Coal seam gas exploration technologies in New Zealand

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Abstract

While coal seam gas is considered to be an unconventional gas, the proliferation of areas under exploration and development mean that it is rapidly becoming main stream. The potential of New Zealand's coals to produce coal seam gas has been recognised for some time. However, key market drivers have not been suitable for the progression of this potential into commercial reality. Kenham Holdings Ltd and CRL Energy Ltd, recognising the potential for the gas in New Zealand have initiated what is the largest ever assessment of New Zealand's coal seam gas potential. The premature demise of the giant Maui field has raised the focus of new developments and has increased interest in coal seam gas.

Over the past couple of years Kenham Holdings Ltd and CRL Energy Ltd have approached the assessment of the coal seam gas potential in a staged programme. To date, preliminary appraisals have been completed or are underway on a significant number of fields. Preliminary assessment of the data on the permit areas indicates that the potential resource may be up to 500PJ. Exploratory drilling has been completed or initiated on several of those fields, with results from this work being fed into preliminary models as data has become available.

In many of the areas being assessed for coal seam gas there is no pre-existing information concerning their gas potential. As world wide experience with gas extraction from lignite is practically nonexistent, it has been a steep learning curve with many surprises. However, initial gas content results and preliminary gas flow models have been on the whole, rather pleasing, with the commerciality of some developments already apparent.

Introduction

Coal Seam Gas (CSG) is a new and developing source of natural gas world wide. Several countries including the United States, Canada, Australia, China, India and the United Kingdom are carrying out active exploration programmes with a few basins (mainly in the US) now producing gas at significant rates. In 2000, CSG gas accounted for 8.8% of the reserves (15.7 tcf) and 9.2% of the annual production (1.38 tcf) of dry gas in the US (Ayers, 2002). New Zealand, with its significant coal resources and looming gas shortage, is ideally placed to join this world-wide trend in exploring for this supply of natural gas.

Assessment of New Zealand's CSG resource started in the 1980's. However, recent changes in the New Zealand energy scene have prompted renewed interest and activity in the area of CSG exploration. At the current time, New Zealand does not have a commercially producing CSG project although significant progress has been made over the last few years by a number of individuals and groups in assessing the nature and size of the potential resource.

Kenham Holdings Ltd (Kenham) and CRL Energy Ltd (CRL) have worked together successfully for a number of years to develop the technologies involved in exploring for and developing the CSG potential of New Zealand's low rank coal resources. This work has been assisted by the award of a three year Technology for Business Growth grant from the Foundation for Research Science and Technology.

The success of the programme of CSG exploration and development in New Zealand's coals depends upon:

1) Satisfactory gas content and recoverability assessments;
2) Adaptation of methodologies and techniques used overseas to suit local conditions; and
3) Successful commercialisation of the CSG resource through an economic commodity price

Potential

The potential of New Zealand's coals to produce gas is well known from mine hazard studies and early CSG projects. However, converting this potential into commercial reality has not been straightforward as several companies have discovered. Often the inability to commercialise has been linked to low gas concentrations which are typical of sub-bituminous coals. However, the successful commercial development of the Powder River Basin (USA) proved the economic viability of CSG production of sub-bituminous coals. This is excellent news for the CSG industry in New

Zealand as the vast majority of New Zealand's coal resource is ranked sub-bituminous or lower (Barry, 1994). The success in the Powder River Basin has spurred on exploration in various low rank coals world wide, including a pilot development in the brown coals of Victoria, Australia (King 2003).

Assessment

The early explorers of CSG in New Zealand have borne significant costs in relation to the work that has been carried out to date. These early explorers have included Southgas/ WestGas, Kenham and RDT, as well as associated groups. While there has been a useful exchange of information with CSG explorers and developers in the USA and Australia, the problems faced in New Zealand are different in a number of ways such as available infrastructure, service companies and the nature of the coal itself. The advancement of local exploration and development techniques has been largely undertaken by groups as they deal with issues related to their areas of interest.

