

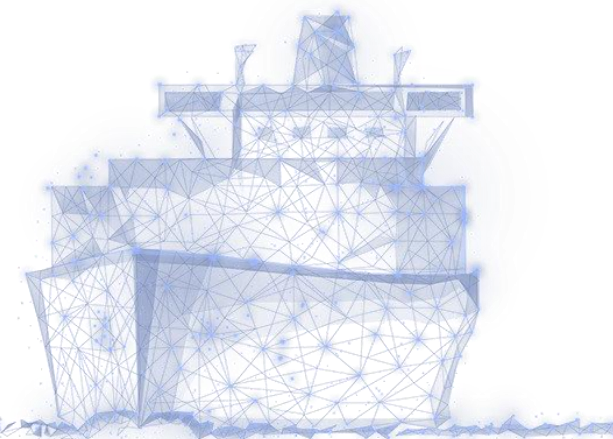


Onboard Carbon Capture Applications & Perspectives



China Classification Society (CCS)

September 11, 2025



1

Background

2

Applications

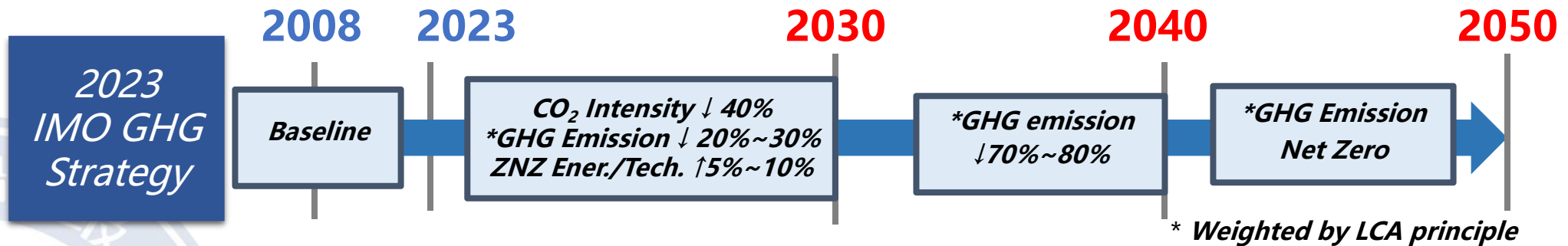
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Perspectives



1 Background

IMO STRATEGY ON REDUCTION OF GHG EMISSIONS FROM SHIPS



- Transition to Alternative Fuel (AF) is a fundamental pathway but with challenges.
- Onboard Carbon Capture (OCC) will be a notable, complementary measure.

2 Applications

Associated Industry Overview

Production

Onboard Application

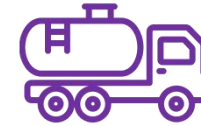
Unloading operation

Transportation

Sequestration



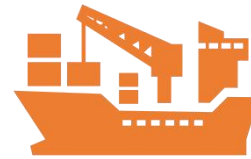
- Onboard tank container unloading
- Ship to Truck unloading
- STS unloading



- Land/Seabed Seq.



- Large Container in operation
- New BC with OCCS under building
- Existing BC under retrofiting
- More OCCS ready ships under building
- First FPSO with OCCS delivered in 2025



Unloading Operation

* SHANGHAI QIYAO



Dedicated LCO₂ Carrier



* ZHOUSHAN DEJIN SHIPPING



ENPING 15-1 Seabed Seq. in operation from June 2023



FPSO with OCCS (in operation)

* COSCO SHIPPING INDUSRY website

CSSC 上海齐耀环保科技有限公司 SHANGHAI QIYAO ENVIRONMENTAL TECHNOLOGY CO., LTD.

海德威科技集团(青岛)有限公司 HAI DE WEI TECHNOLOGY GROUP CO., LTD.

CSSC 中船动力(集团)有限公司 CPGC

COSCO SHIPPING 威海中远海运重工科技有限公司 COSCO SHIPPING HEAVY INDUSTRY TECHNOLOGY (WEIHAI) CO., LTD.

ultrafiltration 宁波环洁超滤科技有限公司 HUANJIE SUPERFILTRATION TECHNOLOGY CO., LTD.

