South Australian Chamber of Mines & Energy

Well integrity & hydraulic fracturing

Onshore gas production has been taking place in Australia since 1960's, with the development of the Cooper Basin.

Together with the onshore Otway Basin (1980's), South Australia has been a significant supplier of natural gas for Australian industry and households for 50 years. Innovation and technology has allowed development of resources that in the past were uneconomical.

Hydraulic fracturing is a well-developed technology that is essential to our energy industries. It has been used in the United States since the 1940s and in Australia since the 1970s.

Along with the development of horizontal (directional) drilling, these technologies have increased the drainage area from a well, meaning fewer wells need to be drilled to produce the same resource; reducing the environmental footprint of production. Directional drilling technology allows wells to be drilled for several hundred metres along the length of a gas bearing formation, maximising the exposure of its surface area to the well.

The application of hydraulic fracturing is not limit to gas production. Fracture stimulation is also an essential process to unlocking geothermal energy contained within deep granite formations (4000 metres below the surface) with temperatures exceeding 200°C. The captured heat energy is transformed to high pressure steam to drive standard turbines coupled to generators.

What is fracture stimulation and why is it necessary?

Hydraulic fracturing (or 'fracture stimulation') is the process of injecting highly pressurised fluid into a drilled well in order to 'fracture' or 'stimulate' an underground geological formation containing oil and/or gas; and is necessary for the production of some low-productivity oil and gas reservoirs, shale gas and shale oil.

The process opens up existing natural fractures, as well as creating new fissures to allow trapped hydrocarbons[1] to flow to wells and be extracted.

[1] *Any organic compound containing only carbon and hydrogen, e.g. methane (natural gas), oil.*

How is it done?

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 into 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.

Once fractured, the formation will release the product for extraction through the well.

What is the difference between shale and CSG?

Shale is a fine-grained rock found in geological formations within sedimentary basins. Shale that contains organic material is the source rock for oil & gas.

Over millions of years, some of the oil & gas naturally migrates upwards from the shale and becomes trapped in sandstone reservoirs by impermeable rock layers (see diagram). This oil & gas is what has been developed in the Cooper Basin for 50 year's using conventional production methods. However much of the gas is still trapped within the deep shale, and reserves are expected to be several times the cumulative production to date from the Cooper Basins conventional reservoirs.

The depth of most of the Cooper Basins reservoirs is between 1000 and 4500 metres ***(Figure 1).***

Coal seam gas (CSG) is natural gas (mostly methane) found within coal seams. The coal seams targeted for CSG in Queensland and NSW are usually less than 1 km in depth. Gas is naturally trapped within the coal by the pressure from water and absorption onto the coals carbon molecules.

CSG wells usually requires de-watering, which reduces the pressure and allows gas to flow to the well. Less than 40% of Australia's CSG wells require fracture stimulation to aid production of gas.

CSG in South Australia is deep and typically does not require de-watering, however the majority of South Australia's gas resources are in the shales, not coal seams. Gas bearing shale formation usually requires fracture stimulation for extraction.

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.

Why are chemicals used in fracturing fluid?

Between 97 to 99 per cent of fracturing fluid is comprised of water and sand. The remaining 1 to 3 per cent is added chemicals, including:

- Thickening agents such as Guar Gum (a natural product from a tree grown mostly in Asia) which is used to create a gel with the water to provide a viscous solution in which to transport the sand through the fractures.
- Sand (quartz sand) is deposited into the fractures to prop them open to preserve a pathway for the gas to flow through back to the well. Without the sand the pressure at depth would eventually force the manufactured fracture system to close.
- Bactericides such as sodium hypochlorite (pool chlorine) and sodium hydroxide (used in soap) to prevent contamination of gas from bacteria that is usually present in formation water.
- 'Breakers' such as ammonium persulphate (hair bleach) to dissolve fracturing gels once in the fracture.
- Acids and alkalis, such as acetic acid (vinegar) and sodium bicarbonate (washing soda) to control the acid balance of the fracture stimulation fluid.

As fracture stimulation technology has improved over the years, additives have become much cleaner and safer. The chemicals used in the fracture stimulation process are all found in common household items such as cleaning products or soaps, which humans come into regular contact with. This does not mean they are all harmless, but with appropriate controls they can be managed.

