Fracking past and present

History of Science Ideas and Technology Group Inc
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Structure of talk

Why do we need oil and gas?
‘Petroleum 101’
Petroleum in SA
What’s conventional and what’s unconventional anyway?
What is hydraulic fracture stimulation?
How is fracture stimulation regulated in SA?
Outcomes delivered to the SA community
Life without oil

- natural gas provides base load electricity, cooking, heating, bbq gas, glass manufacturing, industrial, fertilizer, plastics, pharmaceuticals and fabrics and is a good option for a transition fuel to new sources of energy

https://www.youtube.com/watch?v=4-pNrrVHeQ8
Petroleum - literally ‘rock oil’. How is it formed?

- Source rock (contains organic matter)
- Temperature >70°C
- Pressure (deep burial)
- Time

Oil and / or Natural gas
Petroleum systems

5 elements:
- SOURCE ROCK * – contains deeply buried organic material
- RESERVOIR – rock with pores/fractures e.g. a sandstone
- MIGRATION – pathway from source rock to reservoir
- TRAP – structure to hold hydrocarbons
- SEAL * – rocks to contain hydrocarbons

NOTE *: these can also form 'unconventional' reservoirs

Oil generation starts at about ~70°C

Show me the rocks!
Where is petroleum found in Australia?

1. 1866-68 'All Flat 1' drilled to 7.6 m depth. First oil well in Australia only 7 years after Col Drake’s well.

2. 1955 - Santos Wilkatana 1: Cambrian oil (~540 million years old) indications focussed explorer interest on SA. Santos exploration effort shifted to NE of State.


Where is petroleum found in South Australia?

1978 - oil discovered, exported via Pt Bonython from 1984

1991 - natural gas first supplied to SE industrial, agricultural and domestic customers.
A very brief history of oil & gas in SA

1836 – SA founded
1859 – Col. Drake drills 1st oil well, Pennsylvania USA
1866 - First Australian oil well drilled near Salt Creek
1868 - Moomba 6 fracture stimulated
1870 – Cooper Basin gas supplied to Adelaide
1882 – Economic oil fields discovered
1914 – First oil exports from Pt Bonython
1982 – Economic oil fields discovered
1984 – First oil exports from Pt Bonython
1987 – Katnook gas discovery, Otway Basin, SE
1991 – Natural gas from Katnook field supplied to SE industrial, commercial and domestic customers
2000 – Modern Petroleum Act and Regulations
2010 – SA roundtable for unconventional gas forms
2012 – Roadmap for Unconventional Gas in SA launched
2016 – PACE gas grant program launched to deliver more gas soonest to efficient SA power generators
2017 – >$42 billion oil and gas produced and over >$2.8 billion in royalties paid to government since 1969

What’s conventional and what’s ‘unconventional’?

Natural gas is primarily methane, it may contain ethane, liquid hydrocarbons and CO2. It is neither conventional or unconventional, it’s just CH4.

Natural gas can be found in conventional traps as well as in unconventional reservoirs like shale, coal and tight sandstones.

A petroleum well can target both conventional & unconventional reservoirs. Unconventional reservoir horizons may be fracture stimulated but only if approvals are in place. All petroleum wells are drilled under stringent regulations in SA.
Spudding a well
Seismic data enables prognosis of depths to aquifer and deeper target horizons
Lined mud tank
Small surface footprint

Set surface casing and cement to protect shallow formations and aquifers
Target depth reached. Complete well and rehabilitate surface. Cuttings and water from lined mud pit disposed of as per EPA requirements. If no oil and gas discovered, plug and decommission well, surface rehabilitation.

In SA, petroleum well sites fully rehabilitate back to natural vegetation typically within 5 years. This may be accelerated in desert regions if there’s significant rainfall events.

LHS –
* Stimpee 1, Cooper Basin.
* Rehabilitated well site, Cooper Basin.

RHS –
* Drilling operations at Sawpit 2 in 2013, Otway Basin.
* Rehabilitated site 6 months later
Why explore for unconventional reservoirs?