CSSC 双瑞环境 SUNRUI

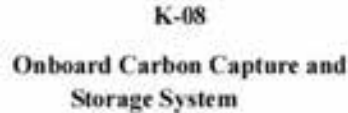
中太能源 Wintech 旺泰 SINO TECH ENERGY

2 Applications

Associated Industry Overview

- *Systematic guidelines by CCS*

Product inspection, Onboard application, Loading & Unloading operation, Dedicated LCO₂ Carrier building, etc.



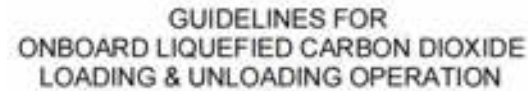
K-08
Onboard Carbon Capture and Storage System



GUIDELINES FOR ONBOARD CARBON CAPTURE SYSTEMS

2023

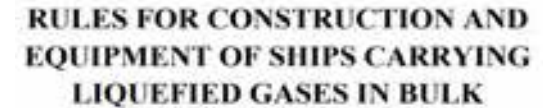
Effective from 1 January 2024



GUIDELINES FOR ONBOARD LIQUEFIED CARBON DIOXIDE LOADING & UNLOADING OPERATION

2025

Effective from 1 July 2025



RULES FOR CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK

Version: 2022, RCN No.1

Appendix 9 APPLICABLE REQUIREMENTS FOR SHIPS DEDICATED TO CARRY LIQUEFIED CARBON DIOXIDE IN BULK

- *Associated National Standards*

GB/T 42797-2023 Carbon dioxide capture, transportation and geological storage - Pipeline transportation systems

GB/T 45121-2024 Technical specifications of energy consumption measurement for flue gas CO₂ capture system in thermal power plants

GB/T 45126-2025 Determination of carbon dioxide content of steel slag during carbonation fixation

GXX Carbon dioxide capture, transportation and geological storage—Carbon dioxide storage using enhanced oil recovery (CO₂-EOR)

GXX Quality requirements for medium entering the carbon dioxide pipeline

GXX Carbon dioxide capture, transportation and geological storage—Geological storage

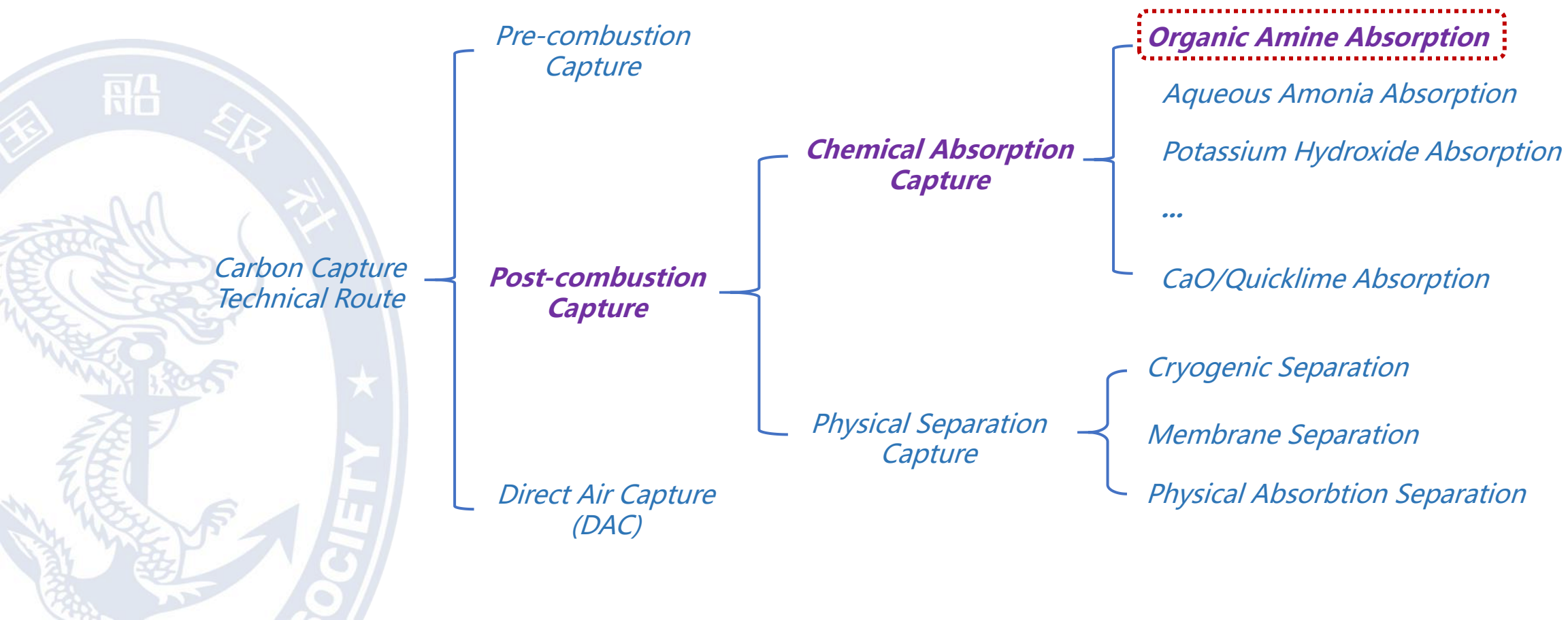
GXX Assessment of CO₂ storage capacity in offshore saline aquifers etc.

