

*JOGMEC-METI-Asia CCUS Network
Joint Workshop*

***Initiatives by
Transportation Operators
Mitsui O.S.K. Lines, Ltd.
(MOL)***

*Masatoshi Numano, General Manager, Offshore Unit
Integrated Tanker & Offshore Projects*

8 February 2024



*JOGMEC-METI-Asia
CCUS Network Joint
Workshop*

*Initiatives by
Transportation
Operators*

*Mitsui O.S.K. Lines, Ltd.
(MOL)*

8/FEB/2024

- 1. Introduction to MOL*
- 2. MOL CCUS Business Model*
- 3. How to transport CO₂ by Ship*
- 4. MOL CCUS Technical Initiatives*
- 5. MOL CCUS Projects*

Introduction to Mitsui O.S.K. Lines, Ltd. (MOL)

Establish
Year of 1884
140th history

of MOL
Group Employee
8,748

of Countries MOL
Group Bases
44

MOL Group Fleets
799
vessels

of Group Companies
509

The year of net-zero
emission
2050

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- 2. MOL CCUS Business Model*
- 3. How to transport CO₂ by Ship*
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2 MOL CCUS Business Model

From the blue oceans, the MOL Group will contribute to the sustainable development of society and the preservation of nature, sustain people's lives, and ensure a prosperous future by expanding business upstream and downstream in the CCS/CCUS value chain, acquiring projects, and accelerating the development of the value chain, with potential partners



CCUS Value Chain

CO₂ Emission

Capture

Interim
Storage

Loading to
Ship

Marine
Transport

Offloading
from Ship

Interim
Storage

Injection

Storage

Utilization

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- 3. How to transport CO₂ by Ship*
- 4. MOL CCUS Technical Initiatives*
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3 How to transport CO₂ by Ship – Characteristics of LCO₂

High Temperature, High Pressure
(10 °C, 40-50bar, 869kg/m³)

