Coal Seam Gas Development and CO2 Sequestration in Low Rank Coals: Progress in New Zealand

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And also:
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Andy Nicol, GNS Science
Grant Gillard, Solid Energy
Carlos Galceran, Solid Energy
Structure of talk

• **Background of CSG in New Zealand** – to give context

• **Our approach** – to show how we got to where we are going

• **Results** – both practical and scientific

• **The Future** – CO₂ sequestration
CSG Exploration in New Zealand

- Some early evaluations by Ministry in 1980s
- Southgas/Northgas experiences in the 1990s
- Westgas developments early 2000s
- Exploration of low rank coals early 2000s
  - Kenham/L&M Group
  - RDT
  - Solid Energy
  - Bridge/Westech
Waikato Prospect

- **Nov. 2002:** RDT awarded PEP
- **Nov. 2004:** CBM Ltd. JV formed Nov. 2004
- **June – Oct 05:** Exploration phase in Huntly Coalfield

**THREE STAGE APPROACH**

1. Initial basin assessment
2. Basin wide exploration
3. Appraisal wells
Expected outcomes of each stage

Initial Assessment: Indicative gas in-place

Exploration: Gas volume, quality & water quality

Appraisal: Flow rates (gas & water), completion technologies, permeabilities

Field Development
## Stage 1: Initial Basin Analysis

### Reported coal volumes

<table>
<thead>
<tr>
<th>Sector</th>
<th>Coal (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Churchill</td>
<td></td>
</tr>
<tr>
<td>Horohoro</td>
<td></td>
</tr>
<tr>
<td>Rangiriri West</td>
<td></td>
</tr>
<tr>
<td>Huntly West</td>
<td></td>
</tr>
<tr>
<td>Okowhao</td>
<td></td>
</tr>
<tr>
<td>Huntly East</td>
<td></td>
</tr>
<tr>
<td>Ralphs</td>
<td></td>
</tr>
<tr>
<td>Weavers</td>
<td></td>
</tr>
<tr>
<td>Kupakupa</td>
<td></td>
</tr>
<tr>
<td>Raynors</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,048</td>
</tr>
</tbody>
</table>

### Reported gas quality

<table>
<thead>
<tr>
<th>Gas Measure</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH4 %</td>
<td>91.00</td>
</tr>
<tr>
<td>CO2 %</td>
<td>5.30</td>
</tr>
<tr>
<td>C2H4 ppm</td>
<td>-</td>
</tr>
<tr>
<td>C2H6 ppm</td>
<td>449.00</td>
</tr>
<tr>
<td>C3H6 ppm</td>
<td>-</td>
</tr>
<tr>
<td>C3H8 ppm</td>
<td>-</td>
</tr>
<tr>
<td>He ppm</td>
<td>-</td>
</tr>
<tr>
<td>O2 %</td>
<td>3655</td>
</tr>
<tr>
<td>N2 %</td>
<td>54</td>
</tr>
</tbody>
</table>

### Reported gas volume

**HUNTLY TWI CH4 Isotherm**

- As Analysed
- Dry Ash Free

**Mean** 5%  
**95%**

- Petajoules

**Pressure (MPa)**

- 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0

**Gas Content (cc/g)**

- Depth AA
- Depth DAF
Stage 2: Exploration Drill Holes

Location selection based on:

- Geology (seam thickness, depth)
- Previous reported gas shows
- Geographic spread
- Access
Stage 2: Data Collection

More detail in –

Reservoir delineation (rock volume)

Reservoir character (gas volume & flow)
Stage 2: Detailed Correlations of Reservoirs
Stage 2:
**Structural Re-interpretation**

- **Structural model for:**
  - Renown coal seam
  - Kupakupa coal seam
  - Basement

- **Probability assessment of faults:**
  - Missing ~50% of faults <10m
  - Fault spacing 600 – 800 m
Stage 2: Detailed isopach & structural models

• Refinement of reservoir vol. model
• Depth related to gas volume model
Stage 2: Data Collection

More detail in –

Reservoir delineation (rock volume)

Reservoir character (gas volume & flow)
Stage 2: Reservoir Character Data Types

- Desorption: lost, measured, residual
- Adsorption
- Matrix permeability
- Gas quality
- Gas isotopes
- Coal type
- Geochemistry

