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## **The Gas to Liquids Industry and Natural Gas Markets**

**November 8, 2004**

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# The Gas to Liquids Industry and Natural Gas Markets

## Summary

Technological improvements and investment commitments from the world's largest oil companies suggest the gas to liquids (GTL) industry is likely to expand rapidly over the next decade. GTL uses large quantities of natural gas to produce liquid petroleum products like diesel fuel and home heating fuel. The GTL industry might become an important competitor to the liquefied natural gas industry (LNG) in the effort to secure natural gas supplies. As a result, LNG markets may be tighter, with higher prices, potentially altering LNG's projected role in the U.S. natural gas market.

The Energy Information Administration projects U.S. natural gas consumption increases of 37% by 2025, compared to 2002 levels. Much of this increased demand is expected to be met by importing LNG. LNG is natural gas that has been cooled to a liquid state to facilitate transportation. Although expanding LNG imports has drawbacks, the main positive factor is the belief that worldwide, there are large quantities of natural gas that have previously not had access to the market. Some believe that as the supply of imported LNG expands, it will provide a price cap for U.S. natural gas markets. An expanded GTL industry makes this result potentially less likely.

The GTL industry is poised for a major expansion based in Qatar, but also in Nigeria and Australia. The expansion is being funded by the major oil companies, in some cases in tandem with synthetic fuel companies and national oil companies. The projected expansion of the industry is based on favorable market conditions in addition to advances in technology. High oil and natural gas prices, declining capital investment costs, and improvements in technology that allow large scale production facilities are important factors in the industry's expansion.

The GTL industry offers an attractive choice to nations with economically stranded natural gas reserves because it allows those nations to diversify in the use of their resources. Diversification allows producing nations to gain higher rates of return than through a singular investment strategy. Consuming nations may find that dependence on one supply source, in this case LNG, does not offer the supply security and potential price stability of a diversified strategy.

For the United States, alternatives to increasing LNG imports include a pipeline to bring natural gas from Alaska, expanded exploration and development in areas, both on and off shore, that are currently restricted, and policies to enhance the development of current reserves. None of these alternatives alone is likely to close the projected gap between U.S. natural gas production and demand. The competition for natural gas resources between the LNG and the GTL industries may alter the parameters of the debate.

This report will not be updated.

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# The Gas to Liquids Industry and Natural Gas Markets

Technological improvements and investment commitments by the world's largest oil companies suggest that the gas to liquids industry (GTL) is likely to transform itself from a small, specialized producer to a large scale fuel producer over the next decade.<sup>1</sup> As expansion of GTL proceeds, the industry may become a major consumer of natural gas, placing it in direct competition with the growing liquefied natural gas (LNG)<sup>2</sup> industry for access to natural gas supply. If competition leads to tighter than expected natural gas supplies, the result is likely to be higher prices for natural gas consumers over the same time frame that the United States looks to world LNG markets to meet increasing domestic demand.

Natural gas consumption in the United States is projected to increase by 37% to 31.2 trillion cubic feet per year in 2025, from a baseline of 22.8 trillion cubic feet per year in 2002, according to the Energy Information Administration (EIA) in the Annual Energy Outlook 2004 (AEO).<sup>3</sup> Almost all of the increased demand over that period is expected to be met through an expansion of LNG imports to the United States.<sup>4</sup>

Large scale expansion of LNG consumption in the United States is expected even though LNG has several drawbacks. Drawbacks to LNG expansion include the large capital outlays for gas receiving plants in the United States, the political instability and non-democratic governments of some potential LNG producing nations, domestic opposition to facility siting, the lack of a transparent market to determine prices, and the lack of an adequate non-dedicated, competitive, tanker fleet. The major offset to these impediments is the belief that there are very large, economically stranded, volumes of natural gas available in the world waiting to be developed and brought to consuming markets. As these reserves are brought to market, it might mean stable supply, and possibly reduced prices, for U.S. consumers.

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<sup>1</sup> GTL uses natural gas as a raw material to produce liquid petroleum products, specifically middle distillates, which include diesel fuel and heating oil. The produced fuels have inherently low sulfur content because of the low sulfur content of natural gas.

