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REVIEW OF DIFFERENT ECONOMIC PARAMETERS FOR EVALUATING GAS-TO-LIQUID TRANSPORTATION MODES USING PIPELINE

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Abstract:

World economies are in constant movement towards developing natural resource reserves and monetizing resources to enable ownership of larger market shares, and Gas-to-liquid has become a growing commercial development, aimed at monetizing stranded gas with conversations as extensive as constructing Floating Gas to Liquid (FGTL) vessels ongoing in the Oil & Gas Industry. Because crude (petrocrude or syncrude) has no value in itself and the movement of crude is essential to its value, this paper thus attempts to evaluate the economic viability of using pipeline in transportation of Gas-to-liquid by considering economic parameters relevant for this analysis including but not limited to Facility CAPEX and OPEX, Markets and proximity, Security etc. with the aim of informing decision and focus based ideas regarding the GTL commercial vehicle.

Keywords: EGTL, GTL pipeline, Gas monetization, Stranded gas, Syngas, Synfuel.

INTRODUCTION

Natural Gas as an energy resource is made up of the lighter forms of naturally occurring hydrocarbons consisting of Methane, Ethane, Propane, Butane and Pentane. Natural gas (for the purpose of this paper Methane) is often termed stranded with regards to it remoteness and peculiarities in storage and transportation, resulting from its high atmospheric pressure nature that makes it difficult to store a reasonable usage amount, and often requires either a physical processing or chemical processing to store it for transportation. It is a growing source of energy with rising global demands and hence recovery of stranded gas and its processing, transportation and storage for monetization tends to be the goal of every economy endowed with this natural resource. The two main modes of transporting Natural Gas are in its Liquefied Natural Gas (LNG) form or as byproducts of the Gas-to-liquid (GTL) process. The LNG form of Natural gas requires a physical process of refrigerating it to allow its molecules bond and compress into a stable liquid state for transportation and storage whereas GTL transportation mode involves the chemical process of transforming methane gas into synthetic gas (syngas) and synthetic liquids (synfuel) for the sole purpose of transportation.

In manufacturing of GTL (see Figure 1), hydrogen is introduced to purified gas which is converted by partial oxidation, steam reforming or a combination of the two processes to produce syngas as the feedstock of Fischer-Tropsch (F-T) synthesis. The syngas is then converted to paraffinic hydrocarbons in an F-T Reactor with the use of cobalt or iron-based catalyst yielding highly desirable middle distillate products. The raw F-T hydrocarbons are subsequently upgraded to final products by using conventional refinery processes: wax hydrocracking, distillate hydrotreating, catalytic reforming etc. to produce Naphtha and Transportation fuels (diesel, jet fuel) Dong Lichun, (2008)

