Gas to Liquids

Howard Bevan provides a perspective from Qatar

Gas to Liquids (GTL) technology has been much publicised during 2003. Qatar is avowed to be the 'GTL capital of the world'. The decision to promote projects which are based on very expensive plants and mostly uncommercial processes, might on the surface be an unusual one. This article seeks to set out the reasons behind this decision and to show how GTL plants fit into a coherent national strategy.

This analysis starts with the crude oil reserves position (Table 1) and some economic fundamentals.

At this stage it is convenient to make a few 'heroic assumptions' and to pick a planning horizon, which for convenience I will pick as 2012. National expenditure is of course difficult to predict and is based on many imponderables. This is especially true of small Gulf States with high indigenous birth rates and a large expatriate population. Again assume that the long-term oil price is $20/barrel and government expenditure is at current rates – say QR18.2 billion ($5 billion) for Current Expenditure and QR4.3 ($1.2 billion) for Capital Expenditure.

If oil production is 700,000 b/d then this will provide $4.8 billion. Other non-oil revenues can be considered small. Of course not all revenues accrue to the state. Much of the offshore production is developed under Sales and Purchase Agreements (SPAs) but by 2012 most of this revenue will come to the state. Qatar current strategy is therefore based on minimising non-hydrocarbon capital expenditure and making such expenditure only when oil is above $20/b. Budgets have historically been balanced by deferring capital expenditure. The figures are somewhat imprecise here but do illustrate the current and future situation.

By 2012 oil production may have sunk to 500,000 b/d and provide an income of only $3.4 billion so there is a shortfall in real terms of about $1.4 billion – with a very big 'ceteris paribus'. Further declines are expected after 2012. Of course more reserves may become 'proven' and come on stream. Recovery rates in some fields are low and some technical progress on these rates is to be expected. However a National Income Policy needs more certainty than that!

With Qatar's national income being almost entirely dependent on oil revenue, it is logical to exploit the country's great national asset, namely the North Field. This gas field is the world's largest non-associated gas field. Qatar's national strategy is to exploit this asset in order to supplement and eventually replace oil revenues. This is necessary in order to maintain national income and hence the well-being of its citizens.

The North Field gas reserves are currently stated as being 'in excess of 900 tcf'.

It is assumed below that LNG production may reach 70 million tonnes per year and that gas for GTL projects may reach 8 billion cubic feet per day (cf/d). Under these assumptions consumption of gas from the North Field will reach between 6–7 trillion cubic feet (tcf) per year or say 120–140 tcf for a typical 20-year life span project. So gas reserves are ample.

Table 1: Qatar Crude Oil Production and Reserves

	1980	1990	2000
Reserves – crude oil (billion barrels)	3.6	4.5	4.5
Production – thousand b/d	476	434	796
Crude Oil R/P Ratio (Years)	22	30	17

The first question to ask is, 'how much income will be needed and when?' This can then closely be followed by the question, 'how long will it take to develop the new sources of income based on monetising the gas resources of the North Field?'

Well, Qatar Petroleum (QP) has a strategy for monetising the North Field. It recognises that there are four principle ways of using and monetising the gas, namely:

1) Liquefied Natural Gas
2) Pipeline Gas
3) Methane and Ethane based Petrochemicals and Fertilisers plants
4) GTL Plants

QP, acting on behalf of the State of Qatar, is pursuing all four legs of its strategy in terms of revenue generating projects. In LNG, Qatar has successfully established its Qatargas and RasGas LNG Plants and in pipelines the Dolphin Project is now underway (pipeline gas to the United Arab Emirates). Qatar already has some petrochemical plants operational (and has had for some time). Companies such as QAFCO (Fertilisers), QAPCO (Plastics), QCHEM (Plastics), QAFAC (MBTE) and QVC (vinyl monomers) are all in operation. Expansions and new plants are planned.

Actual short and medium cash flows are of course subject to commercial confidentiality. However some rough estimates can be made with published data.

First let us simplify matters by assuming that petrochemical profits are small and cyclical – just the icing on the cake and not something to base national income on.

Qatar is committed to build about 70 million tonnes of LNG capacity by 2012. Again, actual terms are confidential, however we can use the alternative fuel cost price of income to the state of $0.50 cents/million Btu (the rationale for this minimum price is explained below). This will provide an income to the state of about $1.8

billion per year. On a similar basis the Dolphin pipeline project may eventually provide sales of 2.5 billion cf/d of gas and a revenue of say $0.5 billion a year.

