East Coast Gas:
Resource potential at different gas price scenarios

Part 1: Quantification of unconventional gas resource potential

Ian Cockerill
Head of Geoscience
Disclaimer

RISC is a truly independent advisory firm, providing impartial advice to a broad range of clients in the oil and gas industry, and enabling them to make their business decisions with confidence.

The statements and opinions attributable to the author and/or RISC in this presentation are given in good faith and in the belief that such statements are neither false nor misleading.

In preparing this presentation the author has considered and relied solely upon information in the public domain. This information has been considered in the light of RISC’s knowledge and experience of the upstream oil and gas industry and, in some instances, our perspectives differ from many of our highly valued clients.

In some cases the views and opinions of the author may differ from those held by others within RISC.

RISC has no pecuniary interest or professional fees receivable for the preparation of this presentation, or any other interest that could reasonably be regarded as affecting our ability to give an unbiased view.

This presentation is the copyright of RISC and may not be reproduced, electronically or in hard copy, without the written permission of RISC.
Heterogeneity in Eastern Australian unconventional plays

At what gas price does it make sense to exploit Eastern Australian unconventional gas potential?

Part 1: Quantification of unconventional gas resource potential

Part 2: Commercialisation of unconventional gas resources

Common Recovery Segment Mapping

Eastern Australia gas market model
There are no hard lines between conventional and unconventional resources.

Unconventional reservoirs share a lot of similar characteristics to conventional reservoirs:

- Zones of higher porosity / permeability
- Zones of higher resistivity
- Zones of higher pressure
- Regional structures or structural highs

It's not just a game of finding a shale and fracting the bejeezus out of it.
Major North American unconventional plays

- Discrete zones of higher porosity /higher resistivity
- Plays are laterally heterogeneous
- Over-pressure. Rate more important than in-place
- Finding the balance in GOR. Rate versus product
- Areas of very mature conventional production – data / infrastructure / tolerant community stakeholders

*Logs presented at same scale. Source PXD
Heterogeneity in unconventional plays

Source: Consensus view from public domain information
Eagle Ford break-even analysis

100% of Eagle Ford break-even at $70> Oil (8,000,000 acres)

Source: Consensus view from public domain information
Growth of the Eagle Ford

Eagle Ford 2007

Eagle Ford 2019

- OIL WELL
- GAS WELL
Growth in US natural gas production

US dry shale gas production

“The US is destined to become a key LNG import market” (BG)

“North America emerges as a major importer of LNG” (EIA, IEEJ & others)

“Natural Gas prices will remain high in the US for the foreseeable future” (EIA)

Source: EIA
History repeating itself on Australia’s east coast

US dry shale gas production

“The US is destined to become a key LNG import market” (BG)

“North America emerges as a major importer of LNG” (EIA, IEEJ & others)

“Natural Gas prices will remain high in the US for the foreseeable future” (EIA)

Australia's east coast needs to urgently start importing LNG: EnergyQuest

Sydney — Australia’s gas-strapped east coast needs to urgently start importing LNG in order to mitigate a range of risk factors stretching from supply issues to regulatory uncertainties, energy consultancy EnergyQuest said Wednesday.

When insanity makes sense: Australia’s best option is LNG imports

Australia has painted itself into a corner with its natural gas industry and faces the stark reality that there are no easy choices to alleviate the dual problem of a looming supply crunch and the associated higher prices.

LNG import terminal approval — an Australian first — a sign of hope for NSW manufacturing

ABC Illawarra. By Kelly Fuller and Glenn Coste

Source: EIA
RISC Eastern States gas market study and unconventional play atlas

RISC has developed a comprehensive Australian Eastern States gas market study. The study is based on the 2P reserve positions for domestic gas producers paired with a range of gas demand forecasts to identify probable supply gaps on the East Coast over the next 10 years. A market response to the high gas pricing on the East Coast in the form of new developments is already underway.

At what gas price does it make sense to start developing unconventional resources in the Eastern States?

The study has analysed all of the potential sources of unconventional gas to fill the East Coast market gap and determines likely gas supply rates, development schedules and breakeven supply costs for each of the major demand centres.

The study illustrates the required gas prices to drive unconventional gas development in Eastern Australia, the subsequent scale of new unconventional gas supplies to the forecast gaps in the market and describes how those developments can reverse the trend of rising prices over time.

The gas price slider bar provides interactive break even development maps for all of the recognised unconventional plays in Eastern Australia.

A quantitative analysis of the unconventional gas potential of Eastern Australian basins has been undertaken using a spatial analysis methodology of play fairway sweet-spot mapping. Play components considered important for the presence and recovery of unconventional gas were mapped across the plays of interest. Modeled horizontal well type curves and development plans from North American analogues for unconventional gas production have been used to quantify the sweet-spot mapping using a methodology RISC has developed called common recovery segment mapping.

A quantitative understanding of unconventional resource potential at different gas price scenarios allows us to understand how potential unconventional resource developments could contribute towards the Eastern Australia energy supply mix.

Deliverables

The Eastern Australia unconventional play atlas is provided in both hyperlinked and Interactive pdf report and as an optional ArcGIS project.

The Eastern Australia gas market study is provided as a .pdf and an optional excel model.
Quantifying unconventional potential – calibration

Developing control calibration data points for each play

- Using existing production (i.e. Walloon coal seam gas production history)
- Upscaling from horizontal fracked completions (i.e. Amungee Mid Velkerri shale test)
- Upscaling from vertical fracs and production test history (i.e. Moomba Murteree shale tests)
Quantifying unconventional potential – standardising development

Creating a spatial grid over each play

Rate

Time

Production test from vertical frac

WELL PAD

2km

400m

2km

400m

5 wells per 2km x 2km cell

Type curve range (calibration)
Quantifying unconventional potential – standardising development

- 5 wells per 2km x 2km cell
- Type curve range (calibration)
Estimated Ultimate Recovery (EUR) of calibration cells

- **LOW CASE**
- **MID CASE**
- **HIGH CASE**

Production test from vertical frac

Type curve range (calibration)

- 22 Bscf (Mid)
- 22 Bscf (Mid)
- 22 Bscf (Mid)

5 wells per 2km x 2km cell
Mapped spatial extent of the play
How does that EUR potential change spatially?

