Coal Bed Methane

- This report gives an overview of the potential of a CBM industry in Zimbabwe covering project development, technology, economics, markets and investment opportunities.

- Coal bed methane (CBM) has made the transition from being a marginal resource and is now a respected mainstream source of gas in some countries.

- In the United States, CBM accounts for almost 10% of total domestic production. In Queensland Australia, CBM accounts for 30% of production. Now other countries are seeking to replicate this success and develop their CBM potential.
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Executive Summary

Zimbabwe has 765 billion cubic metres of measured coal-bed methane resources. This exceeds the total measured resources in the rest of the Southern African Development Community put together. The SADC gas resources amount to 420 billion cubic metres.

Zimbabwe’s CBM has a high purity of 95% methane. Clean water is co-produced with the gas and can be used for irrigation and domestic purposes.

In 2011 fertilizers accounted for 18.5% of Zimbabwe’s total imports.

Zimbabwe is the third largest power consumer in Sub-Saharan Africa after Nigeria and South Africa. 35% of electricity consumed in Zimbabwe is imported from Mozambique and DRC.

CBM can be converted into diesel, petrol or ethanol. Petroleum products account for 13.7% of Zimbabwe’s total imports and are consumed at 1.4 million litres a day.
Summary

Coal Bed Methane (CBM) is a form of natural gas found in coal beds. It is mainly methane gas with trace quantities of ethane, nitrogen, carbon dioxide and a few other gases (which depend on the type of coal and the geographical location). It is nearly identical with natural gas (CH4), and can be used as an alternative to natural gas. However, unlike conventional natural gas, coal bed methane contains very little heavier hydrocarbons such as propane and butane, which makes it more environmentally friendly. In recent decades it has become an important source of energy in countries like the United States, Canada, China and Australia.

Zimbabwe’s power consumption is currently the third highest in sub-Saharan Africa and will rise even higher as the economy continues to recover. Zimbabwe produces 1300 MW against a demand of 2200 MW. To satisfy the deficit, 35% of the total electricity is imported from Mozambique and DRC. In order to meet rising demand and reduce the country’s energy security risk, the Government of Zimbabwe is seeking to diversify its supply of energy. Zimbabwe’s current energy mix is heavily dependent on imported petroleum and electricity.

Coal bed methane recovery and utilization presents an opportunity for Zimbabwe to lessen its dependence on imported petroleum and electricity while also providing an alternative means to produce cleaner energy from coal.

Trent Wheeler, the CEO of Australia’s Magnum Gas & Power which has two prospecting licences for CBM in Botswana says that CBM is a far better value proposition than traditional coal. He says CBM is a flexible, clean fuel source that can either be used as a gas, or can be converted to diesel or liquid natural gas and can also be compressed and used as a feedstock for ammonium nitrate, which is extensively used in fertilizers and mining explosives.

Coal bed methane (CBM) is gas which is created during the formation of coal and is trapped within a coal seam by formation water. CBM is chemically identical to other sources of gas, but is produced by non-conventional methods. CBM is generally more than 95% methane and is often marketed as being “green” as it contains no sulphur compounds such as hydrogen sulphide.

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Introduction

Occurrence

There are two coal basins in Zimbabwe. One is in the western part of the country and the other is in the south east of the country.

Zimbabwe has measured coal-bed methane resources that exceed the total measured resources in the rest of the Southern African Development Community put together. The SADC gas resources amount to 420 billion cubic metres while it is estimated that the Hwange/Lupane basins have 765 billion cubic metres of sulphur free CBM (over 800 million cubic metres of CBM per square kilometre). Early in 2012, Mozambique discovered coal and coal bed methane in areas that border Zimbabwe’s Manicaland Province. The CBM is believed to flow into Zimbabwe’s Manicaland Province.

