

Climate Change Background Paper Mineral Resources

Brad Mullard
Director Coal and Petroleum Development, NSW DPI

Greenhouse gas emissions from electricity and heat production in NSW are currently estimated at approximately 60 million tonnes per annum by the Australian Greenhouse Emissions Information System. This represents approximately 36.6 percent of all NSW emissions and 10.3 percent of total Australian greenhouse gas emissions.

Coal is the world's most abundant and widely distributed fossil fuel source, and will remain so well into the future. At present approximately 23 percent of primary global energy needs are met by coal and 40 percent of electricity is generated from coal. About 70 percent of world steel production depends on coal feedstock.

In NSW about 90 percent of electricity needs are currently met from coal fired power stations. NSW coal fired power stations are located in the Sydney Basin close to significant coal resources in the Hunter, Central Coast and Western coalfield. NSW also obtains on average an additional 700 MW of coal fired electricity per annum from Queensland through the NSW-Queensland interconnector.

Black coal is also Australia's biggest commodity export, generates significant GDP, and directly and indirectly employs many thousands of Australians. NSW coal production was valued at \$8.5 billion in 2005/06. Coal is the largest mining sector in NSW and accounts for 73 percent of all mineral production in NSW. In 2005/6, 90 million tonnes of NSW coal were exported for a total value of \$6.7 billion. NSW coal producers directly employ 12,600 people, and the industry creates significant rural and regional economic opportunities.

CLEAN COAL TECHNOLOGIES

The NSW Government is committed to reaching an interim target of year 2000 greenhouse gas emission levels by 2020 and a long term target of a 60 percent reduction in greenhouse gas emissions by 2050.

Clean Coal technologies in NSW will be a key factor in achieving this target and will help both Australia and NSW to adapt to a carbon constrained future. Such technologies include:

- Pre and post carbon capture and storage technologies;
- New pollution control devices - like advanced scrubbers - that clean pollutants from flue gases before they exit a plant's smokestack;
- Chemical Looping combustion technology to concentrate CO₂ levels in exhaust;
- Production of ultra clean coal which reduces ash from the coal allowing it to be directly fired in gas turbines at higher efficiency and lower greenhouse gas emissions;

- Efficiency upgrades and co-firing with less greenhouse intensive fuels in coal fired power stations;
- Low – NO_x burners which allow coal-fired plants to reduce nitrogen oxide emissions;
- High temperature solar thermal applications integrated into coal fired power generation;
- Stack Gas Treatment - applied to gaseous emissions from Pulverised Fuel (PF) Combustion;
- Advanced Pulverised Fuel Combustion (PF);
- Fluidised Bed Combustion (FBC);
- Gasification and Integrated Coal Gasification Combined Cycle Systems;
- Hybrid and advanced systems;
- Fuel cell technologies utilising gas from coal;
- Oxy-firing technology to raise the concentration of CO₂ in flue gases to better enable its capture;
- Coal Gasification including underground gasification in situ;
- Capture and utilisation of fugitive emissions from coal mines.

CURRENT CLEAN COAL RESEARCH

Funding for research and demonstration projects are now being provided through the:

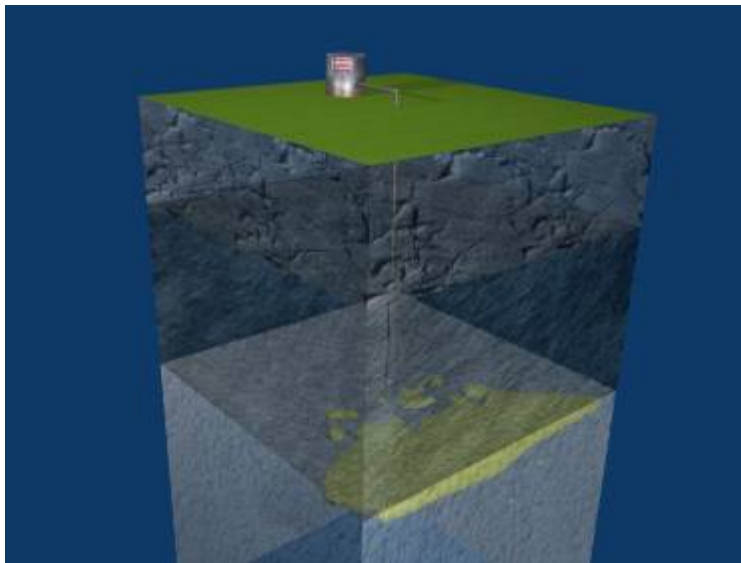
- The Australian Coal Association's COAL 21 Fund;
- Australian Coal Association Research Program (ACARP);
- Australian Research Council;
- Queensland Clean Coal Technology Fund;
- Queensland Centre for Low Emissions Technology;
- The Cooperative Research Centre for Greenhouse Gas Technologies (CO₂CRC);
- The CRC for Coal in Sustainable Development (CCSD) researches future technology for using black coal which is funded until 2008-09;
- The Commonwealth Low Emissions Technology Fund;
- The Asia-Pacific Partnership on Clean Development and Climate.

