facts Natural Resources, Mines and Water
Managing Queensland's natural resources ... for today and tomorrow

mines series

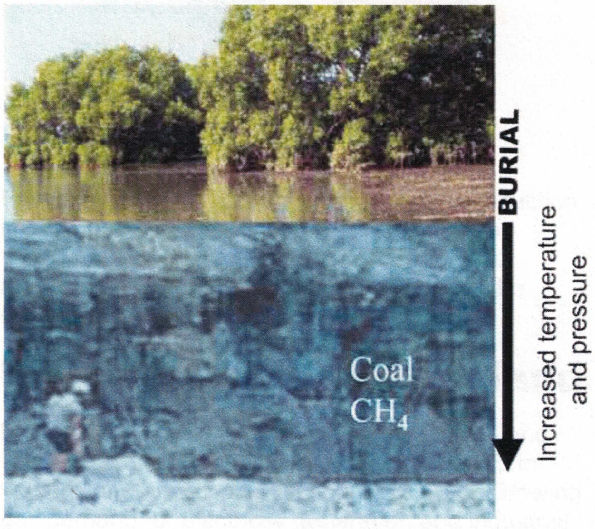
Coal seam gas in Queensland

Coal seam gas (coal bed methane) is the major focus for gas exploration in eastern Queensland. The association between methane and coal seams has long been known, with methane explosions in underground coal mines a major cause of mining fatalities.

Coal miners have traditionally extracted methane from coal seams for safety reasons. Miners also want to minimise the amount of methane being vented as it is a significant greenhouse gas. The extraction of methane from coal seams for use as a fuel is now a commercial reality.

What is coal seam gas?

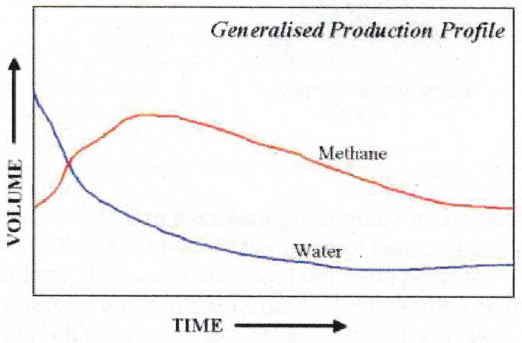
Methane (CH_4) is formed as part of the burial of peat to form coal. Biogenic (bacterial activity) methane forms at shallower depths and thermogenic (burial heat) methane at greater depths. The methane remains attached (adsorbed) to the coal.



The methane is held in the coal by burial pressure and water. Because of natural fractures called cleats, coal has a large internal surface area. Coal is, therefore, capable of holding larger volumes of gas than conventional sandstone reservoirs. The amount of gas present in a coal seam depends on the depth of the seam, the thickness and the extent to which the fracture system is interconnected.

How is coal seam gas produced?

When water is released from coal, the pressure is reduced, and gas flows through the cleats. When a well is first drilled into a coal seam, gas does not normally flow to the surface. Water is pumped from the well (dewatering) with gas flowing subsequently.



As water production declines, gas production increases. A typical production curve for a coal seam gas well is shown above.

To assist the flow of gas through the coal to the producing well, the coal is mechanically fractured (referred to as 'fracturing' or 'fraccing').

At the surface, the methane, other gases and water are separated. The gas from several wells is collected and passed to a central compressor station, where it is added to a pipeline network for delivery to users. Gas used locally does not need compression.

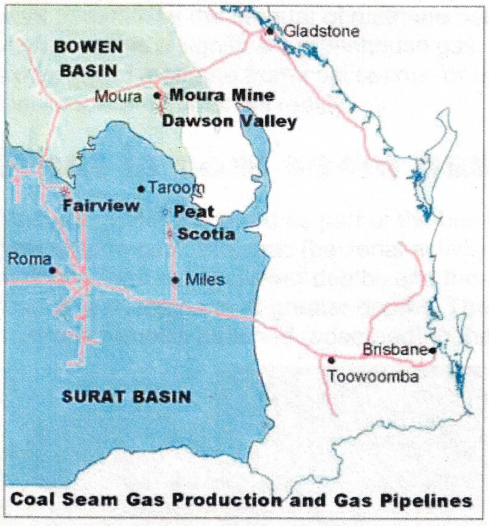
Production from a well must be continuous. If production is halted, water will re-enter the seam and dewatering must begin again.

