LIBYA LNG – REJUVENATING BREGA AND DEVELOPING NEW LNG

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ABSTRACT

Commissioned in 1970 as the second liquefaction plant in the world after Algeria's Arzew plant, Libya's 3mtpa Brega plant has withstood the test of time, surviving the volatility of the LNG industry, the international sanctions imposed on Libya in the 1980s and 1990s, and continuing to meet its delivery commitments to the Spanish market.

In May 2005, the Libyan National Oil Company (NOC) reached a historic Agreement with Shell which, in addition to granting Shell exploration rights covering some 20,000 square kilometres of acreage in the prolific Sirte basin, included a commitment to rejuvenate the Brega plant and to restore its nameplate capacity, thereby giving it another lease of life. The Agreement also provided for the development of a new LNG plant in Libya, allowing the country to leverage its LNG experience and excellent geographical location to supply the growing LNG markets of Southern Europe and North America.

This paper provides an update of the joint NOC, SOC (Sirte Oil Company, an affiliate of NOC) and Shell efforts in rejuvenating the Brega plant, as well as the plans being developed to increase the capacity of the plant back to its nameplate. Furthermore, the paper discusses the progress that has been made in developing a new LNG plant in Libya, and the plans going forward.

1.0 INTRODUCTION

Liquefied Natural Gas, or LNG as it is better known, is certainly not a new discovery, phenomenon, or trend in this industry. The very title of this conference, LNG15, is testament to the long history of LNG in the world's energy market.

It dates back to the early 1900s in North America where natural gas was liquefied for storage and purposes to meet increased demand during peak periods. This process highlighted the ability of natural gas to be transported long distances on ships in a liquefied state and in 1959 this ability was put to the test when the *Methane Pioneer* successfully transported LNG from the US to the UK. Five years later, Algeria with its large gas reserves and relatively low domestic demand, became the world's first commercial exporter of LNG. Libya, also discovering large quantities of natural gas, followed soon after with the Marsa El Brega plant that produced LNG for the market of Southern Europe.

Over the next 30 years, the supply and demand for LNG continued to grow but was far outweighed by its close relatives crude oil and coal that were abundant, inexpensive and had well-established infrastructure. However, as the realisation set in during the 1990's that the world's energy demand is growing rapidly as a result of expanding populations and thriving economies, and that many indigenous and foreign reserves of hydrocarbons are either dwindling or becoming harder and more expensive to produce, the world began striving for more secure and diverse energy sources. Not just any energy source though. Seeking to lessen the impact on the environment and ultimately the standard of living, these diverse energy sources must be cleaner and more economically stable than what the world has been using in the past. Welcome the resurgence of LNG.

Although it has been around for more than four decades, the period from 1990 to 2020 will prove to be the most dramatic for LNG in terms of demand, supply, investment, and infrastructure. During this period, it is estimated that global LNG imports - that is the demand for LNG - will have grown from a relatively small 65 million tonnes to in excess of 500 million tonnes per annum (mtpa), an almost eight-fold increase, which is phenomenal growth for any industry to experience.

During this time the industry will have changed from an Asia Pacific focus where Japan and Korea are the world's largest importers of LNG to a truly global business that sees the US, China and India becoming major importers. Ever larger LNG ships will cross the world's oceans as supplies go from Australia to China, from Nigeria to the UK, and from Qatar to the United States. The true globalisation of LNG.

To achieve that level of growth, and in so doing help suppliers meet the expectations of markets, the industry faces tremendous challenges in investment, capital, training, capacity and knowledge. However, evidence already indicates that the industry is up to meeting these challenges as major resources holders and the international energy companies are implementing the changes necessary to meet the forecasted demand. As an example of the level of activity taking place in the development of LNG worldwide, Shell is investing vast financial, technical and human resources right across the value chain (see Figure 1), but in particular, in the area that is probably of most importance to the world – supply. The governments of countries that are major supply sources such as Russia, Nigeria, Qatar, Libya and Australia are all partnering with Shell and other international companies to maximise their supply positions and gain access to the premium import

markets of Japan, Korea, Europe and the US, and in addition, also the emerging markets of China and India.

