



## COAG Energy Council Gas Supply Strategy

**Frequently Asked Questions about onshore gas, offshore gas and underground gas storage activities in Australia**



© Commonwealth of Australia 2020

Ownership of intellectual property rights

Unless otherwise noted, copyright (and any other intellectual property rights, if any) in this publication is owned by the Council of Australian Governments.

Creative Commons licence



Attribution CC BY

This work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/> or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

Content contained herein should be attributed as COAG Energy Council Gas Supply Strategy Collaborative Action 7 Frequently Asked Questions.

This notice excludes any logos and any material protected by trade mark or otherwise noted in the publication, from the application of the Creative Commons licence. These are all forms of property which the Council of Australian Governments cannot or usually would not license others to use.

*Cover image: Moomba gas plant Cooper Basin South Australia courtesy of Santos*

## Contents

<b>1. Natural gas</b>	<b>1</b>
1.1 What is 'natural gas'?	1
1.2 What is natural gas used for?	1
1.3 How is natural gas energy measured?	1
1.4 How is natural gas formed?	1
1.5 What is the difference between 'conventional' and 'unconventional' gas?	2
1.6 Where is natural gas found?	3
1.7 Why is onshore gas production important?	5
1.8 What is underground gas storage?	5
1.9 How is underground gas storage different to carbon capture and storage?	5
<b>2. Gas extraction methodologies</b>	<b>6</b>
2.1 How is conventional gas extracted?	6
2.2 How is unconventional gas extracted?	6
2.3 What is horizontal drilling?	6
2.4 What is hydraulic fracturing?	6
2.5 How is hydraulic fracturing managed?	8
2.6 Where has hydraulic fracturing been used in Australia?	8
2.7 What is the history of hydraulic fracturing?	8
<b>3. Chemicals</b>	<b>9</b>
3.1 What is hydraulic fracturing fluid and why is it used?	9
3.2 What are BTEX chemicals?	12
3.3 How are hydraulic fracturing fluids managed?	12
<b>4. Water</b>	<b>13</b>
4.1 How are governments involved in the management of water resources used in onshore gas activities?	13
4.2 How much water is used and abstracted in the onshore gas industry?	13
4.3 How much water is used during the hydraulic fracturing process?	13
4.4 Why is 'dewatering' required for coal seam gas extraction?	13
4.5 How does the government ensure surface water sources are not contaminated?	14
4.6 How are any underground water contamination risks managed?	14
4.7 What is 'co-produced water' and is it re-used?	15
4.8 How much salt and brine is in coal seam gas water and how is it treated?	15
4.9 Will aquifers including the Great Artesian Basin be depleted?	15

<b>5. Well integrity</b>	<b>16</b>
5.1 Why is well integrity important?	16
5.2 How reliable is cement as a long-term isolation barrier?	17
5.3 How are wells monitored for potential leaks?	18
5.4 How big is a well site area?	18
<b>6. Fugitive emissions management</b>	<b>19</b>
6.1 What are ‘fugitive emissions’?	19
6.2 What are the fugitive emissions levels from natural gas production?	19
6.3 How are fugitive emissions managed?	19
<b>7. Environmental and geological concerns</b>	<b>20</b>
7.1 How are environmental regulations applied to onshore and offshore gas activities?	20
7.2 How are environmental impacts managed?	21
7.3 Do onshore gas activities result in subsidence, and seismic events?	21
7.4 How is the environment rehabilitated?	21
<b>8. Landholder rights and dispute resolution</b>	<b>22</b>
8.1 What are landholder rights?	22
8.2 How does a petroleum company gain access to land for exploration?	22
8.3 What is a land access or compensation agreement?	22
8.4 Do landholders receive a share of petroleum royalties?	22
8.5 Is compensation available for holders of pastoral and other specified leases?	22
<b>9. Exploration and production</b>	<b>23</b>
9.1 What do natural gas exploration activities include?	23
9.2 Does exploration activity always lead to gas production?	24
<b>10. Community consultation</b>	<b>24</b>
<b>11. Health and safety</b>	<b>25</b>
<b>12. Where can I find out more?</b>	<b>26</b>
New South Wales:	26
Northern Territory:	26
Queensland	26
South Australia	26
Tasmania	26
Victoria	26
Western Australia	26
Australian Government	26

# 1. Natural gas

## 1.1 What is 'natural gas'?

Natural gas is found and produced on land ('onshore gas') and from under the ocean ('offshore gas'). It is composed predominantly of methane (CH<sub>4</sub>) with varying quantities of other inert compounds and hydrocarbons.

Australia has vast resources of natural gas found in sandstone or carbonate reservoirs and 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.

Onshore gas provides Australia with ongoing opportunities for large quantities of gas to be produced 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 natural gas, whether onshore or offshore, involves the use of leading safety, engineering and environmental standards to minimise risks and impacts.

## 1.2 What is natural gas used for?

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

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

As a chemical feedstock (raw material), natural gas provides the 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 natural 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. It is also used as a source of dispatchable power and is considered a transition fuel as carbon-constrained economies shift away from coal-fired power.

Specific products that use natural gas include agricultural fertilisers, petrochemicals, pharmaceutical products, glass manufacturing and explosives for the mining industry.

## 1.3 How is natural 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 natural gas – enough 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.

