Australian Government
Department of the Environment and Energy
Bureau of Meteorology
Geoscience Australia

BIOREGIONAL ASSESSMENTS

CSIRO

Factsheet: Unconventional Gas

What is Unconventional Gas?

It's not the gas that's unconventional.

It's how that gas occurs in the subsurface and the methods used to extract it that make it 'unconventional gas'.

Coal seam gas (CSG), shale gas and tight gas all belong to a family of gas resources called unconventional gas (Figure 1). CSG, shale and tight gas are all forms of natural gas that occur in different geological settings and at different depths below the surface (Figure 2). Natural gas is composed mostly of methane. This composition does not fundamentally change, regardless of whether the gas has been extracted from an unconventional or a conventional reservoir.

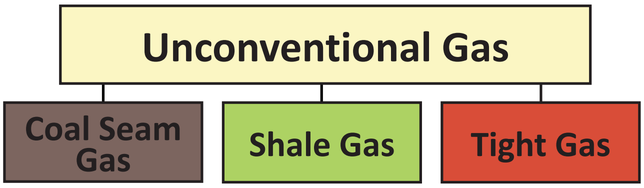


Figure 1: The unconventional gas family

Types of Unconventional Gas

Coal Seam Gas

Coal is an organic-rich sedimentary rock, containing 50% to 100% organic carbon. During the process where organic matter is transformed into coal (coalification), this carbon is converted to natural gas that becomes trapped in the coal seam, absorbed into minute holes in the coal's surface called micropores, or held within the coal's natural fracture network, called cleats. The large surface area to volume ratio of coals allows storage of up to seven times more gas as the same volume of rock in a conventional gas reservoir.

CSG is typically found in coal that is 300 to 1200 metres[2] below the surface (Figure 2). The gas is held in place by the pressure of the surrounding water and rock, known as hydrostatic and lithostatic pressure respectively. To extract the gas, wells are drilled into the coal seam and the hydrostatic pressure is reduced by removing some of the water (dewatering or depressurisation stage) (Figure 3). When sufficient water (produced water) has been removed, the gas begins to flow. Gas production

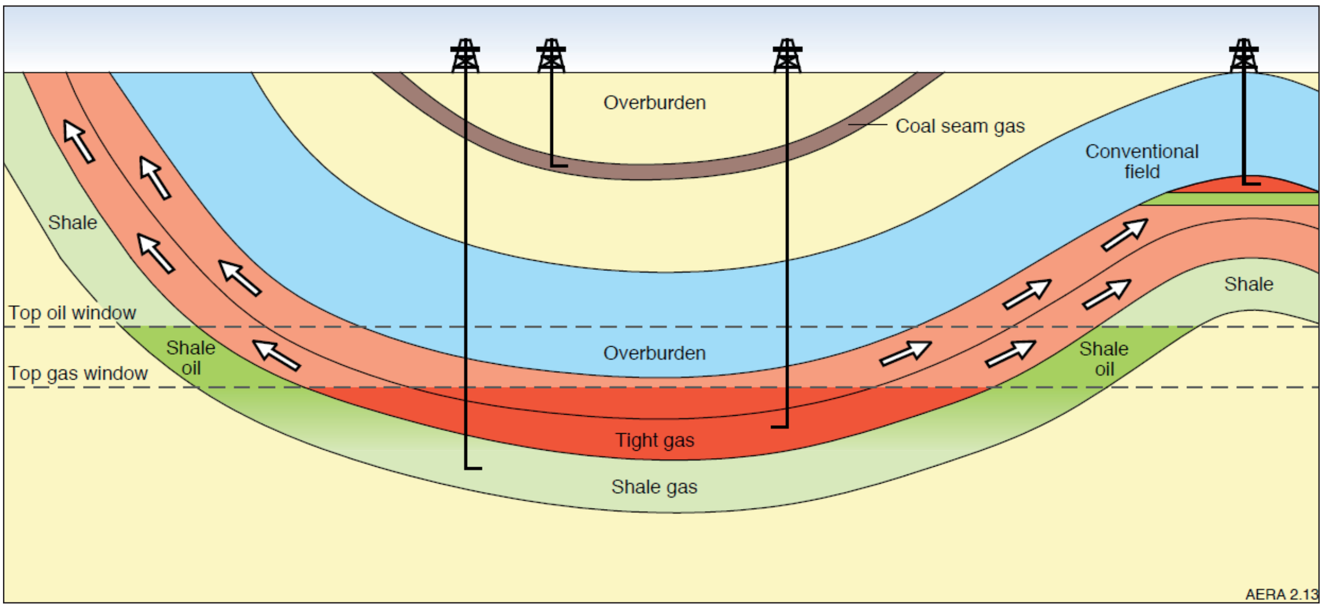
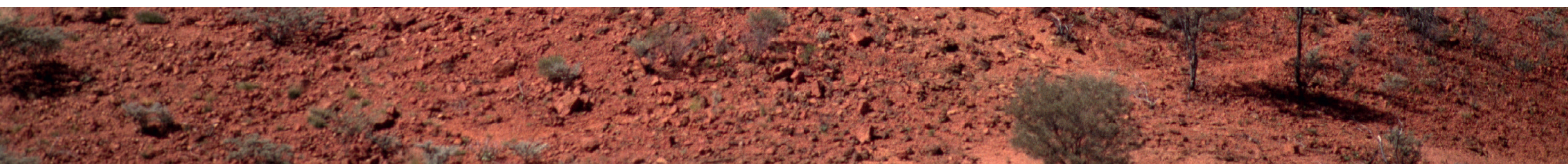