Exploration

Shangani Energy Exploration (Pvt Ltd) completed Africa’s first coal bed methane production well in 1994 at a site near the Shangani River, about halfway between Bulawayo and Victoria Falls. Three companies have been involved in exploration for CBM in Zimbabwe i.e. Shangani Energy Exploration, Afpen Lusishe Developments and Terra Firma. The coals and carbonaceous shales in this area contain 2 to 5 cubic metres per ton in-situ gas of a high purity of 95% methane. Water co-produced with the gas is clean and can be used for irrigation and domestic purposes.
Opportunities

CBM is an attractive industry for upstream companies to be involved in and a number of opportunities exist for those wishing to invest in the sector. Like most mining projects, CBM projects follow a multi-phase development process. CBM projects typically go through the following stages of development:

1. Exploration

2. Geological & geophysical studies

3. Pilot project

4. Phased development

5. Abandonment

The location of most of Zimbabwe’s CBM reserves is well known. However, not all of these reserves are suitable for CBM development. An exploration programme has to be implemented to identify reserves suitable for development. A series of core wells has to be drilled to obtain samples of coal which will then be tested. Once a reserve of CBM has been identified, a full geological and geophysical analysis of the core samples will then be undertaken. This will test for several things including: gas content, permeability and seam thickness.

If the results are positive then the project will move onto the pilot stage. The key objective for the pilot project is to test that a prospect is economic to produce. Production wells are drilled over a limited area of the prospect. The performance of the wells will be used to build a production model and this model will determine the well spacing and therefore the number of wells required for full development. The pilot project also provides an opportunity to test techniques and technology. At this stage an initial reserve certification may occur. This certification can assist gas marketing activities, determination of beneficiation options and also help the company to secure additional capital.

Following a successful pilot project a full development of the project will start. This will normally occur in a number of stages, with each stage aiming to increase production in order to match demand set by downstream beneficiation activities or gas supply contract obligations. The phased approach also allows the company to generate revenues prior to capital expenditure in the next stage. Once the economic production limit of the field is reached, it will then be abandoned.

CBM production leaves coal behind. The energy content of the coal is not adversely affected by CBM production and thus it remains exploitable.
Extraction

In a CBM reservoir, gas is adsorbed to the surface of the coal and is held in place by the pressure of the formation water. A production well penetrates the coal seam causing the water to be produced due to the pressure within the coal seam. During the initial period the well only produces water, but over time less water is produced and increasing volumes of gas are produced. Each well has an effective radius from which it can dewater the coal and produce gas. Gas production will eventually peak and subsequently go into decline.

Fig 2. Typical production curves for a coal-bed methane well showing relative volumes of methane and water through time. Modified from Kuuskraa and Brandenberg (1989).

Fig 3: Typical production well
Drilling

Unlike conventional gas, which is found at depths up to 7,000m, CBM is typically found at depths of 400–1,000m. These shallower depths make it possible to use smaller, more mobile, truck-mounted drilling rigs compared with those used for conventional gas wells. These types of rigs have much lower costs and therefore improve the project economics. The majority of projects use vertical drilling to develop fields. These wells are drilled down and through the seam (sometimes multiple seams are penetrated if this is deemed economic) and a vacuum is applied to the well to extract the methane.

Each well has an effective radius of gas drainage. Therefore, it is important to model the well spacing to ensure that the optimal volume of gas can be accessed. It is typical for a CBM project to require hundreds of vertical wells to be drilled over its lifetime. Advances in horizontal drilling techniques mean that it is now being implemented in suitable projects where it is cost effective. The key advantage of horizontal wells is that fewer wells are required relative to vertical wells. Horizontal wells are able to track coal seams and so they can access more coal and produce more gas. Horizontal wells can also be used where land access is an issue as they can pass under disputed areas. The main drawbacks with horizontal wells are: they are technically more difficult to drill and are more expensive than vertical wells.

Piping infrastructure

Zimbabwe’s CBM is 95% methane and thus identical to any other source of gas. Therefore, once it has been dried and compressed it can be sold into any market. Zimbabwe has a limited use of gaseous energy and little infrastructure in place to convey gas from source to end user. Liquefied Petroleum Gas (LPG) is used in many households as a backup energy source when electricity is not available. It is however mainly used for essential energy requirements such as cooking. Recently however there has been an influx of gas-powered geysers and refrigerators. These are still not as popular as the electric appliances. Gas is however cheaper than electricity and offers a cheaper long term alternative to electricity. Gas is currently imported from Mozambique. Due to its limited use, gas is sold at fuel garages and transported by trucks in large quantities and canisters in smaller quantities. Gas is also used in industry for metal melting and cutting, steam raising, powder-coating and ingredient drying.