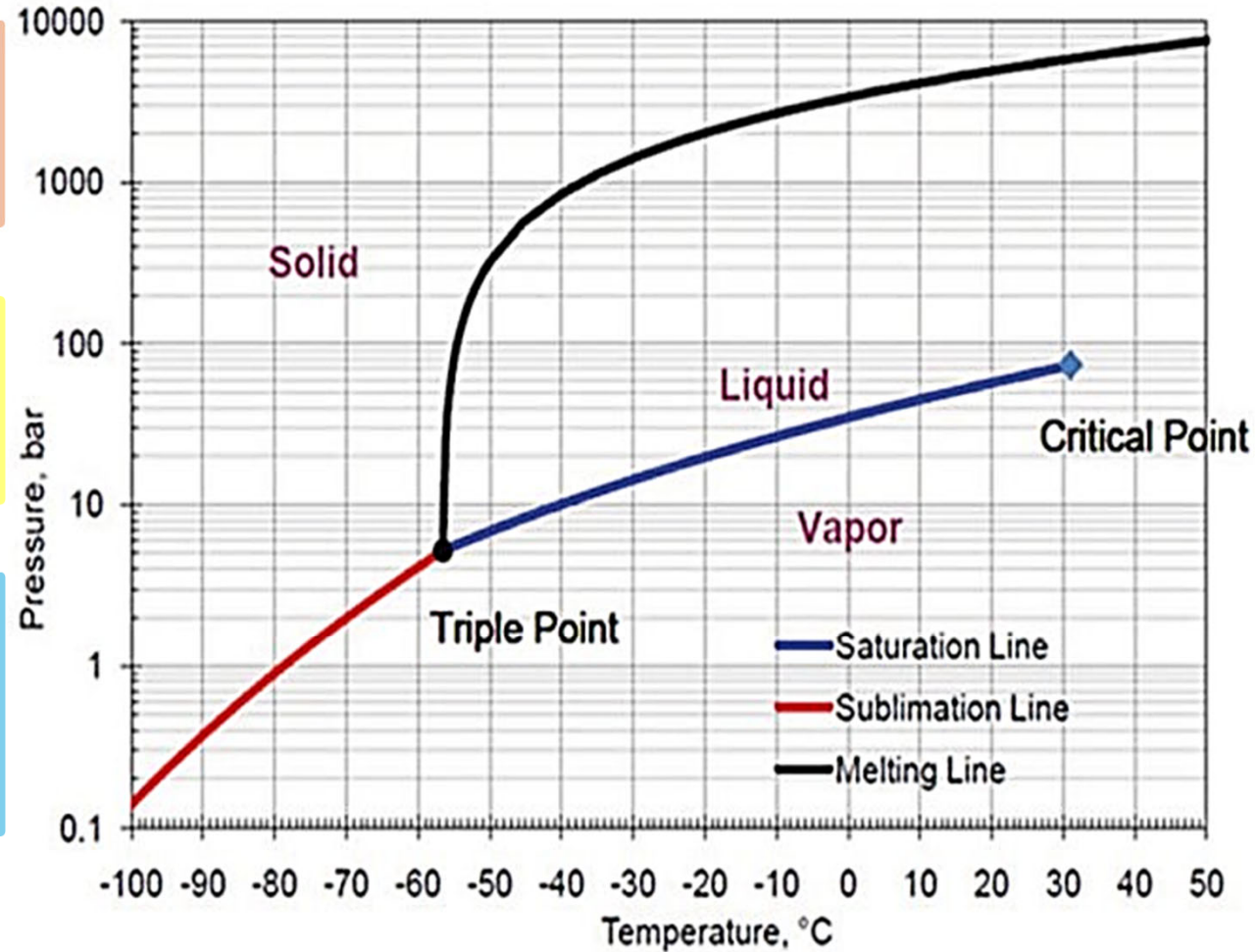
No Track Record

Medium Temperature, Medium Pressure
(-25 °C, 15-18bar, 1,053kg/m³)

Proven Track Record

Low Temperature, Low Pressure
(-50 °C, 6-8bar, 1,150kg/m³)

**Demonstration Test Ship
recently delivered**



(REF) Comparison

TYPE	Low Temp & Low Pressure (Low pressure solution, LTLP) (6~8 barG, -50°C)	Medium Temp & Medium Pressure (Medium pressure solution, MTMP) (15~20 barG, -25°C)	High Temp & High Pressure (High pressure solution, HTHP) (45~60 barG, 10°C)
ADVANTAGES	<ul style="list-style-type: none"> ➤ Higher liquid density, and larger loading capacity <ul style="list-style-type: none"> - LTLP : 1.155t/m³ (-50°C) - MTMP : 1.053t/m³ (-25°C) - HTHP : 0.8690t/m³ (10°C) ➤ Cargo tank capacity can be enlarged up to about 10,000m³ 	<ul style="list-style-type: none"> ➤ Existing technology (Lower dry icing risk) ➤ No need to install reliquefaction equipment 	<ul style="list-style-type: none"> ➤ Pressure range is close to 200 bar, which is the requirement for injection
CHALLENGES	<ul style="list-style-type: none"> ➤ No track record ➤ Operation range closer to the triple point ➤ Reliquefaction equipment potentially necessary to install ➤ Higher heat-resistance potentially necessary 	<ul style="list-style-type: none"> ➤ Smaller tank capacity (up to about 4,000m³) ➤ Potentially lower efficiency compared to Low pressure solution 	<ul style="list-style-type: none"> ➤ No track record ➤ Complex tank structure ➤ Lower liquid density (lower loading efficiency)

3 How to transport CO₂ by Ship – Proven Capability

In March 2021, MOL acquired 25% shares in Larvik Shipping and became an official partner.

MOL can provide safe and efficient marine transport of LCO₂ (medium pressure solution) with more than 35 years safe track record.

LarvikShipping



MOL
Mitsui O.S.K. Lines

- Only one in the world with true CO₂ transportation expertise at sea
- CO₂ transportation for more than 35 years without no severe incidents
- CO₂ experienced crews
- CO₂ cargo operation expertise

- International shipping activities supported by a global network
- Finance resource to develop new CO₂ transportation service
- Cost competitiveness gained from the fleet scale

