Alternative Fuels Industry Potential in South Australia

Peter Fagiano Examines the Potential of the Alternative Fuels Industry in South Australia
Executive Summary

High hydrocarbon prices have resulted in alternative sources of energy being developed to meet the ever-increasing demand especially in Non-Member countries of Organisation for Economic Cooperation and Development (OECD). Coal is considered to be able to service this demand as there are abundant reserves globally, which will not be subject to price volatility as experienced with crude oil.

This report puts forward the strategy of co-development of Coal to Liquids (CTL) and Coal to Methanol (CTM) at the Arckaringa mine development in South Australia. The products from a CTL/CTM complex lend themselves to being substantial blend components for conventional refinery based diesel and gasoline.

The high specification diesel produced can be used as a blend with refinery diesel to improve performance and reduce contaminants or be upgraded to jet fuel standards for the aviation industry. The Methanol product can be blended in the range up to 15%-20% (M15 and M20) with conventional refinery gasoline with the same benefits, reduced contaminants and enhanced performance.

Conventional new oil discoveries represent only some 50% of daily consumption and there is a major concern on a future oil supplied meeting demand as many existing giant oil fields are now past their peak oil production. Current solutions are focused on new technology to develop ‘tight’ shale oil and gas discoveries using processes such as ‘fracking’ to release the hydrocarbons from the petroleum/gas rock formations, which may not be universally acceptable due to environmental issues.

Altona’s Arckaringa project offers an alternative solution. At Arckaringa, the original studies focussed on developing 2x15,000 BPD trains for CTL development at Arckaringa. However, a combination of a single 15,000 BPD CTL Plant in conjunction with a single 6,200 TPD CTM Plant represents a better economic solution with a 18% increase in gross revenue. Both the total coal consumption and the overall investment of CTL/CTM complex is the same magnitude as the original two train CTL plant.

One train of 15,000 BPD CTL plant is capable of providing one third of the diesel demand for South Australia and Northern territories. One train of CTM can supply 90% of the methanol to make M15 grade gasoline for the Australian domestic market. Globally, methanol consumption was 32 million Tonnes per Year (TPY) in 2000 and is anticipated to be at 60 million TPY in 2013/14. Of this, 20 million TPY is utilised primarily in gasoline and diesel blending. The Capital Expenditure (CAPEX) and Operating Expenditure (OPEX) of coal based plants manufacturing CTL and CTM are comparable to conventional/unconventional hydrocarbon feedstocks when recognising the total investment for feedstocks delivery.
Overview of the Alternative Fuels Industry

Background

In the last decade there has been considerable growth in the energy demand for power generation and transportation fuels and this growth is expected to continue in the foreseeable future, particularly in Non OECD countries.

According to BP's World Energy report June 2012, there was a 30% increase in global demand in the decade from 2000 to 2010, compared with 15% in the previous decade. In terms of Non OECD Energy Demand, there was a 67% increase over the decade from 2000 to 2010.

Some 55% of the global demand now comes from Non OECD countries. In the same period there was no growth in the European Union and only some 2% growth across all OECD countries. The increase in energy demand in China over the decade from 2000 to 2010 was some 150% and today China consumes 21% of the world's energy.

When we examine conventional oil and gas resources we have concerns in terms of long term supply as there is a growing gap between discoveries and production which will eventually lead to a gap between production and demand.

On a global basis the size of conventional oil discoveries measured in daily production has been estimated to be only some 50% of daily consumption.

Current Solutions

The solution being proposed to compensate for the declining conventional oil discovery rate is shale oil and shale gas formations which are in many regions globally for example USA, Canada and Russia.

However, shale oil is an expensive short to medium term solution. A typical well reaches peak production in two years and is halved in four years. Maintaining 'flat production' necessitates doubling producing wells every 3 years.

Shale gas is also in abundant supply in USA and Canada. Chesapeake Energy has estimated the average cost of development and production to be at $3-$4 per million (BTU). The assumption is dependent on the depth of the shale gas deposits and lifespan of the wells, which are often shorter than previously predicted.