CO₂ Capture and Storage

Capturing and storing CO₂ has the potential to be a cost-competitive and safe way to achieve large-scale reductions in emissions. CCS technology offers an opportunity to significantly reduce CO₂ emissions while avoiding the enormous cost of scrapping the states fossil fuel dominated energy infrastructure. In order to continue using the State's large coal resources for power generation while constraining emissions of CO₂, NSW will need to rely on technology that can capture CO₂ generated from coal-fired power plants and sequester it in deep stable geological structures. However, the integration and scaling up of existing technologies to capture, transport, and store CO₂ emitted from a full-scale power plant have not yet been fully demonstrated. While it is technically feasible to

integrate a complete CCS system with a commercial-scale power plant it is necessary to build up experience by advancing early deployment.

A complete CCS system relies on three technological components: capture, transport, and storage. Technologies exist for each of these components and are currently used commercially in other sectors. CO₂ capture technology is already widely used in ammonia production and other industrial manufacturing processes, as well as oil refining and gas processing. CO₂ gas has been transported through pipelines and injected underground for decades, most notably in the United States, where it is used to enhance oil recovery from wells where production is declining. In addition, some 3 to 4 million tonnes of CO₂ per year is stored underground at several locations in other countries, with the prospect of this increasing significantly in the future.

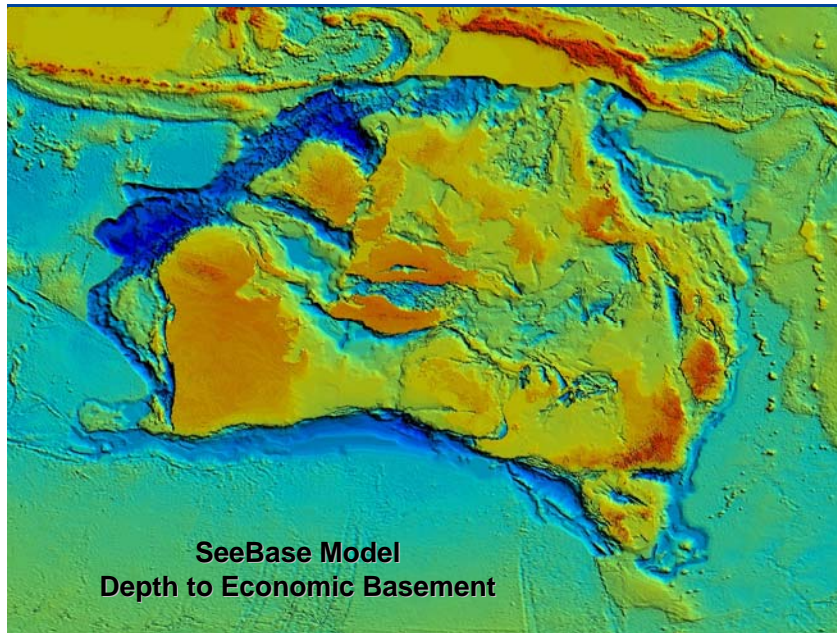


Geosequestration involves the injection of CO₂ as a super critical fluid at depths greater than 800m

CO₂ capture technologies can be divided into three categories:

- post-combustion or “end-of-pipe” CO₂ capture, relying on chemical or physical absorption of CO₂;
- pre-combustion CO₂ capture technologies that separate CO₂ from a syngas fuel (produced from coal, oil, or natural gas) before the fuel is burned; and
- oxyfuel combustion, in which oxygen instead of air is introduced during the combustion process to produce a relatively pure stream of CO₂ emissions.