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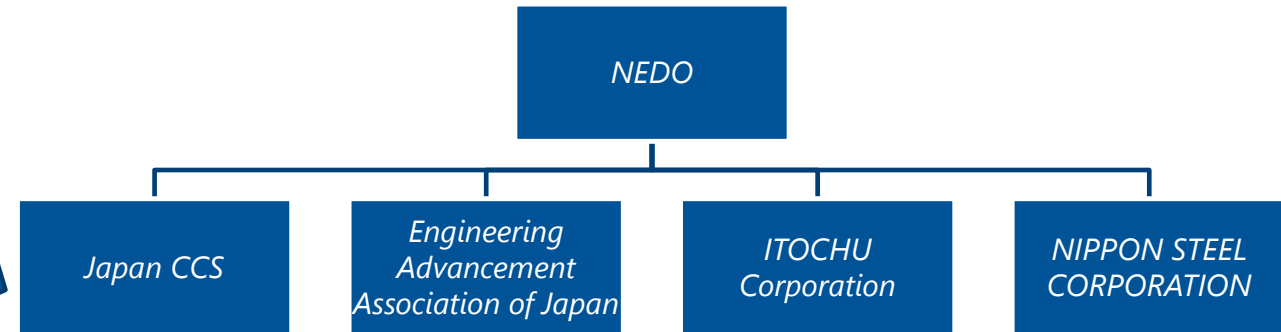
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- 4. MOL CCUS Technical Initiatives*
- 5. MOL CCUS Projects*

4 MOL CCUS Technical Initiatives for Japan

“CCUS R&D and Demonstration Related Project / Large-scale CCUS Demonstration in Tomakomai / Demonstration Project on CO₂ Transportation” (the demonstration projects) being conducted by Japan’s New Energy and Industrial Technology Development Organization (NEDO) and entrusted to the following consortium since JUN/2021



MOL was re-entrusted R&D on the large-size LCO₂ carrier to be put into practical use from Japan CCS, leading the consortium.

AUG/2022
MOL acquired Approval in Principle (AiP) for design of a large-scale LCO₂ carrier from ClassNK.



NOV/2023
The demonstration test ship to transport LCO₂, named “EXCOOL”, was delivered.
LOA 72.0m, Beam 12.5m, Tank Capacity 1,450m³

4 MOL CCUS Technical Initiatives in 2021/2022

- MAR/2022
Concept Study of "Ammonia/LCO₂ Carrier"



- AUG/2022
AiP from ClassNK
(Japan NEDO's demonstration project)



- SEP/2022
HAZID, AiP from DNV



- NOV/2021
Concept Study of LCO₂ Carrier
(Tank Capacity: about 50,000m³)



4 MOL CCUS Technical Initiatives in 2023

➤ JUN/2023
MOL, PETRONAS and SDARI Acquire AiP for LCO₂ Carriers and FSO



Size	Concept	Classification Society
87,000 m ³ LCO ₂ carrier	Long haul transport	DNV
14,000 m ³ LCO ₂ carrier	Short haul transport	DNV
87,000 m ³ LCO ₂ carrier installed dynamic positioning system	Long haul transport & Offshore offloading	ABS
96,000 m ³ LCO ₂ FSO	Intermediate storage & Offloading at offshore	ABS

- AUG/2023
R&D Project Agreement to develop safe and efficient solutions for industrial-scale shipping of CO₂
- Future Energy Exports CRC Limited, JX Nippon Oil & Gas Exploration Corporation, Low Emission Technology Australia, MOL & Osaka Gas
 - To conduct R&D to demonstrate the technical feasibility and operability of low-pressure and low-temp solutions for the bulk transport of CO₂ by ships