Conventional petroleum reservoirs have supplied humans with oil (including asphalt and bitumen) for over 6000 years
- smaller volumes
- cheap to find and easy to produce
- ‘low hanging fruit’

Unconventional reservoirs
- large volumes
- But more expensive to find and harder to develop and produce
- ‘Shale gas boom’ in USA

Resource size

Conventional reservoir rocks – have good porosity and permeability

Smaller pores, but well connected - good permeability for tea and coffee, hence the Tim Tam Slam.
Icing layer = no porosity or permeability = seal

Conventional reservoir rocks
- have good porosity and permeability
- Pindyin Sandstone
- Porosity 22.0%
- Permeability 1.5 Darcies
- Field of view 3.2 mm
- from the SA Offshore Basin

Good porosity, but pores not connected
What does an unconventional reservoir look like?

**Outcrop of the Eagleford Shale, Texas**

- Very low porosity and permeability
- Natural fractures

Local example – siltstone from Holdfast 1 Cooper Basin – Beach Energy

Photo courtesy Sandy Menpes

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**Impact of US shale gas plays like the Eagleford on CO2 emissions**

**International Energy Agency**

March 2017

Global energy-related carbon dioxide emissions were flat for a third straight year in 2016...

The biggest drop came from the United States, where carbon dioxide emissions fell 3%, or 160 million tonnes, while the economy grew by 1.6%. The decline was driven by a surge in shale gas supplies and more attractive renewable power that displaced coal. Emissions in the United States last year were at their lowest level since 1992, a period during which the economy grew by 80%.


https://www.eia.gov
What is Hydraulic Fracturing (fracturing)?

“Hydraulic fracturing (also known as ‘hydraulic fracture stimulation’, and colloquially as ‘frack(ing)’, sometimes spelled ‘frac(cing)’) is the process of injecting a mixture of mainly water, proppants (small particles, such as sand or ceramic) and chemicals (fracking fluid) at very high pressure to create small cracks through which hydrocarbons can flow from a reservoir.”

Over the past 60 years, hydraulic fracturing has also been used for a wide variety of purposes, from grouting dam foundations, soil mechanics, stimulating water flow from water bores and geothermal energy production.

>Fracture Stimulations used to increase yields in water bores in NSW in the 1970s.

>Fracturing can be traced back to the 1860s, when liquid was used to stimulate shallow, hard rock wells in Pennsylvania, New York, Kentucky and West Virginia.

In 1947, Stanolind Oil conducted the first experimental fracturing in the Hugoton field, SW Kansas.

Fracking water wells!?  

Fracture Stimulation has been used to improve yields from shallow water bores in NSW.

This 1970-80 project involved fracture stimulating 3 water bores, 44-80m deep. Hydraulic pressure was applied by isolating the aquifer and pumping in water then a viscous fluid with sand as a proppant or more water to test different methodologies.

Conclusion - that there are ‘good prospects of stimulating yields to acceptable levels by applying hydraulic fracturing techniques’.
Why fracture stimulate aquifers, petroleum and geothermal reservoirs?

John B Curtis (Colorado School of Mines, 2012)

What happens during a fracture stimulation?

John B Curtis (Colorado School of Mines, 2012)
Hydraulic Fracturing in SA

- Stimulation of unconventional reservoirs has been necessary to achieve economic flow rates and improve natural gas recovery - ‘low hanging fruit’ has gone.
- 1968 - Moomba 6 fracture stimulated
- To date: >700 wells fractured stimulated in the SA Cooper Basin region - all without harmful impacts.

Cooper Basin targets

Schematic cross-section showing target zones for horizontal drilling and fracturing.

Typically, a fracture is 3-6 mm wide. Can extend 400 m horizontally, up to 100 m vertically along the gas-bearing rock unit.
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The Westpac building is 132m high. It would need to be stacked >35 times to reach the depth of a 3-4 km Cooper or Otway Basin gas target horizon.

Fractures 3 - 6 mm wide
- Horizontal fracture extent
  400m
- Vertical extent <100m
  (Westpac Building 132m)

Lateral and map view of the locatable microseismic events during monitoring of multi-stage hydraulic stimulation of Cowralli-10. (Santos 2009)

FracPro model output for proposed hydraulic stimulation treatment in Abyra 7.

