FINAL REPORT R1
FUEL AVAILABILITY AND OPPORTUNITIES FOR COST REDUCTION

Client: **The World Bank Group**

Project: ***Libya: Supporting Electricity Sector Reform (PI54606) Task B – Consultancy Services***

Subject: **FUEL AVAILABILITY & OPPORTUNITIES FOR COST REDUCTION REPORT**

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EXECUTIVE SUMMARY

The present document constitutes the “Fuel Availability and Opportunities for Cost Reduction Report” included in Task B, which objective is to study potential options to reduce power generation costs and greenhouse gas emissions while increasing the reliability of the system[1]. This Report has been developed to provide a guideline into the LNG Options Report by identifying the areas for future investment to best meet the needs for demand growth and fuel distribution as economically as possible subject to technical viability that will be addressed in the LNG Options Report.

Libya is located in northern Africa, bordering the Mediterranean Sea, and has a population of around 6.6 million (2017). In 2016, it ranked as the third largest oil producer (i.e. 626mb/d) in North Africa (after Algeria: 1,579mb/d and Egypt: 691mb/d). Its total primary energy consumption is entirely based on fossil fuels. The outlook for the coming years indicates that demand for fuels would probably grow driven by power generation. Since the latter could have a strong impact on the country financial situation it should be properly and timely addressed.

In this regard, the World Bank has contracted Tractebel-ECS-TAQA consortium to undertake the Task-B. “Natural Gas Availability, Cost Reduction and LNG Import Options” Study, as part of the Project “Libya: Electricity Sector Reform Technical Assistance”.

The objective of this Report is to describe the assessment undertaken on the natural gas and electricity markets in order to determine potential options to reduce both the power generation costs and the greenhouse gas emissions while improving the reliability of the power system by increasing the natural gas availability. It has been developed to provide a guideline into the LNG Options Report.

The General Electric Company of Libya (GECOL) and the National Oil Corporation (NOC) are the state-owned companies in charge of running the power system and the oil and gas operations within the country, respectively. This study would provide them valuable insights and data that could be used as a basis for the preparation of their plans for energy cost reduction, increased efficiency, and energy market reform.

While Libya is endowed with significant natural gas reserves, current production is below its historical levels. In fact, in 2016 Libya’s natural gas proved reserves attained 53 TCF (see ‘BP Statistic Review of World Energy 2017’). However, according to local assessments this value could go up to over 70 TCF. Natural gas production during the same year averaged ~2100 mmscf/d; almost 40% lower than 2010. Approximately 720 mmscf/d of natural gas was used at the upstream level (oil operations, injections, flaring, etc.); while the remaining was injected into the gas system.

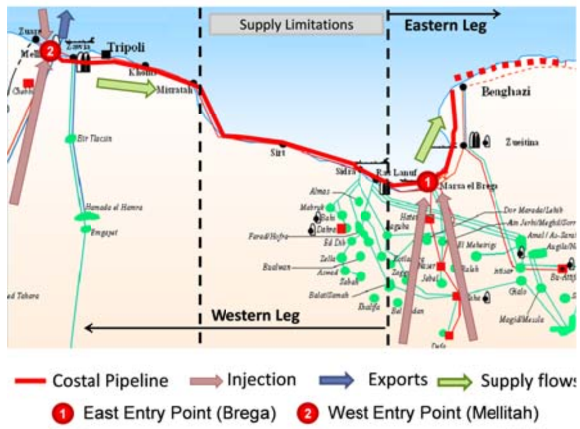
The existing Libyan gas transportation infrastructure connects the main cities to the gas production areas along a gas-pipeline system. There are two distinctive gas network areas connected by the Coastal Pipeline. However, due to compression and supply limitations, these areas operate as separate entities. Gas flows from West to East up to Misurata city where the system experiences a pressure constraint; while from East to

[1] It is worth noting that this report comprises a preliminary valuation of the alternatives.

West gas flows up to the Raf Lanuf complex due to supply restrictions (see the two vertical, dotted lines on the map.)

Around 60% of the available (after upstream uses) natural gas is injected into the local gas system while the remaining 40%[2] is exported to Italy via the Greenstream pipeline, which departs from the Mellitah complex.

Natural Gas Flows



Power plants represent the main natural gas consumer and would be the driver for its demand growth. Although over the last years, natural gas has been increasing its penetration into the generation mix (going from 37% in 2010 to 74% in 2016); hence contributing to reducing the generation costs, there is still room for improvements. Based on preliminary estimations, Libya could have saved approximately 200 MUSD only in liquid fuels during 2016[3].

