The road (downunder) to new conventional and unconventional oil and gas reserves

**CONTEXT**

USA annual production in the “Lower 48” now exceeds consumption

Australia leads the world in the use of CSG as feedstock for LNG – with exports tied to Brent $/barrel

---

Barry Goldstein
Executive Director
Department of State Development
South Australian State Government

---

$/barrel for Brent Crude

- **$160** Venezuela balances budget
- **$130** Iran balances budget
- **$115** Breakeven for highest cost USA shale oil
- **$114** Iraq balances budget
- **$110** Russia balances budget
- **$100** Supports new Canadian oil sands
- **$95** Average crude price to boost airline profits by $15bln
- **$90** Saudi Arabia balances budget
- **$80** High cost deepwater offsh. Angola, Brazil, Norway and UK
- **$60** Median break-even for USA shale oil (assoc’d gas ~free)
- **$50** Kuwait balances budget
- **$40** Break-even for lowest price USA shale oil

---

Guide to Crude Oil Price Implications

*Ed Crooks, pp 8, Financial Times 8 Nov 14*
Background Information: Australia Oil & Gas

Sources: EnergyQuest 2014, EIA 2013, ACOLA 2013 and DSD 2012 (1,000 PJ = 0.94 TCF)

Estimated technically recoverable gas resource in ten unconventional reservoir basin-plays

- Onshore Bonaparte Basin: 6.3 TCF = 6,600 PJ (just for shales)
- Onshore Canning Basin: 90 TCF = 1,022,000 PJ (just for shales)
- Onshore Carnarvon Basin: 9 TCF = 9,500 PJ (just for shales)
- Onshore Cooper Basin: 300+ TCF = 318,000 PJ (8.6 TCF '2C'; all unconventional reservoirs)
- Onshore Bowen Basin: 97 TCF = 102,430 PJ (just for shales)
- Onshore Amadeus Basin: 16 TCF = 16,900 PJ (just for shales)
Overview – oil and gas onshore and offshore South Australia

- 4 Cooper CO2013 blocks attracted aggregate $103 million work program bids (Senex x 2, Strike, Bridgeport)
- Western Flank oil play in the Cooper-Eromanga continues with 50+ % success in finding avg. 2.5 mm bbls oil
- Huge potential for gas in unconventional reservoirs in the Cooper Basin
- Encouraging results from Otway Basin exploration (Beach/Cooper)
- Bight Basin attracting major E&Ps – massive investment
- Frontier basins’ plays include:
  - Conventional oil and gas
  - Unconventional regional plays

Offshore Bight Basin Commonwealth Waters
$1.2 bln guaranteed 2011-16 + $1.1 bln non-guaranteed 2017-20

BP & Statoil
EPPs 37 to 40

CHEVRON
EPP44 & EPP45

SANTOS & MURPHY
EPP43

BIGT PETROLEUM
EPP 41 and EPP 42
Vision for Nirvana: Centuries of safe, secure, competitive energy supplies that meet community expectations for net outcomes

To reach the vision

- Potential risks to social, natural and economic environments are reduced to as low as reasonably practical (ALARP); and meet community expectations for net outcomes **BEFORE IT IS PERSONAL** – before approval sought for land access;
- Affected people and enterprises get timely information describing risks and rewards to enable informed opinions;
- Convene **roundtables** to deliver **roadmaps** for projects to inform: the **PUBLIC, GOVERNMENTS, INVESTORS, AND REGULATORS** and in doing so – enable/attract welcomed oil and gas projects.
- South Australia’s Roadmap for Unconventional Gas (Dec. 2012)

Priorities to foster sustainable, profitable projects - Feedback from Roundtable / Roadmap for Oil & Gas

Top priorities:

- Legal frameworks provide certainty and simultaneously meet community and investor expectations for outcomes
- Trustworthy, people implement and regulate projects
- Environmental sustainability
- Manage supply-chain risks (people and facilities)
- Bolster understanding of risks, risk management and rewards
Key Conclusions

1. Huge potential in unconventional reservoirs in the Cooper. ~$3.5 bln investment 2014-19.
2. Huge potential offshore in the Bight Basin. ~$2.3 Bln investment to 2020
3. Trustworthy regulation / regulators
4. The Roundtable for Oil & Gas Projects will continue to expedite fit-for-purpose outcomes to benefit all South Australians

On the road (downunder) to new conventional and unconventional oil and gas reserves

Barry Goldstein,  
Executive Director – Energy Resources  
South Australian State Government
Natural gas and oil in unconventional rock-reservoirs

EIA / ARI 2013

<table>
<thead>
<tr>
<th>Technically Recoverable Shale Resource Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas (TCF)</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>1 USA</td>
</tr>
<tr>
<td>2 China</td>
</tr>
<tr>
<td>3 Argentina</td>
</tr>
<tr>
<td>4 Algeria</td>
</tr>
<tr>
<td>5 Canada</td>
</tr>
<tr>
<td>6 Mexico</td>
</tr>
<tr>
<td>7 Australia</td>
</tr>
<tr>
<td>8 South Africa</td>
</tr>
<tr>
<td>9 Russia</td>
</tr>
<tr>
<td>10 Brazil</td>
</tr>
<tr>
<td>11 Others</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Fast follower criteria outside North America

- The right rocks (liquids richer)
- Markets
- Trusted regulatory frameworks
- Pre-existing infrastructure
- Supportive investment frameworks
- Two ends against the middle – descend cost & ascend productivity curves

