Low Carbon Day

Low Carbon initiatives in Exploration: CCS

Mikel Erquiaga
Director of Regional Exploration
Eastern Hemisphere
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#RepsolLowCarbonDay
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01. Our Starting Point
The Upstream Business in the Energy Transition context

01. Our Starting Point

Repsol: First O&G Company to announce Net Zero commitment by 2050

Decreasing capital employed in conventional O&G exploration activities and geographically concentrated (2021-2025 Strategic Plan)

Exploration personnel skill sets in conventional O&G exploration activities is being re-converted to Low Carbon Exploration initiatives aligned with our Net Zero ambitions:

- Carbon Capture & Storage (CCS) in the subsurface to abate CO₂ emissions
- Exploration for Geothermal Resources to boost low CO₂ energy generation (similar activity to O&G Exploration)
- Hydrogen Storage to provide solution to buffer H₂ production through storage in saline cavities in the subsurface

The expertise of our G&G workforce will be source of Competitive Advantage in the Energy Transition
02.
Sakakemang Project
02. Sakakemang Project

Discovery & Appraisal

Sakakemang PSC:
Kaliberau Dalam-2X Discovery (KBD-2X)

- Kaliberau Dalam-2X discovery well: February 2019
- Largest Gas discovery in Indonesia in the last decade (>2 TCF)
- Gas with high CO₂ content (26%)
- New Greenfield Projects need to be Net Zero

Appraisal campaign following the KBD-2X discovery:
- KBD-3X appraisal well (2020-2021) – Completed
- Long Duration Test (LDT) on KBD-2X discovery Pressure monitoring in KBD-3X (2021) – Ongoing

Objectives of appraisal program: confirm the volumes associated to the discovery and confirm connectivity between KBD-2X & 3X

- Volumes of CO₂ directly related to discovered volumes of gas
02. Sakakemang Project:

**CCS**

- Development of a 2TCF gas discovery & simultaneous CCS

- First CCS project deployed by Repsol and First in Indonesia.

- Among largest CCS projects worldwide today (only 6 CCS projects operating).

- Storage will commence in 2027 and will be done in two depleted gas fields of Corridor PSC contract (Gelam & Dayun).

- Main Challenges:
  - Regulatory Framework, but the MEMR in Indonesia has already created a Task Force with the objective to have CCS regulation in place by the end of 2021.
  - Financial: cost carried by partners, but captured & stored CO₂ could be subject of further trading.
02. Sakakemang Project:

CCS (Carbon Pricing)

CO2 BE @ 10% – 31 $/Ton
Capture Not included

-4% CO2 gas stream e.g. NGCC Power Generation
-14% CO2 gas stream e.g. Coal Power Generation
27% CO2 gas stream e.g. Steel blast furnace

150 bar <200 ppmv H2O
1 Mtpa, 300km onshore pipeline
20 Mtpa, 180 km onshore pipeline
Offshore geological storage reservoir
Onshore good quality geological storage reservoir

8.1 $/T
3.4 $/T
7 $/T
2.2 – 2.5 $/T

400 ktpa CO2
5 Mtpa CO2
1 Mtpa, 1,500 km
20 Mtpa, 180 km
400 ktpa CO2

USD 2020 per tonne CO2

% of Total Cost

70%
5%
10%
15%
02. Sakakemang Project:

CCS worldwide benchmark

- **Power generation**
  - Sinopec Oilfield
  - Boundary dam
  - Santos Cooper
  - Plant Daniel Cal Capture
  - Dry fork Project Tundra
  - Top ranking high from Mckinsey, 2021

- **Chemicals**
  - Sinopec
  - Illinois Industrial
  - Air products
  - Quest
  - ACTL Sturgeon
  - ACTL Agrium
  - Porthos
  - Carbonnet
  - Quite sizeable project: ~2% of CCS installed capacity by 2027

- **Steel**
  - Eind Fertilizer
  - coffeyville
  - PCS Nitrogen

- **Cement**
  - Century Plant
  - Lost cabin
  - CNPC Jilin

- **Natural gas processing**
  - Shute Creek
  - Petrobras pre-salt
  - Gorgon
  - Qatar LNG
  - Petrobras pre-salt
  - CNPC Jilin

- **Operating**
  - In operation
  - CO₂ → EOR
  - In construction
  - Advanced Development
  - In evaluation
  - = 1 MTPA of CO₂ (Area of circles proportional capacity)

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Today only 6 true CCS projects worldwide

- Sakakemang 2 Mte/yr
- From Mckinsey, 2021

- ~40 Mte/yr
- ~110 Mte/yr
02. Sakakemang Project: CCS Technical Assessment

**SITE SCREENING**
- Regional / basin analysis scale
  - Completed

**SITE SELECTION**
- Short list potential & feasible sites
  - Depleted Gas Fields
    - 2 candidates (Gelam & Dayung)
  - Saline Aquifers
    - For potential upside: corridor tail
  - 3rd & 4th candidates

**SITE CHARACTERIZATION**
- Initial Characterization
  - Seal Analysis
  - Geomechanical Analysis
  - Storage complex
  - Static modeling
  - Dynamic modeling
  - Injection modeling
  - Risk Assessment
    - Storage Capacity
    - Injectivity
    - Containment

**QUALIFIED SITE**
- Detailed Characterization
  - Models refining
  - Risk Management Plan
  - CO₂ injection baseline
  - Monitoring plan
  - Pilot program executed
  - Wells & completions
    - Monitoring
    - Predictive model
    - Final engineering

**Visualization (to be completed by December 2021)**

**Conceptualization Definition**

**Execution**
- Start up injection
  - Geological
  - Carbon
  - Storage
  - Construction & Operations
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Investor Relations
investor.relations@repsol.com

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