Unconventional Gas Monetisation: GTL - an attractive option?

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Keywords: Unconventional Gas
GTL (gas-to-liquids)
FT (Fischer-Tropsch)
Naphtha
Kerosene
Diesel
Base Oils

1 BACKGROUND

Gas-to-liquids (GTL) refers to the chemical conversion of short chain hydrocarbons or other gases into longer chain hydrocarbon products that can be transported as products at room temperature.

Although the term GTL could be argued to include production of oxygenates such as methanol, dimethyl ether (DME) and methyl tertiary butyl ether (MTBE), in reality the term GTL is synonymous with processes that employ FT synthesis.

The FT process was invented by Franz Fischer and Hans Tropsch working at what was then the Kaiser Wilhelm Institute for Coal Research in Mülheim an der Ruhr in the 1920s. It was used extensively in Germany during World War II for the production of synthetic transportation fuels from abundant coal reserves. Shortly afterwards it became established in South Africa, where it is used for the same purpose to this day.

Compared with the history of coal-to-liquids (CTL) processes, GTL is relatively new and there are still only a handful of commercial-scale facilities around the world:

- Shell Bintulu GTL ,Malaysia 14,700 bbl/day Start-up 1993
- PetroSA Mossgas GTL, South Africa 36,000 bbl/day Start-up 1993
- Sasol/QP ORYX GTL, Qatar 34,000 bbl/day Start-up 2007
- Shell Pearl GTL, Qatar 140,000 bbl/day Start-up 2011/2012
- Chevron Escravos GTL, Nigeria 34,000 bbl/day Start-up anticipated 2013

2 AIMS

The aim of this paper is to provide an introduction to the typical processing steps and product slate associated with a typical GTL facility, and compare GTL with competing gas monetisation technologies. The circumstances in which GTL may prove an attractive monetisation option are highlighted, with particular emphasis on unconventional gas opportunities.

3 GTL PROCESS OVERVIEW

Figure 1 provides an overview of a typical GTL process.

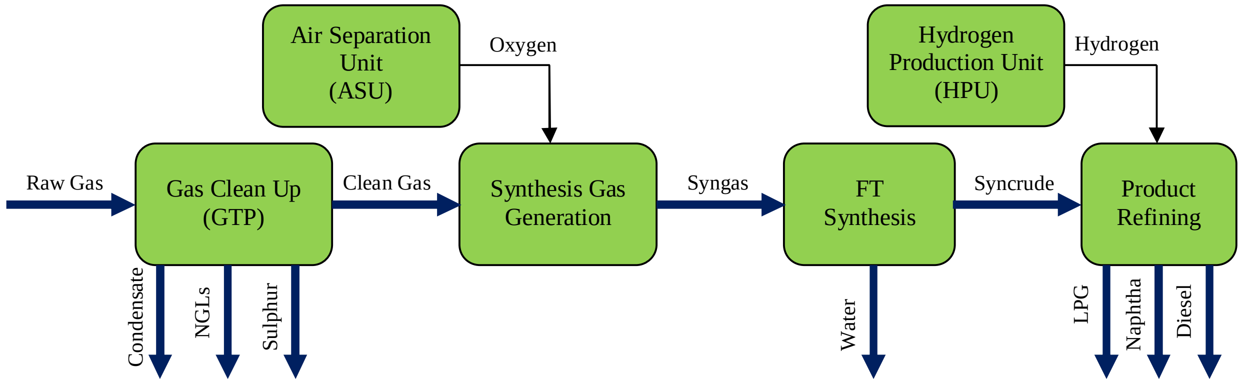

Figure 1 – Simplified GTL Process Scheme

The GTL process consists of four core steps:

Step 1 ***Gas Clean-up***
Gas clean-up for GTL processes usually consists of dehydration and the removal of sulphur compounds, mercury and C3+ hydrocarbons. The process is similar to that required for LNG but without the need for removal of CO_2.

Step 2 ***Synthesis Gas Generation***
Synthesis gas generation involves the conversion of the clean feed gas into a mixture mostly composed of CO and H_2 using a process of reforming or partial oxidation.

The oxygen required for this process is normally supplied as either air or purified oxygen. Use of air has the benefit of eliminating the considerable cost and power demand associated with an Air Separation Unit (ASU) but the use of air results in large quantities of nitrogen that occupy volume and hinder processing in the downstream steps.

