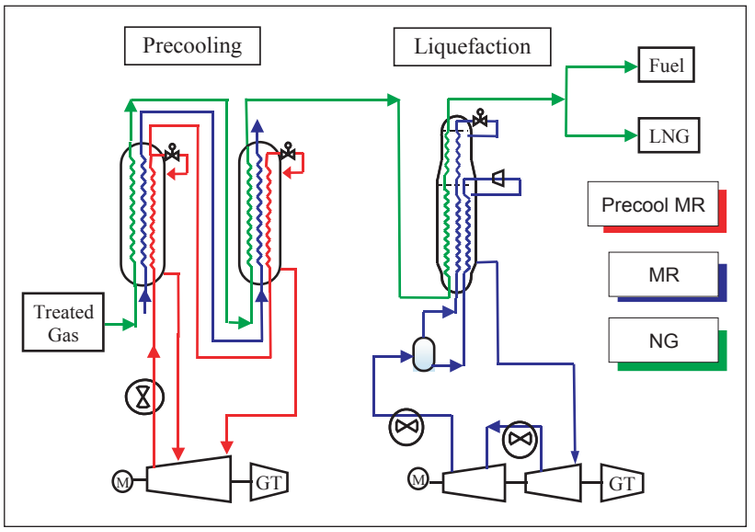

Figure 2: Schematic diagram of the Shell DMR liquefaction process.

pre-cooling and the liquefaction cycles, and is capable of achieving an LNG capacity of 6.0 Mtpa with two industrial gas turbines. An all-electric drive variant with two parallel compressor strings in one train delivers over 8 Mtpa. The mixed refrigerant in pre-cooling makes the process more flexible and efficient under widely varying and particularly cold ambient conditions.

In the pre-cooling cycle the treated natural gas and mixed refrigerant (MR) of the main liquefaction cycle are cooled to a temperature of about -50°C. The pre-cool refrigerant is primarily a mixture of ethane and propane. The pre-cooling cycle is two-stage and uses spool wound heat exchangers, since the liquid pre-cool MR evaporates over a temperature range rather than at one temperature, as is the case with propane. This line-up is simpler than the traditional propane cycle and uses fewer heat exchangers.

The pre-cool MR is compressed in a two-stage air-cooled centrifugal compressor. As a result of the presence of only one side stream to this compressor and lower suction volumes, its design is simpler than that of the four-stage compressor used in propane cycles. Other benefits are the lower liquid inventories in the pre-cooling circuit (which is particularly important in an offshore environment), and the ability to adapt the pre-cooling process to the seasonal temperature variations by changing the propane/ethane ratio of the refrigerant.

The main liquefaction cycle of the DMR process is similar to that of the C3/MR process. However, the main cryogenic heat exchanger (MCHE) sees a much lower inlet temperature due to the different preceding pre-cool cycle. In the MCHE the pre-cooled natural gas is condensed to LNG against the mixed refrigerant, which consists mainly of methane and ethane, with some propane and nitrogen. The MR is compressed in two compressors in series. Subsequently, it is pre-cooled and partially condensed against the pre-cool MR in the pre-cooling cycle, after which it is separated into vapour and liquid in the MR separator, prior to its entry to the MCHE. Both vapour MR, called Light Mixed Refrigerant (LMR), and liquid Heavy Mixed Refrigerant (HMR) flow upwards in the tubes of the MCHE. Here, LMR is condensed and sub-cooled whereas HMR is just sub-cooled. Expanding the refrigerant across a valve and/or an expander then further reduces the temperature of both LMR and HMR. The refrigerant evaporates while it trickles down the outer surface of the wound tubing and the vapour from the bottom of the heat exchanger is sent to the compressor.

As a result of a very flexible pre-cooling cycle the Shell DMR process allows full utilisation of the

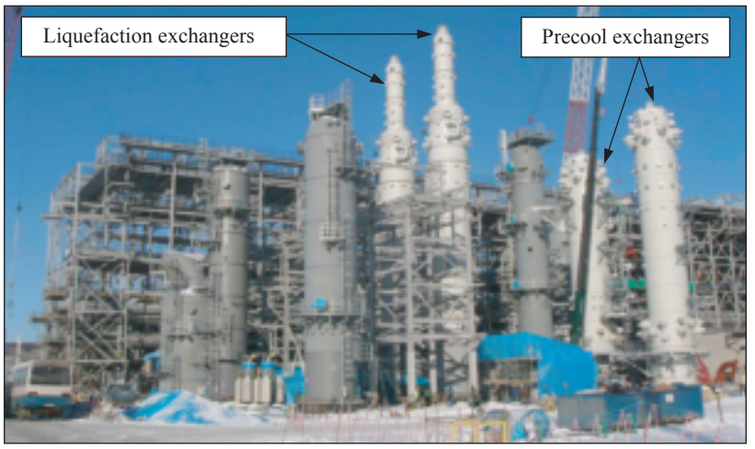

Figure 3: Sakhalin LNG plant (courtesy of Sakhalin Energy).

available power. This is of particular use in LNG plants in colder climates, where the head and the flow limitations of the propane pre-cooling would not be able to make optimum use of the lower ambient and seasonal fluctuating temperatures. The DMR process is the basis of the Sakhalin LNG plant (*see Fig. 3*).

To push the capacity of LNG trains even further, Shell has developed the three-driver **Parallel Mixed Refrigerant (PMR) process**, which is the basis for the Nigeria LNG *SevenPlus* project. With a single pre-cooling cycle and two parallel mixed refrigerant cycles, the capacity can be boosted above 10 Mtpa, depending on the driver size. The process can use either propane or a mixed refrigerant in pre-cooling.