USA “Lower 48”

- 2.9 million wells
- 250,000 wells drilled since 2003
- 30k – 35k wells yr. now (80% horizontal)
- 20k – 30k wells pa to 2020
- Onshore: 1,400 rigs operating (63 onsh Oz)
- Texas/Oklahoma: 700-900 rigs
- Permian Basin: 500-600 rigs (15 in Cooper)
- 2008-13 Horizontal & Stimulated Wells
  - Lateral length incr’d 40% (lease limited)
  - # stages incr’d 100% but shorter intervals

North America

- ~ Nil LNG pa exports (0.9 TCF pa ex-Oz in ‘13)
- 3 LNG projects with Final Investment Decision
- Expect 5-7 plants with FID by 2017
- 5-6 yrs. to commission greenfield projects’

World and Market Share

- Capacity w’wide at YE’13: 11 TCF LNG pa
- W’wide drawing board (FEED+): 7 TCF LNG pa
- North America: in next 10 years: 4+ TCF LNG pa
- USA produced 4 TCF gas more than it consumed in ‘13
- Australia expects 3+ TCF LNG pa capacity by 2020

Gas in the “Lower 48” USA

Ted Beaumont, President AAPG (July 2012 Explorer pp 3)

outside North America, industry is just beginning to explore resource plays.

organic matter, maturity and brittleness

...the USA is now producing more gas than ever

Australia leads in using CSG as feedstock for LNG
Australia:

Shale gas - technically recoverable potential:
- 437 tcf in 6 basins (avg 21% RF), EIA 2013
- > 1000 tcf in all prospective basins, Cook, 2013

Shallow CSG, Queensland & New South Wales
- 235 TCF est. tech. recov. resource (Santos '13)
- 42.8 tcf 2P reserves, YE '12 (Core Energy, 2013)

Shale oil plays
- 17.5 BBO in 6 basins (avg 4% RF), EIA 2013
- In South Australia - prospects targeted in the onshore Otway and Anckaringa basins

Tight gas - technically recoverable potential:
- Still to be assessed nationally. Estimated 300+ tcf gas-in-place resource target in just PEL 218, South Australian Cooper Basin (Beach Energy)

Deep coals - technically recoverable potential:
- Still to be assessed nationally. Considerable gas resource targets. 9+ tcf targeted in just PEL 96, South Australian Cooper Basin (Strike Energy)

A Natural Gas Revolution is Underway

Vision:
- Secure and competitive gas;
- Improved balance of trade;
- Australia’s supplants imports with gas-based transport fuel;
- $ Billions in ESD projects;
- Thousands of jobs;
- Royalties/tax for public good;
- Risks to natural, social & economic environments reduced to ALARP & operations meet community expectations for net outcomes.
Background Information: Cooper – Eromanga Basins

Courtesy of Pitney-Bowes – GPInfo Software
BEACH ENERGY: PEL 218: Potential 300 TCF gas in place in just PEL 218 (Nappamerri Trough, SA) ~100 TCF in shales and >200 TCF in sands. Chevron now PEL 218 partner.

SANTOS: High-side 200+ TCF recoverable raw gas. Moomba 191 (vertical well): 2.6 MMscf/d from unconventional reservoirs at line pressure flowing to market. Santos – Beach – Origin JV have domestic and export markets.

SENEX ENERGY: Est. 75-110 TCF gas in place in tight sandstone, shales & coals. Origin now partner in 3 PEL.

STRIKE ENERGY: Est. 9 TCF gas resource in deep coal in PEL 96 and has attracted a major gas customer (Orica) to back its appraisal program versus terms for project capital and a sales agreement for 237 bcf over 20 years.

DRILLSEARCH ENERGY AND BG IN QLD DEEP GAS PLAY:

Cooper Basin Composite and Deep Coal Plays:

- Nappamerri Group
- Roseneath Shale
- Murteree Shale
- Patchawarra Formation

Gas saturated composite play
Patchawarra Formation Overpressure

Patchawarra Formation pressure gradient data derived from DSTs and other data sources. Water pressure gradient is 0.43 psi/ft. Gradients exceeding ~0.45 psi/ft are indicative of overpressured gas. Overpressured gas in the Patchawarra Formation occurs at depths exceeding ~9500’ (~2900m).

Deep Cooper Basin (Gidgealpa Coals): Enormous Generation Capacity

Senex’s Paning 2 (May 2013): Single 63,000 pound proppant fracture stim. in Toolachee coal (~2900m). Up to 90,000 scf/d, over 4 days.
Progress on recommendations #31 & #52
Updated CO₂ and Gas Wetness Maps, South Australian Cooper Basin
(Epsilon, Patchawarra, Tirrawarra, and Merrimelia Formations)

% CO₂  Barrels of Propane + Butane (LPG) per MMcf Gas  Barrels of Condensate per MMcf Gas

<table>
<thead>
<tr>
<th></th>
<th>50 km</th>
<th></th>
<th>50 km</th>
<th></th>
<th>50 km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patchawarra</td>
<td></td>
<td>Patchawarra</td>
<td></td>
<td>Patchawarra</td>
</tr>
</tbody>
</table>

Indicative Rig Schedule for 6,000 PJ over 15 years:
2,800 wells @ 3Pj / well to book 8,422 Pj (to sell =>6,000 Pj)
(~10% of 93 TCF EIA estimate for gas from shales only)

