Tomakomai CCS Demonstration Project – Key Results and Future Outlook

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Outline of Presentation

- Overview of Tomakomai CCS Demonstration Project
- Key Results of Tomakomai Project
- Public Engagement
- Future Outlook of Tomakomai Project
- Summary
Overview of Tomakomai CCS Demonstration Project
Project Overview

Main objectives and tasks

- Demonstrate a full-chain CCS system from capture to storage
- Demonstrate that the CCS system is safe and reliable
- Remove concerns about earthquakes by the data collected;
  - No influence by natural earthquakes on CO$_2$ stored
  - No perceptible earth tremors induced by CO$_2$ injection
- Disclose project information and data and enhance understanding of CCS by local residents
Project Scheme

- A portion of PSA (Pressure Swing Adsorption) offgas containing approximately 52% CO₂ generated by a hydrogen production unit in adjacent refinery is transported by 1.4km pipeline to Tomakomai Project capture facilities.

**CO₂ source**
- Offgas Containing CO₂

**Capture**
- Activated amine process
- Pipeline 1.4km

**Injection**
- CO₂ capture capacity = 200,000 tonnes/year
- Injection wells: 2 wells
- Compressors

**Storage**
- Offshore Tomakomai

**Typical PSA offgas composition (vol%)**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>51.6</td>
</tr>
<tr>
<td>H₂</td>
<td>38.8</td>
</tr>
<tr>
<td>CH₄</td>
<td>6.6</td>
</tr>
<tr>
<td>CO</td>
<td>2.3</td>
</tr>
<tr>
<td>H₂O</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Reservoir**
- Moebetsu Formation: Sandstone layers 1,000 – 1,200m sub-seabed
- Takinoue Formation: Volcanic rock layers 2,400 – 3,000m sub-seabed
Project Schedule

- Constructed demonstration facilities from FY2012 to 2015
- Started injection at scale of 100 thousand tonnes per annum from April 2016
- Achieved initial target of 300 thousand tonnes cumulative injection on November 22, 2019
- Monitoring is being continued, preparations for second stage of project are underway

※Years are in Japanese Fiscal Years (April of calendar year to March of following year)
Key Results of Tomakomai Project
CO₂ Capture Process

Two-stage absorption process

- CO₂ Capture Results
  - FY2016: 25.3
  - FY2017: 24.3
  - FY2019: 26.4

  - CO₂ recovery (t/h)
  - Reboiler duty (GJ/t-CO₂)
    - FY2016: 0.923
    - FY2017: 0.882
    - FY2019: 0.915

  - Achieved reboiler duty of 0.882 - 0.923GJ/t-CO₂; (1/2 to 1/3 of conventional one stage absorption process)
The captured CO₂ is compressed and stored 3-4km offshore in two sub-seabed reservoirs at different depths – Moebetsu and Takinoue formations by two independent injection wells.

- Deviated CO₂ injection wells drilled from onshore to offshore sub-seabed
  - Cost reduction of drilling, operation and maintenance
  - No disturbance on marine environment and harbor operation

Schematic Diagram of Geological Layers and Injection Wells
Location of Monitoring Facilities

- OBS (Ocean Bottom Seismometer): used for monitoring of micro-seismicity and natural earthquakes.
- OBC (Ocean Bottom Cable): used for 2D seismic survey and monitoring of micro-seismicity and natural earthquakes.
Results of CO₂ injection

- Achieved 300,110 tonnes cumulative CO₂ injection into 2 reservoirs at different depths (Moebetsu Formation – 300,012 tonnes, Takinoue Formation – 98 tonnes)
- At the injection well for the Moebetsu formation, the maximum bottomhole pressures recorded by PT sensor set close to reservoir during injection were much lower than the upper limit set to avoid destruction of the overlying cap rock.
Results of Micro-seismicity Monitoring

No micro-seismicity or natural earthquakes attributable to CO$_2$ injection were detected in vicinity of injection area.
3D seismic survey results: comparison of 2nd to 5th time-lapse 3D seismic surveys

- The 2nd, 3rd, 4th and 5th monitor seismic surveys at cumulative CO₂ injection of approx. 65,000, 207,000 and 300,000 tonnes into the Moebetsu Formation detected anomalies, indicating evolution of the CO₂ plume.

2nd monitor survey: 3D
JFY 2017 (61,239–69,070 tonnes)
During CO₂ injection

3rd monitor survey: mini-3D
JFY 2018 (207,209 tonnes)
During CO₂ injection

4th monitor survey: mini-3D
JFY 2019 (300,012 tonnes)
58–79 days after termination of CO₂ injection

5th monitor survey: 3D
JFY 2019 (300,012 tonnes)
233–257 days after termination of CO₂ injection
Marine environmental surveys

- Marine environmental surveys, seismic surveys and other monitoring were conducted under the five-year injection permit (FY2016–2020) from Ministry of the Environment (MOE) on the condition of implementation of the "monitoring plan" approved by MOE.