Use of steam methane reforming allows the necessary oxygen to be obtained from steam. However, this results in a syngas H_2:CO ratio of ~4:1 whereas a ratio of ~2:1 is required.

Step 3 ***FT Synthesis***
FT Synthesis involves the conversion of synthesis gas into long chain hydrocarbons. The conversion occurs in the presence of a catalyst; most commonly cobalt-based.

Step 4 ***Refining***
Fractionation is then required to separate the components into finished products ready for shipment.

4 GTL PRODUCTS

The product slate from a GTL facility (which is generally quoted excluding products separated during the gas clean-up step) normally consist of LPG (liquefied petroleum gas) naphtha and diesel. However, additional products may include kerosene, normal paraffins and high-grade base oils.

FT-derived liquid products command a premium compared to conventional refinery products due to enhanced characteristics (e.g. GTL diesel has a higher cetane number, lower sulphur levels, lower exhaust particulates, NO_x and SO_x emissions and lower toxicity than conventional diesel) and are generally used as blend stocks.

5 GTL ATTRACTIONS

The reasons why GTL may be a potentially attractive gas monetisation option can be split into four areas:

1. Financial motivation
2. Transportation fuel security of supply
3. Portfolio diversification
4. Environmental pressures

5.1 Financial Motivations

As a means of monetising gas, GTL competes in a crowded market: pipeline gas, compressed natural gas (CNG), gas-to-chemicals (GTC), power production (gas to wire GTW) and liquefied natural gas (LNG) all compete with GTL. In this marketplace, the complexity and inherent inefficiency of the GTL process mean that GTL requires a favourable set of circumstances to compete successfully.

Major financial factors that can favour GTL over other gas monetisation strategies include:

a) Product differentiation
b) Location
c) Gas composition

5.1.1 Product Differentiation

One major difference between GTL and many competing gas monetisation options is that instead of merely providing a means of transporting gas to a different location, GTL transforms the gas into synthetic crude derivatives.

Figure 2 indicates the ratio of oil to Henry Hub gas prices over the past seven years.

