

#### the global energy challenge

With an expected global population increase of over two billion and increasing development, particularly the expansion of affordable transport, per capita energy use by 2030 is set to increase by 50%.

Traditional energy sources will have to be used more efficiently and a range of alternatives will be developed. A more complex energy slate will emerge and the primacy of oil in the long term will draw to a close. However, energy demand will be too widespread and too great to be sustained by new alternatives alone. Hydrocarbons will remain a keystone of the energy mix and natural gas, the cleanest of the hydrocarbon family, will play a critical role. In energy terms, the 21st Century will be the century of natural gas.

Natural gas has emerged as a major force in the global power generation market but, until recently, it lacked the versatility to address other pressing energy needs. Now, using gas-to-liquids (GTL) technology, in which Sasol is globally recognised as a commercial and technical pioneer, natural gas can be transformed into a range of high quality energy and chemical products, including transport fuels, base oils, waxes, paraffins and naphtha. GTL offers gas owners the opportunity to diversify gas monetisation to a degree considered impossible just a decade ago, achieving a product value significantly above that of a feedstock for power generation.

#### the global energy transport challenge

In the context of meeting future global energy demand, the transport sector presents specific challenges. Whilst the power generation sector will be able to call on a range of technologies such as nuclear, wind, coal, solar, biomass and hydro, as well as an increased reliance on natural gas, to meet demand, the transport sector is more restricted in available fuel switching options. Traditional drivetrain technology, with its dependency on spark and compression ignition engines, is set to be the standard for the foreseeable future. Transportation accounts for 20% of global energy consumption and, by 2030, this is estimated to increase by over 21 million barrels per day oil equivalent.

Meeting this demand will require a diverse range of commercially viable fuel supplies compatible with fuel distribution infrastructure and prevailing drivetrain technologies. The fuels themselves will have to deliver improved performance and do so with lower emissions. Through GTL technology, natural gas can be transformed to meet these exact standards, providing a high quality product for a global market where demand is strong and increasing. The GTL process uses natural gas to produce ultra-clean, high performance liquid fuel, as well as other premium products.



### GTL technology

At the core of Sasol's GTL technology is the Sasol Slurry Phase Distillate Process™ (SPD process). This is a three stage process which combines three leading proprietary technologies. In the first stage, natural gas is combined with oxygen to form a syngas. Syngas is then subjected to a Fischer-Tropsch conversion to produce waxy syncrude. In the final stage, syncrude is cracked down to produce final products.

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#### the products

### GTL diesel

With almost zero sulphur, GTL diesel is a high performance, low emissions product. Capable of use in existing diesel engines either in neat form or as a premium blendstock, GTL diesel can achieve particulate matter reductions of between 30 – 70%. This delivers significant air quality advantages. Its high cetane number, 70 compared to a diesel standard of approximately 55, makes for cleaner and more complete combustion, improves cold start properties and reduces noise. As well as enhancing performance, high cetane also means less buildup of deposits in the engine which reduces engine wear and extends engine life. On a full life cycle analysis basis, GTL diesel's overall emissions profile is at least as good as that of diesel produced in a modern refinery and possibly slightly better.

GTL diesel also delivers value to the refiner as well as the end user. As a blendstock it can help the refiner to extend the diesel pool to meet growing demand, upgrade lower grade material, enable increased biodiesel inclusion, increase ultra low sulphur diesel production capacity and enable reformulated diesel blending.





## GTL kerosene

At a time when airline emissions are coming under increasing scrutiny, GTL kerosene offers the world's airline operators a cost-effective means of improving their emissions profile. Synthetic fuels have been a feature of South African aviation for many years but in terms of performance and reduced emissions, GTL has the potential to surpass anything so far achieved. GTL kerosene has now been cleared for use as up to 50% blendstock, unlocking yet another high value and enduring global market in which to realise the premium potential of GTL products.

## GTL base oils

Base oils account for approximately 90% of finished lubricant volumes and GTL base oil is a stand out product in its class. With GTL technology it is possible to produce a Group 3+ synthetic product at a Group 1 conventional cost and GTL base oils are further distinguished from their crude-derived equivalent by an improved tolerance for high temperatures. This quality has made them of special interest to vehicle manufacturers for whom higher operating temperatures are becoming an increasing feature of modern drivetrains in a bid to reduce emissions. The enhanced durability of GTL base oils will extend lubricant life and oil drain intervals. GTL base oils are a high value product for the producer and have a tangible value for the consumer.



