Gas-to-Liquids: The Future of Fuel Technology or a Mere Pipe Dream

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Abstract

The process of gas-to-liquids, GTL, converts natural gases into useful hydrocarbon liquids such as diesel and gasoline through catalysis. GTL process is accomplished by first converting natural gas to synthetic gas through partial oxidation, $CH_4+½O_2 \rightarrow CO+2H_2$, and then to liquid hydrocarbons using a catalyst. At first glance, this process is more environmentally friendly and produces superior quality products compared to using crude oil. However, the uncertainty of large-scale production and investment risks due to high estimated capital costs leaves GTL in doubt. In this paper, we will study the pros and cons of the fuel produced by the GTL process compared to using crude oil with regards to their quality, environmental benefits, and viability/profitability. Looking at both sides of the coin, we will discuss in detail whether GTL is a reliable, profitable, and pragmatic method to supply world's energy needs.

Introduction

Gas-to-liquids method involves the use of the Fischer-Tropsch (FT) process. This process introduces a catalyst, preferably cobalt due to its long lifetime and high activity, to react with synthetic gas to produce liquid hydrocarbons [1]. The hydrocarbon chain is isomerized to achieve different end products such as kerosene, methanol, gasoline and waxes [2]. Hydrocarbon fuels of greater molecular weight are of higher value [1]. GTL industries are aiming to use FT process to profitably bring production to a larger-scale with the hopes of producing 1 million barrels per day, b/d, of fuel products [3]. Current leading energy companies achieved approximately 150,000 b/d of fuel which is a far cry from the goal [3]. However, with the rise of crude oil prices with respect to natural gas prices, GTL is given a green light to expand. In this poster, we will discuss the advantages and disadvantages of GTL and determine the future of this process. Test methods for GTL will also be presented.

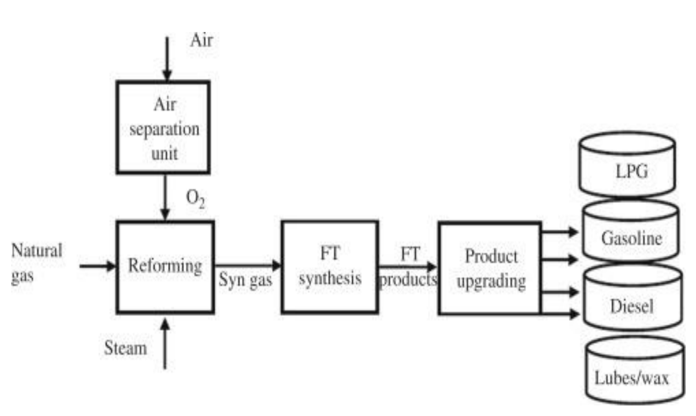

Figure 1. FT-GTL Process [2]

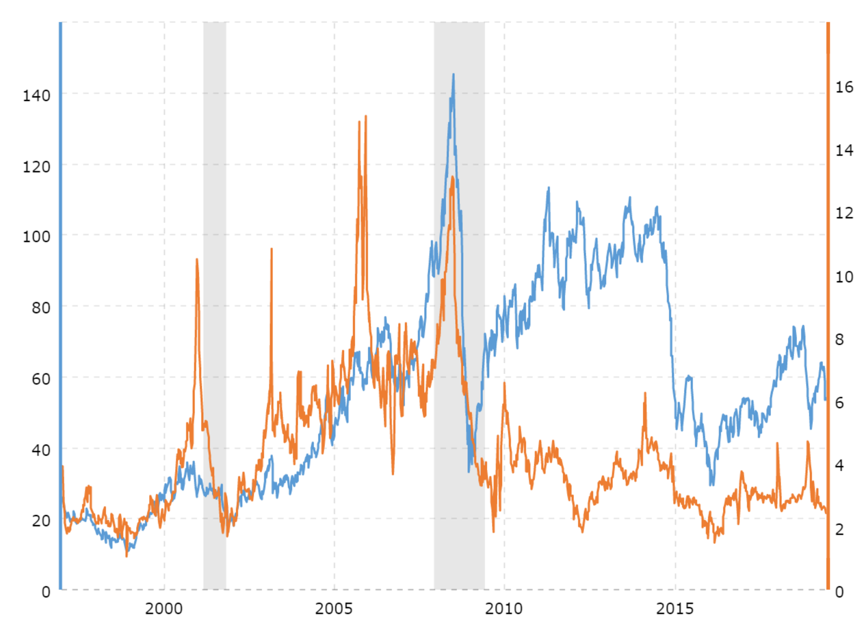

Figure 2. Natural gas (orange) vs crude oil (blue) prices [4]