## 1.4 How is natural gas formed?

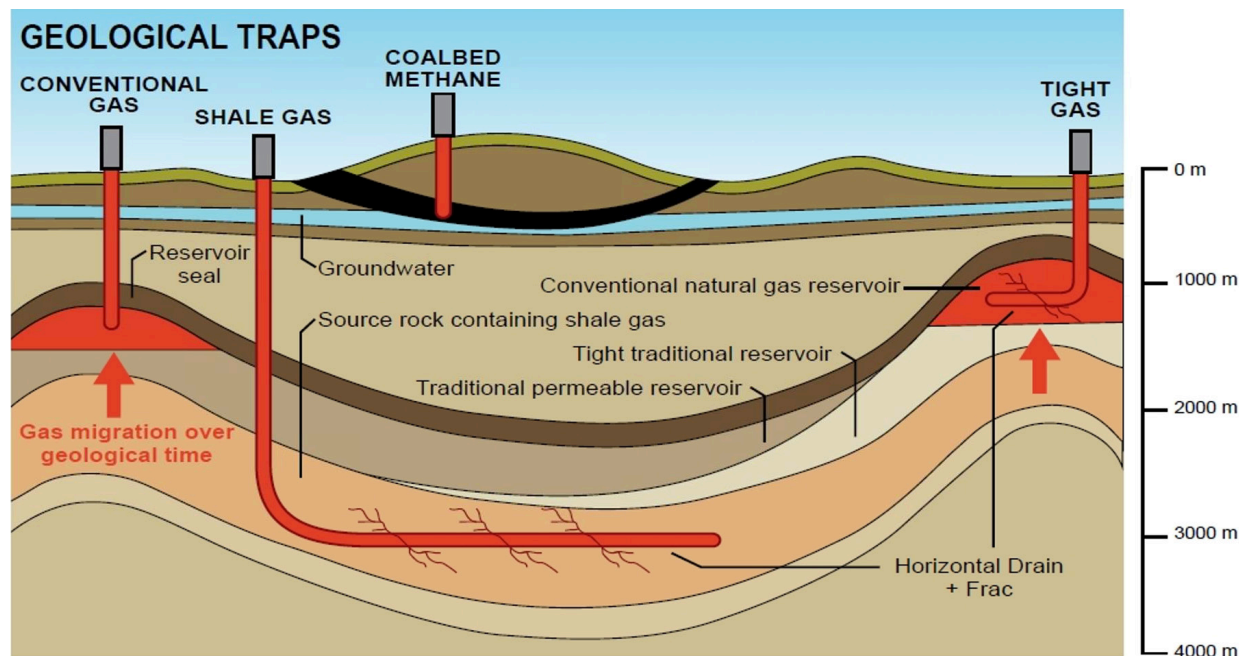
Natural gas is formed in the same way as oil. Both are hydrocarbons formed from decomposed organic matter that became buried over time – often ancient marine micro-organisms deposited over the past 550 million years, or even up to 1.4 billion years in the case of the ancient Beetaloo Sub-Basin in the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

### 1.5 What is the difference between 'conventional' and 'unconventional' gas?

The terms 'conventional' and 'unconventional' refer to the geological formations from where the gas is sourced (see Figure 1).

Figure 1: Natural gas trapped by rock formations underground in conventional and unconventional gas wells



Source: R. Raajiv Menon, *Exploration and production issues in South Asia*, *Journal of Unconventional Gas and Oil Resources*, (1 June 2014), © Elsevier, <https://www.sciencedirect.com/science/article/pii/S2213397613000177>

Conventional gas refers to natural gas that is found in large porous and permeable rock formations such as sandstone and carbonate (dolomite or limestone) and siltstones. Impermeable or solid rocks such as clay or mudstone trap or 'cap' the gas. For more information see CSIRO's [Unearthing conventional gas](#) video.

Unconventional gas refers to natural gas that is found in very low porosity and permeability rocks and requires additional extraction technologies than those used to extract conventional gas, for example dewatering of coal seams or hydraulic fracturing programs for shale and tight gas. See section 2.2 for further information. It can occur in three different types of sedimentary rocks:

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

**Coal seam gas:** 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.

*Table 1: Natural gas extraction methods for different types of rocks, depths, well types and other factors*

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

\*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 onshore (including coastal waters) production currently taking place in Queensland, New South Wales, South Australia, Victoria, Western Australia and the Northern Territory. Oil and gas reserves are also located offshore, with exploration and production activities occurring offshore of almost every state and territory (no production activity occurs offshore of Queensland).

Onshore conventional gas reserves are primarily concentrated in the Cooper and Eromanga basins in South Australia, while the largest known offshore reserves are found in waters off Victoria (Gippsland, Otway and Bass basins) and Western Australia (Carnarvon, Browse and Bonaparte basins).

Unconventional gas is primarily located onshore. 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, however its moratorium on onshore conventional gas activities will be lifted on 1 July 2021.

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)
- Galilee Basin (Qld)
- Clarence-Moreton Basin (Qld, NSW)
- Gloucester Basin (NSW)
- Gunnedah Basin (NSW)
- Officer Basin (WA, SA)
- Perth Basin (WA)
- Sydney Basin (NSW)
- Amadeus Basin (NT).