Of these options, pre-combustion capture is currently the most efficient. In the case of coal-fired power plants, however, pre-combustion capture can be applied only when coal gasification technology is employed; such as in purpose-built integrated gasification combined-cycle coal-fired power plants.



SeeBase Model showing sedimentary Basins (Blue areas) which may have Geosequestration potential

Sequestration of CO₂ in Coal Seams

The injection of CO₂ into coal seams may be feasible as part of an enhanced coal seam methane (CSM) recovery project.

Coal seams can absorb CO₂ and this may provide a permanent disposition provided the coal is not disturbed by mining and does not have fracture pathways to other formations.

The injection of CO₂ into coal seams could also be used to displace methane rapidly resulting in enhanced methane recovery offsetting the cost of disposal of the CO₂.

Coal Gasification (Including *in situ* Gasification)

An alternative to coal combustion is coal gasification. When coal is brought into contact with steam and oxygen, thermochemical reactions produce a fuel gas, which when combusted can be used to power gas turbines. Integrated Coal Gasification Combined Cycle (IGCC) power generating systems are presently being developed and operated in Europe and the USA. These systems give increased efficiencies by using waste heat from the product gas to produce steam to drive a steam turbine, in addition to a gas turbine. At present, there are over 160 gasification facilities in operation around the world using coal, oil, petroleum coke and other solid carbon-containing feed stocks. Of these, only four coal-based gasification plants are for electric power generation. One of the advantages is that it is expected that capture of CO₂ will become cheaper with this technology.

In Australia there are two major gasification projects: ZeroGen IGCC Project in Queensland and Monash CTL Project in Victoria.

It should be noted that some NSW coals are ideally suited for Gasification.

Mineral Carbonation

Mineral Carbonation is a process where CO₂ is chemically reacted with minerals such as serpentinite to produce stable carbonate minerals effectively locking up the CO₂ permanently. The reaction could occur within an industrial reactor using mined material. There are extensive deposits of serpentinite in Australia; The Great Serpentine Belt near Tamworth contains significant resources of suitable rocks.

Substantial additional research needs to be undertaken to assess the potential of Mineral Carbonation. It is understood that Macquarie Generation is considering providing limited funding for research into mineral carbonation.

Microbial Conversion of CO₂ to Methane



Microbial methane burning from a water bore - Western NSW

It is known that bacteria in coal seams can convert CO₂ into methane. CSIRO is interested in carrying out research to isolate and establish highly active methanogenic consortia for Australian coals. The consortia could be tailored to suit particular coals and their nutritional requirements. They could be refined with the aim of providing low cost supplements to optimise *in situ* methane generation. This could lead to CO₂ sequestration opportunities where CO₂ is injected into coal seams and converted into methane which could be extracted as a source of energy.

Fugitive Emissions

Fugitive emissions from Australian black coal mines have been estimated by the Australian Greenhouse Office to constitute 3.1 per cent of Australia's net greenhouse emissions. In order to reduce this emissions source, a number of commercial and technological impediments need to be addressed.

The Australian government has established and is implementing the Australian Coal Mine Methane Reduction Programme, a grant programme designed to reduce fugitive emission from coal mines in the Kyoto commitment period 2008-2012.

Chemical-Looping Coal Combustion with CO₂ Capture

Chemical Looping Combustion aims to dramatically increase efficiency in the combustion of coal by capturing carbon dioxide produced during coal production. The process uses metal oxide oxygen carriers to supply necessary amounts of oxygen to

complete the combustion of fuel. Combined with geosequestration this could reduce CO₂ emissions by up to 90%

Newcastle Port Corporation has committed \$200,000 to a research project into Chemical-Looping at the University of Newcastle (\$50,000 a year over four years).

