Carbon Capture & Storage (CCS)

The Role of CCS in Maritime Decarbonization

14th Oct 2025

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1. Introduction

Compliance & Regulation Framework

- IMO MEPC 78 session (June 2022) introduced the discussion on provisions for considering on-board CO2 capture in the calculation of EEDI, EEXI & CII
- The industry was invited to promote technological initiatives regarding the development of onboard CO2 capture technologies
- Significant R&D efforts are still needed to advance the Technology Readiness Level (TRL) of this technology
- Interested Member States and international organizations to submit concrete proposals for future sessions

CCS: Pros & Cons for the Maritime Industry

The Pros

- **Extraction:** Direct extraction of CO2 from the fossil fuels
- **Application:** It can be applied to all carbon-containing fossil, electro and biofuels
- **Technology:** Proven technology with track record on the shore industry
- **Scalability:** is feasible
- **Circularity:** captured CO2 can be further used in other industries and or trade as a commodity
- **Storage potential:** can be stored permanently underground

The Cons

- **Cost:** High Capex & Opex
- **Footprint:** Installation considerations due to increased footprint
- **Potential Cargo Loss**
- **Application:** CCS shows the most promise for N/Bs. It will be challenging for retrofits entailing substantial costs and major modifications.
- **Energy intensive:** as Carbon Capture requirements lead to higher total fuel consumption (up to 45%) due to regeneration of the chemical used and liquid form storage
- **Global Infrastructure:** Transport/storage network need to be further developed
- **Segregation among vessel types:** Seems to be more promising on large tankers and less to small bulk carriers

2. Amine-based Carbon Capture

On board amine-based carbon capture application

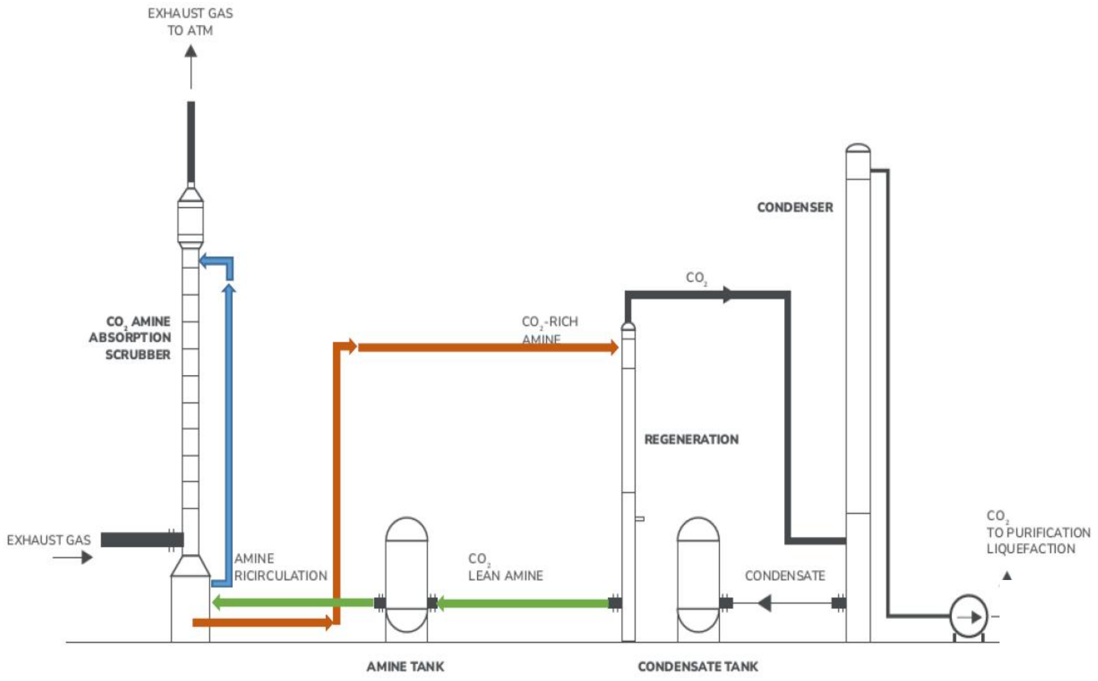
The technology explained

- Amine liquid solution is used as reagent in the CO2-scrubber to reversibly absorb carbon dioxide from the exhaust gas
- CO2-rich amine solution is regenerated (under vacuum and heating) and re-used in the CO2 amine absorption scrubber
- Full-scale plant: desorbed CO2 is liquefied and temporarily stored onboard in cryogenic tanks prior disposal in port (-30ºC, 14bar)

- The regeneration process is very energy intensive and requires additional fuel
- For this reason, additional CO2 needs to be captured, **increasing the size of the plant and the OPEX cost**
- The high regeneration temperature is one of the reasons for the amine chemical degradation
- Amine degradation implies the replacement of the amine batch in order to keep the capturing efficiency performance