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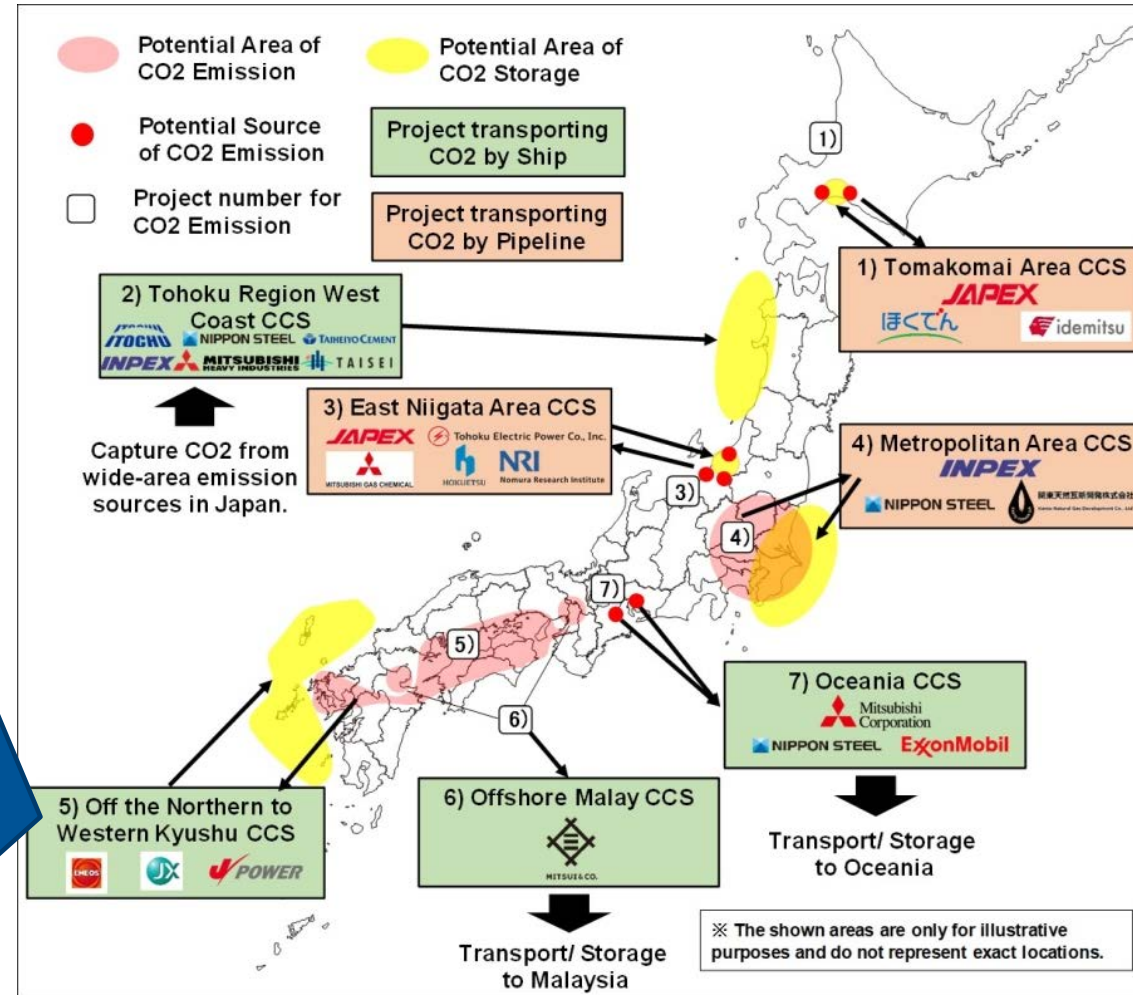
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5. MOL CCUS Projects

5 MOL CCUS Projects – CCS Value Chain in Japan

➤ JUN/2023
 JOGMEC selected 7 role model projects (5 for domestic storage and 2 for overseas storage) for Japanese Advanced CCS Projects.

➤ AUG/2023
 MOL was honored to have contract to study LCO₂ transport by vessel in "Off the Northern to Western Kyushu CCS" by ENEOS, J-Power & JX Nippon Oil & Gas Exploration Corporation. (CO₂ liquefaction conditions: low temp and low pressure, medium temp and medium pressure)



5 MOL CCUS Projects – CCS Value Chain to Malaysia

➤ SEP/2023

MOL principally reached an agreement with two Malaysian companies PETRONAS CCS Ventures Sdn Bhd (PETRONAS CCS Ventures), a wholly-owned subsidiary of Petroliam Nasional Berhad (PETRONAS) and MISC Berhad (MISC), a global provider of energy related maritime solutions and services, for the potential establishment of a joint venture to invest in the development and monetisation of LCO₂ carriers for CCS projects.