Good well design, construction and maintenance reduces any risk of cross flow of fracture stimulation fluid between the stimulated reservoir and aquifers. This is a strictly monitored, tested and reported activity.

What happens to the fracture stimulation fluid?

The bulk of the fracture stimulation fluid returns to the surface where it is contained in tanks or lined storage dams for evaporation.

Wherever possible, the recovered fluid is treated and recycled for further fracturing or taken off-site for storage and further treatment. A very small amount of fluid will remain in the geological formations in a heavily diluted form and will degrade over time.

How is groundwater protected?

Fracture stimulation occurs within a specifically targeted geological formation, hundreds of meters below groundwater aquifers.

During the fracture stimulation process, the fluid and water from the geological formation travels within the well back to the surface. The well is physically separated from all groundwater and beneficial aquifers by a series of high integrity steel pipe casing and cement (***Figure 2*****).**

A wide range of geophysical techniques, including surveying, and modelling and imaging, are used to characterise the separation of geological formations and associated aquifers. These assist in the identification and strict avoidance of fracture stimulation operations that could have potential to cause interference with surrounding aquifers.

Monitoring methods provide quality control on the fracture design and fracture growth, to ensure fractures extend only in the target geological formations.

Well Integrity

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 a 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, 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.

The completion procedures comply with all Australian regulations.

How much water is used in fracture stimulation?

The process of fracture stimulation generally uses between 0.1 and 10 megalitres of water for each specific well.

How is fracture stimulation regulated?

Oil, gas and geothermal ventures are regulated under the South Australian *Petroleum and Geothermal Energy Act 2000*. An Environmental Impact report (EIR) and Statement of Environmental Objectives (SEO) must be submitted and approved by the regulator (DMITRE) before project development is authorised to proceed. These documents detail all aspects of the project, likely impacts and measures (risk management) in place to avoid or minimise these impacts. The reports also detail the design, construction and abandonment of wells and the fracture stimulation program to demonstrate engineering and protocols will maintain aquifer integrity, prevent cross contamination of aquifers and that the fracture stimulation will not propagate beyond target zones.

Typical compliance requirements for the fracture stimulation process also include:

- Specific fracture stimulation simulation conditions
- Source water sampling and reporting prior to and post fracture stimulation
- Fracture stimulation fluid testing and reporting
- Compliance with South Australian and Commonwealth Government standards on restriction of the use of chemicals in fracture stimulation fluid.
- Transparent listings of chemicals used and the amount of water used in the fracture stimulation process.

In addition, where applicable, a petroleum project is also subject to assessment and approval under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*, where the project proponent must demonstrate that activities will not adversely affect water resources.

Where in SA is shale gas being explored?