The schematic diagram of the PMR process is shown in *Figure 4*. After cooling the NG in the pre-cooling cycle, its flow is split over two MR spool wound exchangers, where liquefaction takes place against mixed refrigerant. Each MR loop is provided with its own compressors and driver (typically an industrial gas turbine). The MR streams are cooled in separate tube bundles or a separate set of propane heat exchangers in the pre-cooling cycle. Each MR string has its own MR separator and HMR expander.

The Shell Parallel Mixed Refrigerant technology for large LNG trains has a number of distinct advantages. It allows high production capacity with only two refrigeration cycles in series as opposed to the three cycles in series found in most other large train concepts. The parallel line-up of the MR-loop and the application of the Split Propane technology, described in the C3/MR section, allows an effective 1:2 load distribution between the pre-cooling and the liquefaction cycle at a 50% extra power input into the train. The full utilisation of the installed power of the mechanical drivers, which form a large part of the liquefaction unit cost, makes PMR designs very energy and cost-effective. The pressure drop for a parallel line-up is significantly lower as compared to cycles in series, improving the process efficiency even further. This line-up is simpler to operate and delivers a higher uptime, since the train can continue to operate at 60% capacity if one of the liquefaction strings should trip.

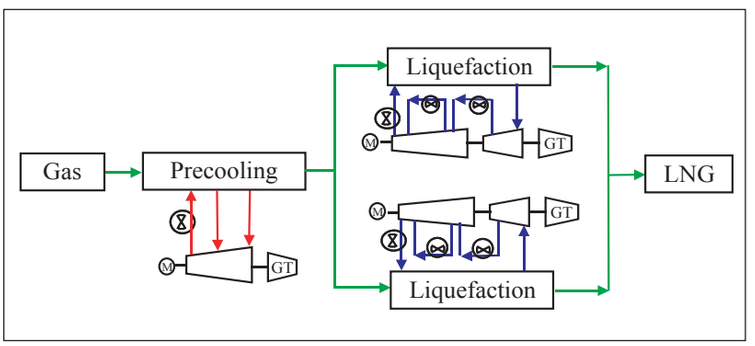

Figure 4: Schematic diagram of the Shell PMR liquefaction process.

Can the pioneers in Liquefied Natural Gas continue to set the standards?

Matsatejo Sokiaw believes so.

1972 saw the start of an extraordinary success story. That year, Brunei LNG–a joint venture between the Government of Brunei, Shell and Mitsubishi–made its first shipment of Liquefied Natural Gas. Since then, Brunei LNG has safely delivered more than 5,000 shipments, the first LNG project in the world to do so. Plant Manager Matsatejo Sokiaw, is not only maintaining this remarkable standard, he is now extending the life of the facilities to 2030 and beyond. Through long-term joint ventures such as this, Shell is at the forefront of global LNG supply. Find out how we're working with governments and partners to meet growing energy demand at **shell.com/matsatejo**

Strong LNG Development Despite Challenges

By John McKay

In June the tiny West African country of Equatorial Guinea will enter the global LNG market with exports to the United States. It will be followed by Europe's first production plant when the Snøhvit project in Norway comes onstream later this year, while many existing producers are expanding capacity and Russia and Yemen are set to start production in 2008.

Meanwhile, China and Mexico joined the ranks of LNG importers in 2006 and US plans to increase imports will see the commissioning in early 2008 of new regasification terminals at Sabine Pass, Louisiana, and Quintana Island, Texas. These terminals are among about a dozen being developed and planned in North America.

This strong growth gives delegates gathering in Barcelona, Spain, for the LNG-15 conference and exhibition this month much to celebrate. However, LNG like other sectors of the energy industry is facing challenges. Access to resources is becoming more difficult, operating costs are higher, capacity constraints are greater, and some countries with LNG potential are over-regulated and present business risks.

A shortage of trained personnel and increased volatility and uncertainty in commodity prices and margins has led several of the LNG engineering and construction players to postpone accepting new contracts until 2008.

The current growth in LNG production is being led by Qatar, Nigeria, Australia, Egypt and Trinidad & Tobago. Russia will become a key player through Gazprom in the years ahead. However, the Russian gas giant has shaken corporate confidence in the industry by not going ahead with the proposed Shtokman LNG venture in the Barents Sea and the way it acquired a controlling stake in the Sakhalin II project.

Gazprom originally announced that it would develop the Shtokman field in partnership with an international energy company and export gas as LNG. It shortlisted Chevron, ConocoPhillips, Norsk Hydro, Statoil and Total in September 2005 and invited final bids. But in October 2006 Gazprom declared that none of the bids was attractive enough and said it would go it alone with initial exports by pipeline. LNG production has not been ruled out in the longer term but is unlikely within the next decade.

The Shtokman disappointment was followed in December by the resolution of the Sakhalin II affair

Sakhalin II has faced enormous engineering, environmental and political challenges.

with Gazprom wresting control from Royal Dutch Shell. Sakhalin II was always an anomaly in as much it was entirely owned by foreign companies, and Shell had been talking to Gazprom for some time about bringing it in as a partner. The talks centred on an asset swap deal, with Shell offering 25% of Sakhalin II in return for a 50% interest in the development of the Zapolyarnoye natural gas field in Siberia plus a cash balancing payment. However, the deal with Gazprom foundered when Shell announced a doubling of costs to $20 billion in 2005 and relations with the Russian authorities soured.

Sakhalin II is being developed in an ecologically sensitive area and the project is governed by about 10,000 primary licences and permits carrying statutory obligations. Each of these permits is typically underpinned by a number of approvals from regulatory agencies giving rise to somewhere in the order of 100,000 approvals overall. Environmental campaigners had long expressed concerns regarding permit violations, but only after the souring of relations were these taken up by the regulators culminating in the threat of legal action. Faced with this situation Shell had no choice but to cede control of Sakhalin II. Gazprom has paid $7.45 billion for a stake of 50% plus one share leaving Shell with 27.5% (formerly 55%), Mitsui with 12.5% (formerly 25%) and Mitsubishi with 10% (formerly 20%).

