TOPIC PAPER #9

GAS TO LIQUIDS (GTL)

On July 18, 2007, The National Petroleum Council (NPC) in approving its report, *Facing the Hard Truths about Energy,* also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the Task Groups and their Subgroups. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached Topic Paper is one of 38 such working document used in the study analyses. Also included is a roster of the Subgroup that developed or submitted this paper. Appendix E of the final NPC report provides a complete list of the 38 Topic Papers and an abstract for each. The printed final report volume contains a CD that includes pdf files of all papers. These papers also can be viewed and downloaded from the report section of the NPC website (www.npc.org).

NATIONAL PETROLEUM COUNCIL

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Gas to Liquids (GTL)

A. Introduction

The term gas-to-liquids refers to a small number of technologies designed to convert natural gas to liquid fuels, as alternatives to the traditional refining of crude oil and other natural gas commercialization routes. Based on the Fischer-Tropsch techniques developed early in the 20th century, and widely deployed to create synthetic fuel in World War 2, the process consists of several steps:

- Treatment of natural gas to remove water and impurities
- Reforming of the natural gas to produce syngas
- Fischer-Tropsch conversion to produce hydrocarbon waxes
- Upgrading to produce finished products

Typical output yields for a GTL process consist of about 70% ultra-clean diesel fuel, 25% naphtha and a few percent LPGs, lubes and waxes. Thus the prime potential markets for GTL fuels are the transport fuel market and the chemical feedstock market. The process requires about 10 mcf of natural gas input to produce 1 barrel of product output, although this can vary with the scale of the GTL plant.

Commercial testing of the GTL process has largely been confined to two plants over the past 20 years. These are the Mossel Bay "Mossgas" plant in South Africa and Shell's GTL plant in Bintulu, Malaysia. Together they have a capacity of less than 40,000 b/d of output and have been used primarily to develop technology and process reliability, while at the same time demonstrating the advantages of the finished products that come from this process compared to conventional refined oil products.

In the past ten years, there has been growing interest in developing GTL on a larger scale, and several world scale plants have been developed or announced. The reasons for this resurgence of interest stemmed from several factors:

- Strong demand outlooks for diesel fuel for road transport, particularly in Europe and developing Asia
- Increasingly stringent environmentally-driven specifications for diesel fuel.
    - GTL diesel has almost zero sulphur, low aromatics, a high cetane number and lower density than traditional ex-refinery diesel. It can be used as blendstock to improve the quality of larger quantities of standard diesel in markets where specifications are becoming stricter
- Aspiration to monetize stranded natural gas in countries where gas markets are small
- Aspiration to reduce flaring of associated natural gas and find an economic use for the gas

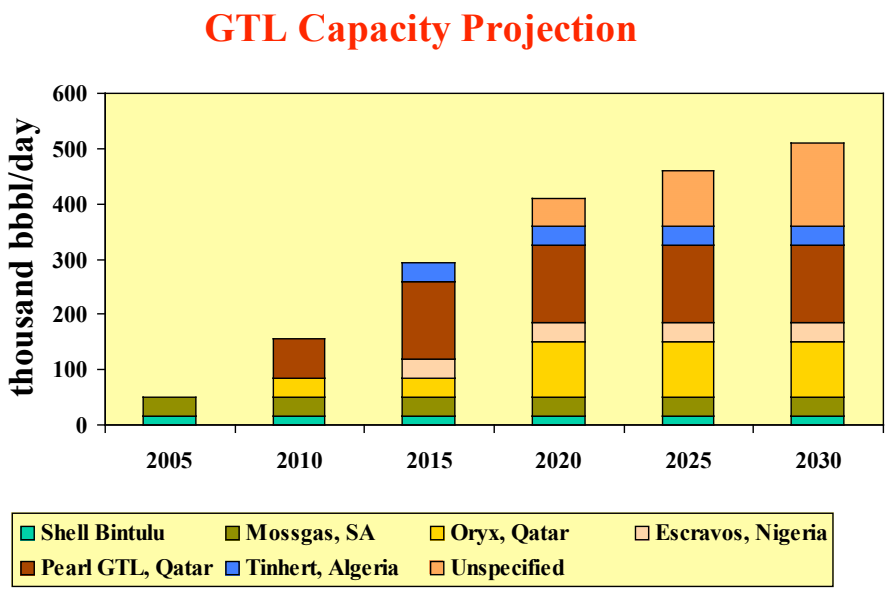
From the early 2000s, several projects began to be developed to build world-scale GTL plants, particularly in Qatar and Nigeria. By 2004, at least 8 new plants were being planned, with a combined capacity which would have totaled over 500,000 barrels per day. However, by early 2007, many of these plants have been deferred or cancelled, with the currently active projects being only the Sasol Oryx plant in Qatar that was recently completed, Sasol Chevron's 34000 b/d plant in Escravos, Nigeria and the Shell Pearl GTL plant in Qatar which has recently begun