NSW GOVERNMENT/ DPI PROJECTS

In 2006 the NSW Government established the Clean Coal Technology working group to provide advice to government on clean coal technology projects. The working group is chaired by DPI and has representation from the NSW Generators, Australian Coal Association, CSIRO, Rio Tinto, Xstrata, Department of Energy and the CO₂ CRC. The working group has been developing a number of priority projects of relevance for NSW. Some of these projects are listed below.

Integrated Capture and Storage Demonstration Project: The priority for NSW is the successful large-scale demonstration of the technical, economic, and environmental performance of the technologies that make up all of the major components of a large-scale integrated CCS system (capture, transportation and storage).

Such a demonstration of post combustion capture at an existing power station is essential prior to implementation at gigatonne scale to address a future carbon mitigation policy, as well as for easing the trade-off between restraining emissions from fossil resource use and meeting future energy needs

The Low Emission Technology Demonstration Fund (LETDF) is funding a number of projects across Australia with the aim of demonstrating large scale low emission technologies. Projects funded to date are:

Solar Systems: Solar concentrator power station (Victoria)

CS Energy: Retrofit oxy-fuel technology with carbon capture and storage (CCS) (Queensland).

International Power: Retrofit brown coal drying (Victoria) and PCC pilot plant

Fairview Power: Coal seam methane extraction, with CCS (Queensland).

Gorgon (Chevron): LNG production, with large CCS (Western Australia)

HRL International: integrated drying gasification combined-cycle (IDGCC) power generation plant (Victoria)

While a number of projects listed above are proposing geosequestration of CO₂, no existing project is planning to test an integrated demonstration of Carbon capture and storage at an existing conventional pulverised coal combustion power station. This is a critical gap in the current portfolio of demonstration projects and is an essential component if NSW is to achieve significant reduction of CO₂ emissions from existing power stations.

The cost of the project is estimated to be \$150 million. To date the NSW Government has committed \$20 million towards the project with the Australian Coal Association agreeing to match the NSW contribution. A business case has been prepared to seek additional funding for the project.

Ultra Clean Coal: The Ultra Clean Coal (UCC) technology and process is being developed by UCC Energy Pty Limited in co-operation with the CSIRO and is supported by both the Federal and State Governments. Since 2002, a pilot plant near Cessnock has been producing Ultra Clean Coal (UCC). The UCC project is unique as unlike other clean coal technologies it is based on Australian owned technologies. The NSW Government has supported the project through a land grant near Cessnock valued at \$1.9 million. The technology will produce high purity, cleaned coal for direct burning in gas turbines to generate electricity.

