sacome South Australian Chamber of Mines and Energy

Inquiry into the potential risks and impacts in the use of hydraulic fracture stimulation (Fracking) to produce gas in the South-East of South Australia

Submission to

Natural Resources Committee

Parliament of South Australia

January 2015

South Australian Chamber of Mines and Energy Incorporated

Contents

Executive Summary

The South Australian Chamber of Mines and Energy ("**SACOME**") is pleased to have this opportunity to make a submission to the Natural Resources Committee ("**the committee**") Inquiry into the potential risks and impacts in the use of hydraulic fracture stimulation to produce gas in the South-East of South Australia.

This submission addresses each of the points of interest of the inquiry, namely;

1. Risk of ground water contamination
2. The impacts upon landscape
3. The effectiveness of existing legislation and regulation
4. The potential net economic outcomes to the region and the rest of the state

The South Australian petroleum industry has an exemplary environmental and safety track record. In the fifty years of petroleum exploration and production in the Cooper Basin, and 30 years of production in the Otway Basin (South-East) there has been no impact on aquifers, no health impacts, and no harm to the surface and subsurface environments. It has also been demonstrated that the petroleum industry has co-existed sustainably with other land uses (*i.e.* agriculture, viticulture and wine production), and with no impact on brand or the 'clean, green' image of South Australian primary production.

Yet the economic and social benefits both for the South-East region and state-wide from petroleum production is very apparent, such as:

1. Regionally
    - Diversified economy
    - Gas processing to support industry and the community (Katnook Plant)
    - Infrastructure development (gas pipelines)
    - Establishment of industries (*e.g.* Safries & Kimberley-Clark)
    - Power augmentation and reliability (Snuggery Power Plant)
    - Employment and population sustainability
2. State-wide
    - Corporate Headquarters
    - Investment in Universities and research
    - Employment
    - Royalties
    - Export revenues
    - Infrastructure
    - Low carbon electricity generation

Certainly the industry operates with risks, but risks are evident in most industries and life experiences. Accordingly, it is proper that the approach of industry, in managing their operations, and the South Australian legislative framework in dealing with economic, environmental and community impacts is objective and risk based. That is, each project is assessed on its own unique set of circumstances, including geology, environment, land use and community.

Each potential risk is identified, avoided (where possible), and effectively managed and mitigated by adhering to global recognised best industry standards.

The South Australian assessment and approval framework is comprehensive integrating all required legislation and the respective administering government agencies in a whole of government approach under the overarching legislation of the *Petroleum and Geothermal Energy Act 2000* ("**PaGE Act"**). The PaGE Act is absolutely clear in requiring all environmental, social, safety and economic matters be identified and exhaustively addressed through community consultation and in the subsequent Environmental Impact Reports ("**EIR**") and approved Statement of Environmental Objectives ("**SEO**").

Use of hydraulic fracture stimulation to enhance the recovery of gas and oil from low permeability formations is not new to South Australia. Hydraulic Fracturing has be used by industry in the Cooper Basin for forty years with no impact on aquifers. Equally government has considerable knowledge and experience, over those forty years, in regulating and managing use of hydraulic fracturing.

In the same way that processes and practices in agriculture, manufacturing and the automotive industry have advanced; well design and construction, hydraulic fracturing, monitoring, health and safety, and environmental impact and performance in petroleum exploration and production has been advanced by continuous improvement in processes, and innovation and technology development.

Linking the industry to practices and technology 50 years ago is akin to suggesting agricultural practices, and manufacturing and automotive technology have not changed in the same time frame.

Moratoriums or bans put in place in recent times have been typified as politically driven reactions to public sentiment based on unsubstantiated information. The implications is clear from the uncertain commercial environment and energy security created in New South Wales (**"NSW"**) from such policies. It is vital that South Australia's policies and regulations are driven by qualified scientific evidence and not by knee jerk reactions to unqualified populist agendas.

SACOME would welcome the opportunity to appear before the committee to present the information covered in this submission.

SACOME

SACOME is the peak industry association for all companies with business interests in the resources industry in South Australia, including those with business, vocational or professional interests in minerals exploration, mining and processing, oil and gas exploration, extraction and processing, power generation, transmission and distribution, logistics, transport, infrastructure, and those with clients in these sectors. The Chamber also represents interests developing geothermal and wind power.

SACOME represents over 300 core industry and services members.

Definitions

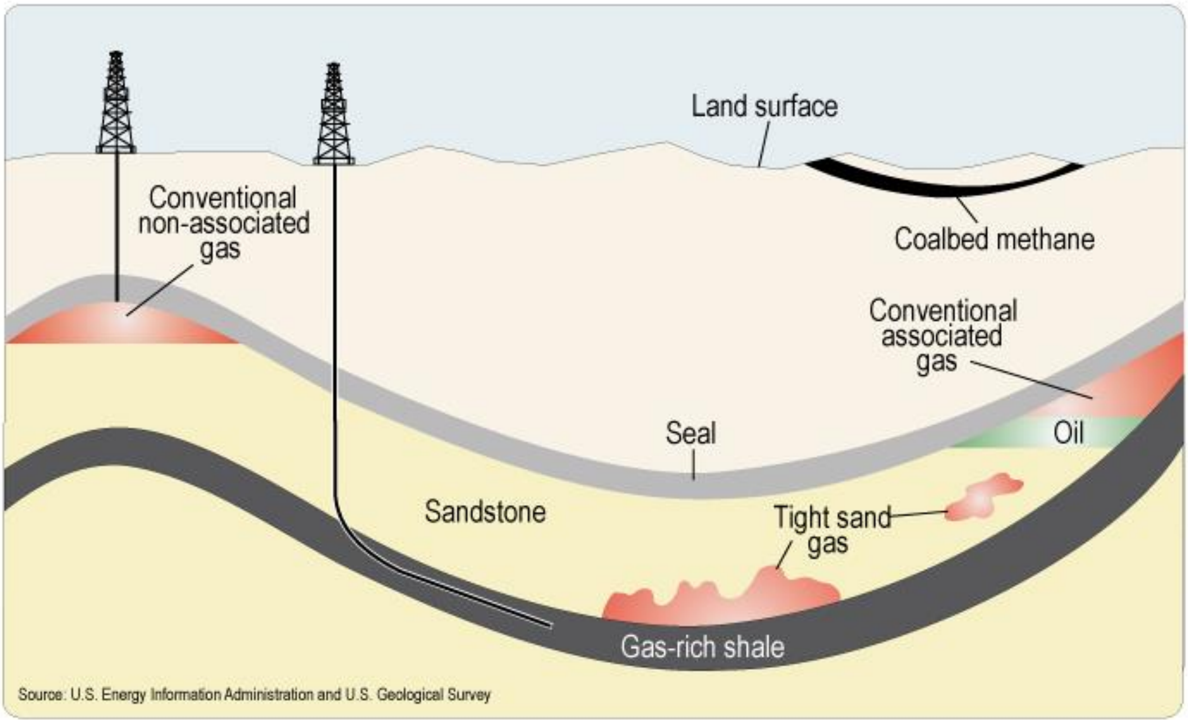
It is important to firstly distinguish between conventional and unconventional gas.