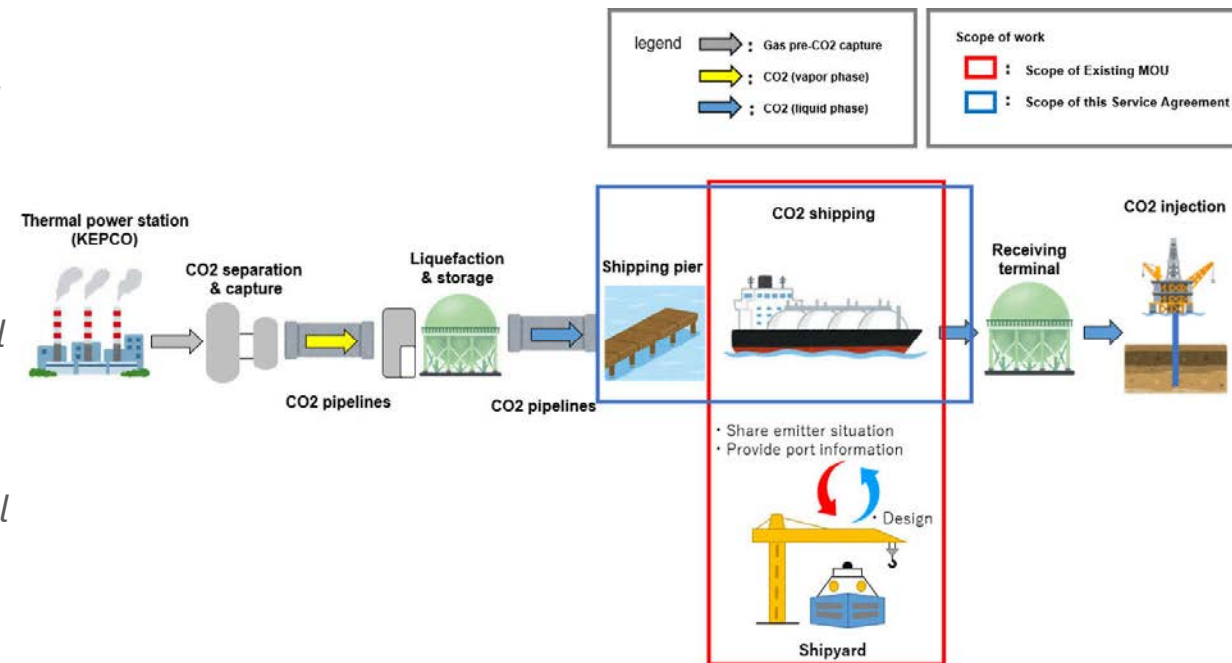
In February 2022, MOL concluded MoU with PETRONAS, and in June 2023, obtained AiP for the design of an LCO₂ carrier and FSO, and had been developing business related to the marine transport of LCO₂. MISC recently became a partner in this collaboration and will cooperate with MOL in the study of development of various transport methods, mainly LCO₂ carriers, as well as the optimal business model through a shipowner JV with the aim of establishing the way toward a flexible approach to various transport needs in the future.



5 MOL CCUS Projects – CCS Value Chain in/from Japan

➤ NOV/2023

MOL and The Kansai Electric Power Co., Inc. (KEPCO) announced the signing of a service agreement to conduct feasibility research on the design of a LCO₂ carrier at shipyards in Japan and overseas. The detailed research and study of CCS value chain, including shipyards, is a pioneering effort for other business operators that emit CO₂. The agreement follows the completion of an initial joint study on liquefied CO₂ transport, based on a MOU between the two companies, by which MOL and KEPCO have been jointly studying the optimal system for ocean transport and storage of liquefied CO₂, targeting CO₂ emitted from KEPCO's thermal power plants to establish a CCS value chain.



5 MOL CCUS Projects – CCS Value Chain in/from Japan

➤ OCT/2023

MOL and Cosmo Oil (Headquarters: Minato-ku, Tokyo) announced the signing of a MoU on the study of ocean transport, with the goal of establishing a CCS value chain.

MOL and Cosmo Oil will collaborate on the establishment of a "CCS value chain consisting of separation, capture, transport, injection and storage" of CO₂ emitted from Cosmo Oil's refineries (emission sources), and conduct the following studies.

(1) Outline specifications of LCO₂ carriers suitable for the distance from the emission sources to the candidate storage sites in Japan and abroad, and the expected transport volume.