<sup>2</sup> LNG is natural gas that has been cooled to a liquid form to facilitate transportation. When delivered to the consuming market it returned to a gaseous state and injected into the standard natural gas pipeline system.

<sup>3</sup> Energy Information Administration, *Annual Energy Outlook 2004*,

<sup>4</sup> In 2003, the United States imported about 16% of the natural gas it consumed from Canada via pipeline. The largest portion, about 82%, is produced domestically. The remaining 2% is LNG imported from a number of countries.

This report analyzes the development of an industry, GTL, which may grow into a formidable competitor to LNG for worldwide natural gas supplies. While the GTL industry is likely to compete for natural gas supplies, its output, which is mainly liquid petroleum products, such as diesel fuel, will do little to satisfy natural gas demand in consuming nations. The resulting net reduction in natural gas supplies may result in instability in the form of tighter than projected availability, and higher than expected prices in U.S. natural gas markets. These factors may be considered additional impediments to the projected increased dependency on LNG.

This report provides and analyzes basic information concerning the GTL industry to inform debate on broad energy legislation, as well as more specific natural gas legislation on supply issues including an Alaskan natural gas pipeline as well as LNG facility development.

## Background

The GTL industry can be viewed as an alternative to oil refining. The basic technology of the industry dates back to 1923 when two German scientists, Franz Fischer and Hans Tropsch (FT), invented a process that could convert natural gas to a hydrocarbon mixture which could then be upgraded into petroleum products. The FT technology provides an alternative to traditional crude oil refining, as liquid petroleum products, most notably diesel fuel, can be produced from a non-liquid input, natural gas.

The process was used by both Germany and Japan during World War II when their access to adequate oil supplies was disrupted by allied forces. In the 1960s, South Africa used the FT process to produce liquid fuels when the United Nations imposed oil import sanctions on the apartheid government. The South African plant used coal as a primary input rather than natural gas, demonstrating the flexibility of the FT process. GTL production continues in South Africa at the Mossel Bay facility, operated by Petro SA. The plant has a capacity of 22,500 barrels per day of petroleum products. Neither the World War II facilities or the initial South African facilities were commercial, profit making enterprises; rather, the facilities were technological solutions to politically disrupted markets. Under normal market prices they would not have been viable.

From the 1960s through the 1990s, several companies specializing in synthetic fuels, as well as joint ventures between major oil companies and synthetic fuels companies, explored and developed the basic FT technology as well as other technological approaches. Improvements in cost, efficiency, and plant scale were achieved. Today, enhanced catalyst design is developing as a key factor in improving the production process and reducing capital costs per barrel of product.

The first fully commercial GTL plant was a 12,500 barrel per day (bpd) plant built in Bintulu, Malaysia in 1993, and owned by Shell. However, an explosion at the plant in 1997 closed it until 2000. Shell, along with other major oil companies has remained interested in developing the GTL technology. ExxonMobil, ChevronTexaco, ConnocoPhillips, and Marathon all either have demonstration plants

running, or have committed to investing in GTL investments, mostly in Qatar, but also in Nigeria and Australia.

## Economic Foundations

In 2001, Shell asserted that the capital expenditures for a new GTL facility might decline from \$50,000 per barrel to \$20,000 per barrel as a result of scale economies consistent with improved technology. The lower level of capital costs per barrel translates into approximately \$2 billion for a plant with a capacity of 100,000 bpd. This level of cost is comparable to the cost of a new oil refinery if built in the United States.<sup>5</sup> More recently, Chevron asserted that the capital cost of building a small, 17,000 bpd GTL plant are about \$25,000 per bpd, and experts at BP America assert that the capital costs can approach \$20,000 per bpd of product output.<sup>6</sup> Economies of scale for very large plants, once they demonstrate technological feasibility, might reduce capital costs even further.

Chevron also estimated that the total of fixed and variable costs for a 17,000 bpd plant are about \$5.00 per barrel. If natural gas were available at 50 cents per thousand cubic feet, according to Chevron, the cash costs of GTL production might total \$10 per barrel.<sup>7</sup> The price of natural gas assumed by Chevron, however, is only a fraction of the current price in the U.S.<sup>8</sup> More expensive natural gas inputs would raise the per barrel cash cost of GTL products. The low price of natural gas used in Chevron's calculations underscores the importance of a large, economically stranded source of natural gas for GTL production.

