The development of Australia’s coal seam gas resources

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Introduction

The aim of this Background Note is to outline recent developments in this increasingly important part of Australia’s energy sector. The Note is primarily about the extent of this resource and its development (including some environmental matters related to this) but it does not cover the details or controversies relating to how and where it is developed.

Coal seam gas (CSG) occurs naturally, in varying quantities, in coal seams. It consists mainly of methane (CH$_4$) – hence its other name of coal bed methane (CBM). Methane burns well in air, and thus can be used as fuel.

Gases in coal seams are formed during the long geological process of coal formation (coalification) when organic matter is converted into coal. The gas accumulates underground, held within the cleats (natural fractures) and pores of the coal itself. Not all coal seams contain useful quantities of methane. In some cases, the coal gas may consist mainly of carbon dioxide (CO$_2$), or it may contain poisonous carbon monoxide (CO), or nitrogen. There may also be quantities of hydrocarbon gases other than methane (for example, ethane, propane, butane).

When methane is released as a side-effect of coal-mining operations it is called coal mine methane (CMM) and is usually vented to the air (although in particular cases it can be captured and used as an energy source). It used to be considered a nuisance that hindered coal mining as it was responsible for serious coal mine fires and explosions in earlier years. CMM nowadays is much more effectively managed using methods such as methane drainage, in association with mining activities.

Coal seam methane is identical to “natural gas” (also methane) associated with traditional oil and gas fields, but its exploitation and use is a relatively new phenomenon. Until recently, the natural gas or methane used in Australia and elsewhere was nearly all supplied from reservoir gas—that is, ‘conventional gas’ that occurs in underground porous sedimentary rock reservoirs (gas fields) rather than in coal seams. But coal seam gas, just like conventional gas, can be used to power water and space heating for industrial, commercial and domestic users, as well as in gas turbines to generate electricity. Thus, the coal seams are merely a new source for an old and valued fuel.

The Eastern Australian natural gas market has for some time been supplied from the Cooper/Eromanga oil and gas fields in central Australia and the Gippsland Basin located offshore from south-east Victoria. While some new, but small, oil and gas fields have been developed in offshore Victoria, and some additions to the central Australian gas fields have been found, the consensus is that these fields are slowly depleting and will be unable to supply the growing Eastern Australian gas market well into the future.

The development of the coal seam gas deposits in Queensland and New South Wales associated with the coal fields will not only enable the supply of natural gas for the growing Eastern Australian

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market but also enable the establishment of major export liquefied natural gas (LNG) industries, providing an impetus to employment, infrastructure investment and Australia’s exports.

It should be noted that as well as pumping out the methane from a coal seam, another method for extracting the gas involves *in situ* combustion of the coal seam and any included methane to form ‘syngas’, which can be used to generate electricity at the surface. This technology, known as “underground coal gasification”, is at a less advanced stage in Australia, with a 5MW facility undergoing development and demonstration near Dalby in Queensland. It offers the potential to extract energy from coal seams that are too deep to mine economically. As this technology represents a different set of technical and environmental challenges to those of coal seam gas, and the timeline for commercial large-scale development is probably a decade or more away, underground coal gasification is not included in the scope of this paper.

**Coal seam gas uses**

CSG is similar to conventional natural gas and is used to power water and space heating for industrial, commercial, and domestic users along with fuel for stoves as well as industrial facilities and gas turbines to generate electricity.

**Coal seam gas recovery**

CSG of commercial interest comprises mostly methane gas formed within coal seams that are usually saturated with water. The gas is not pure and is usually mixed with other gases, as mentioned above. Economic viability will depend on the concentration of methane in the gas mix, together with other aspects, such as the ease with which the gas can be extracted. These factors relate to the tectonic and structural setting of the coal seams together with their permeability and the associated hydrology. The underground water pressure holds the methane which is adsorbed to the coal along natural fractures and cleats. CSG is extracted by means of wells that are drilled down into and (in some cases) along the coal seams. When water is pumped out of the coal seams the confining pressure is reduced, leading to desorption of the gas so that it can be collected. Compressors are usually used to push released gas to a central gas processing facility where it is dried and/or compressed as necessary for transportation along a high pressure transmission pipeline for delivery to energy markets.