With the Russians onboard and the environmental issues having been declared resolved, Sakhalin II is back on track to start LNG exports in mid-2008. Total capacity will be 9.6 mtpa with two trains and contracts have been signed with customers in Japan, Korea and the US.

Capacity boost

Indeed, 2008 will see a significant boost in global LNG production capacity as Russia's entry into the market will be followed at the end of the year by the inauguration of Yemen LNG with a capacity of 6.7 mtpa, in addition to the projects of existing players for a total increase of around 44 mtpa.

Russia's President Valdimir Putin (right) shakes hands on the deal resolving the Sakhalin II affair with Mitsui's CEO Shoei Utsuda as Shell CEO Jeroen van der Veer looks on.

This compares to the 16.3 mtpa of capacity which is expected to be brought onstream during 2007, either through new installations or upgrades and including new exporters Norway and Equatorial Guinea. However, the fall in output from Arun and Bontang in Indonesia is estimated at more than 3 mtpa.

Indonesia's LNG output has been declining after reaching a peak of almost 30 mtpa in 1999. Since then investment in energy exploration and development has fallen, and the country was overtaken as the world's largest LNG exporter by Qatar in 2006, dropping to third position. (Malaysia retained the number two ranking.)

With falling output and rising domestic natural gas demand, Indonesia is struggling to meet its contract commitments for 2007. The country's main long-term contract holders, the largest power utilities in South Korea and Japan, are likely to see their deliveries cut by at least 50 cargoes, forcing them to seek short-term supplies elsewhere. Indonesia has also decided not to renew a contract to supply 1.5 mtpa to Taiwan when it expires in 2009.

However, Indonesia does have one large LNG venture near completion, the BP-led Tangguh

CLP to secure LNG for Hong Kong

Liquefied natural gas (LNG), the world's cleanest burning fossil fuel, is now globally recognised as an important source of energy that can help forward-looking power utilities to transition to a greener, cleaner future.

The key drivers behind the move to LNG are widely known. As air quality and climate change issues increasingly make the headlines, it is essential to find ways to lessen the emission of air pollutants and greenhouse gases. This is something that natural gas can do better than other fossil fuels.

In Hong Kong, which is home to CLP Power, the electricity industry is regulated by what is known as a Scheme of Control. Through a contractual relationship between the Hong Kong government and the power companies, the regulatory regime has enabled CLP to become financially stable and strong – not only delivering returns to investors and providing a safe and reliable power supply, but with the commitment and resources to invest for a greener, cleaner future.

Hong Kong is one of the world's most vibrant and prosperous cities. Often defined by its high-rise, high GDP per capita (2nd highest in Asia), fast-paced 24/7 lifestyle, it boasts a population of approximately 7 million, over half of whom live or work above the 15th floor. Put simply, the city's need for a secure and reliable supply of electricity is extremely high. Yet the electricity supply, which is arguably the backbone that supports this thriving international finance centre, depends entirely on imported fuel.

In fact, Hong Kong is a prime example, if one were needed, to highlight the twin pressures of energy security and climate change that are transforming society.

Ten years ago, as part of its commitment to environmental protection, CLP took the pioneering approach to introduce natural gas into its power generation fuel mix. The company recognises that as part of its role in powering Hong Kong's dynamic city, it must also strive to improve air quality – not only in Hong Kong but also in the Pearl River Delta.

Since the introduction of natural gas to Hong Kong in 1996, CLP has substantially reduced emissions by up to 80%. Today, natural gas contributes 25% of Hong Kong's electricity supply and the CLP Group is increasing its natural gas investments in other countries in the Asia Pacific region including TRUenergy in Australia, GPEC in India and through EGCO in Thailand.

CLP is Hong Kong's largest gas user, accounting for 75% of the territory's total gas needs, and the company's Black Point power station is one of the largest natural gas-fired plants in the world. Consisting of eight 312.5 MW units, with a capacity of 2,500 MW, the plant uses advanced combined-cycle gas turbine technology to generate electricity.

But CLP is also a visionary company that takes pride in its forward-looking fuel strategies. The company recognises that it must make further investments in natural gas if it is to ensure energy security while improving the environment. This approach compliments the company's strategy to increase the proportion of gas in its coal, gas and nuclear fuel mix, thereby ensuring its use of cleaner-burning fuels as it supplies an ever-increasing demand for electricity.

The company's current gas supply comes from Yacheng 13-1, Hainan's offshore natural gas field in southern China. However, since this is expected to be depleted by early in the next decade, CLP requires a long-term replacement. CLP explored all the alternatives and decided to construct a LNG receiving terminal in Hong Kong. This opens up a number of supply options from a variety of LNG suppliers all over the world. It also offers the opportunity of further increasing gas supply when new power generation capacity will be required.

Under a project that has been underway for more than three years, CLP's highly experienced team of more than 30 gas industry experts are delivering on a plan to build the LNG receiving terminal in Hong Kong to be ready for when the existing pipeline supply depletes early in the next decade.

Throughout the process, CLP has been in close cooperation with the Hong Kong government and community and the project is currently in the advanced stages of planning, engineering and supply sourcing. Importantly, an Environmental Assessment Impact study, which is one of the key project milestones, has been submitted and the approval process is under way.

All statutory approvals for construction are expected by early 2007 and, with four years to build, the terminal will be operational by 2011. As it comes on stream, CLP plans to increase the amount of natural gas in its fuel mix from one third, as it is at present, to up to 50%. Running the Black Point power station at full capacity will require about 2.6 million tonnes of LNG per annum. As the largest user of natural gas in Hong Kong, and given the increasing importance that LNG will play in the fuel mix of the future, CLP will continue to be an active player and a trusted partner in the competitive gas market.