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019-2030 (12 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drilling rigs</td>
<td>3</td>
<td>5</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Type of wells</td>
<td>Vertical</td>
<td>Horizontal</td>
<td>Vertical</td>
<td>Horizontal</td>
</tr>
<tr>
<td>Rig Years @ 50% vertical vs horizontal</td>
<td>1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Wells/yr/rig</td>
<td>17.5</td>
<td>11</td>
<td>17.5</td>
<td>11</td>
</tr>
<tr>
<td>Wells Tally</td>
<td>26.25</td>
<td>16.5</td>
<td>43.75</td>
<td>27.5</td>
</tr>
</tbody>
</table>

Work for government-industry:
• Discover local competence possibly without capacity to supply rigs, pipe, roads, rail, materials, services, people, etc, etc.
• Foster pre-qualification for tenders; and
• Enable clusters and IPOs for budding multi-nationals
Field Size Distribution – Proven Productive Oil Play in the Cooper-Eromanga Basins

Swanson’s Mean = 2.53 million barrels per new field discovery

Cooper-Eromanga Basin Oil Discoveries

New oil exploration phase based on long offset 2D seismic, new competitors and now 3D

Western Flank oil exploration Cooper – Eromanga (2000-14):

- 52% wells located with 3D were discoveries (avg 2.5 mmbo)
- 28% located with 2D were discoveries
Case Study – Petroleum Retention Leases for Oil

**Winner’s Curse?**

**Know your market!**

Top (#1) Roadmap recommendation - Provide fit-for-purpose licences

- Giant gas (10s of TCF) resource potential in unconventional reservoirs
- 52% post-3D success rate 2002-14 for oil exploration in western flank of Cooper – Eromanga (avg. 2.5 mmbo find size)
- South Australia Western Flank Oil: 9 operators for 25 companies
- South Australia Cooper Gas: 9 operators for 28 companies

**Operators**

- Australian Gasfields
- Beach Energy
- Blue Energy
- Bridport Energy
- Cremona Energy
- Discovery Energy
- Drilsearch Energy
- Oilsearch Energy
- Outback Energy Hunter
- Rawson Resources
- SAFEX
- Santos
- Sanex Energy
- Strike Energy
- Terra Nova Energy
- Telrose Energy
  - Oil well
  - Gas well
  - Western Flank proven oil play
  - Gas pipeline
  - Gas and liquids pipeline
  - Liquids pipeline
  - Colnergie Lakes control zone – no sources

**Proven Cooper-Eromanga oil play**
Conclusions for the Cooper-Eromanga Basins

1. >50% success rate in finding average 2.5 mmbo post 3D
2. Huge shale, tight sandstone and deep coal gas plays. Four fracture stimulation service companies competing
3. Proven 1,000+ metre gas columns can be developed with a mix of (mostly) verticals and (fewer) horizontal wells
4. Initial resource estimates for the Cooper Basin are high:
   • EIA potential sales gas from shales: 93 TCF
   • Rough estimate of sales gas in Composite Play: ~ 300 TCF
5. Exploration and appraisal ramping up with several E&Ps and gas customers now funding exploration. Expect deals
6. $3.5 bln ‘spend’ in Cooper - Eromanga 5 yrs from 1/7/14

Background information:
Path to Nirvana Investment Frameworks

The kid is good
Vision for Nirvana: Centuries of safe, secure, competitive energy supplies that meet community expectations for net outcomes

To reach the vision

- Potential risks to social, natural and economic environments are reduced to as low as reasonably practical (ALARP); and meet community expectations for net outcomes BEFORE IT IS PERSONAL – before approval sought for land access;
- Affected people and enterprises get timely information describing risks and rewards to enable informed opinions;
- Convene roundtables to deliver roadmaps for projects to inform: the PUBLIC, GOVERNMENTS, INVESTORS, AND REGULATORS and in doing so – enable/attract welcomed oil and gas projects.
- South Australia’s Roadmap (Dec. 2012)

Roadmap for Unconventional Gas informed by the Roundtable for Oil and Gas Projects

Conclusions:
Descend cost & ascend productivity curves to survive supply-side competition
Regional sharing of costs mitigates the tyranny of distance for remote operations

Informed by a Roundtable of: industry; governments; peak bodies for protecting environments and aboriginal people; research institutions & a few individuals. Now 615 members

Now under the auspices of the Roundtable for Oil and Gas Projects with 7 working groups to inform potentially affected people and enterprises while enabling cooperation amongst competitors.

Strategic actions:
- Demonstrate where the net present value of cooperation (JVs for JVs) exceeds the value of go-it-alone planning / investment;
- Local businesses given a ‘heads-up’ to use competence to build capacity to compete (local skin in the game)
Top priorities:

- Legal frameworks provide certainty and simultaneously meet community and investor expectations for outcomes
- Trustworthy, people implement and regulate projects
- Environmental sustainability
- Manage supply-chain risks (people and facilities)
- Bolster understanding of risks, risk management and rewards

To download the Roadmap for Unconventional Gas Projects in South Australia - go to:

**Top (#1) Recommendation: Provide fit-for-purpose licenses**

The highest priority defined in the Roadmap by its Roundtable now implemented with fit-for-purpose Petroleum Retention Licenses with minimum exploration + appraisal expenditure requirements:

- Avoids 18 -24 months delay after intermittent relinquishments;
- Accelerates investment at contestable levels in ways not achieved with PELs;
- Delivers investment, jobs, production and royalties, sooner
- Industry as a whole has greater investment efficiency;
- Competitive levels of investment without ‘winner’s curse’ bidding;
- Nurtures growth of enterprises;
- Overcome a looming issue: Ever-smaller licences;
- Seeks secure investment at a time the State needs stronger investment;
- Farm-outs and sales will further accelerate investment work programs
- With regret, there little chance that all regulatory decision will please all stakeholders, always;

**Recommendation #2: Manage the risk of a shortage of skills and people**

Evergreen responsibility of industry and government. Implemented in part through:

- industry and the State Government’s Department of State Development (DSD) under the auspices of Roundtable Working Group #1
  - Santos, Beach Energy and Senex Energy are working with the DSD and TAFE SA to establish an Onshore Petroleum Centre of Excellence (OPCE) training facility at Tonsley, co-located with the new State Core Library (More on this later in the agenda)
  - A South Australia State chair for unconventional reservoir research has been established in at the University of Adelaide – complimented with funding for international expert lecturers, the State Chair in Petroleum Geology, funding for the CO2CRC, and funding for the State Chair in Geothermal Energy at the University of Adelaide.
  - Suppliers’ study tours of oil and gas facilities in the USA in 2014 will be leveraged-on in another tour in 2015 under the auspices of the Industry Participation Office.
- User-pays fees to sustain the competence and capacity for trustworthy regulations. Enabled by popularity of PRLs….After providing $s for time-writing for upstream petroleum regulation by DSD, DEWNR, EPA, SafeworkSA, and Health – still cut PRL fees by 20%
3rd and 4th Highest Ranked Recommendations
- Use water wisely

Evergreen responsibility of industry and government. **Implemented in part through:**

- Industry and the State Government’s Department of State Development (DSD) under the auspices of **Roundtable Working Group #3**
  - Santos, Beach Energy, Senex Energy and Drillsearch have shared their historical and forecast water production and use in the SA-Qld Cooper-Eromanga basins. DSD called for tenders and provided $ support for a water balancing model. CSIRO and DEWNR providing peer review.
  - Independent expert scientific research review of international oil and gas operations impacts on water to decipher what are significant versus insignificant risks to water resources
  - Regional water studies in the Otway underway and more planned

- Demonstrate safe conduct through outcomes: No evidence or realistic expectation of fracture stimulation resulting in the contamination of fresh water supplies or damaging induced seismicity in the far northeast of South Australia where 717 deep petroleum wells and a few geothermal (hot rock) wells have been fracture stimulated through August 2014 (next slide)

- Regulation must be trustworthy to ban anything everywhere until it is clear all significant risks posed to social, natural and economic environments can be managed to meet community expectations for net outcomes

5th, 11th and 12th Highest Ranked Recommendations – Ensure legislation, regulation, policies & programs are trustworthy, efficient and effective

Evergreen responsibility of government. **Implemented through the leading practice South Australian Petroleum and Geothermal Energy Act 2000 (PGEA):**

- South Australia’s **PGEA** defines the **environment** as: land, air, water, soil; plants and animals; social, cultural and heritage features; visual amenity; economic and other land uses.

- Activities cannot start without an approved SEO in place.

- SEO’s set standards for outcomes from operations

- SEOs are objective-based, transparent drivers for risk management and the protection of environments.

- ‘Owner of land’ means all people and enterprises potentially directly affected by activities, entitling them to notices of entry, the right to dispute entry (in court) and compensation.

~ 14,000 notices of entry for operations issued – without a single person or enterprise taking up their rights to take the matter to court
6th Highest Ranked Recommendation –
Bolster public understanding (with reliable information)
re: hazards and risk management via FAQ on web

Informing stakeholders is an evergreen function of regulators through:

- timely stakeholder engagement jointly by DMITRE-PIRSA-DEWNR-EPA (reading off the same evidence-based pages)
- area- and activity specific SEOs (prepared by PGE Act licence holders) and the SEO approvals process to inform potentially affected people and enterprises.
- published the Roadmap for Unconventional Gas Projects in South Australia in December 2012 – and sustaining the Roundtable that informed that Roadmap – to keep the information-flow at the leading edge of evidence/objective based decision-making;
- publish accounts of the PGE Act and stay contestable;
- routinely update answers to frequently asked questions (FAQs) for historical and potential upstream petroleum operations to inform the public. (see: http://www.petroleum.dmitre.sa.gov.au/__data/assets/pdf_file/0003/218109/FAQ_-_South_East_Unconventional_Gas_and_Oil.pdf)

7th, 8th, 9th & 10th Highest Ranked Recommendations –
Improved transport, supply-chain depots, heavy vehicle road and wiring regulation

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Progress to end January 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td># 7, # 8 &amp; #9</td>
<td>Paved, wide roads more passable year-around</td>
</tr>
<tr>
<td></td>
<td>More under Agenda Item # 6. Implementation in progress through Roundtable Working Group #2.</td>
</tr>
<tr>
<td></td>
<td>• Options for improving roads from ports to operations in the Cooper-Eromanga basins established in dialogs involving the State Government, key operators of petroleum licences in the Cooper-Eromanga basins.</td>
</tr>
<tr>
<td></td>
<td>• Load modelling enabled with equipment lists for wells construction for deep gas in the Cooper Basin (Appendix 2a and 2b of the Roadmap for Unconventional Gas)</td>
</tr>
<tr>
<td>#10: Streamline heavy vehicle road and wiring regulations</td>
<td>More under Agenda Item #7. Implementation in progress through Roundtable Working Group #4</td>
</tr>
<tr>
<td></td>
<td>• Queensland and South Australia State governments cooperating to enable wharf to wellhead transport corridors without extraneous regulation. Discussions also involving the National Heavy Vehicle Regulator.</td>
</tr>
</tbody>
</table>
Implementation of 125 Ranked Recommendations in the Dec ‘12 Roadmap

- Many of the recommendations are for evergreen action
- Industry options for competition vs cooperation (JVs for JVs) are subject to industry positions, though g’ment will assist.