- *Methodology for Carbon Capture, Utilization, and Storages verification - under developing*

2 Applications

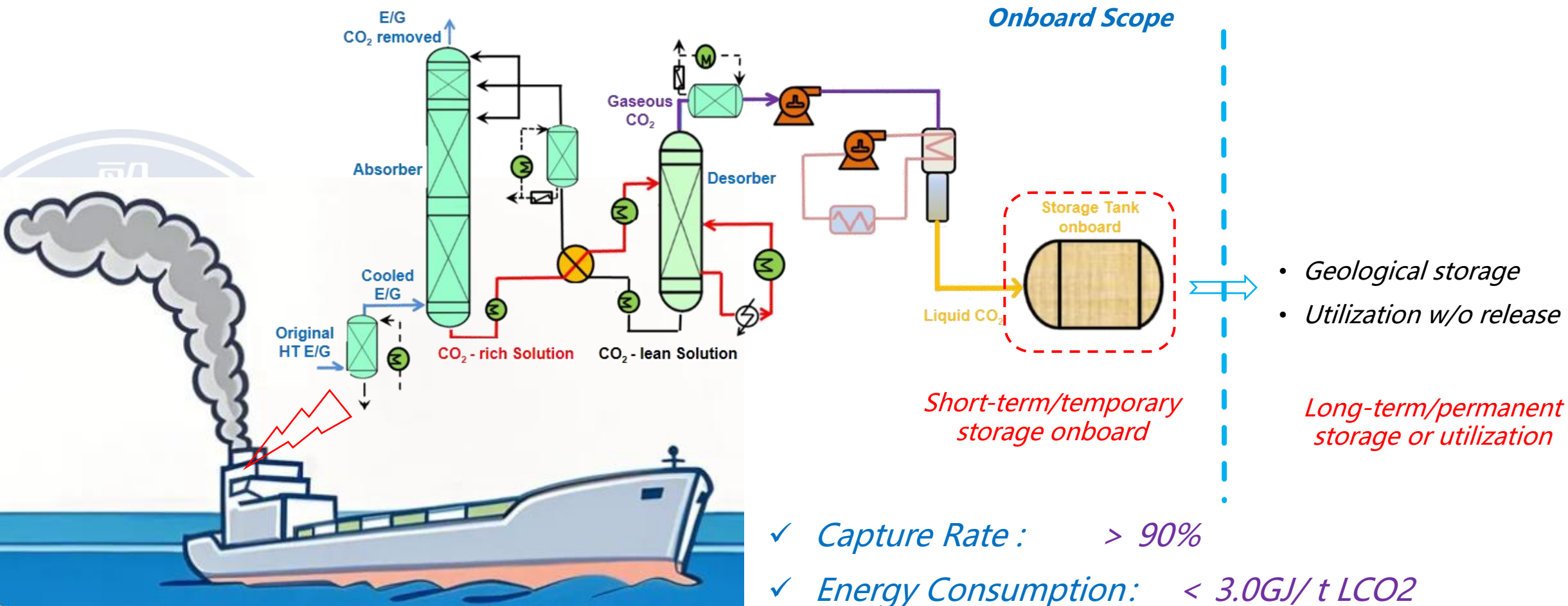
Technical Route

Post-Combustion > Chemical Absorption > Organic Amine (OA) Absorption



2 Applications

Process Onboard (OA Absorption)



2 Applications

Contribution Research

Evaluation Assumptions

OCCS Energy Consumption: $3.0 \text{ GJ} / \text{t LCO}_2$

Onboard Energy Conversion Efficiency: 60%

Lower Calorific Value of MDO: 42.7 MJ/Kg

Equivalent Energy Consumption



$\sim 117 \text{ Kg MDO} / \text{t LCO}_2$



Net CO₂ Emission Reduction onboard



$\sim 0.63 \text{ t} / \text{t LCO}_2$

* $C_f = 3.206$ for MDO in accordance with MEPC.332(76)

Better Net CO₂ Emission Reduction onboard

Should OCCS integrate properly with the onboard system, i.e. fully utilization of the *waste heat* from EG, Cylinder C.W. and *cold energy* from liquefied gas, etc

Contribution under the coming GFI regulation could also be evaluated accordingly.

2 Applications

Contribution Research

Case study: Panamax BC with OCCS

Ship Type	-	Bulk Carrier
DWT	ton	84800
voyage	mile/Y	73558
LSMGO Consumption	ton/Y	738
LSFO Consumption	ton/Y	6052
CO2 Total Release	ton/Y	21435.88
Required CII	-	4.0811
Attained CII	-	3.4365
CII Grade (2023)	-	C
CO2 Capture Rate		50%
CO2 Capture	ton/Y	12604
CO2 Storage volume	M ³	1200*2
Attained CII (With OCCS)		2.02
CII Rate of decline		41.2%

*Evaluation under IMO regulation on short-term measure
(under assumption OCCS contribution was considered in CII)*