If there is to be an energy revolution which will see coal bed methane being used as a major source of domestic and industrial energy, there is need to invest in piping infrastructure that will convey the gas from the coal bed methane fields to distribution points in the major urban centres. The Lupane / Hwange coal bed methane fields are located in the north-western part of the country, hundreds of kilometres from major urban and industrial centres such as Harare, Bulawayo and Mutare. Given the expansive reserves
of coal-bed methane available and the large potential demand for the gas, it is economically sensible to invest in pipelines to convey the gas. As part of its 11th Five Year plan (covering the period 2006 to 2010), China spent US$375 million to build two pipelines with a total length of 1,390 km for coal-bed gas transmission.

Power Generation

Zimbabwe currently imports 35% of its electricity. CBM offers an alternative source of energy for power generation. Power generation is in fact a very convenient use for CBM because CBM supply cannot be switched on and off depending on demand, as wells that are shut-in start to water again. Power generation offers a constant, predictable demand which can be matched to CBM production levels. Another factor is the relatively long lead times required for production to be increased to meet new contracts. Lead times of two years are typical to allow for wells to be drilled and to allow sufficient time for dewatering and subsequent commercial production of gas.

There is a hydro-thermal powered power generation plant in Hwange owned by Zimbabwe Electricity Supply Authority (ZESA). This plant has been performing below capacity recently as the Wankie Colliery Company has failed to supply it with the required quantities of coking coal. The plant uses coking coal to produce steam which turns the turbines which generate electricity. It is viable to use CBM as alternative source of energy for steam generation at the plant. As this plant is not far from the CBM fields, ZESA is a potential major customer for CBM. CBM is a cleaner, environmentally friendlier alternative to coal for hydro-thermal generation of electricity. The high quality of the gas recovered from unmined coal seams also renders it suitable for replacing or supplementing coal in power generation systems, such as gas turbines and gas engine systems. This utilisation option increases in viability the closer the generator is located to the CBM recovery site.

Additionally, investors can implement the so called “wellhead to wires” strategy. In such a project the investor develops the CBM wells, pipeline and also installs and runs the associated power plant. The electricity generated is then sold directly into the national electricity market or to large industries. Such projects provide higher revenue streams than gas supply only projects. It is also attractive to power purchasers as it reduces their risk profile by negating their exposure to CBM production uncertainties. An example of such a project is Queensland Gas’ development of the Chinchilla field to supply a 57 MW power

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3 Dougie Youngson (Fox Davies Capital), Coal Bed Methane Sector Overview, 2007
In the Shanxi region of China, an international consortium of companies (including Sinopec) is spending $1.14 billion over the next five years to develop CBM to supply 189 MW of power generation.

When considering the installation of a CBM-fired power plant, there are a number of factors that must be evaluated, including the length of time it will need to be fully operational, the composition of the gas to be sequestered and the availability of appropriate equipment and support. Typically, a permanently-installed CBM-fired power plant development requires 12 – 18 months from start to completion. Duration depends significantly on site accessibility and the preparation and complexity of the power plant. For mobility and ease of installation, some generator set manufacturers offer pre-configured containerised sets for lease or rental, which can be delivered, installed and commissioned, in as little as one month. Zimbabwe’s CBM consists of nearly pure methane and will not require specialised fuel train, fuel treatment or dewatering equipment.

**Fischer-Tropsch**

CBM can be converted into diesel, petrol or ethanol. Other products include specialist lubricants and waxes. The Fischer Tropsch Synthesis model converts CBM into a product stream that includes petrol, high quality diesel, paraffin, fertilizers, specialist lubricants, waxes and aviation fuel. This model has been successfully implemented by South Africa Synthetic Oil Limited (SASOL). It is also the basis of the pharmaceutical and plastics industries.

**Ammonium Nitrates**

With CBM, Zimbabwe can turn from a net importer of fertilizers to a net exporter. Fertilizers are Zimbabwe’s top import, accounting for 18.5% of total exports in 2011. CBM is used to produce hydrogen which in turn, is used in the manufacture of ammonia for fertilizer. Industrial raw material in the production of fertilizers and petrochemical feed-stocks.