We see therefore that the financial situation is 'comfortable' without GTL projects – at least until steeper crude oil production declines set in. Qatar plans to replace its lost revenue from declining crude oil production with revenue from LNG, pipeline gas and petrochemical sales.

So this still begs the question of why GTLs?

"We can see therefore that capital costs will have to be below $17.00/b for a GTL project to be viable and that sustainable long-term oil prices be above $20/b"

Readers will presumably be aware of the early GTL history and the role of Fischer Tropsch catalysts in sustaining German oil product production during the Second World War. More recently South Africa sustained similar production throughout an oil embargo. However these are special cases. GTL technology has been bedevilled by high capital costs that have prevented this technology from attaining broad commercial viability. Just how the economics stack up can be judged from some simple calculations. Start with the assumption that the long-term oil price might be $20/b, then gas could be priced at a minimum of marginal fuel cost which must be roughly equivalent to the cost of production of a low to medium priced crude oil, say about $0.50 cents/million Btu, equivalent to $3.00/ b. We can see therefore that capital costs will have to be below $17.00/b for a GTL project to be viable and that sustainable long-term oil prices be above $20/b. Obviously, lower capital costs and higher oil prices will strengthen a GTL project. Similarly the higher gas prices associated with alternative gas projects will weaken a project. It is only recently that capital costs have come down to this level.

However this only occurs under certain circumstances. These are:

- Plants have to be 'large' to achieve economies of scale;
- A proven infrastructure (ports, jetties and tankage) for producing gas and liquids and exporting products has to be in place;
- Individual plants are large consumers of gas. To achieve synergies of production it is desirable to have more than one GTL plant on a site.

Consequently a large gas field with low production costs is needed to make GTL projects viable. To illustrate this point, two large GTL plants, consuming say 3000 million cf/d, require a reserve base of 20 trillion cubic feet.

On top of these criteria, there has to be a commercial, financial and political stability present that will allow banks and foreign and national oil companies to invest about $5 to $6 billion in such projects. Perhaps it is understandable that Qatar is considered a prime location for this. Given that the overall economics and business climate may be favourable does not mean GTL projects will flourish. There has to be a strong commercial, and in Qatar's case national, reason to undertake such projects.

We now come to the second question, which is, how long does it take to develop new projects? It is true to say that Qatar Petroleum and its foreign partners have taken a long time to develop some projects – ten years is an often recognised timescale from inception to production. However, much learning has taken place and timescales have come down. Nevertheless, under SPAs, significant cash to the state will not occur for the first few years. So it is obvious that now is the time to plan for post-2012. Projects are considered to be developed in 'waves'. First we have the petrochemical plants, then LNG plants and pipeline projects. Then will come the GTL plants. Already on the horizon is the next wave of projects, perhaps for implementation after 2015!

However we have already said that petrochemical revenue is cyclical. LNG markets are limited and, at least until other less prolific gas fields decline, appear to be well supplied, although new technologies and economies of scale will allow Qatar to expand its markets. There are limits to the number of pipelines that can be built. So all the arms of the strategy have some limitations. Market size and market opportunity are also important issues. World demand for LNG may be between 300 and 400 million tonnes in 2012 with Qatar providing 17 to 25 per cent of that volume. World oil demand may be 90 mb/d with Qatar GTL providing 750,000 barrels (less than 1 per cent). GTLs therefore help provide more diversification in Qatar's portfolio of revenue producers and, as a consequence, risks of a 'market shock' are somewhat reduced.

Table 2 shows Qatar's potential GTL projects and their status. Several things are apparent from this table and I summarise them here:

1) Although there are plans for about

Table 2: Status of GTL Projects

Project	Capacity Barrels/day	On Stream Date	Progress
Oryx- SASOL	34,000	2006	Under Construction
Shell	140,000	2010–12	FEED* / Drilling
Conoco-Phillips	160,000	2010–12	Statement of Intent
Marathon	120,000	2010–12	Statement of Intent
ExxonMobil	102,000	2010–12	Pre-FEED Completed
Oryx Debottleneck	66,000	2009–10	Memorandum of Understanding Economic Appraisal
SASOL Chevron	130,000	2010	Statement of Intent

750,000 b/d of GTL capacity, much is still at the planning stage. Only the Oryx –Sasol plant is under construction and only the Shell Plant is under FEED although they are doing some development and appraisal drilling as well. As pre-FEED and FEED studies progress it is expected that actual capacities may change as design parameters are optimised.