construction. The Oryx plant, with a capacity of about 35,000 b/d started operations in 2006 but has reportedly experienced an extended start up period. The Pearl GTL plant, which is planned to total 140,000 b/d in two phases is reported to be already subject to quite significant cost overruns.

Other planned GTL plants have all been cancelled or deferred for various reasons:

- Two projects planned in Qatar involving Qatar Petroleum partnerships with Marathon and with ConocoPhillips were indefinitely put on hold in early 2006 when Qatar placed a moratorium on new gas developments pending further reservoir evaluation of the giant North field
- In early 2007, ExxonMobil and Qatar petroleum announced the cancellation of the proposed 154000 b/d Palm GTL project, citing severe cost escalation as the main reason. The plant was originally scheduled to cost about $7 billion, but reports suggested that costs may have risen to around as high as $18 billion.
- Sonatrach of Algeria has deferred bids on its planned 65000 b/d Tinhert GTL plant from 2006 until later in 2007

In the light of these developments over the past year or so, it now seems likely that the prospects of a significant contribution from GTL products could be later and smaller than has been envisaged in recent years. The following chart shows GTL capacity projections to 2030, including unspecified capacity as yet unannounced but which may be developed.



B. Outlooks for LNG

We have examined the following primary references to analyse the outlooks for GTL to 2030.

- IEA World Energy Outlook, 2006
- EIA Annual Energy Outlook, 2006
- EIA International Energy Outlook, 2006

Other specialist references to GTL prospects consulted were:

- Fundamentals of Gas to Liquids (*Petroleum Economist, 2005*)
- Le GTL: perspectives de developpement (*IFP, Panorama 2006*)
- Gas Monetisation: A Techno-Economic Comparison of Gas-To-Liquid and LNG (*Foster Wheeler Energy LTD, 2005*)
- The Challenges of further cost reductions for new supply options (Pipeline, LNG, GTL) (*IEA and Cedigaz, 2003*)
- GTL Technology and its potential impact on the Global Energy Markets (Iraj Isaac Rahmin, E-Meta Venture Inc, presented at the International Association for Energy Economics, Houston June 2006)

1) In the IEA World Energy Outlook 2006, it is stated that GTL plants are expected to emerge as a major new market for gas, growing from 8 bcm (0.77 bcf/day) to 199 bcm (19.25 bcf/day) in 2030. This would represent 4.25% of global gas demand and give rise to a liquid fuel production output of almost 2 million barrels per day (assuming a conversion rate of 10 mcf per barrel of product output). This exceedingly optimistic projection is tempered by the caveats that GTL growth depends on lower production costs, lower energy intensity of the conversion process, a high oil to gas price ratio, and the existence of a sustained premium for ultra-clean GTL fuels.

2) The US DoE's EIA Annual Energy Outlook 2006 includes a discussion of GTL prospects and indicates that, in its reference case GTL products output would rise to 1.1 million barrels per day by 2030, and in the high oil price case, GTL production would rise to 2.6 million barrels per day. These would represent 0.9% and 2.5% of world oil supply respectively; and would require gas inputs of 11 bcf/day rising to 25 bcf/day in the high case.

In EIA's high oil price case, a 200,000 b/d GTL plant is built in Alaska to supply North American markets. It is assumed that this plant could co-exist along with a gas pipeline to the lower 48.

