2 AUSTRALIA

2.1 Summary of Coal Industry

2.1.1 ROLE OF COAL IN AUSTRALIA

Australia is the fourth largest producer of coal in the world, behind China, the United States, and India. Although rich in energy resources with significant petroleum, natural gas, and coal reserves, its energy consumption is dominated by coal, which fuels most of the country's power generation. Coal accounts for 85 percent of the country's electricity generation (IEA, 2009).

Australia ranks sixth in black coal (all non-lignite coal) production, with its current economic reserves estimated to sustain production for the next 200 years. About 97 percent of Australia's black coal production comes from Queensland and New South Wales. Australia also produces about 8 percent of the world's brown coal and ranks third after Germany and the United States. All of its brown coal (lignite) production comes from Victoria, with more than 98 percent sourced from the La Trobe Valley (ACA, 2008; M2M-Australia, 2005).

Australia is the world's largest coal exporter. It exported 261 million tonnes (Mmt) in 2008–2009, comprising 28 percent of total world coal exports. As of 2008, Australia exported about 60 percent of its annual coal production, about 46 percent of it to Japan. Other markets included Taiwan, South Korea, and India (ACA, 2008; EIA, 2009).

Table 2-1 quantifies Australian coal reserves and recent production.

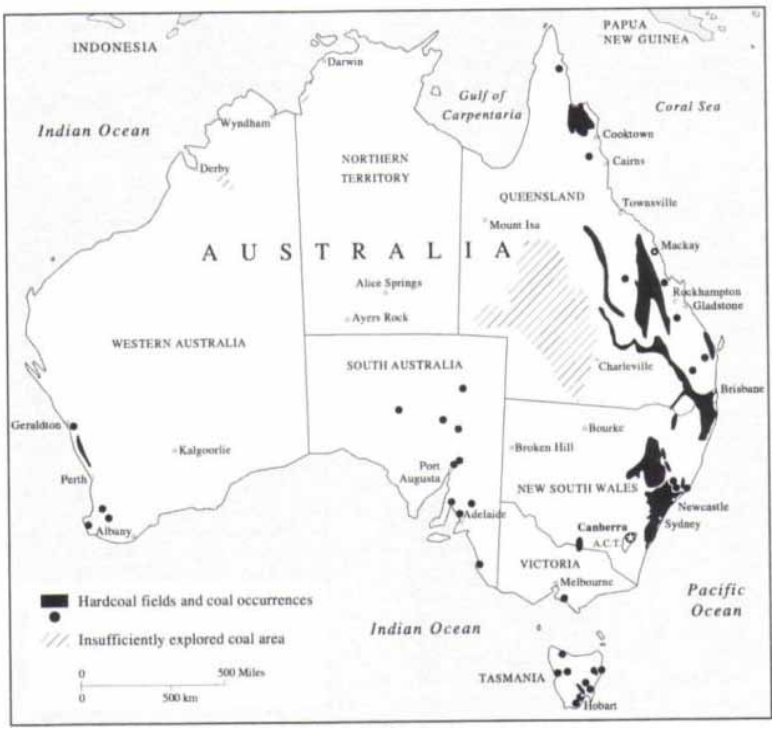
Table 2-1. Australia's Coal Reserves and Production

Indicator	**Anthracite & Bituminous** (million tonnes)	**Sub-bituminous & Lignite** (million tonnes)	**Total** (million tonnes)	**Global Rank** (# and %)
Estimated Proved Coal Reserves (2009)	36,800	39,400	76,200	4 (9.2%)
Annual Coal Production (2009)	348.00*	61.2**	409.2	4 (6.7%)

Source: BP (2010); *ABARE (2010) – all black coal; **ABARE (2010) – lignite only

Australia has large deposits of both brown and black coals, located on the east coast in the states of Queensland, New South Wales (NSW), and Victoria (see Figure 2-1). The Bowen Basin in Queensland contains the largest reserves at 37.8 billion tonnes (Bt). Reserves in the Sydney-Gunnedah Basin and surrounding areas of northern NSW contain about 32.1 Bt (EIA, 2009). Minor reserves are also located in Southern and Western Australia, as well as Tasmania (USGS, 2002).

