

## PRESS RELEASE

### Landmark study on offloading onboard captured carbon dioxide identifies low port readiness as key barrier to large-scale commercialisation

- Infrastructure and procedures for handling captured carbon dioxide (CO<sub>2</sub>) at ports are currently inadequate
- Defining clear pathways to offload, utilise, and/ or sequester CO<sub>2</sub>, is crucial for large-scale commercialisation of onboard carbon capture and storage

**Singapore, 19 March 2024** - A recent study commissioned by the Global Centre for Maritime Decarbonisation (GCMD), in collaboration with Lloyd's Register and ARUP, has identified low port readiness as a major hurdle bottlenecking the adoption of Onboard Carbon Capture and Storage (OCCS) system as a practicable decarbonisation solution. Whilst the technologies required for offloading onboard captured CO<sub>2</sub> exist at high levels of maturity, safe operationalisation of captured CO<sub>2</sub> transfer by trained personnel has not been demonstrated.

The report, titled "*Concept study to offload onboard captured CO<sub>2</sub>*," found that while a limited number of ports possess the infrastructure to offload liquefied CO<sub>2</sub> (LCO<sub>2</sub>), they are primarily designed to handle food-grade CO<sub>2</sub>. The higher purity standards that accompany this use limits the interoperability of facilities to handle onboard captured CO<sub>2</sub>.

The study examined over ten planned LCO<sub>2</sub> related infrastructure projects worldwide. Located near, or with transport links from, CO<sub>2</sub>-emitting industrial clusters, these projects are likely to handle much larger volumes of captured CO<sub>2</sub> than that from OCCS systems; port infrastructure needed for offloading, storing and transporting onboard captured CO<sub>2</sub> will likely need to be integrated with these projects for economies of scale. However, as many of such projects remain in concept phase and have not reached Final Investment Decision (FID), ports have not proceeded with offloading infrastructure investments. This chicken-and-egg dilemma highlights the overall infancy of the carbon value chain.

Furthermore, introducing LCO<sub>2</sub> offloading into already complex port operations will likely impact port efficiency and operational performance. The need for additional buffer zones to address the safety concerns of LCO<sub>2</sub> handling and storage will also add to existing space constraints at ports and terminals.

## About the study: Addressing the gap in the carbon capture value chain

This 9-month long study aims to address a gap in the onboard carbon capture value chain. OCCS has recently gained traction as a potential interim solution to help international shipping meet IMO's emissions reduction targets, with potential deliberations at future Marine Environment Protection Committee (MEPC) sessions. While achieving emissions reductions through OCCS hinges on successfully integrating a shipboard-compatible system within space constraints, equally important is addressing the fate of captured CO<sub>2</sub> by establishing its utilisation or sequestration pathways.

This study complements GCMD's Project REMARCCABLE (Realising Maritime Carbon Capture to demonstrate the Ability to Lower Emissions) by addressing the feasibility of OCCS as a practicable, end-to-end solution at scale. For OCCS systems to be operationally feasible, the industry needs to develop a collaborative ecosystem to enable the value chain for managing captured CO<sub>2</sub>.

By systematically considering the needs of the entire value chain, this study evaluated four concept configurations of offloading infrastructure from a possible 162 scenarios, identified the operational standards and safety guidelines for handling LCO<sub>2</sub>, developed models for the quantification of costs for scaled-up infrastructure, articulated manpower competency frameworks for offloading operations, and analysed the potential regulatory scenarios needed to address the current uncertainties surrounding LCO<sub>2</sub> offloading from OCCS.

### Concepts for safe offloading of LCO<sub>2</sub>

One of the key considerations is to examine how LCO<sub>2</sub> can be offloaded safely to the appropriate infrastructure.

The study determined that captured CO<sub>2</sub> in its liquefied form is likely the most efficient and cost-effective option for onboard storage and transport. Based on this, the study shortlisted four concepts covering key offloading modalities, such as Ship-to-Ship and Ship-to-Shore, serving as building blocks that can be combined to cover a wider range of offloading concepts. (Please refer to Appendix I for the infographics on these four concepts).

In ranking the operability of these concepts, the study identified Ship-to-Ship and Ship-to-Shore transfers using an intermediate LCO<sub>2</sub> receiving vessel as the most promising modalities for offloading at scale, with captured CO<sub>2</sub> eventually sequestered or used as feedstock for manufacturing synthetic fuels.

Ship-to-Terminal transfer of captured CO<sub>2</sub> stored in ISO tank containers was identified to be more compatible at smaller scales and for end uses that require higher grades of CO<sub>2</sub>. This modality of transfer is also most compatible with existing port infrastructure and therefore easier to pilot today.

