery space not cat. A.





ONBOARD INSTALLATION

MAIN AREAS OF CCS INSTALLATION & CHALLENGES

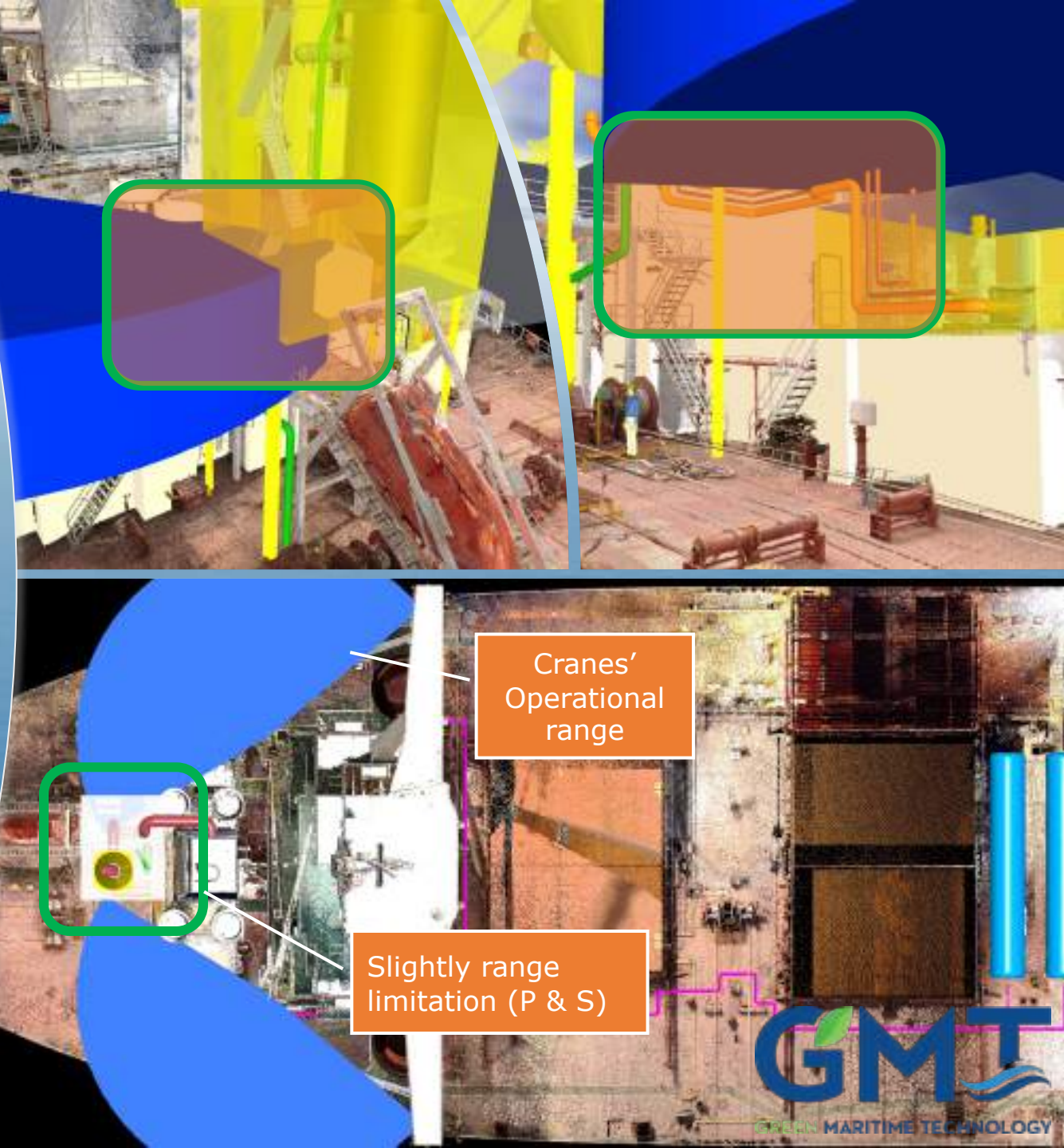


New constructed Backpack, Poop deck area

- Components: Absorption tower and Regeneration tower
- Dimensions: 9.4mx7.8mx15.0m (approx.)
- Challenges: Excessive Large size and weight

➤ Installation notes:

- Slightly range limitation at Crane's extreme operational range due to Backpack and piping installation.