The significant volumes of water extracted must be handled in an environmentally sound manner. The quality of the water can vary from drinkable to saline, depending on several factors. Evaporation, re-injection into deeper aquifers, flowage into natural drainage or local use have all been applied to water disposal overseas, depending on local circumstances.

Coal seam gas production in Queensland

In May 2002, the Queensland Government's Queensland Energy Policy–a Cleaner Energy Strategy required 13% of Queensland's electricity to be generated from gas by 2005. This has acted as a catalyst for active exploration and development programs for coal seam gas. In 2002, 25% of Queensland's gas demand was met by coal seam gas production.

Production in Queensland is currently restricted to the uppermost coal seams of the Bowen Basin. The first commercial production was from the Dawson Valley gas field, south of Moura, where gas flowed into the Wallumbilla–Gladstone pipeline in 1996. In the same year gas was also marketed from the Moura coal mine.

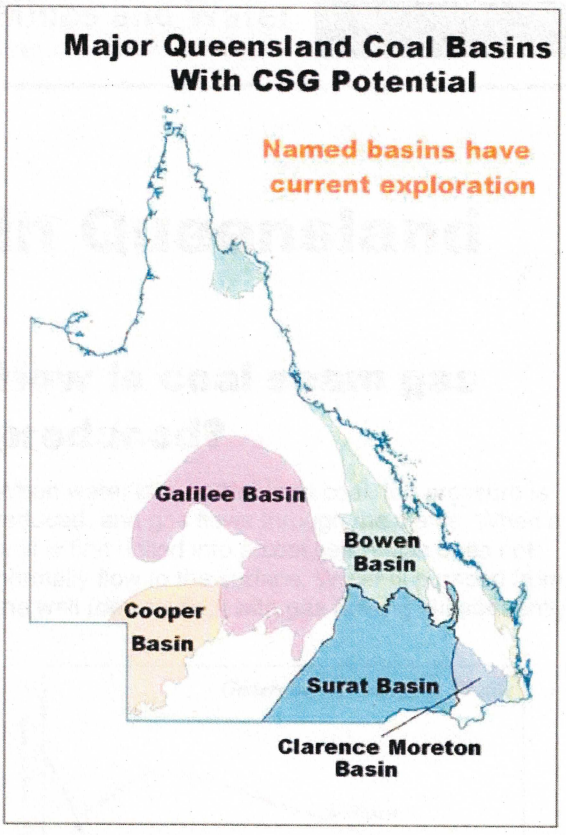


Fairview gas field, north of Injune, began production in early 1998. The Peat and Scotia fields near Wandoan began production in 2001 and 2002 respectively. Total production is currently in the order of 23PJ per annum.

Exploration in Queensland

Exploration is mainly focussed on the Bowen and Surat Basins, although all coal-bearing basins in Queensland are a potential source of CSG. Growing gas demand for electricity generation and industrial development are driving exploration.

Although proximity to existing infrastructure had been important in exploration, the growing maturity of the industry has seen explorers work in more remote locations. The main competitors to coal seam gas development are the proposed natural gas pipelines from Papua New Guinea and the Timor Sea.



Queensland has excellent prospects for coal seam gas (CSG) discoveries because of favourable geology. The extensive coal deposits provide numerous exploration targets. Coal seams are thick and multiple seams are present in many basins, with vast resources shallower than 1000 m.

Exploration in the Bowen Basin continues near Fairview (Durham, Comet Ridge) and in the Dawson Valley area. Production from the Grosvenor area near Moranbah in the northern Bowen Basin is being delivered to Townsville through a 391km gas pipeline. Exploration is continuing throughout the central Bowen Basin. Testing of the Rodney Creek prospect in the Galilee Basin continues.

The Surat Basin in south-east Queensland is the focus for a major exploration effort. Although the coals were not buried as deeply as those in the Bowen Basin and, hence, have lower gas contents, the proximity to infrastructure and markets, and lower drilling costs, make these deposits potentially economic. Several companies are undertaking production testing in different areas.