Figure 2-1. Australia's Coal Fields



Source: Schwochow (1997)

2.1.2 STAKEHOLDERS

Table 2-2 identifies potential key stakeholders in Australian coal mine methane (CMM) development.

Table 2-2. Key Stakeholders in Australia's CMM Industry

Stakeholder Category	Stakeholder	Role
Mining Companies	▪ BHP-Billiton ▪ Rio Tinto (Coal & Allied Industries Limited; Pacific Coal) ▪ Xstrata ▪ Anglo Coal ▪ Peabody Energy ▪ Vale ▪ Ensham Resources ▪ Anglo Coal Australia Pty Ltd ▪ Illawarra Coal Holdings Pty Ltd ▪ Planet Gas Ltd. ▪ Centennial Coal	Project hosts/Potential project hosts
Developers	▪ Arrow Energy ▪ BG Group ▪ Santos ▪ Queensland Gas Company (QGC) – a BG subsidiary ▪ Petronas ▪ Energy Developments Ltd. ▪ See http://www.epa.gov/coalbed/networkcontacts.html	Project opportunity identification and planning

Stakeholder Category	Stakeholder	Role
Equipment Manufacturers	▪ BCCK ▪ BOC Gases ▪ Caterpillar ▪ ComEnergy ▪ Cummins Engine ▪ Engelhard ▪ Ingersoll-Rand ▪ MEGTEC Systems ▪ Northwest Fuels Development ▪ Solar Turbines ▪ Waukesha Engines	Methane treatment and utilization equipment
Engineering, Consultancy, and Related Services	▪ See http://www.epa.gov/coalbed/networkcontacts.html	Technical assistance
Natural Gas Transmission & Distribution Companies; Power Companies	▪ Stanwell Corporation ▪ CS Energy ▪ Tarong Energy Corporation ▪ AGL Energy ▪ Epic ▪ Ergon ▪ Energex	
Universities, Research Establishments	▪ Australian Coal Association Research Program ▪ Commonwealth Scientific and Industrial Research Organization (CSIRO) ▪ Energy Development Limited	Technical assistance
Regulatory Agencies	▪ Queensland Department of Natural Resources and Mines ▪ NSW Department of Primary Industries Minerals	Project identification and assessment support
Government Groups	▪ Department of Industry, Tourism, and Resources ▪ Australian Greenhouse Gas Office ▪ Department of Environment, Water, Heritage, and the Arts	Licensing and permitting
Other	▪ Large-scale industrial applications ▪ Fertilizer plants (Incitec) ▪ Retail consumers	

2.1.3 STATUS OF COAL AND THE COAL MINING INDUSTRY

Australia's coal production has increased by 34 percent over the last two decades, with more operations coming online every year (EIA, 2009). There are 112 black coal mines located across Australia – 70 open pit and 42 underground operations (M2M-Australia, 2010). Underground mines account for 59 percent of coal production in NSW and 10 percent of coal production in Queensland. Table 2-3 breaks up Australia's coal production by mining method and region (ACA, 2008).

In addition to Australian private mining companies, international companies also play a large role in Australian coal production. Major coal companies operating in Australia include: BHP-Billiton, Rio Tinto Coal, Xstrata, Peabody, Vale and Anglo Coal. Australia mostly produces high-quality coking and steaming coals that are high in energy content and low in sulfur, ash, and other contaminants.

Table 2-3. Australia's Coal Production by Mining Method and Region (million tonnes)

Mining Method	Black Coal (Saleable Production)	
	2006–20007	2007–2008
Underground	73.6	83.8
Open pit	251.6	243.0
Total	325.2	326.8
States Production		
NSW	130.9	135.0
Queensland	184.1	180.9
South Australia	3.6	3.8
Western Australia	6.1	6.4
Tasmania	0.4	0.4
Total Australian Production	325.2	326.8

Source: ACA (2008)