2) One should note that the GTL production may well be greater than crude production by 2012. Furthermore, field condensate and LPG production have been ignored in this very simplified outlook of revenues.
3) The on stream dates look very congested. It is obvious that all the GTL projects cannot be built at once even if the phasing of construction is taken into account.

“there is an entrepreneurial spirit within Qatar and Qatar Petroleum”

The GTL projects will use about 8000 million cf/d and, using the same revenue to the state assumption, generate another $1.4 billion per year. Whilst it has been shown that the revenue is not strictly needed for some time, more revenue obtained from monetising the North Field is of course welcome.

So I return to the question, ‘Why GTL and why now?’ The second question is easier to answer than the first. It takes a long time to implement these projects; eventually more revenue will be needed.

However there is an entrepreneurial spirit within Qatar and Qatar Petroleum which gives the confidence to take on and implement big projects. There is a feeling that if anyone can bring in this new technology then Qatar and its partners can. Qatar is widely recognised as a good place to do business. Obviously in this case, agreements to implement GTL projects will have a considerable amount of risk mitigation built into them.

Let us now turn to the uses of products from GTL projects. Plants will obviously be ‘tuned’ to meet downstream marketing needs. A typical 150,000 b/d plant may produce 32,000 barrels of mixed LPGs, 39,000 barrels of naphthas, 57,000 of gasoils, 16,000 of lube base oils and 6000 of normal paraffins per day. Again, some interesting insights can be made from these simple figures.

In LPGs, as gas producers ramp up their gas production (from LNGs as well as GTLs) then they will become significant producers (and exporters) of LPGs (and incidentally of field condensate).

GTL naphthas are straight chained. They are therefore an ideal feedstock for steam crackers and are expected to fetch a premium over conventional naphthas.

With GTL gasoils, the initial interest was in the production of ‘green’ diesel as these gasoils are of extremely low sulphur content. There is now a realisation that diesel markets are controlled by specifications for diesel. Sulphur specifications can be met by a variety of blending options and processes. A sulphur premium for GTL gasoils will therefore be set by its blending value. However GTL gasoils (again being straight chained) have a very high cetane value so they again acquire a blending value from this property. It is envisaged, therefore, that GTL gasoils will, when available, take their place as a premium component in the gasoil blending pool. They may very well be useful in upgrading FCC bottoms for diesel uses rather than, for instance, allowing them to be down graded into bunker fuels.

Lube Base oils and N-paraffins are specialist uses for GTL gasoil cuts. Again they have unique properties. They represent good ways of making high value product – but this is really the subject for another article. They also represent good ways of increasing employment opportunities in Qatar.

We see therefore that Qatar has a unique opportunity to implement GTL projects. The view of their profitability and the need for the projects is very long term. They are something for the future. However the drive and enthusiasm for these projects is present now. This long-sighted view of planning the development of Qatar’s hydrocarbon resources coupled with a natural entrepreneurial spirit is a typical one today in Qatar as waves of projects follow each other.

Johann Van Rheede looks at GTL technology and the market for diesel fuels

Key political, economic, environmental and technical trends are converging around the world in favour of stimulating the growth of new-generation gas-to-liquids (GTL) conversion technology, arguably one of the most viable and promising solutions for the future of alternative and cleaner energy technologies.

In a nutshell, a GTL plant – such as ORYX GTL, currently being built at Ras Laffan in Qatar by Sasol in partnership with Qatar Petroleum – converts natural gas in three integrated production steps to produce an ultra-low-emissions form of diesel, as well as a premium-grade GTL naphtha and some liquefied petroleum gas (LPG).

The following factors underpin these key trends:

- the vastness of the world’s natural gas reserves, many of which lie in remote regions not conducive for economic conversion into liquefied natural gas (LNG);
- diminishing reserves of crude oil;
- unusually high crude oil prices – and the threat of these recurring frequently;
- the growing focus by an increasing

number of countries on their strategic need to secure and diversify their future energy requirements, thereby lessening their dependence on traditional crude oil imports;

- ever-increasing pressures for further reductions in exhaust tailpipe emissions;
- the increasing swing towards dieselisation in regions such as Europe, Australia and South Africa because of the significant advances gained in recent years in developing high-performance, diesel-powered passenger cars, and the diesel engine's superior energy efficiency compared with gasoline and other alternative-fuelled engines; and
- the mounting global drive to reduce emissions of greenhouse gases, most notably carbon dioxide (CO_2).

Diesel Enjoys Higher Status

Until recently, diesel engines used in the passenger-car market were largely stigmatised in many of the world's more developed economies because motorists regarded this fuel as too dirty, odorous and inferior. Diesel-fuelled compression-ignition engines in passenger cars were also noisier and less potent than their petrol-fuelled, spark-ignition counterparts. The situation was exacerbated because of diesel's poor cold-start properties in the long, cold European and American winters.