Further information

For further information on coal seam gas and petroleum in Queensland visit our web site at <www.nrm.qld.gov.au> or contact the Geological Information Hotline 07 3006 4666. ■

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Coal seam gas developments

Introduction

The future for the coal seam gas (CSG) industry in Queensland is very encouraging, and exploration and development of CSG now forms a major part of petroleum exploration and development undertaken in the State.

In recent years companies have been able to reduce drilling and production costs, and demonstrate new extraction techniques. A greater reliability of supply has been proven, aggregation of production is now occurring, long-term contracts are being entered into, and new gas markets are developing.

In May 2000, the Queensland Government released its 'Queensland Energy Policy—A Cleaner Energy Strategy'. This strategy requires the increasing use of gas, including CSG, as an energy source. The Government is committed to 13% of electricity sold in Queensland by 2005 being derived from gas and 2% from renewable energy.

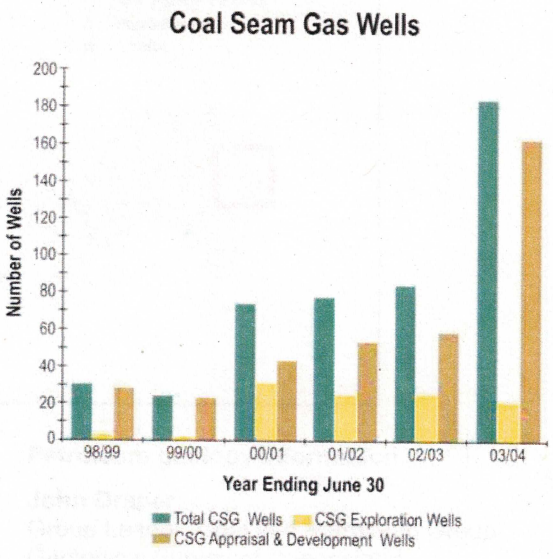
The State Government has enacted new legislation that provides an efficient and effective administrative and legislative regime that facilitates coal seam gas exploration and production, and efficient and safe coal mining. Further information on the legislation can be found at:
<www.nrm.qld.gov.au/mines/petroleum_gas>.

Exploration and production

Major companies exploring for CSG in Queensland are focusing on the Bowen and Surat basins, though all coal-bearing basins are considered prospective for CSG. Exploration is being driven by the growing gas demand for electricity generation and industrial development.

Queensland has excellent prospects for CSG discoveries because of favourable geology. The State's extensive coal occurrences provide numerous exploration targets. Coal seams are thick and multiple seams are present in many basins, with vast resources shallower than 1000 metres. CSG development in the Bowen Basin continues near Fairview (Durham, Comet Ridge) in the Dawson Valley area and at Moranbah. Exploration is continuing in the central Bowen Basin.

The Surat Basin in south-east Queensland is also being explored. The lower exploration and development drilling costs, and their proximity to infrastructure and nearby markets, make these deposits potentially economic. Several companies are undertaking production testing of identified gas resources.



Total CSG production increased to approximately 27 Petajoules (PJ) in 2004. This equates to about 25% of Queensland's current gas demand, and is a dramatic increase from around 2 PJ in 1998 and about 11 PJ in 2001.