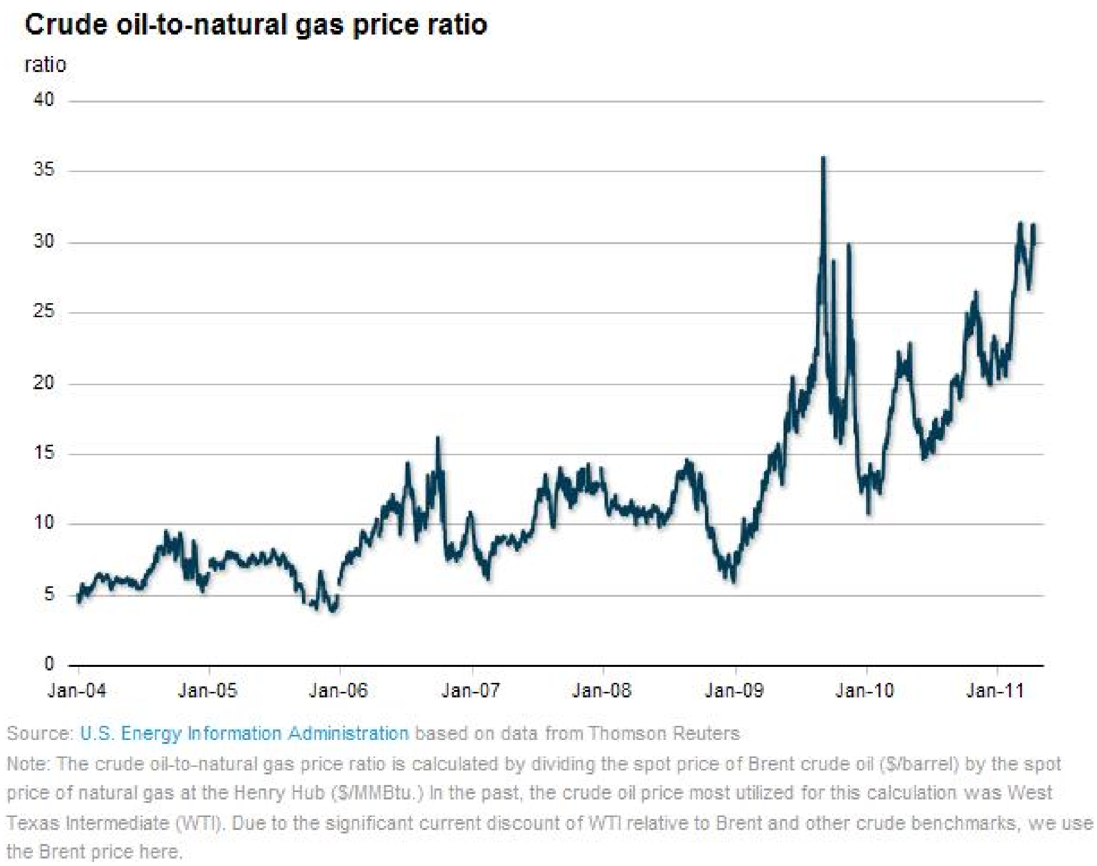

Figure 2 – Ratio of Oil to Gas Prices

Figure 2 shows that the current oil to gas price ratio is particularly high. A high ratio makes synthetic crude derivatives more valuable than gas, making GTL more economically attractive.

Unconventional gas sources in North America have been a major influence on the recent shape of Figure 2. Gas markets in other parts of the world have not shown such a marked trend, but extension of the shale gas "revolution" to the other parts of the world may yield similar opportunities, particularly in parts of the world with limited existing gas distribution infrastructure.

5.1.2 Location

Site location is hugely important to the relative attractiveness of GTL.

GTL is a complex, multi-stage chemical process. For this reason, GTL facility capital and operating costs seldom compare favourably with competing monetisation options such as pipeline gas, CNG, GTW or LNG.

In common with LNG, the economics of GTL generally favour coastal locations, since these provide:

- A large, reliable source of cooling water and raw water
- Simple product export logistics

- Less constrained construction logistics

All the commercial-scale GTL plants to date have been constructed in coastal locations.

Inland locations are generally less favourable for GTL due to the additional cost associated with product export logistics and construction logistics. However, Sasol has announced the front-end engineering design (FEED) for a GTL facility in Uzbekistan, a land-locked country. They are also pursuing a Canadian GTL project that may be located in the land-locked state of Alberta.

The Sasol Canada GTL opportunity is particularly noteworthy in that it is associated with Sasol's 14 billion Rand acquisition of 50% of Talisman Energy’s Cypress A and Farrell Creek shale gas assets in the Montney basin of British Columbia. As well as the low gas price due to plentiful shale gas, a particular benefit which could be offered by this location is the use of, and possible premium for, synthetic GTL naphtha as a bitumen diluent for the local oil sands industry.

5.1.3 Gas Composition

Most gas monetisation options require an upstream gas clean-up step, and in this sense the gas composition could be said to have little impact on the relative attractiveness of GTL.

Two ways in which gas composition differences can impact the relative attractiveness of GTL are:

1. Acid gas content.
   For most gas monetisation options, CO_2 content needs to be removed down to low levels for higher heating value (HHV) control and/or to prevent CO_2 freeze out. For GTL however, CO_2 is a potential reactant via the water gas shift reaction:

   $$CO_2 + H_2 = CO + H_2O$$

   Hence, if feed gas has a high CO_2 content, this can favour GTL.
2. Heavier hydrocarbon content.
   For some locations, gas HHV specifications require dosing or retention of C2+ hydrocarbons in the gas stream. Feed gas with low C2+ content may require import of LPG for product gas HHV control. GTL does not require any C2+ material; in fact a low level of C2+ may reduce capital cost through a reduction in pre-reformer duty in the syngas generation step.

Coal bed methane (CBM), otherwise known as coal-seam gas (CSG) is an unconventional gas source that often has a high CO_2 content and a low C2+, and may therefore favour GTL. CBM also requires extraction of large quantities of water, which fits well with the high water requirements associated with GTL steam and cooling systems.

Keeping on the subject of coal, another source of unconventional gas is the syngas produced by underground coal gasification (UCG). This technology provides a means of utilising coal buried too deeply for economic mining: an oxygen rich gas is injected into the coal seam and gasification occurs, producing a hot syngas that is extracted via a second well.

UCG has its fair share of technical challenges, but it partially eliminates the cost and technical challenges associated with coal preparation and storage, gasification equipment and ash handling. UCG represents the first step in the CTL process, so construction of the remaining gas clean-up, FT synthesis and refining steps in a surface facility can result in a pseudo-GTL CTL solution.