Other basins **potentially containing CSG** include:

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

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

- Arckaringa Basin (SA)
- Beetaloo Sub-Basin (NT)
- Canning Basin (WA)
- Cooper Basin (SA, Qld)
- Georgina Basin (NT, Qld)
- Greater McArthur Basin (NT)
- Isa Super-Basin (Qld)
- Onshore Perth Basin (WA)

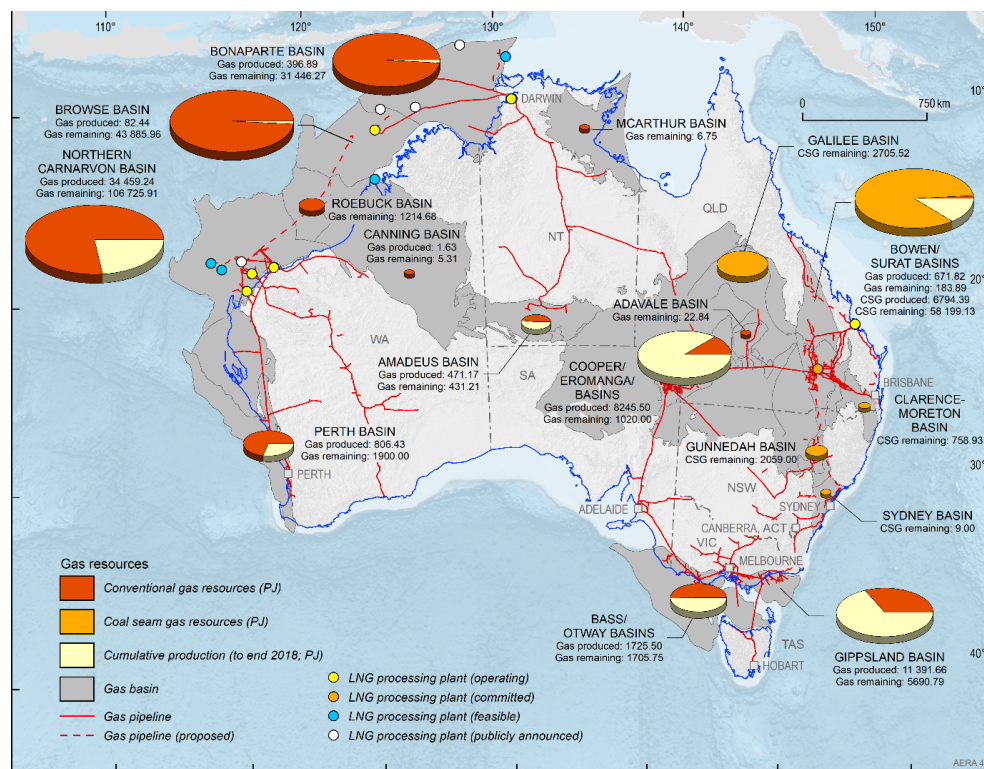
In addition, these basins have **potential shale gas prospective resources**:

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

Figure 2 illustrates Australia's identified remaining gas resources (2P plus 2C) and cumulative production for conventional and CSG gas in 2018, in petajoules (PJ). Offshore data are provided by NOPATA to year-end 2018, except for Roebuck Basin data which are sourced from Carnarvon Petroleum Ltd. (2019). Onshore data are sourced from state geological surveys (Queensland and Northern Territory), company reports, and ACCC (2020). For information about petajoules, see [Question 1.3](#): How is natural 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, where, when and how resources are developed.

*Figure 2: Location of basins where natural gas and CSG is known to occur in Australia.*



Source: Geoscience Australia, 2020.



### *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. Natural gas provides a cleaner alternative to coal and is a good source of fuel which can compliment the development of renewables. It provides a reliable energy source as it is dispatchable, meaning it will continue to provide power when renewables cannot, for example, solar does not work at night and wind does not generate power when it does not blow.

Production of natural gas generates revenue for government, creating social and economic benefits for the broader community – including jobs and regional development. Information about how much onshore and offshore gas accounts for the total energy consumed in Australia, see the [Australian Energy Statistics](#).

### *1.8 What is underground gas storage?*

Natural gas can be stored in different ways. For example, gas can be held underground in depleted reservoirs in oil and/or natural gas fields, or above ground using LNG facilities or in gas transmission pipelines. Using depleted underground gas reservoirs for storing gas means that existing wells, gathering systems, and pipeline connections can be re-used.

Keeping natural gas in underground storage means it can be held in reserve as a buffer at times when there may be peaks in demand. High demand for gas can happen in winter when people are using gas to heat their houses, or at other times when gas is needed to produce extra electricity – for example during summer heat waves.

Having reserves of natural gas that can be released easily and quickly plays an important part in ensuring Australia has a secure and reliable gas supply, and helps mitigate price peaks at times of high gas demand. There are underground natural gas storage facilities in Queensland ([Roma](#), [Silver Springs](#), [Ballera/Chookoo](#), [Newstead/Kincora](#)), South Australia ([Moomba](#)), Western Australia ([Mondarra](#) and [Turbridgi](#)) and Victoria ([Iona](#)). In Australia, underground gas storage is linked to petroleum production approvals. This means that the owner of oil and gas rights for a petroleum reservoir is also the owner of the storage rights. More information about underground (and above ground) gas storage facilities in eastern Australia is available on the [Australian Energy Market Operator's website](#).

### *1.9 How is underground gas storage different to carbon capture and storage?*

Carbon capture and storage (sometimes called carbon sequestration or carbon control and sequestration) is the process of capturing the [carbon dioxide](#) (CO<sub>2</sub>) that is released from burning [fossil fuels \(e.g. coal-fired power plants\)](#) and transporting it to a storage site (often an underground reservoir) in a way that ensures that the CO<sub>2</sub> does not enter the atmosphere and contribute to global warming.

Underground gas storage is designed to keep methane gas in reserve on a temporary basis so that it can be easily extracted and used to produce energy. Carbon capture and storage is designed to convert waste CO<sub>2</sub> into a form that can be stored underground indefinitely.

## 2. Gas extraction methodologies

### *2.1 How is conventional gas extracted?*

Conventional gas extraction is mainly applied to 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 natural 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. Conventional gas extraction does not involve dewatering and may not require hydraulic fracturing.