MAIN AREAS OF CCS INSTALLATION & CHALLENGES

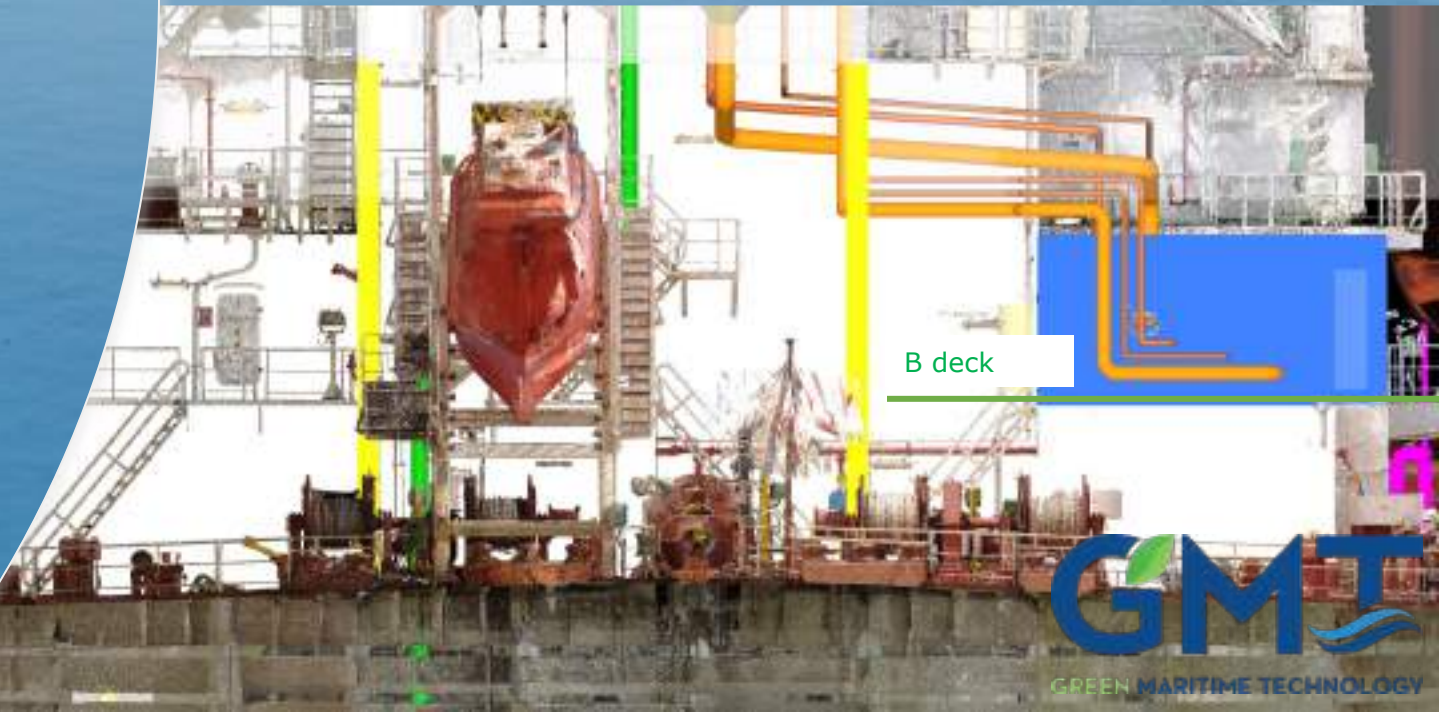


New constructed technical space (other machinery space), for the new amine process tank, B deck

- Components: Amine tank, System's main pumps associated with Absorbing pump, Regeneration pump
- Dimensions (approx.)
 - technical space: 6.40mx7.40mx3.15m
 - Amine tank: 25m³
- Challenges: Piping installation with the required slope.



New double hull
tank/room



B deck



MAIN AREAS OF CCS INSTALLATION & CHALLENGES

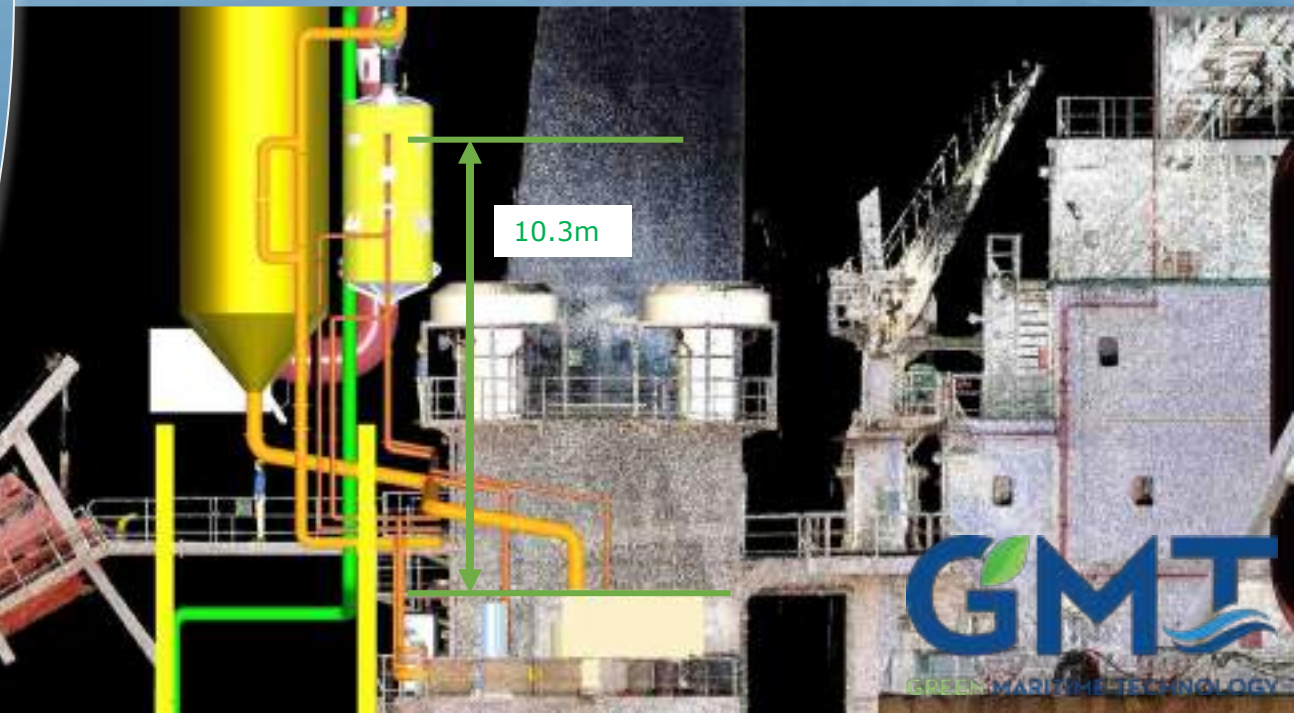


New constructed technical space (other machinery space), for the new amine process tank, B deck

- Components: Amine tank, System's main pumps associated with Absorbing pump, Regeneration pump
- Dimensions:
 - technical space: 6.40m x 7.40m x 3.15m
 - Amine tank: 25m³
- Challenges: Piping installation with the required slope.
- **Installation notes:**
 - System's limitation: At least 10.3m between the amine tank and the amine inlet pipe to the Regeneration tower



System's height limitation at amine tank & Regeneration tower



10.3m



MAIN AREAS OF CCS INSTALLATION & CHALLENGES



New constructed technical space (other machinery space), for the new amine process tank, B deck

- Components: Amine tank, System's main pumps associated with Absorbing pump, Regeneration pump
- Dimensions:
 - technical space: 6.40m x 7.40m x 3.15m
 - Amine tank: 25m³
- Challenges: Piping installation with the required slope.