In cases where recovery is slow because the gas is tightly held within the coal seam, the method of hydraulic fracturing (fracturing) is undertaken. This process involves high pressure injection of a sand/water slurry—including in some cases a range of chemicals—into the coal seam to fracture the rock and hold the fractures open, thus releasing the gas. Some of the chemicals used in the extraction are potentially toxic. One mixture often used in fracturing is BTEX—a combination of

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benzene, toluene, ethylbenzene and xylene. Other chemicals, however, may be used, such as sodium hypochlorite and hydrochloric acid, cellulose, acetic acid and disinfectants.⁴

### Coal seam gas production

There has been very strong growth in the Australian CSG sector. Production in 1995 was zero and this had only increased to some 20 petajoules (PJ) by 2003.

| Note: A petajoule (PJ) is a unit of energy and is equivalent to 10¹⁵ joules. A megajoule (MJ) is equivalent to 10⁶ joules. For comparative purposes one kilowatt hour is equivalent to 3.6 MJ. Hence 1PJ is equivalent to around 278 million kWh. An average household would use in the order of 8 000 to 10 000 kWh of electricity per year. |

But in the next five years, a large expansion in CSG occurred. According to figures released by Geoscience Australia, total Australian CSG production in 2008 rose to about 138.5 PJ, of which 133.2 PJ came from Queensland and 5.3 PJ from New South Wales. CSG provided about 60 per cent of the Queensland total.⁵ While these CSG numbers are still relatively small in terms of national consumption (Australia’s total natural gas consumption in 2007–08 amounted to 1 249 PJ of which over 40 per cent occurred in Western Australia), the rate of growth is strong. With rapid increases in the delineation of CSG reserves and resources, production is projected to increase substantially.

**Australia Pacific LNG** (a joint venture between Origin Energy and ConocoPhillips) is presently the leading producer of CSG in Australia and holds the country’s largest CSG reserves.⁷ During 2008–09, the company produced 71 petajoule-equivalent (PJe) of CSG. Production capacity at the end of 2010 is estimated at 350 TJ per day—which is 128 PJ per annum. The **Spring Gully** gas production facility belonging to the company continued to be developed during the year, while the **Talinga Stage 2** gas production facility was commissioned in early 2010.⁸ Australia Pacific LNG also has interests in producing projects operated by others in the Bowen and Surat basins.⁹

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This growth in production capacity reflects the strength of exploration activity and infrastructure development—over the last 15 years the number of coal seam gas wells drilled in Queensland increased from 10 per year in the early 1990s to a record high of 735 in 2008–09. More than 4 000 kilometres of gas transmission pipelines have been constructed, with additional links to markets interstate and for the supply of gas to proposed Gladstone LNG plants.

As well as supplying the domestic market, Australia Pacific LNG has plans to export some of its CSG production via a proposed LNG plant at Gladstone.

CSG reserves and resources

The coal basins of Queensland and New South Wales—the Surat, Bowen and Galilee basins in Queensland and the Gunnedah, Gloucester and Sydney basins in New South Wales—cover extensive areas of Eastern Queensland and New South Wales and have associated CSG. The economic accumulations of CSG outlined to date cover only small parts of these basins, but as exploration continues it is probable that economic CSG reserves will be relatively widespread.

Figure 1: The Queensland and New South Wales coal fields

As at December 2008 the proven and probable (2P) reserves of CSG in Australia were 16 179 PJ, a 116 per cent increase over 2007. The life of these reserves is more than a hundred times greater.
than the current rates of production. Queensland presently has 15 302 PJ (or 94.6 per cent) of total 2P reserves with the remaining 5.4 per cent of 2P reserves in New South Wales. 10

**Environmental aspects**

Methane as an energy source has significant environmental benefits over both coal and oil in terms of lower greenhouse gas and other emissions and as a cleaner-burning source of energy. These aspects are of considerable advantage in its further promotion, and in particular for coal seam gas in Eastern Australia. Furthermore, the use of the methane, rather than merely venting it to the air, offers an additional greenhouse benefit. This is because methane is a far more powerful greenhouse gas than carbon dioxide (CO₂). A molecule of methane has a global warming potential that is about 23 times that of a CO₂ molecule. If coal seam methane were vented to the air, this would be a worse greenhouse outcome than collecting the gas and using it for combustion (even though that combustion produces CO₂).

The Queensland Government is encouraging a transition from coal to gas, as an effective mechanism to reduce greenhouse gas emissions. The Queensland Government’s [Smart Energy Policy](http://www.dme.qld.gov.au/Energy/energy_policy.cfm) requires that by 2010, 15 per cent of all electricity sold in Queensland is to be sourced from gas-fired generation. 11 This requirement may be increased to 18 per cent by 2020.

As with any resource development, the extraction of coal seam gas can have environmental impacts. There are three aspects of coal seam gas production which need to be managed carefully to avoid potentially significant environmental impacts. These are:

1. copious amounts of water by-product with the pumping of water from the coal seams;
2. the process of hydraulic fracturing to extract tightly held gas in the production process; and
3. leakage of methane gas during production and transportation.

The ramifications and impacts from multiple developments in the same area also need to be considered.