Modelling and real time monitoring of a fracture stimulation


Lateral and map view of the locatable microseismic events during monitoring of multi-stage hydraulic stimulation of Cowralli-10. (Santos 2009)
Separation of fracture stimulation in the Cooper Basin from fresh water supplies

- ~7-10,000 feet (~2-3.8 km) (similar separation in Otway Basin)

What is injected into the formation during a hydraulic stimulation?

Unconventional hydraulic stimulation treatments can use an average of 2-3 ML of water per well. Standard Olympic pool = 2.5 ML.

Water use is controlled by regional Water Allocation Plans, water disposed to an on site evaporation pond.
Surface Footprint
- it’s not Coal Seam Gas

From SARIG – gas wells, pipelines & processing plant ~ 10km south of Penola.
Google Earth image.
Approx 2km

Ladbrooke Grove Power Station and Katnook Gas Plant.
Former gas-powered SAFRIES factory, now operated by the Union Dairy Company.

Multi-well pad in Cooper Basin – minimising disturbance.

Shale Gas development scenario.

Where has fraccing + oil & gas production occurred adjacent to agricultural activities in SA?

Cooper Basin region (and Otway Basin region)

Map shows Cooper Basin region:
- all wells, fracced wells, seismic surveys, pipelines, oil and gas gathering facilities and processing plants
- cattle stations producing organically certified beef
Oil or gas field life cycle – every step is regulated and monitored for compliance in SA

South Australian Regulatory framework

Petroleum and Geothermal Energy Act 2000 (PGE Act); Environment Protection Act 1990;
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 - Commonwealth

ERD interacts with co-regulators & related agencies to achieve best net outcomes:
• Dept of Environment, Water and Natural Resources,
• Environment Protection Authority,
• Primary Industries and Regions SA,
• SA Health and
• SafeWork SA.

Petroleum and Geothermal Energy Act 2000 (PGE) - Objectives

Avoid environmental damage from activities involved in:

• Exploration for, the recovery and processing, of petroleum and other resources to which this act applies; and

• The construction or operation of transmission pipelines for transporting petroleum and other substances to which this act applies.

Establish appropriate consultative processes involving co-regulator experts, people directly affected by regulated activities and the public generally.

ERD regulators are engineers, geologists, geophysicists and environmental scientists

Before a regulated activity can be considered for approval under the Petroleum and Geothermal Energy Act 2000, a company must go through a 3 stage approval process:

• Licence approval and grant
• Statement of Environmental Objectives (SEO) approval
• Activity Notification approval.

**ERD’s regulatory approach**

- SA’s *Petroleum and Geothermal Energy Act 2000* (PGE Act) defines the *environment* as: land, air, water, soil; plants & animals; social, cultural & heritage features; visual amenity; economic & other land uses.

- **Statements of Environmental Objectives (SEO)*** set standards for the protection of social, natural and economic environments.
  - Specific SEOs exist for normal activities: e.g. Seismic, Drilling and Well Operations, Fracture Stimulation in Cooper Basin region, Production
  - Area-specific SEOs where needed

- Regulated activities can’t be carried out unless an approved SEO is in place.
- **Case-by-case science and engineering based assessment** will determine where potential risks are realistically manageable and where not realistically manageable.
- Where the latter is the case – the activity will not be approved.

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**SEO Objectives Include…**

**Avoid:**
- Contamination of aquifers
- Adverse impacts on other land users and uses
- Contamination of soil
- Disturbance to heritage sites
- Adverse impacts on vegetation

**Aim of regulatory processes** is to have licensees demonstrate that they can and are achieving these objectives. Breaching these objectives are offences under the PGE and other relevant Acts.

**SEOs are public documents freely accessible by all here:**


Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia – EIR Dated July 2012
Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia – SEO Gazetted 2 August 2012
Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia – Significance assessment
**Inquiries and experts**

2011 House of Commons Energy and Climate Change Committee (ECCC) 2011 report: there is no evidence that the hydraulic fracturing process itself poses a direct risk to underground water aquifers ... hypothetical and unproven risk must be balanced against the energy security benefits that shale gas could provide to the UK ... a moratorium in the UK is not justified or necessary at present.

