Experience of Tomakomai CCS Project

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Tomakomai CCS Demonstration Project

First Large-scale CCS Demonstration Project in Japan
Project Period: FY2012-2020 (9 years)
Location: Tomakomai City, Hokkaido
Flow Scheme of Project

First full-chain CCS system in Japan from capture to storage has been conducted successfully.

Injection Target: 300,000 tonnes in total

Typical composition of offgas
\[ \text{CO}_2 = 50\%, \quad \text{H}_2 = 40\%, \quad \text{CH}_4, \text{etc.} = 10\% \]
Schedule of Project

- Target of 300,000 tonnes of CO₂ injection achieved on November 22, 2019
- Monitoring operations are being continued
CO₂ Capture Process – Two Stage Absorption System

Loading Factor: 98% (100% = 25.3 t-CO₂/h)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ recovery rate %</td>
<td>99.97</td>
</tr>
<tr>
<td>Reboiler duty (GJ/t-CO₂)</td>
<td>0.88</td>
</tr>
<tr>
<td>Heat energy 1) (GJ/t-CO₂)</td>
<td>0.98</td>
</tr>
<tr>
<td>Electric energy (GJ/t-CO₂)</td>
<td>0.18</td>
</tr>
<tr>
<td>CO₂ capture energy 2) (GJ/t-CO₂)</td>
<td>1.16</td>
</tr>
</tbody>
</table>

Note 1) : Reboiler duty/steam boiler efficiency
Note 2) : Heat energy + Electric energy

- In LPFT (Low-pressure Flash Tower), CO₂ is stripped by depressurization; thermal energy of steam of CO₂ Stripping Tower is also utilized to strip CO₂
- Greater part of semi-lean amine from LPFT is returned to CO₂ Absorption Tower for CO₂ absorption; as only the remaining smaller portion is sent to CO₂ Stripping Tower, reboiler heat required can be reduced
Injection Wells

- Deviated CO₂ injection wells drilled from onshore into offshore reservoirs
  - Cost reduction of drilling, operation and maintenance
  - No disturbance on marine environment and harbor operation
- Injection interval length exceeding 1,100m to enhance injection efficiency
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.

Micro-seismicity monitoring area (6km x 6km)

Observation well OB-1 for Takinoue Form. (deviated)

Observation well OB-2 for Moebetsu Form. (vertical)

Observation well OB-3 for Takinoue Form. (vertical)

Receiver line area of 3D seismic survey

Extensive monitoring system to address concerns about earthquakes

Image: LC81070302016141LGN00, courtesy of the U.S. Geological Survey, text by JCCS
Schematic Diagram of Monitoring System

- **Control Building**
- **Onshore Seismic Station**
- **Observation well OB-1 for Takinoue Fm.**
- **Inj. Well Takinoue Fm.**
- **Inj. Well Moebetsu Fm.**
- **CO₂**
- **Observation Well OB-2 For Moebetsu Fm.**
- **Observation Well OB-3 For Takinoue Fm.**
- **Permanent-Type OBC**
- **Moebetsu Fm. Sandstone Layer**
- **Takinoue Fm. Volcanic Rocks Layer**

**Symbols:**
- : CO₂ Flow Meter
- : Pressure & Temperature Sensor
- : 3-Component Seismic Sensor

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Seismic Survey Results - 2nd & 3rd Monitor Surveys -

- Distribution of CO$_2$ in Moebetsu Formation confirmed by seismic surveys since FY2017. Injected CO$_2$ is limited to upper portion of reservoir in correspondence with predictions made in advance, and not believed to have behaved abnormally.

2nd monitor survey (61,239 - 69,070 tonnes; JFY2017)

3rd monitor survey (207,209 tonnes; JFY2018)

※ S/N ratio and accuracy of difference calculation is low due to the limited area of the data utilized for calculation.
Results of Micro-seismicity Monitoring

- No micro-seismicity or natural earthquakes attributable to CO₂ injection were detected in vicinity of injection area between startup of injection and December 2019, including before and after 2018 Hokkaido Eastern Iburi Earthquake.