CLP 中電

Asia's trusted energy partner

Hong Kong is one of the most dynamic and metropolitan cities on earth, relying on electricity to fuel its growth and prosperity.

As the largest electricity supplier in Hong Kong, CLP is also the city's largest consumer of natural gas. With a solid track record and many years of experience in using gas for electricity generation, CLP has developed a reputation as a trusted partner in the Asia Pacific region, powering homes and businesses in Chinese Mainland, Australia, India and Thailand.

By pioneering the use of clean natural gas in Hong Kong, CLP is doing our part to address climate change and improve the environment – while supplying clean, reliable and affordable electricity to Asia's cities.

Work is underway on the expansion of Australia's Northwest Shelf Venture with a fifth train.

HH Sheikh Tamim bin Hamad Al Thani (CENTRE), Heir Apparent of the State of Qatar lays the ceremonial foundation stone for the Qatargas 3 and Qatargas 4 projects in April 2006 as Qatar's Second Deputy Premier and Minister of Energy & Industry H.E. Abdullah Bin Hamad Al-Attiyah (RIGHT) looks on.

project. BP holds almost 40% in the project under a production sharing contract with Indonesia's BPMigas, a state agency for upstream energy activities. Centred on the Bintuni Bay area of Papua, Tangguh is due to go onstream in late-2008 and will produce 7.6 mtpa from two liquefaction trains. The project involves the tapping of the Tangguh fields of Vorwata, Wiriagar deep, Roabiba, Ofaweri, Wos and Ubadari to extract proven reserves of around 400 bcm of gas and will eventually be capable of supporting up to eight trains.

The Tangguh shareholders include CNOOC and have signed contracts to deliver LNG to China's second LNG terminal being built in Fujian province, South Korea, Japan and to Sempra Energy's Costa Azul reception terminal being built on the west coast of Mexico.

Also due to start shipments by the end of 2008 is Train 5 of Australia's Northwest Shelf Venture. This will add 4.2 mtpa giving the Woodside-operated venture a total capacity of 16 mtpa. Meanwhile, Australia's second LNG project started exports in February 2006. Darwin LNG is led by ConocoPhillips and has a single 3.2 mtpa train.

Qatar, having celebrated achieving its long-stated aim of becoming the top LNG exporter in 2006, continues to forge ahead. RasGas's Train 5 was commissioned in January and has an output capacity of 4.7 mtpa, while future trains at both RasGas and Qatargas will have a massive 7.8 mtpa capacity. Trains 6 and 7 at RasGas will go onstream in 2008 and 2009 respectively, while Qatargas 2 is set to begin production from its first train in early 2008 followed by the second in late 2008 or early 2009. Two more trains are being built under the Qatargas 3 and 4 projects giving Qatar a total capacity of 77 mtpa.

In Africa, Equatorial Guinea is set to enter the LNG market in June with one train whose output of 3.4 mtpa has been contracted to BG Group for 17 years. The Marathon-led venture, located on Bioko Island, is also in discussions with potential natural gas suppliers in Nigeria and Cameroon to provide

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Nigeria LNG continues to develop its Bonny Island complex.

the basis for additional trains, and a front-end engineering and design study is underway on a potential Train 2 of 4.4 mtpa.

Having boosted output in 2006 with the first shipments from Trains 4 and 5, NLNG will further increase capacity at its Bonny Island complex by 4.1 mtpa when Train 6 comes onstream late this year, raising the company's total production capacity to 22 mtpa. Volumes from Train 6 will be marketed in Europe and the US by Shell and others.

Nigeria is the third-largest exporter of LNG to the US while Egypt has risen from start-up of LNG production in 2005 to become the number two US supplier. BG and Petronas are the main shareholders in Egyptian LNG, which has a two-train plant at Idku. Gaz de France has off-take rights under a 20-year agreement for the 3.6 mtpa output of Train 1, while BG has a similar contract for Train 2's 3.6 mtpa, most of which is sold into the US market through the Lake Charles LNG terminal in the Gulf of Mexico.

Trinidad & Tobago remains the top US supplier from the Atlantic LNG plant at Point Fortin. Atlantic LNG completed an expansion project at the end of 2005 and the new 5.2 mtpa Train 4 sent out its first cargo in January 2006.

Snøhvit LNG – Europe's first LNG production project – will also count the US among its customers when shipments start in the last quarter of the year. Operated by Statoil and fed by gas from the Snøhvit, Albatross and Askeladd fields in the Barents Sea, Snøhvit has a single train with a capacity of 4.1 mtpa.

Egyptian LNG has risen from start-up of production in 2005 to become the second largest supplier of LNG to the US.

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SBM, the pioneer in offshore (off)loading and owner/operator of the world's largest fleet of FPSOs, intends to be a strong and reliable partner in bringing offshore solutions to the LNG market.

Three main product lines have been developed to cover a wide range of LNG import and export projects.

1) Offshore LNG import :

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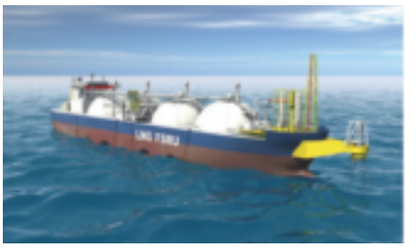
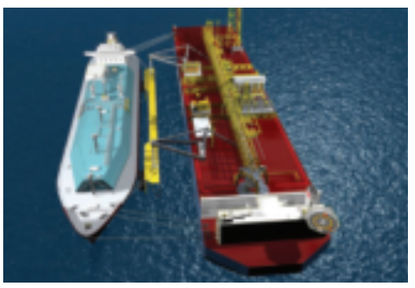
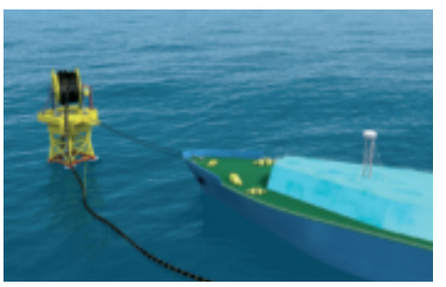
- Gas Link™ Barges


2) Cryogenic Offshore (Off)Loading (COOL™) Systems :

- LNG import or export terminals
- Arrangements for Side-by-Side and tandem (off)loading between two vessels





3) Offshore LNG and/or LPG production :

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- LPG Floating Production Storage and Offloading Unit (LPG FPSO)

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The Snøhvit LNG plant is due to start production in December.