Figure 2: Conceptual diagram of conventional and unconventional natural gas reservoirs



peaks during the production stage, which is followed by a long period of slow decline. Some coals are very wet i.e. they produce large quantities of water before producing gas. Others can be drier, producing much less water before the gas flows. Some coal seams require hydraulic fracturing (fracking) to enable the flow of gas. Hydraulic fracturing is a process where fractures are opened or enhanced by pumping fluids and proppants (usually sand, but may be another material), at high pressure into the rock.

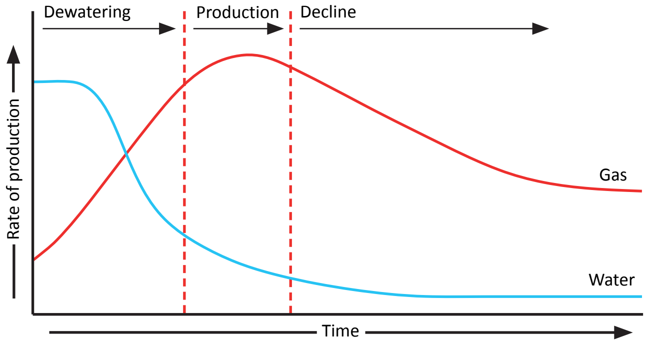


Figure 3: Typical water and gas production for a CSG well

In some circumstances, deep coal seams (greater than 1500 metres), can also be reservoirs where gas is generated and stored. Unlike CSG, these 'deep coal gas plays' often do not require dewatering and the gas is extracted using methods similar to those used for shale gas production.

Shale Gas

Shale is a fine-grained sedimentary rock that can contain between 10% and 50% organic carbon. During the rocks' formation, the organic matter is converted to natural gas and remains trapped within the shale (shale gas).

Shale gas typically occurs in rocks at depths greater than 1500 metres[2] (Figure 2). In shale, the gas can be either absorbed onto the surface of organic material or be stored as free gas in pore spaces in the rock. Shale gas reservoirs have very low porosity and permeability and the entire petroleum system is contained within the rock unit. Shale gas reservoirs require hydraulic fracturing to create pathways through which gas can flow into the well.

Tight Gas

Gas that occurs in sandstone and limestone reservoirs which have low permeability and low porosity is called 'tight gas'. The source of the gas may or may not be from the same rock, i.e. the gas can migrate over relatively short distances into adjacent rock units. Like shale gas, tight gas reservoirs typically occur deeper in the subsurface than CSG (Figure 2). Tight gas reservoirs require some form of stimulation to encourage gas flow. Typically hydraulic fracturing is used.