Today's new-generation passenger car compression-ignition engines, offered by almost all leading European, Japanese and Korean vehicle manufacturers, are a far cry from those built twenty years ago. Now that diesel-powered cars are quieter, smoother, cleaner and zestier, a growing number of motorists are attracted to the diesel engine's superior fuel efficiency. A typical automotive manufacturer can today produce any model of car with the certainty that a diesel-fuelled version will travel up to 60 per cent further than its gasoline-fuelled counterpart with the same size fuel tank and driving under the same conditions.

Inspired by such encouraging factors and, in particular, the significant advantage that GTL diesel is demonstrating over its crude oil-derived counterpart regarding reduced exhaust emissions, the South African-based, integrated fuels and chemicals company, Sasol, decided to expand its international footprint by commercialising one of its latest breakthroughs in the field of Fischer-Tropsch process technology, the Sasol Slurry Phase Distillate (Sasol SPD) process.

Sasol has been successfully using commercial Fischer-Tropsch technology since 1955. Since the late-1980s, the company has developed two advanced variants of its unique Fischer-Tropsch process, both of which are applied commercially in South Africa:

- the high-temperature version using Sasol Advanced Synthol (SAS) reactors at Secunda; and
- the low-temperature Sasol SPD process using at its heart the low-temperature Fischer-Tropsch (LTFT) Slurry Phase reactor at Sasolburg.

Sasol developed and refined these versions during the 1980s and the early-1990s to convert synthesis gas (syngas) derived from coal gasification. Both processes, however, can be adapted with very little modification – and harnessed competitively – to process syngas derived from natural gas reforming.

Launching the Global GTL Industry

Sasol, together with Qatar Petroleum (QP), is pioneering the world's GTL industry at Ras Laffan in north-east Qatar on the Arabian Gulf. Here, close to Qatar's vast North Field gas reserves, QP and Sasol (through Sasol Synfuels International) are developing the US$950 million ORYX GTL plant through their 51:49 joint-venture company, ORYX (Q.S.C.). The European construction company, Technip, is currently building the plant through a US$675 million, lump-sum contract in an established Qatari industrial region with harbour facilities.

Site work for the construction of the ORYX GTL plant commenced in October 2003. All civil engineering work, including pipe laying, will be completed in mid-2005. Major pieces of equipment, including the LTFT Slurry Phase reactors being fabricated in Japan, Haldor Topsøe autothermal reformers, a ChevronTexaco Isocracking unit and all compressors – all on long-lead order – will arrive at Ras Laffan in phases during the latter half of 2004.

Once brought into beneficial operation during the first quarter of 2006, the ORYX GTL plant will have a design capacity of about 34,000 barrels a day (b/d). It will produce, on average each day, about 24,000 barrels of GTL diesel, 9000 barrels of GTL naphtha and 1000 of LPG. The ExxonMobil Enhanced Gas Utilisation project at Ras Laffan will clean and supply cost-competitive natural gas from Qatar's North Field. This field has about 900 trillion cubic feet (tcf) of proven gas reserves – an oil equivalent of more than 160 billion barrels.

> "Until recently, diesel engines used in the passenger-car market were largely stigmatised … because motorists regarded this fuel as too dirty"

Most of the GTL diesel from the ORYX venture (about 8 million barrels a year) will be marketed to customers in Europe, where most of this ultra-low-sulphur diesel will most likely be used as blend stock for higher-sulphur diesel derived from conventional crude oil refining.

The need constantly to lower the capital and operating costs of GTL plants remains the biggest technological challenge faced by the industry. The focus is on reducing the per-barrel-a-day installation cost from an initial $30,000 to $20,000 and even less. Continuous research and technology improvement is the mainstay of Sasol's effort to continuously improve its process integration, catalyst efficiency and low temperature Sasol Slurry Phase FT reactor technology to this end. Costs are also subject to the remoteness of the operation, the scale of the project, feedstock costs, infrastructure and many other factors. We at Sasol believe that GTL can be economically sustainable at a crude oil price of $20/b or even less.

Sasol Chevron is a global joint venture (50/50) between Sasol and ChevronTexaco and is responsible for the development, implementation and management of GTL ventures based on the Sasol Slurry Phase Distillate process and the marketing of their products. The GTL project which became Oryx GTL in Qatar, a joint venture agreement between Qatar Petroleum (51 per cent) and Sasol (49 per cent), preceded the formation of Sasol Chevron.

