Gas to Liquids: Economic Study

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Abstract

This project examines the prospect of Gas to Liquid (GTL) technology in the Australian market as an alternative means to monetising Australia's vast gas reserves. It sets out to understand whether GTL technology is an economically viable alternative for monetising natural gas resources in an Australian context, and if not, what economic, political and regulatory conditions are required to ensure the success of an Australian GTL industry. The key objectives of this study include: (1) to understand the economics of the GTL process based on a range of variables including feedstock gas price, capital and operating costs and the market and price of the end products; (2) understand how GTL technologies are linked to the economics of the process; (3) develop an understanding of how GTL compares to alternative gas monetisation options; (4) develop a rationale for pursuing a GTL strategy within different regulatory frameworks and market scenarios; and (5) understand the markets and marketing challenges for GTL products. The approach taken has been to develop an economic model of potential GTL scenarios and use this as the basis for discussion. Results to date indicate that medium scale GTL in Australia is not economically viable based on conservative assumptions. However, under certain economic conditions GTL is feasible.

1. Introduction

Woodside has significant gas resources in Australia that it is seeking to commercialize. It is these vast gas resources, together with long-term supply contracts that underpin Woodside's vision to become a world class LNG player. GTL technology is potentially an alternative or complementary way for Woodside to develop its gas resources, diversify its product portfolio and access new sales markets for its products.

The problem addressed by this report is to understand whether GTL technology is an economically viable alternative for monetising natural gas resources in an Australian context, and if not, what economic, political and regulatory conditions are required to ensure the success of an Australian GTL industry.

Woodside has initiated this research in response to the increased movement in the GTL industry of late, and with a view of staying up to date and on top of the latest developments to enable them to remain competitive. As a result of this research paper, Woodside will gain a thorough understanding of the current and future situations of the international GTL industry as a whole, and how GTL might fit in the Australian marketplace.

1.1 Current State of the Art

GTL technology refers to the process for converting natural gas into synthetic oil, which can then be further processed into fuels and hydrocarbon based products (Stanley 2009). As can be seen in Figure 1 below, Fischer Tropsch (F-T) GTL technology can be simplified into five main process steps: (1) natural gas pre-treatment, (2) air separation, (3) syngas production via reforming, (4) Fischer-Tropsch reaction synthesis and (5) product upgrading.

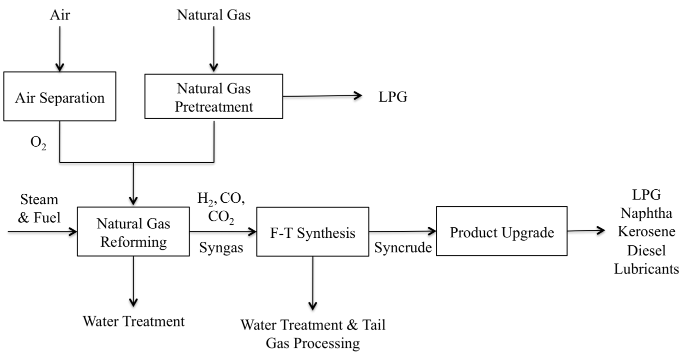

Figure 1 Basic GTL Fischer-Tropsch process flow diagram (Udaeta 2007)

GTL products fall into three categories: fuels (diesel, jet fuel and kerosene), specialty streams (lube based-stocks and waxes), and petrochemicals (naphtha for steam cracking). A reasonably accurate description of the hydrocarbon product distribution given by the F-T process can be described by the Anderson-Schulz-Flory (ASF) distribution that is expressed as shown in equation 1.

$$W_n/n = (1-\alpha)^2 \alpha^{n-1} \quad (1)$$

W_n is the mass fraction of the hydrocarbon molecules containing n carbon atoms. α is the chain growth probability or the probability that a molecule will continue reacting to form a longer chain. The ASF distribution is dependant on the temperature, pressure, stoichiometric ratio of the synthesis gas, the catalyst type and the age of the catalyst (Balogun & Onyekonwu 2009).

The general view within the oil and gas industry of GTL technology is that as the technology improves and capital costs are brought down, GTL is becoming increasingly more attractive as an alternative means to monetising gas resources, particularly in the context of the following factors (Rahmim 2005; Arzamendi et al. 2009; Balogun & Onyekonwu 2009):

- The steady increase in global energy demand against declining oil reserves and the need to develop and exploit additional energy resources
- The need to strategically diversify and secure energy resources on both the supply and demand sides of the market given concerns surrounding energy security
- Strategic avenue for portfolio diversification among the major resource holders
- Stricter environmental regulations as a result of tighter fuel specifications in the automotive industry
- Movement toward reducing associated flared gas for environmental and economic reasons

The economics of GTL are primarily a function of the feedstock gas price, the capital and operating costs, and the oil price (Hay 2009). Low feedstock gas prices coupled with high crude oil prices would ensure the economic viability of GTL plants (Al-Saadoon 2007). It is this combination of feedstock gas and crude oil prices that has been the basis for investment in the GTL plants in existence today.