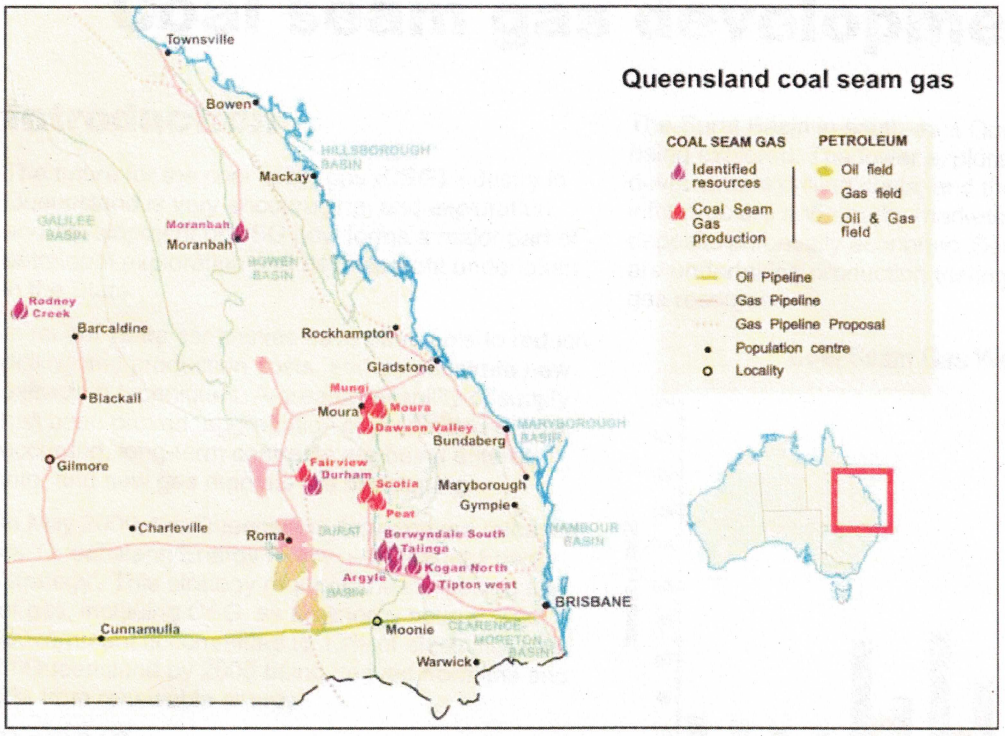
Resources

Queensland's known coal seam gas resources are confined largely to the extensive coal resources contained within the sediments of the Bowen Basin and the adjoining and overlapping sediments of the Surat Basin.

As exploration of the CSG resources of these basins is at a relatively preliminary stage, few well-defined estimates are available. Sales gas production is currently confined to the Bowen Basin.

Major explorers and producers in Queensland

- Anglo Coal (Moura) Pty Ltd
- Arrow Energy NL
- CH4 Pty Ltd
- Molopo Australia N.L.
- Origin Energy CSG Ltd
- Queensland Gas Company Ltd
- Santos QNT Pty Ltd
- Tipperary Oil and Gas (Australia) Pty Ltd
- Galilee Energy Pty Ltd



Contact information

Petroleum (includes coal seam gas) tenure applications.

For information coal seam methane contact:

Ross Randall
Project Officer, Petroleum and Gas
Department of Natural Resources, Mines and Water
3rd Floor, 41 George St, Brisbane Qld 4000
GPO Box 2454, Brisbane Qld 4001
Ph: +61 7 3247 5377 Fax: +61 7 3237 1534
Email: ross.randall@nrm.qld.gov.au

Andy Kozak
Senior Petroleum Engineer, Petroleum and Gas
Department of Natural Resources, Mines and Water
Southern Regional Office
Landcentre Woolloongabba
Level 2, cnr Main and Vulture Streets
Locked Bag 40 Coorparoo DC Qld 4151
Ph: + 61 7 3237 1491 Fax: + 61 7 3237 1534
Email: andy.kozak@nrm.qld.gov.au

Petroleum geology information

John Draper
Group Leader, Coal and Petroleum Group
Geological Survey of Queensland
Department of Natural Resources, Mines and Water
80 Meiers Rd, Indooroopilly Qld 4068
Ph: +61 7 3362 9340 Fax: +61 7 3362 9343
Email: john.draper@nrm.qld.gov.au

Coal seam gas policy and legislation matters

Peter Green
Manager: Mining, Exploration and Petroleum Strategies
Department of Natural Resources, Mines and Water
3rd Floor, 41 George St, Brisbane Qld 4000
GPO Box 2454, Brisbane Qld 4001
Ph: + 61 7 3237 1414 Fax: + 61 7 3237 1534
Mob: 0409 260 388
Email: peter.green@nrm.qld.gov.au

Further information

For information on current CSG legislation refer to <www.nrm.qld.gov.au/mines/legislation/current_leg.html>. ■

Water from Coal Seam Gas

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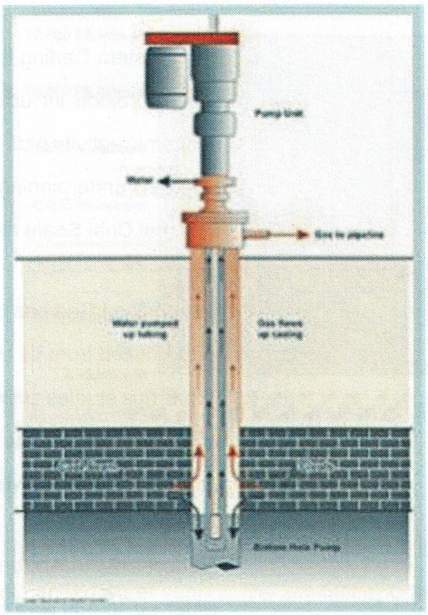
Coal Seam Gas and Water Co-exist



Click to enlarge.