2.2 Overview of CMM Emissions and Development Potential

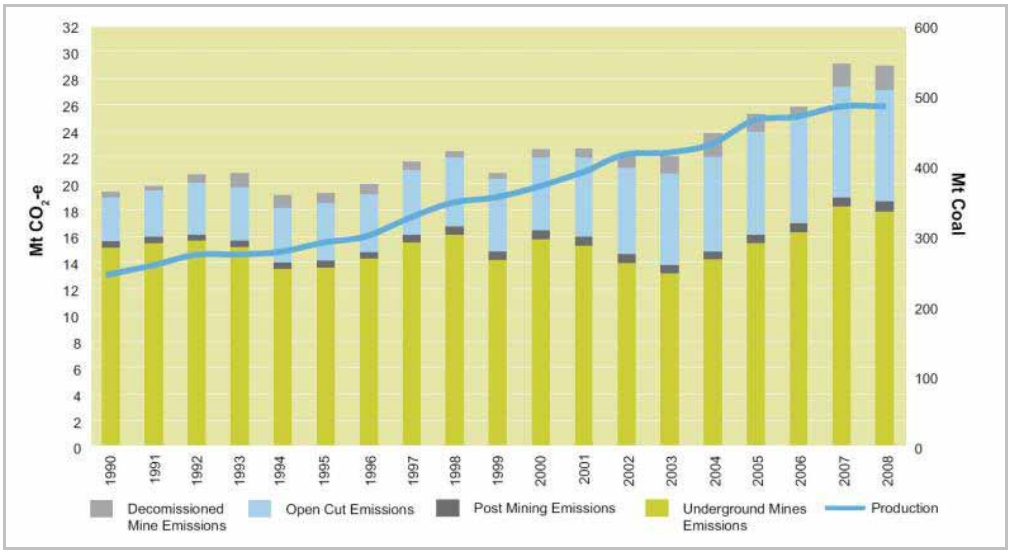
Australia has the second largest (after the United States) commercially advanced CMM and coalbed methane (CBM) industry.

2.2.1 CMM Emissions from Operating Mines

In 2008, net emissions associated with coal mining and handling, and decommissioned mines were 28.8 million tonnes of carbon dioxide equivalent ($MmtCO_2e$) and accounted for just more than 5 percent of Australia's total greenhouse gas (GHG) emissions of 549.5 $MmtCO_2e$ (DCCEE, 2010). Coal sector methane emissions increased 65 percent between 1990 and 2007, while coal mine production doubled. Emissions per 1000 tonnes of coal produced decreased by 16.5 percent from 67 tonnes CO_2e to 56 tonnes CO_2e over the same time period and this reduction is primarily attributed to the mining of less gassy coal reserves and the expanding implementation of methane recovery, use, and flaring technologies (M2M-Australia, 2010).

The Australian government estimates that ventilation air methane (VAM) is responsible for 64 percent of Australia's coal mine emissions, with a typical gassy mine producing VAM at a rate of 150–300 cubic meters (m^3) per second (M2M-Australia, 2005). Figure 2-2 shows Australia's CMM emissions (including emissions from abandoned mines) from 1990 to 2008.

Figure 2-2. Australia's Fugitive Emissions from Coal Mining, 1990–2008



Source: DCCEE (2010)

There are currently 17 CMM projects registered in Australia at 15 mines, 10 of which are active underground mines and five are abandoned mines. Three of the projects involve flaring recovered gas, nine projects generate electricity using reciprocating engines, four projects destroy ventilation air methane (VAM), and one project involves injection of high quality CMM into a sales pipeline (M2M-Projects, 2010).

Seven projects use CMM to generate 215 MW of electricity sold into the national grid, with a resultant annual emissions reduction of 6.5 $MmtCO_2e$ (M2M-Australia, 2010). The largest CMM power station is located at BHP Billiton's Appin and Tower mines near Sydney. Commissioned in 1996, this project consists of 94 1-MW reciprocating engines and consumes 600,000 m^3 of CMM a day. Other large power plants, built and operated by Energy Developments Ltd., include a 32-MW project at the German Creek coal mine (uses 16 2-MW engines and came on-line in November 2006) and the $60 million 45-MW plant at Anglo's Moranbah North coal mine (uses 15 3-MW engines and started operation in late 2008). Both of these plants are located in the Bowen Basin in central Queensland (Energy Developments, 2010).

In one landmark CMM project, BHP Billiton was awarded up to $6 million from the Australian Greenhouse Office to construct a CMM power station at the Westcliff Colliery, near Wollongong, NSW, to allow the combustion of VAM (BHP, 2010). The West Cliff VAM Project (WestVAMP) officially opened on September 14, 2007 and was the first to generate commercial power solely from VAM. The project burns 0.9 percent VAM concentration to produce 6 MW of electricity via a conventional steam turbine. Along with displacing coal-fired electricity generation, WestVAMP is estimated to reduce emissions by up to 0.250 $MmtCO_2e$ each year (MEGTEC, 2008, 2010).

