1. Overview
2. Offshore Oil & Gas
3. Onshore Conventional Oil
4. Unconventional Petroleum
5. Vision for Nirvana
6. Roundtable and Roadmap for O&G

Barry Goldstein,
Executive Director – Energy Resources
Department of State Development
South Australian State Government
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 mln bbls oil
- Huge potential for gas in unconventional reservoirs in the Cooper Basin
- Encourage results from Otway Basin exploration (Beach/Cooper)
- Bight Basin attracting the majors — 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

Bight Petroleum
EPP 41 and EPP 42
Case Study – Petroleum Retention Leases for Oil

Winner’s Curse?

Know your market!

Average for High Bids: $4,435 per sq km per year
g

$4,500 / km² pa

\( y = 16418e^{-0.03x} \)

\( R^2 = 0.6809 \)
Petroleum Licence Holders

Oil exploration wells (Jan 2002-Aug 14), western Cooper – Eromanga

- 52% post-3D were discoveries (and find-size ↑)
- 28% post-2D were discoveries
- Average 2.5 mmbo find size
- 10 operators for 25 companies

Fit-for-purpose oil leases

Proven Cooper-Eromanga oil play
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.

2014 Context:
Eastern Australia 2P Gas Reserves

<table>
<thead>
<tr>
<th>Type</th>
<th>Percentage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>13%</td>
<td>52,522 PJ</td>
</tr>
<tr>
<td>Unconventional</td>
<td>87%</td>
<td></td>
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</tbody>
</table>

Unconventional (Coal Seam Gas)

Core Energy Group June 2013 statistics
Natural gas and oil in unconventional rock-reservoirs

EIA / ARI 2013

<table>
<thead>
<tr>
<th>#</th>
<th>Region</th>
<th>Gas (TCF)</th>
<th>Oil (Billion Bbls)</th>
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<tbody>
<tr>
<td>1</td>
<td>USA</td>
<td>1,161</td>
<td>Russia</td>
</tr>
<tr>
<td>2</td>
<td>China</td>
<td>1,115</td>
<td>USA</td>
</tr>
<tr>
<td>3</td>
<td>Argentina</td>
<td>802</td>
<td>China</td>
</tr>
<tr>
<td>4</td>
<td>Algeria</td>
<td>707</td>
<td>Argentina</td>
</tr>
<tr>
<td>5</td>
<td>Canada</td>
<td>573</td>
<td>Libya</td>
</tr>
<tr>
<td>6</td>
<td>Mexico</td>
<td>545</td>
<td>Australia</td>
</tr>
<tr>
<td>7</td>
<td>Australia</td>
<td>437</td>
<td>Venezuela</td>
</tr>
<tr>
<td>8</td>
<td>South Africa</td>
<td>390</td>
<td>Mexico</td>
</tr>
<tr>
<td>9</td>
<td>Russia</td>
<td>285</td>
<td>Pakistan</td>
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<tr>
<td>10</td>
<td>Brazil</td>
<td>245</td>
<td>Canada</td>
</tr>
<tr>
<td>11</td>
<td>Others</td>
<td>1,535</td>
<td>Others</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>7,795</td>
<td>Total</td>
</tr>
</tbody>
</table>

Fast follower criteria outside North America

- The right rocks (liquids rich better)
- Markets
- Supportive investment frameworks
- Trusted regulatory frameworks
- Pre-existing infrastructure
- Two ends against the middle – descend cost & ascend productivity curves
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 Arkaringa 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)
DEEP GAS IN THE COOPER BASIN

EIA (2013): 93 TCF sales gas in Cooper shales

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

Regional Seal

Gas saturated composite play

PRIMARY SOURCE INTERVAL
CO₂ and Gas Wetness, 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

Patchawarra Absent

Patchawarra Absent

Patchawarra Absent
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.
3. Proven 1,000+ metre gas columns can be developed with a mix of (mostly) verticals and (fewer) horizontal wells
4. Initial unconventional 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
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)**