Roundtable for O&G Working Groups

#1 Training (Tonsley CoE, Chair Unconventional reservoirs)

#2 Supply hubs, roads, rail and airstrips for the Cooper-Eromanga basins (Innamincka airport, depots, Strez. Track)

#3 Water use in the Cooper-Eromanga basins

#4 Minimize redtape for interstate 'wharf to well' corridors to/fro the Cooper-Eromanga basins (heavy vehicle, wiring)

#5 Cost-effective, trustworthy GHG detection

#6 Suppliers’ forum (make locals smart) (MIPO)

# 7 Use gas for transport and heavy equipment
Recap Working Group #1 - Training

Leading Operators in the Cooper Basin (Santos, Beach and Senex) have agreed to contribute an aggregate of > $1million in cash and in kind to establish shared training facilities at Tonsley. Co-located with new core library

Strengthening capabilities in local Universities –
• SA Research Fellow in Unconventional Resources
• SA Chair – Petroleum Geology
• $s for Visiting Experts
• CO2CRC (cognate)
• SA Centre for Geothermal Energy Research (cognate)

Recap Working Groups #2 - Supply hubs, roads, rail and airstrips, Cooper-Eromanga basins

• Have mapped existing supply options (road, rail, air, ship);
• Used *Roadmap* details to inform probabilistic dimensions, weights and timing for transport scenarios – in turn enabling optimisation modelling for road, rail and air for minimum 6,000 pj unconventional gas ex-Cooper Basin to supply a15 year gas contract. Also accounting for oil
• Special facility licences (SFLs) enable additional depots, airstrips and petroleum handling facilities
• DPTI has estimated requirements to seal the Strzelecki Track as part of SA's Integrated Transport and Land Use Plan. Looking at intra-basin requirements, too
• Building economic models to elucidate public vs private benefit in context of Infrastructure Australia criteria for Federal funding.
Leading operators pooled water use and production records and forecasts for Cooper-Eromanga (SA-Qld) basin-wide modelling of water supply: demand, to deduce cost- and water-saving options. This will inevitably bolster environmental sustainability, project economics, transparency/trust, and business opportunities. Golders modelling funded by the South Australian Government. Results published in February 2015.

Australia’s National Centre for Groundwater Research and Training will publish in late 2015 a review of global literature to substantiate the efficacy of risk management by the oil and gas industry in protecting water resources.

No evidence or realistic expectation of fracture stimulation resulting in the contamination of fresh water supplies or damaging induced seismicity in the far northeast of South Australia where 700+ deep petroleum wells and a few geothermal (hot rock) wells have been fracture stimulated.
Recap Working Groups #4  SA-Qld 'wharf to well' corridors for the Cooper-Eromanga basins

South Australian State Government; Queensland State Government; and National Heavy Vehicle Regulator - Now cooperating to enable efficient and effective interstate transport and heavy equipment regulations

Recap Working Groups #5  Cost-effective, trustworthy GHG detection

ARC Linkage grants worth ~A$1 million awarded for University of Adelaide research to develop more cost-effective GHG monitoring, including detection of natural seeps

Subsequent to discussions – a sub-set of WG#5 members agreed revisit NGERS and other data develop FAQ s to better inform the public, business leaders and policy makers as to the materiality of various sources of GHG emissions. No doubt, all mitigation contributes to lowering carbon intensity. The objective of market-based GHG emissions mitigation policies are to reduce maximum GHG at the lowest costs. SA Government providing resources for this compilation and assessment
Recap Working Group #6
MIPO’s oil and gas suppliers’ forum
(to foster local content in upstream petroleum projects)

- Established in 2014 with an inaugural meeting on 22 October 2014.
- The Forum assists in developing South Australian capability in the oil and gas supply chain to (1) drive reduced cost curves, and (2) attracting competent and competitive local content into oil and gas projects.
- A key function of the Oil and Gas Supplier Forum is to assist suppliers to understand which tier level to target, and provide opportunities to connect with relevant customers.

Recap Working Group #7: Use of gas for transport and heavy equipment fuel

- To be established in 2015.
- Enabling supply chains for the use of LNG and CNG to fuel transport and heavy equipment – improving security of transport fuel supplies and developing additional gas markets.
- Will take a national perspective, and aim to develop an associated manufacturing sector.
Answers to frequently asked questions regarding oil and gas operations (including fracture stimulation) – focus on engagement in relation to oil and gas operations in the Coonawarra Wine District – Otway Basin, South Australia)

Go to:

Energy Resources Division (ERD)
Petroleum, Geothermal, Geologic Gas Storage

Executive Director
Barry Goldstein

Legislation: Objective based & outcome driven
Mantra: Build trust, reduce uncertainty, have fun
Matrix Organisation: Branches have functional competence – Teams form and un-form to deliver competent capacity – enabling a one-stop-shop
VISION: Deep unconventional gas delivering decades of safe, secure and competitive gas

