Japan-Asia CCUS Forum 2021

CO_2 Ship Transportation
Current Status and Approach to Challenges

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Contents

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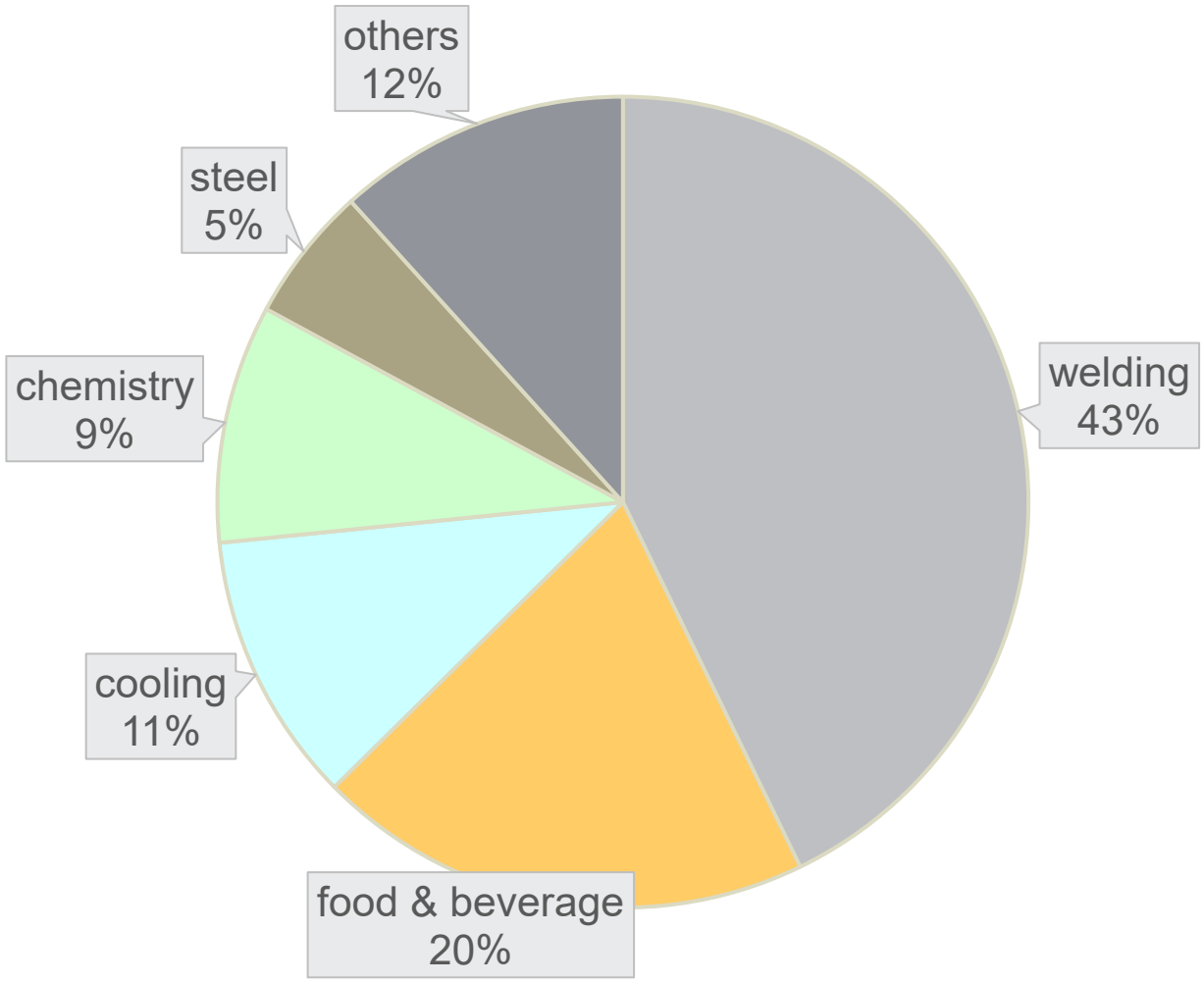
Current Status of CO_2 Transportation

Demand and supply of liquified CO_2 in Japan

Ex. Factories - 674,982 Tons (2020.4-2021.3)



Data Source : Japan Industrial and Medical Gases Association（JIMGA）

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Transportation of CO_2 in Japan

Japan:

- CO_2 for industrial use is transported in the form of liquid.
- Tank trucks are mainly used (land / car ferry).
- No record / experience of transportation for CCUS.