※ Detectability: Mw > -0.5
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

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Outreach Activities

1) **Panel Exhibitions**
2) **Forum for Tomakomai Citizens**
3) **Site Tours**
4) **Information Disclosure System**
5) **Mini seminars for students**
6) **Kids’ lab classes/site tours**

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Outreach Activities (JFY2019)

- 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

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Cost Estimation of Practical Model

- Based on Tomakomai demonstration data, conducted cost estimation of 200-thousand tonnes/yr practical model, and 1-million-tonnes/yr practical model under similar conditions and certain assumptions.

<table>
<thead>
<tr>
<th>CCS Cost</th>
<th>200-thousand-ton practical model</th>
<th>1-million-ton practical model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capture / Injection</td>
<td></td>
</tr>
<tr>
<td>CAPEX</td>
<td>852</td>
<td>590</td>
</tr>
<tr>
<td>OPEX</td>
<td>4,720</td>
<td>4,079</td>
</tr>
<tr>
<td>Total</td>
<td>5,572</td>
<td>4,669</td>
</tr>
<tr>
<td></td>
<td>Injection wells / Storage</td>
<td></td>
</tr>
<tr>
<td>CAPEX</td>
<td>922</td>
<td>369</td>
</tr>
<tr>
<td>OPEX</td>
<td>4,635</td>
<td>1,148</td>
</tr>
<tr>
<td>Total</td>
<td>5,557</td>
<td>1,517</td>
</tr>
<tr>
<td></td>
<td>Grand Total</td>
<td></td>
</tr>
<tr>
<td>Captured</td>
<td>11,129 (=103 USD/t-CO₂)</td>
<td>6,186 (=57 USD/t-CO₂)</td>
</tr>
<tr>
<td>Avoided</td>
<td>13,328 (=123 USD/t-CO₂)</td>
<td>7,261 (=67 USD/t-CO₂)</td>
</tr>
<tr>
<td>t-CO₂/t-CO₂</td>
<td>0.165</td>
<td>0.148</td>
</tr>
</tbody>
</table>

- CO₂ source gas is separated from PSA upstream; treated off-gas is returned to PSA upstream.
- CO₂ transportation cost not included; facility housing, operator labor costs assumed to be provided by refinery and not included.
- Fuel gas unit cost: JPY1,205/GJ (equivalent to JPY48.2/Nm³), electricity unit cost: JPY10.84/kWh (excluding consumption tax).
- Captured cost: CCS cost/injected CO₂ amount; Avoided cost: CCS cost/(injected CO₂ amount — CO₂ generated by CCS)
Summary

• Operation of full chain CCS system from capture to storage has been conducted successfully and target of 300,000 tonnes of CO₂ injection has been achieved.

• Safety and reliability of CCS system has been demonstrated.

• METI, NEDO and JCCS compiled the results and issues of the Tomakomai CCS Demonstration Project and released a Summary Report.

Notes:
METI: Ministry of Economy, Trade and Industry  NEDO: New Energy and Industrial Technology Development Organization

Experience and Lessons Learned

• Understanding and support of local community is vital for implementing CCS.

• CO₂ capture process comprising a two-stage absorption system has achieved significantly lower capture energy than conventional system.

• Deviated injection wells from onshore site into offshore reservoirs saved drilling cost and avoided disturbance of local livelihood.

• Concerns about earthquakes and induced seismicity have been addressed.
  • Natural earthquakes have not caused any damage to reservoirs.
  • No seismicity (Mw > -0.5) has been detected in/around the depth range of the reservoirs before and during injection.
Thank you for your attention.

http://www.japanccs.com/

Japan CCS Co., Ltd. would like to express thanks to Ministry of Economy, Trade and Industry (METI), New Energy and Industrial Technology Development Organization (NEDO) for kind permission to disclose information.