GTL is an attractive option for nations seeking to develop large natural gas holdings, because traditionally they have had only two choices.<sup>9</sup> If the geography was favorable, they could develop their gas fields and connect them by pipeline to consuming markets. If that alternative was not feasible, they could invest in LNG facilities and ship their gas to consuming markets by tanker. In either case, the final product they offered was natural gas, generally for use as a fuel for electric power generation. If the consuming nation had significant domestic gas supplies, the price earned by the producing nation would be based on the price of gas determined in the

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<sup>5</sup> A new oil refinery, the first to be built in decades, is in the permit process in Yuma, Arizona. The estimated cost of the refinery is \$2.5 billion for a facility that may process 150,000 barrels per day of crude oil. Max Jarman, *Arizona Refinery Project Facing Approval Process*, The Arizona Republic, Online Print ed. July 29, 2004.

<sup>6</sup> Alexander H. Tullo, *Catalyzing GTL*, Chemical & Engineering News, Vol. 81, No. 29, July, 21, 2003. pp.18-19.

<sup>7</sup> Ibid.

<sup>8</sup> The futures price for natural gas was over \$8 per thousand cubic feet on October 22, 2004. Energy Daily, *Daily Oil & Gas Price Review*, Vol.54, No.205, October 25, 2004. p.3.

<sup>9</sup> The traditional way of using natural gas associated with oil wells when there is no market access, is flaring, burning off the gas as it rises from the well. More recently, natural gas associated with oil production has been re-injected into the well to enhance wellhead pressure.

consuming market. If the consuming nation has no domestic natural gas supplies, the price is likely to be determined as part of a negotiated long term contract, in many cases indexed to the price of oil.

GTL offers nations seeking to develop natural gas resources a third alternative, effectively allowing them to diversify their resources beyond natural gas markets. Diversification allows the producing nations to compare relative rates of return from GTL and LNG before choosing an investment strategy. The benefits of diversification are enhanced because the products of the GTL industry do not compete with LNG in the natural gas product market, they compete with petroleum products. The GTL product mix includes a variety of middle distillates, including a large proportion of ultra clean diesel fuel. This product mix is desirable, and likely to earn a premium return, for two reasons. In the European market, and possibly in the future the North American market, diesel powered automobiles and light trucks are expanding their market shares and increasing their fuel needs. In addition, air pollution regulations are clearly moving in the direction of very low, to zero, sulfur content. Diesel fuel derived from GTL processes can meet the 2005 U.S. standards for sulfur emissions without further processing. Producing complying diesel fuel from crude oil at U.S. refineries requires investment at those refineries that might total \$4 to \$13 billion to meet mandated on-road diesel fuel requirements.<sup>10</sup> As world demand for ultra clean fuels increases, it is likely that the ultra clean fuels produced by the GTL industry will command premium prices, allowing GTL investments to be profitable.

The pricing of diesel fuel in the world market is different from that of natural gas, however. Since diesel fuel that meets national environmental regulations is a fungible product whether derived from a traditional oil refinery or from the GTL industry, and is perfectly substitutable, the price received by gas producing nations for their GTL-processed natural gas is far more likely to be influenced by market fluctuations than pipeline natural gas or LNG. The potential for market induced price volatility represents a greater long term risk for producing nations pursuing a GTL-based investment strategy compared to a long term, negotiated LNG supply contract.

The value of diversification offered by the GTL industry is that it gives countries with undeveloped natural gas reserves expanded economic choice. Producing nations can choose the alternative use for their gas reserves which offers the highest potential return. If LNG, for example, is the only technologically feasible use for currently stranded natural gas, then it is likely that profit margins associated with LNG will be driven down as more and more nations supply the market. The choice of GTL allows the returns to both LNG and GTL to be balanced as nations make economic choices about which direction they will take to commercialize their natural gas resources. However, the value of expanded choice is likely to be of the one time variety. Because of the high capital costs and large gas inputs associated with each industry, only the largest holders of reserves will be able to successfully develop both industries.

