COAG Energy Council Gas Supply Strategy
Collaborative Action 7
Frequently Asked Questions
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1. Onshore gas

1.1 What is ‘onshore gas’?

Onshore gas is gas that is found and produced on land rather than from under the ocean. Australia has vast resources of onshore gas (including oil and gas) found in ‘conventional’ sandstone or carbonate reservoirs and gas found in coal seams, shale and tight sandstone formations. The gas is found in geological structures and depending on the physical properties of the geological formations may be difficult to extract, requiring innovative technological solutions for production.

Developing our onshore gas reserves will provide Australia with large quantities of gas to meet domestic needs and supply gas to international consumers through export, for example through liquefied natural gas. Any exploration and production of oil and gas, whether onshore or offshore, involves the use of leading safety, engineering and environmental standards to minimise risks and impacts.

1.2 How is gas energy measured?

A joule is a measure of thermal energy and a petajoule is a million billion of these units. One petajoule equates to about one Bcf (billion cubic feet) of gas—enough gas to fuel demand for a year from an area such as Wollongong or Penrith. When a tanker pulls out of an Australian port loaded with liquefied natural gas for sale overseas it is carrying around 3.5 petajoules (PJ) of the fuel.

1.3 How is natural gas formed?

Natural gas is formed in the same way as petroleum. Both are hydrocarbons formed from decomposed organic matter that became buried over time - often ancient marine micro-organisms deposited over the past 550 million years, or even up to 1.4 billion years in the case of the ancient Beetaloo Sub-Basin in the Northern Territory.

Sealed off in an oxygen-free environment deep beneath the surface of the earth and exposed to increasing amounts of heat and pressure, the organic matter went through a thermal breakdown process that converted it into energy-rich hydrocarbons. The lightest of these hydrocarbons exist as a gas under normal conditions and are known collectively as natural gas.

1.4 What is the difference between ‘conventional’ and ‘unconventional’ gas?

Conventional gas reservoirs consist mainly of porous sandstone and carbonate (dolomite or limestone) rock formations which are capped by impermeable rock (such as clay or mudstone, commonly referred to as ‘shale’). This means that under mostly normal pressure conditions, the gas is contained and effectively sealed in the rock as it is unable to move upwards. Usually conventional gas has migrated upwards from a source rock into the overlying porous and permeable formation, and this enables it to be more readily extracted.

Unconventional gas refers to gas resources that are contained within underground formations such as coal, shale and very low-permeability sandstone and limestones. Numerous production wells, often spread over many tens of square kilometres, are required to commercially exploit unconventional fields.

Figure 1 illustrates the different ways that gas migrates and is trapped, and sourced, in conventional and unconventional gas wells.
1.5 What are the different types of unconventional gas?

The main difference between the different types of gases is the type of rock in which the gas occurs and the way the gas is stored in these rocks.

Unconventional gas can occur in different sedimentary rocks:

- **coal seams (coal seam gas or CSG).**
- **shales (shale gas)**
- **low permeability sandstone or limestone (tight gas).**

**Coal seam gas (CSG):** CSG occurs naturally in coal seams and is trapped underground by water pressure. To extract CSG, water already in the coal seam, known as ‘formation water’, needs to be pumped out to release the gas. Hydraulic fracturing of vertical and/or horizontal wells is sometimes used to assist in extracting gas from a coal seam more economically.

**Shale gas:** Shale gas is sourced from very fine-grained sedimentary rocks (shale) that are rich in organic material but are not very porous or permeable. The gas is held in organic matter in the rock, in tiny pores between grains, in cracks in the rock and as a thin film on the surface of the rock itself. Hydraulic fracturing of the rocks creates pathways for the gas to flow and helps with extraction of the gas.

**Tight gas:** Tight gas is sourced from relatively low permeability and low porosity sedimentary reservoirs (tight sandstones). The lack of permeability means that the gas cannot readily migrate out of the rock, so hydraulic fracturing is usually required to assist in extracting the gas.

Table 1 provides information on these different types of natural gas resources in Australia and their extraction methods. Figures are estimates only. For more information about obtaining natural gas from shale and tight rocks, see Natural gas from shale and tight rocks.
**Table 1: Natural gas extraction methods for different types of rocks, depths, well types and other factors**

<table>
<thead>
<tr>
<th>Rock type</th>
<th>Coal seams (Coal seam gas)</th>
<th>Shale (Shale gas)</th>
<th>Compacted sandstone and limestone (tight gas)</th>
<th>Sandstone, limestone and dolostone (conventional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource type</td>
<td>Natural gas</td>
<td>Natural gas</td>
<td>Natural gas</td>
<td>Natural gas</td>
</tr>
<tr>
<td>Depth below surface</td>
<td>300–1000 metres</td>
<td>2000–5000 metres</td>
<td>2000–5000 metres</td>
<td>1000– 5000 metres</td>
</tr>
<tr>
<td>Production well type</td>
<td>Vertical or horizontal</td>
<td>Vertical or horizontal</td>
<td>Vertical or horizontal</td>
<td>Vertical or horizontal</td>
</tr>
<tr>
<td>Is hydraulic fracturing required?</td>
<td>Occasionally</td>
<td>Always</td>
<td>Usually</td>
<td>Rarely</td>
</tr>
<tr>
<td>Average number of production wells per well pad*</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Average well pad* spacing in producing field</td>
<td>0.5–1 kilometres (km apart)</td>
<td>1-6 km apart</td>
<td>1.6 km apart</td>
<td>Varies</td>
</tr>
</tbody>
</table>

*A ‘well pad’ is an area that has been cleared for a drilling rig to work on a plot of land designated for natural gas or oil extraction.

### 1.6 Where is natural gas found?

Natural gas occurs all around mainland Australia with production currently taking place in Queensland, New South Wales, South Australia, Western Australia and the Northern Territory. The development of coal seam gas (CSG) reserves is already underway, while the shale and tight gas industries are in the exploration phase. Many confirmed unconventional gas resources are located within existing conventional gas fields.

Victoria has a permanent, legislative ban on onshore unconventional gas activities and a moratorium on onshore conventional gas activities until 30 June 2020.

Onshore gas basins are regions where gas of economic value occurs within a basin-like structure. In Australia, **gas basins** with known CSG reserves include:

- Bowen and Surat basins (NSW, Qld)
- Cooper and Eromanga basins (SA, Qld)
- Clarence–Moreton Basin (Qld, NSW)
- Gloucester Basin (NSW)
- Gunnedah Basin (NSW)
- McArthur Basin (NT, Qld)
- Officer Basin (WA, SA)
- Perth Basin (WA)
- Sydney Basin (NSW).

Other basins potentially containing CSG include:

- Arckaringa Basin (SA)
- Gippsland Basin (Vic)
- Ipswich Basin (Qld, NSW)
- Galilee Basin (Qld)
- Maryborough Basin (Qld)
- Pedirka Basin (SA, NT)
- Perth Basin (WA).

**Shale gas** resources have been identified in:

- Arckaringa Basin (SA)
- Beetaloo Basin (NT)
- Canning Basin (WA)
- Cooper Basin (SA, Qld)
- Georgina Basin (NT, Qld)
- Greater McArthur Basin (NT)
- Isa Super-Basin (Qld)
In addition, these basins have **potential shale gas prospective resources**:

- Onshore Perth Basin (WA)
- Otway Basin (SA, Vic)
- Bowen Basin (Qld, NSW)
- Clarence–Moreton Basin (Qld, NSW)
- Gippsland Basin (Vic)
- Pedirka Basin (SA, NT)
- North Carnavon Basin (WA)
- Maryborough Basin (Qld).