Conventional vs Unconventional Reservoirs

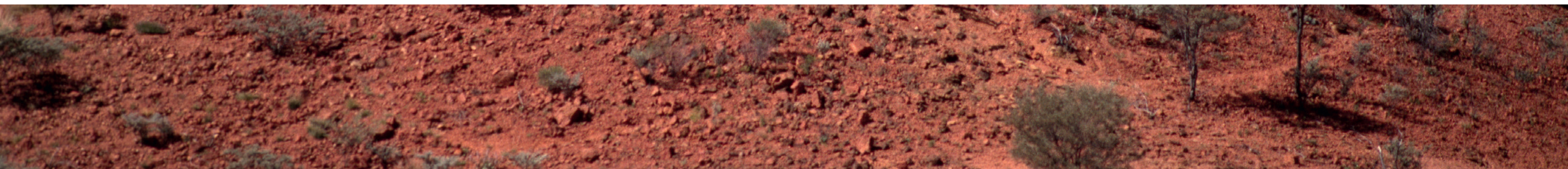
Unlike conventional gas accumulations, where the gas moves relatively easily through the rocks and is concentrated in localised, discrete traps; unconventional gas accumulations are regional and the gas is widely dispersed throughout a low porosity, low permeability reservoir.

Commercial extraction of unconventional gas is fundamentally technology driven. These regional, low porosity and permeability accumulations require: (1) significantly more extraction wells than for a conventional accumulation; (2) the application of specialised drilling methods (e.g. horizontal drilling); and (3) usually, some form of stimulation to enable the gas to flow. Production from unconventional wells can also be unpredictable and is generally several orders of magnitude less than that for a conventional well.

Therefore, unpredictable and low production rates coupled with gas that is widely dispersed in low porosity and permeability reservoirs mean that unconventional gas production is relatively costly. To be commercial, unconventional gas fields need to be large and are many hundreds of square kilometres larger than conventional fields (Figure 2). A comparison of the complexity of unconventional versus conventional reservoirs is summarised by the resources pyramid presented in Figure 4.

Potential risks to water resources

Unconventional gas exploration and production activities could impact water resources (Figure 5). Most risks are associated with water extraction and hydraulic fracturing processes and can be categorised as follows: materials handling, water-use conflicts, well integrity and connectivity. The possible impacts on water resources



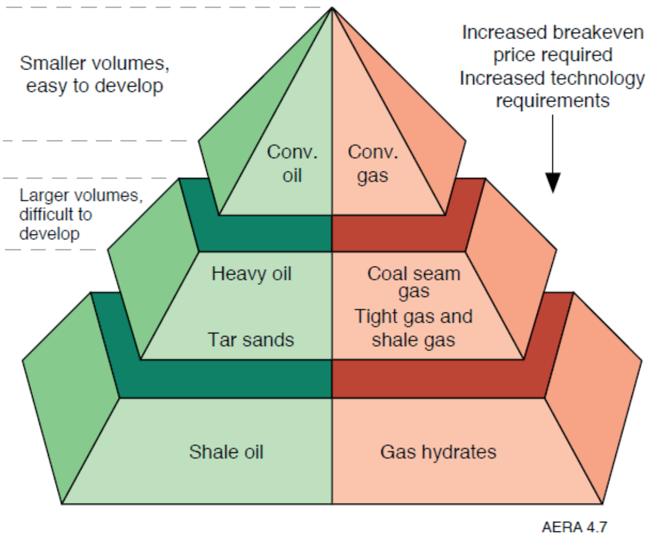


Figure 4: The petroleum resources pyramid. © Commonwealth of Australia (Geoscience Australia) 2014, adapted from McCabe 1998 and Branan 2008.

posed by unconventional gas operations are shown in Figure 5:

1. Poor storage and/or handling practices resulting in leakage or spills where raw chemicals and/or flowback fluid (fluid that flows from a well following a hydraulic fracturing treatment) leach into the ground and could potentially reach shallow groundwater (materials handling).

2. Poor storage and/or handling practices resulting in leakage or spills where raw chemicals and/or flowback fluid flows into water storages, streams or rivers (materials handling).

3. Impact on local water resources through water extraction for use in hydraulic fracturing operations (water-use conflicts).

4. Drawdown of productive aquifers due to the depressurisation of target formations - limited to CSG operations (interconnectivity and water-use conflicts).

5. Contamination of groundwater due to well failure issues (well integrity). These risks are generally considered to be low during exploration, production and decommissioning.

6. Where a reservoir and aquifers are in close proximity (more likely in CSG than shale and tight gas operations), fractures created by hydraulic fracturing processes may provide a pathway to surrounding aquifers for fracturing fluids (increased connectivity).

7. If an open fault intersects an aquifer, it could act as a conduit enabling flow of fracturing fluids to an aquifer during hydraulic fracturing operations or drawdown groundwater during production (connectivity).