A feature of Coal Seam Gas operations is the necessary uplift of associated water from the coal beds to liberate the adsorbed gas. Indeed, the commerciality of the gas extraction is linked to the initial presence of water within the coal bed, and the ability to subsequently remove that water.

The specialist knowledge of geological structures and well construction techniques required to commercially extract the Coal Seam Gas have meant that the coal seams have been a largely untapped water source that are not normally accessible without the gas extraction operations. The majority of groundwater accessed in the region comes from aquifers above or below, and generally isolated from, the coal measures. The coal seam aquitards represent an abundant water resource that does not impact on other groundwater sources, and provide the capacity to sustain regional development and growth. This growth can be achieved whilst reducing the current impact on groundwater and catchments, leading to an improvement in the health of downstream riverine systems.

Under the relevant petroleum legislation, Queensland Gas may capture and dispose of the associated water within its tenure boundaries for use in its own operations and for stock watering and domestic purposes on landholdings in the immediate vicinity. The quantities of water available far exceed the demand for

these purposes and excess volumes in gas undertakings have traditionally been disposed of by way of evaporation or re-injection in accordance with appropriate environmental approvals. The water brought to the surface in Queensland Gas Company's operations is mildly brackish, similar to water within the regional aquifers that require treatment to produce potable water. The Water Act provides licensing mechanisms for transmission of untreated or treated water to sites outside the petroleum tenures to enable this resource to be harnessed.

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Beneficial Applications

The Western Darling Downs region is the focus for major capital investment in energy projects including the Kogan and Braemar power stations. This new economic activity plus the progressive expiry of long-term conventional natural gas contracts underpinning South-East Queensland supply now allow for evolution of the local Coal Seam Gas industry.

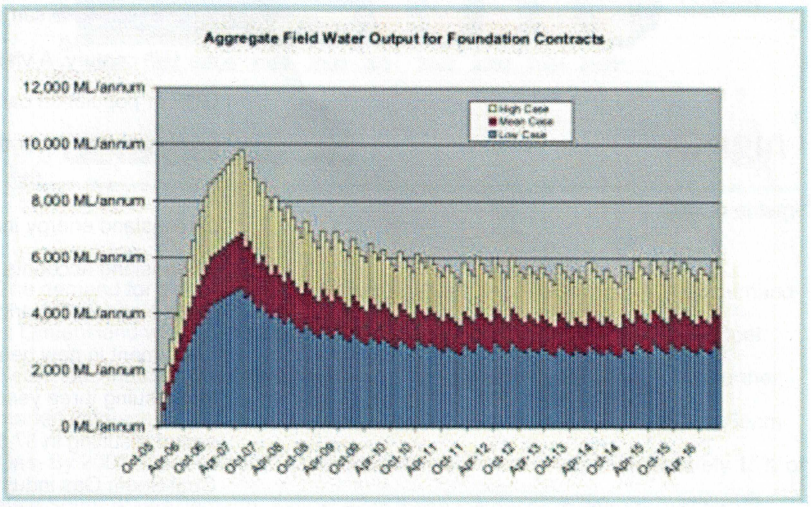
Queensland Gas has been actively pursuing beneficial applications for the water to be produced from its current and future activities. To this end, it has commissioned numerous studies over the last three years, including a recent jointly funded report in conjunction with the State and Federal Governments and neighbouring gas producers (State Government media release).

A successful trial of treatment of the raw water by reverse osmosis to drinking water standards was concluded at the Argyle field in December 2003. The reverse osmosis process is mature technology in widespread application across the globe, is proposed to be implemented in potential seawater desalination plants in Sydney, Brisbane, the Gold Coast and Perth, and is used successfully to treat groundwater for supply of potable water at Dalby. The gas fields provide the energy required for the treatment processes and initial pumping.