New escape
weathertight
door

Existing Spare
parts to be
removed

Amine tank
25m³

System's main
pumps

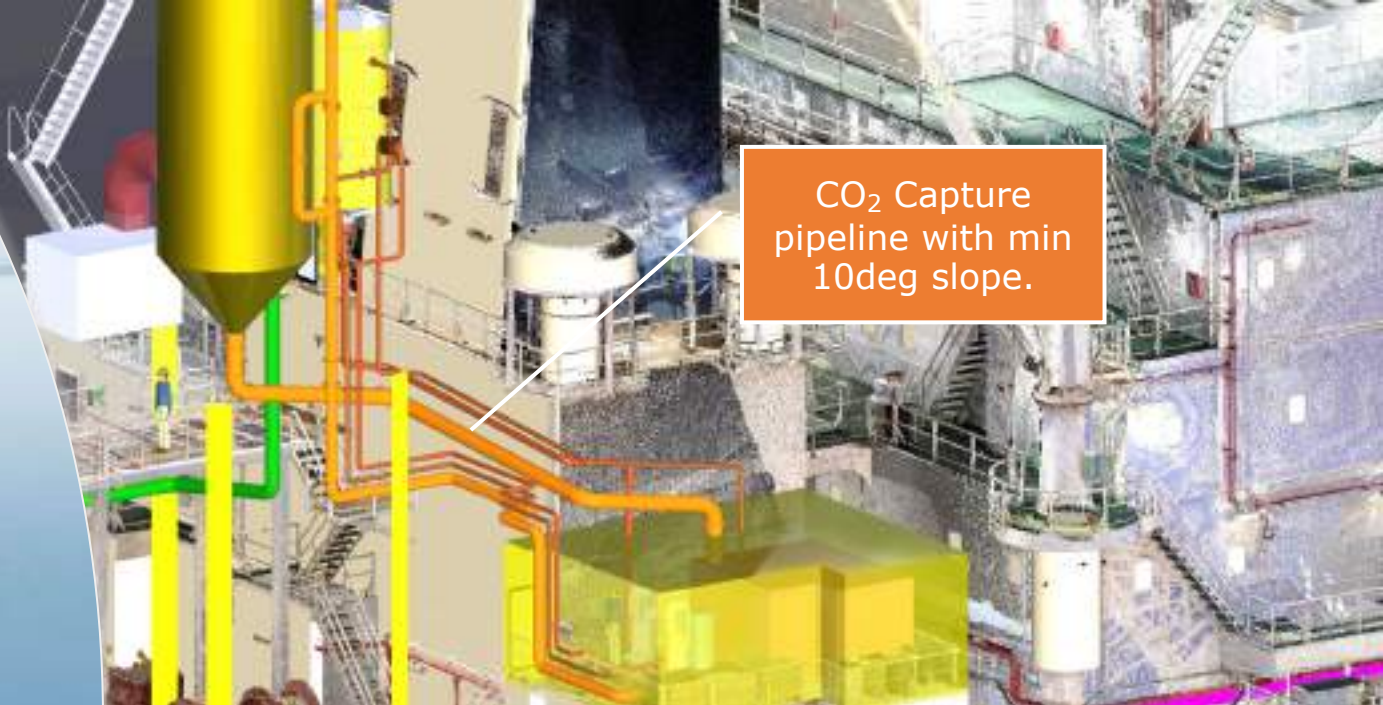


MAIN AREAS OF CCS INSTALLATION & CHALLENGES

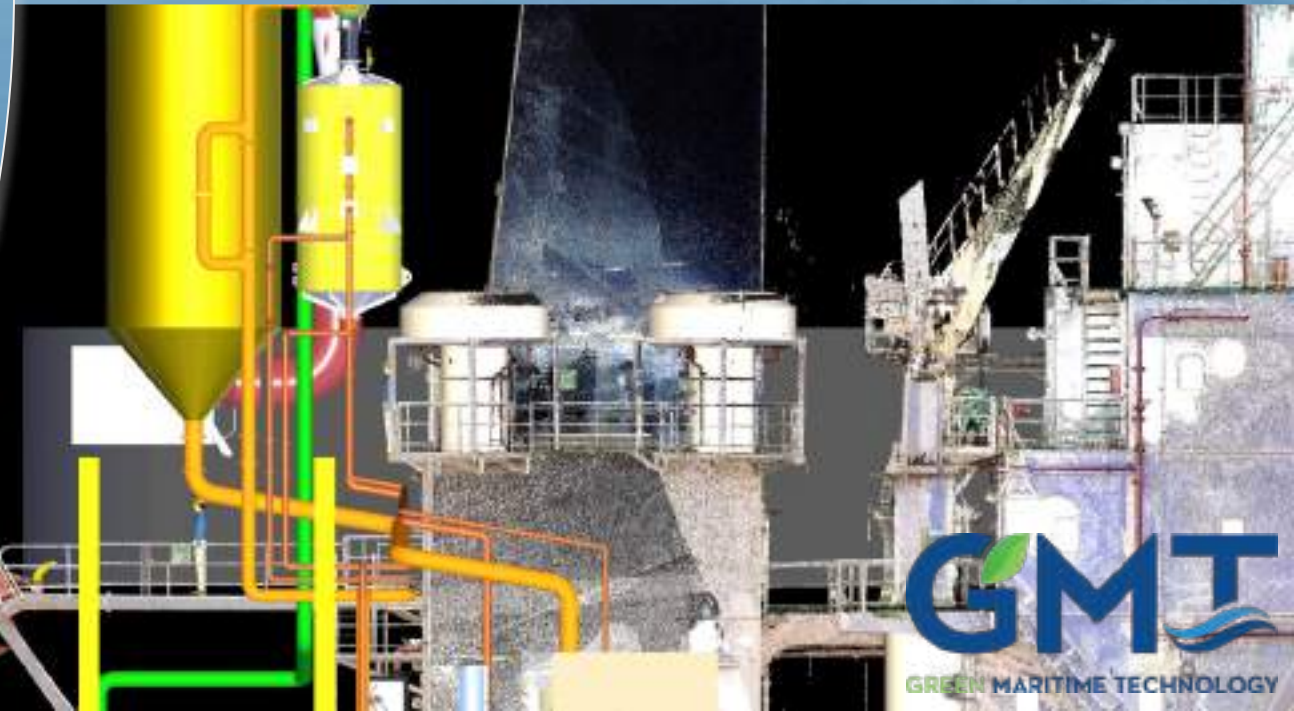


New constructed technical space (other machinery space), for the new amine process tank, B deck

- Components: Amine tank, System's main pumps associated with Absorbing pump, Regeneration pump
- Dimensions: (approx.)
technical space: 6.40m x 7.40m x 3.15m
Amine tank: 25m³
- Challenges: Piping installation with the required slope.
- **Installation notes:**
 - As per ECOSPRAY guidelines all the required pipelines have been designed with a minimum slope of 10deg



CO₂ Capture pipeline with min 10deg slope.





MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Steering Gear Room & Engine room 2nd deck

➤ Components: Vacuum Pump and Air-Cooled Condenser, Chillers and Compressors

➤ Dimensions:

Vacuum Pump Unit: 7.30mx3.90mx5.50m

Chillers 1st stage: 3.90mx2.10mx2.50m

Chillers 2nd stage: 4.60mx1.60mx2.50m

Compressors(*): 3.00mx1.60mx2.50m

➤ Challenges: Large equipment's size and maintenance space. Additional mechanical ventilation in the Steering Gear room, to comply with class requirements.

