Coal Seam Gas in Australia: Resource Potential and Production Issues*

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Abstract

In 2009, Australia’s estimated proven and probable coal seam gas (CSG) reserves were 21,180 petajoules (EnergyQuest, 2009); current total resource estimates, however, range up to 250,000 PJ. Last fiscal year, CSG production was 143 PJ to supply Australia’s domestic market. Eight separate CSG to LNG projects have recently been proposed and “The Blueprint for Queensland’s LNG Industry” estimates that collectively these would process more than 50 Mt/y (~2700 PJ/y) for export. This expansion, however, leads to challenges in developing sufficient production capacity, handling systems and water management. In 2007-08, >13 gigalitres of formation water were produced during CSG production and disposed of mainly in evaporation ponds, a practice which is about to be terminated. Government regulators estimate 126 and 280 GL/yr water production for a 10 and 40 Mt/yr LNG industry respectively. As most of the CSG reserves are located within the Great Artesian Basin, concerns exist on the effects of the major increase in production on water resources in adjacent aquifer systems.

The anticipated expanded production requires improved definitions of resource distributions, reservoir properties and compartmentalisation. A ‘coal systems analysis’ approach assists in accurately predicting reservoir quality and gas content. Fracture stimulation techniques lead to improving producibility of low permeability CSG reservoirs and numerical modelling techniques have been developed to improve predictions of dynamic reservoir response and aid in the design of production strategies. With adequate legislation in place and integrated reservoir management tools, Australia has the potential to develop a substantial CSG to LNG export industry.

Selected References


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Estimated proven and probable CSG reserves

- **21,180 petajoules** (EnergyQuest, 2009);
- Current total resource estimates - up to 250,000 PJ.
- Last fiscal year, CSG production was ~143 PJ to supply Australia’s domestic market.

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2007-08:

• >13 gigalitres of formation water were produced
• disposed of mainly in evaporation ponds

Government regulators estimate:

• for 10 Mt/yr LNG – 126 GL/yr water production
• for 40 Mt/yr LNG – 280 GL/yr water production

Most CSG reserves are located within the Great Artesian Basin
CSG IS NOT LOW IMPACT
Other Challenges in Australia

• Resource Characterisation
• Production Performance
• Reservoir Stimulation
• Fugitive Emissions
• Ramp Gas Utilisation
Events Timeline

April 2009

APLNG
(Origin – ConocoPhillips)

QLD Govnt declares it a “special project”
April 2009

APLNG
(Origin – ConocoPhillips)

QLD Govt declares it a “special project” worth $35 billion AUS
Events Timeline

March 2010:
- Queensland CSG to LNG contract
- Up to 8,500 Queensland jobs and ~$60 billion in export

Premier Anna Bligh announced:
“the BG Group....... China National Offshore Oil Corporation (CNOOC) .......72 Mt of LNG from Queensland over 20 years“

March 2010:
Shell and a subsidiary of PetroChina (CS CSG (Australia) Pty Ltd) offer to purchase Arrow Energy Ltd. (acquisition complete in August 2010).
April 2010:

Premier Anna Bligh announced:

“$490 m for Gladstone as plans underway to handle Surat Basin LNG boom” to include:

• Port Facilities
• Housing
• Health
• Land acquisition for pipeline
• Training
Events Timeline

May 2010:

QLD Department of Infrastructure and Planning produce a, “Management of Water Produced from Coal Seam Gas Production Discussion Paper”.

The policy deals with:

• use of CSG water
• evaporation dams
• design standards for CSG water aggregation and brine dams
• transitional arrangements for existing dams
• management of saline effluent and solid salt wastes from water treatment and evaporation processes.
Farmers protest at Cecil Plains

Doug Parrington | 20th May 2010

FARMERS turned out in force at Cecil Plains yesterday to demand an immediate Queensland Government moratorium on coal seam gas exploration and production in the area.

About 400 people and the massing of 54 cotton and grain harvesters and tractors created a strong show of farm power to protest against the intrusion of mining companies on prime agricultural land.

The farmers cheered when rally organiser Dave Armstrong called for a moratorium on mining activities so that major environment issues, such as the mining companies' proposed use of large quantities of underground water, could be

Ana Armstrong, left, and Kay and Greg Cook sum up their feelings with signs at the Cecil Plains rally

Doug Parrington
Events Timeline

May 2010:
QLD State Government grants conditional approval to the $7.7 billion Santos/PETRONAS Gladstone Liquefied Natural Gas.

Premier Anna Bligh said:
“independent Coordinator-General (CG) Colin Jensen had completed a review of the Environmental Impact Statement (EIS) and approved it with strict conditions”.

June 2010
Premier Anna Bligh Announces:”The State has granted conditional approval to QGC Pty Limited's multi-billion-dollar Queensland Curtis Liquefied Natural Gas project (QCLNG)”. 
Events Timeline

July 2010: The Bligh Government announced extra compliance staff to continue to closely monitor the coal seam gas industry.