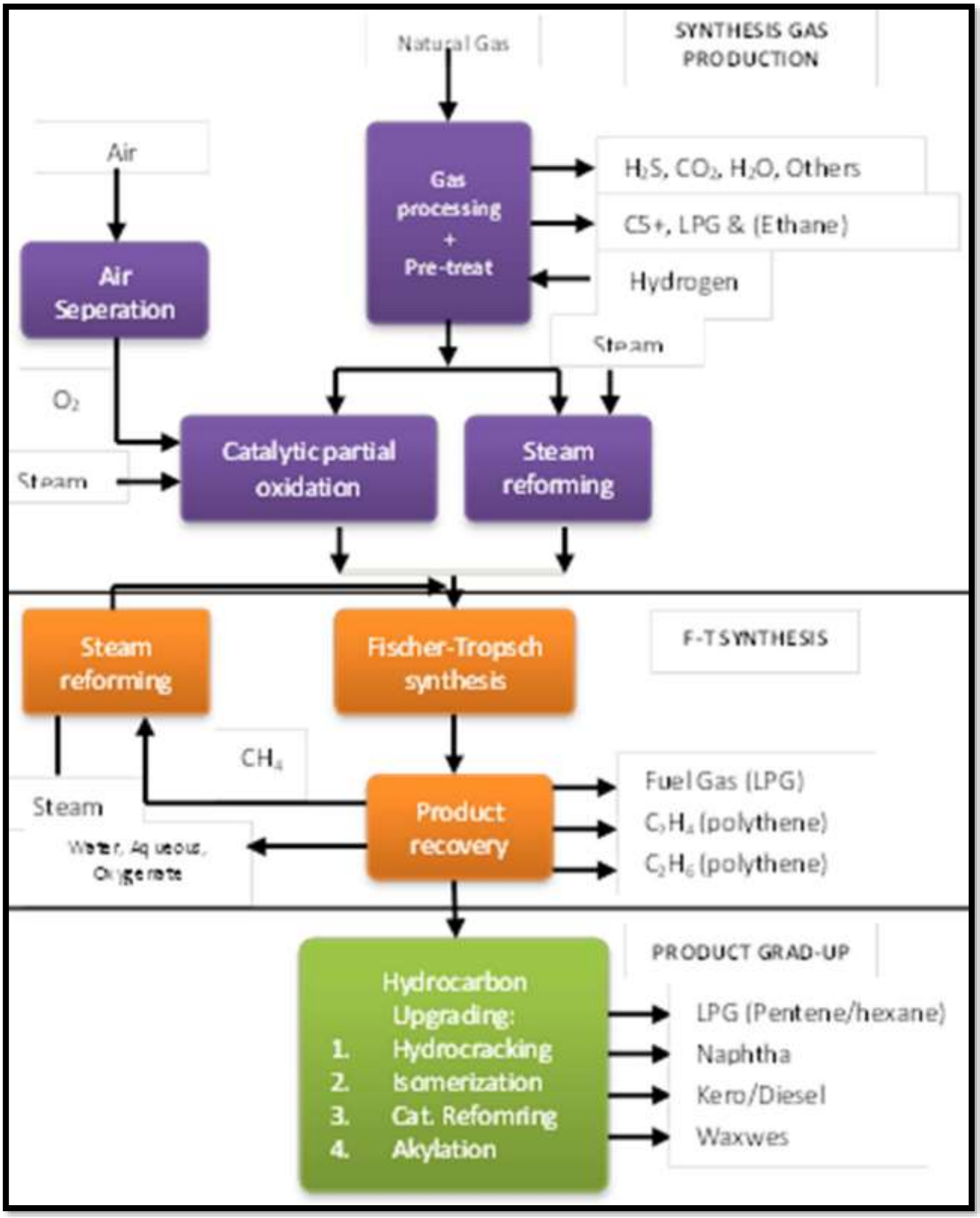

Figure 1: Overall schema of a GTL process (Dong Lichun, 2008)

Towards the tail end of the F-T GTL process, because upgraded consumable products (transportation fuels) of the GTL are produced via conventional refining processes, it becomes economically viable to transport syncrude as the final product of the process either via pipelines or marine tankers and, would not be economically viable to transport syngas, because syngas produced at the rather peripheral phase of the GTL process by partial oxidation or steam forming, would result in extensive F-T Reactor capital investment at points of delivery, leading to multiple repeated investments in an economy where conventional refining can be employed to produce these upgraded final products. This review's sole thrust is to evaluate the economic viability and profitability of using pipeline in the transportation of GTL products and would carry out a study and provide insight on this transportation mode as applicable within model economic environments and would attempt to answer questions about:

(1) GTL facility and process, product's performance and feedstock price;

(2) GTL pipeline transportation Infrastructure Tariff, capital expenditure (CAPEX) and operational expenditure (OPEX);
(3) Markets for GTL products and proximity;
(4) Advantages of GTL pipeline transportation over GTL marine tanker transportation;
(5) Security of supply and politics.