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<sup>10</sup> D.J. Peterson and Sergej Mahnovski, *New Forces at Work in Refining, Industry Views of Critical Business and Operations Trends*, RAND Science and Technology, 2003, p.64.

Most producers are likely to develop one, or perhaps two, alternative uses for their natural gas reserves. Three nations; Malaysia, Nigeria, and Qatar currently are involved in all three natural gas industries. The Malaysian operation is small, and keyed to local and regional supply needs. Qatar has large reserves of natural gas and may become the key nation in both the GTL and LNG industries.

## Investment Activity

The GTL industry has been reported to be on the verge of a boom in investment for some time. In 2001, it was reported that the combination of high oil prices, technical advances, and environmental regulations might set off an investment boom, ultimately leading to production of 1 to 2 million barrels per day, worldwide, by 2015.<sup>11</sup> High investment cost, technological problems, and natural gas price uncertainty had delayed the expansion of the industry in the past.

This year, the number of announced projects has increased. Most of the investment activity is to take place in Qatar, where ExxonMobil, Shell, ConocoPhillips, Marathon, Sasol Chevron, and Qatar Petroleum, in conjunction with others, have all announced projects. All of the announced projects are projected to become operational by 2011. Taken together, their capacity is estimated to be 750,000 bpd of liquid petroleum products. Most will use proprietary technologies that are planned to offer advantages over the basic FT process. Adding the existing capacity in South Africa and Malaysia to the planned projects in Qatar, Nigeria, and Australia, total capacity might reach 1 million barrels per day by 2010, even if no additional new projects are announced or completed in the near term.<sup>12</sup>

The scale of investment is large. For example, the ExxonMobil project in Qatar reportedly will cost \$7 billion for a GTL plant of approximately 150,000-180,000 bpd, producing diesel fuel, naphtha, and lubricant basestocks. The Royal Dutch/Shell Group and Qatar Petroleum agreed in 2003 to invest \$5 billion in a GTL plant of approximately 140,000 bpd capacity. ConocoPhillips signed a letter of intent in 2003 to build a GTL plant with a capacity of 180,000 bpd. Other projects with U.S. as well as foreign oil companies are either under construction, or planned with agreements in place.

The investment costs for the ExxonMobil project were reportedly to be met solely by the company, which is also to provide its proprietary technology and management skills to the project, while partner Qatar Petroleum provides the natural gas for the project.<sup>13</sup> Only a few energy companies, mainly the largest oil companies that have announced investment projects, have capital budgets large enough to operate in the GTL or the LNG industries.

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<sup>11</sup> Alexander's Gas and Oil Connections, *GTL Industry Could Soon Turn Some of Its Pipedreams into Projects*, Vol. 6, Issue #16, August 28, 2001.

<sup>12</sup> Petroleum Economist, *Using all the Options*, Vol. 71, No. 5, pp.16-20.

<sup>13</sup> Oil Daily, *ExxonMobil Commits to Qatar GTL Facility*, Vol. 54, No. 134, July 15, 2004, p.1.



Because the GTL industry both competes for inputs with the LNG industry, and competes for customers with the petroleum refining industry, key factors in economic feasibility also span various energy markets. The price of oil is key. For a viable GTL industry, oil prices must not collapse. Estimates of a key price for GTL viability center around \$20 per barrel. In 2001, the refiners' acquisition cost for crude oil was approximately \$24 per barrel. Uncertainty regarding the \$4 per barrel premium of actual crude oil prices above the minimum price for GTL feasibility, or the narrowness of the margin itself might have been an impediment to investment. In October 2004, with crude oil trading at over \$50 per barrel the \$20 per barrel minimum requirement for GTL feasibility seems likely to pose less of an impediment.

Comparative returns to LNG development also influence the economics of GTL. LNG returns still appear to be adequate, even if they are not at levels they attained 10 or 15 years ago.<sup>14</sup> LNG has become a mature industry. Even with the large increases in demand projected in the AEO 2004, there has been little new project development. 2004 has seen no new LNG projects begun in producing nations. This might seem to indicate that GTL is a viable alternative, or that producers are waiting to see the outcome of the elevated price levels for natural gas as well as oil before making binding decisions.