E/R

S.G.R

E/R

S.G.R

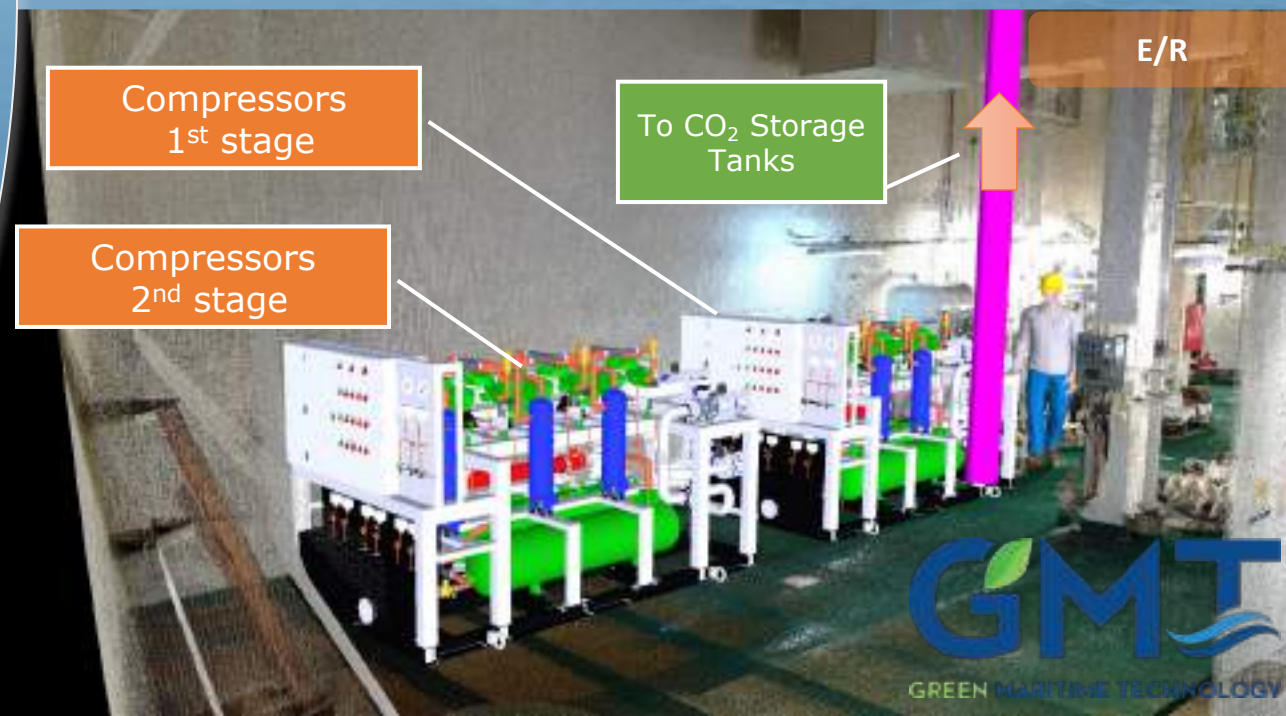
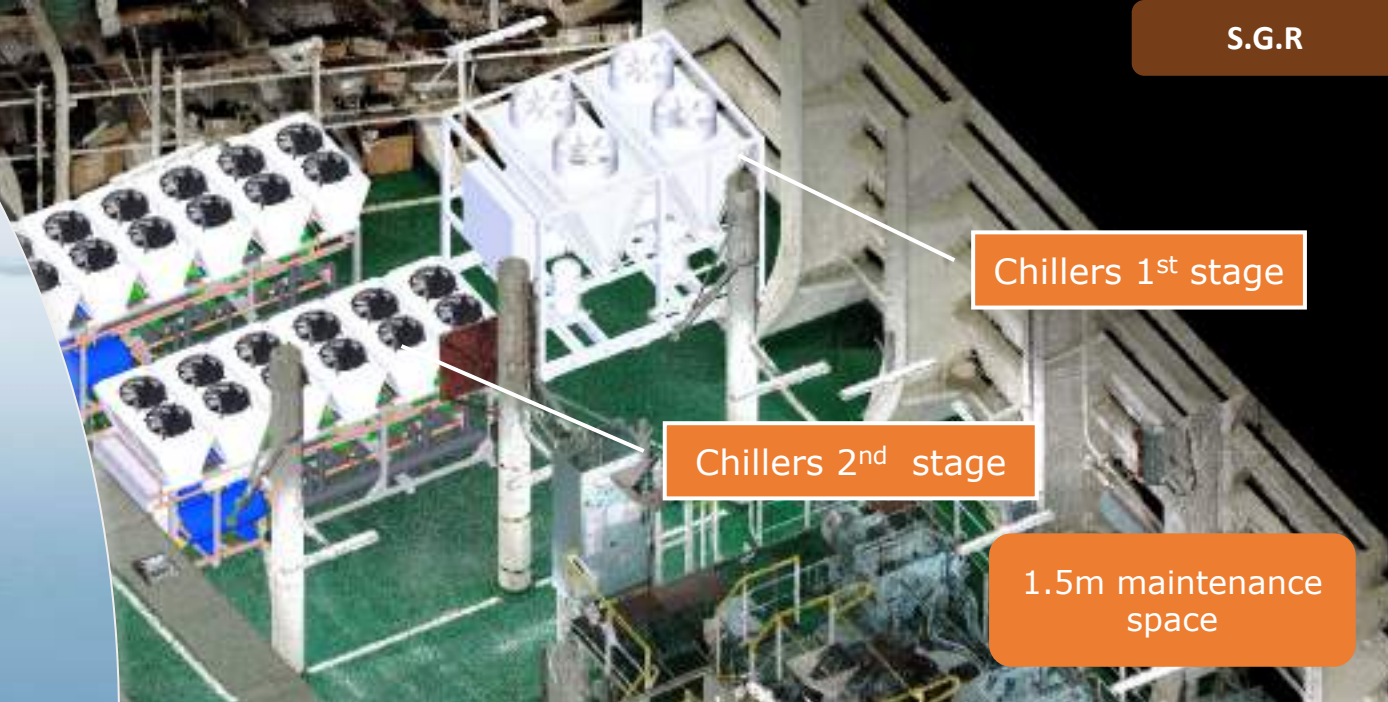


MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Steering Gear Room & Engine room 2nd deck

- Components: Vacuum Pump and Air-Cooled Condenser, Chillers and Compressors
- Dimensions:
 - Vacuum Pump Unit: 7.30mx3.90mx5.50m
 - Chillers 1st stage: 3.90mx2.10mx2.50m
 - Chillers 2nd stage: 4.60mx1.60mx2.50m
 - Compressors(*): 3.00mx1.60mx2.50m
- Challenges: Large equipment's size and maintenance space. Additional mechanical ventilation in the Steering Gear room
- **Installation notes:**
 - Chillers requires at their perimeter 1.5m maintenance space for their proper operation



