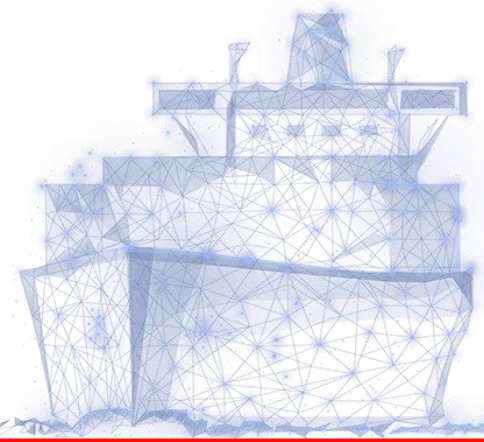
Onboard Carbon Capture Applications & Perspectives

China Classification Society (CCS)

September 11, 2025



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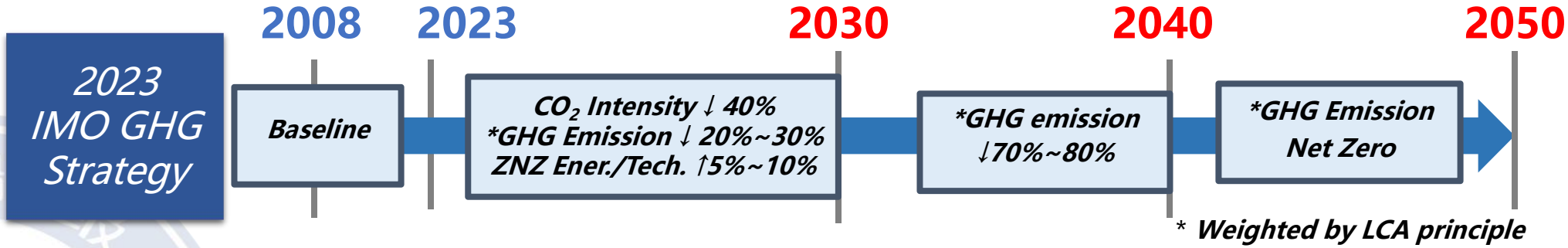
1 Background

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

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

Onboard Application

Unloading operation

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

Transportation

- *Truck*
- *LCO_2 carrier & Truck*
- *LCO_2 carrier*
- *Pipelines*

Sequestration

- *Land/Seabed Seq.*

FPSO with OCCS (in operation)

** COSCO SHIPPING INDUSRY website*

Unloading Operation

** SHANGHAI QIYAO*

Dedicated LCO_2 Carrier

** ZHOUSHAN DEJIN SHIPPING*

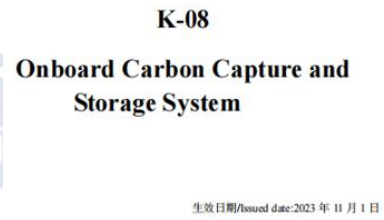
ENPING 15-1 Seabed Seq. in operation from June 2023

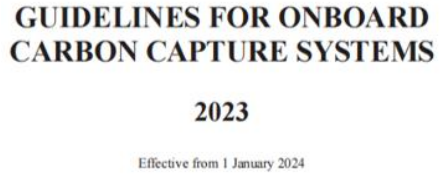
2 Applications

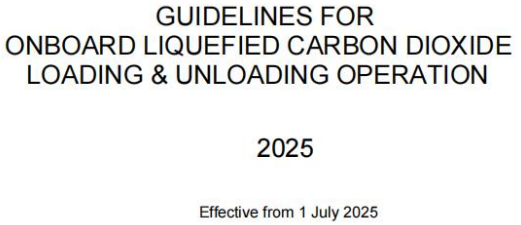
Associated Industry Overview

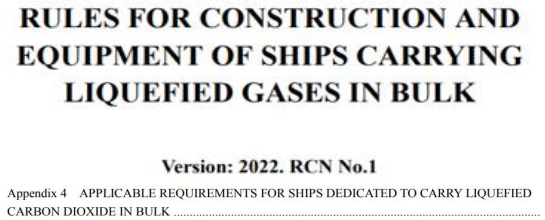
- *Systematic guidelines by CCS*

  Product inspection, Onboard application, Loading & Unloading operation, Dedicated LCO_2 Carrier building, etc.