### Monitoring Plan

#### Marine environmental survey
- Seasonal survey at 12 survey points
- Chemical measurements of seawater
- Chemical measurements of sea bottom sediments
- Plankton observation
- Benthos observation

#### Location and extent of CO₂
- Seismic survey (once a year)

#### Conditions of the formations
- Pressure and temperature at the injection wells and the observation wells (continuous observation)

#### Conditions of CO₂
- Measurement of CO₂ injection rate and injection temperature and pressure (continuous observation)
- CO₂ concentration analysis (gas chromatography analysis: once a year)

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![Diagram showing monitoring plan and locations](attachment:monitoring_plan_location.png)

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* pCO₂: partial pressure of CO₂  ** DO: dissolved oxygen

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Threshold line Upper limit of 95% prediction interval using data from baseline and Feb. 2017 to Feb. 2018

Initial threshold line using baseline data

pCO₂/DO threshold in the monitoring plan (revised on Aug. 31st, 2018)
Public Engagement
Public Outreach Activities

Voice of Tomakomai Citizens

1. Information Disclosure
   Thorough disclosure should be made

2. Safety/CO₂ leakage
   Want more detailed information on risk of CO₂ leakage

3. Dissemination to Young Generation
   Should consider efforts to involve young generation

Outreach Activities

- Panel Exhibitions
- Forum for Tomakomai Citizens
- Site Tours
- Information Disclosure System
- Mini seminars for students
- Kids’ lab classes/site tours

Outreach Activities (JFY 2019)

- Site Visitors: 2168 people (401 from overseas)
- Mini seminars: 27 times
- Panel Exhibitions: 8 times
- Kids’ lab classes: 3 times
- Booth in Environmental exhibitions: 11 times
- CCS Forum: 600 people

Project being conducted with understanding and support of local community
2018 Hokkaido Eastern Iburi Earthquake

- At 3:07am Sept. 6, 2018, a moment magnitude 6.6 earthquake at 37km depth occurred in central eastern part of Iburi region of Hokkaido. Tomakomai CCS demonstration site recorded seismic intensity of lower 5.
2018 Hokkaido Eastern Iburi Earthquake

- Bottom hole pressures, temperatures of Moebetsu Formation injection well before/after earthquake

- CO₂ supply suspended for scheduled maintenance
- Injection Suspension
- Main Shock
- Power Outage
- Resumption of Injection
Measures taken by JCCS after the Hokkaido Eastern Iburi Earthquake

- 6th Sept. 2018: Moment Magnitude 6.6 earthquake occurred
- 12th Sept 2018: Posted JCCS's views on JCCS on HP
- 19th Oct. 2018: Convened an expert review meeting
- 21st Nov. 2018: Posted summary of review meeting on HP

Key points on JCCS HP:
1. No relationship between CO₂ injection and earthquake
2. No CO₂ leakage

Key principles to minimize concerns of local community and general public:
- Respond quickly
- Include technical explanation

Future Outlook of Tomakomai Project
Overview of CO₂ Ship Transportation Project

Objectives and schedule of project

1. R&D of long-distance and large-scale transportation (~1M tonnes/year) and design of equipment
   Schedule: FY2021 to FY2026 (FY: April to March)

2. Liquefied CO₂ ship transportation demonstration (~10,000 tonnes/year)
   Schedule: Engineering, Procurement and Construction / FY2021 to FY2023
   Ship transportation demonstration / FY2023 to FY2026

3. Study of ship transportation business models
   Schedule: FY2021 to FY2026
Demonstration of CO₂ Ship Transportation

Key Points
- World first CO₂ ship transportation for CCUS
- Identifying issues for social implementation in anticipation of future era of large-scale liquefied CO₂ shipping

Gross tonnage: 999 tonnes
Loadable cargo volume: Approx. 1,000 tonnes

Map showing transportation routes from Maizuru to Tomakomai.
Utilize the Tomakomai CCS facility effectively and promote the development of “Carbon Recycling”.

Carbon recycling: Considering CO₂ as source for Carbon, capture CO₂ then utilize and recycle it as Carbon compounds.
Summary
Summary

Key Results

- Operation of full chain CCS system from capture to storage conducted successfully, target of 300,000 tonnes of CO₂ injection achieved. Monitoring operations being continued.
- CO₂ capture process comprising two-stage absorption system with low pressure flash tower achieved significantly lower capture energy than conventional system.
- Deviated injection wells from onshore site into offshore reservoirs saved drilling cost, avoided disturbance of marine environment and harbor operation.
- Safety and reliability of CCS system demonstrated.
- Concerns about earthquakes and induced seismicity addressed:
  - Natural earthquakes have not caused damage to reservoirs; no data suggesting connection between CO₂ storage and earthquakes.
  - Important to respond as quickly as possible, and to include technical data to minimize concerns.
- Project being conducted with understanding and support of local community:
  - Importance of information disclosure and diligent efforts to secure understanding of local stakeholders.

Looking Ahead

- Studies of CO₂ ship transportation and carbon recycling are in progress.
Thank you for your attention

The Tomakomai CCUS Demonstration Project and CO₂ Ship Transportation Project are commissioned by New Energy and Industrial Technology Development Organization (NEDO).

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