CCS Research in Indonesia

CCOP CO2 Storage Mapping Program (CCS-M)

CCS-M National Coordinators Meeting (M2)

CCOP Technical Secretariat, Bangkok, Thailand
15-16 Feb 2016
CONTENTS

1. CCS research history
2. Lemigas – WB CCS study
3. Lemigas CCUS - EOR Pilot Project
4. GUNDIH CCS Pilot Project – ITB, PERTAMINA (ADB)
5. Conclusions and Recommendations
1 Lemigas CCS research history
Lemigas CCS Research

2003 - 2008
Sojitz & Mitsubishi:
Investigating CO2 storage potential combined with EOR

2009 - 2011
Joint study with UK government: a first comprehensive study
to identify CCS potential deployment in Indonesia

2011 - 2012
ADB:
Identify a promising demonstration project in specific site

2014 - 2015
The World Bank
EOR market and CO2 storage capacity study

2006 - 2009
Shell:
Jointly develop detailed scopes for CCS project’s proposals
that have potential to attract external funding

2012 - 2013
MHI & JCOAL:
Schedule for CO2 injection to oil fields
Economical study for CO2 EOR

2010 - 2011
Total Indonesia:
Multiyears joint research at TOTAL field

2016 - 2018
Center of Excellence CCS - ESDM:
(1) CCS EOR Pilot Project
(2) Regulatory Framework
CO\textsubscript{2} emission from PLN Coal-fired Power Plants of South Sumatra and West Java

<table>
<thead>
<tr>
<th></th>
<th>Sumsel-6</th>
<th>Bojonegara</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Planned Steam Coal Power Plant  1 x 600 MWatt</td>
<td>Planned Steam Coal Power Plant  2 x 1000 MWatt</td>
</tr>
<tr>
<td></td>
<td>CO\textsubscript{2} Emissions 3.68 Mt/year</td>
<td>CO\textsubscript{2} Emissions 10.92 Mt/year</td>
</tr>
<tr>
<td></td>
<td>Starting 2027</td>
<td>Starting 2025</td>
</tr>
</tbody>
</table>

**Total** = 14.6 Mton / Year

CO\textsubscript{2} Emissions for 20 Years = 292 Mton

**Illustration:**

- **Sumsel 6**
- **Bojonegara**
127 Oil Field in South Sumatera were studied for EOR

661 MMSTB oil RF for 20 years

243 MMTon of CO₂
45 Gas Field in South Sumatera

Legend:
- Power Plant
- Gas Field
- Onshore
- Offshore
- GFSS Name Of Field

537.02 Total Storage Capacity in South Sumatera Basin (10^3 Tons)

Field Number 45
Storage (MMTon) 537
## 51 Gas Field in West Java

<table>
<thead>
<tr>
<th>Location</th>
<th>Field Number</th>
<th>Storage (MMTonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onshore West Java</td>
<td>22</td>
<td>171</td>
</tr>
<tr>
<td>Offshore West Java</td>
<td>29</td>
<td>224</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>51</strong></td>
<td><strong>395</strong></td>
</tr>
</tbody>
</table>
## TOTAL CAPACITY STORAGE SALINE AQUIFER SOUTH SUMATERA AND NORTH WEST JAVA BASIN

<table>
<thead>
<tr>
<th>NO</th>
<th>BASIN</th>
<th>CO\textsuperscript{2} CAPACITY STORAGE (GTones)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P10</td>
</tr>
<tr>
<td>1</td>
<td>SOUTH SUMATRA</td>
<td>2.12</td>
</tr>
<tr>
<td>2</td>
<td>NW JAVA</td>
<td>3.19</td>
</tr>
</tbody>
</table>

**PROBABILISTIC E FACTOR US. DEP. ENERGY 2010**

(P10) : $E = 0.074$ (Sand Stone); $E = 0.10$ (Lime Stone)

(P50) : $E = 0.14$ (Sand Stone); $E = 0.15$ (Lime Stone)

(P90) : $E = 0.24$ (Sand Stone); $E = 0.21$ (Lime Stone)
3 Lemigas CCUS - EOR Pilot Project (2016-2018)
“Road Map” Target Implementasi CCS di Indonesia