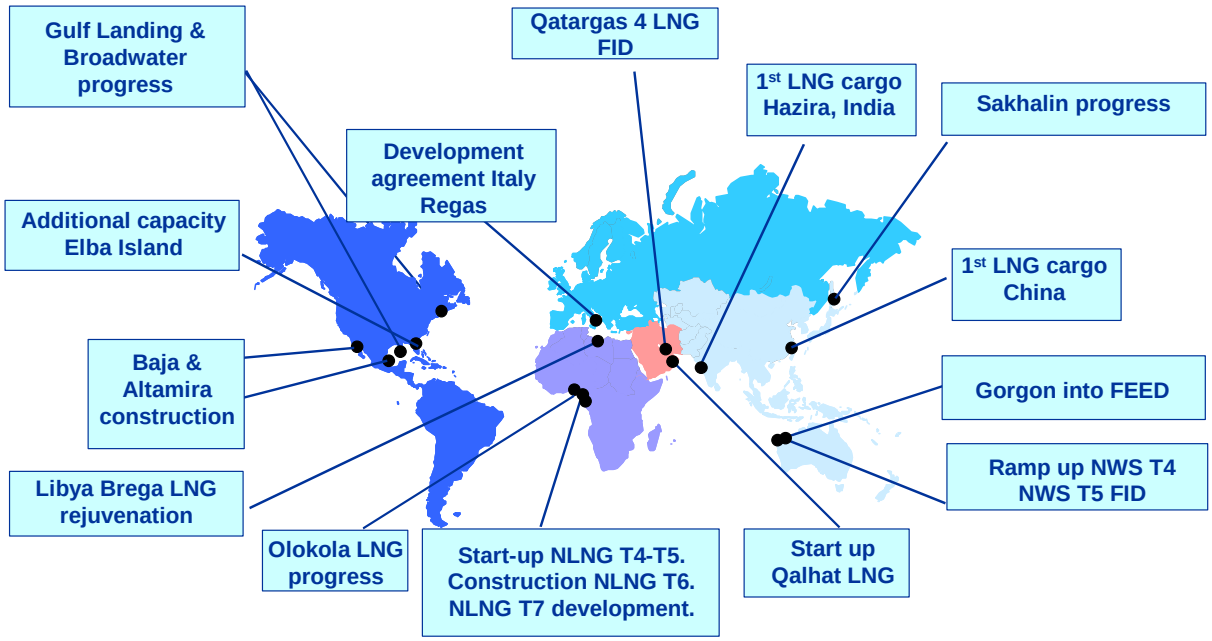

Figure 1

Of all the major resources holders, one of the pioneers of the LNG industry is rapidly moving ahead in its investment, infrastructure, manpower and global relationships in an effort to help meet the world's energy needs. That country is Libya.

Libya is plentiful in both crude oil and natural gas reserves, with proven plus probable discovered reserves at a level making Libya a major resource Holding Country potentially playing a key role in the global energy supply mix. The majority of these reserves have been found in the Sirte Basin, which is one of the most prolific basins in Africa. The average field size and total number of discoveries in the Sirte Basin also exceed those found elsewhere in Libya. This discovered gas resource base comprises both associated and non-associated gas. In the Sirte Basin discovered gas is currently being used for enhancing oil production (gas lift, pressure maintenance), as fuel gas, for domestic gas and as feedstock for the existing Brega LNG plant and Petrochemical Plant.

To date exploration in the Sirte Basin has focussed on established, relatively shallow, mainly oil plays – the deeper, largely gas-prone troughs have only been tested with a handful of wells. Modelling indicates that these areas may contain very substantial, untapped recoverable gas volumes.

At an early point, the government identified the potential opportunities to monetise the large reserves of natural gas, secure long-term foreign revenue streams and help to meet global energy demand. The country was not able to fully capitalise on its position in the world market due to sanctions imposed in 1980s that led to many lean years for its LNG exporting capabilities. Those years of low production and ultimately very little

export have now been replaced by plans and actions for significant greater levels of liquefaction capacity and access to new markets.

The first stage in this re-entry to global LNG is through existing facilities. Commissioned in 1970 as the second exporting liquefaction plant in the world after Algeria's Arzew plant, Libya's 3.2 mtpa Marsa El Brega LNG plant has withstood the test of time. Surviving the volatility of the LNG industry and two decades of sanctions imposed on Libya, the plant today continues to meet its delivery commitments to the Spanish market, although capacity has been dramatically reduced to only 0.7 mtpa.

Although never directly involved with the construction or operation of this original plant, Shell's reputation in Libya was built and consolidated through expertise in downstream oil products. In May 2005, the Libyan National Oil Company (NOC) and Shell reached a historic agreement that would see Shell explore for natural gas and oil across 22,000 square kilometres of acreage in the prolific Sirte Basin, commit financially and technically to the rejuvenation the Marsa El Brega plant in co-operation with Sirte Oil Company (SOC), an affiliate of NOC and operator of Marsa El Brega LNG Plant, and potentially restore its nameplate capacity, thereby giving it another lease of life. Not content with just increasing the existing plant back to nameplate capacity, and in doing so increase the current level of production more than four times, NOC also wanted Shell to investigate and undertake the development of a completely new LNG plant.

In signing this agreement with one of the major international energy companies and implementing its development plans, NOC envisages the country leveraging its LNG experience and excellent geographical location to supply the growing LNG markets of Southern Europe and North America. The following provides an update of the joint NOC, SOC and Shell efforts in rejuvenating the Marsa El Brega LNG plant, as well as the progress on the plans being developed to return the plant's capacity back to near its original nameplate. In addition, the status of exploration in the Sirte Basin, where seismic activity is underway, is detailed as is the most exciting aspect of the agreement between NOC and Shell: conceptual work and recommendations for the new LNG plant in Libya that is being developed, the potential economic impact of this facility, and what the future may hold.

2.0 SIRTE BASIN EXPLORATION

As mentioned above, the Sirte Basin is expected to hold a very significant gas potential. The majority of this yet undiscovered gas is expected to be in the deeper and underexplored troughs of the Sirte Basin. To test these deeper parts of the Sirte Basin, Shell committed a substantial exploration work programme as part of the LNGDA. As exploration and subsequent development of these deeper targets poses various challenges which require the application of state-of-the-art technology, Shell's exploration programme comprises large volumes of 2D and 3D seismic and several wells in the blocks awarded. Seismic acquisition commenced in November 2005, ramping up to three 2D and one 3D crews by March 2006. To date, approximately 87% and 55% respectively of the 2D and 3D seismic have been acquired. In addition, Shell acquired over 70,000 line km of high resolution aeromagnetic data over the bulk of its acreage in the Sirte Basin. The prospectivity emerging from the acquired data is in line with Shell's expectations, with good imaging of deep subsurface structures that on older data were not visible. Plans are in place to spud the first exploration well in the acreage in the second half of 2007.