GTL Diesel Reduces Tailpipe Emissions Significantly

Through the combined expertise of Sasol Synfuels International, Sasol Technology, Sasol Oil and Sasol Chevron, Sasol has worked closely with original equipment manufacturers (OEMs), government bodies, automotive industry associations and reputable research, testing and standards authorities in Europe, the United States, Japan and South Africa in evaluating and testing GTL diesel since the early 1990s.

GTL diesel produced through the Sasol SPD process has virtually no sulphur (less than five parts per million; 5ppm), a high cetane number (greater than 70) and a notably low aromatic content (less than 1 per cent). These properties enable significant reductions in tailpipe emissions generated by vehicles powered by compression-ignition engines. The benefits may include substantially reduced emissions of nitrous oxides, sulphur oxides, carbon monoxide, unburned hydrocarbons and particulates.

GTL diesel has a significant combustion performance advantage because its cetane value is much higher than that of conventional diesel fuels. The higher cetane number not only decreases tailpipe emissions, but also allows for easier engine starting in cold conditions. GTL diesel is also significantly more efficient when comparing its use in a compression-ignition car with that of gasoline in a spark-ignition counterpart.

Besides reduced tailpipe emissions the ultra-low sulphur content of GTL diesel also offers a number of commercial benefits over its crude oil-derived counterpart in that:

- better engine wear is achieved;
- lubricants have greater longevity;
- fewer deposits are formed inside the engine; and
- exhaust catalysts achieve greater performance and durability.

In addition:

- exhaust odour is reduced, particularly after start-up; and
- engine noise is reduced.

“Sasol GTL technology may become the energy technology of choice for many countries during the next few decades”

Like most other severely hydrotreated low-sulphur diesel fuels, GTL diesel lacks natural lubricity and requires the addition of a lubricity improver.

Given Sasol Chevron’s forecasts that GTL diesel could account for about 5 per cent of the current global diesel market within the next 12 to 15 years – and considering the relative growth in diesel over gasoline – Sasol GTL technology may become the energy technology of choice for many countries during the next few decades. This is especially relevant for countries seeking greater diversity in their energy supply, while keeping abreast of new developments in diesel formulation and usage.

Looking ahead, GTL naphtha may well be suited as a fuel of choice for future use in reformers for the production of hydrogen for fuel cell applications because it is sulphur-free and, compared with crude oil-derived counterparts, has a notably high hydrogen/carbon ratio. Fuel cells are expected to become an increasingly important component of the world’s future energy mix.

GTL naphtha also contains a high proportion of paraffinic material, making it ideal for use as a cracker feedstock, or as feedstock for manufacturing solvents. It is therefore likely to become a preferred feedstock for chemical crackers because it has the right combination of chemical properties to increase the yields of ethylene and propylene, the two most important monomers for the high-growth international polyolefins industry.

GTL is Backed by Vast Gas Reserves

The world’s vast natural gas reserves are currently estimated to be at least 146 trillion cubic metres or more than 5150 trillion cubic feet (tcf), an oil equivalent of at least 960 billion barrels. The larger reserves are found in and around the North Sea, the USA, Canada, Russia, Ukraine, Kazakhstan, Turkmenistan, Qatar, Iran, Iraq and other parts of the Middle East, as well as Algeria, Malaysia, Indonesia and Australia. The former Soviet Union (FSU) and the Middle East each hold an estimated one-third of these reserves.

About 50 per cent of gas reserves are in remote regions, far from established infrastructure. This factor makes remote natural gas largely uneconomic to develop through conventional monetisation methods because of high, if not prohibitive, transport costs.

In addition, large volumes of natural gas are being flared as associated gas in many commercial oilfields, as is the case in Nigeria, which flares more than 700 billion cubic feet (bcf) of natural gas annually. This amount of gas could produce about 180,000 b/d of GTL diesel.

Up until now, the preferred way to commercialise remote natural gas has been to produce LNG and transport it in specialised and expensive ships to selected markets. Through the Sasol SPD process, however, natural gas can now be converted, in situ, into high-quality GTL diesel suitable for the most advanced compression-ignition engines, as well as other higher-value hydrocarbon products, most notably GTL naphtha.

Upbeat Future of GTL

From the perspective of Sasol, working through Sasol Synfuels International and Sasol Chevron, the global GTL era has dawned. With ORYX GTL, the GTL industry has proved its commercial viability to the international money markets.