## Safety considerations handling LCO<sub>2</sub>

Handling LCO<sub>2</sub> onboard presents a unique set of safety challenges not commonly encountered when handling fuels in shipping. The study offers an in-depth examination of hazards, such as asphyxiation and toxicity, if a leak or a loss of containment takes place.

Unique to CO<sub>2</sub> is evaluation of its storage at conditions near its triple point, where the gaseous, liquid and solid phases of CO<sub>2</sub> co-exist. Storage at or near the triple point is sensitive to impurities, and minor changes in temperature and pressure can lead to a phase change from liquid to solid CO<sub>2</sub>, leading to hazardous situations, such as blockage in pipes and build-up of pressure.

To address these hazards, a series of safety studies, including a Hazard Identification (HAZID) of offloading, Simultaneous Operations (SIMOPS) and a coarse Quantitative Risk Analysis (QRA), were conducted and mitigation measures and emergency response procedures articulated for handling LCO<sub>2</sub>.

Professor Lynn Loo, CEO of GCMD, said, "While pilots have successfully demonstrated numerous capture technologies onboard ships, it is still uncertain how captured carbon on merchant ships can be safely offloaded, and what the rest of the value chain looks like. This study sheds light on these challenges, and highlights recommendations to holistically address these concerns for parties interested in advancing OCCS / LCO<sub>2</sub> offloading concepts."

Nick Brown, LR CEO said: "The maritime industry requires a comprehensive understanding of the safety and operational challenges posed by all emissions reduction technologies. This study, which focused on port readiness and considerations for the safe handling and offloading of LCO<sub>2</sub>, addresses some of the gaps that exist in the carbon capture value chain and will support industry stakeholders in making informed investment decisions around carbon capture solutions and the creation of regulatory and operational guidelines."

Robert Cooke, Design Lead of Arup said, "As a result of the study, it has been promising to see how transferable existing CO<sub>2</sub> industrial knowledge is to an offloading application. Arup brought together energy and maritime capabilities to outline the concepts for onboard captured CO<sub>2</sub> offloading and develop how this new process can practically and safely integrate into busy port environments. We look forward to seeing the technologies and implementation develop into effective marine decarbonisation solutions."

To access the full study findings, please download the report [here](#).

## About the Global Centre for Maritime Decarbonisation

The Global Centre for Maritime Decarbonisation (GCMD) was established as a non-profit organisation on 1 August 2021 with a mission to support the decarbonisation of the maritime industry by shaping standards, deploying solutions, financing projects, and fostering collaboration across sectors.

Founded by six industry partners namely BHP, BW Group, Eastern Pacific Shipping, Foundation Det Norske Veritas, Ocean Network Express and Seatrimum (formerly Sembcorp Marine), GCMD also receives funding from the Maritime and Port Authority of Singapore (MPA) for qualifying research and development programmes and projects. To-date, over 100 centre- and project-level partners have joined GCMD, contributing funds, expertise and in-kind support to accelerate the deployment of scalable low-carbon technologies and lowering adoption barriers. Since its establishment, GCMD has launched four key initiatives to close technical and operational gaps in: deploying ammonia as a marine fuel, developing an assurance framework for drop-in green fuels, unlocking the carbon value chain through shipboard carbon capture and articulating the value chain of captured carbon dioxide as well as closing the data-financing gap to widen the adoption of energy efficiency technologies.

GCMD is strategically located in Singapore, the world's largest bunkering hub and second largest container port. For more information, go to [www.gcformd.org](http://www.gcformd.org)

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## About Lloyd's Register

*Trusted maritime advisers, partnering with clients to drive performance across the ocean economy.*

Lloyd's Register (LR) is a global professional services group specialising in marine engineering and technology. With a heritage going back more than 260 years to the establishment of the world's first marine classification society, LR is dedicated to setting and improving standards for the safety of ships.

Today we are a leading provider of classification and compliance services to the marine and offshore industries, helping our clients design, construct and operate their assets to accepted levels of safety and environmental compliance.

We also provide advice, support and solutions on fleet performance, fleet optimisation and voyage optimisation, enhancing our clients' digital capabilities. Our digital solutions are relied upon by more than 20,000 vessels.

In the race to zero emissions, our research, technical expertise and industry-firsts are supporting a safe, sustainable maritime energy transition.

Lloyd's Register Group is wholly owned by the Lloyd's Register Foundation, a politically and financially independent global charity that promotes safety and education.

Find out more [lr.org](http://lr.org).

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## **About ARUP**

Dedicated to sustainable development, Arup is a collective of 20,000 designers, advisors and experts working across 140 countries. Founded to strive for humanity and excellence in everything that we do, we collaborate with our clients and partners, using imagination, technology and rigour to shape a better world.