Figure 2 illustrates the locations of the main basins and their annual production in 2014, in petajoules. For information about petajoules, see [Question 1.2: How is gas energy measured?](#).

Just because resources are present, this does not mean they are being developed, as each state and territory has a unique regulatory framework that will determine if, when and how resources are developed.

**1.7 Why is onshore gas production important?**

Australia has relatively large supplies of onshore gas resources, with the potential to provide a secure supply of energy for Australian and international markets over the coming decades. Production of gas generates revenue for government, creating social and economic benefits for the broader community - including jobs and regional development. Onshore and offshore gas accounted for around 24 per cent of the total energy consumed in Australia in 2015-16. For more information about energy usage, see the [2017 Australian Energy Statistics](#).

**1.8 What is onshore gas used for?**

Natural gas has a wide range of applications and new uses are regularly found. Onshore gas is processed, and is used in:

- our homes for cooking, heating and hot water systems
- our places of work
- industry
- other industrial processes and electricity generation.

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**Figure 2:** Location of basins where natural gas and CSG is known to occur in Australia. Source: Australia’s identified natural gas and CSG resources, and annual production (PJ) as of end 2016 (Geoscience Australia).
Industrial uses
Natural gas is an important chemical feedstock (raw material) for industrial processes that manufacture chemicals. These chemical processes convert raw gas molecules into a range of intermediate and finished products that are used throughout the supply chain.

A critical aspect of gas feedstock is that electricity cannot be used as substitute. Gas consumed as chemical feedstock has applications within Australia’s agriculture, irrigation, food and packaging, mining, building and construction, healthcare and medical sectors and also for plastics and advanced manufacturing.

Specific products include agricultural fertilisers, pharmaceutical products, glass melting, milk bottles, and explosives for the mining industry. For more information, see Uses of natural gas.

2. Unconventional gas extraction

2.1 What is ‘unconventional gas’?

Unconventional gas refers to gas resources that are often spread over many tens of square kilometres and are contained within underground formations such as coal, shale and very low-permeability sandstone and limestones. Unconventional gas reservoirs have low gas flow rates because the rocks are not very porous or permeable, trapping the gas.

See Question 1.4: What is the difference between ‘conventional’ and ‘unconventional’ gas?

2.2 How is unconventional gas extracted?

The extraction of unconventional gas resources requires technologies to access the gas, in some cases, hydraulic fracturing. These processes are described in detail below.

2.3 What is horizontal drilling?

Usually, the most efficient way to access the trapped gas is to drill horizontally so that the well follows the layer in which the gas occurs (the target layer). This horizontal drilling maximises the exposure of the well to the rock surface area and therefore increases the rate of gas production. Horizontal wells can also be oriented so that they intersect natural fracture systems and increase flow rates.

The initial drilling of the wells is vertically downwards to a pre-determined depth above the target layer, before switching from vertical to horizontal using directional drilling equipment. This equipment means that the well can be drilled horizontally for hundreds to thousands of metres within the target layer.

Recent advances in horizontal drilling technology allow much greater precision and reduced cost. A benefit of horizontal drilling is that multiple wells can be drilled from the one surface location, reducing the overall surface footprint of the operation.

2.4 What is hydraulic fracturing?

Hydraulic fracturing is sometimes referred to as ‘fracture stimulation’ ‘fraccing’ or ‘fracking’. This is the method used to create or enlarge fractures and fissures in the target rock formation, to increase the flow and recovery of gas from hydrocarbon reservoirs. The oil and gas industry has used hydraulic fracturing for over 70 years in other countries and over 60 years in Australia.

The technique uses a fluid consisting of water, sand and selected chemicals. This is pumped under high pressure, through strategically placed perforations in the well casings, into the target reservoir zone, so as to create or enlarge fractures in the rock. This process typically happens in stages to maximise the amount of fractures or fissures created in the rock that will allow as much gas as possible to flow from the rock.

Agents that modify viscosity (the thickness of a fluid affecting the rate of flow), such as guar gum and other chemical additives, are added in low concentrations. This added ‘stickiness’ enables proppants, typically sand or ceramic beads, to be carried from the surface to the underground zone. The proppants ‘prop’ the newly created fractures open and prevent them from closing up after pressure is released. As a result, the trapped gas can flow through the induced fracture system up to the production well. The fracture network created by a successful hydraulic fracturing operation is very complex with many fine fractures or fissures created in the rock. It may be best compared with a shattered windscreen rather than as big faults or cracks in the rock.
For a visual example of an induced fracture, see Figure 3. Scientific measurements confirm that, by ensuring there is a
distance of 400–600 metres vertical separation from any fresh water aquifer, the risk of fractures intersecting the aquifer
is reduced to negligible—with fractures not reaching beyond 30–100 metres vertically.

2.5 How is hydraulic fracturing managed?

The nature of an individual hydraulic fracture is complex and depends on various factors - such as the type of land use in
surrounding areas, the local geology and hydrodynamics.

Geomechanical modelling of the stresses that exist between various layers of underground rock assists in the design of
hydraulic fracture treatments. The pumping of fluid down a well to create these fractures is controlled and monitored in
real-time. Pumping generally occurs at a pressure of approximately 69 megapascals (MP). One MP is a unit equal to
one million times the force of one newton per square metre, which is a pascal. One MP is about 300 times the pressure of
an average car tyre.

Figure 3: Schematic diagram showing a well, initially drilled vertically through several different rock formations then turned and drilled
horizontally through a shale formation, in a typical Western Australian setting. The inset to shows a structure known as a 'Christmas Tree'.
This equipment is around two metres high and is attached to the top of the well head to allow for controlled production.
Before any hydraulic fracturing involving chemicals can begin, the well must be pressure tested up to its maximum allowable pressure with fresh water. Pumping pressure and flow rates are closely monitored during the hydraulic fracturing operation with automatic shutdown systems in place should anything unexpected occur.

Seismic monitoring techniques can be used to monitor the propagation of fractures during the hydraulic fracture process, to confirm that treatments work. As water can slow or stop gas production and result in a poor commercial outcome, every effort is made to avoid hydraulically fracturing the water zone. Where there are aquifers nearby, micro-seismic monitoring can help determine when to stop pumping to prevent fracturing into the water zone. Seismic monitoring techniques can also be used to provide assurance that there is no impact from hydraulic fracturing on overlying potable (drinking water) aquifers.

2.6 Where has hydraulic fracturing been used in Australia?

Hydraulic fracturing has been widely used in Australia in the oil and gas industries. Hydraulic fracturing for stimulation of petroleum wells (both oil and gas), as distinct from coal seam gas (CSG) wells, has been used in most states, with the bulk of activity in South Australia, Western Australia and Queensland. Hydraulic fracturing of CSG wells has been carried out mostly in Queensland and New South Wales. About 5-10 per cent of CSG wells require hydraulic fracturing.

In Western Australia, 615 wells have been hydraulically fractured, the first in 1958. Most of these were in conventional oil and gas wells on Barrow Island. In South Australia’s Cooper Basin, over 850 wells have been hydraulically fractured in both unconventional and conventional reservoirs since 1969. Since 2011, more than 880 wells in Queensland have been hydraulically stimulated, mostly CSG wells.