In 2005, Queensland Gas is proceeding with development of its Coal Seam Gas fields and has escalated its efforts to find beneficial applications for the forecast water output. This is the outcome of the work undertaken to delineate its reserves of gas and associated water adjacent to Chinchilla and Miles that has enabled major gas sales contracts to be secured. The quantities of water that will become available from the operational phase of Queensland Gas Company's properties provide a platform for development of beneficial use options that are realisable due to the stable water output over economically realistic timeframes.

The company's exploration efforts have identified that up to 350,000 ML of

treatable water may be extracted from ⅔ of the coal seams of interest over the small area of our permits currently being developed. By comparison, the communities of Miles, Chinchilla, Dalby and Toowoomba have a combined population in excess of 115,000 and an annual water demand of some 17,000 ML. The rate of water extraction is linked to the rate of gas delivery under our gas sales contracts, with initial output depicted below. The reserves and delivery rates will grow with increased sales to meet growth in the gas market and offset the decline of the more distant conventional natural gas sources currently servicing South-East Queensland.



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The benefits are not limited to meeting the needs of any communities receiving an enhanced water supply. The availability of water from Coal Seam Gas operations can:

- mitigate stress on the water resources in the immediate area of those communities;
- replace some of the need to extract water from the Murray-Darling Basin system;
- support further economic development without additional loading on the catchments and traditional groundwater resources;
- facilitate energy and industrial projects of national significance;
- establish a sustainable long-term drought-proof water supply scheme;
- deliver urban water supplies more cost effectively than a dam, without the environmental impact or losses due to seepage and

evaporation.

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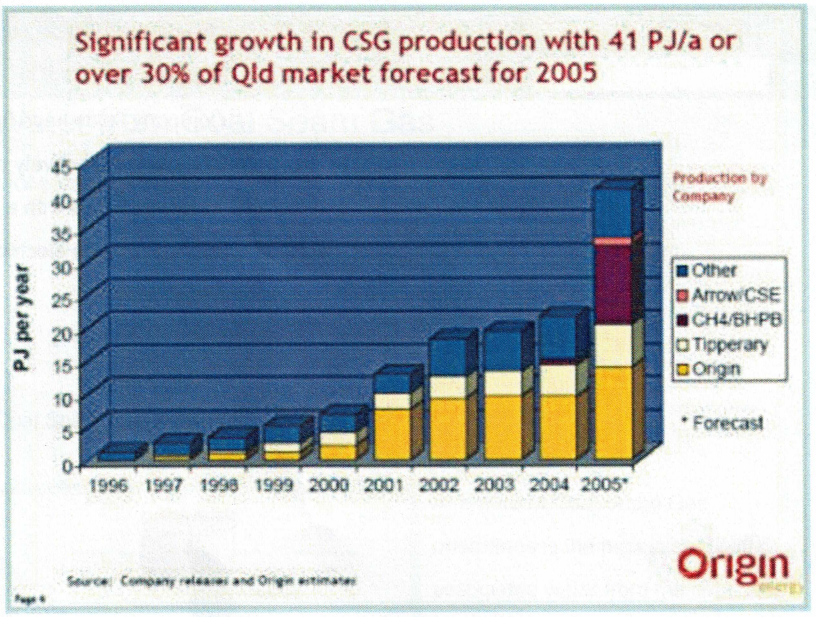
Growth in Production of Coal Seam Gas and Water

Gas resources of magnitude have historically been found in remote locations such as Ballera and Moomba near the QLD/SA border, and conventional production does not entail release of water in significant quantities. Conveniently, Coal Seam Gas can be accessed closer to population centres. This is due to the historical reliance on those same coal resources that sustained populations and growth in the 19th century. A viable field can be developed in increments, thus increases in GDP or population can be met by growth in Coal Seam gas output with an accompanying water benefit.

Queensland energy industries are going through a period of substantial growth. Queensland accounts for 70% of all new electricity generation output constructed in the National Electricity Market since its inception five years ago. $1.5 billion of investment in new generation is occurring in the Chinchilla and Wambo shires over the ensuing three years with 25% of that expenditure undertaken by the private sector resulting in 37.5% of the new output coming from gas turbine plant. The Coal Seam Gas industry is building up to meet that demand and making its own investments measured in hundreds of millions of dollars over the same timeline.