3.0 MARSA EL BREGA LNG

The LNGDA provides for the rejuvenation and potential upgrade on the existing LNG plant at Marsa El Brega (Figure 2). The rejuvenation aims at ensuring the long-term safe and reliable operation of the LNG plant while the upgrade (debottlenecking) focuses on enhancing the plant's operational capacity and optimising its production output.

Figure 2

Plans for the rejuvenation have been prepared by Shell with full support and commitment of the LNG plant operator, the Sirte Oil Company, with construction now planned to commence in 2007.

The LNG plant at Marsa Al Brega has never been fully rejuvenated in its 36 years of operational life. Following numerous site investigations, studies and inspections by a multi-disciplinary team of both SOC and Shell engineers and experts, some of whom have worked on the similar rejuvenation project of the Brunei LNG plant, the project scope was developed and this will form the basis for contracting and execution.

Rejuvenation Scope

The fundamental rejuvenation scope items that have been identified include:

- Blasting, painting and reinsulation of the major plant equipment.
- Overhaul of the major rotating equipment items.
- Rejuvenation of the surveyed civil structures, foundations and replacement of fireproofing.
- Reconditioning the offline boilers and make necessary improvement to the boiler feed water quality.
- Making substantial improvements to the cooling water system, which could include potential replacement.

- Refurbishment and improvement on the firewater network.
- Treatment of environmental emissions.
- Implementation of a state of the art safeguarding and DCS control system.
- Replacement of defective process equipment.

De-bottlenecking and Plant Capacity Upgrade

Anticipating that sufficient gas would be available in the future, initial plans have been developed to de-bottleneck and upgrade the Marsa El Brega LNG facility by increasing the plant capacity and availability that will enable production of approximately 3 mtpa at a heating value (HHV) specification of less than or equal to 1150 Btu/scf.

Consequent to this increase in gas production capacity, options for the expansion of the existing marine facilities and harbour were developed to allow larger LNG and LPG carriers to access the port and reduce vessel turnaround times.

Detailed scope of the Rejuvenation and Upgrade projects goes beyond the extent of this paper. However, the following section provides more details regarding three specific scope items - the installation of a new control room, the restoration of LNG storage integrity, and the treatment of environmental emissions.

3.1 Installation of New Control Room

The civil and foundation scope consists of the restoration of the existing plant civil infrastructure and the installation of a new control room and office building. The former is considered a standard plant maintenance or rejuvenation activity and relates in particular to the restoration of roads, pavements and equipment foundations. The existing civil road and pavement network is in a poor condition and in areas can present a safety hazard. Following the rejuvenation of major equipment the civil network will be restored as the final step. The repair equipment foundation is a necessary part of rejuvenation to confirm the integrity of the plant for a further 20 years.

The construction of a new control room is driven by the requirement to install a modern plant Distributed Control System (DCS). The benefit of building a new control room is that it will allow installation and testing of the new control system whilst continuing to have the plant operational and therefore not create unnecessary interruption and production downtime. The new room would permit seamless transition from the old system to the new, allowing the commissioning team to test in real time the actual DCS without disruption to operations and provide the knowledge that when the system is transferred into the live state each module is working. This should provide a flawless start up. The complexity of installing a new DCS in the existing control room whilst attempting to maintain the plant at operational status adds unnecessary risk. Noting that a typical plant trip of this nature could correlate to a potential 3 to 7 day equivalent loss of production, the construction of a new control room is considered a justifiable expenditure.

Furthermore, the new control room would be located further away from the existing plant, outside of the current blast and explosive gas radii. The existing control room is located within the third highest explosion risk and highest flammable gas explosion contour (see Figure 3 and Figure 4). In addition, no design calculations are available for the existing control room to confirm its adequacy in a blast situation.