2.2.2 CMM Emissions from Abandoned Coal Mines

The latest report on Australia's GHG emission trends, released by the Department of Climate Change, notes that emissions from decommissioned mines are small (relative to total emissions), at 1.4 $MmtCO_2e$

in 2008. Emission levels vary with mine closures, but are projected to be 1.3 $MmtCO_2e$ in 2020 (DCC, 2009).

2.2.3 CBM FROM VIRGIN COAL SEAMS

Australia has the most active development of unconventional gas outside of North America. CBM recovery activity predominately has been in NSW and Queensland, Australia's two largest coal-producing states, but exploration for CBM is also occurring in Victoria (M2M-Australia, 2005). Drained CBM has been used to generate electricity in NSW since the 1980s, while commercial CBM production began in Queensland in 1996, providing pipeline-quality gas to three coastal cities (Schwochow, 1997).

Annual CBM production in Australia more than doubled between 2003 and 2006, from 538 million m^3 to 1.6 billion m^3 (Bcm). The rapid rate of increase in production has continued with 2.9 Bcm produced in 2007 and 3.7 Bcm in 2008. At the same time, proved and probable reserve estimates have risen rapidly to 435 Bcm in 2008 with 95 percent of reserves located in Queensland and the rest in New South Wales (AIMR, 2009). In 2008, 96 percent of Australia's CBM production came from the Bowen and Surat Basins in Queensland and provided 60 percent of Queensland's gas demand for that year. Analysts believe CBM could provide up to 50 percent of the Australian east coast natural gas supply by 2020 (AIMR, 2009).

From 2007 to 2008, CBM exploration in Queensland continued at record levels with about 600 CBM wells drilled, compared to 70 natural gas wells. The Bowen, Galilee, and Surat Basin continue to be the main areas of focus, while the Sydney, Gunnedah, Gloucester, and Clarence-Morton Basin are being targeted in NSW.

Driving much of the recent CBM activity, several major international companies have acquired stakes in Australia's CBM industry with plans to convert CBM into liquid natural gas (LNG) for export to the energy hungry markets of Southeast Asia. The BG Group, Santos Ltd., (with Petronas), ConocoPhilips (with Origin Energy), and Royal Dutch Shell are planning four separate CBM-to-LNG projects in Queensland (Dow Jones Newswires, 2010).

For details on all ongoing CBM operations and the vested companies, visit the Australian Mines Atlas at http://www.australianminesatlas.gov.au/aimr/commodity/coal_bed_methane_09.jsp.

2.3 Opportunities and Challenges to Greater CMM Recovery and Use

Source: M2M-Australia (2005), unless otherwise noted

Australia is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and ratified the Kyoto Protocol in 2007 (see Table 2-4). Australia is committed to meeting its Kyoto target to reduce GHG emissions by 60 percent of 2000 levels by 2050 and will be engaged in the negotiations for a new agreement when Kyoto expires (Kyoto, 2007).

Table 2-4. Australia's Climate Change Mitigation Commitment

Agreement	Signature	Ratification
UNFCCC	June 4, 1992	December 30, 1992
Kyoto Protocol	April 29, 1998	December 3, 2007

Source: UNFCCC (2004); UNFCCC (2005)

Having ratified the Kyoto Protocol, Australia is now able to take advantage of the revenues generated by its carbon emission reductions. Other opportunities for project financing include the Greenhouse Gas Abatement Program (GGAP), providing up to $43.47 million to support the development of power stations using CMM. GGAP aims to reduce Australia's net GHG emissions by limiting emissions to 108 percent of 1990 levels between 2008 and 2012. The country is on track to meet this target. The Australian government is funding four CMM projects (for seven individual power stations) in Queensland and NSW under the GGAP (IEA, 2009).