Natural gas prices are also important in determining GTL feasibility. The cost of natural gas to supply either a GTL or LNG facility is negotiated between the producing nation and the investors, and likely has little relationship to observed market prices, because the available alternative is not to sell the gas in consuming markets, but to leave it undeveloped or flare it off. Reports of GTL investments funded entirely by the major energy companies, but still in partnership with national oil companies, or the government directly, suggest preferential prices will be available to GTL facilities. However, the price of natural gas in consuming nations, specifically the differential between natural gas and diesel fuel, is still relevant to the choice between GTL and LNG investment. This is because natural gas sold as LNG will earn the natural gas consumption price, and natural gas used for GTL will earn the diesel, or more generally, middle distillate product prices.

## Gas Supplies

Qatar is a clear choice for so many GTL projects because of its natural gas reserve position. It has been estimated that as of January 1, 2004 Qatar had natural gas reserves of over 900 trillion cubic feet.<sup>15</sup> Qatar also has a substantial LNG industry, exporting to Europe, Asia, and the United States. The reason for this diversity, beyond the reserve position second only to Iran in the Persian Gulf region, is location. Shipping distances from Qatar to the Atlantic and the Pacific LNG markets are approximately equal, allowing Qatar to allocate supply by price.

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<sup>14</sup> Petroleum Economist, *Using all the Options*, Vol. 71, No. 5, p.16.

<sup>15</sup> British Petroleum, *BP Statistical Review of World Energy*, p.20. Other estimates have put natural gas reserves in Qatar at up to 1.2 quadrillion cubic feet.

The other two nations with GTL investment activity, Nigeria with 176 trillion cubic feet of natural gas reserves, and Australia with 90 trillion cubic feet of natural gas reserves, are not likely to support an industry as large as that developing in Qatar, even though both have production capacity in excess of their domestic consumption needs.<sup>16</sup>

Large natural gas reserves are important to the GTL industry because the high capital costs of investing in GTL facilities must be amortized over a long period of time in much the same way as with an LNG facility. The facilities must also operate at, or near, full capacity for the economics of the project to be feasible. GTL facilities, like LNG facilities, are also heavy consumers of natural gas. The ExxonMobil project in Qatar is expected to consume 1.5 billion cubic feet per day of natural gas to produce 150,000 to 180,000 barrels per day of petroleum products. The Royal Dutch/Shell 140,000 barrel per day facility is expected to consume 1.6 billion cubic feet per day of natural gas.<sup>17</sup> The difference in consumption rates at the two facilities may be due to both differences in technology as well as differences in the final product mixes chosen by the companies. If these natural gas consumption rates are extrapolated to an industry in Qatar producing about 1 million barrels per day of petroleum products, it might mean that natural gas supplies of over 10 billion cubic feet per day are required. For comparison, the total of U.S. imports of LNG in 2003 was about 506 billion cubic feet, and about 229 billion cubic feet in 2002.<sup>18</sup> These annual totals suggest that the currently planned GTL industry might consume natural gas at a rate of over six times U.S. LNG import totals for 2003 and at a rate equal to approximately 15% of total U.S. natural gas consumption in 2003. The resulting output, 1 million barrels per day of middle distillates and other products, represents less than 5% of world consumption of middle distillates in 2003.<sup>19</sup>

## Implications

The growth of the GTL industry is likely to have wide ranging effects on energy markets in both producing and consuming nations. In some cases, consumers will see prices increase, while in others they will see prices decrease. Rates of return for industries that use natural gas, even though their final products may not be in competition, will tend to equalize.

- The GTL industry is an alternative to LNG for nations with economically stranded natural gas reserves. Producing nations will choose among alternative investments depending on the relative returns to each, adjusting for variations in risk and capital investment requirements. The outcome is likely to be an expansion of each industry until risk adjusted returns are equalized. Competition is

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<sup>16</sup> Ibid.