465+ members in SA’s Roundtable for O&G Projects
Roadmap for Unconventional Gas

Now under the auspices of the Roundtable for Oil and Gas Projects

Search words: DSD & Unconventional Gas

Informed by a Roundtable including: industry; governments; peak bodies for protecting environments and aboriginal people; research institutions and a few individuals

Now 440 members & 6 working groups:

1. Training;
2. Supply hubs, roads, rail and airstrips for the Cooper-Eromanga basins;
3. Water use in the Cooper-Eromanga basins;
4. SA-Qld ‘wharf to well’ corridors for the Cooper-Eromanga basins;
5. Cost effective, trustworthy GHG detection; and
6. Supplier’s forum to boost local content
### 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>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018-2029 (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
Top priorities to build trust:

- 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
<table>
<thead>
<tr>
<th></th>
<th>Top 5 of 125 Roadmap Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deploy fit-for-purpose licence terms and conditions</td>
</tr>
<tr>
<td>2</td>
<td>Enable fit for purpose skills</td>
</tr>
<tr>
<td>3</td>
<td>Use water wisely</td>
</tr>
<tr>
<td>4</td>
<td>Communicate effectively to demonstrate the efficacy of managing environmental risks</td>
</tr>
<tr>
<td>5</td>
<td>Regulation simultaneously meets public and investor expectations for net outcomes</td>
</tr>
<tr>
<td>Rank</td>
<td>Recommendation</td>
</tr>
<tr>
<td>------</td>
<td>----------------</td>
</tr>
<tr>
<td>6</td>
<td>Bolster public understanding re: hazards and risk management via FAQ on web ✓</td>
</tr>
<tr>
<td>7</td>
<td>Pave roads between Moomba and Qld</td>
</tr>
<tr>
<td>8</td>
<td>Pave roads between southern ports &amp; Moomba</td>
</tr>
<tr>
<td>9</td>
<td>Water crossings more passable year-round</td>
</tr>
<tr>
<td>10</td>
<td>Streamlined approvals for imported equipment - especially road and wiring regulations</td>
</tr>
</tbody>
</table>
Separation of fracture stimulation in the Cooper Basin from fresh water supplies

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.

Number of fracture stimulated stages in 717 fracture stimulated wells in the Cooper Basin to end Aug.’14
Recap 5 Working Groups

#1 Training

#2 Supply hubs, roads, rail and airstrips for the Cooper-Eromanga basins

#3 Water use in the Cooper-Eromanga basins

#4 SA-Qld 'wharf to well' corridors for the Cooper-Eromanga basins

#5 Cost-effective, trustworthy GHG detection

#6 Suppliers’ Forum
South Australia’s *Petroleum and Geothermal Energy Act 2000* defines the **environment** as: land, air, water, soil; plants & animals; social, cultural & heritage features; visual amenity; economic & other land uses.

Activities cannot start without an approved SEO in place.

SEO’s set standards for outcomes from operations

SEO’s 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
Productivity Commission concluded:

One-Stop-Shops are the most efficient regulatory approach when well managed without ‘CAPTURE’

Recommendation – Establish lead agencies

South Australia is widely seen as a model for other jurisdictions to emulate”.

“With appropriate governance, experience in South Australia suggests that such an agency can achieve an appropriate balance between enforcing legislative provisions and expediting approvals”. 
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
Barry Goldstein,
Executive Director - Energy Resources
South Australian State Government

New York Energy Forum
Monday 22nd September 2014
Background information
(with engagement in relation to oil and gas operations in the Coonawarra Wine District – Otway Basin as an example)
Pitney Bowes (Encom) Gpinfo Petroleum Permit Maps 2014
Field Size Distribution – Proven Productive Oil Play in the Cooper-Eromanga Basins

Swanson's Mean = 2.53 million barrels per new field discovery
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
Key Matters Considered in Decision-Making for the Regulation of PRLs

• The highest priority defined by the Roundtable for Unconventional Gas is the appropriate recognition of the life-cycle for finding, appraising, developing and producing resources. Fit-for-purpose licenses terms are the most direct way to recognize this life cycle. This is equally relevant to all mineral and energy resource sectors. The Subject Area Arrangement:

- Avoids 18 -24 months delay in exploration/discoveries after: intermittent relinquishments; call for bids; bids; negotiation of land access agreements; and grant of successively smaller PELs;
- Accelerates investment at contestable levels through renewal terms in ways not achieved with PELs;
- Delivers investment, jobs, production and royalties, sooner - clearly in the interest of the People of South Australia;
- Industry as a whole has greater investment efficiency;
- Attains very competitive levels of investment without the perverse outcome of ‘winner’s curse’ bidding;
The Subject Area Arrangement (continued):

- Based on DSD’s mapping of the proven oil play trend - 21 companies in JVs under 10 Operators may opt into Subject Area Agreements (e.g. cross-section of industry will benefit, including service companies who will get more extensive contracts);

- Nurtures small enterprises to become medium to large in size enterprises;

- Overcome a looming issue: Ever-smaller licences attracting circa $20 million bids (400 sq km 3D + 4 exploration wells) stretch the financial competence of ASX IPOs – and financial competence is a requirement for compliant licence-holders;

- Seeks secure investment at a time the State needs stronger investment;

- Farm-outs and sales are expected to further accelerate investment than is likely to be attracted through success, intermittent work program bids;

- A company approached Government with a proprietary request to progress applications for PRLs;

- Undertook targeted consultation with a cross-section of key Operators, at least one non-Operator and service companies active in the Cooper-Eromanga basins;

- The clear majority of enterprises considered the concept of PRLs for oil as a significant (even visionary) step worth taking;

- With regret, there little chance that all regulatory decision will please all stakeholders, always;
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.
To download the Roadmap for Unconventional Gas Projects in South Australia - go to:

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

Executive Director
Barry Goldstein

Engineering Operations Director
Michael Malavazos

Geology/Promotion Director
Elinor Alexander

Licensing Director
Joe Zabrowarny

Royalty Branch Director
Nick Panagopoulos

Geophysics Branch Director
David Cockshell

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
Answers to Frequently Asked Questions Regarding Oil and Gas Operations (Including Fracture Stimulation)

Go to:

Recap Working Group #1 - Training

Leading Operators in the Cooper Basin (Santos, Beach and Senex) have agreed to contribute an aggregate of > $1 million 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 a 15 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 have met / are planning to pool water use forecasts for Cooper-Eromanga (SA-Qld) basin-wide modelling of water supply: demand balance, to deduce cost- and water-saving options.

This is a first, fundamental step towards life-cycle water-use planning – will inevitably foster environmental sustainability, project economics, transparency/trust, and business opportunities.

Santos coordinating. Golders contracted for modelling with South Australian Government funding.
Recap Working Groups #4  SA-Qld 'wharf to well' corridors for the Cooper-Eromanga basins

Need traction with colleagues in Qld

Qld regulators at Roundtable in Adelaide, 2-3 Dec 13

**Upstream:** Mike Malavazos (DSD) in direct discussions with Qld’s Coal Seam Gas Compliance Unit, Department of Natural Resources and Mines

**Transport:** DPTI in direct discussions with new National Heavy Vehicle Regulator and Qld counterparts
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
**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
PGE Act defines the *environment* as:

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

SEO Approval Process

EIR & Draft SEO

Environmental Significance Assessment

LOW IMPACT
Internal Govt Consultation

MEDIUM IMPACT
Public Consultation

HIGH IMPACT
EIS Process

Statement of Environmental Objectives

APPROVAL
**Petroleum and Geothermal Energy Act 2000**

**Regulatory Framework in South Australia**

**Significance Criteria**

<table>
<thead>
<tr>
<th>PREDICTABILITY</th>
<th>MANAGEABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of confidence that for each impact and consequence these issues have been addressed:</td>
<td>Extent to which consequences can be managed:</td>
</tr>
<tr>
<td>• Size</td>
<td>• Avoidance</td>
</tr>
<tr>
<td>• Scope</td>
<td>• Probability</td>
</tr>
<tr>
<td>• Duration</td>
<td>• Duration</td>
</tr>
<tr>
<td>• Likelihood/Frequency</td>
<td>• Size</td>
</tr>
<tr>
<td>• Stakeholder Concerns</td>
<td>• Scope</td>
</tr>
<tr>
<td></td>
<td>• Cumulative Effects</td>
</tr>
<tr>
<td></td>
<td>• <strong>Stakeholder concerns</strong></td>
</tr>
</tbody>
</table>
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
Petroleum and Geothermal Energy Act 2000