<table>
<thead>
<tr>
<th>CRL Ref</th>
<th>Ash (db)</th>
<th>Sulphur (db)</th>
<th>Sulphate Sulphur (db)</th>
<th>Pyritic Sulphur (db)</th>
<th>Organic Sulphur (db)</th>
<th>Relative Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>70476</td>
<td>6.2</td>
<td>0.30</td>
<td>&lt;0.01</td>
<td>0.04</td>
<td>0.31</td>
<td>1.330</td>
</tr>
<tr>
<td>70477</td>
<td>4.4</td>
<td>0.34</td>
<td>0.01</td>
<td>0.03</td>
<td>0.31</td>
<td>1.320</td>
</tr>
<tr>
<td>70478</td>
<td>3.2</td>
<td>0.33</td>
<td>0.01</td>
<td>0.03</td>
<td>0.30</td>
<td>1.270</td>
</tr>
<tr>
<td>70479</td>
<td>3.3</td>
<td>0.33</td>
<td>&lt;0.01</td>
<td>0.02</td>
<td>0.31</td>
<td>1.317</td>
</tr>
<tr>
<td>70480</td>
<td>3.4</td>
<td>0.43</td>
<td>0.02</td>
<td>0.03</td>
<td>0.38</td>
<td>1.287</td>
</tr>
<tr>
<td>70481</td>
<td>3.1</td>
<td>0.29</td>
<td>0.01</td>
<td>0.03</td>
<td>0.25</td>
<td>1.320</td>
</tr>
</tbody>
</table>
Stage 2: Holding Capacity (Adsorption)
Stage 2: Measured Gas Content (Desorption)

\[ n = \text{over 100 canisters} \]
## Stage 2: Gas Quality

<table>
<thead>
<tr>
<th>Gas</th>
<th>basis</th>
<th>Mean</th>
<th>Stand. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄</td>
<td>%</td>
<td>98.43</td>
<td>1.77</td>
</tr>
<tr>
<td>CO₂</td>
<td>%</td>
<td>1.52</td>
<td>1.77</td>
</tr>
<tr>
<td>C₂H₄</td>
<td>ppm</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>C₂H₆</td>
<td>ppm</td>
<td>338.72</td>
<td>280.38</td>
</tr>
<tr>
<td>H₂</td>
<td>ppm</td>
<td>154.90</td>
<td>403.96</td>
</tr>
<tr>
<td>O₂</td>
<td>%</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>N₂</td>
<td>%</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

\( n = 41 \)
Stage 2: Origin of Gas – Isotopic Analysis
Stage 2 Output: Gas in-place uncertainty
Stage 2: Outcome – Next Stage?

Stage 2: Exploration results

- Gas in-place good (25 – 200 PJ)
- Gas quality great (98% methane)
- Gas flows good, 2-5 PJ/yr
- Water quality good

Stage 3: Appraisal Well Drilling

- Five closely spaced wells (~450m)
- Test permeability (reservoir character)
- Determine completion methodology
- Establish gas flow profiles

- Assess character of pore and fracture systems etc.
Practical Result: Before and After Desorption

Methane Adsorption Isotherms daf for Kupakupa Seam

Black line = adsorption sample collected in the field
Red line = collected post desorption

1 m³ = ~35 scf
CO₂ Sequestration: Objectives

- Investigate the potential for CO2 and N2 gases storage in depleted Coal Seam Gas (CSG) reservoirs.
- Enhance methane recovery from CSG wells.
Reservoir sensitivity analysis for Huntly

- 80 Acres well spacing
- 4 injection wells at the corners and 1 production well in the middle
- Constant permeability
- Production from Renown and Kupakupa.
- Maximum pump capacity (400 bbl/day)
- Flue gases are injected in the gas phase
- Variable CO2 and N2 injection rates
Enhanced methane recovery using CO$_2$ sequestration after 5 years of production

![Graph showing methane production over time for different CO$_2$ injection rates.](image-url)
CO2 production rate per well

![Graph showing CO2 production rate per well over time with different rates for each well.]
Comparison between CO2 and N2 sequestration for 5 ton/day gas injection
Flue gas injection 5 ton/day

25% CO2 + 75% N2

75% CO2 + 25% N2
CO$_2$ Sequestration: Conclusions

- The injection of CO$_2$ and N$_2$ significantly increase the rate of methane recovery.
- The breakthrough of N$_2$ is much faster than that of CO$_2$, due to the low adsorption capacity for N$_2$ compared to CO$_2$.
- The use of CO$_2$ is recommended for the enhancement of methane recovery.
FINAL SUMMARY

- Exploration phase successful:
  - Reservoir & gas data good

- Appraisal phase underway:
  - Begun drilling August 06
  - Testing for 6-12 months

- Decision for FIELD Development:
  - By June 07

- Commercial development of gas:
  - Possibly by Feb. 08

- Making Scenarios [Stats] CRUCIAL
- Having Science Correct & Targeted CRUCIAL
- Looking Forward IMPERATIVE