LITERATURE REVIEW

An analysis of the economic parameters for evaluating a GTL transportation mode using pipeline would not be complete without an enquiry into the GTL facility, process, product performance and feedstock price in a sensitivity analysis for determining the complete profitability of GTL pipeline transportation mode. Crude oil and Natural gas are the main constituents of a hydrocarbon reservoir which become proven reserves and company assets after development and production planning decisions are reached, usually consisting of decision on how and when to process produced hydrocarbon like, embarking on flow station projects; constructing a Floating Production Storage and Offloading (FPSO) vessel (Hyun-Jin Kim, 2014); product gathering decisions; transportability decisions and other components that form the E&P industry capital expenditure. Because crude oil has no value in itself but must be transported to refineries to derive economic value and, natural gas requires activities to enable its storage and transportation, transportability becomes a major component of the midstream sector of the industry, often bundled up with the upstream because of its vital role, affecting the cost of product and profitability.

GTL facility and process, product's performance and feedstock price

As at 2008, GTL facilities and infrastructures were majorly large scale and characterized as being highly capital intensive and complex, resulting in comparable investment CAPEX and depending on owner's perspective (Dong Lichun, 2008) but advanced technology in the last decade however has provided that at reduced capital cost, small scale and modular GTL plants can be built (Brancaccio), creating a major reduction in the total cost of production, making GTL diesel cheaper and increasing business profit prior to effect of transportation costs. A major advantage of the GTL process however, is that it produces cheaper transportation fuels also because prior to the effect of a GTL facility's CAPEX and OPEX, the cheap cost price of the feedstock of methane gas acts on the total cost of production affecting profitability of the GTL process positively as illustrated in Table 1. Table 1below illustrates the comparative analysis for producing a barrel of Diesel at a natural gas price of $1.796/MMBTU of natural gas and $41/bbl of crude oil. Using the Nigerian Escravos GTL (see Table 2) daily gas feed and production capacity, where 1m3 = 36.295MBTU, 1bbl = 159.18ltrs = 42gallons and 27.4% of a barrel of crude oil is diesel, the table shows that Natural gas feedstock is cheaper in producing a barrel of Diesel compared to crude oil with a difference of over $120 even while producing a superior and safer product.

Table 1: Feedstock cost for producing a barrel of Diesel using GTL and Petrocrude (Author's conception)

Facility	GTL	Refinery
Product	SYNCRUDE	PRTOCRUDE
MMBTU of gas	10.37	
BBl of crude oil		3.65
$/MMBTU/BBL	$ 1.796	$ 41.00
Total Feed stock cost to produce a bbl of diesel	$ 18.62	$ 149.65

Gas to liquid transportation fuels (synfuel) have low sulphur content and so fall under the Ultra Low Sulphur Diesel (ULSD) category. It is odorless and omits lesser carbon in processing and exhaust emissions when compared to petroleum fuels because of its high hydrogen to carbon ratio. The GTL diesel, referred to as a clean fuel, is preferred to crude oil diesel because it low carbon emission makes it healthier to work with and contributes majorly to Intended Nationally Determined Contribution (INDC) agreements and policy in reducing greenhouse gas emissions. GTL in the long run, also minimizes cost associated with safety hazards as its ULSD feature would serve as a tax premium in places like the UK. With an added advantage of serving different markets, in application of facility CAPEX and OPEX to GTL product profitability, (Ekwueme et al., 2019) after carrying out an economic valuation of the GTL facility using Net Present Value (NPV) and Internal Rate of Return (IRR) for different synthesis methods enumerates that the GTL process is a profitable venture that would compete very well with other gas monetization facilities.