Conventional gas is commonly found in sandstone formations, between 400 – 1,000 metres below the ground level, trapped by an overlying impermeable rock formation (see Figure 1). The gas has migrated from very deep gas-rich shales over millions of years. Associated gas accumulates in conjunction with oil, while non-associated gas does not accumulate with oil.

Unconventional gas is gas trapped within low to very low permeability rock.

1. **Coal seam gas** does not migrate from shale, but is generated during the transformation of organic material to coal. Gas is naturally trapped within the coal by the pressure from water and absorption onto the coals carbon molecules. The coal seams targeted for CSG in Queensland and NSW are usually less than 1 km in depth.
2. **Tight sand gas** accumulations occur in a variety of geologic settings where gas migrates from a source rock into a sandstone formation, but is limited in its ability to migrate upward due to reduced permeability in the sandstone.
3. **Gas-rich shale** is the source rock for many natural gas resources, but until the last few years has not been a focus for production. Horizontal drilling and hydraulic fracturing have made shale gas an economically viable option. Shale is laminated; in other words made up of thin layers, and the gas is trapped within the organic material in these layers. The fracture stimulation produces fissures (or expands existing fine cracks), allowing trapped gas to flow through the induced pathways to the production well.

Figure 1:



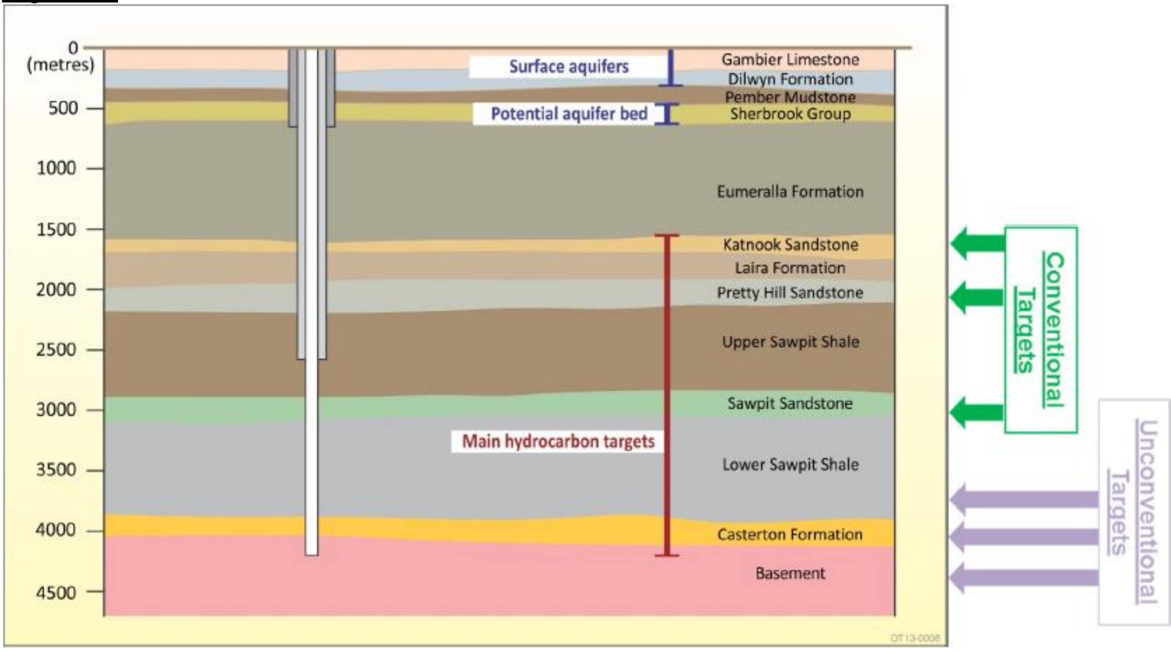
Source: US Energy Information Administration[1]

[1] US Energy Information Administration, http://www.eia.gov/todayinenergy/detail.cfm?id=110.

The use of the terminology "unconventional" is misleading as there is nothing 'unconventional' about the gas; it is methane (CH_4). It really refers to the geology from where the gas is extracted.

In South Australia, the primary unconventional targets are shale and deep coals. In the South-East the unconventional targets are between 3,000-4,000m below ground level and at least 2,500m below the aquifers (Figure 2).

Figure 2:



Source: Beach Energy

Hydraulic fracture stimulation is one part of the process of extracting gas or oil from unconventional reservoirs, and is also regularly used on a smaller scale for stimulating flow in conventional reservoirs. It does not define the entire petroleum production process. In Australia, leading industry practise follows a multi-stage hydraulic fracturing process[2]. A well is drilled to a pre-determined depth within the oil or gas bearing formation and lined by a series of steel casings that is cemented into the rock to isolate the hydrocarbon-bearing zone from any water bearing zones. Small holes are perforated through the steel and cement within the hydrocarbon bearing formation. The fracture stimulation fluid is then pumped into the well at high pressure in order to 'fracture' or 'stimulate' the geological formation. The size and type of fracture created is controlled by the rock strength and by the amount and pressure of the fluid that is pumped into the well. Fractures generated typically range in size from a few metres to several tens of metres. The hydraulic fracturing fluids are recovered and disposed of appropriately.