To reach this vision

• **Must demonstrate:** Potential risks to social, natural and economic environments are *reduced to as low as reasonably practical* (ALARP); and meet community expectations;

• Stakeholders get timely information describing risks to enable informed opinions/decisions

Legislative Controls

*Petroleum and Geothermal Energy Act 2000* covers the life-cycle of upstream petroleum, geothermal energy and geologic gas storage in the State of South Australia, Australia
Petroleum and Geothermal Energy Act 2000

Regulatory Objectives/Conditions

Objective is to avoid:

• Contamination of aquifers
• Adversely impacting other land users and uses
• Contamination of soil
• Disturbance of heritage sites
• Adversely impacting vegetation
• etc

Aim of regulatory processes is to have licensees demonstrate that they can and are achieving these objectives

Petroleum and Geothermal Energy Act 2000

Regulatory Framework in South Australia

Petroleum Exploration and Production Activities regulated under:

• Petroleum and Geothermal Energy Act 2000 (PGE Act);
• Environment Protection Act 1993;
• Natural Resources Management Act 2004;
• National Parks and Wildlife Act 1972;
• Aboriginal Heritage Act, 1988;
• Development Act, 1993;
• Work Health and Safety Act 2012;
• Public and Environmental Health (Waste Control) Regulations 2010;
• EPBC Act 1999

Interaction between PGE Act and other South Australian Acts administered through Administrative Arrangements with respective agencies
**Petroleum and Geothermal Energy Act 2000**

**Regulatory Framework in South Australia**

PGE Act defines the *environment* as:

- land, air, water, soil;
- plants & animals;
- social, cultural & heritage features;
- visual amenity;
- economic & other land uses.

---

**Petroleum and Geothermal Energy Act 2000**

**Regulatory Framework in South Australia**

**Statements of Environmental Objectives (SEO)**

- Regulated Activities cannot be carried out unless there is an approved SEO in place.
- SEO’s set approval conditions for regulated activities e.g. seismic, well operations, production, processing, pipelines, gas storage, etc.
- Activity notifications – licensee demonstrates how it will achieve SEO before approval granted.
Approval Process

Two approval stages:

1. Licence approvals
   - Exploration, Retention
   - Production, Gas Storage, Pipeline, Special Facility Licences

2. Activity approvals
   - SEO Approval Process
     - what they must achieve
   - Activity Notification Process
     - demonstrate how they will achieve
**Petroleum and Geothermal Energy Act 2000**

**Regulatory Framework in South Australia**

**Approvals Processes**

- EIR & Draft SEO
  - Environmental Significance Assessment
  - Statement of Environmental Objectives
    - APPROVAL

**SEO Approval Process**

- LOW IMPACT
  - Internal Govt Consultation

- MEDIUM IMPACT
  - Public Consultation

- HIGH IMPACT
  - EIS Process

---

**Petroleum and Geothermal Energy Act 2000**

**Regulatory Framework in South Australia**

**Significance Criteria**

**PREDICTABILITY**

Level of confidence that for each impact and consequence these issues have been addressed:

- Size
- Scope
- Duration
- Likelihood/Frequency
- Stakeholder Concerns

**MANAGEABILITY**

Extent to which consequences can be managed:

- Avoidance
- Probability
- Duration
- Size
- Scope
- Cumulative Effects
- Stakeholder concerns
Avoidance of:
- Contamination of aquifers
- Adverse impacts on other land users and uses
- Contamination of soil
- Disturbance to heritage sites
- Adverse impacts on vegetation
- etc

Breaching these objectives is a PGE Act offence

Notices of Entry (NoEs)

- **Owners of land** means all persons and enterprises potentially directly affected by regulated activities,

- **NoEs** must provide timely information to enable potentially affected people and enterprises to reach informed views regarding impacts on their interests.

- **Owners of land** must be given **NoEs** at least 21 days in advance of the start of any activities – and have 14 days to lodge objections

- All potentially directly affected people and enterprises have **rights to object** to the approval of land access for regulated activities, and **all such objections are a show-stopper** until objections are resolved.
**Petroleum and Geothermal Energy Act 2000**

**Regulatory Framework in South Australia**

**Notices of Entry (NoEs)**

- These **Owner of Land** rights are sustained without support for vexatious objections. **Owners of land** are due compensation from relevant PGE Act licence holders for reasonable costs of assessing NoEs (including the cost of legal advice) and for any loss or deprivation that might result from activities regulated pursuant to the PGE Act.

- The **dispute resolution process** for objections to NoEs
  - starts with **engagement** between the concerned stakeholder and the relevant PGE Act Licence holder;
  - can escalate to **mediation** stewarded by the Minister; but
  - **court proceedings** are the ultimate dispute resolution process.

---

**Best Practice Regulatory Principles**

**Delivering Regulatory Best Practice through 6 Principles:**

1) Certainty  
2) Openness  
3) Transparency  
4) Practicality  
5) Flexibility  
6) Efficiency
Openness

- Inclusive stakeholder consultation in establishing regulatory objectives, broad community engagement on addressing potential environmental, economic and social/cultural impacts.

Transparency

Public Access to regulatory decision making.
- Criteria for classifying the level of Environmental Impact
- All Environmental Impact Reports, assessments and Statements of Environmental Objectives (Approval Conditions) are online

Community access to industry performance information:
- environmental performance
- regulatory enforcement actions
- surveillance activity information
- Licensee Annual Compliance Reports
- PGE Act compliance policy
- PGE Act Annual Compliance report
Appropriate range of regulatory enforcement tools to elicit compliant behaviour.