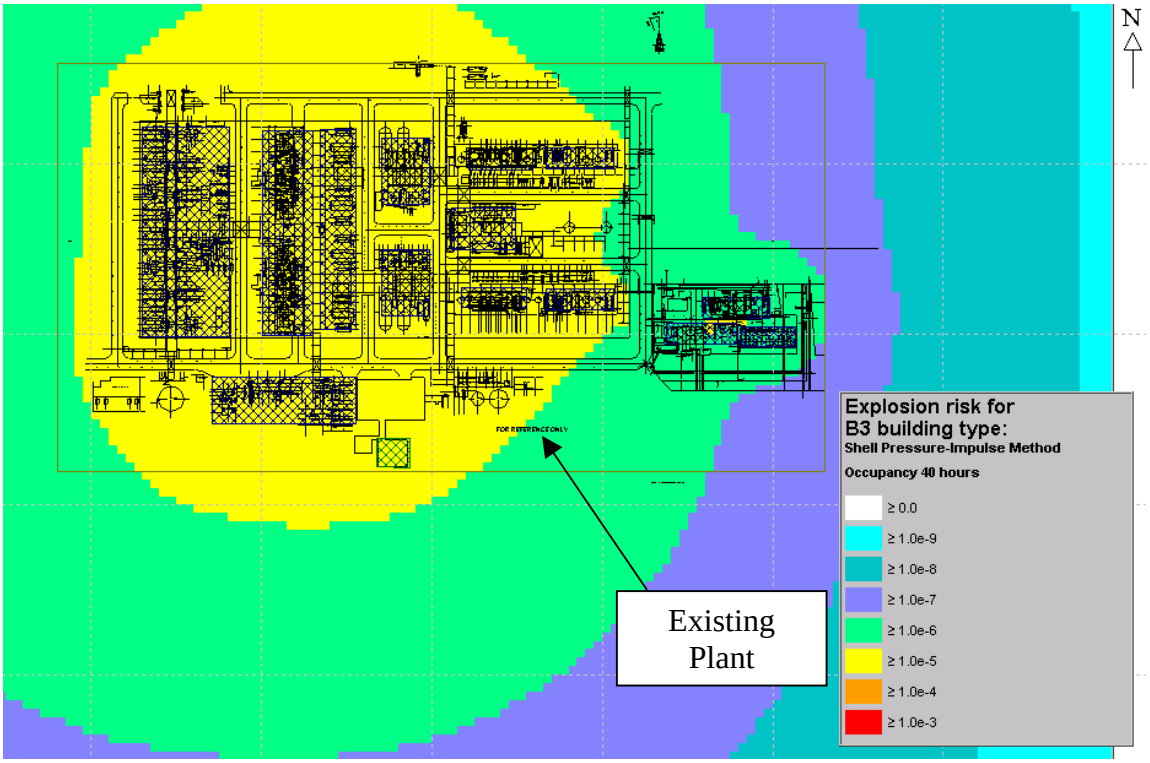

Figure 3: Explosion Risk Contour for Marsa Al Brega LNG Plant

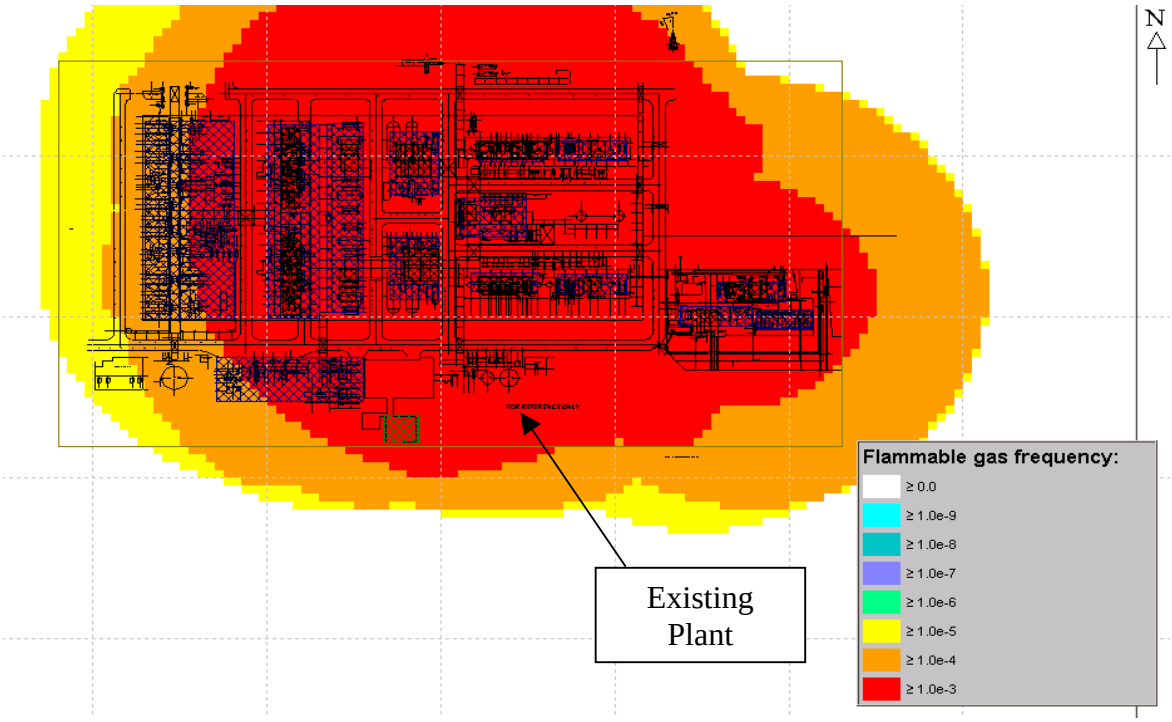

Figure 4: Flammable Gas Accumulation Frequency Contour for Marsa El Brega LNG

The additional advantage of installing a new control room would be that it is designed to the latest architectural standards, and specific design elements such as ergonomics, human factors engineering, lighting and HVAC systems can be inline with modern standards. The new control room would be designed to optimise space thus reducing its replacement cost and will be provided wit enough capacity to entertain the upgrade phase extension.

The major hazard report confirmed that the office building (old control room) would not be suitable to meet the latest applicable standards. A new office building, designed to modern standards, has been scoped based on its existing footprint.

3.2 Storage Facilities

The basic scope for all storage facilities is incorporated in the blasting and painting activities. In addition to this both LNG tanks require their base heaters to be replaced and LNG Tank (TK1200) is suffering from a cold spot. A thermal imaging survey of the tank was undertaken to assess the severity of the problem and to register if any other spots were likely to form in the near future (see Figures 5 and 6). The results from this work confirmed that the Perlite has slipped in both LNG tanks as a noticeable temperature difference was recorded at the top of the tank. However the severity of this and the isolated cold spot on TK1200 is not critical. The low side temperature reading on the outside of the tank was recorded at 15°C, which is well above the temperature required to cause brittle fracture. This offers some flexibility if the project chooses to defer this action.