July 2010: Health concerns shut down Kingaroy UCG plant Queensland after water quality tests detected benzene and toluene in groundwater monitoring bores close to the plant.

July 2010: $1.5 million for Namoi Water Study

Senator the Hon Penny Wong, said “The Federal Government understands local community concerns about the potential impacts of coal mining and coal seam gas extraction on local communities and water resources.”
“DUST-UP: Cancer causing chemicals have been found in water near a coal seam gas project at Kingaroy. Gordon Gay has been told he can't use his bores”.

Source: The Sunday Mail (Qld)
Events Timeline

July 2010:

Federal Environment Minister Peter Garrett delays an environmental assessment on two LNG projects, owned separately by Santos Ltd and Britain's BG Group, by three months until Oct. 11 to consider the long-term environmental impact of these developments.

Australian Federal Election

Aug 23 - With no clear winner in Australia's election – hung parliament
Events Timeline

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News Flash: Labour coalition with independents
Events Timeline

Targeted Production to start in 2014:

- **BG** (is planning to approve its project by year-end)
- **Santos** and **Petronas**
- **Origin Energy** and **ConocoPhillip's**
- **Shell** and **CS CSG** (Australia) Pty Ltd (not yet submitted an environmental impact statement).
Challenge: Subsurface Management

Competing use of pore space

- Groundwater
- Coal Seam Methane
- Conventional Petroleum
- Geothermal
- CO₂ Storage
- Marine Park
Integrated Coal Systems Analyses (CSA)

- Coal Rank and Type
- Structural & Stratigraphy
- Geology
- Hydrodynamics
- Geothermics
- Sorption, Diffusion and Permeability
- Gas Content and Composition

From Faiz (2005)
### CSA events chart, S. Sydney Basin

<table>
<thead>
<tr>
<th>Permian</th>
<th>Triassic</th>
<th>Jurassic</th>
<th>Cretaceous</th>
<th>Tertiary</th>
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<td><img src="image3" alt="Jurassic" /></td>
<td><img src="image4" alt="Cretaceous" /></td>
<td><img src="image5" alt="Tertiary" /></td>
</tr>
</tbody>
</table>

**Geological Time Scale**
- Permian
- Triassic
- Jurassic
- Cretaceous
- Tertiary

**Petroleum System Events**
- Source Rock
- Reservoir Rock
- Seal Rock
- Overburden rock
- Trap formation
- Thermogenic gas generation, migration, accumulation
- Preservation time
- Secondary biogenic gas generation
- Critical moment

**Source:** Faiz (2008)
CSA model, Sydney Basin

Source: Faiz & Hendry (2007)
Integrated Coal Systems approach

Oz Coal Seam Gas – Research Priority

1. Reservoir Simulation
2. Unconventional Reservoir Stimulation
3. Coal Rock Properties
4. Resource Characterisation
5. Microbial Enhanced Coal Seam Methane
6. CSG Water Production and Management
7. Unconventional Reservoir Monitoring
Coal seam gas recovery process

1. Initial state – pore fluid pressure maintains gas adsorbed within matrix

2. Fluid pressure lowered in cleat/fracture system – pressure difference between cleat and matrix

3. Pressure lowered, gas desorbs and diffuses through matrix to cleat – water and gas flow within cleats
Flow process in coal

Conceptual model for the cleat-matrix system

Coal structure

Fluid pressure, $P$

Stress, $\sigma_{xx}$

From Shi & Durucan 2005
How does gas de-sorb and flow to the well?

Keffective = K_{relative} \cdot K
Example simulation of CSG production

How do properties affect gas rate?

Gas production and reservoir properties
Gas production and reservoir properties

- Numerical Simulation
- Laboratory experiments
- Field Pilots
- Calibration
Coal is a naturally fractured reservoir rock.

- Permeability is directional
- Permeability is stress sensitive
- Hydraulic fractures interact with natural fractures and roof and floor rock
  - Non-linear (pressure dependent) leakoff
  - T-shaped, branching and multiple fractures occur
  - Offsets develop along the fracture path
- Fracture treatments in coal can result in higher pressures, complex geometries and shorter than designed propped extent.
Fractures exposed by mining

a) Plan view of fracture with growth in face and butt cleat directions.

b) Vertical section of a gamma-shaped fracture.

c) Vertical section of fracture offset at MSSZ and blunted at lower point.

d) Vertical section of fracture with both horizontal and vertical branches.

(Jeffrey and Zhang, 2008)
Hydraulic fracture containing offsets in roof rock, ECC87

Offset fracture in roof rock near DDH 190

From SPE 119351
• Numerical Simulation
• Laboratory experiments
• Field Pilots
• Calibration
Conclusions

• Coal Seam Methane to LNG is an exciting new export industry for Australia

• Reserves estimates are substantial

• Some technical challenges exist (water production and disposal, simulation, stimulation, etc.)

• We are building R&D capability (people, equipment and techniques) to address industry and regulatory needs
Thank You

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