Queensland Gas has expended considerable sums of money over the last 5 years assessing the Coal Seam Gas reserves under its operatorship. This has resulted in identification of commercially recoverable reserves to meet its substantial sales contracts that have now become unconditional. In the second week of September 2005, production drilling commenced on the Berwyndale South field. Drilling of wells and connecting those wells to market will continue throughout 2006. By September 2007, Queensland Gas Company will be providing 25% of the gas requirements of South-East Queensland.



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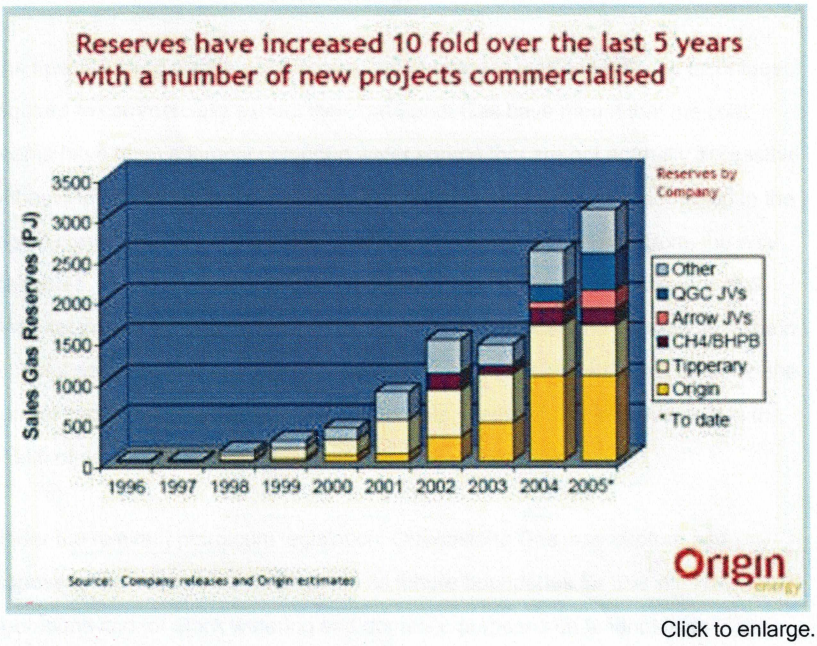
The demand for gas in Queensland has doubled since 1999, and in 2005 demand in Queensland will exceed that of New South Wales for the first time. The Coal Seam Gas industry has proved itself capable of meeting that growth, with further market increase of 10% in 2006 being satisfied almost exclusively by Coal Seam Gas. By 2007, Queensland Coal Seam Gas will be providing approximately 15% of New South Wales demand. Almost all of these increases in demand will be satisfied by the fields to the west of Toowoomba that present a gas resource greater than that offered by any potential pipeline from Papua New Guinea. Only Coal Seam Gas can produce the associated water benefit.



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Potential markets for larger water volumes that would be generated under full-scale development of the Argyle, Berwyndale South and other Queensland Gas Company fields have been identified. Companies other than Queensland Gas Company are actively developing reserves in close proximity and linking of the water resources with a transmission system facilitated by an independent operator as occurs in the electricity grid is seen as a logical extension of regional development.

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COAL SEAM GAS
BENEFICIAL USE OF ASSOCIATED WATER

QUEENSLAND GAS COMPANY
QGC

Background

Over the past three years Queensland Gas Company has been actively undertaking research into the use of associated water from its coal seam gas (CSG) operations for the benefit of the Western Darling Downs region. Investigations to date have resulted in trials including:

- Treatment to produce potable water for local communities; and
- Application to irrigation in sustainable agriculture.

This research has provided QGC with a rich platform of information on CSG water quality, available quantity and local water demand. Subject to commercial viability QGC intends to develop complementary projects to facilitate water security. The research conducted to date by QGC on sustainable irrigation trials shows some promise.