- *Associated National Standards*

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

  GB/T 45121-2024 Technical specifications of energy consumption measurement for flue gas CO_2 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 (CO_2-EOR)

  GXX Quality requirements for medium entering the carbon dioxide pipeline

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

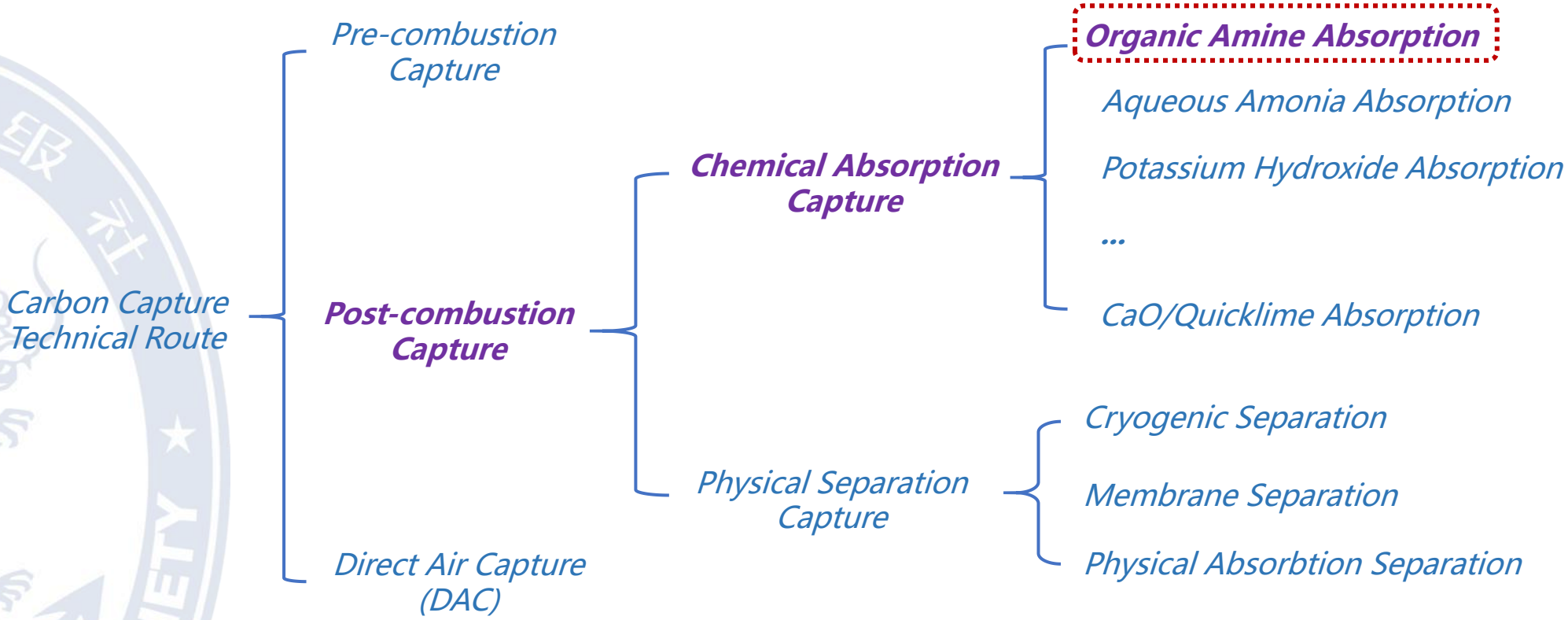
  GXX Assessment of CO2 storage capacity in offshore saline aquifers etc.