Regulatory Framework in South Australia

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

- **PGE Act compliance policy**
- **PGE Act Annual Compliance report**
Part 2
What are the risks?
How do we identify and manage the risks?

Beach Energy Shale Gas Fraccing - EIR

Beach Energy Shale Gas Fraccing - SEO
<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>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>Fraccing into adjacent and overlying aquifers</td>
<td></td>
<td>Non-toxic frac fluid.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monitor frac through micro seismic and control pump pressures accordingly</td>
</tr>
</tbody>
</table>
**Environmental Impact Report - Summary**

<table>
<thead>
<tr>
<th>HAZARDOUS EVENTS</th>
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</tr>
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</tr>
<tr>
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<td>Pollute water source of other users</td>
<td>Use of non-toxic muds.</td>
</tr>
<tr>
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<td></td>
<td>Non-toxic frac fluid.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monitor frac through micro seismic and control pump pressures accordingly</td>
</tr>
<tr>
<td>HAZARDOUS EVENTS</td>
<td>POTENTIAL CONSEQUENCES</td>
<td>MITIGATION MEASURES</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td></td>
<td>Monitor frac through micro seismic and control pump pressures accordingly</td>
</tr>
</tbody>
</table>
Contained
Wells have as many as eight layers of steel casing and cement that form a continuous, protective barrier between the well and the surrounding rock. The well design and program is reviewed, approved and monitored by the State or Territory regulator.
Hydraulic Fracturing Operations—Well Construction and Integrity Guidelines

API GUIDANCE DOCUMENT HF1
FIRST EDITION, OCTOBER 2009
Recommended Well Construction Practice

- 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 250 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 004 210 164)

On
21st AUGUST 2009
<table>
<thead>
<tr>
<th>HAZARDOUS EVENTS</th>
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<td>MITIGATION MEASURES</td>
</tr>
<tr>
<td>-------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------</td>
</tr>
<tr>
<td>Flow back of frac fluids</td>
<td>Contamination of soil, impact vegetation and potential contamination of surface aquifers</td>
<td>Frac fluid contained within lined pits</td>
</tr>
<tr>
<td>Vehicle and plant refuelling during operations.</td>
<td>Oil spill damage to soil &amp; vegetation.</td>
<td>Refuel in designated bunded area.</td>
</tr>
<tr>
<td>Seed importation on vehicles and equipment.</td>
<td>• Introducing alien vegetation species (weeds).</td>
<td>All vehicles steam cleaned prior to entering district.</td>
</tr>
<tr>
<td></td>
<td>• Impact on other land users, eg farmers, pastoralists</td>
<td></td>
</tr>
</tbody>
</table>
Offset -Well Microseismic Mapping

Microseismic Monitoring Is
Applied Earthquake
Seismology

- A Microseism Is a
  Micro-Earthquake, a
  Shear Slippage Along
  An Existing Plane Of
  Weakness.
- Microseisms That
  Occur During
  Hydraulic Fracturing
  Are Caused By:
  - Changes In
    Stress And
    Pressure As A
    Result Of The
    Treatment

Recorded Events
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

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
Figure 24: Typical fracture height growth measured during shale gas stimulation in the Eagle Ford (USA) with Nappamerri Trough well section superimposed.
Chemistry of Fracture Stimulation Fluids

Diagram showing the composition of fracture stimulation fluids. The main component is water and sand at 99.51%. Other components include:

- KCl: 0.06%
- Surfactant: 0.085%
- Other: 0.49%
- Gelling Agent: 0.056%
- Scale Inhibitor: 0.043%
- pH Adjusting Agent: 0.011%
- Breaker: 0.01%
- Crosslinker: 0.007%
- Iron Control: 0.004%
- Corrosion Inhibitor: 0.002%
- Friction Reducer: 0.088%
- Acid: 0.123%
- Biocide: 0.001%
<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 (15%)</td>
<td>Hydrochloric acid</td>
<td>Help dissolve minerals and initiate cracks in the rock</td>
<td>Swimming pool chemical and cleaner</td>
</tr>
<tr>
<td></td>
<td>or muriatic acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biocide</td>
<td>Glutaraldehyde</td>
<td>Eliminates bacteria in the water that produce corrosive byproducts</td>
<td>Disinfectant; sterilize medical and dental equipment</td>
</tr>
<tr>
<td>Breaker</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-dimethyl formamide</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></td>
<td>Mineral oil</td>
<td></td>
<td>Make up remover, laxatives, candy</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>Citric acid</td>
<td>Prevents precipitation of metal oxides</td>
<td>Food additive, flavouring 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 cleansers, and de-icing agent</td>
</tr>
<tr>
<td>Surfactant</td>
<td>Isopropanol</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's all about Containment
Well and Fracking Operation Standards
Are Earthquakes are 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.
Presence of Hydrocarbon in Shallow Aquifers
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPORT BOOK 95/17

GAS SAMPLING FROM WATER BORES
IN THE NORTHERN GAMBIER BASIN,
SOUTH AUSTRALIA

by

A.J. HILL
Petroleum Division

D.R. VINALL
Petroleum Division

JUNE 1995

DME

©Department of Mines and Energy South Australia 1995
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Available on DSD SARIG Web site
Table 1: Compositional analysis of water bores sampled in 1987 survey.

<table>
<thead>
<tr>
<th>Sample</th>
<th>RIV 11 sample 1</th>
<th>SYM 61 sample 1</th>
<th>SMT 29 sample 2</th>
<th>SMT 29 sample 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N_2 + O_2)</td>
<td>92.67</td>
<td>99.39</td>
<td>94.51</td>
<td>98.92</td>
</tr>
<tr>
<td>CO(_2)</td>
<td>0.96</td>
<td>0.32</td>
<td>3.12</td>
<td>0.39</td>
</tr>
<tr>
<td>CH(_4)</td>
<td>5.39</td>
<td>0.29</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>C(_2)H(_6)</td>
<td>0.30</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>C(_3)H(_8)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>C(_4)+</td>
<td>0.68</td>
<td>0.00</td>
<td>2.37</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 2. Headspace gas volumes, 1993 survey.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Volume (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOY-17-1</td>
<td>100</td>
</tr>
<tr>
<td>JOY-17-2A</td>
<td>800</td>
</tr>
<tr>
<td>SMT-29-1</td>
<td>50</td>
</tr>
<tr>
<td>SMT-29-2</td>
<td>450</td>
</tr>
<tr>
<td>SMT-29-1A</td>
<td>950</td>
</tr>
<tr>
<td>6824-1549-1</td>
<td>100</td>
</tr>
<tr>
<td>6824-1549-2</td>
<td>1100</td>
</tr>
<tr>
<td>FOX-10-2</td>
<td>1150</td>
</tr>
<tr>
<td>SYM-61-1</td>
<td>400</td>
</tr>
<tr>
<td>MTB-18-1</td>
<td>1000</td>
</tr>
</tbody>
</table>
### Methane

