CO2-EOR R&D in Korea:
CO2-EOR pilot test project

KIGAM
(Korea Institute of Geoscience and Mineral Resources)
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1. CO2–EOR project outline

I. Title: Development of CO2 geological storage technologies through 1,000 ton CO2-EOR pilot test

II. Period: 2012. 11. 01 – 2015. 10. 31
   (3 years for the first stage)

III. Participant: KIGAM, Hanyang, Sejong, Hongik, Konkuk, GS Cons, DSI, GTC, Kwangsin

IV. Funding Agency: KETEP supported by Ministry(MOTIE)
1. CO2–EOR project outline

- CO2 injection & EOR chain

- CO2 capture & transportation
  - CO2 injection & EOR chain
  - Enhanced recovery & CO2 storage

- CO2 injection
- CO2 Purification 1
- CO2 compression
- CO2 injection in single well

- CO2- oil separation

- R&D project scope
  - CO2 securing & transportation
  - CO2 injection in single well

Enhanced recovery & CO2 storage

Recovery response to pressure

Relative Miscible or Near-Miscible

Enhanced recovery & CO2 storage
1. CO2-EOR project outline

◆ Objectives
To develop the integrated technology of CO2 EOR and storage through 1,000 ton CO2 injection pilot test
CO2 injection was way behind the schedule due to delay on selecting oil field.
1. CO2-EOR project outline

- Target oil field

- Meruap oil field in the Sumatra Island, Indonesia
1. CO2–EOR project outline

- CO2 immiscible Huff and Puff
  - Immiscible CO2 injection: low reservoir pressure below MMP (minimum miscibility pressure)
  - Huff and Puff: CO2 injection and oil production in one single well

- Oil swelling
- Viscosity reduction

**CO2 EOR mechanism**

** Reservoir Temperature (°F) **

- CO2 injection
- Oil in Place
- Depleted Oil Sand
- Produced Fluids

- Swelling
- Viscosity reduction

**INJECTION**

- Carbon Dioxide

**SOAKING (Shut-in Phase)**

- CO2 Swells the Oil and Reduces its Viscosity

**PRODUCTION**

- Oil in Place
- Oil, and CO2

(NETL, 2013)
1. CO2-EOR project outline

Reservoir characterization & simulation

- Lab analysis
  - CO2-oil phase behavior
  - MMP prediction model
  - CO2 core flooding

- Reservoir characterization
  - Geological and petrophysical analysis
  - 3D static modeling

- CO2-EOR simulation
  - CO2 Huff and puff
  - Cutting edge CO2-EOR

- CO2 MMV analysis
  - CO2 monitoring
  - Risk assessment
  - Nano-based OWC

CO2 injection & facilities

- CO2 securing & injection
  - CO2 securing and transportation
  - CO2 injection process

- CO2 injection facilities
  - Compressor design
  - Construction of modular package

- CO2-oil separation design
  - Surface facilities basic design
  - Column Internals basic design

1,000 ton CO2 injection pilot test
2. R&D results

- Laboratory analysis for CO2-EOR
  - Phase behavior of CO2 and oil mixtures
  - MMP measurement and prediction
  - CO2 core flooding

Phase behavior analysis
- swelliing factor
- Viscosity of swollen oil

MMP & coreflooding analysis
- MMP & coreflooding analysis
- Verification of MMP prediction model

(MMP: minimum miscible pressure)
2. R&D results

- Reservoir characterization
  - Geological data analysis
  - Well log and Petrophysical data analysis
  - 3D static modeling
2. R&D results

- CO2-EOR dynamic simulation
  - CO2-EOR simulation with 3D static model
  - Simulation study on cutting-edge CO2-EOR technology
  - Sensitivity analysis for fault reactivation

- CO2 huff and puff
- CO2 WAG
- CO2 continuous injection
- Polymer CO2-WAG
- LPG CO2-WAG
- Pore pressure distribution
- Strain distribution
2. R&D results

- **CO2 MMV study**
  - Lab experiment for CO2-Oil-Water monitoring using X-ray CT
  - In-situ experiment for downhole CO2 monitoring using PLT and RST
  - Analysis of damage assessment and performance enhancement of oil well cement

![X-ray CT system and result of saturation distribution](image1)

![SEM images before/after reaction with CO2-saturated brine](image2)

![OWC curing reactor](image3)

![Result of RST test – CO2-Oil saturation distribution](image4)

![Result of PLT test – CO2 flow rate and fluid contact](image5)
2. R&D results

- CO2-oil separation process design

Basic design of CO2 EOR surface facilities

Basic design of column internals for separation and refining of CO2-Oil mixtures
2. R&D results

- CO2 injection facility

**Design of CO2 compressor**

- Specification analysis
- CO2 compressor design

**Construction of CO2 compressor modular package**

- Construction of CO2 compressor
- Test run
2. R&D results

- CO2 injection facility

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<th>Installation and operation</th>
<th>Injection data collection and analysis</th>
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<td><img src="image2.png" alt="Real-time data monitoring" /></td>
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<tr>
<td><img src="image3.png" alt="Field operation of CO2 injection" /></td>
<td><img src="image4.png" alt="Analysis of injection data" /></td>
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3. Pilot test

- **CO2 source & transportation**

  - **CO2 source**: drinking CO2
  - **CO2 Plant location**: Jalan Subang in West Java
  - **Distance from test site**: about 1,000 km
  - **Transportation**: truck and ship
  - **Production capacity**: 100 t/day
3. Pilot test

- CO2 injection process

- Workover
- RST & Injectivity Test
- Inspection
- CO2 Injection Setting
- CO2 Injection
3. Pilot test

- **Cumulative vol.**
  - **1st injection period**
  - **2nd injection period**
  - **Vol. injected per day**
  - **Lebaran holidays**

- **Total volume of CO2 injected** – 987 tons
- **Maximum injection rate** – up to 39 ton/day
The scientific trial of 1,000-ton CO2-EOR pilot test was successfully performed in cooperation with Indonesia, which is Korea’s first record of successful CO2 injection in geological formation.

Production phase after soaking period is now in progress.

Based on encouraging results, it is expected to pursue the second stage of CO2-EOR project using naturally occurring or industrial CO2 sources in Indonesia.

In Korea, CO2-EOR lies in the ambiguous position between GHG reduction technology and EOR technology.
Thank you!!

- Vaporizer
- Generator
- CO2 ISO Tank
- Injection system
- Injection well
- Injection pipe