Similar to GGAP, the Australian Coal Mine Methane Reduction Program (ACMMRP), sponsored by the Australian Greenhouse Office, was created to reduce methane emissions to help Australia meet its Kyoto targets. The goal was to reduce emissions by 0.9 Mmt per year, amounting to 4.5 Mmt over the 2008–2012 period. Developers of CMM projects originally had $15.9 million available through grants beginning in 2008 (ACMMRP, 2008). In 2008, the Strategic Review of Australian Government Climate Change Programs found that both the GGAP and ACMMRP had difficulties finding suitable, viable projects despite the potential impact of CBM/CMM mitigation projects (Strategic, 2008). In the 2009–2010 budget, the ACMMRP was terminated because it no longer aligned with the proposed Carbon Pollution Reduction Scheme (CPRS), but existing commitments from the program would still be honored (Budget, 2009). Legislation for the CPRS has not yet passed the Australian Parliament and has been delayed until the end of the current Kyoto Protocol commitment period in 2012 (CPRS, 2010).

Australia has included coal seam methane in its Renewable Energy Target definition for a transitional period to greater renewable production (Renewable Energy, 2010). Aside from the federal level support for CMM/CBM development, the governments of NSW and Queensland provide further incentives for their development. Queensland is promoting a transition to gas supplies via its Smart Energy Policy. Starting in 2010, 15 percent of all electricity sold in Queensland has to be from gas-fired generation, which may be increased to 18 percent by 2020 (Smart Energy, 2010). NSW has had a Greenhouse Gas Reduction Scheme since 2003 that encourages a switch from coal-based energy production to natural gas-based production, including CBM/CMM (GHG Reduction, 2010).

2.3.1 MARKET AND INFRASTRUCTURE FACTORS

Although Australia's CMM development has been primarily driven by mine safety concerns, the industry has received a boost from the country's GHG emissions reduction obligations and accompanying incentives from the national government (see GGAP discussion in section 2.1). State-based schemes have also provided additional incentives to encourage a shift in energy use towards natural gas, including CBM and CMM.

Electricity generation has provided the main market for drained CMM and based on expected growth in the industry, there is potential to double generating capacity over the next decade (M2M-Australia, 2010). Growth in the coal mining industry is robust with six new coal mine projects, valued at more than $1.5 billion, completed in 2008–2009, and a further 21 projects scheduled for completion in the near to medium term (ACA, 2009).

While Queensland produces more than 90 percent of CBM volumes, NSW coal basins hold greater potential for CMM development with greater coal production from underground mines in NSW than in Queensland (51.6 thousand tonnes [Mt] versus 30.8 Mt respectively – NSWMC,2009; GSQ, 2010) and generally gassier mines. With natural gas infrastructure in place and serving the Sydney-Newcastle corridor, local major energy markets are conveniently accessible.

In contrast with eastern NSW, gas transport infrastructure is more limited in Queensland, and CBM projects have historically been sited near existing gas pipelines, such as the 750-km Wallumbilla-Ballera pipeline which connects the gas fields of the Cooper Basin to eastern Queensland. But major pipeline

projects are in development, driven by planned CBM to LNG projects. The BG Group is planning a 380 km underground pipeline from the Surat Basin to the port of Gladstone to deliver CBM to its proposed LNG plant. Additional pipeline capacity will be built to link BG's CBM resources to the new transmission pipeline. In 2009, BG Group signed an LNG Project Development Agreement with China National Offshore Oil Corporation (CNOOC) who is the intended customer for the produced LNG (BG Group, 2010). Santos Ltd reports that it plans to upgrade field infrastructure at the Fairview CBM field and also build a pipeline to Gladstone as part of its proposed CBM to LNG project (OGJ, 2010).

Major pipeline operators such as Epic Energy and the APA Group have been active in expanding the capacity of existing pipelines in Queensland and NSW, adding compression facilities, building links between the major pipelines and adding new inlet stations to receive CBM from new production areas (AGL, 2009; APA, 2010).

Australia has been a world leader in work on the development and trial of technologies to capture and use CMM, VAM and CBM. Commonwealth Scientific and Industrial Research Organization (CSIRO), Energy Development Limited, and BHP Billiton are some of the Australian organizations who have conducted research, development, and demonstration work related to the recovery and utilization of CMM and VAM.