#### Dilwyn Formation

<table>
<thead>
<tr>
<th>Components</th>
<th>JOY-17-1</th>
<th>JOY-17-2A</th>
<th>SMT25-1</th>
<th>SMT29-2</th>
<th>SMT29-1A</th>
<th>6824-1549-1</th>
<th>6824-1549-2</th>
<th>FOX10-2</th>
<th>SYM61-1</th>
<th>MTB18-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₂ (mol %)</td>
<td>52.3</td>
<td>50.9</td>
<td>47.2</td>
<td>46.2</td>
<td>48.3</td>
<td>7.74</td>
<td>10.2</td>
<td>35.1</td>
<td>72.5</td>
<td>95.5</td>
</tr>
<tr>
<td>O₂+Ar (mol %)</td>
<td>4.79</td>
<td>1.03</td>
<td>2.46</td>
<td>2.87</td>
<td>1.17</td>
<td>0.42</td>
<td>0.50</td>
<td>0.80</td>
<td>1.38</td>
<td>1.45</td>
</tr>
<tr>
<td>CO₂ (mol %)</td>
<td>0.18</td>
<td>1.86</td>
<td>0.05</td>
<td>0.15</td>
<td>0.09</td>
<td>0.04</td>
<td>0.06</td>
<td>0.08</td>
<td>0.56</td>
<td>2.90</td>
</tr>
<tr>
<td>C₁ (mol %)</td>
<td>42.7</td>
<td>46.2</td>
<td>50.3</td>
<td>50.8</td>
<td>50.4</td>
<td>91.8</td>
<td>90.2</td>
<td>64.0</td>
<td>25.6</td>
<td>0.16</td>
</tr>
<tr>
<td>C₂ (μL/L)</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>&lt;30</td>
<td>3</td>
</tr>
<tr>
<td>C₃ (μL/L)</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>C₄ (μL/L)</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>&lt;1</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>C₅ (μL/L)</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>C₆ (μL/L)</td>
<td>&lt;1</td>
<td>60</td>
<td>30</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>20</td>
<td>4</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

**Table 3**: Bulk composition, water bore gases
## Methane

### Dilwyn Formation

**Table 4.** Stable Carbon isotope analyses, $\delta^{13}C/_{\infty}$ PDB

<table>
<thead>
<tr>
<th>Sample</th>
<th>Methane $\delta^{13}C$</th>
<th>Carbon Dioxide $\delta^{13}C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOY-17-2A</td>
<td>-77.7</td>
<td>-20.2</td>
</tr>
<tr>
<td>SMT-29-1A</td>
<td>-72.4</td>
<td>-</td>
</tr>
<tr>
<td>6824-1549-2</td>
<td>-52.4</td>
<td>-</td>
</tr>
<tr>
<td>FOX-10-2</td>
<td>-64.1</td>
<td>-</td>
</tr>
<tr>
<td>SYM-61-1</td>
<td>-99.8</td>
<td>-</td>
</tr>
<tr>
<td>MTB-18-1</td>
<td>-63.3</td>
<td>-18.6</td>
</tr>
</tbody>
</table>

**Carbon Isotope Thresholds**
- $<-60$ Biogenic Source
- $> -60$ Thermogenic Source
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?
What is hydraulic fracturing?
Key Historical Milestones for Oil & Gas in the South East of South Australia

- Exploration commenced in 1866 in the South East with a well drilled near Salt Creek
- First flow at Kalangadoo-1 in 1965 and Caroline-1 in 1966 – both CO2
- First commercial flow of hydrocarbons in 1987 at Katnook-1
- Katnook Plant built and commissioned in 1991 – now mothballed
- Oil recovered from Sawpit-1 in 1992, flowed from Wynn-1 in 1994 – neither well commercial
Conventional Oil and Gas Exploration Nothing New
History of Gas Extraction in SE
Otway Basin, South Australia
Kalangadoo #1 1964
South East South Australia
Source of Gas and Where to Next

[Diagram showing geological strata and hydrocarbon targets]
Gas Supply in South East South Australia

SOUTH EAST PIPELINE SYSTEM - 2003

Map showing the gas supply infrastructure in South East South Australia, including locations such as Kamook Plant, Safries MS, Nangwarry MS, Nangwarry RS, Glencoe Junction, Apcel MS, and Mt. Gambier MS.
Historical Gas Production in South East South Australia