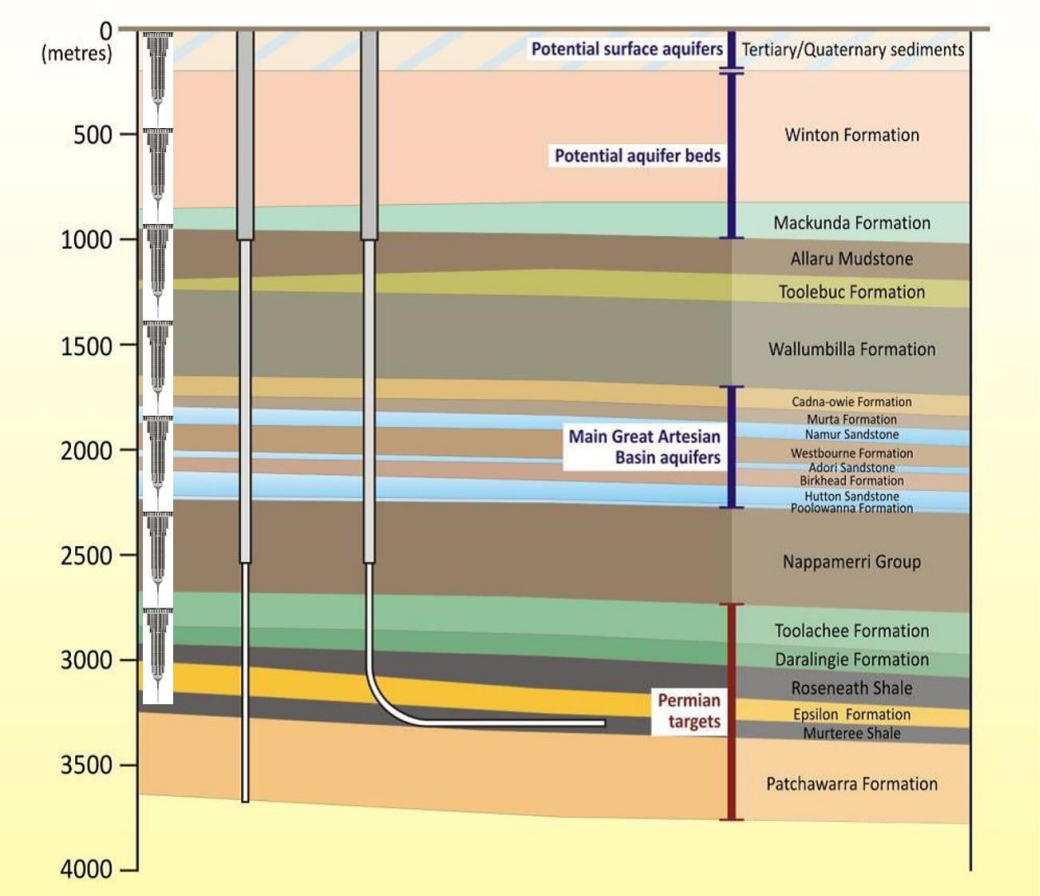
Cooper Basin

- Gas has been produced in the Copper Basin since the 1960's
- Australia's first production of gas from shale formations began in 2012 at the Moomba-191 well
- Shale gas potential is 15 times the cumulative production from the basin's conventional reservoirs since 1963

Otway Basin (SE)