Table 2: Large scale GTL plants economy of scale (Fleisch, 2012)

Plant	Country	Gas Feed Rate	Product	Production
Shell Bintulu	Malaysia	3.4mm m^3/d	Diesel+	24,000bpd
Mossgas	South Africa	6.8mm m^3/d	Diesel+	12,000bpd
Sasol Oryx	Qatar	10mm m^3/d	Diesel+	35,000bpd
Shell Pearl	Qatar	40mm m^3/d	Diesel+	140,000bpd
Titan	Trinidad	2.1mm m^3/d	Methanol	2,500tpd
Atlas	Trinidad	4.2mm m^3/d	methanol	5,000tpd
Escravos	Nigeria 2013	10mm m^3/d	Diesel+	35,000bpd

GTL paraffin is a feedstock for petrochemical plants however the major market for GTL is transportation fuels as a byproduct of methane gas as opposed to LNG whose major market is Electricity and domestic/industrial heating. The parameters for measuring transportation fuel performance include but is not limited to consumption and flow rate, carbon emission and, fitness to conventional engines. While economies remain in constant search for cleaner fuel, GTL products are considered premium and exceeding requirements when compared to Petroleum fuels because of its ability to maintain a constant flow rate in diverse weather conditions and temperatures in lubricating engines.
The GTL as a commercially viable tool for the monetization of Natural gas alongside LNG creates room for commercializing Natural gas remotely located and, by generating revenue for more exploration and production of Natural Gas, ensures the exploitation of natural gas reserves as reserves can only be increased by increased exploration. Its processing plants also, use feedstock of either coal, biomass or methane gas in production of Naphtha, Transportation fuels, Paraffin and Lubricants, serving a major tool in diversification of energy mix for economies aiming at supporting their economy with oil by increasing revenue or planning towards security of energy supply. It creates a source for increased revenue as well as sets the motion for the industrial development of the petrochemical sector as a major source of Naphtha/Paraffin production. As it is well known that major Oil and Gas companies go into petrochemicals with the aim of expansion in a vertical integration system of the Upstream, Midstream and Downstream sectors of the oil and gas industry, the GTL becomes a major milestone towards the industrialization of the downstream sector as it constitutes a major part of the downstream sector alongside refining.
GTL processing plants use feedstock of either coal; biomass or methane gas in production of Naphtha and Transportation fuels and so serves a futuristic purpose at the event of petroleum depletion by creating a better alternative for petroleum diesel and jet fuel while producing a major component of the paraffin, waxes and lubricant oils as petrochemical feedstock.

METHODOLOGY

This review uses both an empirical and quantitative methodology to examine the various economic parameters relevant in evaluating the gas to liquid transportation mode using pipeline; empirically using secondary data sources including textbooks, published papers, journals, industry related websites and reports and; quantitatively applying a mathematical approach in order to adequately analyze these parameters. The mathematical approach adopted for this paper uses the below conversion rates.

1barrel = 42gallons (1)
1 gallon = 3.79liters (2)

The liquid conversion rates above would translate to 1 barrel of oil containing 159.18liters equivalent of oil. A barrel of crude is a mixture of petroleum product that when undergone through the distillation process separates the petroleum products according to their various composite percentages. Diesel makes up 27.4% of a barrel of petroleum crude. GTL crude however is upgraded and developed based on desired output and mixture of finished products.

1cubic meter = 35cubic feet (3)
1 cubic feet = 1037btu (4)

The units (4) and (5) translate to 1 cubic meter of gas being equivalent to 36,295btu. Going by the report on Table 2 using the EGTL record, 10mm m3/d feedstock of gas would produce 35,000bbl of GTL which is an equivalent of 362,950mmbtu which would translate to an equivalent of 5,571,300liters of diesel if the entire day's production is upgraded to diesel only. The above analysis then translates as thus

1 barrel of diesel = 3.65barrels of petrocrude (5)
1barrel of diesel = 10.37mmbtu of gas (6)

RESULTS AND DISCUSSIONS

Pipeline for GTL Infrastructure Tariff, capital expenditure (CAPEX) and operational expenditure (OPEX)

Tariffs are a significant part of pipeline transportation economics and the capital cost and operational costs of a pipeline make up a major part of tariffs for pipeline transportation because every US$ per bbl service charge and tariff rate is expected to be efficient enough to cover operational cost and at the same time yield a return on investment with expected profit for the pipeline infrastructure owner. Depreciation and Amortization is used in spreading the sum of both capital and equity investment costs throughout the expected lifespan of an asset.

