



Original Research Article

Coals seam gas (CSG) in agriculture – A review: Technical and market analysis for Australia

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ARTICLE INFO

Article history:

Received 31 May 2014

Revised 16 August 2014

Accepted 21 August 2014

Keywords:

Coal seam gas

Agriculture

Liquefied natural gas

Compressed natural gas

Diesel

Alternative fuel

ABSTRACT

This feasibility study is a response to the increasing of interest in coal seam gas (CSG) in Australia and due to the demands for alternative fuels by high fuel-consumption industries such as agriculture. A technical analysis of LNG as an alternative fuel to diesel in agriculture was conducted. A comparison of different conversion methods (dual-fuel and mono-gas systems) is undertaken. Data was collected from a number of sources to determine the potential demand for natural gas in the agricultural sector in Queensland (QLD) and New South Wales (NSW). This paper aims to evaluate the payback period when CNG/LNG is used as an alternative fuel for diesel engines in different applications. The payback period of 1000 Ha (of wheat planted and harvested) was found to be 3.99 year when CNG is used (no till, harvest), while the payback period was found to be 25 years when LNG is used. As for water pumping, it was found that the payback period was 0.9 years when CNG is used, while the payback period was found to be 3.93 years when LNG is used. Analysis finds compressed natural gas (CNG) to be the preferred alternative fuel to diesel engines in the agricultural sector.

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Introduction

Dependence on fossil fuels around the globe as the dominant transport fuel has brought to light issues such as its imminent scarcity and harmful emissions from heavy vehicles. As a result, the global search for suitable alternative fuels has picked up pace and alternatives such as natural gas are becoming attractive options. Australia has natural gas (derived from CSG) resources with reserves of around 150 tcf which is equivalent to 100 years at the current production rate [1]. Recent study has shown that Total identified resources of CSG are estimated to be around 203 tcf [2]. Natural gas is affordable and a convenient substitute for other conventional fuels such as gasoline and diesel. Thus natural gas has the potential to become one of the most attractive alternative fuels in agricultural applications. In Nigeria, compressed natural gas (CNG) has been found to be a good alternative fuel for tractor engines because CNG is claimed to be a good alternative fuel for small-medium sized general purpose tractors (30–70 kW) [3].

If currently planned projects proceed, Australian liquefied natural gas (LNG) supply capacity has the potential to reach around

60 mtpa by 2015 [1]. Since 2007, five LNG projects have been announced on the east coast of Australia [1]. This includes coal seam gas (CSG) from Queensland's Surat and Bowen Basins utilised as an LNG feedstock. Demand for fuel in the agricultural sector varies depending on the tillage, irrigation water pumping systems and planting and harvesting methods (Technical and market analysis). Fuel usage is dependent on the farming system adopted and the crops grown. For example, a no till wheat grower uses less than a full till cotton grower. Opportunities for natural gas as an alternative fuel source in agriculture will therefore depend on a number of specific arming practices.

The use of CSG as alternative fuel in agriculture is applicable to other countries such as United State and China. The US has a majority share of the mature coalbed methane market in the world. Throughout the past two decades, CBM production in the US increased dramatically, up to 49.7 Bm³ in 2007, accounting for 9.1% of total natural gas production in the US. Today, there are more than 4650 active CSG wells in the US, and the cumulative gas production now exceeds 52 Bm³. In 2002, the US Geological Survey (USGS) assessed the technically recoverable, undiscovered coalbed-gas resources in the Appalachian basin and Black Warrior basin to be about 472 Bm³. The CSG development in China has increased significantly through the past decade. Until 2003 there were only 250 documented CSG wells, however this number

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increased to 2500 wells in 2008. The total CBM resources present in China in Huaibei and Huainan coalfields exceeds 1.4 Bm³. CBM in China represents a very promising source of energy and some studies recognise the geological CBM resource volume as third in the world behind the United States and Canada. There are nine major CBM basins in China, their total reserve is 30.9 Tm³ which is 84% of the total resources in China. In recent years, natural gas demand in China has grown significantly due to the rapid and continuous growth of its economy. Over the past 30 years, China's natural gas consumption has increased from 12.1 Bm³ in 1977 to 67.3 Bm³ in 2007. A projection by the International Energy Agency (IEA) showed that China's natural gas demand will elevate to 110–120 Bm³/year [4].