<sup>17</sup> Oil Daily, *ExxonMobil Commits to Qatar GTL Facility*, Vol. 54, No. 134, July 15, 2004, pp.1-2.

<sup>18</sup> Energy Information Administration,

<sup>19</sup> *BP Statistical Review of World Energy 2004*, June, 2004. p.12.

likely to be managed because only a few major energy companies have investment budgets large enough to undertake GTL, or GTL and LNG, projects.

- Because the GTL industry is potentially likely to be a heavy consumer of natural gas, the over-all demand for natural gas will be increased, stabilizing its price at a higher level than would otherwise occur. World prices for natural gas are geographically dispersed. The upward price pressure exerted by GTL is likely to be in producing nations where the lowest prices are currently found.
- The LNG industry is less likely to expand to the point where competition drives the price of LNG down to the cost of production. Some observers saw the potential for LNG to establish a price cap for natural gas in the U.S. market due to competition among suppliers. This competition, based on an over-supply of LNG, is less likely to materialize when GTL investments are available. The limited number of investing companies, for the most part major oil firms, suggests that coordination rather than direct competition will be the result of GTL and LNG projects.
- The market for diesel fuel that meets the tight sulfur standards being implemented over the next several years is likely to be more stable. Availability of GTL-based fuel may help encourage the transformation of the vehicle fleet from gasoline to diesel, a trend currently occurring in Europe, to continue without disruption. This conclusion must be weighed against the uncertainties of an industry that is not yet mature and does not promise significant output into the world market for at least six years.
- Even if all the projects currently proposed become operational, GTL will still be a minor part of the world distillate market. That market has estimated consumption of over 26 million bpd, worldwide.<sup>20</sup> However, recent supply conditions in the world crude oil market have suggested that even marginal availability of supply can have significant price effects in a tight market. If technological improvements continue to reduce the cost of GTL products, the low inherent sulfur content of these fuels will tend to insure a strong market for them.
- Development of a substantial GTL industry may relieve the pressure on consuming nations to invest in petroleum refining. The U.S. has experienced a tight refining market in 2004, with monthly capacity utilization rates at 94% or higher. No new refineries have been constructed in decades. If liquid petroleum fuels could be imported from GTL facilities growing product demand might be met with the current refining industry. The cost of this would be larger imports

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<sup>20</sup> *BP Statistical Review of World Energy*, June, 2004, p.12.

and a potential increased dependency for finished products on areas of the world with the known potential for political instability.

- The scale of GTL investment requirements means that it is likely that only large energy companies will be able to participate in the industry. Even for these firms, competition for investment funding between exploration and production of new oil and natural gas resources, refining upgrades to meet environmental standards, as well as needed capacity expansion, and LNG and GTL facilities might mean that one or more areas might well receive less emphasis in investment decisions.

## Conclusions

It appears likely that the GTL industry will begin to develop into a commercial factor in world energy markets over the next few years. Technological improvements coupled with favorable economics are responsible for the increased investment activity. Developing the industry is in the interest of producing nations with economically stranded natural gas resources, because it gives those nations the opportunity to choose the best use for their resources consistent with available rates of return and risk.

The major oil companies are committing to multi-billion dollar investments in GTL, as well as LNG facilities, at a time when their investment in oil refining capacity expansion in the U.S. is low. The reason for this investment strategy is likely based on forecast relative rates of return. The combination of a receptive business environment from the producing countries, especially Qatar, and the investment commitments of the major oil companies suggest that rapid growth is likely to be made by the GTL industry over the next decade.

The implications of the growth of the GTL industry for the consuming nations is mixed. While the availability of ultra clean diesel fuel is a benefit, promising to relieve supply worries and moderate price increases due to the increased supply, the beneficial effects on the natural gas side of the market are less clear. More GTL means that less LNG will be available on the world market, slowing the development of competition and resulting in higher prices and less available supply of natural gas.

These developments suggest that consuming countries might also consider the benefits as well as the costs of developing other sources of natural gas. Beyond LNG, available natural gas supply options include an Alaskan pipeline, increased exploration and production on protected land and water areas, and more intense development of existing known fields. No one source is likely to provide the supply and price stability that consumers desire.