GTL vs Crude Oil

GTL lubricant oils, also known as ISO paraffins, is a viable alternative to API Group III and IV base stocks [5]. These stocks are in high demand for industrial manufacturing companies due to their superior fuel quality compared to crude oil fuels. GTL fuel products have high cetane number, near-zero sulfur content, good oxidation stability and low viscosity at low temperatures which improves performance and is environmentally-friendly [6]. Developing these stocks to increase production and meet demands will make GTL a reliable alternative to lubricants derived from crude oil. With over 14,000 trillion cubic feet of unused natural gas reserves, there is an abundance of resources for GTL plants to exploit [5]. Commercializing these stranded reserves will help produce hundreds of billions of fuels and offer great economic value to the residing country. Millions of people can be employed to mine, transport and distribute natural gases [7]. Natural gases are also cost effective compared to crude oil. For example, a low price point of $49 per barrel of crude oil equates to $8.5 per 1 million BTU of natural gas [7]. Finally, capitalizing on natural gases will eliminate the need for gas flaring which reduces harmful emissions [5].

Table 1. Desirable Properties in a Lubricant Base Stock

Base Stock Properties	ASTM	GTL-5 (typical properties)	Industry Range (min-max)	Value
Viscosity@100°C, cSt	D445	4.5	4.0 - 5.0	-
Viscosity Index	D2270	144	120 - 141	High
Pour Point, °C	D97	-21	-24 to -12	Low
Cold-Cranking Simulator@-25°C, cP	D5293	816	729 - 2239	Low
NOACK wt%	D5800	7.8	10.4 - 14.8	Low
Composition, Mass %				
Iso-paraffins		100	47.3 - 80.9	High
Mono-Cycloparaffins		0	18.7 - 28.8	Low
Poly-Cycloparaffins		0	5.3 - 22.2	Low
Aromatics		0	0.0 - 1.2	Low

Figure 3. Properties of GTL products. Great combination of kinematic viscosity, volatility, and pour point for quality products [5].

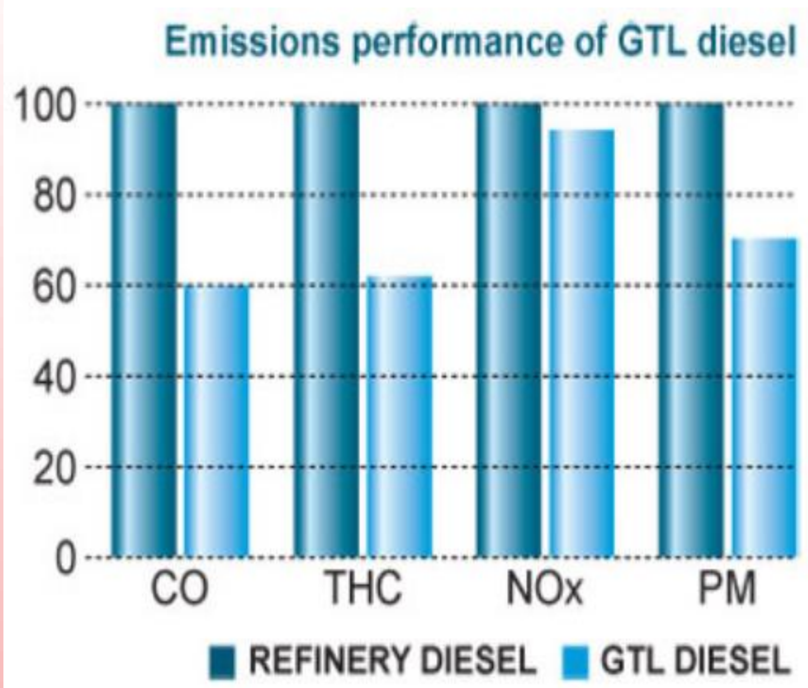

Figure 4. GTL vs Refinery emissions [8]