New import terminals

The US currently has five import terminals in operation and Cheniere Energy's Sabine Pass and the Freeport LNG consortium's Quintana Island facilities are set to join them in early 2008. More US plants are in the pipeline, while Mexico has launched an ambitious plan to develop several LNG terminals to meet its domestic needs and provide energy to its neighbour.

The first of these is the Altamira terminal, located in the port of Tampico on the Gulf coast.

China and Mexico joined the ranks of LNG importers last year – Australian Prime Minister John Howard and Chinese Premier Wen Jiabao at the ceremony marking the arrival of the first cargo at Guangdong LNG terminal on June 28, 2006.

Despite the engineering and construction restraints facing the industry globally, the Mexican government helped make the project possible in just 33 months from contract award to the first cargo arrival on August 17, 2006. The terminal stakeholders are Shell, Mitsui and Total. Mexico's power authority, the Comisión Federal de Electricidad, has contracted to purchase the entire capacity of 3.6 mtpa for electricity generation.

Mexico is also moving ahead with the Energía Costa Azul venture, located on the Pacific Coast north of the town of Ensenada in Baja California. Owned by Sempra Energy, the project will have a capacity of 7.7 mtpa and is set to become operational in 2008 as a supplier to the US state of California.

Western European countries are also building new import terminals as domestic gas production declines. In 2005 LNG accounted for 16.4% of EU gas imports and this proportion is expected to grow to 25% by 2009 according to figures presented at the World Gas Conference in June 2006 by IGU's Study Group D3.

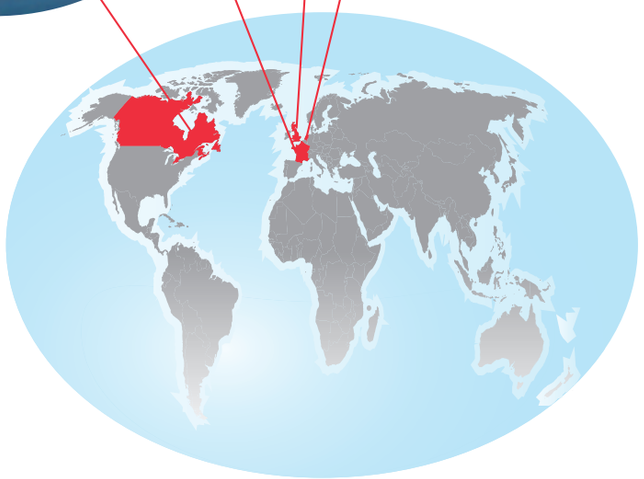
The UK has the most urgent need of capacity as, despite being the world's first commercial importer of LNG back in 1964, its original terminal was subsequently closed with the development of North Sea gas. LNG imports only restarted in 2005 with the opening of a new terminal on the Isle of Grain, southeast of London. Now Excelerate

Construction Dragon LNG Terminal well under way, Milford Haven (UK)

Pegaz LNG, Le Verdon, Port of Bordeaux (FR)

Aerial photo site LionGas, Rotterdam (NL)

MapleLNG, development of LNG Terminal at Goldboro, Nova Scotia (CAN)



4Gas is an independent company dedicated to developing and operating LNG import terminals around the world. 4Gas is the world's only independent LNG-terminaling company with a global reach. Our objective is to establish a global terminal network that will play a crucial role in fulfilling the increasing needs of countries and companies for access to natural gas. We developed Dragon LNG in Wales which will enter service in 2007. 4Gas has received the Environmental Permit for LionGas in Rotterdam and is currently permitting the proposed MapleLNG terminal in Goldboro, Nova Scotia and Pegaz LNG In Bordeaux, France. 4Gas is dedicated to LNG. www.4gas.com

Dedicated to LNG

4GAS

Energy's ship-based regasification system has been introduced to give the UK a second reception facility.

Excelerate launched its Energy Bridge system with the opening of the Gulf Gateway terminal in the Gulf of Mexico in 2005, and expects to inaugurate a second US facility in Massachusetts Bay this December.

The Excelerate facility at Teesport in northeast England started operations in January and is set to be joined by the end of the year by two new land-based terminals in Wales (Dragon and South Hook).

France was the second country to start LNG imports and its two current terminals at Montoir-de-Bretagne on the Atlantic coast and Fos-sur-Mer on the Mediterranean will be joined soon by the Fos II facility. Meanwhile, Spain recently opened its sixth terminal at Mugardos in Galicia and Italy is developing its second and third terminals on the Adriatic at Brindisi and offshore the province of Rovigo, which are due to enter service in 2008.

Projects for 2009 and beyond

Angola aims to become the sixth African LNG producer in 2009 with a single-train, 5 mtpa plant near Soyo in the north of the country. The Chevron-led project includes Sonangol, ExxonMobil, Total and BP as partners. Peru is also working towards a 2009 inauguration of Phase II of the Camisea project, Peru LNG. This venture is operated by Hunt Oil in partnership with Repsol YPF and SK Corp. and is a single-train plant with a capacity of 4.4 mtpa. The LNG will be sold into the West Coast of Mexico, and eventually California.