- Using **thin-film regeneration**, allows the removal of CO2 from the amine solution at **lower temperatures**
- Optimum combination of temperature, vacuum and low quantity of steam injection

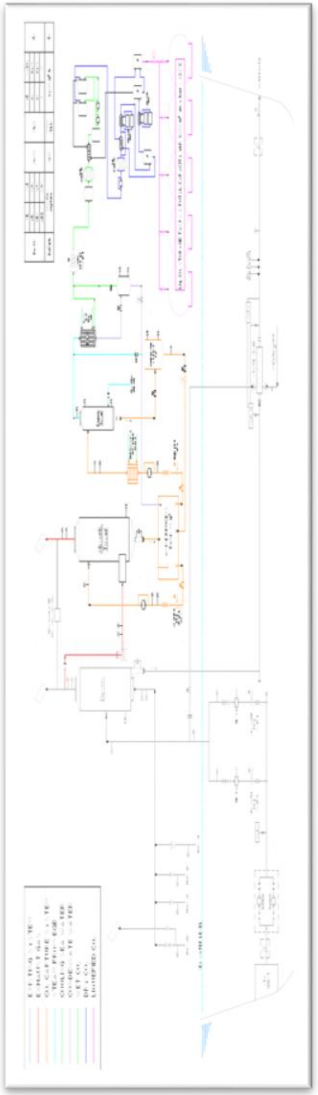
Important saving: In the full-scale system heat can be recovered by the engine cooling system without burning additional fuel



$$CO_2 + NR_3 + H_2O \leftrightarrow HNR_3^+ + HCO_3^-$$

Overall reaction for a tertiary amine. R represents carbon bonded to other species.

3. Pros & cons of the two pilot tested systems (Amine CC vs Lime CC)

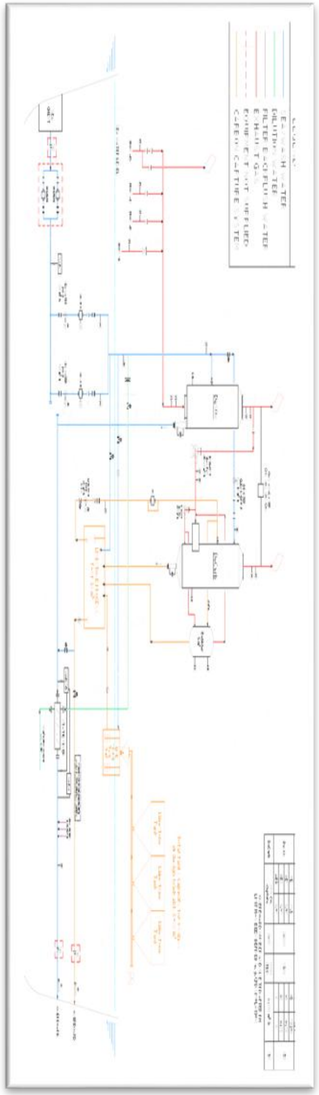


- OPEX of Amine system is lower (~80K €/month)
- Less uncertainty in the regulations for the disposal of the captured CO_2
- More suited for newbuilding projects as the CO_2 storage and the additional electrical energy requirements will be taken into consideration in the design stage

- CAPEX of Lime system is lower (~3.7 mil. € excl. installation)
- System is less complicated in terms of operation
- Lower electric power requirements (~0.4MW)
- More suited for retrofit projects as the process is simpler and the initial cost is lower

- CAPEX of Amine system is higher (~8 mil. € excl. installation)
- Higher electric power requirements (~1.1MW) due to the liquefaction process
- Difficult installation of the CO_2 storage tanks (may require cargo space to be used)
- Additional generator may be required

- OPEX of Lime system is higher (~290k €/month)
- Uncertainty in the regulations regarding the discharge of limestone
- Difficult to find suitable storage space for the lime powder (requires huge dry space, ~4,000m3 for a NCMax 60 days trip)



4. CO_2 Carrier Designs & Shipyard Progress

- Majority of ship-builders with expertise on gas vessel designs have the capacity to offer CO_2 vessel designs on confirmed projects
- Capex: is initially estimated ranging from 38%-70% as % of the newbuild price basis LSFO +OCC
- Obviously principal objective is to increase cargo capacity, but temperature requirements pose challenges
- There is still lack of standardization in project and vessel design
- Owners would need the guarantee of long-term employment and so far, there not many charterers able to provide firm, long term contracts, although expected to grow.
- Indicative yards involved in CO_2 carrier designs: DSME and Samsung are frontrunners and following closely HHI, DSME, Samsung, Mitsubishi, Dalian, Jiangnan and CIMC-SOE &CMJL Yangzhou.
- First LCO_2 carrier delivered to Capital during 2025
- There is an arbitrary estimation that there will be demand of approximately 120 vessels by 2030. DNV mentions an indicative forecast of 200 vessels by 2050.

Source: ABS – White Paper : Carbon Capture, Utilization and Storage


Thank you!