According to the most recent projections, electricity demand is expected to keep on growing in coming years. Depending on the various scenarios, growth rates could go from ~5% to ~8% (CAGR) until 2030, reaching circa 60 TWh to 80 TWh. On the contrary, natural gas production projections show that availability will increase in the short term but start to fall after 2020 (overall, CAGR rate would decrease at -2%).

As a result of these projections, it could be expected that under current conditions the system operation would be tight and liquid fuels would be largely required. These significant amounts of liquid fuels would probably be imported (or prevented to be exported, should them be locally produced), resulting in significant costs for the country (between 3.8 and 4.7 BUSD/year in average).

Given this situation, the Consultant assessed four different alternatives to increase natural gas availability for the power generation system (by modelling both the electricity dispatch and the natural gas flow) as part of the exercise to help determine the final optimum solution as defined in the later LNG Options Report:

[2] Due to the increase in the domestic natural gas requirements and fall in production, NOC has managed to negotiate with ENI a reduction of exports to almost half (in 2016).

[3] Assuming the replacement of liquid fuels for LNG, but without taking into account the new infrastructure requirements for so doing.

A- Devoting all the local gas production to the power generation system by expanding[4] the Coastal Pipeline gas system and reducing gas exports when necessary.

B- Converting the existing on-shore liquefaction terminal located on Marsa El-Brega to a regasification terminal, and expanding the Coastal Pipeline.

C- Constructing an off-shore regasification terminal (FSRU) next to Khoms and expanding the natural gas transportation system.

D- Constructing an off-shore regasification terminal (FSRU) to connect directly to the most efficient power plants located in the West (rather than connecting to the existing Coastal Pipeline).

In order to compare the different alternatives and determine the possible savings of using the optimal fuel, total power generation fuel costs were estimated based on:

i) The investment and operational costs - CAPEX and OPEX - of the new infrastructure, that is, regasification terminals and transport capacity expansion; and

ii) The fuel prices.

The results indicate that, in the short term, reducing the exports to Italy and increasing the Coastal Pipeline capacity is a good immediate solution to reduce liquid fuels[5] consumption for power generation. However, in the mid- to long-term this solution proves short to offset the fall in local gas production. Thus, this alternative does not result in being the alternative with the largest saving.

In the mid-term (from 2020 to 2028), replacing liquid fuels by LNG would deliver the higher savings in generation costs, although the required expansion in existing transportation and import infrastructure would reduce the savings. Given that, on one hand, the greater fall in natural gas production will be observed in the West, where a large part of the most efficient power plants are located; and, on the other hand, the Mellitah – El Khoms pipeline has the largest capacity, the most economical alternative is to place the LNG import terminal(s) in the West somewhere around Khoms. Total savings under this alternative have a net present value (@10% discount rate) of 8 to 10.5 BUSD depending on the electricity scenario

In the long term (after 2028), the country could either move forward with an onshore terminal or end LNG imports depending on the evolution in the natural gas exploration and exploitation. The decision would need to be taken around mid-´20s

[4] In this report expanding the pipeline could either be additional compression or loops not new pipeline trenches. In the LNG Option Report the most appropriate solution for expanding the pipeline to meet demand will be studied.
[5] NOC is already partially implementing this solution.

1. INTRODUCTION

The World Bank Group has provided a Terms of Reference document outlining the key requirements for the provision of consulting services for Selection # 1227307/ Libya: Supporting Electricity Sector Reform (P154606) - Task-B. Fuel (Natural Gas) Availability, Cost Reduction and LNG Import Options Study.

The study will provide data to both GECOL and NOC that could be used as a basis for the preparation of their plan for energy cost reduction, increased efficiency and energy market reform in Libya.

The present document constitutes the "Fuel Availability and Opportunities for Cost Reduction Report" included in Task B. The objective of this Report is to review the natural gas and electricity markets to determine potential options to reduce power generation costs and greenhouse gas emissions while increasing the reliability of the system through the increase of natural gas availability. It is worth noting that this report comprises a preliminary valuation of the alternatives.

This Report has been developed to provide a guideline into the LNG Options Report by identifying the areas for future investment to best meet the needs for demand growth and fuel distribution as economically as possible subject to technical viability that will be addressed in the next report (LNG Options).