**Concerns**

The USA and Australia are the leading users of CBM. These countries have experienced a number of issues that impact the industry. Such issues include: water disposal, land access, licensing and methane loss to the atmosphere. Zimbabwe has a strong legal and policy framework on environmental protection and it is important that potential investors plan for these issues well in advance. In doing so, these issues will be

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4 [http://www.energynewspremium.net/storyview.asp?storyid=32916&sectionsource=s0](http://www.energynewspremium.net/storyview.asp?storyid=32916&sectionsource=s0)

5 Zimtrade
overcome in a manner that ensures the investor, communities and the environment all benefit from the extraction of CBM thus making the industry viable in the long term.

1. Produced Water

In a coal-bed methane well, water is produced in large volumes, especially in the early stages of production; as the amount of water in the coal decreases, gas production increases (Fig. ). The water must be disposed of safely. CBM produced water has the potential to affect groundwater quantity and quality. Coal seam aquifers may have competing water rights and be diminished as CBM production increases. Surface water quality could be altered by mineral-laden discharge, and agricultural productivity of soils could be reduced by irrigating with altered surface water. Riparian ecosystems may be negatively affected by the release of large quantities of produced water. Some produced water on the other hand, has the potential to be a prized source of fresh water in many arid regions.

The Lupane/Hwange area is an arid region which would benefit immensely from an additional water source. Irrigation projects and ranches can be established around the CBM wells thus alleviating poverty and providing sustainable livelihoods in surrounding communities. The production of large quantities of water will cause long term water table depletion and this should be mitigated through water capture.

2. Land Access

CBM projects cover large areas of land. Most of the land overlying the Hwange / Lupane CBM reserves is Communal Land occupied by rural communities engaging in subsistence agriculture and animal husbandry. Communal land is property of the State on which communities are allowed to dwell but not allowed to own it. CBM producers will need access to drill hundreds of wells and this can cause conflict with communities. While historically, the Zimbabwean government has prioritized the extractive industry over the rights of communities resulting in relocations of large populations, it is important that investors carry out adequate social impact assessments which will ensure they implement corporate social responsibility programmes that leave a positive impact of the communities. Horizontal drilling can be used to minimize the amount of land required for CBM projects.

3. Licensing

The unconventional nature of CBM is likely to cause problems when granting production licences. In countries that have begun the production of CBM, there has been confusion regarding what resource the licence covers, gas only or gas and coal. In most cases CBM producers are only interested in the gas resource, but the ambiguity has resulted in amendments to licensing rules in some countries e.g.
Australia. It is thus important for investors to ensure clarity on the matter when contracts are being made.

4. Methane Loss to Atmosphere
Methane heats the atmosphere twenty one times more than carbon dioxide, making it a more harmful emission. Conventional coal mining operations release large volumes of methane into the atmosphere. One tonne of coal has the energy equivalent of 826 m³ of CBM. However this amount of CBM releases 12 tonnes of CO² less than one tonne of coal. CBM production releases less methane and CO² than coal mining and is thus a means to reduce greenhouse gas emissions and this bolsters its green credentials.

5. Other issues
Other potential primary impacts of the development, extraction, and transportation of CBM include:

- Degradation of the land being drilled
- Contamination of downstream waters
- Contamination of land, wetlands and water bodies along pipeline routes
- Ground disturbance during development of for roads, drilling pads, pipelines and utilities.
- Equipment noise
- Compressor exhaust
- Dust development
- Wildlife habitat changes
- Non-native plant infestations

Project Economics

CBM production is initiated by capital intensive drilling followed by long lead times before commercial production rates are achieved. Thus like the majority of mining projects, companies are unable to generate positive cash flow for a number of years.

During the pilot project a company will determine the economic viability of a site. The project economics are determined by a number of factors:
1. **Well flow rates**
Wells need to be able to produce gas at a rate which is able to supply gas contracts. The coal seams need to have either high gas content with reasonable permeability or low gas content with high permeability. Flow rates of 500mcfd - 1,000mcfd following dewatering are typical, but higher flow rates in certain regions have also been experienced.

2. **Well spacing**
The characteristics of the coal will determine the spacing between the wells. The well spacing will be determined during the pilot project and will be optimised to ensure the greatest volume of gas can be reached. If the permeability of the coal is too low it is possible that it may not be cost effective to produce gas as the well density would have to be higher. In the San Juan Basin wells (USA) are drilled every 160acres - 300acres, but in the Powder River Basin (USA) it can be as high as 80acres.