Petroleum and Geothermal Energy Act compliance policies and Annual Compliance Report

What are the risks?
How do we identify and manage the risks?

Environmental Impact Report - Summary

<table>
<thead>
<tr>
<th>HAZARDOUS EVENTS</th>
<th>POTENTIAL CONSEQUENCES</th>
<th>MITIGATION MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access &amp; pad construction, vehicle &amp; people movement.</td>
<td>Intrusion or physical damage to areas of Aboriginal</td>
<td>Scouting for such sites to be undertaken ahead of activity.</td>
</tr>
<tr>
<td></td>
<td>heritage significance.</td>
<td></td>
</tr>
<tr>
<td>Crossflow from hydrocarbon zones or lesser quality aquifers.</td>
<td>Contamination of aquifers.</td>
<td>Identified aquifers isolated behind casing.</td>
</tr>
<tr>
<td>Drilling through fresh water aquifers.</td>
<td>Pollute water source of other users</td>
<td>Use of non-toxic muds.</td>
</tr>
<tr>
<td>Fracking into adjacent and overlying aquifers</td>
<td></td>
<td>Non-toxic frac fluid.</td>
</tr>
</tbody>
</table>
### Environmental Impact Report - Summary

<table>
<thead>
<tr>
<th>HAZARDOUS EVENTS</th>
<th>POTENTIAL CONSEQUENCES</th>
<th>MITIGATION MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access &amp; pad construction,</td>
<td>Intrusion or physical damage</td>
<td>Scouting for such sites to be undertaken ahead of activity.</td>
</tr>
<tr>
<td>vehicle &amp; people movement.</td>
<td>to areas of Aboriginal heritage significance.</td>
<td></td>
</tr>
<tr>
<td>Crossflow from hydrocarbon</td>
<td>Contamination of aquifers.</td>
<td>Identified aquifers isolated behind casing.</td>
</tr>
<tr>
<td>zones or lesser quality aquifers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling through fresh water</td>
<td>Pollute water source of other users</td>
<td>Use of non-toxic muds.</td>
</tr>
<tr>
<td>aquifers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracking into adjacent and overlying</td>
<td></td>
<td>Non-toxic frac fluid.</td>
</tr>
<tr>
<td>aquifers</td>
<td></td>
<td>Monitor frac through micro seismic and control pump</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pressures accordingly.</td>
</tr>
</tbody>
</table>

---

71
## Environmental Impact Report - Summary

<table>
<thead>
<tr>
<th>HAZARDOUS EVENTS</th>
<th>POTENTIAL CONSEQUENCES</th>
<th>MITIGATION MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access &amp; pad construction, vehicle &amp; people movement.</td>
<td>Intrusion or physical damage to areas of Aboriginal heritage significance.</td>
<td>Scouting for such sites to be undertaken ahead of activity.</td>
</tr>
<tr>
<td>Crossflow from hydrocarbon zones or lesser quality aquifers.</td>
<td>Intrusion or physical damage to areas of Aboriginal heritage significance.</td>
<td>Scouting for such sites to be undertaken ahead of activity.</td>
</tr>
<tr>
<td>Drilling through fresh water aquifers.</td>
<td>Contamination of aquifers.</td>
<td>Identified aquifers isolated behind casing.</td>
</tr>
<tr>
<td>Fracoring into adjacent and overlying aquifers</td>
<td>Pollute water source of other users</td>
<td>Use of non-toxic muds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monitor frac through micro seismic and control pump pressures accordingly.</td>
</tr>
</tbody>
</table>

![Diagram of well construction and containment](image.png)

*Courtesy: APRA Natural Gas Revolution Brochure, 2013*
Best Practice Industry Standards


Recommended Well Construction Practice

Figure 1—Typical Well Schematic

- All surface aquifers behind cemented casing to surface
- All other strings cemented casing above shoe across aquifers or productive zones
Well Construction Otway Basin (Example)

Caroline #1 CO2 production well

Approved practice for all future wells

- Well will be drilled through the surface sediments into the Eumeralla Formation and casing run so that the surface aquifers are not in communication with the well bore
- All casing strings will be cemented to surface
- Beyond recommended practice
What are the risks

Casing and cement integrity

Not acceptable or tolerable...

BRIEF OF EVIDENCE

Investigation into the circumstances surrounding the Uncontrolled Release of Oil and Gas from the Montara Wellhead Platform

MONTARA DEVELOPMENT PROJECT

located in the Timor Sea approximately 350 km north-west of the Western Australian coast, almost 700 km from Darwin in the offshore area of the Territory of Ashmore and Cartier Islands

Owned and Operated

By

PTTEPAA Australasia (Ashmore Cartier) Pty Ltd
PTTEPAA

(ACN 004 218 164)