Hydraulic fracturing is not a new process, it was first used commercially in the US in 1949. In South Australia the process has been used since the 1970's.

In the same way that practices in agriculture, manufacturing and the automotive industry have advanced; well design and construction, hydraulic fracturing, monitoring, health and safety, and environmental impact and performance in petroleum exploration and production has been advanced by innovation and technology development.

[2] APPEA Submission to the Environment and Public Affairs Committee 'Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p14 & Attachment 1.

Linking the resources industry to practices and technology 50 years ago is akin to suggesting agricultural practices, and manufacturing and automotive technology (including chemical use and management) have not changed in the same time frame.

Background

Petroleum Production in South Australia has occurred since the 1960's when Santos commenced production in the Cooper Basin, Australia's largest and most important onshore petroleum basin. The Basin supplies gas to markets in South Australia, Queensland and NSW, and is a significant producer of oil and other petroleum liquids. The industry and the gas produced is a significant economic contributor to South Australia, supporting thousands of jobs (directly and indirectly), manufacturing, domestic consumption, electricity, export revenues and royalties.

Department of State Development (**"DSD"**) figures of the cumulative production from the Cooper Basin (estimated to end June 2012) underscores the importance of the industry to SA (Table 1).

Table 1:

Gas (sales) (since 1970)	5,363 PJ	922.0 mmboe	5.06 tcf
Oil (since 1983)	25,086,811 kL	157.8 mmbbl	
LPG (since 1984)	9,249,127 t	78.2 mmboe	
Condensate (since 1983)	13,066,364 kL	76.9 mmboe	
Royalties	**$2.58 bn** (2013/14 dollars)		

Since the 1970's over 700 wells have been hydraulically fractured in the Cooper Basin with no impacts on aquifers within the Great Artesian Basin and other shallow aquifers. In total approximately 2000 wells in conventional gas formations have been drilled in the Cooper Basin without incident.[3]

In the South Australian portion of the Otway Basin (South-East) approximately 130 petroleum exploration and production wells have been drilled since 1910 without incident. Data for petroleum production in the South-East of South Australia is in Table 2.

Table 2:

Gas (sales)	68.1 PJ	64.5 bcf
Condensate	60,775 kL	382,301 bbl
Royalties	**$11.77 million** (2013/14 dollars)	

The potential risks of recent drilling operations and past production operations in the South-East have been adequately addressed through the environmental assessment and approval process under the PaGE Act culminating in publicly disclosed EIR and SEO.

Internationally, over 1 million wells have been hydraulically fractured (for conventional and unconventional gas) in the past 60 years, with no confirmed evidence of drinking water contamination from the fracking process[4].

[3] Australian Council of Learned Academies (ACOLA), Engineering Energy: Unconventional Gas Production, Final Report, 2013, p124
[4] Halliburton submission to the Environment and Public Affairs Committee 'Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p7.

SA has industry best practice in petroleum exploration and production

The South Australian industry has an exemplary history of best practice in Australia. The fact that there has been no impact from petroleum activities in either the Cooper Basin or Otway Basin bears testament to combined high industry standards and effective risk based government regulation.

The EIR and SEO obligations under the PaGE Act require proponents to provide a comprehensive assessment all social and environmental impacts of a proposed activity, identify all risks and the management framework that will be put in place to avoid and minimise impacts. Each stage of the petroleum production process requires an SEO (i.e. exploration-seismic/geophysical surveys; exploration-drilling, completion and rehabilitation; hydraulic fracture stimulation operations; and well operation, decommissioning and rehabilitation). For detailed advice on the regulatory requirements and assessment of EIR and SEO, SACOME refers the committee to the DSD. SACOME fully supports the risk based approach to regulation of the industry.

Risks of groundwater contamination

The risk of ground water contamination from petroleum activities, including the use of hydraulic fracturing, is very low. International and national data demonstrates that by employing globally leading industry practice, risks of groundwater contamination can be effectively managed or avoided entirely.

The track record of the industry in South Australia speaks for itself. Petroleum exploration and production has had no impact on ground water quality. In terms of the use of hydraulic fracturing more specifically, the use of the process in the Cooper Basin has not impacted on Great Artesian Basin aquifers.

Well integrity

Ensuring that wells are constructed to standard is fundamental to eliminating the risk of groundwater contamination. In South Australia, strict standards apply to the construction of wells consistent with globally recognised best industry practice[5]. Wells designed and constructed to industry best practice have a very low risk of causing groundwater contamination.

Wells are designed with multiple layers of steel (casing) and cement (Figure 3), forming a physical barrier between the gas being extracted and the surrounding geology. Cement is fundamental in maintaining integrity throughout the life of the well and helps protect casing from potential corrosion. Because of the natural variability of formation geology, the chemical formulation of the cement is custom designed according to site specific conditions to ensure complete bonding with the bore wall and provide the physical barrier, as well as protect the casing from corrosion that could otherwise occur over time if exposed to formation fluids. The well is constantly monitored during its production life to ensure well integrity is maintained. At completion of a well's productive life (*i.e.* the reservoir has been depleted of gas), the well is plugged with cement to ensure all formations are isolated from each other. The cement ensures the well's integrity and maintains isolation from other zones.

In the exploration phase, geophysical and seismic surveys, and exploration well drilling is critical to understanding the geology of the environment and the formations of target zones and overlying structures. These inform the production potential of the target formations and the economics of extraction, but is also crucial for the design and construction of production

[5] Department of State Development, Unconventional Gas and Oil in the South East of South Australia, 2014, p6.

wells, casing requirements and cement formulations, and planning and design for any future hydraulic fracturing. To maintain the integrity of the well to protect the environment and maximising productivity.

Figure 3:

Source: Virginia Department of Mines, Minerals and Energy [6]

When discussing well integrity it is import to define well integrity failure. King and King (2013)[7] describe well integrity failure as when all barriers (*i.e.* all layers of casing and cement) fail and a leak is possible.