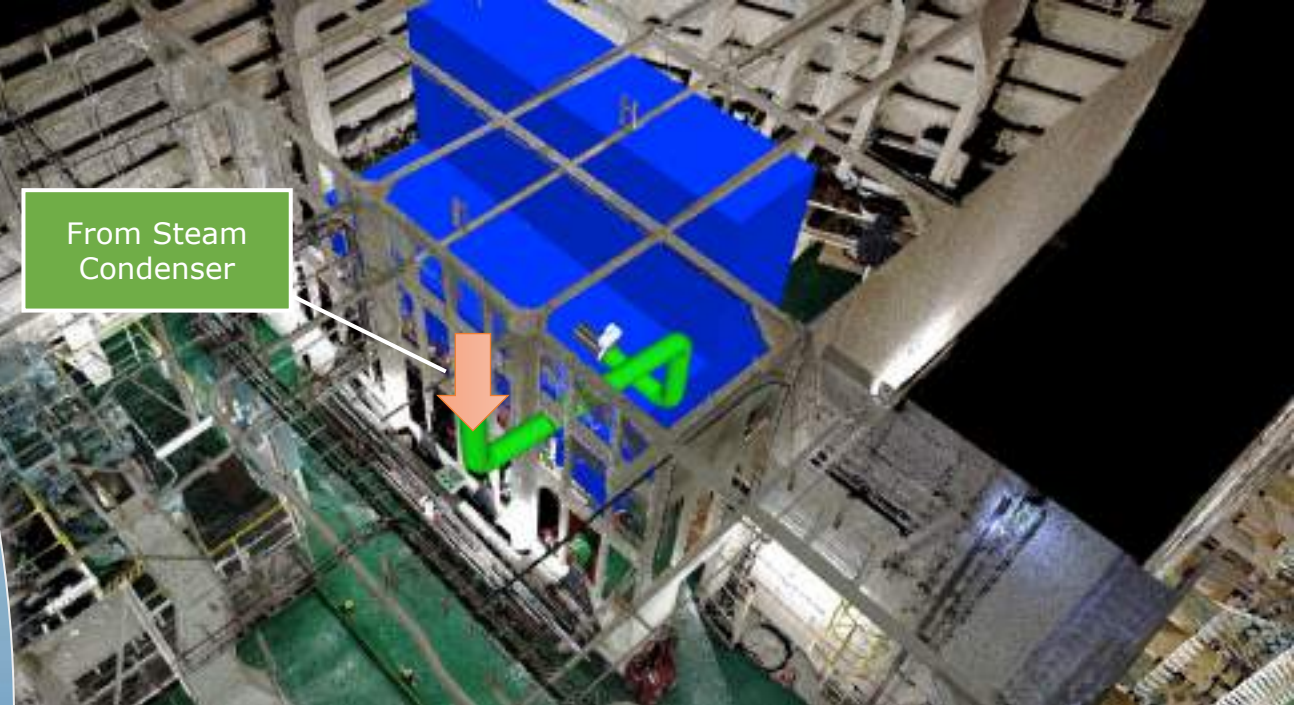


MAIN AREAS OF CCS INSTALLATION & CHALLENGES

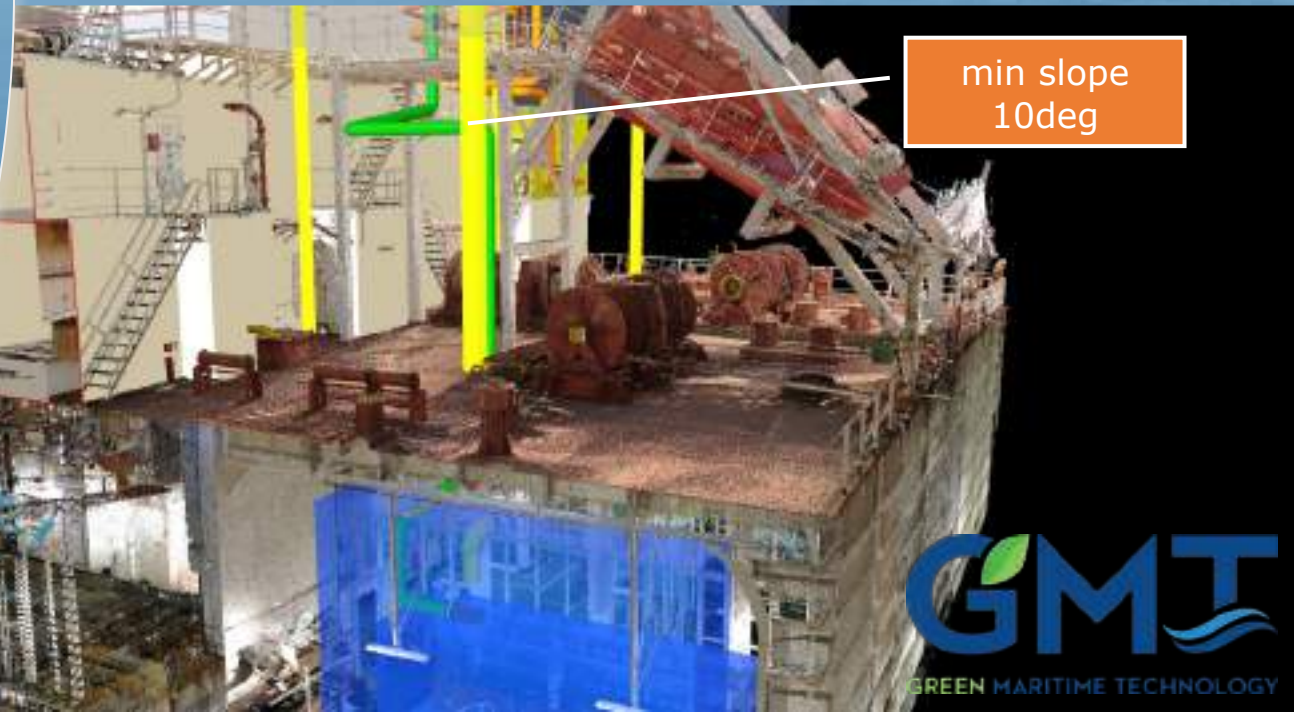


Steering Gear Room & Engine room 2nd deck

- Components: Vacuum Pump and Air-Cooled Condenser, Chillers and Compressors
- Dimensions:
 - Vacuum Pump Unit: 7.30mx3.90mx5.50m
 - Chillers 1st stage: 3.90mx2.10mx2.50m
 - Chillers 2nd stage: 4.60mx1.60mx2.50m
 - Compressors(*): 3.00mx1.60mx2.50m
- Challenges: Large equipment's size and maintenance space. Additional mechanical ventilation in the Steering Gear room
- **Installation notes:**
 - As per ECOSPRAY guidelines all the required pipelines have been designed with a minimum slope of 10deg.