3. **Cost of drilling and development**
Due to the number of wells required for a CBM project, it is essential for the drilling costs to be as low as possible. Projects can require hundreds of wells and drilling accounts for the majority of the capital expenditure. Costs can range from US$35,000 – US$300,000, but some operators have quoted US$1mn. However, these very high cost vertical wells are exceptionally expensive.

4. **Development costs**
Development costs are usually dictated by the length of the high pressure pipeline. Typically such pipelines cost US$1mn/km.

5. **Ability to dispose of water cheaply**

6. **Good land access**

7. **Access to market**
Producers will need to identify a market for the gas. Should a project be remote from a market or from infrastructure, then a project may require the construction of a high pressure pipeline. Such pipelines are very expensive to build.
Business operation framework

Legal Framework

The exploration and production of coal bed methane is addressed in the Mine’s and Minerals Act (Chapter 21:05), Part XX: Subsections 297 to 307. Subsection 298 states, “Rights to mine coal, mineral oils or natural gases may only be acquired under Special Grant”. Anyone is allowed to apply to the Mining Affairs Board for a special grant. This Board then makes a report and recommendations to the Minister of Mines and Minerals Development. Recommendations made will include: the minimum capital to be invested; the time period in which production should start; the minimum rate of production of the coal bed methane; and the amount of royalty to be paid. The Minister then submits the report and recommendations to the President. It is the President’s sole right to grant or refuse the Special Grant. The President can extend or reduce the area to be covered under the Special Grant. The law does not set a duration period for Special Grants. Terms and conditions of each special grant are specified when it’s granted. Historically, the Government of Zimbabwe has issued Special Grants on a five year renewable basis.

Zimbabwe is set to repeal the Mines and Minerals Act in the first quarter of 2014 and enact a new Minerals Development Act. No drafts of the Act have been released and very little is known of the proposed Act. In 2007, Zimbabwe’s parliament tabled a Bill to amend the Mines and Mineral’s Act. It proposed to make four additions to Subsections 297 to 307 which had no effect on the process to obtain a Special Grant as described above.

Policy Framework

The Zimbabwean Cabinet accorded National Project Status to CBM. This means that all equipment and materials for the projects are imported duty free. Cabinet approved the following investment models for CBM exploration and extraction:

1. **Joint Venture/Public Partnership**
   
   Private investor forms a joint venture with government (or government designated organization).

2. **Special BOT arrangement**
   
   Investor provides 100% funding with flexible shareholding arrangements.

3. **Private Sector**
Private companies with requisite resources are allowed to operate under specified conditions such as: minimum investment capital, technical skills, set lines for completion of certain tasks etc.

Zimbabwe’s 2013 – 2018 economic blueprint, the Zimbabwe ASSET recognizes the importance of coal bed methane. It states that the Ministry of Energy and Power Development should carry out a feasibility study of a gas power station in Lupane.

Taxation regime

An investor in the coal bed methane sector can expect the following taxes:

<table>
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<tr>
<th>Tax</th>
<th>Rate</th>
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<tbody>
<tr>
<td>Royalty</td>
<td>2% (ad valorem)</td>
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<tr>
<td>Corporate tax</td>
<td>15% of income</td>
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<tr>
<td>Resource depletion fee</td>
<td>2.5% of revenue</td>
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<tr>
<td>Withholding tax</td>
<td>10% of foreign investor’s dividends that leave Zimbabwe</td>
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<tr>
<td>Ground Rental Fee</td>
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Conclusion

Zimbabwe’s CBM sector is one the least-known, high potential investment opportunities in the Sub-Saharan Africa. While Zimbabwe’s current investment climate leaves a lot to be desired, it is surely not as bad as widely touted. Views on the situation in Zimbabwe are diverse. However in the past 12 months the country has seen the reintroduction of international flights such as KLM, Egypt Air and Emirates, signifying a renewed interest to explore possibilities of doing business in Zimbabwe. Some believe the risk associated with doing business in Zimbabwe has been exaggerated. One individual who believes the risk is exaggerated is Essar’s Resident Director for Africa, Middle East and Turkey, Firdhose Coovadia. He is quoted as saying: “Foreign investors need to come and have a look at the country. In my mind the risk has been over-priced. Once you are on the ground you will find that Zimbabwe is an easier place to do business than you think.”

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