Numerous studies have investigated well integrity failure rate. A Canadian study found that following the implementation of stricter standards in 2000, less than 0.05% of wells failed[8]. Research from the United States found that failure rate is between 0.01 and 0.03%[9,10]. None of the identified incidents were a result of hydraulic fracturing. The US EPA investigating claims of drinking water contamination in Wyoming found no evidence of hydraulic fracture stimulation fluids contaminating drinking water[11]. The United States Geological Survey also analysed 127 groundwater samples from Arkansas in 2013 for effects of gas production activities, and concluded that there were no apparent effects on groundwater quality[12].

In the UK, an Energy and Climate Change Committee study found that provided the drilling well is properly constructed, hydraulic fracturing poses no direct risk to groundwater contamination[13].

King and King (2013) provides a comprehensive analysis of 600,000 wells worldwide on the environmental risk arising from well failure and confirms the results of the above studies, adding that the most common failures occurred in the gaskets or valves at the surface which are easily and quickly repaired.

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[6] Virginia Department of Mines, Minerals and Energy, http://www.dmme.virginia.gov/dgo/HydraulicFracturing.shtml.
[7] King, GE and King, DE, Environmental risk arising from well-construction failure – Differences between barrier and well failure, and estimates of failure frequency across common well types, locations and well age, Society of Petroleum Engineers, 2013.
[8] Royal Society and Royal Academy of Engineering, Shale Gas Extraction in the UK: a Review of Hydraulic Fracturing, 2012, p26. www.royalsociety.org/policy/projects/shale-gas-extraction and raeng.org.uk/shale.
[9] APPEA submission to the Environment and Public Affairs Committee 'Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p17.
[10] APPEA submission to the Environment and Public Affairs Committee 'Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, Attachment 4.
[11] Royal Society and Royal Academy of Engineering – Shale Gas Extraction in the UK: a Review of Hydraulic Fracturing,2012, p12. www.royalsociety.org/policy/projects/shale-gas-extraction and raeng.org.uk/shale.
[12] Halliburton submission to the Environment and Public Affairs Committee 'Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p8.
[13] House of Commons Library, Shale Gas and Fracking, Standard Note SN/SC/6073, 2014, p16.

Ongoing monitoring of the integrity of wells is performed using pressure testing and well logging instruments. Below is an extract from Beach Energy's EIR for well construction and fracture stimulation of the Nappamerri Trough in the Cooper Basin summarising the standard operation monitoring in place to manage well integrity. The EIR and subsequent SEO provides further detailed information on the safety protocols to be implemented in the event that well integrity is compromised.

> The risk (of loss of well integrity) is reduced to as low as possible in the well design process and managed through operational monitoring during each step in the process. In particular:
>
> - The well design and construction provides the mechanical integrity that reduces this risk to as low as possible
> - Pressure testing confirms that production casing meets designed pressure specification
> - Cement bond logs confirm the integrity of cement that fills the casing-wellbore space and prevents migration
> - Pressure safety trip out systems during the fracture stimulation prevent pressure limits of the surface pipework and downhole casing equipment being exceeded
> - Pressure monitoring during the fracture stimulation provides confirmation that the stimulation has not resulted in a well integrity issue
> - Installation of a tubing string, after stimulation, provides further isolation of production fluids from aquifers.
>
> Beach Energy: Environment Impact Report - Fracture Stimulation of Deep Shale Gas and Tight Gas Targets in the Nappamerri Trough (Cooper Basin), South Australia, p58. July 2012.

Migration of hydraulic fracturing fluids

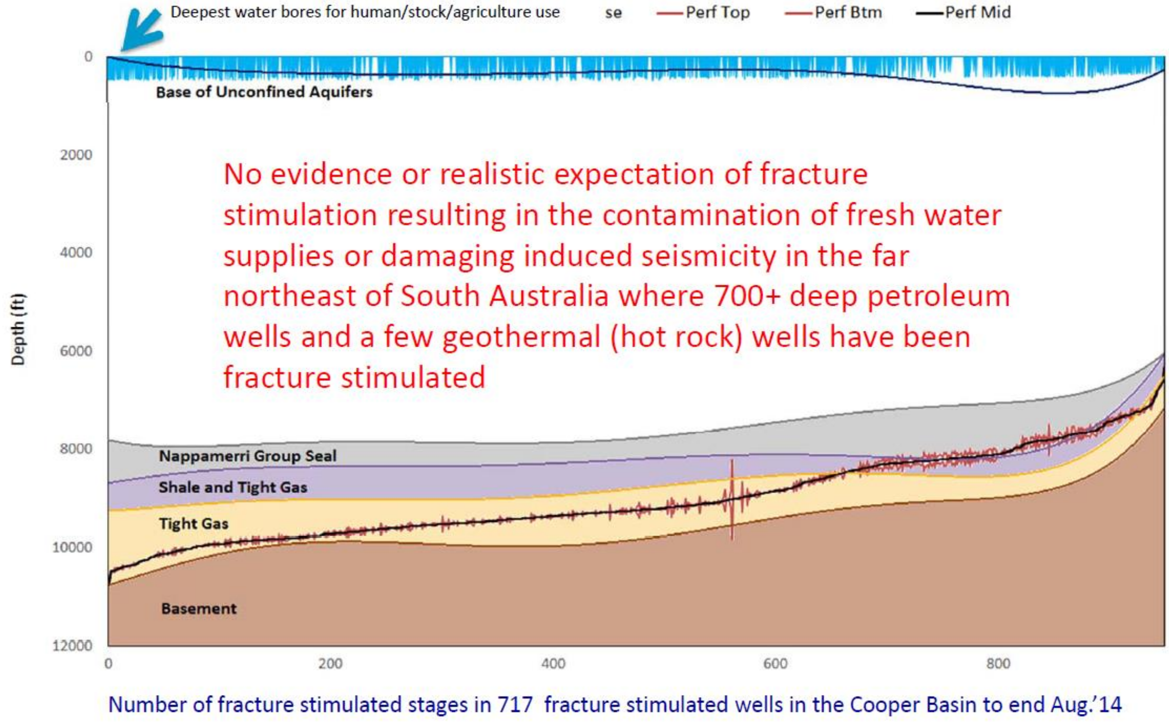
There is community concern relating to the risk of migration – of gas or other fluids - through naturally occurring cracks or fissures created by induced stimulations from the hydrocarbon zones to intersect with aquifers.