### *2.2 How is unconventional gas extracted?*

Unconventional gas extraction is applied to natural gas that is contained within underground formations such as coal, shale and very low-permeability sandstone and limestones. Depending on the specific characteristics, dewatering and/or hydraulic fracturing are required to extract natural gas from these reservoirs. Numerous production wells or groups of wells, often spread over many tens of square kilometres, are required to commercially exploit fields of this type.

### *2.3 What is horizontal drilling?*

Usually, the most efficient way to access the trapped natural gas is to drill horizontally so that the well follows the layer in which the natural 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 natural 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 building the angle off the well 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.

Horizontal drilling can also be used to access near shore resources from onshore which significantly reduces the costs and risks associated with offshore production. Production from the offshore Victorian Halladale-Speculant field is a recent example of this.

### *2.4 What is hydraulic fracturing?*

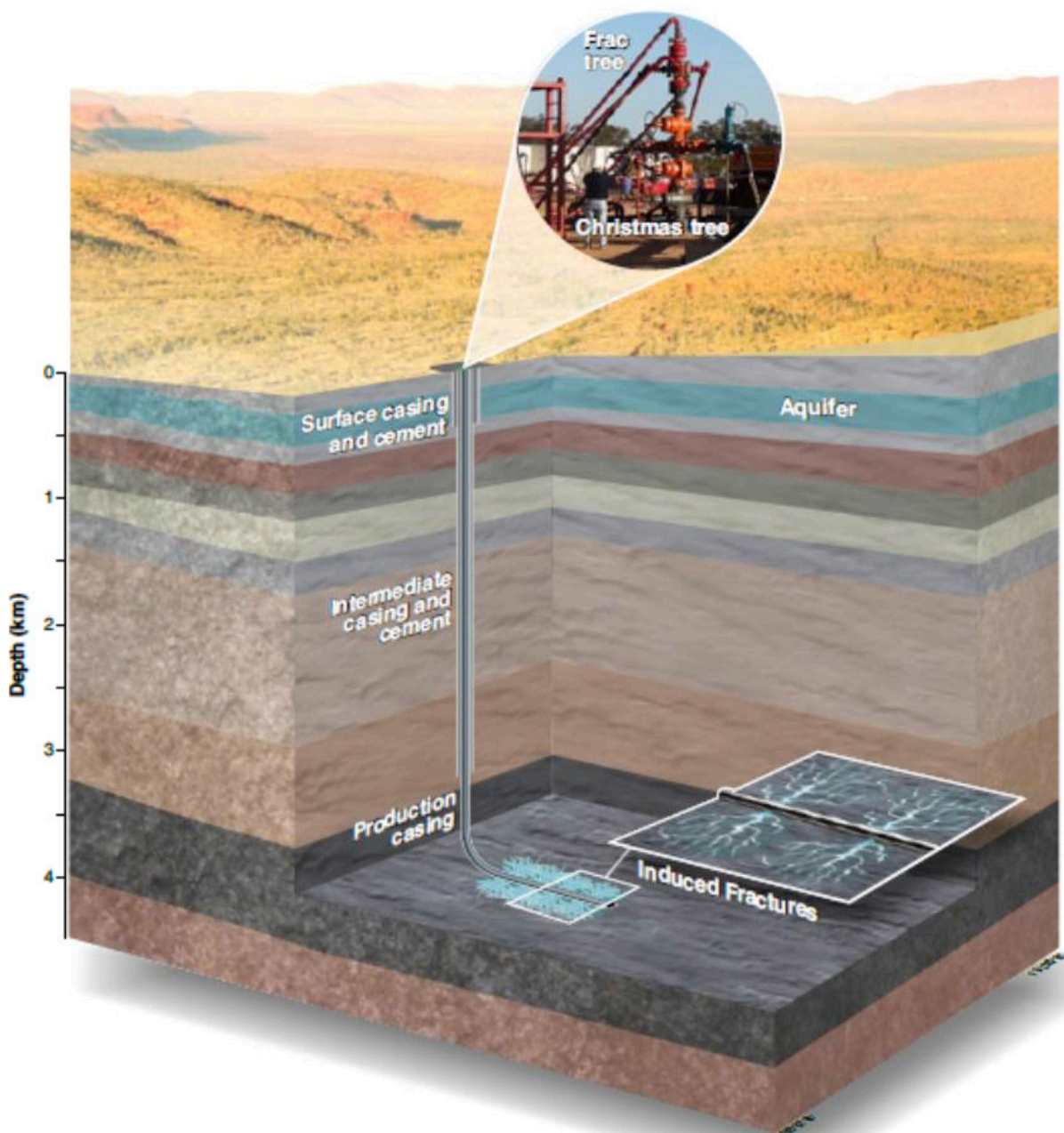
Hydraulic fracturing is sometimes referred to as 'fracture stimulation', 'fraccing' or 'fracking'. This is the method used to create or enlarge fractures and fissures in the target rock formation, to increase the flow and recovery of natural gas from hydrocarbon reservoirs. The oil and gas industry has 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 natural 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 natural 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 (an ‘aquifer’ is an underground layer of water-bearing rock), the risk of fractures intersecting the aquifer is reduced to negligible – with fractures not reaching beyond 30 – 100 metres vertically. The actual separation required varies between jurisdictions.

*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.*



Source: Western Australian Government (2015) [Guide to the Regulatory Framework for: Shale and Tight Gas in Western Australia](#)



## *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.

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 natural gas production and result in a poor commercial outcome, hydraulically fracturing the water zone is avoided. 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 natural 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 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. In Western Australia hydraulic fracturing is only permitted on approximately two per cent of the state.

## *2.7 What is the history of hydraulic fracturing?*

Hydraulic fracturing has been a commercial process in the international oil and natural 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 natural gas flow. However, advances in technology mean that higher pressures can now be used to create small fractures to release natural gas from shale and tight rocks, and also from coal seams with low permeability.