In addition, GTL diesel has a strong advantage on the environmental and strategic supply fronts, and that is why a growing number of gas-rich countries are thinking in terms of GTL technology as a potential way in which to monetise some of their gas reserves.

Bipin Patel looks at the economics of gas to liquids

Introduction

Over the last decade the GTL industry has made great strides towards becoming a global commercial enterprise. GTL in the form of LNG has grown from an industry of 80 million tonnes per annum (tpa) in 1993 to 130 million tpa today and is set to double this in the next 5–6 years. GTL technology, which primarily uses the low temperature Fischer Tropsch (FT) process, is poised to become a viable technical and commercial option to bring remote gas resources to markets. The FT technology provides an important and strategic option, complementing existing capabilities in the pipeline and LNG gas-technology for monetising gas resources.

The primary products from a GTL-FT process are high quality diesel for use in transportation fuels industry and naphtha as feedstock for the petrochemical industry. The transportation fuels market is estimated at 20 million b/d, which provides an unconstrained market for GTL products.

GTL therefore can demonstrate a significant role in the monetisation of gas reserves, at the same time providing a superior product in the market place.

Discussion

Does it make sense for Qatar to declare itself as capital of the GTL world?

The following factors tend to support this proposition:

- Qatar North Field Gas reserve is enormous and estimated to be more than 500 trillion cubic feet (tcf).
- Monetisation to date was only possible via LNG projects, and the limited regional pipeline (UAE)
- Further diversification is critical for Qatar and GTL provides this option
- Qatar's oil reserves are forecast to last for approximately twenty years. Large-scale monetisation of natural gas is vital for the country's future.

  In addition to the above Qatar, with its current political stability and favourable fiscal regime, can claim priority in the implementation of GTL facilities.

What is the value of GTL to Qatar?

- Monetisation of the resource, which is in practice remote from consumers.
- Future economic security and stability through diversification
- Value added products rather than direct sale of resources
- Maintenance of internal economic balance which reflects the world's highest resource income per capita
- LNG is faced with the competitive challenge of long-term contracts and price pressures
- GTL competes with crude-oil based products in an essentially unlimited market.
- Higher value for the gas is derived via GTL than via LNG when crude oil prices remain around the $25 range.
- Prestigious position in the Middle East and the world

What is the value of GTL to the companies?

- Overall economics i.e. reserves as assets, value of the associated liquids, better margins from gas than crude oil refining.
- GTL produces cleaner products, a plus for company profile in public perception and environmental responsibility.
- Diversification
- Overall improvement in companies' refinery pool – Cetane and Sulphur

Qatar needs to monetise its large gas reserves for its future economic stability. To date the primary route for this monetisation has been via LNG. GTL presents an alternative and is a close competitor to LNG.

In addition to the monetisation of large fields, GTL also has a role in the monetisation of associated gas where flaring is recognised both as a waste of resource and as a source of emission of greenhouse gases. Nigeria is one location, for instance, where efforts to curtail flaring by implementing GTL facilities are being aggressively pursued.

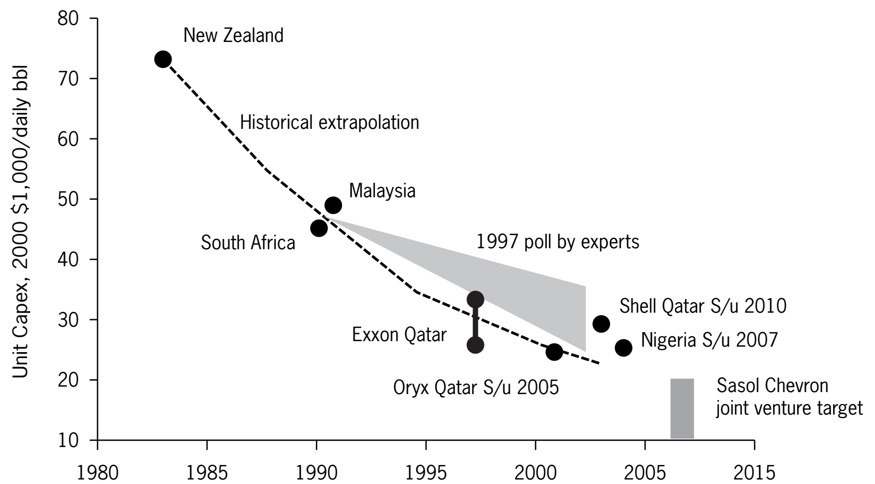
The following is an economic assessment of LNG vs. GTL for resource monetisation, and a comparison between crude oil refined products and GTL products.