Southeast Gas Production

Graph showing historical gas production in South East South Australia from Jan-91 to Jan-13. The graph indicates a decline in gas production over time with peaks in production around Jan-94 and Jan-97. The production data is broken down by location, including Katnook, Haselgrove, Redman, Jacaranda Ridge, and Limestone Ridge.
Caroline#1
CO2 Production

CO2 Production (tonnes/day)

Jan-68 Jan-72 Jan-76 Jan-80 Jan-84 Jan-88 Jan-92 Jan-96 Jan-00 Jan-04 Jan-08 Jan-12

CO2 Production (tonnes/day)

Cumulative CO2 (kt)

Jan-68 Jan-72 Jan-76 Jan-80 Jan-84 Jan-88 Jan-92 Jan-96 Jan-00 Jan-04 Jan-08 Jan-12

Cumulative CO2 (kt)
Where to next in the Otway Basin?

Oil or liquids rich gas
South East (Otway Basin) Geology
South East (Otway Basin) Geology

Fig. 2  Schematic section of the Katnook field (Pretty Hill Sandstone reservoir).
South East (Otway Basin) Geology

Fig. 3  Block diagram of channel sands in a braided fluvial environment (Scholle and Spearing').
South East (Otway Basin) Geology

Abstract

The long-term, production tests of the Katnook gas field in the South-East of South Australia are analysed to enable a better understanding of the reservoir geometry.

The pressure-transient responses are interpreted to indicate a compartmentalised reservoir, comprising a series of high-permeability sand bodies in relatively poor communication. This is consistent with the geological model, which describes the stacked-channel reservoirs having been formed in a low-sinuosity, braided-stream palaeoenvironment.

Estimates of channel width and reservoir connectivity are made using the proportion of transverse fractures observed in thin-section analysis.

The initial discovery was made in the Windermere Sandstone of the basal Eumenalla Formation. The subsequent drilling of Katnook #2 and #3 confirmed that the major gas reserves are located in a faulted anticline structure of the Pretty Hill Sandstone, covering an area of about 4 km².

A drill stem test gas flow of 16.4 MMscfd (462,000 m³/d) on a 1/2 inch (12.7 mm) choke was measured during DST #12 in Katnook #2. This is a record for a well drilled onshore in South Australia.

Delivery of natural gas from Katnook to the industrial, commercial and domestic markets in the South-East of South Australia commenced in March 1991. Under the terms of the contract the producers will supply 22.5 PJ over a 15 year period.
Hot Rock Geothermal Energy in Australia

This design makes walking impossible

From: AGU’s Physics Today May 07
Geodynamics’ Habanero Cooper Basin, SA

Habanero EGS Field

4 wells >4300m into >240°C fractured, over pressured granite reservoir

Granite reservoir stimulated

Proven reservoir connection between Habanero 1 & 3

Habanero 4 drilled to 4,300m and frac’d (east of H3)

Injection-production to demonstrate net positive heat exchange

Next: Get a local market

AU$90m grant from the Federal Renewable Energy Development Program
Engineered Geothermal Systems - Plan View, Same Scale

Engineered Hot Rocks
Water is injected under pressure into naturally fractured rocks to increase the intensity and extent of fractures. The micro-shifting of rocks during that fracture stimulation process is located in the same way epicentres of blasting and earth tremors are determined.

EGS Trials (Displayed)
- Fenton Hill, USA: 70 – 95
- Fjalbacka, Sweden: 84 - 88
- Rosemanowes, UK: 84 - 91
- Hijiori, Japan: 85 - 00
- Soultz, France: 87 – Current
- Ogachi, Japan: 89 - 00
- Habanero, Australia: Current
- Bad Urach, Germany: Current
- Basel, Switzerland: Abeyance
- Landau, Germany: Current

Grey dots are seismic events from earlier stimulations of Habanero 1, 2 and 3

Fenton Hill, Los Alamos USA 1970-95
500 metres

Rosemanowes Cornwall, UK 1984-91

Since 1987

Epicenters of stimulated fracture growth

~1 km

~12 km

~1 km

Courtesy of Doone Wyborn – Geodynamics

Australian EGS > 4x’s than attained elsewhere