In general, the 'estimated ultimate recovery', is approximately half of the values presented by the operators (The Oil Drum 5 August 2011). Therefore, shale oil or shale gas will not be able to make up the long term short fall between energy supply and demand because of over-estimate of reserves compounded by the under-estimate of development and production costs.

“On a global basis the size of conventional oil discoveries measured in daily production has been estimated to be only some 50% of daily consumption”
Growth in energy demand will be driven in Non-OECD countries with growing economies, such as China and India. However, both these countries are investing in coal based energy sources to the extent that the International Energy Agency (IEA) forecast global coal consumption to be at around 4.3 billion tonnes of oil equivalent (BTOE) by 2017, almost reaching 4.4 BTOE for conventional oil. Would these countries China (indigenous coal) and India (imported coal) make such investments if they considered the price of oil is going to collapse?

Unconventional oil and gas, with coal will play an important role in providing sources of energy to meet the growing demand in Asian economies.

Coal reserves globally are in excess of 860 billion tonnes and today coal represents some 30% of the global source of energy consumption (BP Energy Report 2012).

If coal reserves were measured in terms of hydrocarbon equivalents, they would equate to some 1.25 trillion barrels of refined products which is 75% of the global conventional oil reserves or parity in terms of conventional refined products excluding bottom of the barrel by products.

A massive expansion in coal utilisation is already taking place in China and India, whereas investors elsewhere express concern that at low oil prices (sub $50 per barrel), synfuel plants could become loss making compared to conventional refineries.

Altona Energy's mandate is to develop the coal assets in the Arckaringa basin in South Australia and create an Alternative Energy business for Australia and the region. The scale of the Arckaringa coal deposits of 7.8 billion tonnes offers the opportunity to develop a wide ranging portfolio of coal monetisation investments.

The initial development being evaluated for Arckaringa is to build a “two train” 30,000 BPD CTL synfuels plant along with 560 MW power export into the SA transmission grid.

In parallel, Altona is now evaluating an alternative Phase 1 build:
• One train of 15,000 BPD CTL synfuels plant
• One train of 6,200 Tonne per day CTM methanol plant.

The economics of this plant configuration are very attractive as this results in a minimum investment for the CTM plant because of the available electricity as well as the resultant cost savings.

Also it allows Altona to minimize its infrastructure costs to the following requirements:
• Road and Rail tie in to the plant site
• CO₂ pipeline to East Officer Basin

Depending on demand, the CTL facilities in Phase 2 can be expanded by a further 15,000 BPD or 30,000 BPD, in addition to the generation of 280 to 560 MW of export power.

Trinidad 3 Methanol Plant. Image provided by Johnson Matthey Catalysts

“The scale of the Arckaringa coal deposits of 7.8 billion tonnes offers the opportunity to develop a wide ranging portfolio of coal monetisation investments”
The Jacobs study confirmed the following:
- The same quantity of gasified coal needed to make 15,000 BPD of FT liquids could instead produce 6200 TPD of methanol.
- The surplus CTL electrical power was sufficient to operate the CTM plant.
- The CO₂ emissions from the CTM plant were 0.3 tonnes of CO₂ per tonne of methanol.
- The investment costs for CTL / CTM plant were essentially the same as the original two train CTL plant.

Altona used the information from the Jacobs study and developed its techno economic model which showed there was a potential 18% increase in project revenue for the CTL / CTM plant equivalent to US$ 212 million annually. There was also a US$ 57 million annual saving in carbon tax payments.

In evaluation of a CTL/CTM complex, we have considered methanol and its conversion into Dimethyl Ether (DME), Methanol to Olefines (MTO), Methanol to Gasoline (MTG) etc.

If the plant was expanded in the future then a multiproduct pipeline would be installed to convey the diesel, naphtha, methanol products to Port Bonython. At Port Bonython separate products storage facilities would be provided as well as optional processing facilities for the conversion of methanol into DME, Olefines etc.