This Report is based on the discussions that took place during the meeting (held in Tunis in February, May and October) and the subsequent information provided by GECOL and NOC. Additionally, the base line data / assumptions for the electricity sector forecast was established in the Sector Rapid Assessment and further analysis conducted by Task A consultant: PwC[6]

Further technical detail information regarding the characteristics and possibility to expand transportation system and connection of existing and future power plants as well as the possible LNG terminal locations, is covered in the second report of Task B, "LNG Import Options" Report

[6] In addition to Task B: "Fuel (Natural Gas) Availability, Cost Reduction and LNG Import Options Study" the World Bank is undertaking three other assignments / tasks, at the same time, to support the country's electricity reform.

2. COUNTRY OVERVIEW

Libya is located in northern Africa, bordering the Mediterranean Sea, and has a population of around 6.6 million (CIA World Factbook, 2017).

The largest city and capital, Tripoli, is located in western Libya and contains over a sixth of Libya's population. The other large city is Benghazi, located in eastern Libya.

Libya is considered an upper middle income country. However, its economy is one of the smallest in Africa and depends mainly on the oil and gas (O&G) sector, which accounts for 60-80% of total GDP and about 95% of total fiscal revenues and exports.

During the last years, political instability and the drop of oil prices have affected the country’s economy in general and the energy sectors in particular. However, the economic and social outlook could be auspicious.

Libya is the largest oil producer in North Africa. Total primary energy consumption and installed capacity is 100% based on fossil fuels. Recently, natural gas has been increasing its share in the energy matrix. The outlook for the coming years indicates that it could continue to grow mainly driven by power generation. Thus, Libya would require an increase in natural gas production and/or imports, as well as a boost in infrastructure investments.

2.1. ENERGY INSTITUTIONAL FRAMEWORK.

There is no official regulatory authority in place in Libya today and energy markets are run by the National Oil Corporation – NOC – and the General Electricity Company of Libya - GECOL.

In the O&G sector, NOC, established in 1970, is the main company and is in charge of exploration, production, transportation and commercialization of O&G. NOC carries out its activities through its own affiliated companies or in association with international companies, such as ENI, Wintershall and Repsol, among others. NOC owns but does not operate refining and O&G processing companies - such as Zawia (northeast) and Ras Lanuf (north centre) - ammonia, urea and methanol plants; the Ras Lanuf petrochemical complex and the gas processing plant.

In 2007 the General Gas Transmission and Distribution Company - GGT&D was created with the objective of separating upstream from downstream activities. It is specialized in the construction and management of the natural gas distribution network.

In regards to the electricity sector, GECOL was established based on the law number 17 in the year 1984. It is the only vertically-integrated power utility, hence responsible for not only the generation, transmission and distribution of electricity, but also the planning, development, O&M and dispatch of the power system. In addition to GECOL, there are nine other companies; most of them controlled by GECOL, involved in the market mainly as service providers.

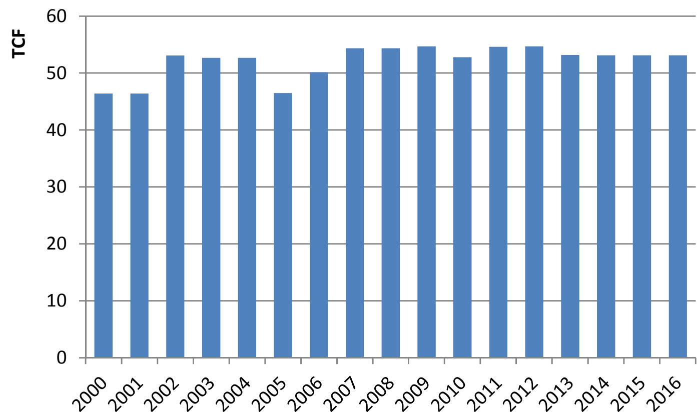
In addition, the development and implementation of renewable projects is carried out by the Renewable Energy Authority of Libya – REAOL.

2.2. NATURAL GAS MARKET

2.2.1. Upstream:

According to the BP Statistic Review of World Energy, in 2016 Libya's total proved reserves were 53.1 TCF. However, according to local assessments this value could go up to 70 TCF. Production in 2016 reached around ~2120 mmscf/d of which ~960 mmscf/d was injected for domestic consumption (the remaining was used in upstream or exported).

