Gas-to-Liquids: Time is of the Essence

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Abstract

Gas-to-liquids (GTL) process is surfacing as a popular and viable method for producing liquid fuels with the current surplus of natural gas fields in the U.S. Compared to liquid fuels produced from crude oil, GTL fuels are superior in environmental friendliness and quality which is of paramount importance in today's stringent environmental regulations. The problem lies in the unpredictability of available natural gas fields for upcoming years. Currently, small GTL plants are advantageous in every facet for exploiting stranded gas compared to large GTL plants which require heavy investments and large productions to be profitable. In this paper, we will dive into the current and future states of GTL and determine whether it is plausible for this process to be a viable and profitable alternative to crude oil.

Introduction

Gas-to-liquids method involves the use of the Fischer-Tropsch (FT) process. The FT-GTL process is accomplished by converting natural gas to synthetic gas through partial oxidation, $CH_4 + \frac{1}{2}O_2 \rightarrow CO + 2H_2$, and then to liquid hydrocarbons using a catalyst. The hydrocarbon chain is isomerized to achieve different end products such as kerosene, methanol, gasoline and waxes [1]. The excess of natural gas in today's economy drags the prices down significantly while crude oil prices continue to rise which paves a explicit path for GTL to develop [2]. Small GTL plants are currently the wave in the market and are more profitable and viable than larger GTL plants. With this said however, it is uncertain whether small GTL plants can produce enough to supply the world's energy needs.

Prices	2017	2018	2019	2020
WTI Crude Oil[a] (dollars per barrel)	50.79	65.06	56.45	54.60
Brent Crude Oil (dollars per barrel)	54.15	71.19	63.59	60.10
Gasoline[b] (dollars testper gallon)	2.42	2.73	2.60	2.62
Diesel[c] (dollars per gallon)	2.65	3.18	3.06	3.04
Heating Oil[d] (dollars per gallon)	2.51	3.01	3.01	3.05
Natural Gas[d] (dollars per thousand cubic feet)	10.86	10.46	10.85	10.66
Electricity[d] (cents per kilowatthour)	12.89	12.89	12.99	13.11
Coal[e] (dollars per million Btu)	2.06	2.06	2.07	2.10

Figure 1. Oil and gas prices from 2017-2020 [2]

Current State of GTL

GTL fuel products have myriad properties that are advantageous compared to crude oil products such as have high cetane number, near-zero sulfur content, good oxidation stability and low viscosity at low temperatures [3]. With trillions of cubic feet of unused natural gas reserves and a peak this year compared to the last five-year average, there is an abundance of resources for GTL plants to exploit [4]. In today's economy, natural gases are 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 [5]. Also, capitalizing on natural gases will eliminate the need for gas flaring which reduces harmful emissions. Amongst these benefits, there are disadvantages that hinders GTL's growth. Production efficiency and capital costs are two salient issues that encumbers GTL from large-scale production. Small GTL plants are able to weave through these issues while producing higher value end products which allows it to prosper as the most viable option currently.

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 2. Properties of GTL products. Great combination of kinematic viscosity, volatility, and pour point for quality products [6].

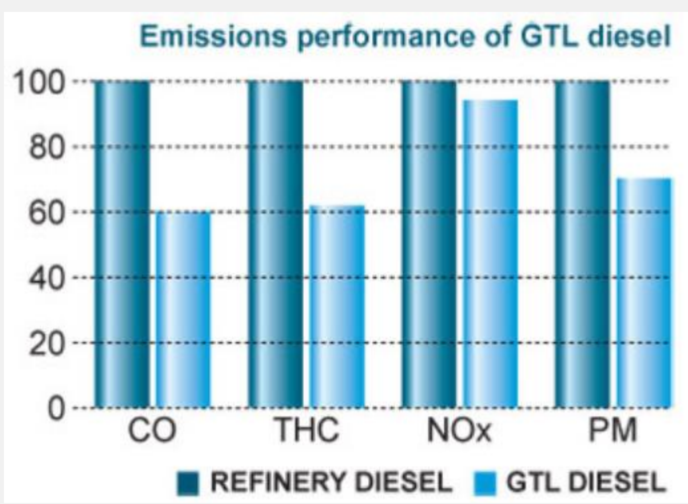

Figure 3. GTL vs Refinery emissions [7]