The bulk of such products would be for export into Australian and Asian regional markets. Likewise the CTL plant producing syndiesel and petrochemical grade naphtha would service both domestic and international regional markets.

To get fuels or chemicals to either Australian or export markets could for the first phase be achieved by freight rail to Port Bonython.

If we were to monetise the entire Arckaringa coal asset, we could produce either / or
- CTL - 7 Billion Barrels
- Methanol - 3 Billion Tonnes
- SNG - 65 Trillion SCF

At Arckaringa, a three phase programme could be built in manufacturing
- CTL - 45,000 BPD
- Methanol - 20,000 TPD

This production rate could be maintained for some 116 years.

“Altona used the information from the Jacobs study and developed its techno economic model which showed there was a potential 18% increase in project revenue for the CTL / CTM plant equivalent to US$ 212 million annually”
Australian Fuels Market Overview

The projected demand for diesel and gasoline in Australia for year 2020 as published by ACIL Tasman in 2009 is as follows:

<table>
<thead>
<tr>
<th>Territory</th>
<th>Diesel (Megalitres per year)</th>
<th>Gasoline (Megalitres per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland</td>
<td>5,677</td>
<td>5,478</td>
</tr>
<tr>
<td>N.S. Wales</td>
<td>4,864</td>
<td>6,358</td>
</tr>
<tr>
<td>Victoria</td>
<td>3,539</td>
<td>5,180</td>
</tr>
<tr>
<td>West Australia</td>
<td>3,782</td>
<td>2,229</td>
</tr>
<tr>
<td>South Australia (SA)</td>
<td>1,525</td>
<td>1,323</td>
</tr>
<tr>
<td>Northern Territories (NT)</td>
<td>507</td>
<td>140</td>
</tr>
<tr>
<td>Tasmania</td>
<td>447</td>
<td>457</td>
</tr>
<tr>
<td>Total</td>
<td>20,341</td>
<td>21,164</td>
</tr>
</tbody>
</table>

The total Diesel demand is equivalent to 350,495 BPD. The overall sum of SA and NT is equivalent to 35,000 BPD. Therefore, one train of 15,000 BPD CTL liquids would provide for some 34% of the demand for SA/NT. Three trains of CTL would provide for a 10% of the diesel demand of Australia. These production levels of synthetic diesel would be readily absorbed into the domestic market. Likewise the co-produced naptha would be easily traded in the export market.

The total Gasoline demand is equivalent to 364,728 BPD. The overall sum for SA and NT is equivalent to 25,209 BPD. M15 is an internationally recognised methanol blend (15% methanol in gasoline). Currently in Australia M15 tests are underway at Ford’s ACART testing centre in Geelong, Victoria, which could be extended to study the impact on engine design of M25 or similar blends.

Assuming that Australian fuels legislation accepts M15, demand for methanol in the gasoline market would be:

- Australia = 54,109 BPD (2,505,494 TPY)
- SA and NT = 3,781 BPD (173,157 TPY)

One train of CTM could supply essentially 90% of the methanol needed to make M15 gasoline for the Australian domestic market.

M15 fuel only requires minor modifications to the vehicle’s fuel injection system which is due to the increased volume necessary to maintain engine performance.

A major financial advantage of M15 is that methanol constituent is not subject to excise tax which could be a saving of AUS$ 5.7 cents/ litre.

The cost of mined dried coal from Arckaringa is forecast to be less than US $2 per million BTU.

The CAPEX/OPEX cost of methanol produced at Arckaringa is forecast to be US $138 per tonne.

The CAPEX/OPEX cost of CTL liquids produced at Arckaringa is forecast to be US $53 per barrel.