Hydraulic fracturing for onshore gas was legislatively banned in Victoria in 2017.

2.7 What is the history of hydraulic fracturing?

Hydraulic fracturing has been a commercial process in the international oil and gas industry since the late 1940s. Approximately 2.5 million hydraulic fractured stimulated stages have been completed worldwide, with about one million of those for shale gas or oil mostly in North America. The process has been used to enhance coal seam gas production since the 1970s in the United States and since the 1990s in Australia.

Historically, hydraulic fracturing involved pumping a small amount of fluid under relatively low pressure into a targeted rock formation to open up small gaps in the rock to increase oil and gas flow. However, advances in technology mean that higher pressures can now be used to create small fractures to release gas from shale and tight rocks, and also from coal seams with low permeability.

3. Chemicals

3.1 What is hydraulic fracturing fluid and why is it used?

Hydraulic fracturing fluid consists of approximately 99 per cent water and proppants, such as sand, and is used to hold open fractures so that gas can be released. The remaining one per cent consists of 3-10 common chemical types (refer to Table 1), used for a variety of purposes:

- **Microbial** controls inhibit the growth of organisms which may contaminate the coal seam and the hydraulic fracturing fluid. Bactericides (biocides), such as sodium hypochlorite (pool chlorine) and sodium hydroxide (used to make soap) are used to prevent bacterial growth that contaminates gas and restricts gas flow.
- **Buffers, stabilisers and solvents** maintain the stability of the hydraulic fracturing fluid, immobilise clays and enhance pre-fracture rock properties.
- **Acids and alkalis**, such as acetic acid (vinegar) and sodium carbonate (washing soda), are used to control the acid balance of the hydraulic fracturing fluid to prevent the precipitation of dissolved minerals.
- **Clay management** is used to minimise clay swelling in the vicinity of the well and in the formation.
- **Gelling agents and binders** are used to increase the viscosity (‘stickiness’) of the hydraulic fracturing fluid and allow more sand to be carried into the fractures. For example, guar gum (a food thickening agent derived from a plant) is used to create a gel that transports sand through the fracture.
- **Breakers** are used to break down the hydraulic fracturing gel and enable the release of the proppant into fractures. They also enhance the recovery of the hydraulic fracturing fluid. For example, ammonium persulfate (used in hair bleach) dissolve hydraulic fracturing gels so that water and gas surfactants can be transmitted. Ethanol and orange (citrus) oil, are used to increase fluid recovery from the fracture.
- **Surfactants** reduce the surface tension thereby aiding fluid recovery.

The exact nature of the hydraulic fracturing fluid mixtures can vary from well to well.
Table 1: Chemicals and compounds used in coal seam gas hydraulic fracturing. Please visit state government websites for detailed information regarding individual states