### 3. Chemicals

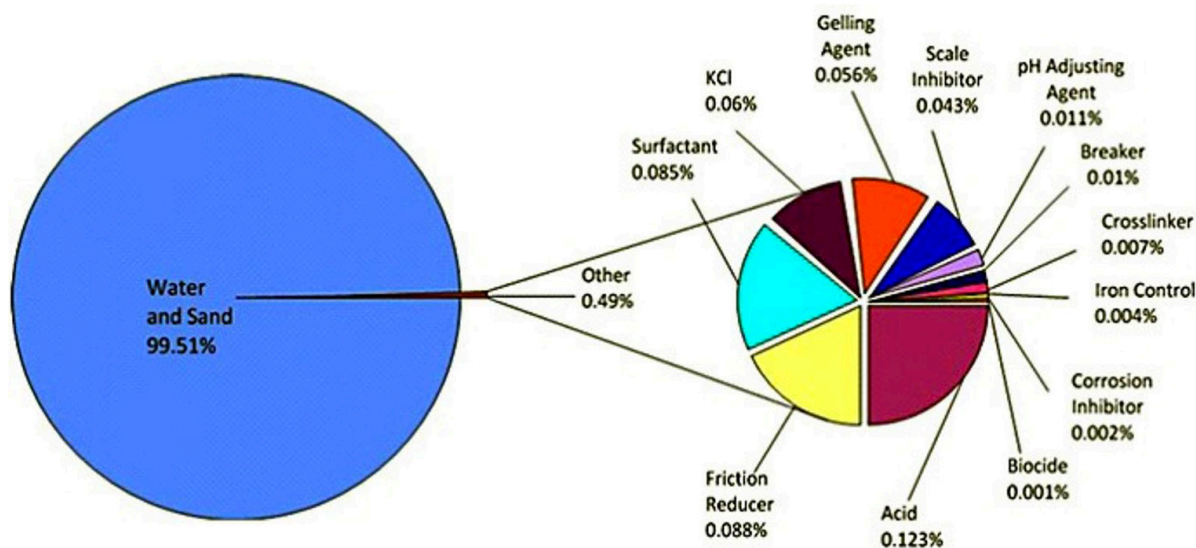
#### 3.1 What is hydraulic fracturing fluid and why is it used?

Hydraulic fracturing fluid consists of approximately 99 per cent water and proppants, such as sand, and is used to hold open fractures so that natural gas can be released. The remaining one per cent consists of 3–10 common chemical types (refer to Table 2), 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.

Figure 4: Schematic diagram with representative proportions and the purpose of different additives used in hydraulic fracturing fluid mixes



Source: [Unconventional gas in South Australia: Shale gas, tight gas, coal seam gas and regulation activities](#)

*Table 2: Chemicals and compounds used in coal seam gas hydraulic fracturing.*

*Please visit state government websites for detailed information regarding individual states*

CHEMICAL TYPE / NAME	COMMON FUNCTION	COMMON USE	PERCENTAGE VOLUME USED *
Water	Fracking / proppant suspension	Drinking, bathing, cooking	75-99
Nitrogen	Fluid weight reducer / proppant suspension	Used in cryogenic, food processing, medical	0-70
Crystalline silica (quartz)	Proppant	Cat litter, tile mortar, arts and crafts, glass, ceramic glaze, glaze, concrete, paint	0-25
Crystalline silica (cristobalite)	Proppant	Sand, gravel	0-25
Glycerine	Additive	Food and pharmaceutical industry, hair products	0-1
5-chloro-2-methyl-2h-isothiazolol-3-one	Microbial control	Used in toiletries, cosmetics, dishwashing liquids	0-1
2-methyl-2h-isothiazol-3-one	Microbial control	Used in toiletries, cosmetics, dishwashing liquids	0-1
Sodium hypochlorite	Microbial control	Disinfectant, bleach, milk production, water treatment, dental/medical, wood/deck cleaner, mildew remover	0-1
Phosphonium sulfate	Microbial control	Cooling systems, paper-making industry	0-1
C.I. pigment red 5	Microbial control	Food colouring, paints, agriculture	0-1
Potassium carbonate	Buffer, stabiliser, solvent	Soap, glass, and china production	0-1
Sodium acetate	Buffer, stabiliser, solvent	Flavouring additive in food industry	0-1
Sodium hydroxide (caustic soda)	Buffer, stabiliser, solvent	Food preparation, household drain cleaner, paper, soaps, detergents	0-1
Sodium bicarbonate	Buffer, stabiliser, solvent	Used as baking soda, cleaning, anti-pollutant	0-1
Sodium carbonate (soda ash)	Buffer, stabiliser, solvent	Water softener, swimming pools food additive (E500), glass	0-1
Hydrochloric acid (muriatic acid)	Buffer, stabiliser, solvent	Household cleaning, food additive, swimming pools, drinking water	0-1
Carbonic acid	Buffer, stabiliser, solvent	Soda drinks	0-1
Citric acid	Buffer, stabiliser, solvent	Flavour additive, biological, cleaning, pharmaceutical	0-1
Acetic acid	Buffer, stabiliser, solvent	Vinegar, found in citrus fruits, descaling agent	0-1
Carbonic acid, sodium salt	Buffer, stabiliser, solvent	Food additive	0-1
Tetrasodium ethylenediaminetetraacetate	Chelating agent	Cosmetic industry	0-1
Choline chloride	Clay management	Poultry feed additive	0-1
Potassium chloride	Clay management	Table salt substitute, medical treatments, garden products, pet supplements, hair products	0-1.5
Polydimethyldiallylammonium chloride	Clay management	Water treatment (drinking, waste-water), textiles, cosmetics, paper-making, soil treatment, drinking, bathing, cooking	0-1
Tetramethyl ammonium chloride	Clay management	Type of salt	0-1
Trimethylammonium chloride	Clay management	Dyeing	0-1
Gelatine	Corrosion inhibitor	Capsules for medicines, desserts, jellies, ice cream	0-1
Calcium chloride	Filler, stabiliser	Detergents, cosmetics, deodorant, pet products, desiccant (moisture absorber), food additive, sports drinks, pickles	0-1
Ethylene glycol	Filler, stabiliser	Anti-freeze agent, de-icing, printer inks	0-1