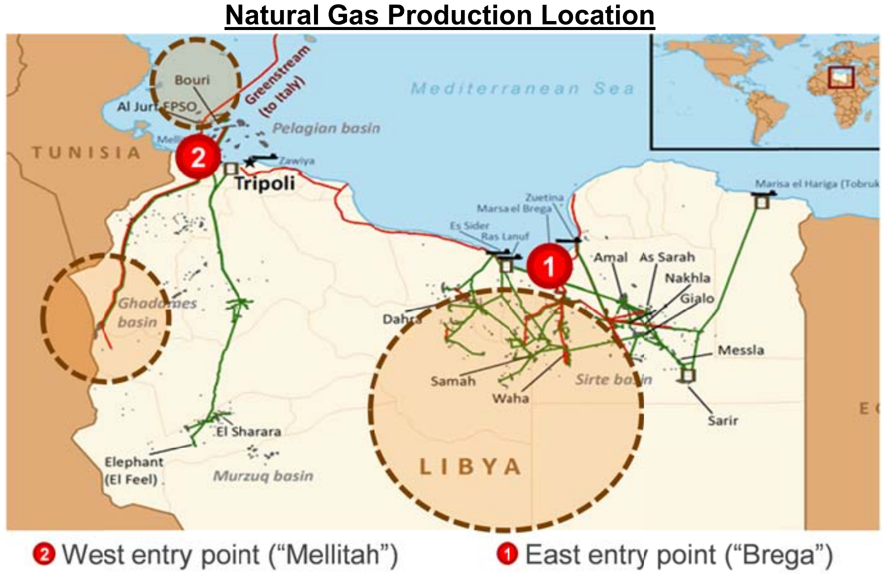
Libya's Natural Gas Reserves [2000-2016]



Source: BP Statistic Review of World Energy 2017

Most of the natural gas production comes from three basins: in the West; Ghadamis (where the prolific Al Wafaa onshore field is located), and Sabratah (where offshore Bahr Essalam and Bouri fields are located) basins; in the East, the Sirte basin contains several associated and non-associated onshore fields (e.g. Zahrah-Hufrah, Sabah, Raquba, Nasser, Sarir, Sahel, Hateba, Esteklal, Alrada, etc.).

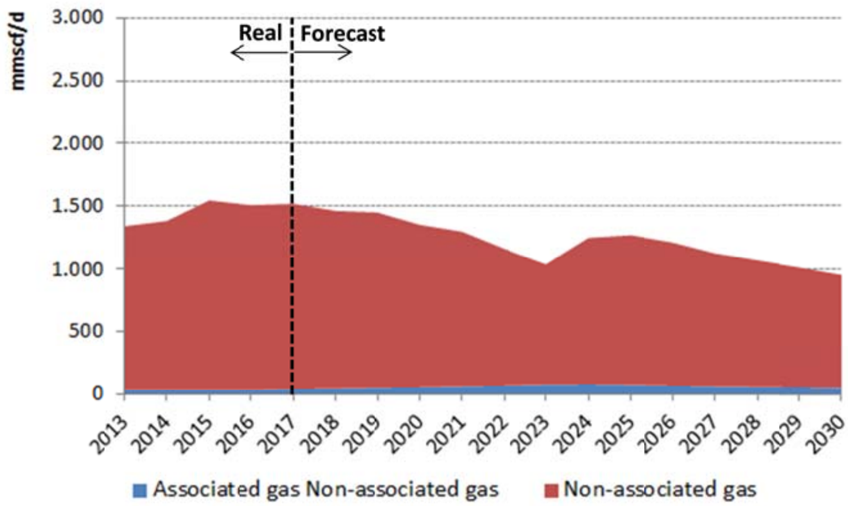
Natural Gas Production Location



Source: US Energy Information Administration

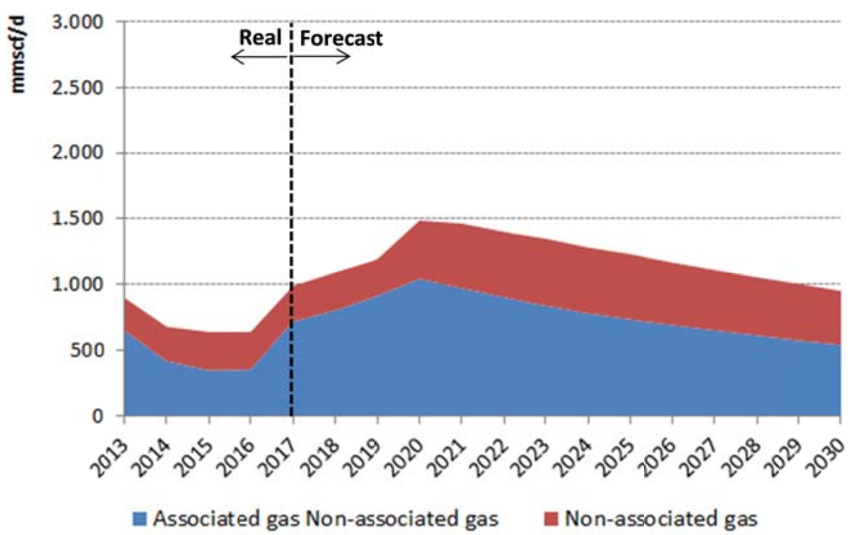
The Western natural gas production accesses the transportation system through an Entry Point referred to as “Millitah” while the Eastern production does it through “Brega” Entry Point. The natural gas production entering each point for the forecast period of 2017 – 2030 is shown in the following graphs construed on the basis of the information provided by NOC[7].