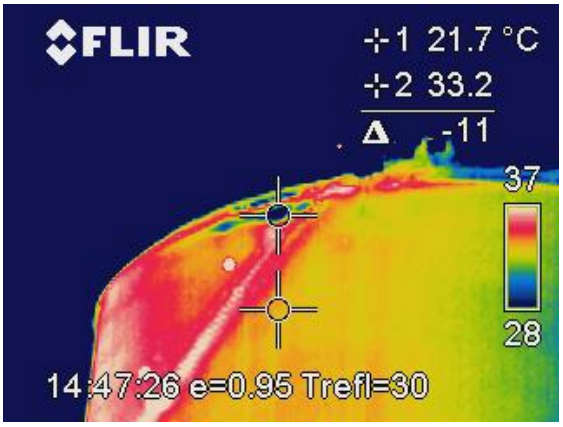

Figure 5: IR Thermal Image of LNG Cold Spot

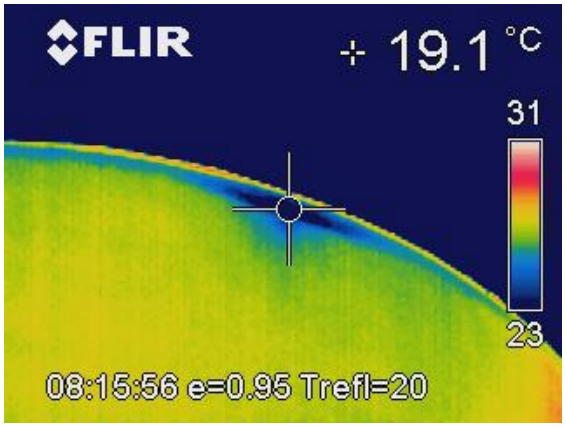

Figure 6: IR Thermal Image of LNG Cold Spot

Specialist advice from two sources[1] recommend to keep monitoring the external tank wall temperature and prepare an action plan to remediate only when the deterioration of the temperature trend becomes obvious.

As for the other LPG spheres and in order to counter the risk of LPG sphere leg failures, Shell has performed a Pulsed Eddy Current (PEC) survey technology that allows operators to assess the condition of the metal leg underneath passive fireproofing. A near

1 *Shell Affiliate and TKK*

full assessment of all four sphere's legs of the LPG storage tank at Marsa El Brega confirmed that each are in good condition and that no rejuvenation work is necessary.

The potential upgrade project has identified the potential requirement to increase the LNG and LPG storage capacity at site. The sizing of these vessels will depend on the outcome of the studies regarding the LNG production scenarios and the marine study (carrier sizing).

3.3 Environment

To lift the plant's current environmental emission levels up to current internationally accepted standards, a number of actions have been proposed during rejuvenation. These actions include:

- Installation of a spent caustic neutralisation unit. Currently spent caustic is discharged directly into the sea.
- Provision of acid gas treatment to combat Hydrogen Sulphide (H_2S) venting over the Brega region.
- Replace or modify burn pits. Burn pits are no longer considered best practice in modern oil and gas plants.
- Installation of boil off gas recovery system and storage and loading flare. The boil off gas is currently vented direct to atmosphere.
- Installation of a neutralisation pit with a controlled discharge for the process waters, particularly targeting hydrocarbon containing streams.

The environmental emission treatment options outlined below form the findings from an environmental feasibility study that was coordinated by Shell. The proposed treatment solutions are to satisfy the objective to bring the plant inline with international best practices, notwithstanding that the plant is operating in its current configuration within applicable and allowable national limits. The following section details some of the possible treatment solutions..

Boil Off Gas Emissions

The installation of a boil off gas compression system would not only reduce the present hydrocarbon emission quantity of the complete LNG plant, it would also reduce the flammable risk related to venting hydrocarbons to atmosphere. It is recommended that a new BOG compression system unit be designed to cater for the plant and the loading capacity of the present installation and the provision of additional LNG storage and loading capacity anticipated as part of the Upgrade Phase. The added benefit of installing a BOG system is that the recovered hydrocarbons in themselves have commercial value such that the cost of implementing this system is recoverable.

The project scope comprises three elements:

1. A centrifugal compressor, current proposal is electric driven.
2. A suction drum consisting of a vertical knock out drum with demister mat, liquid distribution spider and a 2,000 mm packed bed filled with 50 mm Pall rings.
3. A submersible LNG return pump with spare.

Gaseous Emission of Hydrogen Sulphide

The present operational mode to send the separated mixed Hydrogen Sulphide (H_2S) and Carbon Dioxide (CO_2) gas stream from the LNG feed to flare is considered inadequate to meet present international Health, Safety and Environment (HSE) standards and guidelines, as incomplete combustion takes place. It is proposed to separate the CO_2 from the H_2S resulting in an enriched acid gas prior to the sulphur treatment. For this approach two distinct treatment options have been identified:

1. Superclaus SRU is a thermal oxidation reactor combined with a catalytic conversion process.
2. Thiopaq is a biological oxidation process.

Burn pits

The existing burn pit configuration presents a major health and environmental concern with respect to the creation of the heavy black clouds of smoke caused by incomplete oxidisation of the hydrocarbons. To overcome this the installation of a smokeless ground flare is required. Since the present feed of the ground flare contains water, the installation of a separator unit may be necessary to ensure the proper separation and therefore function of the smokeless ground flare system.

The system proposed consists of a collection vessel that allows phase separation between the gas, oil and water mixtures. From here the gas is vented to the flare stacks, the oil is routed to the smokeless ground flare located in a newly installed burn pit and the water is routed to the process water discharge system.