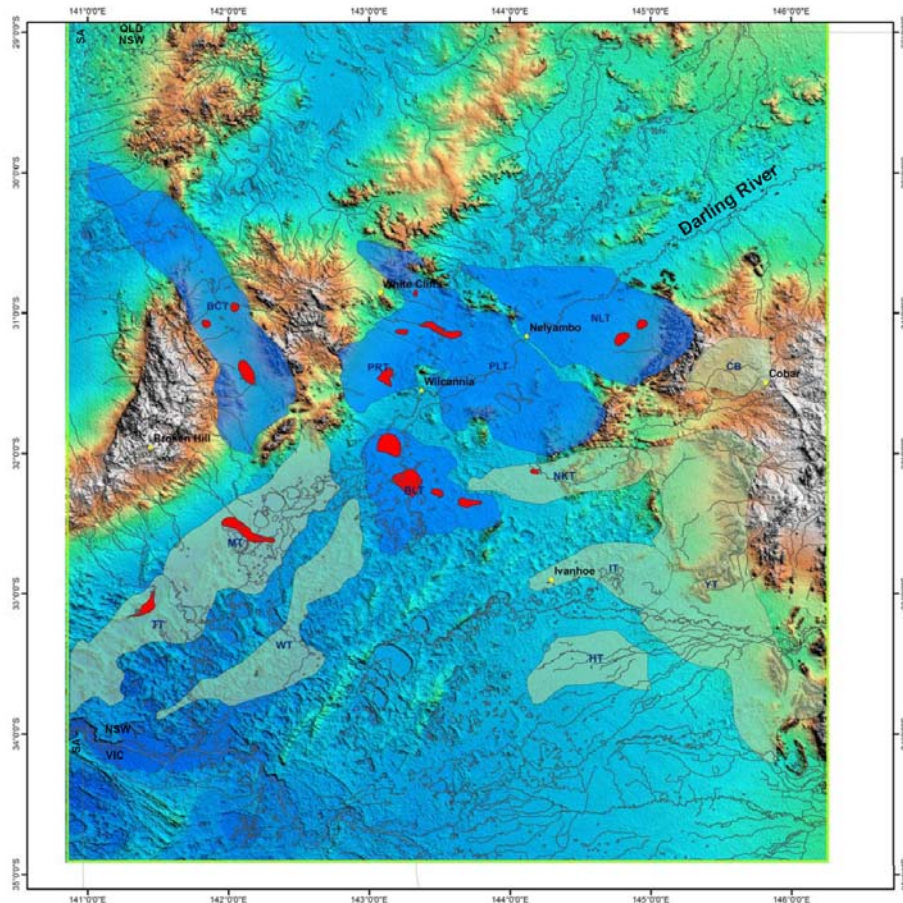
Munmorah PCC Pilot Plant: Delta Electricity is working with CSIRO to jointly develop a \$5 million research scale pilot facility at Munmorah Power Station to capture (and release) up to 5,000 tonnes per year of CO₂. It is proposed to use an ammonia absorption process as it may be more tolerant to acid contamination in the flue gas when compared with amine reagents. A post combustion capture (PCC) technology has been chosen for the pilot as it is a prospective retrofit technology and is complimentary to other carbon capture and storage demonstration projects under development in Australia.

Sydney Basin Reservoir Prediction project: The project has developed a structural framework to understand the stratigraphic architecture and provenance of key basin fill sequences, with an emphasis on predicting the distribution and character of saline aquifers suitable for CO₂ sequestration. An area of interest in the western part of the Sydney Basin has been identified in the Study.

National Geoscience Mapping Accord: Within the framework of the National Geoscience Mapping Accord DPI is conducting a number of projects with geoscience Australia which will provide base geological data on NSW sedimentary basins.

Darling Basin Reservoir Prediction project: The Darling basin in central NSW has significant potential for the large scale storage of CO₂ into deep saline aquifers. A total of 16 areas of interest have been identified in the Darling basin as having reservoir and seal potential at subsurface depths appropriate for CO₂ sequestration.

Additional work is currently being undertaken to further characterise these areas of interest including a program of work involving seismic and deep drilling.



The figure above is a DEM image (digital elevation model) that shows the locations of the 16 AOI (Areas of Interest) where potential traps are associated with predicted or identified reservoir units (indicated by the red polygons).

The main population centres in the region are also shown (yellow dots=Broken Hill, Cobar, White Cliffs, Wilcannia and Ivanhoe). The blue polygons show the extent of the Darling Basin depocentres where an AOI has been ranked.

Those depocentres which contain AOI that have not been ranked are shown by the light green polygons. The DEM also shows the location of the Darling River and the surrounding creeks that comprise the surface drainage basin, relative to the AOI which occur in the subsurface.

Gunnedah Basin Storage Assessment Project: In conjunction with CO₂CRC DPI is conducting an assessment of the storage potential of the Gunnedah Basin.

Clarence Moreton SeeBase Study:

A SeeBase structural framework study has commenced in the Clarence Moreton Basin. This is a first step in developing an assessment of the storage potential of the Basin.

PRIORITY AREAS FOR NSW

Identification and Characterisation of CO₂ Storage Sites in NSW

Identification of geosequestration sites in NSW remains the number one clean coal priority for the State.

While work is progressing on potential sites for storage of CO₂ in the Sydney and Darling basins, further work is required in NSW to define suitable safe storage sites in areas such as Oaklands basin, Murray, Eromanga, Gunnedah and Clarence Moreton and offshore areas.

Large-scale demonstration of Capture and Storage Technologies

The NSW Clean Coal Working Group is developing a master program for a demonstration plant which would begin carbon capture and storage by 2013. The estimated cost of the project is \$150 million.