<table>
<thead>
<tr>
<th>CHEMICAL TYPE / NAME</th>
<th>COMMON FUNCTION</th>
<th>COMMON USE</th>
<th>PERCENTAGE VOLUME USED *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Fracking / proppant suspension</td>
<td>Drinking, bathing, cooking</td>
<td>75-99</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Fluid weight reducer / proppant suspension</td>
<td>Used in cryogenic, food processing, medical</td>
<td>0-70</td>
</tr>
<tr>
<td>Crystalline silica (quartz)</td>
<td>Proppant</td>
<td>Cat litter, tile mortar, arts and crafts, glass, ceramic glaze, glaze, concrete, paint</td>
<td>0-25</td>
</tr>
<tr>
<td>Crystalline silica (cristobalite)</td>
<td>Proppant</td>
<td>Sand, gravel</td>
<td>0-25</td>
</tr>
<tr>
<td>Glycerine</td>
<td>Additive</td>
<td>Food and pharmaceutical industry, hair products</td>
<td>0-1</td>
</tr>
<tr>
<td>5-chloro-2-methyl-2h-isothiazol-3-one</td>
<td>Microbial control</td>
<td>Used in toiletries, cosmetics, dishwashing liquids</td>
<td>0-1</td>
</tr>
<tr>
<td>2-methyl-2h-isothiazol-3-one</td>
<td>Microbial control</td>
<td>Used in toiletries, cosmetics, dishwashing liquids</td>
<td>0-1</td>
</tr>
<tr>
<td>Sodium hypochlorite</td>
<td>Microbial control</td>
<td>Disinfectant, bleach, milk production, water treatment, dental/medical, wood/deck cleaner, mildew remover</td>
<td>0-1</td>
</tr>
<tr>
<td>Phosphonium sulfate</td>
<td>Microbial control</td>
<td>Cooling systems, paper-making industry</td>
<td>0-1</td>
</tr>
<tr>
<td>C.I. pigment red 5</td>
<td>Microbial control</td>
<td>Food colouring, paints, agriculture</td>
<td>0-1</td>
</tr>
<tr>
<td>Potassium carbonate</td>
<td>Buffer, stabiliser, solvent</td>
<td>Soap, glass, and china production</td>
<td>0-1</td>
</tr>
<tr>
<td>Sodium acetate</td>
<td>Buffer, stabiliser, solvent</td>
<td>Flavouring additive in food industry</td>
<td>0-1</td>
</tr>
<tr>
<td>Sodium hydroxide (caustic soda)</td>
<td>Buffer, stabiliser, solvent</td>
<td>Food preparation, household drain cleaner, paper, soaps, detergents</td>
<td>0-1</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>Buffer, stabiliser, solvent</td>
<td>Used as baking soda, cleaning, anti-pollutant</td>
<td>0-1</td>
</tr>
<tr>
<td>Sodium carbonate (soda ash)</td>
<td>Buffer, stabiliser, solvent</td>
<td>Water softener, swimming pools food additive (E500), glass</td>
<td>0-1</td>
</tr>
<tr>
<td>Hydrochloric acid (muriatic acid)</td>
<td>Buffer, stabiliser, solvent</td>
<td>Household cleaning, food additive, swimming pools, drinking water</td>
<td>0-1</td>
</tr>
<tr>
<td>Carbonic acid</td>
<td>Buffer, stabiliser, solvent</td>
<td>Soda drinks</td>
<td>0-1</td>
</tr>
<tr>
<td>Citric acid</td>
<td>Buffer, stabiliser, solvent</td>
<td>Flavour additive, biological, cleaning, pharmaceutical</td>
<td>0-1</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>Buffer, stabiliser, solvent</td>
<td>Vinegar, found in citrus fruits, descaling agent</td>
<td>0-1</td>
</tr>
<tr>
<td>Carbonic acid, sodium salt</td>
<td>Buffer, stabiliser, solvent</td>
<td>Food additive</td>
<td>0-1</td>
</tr>
<tr>
<td>CHEMICAL TYPE / NAME</td>
<td>COMMON FUNCTION</td>
<td>COMMON USE</td>
<td>PERCENTAGE VOLUME USED *</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------</td>
<td>-----------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Tetrasodium ethylenediaminetetraacetate</td>
<td>Chelating agent</td>
<td>Cosmetic industry</td>
<td>0–1</td>
</tr>
<tr>
<td>Choline chloride</td>
<td>Clay management</td>
<td>Poultry feed additive</td>
<td>0–1</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>Clay management</td>
<td>Table salt substitute, medical treatments, garden products, pet supplements, hair products</td>
<td>0–1.5</td>
</tr>
<tr>
<td>Polydimethylallylammonium chloride</td>
<td>Clay management</td>
<td>Water treatment (drinking, waste-water), textiles, cosmetics, paper-making, soil treatment, drinking, bathing, cooking</td>
<td>0–1</td>
</tr>
<tr>
<td>Tetramethyl ammonium chloride</td>
<td>Clay management</td>
<td>Type of salt</td>
<td>0–1</td>
</tr>
<tr>
<td>Trimethylammonium chloride</td>
<td>Clay management</td>
<td>Dyeing</td>
<td>0–1</td>
</tr>
<tr>
<td>Gelatine</td>
<td>Corrosion inhibitor</td>
<td>Capsules for medicines, desserts, jellies, ice cream</td>
<td>0–1</td>
</tr>
<tr>
<td>Calcium chloride</td>
<td>Filler, stabiliser</td>
<td>Detergents, cosmetics, deodorant, pet products, desiccant (moisture absorber), food additive, sports drinks, pickles</td>
<td>0–1</td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>Filler, stabiliser</td>
<td>Anti-freeze agent, de-icing, printer inks</td>
<td>0–1</td>
</tr>
<tr>
<td>Diatomaceous earth, calcined</td>
<td>Filler, stabiliser</td>
<td>Toothpaste, hydroponics, agriculture (grain storage), filter media (drinking water)</td>
<td>0–1</td>
</tr>
<tr>
<td>Magnesium silicate hydrate (talc)</td>
<td>Filler, stabiliser</td>
<td>Talcum powder, cosmetics, food additive, soaps, paper, paints, rubber, pottery</td>
<td>0–1</td>
</tr>
<tr>
<td>Non-crystalline silica</td>
<td>Filler, stabiliser</td>
<td>Glass, paints, coatings, fillers, plastics</td>
<td>0–1</td>
</tr>
<tr>
<td>Boric acid</td>
<td>Gel management</td>
<td>Cosmetics, skin care products</td>
<td>0–1</td>
</tr>
<tr>
<td>Triethanolamine</td>
<td>Gel management</td>
<td>Cosmetics, skin care products</td>
<td>0–1</td>
</tr>
<tr>
<td>Sodium tetraborate</td>
<td>Gel management</td>
<td>Component of many detergents, cosmetics, texturing agent in cooking</td>
<td>0–1</td>
</tr>
<tr>
<td>Vinilidene chloride/methylacrylate</td>
<td>Gel management</td>
<td>Plastic wrap for foods</td>
<td>0–1</td>
</tr>
<tr>
<td>MEA borate</td>
<td>Crosslinker</td>
<td>Cosmetics, hair texturiser, hairspray, antiseptic, laundry detergent</td>
<td>0–1</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>Gel management</td>
<td>Food production, food additive, detergents, hair products, water softener</td>
<td>0–1</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>Gel management</td>
<td>Hair bleach, food processing</td>
<td>0–1</td>
</tr>
<tr>
<td>Diammonium peroxidisulphate</td>
<td>Gel management</td>
<td>Hair bleach</td>
<td>0–1</td>
</tr>
<tr>
<td>Sodium thiosulfate</td>
<td>Gel management</td>
<td>Personal care, pet care, food production, aquarium/commercial aquaculture (food)</td>
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</tr>
<tr>
<td>Sodium persulfate</td>
<td>Breaker</td>
<td>Hair bleach</td>
<td>0–1</td>
</tr>
<tr>
<td>Guar gum</td>
<td>Gel</td>
<td>Thicker in cosmetics, baked goods, ice cream, toothpaste, sauces and salad dressing</td>
<td>0–1</td>
</tr>
<tr>
<td>Hemicellulase enzyme</td>
<td>Breaker</td>
<td>Food industry, washing powder</td>
<td>0–1</td>
</tr>
<tr>
<td>Hemicellulase enzyme carbohydrates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium sulfate</td>
<td>Gel management</td>
<td>Textiles</td>
<td>0–1</td>
</tr>
<tr>
<td>Sodium sulfite</td>
<td>Gel management</td>
<td>Paper industry</td>
<td>0–1</td>
</tr>
<tr>
<td>Magnesium nitrate</td>
<td>Clay management</td>
<td>Facial care, home garden uses, ceramics</td>
<td>0–1</td>
</tr>
<tr>
<td>Magnesium chloride</td>
<td>Clay management</td>
<td>Food industry (tofu from soy milk), magnesium health supplements</td>
<td>0–1</td>
</tr>
<tr>
<td>Silica gel</td>
<td>Clay management</td>
<td>Cat litter</td>
<td>0–1</td>
</tr>
<tr>
<td>2-Butoxyethanol</td>
<td>Surfactant</td>
<td>Home surface cleaners, jewellery cleaner</td>
<td>0–1</td>
</tr>
<tr>
<td>Ethanol</td>
<td>Surfactant</td>
<td>Beer, wine, spirits</td>
<td>0–1</td>
</tr>
<tr>
<td>Propan-2-ol</td>
<td>Surfactant</td>
<td>Solvent in cleaning fluid</td>
<td>0–1</td>
</tr>
<tr>
<td>C6-C10 Alcohol ethoxylate (surrogate C6-C12)</td>
<td>Surfactant</td>
<td>Laundry detergent</td>
<td>0–1</td>
</tr>
<tr>
<td>Alcohols C6-C10 ethoxylated (surrogate C6-C12)</td>
<td>Surfactant</td>
<td>Household cleaners</td>
<td>0–1</td>
</tr>
</tbody>
</table>

* Percentage volume of chemical in the hydraulic fracturing fluid
Source: Reproduced from Chemicals and compounds used in CSG hydraulic fracturing
3.2 What are BTEX chemicals?

BTEX compounds are among the most abundantly produced chemicals in the world. BTEX refers to the chemicals benzene, toluene, ethylbenzene and xylenes. BTEX compounds are created and used during the processing of petroleum products and during the production of consumer goods such as paints and lacquers, thinners, rubber products, adhesives, inks, cosmetics and pharmaceutical products. BTEX compounds are commonly released through motor vehicles and aircraft emissions, and from cigarette smoke, bushfires and volcanoes.

BTEX chemicals may occur naturally in water sources, so in some instances, trace levels of these chemicals may be detected before hydraulic fracturing. They can also be detected in industrial and irrigation waters that farmers and pastoralists use all the time. At low level or trace concentrations, BTEX chemicals do not pose a risk to human health or the environment.

Exposure to higher levels of BTEX chemicals can be hazardous in the short term and cause skin irritation, central nervous system problems (tiredness, dizziness, headache, loss of coordination) and affect the respiratory system (eye and nose irritation). Prolonged exposure to these compounds can also negatively affect the functioning of the kidneys, liver and blood system. Long-term exposure to high levels of benzene in the air can lead to leukaemia and cancers of the blood.

For more information, see A short primer on benzene, toluene, ethylbenzene and xylenes (BTEX) in the environment and in hydraulic fracturing fluids on-line.

Each state and territory has regulations in place to manage BTEX chemical use in the onshore petroleum industry. Some states and territories, such as New South Wales and Victoria, ban the use of BTEX chemicals in the onshore petroleum industry altogether. Others assess the risks of BTEX (and other chemicals) on a case-by-case basis through Environmental Impact Statements or similar assessments. In addition, there are a number of guidelines that stipulate acceptable levels of BTEX chemicals. These include Australian Drinking Water Guidelines and The National Environment Protection (Air Toxics) Measure (Air Toxics NEPM). Queensland has such stringent restrictions and low allowable levels that in practice BTEX cannot be added to fracturing fluids.