The purpose of this article is to assess the technical feasibility and market potential for the use of CSG as an alternative fuel in agricultural operations. Due to the availability of information in regards to usage of CSG in agriculture in both Southern Queensland (QLD) and Northern New South Wales (NSW) locations, both were selected as case studies in Australia.

CNG/LNG use in compression ignition engines

Diesel engines are currently at new levels of power and economy due to significant technological improvements in the field of fuel injection and turbo-charging. Diesel fuel is considered a high emission fossil fuel causing engineers and geologists to work on alternative fuels for the conventional compression ignition (CI) engine. Engine conversions are classified into two groups, dual fuel and mono gas systems [5]. A comparison to natural gas and diesel as a fuel source is given in Table 1. Also, a comparison of various diesels to natural gas conversion methods is given in Table 2.

Dual fuel system

In dual fuel conversions, the engine operates on approximately 90% natural gas, and 10% diesel fuel [5]. This application of natural gas has advantages and disadvantages which hinge on the delivery method of the fuel. In a study on the use of CNG and diesel as a dual-fuel system, better thermal efficiency was achieved and experimental results confirmed that lean combustion of CNG achieved more complete combustion, thus reducing CO emissions [6].

Mono gas system

When converting standard diesel engine to a mono-gas fuel system, the diesel engine will be modified significantly. Where the engine was once fired by compression ignition, a distributor and

spark ignition system is employed due to the low cetane number of gas and associated reluctance to ignite under compression. LNG converted vehicles store the fuel cryogenically as a liquid and convert it back to CNG via a vaporiser which warms the gas and uses that expansion to pressurise it in one step. LNG can be the preferred method of fuel storage in some natural gas conversions due to the higher energy density of LNG in comparison to CNG.

Technical and market analysis

Comparative assessment of CNG and LNG transport

Selection of either LNG or CNG as an alternative to diesel fuel has a number of advantages and disadvantages relating to transportation and distribution as summarized below:

Advantages of CNG over LNG [7]

- Appropriate for projects using lower throughput of gas.
- Lower capital required.
- Ease of deployment and faster implementation of a project.
- Majority of the investment is in transport and distribution, making the assets movable and reducing the risk involved.
- CNG is more economical to deliver than LNG for distances up to 5500 km.

Advantages of LNG over CNG [7]

- Three times the volume of LNG can be transported as CNG in a shipping unit with the same volume.
- At distances above 5500 km the cost of CNG becomes greater than LNG thus making LNG attractive because of the ability to transport more gas per shipment.

LNG in agriculture – boil-off issue

The key technical issue of using LNG in agriculture is boil-off. LNG is effective where there is a constant usage such as the demand experienced in the transport industry. If a tractor was left to sit for a period of more than two to three weeks it is possible there would be no fuel left when trying to restart the engine (depending on the quantity of fuel initially in the tank). It has also been reported that when there is low usage from a storage tank, boil-off becomes an issue [8].

Boil-off occurs when the LNG temperature slowly rises in the tank to reach the boiling point of –162 °C. The cryogenic tanks are essentially similar to a large thermos. They have an inner skin

Table 1
Comparison of NG and diesel.

Disadvantages of natural gas	Advantages of natural gas
<ul style="list-style-type: none"> • NG has a lower energy density compared to diesel fuel. Thus large fuel tanks are required • In Australia there is very limited natural gas distribution infrastructure. Development of transmission and distribution infrastructure based on pipelines will increase cost efficiency of gas distribution. It could afford more efficient pathways to produce and distribute the fuel as distribution will rely less on road transport and more on pipelines 	<ul style="list-style-type: none"> • 90% less smoke and carbon monoxide emissions' 85% less nitrogen oxides and carcinogenic particulate emissions 75% less hydrocarbons • 60% less noise, 10–20% less carbon dioxide
	<ul style="list-style-type: none"> • Brisbane City Council has documented a halving of running costs of their new CNG bus fleet after 30 million kilometres • Australia has extensive reserves of natural gas which will easily last 100 years at the current production rate (more than double the time domestic fossil fuels will last) • Natural gas has much lower refining costs than diesel and is subsequently less than half the cost of diesel per unit of energy • If the engine is converted to dual fuel it can still run on straight diesel, minimising the vehicles reliance on natural gas distribution centres

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