<table>
<thead>
<tr>
<th>STAGE 1</th>
<th>2016-2020</th>
<th>Pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50-100 tonnes per day of CO₂ over several months</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge of reservoir performance to support financing and designing a Demo project.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STAGE 2</th>
<th>2020-2030</th>
<th>Demonstration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Larger quantities of CO₂ injected into many wells continuously over many years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500-1,000 tonnes per day or more of CO₂ injected over 10+ years.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Confirmation of long-term successful CO₂ storage to support financing and construction of at least one full scale commercial operation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STAGE 3</th>
<th>2030-2050</th>
<th>Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Very large quantities of CO₂ captured from one or more sources injected into one or more locations for a very long time period</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,500 -5,000 tonnes per day CO₂ captured and injected over 20+ years.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Capture and store sufficient quantities of CO₂ to substantially reduce Indonesia’s CO₂ emissions</td>
</tr>
</tbody>
</table>
Lemigas CCUS-EOR South Sumatera Pilot Project Stages

2016
Feasibility study

2017
- FEED, DED, EPC
- Commissioning
- Pilot Project On-stream
- Injection phase

2018
- Monitoring
- Measurement
- Evaluation
LEMIGAS Activities in 2016

Activities in this year consist of:

- **Subsurface Study**
  - Selection of Injection Target Field
  - Reservoir Screening
  - Fluid Sampling
  - Study of reservoir fluid
  - Study of CO₂ injection
  - Field and reservoir data collection
  - Study of geology and geophysics
  - Petro-physic Study and formation evaluation
  - Study of engineering data

- **Surface Study**
  - Study of CO₂ Capture Technology
  - Study of CO₂ Transportation Technology
  - Study of CO₂ Injection Technology
  - Equipment Sizing and costing

- **Study of Monitoring and Evaluation**

- **Economic Study of CCS-EOR Pilot Project**

- **Study of CCS-EOR Regulation and Policy**

- **Risk Analysis Study of CCS-EOR Pilot Project**
Activities in 2017

• In this year CCS-EOR is planned to be running on-stream. Activities in this year consist of:
  – Injection Well Drilling/ Work-over
  – Injection well preparation through Huff and Puff as well as flooding
  – Pre test of injection rate and pressure
  – Front End Engineering Design (FEED) and Detail Engineering Design (DED) of surface facilities
    • CO₂ Capture Facility
    • CO₂ Transportation Facility
    • CO₂ Injection Facility
  – Project Management
  – Engineering, Procurement and Construction (EPC) and commissioning of surface facilities
    • Construction of CO₂ Capture Facility
    • Construction of CO₂ Transportation Facility
    • Construction of CO₂ Injection Facility
    • Installing Monitoring Equipment
  – Operation of CO₂ capture and transportation Facilities
  – Operation of field injection according to reservoir simulation study design and surface facilities design
Activities in 2018

– Operation of CO$_2$ capture and transportation Facilities
– Operation of field injection according to reservoir simulation study design and surface facilities design
– Monitoring, Measurement and Verification (MMV)
– Technical Evaluation
– Economical Evaluation
4 GUNDIH CCS-Pilot Project (ADB-ITB-PERTAMINA)
GUNDIHI CCS PILOT

(Separate presentation is available by Wawan Gunawan A. Kadir, Project Director of Indonesian side)

• Gundih field is a gas field, has been in production since the end of 2013. CO2 content which is generated directly from this field is 21% of the produced gas. After the CPP (Cental Processing Plant), about 15% of the total product is separated as almost pure CO2, which equivalent with 800 tonnes per day of CO2.

• The gas is produced from the 3 main structures, which are situated inside the Gundih field, namely Kedung Tuban, Randu Blatung and Kedung Lusi structures, which can produce around 60 MMSCFD within 12 years.

• The selected area is located in Cepu Sub-district, centered at around Jepon-1 well (Jepon Structure).

• The planned CCS Pilot project will inject around 30 tonnes of CO2 per day or totally 20,000 tonnes of CO2 within 2 years.
The Needs of Indonesia CCS to meet the COP21 commitments
TARGET OF NATIONAL GHG REDUCTION PLAN

Scenario of 26% GHG Emission Reduction

President Commitment
G-20 Pittsburgh and COP15
To reduce the GHG Emission in 2020

26% → 26%
Unilateral

15%
41%
Unilateral and International Support

National Action Plan

FORESTRY & PEATLANDS
AGRICULTURE
ENERGY AND TRANSPORTATION
INDUSTRY
WASTES
Presidential Decree No. 61, 2011 on National Action Plan of GHG Reduction

RAN-GRK (GHG ACTION PLAN)
NATIONAL-PROVINCE GHGRP RELATIONSHIP

NATIONAL LEVEL

Coordination of technical supports & capacity building:
Guidance, training materials, trainings

PROVINCE LEVEL
(Cities & Regencies)