Plant Overall Economics

The economic viability of a GTL plant is affected primarily by three main variables, the crude oil price, the capital cost and the operating costs including the cost of gas feed. This is different to the economics of LNG, which are related not to the crude oil price, but to the gas market dynamics. The operating costs of an LNG plant are also much lower as the process does not involve expensive catalysts; furthermore, the number of processing units in a LNG facility are fewer than those required for a GTL facility.

In terms of capital investment, both GTL and LNG involve high upfront investment costs. Although the LNG facility is less capital intensive than GTL (about 50 per cent of a GTL facility) the overall costs, taking into

Figure 1: GTL Capital Costs – Trend



consideration full value chain (costs of LNG ships and re-gasification facilities) are essentially similar.

Another important factor is the product yield or carbon efficiency. The LNG plant being a physical change process exhibits high carbon efficiencies in excess of 92 per cent, whereas the GTL chemical change process results in lower product yields reflected in carbon efficiencies of around 77 per cent range. A higher efficiency means lower feed costs.

Products from crude oil refining dominate the GTL products market. However, a key economic distinguishing characteristic of the two processes is that, unlike refinery ventures where the feedstock (crude) accounts for majority of the cash outflow, the capital cost repayment for a GTL venture represents the majority of the cash outflow. Consequently, the capital costs of a GTL facility play the most important role in the plant economics, and this high capital cost has been one of the criteria that have until now prevented GTL technology from reaching commercialisation.

Capital Costs

The capital cost of an integrated GTL facility (including the upstream gas plant) ranges from $25,000–35,000 per daily barrel of liquid capacity. This wide range in capital cost illustrates the effect on cost of a number of project specific factors. These include:

- Technology utilisation
- Location and site specific conditions
- The degree and scope of product upgrade facilities
- Availability of shared infrastructure
- Size of the plant

The capital cost trend of some of the projects over the past twenty years is illustrated in Figure 1. (Standalone basis)

The economies of scale have a profound impact on the capital cost of a GTL plant. This is illustrated in Figure 2.

All GTL complexes essentially consist of similar units with only minor variations specific to the technology selected.

Operating Cost

The most effective method of reporting operating costs for a GTL facility is to link it to the end product rather than to use a gas feed basis. This provides a more accurate assessment based on the unit cost of production and the unit of product sales.

The operating cost for a GTL plant excluding the cost of feedstock ranges from US$4.00–5.50/barrel of liquid product. The major part of this cost is associated with the cost of the FT catalysts.

The cost of the natural gas feedstock to the facility also represents a significant share and may be as much as $10/barrel based on a cost of approximately $1.0 per million Btu of gas.

Capital cost repayment is by far the largest portion of the overall GTL production cost.

A typical production cost comparison based on a barrel of GTL product, crude oil refined product and for a MBtu of LNG is shown in Table 1.

Profitability

Although Capex is a significant factor in determining the viability of the GTL venture, the swing in netback value is much more pronounced and influenced by the crude oil price. Consequently the decision to invest in GTL is largely dependent on the perception of future oil prices. A low crude oil price of $14–16 would place

Figure 2: Economies of Scale

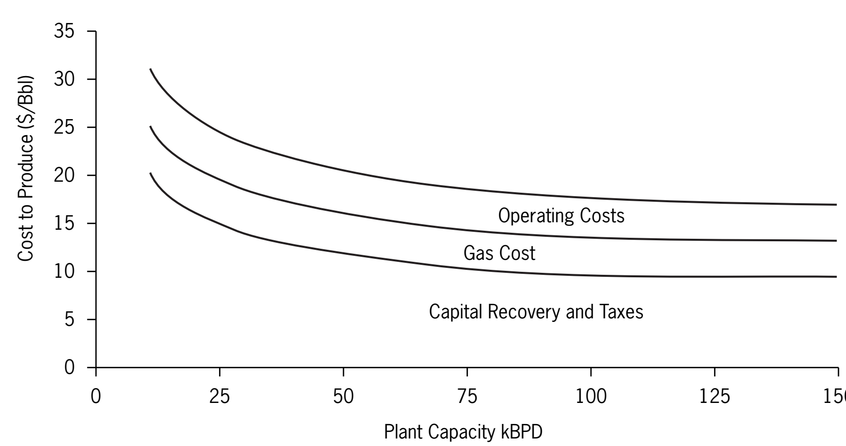


Table 1: GTL – Product Valuation (Typical Cost of Production)

	Cost per barrel GTL	Cost per barrel Refinery	Cost per MBtu LNG
Natural Gas	$6–10		$0.6–1.0
Crude Oil		$18–25	
Operating costs	$3-4	$2–3	$0.2–0.3
Cash costs	$9–14	$20–28	$0.8–1.3
Capital costs	$9–14	$4–7	$1.8–2.0
Cost of Product	$18–28	$24–35	$2.6–3.3
	Integrated GTL 100 Kb/d	Standalone Refinery 100 Kb/d	Full chain LNG 7.3MMtpa

GTL ventures in an area of economic uncertainty. The overall profitability of a GTL plant can, therefore, be benchmarked against crude oil prices.