BHP Billiton's WestVAMP (see section 2.2.1) was the first commercial demonstration using a thermal flow-reversal oxidizer for VAM-fueled power generation, while CSIRO has funded the development of new lean-fuel catalytic gas turbines designed to capture 1–2 percent of methane from ventilation air (VAMCAT). The first trial of the technology, sponsored by Australian Greenhouse Office (AGO), is taking place at the Huainan mine in China. Other VAM mitigation technologies being researched include catalytic flow reverse reactors; catalytic monolith combustors; and recuperative gas turbines.

CSIRO is also investigating enhanced CBM techniques to increase methane drainage from coal seams before opencast mining takes place. Other research topics include gas drainage systems improvement and cogeneration of electricity using CMM in coal-fired power plants (M2M-Australia, 2010; M2M-Australia, 2005).

As a member of the GMI Coal Subcommittee, Australia has generated and maintains a CMM Technology Database. The database serves as a reference for CMM technologies and holds company contact info. The database can be found at http://methanetomarkets.org/documents/partners_australia_cmm_tech_database.pdf.

2.3.2 REGULATORY INFORMATION

The legal framework governing resource ownership and licensing in Australia is complex because there is currently no national legislative framework in place for CMM. Each state has its own legislation and licensing arrangements.

In Queensland, a Mining Lease for coal does not provide rights to the contained coal seam gas. CMM production comes under the *Petroleum and Gas (Production and Safety) Act of 2004* and requires a Production License, which can co-exist with a Mining Lease covering the same area. The Queensland government had released a new regimen in November 2002 to address issues that arise where CBM and coal exploration and production activities may occur under different tenures granted over the same area. To implement the regimen, a new *Petroleum and Gas (Production and Safety) Act* was passed in 2004 to replace the *Petroleum Act of 1923*. Recent amendments to legislation in Queensland have established a clear distinction between resources administered under the *Mineral Resources Act of 1989* and those coming under the *Petroleum and Gas (Production and Safety) Act of 2004.*

In NSW, a Mining Lease or Exploration License is required before mining operations commence. If the holder of the lease wants to extract coal seam gas, an application must be made for the inclusion of petroleum in the Mining Lease. Although CMM extraction and utilization currently falls under a coal extraction or Mining Lease, more specific regulation is being drafted. The *Mining Act of 1992* is the principal legislation governing mineral exploration in NSW. Under the *Mineral Resources Act 1989 (NSW)*, where CMM is produced as a by-product of coal mining, there is no provision for payment of royalties on VAM, or on pre- or post-drainage methane that is flared. Waste methane flaring in NSW has been standard, but further legislative changes to the *Mineral Resources Act* now require that pre- and post-drainage methane is used or flared rather than simply being vented. CBM is however considered a petroleum product in NSW and hence, falls under the *Petroleum (Onshore) Act of 1991*.

In Queensland, where an oil and gas exploration tenement co-exists with a coal mining lease, and production testing within that exploration tenement yields in excess of 3 million m^3 of gas, the tenement holder is liable for royalty payments. However, in order to facilitate the development of deep coal seams in and around Sydney, the NSW state government has not been imposing royalties on the capture and utilization of waste gases from coal mining and is providing a 5-year exemption for stand-alone coal seam gas operations.

In Victoria, CBM resources are administered under the legislation for mineral resources development.

2.4 Profiles of Individual Mines

Some of Australia's most productive underground coal mines are listed in Table 2-5. Individual mine profiles, showing CMM production are unavailable.

Table 2-5. Major Australian Underground Coal Mines

Mine	Location	Operator	Annual Coal Production (million tonnes)
Broadmeadow	Bowen Basin, Queensland	BMA (BHP Billiton Mitsubishi Alliance)	4
Moranbah North	Bowen Basin, Queensland	Anglo Coal	4.5
German Creek mines	Bowen Basin, Queensland	Anglo Coal	6
Kestrel	Bowen Basin, Queensland	Rio Tinton Coal Australia	4
North Goonyella	Bowen Basin, Queensland	Peabody Energy	2-3
Oaky Creek	Bowen Basin, Queensland	Xstrata	11 (Run of Mine)
Beltana	Hunter Valley, NSW	Xstrata	7.6
Clarence	Western Coalfield, NSW	Centennial Coal	2.5
Springvale	Western Coalfield, NSW	Centennial Coal	7
Mandalong	Newcastle Coalfield, NSW	Centennial Coal	5

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