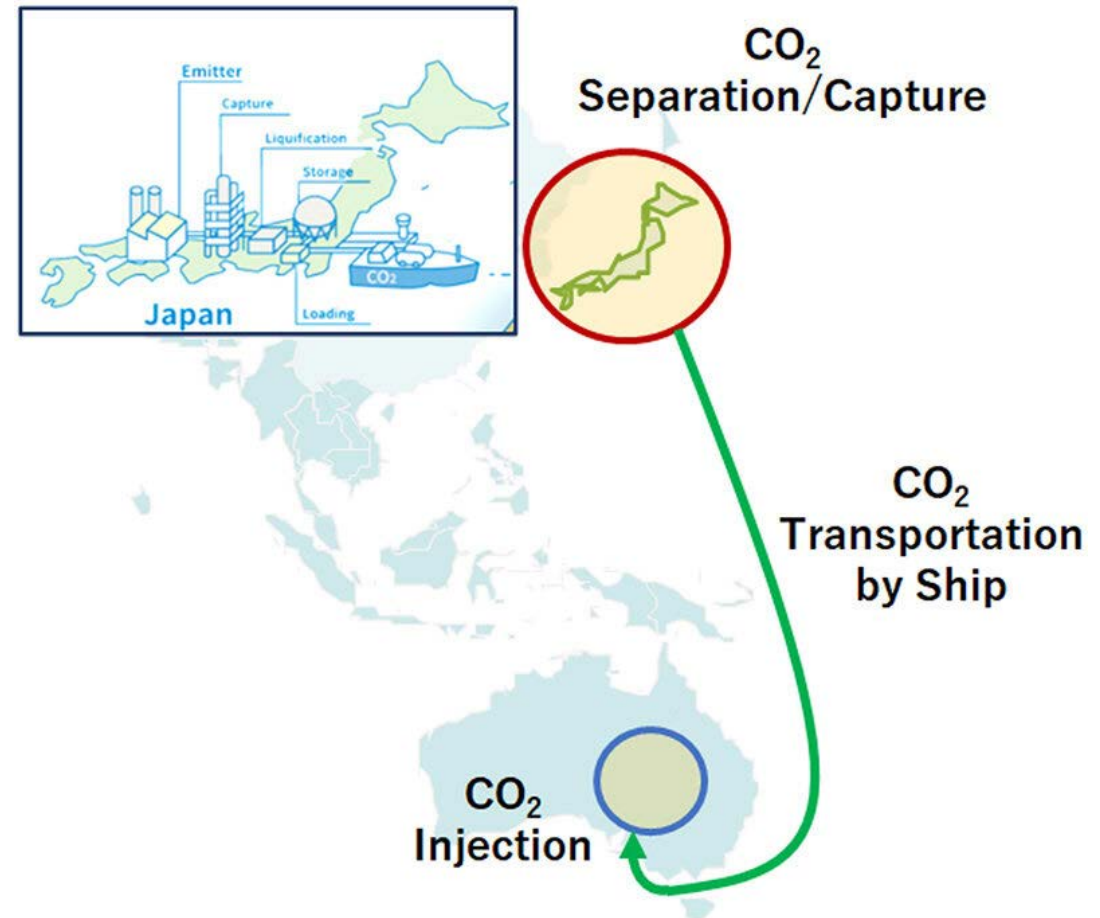
(2) Estimate of ocean transport costs based on the results of the study in (1) above.

(3) Further possible collaborations on any potential projects on CCS, CO₂ capture, separation, ocean transport, and reuse.

5 MOL CCUS Projects – CCS Value Chain (JPN/AUS)

➤ FEB/2024

MOL and JX Nippon Oil & Gas Exploration Corporation are pleased to announce that MOL and JX have signed MoU to develop a CCS value chain between Japan and Australia, including marine transport of CO₂.
The MoU focuses on the establishment of a CCS value chain by capturing CO₂ emitted from ENEOS refinery and nearby various industries in Japan, transporting it by CO₂ carrier to the Port of Bonython in Australia, and injecting and storing it at the selected storage site.