The deep shale reservoirs targeted in the South-East are at depths greater than 3,000 metres below ground level, and not in the immediate vicinity of important groundwater aquifers (0-600m from surface).

Industry has at its disposal various technologies to manage the extent of induced fractures and minimise the possibility of migration of natural gas or hydraulic fracture fluids into groundwater. High resolution 3D seismic is used to map locations where fault risks may exist (and avoiding these locations), using micro seismic sensing to map the real-time vertical growth of fracture stimulation treatments and monitoring downhole pressure; stopping hydraulic fracturing if unwarranted fracture growth is observed. Geomechanical modelling is also a useful mitigation tool in predicting the susceptibility of different fault orientations to transmit fluids.

Figure 4 illustrates the separation of hydraulic fracture stimulation from aquifers of hundreds of deep petroleum wells in the Cooper Basin demonstrating that fractures induced by hydraulic fracture stimulation are confined to the target zone and do not extend anywhere near aquifer zones.

Figure 4:



Source: Department of State Development[14]

At the depths where hydraulic fracturing would be conducted, natural geological barriers provide an effective constraint on the distances that fractures may propagate vertically[15], impeding any migration of natural gas and hydraulic fracturing fluids. A 2013 Halliburton commissioned study by Gradient Corporation, one of the world's leading environmental and risk science firms, examined various shales, concluding that the migration of fracturing fluids from the Marcellus shale to an overlying groundwater aquifer is "an implausible contamination pathway" [16].

Gradient Corporation also recently prepared two peer-reviewed journal articles on the lack of risk to groundwater. The first concludes that upward migration of hydraulic fracturing fluid and brine as a result of hydraulic fracturing activity does not appear to be physically possible[17]. The second concludes that it is not physically plausible for induced fractures to create a hydraulic connection between tight formations at depth and overlying drinking water aquifers[18].

The report by the Australian Council of Learned Academies ("**ACOLA**") adds that it is difficult to propagate a fracture further than a few tens of metres, other than where a transmissive fault is intersected[19]. But these can be identified and avoided.

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[14] Barry Goldstein, New York Energy Forum, 22 September 2014, http://petroleum.dmitre.sa.gov.au/__data/assets/pdf_file/0020/225056/New_York_Sept_2014.pdf

[15] Royal Society and Royal Academy of Engineering, Shale Gas Extraction in the UK: a Review of Hydraulic Fracturing, 2012, p4. www.royalsociety.org/policy/projects/shale-gas-extraction and raeng.org.uk/shale.

[16] Halliburton submission to the Environment and Public Affairs Committee 'Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p8.

[17] Flewelling, SA & Sharma, M, 2014, Constraints on upward migration of hydraulic fracturing fluid and brine, *Groundwater*, 52: 9-19.

[18] Flewelling, SA, Tymchak, MP & Waroinski, N, 2013, Hydraulic fracture height limits and fault interactions in tight oil and gas formations, *Geophysical Research Letter*, 40: 3602-3606

[19] ACOLA, Engineering Energy: Unconventional Gas Production, Final Report, 2013, p125.

Impacts upon Landscape

Advances in technology and innovation have resulted in significant reductions in the impact upon the landscape from petroleum activity.

Water use

Water resources for petroleum exploration and production and other extractive activities (e.g. irrigation) are regulated through the *Natural Resources Management* ("**NRM"**) *Act 2004* and subject to provisions within the relevant regional NRM plans and Water Allocation Plans. Where petroleum activity has historically existed, and future development would proceed in the South-East, the groundwater has been prescribed (Lower Limestone Coast Prescribed Wells Area, "**LLCPWA"**). Prescribed water resources and the associated water allocation plans require licencing for water taking activities. Unless separately authorised or exempted petroleum activity requires a water licence which is authorised through the Department of Environment, Water and Natural Resources.

An exploration well has a 'one-off' requirement of 1 to 2 megalitres (**"ML"**) of water, which is deemed as not large when viewed in context with other industrial, agricultural and commercial water uses[20]. There is no need for ongoing water use and as a result, no ongoing water disposal issues.

The fracture stimulation of wells can use up to 20ML of water per well, depending on the number of stages. A vertical well can have up to 10 stages and a horizontal well up to 30 stages[21].

Although no fracture stimulation has been proposed for the South-East, should development of unconventional gas proceed, it is likely that the number of wells drilled will be minimal; with water usage in the order of a few 100 ML, which based on figures from Primary Industries and Regions South Australia (**"PIRSA"**)[22] would only be a very small fraction of the groundwater taken for irrigation (128,391ML in 2010-11) in the LLCPWA.

The PIRSA Report further indicates that there is water available (unused allocations) in the region that can provide extensive opportunities for increased water use within sustainable limits. Actual average demand between 2006 and 2011 was approximately 384 GL or 34% of the indicative allocation available as at 2010-11 for use each year (1,119 GL). This demonstrates capacity within unused allocations to be traded to new or higher uses from entitlement holders via a trade market.

Within the management area of the Coonawarra (Zone 3A) greater than 50% of allocated water is unused based on 2006-2011 average usage.

Within the Cooper Basin, co-produced water from adjacent oil and gas production wells is re-used to reduce the amount of bore water required for hydraulic fracture stimulation[23]. In addition, companies are proactively pursuing sources of water not suitable for human or agricultural consumption for use in drilling and fracture stimulation operations (Otway Bain included).

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[20] IESC, Background Review: Hydraulic Fracturing ('fraccing') techniques, including reporting requirements and governance arrangements, 2014, p8.Federal Department of the Environment.

[21] Santos presentation, SACOME Breakfast Briefing, 23 October 2013. http://www.sacome.org.au/images/0747_Colin_Cruickshank_Santos_-_Well_Construction_-_Fracture_Stimulation_Overview_2014_-_SACOME_-_Oct_2017474.pdf.

[22] Primary Industries and Regions SA, November 2013, http://www.pir.sa.gov.au/__data/assets/pdf_file/0019/214057/03_Water_resources_of_the_Limestone_Coast.pdf.