Capital costs in excess of $50,000/bbl (total installed costs) have dropped to $25,000-$30,000/bbl due to technical advances with $20,000/bbl in sight and even smaller goals on the radar, for example Shell's stated goal is $12,000/bbl (Rahmim 2005). However, in recent years considerable cost escalation has driven capital costs to in excess of $120,000/bbl.

The few GTL plants in operation today are very large facilities that cover large areas and can produce over 100,000 bpd of GTL products. Despite this, there is research being done concentrating on developing technology aimed at much smaller GTL plants. For example, the British based company CompactGTL expects the first commercial small scale plant by 2012 as a result of its partnership with Petrobras, the Brazilian government-backed oil company.

1.2 Project Objectives

In order to understand whether GTL technology can be implemented economically within the Australian market place as an alternative means to monetising natural gas resources; as well as understand under what economic, political and regulatory conditions a GTL industry would likely exist in Australia, the following are the project objectives:

- Understand the economics of the GTL process based on a range of variables including feedstock gas price, the capital and operating costs, and the market and price of the end products;
- Understand how the various GTL technologies are linked to the economics of the project;
- Compare GTL with alternative gas monetisation options;
- Within the constraints of potential regulatory/fiscal environments and government policy settings, discuss a rationale for pursuing a GTL strategy;
- Explore the markets and marketing challenges for GTL products

2. Project Process and Research Methodology

In order to fulfil the stated objectives, the following was the research plan.

1. Conduct a review of the literature on GTL technology, economics, products and markets, and policy and regulatory/fiscal conditions to inform the direction of the project.
2. Establish a set of GTL development choices based on the review of the GTL literature.
3. Take a 'low risk', reasonably well understood development choice as the basis for the economic model.
    a. Estimate capital costs, operating costs, production quantities etc. and incorporate company taxes and the Petroleum Resource Rent Tax into the model.
    b. Forecast cash flows for the project and perform a sensitivity analysis to identify key parameters and their effect on the valuation metrics.
4. In performing the sensitivity analysis and learning the effect of key parameters on the economics of the project, construct plausible GTL scenarios for some of the variations in order to enhance the value of the results.
5. Explore various policy and fiscal setting scenarios

6. Apply the results of the model to the current understanding within the industry and the literature to reach some conclusions.

3. Results and Discussion

Results to date have demonstrated that a medium scale (50,000 bpd) GTL plant in Australia is uneconomical based on the set of assumptions in Table 1. Based on this set of assumptions the NPV is negative US$5.3 billion.

Input factor	Value	Comments
Oil Price	US$75/bbl	Current price inflated at 2.5% going forward
Gas Reserve	4.79tcf	Woodside's Pluto gas reserve used as a proxy
Production Profile	-	Woodside's Pluto gas field production profile used as a proxy
CO_2 price	US$0/tonne	Price of carbon in an emissions trading scheme – inflated at 2.5% going forward
Feedstock Gas Price	US$3.15/GJ	15% rate of return on upstream investment - inflated at 2.5% going forward based on third party data for an approximately 5tcf offshore development in north western Australia
Syncrude product prices	10%	This is a premium that GTL derived products would receive over crude oil derived products
CAPEX	US$7.7b	This is total capital expenditure ($US 154,734/bbl)
OPEX	US$10/bbl	This is operating expenditure per barrel of syncrude produced

Table 1 Base case GTL scenario assumptions

Figure 2 is a sensitivity analysis of the results around the base case NPV where the set of assumptions above are individually varied from low through to high values. This sensitivity analysis demonstrates that the feedstock gas price, oil price and CAPEX are the three most significant factors for the NPV of a GTL project, with the feedstock gas price being the most significant.