CHEMICAL TYPE / NAME	COMMON FUNCTION	COMMON USE	PERCENTAGE VOLUME USED *
Diatomaceous earth, calcined	Filler, stabiliser	Toothpaste, hydroponics, agriculture (grain storage), filter media (drinking water)	0-1
Magnesium silicate hydrate (talc)	Filler, stabiliser	Talcum powder, cosmetics, food additive, soaps, paper, paints, rubber, pottery	0-1
Non-crystalline silica	Filler, stabiliser	Glass, paints, coatings, fillers, plastics	0-1
Boric acid	Gel management	Cosmetics, skin care products	0-1
Triethanolamine	Gel management	Cosmetics, skin care products	0-1
Sodium tetraborate	Gel management	Component of many detergents, cosmetics, texturing agent in cooking	0-1
Vinylidene chloride/ methylacrylate	Gel management	Plastic wrap for foods	0-1
MEA borate	Crosslinker	Cosmetics, hair texturiser, hairspray, antiseptic, laundry detergent	0-1
Sodium chloride	Gel management	Food production, food additive, detergents, hair products, water softener	0-1
Hydrogen peroxide	Gel management	Hair bleach, food processing	0-1
Diammonium peroxidisulphate	Gel management	Hair bleach	0-1
Sodium thiosulfate	Gel management	Personal care, pet care, food production, aquarium/commercial aquaculture (food)	0-1
Sodium persulfate	Breaker	Hair bleach	0-1
Guar gum	Gel	Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces and salad dressing	0-1
Hemicellulase enzyme	Breaker	Food industry, washing powder	0-1
Hemicellulase enzyme carbohydrates	Breaker	Common food additive	0-1
Sodium sulfate	Gel management	Textiles	0-1
Sodium sulfite	Gel management	Paper industry	0-1
Magnesium nitrate	Clay management	Facial care, home garden uses, ceramics	0-1
Magnesium chloride	Clay management	Food industry (tofu from soy milk), magnesium health supplements	0-1
Silica gel	Clay management	Cat litter	0-1
2-Butoxyethanol	Surfactant	Home surface cleaners, jewellery cleaner	0-1
Ethanol	Surfactant	Beer, wine, spirits	0-1
Propan-2-ol	Surfactant	Solvent in cleaning fluid	0-1
C6-C10 Alcohol ethoxysulfate	Surfactant	Laundry detergent	0-1
Alcohols C6-C10 ethoxylated (surrogate C6-C12)	Surfactant	Household cleaners	0-1

\* 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?*

The BTEX group of chemicals have been a significant driver of community concern about the development of unconventional gas and the use of fracking.

BTEX refers to the chemicals benzene, toluene, ethylbenzene and xylene. 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 things like cigarette smoke, bushfires and even volcanoes. BTEX has been used in the past as an additive in fracking fluids in Australia.

BTEX chemicals may occur naturally in water sources, so in some instances, trace levels of these chemicals may be detected before hydraulic fracturing. They may on occasions also be detected at low levels in stock and irrigation water. 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 and cause a range of health impacts including skin and nose irritation, tiredness, dizziness, headache and a loss of coordination. Prolonged exposure to these compounds at higher levels is very dangerous and can cause a range of diseases including cancers. For more information, see [A short primer on benzene, toluene, ethylbenzene and xylenes \(BTEX\) in the environment and in hydraulic fracturing fluids on-line.](#)

### *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 fracking 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 fracc has been 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 policies 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 natural 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. Large scale water abstraction and use is not undertaken as part of conventional gas extraction or in shale and tight gas once hydraulic fracturing has been completed.

### *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.

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. Horizontal wells can have up to 60 stages in a 2000-metre long horizontal well in order 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 1.3](#): How is gas energy measured? The expected ultimate recovery of natural gas from shale wells in Australia has not yet been determined.

### *4.4 Why is 'dewatering' required for coal seam gas extraction?*

'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 natural gas in the seam, some of the water must be pumped out first to reduce pressure. As water production declines, natural gas production increases.

Some coal seam gas operations produce 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 surface 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 technical risk assessments to maintain separation of hydrocarbons from water resources
- best-practice well construction standards which ensure isolation of the oil and natural 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.

Monitoring is put in place to detect any possible changes in the environment as a result of operations.

#### *4.6 How are any underground water 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 natural 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 natural gas bearing formation and surrounding rock. This enables each hydraulic fracturing operation to be designed so that the hydraulic fracture is contained within the natural 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 remote monitoring to assess the potential risks of fracturing into zones above or below the natural gas bearing rock. It should be noted that even if a hydraulic fracture reaches an aquifer, any fluid would 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 natural 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 of varying quality and is treated where required to remove salts and other chemicals to ensure it meets water quality and safety standards before being reintroduced into the hydrological system.

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.

When treated, the co-produced water can be 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, co-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. It is worth noting the agriculture industry extracts and uses water (without treatment) from the same formations that provide coal seam gas. For instance 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?*

If the treatment of coal seam gas (CSG) uses desalination technologies brine results, 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.