Elsewhere in South America, Brazil is seen as the country with most potential. In late 2006, Woodside Petroleum won exploration licensing in the Santos Basin offshore Brazil and with its LNG expertise could be a potential partner, along with several majors, including Repsol, for a development led by Petrobras.

One of the biggest planned new projects in the Asia-Pacific region, the $11-billion Gorgon venture on Barrow Island was finally given the go-ahead in December 2006. Chevron owns 50% of Gorgon and Shell and ExxonMobil each have 25%.

The Gorgon LNG project had been held up on environmental grounds as Barrow Island is home to a rare species of turtle. However, as part of the approval the authorities ruled that the Gorgon joint venture group would be required to spend $60 million on new initiatives to help conserve the rare species. The Gorgon partners have also committed to use technology to store greenhouse gases underground.

The liquefaction plant will have two trains and an initial capacity of 10 mtpa with a target start-up date of late 2010. Gorgon LNG has already signed three supply agreements with Japanese utility companies and LNG is also expected to be exported to China, South Korea and the US West Coast.

Further down the line, for 2011, Nigeria is aiming to inaugurate two new two-train ventures. Brass LNG and Olokola LNG will each have a capacity of 10 mtpa. Nigerian National Petroleum Corporation is the main shareholder in both Nigeria LNG and the new companies with Shell, Total and Eni as partners in NLNG, ConocoPhillips, Eni and Total as partners in BLNG, and Chevron, Shell and BG as partners in OKLNG.

Shipping and marketing

The LNG shipping sector is facing a major restructuring in the form of mergers, acquisitions and more strategic joint ventures. There is currently an oversupply in the LNG carrier market which is forecast to continue for up to five more years. Average daily time charter equivalent rates at the end of 2006 were around $52,000 a day compared with $65,000 a day for a very large crude carrier.

More serious financial consequences from the supply-demand imbalance were only avoided in 2006 because the current practice of storing cargoes on carriers has removed most of the over-capacity in the short term. At the end of 2006, about 10 LNG carriers were storing LNG in the

Atlantic Basin for a couple of months before the cargoes were sold at winter prices.

However, carrier orders are still growing. In 2000, the fleet of large LNG carriers was 126 and 23 other ships were in the order books. In early 2007, the sailing fleet of LNG carriers numbered 217 vessels, with almost another 140 carriers on order.

A $1-billion venture was also recently launched in Dubai to monetise the growing transportation and supply chains by offering new services. This will complement the UAE's LNG production capacity, which is located in Abu Dhabi, and reflects the increasing role of spot trading. Final figures were not available for 2006 at presstime, but the proportion of LNG sales accounted for by spot trades had risen to 12.9% by 2005.

LNG Impel of Canada and the Dubai Multi Commodities Centre, which was created by the Dubai government to establish a market place for energy, gold and other commodities, are establishing an LNG storage hub in Dubai. The aim of the hub is to offer customers the ability to store, trade and plan supplies of LNG. The hub would also provide other services such as LNG loans and LNG quality blending. Over time it is expected to offer financial derivatives around LNG and shipping.

The potential customer group includes national oil companies, European and Asian utilities, major and super-major producers, LNG marketing/trading companies, and banks involved in the industry.

The developers say Dubai was chosen as it is on an axis between Europe and Asia with some 50% of the world's existing and planned LNG production within 11 shipping days. It is another sign that we are moving towards a fully global LNG market.

John McKay is the Editor of LNG Journal *(www.lngjournal.com).*

With a capacity of 153,500 cubic metres, Gaz de France's Provalys is currently the largest carrier in the world LNG fleet. It will be surpassed by the "QMax" ships on order by Qatar Gas Transport Company, which will carry up to 266,000 cubic metres and are due to enter service in 2008.

A major player in LNG

Following the successful debottlenecking of the three Qatargas LNG trains (Ras Laffan, Qatar) Technip was awarded successively the EPC contracts for Qatargas II (trains 4 and 5), RasGas III (trains 6 and 7) and for Qatargas III and IV (trains 6 and 7). So, Technip, in joint venture, is now building the world's six largest LNG trains (7.8 Mtpa each) that will allow Qatar to become by far the largest LNG producer (with some 77 Mtpa). Still in the Middle East, Technip signed in September 2005 a major lump sum turnkey contract with Yemen LNG Company Ltd (YLNG) for the country's first LNG plant.

Technip is also currently executing major LNG turnkey projects in West Africa and the United States including the sixth train of Nigeria LNG Ltd. at Bonny Island and the Freeport LNG receiving terminal in Texas.

This extensive experience at both ends of the LNG chain is now being used to address the challenges of nearshore and offshore LNG terminals. By combining this know-how with that of our marine and subsea divisions, a range of new technologies and methods has been evolved, which include cryogenic flexibles, rigid pipe-in-pipe, and complete transfer systems and architectures. These compliant transfer systems are custom built to allow LNG transfer to or from marine floating (FPSO/FSRU) or fixed structures (GBS/Platform). The cryogenic pipe-in-pipe allows a nearshore LNG loading terminal to be directly linked to onshore facilities and can easily be installed on land, subsea or on trestles, as it has no expansion loops or bellows, and has a highly effective, passive insulation system.

Continuous R&D activities have also allowed Technip to offer innovative solutions for the benefit of investors in LNG production plants. This includes :

- The use of hydraulic turbines in place of Joule-Thomson valves,
- Efficient Nitrogen Removal process applied in several Middle East projects,
- Deep NGL extraction integrated into the liquefaction scheme,
- Increase of LNG production with the MLP (Maximum LNG Production) gas phase sub-cooling cycle,
- The use of highly efficient exchanger tubes for refrigerant evaporators and condensers.