3.3 How are hydraulic fracturing fluids managed?

Once the hydraulic fracturing stage is completed, the operator recovers as much hydraulic fracturing fluid as possible. In Queensland, after fracturing the quality and quantity of water from the well must be monitored until one and a half times (150%) the amount of the fluid used in the frac has been removed. This is to ensure that all water used for the frac is removed. Recovered fluid is stored in lined pits or steel tanks and is re-used in another hydraulic fracturing stage or in another well. The fluid that could not be recovered remains trapped in the rocks below the ground.

Petroleum companies must comply with state and territory regulations when managing hydraulic fracturing fluids. In general, these regulations require that hydraulic fracturing fluids are placed in lined holding ponds for treatment and disposal after use. Most of the additives will break down quickly under sunlight and the sand will settle with the remaining salt residue. Water and solids produced (such as sand and salt) must be processed by a licensed disposal facility.

4. Water

4.1 How are governments involved in the management of water resources used in onshore gas activities?

State and territory governments have primary responsibility for water resources and regulating environmental impacts associated with the resources sector. States and territories have also introduced targeted policy and codes to ensure that companies meet relevant standards.

The Australian Government’s role is to protect the environment from the potential impacts of development activity, with a focus on matters of national environmental significance. In the case of development activity related to the extraction of coal seam gas, this includes potential impacts on water resources.

The Australian Government’s approach to regulating gas extraction is risk-based and deals with uncertainty through adaptive management. Projects are monitored to ensure that all conditions are complied with. Non-compliance is treated seriously and significant penalties can be applied.

4.2 How much water is used and abstracted in the onshore gas industry?

Water use and the taking of water from aquifers (abstraction) differs depending on the type of gas and location. Gas companies generally require a licence to use water. Potable (drinkable) water is not required in drilling and hydraulic fracturing. Instead, brackish or salty water can be used, as well as recycled water which may need to be pre-treated, depending on its composition.
4.3 How much water is used during the hydraulic fracturing process?

The volume of water it takes to hydraulically fracture a well varies from project to project. It depends on the size and length of the well, and the properties of the rocks to be fractured. Hydraulic fracturing occurs in stages and each stage requires a certain amount of water. See Question 4.2 for more information about water use in the hydraulic fracturing process.

For CSG vertical drilling operations, between 0.02 and 0.04 ML (or one per cent of an Olympic size swimming pool) may be used and can be recycled for use at other wells. If a coal seam gas well is hydraulically fractured, around 0.5–3 ML of water may be used.

For shale and tight gas, about 1 ML of water is used for each stage of hydraulic fracture (that is, in each fracture stimulated zone). Typically in Australia, a single, vertical exploration well program for hydraulic fractures is made up of an average of four stages (thus, 4 ML of water). More stages are typical in horizontal production wells. For horizontal wells (with a horizontal reach of one kilometre) using 10 fracture stages, around 10 ML would be required for hydraulic fracturing and 1 ML for drilling. This equates to about four Olympic size swimming pools. Having said this, more water may be used for longer horizontal wells with more stages of fracturing—sometimes up to 60 stages in a 2000-metre long horizontal well. The key is to try to maximise gas recovery while minimising surface environmental impacts and costs. A US shale gas well may recover up to 30 petajoules (PJ) of gas compared to about only 1 PJ for a CSG well. See Question 1.2: How is gas energy measured? The expected ultimate recovery of natural gas from shale wells in Australia has not yet been determined.

4.4 What is ‘dewatering’?

‘Dewatering’ means draining or removing water. Many coal seams contain water and gas together and some of the water may need to be removed to enhance productivity.

Methane is adsorbed or attached to the coal and is held in the coal underground by pressure from water within the seam. This means that to extract the gas in the seam, some of the water must be pumped out first to reduce pressure. As water production declines, gas production increases.

Some coal seam gas operations produce a significant amount of water (generally a small percentage of the total water contained in the aquifer), which must be managed in accordance with state regulations. Water management may differ greatly between projects depending on the local environment, the quality of the produced water and any potential uses.

4.5 How does the government ensure water sources are not contaminated?

Operators are required to develop environmental management plans, which include water management plans that describe the risks and how they will be managed. Each state and territory implements a range of strict controls to manage the potential risk of multiple-user access to water resources - and in particular the potential for material contamination of surface streams, aquifers and water wells. The main causes of contamination could be improperly constructed wells or spills during surface operations. Key controls include:

- baseline monitoring of water quality (salinity, physical and organic chemistry and pressure) in the project area
- detailed and structured impact and risk assessments based on sound understanding of the environment and sensitive areas to identify key technical aspects to maintain separation of hydrocarbons from water resources
- best-practice well construction standards which ensure isolation of the oil and gas wells from intersected water resources with strict regulatory oversight
- best-practice operating procedures for handling hazardous materials including the use of bunds, dry chemicals and smaller containers (to limit spills from any isolated event) etc.

Companies use extensive monitoring to detect any possible changes in the environment as a result of operations.

4.6 How are any contamination risks managed?

In all cases with good well design, construction and maintenance, the risk of crossflow between the stimulated reservoir and aquifers can be reduced to low and acceptable levels. To verify compliance, government inspectors may take samples of drilling additives and hydraulic fracture fluid additives at any time.

A number of techniques are employed to reduce the contamination risks. Wells to be hydraulically fractured are lined with steel casing, which is cemented in place to isolate aquifers. Before hydraulic fracturing is conducted, the integrity of the casing and the cement bond between the casing and rock is tested and verified. The most common methods used for monitoring include cement bond logging and well pressure and leak tests.
A wide range of geophysical techniques are used to characterise the separation of gas bearing rock layers from surrounding aquifers. These include surveying, modelling and imaging to identify and avoid water-bearing faults, and hydraulic and hydrochemical investigations to understand potential interactions between aquifers (underground layers of water-bearing rock).

A similarly wide range of geological and geo-mechanical measurements are carried out in order to understand the properties of the gas bearing formation and surrounding rock. This enables each hydraulic fracturing operation to be designed so that the hydraulic fracture is contained within the gas bearing formation. The extent of fracturing can be measured at the time of hydraulic fracturing through well logging and micro-seismic monitoring. Tilt meters can be used to measure the fracture orientation and volume. Offset instrumented wells are sometimes drilled and used to monitor fracture growth and are used later during production to monitor the produced reservoir formation pressure.

Models that predict fracture growth are used with the remote monitoring methods to assess the potential risks of fracturing into zones above or below the gas bearing rock. However, absolute guarantees about fracture growth are not possible because estimation of the growth is based on limited data reflecting the statistical variation of parameters in a sequence of rock layers. Should a hydraulic fracture grow into an aquifer, the fluid produced during production will predictably flow from the aquifer towards the well. This minimises the risk of groundwater contamination.

4.7 What is ‘co-produced water’ and is it re-used?

‘Co-produced water’ (also known as ‘associated water’) is formation water, which is water that is already present in the gas formation, or a combination of formation water and hydraulic fracturing fluid (if hydraulic fracturing has occurred). Co-produced water is associated with shallow coal seam gas operations and is almost non-existent for shale, tight and conventional gas production.