NATIONAL ACTION PLAN - GHG

Bottom-Up:
Prov. Setting AP based on local conditions

Top-down:
Prov. mandatory to set AP

Provinces Action Plan
Provinces Action Plan
Provinces Action Plan

Provinces Coordination of the same methodology & process
## TARGET OF GHG EMISSION REDUCTION

<table>
<thead>
<tr>
<th>Sector</th>
<th>Emission Reduction (Giga ton CO2e)</th>
<th>Action Plan</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forestry and Peatland</td>
<td>0.672</td>
<td>Forest and land fire control, water nd hydrology mangement on peatland, forest and land rehabilitation, illegal logging control, avoiding deforestation, community development</td>
<td>MoFr, MoPW, MoA, MoE</td>
</tr>
<tr>
<td>Waste</td>
<td>0.048</td>
<td>Sanitary landfill development, 3 R and sewerage system in urban areas</td>
<td>MoPW, MoE</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.008</td>
<td>Introduction of low carbon rice variety, irrigation efficiency, organic fertilizer utilization</td>
<td>MoA, MoPW, MoE</td>
</tr>
<tr>
<td>Industry</td>
<td>0.001</td>
<td>Energy efficiency, renewable energy development</td>
<td>MoI</td>
</tr>
<tr>
<td>Energy and Transportation</td>
<td>0.038</td>
<td>Biofuel development and utilization, fuel efficiency improvement, mass transportation, demand side management, renewable energy, energy efficiency</td>
<td>MoT, MoEnergy, MoPW, MoF</td>
</tr>
</tbody>
</table>

*Methane emissions reduction*
Paragraph 1 (b) (ii) of the Bali Action Plan of 2007: “[…] Nationally appropriate mitigation actions [developed] by developing country Parties in the context of sustainable development, supported and enabled by technology, financing and capacity building, in a measurable, reportable and verifiable manner.”
**Implemented Policy**

1. Energy saving by implementing more efficient technology.
2. Use of more efficient fuels
3. Use of renewable energy
4. Clean technology applications (generators, transportation)
5. Mass transportation with low emission, continual and environmentally friendly.
6. Mining lands reclamation.

**Target of Emission Reduction**

- (26%) ≈ 0,038 Giga ton CO2
- (41%) ≈ 0,056 Giga ton CO2

**Energi Sector (including mining)**

≈ 0,0275 Giga ton CO2
• Indonesia’s **Intended Nationally Determined Contribution** (INDC), released on 24 September 2015, includes an unconditional 2030 GHG emissions reduction target (including land-use, land-use change and forestry (LULUCF)- emissions) of 29% below business-as-usual (BAU) and a conditional 41% reduction below BAU by 2030 (with sufficient international support).
Conclusions and Recommendations
Conclusions & Recommendations

- In short term CCS development in Indonesia should be started from oil and gas upstream industry.

- A roadmap is required thus government and all stakeholder could step forward and create synergy in specific agenda and precise schedule to solve issues related with CCS development in Indonesia.

- Lemigas CCUS is in full readiness to conduct pilot project of CCS supported by accredited laboratory units.

- The Gundih project is ready to have CCS at 2016 (Regulation and JCM already been prepared)

- As CCS or CCUS is a HighTechnology & High Cost project that may Increase the cost per barrel
- Oil Price will define how the CCS project will work
- Need regulatory framework of CCS from The Government
- Need guidelines and from study, pilot and full scale project of CCS / CCUS
- Need guidelines and regulations of EOR from Study, Laboratory, Pilot & EOR (Pertamina, SKKMigas, Government)
- Need exchange of special knowledge and expertises from collaboration among countries of their experiences
Thank you

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Table 3-1  Key parameters for the reference plants for the CO₂ Capture-Ready Study

<table>
<thead>
<tr>
<th></th>
<th>North West Java</th>
<th>South Sumatra</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>North West Java</td>
<td>South Sumatra</td>
</tr>
<tr>
<td><strong>Installed Capacity</strong></td>
<td>2 x 1000 MW</td>
<td>1 x 600 MW</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>Ultra supercritical</td>
<td>Supercritical</td>
</tr>
<tr>
<td><strong>Commissioning year</strong></td>
<td>2020</td>
<td>2022</td>
</tr>
<tr>
<td><strong>Source of coal</strong></td>
<td>Kalimantan</td>
<td>Mine mouth</td>
</tr>
<tr>
<td><strong>Capacity Factor</strong></td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td><strong>Boiler Efficiency (HHV)[1]</strong></td>
<td>83.3%</td>
<td>76.3%</td>
</tr>
<tr>
<td><strong>Turbine Efficiency</strong></td>
<td>46.2%</td>
<td>44.0%</td>
</tr>
</tbody>
</table>