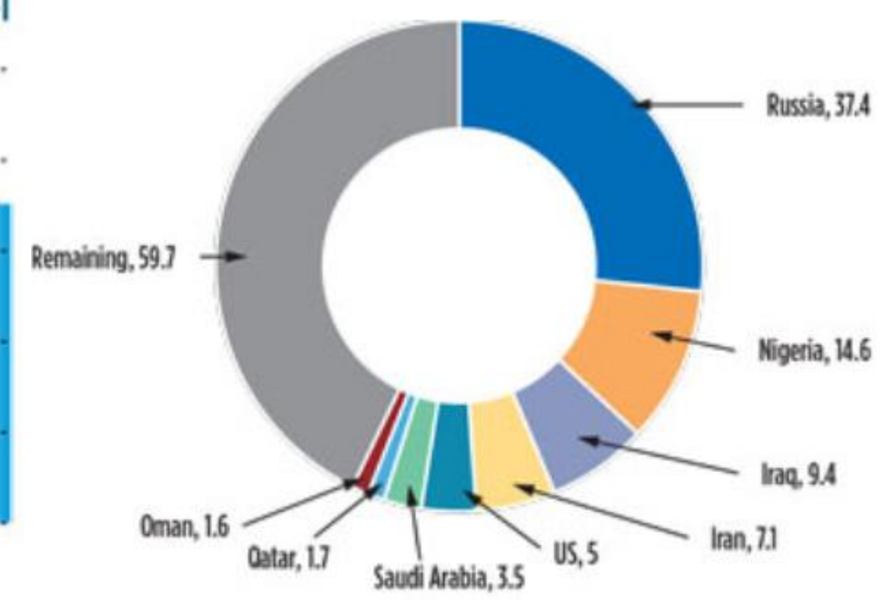

Figure 5. Gas flare volumes [9]

While GTL has its benefits, there are disadvantages that hinders its growth. Production efficiency and capital costs are issues that encumbers GTL from large-scale production [3]. The process will need to be tampered with and lower priced for it to be advantageous over crude oil. There are significant investment risks that bars industries from going forward with the GTL plan. Transporting natural gas is one of the major issues because creating infrastructures for delivery is expensive [7]. Also, due to the dependence of natural gases on competing product prices, GTL future is uncertain [10]. The future also depends on the availability of natural gases because it is non-renewable and there is a finite amount of reserves [7]. Finally, GTL does not contribute significantly to greenhouse gas reduction, which still leaves a major problem on the table [10].

Test Methods for GTL

ASTM D445- Kinematic Viscosity of Transparent and Opaque Liquids.
This test method is used to determine the kinematic viscosity of liquid petroleum by using a viscometer to measure time for the volume of liquid fuel to drop due to gravity.

Figure 6. K23702 Constant-Temperature Viscosity Bath

ASTM D381- Existent Gum in Fuels by Jet Evaporation.
This test method is used to determine the gum or residue in liquid fuel through evaporation. Sample is evaporated in an aluminum block at high temperatures, max at 475 F, under controlled conditions.

Figure 7. K33700 Existent Gum Evaporation Bath

ASTM D4294- Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry.
This test method is used to determine the total sulfur in petroleum and petroleum products by exciting the sample through x-ray radiation. High sulfur content lowers the quality of the fuel product.

Figure 8. EDXRF- Elemental Analyzer

ASTM D613- Cetane Number of Diesel Fuel Oil.
This test method is used to determine the cetane number which measures the ignition characteristics of fuel. Near-infrared (NIR) transmission spectroscopy is done to achieve results.

Figure 9. K88600 Portable Octane Analyzer

ASTM D1319- Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption.
This test method is used to determine the hydrocarbon volume percent of saturates, olefins, and aromatics to characterize the quality of the product. Maximum of six samples can be tested simultaneously distilled below 315 C.

Figure 10. K41506 Fluorescent Indicator Adsorption Apparatus

ASTM D524- Ramsbottom Carbon Residue of Petroleum Products.
This test method is used to determine carbon residue value of burner fuel after evaporation and pyrolysis of the oil. The deposit formed will be measured.

Figure 11. Ramsbottom Caron Residue Apparatus

Future of GTL

The future of GTL is contingent on crude oil prices relative to natural gas prices. Recent economics reveal that natural gas prices are favorable which makes GTL a viable market. Also, with over 14,000 trillion cubic feet of stranded natural gas reserves available, there is good incentive to exploit it. However, crude oil prices are capricious, and any price drop will have a significant impact on the profitability of GTL in the future. Also, natural gas is non-renewable which will be problematic when all the available reserves are used. Another struggle is pushing GTL production to a larger scale because it requires high investment risks. Industries will need to improve production efficiency and cost to make GTL a pragmatic alternative to crude oil. Looking back throughout history, many large energy companies abandoned their GTL plants due to cost escalations, capital prices, and inability to create higher-value products [3]. Only a few companies were successful in retaining their GTL plants. However, technological improvements and current price advantages of natural gas allows industries to continue the pursuit.