Co-produced water is treated to remove salts and other chemicals to ensure it meets water quality and safety standards before being reintroduced into the hydrological system. When safe, the co-produced water is either re-used or disposed of according to state government regulations. In NSW, the water must be disposed of via a licensed water facility if it is not recycled for beneficial re-use. Also, any operator proposing to extract more than 3 megalitres of water per year (equivalent to 1.2 Olympic sized swimming pools) from groundwater sources must hold a water access licence. In Queensland, produced water must be treated so as to be of an acceptable quality. Some of this water is used for other beneficial purposes, such as irrigating crops or watering livestock.

In all cases co-produced water must be treated to a safe level before being reintroduced into the hydrological system.

Of note the agriculture industry extracts and uses water (without treatment) from the same formations that provide coal seam gas. More than 1600 bores unrelated to the gas industry take water from Queensland’s Walloon Coal Measure formation for agriculture, stock and domestic purposes.

4.8 How much salt and brine is in coal seam gas water and how is it treated?

The treatment of coal seam gas (CSG) water using desalination technologies results in brine, which is a high-concentration solution of salt (usually sodium chloride) in water. Brine is defined as saline water with a total dissolved solid concentration greater than 40,000 milligrams per litre.

Brine results, ultimately, in salt residues that must be appropriately managed. The concentration and composition of salts depends on the characteristics of the CSG water and the treatment process.

The salinity of CSG water is typically measured as the concentration of total dissolved solids (TDS) with values ranging from 200 to more than 10,000 milligrams per litre.

By comparison, good quality drinking water has TDS value of less than 500 milligrams per litre. The TDS of sea water is between 36,000 and 38,000 milligrams per litre.

There are two priorities for the treatment of saline waste. First, whenever feasible, it is treated to create useable products. Where this is not possible, it is disposed of in accordance with strict standards that protect the environment.
4.9 Will aquifers including the Great Artesian Basin be depleted?

An ‘aquifer’ is an underground layer of water-bearing rock. The Great Artesian Basin aquifer is one of the largest natural underground water reservoirs in the world and is Australia’s largest groundwater basin, containing around 65 million gigalitres (GL) of water. It extends beneath parts of Queensland, New South Wales, South Australia and the Northern Territory.

Over the expected life of the coal seam gas (CSG) industry in Queensland (around 50 years), it is estimated that the industry will extract around 2500 GL of water from the Great Artesian Basin. This is about 0.004 per cent of the Basin’s total volume. On current authorisations, the agriculture sector would be allowed to extract an estimated 9200 GL from GAB aquifers in Queensland over the same period. In New South Wales, a Water Access Licence is mandatory for any CSG activity extracting more than three megalitres per year from groundwater sources. New licences will not be issued in cases where the proposed activity means that extraction limits in water sharing plans will be exceeded.

5. Well integrity

5.1 Why is well integrity important?

The design and integrity of the well is critical to the protection of ground and surface water. States and territories apply best-practice international standards for well design and integrity. These standards specify technical requirements through design, construction, production, maintenance and rehabilitation for industry to meet during the well’s life cycle. Multiple layers of steel and cement create a protective barrier between the well and the various rock formations. The use of multiple layers of protection around wells has been standard practice in oil and gas production for many decades. Current international standards for onshore petroleum casing design include:

- **Conductor casing**: This prevents loose surface sediment from collapsing into the well and protects shallow surface aquifers. This casing is approximately 50 metres deep and is cemented to the surface.

- **Surface casing**: The key purpose is to protect groundwater, provide hole stability and allow for the installation of equipment to prevent blowouts. Blowout preventers allow the well to be closed in if overpressured gas/fluids are intercepted. This prevents them from escaping through the top of the casing and also prevents drill pipes from being blown out of the well. A blowout preventer is an important safety and environmental protection device which is usually set at up to 800 metres depth and is cemented to the surface.

- **Intermediate casing**: This is optional and is usually used for deeper wells to manage hole conditions when drilling to the target formation. Cementing procedures must meet international standards.

- **Production casing or liner**: This is the final casing set for a production well. Casings run from total depth to the surface and liners run from total depth to an appropriate overlap inside the previous casing. Cementing procedures must meet international standards.

- **Production tubing**: This is commonly installed inside the casing to act as a conduit for oil or gas production.

Maintaining well integrity ensures that there is no connectivity with water aquifers and also assists in preventing uncontrolled flows from well (or ‘blowouts’). Blowouts, although rare, involve a sudden and uncontrolled escape of fluids and can occur above or below the surface. Instances of well failure are very rare but are managed through mitigation and remediation measures to avoid permanent harm.

A number of highly regarded standards development and accreditation bodies work to develop and update the relevant standards. These include the American Petroleum Institute (API) accredited by the American National Standards Institute (ANSI) and the International Standards Organisation (ISO). All aspects of well integrity are highly standardised and rigorously tested to ensure that any equipment and techniques used in oil and gas well design and construction significantly reduces any chance of failure to acceptable levels of risk-based management.
5.2 How reliable is cement as a long-term isolation barrier?

Research work demonstrates that effective cementing is all about selecting the appropriate cement composition to meet the particular down hole conditions (this will first be tested in a laboratory) and then the effective and comprehensive placement of the cement in the well. In terms of deterioration, in a corrosive naturally occurring carbonic acid environment as found in mines, the research concludes that it takes tens to hundreds of thousands of years to dissolve 25 millimetres of cement. So, in a typical oil and gas well environment, if cement is effectively placed, it can be considered to be a permanent barrier. For more information, see Duguid, A, 2009; An estimate of the time to degrade the cement sheath in a well exposed to carbonated brine.

5.3 How are wells monitored for potential leaks?

A number of safeguards and measures are put in place to ensure there are no uncontrolled leaks or loss of control in a well. States and territories require all completed wells to be tested to ensure cement is sealed and bonded correctly. To ensure their integrity during production life, wells are also pressure tested far in excess of their operating pressures. Pressure testing makes sure the cementing and casing can take the pressures involved in activities such as hydraulic fracturing - which puts cyclic loads on casing and must comply with specific burst and collapse ratings. Companies are also required to carry out monitoring logs. This includes sending a probe similar to a stethoscope down the well to see through the sides of the well. This tool sends sound waves through the steel casing, cement and rock. This helps them examine if the cement at the sides of the well has properly bonded to the rock and steel casing. This process is called ‘cement bond logging’. During the well construction phase, petroleum companies must undertake real-time monitoring of pressures and report these daily. Engineers review these reports and conduct site audits and inspections to ensure activities are conducted in accordance with the approved plans and best practice management is being implemented. In addition, all petroleum operators must self-audit their activities to ensure environmental impacts and risks are managed appropriately and are continuously reduced to as ‘low as reasonably practicable’.
5.4 How big is a well site area?

A typical drill site requires a cleared area of about 75 metres by 75 metres (approximately 0.6 hectares). For coal seam gas operations, the well-head and associated infrastructure is smaller than an average water tank. The well head takes up less room than a car. Once the drill site proceeds to operation the area required is considerably smaller and is typically fenced off. In Queensland, the average operational drill site footprint is up to 25 square metres depending on the equipment.

Shale or tight gas well pads typically require 1.5–2 hectares of land for the well and site access. If a petroleum company were to drill six shale gas wells from one well pad and used horizontal drilling, it is estimated one well pad would be required for every eight square kilometres of land.