2 Applications

Associated R&D



Kamsarmax BC with OCCS



VLCC with OCCS



VLGC with OCCS



16,000TEU Container with OCCS



9,000 PCTC with OCCS



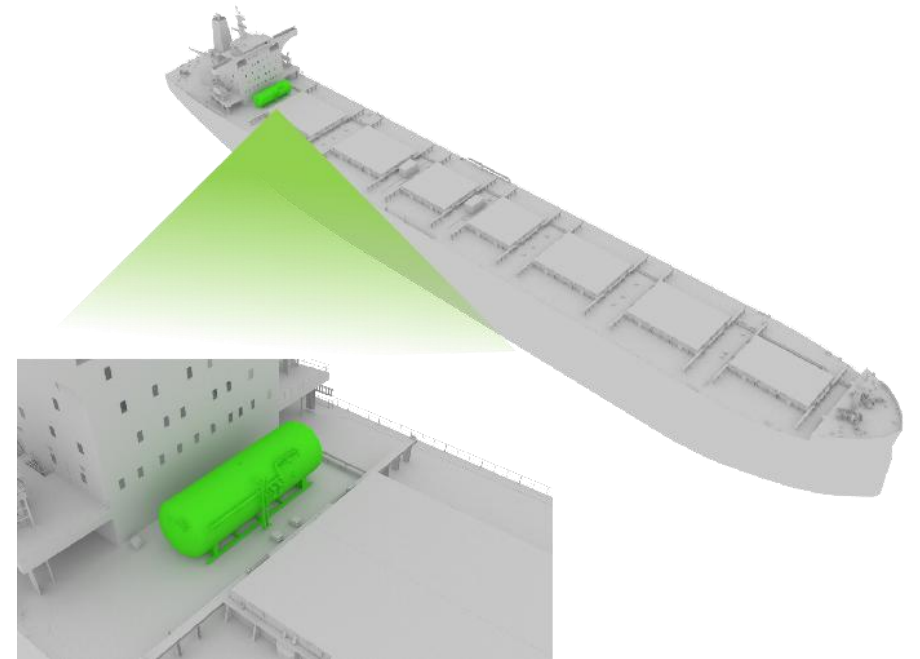
174,000m³ LNGC with OCCS

2 Applications

Onboard Application

82K DWT BC with OCCS -under building

- OCCS Parameter
 - Rated Capacity: 0.5 t/h (designated by owner)
 - Onboard storage tank volume: 300 m³
- OCCS associated Investment:
 - ~ 2 million dollars with abt. 1/3 for the storage tank
- Risk Assessment
 - Risk controllable, No unacceptable challenge exist



2 Applications

Industry Chain building



Site Investigation of LCO₂ Unloading



Zhoushan Dejin Shipping Co., Ltd



*Seminar on OCCS Industry Chain Building
July 2024*

2 Applications

Full Process Application (in operation)



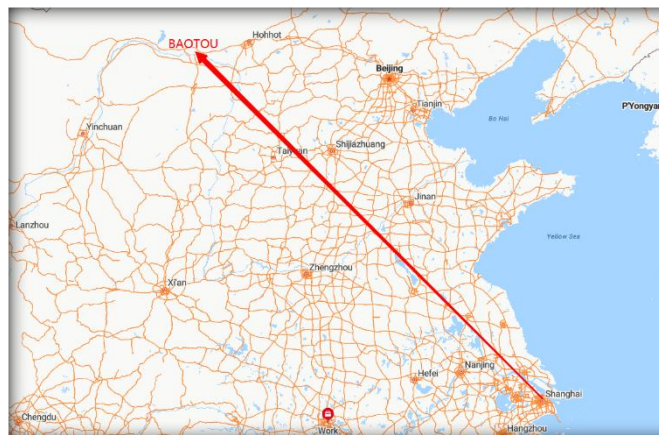
Successful test in ship trial (ship retrofitting), Jan. 2024



Onboard tank to truck & Direct onboard tank unloading Apr. 2024



STS unloading, Jun. 2025



Follow-up treatment on shore



Mineralization magnesium limestone (Huntite)

* from Shanghai Qiyao

3 Perspectives

Application Outlook

- *Existing ship decarbonization*
- *LNG Carrier decarbonization*
- *N. B. decarbonization option*



3 Perspectives

Onboard Carbon Capture System

● *Disadvantages*

- *High energy consumption*
- *Large equipment / Space occupation*
- *Net GHG reduction depends on its integration with onboard energy system*

● *Countermeasures*

- *More higher efficient absorbing agent, more lower energy-consuming absorbing & desorbing , compression & liquefaction process*
- *Compact modularization , functions intergration*
- *Integration technology with the onboard energy system, particularly utilization of the onboard waste heat / cold energy etc.*

3 Perspectives

Regulation

● Challenge

- *OCCS's contribution is not taken into account in mandatory regulations.*

● Suggestion

- *Take OCCS contribution into account in current regulations under short-term measures, e.g. CII.*



3 Perspectives

Follow-up Industry Chain

● Challenge

- *Sequestration of the onboard captured-carbon goes beyond the international shipping sector, so respective international regulations is needed.*
- *Port reception capability building is necessary.*
- *Only geological sequestration is admitted in current regulations, associated business model is hard to be established. Then large scale application of OCCS might be hindered.*

3 Perspectives

Follow-up Industry Chain

● Suggestion

- *LCO₂ Carrier could help the port a lot in its capability building of onboard captured-carbon reception and transfer.*
- *More measures of carbon sequestration are suggested to be permitted while following the principle that "avoid emission into air and discharge into sea that are harmful to the enviroment and ..." .*

***Thanks for
your
Attention!***