Evaporation of brine produces 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.

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?*

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?*

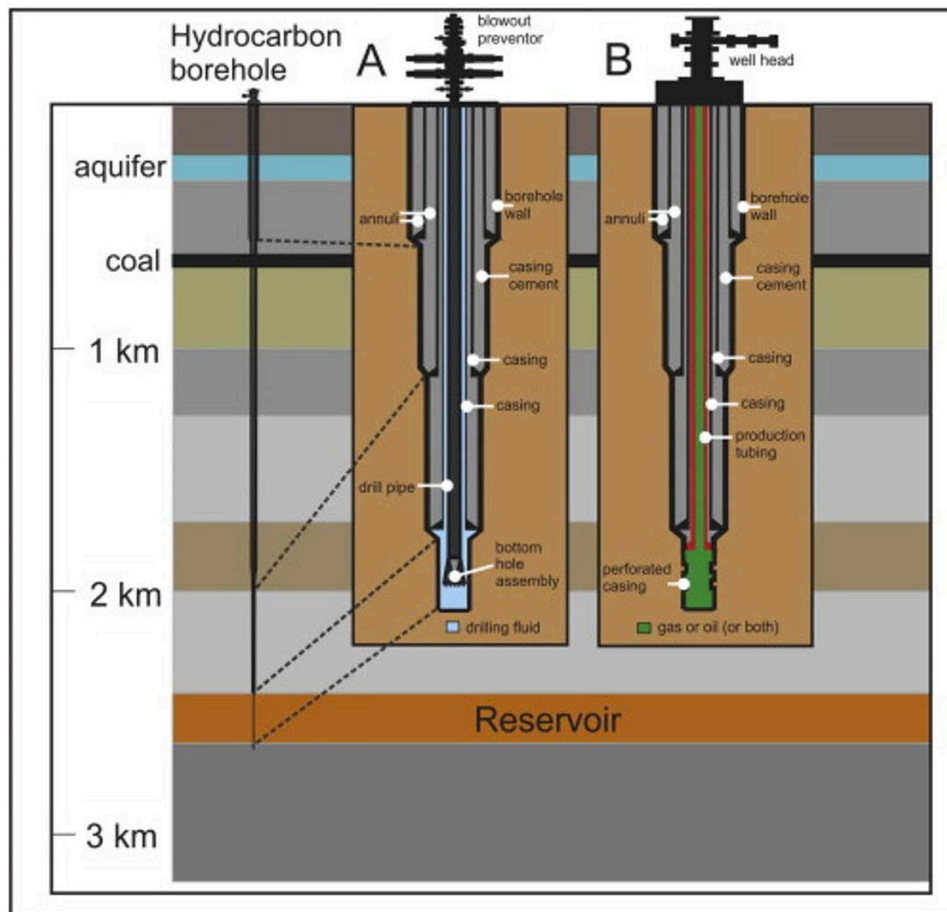
The design and integrity of the well is critical to the protection of ground and surface water. In both conventional and unconventional industries states and territories apply best-practice international standards for well design and integrity. These standards specify technical requirements through design, 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 (Refer to Figure 5). 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 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.

Figure 5: Schematic diagram showing the design of a well with multiple layers of protection between the production well and the rock



Source: RJ. Davies et al. Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation, *Marine and Petroleum Geology* 56 (2014) 239-254

## 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 natural 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.

In the year to September 2019, fugitive emissions accounted for 10.8 per cent of Australia's national inventory of greenhouse gases. For more information, see the latest [Quarterly Update of Australia's National Greenhouse Gas Inventory](#).

### 6.2 What are the fugitive emissions levels from natural gas production?

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 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 emissions.

Flaring is the practice of combusting (burning) the natural gas before it would be released to the atmosphere. Flaring should be reduced but it is preferable to venting methane.

Conventional gas extraction, particularly offshore, comes from large continuous reservoirs and typically has a smaller number of wellheads which create fewer fugitive emissions than unconventional extraction methods. As a rule of thumb, if fugitive emissions are less than 4 per cent, natural gas has lower greenhouse gas emissions when compared with coal. The CSIRO has a range of programmes underway using measuring, monitoring and lifecycle analysis to build a comprehensive picture of natural and fugitive emissions. For more information see CSIRO's [What does science tell us about fugitive emissions from unconventional gas?](#) factsheet and [GISERA's greenhouse gas and air quality research](#) webpage.

### 6.3 How are fugitive emissions managed?

Fugitive emissions from improperly sealed wells, leaking well heads or flaring and 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.
- Some state and territories require petroleum companies to seek approval before flaring and venting of gas
- Ongoing monitoring of greenhouse gas emissions.

## 7. Environmental and geological concerns

### *7.1 How are environmental regulations applied to onshore and offshore 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
- ongoing regulatory monitoring.

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.

The Australian government also regulates occupational health and safety (OHS), well integrity and environmental management of offshore petroleum exploration and development (beyond three nautical miles offshore) through the [Offshore Petroleum and Greenhouse Gas Storage Act 2006 \(OPGGGS Act\)](#). In Commonwealth waters, the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) is the national regulator. No offshore petroleum activity can occur without a valid environment plan in place. Activities accepted by NOPSEMA are deemed by the Minister for the Environment and Energy to have been accepted under the EPBC Act, under a class approval.

In coastal waters (the first three nautical miles from the coastline), the states and the Northern Territory are responsible for environmental regulation; and the EPBC Act also applies. Under the Offshore Constitutional Settlement, the Commonwealth, the States and the Northern Territory have agreed to align regulation around the exploration and extraction of offshore petroleum.