In seeking to develop the gas potential of low rank coals Kenham & CRL have carried out a very structured and carefully planned work programme:

Preliminary appraisal

The stratigraphy, coal resource and any previous work in the permit are reviewed and the CSG potential is estimated. Key aspects of this work include the identification of high potential areas as well as areas of limited or no potential and the forward exploration plan. The areas of high potential are targeted in the first round of exploratory drilling.

Exploratory drilling and analysis

Although there is a considerable amount of exploration drilling data for the coal fields in New Zealand, there is a need to gather more data on the potential for storage and production of gas. This can only be achieved by collecting samples for desorption and analyses. Kenham and CRL have modified and redesigned existing coal desorption equipment, spreadsheets and procedures to make them more applicable to New Zealand. These have subsequently been tested in the field on a number of occasions. Lessons learnt have and continue to be, incorporated into desorption related techniques and methodologies.

Key information gathered during the exploration programme is as follows:

- All coal seams in excess of 1.00m thickness are sampled as the drill holes are fully cored through the coal section.
- Coal core is desorbed to determine its gas content and desorption rate
- The coal characteristics of the core are assessed prior to it being sampled for moisture, ash and coal quality.
- Samples of the core are also taken for methane adsorption isotherm and coal matrix permeability determination.
- Gas produced by the coal during desorption is sampled to determine gas composition, and carry out isotope studies to assist in determination of provenance.
- Groundwater studies are also undertaken to determine both water quality and seam permeability.

Preliminary modelling

Auckland University has been working with us to develop a simple single layer model with radial flow to a well. This model provides preliminary estimates of gas and water flow from the well over time. This model uses information gathered in the field together with some assumptions to determine which fields will undergo full 3-D modelling prior to development. The main data inputs are:

- Coal field geometry, coal thickness, depth and quality.
- Coal methane adsorption and desorption data relevant to the proposed production depth.
- Coal permeability.
- Well spacing and completion type.

Follow-up drilling and pilot development

Follow-up drilling will only be undertaken if further data is required to clarify issues from the first pass drilling. Pilot development would comprise a three to five well grid, with holes developed as production wells.

Kenham and CRL are actively progressing the first three of these four steps on several permits. The work completed and underway as at December 2003 is summarised in Table 1.

Results

Preliminary appraisals

The main focus of the appraisals is to gather as much detail as possible on the coal resource (quality, quantity, structure etc). Preliminary groundwater quantity and quality information is also gathered. Any information on gas content is also collected but this is generally sparse. The reviews and analyses completed to date have effectively compiled and reinterpreted the available data so that exploratory drill holes can be placed to gain the maximum amount of information.

Exploratory drilling

The key information to be gathered from exploration work is gas content and production curves, gas adsorption isotherms, permeability and gas composition data. Coal quality data is also gathered as it provides an important basis on which the results can be better understood and compared within and between fields.

Gas production curves are developed by measuring the amount of gas produced by a coal sample over time. They show both how much gas is actually present in a particular sample and the rates at which it will desorb from the coal. The total gas content of the coal is made up of three components, lost gas, measured gas and residual gas. The total amount of gas released from the desorption canisters over time (after standardisation) equals the measured gas. Lost gas is calculated for each sample separately by using trend line analysis through the cumulative total of the early measured gas results. Residual gas is the amount of gas released by a desorbed coal sample after it has been crushed to a fine powder.

Gas adsorption isotherms are measured by grinding the coal to a fine powder in a pure methane atmosphere and measuring the amount of methane taken up by the coal at different pressure points. They provide the theoretical maximum gas content of the coal at specific pressure levels and effectively equate to the methane holding capacity of the coal in a particular pressure regime however do not represent the actual methane content of the coal.