On

21st AUGUST 2009

80
## HAZARDOUS EVENTS | POTENTIAL CONSEQUENCES | MITIGATION MEASURES
--- | --- | ---
Access & pad construction, vehicle & people movement. | Intrusion or physical damage to areas of Aboriginal heritage significance. | Scouting for such sites to be undertaken ahead of activity.
Crossflow from hydrocarbon zones or lesser quality aquifers. | Contamination of aquifers. | Identified aquifers isolated behind casing.
Drilling through fresh water aquifers. | Pollute water source of other users | Use of non-toxic muds.
Fracking into adjacent and overlying aquifers | Non-toxic frac fluid. | Monitor frac through micro seismic and control pump pressures accordingly.
Flow back of frac fluids | Contamination of soil, impact vegetation and potential contamination of surface aquifers | Frac fluid contained within lined pits.
Vehicle and plant refuelling during operations. | Oil spill damage to soil & vegetation. | Refuel in designated bunded area.
Seed importation on vehicles and equipment. | • Introducing alien vegetation species (weeds).  
• Impact on other land users, eg farmers, pastoralists | All vehicles steam cleaned prior to entering district.
Fracture half length and complexity is controlled by:

- Frac fluid viscosity (gel vs "slickwater")
- Pump rate
- Pump pressure
- Proppant “mesh” size
- In situ stresses
- Existing natural fractures
- Natural frac barriers (ductile rocks that don’t break easily)
- Rock brittleness

Specialised extraction Technology

Stimulated rock volume in horizontal well (from microseismic monitoring)
Coloured dots indicate fracture events related to hydraulic stimulation of each perforated stage

http://www.weatherford.com/Products/Evaluation/BoreholeSeismicServices/MicroseismicMonitoring/index.htm
Chemistry of Fracture Stimulation Fluids
<table>
<thead>
<tr>
<th>Additive Type</th>
<th>Main Compound(s)</th>
<th>Purpose</th>
<th>Common Use of Main Compound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluted Acid (5%)</td>
<td>Hydrochloric acid or sulfuric acid</td>
<td>Helps dissolve minerals and initiate cracks in the rock</td>
<td>Swimming pool chemical and cleaner</td>
</tr>
<tr>
<td>Biocide</td>
<td>Glutaraldehyde</td>
<td>Eliminates bacteria in the water that produce corrosion byproducts</td>
<td>Disinfectant, sterilize medical and dental equipment</td>
</tr>
<tr>
<td>Biocide</td>
<td>Ammonium persulfate</td>
<td>Allows a delayed break down of the gel polymer chains</td>
<td>Bleaching agent in detergent and hair cosmetics, manufacture of household plastics</td>
</tr>
<tr>
<td>Corrosion inhibitor</td>
<td>N, N-dimethylformamide</td>
<td>Prevents the corrosion of the pipe</td>
<td>Used in pharmaceuticals, Acrylic fibers, plastics</td>
</tr>
<tr>
<td>Crosslinker</td>
<td>Borate salts</td>
<td>Maintains fluid viscosity as temperature increases</td>
<td>Laundry detergents, hand soaps, and cosmetics</td>
</tr>
<tr>
<td>Friction reducer</td>
<td>Polyacrylamide</td>
<td>Minimizes friction between the fluid and the pipe</td>
<td>Water treatment, soil conditioner</td>
</tr>
<tr>
<td>Gel</td>
<td>Guar gum or hydroxyethyl</td>
<td>Thickens the water in order to suspend the sand</td>
<td>Cosmetics, toothpaste, sauces, baked goods, ice cream</td>
</tr>
<tr>
<td>Iron control</td>
<td>Chelate acid</td>
<td>Prevents precipitation of metal oxides</td>
<td>Food additive, flavoring in food and beverages, lemon juice, 7% Citric Acid</td>
</tr>
<tr>
<td>KCl</td>
<td>Potassium chloride</td>
<td>Creates a brine carrier fluid</td>
<td>Low sodium table salt substitute</td>
</tr>
<tr>
<td>Oxygen scavenger</td>
<td>Ammonium bisulfite</td>
<td>Removes oxygen from the water to protect the pipe from corrosion</td>
<td>Cosmetics, food and beverage processing, water treatment</td>
</tr>
<tr>
<td>pH Adjusting Agent</td>
<td>Sodium or potassium carbonate</td>
<td>Maintains the effectiveness of other components, such as crosslinkers</td>
<td>Washing soda, detergents, soap, water softener, glass and ceramics</td>
</tr>
<tr>
<td>Proppant</td>
<td>Silica, quartz sand</td>
<td>Allows the fractures to remain open so the gas can escape</td>
<td>Drinking water filtration, play sand, concrete, brick mortar</td>
</tr>
<tr>
<td>Scale inhibitor</td>
<td>Ethylene glycol</td>
<td>Prevents scale deposits in the pipe</td>
<td>Automotive antifreeze, household cleaners, and de-icing agent</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Isopropyl alcohol</td>
<td>Used to increase the viscosity of the fracture fluid</td>
<td>Glass cleaner, antiperspirant, and hair color</td>
</tr>
</tbody>
</table>


---

**Green Completion**

It is all about containment
Well and Fracture Stimulation Operation Standards

Are Earthquakes a risk?
Impacts on Other Landowners

Environmental footprint of deep natural gas. It is not the same as shallow coal seam gas.
Environmental footprint of deep natural gas. It is not the same as shallow coal seam gas.

Oil and Gas
Conventional and Unconventional
What is hydraulic fracturing?

“. is a technique in which a mixture of mainly water mixed with sand (99.5% vol.) and chemicals (0.5% vol.) is injected at high pressure into a well to create small fractures (typically less than 1-2 mm), along which fluids such as gas and oil may migrate to the well.”

720 wells in the South Australian Cooper Basin have been fracture stimulated without Harm to social, natural or economic environments.

What is hydraulic fracturing?
What is hydraulic fracturing?