- Improved Recovery Potential Relative to Calibration
- Diminished Recovery Potential Relative to Calibration
Common recovery segment mapping

Common Recovery Segment Map
(Sweet Spot Map)

Recovery Potential is the Combined Effect of Multiple Attributes

- Depth/Pressure
- Structure
- Reservoir Quality
- Hydrocarbon Generation
- Reservoir Thickness

Example from the Murteree shale, Cooper basin
Break-even gas price mapping

Production test from vertical frac

Example from the Murteree shale, Cooper basin

Calibration Murteree type curve EUR (Bscf)

HIGH CASE (7.6)
MID CASE (3.4)
LOW CASE (1.2)

COMMON RECOVERY SEGMENT MAP
Break-even price development of the Murteree play

MURTEREE ESTIMATED ULTIMATE RECOVERY POTENTIAL

GAS PRICE SLIDER BAR (A$/GJ)

0  8  10  12  14  16  18  20

Break even gas price ($A/GJ)

$< 8
$8 - $10
$10 - $12
$12 - $14
$14 - $16
$16 - $18
$18 - $20

Estimated resource: 10.3 Tcf *

* Mid-case type curve EUR with full development (Well count: 2828)
### Eastern Australian unconventional plays of interest

<table>
<thead>
<tr>
<th>BASIN</th>
<th>PLAY / RESERVOIR</th>
<th>PLAY TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>COOPER</td>
<td>TOOLACHEE</td>
<td>SHALE GAS</td>
</tr>
<tr>
<td>COOPER</td>
<td>DARALINGIE</td>
<td>TIGHT GAS</td>
</tr>
<tr>
<td>COOPER</td>
<td>ROSENEATH</td>
<td>SHALE GAS</td>
</tr>
<tr>
<td>COOPER</td>
<td>EPSILON</td>
<td>TIGHT GAS</td>
</tr>
<tr>
<td>COOPER</td>
<td>MURTEREE</td>
<td>SHALE GAS</td>
</tr>
<tr>
<td>COOPER</td>
<td>PATCHAWARRA</td>
<td>TIGHT GAS</td>
</tr>
<tr>
<td>EROMANGA</td>
<td>WINTON</td>
<td>TIGHT GAS</td>
</tr>
<tr>
<td>BOWEN</td>
<td>BANDANNA-BARALABA</td>
<td>COAL SEAM GAS</td>
</tr>
<tr>
<td>BOWEN</td>
<td>TINWON</td>
<td>TIGHT GAS</td>
</tr>
<tr>
<td>BOWEN</td>
<td>REIDS DOME BEDS</td>
<td>TIGHT GAS</td>
</tr>
<tr>
<td>SURAT</td>
<td>WALLOON</td>
<td>COAL SEAM GAS</td>
</tr>
<tr>
<td>SURAT</td>
<td>PRECIPICE</td>
<td>TIGHT GAS</td>
</tr>
<tr>
<td>SURAT</td>
<td>SPRINGBOK</td>
<td>TIGHT GAS</td>
</tr>
<tr>
<td>GALILEE</td>
<td>BETTS CREEK / ARAMAC</td>
<td>COAL SEAM GAS</td>
</tr>
<tr>
<td>BEETALOO</td>
<td>VELKERRI</td>
<td>SHALE GAS</td>
</tr>
</tbody>
</table>

- **Beetaloo Sub-basin**: Middle Velkerri
- **Permian basins**: Cooper-Bowen-Galilee-Gunnedah-Sydney
- **Great Artesian basins**: Eromanga-Surat
Gas Price Slider Bar (A$/GJ)

Break-even analysis assuming NPV10 well head price at 2019 development costs.
Cooper basin resource totals (all prospective units) at $8/GJ break-even

Total resource estimates for Cooper unconventional plays at $8/GJ

- 106 Tcf (Low estimate)
- 288 Tcf (Mid estimate)
- 548 Tcf (High estimate)

-10% for inert gas and assuming 40% of maximum development

- 5.4 Tcf of produced gas to date
Cooper basin resource totals (all prospective units) at $12/GJ break-even

Low estimate
Mid estimate
High estimate

158 Tcf
427 Tcf
829 Tcf

-10% for inert gas and assuming 40% of maximum development
-5.4 Tcf of produced gas to date

52 Tcf
149 Tcf
294 Tcf
Cooper basin resource totals by permit area

Cooper Basin total unconventional prospective resource potential at $8/GJ by grid cell

PCA 172
6.9 Tcf (Mid estimate)

PLR 2019-2-6
Proposed for release Jul-Sept
6.2 Tcf (Mid estimate)
Some closing thoughts (to Part 1)

• Proven unconventional systems are typically extensions of conventional petroleum systems

• Heterogeneity is key. Resource potential is tied to wells drilled – which is tied to demand and pricing. The ‘unconventional accordion’

• Rising gas prices in the Eastern Australian gas market are driving speculation about LNG import requirements for the market. The same speculation occurred in the US in the mid 2000’s. The US responded by developing unconventional resources

• We need to quantify and understand Eastern Australian unconventional potential to determine in what gas price environment does it make sense to develop our unconventional resource potential