Western Natural Gas Production Forecast [2017-2030]



Source: Own elaboration based on NOC

Eastern Natural Gas Production Forecast [2017-2030]

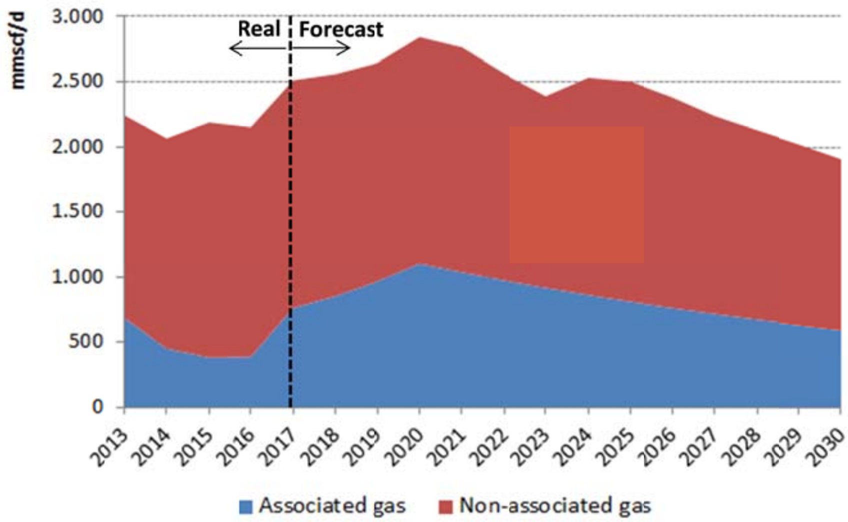


Source: Own elaboration based on NOC

Thus, the overall Libyan gas production is depicted in the graph below and entails a CAGR of -2.3% over the forecast period:

[7] Note that this is total gas produced and includes gas used in the upstream.

Libyan Natural Gas Production Forecast [2013-2030]



Source: Own elaboration based on NOC

As indicated by NOC, this forecast is a conservative estimation of gas production based on:

- The continuation of the on-going development of on-shore gas fields of Sirte Oil;
- The completion of stage two development of on-shore El-Fareg gas field (by 2020); and,
- The second stage development of off-shore of Bahr Assalam field and developing structures A & E (by 2023).

This projection assumes that there is enough stability and security in Libya in order to allow the return of international contractors and service companies and that required funds are available.

It is worth noting that over the last decade there have been no significant investments in exploration and exploitation. Taking into account the actual condition of existing facilities, the number of new wells to be drilled and the construction of new facilities to process the new volume, the successful development of the gas fields would require at least 8 or 9 years, even with unlimited access to investment. Furthermore, OPEC has estimated in its Monthly Oil Market Report of August 2017, that there is only one oil-rig available in Libya. Thus, in addition to the exploration and exploitation the country would need to get hold of significant amount of equipments in order to revert the falling trend in the gas production in the long term.

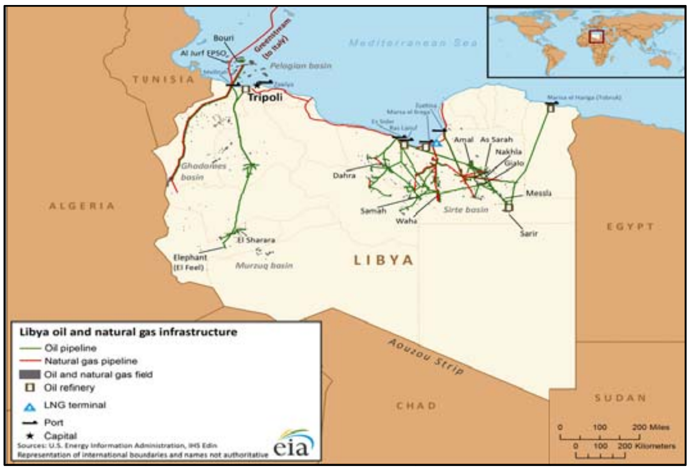
Based on rough estimations, in order to meet gas demand by the end of the period investments should be at least 4.000/5.000 MUSD[8] if production is successful.