# GTL naphtha

In terms of quality, GTL naphtha is well ahead of any competitor in its class. GTL naphtha is highly paraffinic and has virtually no aromatics or sulphur and negligible metallic contaminants. Light paraffinic naphthas are the most efficient liquid feedstocks for ethylene cracking and ethylene is one of the basic building blocks of the petrochemical industry; the precursor of widely used plastics such as polyethylene, polystyrene and other derivatives.

GTL naphtha paraffin content is typically 98%, which is considerably higher than the 65–75% of typical open-spec naph tha and 85% of typical full-range naph tha. It is even higher than the 92% paraffin content of Saudi A-180, which is one of the best products currently available for this application. A further advantage of GTL naph that is the low coking/fouling rate for furnace tubes during cracking.









#### project value for the host country

Creating a GTL capability not only allows gas owners to diversify their product slate to reach previously inaccessible markets, it also creates considerable in-COUNTRY investment and use of products and drives a major skills transfer to the local workforce to enable the plant to be operated safely and efficiently.

In the construction phase, GTL projects typically employ between 5 000 and 10 000 people and Create significant commercial opportunities for the local economy needed to support such a large workforce and such an infrastructure intensive project.

Even when the project GTL is completed, it will create between 400 – 700 new and largely skilled jobs which, in turn, are estimated to create up to a further 3 000 indirect jobs. A GTL project stimulates significant additional development in ancillary businesses, commerce and infrastructure. A GTL plant is a major technological achievement and is the symbol of a national energy industry which is capable of managing one of the most complex projects the global energy industry can undertake.

#### project value for the resource owner

GTL technology allows gas resource owners to take a wider range of high quality products to the domestic or global market more flexibly than any other gasrelated technology. With GTL, finished products are produced rather than just a raw material. The quality of the fuels themselves mean that they are not only a valuable product, but also that they are capable of playing a strategic role in the wider development of local or international trade. Without GTL technology, a gas resource owner lacks the full set of options required to maximise value and provide balance against the variations in the power generation market.

Domestically, where there is a domestic shortfall in energy supplies, GTL technology can help to avoid additional expensive imports and is a cost-effective way for domestic refiners to improve the quality of the national fuel pool through .....

#### **GTL projects**

GTL is both a commercially viable and a strategic choice and technically and commercially proven technology. GTL technology gives gas owners the opportunity to develop a diverse range of high quality low emissions energy products for the global market. Easily transportable and capable of use in existing infrastructure, GTL products can also meet domestic demands, reducing imports and actively meeting key national environmental challenges such as maintaining air quality.

There is no such thing as a standard GTL project or standard GTL project economics. Each GTL project offers a unique commercial prospect which can be optimised by working closely with the gas owner and leveraging Sasol's significant experience to capitalise on value opportunities. As the only company in the world to have commercialised GTL production on two continents, Sasol is uniquely placed to give practical examples of what this means.

## ORYX – the commercial pioneer

As the first GTL plant to be financed via project financing, the inauguration of ORYX GTL marked the moment when the international money markets viewed GTL as a viable commercial alternative to traditional crude-derived products. Billions of dollars have been invested in GTL since then but ORYX was and remains the commercial GTL pioneer. A 51:49 joint venture between Qatar Petroleum and Sasol, ORYX GTL has a nameplate capacity of 32 400 barrels per day. The plant produces a combination of GTL diesel, GTL naphtha and LPG (liquid petroleum gas). A powerful player in the global LNG (liquified natural gas) market, Qatar took a strategic decision to diversify its gas production into GTL and access the lucrative global transport markets. In addition to premium returns, GTL technology has enabled Qatar to enjoy a more versatile and balanced production portfolio than any other gas producer in the world.