The design will connect the three plant burn pits (storage and loading, LNG plant and slug catcher) into one central location adjacent to the existing LNG plant pit. The slug catcher system, with associated vessels, does have a feed stream that contains waxy compounds. All piping systems will likely contain similar compounds and therefore shall be heat-traced to avoid potential plugging problems. Further evaluation is planned to assess whether it would be more cost effective to install a dedicated smokeless ground flare for the slug catcher burn pit versus the option of trace heating a line from the burn pit 1.5kms apart.

Environment, Social and Health Impact Assessment

An integrated Environmental, Social and Health Impact Assessment (ESHIA) was conducted by ERM, an international consultancy, working in close collaboration with a well-established local environmental consulting company, Akakus. Active engagement and capacity building of the local consultancy was an essential component of the project. This type of integrated ESHIA is the first of its kind in Libya, and therefore offered many challenges, which have led to interesting stakeholder discussions, relationships and knowledge transfer.

The LNG plant is positioned within a larger industrial and residential complex, which meant that it was important to ensure that the LNG plant’s environmental, social and health components were not assessed in isolation. The objectives of the ESHIA were to establish an environmental, social and health baseline to assess the effect of the LNG

rejuvenation activities; to identify the potential changes arising from the LNG rejuvenation project (eg. influx of workers, creation of waste) and recommend mitigation measures for identified impacts (eg. construction camp management, code of conduct for workers, waste disposal plan); to engage with stakeholders regarding the environmental, social and health issues associated with the LNG rejuvenation project and potential future plant development (eg. upgrade phase); and to obtain approval from the Libyan Environmental General Authority for the LNG rejuvenation project to proceed. A further objective was to identify where procedures, systems or structures could be put in place to build on existing environmental, social and health provisions at the LNG plant.

Conducting the ESHIA consisted of three phases. Firstly a scoping exercise was conducted at the onset of the project to ensure alignment between the technical developments and to provide focus on significant environmental, health and social issues. The scoping exercise consisted of a desktop study, a site visit and a scoping workshop that included an issue and stakeholder identification session.

The objectives of the scoping workshop were to detail the timeline, roles and responsibilities, and identify the environmental, social and health data requirements. In the workshop the environmental, social and health sources were identified and a gap analysis was performed to inform the scope for the baseline data surveys. Another key component of the workshop was the identification of the stakeholders for the LNG rejuvenation project and to understand their roles and interest within it. Subsequent to this a stakeholder engagement plan was developed. The key stakeholders identified for the baseline phase were various departments of SOC (including loss prevention, employee relations, the clinics and marine division), NOC, the Environmental General Authority and Secretaries of the Local Community Council.

The final deliverable from this phase was a scoping report that detailed the scope of work, baseline studies required, list of identified stakeholders and a stakeholder engagement plan.

The output of the scoping report identified the following key issues for the rejuvenation project; waste, employment, utilities, soil contamination, sea and groundwater quality, air quality and traffic.

A legislation and standards document was also produced identifying all applicable Libyan legislative requirements, as well as providing a detailed comparison against International and European conventions that Libya subscribes to. This document has been used to ensure that the rejuvenation project and the mitigation plans are developed in line with the national requirements, as well as international best practice.

The second phase was collecting and analysing the baseline data. The following surveys were conducted; environmental due diligence, soil and groundwater sampling, air quality sampling, noise monitoring, terrestrial and coastal survey, near shore marine water quality and benthic, and health and social data collection. The full collaboration and active support of SOC was essential in completing these baselines.

The third phase was developing the mitigation plans, by identifying the potential impacts that the rejuvenation project will have on the environment, community and health, evaluating their importance or significance and identifying ways of minimising

the negative or maximising the positive predicted impact. Clear and practical recommendations will be taken up into the engineering design, project specifications, and be incorporated into the invitation to tender documents for the contractors. The main plans that have been proposed include a Community Relations and Impact Management Plan, Worker Management Plan, Camp Siting, Installation and Removal Plan, Traffic Management Plan, Waste Management Plan, Pollution Prevention and Counter Control Plan, Ecological Protection Plan, Archaeology and Cultural Heritage Protection Plan, Contingency Plan for Unforeseen Events and Emergency Response

In addition, as the LNG plant is positioned within a larger industrial and residential complex, the ESHIA will also act as a guidance for the long-term improvement of the overall environmental, social and health performance of the LNG plant and the wider SOC complex.

4.0 NEW LNG

The LNGDA also provides provisions for Shell and NOC to jointly develop a new LNG plant that would commercialise gas discoveries that are in excess of domestic needs and the requirements of the upgraded Marsa Al Brega plant. These gas discoveries could be either in Shell's awarded acreage, or in acreage held by other parties in Libya.

Shell and NOC demonstrated their strong confidence in the significant potential for future gas discoveries in Libya by early commencement on the feasibility of the new LNG plant, ahead of any firm gas supply commitments to the plant. New LNG would enable access to a diversified range of target export markets and give Libya the opportunity to claim a leading role in the growing global LNG industry.

4.1 Location

In 2006, Shell and NOC completed a selection study on a number of potential sites within Libya. The selection process was based on a number of criteria, namely cost differential, safety, schedule impact, social impact and environmental impact. These criteria have been developed through Shell's experiences in developing a number of Greenfield projects in countries such as Oman, Qatar and Nigeria.

At the conclusion of the studies, Shell made the recommendation to NOC to develop the new LNG plant at the existing Ras Lanuf Complex. (see Figure 7). The Ras Lanuf Complex consists of a refinery, ethylene plant, utilities plant and a harbour for loading vessels for product export. The complex is operated and maintained by the Ras Lanuf Oil & Gas Processing Company (RASCO).