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

2 Applications

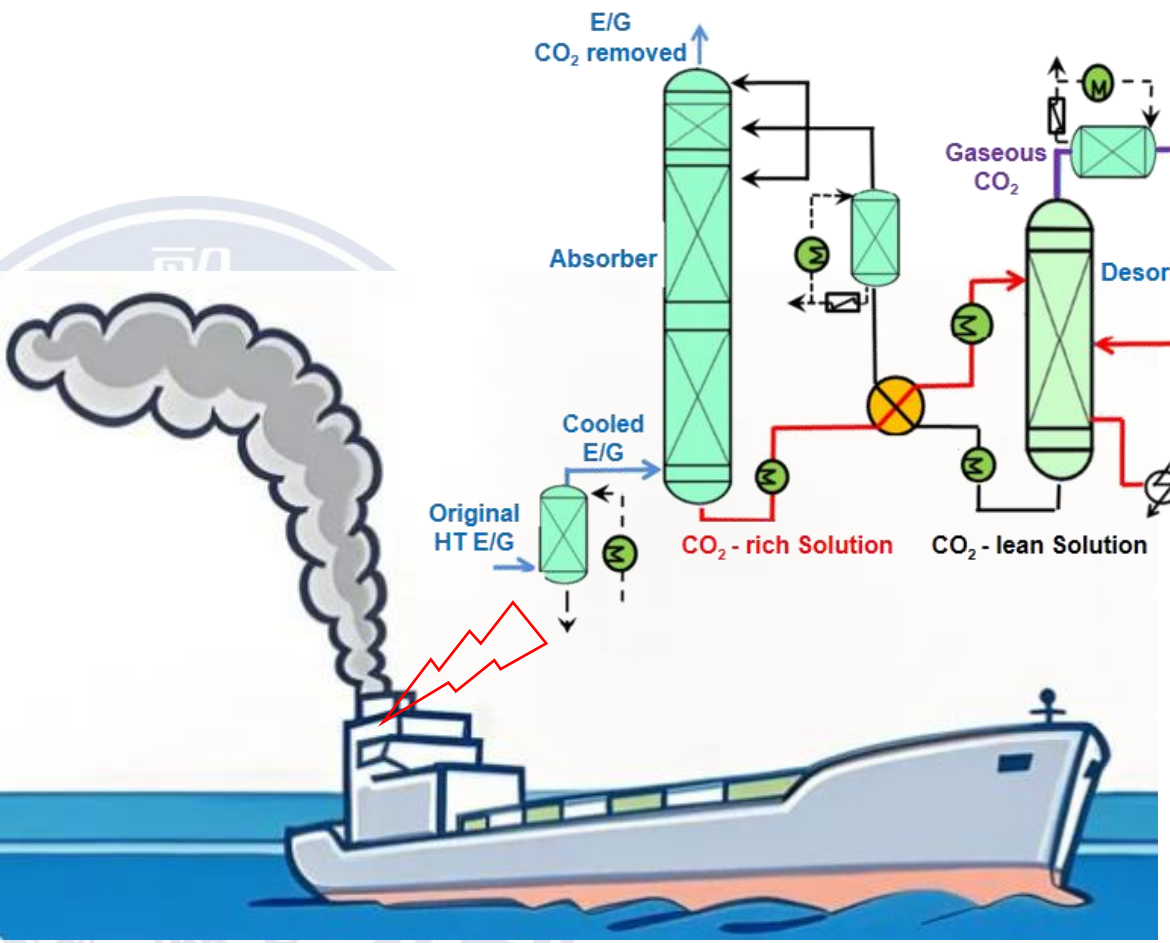
Technical Route

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



2 Applications

Process Onboard (OA Absorption)