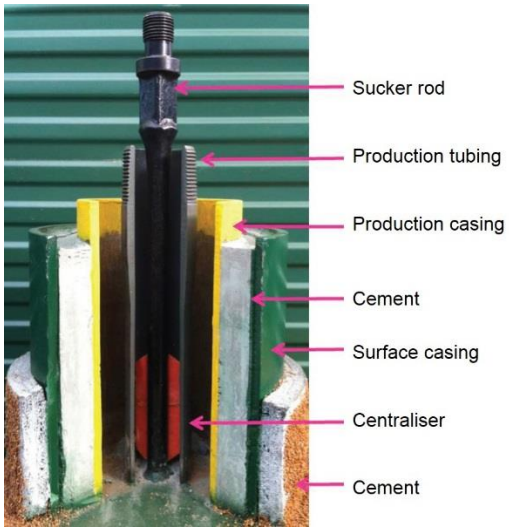
- Gas production since the 1987

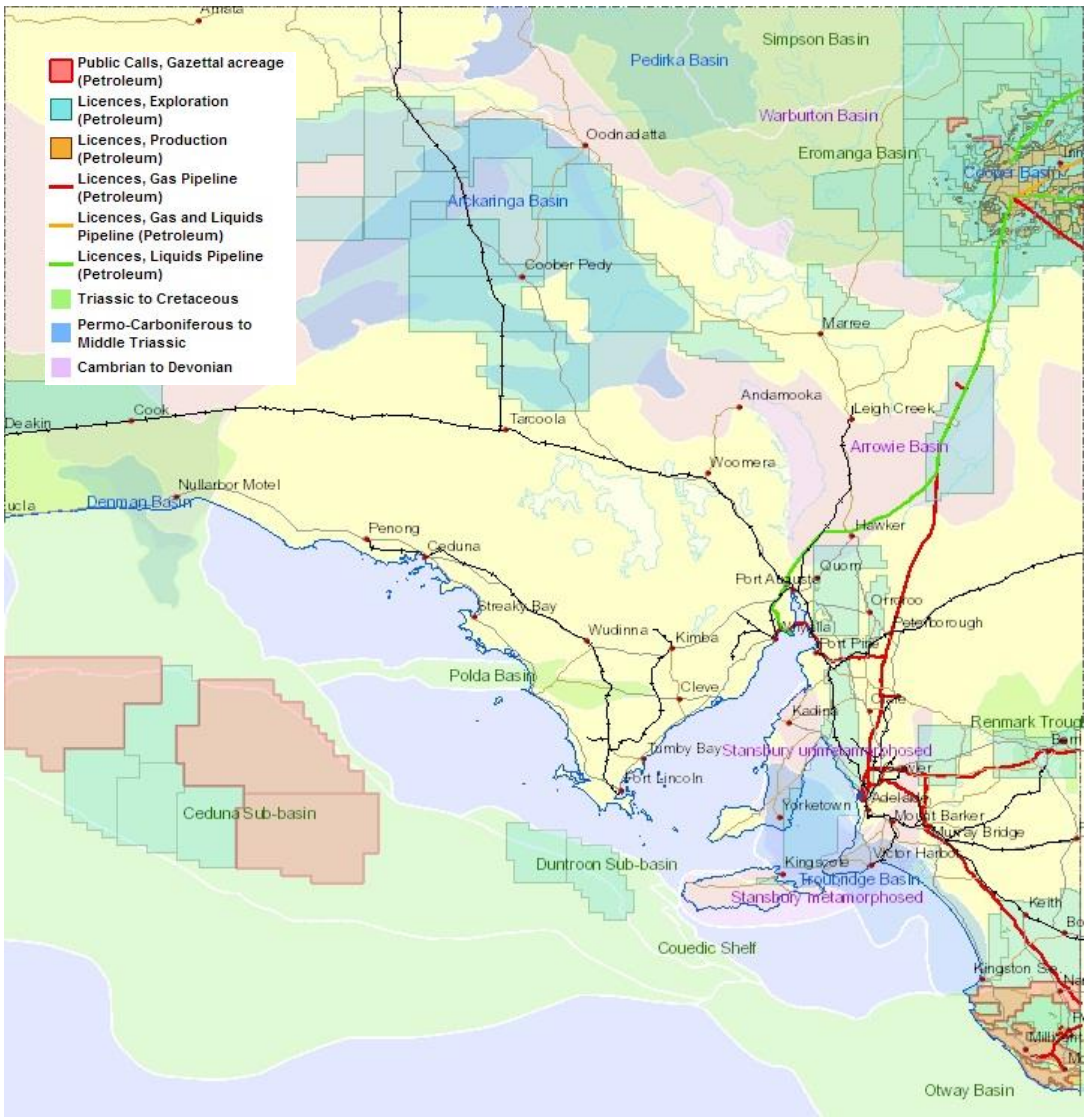
Figure 1



Empire State Building = 443m Illustration courtesy of Beach Energy

Figure 2




Public Calls, Gazettal acreage (Petroleum)
Licences, Exploration (Petroleum)
Licences, Production (Petroleum)
Licences, Gas Pipeline (Petroleum)
Licences, Gas and Liquids Pipeline (Petroleum)
Licences, Liquids Pipeline (Petroleum)
Triassic to Cretaceous
Permo-Carboniferous to Middle Triassic
Cambrian to Devonian
Simpson Basin
Pedirka Basin
Warburton Basin
Eromanga Basin
Cooper Basin
Arckaringa Basin
Oodnadatta
Coober Pedy
Marree
Andamooka
Leigh Creek
Arrowie Basin
Tarcoola
Woomera
Cook
Deakin
Nullarbor Motel
Denman Basin
Penong
Ceduna
Hawker
Quorn
Port Augusta
Orroroo
Peterborough
Streaky Bay
Wudinna
Kimba
Port Pirie
Polda Basin
Cleve
Kadina
Renmark Trough
Stansbury unmetamorphosed
Tumby Bay
Port Lincoln
Yorketown
Mount Barker
Murray Bridge
Victor Harbor
Kingscote
Troubridge Basin
Stansbury metamorphosed
Keith
Ceduna Sub-basin
Duntroon Sub-basin
Couedic Shelf
Kingston SE
Otway Basin