Aim

QGC is conducting Australia's first crop trial applying untreated associated water from CSG production for agricultural use, with a rotation of barley and sorghum crops. In the USA, saline waters of up to 4600ppm total dissolved solids (TDS) have been successfully used for irrigation for periods of 75 to 100 years in several areas of the Southwest. Other examples of application of water with high TDS can be found in the Middle East. The knowledge accumulated in these areas has allowed development of a model (Watsuit) to predict the impact of the water and the associated soil and water treatments.

Comprehensive management of agriculture inputs is expected to enable a successful outcome using untreated CSG production water. If successful, similar regimes are potentially able to be developed for agricultural utilisation of similar unconventional water sources and allow release of conventional water resources for municipal and other higher value applications.

Water Quality

- The trial uses associated water pumped from coal seams 300 – 800 metres below the earth's surface.
- Potable drinking water is ≤500 ppm TDS.
- Water from QGC's CSG operations is 2000 – 3500 ppm TDS, $^{2}/_{3}$ of which is carbonates and only 15% is chlorides.
- Tests conducted by QLD Health have determined that the untreated production water does *not* contain radionucliides, aromatic hydrocarbons or any carcinogenic constituents at levels of concern to human health.
- The production water is of equivalent quality to the groundwater of the region.
- Untreated water from the coal seams can be used for aquaculture, stock watering and in industrial applications such as coal wash plants.

Field Trial Overview

- QGC is conducting the trial under the supervision of NAC Agricultural Company in conjunction with Dr. Pat Hulme of Sustainable Soils Management.
- The trial is being undertaken at "Windibri", a freehold property owned by QGC at its Berwyndale South gas field, 30minutes from Miles and Chinchilla.
- A significant aspect of the trial is identification of soil types that are suitable for cropping with the associated water.
- The soil requires treatment before irrigation with the associated water.
- Treatment of the soil involves adding gypsum and sulphur to the topsoil after deep ripping the paddock.
- Organic matter is added in the form of composted manure from adjacent feedlots.
- An alternative method of applying the sulphur by pre-treatment of the water is also undergoing assessment. This option gives the added benefit of lowering the pH level of the water.
- The aim of the trial is for any dissolved solids in the water to leach into soil to at least 1 metre, well below the root zone. The capacity of the selected areas on 'Windibri' with suitable soil to accept the salts added during irrigation will be assessed.
- The trial initially proposes use of the production water in rotations of five years double cropping, followed by two year periods where the field is to be left fallow.

Trial Progress

- Water usage for the barley winter crop equated to 5 megalitres per hectare.
- The crop of 20 hectares (50 acres) of barley has now been harvested.
- The trial produced a yield in the order of 1.8 tonnes per acre a good result for the initial crop upon a deeply ripped paddock.
- The ability to produce a robust crop in an environment of widespread drought enabled a superior price to be obtained.
- The harvested barley was delivered to a local feedlot.
- Proceeds from sale of the barley will be distributed by QGC to schools at Miles, Chinchilla, Condamine and Tara.
- Follow up monitoring is being undertaken in accordance with the regime set out below.
- The trial plot will now be planted with the sorghum summer crop.

Environmental Monitoring

A number of soil properties are monitored in soil sampled from cores at the same sites (in irrigated and non-irrigated areas) at the beginning and end of each cropping year. The following parameters are regularly monitored:

- Change in soil moisture – continuous recording of soil moisture is used to establish efficient irrigation cycles, monitor water movement through the soil profile and the depth of water uptake by plants.
- Chloride mass balance – the amounts of Chloride applied in the water and the observed levels through the soil profile are measured as an estimate of the volume of water that has passed through the profile and to provide early detection of changes in soil salinity.
- Sodium level – the levels of Sodium are measured through the soil profile at the beginning and end of each cropping year to monitor changes in soil sodicity.
- Organic Carbon – the level of Carbon through the soil profile is measured to give an indication of soil health.
- Soil dispersion – is measured through the soil profile to give an indication of changes in soil structural stability.
- Visual soil inspection - to detect changes in soil properties and behaviour.

Additionally, the crop is monitored:

- Visual plant monitoring – seedling vigour and plant growth is assessed and compared to crops grown using conventional water resources.
- Tissue sampling is undertaken to determine any plant nutritional problems or mineral accumulations.
- Crop productivity is measured with yield monitors in crop harvesters.