The GTL-FT should not, however, be viewed as a standalone business based on purchased gas conversion to high-value liquid product. It should, rather, be viewed as a gas-monetisation option, and the economics of the upstream facilities need to be accounted for in the overall assessment.

The Internal Rate of Return (IRR) for a typical project based on an integrated facility is much higher than one based on standalone facilities. This is primarily due to the additional products, such as condensate and NGL liquids, produced from the reservoir while processing only the lean gas in the GTL facility.

An illustrative IRR profile at various crude oil prices is shown in Figure 3.

The cost of the GTL facility will be largely determined by its location and be specific to particular site conditions and the availability of appropriate infrastructure. Qatar currently provides some of the most attractive frameworks for implementation of GTL projects, with its opportunities for further integration with other facilities and infrastructure within an industrial set-up.

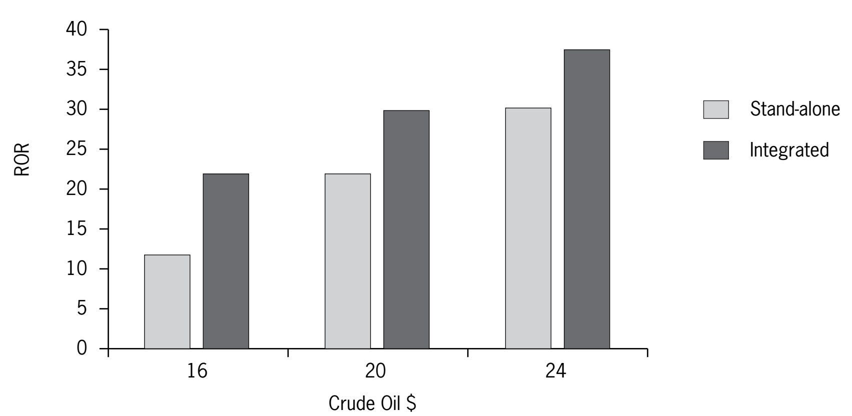
Conclusions

The main reasons for GTL to be the 'flavour of the year' can be summarised as follows:

- Diversification of resource monetisation
- Substantial technology and capital cost improvement potential
- Profitable and comparable economics to LNG alternative
- Large market for the products

Qatar exhibits characteristics which are conducive to GTL venture developments and can rightfully claim to be the capital of the GTL world.

Figure 3: Economics of GTL



Why Oil Prices Have Moved Higher

Paul Horsnell

The central point to be made about the move up in oil prices is that it reflects structural rather than cyclical issues. That is to say that higher prices are not the result of a random coincidence of short-term factors that could easily go away again. Instead, the move represents a significant structural shift upwards from the circumstances of the 1990s. Over the past two years, that shift has become reflected in longer-term market values, as is seen in the time curve for West Texas Intermediate (WTI) crude oil prices (Figure 1).

The back end of the oil price curve stayed between $18 and $21 for almost the entire period from 1986 to 2002. Whether prompt prices were at $40 or $10, longer-term prices rarely strayed from the narrow $18 to $21 band. A powerful consensus formed around the view that oil prices could not be sustained at levels above that band, and indeed that the longer-term trend had to be downwards. Over the past two years that consensus has been shattered by the sharp move up along the entire price curve. Over the course of 2004, crude oil for December 2010 delivery has not traded below $27, and it has at points traded above $30. Even during periods of weaker prompt prices, the middle and back of the curve have remained robust, with any moves down creating a burst of consumer hedging that has supported prices.

We see the move up in prices as being a drama in two acts. The first act was the period in which the market realised that the $18 to $21 consensus was too low for longer-term equilibrium. The second act has been a period in which further upwards pressure has arisen, primarily because of the consequences of keeping prices too low in the 1990s and creating absolutely the wrong set of market signals. In other terms, in the first act the market signalled that prices had to be higher to avoid a longer-term capacity crunch, and in the second act it signalled that just maybe things had been left a bit too late.