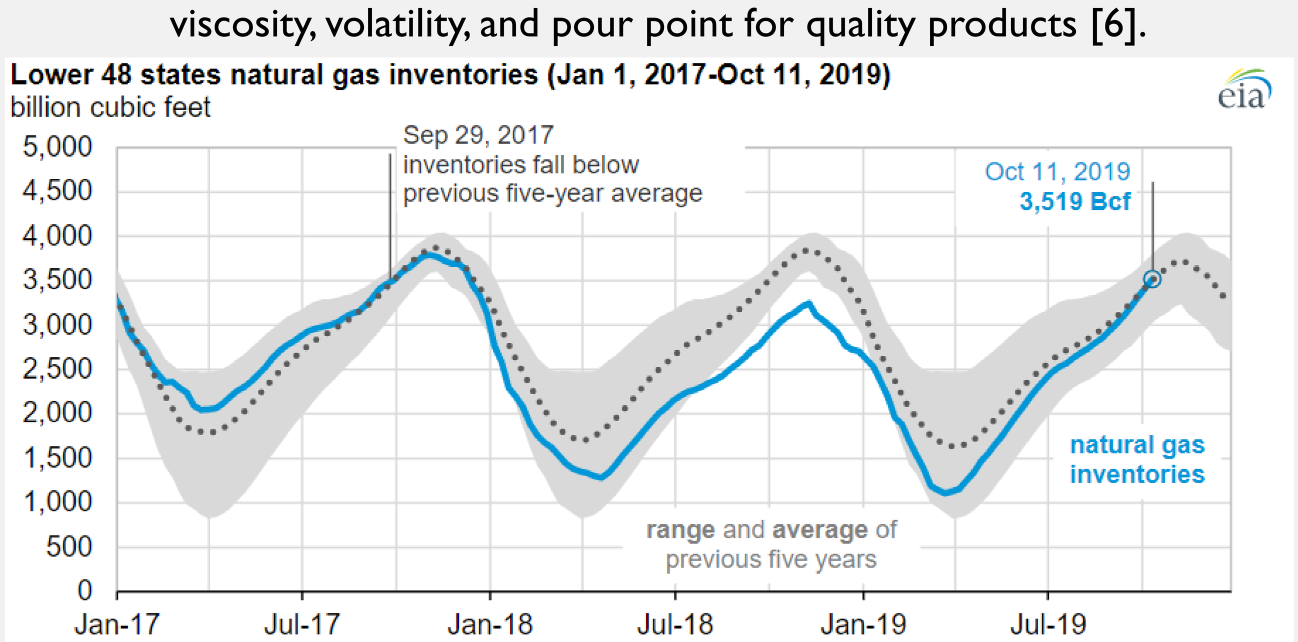

Figure 4. Natural gas inventory in the last two years [4]

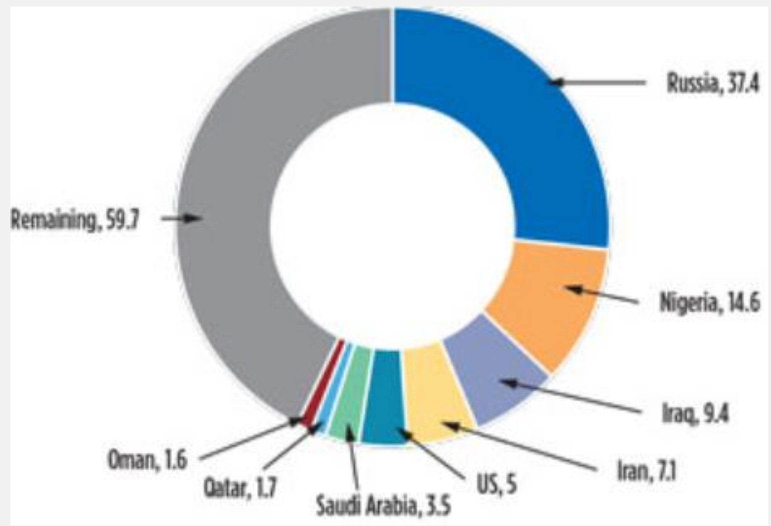

Figure 5. Gas flare volumes [8]

Test Methods for GTL

ASTM D445- Kinematic Viscosity of Transparent and Opaque Liquids. K23702 Constant-Temperature Viscosity Bath

ASTM D381- Existent Gum in Fuels by Jet Evaporation. K33700 Existent Gum Evaporation Bath