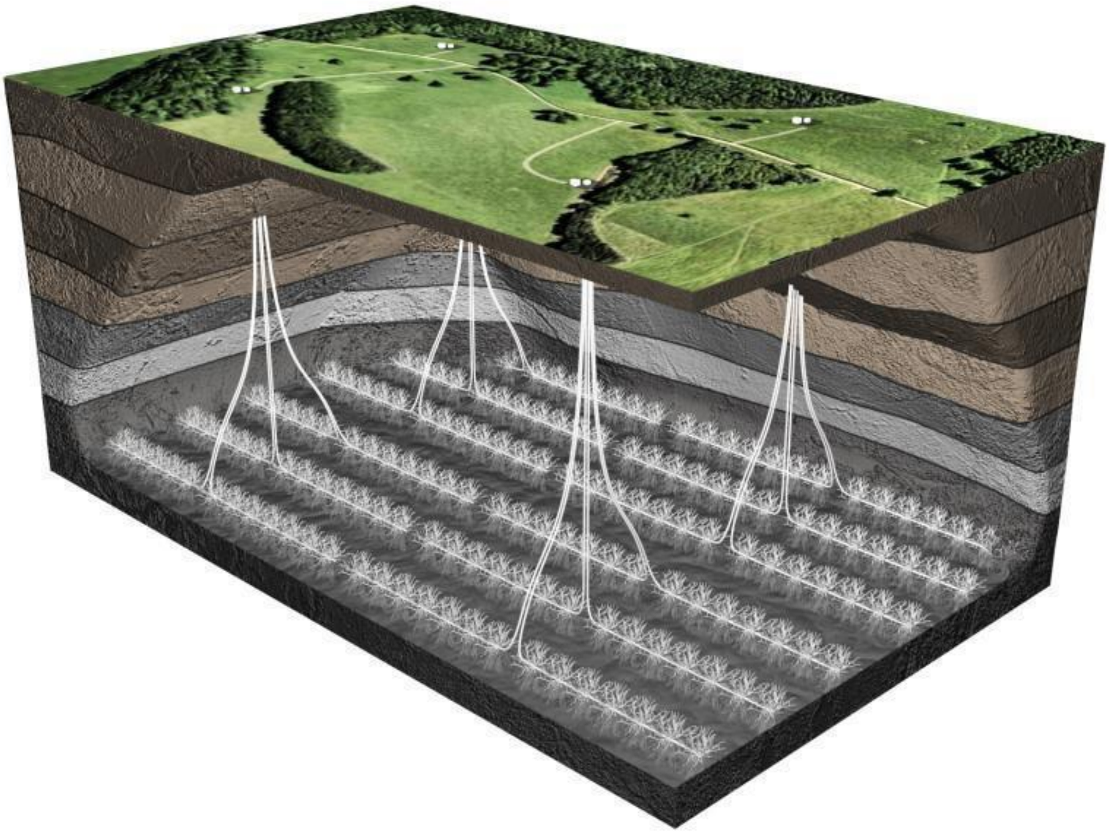
[23] Santos submission to the Environment and Public Affairs Committee 'Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p10.

Surface footprint

SACOME is frustrated by the continued propagation of incorrect information suggesting thousands of petroleum production wells will be drilled to extract gas in the South-East. The number of wells required will depend on the size of the resource and the economics of the flow rate. In addition, the naturally higher pressure at the depths where the gas bearing shale exists has relevance on well number.

Innovation in drilling technology has reduced the surface footprint of petroleum activities. Directional drilling technology, where well construction can move from the vertical to the horizontal, and multi-well pad drill rigs means rather than drilling multiple single wells, four to eight wells can be drilled from a central pad each radiating in different directions (horizontal) to access a greater area of shale whilst significantly reducing the surface footprint (Figure 5). Length of well within target zones from horizontal drilling can be from several hundred metres to over 1,000m[24]. Based on this, and depending on the resource, distance between multi-well pads could be between 1,000 and 2,000m.

Figure 5:



Source: Statoil[25]

The International Gas Union[26] found that the surface footprint from a four-well horizontal well pad would be ten times less than drilling 16 vertical wells (0.03 square kilometres compared to 0.3 square kilometres respectively). In the Cooper Basin, multi-well pad development has resulted in a 55% reduction in surface disturbance compared to single well pads[27]. The

[24] Beach Energy, Environmental Impact Statement, Drilling, completion and initial production testing in the Otway Basin, South Australia, November 2013.
[25] 'Statoil strengthens US shale gas position', Statoil (2010), http://www.statoil.com/en/newsandmedia/news/2010/pages/26marmarcellus.aspx
[26] International Gas Union, Shale Gas: The facts about the Environmental Concerns, p24.
[27] Santos submission to the Environment and Public Affairs Committee 'Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p10.

additional advantage of multi-well pads and horizontal drilling over single horizontal wells is the flexibility in the siting of well pads.

A pad containing between four and eight wells would normally cover a similar surface area as a standard house block after rehabilitation. The level of land disturbance associated with horizontal well pads is also expected to be lower than disturbances associated with agriculture or urban development.

The surface footprint of low-permeability rock oil and gas extraction is generally relatively small and temporary in nature. The exception to this is access roads and occasional infrastructure. Wells are normally of an area of 1.5 ha or less for up to one year during construction, and then decrease to approximately 25x25m for their productive life of 20-30 years[28].

The largest impact on existing land use is during well construction (temporary), while during the production phase the amount of land unavailable for other land uses is minimal. However during all stages of development and production existing land use is able to continue on surrounding land.

The only visible structure following completion of the well is a two metre tall ‘Christmas Tree’ type well head which controls gas production. Companies exhibiting best practise make every reasonable attempt to ensure that surface facilities are not visible from public roads and infrastructure corridors are made in discussions with landholders.

Well decommissioning and abandonment are leading practice in South Australia and tightly regulated. Modern practices include removing surface facilities, filling the well with cement and capping it at the surface. The natural pressure of the surrounding rock also provides an effective mechanism to seal around the cement casing over long periods of time. The well pad and surrounding land (including tracks and any structures) are rehabilitated back to the former land use (if appropriate) in consultation with the landholder. Effectively no surface impact remains[29].

Seismicity

Seismic risks associated with hydraulic fracturing are low, and have a realistic upper limit of 3-4ML on the Richter scale. A seismic event of 3ML is said to be felt by a few people and would result in negligible, if any surface impacts.[30] Because hydraulic fracture stimulation occurs at great depths, surface impacts are reduced considerably as the vibrations have almost entirely dissipated by the time they reach the surface. Shale is a relatively soft rock, and attenuates seismic wave’s more than hard rocks, resulting in far smaller surface vibrations.