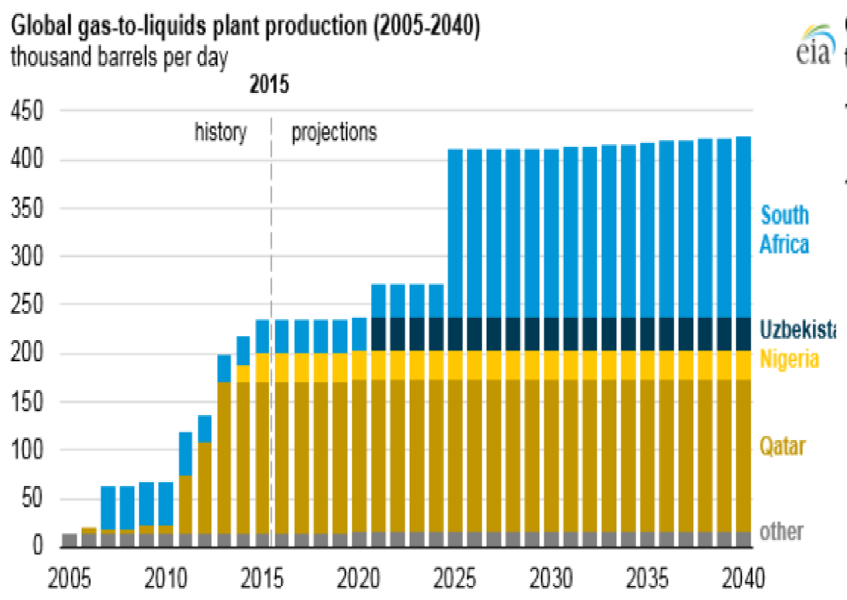

Figure 12. GTL production forecast [11]

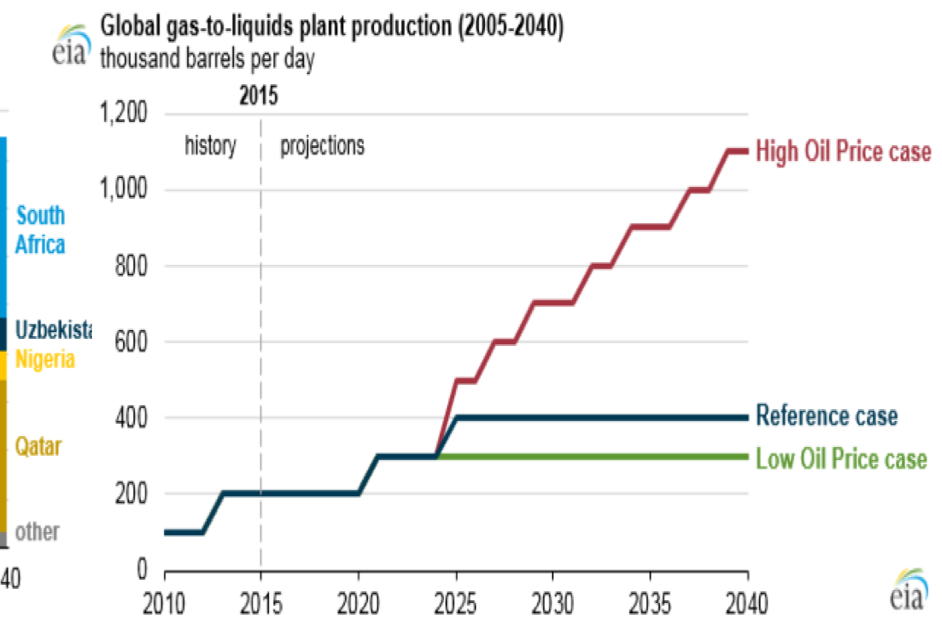

Figure 13. Crude oil prices forecast [11]

Conclusion

Gas-to-liquids technology has significant advantages over crude oil in producing higher quality fuel and being more environmental-friendly. With crude oil prices going up and a surplus of natural gas reserves, there is a passageway for GTL to grow. However, a decrease in crude oil prices will have an adverse effect on GTL which makes it economically risky to invest in. Overall, the question lies in whether the benefits of GTL is worth the economic risks needed to improve the technology and bring it to large-scale. Not only that but also, can GTL sustain and become a reliable supplier of world's energy needs. There are no clear cut answers but in this era where technology is skyrocketing and natural gas is so readily available, there is definitely a way for GTL to reach its potential.

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Acknowledgements

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