From Steam
Condenser



min slope
10deg



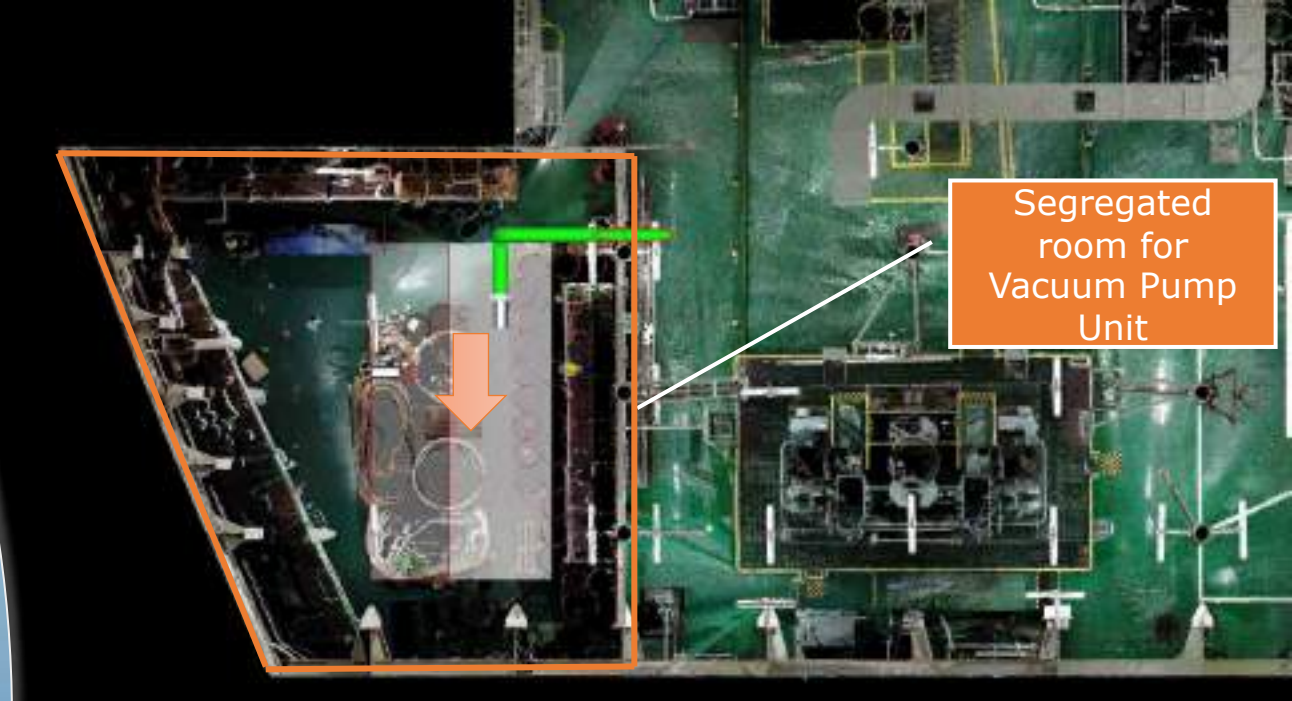
MAIN AREAS OF CCS INSTALLATION & CHALLENGES



Steering Gear Room & Engine room 2nd deck

- Components: Vacuum Pump and Air-Cooled Condenser, Chillers and Compressors
- Dimensions:
 - Vacuum Pump Unit: 7.30mx3.90mx5.50m
 - Chillers 1st stage: 3.90mx2.10mx2.50m
 - Chillers 2nd stage: 4.60mx1.60mx2.50m
 - Compressors(*): 3.00mx1.60mx2.50m
- Challenges: Large equipment's size and maintenance space. Additional mechanical ventilation in the Steering Gear room
- Installation notes:
 - The sub compartment of S.G.R, where the Vacuum Pump Unit is placed to segregated → Machinery Space with Mechanical Ventilation