In the United Kingdom, hydraulic fracture stimulation operations in Caudrill caused a seismic of approximately 2.0 on the Richter scale. This event did not result in any surface damage.[31]

Larger seismic events may result from a pre-stressed fault, but this would be a rare occurrence. As discussed in the section on ‘mitigation’, it is standard practice in Australia for companies to undertake extensive surveys (including 3D seismic) to fully understand the environment before commencing hydraulic fracture stimulation activities.[32]

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[28] Santos submission to the Environment and Public Affairs Committee ‘Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p9.
[29] Santos submission to the Environment and Public Affairs Committee ‘Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p9.
[30] Royal Society and Royal Academy of Engineering, Shale Gas Extraction in the UK: a Review of Hydraulic Fracturing, 2012, p4. www.royalsociety.org/policy/projects/shale-gas-extraction and raeng.org.uk/shale.
[31] WA CME submission to the Environment and Public Affairs Committee ‘Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p18.
[32] APPEA Submission to the Environment and Public Affairs Committee ‘Inquiry into the Implications for WA of Hydraulic Fracturing for Unconventional Gas, 2014, p17.

It should be noted that seismicity is not a risk unique to hydraulic fracture stimulation, coal mining, large dams, mining operations and geothermal operations also have the potential to induce small seismic activities.

Soil and land contamination due to surface spills

Companies purporting to conduct petroleum activities (including the use of hydraulic fracture stimulation) in South Australia must address any potential contamination of land or soil resulting from surface spills in their SEO as required under the *Petroleum and Geothermal Energy Act 2000*. Fluids recovered during the well construction phase and hydraulic fracturing stages are contained in waste storage facilities, either lined dams or above ground storage tanks. The waste fluids can be re-used or disposed through approved facilities. The storage and disposal of waste fluids is appropriately regulated by the *Environment Protection Act 1993*.

Health Impacts

Studies in the USA on birth outcomes in the proximity of gas development relied upon by some states to introduce moratoriums on hydraulic fracturing do not provide evidence of causation, admit to limitations in the nature of the available data and recognise that other potential contributing factors such as maternal socioeconomic status, health, nutrition, prenatal care and pregnancy complications which were not assessed may have influence on results[33].

As with other aspects discussed in this submission, risk to public health can be effectively managed with good regulation and use of industry leading standards and practice in all aspects of petroleum development.

Potential health impacts to workers and the community is addressed through the SEO process, which must attend requirements of the *Work, Health and Safety Act 2012*. A study released in the UK by the Public health England concluded that any such risks are manageable through proven well construction and fracture stimulation design, good on-site management and appropriate monitoring[34].

Carbon footprint/ greenhouse gas emissions

Greenhouse gas emissions from the extraction and use of shale gas is equivalent to conventional gas and lower than the emissions profile of liquefied natural gas (LNG). When used to generate electricity, the carbon footprint of shale gas is significantly lower than carbon footprint of coal[35]. Natural gas has the lowest carbon emissions content per unit of energy of all fossil fuels, and is therefore considered the cleanest source of energy available at this time after renewables.

In the United States, shale gas production has resulted in significant reductions in greenhouse gas production. This reduction can be predominantly attributed to the fact that less coal is being burnt to generate electricity. US carbon emissions are said to have fallen by 9% since 2005, reversing a strong upwards trend, the US EPA attributes almost half of this reduction to the extraction of shale gas[36]. This conclusion has also been confirmed by a

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33 McKenzie, LM, Guo, R, Witter, RZ, Savitz, DA, Newman, LS and Adgate, JL, Birth outcomes and maternal residential proximity to natural gas development in rural Colorado, *Environmental Health Perspectives*, 122: 412-417.

34 Public Health England, www.gov.uk/government/news/shale-gas-extraction-emissions-are-a-low-risk-to-public-health.

35 Department of State Development, Unconventional Gas and Oil in the South East of South Australia, 2014, p15

36 Brooks, M, Frack on or frack off: Can shale gas save the planet?, *New Scientist*, 10 August 2013 pp.36 – 41.

recent study conducted by the UK Department of Energy and Climate Change[37], and the recent report by ACOLA[38].

The effectiveness of existing legislation and regulation

Mining and petroleum as economic activities are subject to the need to meet more regulatory requirements than most, if not all, other economic activities.[39]

Commonwealth

At the commonwealth level, the EPBC Act provides a legal framework to protect and manage impacts upon matters of national environmental significance. Under the EPBC Act, the Australian Government has established the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development ("**IESC**"). The IESC is a statutory body that provides advice to the Commonwealth and state governments on Coal Seam Gas and Large Coal Mining impacts on our water resources. South Australia is party to a National Partnership Agreement on Coal Seam Gas and Large Coal Mining, which is a joint initiative between the Commonwealth government and participating states (SA, NSW, VIC and QLD). This joint initiative strengthens the regulation of Coal Seam Gas and Large Coal Mining developments.

South Australia

In South Australia, oil and gas exploration and production activities are regulated under the PaGE Act and associated regulations. All activities regulated under the PaGE Act are also subject to the provisions of other state environmental regulation such as the *National Parks and Wildlife Act 1972*; the *Natural Resources Management Act* 2004; the *Work, Health and Safety Act 2012*; the *Native Vegetation Act 1991*; *Aboriginal Heritage Act 1998*; *Development Act 1993* (where it applies); *Marine Park Act 2007* (where it applies) and the *Environment Protection Act 1993*. It is a requirement under the PaGE Act that companies purporting to undertake hydraulic fracture stimulation activities undertake a full environmental assessment detailed in the publicly disclosed Environmental Impact Report and approved Statement of Environmental Objectives.

The Department of State Development's Energy Resources Division is the lead agency in the regulation of the petroleum industry under the PaGE Act. Approvals and compliance monitoring of regulated activities includes departments and agencies that administer other relevant pieces of legislation in the regulation of the industry.