# EGTL – value from waste

Originally developed to reduce flaring, Escravos GTL (EGTL) is designed to take what has been historically a waste product in Nigeria and turn it into high value products with the potential to access export markets anywhere in the world. Currently under construction and of similar design and specification to ORYX GTL, EGTL is a joint venture between Chevron, the Nigerian National Petroleum Corporation and Sasol. EGTL has proved that Sasol's GTL technology can be deployed in a diverse range of circumstances and the remote site at Escravos in the Niger Delta is in complete contrast to the ultra-modern infrastructure and port facilities available to ORYX GTL via Ras Laffan Industrial City. Project firsts include the heaviest single lift on record in Africa. Through EGTL, Nigeria has acquired a strategic energy technology and the knowledge transfer and skilled jobs that accompany it.

### Uzbekistan – the domestic enabler

One of only two double-landlocked countries in the world, Uzbekistan was not an obvious prospect for an industry which held the belief that project economics were only viable with export access to the sea. In a demonstration of the versatility of GTL technology and a reminder that GTL economics and opportunities are project specific, Uzbekneftegaz, Petronas and Sasol are now at an advanced stage of planning for a facility which will use some of Uzbekistan's gas reserves to make transport fuel. Currently fuel has to be imported and is of a lesser quality. This strategic asset will transform the energy production profile of Uzbekistan, actively improve fuel quality with immediate benefits in terms of reduced emissions and have a measurable effect on the balance of trade and security of energy supply. The plant is planned to be a bit larger in size and output to both ORYX GTL and EGTL based on the Sasol GTL process improvements effected over the last few years. One of the critical enablers for developing a project in such a demanding location has been the experience Sasol has gained in Qatar and Nigeria.

#### the GTL value chain - experience at every stage

Excellence in GTL depends not on any single factor but on the optimisation of every link in the GTL value chain and excellence at every point of execution.

Because Sasol is involved in every aspect of GTL, from the initial feasibility of the project to the point where the products reach the market, we are well-placed to ensure that every stage is developed with the maximisation of value in mind.

A GTL project is a partnership between the gas owner and ourselves and we draw on our experience to ensure that the expertise of all is applied to maximum effect – our knowledge of the global markets combines with the local knowledge of our partners to optimise the overall economics.

In terms of technology, the Sasol SPD<sup>m</sup> process combines leading edge technology from the acknowledged experts, but we are always looking to improve both the technologies and the way we optimise their combination. This ability to optimise has a profound effect on generating positive economics over the project lifetime.



GTL projects are not small undertakings. In 2009, EGTL was the second largest construction project in the world. Construction is on a worldwide scale and involves a workforce of several thousands. GTL excellence is not simply about technology; the ability to plan and execute mega-projects is a critical capability which is as important to Sasol as our technological pre-eminence.



15

The GTL process creates high value products which compete strongly with their crude-derived competitors. Though the value is self-evident in many cases, Sasol has been active in generating a better understanding of the extent of that value, backing a range of tests and trials across the world to make a data-based case for GTL. The energy market and the technologies it supplies are in constant flux and it is important that GTL producers remain aggressively inquisitive as to the new answers GTL might provide in this evolving world. Enhancing value depends on proactive curiosity.

Finally, the premium qualities of GTL need to be promoted to the market and new market opportunities need to be developed in order to maximise the full commercial potential of GTL. As the global energy slate evolves the role of GTL will expand and the premium opportunities will expand with it.

The commercialisation of GTL was a major achievement and fundamentally depended on a demonstrable ability to maximise value at every point of the value chain – the right partners, the right technology, the ability to project manage a massive venture, understand the product offering and, finally, to deliver that offering to market.



#### sasol – a global industry leader

No company in the world can match Sasol's more than 60 years of experience in the production of synthetic fuels.

Since the middle of the last century, Sasol's innovative technology has been generating fuel solutions from non-crude oil sources. Now, Sasol is the only company to have comprehensively developed and operated commercial scale, cobalt-based Fisher-Tropsch *processes*. From the earliest days when coal was the only feedstock, Sasol's technology has developed to the point where we are now able to process natural gas and produce synthetic products with an environmental profile that is far superior to anything previously achieved.

In an industry which is inherently innovative, experience matters. With successful commercial operations on two continents, Sasol's technology excellence in the past is the guarantee for innovative energy solutions in the future.