Gross profit is basically determined by deducting cost from price and hence lesser cost or increased attempt to reduce cost would mean higher profit. The capital expenditure of a pipeline facility comprises mainly of material cost, cost of labor and right of way fees where applicable and, depending on the salvage value of the pipeline and how levered construction finances are, concepts like depreciation and amortization affect cash flow while cash flow is used in determining the profitability of a project by calculating weighted average cost of capital (WACC), equity risk premium

(ERP), net present value (NPV), internal rate of return (IRR) etc. These can come into play to affect the capital cost for constructing a pipeline and subsequently tariffs.
The operating and maintenance cost of a pipeline are as relevant in affecting the cost of transporting GTL via pipeline as well. Where operational expenses (OPEX) can be referred to as a fraction of CAPEX, it consists of cost for maintenance and repairs on pipeline meters and pump machines; electricity cost; communication cost; supervision, monitoring and administrative payroll; etc. (Ahmed Adamu, 2019).
In determining construction cost for pipeline transportation, a calculated average (cost per inchmile) is often used to arrive at the total charge derived using diameter and length of pipe to calculate volume, pressure and horsepower or force.

Markets for GTL products and proximity

Crude (syncrude or petrocrude) has an established global market but a key determinant on the profitability of GTL transportation mode using pipeline is proximity of the market and availability of infrastructure for an effective pipeline transportation system in reaching the market. The crude oil pipeline transportations system is well developed as 70% of petroleum products produced is transported using pipeline with GTL syncrude and petro crude transported through a network either in batches by pumping alternate slugs of GTL and Crude oil product or in a comingled mode where petrocrude and syncrude is blended. The major determinant of the mode of pipeline transportation to be adopted is usually the purity and specification of expected shipment as well as an offset between costs of leaving GTL product in tank against cost resulting from reduction in product purity (Ejiofor, 2003). The comingled mode of GTL pipeline transportation is also usually adopted as an industry practice to improve petrocrude refined product's quality and at the same time reduce pollution from diesel combustion engines and exhausts.
There are multiple factors that influence the increasing demand for GTL products and these include environmental safety demands, energy mix and security of supply demands and, highly volatile oil prices. However, the current trend in GTL infrastructure and utilities investments is a positive market trend indicator that depicts the increase in demand of GTL products (Walwyn, 2016). The GTL market thus can be described as regionally segmented to include the Europe Asia pacific, North America, Middle East /Africa and Central/South-America with high consumption in the Middle East/Africa region. Europe however is a potential market for GTL products because of tis tough oil specifications and declining domestic supply supports with only diesel supply to Europe accounting for more than 50% of its total oil supply. However, this can only be sustained while crude prices remain relatively higher than the price of gas (Brown, 2013).

GTL marine tanker transportation's cross-sectional analysis with GTL pipeline transportation