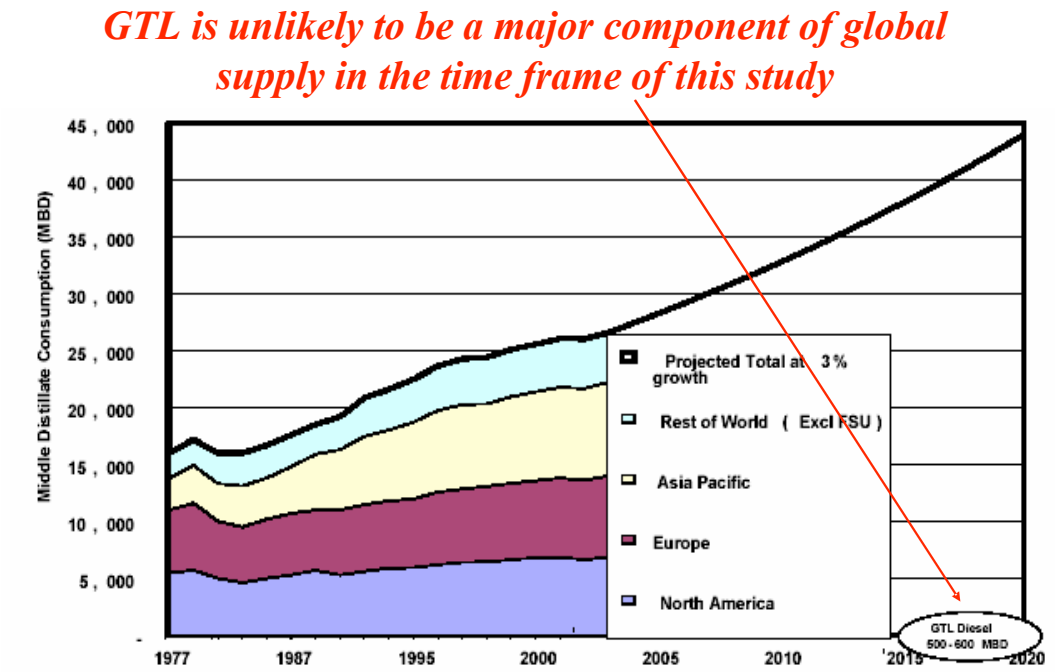
3) In the EIA AEO 2007, the high costs of GTL exclude it from the reference case, and it is only included in the high oil price case. US supply of GTL fuels comes in at 100,000 barrels per day from 2020 and remains at this level through 2030. This is less than 0.5% of total liquid fuels supply to the US, and therefore a very small contributor. The global total supply from GTL is not made explicit in the AEO 2007 outlook.

4) The EIA International Energy Outlook, 2006 does not explicitly quantify either GTL production or gas requirements but states that by 2030 significant GTL volumes could be produced in Russia, Africa, the Middle East and non-OECD Asia, presumably coinciding with the largest sources of undeveloped gas.

C. Observations on the Outlooks

All the 2006 outlooks imply that GTL can grow quite fast from a very low base, but none has GTL growing to sufficient scale to make a really significant difference in oil products markets as a supplement to traditional oil supply. Since it is likely that recent disappointments have reduced the potential of GTL for some years to come, it now looks unlikely that even the projections contained in the 2006 forecasts can be achieved by 2030. For the US, given its greater distance from the major locations of stranded gas and the relatively lower importance of diesel in its transport fuel market relative to other regions of the world, it is even more unlikely that GTL will be a significant contributor.

The following graphic puts the potential role of GTL diesel in the global market in perspective, at least out to 2020. Even with a quite optimistic scale of GTL development, up to 500-600 mbd by 2020, GTL fuel would only make up about 1-1.5% of global middle distillate fuel requirements.



Source: Iraj Isaac Rahmin, E-Meta Ventures, 2006

D. Policy Implications for the US

At the current stage of development of GTL technologies, it would be premature to prescribe specific policy directions which would impact GTL. Technology development has been taken on by commercial companies on a risk basis, and learnings will presumably be leveraged into future projects. Product specifications for diesel fuel will be established taking due account of costs and benefits, and GTL fuel will take advantage of these if its costs can become competitive with the alternatives. There may be a role for government agencies in assisting the take up of new fuels in the market place through demonstration in fleet vehicles, but such programmes should not precede the wider availability of GTL fuels than is currently the case.