➡ Establishment of CO_2 transport will lead to development of CCS.

Overseas (as comparison) :

- 5 dedicated CO_2 tankers are under operation in Europe.
- Pipelines are used for CCS/EOR.

Fleet List of CO_2 tankers in the world

Vessel Name	FROYA	EMBLA	GERDA	HELLE (ex. CORAL CARBONIC)	IDUNA (ex. YARA GASⅢ)	AMAGI MARU (※)
Gross Tonnage	2,506 t	2,506 t	2,506 t	1,825 t	2,198 t	199 t
Cargo Tank Capacity	1,800m^3	1,800m^3	1,800m^3	1,250m^3	1,250m^3	365m^3
Cargo Temperature (lowest)	-30℃	-30℃	-30℃	-40℃	-30℃	-30℃
Maximum Pressure	19.0 bar (1.9 MPa)	19.0 bar (1.9 MPa)	19.0 bar (1.9 MPa)	18.0 bar (1.8 MPa)	20.0 bar (2.0 MPa)	25.0 bar (2.5 MPa)
						NO IMAGE

(※)It is recorded that only one CO_2 dedicated tanker was operated in Tokyo Bay in 1980's.

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Characteristics of each Transportation Mode

Mode	Phase	Distance	Quantity	Advantage
Tank truck 	Liquid Temp:-20℃ Press:2MPa	Short (<100km)	Small	Frequency
Pipeline 	Dense	Short to Long	Large	Cost effective for plain
Ship/Vessel 	Liquid Temp:unfixed Press:unfixed	Long (>200km)	Large	Flexibility and Cost effective for overseas

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Feasibility of CO_2 transportation in Japan

Conditions: 1 Million tons per year / over 200km

- Tank truck – “disadvantageous”
  quantity not sufficient of units and drivers ➡ costly

- Pipeline – “disadvantageous”
  construction cost on hilly country like Japan

- Ship/Vessel – “advantageous”
  the most suitable for large-scale and long-distance transportation as an energy efficient mode per ton-mile.

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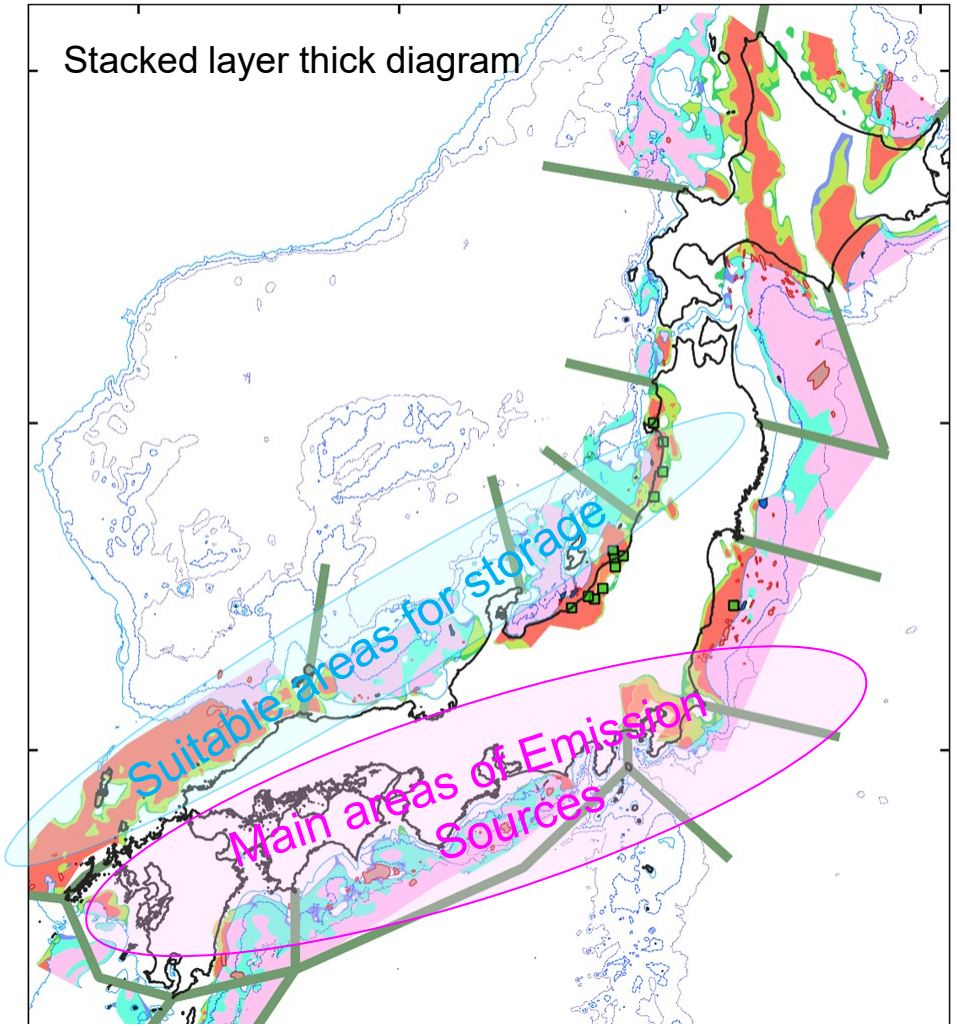
Locations of main emission sources and potential storage sites in Japan