The Yerostigaz facility in Uzbekistan, owned by Linc Energy, represents the only commercial UCG facility in the world, producing power from UCG syngas since 1961. Linc Energy also owns and operates a UCG based GTL demonstration facility in Chinchilla, Australia.

5.2 Transportation Fuel Security of Supply

Gas is a source of energy for uses including electricity power generation, industrial turbine shaft power, industrial and domestic heating. However, gas is not readily adapted for use as a fuel in most private, commercial or military vehicles and it cannot be refined into lubricants or petrochemical feedstocks.

Increasing forecasts of gas availability (most notably gas from unconventional sources), coupled with relatively stagnant forecasts for crude oil availability, make it increasingly common for nations to find themselves in a situation where forecasts predict a surplus of gas production capacity but a deficit in crude derivatives. In such situations, there is a strong political motivation to reduce the reliance on imports by bridging this gap. This motivation is strongest in times of political or economic uncertainty.

GTL provides a process by which gas can be converted into synthetic crude derivatives, helping to bridge the gas/oil imbalance. For national oil companies (NOCs), this political motivation alone can inform investment decisions. For international oil companies (IOCs), this motivation can manifest as financial incentives (tax concessions or product premiums).

5.3 Portfolio Diversification

In most situations, investment decisions are made based on the gas monetisation option with the most favourable economics. Economic comparisons however are not without risk since they rely on a number of assumptions including raw material costs, labour costs, tax regimes, product revenues, exchange rates and interest rates.

In some circumstances, GTL may not be the most economically attractive gas monetisation strategy for a particular project, but may be selected on the basis of diversity: a wider investment portfolio reduces company exposure to the risk associated with a single unexpected event (such as a sudden reduction in wholesale gas price).

As well as commercial risk, GTL has traditionally been seen as having a relatively high technical risk. Shell Bintulu and PetroSA Mossgas were started up in the early 1990s, but no other moderate or large-scale GTL facility was then commissioned until Sasol/QP ORYX GTL nearly fifteen years later. The successful resolution of initial ORYX operating issues will have helped to allay some fears over GTL technical risk. Furthermore, Shell Pearl shipped its first cargo in 2011 and the Chevron Escravos GTL facilities are expected to start up in 2013.

5.4 Environmental Pressures

Gas monetisation strategies such as CNG, GTW and LNG are often favoured over GTL from a legislative perspective, due to GTL's relatively low conversion efficiency and high effluent and emissions burden.

One major area where legislative pressures can favour GTL is in the processing of ‘unwanted’ associated gas. Flaring of such gas is increasingly legislated against, meaning that if an alternative solution cannot be found for the gas the oil cannot be extracted. While re-injection of gas, export via pipeline, CNG and LNG may be potential alternatives to flaring, they may be impractical or less economically attractive than a GTL solution, particularly at small scales.

A number of small-scale GTL solutions have been developed in recent years. Several are currently operating at demonstration scale and specifically target the huge niche market offered by small-scale, stranded, associated gas.

A particular benefit offered by use of GTL for associated gas is the potential to remove the final step of the normal GTL process: syncrude refining. Instead of providing a dedicated, small-scale refinery for the GTL syncrude, this can be blended into the conventional crude and co-transported to an existing refinery.

6 SUMMARY

Interest in GTL has picked up significantly over the past few years following a protracted lull: significant additional capacity is coming on line in terms of Sasol/QP ORYX GTL debottlenecking, Pearl start-up and Chevron Escravos GTL is due to start in 2013; there is also a marked increase in early phase work, with the two main players – Shell and Sasol – showing interest in exploiting the market conditions created by the US shale gas industry, and Sasol who are involved in a FEED level study for a facility in Uzbekistan (based on conventional gas).

Novel processing technologies, including modular micro-and mini-channel reactors have been developed to target small scale GTL opportunities such as offshore stranded gas: CompactGTL announced in January 2012 the successful completion of a test programme with Petrobras for just such a technology.

Elsewhere in the world, trends in the relative price of oil and gas do not yet compare with the USA, but shale gas, CSG/CBM, small scale stranded associated gas and even UCG, present new gas monetisation opportunities where GTL can be more competitive. Moreover, the long-term prospects for crude oil (peak oil), portfolio diversification and security of supply issues also look to be in GTL's favour.