Permeability data is required to determine the flow rates of both water and gas through the coal seam. Seam permeability is a particularly important variable that is frequently overlooked. The other key data to be gathered is gas type. In New Zealand this is typically 90%+ methane with some carbon dioxide, hydrogen and heavier hydrocarbons.

All four factors above are critical in the development of a realistic gas and water production model. By comparing the total gas content to the isotherm, the pressure regime at which gas production is initiated and how much gas is released at a given pressure drop can be determined. The permeability data gives information as to how quickly the coal can be dewatered and the timing to critical pressure regimes within the coal. A gas and water production model is a fundamental aspect of determining the economic feasibility of any CSG development.

As at December 2003, Kenham and CRL have obtained and are analysing data for Ohai, Hawkdun, Mataura and Maramarua. As expected, the results of the drilling reflect the obvious differences in coal type, rank, depositional environment and depth of burial. There is obviously a wide variation between the fields tested to date, with the lignites having lower gas contents than higher rank coals. Despite the low levels of gas in the lignites, the fields are considered to be prospective. As a comparison, the Powder River Basin coals also contain low gas content but are able to be developed successfully due to other favourable factors. One of the main positive factors in the successful development of the Powder River is the very high permeability which is reflected in gas flow rates of between 500 and 5,000 m3/day (Anadarko, 2002).

Preliminary modelling

To date, single layer models that use radial flow to a well have been developed by Auckland University for both Hawkdun and Ohai. These models provide indications of expected gas production rates from wells in these fields.

While further work is required to refine the input parameters into both of these models, the results indicate that further work is certainly justified. In the case of Ohai, commercial production rates are certainly very achievable. In the case of Hawkdun the modelled results are lower than Ohai but higher than the flows reported from the Powder River Basin. Based on the modelling the field has potential for commercial gas flows. Site variables in determining gas flow rate include gas content, coal thickness, pressure and permeability. Other determinants can be varied to enhance flow and include well spacing and completion methods. Models for variable drainage areas and completion systems will be run to further determine the potential of the fields.

3-D Modelling

3-dimensional reservoir models of gas flow and groundwater will be developed to ascertain the best way to develop the field and in particular, assist in determination of the size and location of the production grid prior to undertaking pilot production projects on areas with favourable assessment results. Following pilot production tests, history matching the performance of the wells with the model is carried out.

Pilot production developments

Once the results of the exploration drilling, coal desorption, analytical and 3-D modelling have been interpreted, a decision to proceed with pilot production development, will be made. The pilot production development is typically a 5-well test pod that allows production parameters to be tested. The five well test pod is a design that enables the best development of a water drawdown cone within the coal, and subsequent release of CSG on a small scale. In this design a well is placed at each corner of a square of pre-determined size and the fifth well is placed in the middle of the square. The spacing of the wells is dependent upon the characteristics of the coal and the required production scenario.

Conclusions

Over the past few years, Kenham and CRL have been actively advancing the available knowledge base on development of coal seam gas in New Zealand. In particular, the focus is on low rank coals and the CSG potential of these coals is becoming more clearly defined. The key factors that make up a commercial deposit are also becoming clearer. While there is still some way to go before commercial development, excellent progress is being made in what is truly, a frontier energy development in New Zealand. All permits are still being evaluated carefully as it is too early in the programme to make any final determinations especially given the changing nature of the New Zealand energy market.

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Table 1. Status of Kenham permits relative to the four step work programme outlined above as at December 2003.

Field	Preliminary Appraisal	Exploratory Drilling	Preliminary Modelling	Pilot Development
Ohai	Completed	Completed	Completed	Planning
Maramarua	Completed	Completed	Underway	
Hawkdun	Completed	Completed	Completed	
Mataura	Completed	Completed	Underway	
Reefton	Completed	Underway		
Kaitangata	Completed	Underway		
Ashers Waituna	Completed	Underway		
Kamo	Completed	Planned		
Nth Waikato	Completed	Planned		
Edendale	Completed	Planned		
Buller	Underway	Planned		
Waiau	Underway			