Figure 7

Some of the key reasons for the recommendation of this complex for LNG development include excellent marine infrastructure, availability of land, the integration opportunities with existing infrastructure, and the residential town some 20 kilometres to the West of the industrial site. In addition, an area sufficient in size to accommodate a five train LNG facility is available that will allow for any future expansion of the plant. The existing port facilities are suitable to accommodate very large LNG carriers (>200,000 cm). This is due to the presence of existing breakwaters providing shelter against waves and currents and adequate manoeuvring space in port approach and basin.

Figure 8 provides an overview of the suggested plot plan for New LNG.

Figure 8

4.2 Technology

A feasibility study for the development was also completed by Shell. The study identified a train size of 4 to 5 mtpa as being technically optimal, and would fit well into the gas supply profile that is expected to be available to the plant from future discoveries. The train design under consideration is based on Shell's Propane/Mixed Refrigerant technology, which is similar to the technology used in other projects where Shell is involved. This technology is built around well-proven equipment packages – in particular the robust Frame 7 gas turbine drivers in the main refrigeration cycles. This application of only proven equipment avoids step-changes in technology and associated scale-up risks, which will be essential to ensure the reliable operation of the LNG plant. Figure 9 provides an overview of the overall envisaged process flow for the plant facilities.

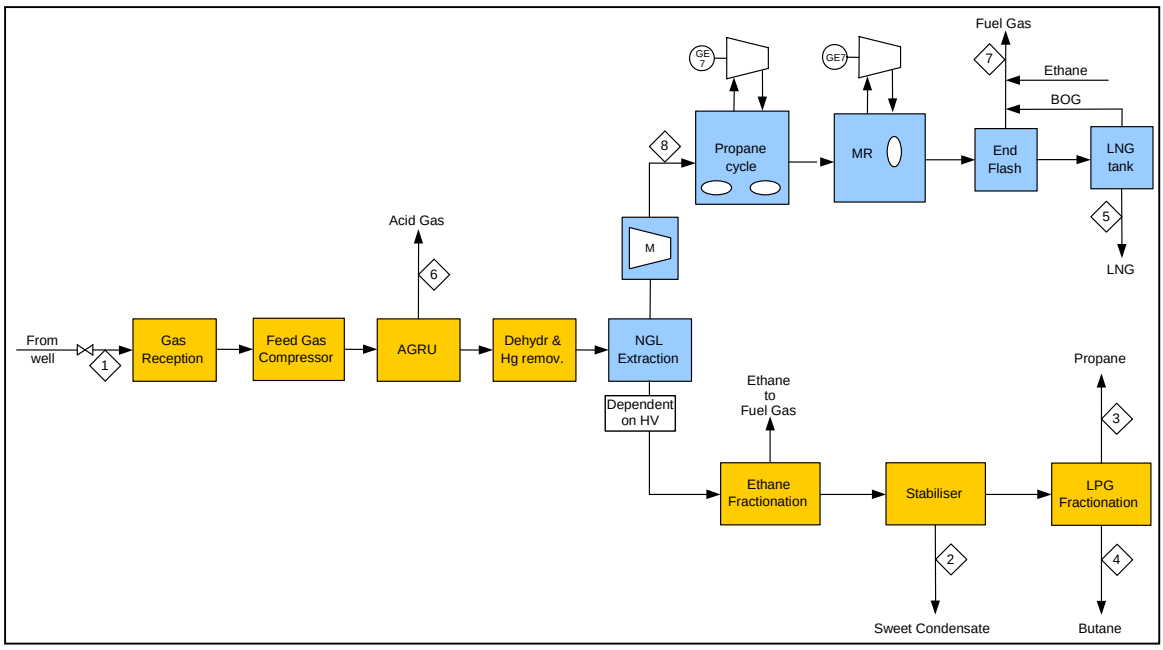

Figure 9

4.3 Marketing

Preferred LNG markets for Mediterranean suppliers tend to be the Atlantic Basin, due mainly to geographical proximity and the expense associated with taking cargoes through the Suez Canal. Based on a review of Atlantic Basin markets growth expectations, potential return and development of LNG receiving capacity, the prime markets for the new Libya LNG project are the United States and Southern Europe. South Africa, the United Kingdom, India and the Far East could also be considered. In determining the final project market mix, a number of objectives will need to be considered including returns, demand and customer robustness and the potential to support sales of sufficient term to ensure the project can be financed. Diversified locations and/or sales sectors are also important (ie. industrial & commercial, power and domestic sales). The final allocations to the markets above will be a function of train size and shipping optimisation to minimise costs while maximising return.

4.4 Economic Impact

When examining the increase in the level of industry in any country or region, the potential benefit to the overall economy can be a positive factor for the country. While a new LNG plant might create jobs in the construction and operation phases, it can also create service industries and employment through the need to supply the plant and its workforce. Shell wanted to test the flow-on effects that building a new LNG plant would have on the Libyan economy and in mid 2006 it requested Booz Allen Hamilton, a global strategy and technology consulting firm, to assess the impact of Shell's proposal for a Greenfield LNG plant. Booz Allen Hamilton consequently developed an economic multiplier model that quantifies the project's potential impact on Libyan Gross Domestic Product (GDP) and job creation.