“The total Diesel demand is equivalent to 350,495 BPD. The overall sum of SA and NT is equivalent to 35,000 BPD. Therefore, one train of 15,000 BPD CTL liquids would provide for some 34% of the demand for SA/NT”
Global Coal Solution

The proven coal reserves of key countries (BP Energy Report 2012), measured in Billion of Tonnes, is expressed below:

<table>
<thead>
<tr>
<th>Countries</th>
<th>Bituminous Coal</th>
<th>Sub-Bituminous Coal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>37,100</td>
<td>39,300</td>
<td>76,400</td>
</tr>
<tr>
<td>China</td>
<td>62,200</td>
<td>52,300</td>
<td>114,500</td>
</tr>
<tr>
<td>India</td>
<td>56,100</td>
<td>4,500</td>
<td>60,600</td>
</tr>
<tr>
<td>Russia</td>
<td>49,088</td>
<td>107,922</td>
<td>157,010</td>
</tr>
<tr>
<td>USA</td>
<td>108,501</td>
<td>128,794</td>
<td>237,295</td>
</tr>
</tbody>
</table>

China’s Sub-Bituminous Coal reserves are only 33% higher than the equivalent of Australia’s, yet China is making gigantic efforts to build methanol plants for the fuel market. India, which is gasifying coal for power and petrochemicals and has limited sub-bituminous coal, is importing coal for its power plants and petrochemical plants. It’s 2012/13 import figures are forecast to be around 80 million tonnes.

Both China and India have huge populations compared to Australia, but Australia has the mineral resources in abundant supply to meet domestic and international requirements for the Alternative Fuels and Petrochemicals markets.

The USA is not exploiting its coal reserves but instead is focussed on exploiting its shale oil and shale gas reserves. This is a medium-term solution, which will be fully depleted in some 30-40 years; while at the same time having a major negative environmental impact due to water demand and pollution (Natural Geographic, March 2013).

Under the Republican Administration, the oil industry does not have to comply with the Safe Drinking Water Act.

We will now examine a number of potential alternative fuel sources that could also make a significant contribution to global energy supply which can be manufactured from coal with specific reference to a CTM plant.

“China’s Sub-Bituminous Coal reserves are only 33% higher than the equivalent of Australia’s, yet China is making gigantic efforts to build methanol plants for the fuel market ”

SIPCHEM Methanol Plant in Saudi Arabia. Image provided by SIPCHEM
Global methanol market demand has grown from some 32 million TPY in 2000 and is anticipated to reach 60 million TPY in 2013. Some 20 million TPY of this growth is in DME, MTO and gasoline blending. The two prime areas of extraordinary growth are transportation fuels and petrochemicals. By 2016 it is estimated that these two areas alone will consume in total some 28 million TPY of methanol as compared to 10 million TPY in 2010.

This is an exciting market growth period for the methanol industry which was not even predicted some 5 years ago. Unless crude oil prices collapses then our future energy programmes will include a ‘methanol economy’. The sourcing of methanol will be coal based primarily in Non-OECD countries and emerging economies. The only barriers to this achievement is not cost but the acceptance by environmentalists it is clean energy with emissions less than natural gas for power plant and also allows cost effective CCS.

Shale gas also has a major methanol feedstock role to play where ‘fracking’ is approved environmentally and the economics of the production programme are acceptable.

The major market growth region for methanol is China for their domestic fuel market. Australia could also develop a domestic alternative fuels market. Neither country has substantial oil reserves and today imports hydrocarbons from overseas producers. Since 2010 China has built / is building some 8 plants designed to produce 55,000 TPD of methanol from some 40 million TPY of coal.

Australia can produce from its abundant sources of coal, similar scale plants but the bulk of the methanol will be for the export market such as China, India and Asian region generally.

Just as Australia is developing multi-train LNG plants for the export energy market the same can be achieved with coal based methanol for the export fuels and petrochemicals markets.

Mined dried coal from Arckaringa costs less than US$ 2 per million BTU. The cost of coal per tonne of methanol is US$ 60 which compares favourably with natural gas based methanol plants.

The CAPEX / OPEX cost of methanol produced at Arckaringa is US$ 138 per tonne.