Classification by RITE (2005, 2007)

- A1 (Oil and gas field)
- A2 (Drilled structure)
- A3 (Undrilled structure)
- B-1 (Water-soluble gas field)
- B-2 (Stacked layer>2,000m, depth<200m)
- B-2 (Stacked layer 1,000~2,000m, depth<200m)
- B-2 (Stacked layer 800~1,000m, depth<200m)
- B-2 (Stacked layer>2,000m, depth>200m)
- B-2 (Stacked layer 1,000~2,000m, depth>200m)
- B-2 (Stacked layer 800~1,000m, depth>200m)

- depth 2,000m
- depth 1,000m
- depth 200m



Edited by JCCS (FS by RITE 2005, 2007)

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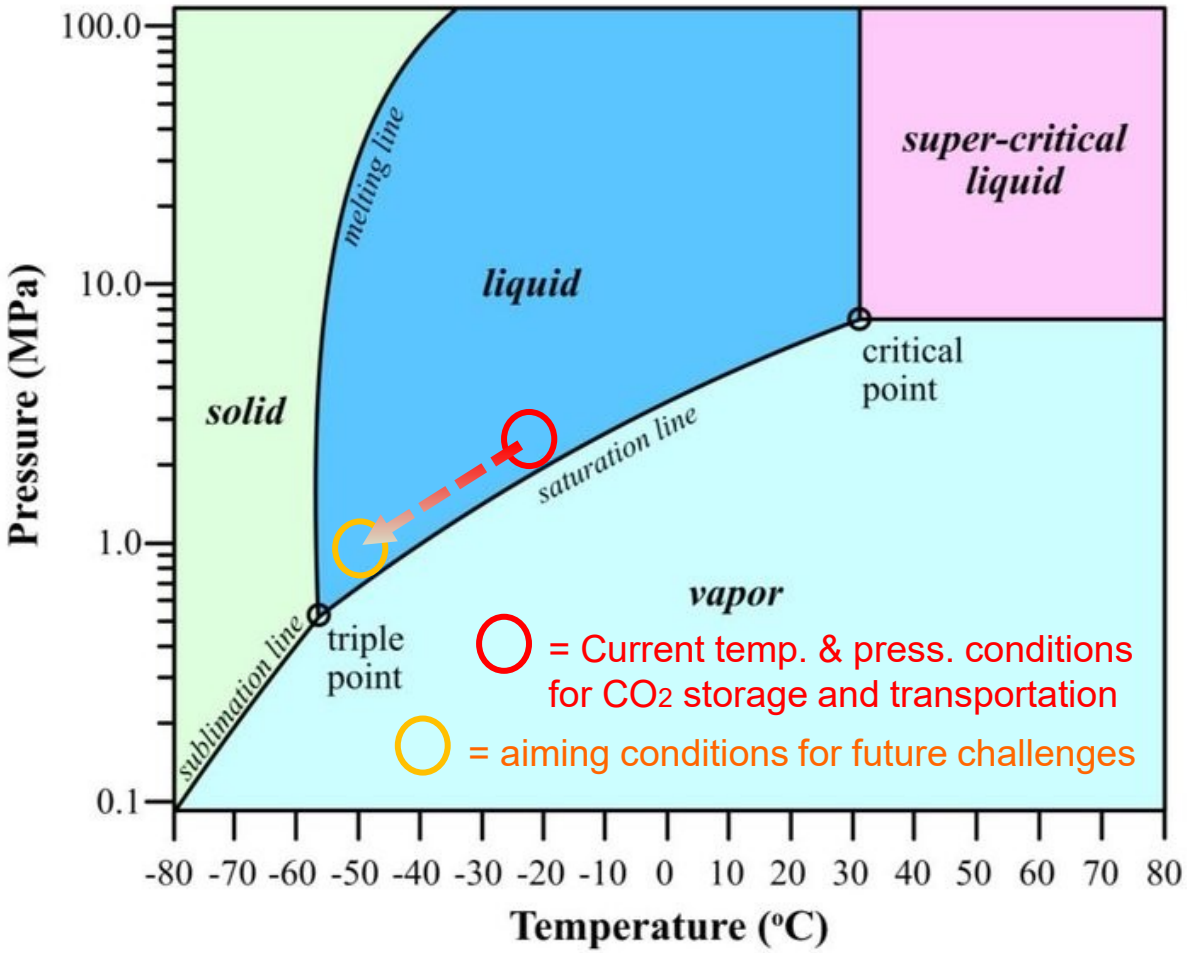
Approach to Challenges