With a workforce of over 21,000 people and an average annual revenue of more than €5 billion, Technip ranks among the top five corporations in the field of oil, gas and petrochemical engineering, construction and services. Headquartered in Paris, the Group is listed in New York and Paris. The Group's main operations and engineering centers and business units are located in France, Italy, Germany, the UK, Norway, Finland, the Netherlands, the USA, Brazil, Abu-Dhabi, China, India, Malaysia and Australia. In support of its activities, the Group manufactures flexible pipes and umbilicals, and builds offshore platforms in its manufacturing plants and fabrication yards in France, Brazil, the UK, the USA, Finland and Angola, and has a fleet of specialized vessels for pipeline installation and subsea construction.

A pioneer and world leader in the gas sector: NGL, GTL, LNG

With nearly 50 years of experience, the Technip group has established itself as a world leader in the conceptual design, engineering and construction of gas production, transport, processing, liquefaction and storage facilities and terminals.

References cover grassroots facilities, ranging from small individual units to gigantic complexes, in every sort of environment, as well as upgrades of existing installations.

Technip

Tour Technip - 8 allée de l'Arche
92973 Paris La Défense Cedex - France
Tel. +33 1 47 78 21 21
Fax +33 1 47 78 33 40
www.technip.com

Technip

Qatar Starts GTL Production

By Gina Coleman

Qatar's exploitation of its enormous gas reserves – the world's third largest – passed two major milestones last year when the country became the number 1 exporter of LNG and inaugurated its first gas-to-liquids (GTL) plant in the northern industrial city of Ras Laffan. The rate of future expansion of the gas industry will depend on the results of an appraisal of the North Field, but Qatar still has its eye firmly on the title of "GTL capital of the world".

Oryx GTL was formally opened by the Emir of Qatar, HH Sheikh Hamad bin Khalifa Al Thani, on June 6, 2006, and in October its joint venture partners, Qatar Petroleum (51%) and Sasol (49%), received the Walter Flowers Achievement Award from Energy Frontiers International (EFI) for the project. EFI is a non-profit association of major international energy companies and the award recognises significant achievements in the commercial evolution of the synthetic fuels industry. It is named after the late Walter Flowers, an early American proponent of synthetic fuel development and a Representative in the US Congress. "The award recognises Sasol's and Qatar Petroleum's commitment and substantial contribution to the commercialisation of the world's largest and most technologically advanced GTL plant," said EFI President Christopher Kidder at the time of the announcement.

Construction had started in December 2003 under an EPC contract with Technip and Oryx GTL General Manager, Chris Turner, explains that the high level of industrial expansion throughout the region and Qatar's rapidly growing economy presented a big challenge in resource availability. "But we overcame those challenges by getting all the support systems implemented and working as a team," he says.

Following the inauguration ceremony and start-up testing, production began ramping up. Oryx GTL uses Sasol's slurry phase distillate (SPD) technology and with a daily feedstock of 330 mcf (9.24 mcm) of lean gas from the North Field can produce a total 34,000 b/d of liquids: 24,000 b/d of diesel, 9000 b/d of naphtha and 1000 b/d of LPG. Sasol Chevron, the London-based joint venture between Sasol and Chevron, is responsible for marketing production.

Market opportunities for the high-quality, environmentally-friendly GTL diesel are vast. Chris Turner says that the product will initially be sold as blend stock, moving into specialty markets in the future. In geographical terms the initial focus will be on Europe before looking at markets elsewhere in the world.

GTL naphtha is a highly paraffinic product with a low sulphur, naphthene and aromatic content, properties which are expected to make it a very attractive feedstock for the petrochemical industry, and particularly for the production of ethylene. The average Japanese ethylene cracker's throughput of naphtha is 60,700 b/d with Japan alone importing about 500,000 b/d. Asian demand for naphtha is about 2.4 million b/d and global demand about 5.4 million b/d. In November 2006, the Japanese ambassador to Qatar, Masahiko Horie, told local reporters: "We are likely to be buying GTL. […] No contracts have been concluded yet, but buying GTL from Qatar will mean diversification of our energy sources which is important."

New plants

"We believe that Oryx GTL will pave the way for developing substantial new GTL capacity in Qatar and other gas-rich regions. At a time when an ever increasing number of countries are looking for greater diversity and security of energy supply, GTL plants make good strategic, economic and environmental sense," declares Sasol Chief Executive Pat Davies.

Plans are in hand to increase the capacity of Oryx GTL by 65,000 b/d and a new project with a capacity of about 130,000 b/d is under evaluation.

Qatar Petroleum and Sasol Chevron are the partners for these expansion plans. (The original Oryx contract was agreed before Sasol and Chevron formed their joint venture.)

Meanwhile, work has begun on a second GTL plant in Ras Laffan in partnership with Shell. This is Pearl GTL which will have a capacity of 140,000 b/d. A further plant with a 154,000 b/d capacity in association with ExxonMobil, which was originally scheduled for 2011, is still on the cards, but a number of other earlier proposals have been shelved, at least temporarily, as the country has called a moratorium on new projects to wait for the outcome of a full appraisal of the North Field. Energy Minister, Abdullah bin Hamad Al Attiyah, who has said that by the end of the decade, "Qatar will be exporting 77 million tonnes of LNG, 400,000 b/d of GTL and 14 million tonnes of LPG per year," explains that: "We could produce and sell more gas products now but we want to ensure the long-term health of the reservoir so that future generations of Qataris can also benefit from it. We want to manage the reserves effectively and we'll have a better picture of things when the report is complete in 2007."

After much industry speculation that Pearl GTL would be delayed either because of the moratorium or because of spiralling costs that affected the initial budget, Qatar Petroleum and Royal Dutch Shell finally announced the launch in July 2006. The integrated project will produce 1.6 bcf (44.8 mcm) per day

Oryx GTL in Ras Laffan is now operational.