6. Fugitive emissions management

6.1 What are ‘fugitive emissions’?

‘Fugitive emissions’ refer to greenhouse gases, such as methane, that can escape into the atmosphere from fossil fuels. Fugitive emissions may occur naturally and can be expected in some areas where shallow gas reservoirs occur.

Natural gas is primarily methane, and methane is a very powerful greenhouse gas, with about 25 times the greenhouse warming potential of carbon dioxide. Methane is also released naturally, seeping from coal seams or biological processes occurring in wetlands, swamps, rivers and dams. Fugitive emissions of methane may also occur during the production, processing, transport, storage, transmission and distribution of fossil fuels such as coal, crude oil and natural gas.

Emissions from decommissioned underground coal mines also contribute to greenhouse gases. In the year to March 2017, fugitive emissions accounted for 9 per cent of Australia’s national inventory of greenhouse gases.

For more information, see Quarterly Update of Australia’s National Greenhouse Gas Inventory: March 2017, Commonwealth of Australia 2017.

6.2 What are the fugitive emissions levels from coal seam gas (CSG)?

The 2017 Commonwealth Science and Industrial Research Organisation (CSIRO) report, Methane Emissions from CSG Well Completion Activities prepared for the Department of the Environment and Energy measured methane emissions at nine well completions and one well workover at two CSG sites in Queensland. Well completions and workovers are the point where there is significant potential for emissions. The measurements found total methane emissions from well completions were low, with the majority of emissions occurring during well construction.

Shale gas operations in Australia employ so-called ‘green completions.’ This means that the well is connected to a two-phase separator during the initial phases of flowback and testing. This allows liquids and gas to be separated and the natural gas to be flared which reduces the global warming impacts significantly. Flaring is the practice of combusting (burning) the natural gas before it would be released to the atmosphere. It reduces global warming impacts significantly because the methane is not released.

As a rule of thumb, if fugitive emissions are below 1–2 per cent, natural gas has lower greenhouse gas emissions compared with coal (based on current technologies) for power generation. Above levels of about 4 per cent fugitive emissions, the greenhouse benefits are lost. The CSIRO has a range of programmes underway using measuring, monitoring and lifecycle analysis to build a comprehensive picture of natural and fugitive emissions.

6.3 How are fugitive emissions managed?

Fugitive emissions from improperly sealed wells, leaking well heads or venting of gas from wells require close monitoring and mitigation. The best available methods to reduce the environmental impact and risks to a level that is acceptable include:

- reducing flaring and venting (discharging of gas) as far as practical, such as via strategic planning of field operations
- where flaring or venting cannot be avoided (for testing or safety reasons), ensuring appropriate design and controls are put in place to maximise efficiency and avoid unacceptable impacts
- designing and constructing wells to strict industry standards
- regularly inspecting well heads and process piping and equipment subject to a rigorous maintenance and inspection regime
- continuous monitoring and/or regular testing of wells and process equipment.
7. Environmental and geological concerns

7.1 How are environmental regulations applied to onshore gas activities?

Environmental approval is a critical aspect of the onshore petroleum approvals process and occurs at the same time as each of the project phases. The states and the Northern Territory are the day-to-day regulators and authorities for the environmental management of mines, petroleum, geothermal energy and gas storage projects within their respective jurisdictions.

Environmental management of petroleum projects in Australia is based on the integration of all phases of resource exploration, development planning and development - from assessment, through construction, operation and closure to rehabilitation.

Approval processes involve identifying environmental risks and impacts and determining ways to reduce the likelihood of risks and eliminate or reduce the impacts. Best practice regulation, as defined by the Australian Government Office of Best Practice Regulation, involves assessing risks and focusing on outcomes - rather than prescribing detailed procedures and mitigation measures that may fall behind leading practice over time. Processes vary among the states and territories, but there are some common features. The main steps are:

- proposal, notice of intention, environmental management plan or initial advice statement
- government assessment, including consultation with potentially affected people, enterprises and organisations such as expert advice from the Independent Expert Scientific Committee (IESC) on Coal Seam Gas (CSG) and Large Coal Mining Development
- government approvals that entail line-of-sight and at times, management of stakeholder and landowner consultation.

In addition to state and Northern Territory requirements, the Australian Government regulates through the Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act). The EPBC Act provides a legal framework to protect and manage matters of national environmental significance, including World Heritage properties and listed threatened species and communities. For CSG, the water trigger also applies, allowing the impacts of proposed CSG and large coal mining developments on water resources to be comprehensively assessed at a national level. When making a decision, the Minister for the EPBC Act cannot consider matters that fall outside the EPBC Act.

7.2 How are environmental impacts managed?

The disturbance associated with onshore gas activities is less intense than most other forms of resource extraction, such as open cut mining activities, but may cover a larger overall area. All onshore gas operators must demonstrate that they have reduced identified environmental risks and impacts to as low as reasonably practicable and acceptable through the following steps:

- **Avoid the impacts** – such as by relocating wells or infrastructure away from environmentally sensitive areas.
- **Minimise the impacts** – such as by using multi-well pads to minimise the footprint required in environmentally sensitive areas.
- **Mitigate the impacts** – such as by rehabilitation of vegetation and relocation of fauna.
- **Offset the impacts** – to ensure overall net benefit such as by securing protection and improving the quality of a larger amount of the same type of ecosystem elsewhere.

7.3 Do onshore gas activities result in subsidence, and seismic events?

Onshore gas activities do not result in significant subsidence of the land surface. The *Subsidence from coal seam gas extraction in Australia, Background Report* prepared for the Independent Scientific Expert Committee on Coal Seam Gas and Large Coal Mining in June 2014 states there is no confirmed subsidence resulting from coal seam gas development in Australia and impact assessments reviewed generally predict minimal ground movements.

Scientists in the United States of America have found a link between the underground disposal of hydraulic fracturing waste water in deep wells and an increased occurrence of earthquakes. This method of underground disposal does not occur in Australia where all waste water must be brought to the surface and treated for re-use.

7.4 How is the environment rehabilitated?

Onshore gas operators are required to rehabilitate any land disturbed by work. Rehabilitation works should be carried out progressively in conjunction with production and exploration activities and must, as far as practicable, be completed before the expiry of the tenement.
Well sites that are no longer in production or use must be rehabilitated to their previous state or as agreed with the landholder, and to a standard acceptable to the state or territory government. When onshore gas operations cease, wells are cemented, plugged and decommissioned and the site is fully rehabilitated in accordance with regulatory requirements. State and territory legislation includes provisions to hold financial securities to cover rehabilitation activities in the event a gas company defaults on its obligations.

8. Landholder rights and dispute resolution

8.1 What are landholder rights?
Landholder rights are detailed in state and territory legislation with approaches differing between jurisdictions and land title - for example, freehold, pastoral leases and grazing leases. Before undertaking any onshore petroleum exploration or production activities, companies must hold a valid petroleum license and be a legitimate petroleum title holder, and gain agreement to enter the land. Access arrangements may include provisions to minimise any potential loss or interference. It is a landholder’s right to be compensated for any loss or interference to their normal activities.

8.2 How does a petroleum company gain access to land for exploration?
Before commencing any exploration works, petroleum title holders are required to gain regulatory consent(s) for area-specific and location-specific operations. They then need to notify landholders and lessees of their proposed activities. Landholders and parties with a legal interest in lands are entitled to have a reasonable amount of time to assess the proposed operations and to be reasonably compensated for damage and loss caused by the petroleum title holder. The petroleum title holder must agree on the compensation amount with the landholders/lessees. If agreement cannot be reached within the timeframe stipulated within state and territory legislation, either party may apply for arbitration or to the relevant court, civil administration tribunal or Ombudsman to determine a fair compensation arrangement.