CARBON CAPTURE & STORAGE PROJECT



Segregated
room for
Vacuum Pump
Unit



Segregated
room for
Vacuum Pump
Unit



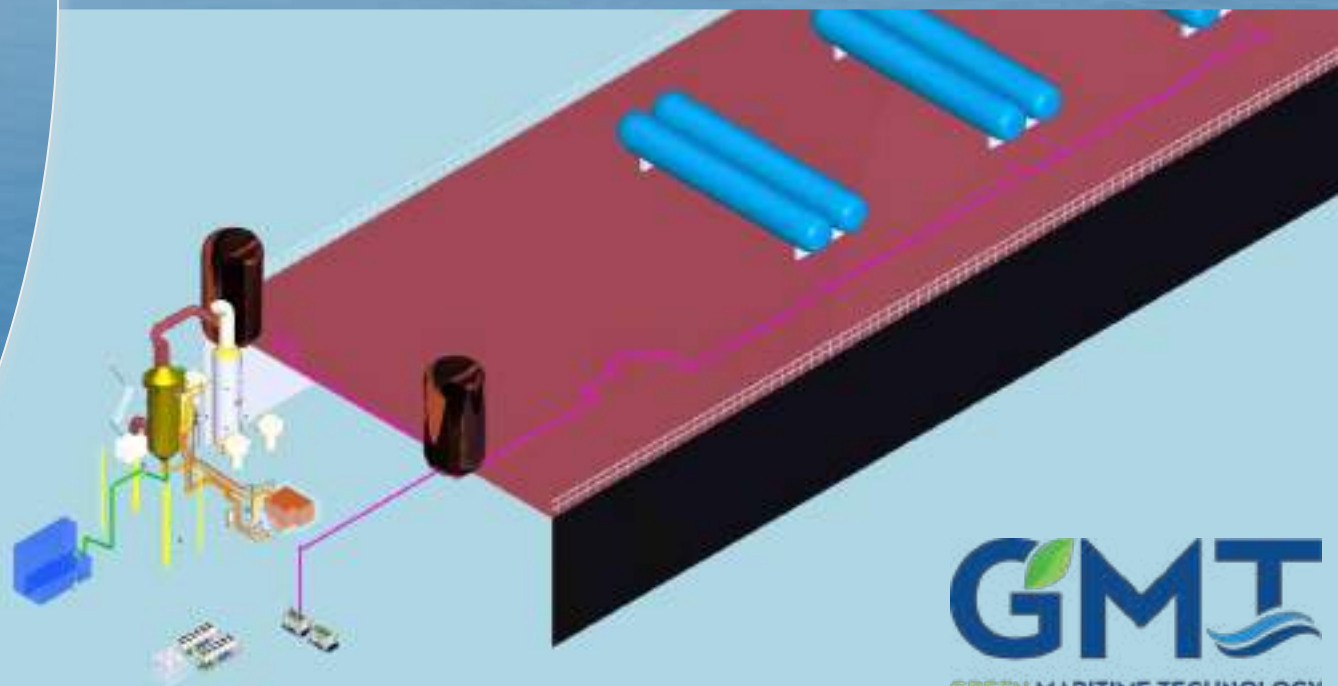
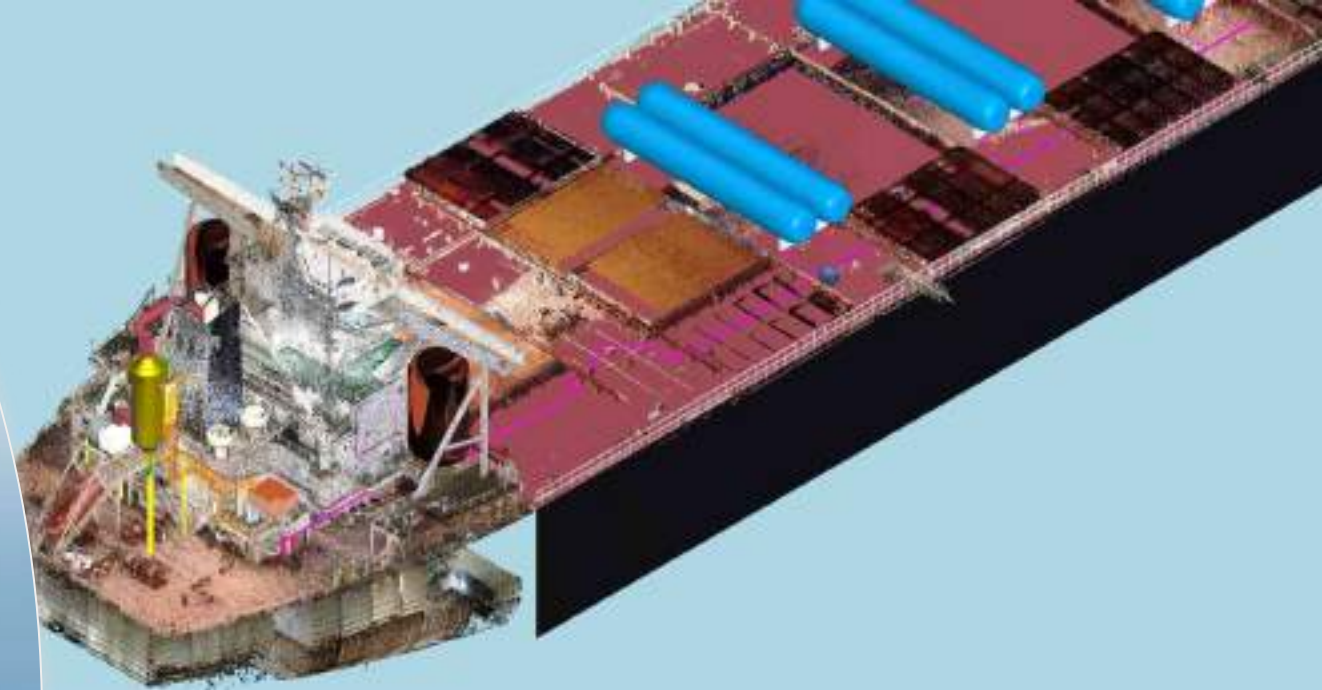
ONBOARD INSTALLATION

CCS DRY WEIGHT & STABILITY ANALYSIS

Added weight

- Estimated dry weight for the CCS installation

Description	Weight
CCS Equipment	130 ton
LCO ₂ storage tanks (~1800m ³)	650 ton
Piping/Foundation etc.	150 ton
Total estimated CCS dry weight	950 ton





CCS DRY WEIGHT & STABILITY ANALYSIS



Stability Analysis:

Based on the rough estimation regarding the total added dry weight, the following issues will be raised:

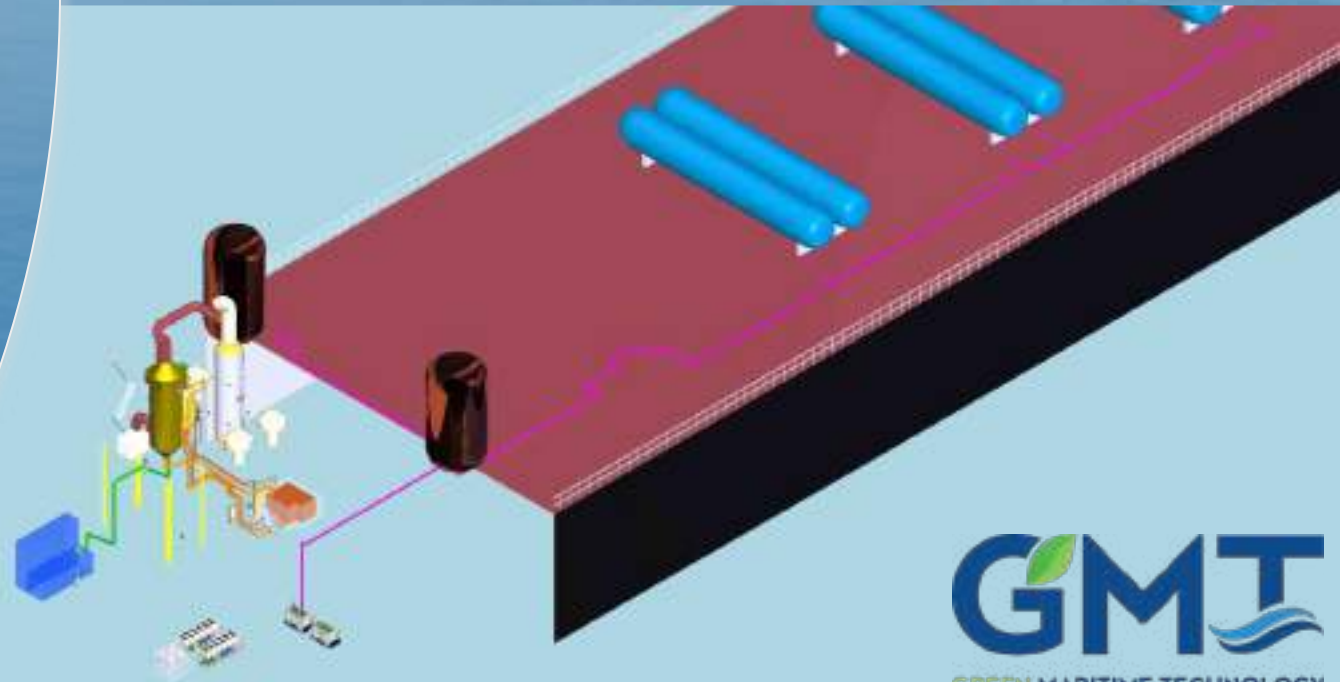
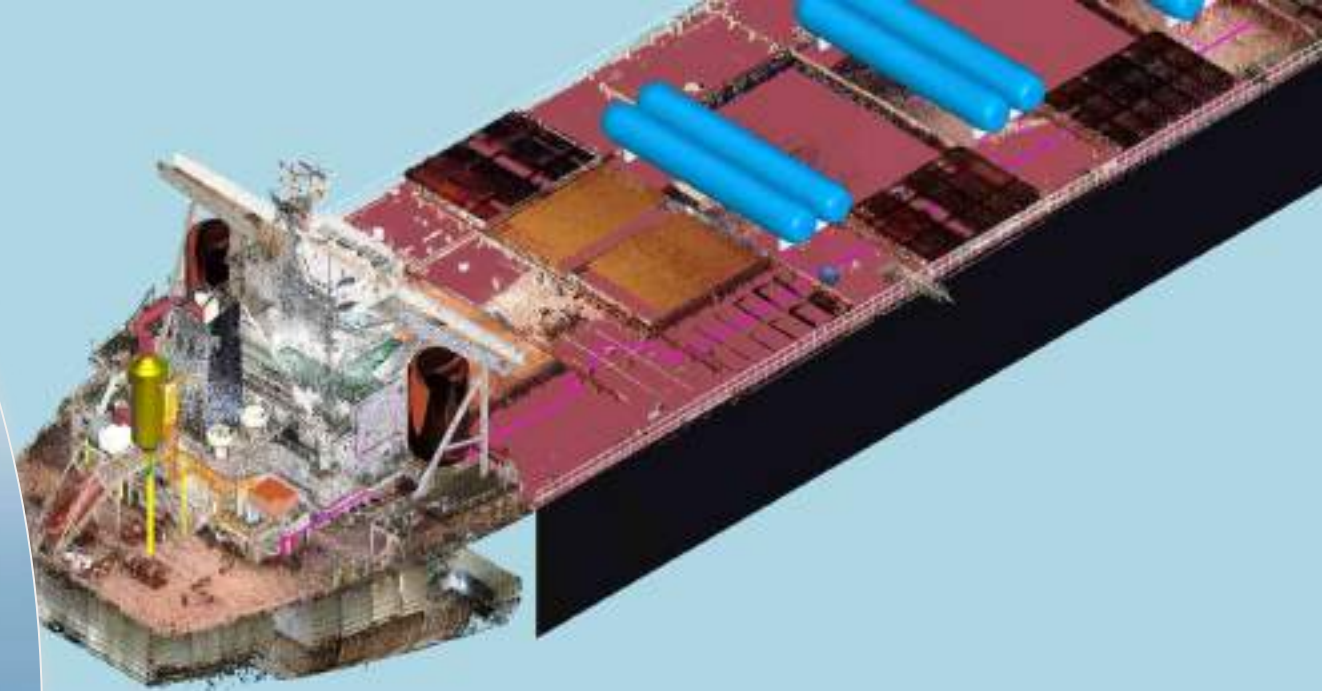
- **added weight > 1% Lightship**
- **$\Delta VCG > 0.5\%$**