- *Geological storage*
- *Utilization w/o release*

Short-term/temporary storage onboard

Long-term/permanent storage or utilization

✓ *Capture Rate : > 90%*

✓ *Energy Consumption: < 3.0GJ/ t LCO2*

2 Applications

Contribution Research

Evaluation Assumptions

OCCS Energy Consumption: 3.0GJ / t LCO_2

Onboard Energy Conversion Efficency : 60%

Lower Calorific Value of MDO: 42.7 MJ/Kg

⟹

Equivalent Energy Consumption

~117 Kg MDO / t LCO_2

⇓

Net CO_2 Emission Reduction onboard

~0.63 t / t LCO_2

⟸

***Better** Net CO_2 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

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

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

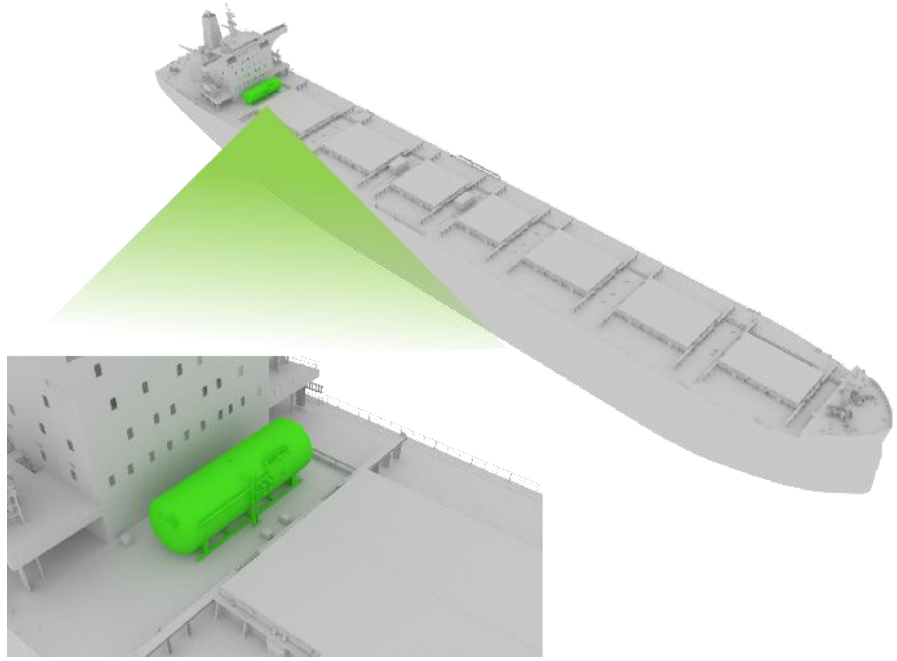
Onboard Application

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 Assesment
  Risk controllable, No unacceptable challenge exist



2 Applications

Industry Chain building

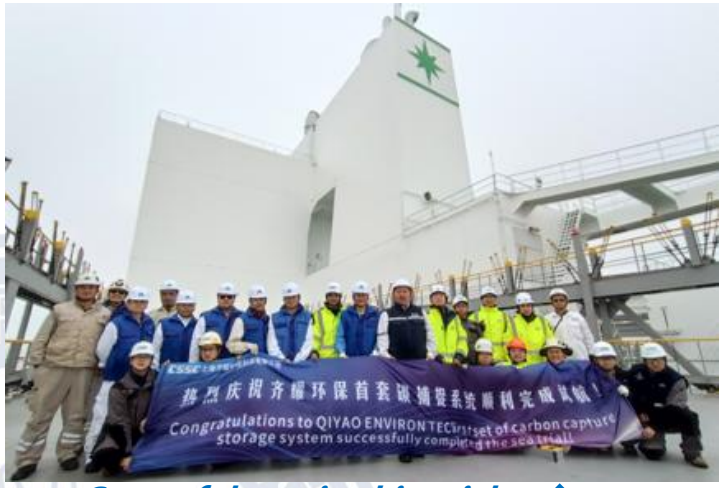
Site Investigation of LCO_2 Unloading

Zhoushan Dejin Shipping Co., Ltd

Seminar on OCCS Industry Chain Building
July 2024

2 Applications

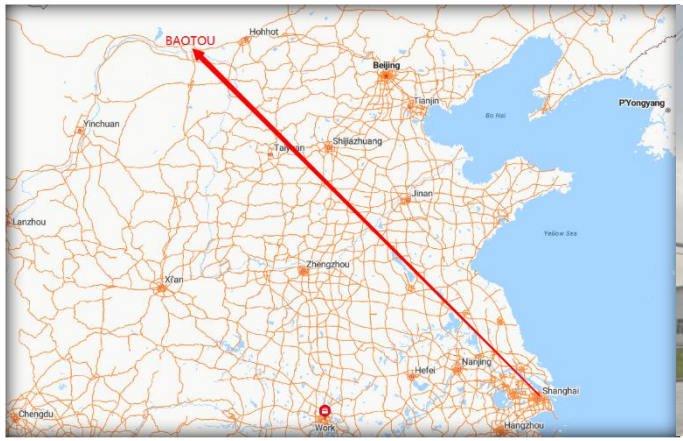
Full Process Application (in operation)



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

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

STS unloading, Jun. 2025



Mineralization magnesium limestone (Huntite)

Follow-up treatment on shore

** 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 comsumtion*
  - *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 techonoloy 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***

  - *LCO_2 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 ..." .*

CCS
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Thanks for your Attention!