- Step toward Actual Utilization -

CO_2 Triple point (-56.6℃ / 0.518MPa)



Development tasks and goal

a. Why the current temperature & pressure are preferred?

Far from Triple Point, which means lower operation risks.

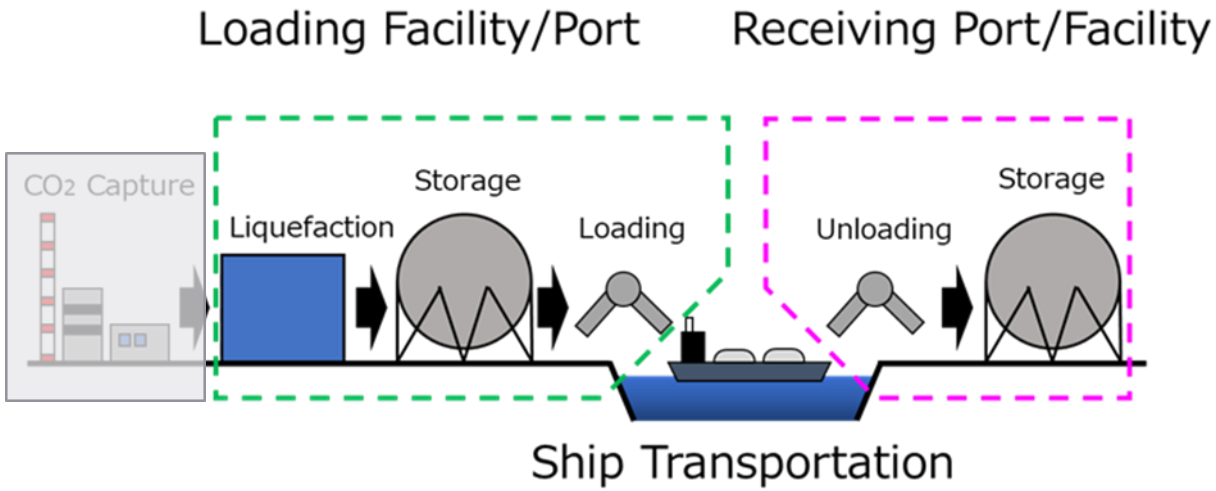
b. Suitable cargo conditions for larger on-shore storage tanks and tanks equipped on CO_2 tankers

To identify the optimal conditions of liquified CO_2 in terms of temperature and pressure in order to make tank capacity larger suitable for on-shore storage tanks and large liquified CO_2 tankers for long-haul. Under such conditions safety operation with minimized risk is adequately secured.