5 MOL CCUS Actions – CCUS Value Chain (SIN/AUS)

➤ NOV/2022

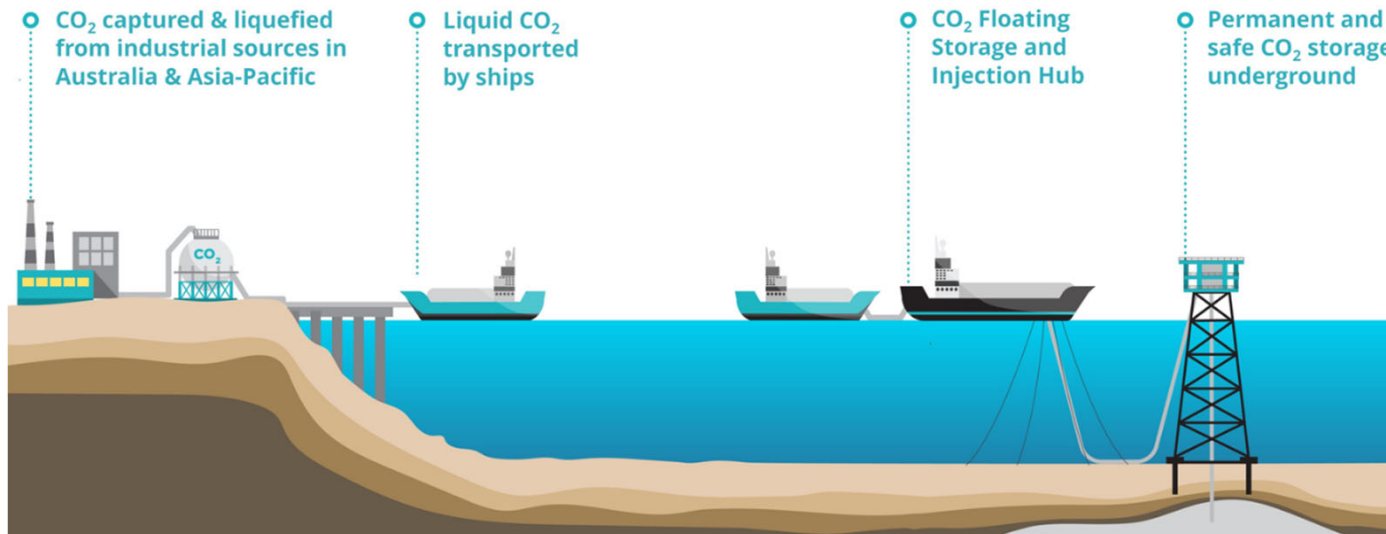
Chevron Corporation, through its Chevron New Energies International Pte. Ltd. (Chevron) subsidiary, and MOL announced the signing of a Joint Study Agreement (JSA) on the feasibility of transporting LCO₂ from Singapore to permanent storage locations offshore Australia.



5 MOL CCUS Projects – CCS Value Chain to Offshore Australia

An Australian CCS project developer and operator - deepC Store – has lead a project called CStore 1, which consists of (1) Capturing and liquefying CO₂ from multiple industrial sources in Australia and potentially the Asia-Pacific Region. (2) Shipping LCO₂ from industrial sources to CStore1's Floating Storage and Injection (FSI) Hub located in offshore Northern / Western Australia. (3) Offloading and temporarily storing LCO₂ at the FSI Hub prior to injection. (4) Injecting and storing CO₂ in a permanent subsurface geological formation near the FSI Hub.

➤ DEC/2020 – MOL officially joined the project.



CStore 1 Project Partners

- Add Energy
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- JX Nippon Oil and Gas Exploration Corporation
- Kyushu Electric Power
- MOL
- Osaka Gas
- Technip Energies
- Toho Gas

5 MOL CCUS Projects – CCS Value Chain to Bahrain

➤ DEC/2023

MOL and Bapco Energies (Headquarters: Manama, Kingdom of Bahrain) announced the signing of MoU for development of cross border CO₂ transport and sequestration with the goal of establishing a CCS value chain, where MOL provides marine transportation of LCO₂ and Bapco Energies provides the sequestration sites.

MOL and Bapco Energies will collaborate on the future establishment of a CCS value chain consisting of separation, capture, transport, injection and storage of CO₂ through the following studies.

- ① To conduct the study of the estimated cost of CO₂ for using the permanent CO₂ storage owned and operated by Bapco Energies in the Kingdom of Bahrain, including the receiving cost of CO₂ at the CO₂ receiving terminal, and the unit cost of liquified CO₂ transportation by ship.
- ② To jointly conduct the study of the potential markets in Asia Pacific regions for instance, and to discuss in good faith future business structure.