8.3 What is a land access or compensation agreement?
A compensation agreement between a petroleum company and a landowner or lessee can include a negotiated compensation for access to private land. The compensation is to make up for the landowner or occupier being deprived of possession of the land and for damage to the land and/or improvements. Compensation can include financial and/or non-financial arrangements and may include reimbursement for legal, accounting and valuation costs incurred in negotiating and preparing a compensation agreement.

Agreements can also determine:
• which areas of land can be accessed and how often
• which entrance and access tracks vehicles are permitted to use
• the landowner’s preferred method of communication.

8.4 Do landholders receive a share of petroleum royalties?
Landholders are not entitled to royalties for oil or gas in Australia, as these resources are owned by the Crown for the benefit of the state. It is the responsibility of each state and territory to manage royalties. In general, royalties go into consolidated revenue to fund services including hospitals and schools. Some states have established specific programs like Community Benefit Funds (royalty rebate) or royalties for regions to support economic development in regional areas.

South Australia is the only jurisdiction to introduce a direct royalty sharing scheme. For more information about the scheme, see Oil and gas royalty return. In New South Wales, petroleum producers are encouraged to set up Community Benefit Funds and receive a $1 refund on royalties, up to a maximum of 10 per cent of the total royalties due, for each $2 paid into the fund.

8.5 Is compensation available for holders of pastoral and other specified leases?
Compensation arrangements for pastoral leases, grazing leases, timber leases and leases for the use and benefit of Aboriginal peoples are detailed in state and territory regulatory frameworks.

Petroleum titleholders should notify the lessee of proposed operations and determine the likelihood and extent of any damage to improvements, so that some mutually satisfactory arrangement can be reached.
9. Exploration and production

9.1 What do onshore gas exploration activities include?

Petroleum companies and geologists carrying out gas exploration work need to have a licence for a term stipulated by the relevant authority but will usually be between three and five years. A typical gas exploration program includes an initial phase where geologists collect data about the region. The next phase involves a closer examination of areas that appear to be geologically significant. Small areas considered to be worth exploring further may then be selected for detailed investigation, which may lead, in a small proportion of cases, to testing by drilling.

On average, a petroleum title holder’s exploration and production activities are temporary and do not take up all of the total petroleum title. In other words, a company only performs activities in part of the title, not the entire geographical extent of the title.

Potential impacts on communities or sensitive areas would trigger additional assessment processes. Land access negotiations will need to occur prior to any on-ground exploration activity.

Exploration activities include:

- **Studies and data processing**: This helps identify areas with the best potential for exploration work. Existing seismic data is processed by computers and interpreted by experts to gain extra knowledge about the rocks. There are no impacts on the community or the environment from this activity.

- **Airborne surveys**: These are carried out by fixed wing aircraft or helicopters flying approximately 300 metres above the ground. In the aircraft, computers take readings of the earth’s geophysical signals - for example, magnetism and gravity. This gives the petroleum companies information about the potential for further studies. This activity generates short-term noise but no significant impacts.

- **On-ground surveys**: There are several different types of on-ground surveys. Some use hand held instruments to take readings or small samples. The most common on-ground survey is a seismic survey. This type of survey uses trucks with vibrator pads to send small sound waves deep below the ground.

- **Exploration drilling for oil and gas**: Drilling into layers of rock can be carried out to a depth of a few hundred metres or up to more than 4 kilometres below the surface. If the exploration program finds a petroleum resource, flow testing helps to determine the composition, volume and amount of gas that can be recovered in the discovered accumulation. These results help the company decide whether the discovery has commercial potential. A drilling site covers an area about the size of a football oval and can take week(s) to several months to drill, depending on the required depth. When drilling is finished, the well is capped and sealed, then fenced off and the area rehabilitated. If the well is to be used later, a structure around two metres high - known as a Christmas Tree - will be attached to the top of the well head to allow for controlled production.

- **Obtaining a production license**: When a commercial discovery is made, the petroleum company needs to establish how best to develop the resource. The company is required to apply for a production licence. A production licence allows for the unique entitlement to production within the licence area, while separate approvals that entail comprehensive assessment are required before commercial operations can be approved. Further exploration is permitted in both the new production and the remaining title areas by the titleholder.

- **Rehabilitation**: Most lands disturbed by petroleum operations are rehabilitated once exploration work is finished. Structures are removed and the land is replanted with native vegetation. The only exceptions are drill sites that might be used in future production. These are kept and maintained until production starts.

9.2 Does exploration activity always lead to gas production?

The decision about whether to apply for a production licence usually depends on the discovery of gas or oil that can be extracted commercially - taking into account risk factors such as the ultimate recovery of petroleum, predicted flow rates, cost of development and forecast gas and oil prices.

An exploration licence gives the licence holder exclusive rights to explore for specific resources within a designated area. However, an exploration licence does not confer the right to production, and to produce requires a number of consents and approvals and the granting of a production licence.

An exploration licence only allows extended production flow tests to establish commercial viability and does not guarantee that a production license will be granted. Where oil or gas is discovered but is not yet commercially viable, a retention lease can be applied for.

Only a very small percentage of land that is subject to exploration licences ever proceeds to production licences.
10. Community consultation

The Commonwealth, states and Northern Territory governments require community consultation about planned exploration and gas production, through their regulatory frameworks. Stakeholders, including landholders, must be informed of the potential risks associated with proposed activities, and any management strategies to be put in place to minimise such risks to an acceptable level.

Consultation is carried out during the approval process, specifically through the environmental assessment process and when the Notice of Entry is provided. At this point landholders have the right to object to the production licensee’s proposed entry.

Most jurisdictions have Community Consultation Guidelines and/or specific regulatory requirements in place either at exploration and/or planning assessment or both.

11. Health and safety

Properly regulated gas operations are safe and the Australian gas industry has a strong record of compliance with health and safety regulations. The people with the highest exposure to gas are those who work in the industry. An independent epidemiology program linked with Monash University shows clearly that petroleum industry employees have better health than the general Australian community and are less likely to die of diseases such as cancer and heart and respiratory conditions. For more information, see Monash Health Watch Cohort Study.

The Gas Industry Social and Environmental Research Alliance (GISERA) newest research area focuses on reviewing current information for the purpose of designing a study to look at potential health impacts from coal seam gas activities. For more information about GISERA, see www.gisera.org.au.

The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) is participating in a National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia is examining human health and environmental risks from chemicals used in drilling and hydraulic fracturing for CSG extraction in Australia. For more information about NICNAS, see www.nicnas.gov.au.

Funded by the Australian Government’s Office of Water Science, the National Assessment is a collaboration between NICNAS, CSIRO, the Department of the Environment, and in an advisory role, Geoscience Australia.

12. Where can I find out more?

Visit your state or territory government websites for information. All states and the Northern Territory have published information about the legal and regulatory framework for unconventional gas activities for each jurisdiction, including monitoring, compliance and penalty arrangements.


Northern Territory: https://nt.gov.au/industry/mining-and-petroleum


Tasmania: www.mrt.tas.gov.au


Western Australia: www.dmp.wa.gov.au/Petroleum