“The two prime areas of extraordinary growth are transportation fuels and petrochemicals. By 2016 it is estimated that these two areas alone will consume in total some 28 million TPY of methanol as compared to 10 million TPY in 2010”
Dimethyl Ether (DME) is a clean burning synthetic fuel that could replace Liquid Petroleum Gas (LPG) or be blended up to 20% into LPG for the “bottled gas” market.

The manufacture of DME from methanol is a simple process with proven technology available from several licensors.

DME is essentially two molecules methanol with one molecule of water removed.

The current main market for DME is as an aerosol propellant replacing harmful chlorofluorohydrocarbons which attack the ozone layer in the earth atmosphere.

The largest areas of growth for DME is as a substitute for diesel or as a blend for diesel, primarily in Asia in countries such as China, Japan.

Vehicle manufacturers are designing car engines to run on 100% DME. DME enhances diesel fuel as it raises the cetane number and reduces particulate emissions.

The largest market for DME is in Asia where manufacturing capacity has continued to grow over the last decade. Again China is leading the way for DME production as a fuel blend, followed by Japan.

The DME market was virtually non existent in 2004 but by 2012 it had reached 5 million TPY, with future growth forecast to be at 8 million TPY by 2016.

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The DME market was virtually non existent in 2004 but by 2012 it had reached 5 million TPY, with future growth forecast to be at 8 million TPY by 2016.

“DME is a clean fuel that like FT diesel is non carcinogenic, has low emissions which have a short half life in the atmosphere”

SIPCHEM Methanol Plant in Saudi Arabia. Image provided by SIPCHEM
Methanol to Gasoline (MTG)

The process to polymerise methanol via DME into gasoline was developed by Mobil in the 1970’s.

The MTG process is essentially two stage dehydration polymerisation:
- methanol converted to DME
- DME converted to gasoline and/or LPG

The MTG process converts 90% of the hydrocarbons in methanol to gasoline, which is both free of nitrogen and sulphur.

The first commercial plant was built in New Zealand. Although the overall energy efficiency of the MTG Process is high, the plant was shut down for economic reasons in the mid 1990’s.

However, the maintenance of high petroleum prices and the availability of low cost coal and shale gas may make industry reconsider the MTG process.

With China committed to coal based methanol for fuel blending and petrochemicals manufacture, the potential for MTG may only be in the USA due to its abundant source of cheap shale gas.

There is an enormous gasoline market in the USA amounting to 9 million barrels per day. Thus, the potential for MTG lies in using low cost shale gas to manufacture methanol and convert it to gasoline for the USA market.

Overall, the MTG does not yet have an established market and it may be more advantageous to manufacture low cost methanol for blending into the existing gasoline pool.

In 2009 the world capacity for MTO plants was less than one million TPY. In 2012 it reached in excess of three million TPY.

The ICIS consultancy has stated that by 2015 a further four million TPY of MTO will be in operation in China.

The Methanol Market Services consultancy has estimated that by 2030 some 28 million TPY of Chinese coal based methanol will be converted into olefines with a gross production of 10 million TPY.

However the global market for conversion of methanol to olefines is very difficult to estimate as traditionally the bulk of the olefines were first manufactured by naphtha (52%) and / or followed by use of alkanes (ethane, propane, butane) extracted from natural gas or associated gas (41%).

All new conventional production will come from alkanes due to low cost gas sources. However coal based methanol is the preferred feedstock in China where mega methanol plants are being built either to service the MTO market or alternative fuels market.

Although methanol can be shipped to the location where olefines are produced integrated MTO plants will be built in “hub” locations.

“...The Methanol Market Services consultancy has estimated that by 2030 some 28 million TPY of Chinese coal based methanol will be converted into olefines with a gross production of 10 million TPY...”
The continued high cost of oil alongside increased energy demand means there will be ongoing pressure to find alternative sources of fuel from non-conventional/traditional markets.

Coal can adequately service the demand both for fuels and petrochemicals by the production of FT liquids and methanol. From both these products a wide range of chemicals and fuels can be produced.