While these risks may be amplified by the number of wells required for commercial production, many also diminish with depth. Best practice operation aims to either avoid or manage and mitigate impacts.

The potential impacts of unconventional gas projects are managed by the relevant State and Territory government through legislation and regulation. Where actions have, or are likely to have, a significant impact on a Matter of National Environmental Significance (MNES) the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) applies. Under the EPBC Act, water resources are a matter of national environmental significance in relation to coal seam gas and large coal mining development (the 'water trigger'). This allows the impacts of proposed coal seam gas and large coal mining developments on water resources to be comprehensively assessed at a national level. Whilst the 'water trigger' does not apply to other sources of unconventional gas,

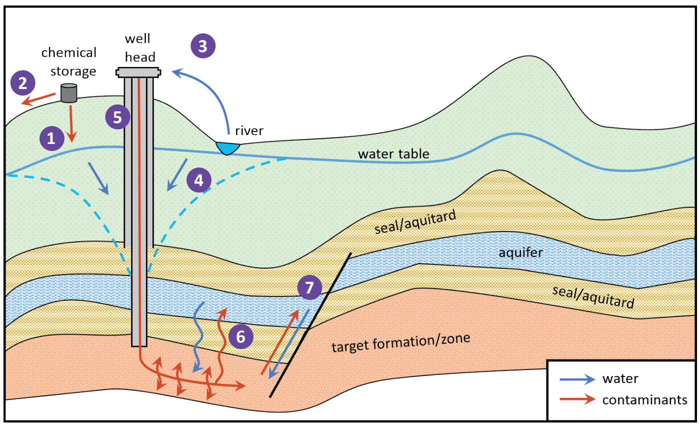


Figure 5: Potential impacts to water resources posed by unconventional gas operations can be broadly categorised as materials handling (1 & 2), water-use conflicts (3 & 4), well integrity (5) and connectivity (6 & 7).

proponents should consider whether the water related impacts of their action will have or is likely to have a significant impact on other MNES (e.g. Ramsar wetlands, important habitat for listed threatened species and communities). Further information on the requirements of the EPBC Act is available at http://www.environment.gov.au/protection/environment-assessments.

Background

Petroleum Systems

Petroleum systems comprise the following elements:

- Source rocks – rocks rich in organic matter where the oil and gas is formed.
- Reservoir rocks – rocks where oil and gas can be stored. Conventional reservoirs have high porosity and permeability, while unconventional reservoirs have low porosity and permeability.
- Seal rocks – rocks that are impermeable and are barriers to the migration of oil and gas.

For conventional gas accumulations, the gas forms in a source rock, then migrates over a distance through a carrier bed, to a reservoir where it is captured and concentrated in discrete geological structures (traps) and held in place by a seal. For some unconventional gas types, CSG and shale gas, all of the petroleum system elements (source, reservoir and seal) occur in the same rock unit.

Porosity and Permeability

Porosity and permeability are properties of rocks relating to how gas and fluids are stored and move. Porosity is a measure of the pore space within a rock and is normally expressed as a percentage of the total rock volume that is taken up by pore space. Permeability is a measure of how easily fluids or gasses move through a rock. If a gas or liquid moves easily, then the rock is said to have high permeability. If there is resistance to flow, then the rock has low permeability. Conventional reservoirs have relatively high porosity and permeability i.e. gas and fluids move relatively easily through the rock,

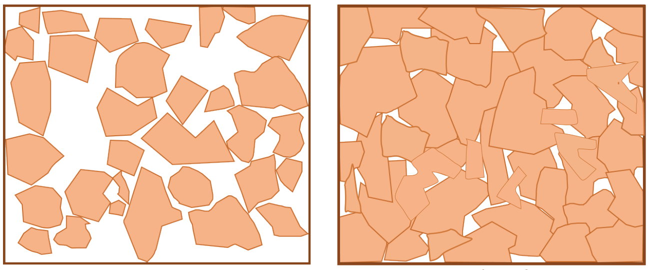


Figure 6: Porosity and permeability in conventional gas and unconventional gas reservoirs.

while unconventional reservoirs have low porosity and permeability, the movement of gas and fluids is restricted, and therefore they are often referred to as being 'tight' (Figure 6).

References

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3. The Scientific Inquiry into Hydraulic Fracturing in the Northern Territory 2018. Final Report. Available from: https://frackinginquiry.nt.gov.au/inquiry-reports (12/07/2018)