➤ **Installation notes:** ⚠

As a result, the following possible actions will be required:

- ✓ **Inclination test**
- ✓ **Reduction of Cargo Carriage**





CCS CONSUMPTIONS

Capture CO₂ at Design Point: **1980 kg/h**

CCS consumptions on 20% CO₂ Capture Rate

➤ Electrical consumption:

at Normal Sea Load: **1051 kW**

➤ **Installation notes:**



Based on the Electric Load Analysis, the existing number of DG is not sufficient to cover CCS needs at all vessel's operation, considering one DG off for redundancy at sea.

✓ **New Shaft Generator** will be required.

Item	Sea service	Maneuvering	Loading & unloading	Rest in port
Total kW - Original	1337.3	1248.4	1683.5	461.8
No of DG	2	2	3	1
Load factor (%)	74.3%	69.4%	62.5%	51.3%
CCS kW cons.	1051	570	250	250
Total kW - with CCS	2388.3	1818.4	1933.5	711.8
No of DG	3	3	3	1
Load factor (%)	88.5%	67.3%	71.6%	79.1%



CCS CONSUMPTIONS

Capture CO₂ at Design Point: **1980 kg/h**

CCS consumptions on 20% CO₂ Capture Rate

➤ Cooling Sea Water Consumptions:

at max. CCS operation: **98.7 m³/h**

➤ Installation notes:

- ✓ Based on vessel's available CSW system, the CCS consumption **will be sufficient** for the subject use.
- ✓ A **new CSW booster pump** might be required.

Cooling Sea Water Consumptions

Utilizer	Heat Duty	CSW Flow
	kW	m ³ /h
Total	1176	98.7



CCS CONSUMPTIONS

Capture CO₂ at Design Point: **1980 kg/h**

CCS consumptions on 20% CO₂ Capture Rate

➤ Hot Technical Water Consumptions:

at max. CCS operation: **135.0 m³/h**

➤ **Installation notes:**

- ✓ A **new Heat Exchanger** will be installed near to vessel M/E Jacket FW system, as a bypass line to M/E Jacket FW cooler, to cover the FW cooling demands.
- ✓ A **new FW booster pump** might be required.

Hot Technical Water Consumptions

Utilizer	FW Flow
	m ³ /h
Amine Heat Exchanger	135



CCS CONSUMPTIONS

Capture CO₂ at Design Point: **1980 kg/h**

CCS consumptions on 20% CO₂ Capture Rate

➤ Steam Consumptions:

at max. CCS operation: **1157 kg/h**

➤ Installation notes:



Based on vessel's available Steam system, the existing Boiler (and in conjunction with oil fired section) is not sufficient for the CCS consumption.

- ✓ Vessel's spare steam production will be used for CCS needs.
- ✓ **An independently new Boiler will be required**, for the remaining steam consumption needs (fuel oil type: MDO).

Steam Consumptions

Source	Steam production	Additional fuel cons.	Additional CO2 emission
	kg/h	kg/h	kg/h
CCS steam demand	1157	-	-
Exhaust gas section (MCR 60%)	650	-	-
Oil fired section	507	38.5	123.5
Total	1157	38.5	123.5



CONCLUSIONS



CCS installation areas: upper deck, open deck areas (poop deck), Engine room and Steering Gear room.



System significant footprint will affect vessel's **stability**; thus, inclination test will be required and possible reduction of cargo carriage.



High electrical consumption.

New Shaft Generator will be required or a new extra Diesel Generator.



LCO₂ storage tanks need to be determined upon communication with tank's relative maker.



High steam consumption.

A new independently new Boiler will be required (fuel oil type: MDO)



Cooling Sea Water & Hot Technical Water consumption are sufficient.

New booster pumps might be required.





Road to 2050

*Amines and Lime milk-based
Carbon Capture pilot plant*

Installation onboard & testing

THANK YOU!!!