The FT synfuels market has not grown as fast as originally predicted for the OECD countries, primarily due to the global recession as well as the increase in development of shale oil and shale gas reserves.

However, in Non-OECD countries and in the emerging economies of Asia, methanol is a rapidly growing source of alternative fuels and petrochemicals. These new markets are fuel blending, DME, Olefines and potentially Gasoline.

The methanol market is possibly the most dynamic growth market globally and combined with FT liquids, production can service the complete transportation fuels market.

Altona Energy’s proposed CTL/CTM project developments at Arckaringa would service both the Australian market and the regional Asian market, thus in part reducing the dependence on conventional hydrocarbons.

Importantly, not to be ignored are the vital health and environmental benefits from the use of ‘alternative fuels’.

They are considered to be non-carcinogenic to humans and contain minimum particulates, as well as no sulphur compounds. Conventional refinery fuels are considered to be substances of concern by the World Health Organisation (WHO).

With respect to methanol, it is less harmful to the environment than conventional refinery fuels as it is bio-degradable. The half life of methanol in ground water is up to 7 days whereas aromatics (Benzene) in conventional gasoline are up to 730 days.

In summary, alternative fuels are significantly more benign to humans and the environment than conventional refinery fuels. Nevertheless, the CAPEX/OPEX costs of coal plants manufacturing FT liquids, methanol and its derivatives are competitive in comparison with hydrocarbon feedstocks.

Conclusion

Glossary of Terms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>BPD</td>
<td>Barrels per day (liquids)</td>
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<tr>
<td>BTOE</td>
<td>Billion tonnes of Oil Equivalent</td>
</tr>
<tr>
<td>BTU</td>
<td>British Thermal Unit</td>
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<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>CAPEX</td>
<td>Capital Expenditure</td>
</tr>
<tr>
<td>CCS</td>
<td>Carbon Capture and Storage</td>
</tr>
<tr>
<td>CTL</td>
<td>Coal to Liquids (Diesel, Naphtha)</td>
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<td>CTM</td>
<td>Coal to Methanol</td>
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<tr>
<td>DME</td>
<td>Dimethyl ether (Diesel additive)</td>
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<td>FT</td>
<td>Fischer Tropsch Liquids (Diesel, Naphtha)</td>
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<tr>
<td>IEA</td>
<td>International Energy agency</td>
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<tr>
<td>LNG</td>
<td>Liquid Natural Gas</td>
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<tr>
<td>LPG</td>
<td>Liquid Petroleum Gas</td>
</tr>
<tr>
<td>MTG</td>
<td>Methanol to Gasoline</td>
</tr>
<tr>
<td>MTO</td>
<td>Methanol to Olefines (Ethylene, Propylene)</td>
</tr>
<tr>
<td>M15</td>
<td>Gasoline containing 15% methanol</td>
</tr>
<tr>
<td>MW</td>
<td>Mega Watt</td>
</tr>
<tr>
<td>NT</td>
<td>Northern Territory</td>
</tr>
<tr>
<td>OECD</td>
<td>Member Countries of Organisation for Economic Cooperation and Development</td>
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<tr>
<td>OPEX</td>
<td>Operating Expenditure</td>
</tr>
<tr>
<td>SA</td>
<td>South Australia</td>
</tr>
<tr>
<td>SCF</td>
<td>Standard Cubic Feet</td>
</tr>
<tr>
<td>SNG</td>
<td>Synthetic Natural Gas</td>
</tr>
<tr>
<td>TPD</td>
<td>Tonnes per Day</td>
</tr>
<tr>
<td>TPY</td>
<td>Tonnes per Year</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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Altona Energy plc

London
First Floor
18-19 Pall Mall
London
SW1Y 5LU

Register Office:
Third Floor
55 Gower Street
London, WC1E 6HQ

Adelaide
Level 9
420 King William Street
Adelaide
South Australia 5000

Beijing
Unit 2907, T3 of CCP
77 Jianguo Road
Chaoyang District
Beijing, China 100025

www.altonaenergy.com