[8] This estimation assumes a conservative Finding & Development Cost of 2 USD/mcf. These costs refer to the resources required to locate a new O&G reservoir and the expenses of exploiting it throughout the lifecycle of the reserve.

2.2.2. Midstream:

The existing Libyan gas transportation infrastructure connects the main cities to the gas production areas along a total gas-pipeline system length of 5,080 km. There are two distinctive gas network areas: East & West. These areas are connected by the 34" Coastal Pipeline system with a total longitude of ~1,120 km.

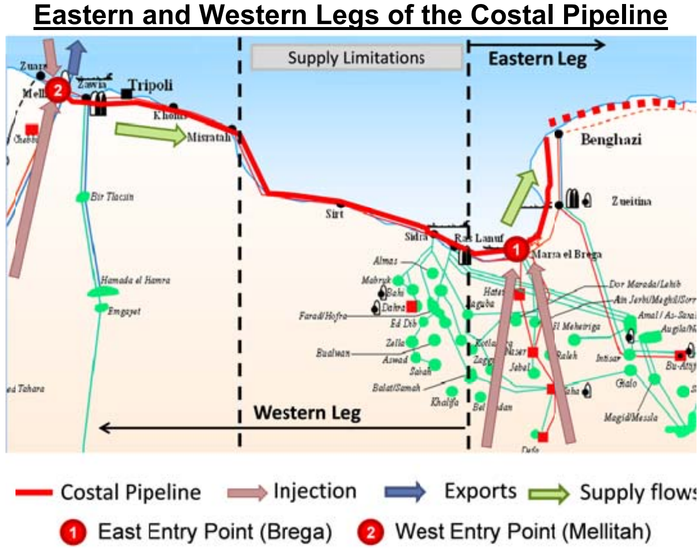
Libya's Natural Gas Pipelines



Source: US Energy Information Administration

The eastern section of the pipeline comprises a section that stretches 246 km from Marsa El Brega (the East Entry Point) to Benghazi and was designed to transport around 410 mmscf/d towards Benghazi. There has been consideration for extending this Coastal pipeline further east in order to reach the cities of Derna and Tobruk. However given the expected demand in these cities it would not be economically viable to extend the pipeline[9].

Eastern and Western Legs of the Costal Pipeline



Source: NOC

[9] See Annex: "7.2 Preliminary Analysis on Tobruk".

The western section of the pipeline spans 871 km from Mellitah (the West Entry Point) to Marsa El Brega. Two trenches of the pipeline can be identified:

- From Mellitah to Tripoli and then to Khoms (222 km) with a nominal capacity of around 600 mmscf/d. It is worth noting that NOC is undergoing an upgrade to increase injection capacity at Mellitah in around 150 mmscf/d.
- From Brega to Khoms (645 km) with a capacity of ~370 mmscf/d.

Currently, gas flows to Mellitah treatment plant from southern onshore Al Wafaa field and northern offshore fields (Bahr Assalam, etc.). Hence, the natural gas injected at Mellitah runs to the East supplying power plants and industrial consumers as it is transported to Misurata city where the system experiences pressure constraints. Gas flows could go from Marsa El Brega (the East Entry Point) to the West, however due to supply restrictions, injection in this direction only reachs the Raf Lanuf complex. In the near future, according to NOC supply projections, as gas available in the East Entry Point would be larger than in recent years, higher flows to the West could be expected.

The gas transmission pipeline was designed to handle a relatively low pressure: 780 psig (i.e. circa 53 bar). Such a low pressure reduces the operational flexibility across the network, specifically the ability to interconnect the East to West systems and vice versa. As a result, there is not one single gas system, but two; operating as separate entities.

The pipeline network is not optimised to help maintain flow pressure (for instance, the connection pipelines to the power plants are considered too large: 34” diameter). This lack of optimisation is also due to the above-mentioned low operating pressure of the system that allows almost no flexibility.