As already discussed in this submission, the EIR and SEO processes are fundamental in complying with regulatory requirements. It exhaustively addresses all social and environmental aspects of a proposed activity including impacts on communities, well integrity, requirement for background sampling and analysis of aquifers prior to commencement of drilling activities, and requires regular ongoing sampling to ensure no contamination occurs. The EIR and SEO are appropriately risk based. SACOME fully supports the risk based approach to regulation of the industry.

All potentially affected stakeholders have the right under the EIR and the SEO to raise any issues and concerns well ahead of land access. Companies seeking to undertake hydraulic fracture stimulation must issue a notice of entry to land which also provides land owners further opportunity to negotiate appropriate land access agreements.

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[37] Department of Environment & Climate Change, Potential greenhouse gas emissions associated with shale gas extraction and use, September 2013.
[38] ACOLA, Engineering Energy: Unconventional Gas Production, Final Report, 2013.
[39] URS, Update of National Audit of regulations influencing mining exploration and project approval processes, Final Report, 2013, p182. Minerals Council of Australia.

The whole of government framework for managing the approvals and compliance processes of the resources industry in SA delivers a robust and comprehensive system to manage all impacts, and is recognised as the standout regime for regulation of the industry in Australia.

This has been re-enforced by a URS Report in 2013 which compared the strengths and weaknesses within different Australian jurisdictions in their mining approval and compliance processes. On aggregate score, South Australia scored highest compared to all of the other states and territories, particularly in areas of regulatory administration and compliance[40]. Areas assessed included: clarity of process, timeliness, compliance cost, capability, certainty and effectiveness. While there is always room for continuous improvement, the environmental safeguards in the South Australian legislative framework are effective and appropriate.

The most recent Fraser Institute 'Global Petroleum Survey' reported that South Australia is the most attractive jurisdiction for investment in Australia. In spite of Australia generally "being regarded as a much less attractive region for investment than it was as recently as three or four years ago", South Australia continues to rank in the second quartile of favourable jurisdictions worldwide[41].

Net outcomes to region and rest of state

Economic Benefits

Because the recovery of shale gas in Australia is relatively new, there is little to no historical data enabling SACOME to accurately estimate the economic benefit to the region and the rest of South Australia. Internationally, benefits from unconventional gas development have seen increases and improvement in industry development, employment, infrastructure development, royalty and security of energy supply.

Petroleum production in the South-East of South Australia has a successful history. The recovery of conventional gas in the Katnook gas fields (located in the South-East) over a 30 year period resulted in $163.3 million from gas sales and $17.9 million from total condensate sales. The total royalty paid to the State of South Australia was $11.77 million.

In the United States of America the development of unconventional gas has resulted in a number of key benefits to the region. Studies conducted by the IHS (a private US company) from 2009 to 2012 have revealed that the unconventional gas and oil activity was supporting 2.1 million jobs across a vast supply chain; about 1.3 million of these jobs are specific to shale gas activity, and is set to increase to 1.8 million by 2020[42].

In 2012, the revolution in oil and gas in the US added $74 billion to federal and state government revenues, and is set to increase to around $125 billion by 2020. In the same year, developments in unconventional natural gas contributed an increase of $1,200 to household disposable income. This is projected to increase to $2,700 by 2020. This increase is largely attributed to savings on utilities and lower costs for goods and services.

Australia generally has a higher costs associated with extracting shale gas than countries such as the United States and the United Kingdom, which makes determining the extent of the economic benefit of unconventional gas difficult to determine.

The development of gas in the South-East has contributed to industrial development, creation of jobs, diversification of the local economy and population stability.

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[40] URS, Update of National Audit of regulations influencing mining exploration and project approval processes, Final Report, 2013. Minerals Council of Australia.
[41] Fraser Institute, Global Petroleum Survey 2014, P52.
[42] http://press.ihs.com/press-release/energy-power/daniel-yergin-congressional-testimony-joint-economic-committee-united-sta.

The gas pipeline network in Katnook supplied gas to the Ladbroke Grove and Snuggery Power Plants, Safries Chip Factory, Kimberley-Clark paper mill and the town of Mt Gambier with gas, contributing to their prosperity. The SEAGas pipeline now delivers these facilities with gas from the Otway Basin. The past and future prosperity of the operation of these facilities is attributed heavily to the supply of natural gas.

As already cited the Fraser Institute has South Australia as the most attractive jurisdiction for investment in Australia. This has been built on this state's consistent and risk based policy and regulatory settings, and the potential of the resources. However this could be undone through poorly constructed changes to policy and regulation based on reactions to misleading and populist agendas. This would have serious negative economic implications for a very important industry to the South Australian economy.

Energy Security

South Australia's electricity supply is dominated by gas-fired power generation (45% of electricity generation, 2013/14) and many industries and households are reliant on gas as a primary source of energy.

Energy security in Australia is of fundamental importance and can be undermined by poor government policy based on kneejerk reaction to ill-informed community pressure. New South Wales is a case in point. New South Wales currently domestically imports 95% of gas requirement. A large majority of current domestic gas contracts that supply New South Wales with natural gas are due to mature, resulting in a gas supply cliff in NSW[43]. This coupled with lower than forecast flow rates from wells within Queensland's coal seam gas projects; uncertain CSG policy, such as the federal industry specific water trigger, moratoriums on CSG development and the two kilometre exclusion zone; and rising production costs as conventional gas reserves become increasingly depleted has created serious doubts regarding NSW's future energy security.

The Fraser Institute 'Global Petroleum Survey 2014' is less than complimentary of NSW highlighting the very low confidence of industry in doing business in that state in terms of policy perception, commercial environment, regulatory environment and potential for improvement[44].

The NSW experience creates an opportunity for South Australia to potentially supply this demand, but also a lesson to ensure policies and regulation maintain certainty to invest in gas development, to ensure self-sufficiency; otherwise SA could well suffer the same consequences.

For the South-East more specifically, a local supply of gas to feed the Ladbroke Grove and Snuggery Power Plants would ensure power security and reliability within the region.

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[43] Simshauser, P and Nelson T, Solving for 'x' – the New South Wales Gas Supply Cliff, AGL Applied Economics and Policy Research, Working Paper No.40, p1.
[44] Fraser Institute, Global Petroleum Survey 2014.