In choosing a mode of transportation for oil factors like availability of utility, cost, reliability of process and security of product integrity are to be considered. GTL pipeline transportation provides a faster, easier and more effective means of transporting GTL products because it eliminates delays caused by bureaucracy and limits the tendency of human factor in increasing cost of product supply as applicable in oil marine shipping. Transportation of oil via marine tankers are charged based on a daily rate of about $21,000/day for the shipment of 5,000MT – 15,000MT of cargo within national territories on a laycan of 8- 10days and requires a lot of statutory requirements that a shipper and ship owner are often expected to meet in order to convey their oil to required locations. These include Port's authorities' requirements, Water way requirements, Naval and security requirements, Port health, insurance, product standardization etc. Because these requirements are checked and satisfied per shipment and certifications or fees only last for a specified period of time before they expire, it leads to a problem of availability of procedure standard vessels and creates complexity and undue cost in shipping oil via marine tankers.
These bureaucracies also create room for corruption and extortion of shippers in the event where a charter or shipper in the bid to avoid demurrage costs would utilize options of paying out an added percentage of the actual cost of operations for facilitation of his operations. Another form of this delay is seen also at the internal level of marine logistics where a lot of requirements such as securing fenders, hoses, reviewing charter parties and the mundane process of ensuring that vessels meet jetty specifications in terms of outlets and inlets of both supplier and receiver. Pipeline transportation however requires less of these bureaucratic and mundane processes. The major advantage of pipeline transportation then becomes its level of market penetration and concentration characterized by a few market operators which make satisfying requirements become almost standardized and eliminates room for bureaucratic activities. In transportation of oil via pipeline, operations and transactions are almost timeless and can run continuously over time; Marine transportation however is easily hampered or delayed by low water tides and other environmental circumstances. Security of product integrity is also guaranteed via pipeline transportation because it limits access to product during transmission and a shipper can be guaranteed of the quality of product supplied. Because other modes of transportation like marine and road require a high level of human factor, product integrity is more likely to be compromised at any point of a voyage while being transported by marine and road other than via pipeline.

Security of supply and politics in pipeline transportation

Oil does not exist everywhere and because it requires transportation as a strategic commodity, brings about territories with predominant resources wielding the power to exert influence on global economy which requires the rest of the world to engage in adequate international relations in handling these territories creating a political orbit around the

commodity oil. Time after time events leading to a shortfall in the security of supply of oil, a decrease in demand for oil or other factors affecting oil price materialize leading to an oil shock of which majority are as a result of human political cycle. The most recent of these events include Iran's 2019 threat to block off the Strait of Hormuz a waterway crucial to international oil trade in a faceoff with the US and the 2020 Russian and Saudi Arabia's price war worsening the effect on crude oil prices caused by demand fall resulting from the Covid-19 pandemic lockdown. These issues of Security of supply and politics are ones that could affect every mode of transportation and require adequate management to ensure the impact of loss or delay is reduced to the barest minimum.

Asides politics, another major issue affecting supply and cargo transportation is that of theft and hijacking. While sea transport is subject to piracy, contamination and vessels being lost at sea, pipeline transportation is subject to vandalism and sabotage of pipelines. Common practices in safeguarding pipelines from attacks by vandals include the use of drones and cameras to maintain surveillance of pipelines, designed to also carry out x-rays on pipelines and detect leakages or other malfunctions. The issue of theft and hijacking however is more of a management problem that it is a political problem which can be handled by effective company policies and decision making because it requires handling environmental strengths and weaknesses to avoid unfavorable incidents. A few companies operational in communities susceptible to pipeline vandalism have made it part of their policy to make the communities shareholders of the company and thereby making losses incurred by the company's business to affect these communities directly. This management decision in turn plays out in community members protecting the pipelines within their environment as they are direct beneficiaries of the company's success.

CONCLUSION

In order to carry out an effective evaluation of the GTL transportation mode using pipeline, all relevant components of economics and its factors affecting the operations ought to be considered and analyzed as they develop which makes this study a continuing and inconclusive process. Other factors relevant to GTL transportation mode using pipeline include driving local content development and developing the domestic markets because they have capacity to monetize their resident oil and gas industry. These are key components of the evaluation process because Local Content Development goes a long way in minimizing cost of constructing infrastructure (CAPEX) as well as operations and maintenance (OPEX). It also facilitates community cooperation creating a less hostile work environment where vandalism of pipelines is prevalent. Monetizing domestic markets on the other hand as well would involve effective management of refineries, reduction of capital flights and most importantly developing an efficient grid of local product pipelines that could end up as a strategic pipeline network in connection to oil market regions.

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