2.2.3. Downstream:

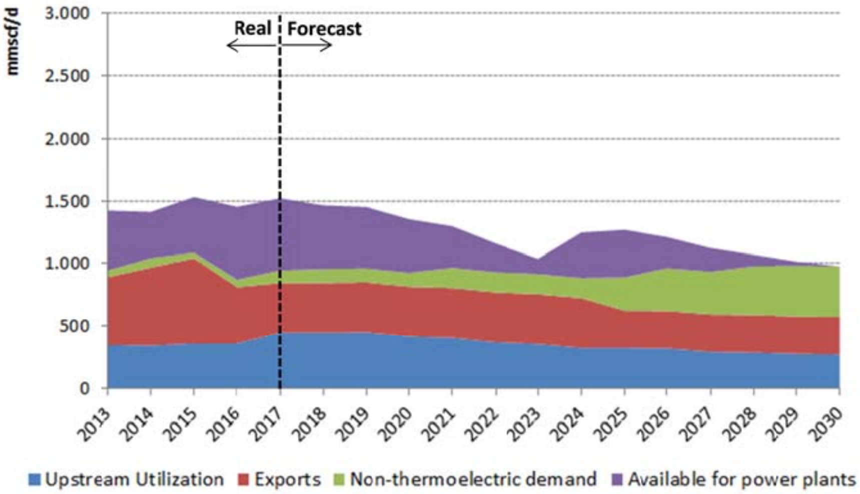
Over the last few years, around 60% of the local available gas supply[10] has been consumed domestically, mainly by the power sector (~80%)[11] and industries (~20%).

The remaining 40% is exported to Italy via the Greenstream pipeline, which departs from Mellitah treatment plant. Through a joint venture with the NOC, ENI has had a 25 year contract since October 2004, to export 60% of the gas produced by Mellitah Oil & Gas. However, due to the increase in the gas requirements for power generation and fall in production, NOC has managed to negotiate with ENI and reduce the amount of gas being exported from its original 800 mmscf/d to around 450 mmscf/d (in 2016).

Based on information provided by NOC, the Libyan natural gas available for power generation and demand for other uses (for the period 2017 to 2030) would evolve as shown in the graphs below[12]. Given the characteristics of the Libyan transportation system referred to above, it is key to understand the gas demand patterns geographically disaggregated by both, the West and East sections, in order to be able to produce meaningful natural gas supply/demand balances and requirements of pipeline expansion.

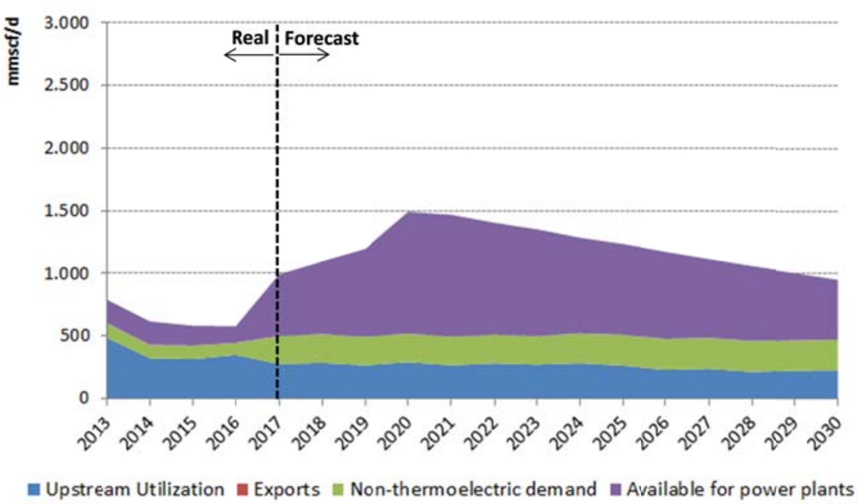
[10] Approximately 720 mmscf/d of natural gas is used at the upstream level (oil operations, injections, flaring, etc.).
[11] See the following section for the Power Sector details.
[12] Gas available considers that power generation has lower priority than upstream, exports and non-thermoelectric demand. And additional analysis with adjusted priorities has been included in Annex 7.3.

Gas Available for different uses Forecast at the West [2013-2030]