May 2013 - Australian Council of Learned Academies (ACOLA) review of shale gas in Australia (peer-reviewed by the CSIRO): “The evidence suggests that, provided appropriate monitoring programs are undertaken and a robust and transparent regulatory regime put in place (and enforced), there will be a low risk that shale gas production will result in contamination of aquifers, surface waters or the air, or that damaging induced seismicity will occur.”

Sept 2014 - Chief Scientist and Engineer NSW Final Report of the Independent Review of Coal Seam Gas Activities in NSW: Overall, the Review found many of the technical challenges and risks posed by the CSG industry can in general be managed through careful designation of areas appropriate for CSG extraction; high standards of engineering and professionalism in CSG companies; creation of a State Whole-of-Environment Data Repository; comprehensive monitoring of CSG operations with ongoing scrutiny of collected data; a well-trained and certified workforce; and applying new technologies as they become available.

Nov 2014 - Independent Inquiry into Hydraulic Fracturing in the Northern Territory: The major recommendation, consistent with other Australian and International reviews, is that the environmental risks associated with hydraulic fracturing can be managed effectively subject to the creation of a robust regulatory regime.

November 2015 - Inquiry into the Implications for Western Australia of Hydraulic Fracturing for Unconventional Gas: The Committee has found that there is significant concern amongst the community about the risks associated with hydraulic fracturing but at the same time, there is a level of misinformation present in the public domain that can cause confusion and mistrust.

28 October 2015 - Dr Alan Finkel, Chief Scientist, told ABC Lateline that: “…there is a lot of evidence that fracking is safe.” “That it’s being used widely already in the coal seam gas fields, particularly in Queensland. It’s being used widely across America. The evidence is not there that it’s dangerous. In fact, the evidence is that, if properly regulated, it’s completely safe.”

**Inquiries have typically concluded that if fracture stimulation is properly regulated in a transparent and robust regulatory regime, there is a low risk of impacts.**

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**Transparency**

ERD welcomes people accessing regulatory decision making and industry performance information. The following regulatory documents are freely available to all via the website:

- FAQs,
- Tenement documents,
- Criteria for classifying the level of Environmental Impact environmental performance,
- PGE Act compliance policy,
- regulatory enforcement actions,
- surveillance activity information,
- Annual compliance report,
- All EIRs and SEOs – including SEOs for fracture stimulation in the Cooper Basin.

Benefits of petroleum exploration and production?

- Since gas sales to Adelaide commenced in 1969, Cooper Basin expenditure has averaged ~$840 million per year.
- Cooper Basin gas supplies industrial, manufacturing, commercial, agricultural and domestic customers in Adelaide, Sydney and regional SE Australia.
- >$42 billion oil and gas produced and over >$2.8 billion in royalties paid to government since 1969.
- Direct and flow-on employment in this high tech sector.
- Service and supply sector jobs and activity.
- Environmental impacts have been monitored and minimised.
- Native Title claimants – work area clearances, businesses established, royalty stream.

Roundtable for Oil & Gas in SA

Designed to inform industry strategies, government policies, and regulations to facilitate oil & gas projects in ways that SA communities welcome.

>2,000 members >1000 organisations ~30 individuals

Has 8 working groups:
- • Training – Tonsley Centre of Excellence;
- • Cooper Basin supply hubs, roads & air strips;
- • Cooper Basin water use;
- • Transport with reduced red tape;
- • GHG detection;
- • Supplier forum;
- • Gaseous fuels for transport & heavy machinery;
- • Sharing Information.

New members are welcome – please see me to join up.

Next meeting: Thursday 30 November 2017

National Wine Centre, Adelaide, SA.

Thank you for your attention
For more information, please check out the FAQs:

• http://petroleum.statedevelopment.sa.gov.au/frequently_asked_questions/unconventional_gas_in_south_australia

CSIRO:
Informative animation of how hydraulic fracturing works:
https://www.youtube.com/watch?v=PQKjLFY5YEY