## 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.

Offshore oil and gas companies must also manage their activities' environmental impacts and risks to a level deemed as low as reasonably practicable, and acceptable. The [Offshore Petroleum and Greenhouse Gas Storage \(Environment\) Regulations 2009](#) (the Environment Regulations) outline environment plan requirements. The Environment Regulations seek to ensure that every offshore petroleum activity in Commonwealth waters is carried out in a manner:

- consistent with the principles of ecologically sustainable development
- such that the environmental impacts and risks of the activity will be acceptable and reduced to as low as reasonably practicable (ALARP).

## 7.3 Do onshore gas activities result in subsidence or seismic events?

A common concern associated with hydraulic fracturing is that it will cause land subsidence or seismic events. Research has shown that 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 hydraulic fracturing 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 such as in New South Wales where petroleum producers are encouraged to contribute to a 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. Western Australia's Royalties for Regions sets aside 25 per cent of the state's mining and petroleum royalty revenue, with a cap of \$1 billion, for rural areas.

### *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 natural gas exploration activities include?*

Petroleum companies carrying out natural gas exploration work need to have a licence for a term stipulated by the relevant authority. This licence term will usually be between three and six years. A typical natural 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 onsite activities will be concentrated on geologically significant parts of the 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.
- **Offshore seismic surveys:** In offshore operations, a vessel tows a “seismic streamer”, or a collection of cables with seismic sources and hydrophones attached. The seismic sources use compressed air to produce acoustic energy. The reflected sound waves are then measured by the hydrophones in the cable and the data is analysed to produce a geological picture of the subsurface.
- **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.
  - Onshore, a drilling site covers an area around 100m x 100m (one hectare), depending on the need for storage of equipment and supplies 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.
  - Offshore the size of a drilling site will alter depending on the water depths, which will affect the type of rig used to undertake drilling operations. When drilling is finished the well will be plugged and abandoned if unsuccessful, suspended with a cement plug if further testing is needed or a Christmas Tree is attached if it will shift to production.
- **Obtaining a production licence:** 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**

Most jurisdictions have community consultation guidelines and/or specific regulatory requirements in place either at exploration and/or planning assessment or both.

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.

Offshore, under the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009*, a titleholder is required to consult with 'relevant persons' throughout the planning, decision making and implementation stages of a petroleum activity within Commonwealth waters. A relevant person includes any person whose functions, interests or activities may be affected by the proposed offshore petroleum activity.

Offshore project proposals (OPP) are subject to a minimum 4-week period of public comment as part of the assessment process, providing transparency and an opportunity for members of the public to comment on the project. Proponents of an OPP must consider the comments received, make modifications to their project if required and submit a final copy of the proposal to NOPSEMA for assessment.

## 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](#).

Australia's offshore oil and gas health and safety regulatory regime aims to:

- protect the personal safety of workers
- prevent major accidents from happening

The occupational, health and safety (OHS) regime for offshore petroleum operations is outlined in the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGGS Act) and its associated regulations. Schedule 3 imposes duties on the operator of a facility, who must take all reasonably practicable steps to protect the health and safety of the facility workforce and of any other persons who may be affected. It also imposes duties on a range of other parties including employers, manufacturers and the workforce.

Oil and gas companies must prepare a safety case demonstrating how they'll manage risks to ensure their offshore activities are safe. More information on safety cases and health and safety requirements is available on the [NOPSEMA website](#).

The CSIRO Gas Industry Social and Environmental Research Alliance (GISERA) newest research area focuses on potential health impacts from coal seam gas activities in the southern Surat Basin, Queensland. For more information about GISERA health research, see <https://gisera.csiro.au/research/health/>.

The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) participated in a National Assessment of Chemicals Associated with Coal Seam Gas Extraction in Australia which examined 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](http://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 Australian, state or territory government websites for information. All states and the Northern Territory have published information about the legal and regulatory framework for natural gas activities for each jurisdiction, including monitoring, compliance and penalty arrangements.

### *New South Wales*

[www.resourcesandenergy.nsw.gov.au/miners-and-explorers/codes-and-guidelines/guidelines](http://www.resourcesandenergy.nsw.gov.au/miners-and-explorers/codes-and-guidelines/guidelines)

### *Northern Territory*

<https://nt.gov.au/industry/mining-and-petroleum>

<https://hydraulicfracturing.nt.gov.au/implementation-plan>

### *Queensland*

[www.business.qld.gov.au/industries/mining-energy-water/resources](http://www.business.qld.gov.au/industries/mining-energy-water/resources)

[www.des.qld.gov.au](http://www.des.qld.gov.au)

### *South Australia*

<http://www.petroleum.statedevelopment.sa.gov.au/>

### *Tasmania*

[www.mrt.tas.gov.au](http://www.mrt.tas.gov.au)

### *Victoria*

<http://earthresources.vic.gov.au/earth-resources/victorias-earth-resources/petroleum>

### *Western Australia*

<http://www.dmirs.wa.gov.au>

### *Australian Government*

<https://www.industry.gov.au/regulation-and-standards/offshore-oil-and-gas-in-australian-waters>

<https://www.nopsema.gov.au/>

<http://www.environment.gov.au/>

CSIRO Gas Industry Social and Environmental Research Alliance (GISERA) research is currently underway in Queensland, New South Wales, South Australia and Northern Territory. Research topics include:

- agricultural land management
- greenhouse gas and air quality
- health impacts
- marine environment
- social and economic impacts and opportunities
- surface and groundwater
- terrestrial biodiversity.

All GISERA reports, fact sheets, videos and other information are published on the CSIRO GISERA website <https://gisera.csiro.au/>.