The winning Audi R10TDI fills up with V-Power Diesel during the 2006 Le Mans race.

of wellhead gas from the North Field for processing to extract around 120,000 b/d of condensate, LPG and ethane, and supply dry gas to two 70,000 b/d GTL trains and associated facilities producing naphtha, GTL fuel, normal paraffins, kerosene and lubricant base oils. The first train is due to enter service in 2010 and the second a year later.

Pearl GTL is being developed under a Development and Production Sharing Agreement with the Qatari government, covering offshore and onshore costs, with Shell providing 100% of project funding. The EPC contractor is a joint venture between JGC Corporation (which built Shell's first commercial GTL plant in Bintulu, Malaysia) and Kellogg Brown & Root, and GE will supply six 42-megawatt Frame 6B gas turbines. The effluent treatment plant will be built under a design-build contract by a consortium of Veolia Water, Saipem and a local construction company, Al Jaber.

Speaking at the launch, HE Abdullah Al Attiyah said: "GTL opens a new global market for Qatari natural gas and allows Qatar to contribute constructively to improving the local environment by supplying a cleaner alternative transport fuel. Shell has extensive expertise in all aspects of the GTL value chain and I am pleased to have them as

Celebrating the arrival of the South Africa-Qatar GTL-fuelled rally in June 2006.

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A simple dip stick test shows how much cleaner the GTL-fuelled vehicle (left) ran for over 10,000 kilometres compared to a 4500-kilometre sector with a conventionally-fuelled vehicle (right).

partners on our journey to become the GTL capital of the world." For Shell's Chief Executive Jeroen van der Veer, the announcement was: "Another clear demonstration of our long-term commitment to partnering with the State of Qatar to deliver Qatari natural gas and GTL products to markets around the world. It is also evidence of our commitment to leverage leading Shell technology in order to increase the world's supply of cleaner and more diverse liquid hydrocarbon products."

Shell currently sells GTL fuel at around 4000 sites in Europe as a component of its V-Power Diesel, which also fuelled the winner of the Le Mans race in June 2006. Indeed, the Audi R10TDI was the first ever diesel-powered car to win this 24-hour endurance race.

In Asia, Shell sells a GTL-blended fuel under the Pura brand in Thailand and is a partner with the Shanghai municipal government in the Shanghai Clean Energy Centre, which promotes clean fuels through demonstrations of GTL-fuelled buses and taxis.

Shell says there is considerable interest in the full range of GTL products from the US, China and Japan. It highlights the benefits of GTL naphtha in terms of higher ethylene and propylene yields compared to petroleum-based naphtha feedstock, and points out that clean-burning GTL kerosene is attractive for domestic heating appliances in Japan. Shell also says that GTL base oils will bring a step change in the ability to meet future lubricant requirements, as advances in engine design and the need to improve emissions and fuel economy place increasing demands on lubricants. "All of these benefits will create market pull for new GTL projects," declares the company.

Qatar started trials with a fleet of 10 GTL-fuelled school buses at the end of November 2006.

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Qatari trials

Following on from the experiences of Europe and the Far East, Qatar started trials with a fleet of 10 GTL-fuelled school buses at the end of November 2006. Qatar Petroleum, Sasol Chevron and Shell launched the initial three-month trial as part of a campaign to showcase Qatar's GTL initiative. The buses have been provided by the public transport company Mowasalat and they are refuelled by Qatar Fuel (WOQOD) at the Al Asiri petrol station in Doha.

To educate the general public, and school children in particular, Qatar Petroleum, Shell and Sasol Chevron organised a GTL fuel exhibition at the City Center-Doha shopping mall in December 2006. The "GTL Capital of the World" campaign featured a Toyota Hilux Raider that ran entirely on GTL fuel in a gruelling 10,000-kilometre rally from South Africa to Qatar, timed to coincide with the opening of the Oryx GTL plant.

Proving just how environmentally friendly the GTL fuel is, analysis of the results showed that on the tough 46-day journey to Ras Laffan, the GTL-fuelled car produced 4500 cubic metres less sulphur dioxide and 102,000 cubic metres less CO_2 than a control vehicle running on conventional diesel.

Qatari research

Apart from producing GTL in Qatar and recognising the global importance of developing GTL technology, Shell has also announced plans to conduct GTL-related research at its facility in the Qatar Science and Technology Park (QSTP).

Shell plans to spend up to $100 million over the period to 2015 on R&D and training activities in Qatar. Its QSTP facility is part of the company's global research and technology organisation, and will initially focus on exploration and production and GTL technologies as well as on related training programmes. The research centre will include a learning centre, and Shell organised its first research and technology lecture in Qatar in March 2006 at the Texas A&M University Qatar Campus.

Gina Coleman is a broadcast and print journalist who has lived and worked in Qatar for the past 27 years. She writes extensively about the country and its industrial development for publications throughout the Middle East and Europe.

COMMERICAL GTL PLANTS IN OPERATION AND UNDER CONSTRUCTION

Name/Location	*Owners*	*F-T Process*	*Capacity (b/d)*	*Status*
Mossel Bay, South Africa	Petro SA	Synthol	22,500	Operational
Bintulu, Malaysia	Shell Gas, Diamond Gas, Petronas, Sarawak govt.	Shell middle distillate synthesis	14,700	Operational
Oryx, Ras Laffan, Qatar	Qatar Petroleum, Sasol	Slurry phase distillate	34,000	Operational
Escravos, Nigeria	Chevron Nigeria, Nigerian National Petroleum Co.	Slurry phase distillate	34,000	Under construction, in service late 2009/early 2010
Pearl, Ras Laffan, Qatar	Qatar Petroleum, Qatar Shell GTL	Shell middle distillate synthesis	70,000 (Train 1) 70,000 (Train 2)	Under construction, in service 2010 (Train 1) 2011 (Train 2)

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