ASTM D4294- Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry. EDXRF- Elemental Analyzer

ASTM D613- Cetane Number of Diesel Fuel Oil. K88600 Portable Octane Analyzer

ASTM D1319- Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption. K41506 Fluorescent Indicator Adsorption Apparatus

ASTM D524- Ramsbottom Carbon Residue of Petroleum Products. Ramsbottom Caron Residue Apparatus

Future of GTL

The future of GTL is contingent on crude oil prices relative to natural gas prices and the availability of natural gas reserves. Currently, China is the leading region of GTL market as well as U.S. and European Union [9]. With increased environmental regulations, GTL is soaring in demand and the opportunity is now due to the abundance of natural gas reserves and increase number of small GTL plant reactors [9]. However, large-scale production is still up in the air.

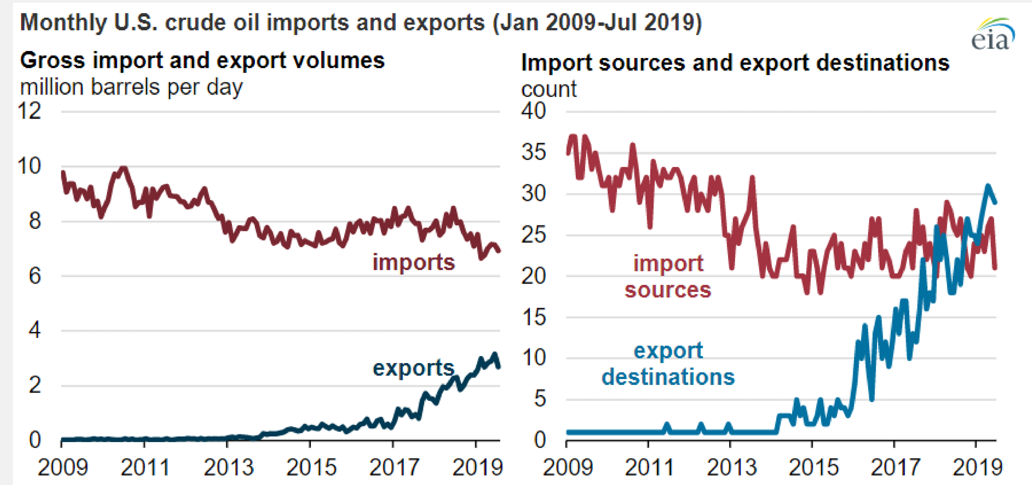

Figure 6. U.S. export and import crude oil [9]

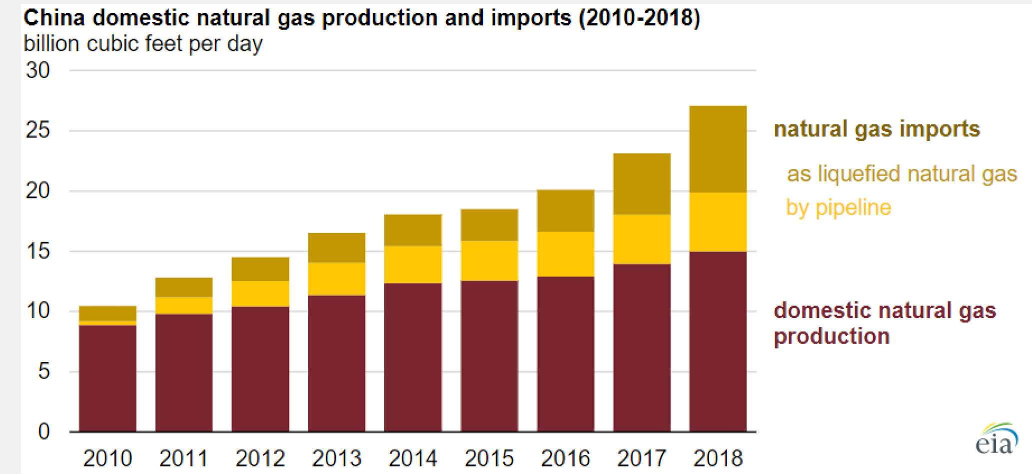

Figure 7. China natural gas production [10]

Conclusion

Gas-to-liquids technology is explicitly given a green light to grow but the question lies in whether it is profitable long-term and can be a reliable supplier of world's energy.

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Acknowledgement

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