**Coal quality**

- **Gross Calorific Value (HHV)**: 3,880 kcal/kg \([^{[2]}]\), 2600 kcal/kg \(\text{(as received)}\)
- **Total moisture content**: Average 35% \(\text{Average 54%}\)
- **Ash content**: Average 5.0% \(\text{Average 6.5%}\)
- **Sulfur content (dry ash free)**: Average 1.8% \(\text{Average 0.86%}\)

**Annual CO₂ emissions**

- 12.13 million tCO₂ \([^{[3]}]\)
- 4.09 million tCO₂

**Desulfurization technology**

- Seawater scrubber
- None

**Power plant efficiency**

- 42.5%\(\text{hiv}[1]\)
- 38.5%\(\text{hiv}[1]\)
- 40.8%\(\text{hiv}\)
- 34.4%\(\text{hiv}\)

*Notes*: [1] HHV (or hiv) denotes Higher Heating Value, which is also known as Gross Calorific Value, and is a measure of heat of combustion for fuels. “lhv” denotes Lower Heating Value, which is also known as Net Calorific Value; [2] kcal/kg means kilocalories per kilogram; [3] tCO₂ means tonnes of carbon dioxide.
<table>
<thead>
<tr>
<th></th>
<th>No capture</th>
<th>90% capture</th>
<th>45% capture</th>
<th>22.5% capture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity output - MWe</td>
<td>600</td>
<td>415</td>
<td>507</td>
<td>554</td>
</tr>
<tr>
<td>CO₂ captured – t/hr</td>
<td>0</td>
<td>527</td>
<td>264</td>
<td>132</td>
</tr>
<tr>
<td>CO₂ discharged to air – t/hr</td>
<td>586</td>
<td>59</td>
<td>322</td>
<td>454</td>
</tr>
<tr>
<td>Fraction of power plant flue gas sent to CO₂ capture</td>
<td>0%</td>
<td>100%</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>CO₂ emission factor - kg/MWh</td>
<td>976</td>
<td>142</td>
<td>635</td>
<td>819</td>
</tr>
<tr>
<td>Number of MEA trains</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Annual CO₂ storage at 80% capacity factor – million tonnes</td>
<td>0</td>
<td>3.68</td>
<td>1.84</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>CCS implementation in West Java</td>
<td>CCS implementation in S Sumatra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------------</td>
<td>---------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td>2030</td>
<td>2035</td>
<td>2027</td>
</tr>
<tr>
<td>Capture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.5%</td>
<td>55</td>
<td>41</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>45%</td>
<td>109</td>
<td>82</td>
<td>55</td>
<td>37</td>
</tr>
<tr>
<td>90%</td>
<td>218</td>
<td>164</td>
<td>109</td>
<td>74</td>
</tr>
</tbody>
</table>

**Table 4-10** Capital cost estimates for CO₂ capture equipment (US$ million)

<table>
<thead>
<tr>
<th>West Java</th>
<th>90% capture</th>
<th>45% capture</th>
<th>22.5% capture</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR process plant</td>
<td>180</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>FGD process plant</td>
<td>378</td>
<td>214</td>
<td>119</td>
</tr>
<tr>
<td>MEA process plant</td>
<td>870</td>
<td>460</td>
<td>291</td>
</tr>
<tr>
<td>CO₂ compressors and dryers</td>
<td>173</td>
<td>123</td>
<td>61</td>
</tr>
<tr>
<td>LP steam power recovery turbine</td>
<td>80</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1681</strong></td>
<td><strong>1016</strong></td>
<td><strong>681</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>South Sumatra</th>
<th>90% capture</th>
<th>45% capture</th>
<th>22.5% capture</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCR process plant</td>
<td>56</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>FGD process plant</td>
<td>128</td>
<td>98</td>
<td>79</td>
</tr>
<tr>
<td>MEA process plant</td>
<td>425</td>
<td>248</td>
<td>159</td>
</tr>
<tr>
<td>CO₂ compressors and dryers</td>
<td>94</td>
<td>58</td>
<td>43</td>
</tr>
<tr>
<td>LP steam power recovery turbine</td>
<td>40</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>743</strong></td>
<td><strong>490</strong></td>
<td><strong>357</strong></td>
</tr>
</tbody>
</table>