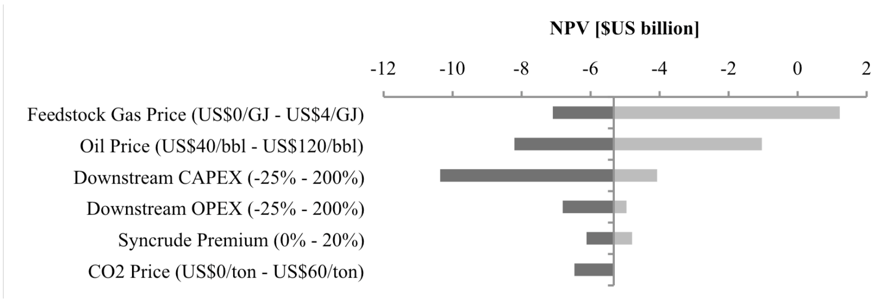

Figure 1 Sensitivity analysis of base case GTL scenario

The degree to which the feedstock gas price affects the economics is somewhat unforeseen given that a consensus view of the literature tends to suggest that the oil price and capital costs are the most influential on the economics of a GTL project. However, this is most likely because GTL has historically been intended for monetising stranded or associated reserves where it is assumed that the cost of the gas is relatively low, in the order of US$0-1.5/GJ. Looking at current commercial GTL projects such as the Pearl and Oryx GTL plants in Qatar, and the Escravos GTL plant in Nigeria, they all utilise cheap sources of gas.

Despite the seemingly negative results, preliminary analysis demonstrates that there are plausible scenarios in which GTL is economically competitive. Using a low gas feedstock price of $US1/GJ as is available around the world, the project breaks even at an oil price of approximately $US83/bbl, and under a high oil price of $US120/bbl the project has an NPV of US$3.8b.

It is also important to remember that the capital costs used in this analysis have taken into account the extreme cost escalation observed in the last 5 years. Using capital cost data adjusted to prior to the beginning of the extreme cost escalation in approximately 2005-2006, whilst holding the other assumptions in Table 1 constant, the project has an improved NPV of negative $US1.6b without also adjusting for a reduction in the feedstock gas price as a result of a decrease in upstream costs.

It is anticipated that by the completion of this project, a clearer and more comprehensive understanding of these conditions will be reported with plausible scenarios in which they might occur.

Given the significant influence of capital costs on the economics of GTL, the selection of process route is extremely important. Take for example the main syngas generation choices: partial oxidation POX, catalytic steam methane reforming SMR, two-step reforming, autothermal reforming ATR, and heat exchange reforming. The choice of this technology is determined by balancing between the characteristics of each one. For example, SMR doesn't require pure oxygen and therefore doesn't require an air separation plant, but it tends to be limited to smaller scale plants. POX on the other hand is suitable for large scale plants, it could also allow the absence of a catalyst and thus lower CO_2 content but it requires pure oxygen and a high operating temperature causing soot formation that's difficult to handle (Bao 2010). From just these two technologies, the choice of reformer determines whether the additional costs associated with an air separation unit are required.

At the time of publication, a small amount of work into understanding how GTL compares to alternative gas monetisation options as well as developing a rationale for pursuing a GTL strategy under various regulatory and market scenarios had been undertaken. It is expected that in the final report a clear understanding of each of the following will be achieved:

1. How GTL compares to other monetisation options such as LNG.
2. The viability of GTL using different feedstock gas sources such as coal seam methane.
3. For what reasons and under what conditions would the government consider GTL
    a. Mechanism for ensuring energy security and less dependence on imported liquid fuels
    b. Contribution to a gas based economy
    c. GTL diesel is an environmentally cleaner product than conventional diesel – how would the state/federal government deal with this?
4. What role would GTL play in a domestic gas reservation policy
5. Is there a possibility of receiving a "holiday" on the excise of GTL diesel, particularly to encourage the use of this fuel in the mining industry and in the pursuit of energy security in Australia.

4. Conclusions and Future Work

Based on a not overly conservative set of assumptions and in an Australian setting, a 'base case' GTL project is not economically viable. However, under the right economic conditions, GTL technology is certainly feasible with the feedstock gas price, oil price and capital costs being the key drivers. To date a limited number of the aims of the project have been achieved to a sufficient level, however it is anticipated that by the end of the project all project objectives will be achieved.

In light of this, identification of gas fields that might provide a low feedstock gas price is an area for further work. In addition to this, monitoring the market for the right combination of oil price and cost environment will help to identify when the time might be right to pursue a GTL strategy further. Furthermore, advancement in the technology used in the GTL process should be monitored for opportunities that drastically reduce the operating or capital costs. Although not explicitly covered to date, small scale GTL should be investigated as an option for a GTL FPSO.

In addition to this, there exist alternative GTL processes to Fischer Tropsch for monetising gas resources. Dimethyl ether (DME) is one such alternative and should be considered as complementary or even standalone alternatives to LNG.

5. Acknowledgements

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