**Production water**

Water is produced as a by-product of gas extraction. Any beneficial reuse depends on a number of factors including its quality, cost of treatment required and pipeline infrastructure. Water of suitable quality can be used for town water, aquaculture, recharging aquifers, wetlands, recreational lakes or at mining operations and power stations, and recent practice has been for poor quality water to be contained in storage ponds. 12 However, concerns about the potential environmental impacts posed by poor quality or contaminated production water, abetted by claims of land and stream pollution and impacts on livestock health arising

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10. Geoscience Australia (GA), op. cit., p. 22.
from contaminated production water from shale gas extraction wells in the USA, have led the Queensland Government to amend the Environmental Protection Act 1994 to limit construction of evaporation ponds for production water wherever possible. Best practice would involve approaches such as water treatment to enable beneficial use, re-use of the water in the gas extraction project, or injecting saline water into poor quality aquifers.

Hydraulic fracturing ("fracking")

Claims in the USA of significant contamination of surface water and aquifers resulting from hydraulic fracturing of shale gas, and subsequent impacts on human and animal health, have resulted in concerns that similar risks may arise in Australia from hydraulic fracturing during the production of CSG. The fracking fluids used in shale gas extraction commonly contain chemicals known to have significant impacts on human health such as carcinogens and endocrine disruptors. However, gas in coal seams is usually released more readily than gas in shale, so that the technique required is essentially a physical process involving the reduction of water pressure and opening of fractures to facilitate gas desorption. The chemical complexity of the hydraulic fluids used to release the 'tight gas' from shale rocks is generally not necessary.

These chemically complex fluids include the carcinogenic BTEX group (benzene, toluene, ethylbenzene and xylene), albeit used in small quantities. Traces of BTEX were detected in water samples at a CSG project in Queensland in October 2010, raising concerns of risk to water supplies and human health. Investigations showed that the incident was minor and localised and arose from contamination during exploratory drilling for CSG. The industry claims that fracking fluids used in Australia are safe, and do not contain carcinogens such as the BTEX group. Nevertheless, the Queensland government has taken the precaution of banning the use of BTEX in CSG extraction, and a similar ban has been proposed in NSW. Chemicals used in fracking fluids are required to be listed on the national chemical inventory maintained by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS). Most of these chemicals have not been assessed by NICNAS. Chemicals listed on the inventory are assessed by NICNAS on a priority basis and those

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19. Christine Kenneally, 'Labor's coal and coal seam gas plan' NSW Labor policy proposal 15 March 2011,
assessments, which include recommendations about safe usage, are made available from the NICNAS website.

The Australian Government recognises that there is a large number of unassessed chemicals on the inventory and NICNAS is working with stakeholders on the development of a framework to address the issue. Enforcement of NICNAS recommendations occurs through state and territory legislation.

Methane leakage

A recent analysis of fugitive methane emissions related to shale gas development and production in the USA concluded that when all sources of emissions are taken into consideration, the greenhouse gas footprint of shale gas is between 20 and 100 per cent greater than that of coal. Emissions range from developmental drilling, to gas extraction, storage, piping and treatment. There is substantial uncertainty regarding the magnitude of the problem, although significant reductions are possible through technical improvements, and legislative requirements. The authors consider that fugitive emissions from shale gas raise questions about the effectiveness of gas as a ‘bridging fuel’ to a new, low-carbon energy sector.

There appears to be little information on the level of fugitive emissions from CSG development, extraction, storage, transport and processing in Australia. A report by ABC Four Corners has described uncontrolled methane emissions from CSG exploration wells, suggesting that methane leakage is probably a significant issue in Australia, and that improvements in managing fugitive methane emissions are warranted.

Liquefied natural gas (LNG) developments

A realisation of the enormous potential of growth in the CSG sector in Eastern Australia has led to a number of proposed LNG developments, which to some extent parallels the huge offshore LNG developments in the North West Shelf and Browse Basin in Western Australia. A particular irony is the fact that less than a decade ago, there was concern that Eastern Australia was rapidly running out of natural gas reserves and that gas may have to be either shipped or piped from Western Australia.

Supplies of natural gas (as CSG) appear assured in Eastern Australia, and the potential for large reserves is such that a number of LNG export projects have been proposed to cater for production in excess of domestic needs.

By June 2009, eight proposals for LNG plants in Queensland had been announced, most involving partnerships between Queensland companies with coal seam gas resources and international

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petroleum companies. If all eight proposals reach full capacity, it would represent a potential LNG market for the state of about 43 million tonnes per annum. By mid-June 2011, three of the eight proposals had received Federal Government approval, and LNG exports are expected to begin in 2015.