Booz Allen Hamilton's model is based on the spending/income multiplier theory associated with Keynesian economics and assesses the direct, indirect and induced impact

of the proposed investment on Libyan GDP. The direct impact refers to the initial spent in the country net of imported goods and services. The indirect impact measures the incremental output generated through local procurement in the Libyan supply chain. The induced impact is the additional output generated through the share of income workers and suppliers spend in the Libyan non-hydrocarbon economy. The ratio of direct impact over total impact is referred to as the multiplier effect and represents the ability of the Libyan economy to generate output in the wider economy from an initial investment in the hydrocarbon sector.

Figure 10 illustrates an overview of Booz Allen Hamilton's economic model. The green arrows indicate flows that enhance GDP growth while that red arrows highlight leakages out of the economy that diminish the multiplier effect.

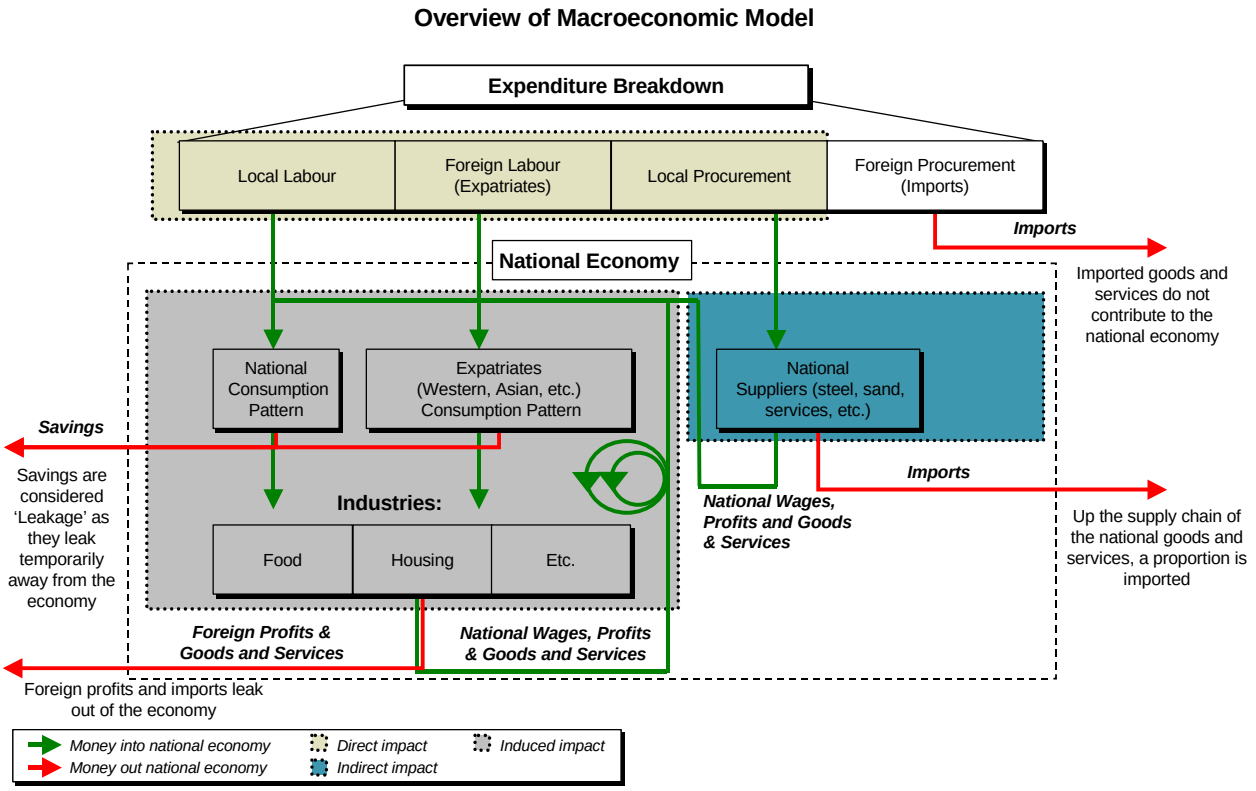

Figure 10

Case studies from existing LNG developments in Oman, Russia and Nigeria are used to assess Shell's LNG global experience and capture learnings from good practice in other countries.

The study concludes by assessing Shell's investment programme against Booz Allen Hamilton's view of Libya's economic priorities and provides specific recommendations to optimise project development going forward.

5.0 Conclusion

Libya is now well positioned to move forward as being a key supplier of natural gas to the energy-thirsty world. Its natural location with a Mediterranean coastline means that export ability to Europe and the United States, amongst others, is particularly strong. It is

already part of the international gas market through LNG export from Marsa El Brega and the development of the Greenstream Gas Pipeline that is delivering important gas supply to Europe through an offshore pipeline crossing the Mediterranean and linking the West of Libya to Sicily.

The signing of the LNG Development Agreement with Shell in May 2005 provided Libya with a solid platform on which to build its LNG capabilities and to 'catch up' with its neighbours Egypt and Algeria in supplying the growing Atlantic Basin marketplace.

More than three decade ago, the government identified the potential opportunities to monetise Libya's large reserves of natural gas, secure long-term foreign revenue streams and help to meet global energy demand. The nation now has another opportunity to pursue that vision and within a decade, Libya has the potential to become one of the top ten LNG producers in the world. However, this vision sits atop a mountain that is long and steep. The ascent has already commenced and is gaining pace with the rejuvenation of the existing Marsa El Brega LNG plant, but there are many technical, structural and environmental challenges to be met. More challenges lie ahead though with a phased multi-train Greenfield LNG development that is underpinned by gas exploration success in the Sirte Basin. But as partners, NOC and Shell have already developed the teamwork, confidence and respect that will drive this vision upwards.