The ultimate aim of this development is to provide a pathway for commercialisation of carbon capture and storage technology in NSW. To achieve this goal the project must ensure equipment suppliers, generators and regulatory bodies build sufficient confidence in the technology on completion of the demonstration to offer, purchase and approve it on a commercial basis.

Legislative Framework: Work is progressing in developing a legislative framework for carbon dioxide capture and geological storage in NSW based on the current model being developed by the States and Commonwealth for the offshore regime.

CURRENT GAPS

In terms of the current work program there are no major gaps in the portfolio of proposed projects. While initial funding has been made available to commence most projects, additional funding will be required. Proposals have been submitted or are currently being prepared to secure the additional funding.

POSSIBLE CROSS DIVISIONAL AREA OF INTEREST

The Minerals Division in conjunction with Geoscience Australia have been involved in looking at the NSW offshore geology. Recent studies have identified a substantial thickness (500 meters) of unconsolidated sediment. This sediment is likely to provide the best preserved history of long-term climate change relevant to NSW. While onshore areas may provide information on climate history during the Quaternary, the offshore could provide information back to the Miocene or Eocene period.

The type of information that could be obtained from this sediment includes:

- Long-term history of the East Australian Current
- Salinity history
- Long term history of water temperature (both deep and surface)
- Thermocline depths
- History of onshore plant communities
- Information on climate extremes
- Past oceanic and atmospheric circulation
- Sediment fluxes may provide information onshore climate conditions.

To date there has been no intersection off the NSW coast of these sediments. A drilling program to intersect these sediments could provide substantial information on climate history back as far as 50 million years.

Carbon Capture and Storage Projects in Australia						
Project	Proponent	Description	LETDF Grant /Total Cost	Timing	Location	Partners
Gorgon CO ₂ Injection Project	Chevron	Separating and capturing the CO ₂ from natural gas and injected into 2.5km deep saline aquifer up to 3 Mt/y	\$60m / \$840m	CO ₂ injection commencing 2009	NW Shelf/ WA	Shell Development Australia Pty Ltd and Mobil Australia Resources Company Pty Ltd
Oxy-fuel Demonstration Project	CS Energy	Retrofit Oxy firing to Calide A 30 MW power station, capture and store the resultant flue gas	\$50m / \$188m	Commence: 2007 Operation: 2009 Storage: 2010 Completed: 2015	Biloela in Central Queensland	IHI, Schlumberger, JPower, ACA, Xstrata Coal, CCUJ (Japan), CCSO, CO ₂ CRC
CSM Power Project & CCS	Fairview (Santos)	Construction of a new 100MW gas fired power station. One-third of the CO ₂ emissions will use post combustion capture of CO ₂ and inject into an unmineable coal seam.	\$75m / \$445m	Commence: April 2007 Completed: 2015	Injune in south-west Queensland	GE Energy, BHP Billiton, Ergon Energy, AJ Lucas Group, CSIRO, CO ₂ CRC, Leasing Corp Pty Ltd
Hazelwood 2030 A Clean Coal Future	International Power	Retrofit brown coal drying technology to 220MW Hazellwood power station unit and pilot-scale facility to capture and store carbon dioxide at a rate of 25 t per day	\$50m / \$360m	Commence: early 2007 Complete: 2009	Latrobe Valley Victoria	Only IP
HRL's Clean Coal Technology	HRL	400 megawatt integrated drying gasification combined-cycle (IDGCC) power generation plant at the Loy Yang coal mine (no carbon capture)	\$100m / \$750m	Commence: mid 2007 Complete: end 2009	Latrobe Valley Victoria	Harbin Power Engineering Company Ltd
Otway Project	CO ₂ CRC	Inject CO ₂ into sedimentary basin and undertake monitoring program.	\$0 / \$30m	Injection: 2007 Complete:2009	Western Victoria	CO ₂ CRC
Zero Gen	Zero Gen Pty Ltd (Queensland State Gov)	60-80MW IGCC plant and store 320,000 tpy of CO ₂ in gas aquifer or saline aquifers (to be determined)		Test drilling undertaken Plant Operating by 2011	Rockhampton, Queensland	Stanwell, Shell (gasifier & geosequestration)