NEDO project for challenges (1)

【Purpose of the Project】

For the purpose of the safe and efficient transportation of CO_2 emitted from factories and thermal power plants etc. for carbon recycle or CCS, NEDO and Contractors will develop the integrated transportation system (CO_2 liquefaction, ship transportation and tank storage) under optimal temperature and pressure conditions.



NEDO project for challenges (2)

NEDO

New Energy and Industrial Technology Development Organization

commission

JCCS Japan CCS Co., Ltd.

ENAA Engineering Advancement Association of Japan

(Subcontractors)

MOL Mitsui O.S.K. Lines

NIPPON STEEL PIPELINE & ENGINEERING

NIPPON STEEL

(Subcontractors)

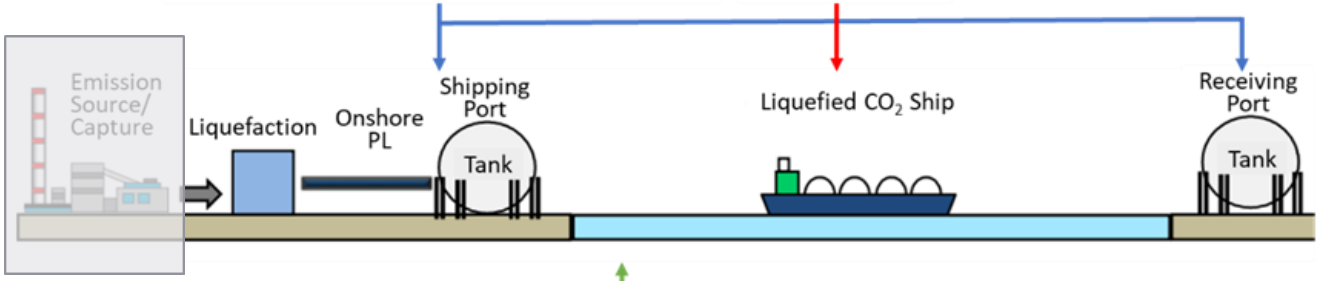
K LINE KAWASAKI KISEN KAISHA, LTD.

NGL NIPPON GAS LINE

Ochanomizu University

R & D of CO_2 liquefaction/storage systems, social implementation of large-sized ships

R & D of transport ships



Feasibility Study

(Overall study) ITOCHU

(Steel industry) NIPPON STEEL

Note: figure adapted from METI document

NEDO project for challenges (4)

【Goal】

To complete the efficient preparations for the social implementation of CO_2 transportation for CCUS of approx. 1 Million tons per annum as of 2030

Research and development for the goal

1. Technology development for CO_2 liquefaction system
2. Technology development for liquefied CO_2 mass storage system
3. Conceptual / Basic design of large liquefied CO_2 carrier
4. Research and development on stability in CO_2 ship transport and specification examination of liquefied gas combined ship
5. Survey on trends in domestic CO_2 emission sources and domestic and overseas CO_2 transportation businesses
6. Examination of business model (domestic steel industry)

NEDO project for challenges (5)

【Demonstration as technology development】

As the demonstration tests to verify the technology establishment, 10,000 tons of liquified CO_2 will be annually transported from a coal-fired power plant in Maizuru (Kyoto pref.) to a base in Tomakomai (Hokkaido). A 999GT sized CO_2 tanker will be used for this demonstration test.

NEDO project for challenges (6)

【Schedule】

FY 2021 – 2026 (planned)

THEMES

1. **Research and development** to establish liquefied CO_2 ship transport technology (FY2021-2026)

2. Liquefied CO_2 ship transport **demonstration**
   - ■ Engineering, procurement and construction of land-based equipment (FY2021-2023)
   - ■ Marine Transport Demonstration Test (FY2023-2026)

3. **Commercialization survey** of shipping for the purpose of CCUS (FY2021-2026)

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