5 MOL CCUS Actions – CO₂ from Lithuania & Latvia

MAY/2021

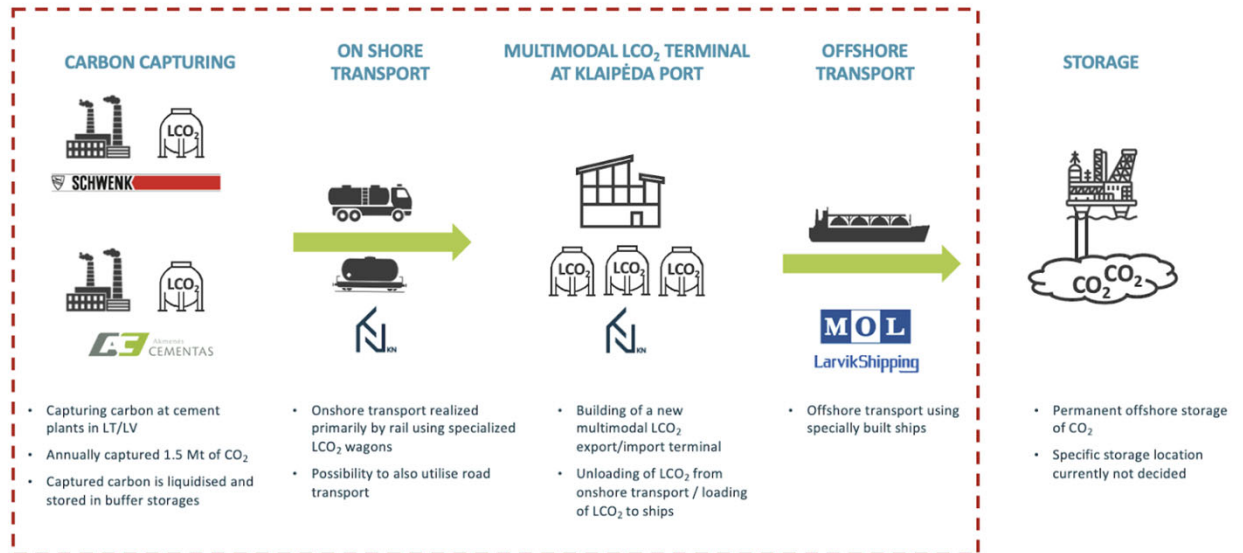
Klaipėdos nafta, Larvik Shipping, and MOL to carry out a feasibility study for LCO₂ and hydrogen project in Klaipėda, Lithuania.

Klaipėdos nafta, Larvik Shipping, MOL, Schwenk and Cenentas have formed CCS Baltic Consortium, which project is primarily aimed at significantly decreasing CO₂ emissions originating from two EU Member States – Lithuania and Latvia, through CCS.



CCS Baltic Consortium project value chain

Covered by the Baltic CCS Consortium PCI



5 MOL CCUS Projects - Network



CO2LOS III (CO₂ Logistics by Ship Phase III) conducting various studies including cost model, low-pressure large-scale CO₂ ship, Zero emission ship, Unmanned FSI, Direct injection, etc.



Funders: **CLIMIT**

(REF) MOL Organizational Change (effective 1 April 2024)

Headquarters of Energy Business (Present)	Headquarters of Energy Business (effective 1 April 2024)
Energy Business Strategy Division	
Marine Fuel GX Division	
Integrated Tanker & Offshore Projects <ul style="list-style-type: none"> ➤ Tanker Unit ➤ Offshore Unit 	Carbon Solution Projects <ul style="list-style-type: none"> ➤ Tanker Unit 1 ➤ Tanker Unit 2 ➤ Electric Power Unit ➤ Carbon Solution Development Unit
Integrated Wind and Carbon Power Solutions <ul style="list-style-type: none"> ➤ Carbon Power Solutions Unit ➤ Wind Power Projects Unit 	Wind Power and Offshore Projects <ul style="list-style-type: none"> ➤ Offshore Unit ➤ Wind Power Unit
Integrated Liquified Gas Transport and Offshore Projects	
MOL Chemical Tankers Pte. Ltd.	

The newly established "Carbon Solution Development Unit" will centrally lead the strategic planning and promotion of the CCUS business, carbon recycling business, and business development related to new energy sources such as hydrogen and ammonia.

Thank you very much !

From the blue oceans, the MOL Group will contribute to the sustainable development of society and the preservation of nature, sustain people's lives, and ensure a prosperous future by expanding business upstream and downstream in the CCS/CCUS value chain, acquiring projects, and accelerating the development of the value chain, with potential partners



CCUS Value Chain