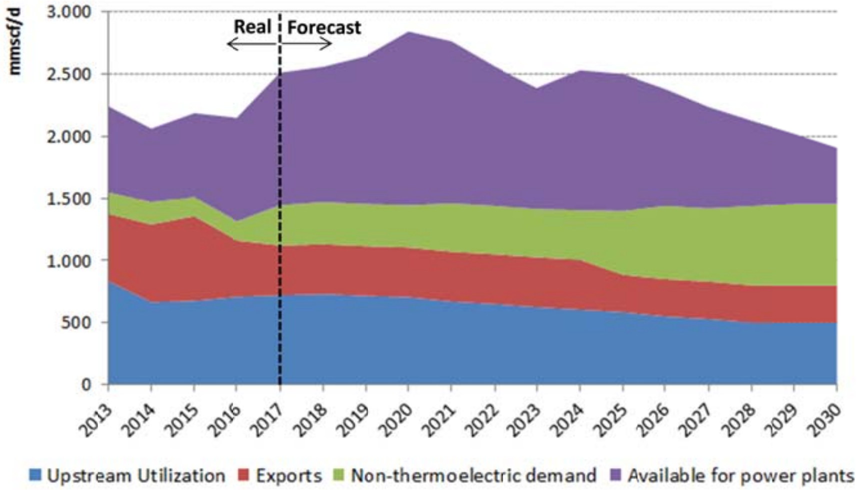
Source: Own elaboration based on NOC

Gas Available for Different Uses Forecast at the East [2013-2030]



Source: Own elaboration based on NOC

Libyan Gas Available for Different Uses Forecast
[2013-2030]



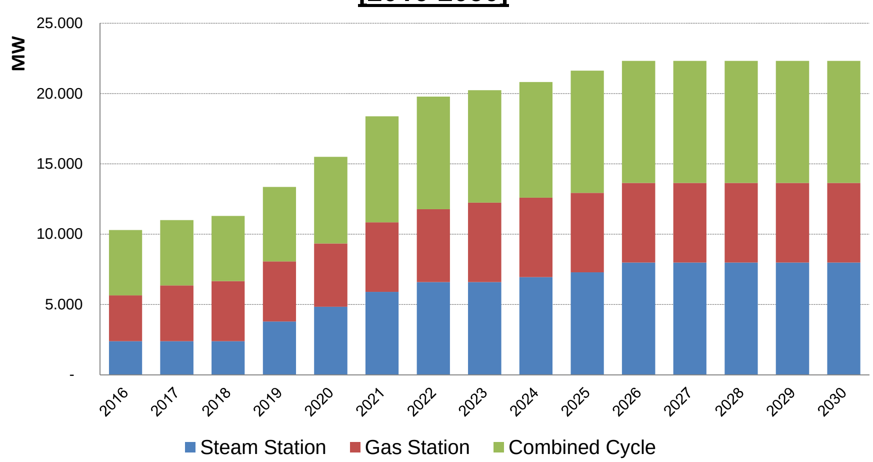
Source: Own elaboration based on NOC

2.3. ELECTRICITY MARKET

2.3.1. Power Generation:

Libya's total installed capacity is 10.3 GW, all thermal units. Capacity growth over the 2012 – 2016 period has been around 3.3% (CAGR). Not all installed capacity is currently online, though. Given the social unrest, the operation and maintenance of some of the existing power plants have been strongly compromised; hence approximately 27% of the installed capacity is currently unavailable. Thus, the "real" installed capacity is about 7.5 GW (below 2010 level). Also, there are significant amount of projects planned or under construction currently on standby. The project forecast according to GECOL Expansion Plan is shown next.

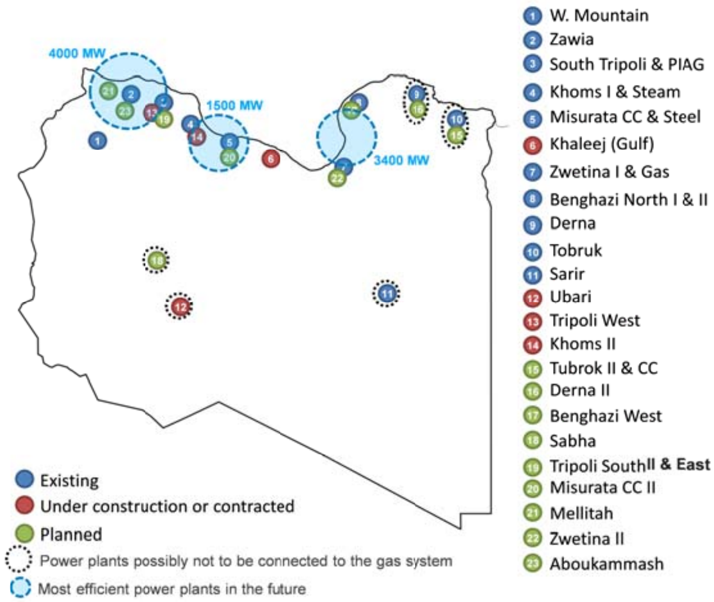
Installed Capacity Forecast
[2016-2030]



Source: GECOL

As can be seen in the following map, most of the existing and planned capacity was and would be located along the coast of the country.

Location of Existing, Under Construction and Planned Power Plants



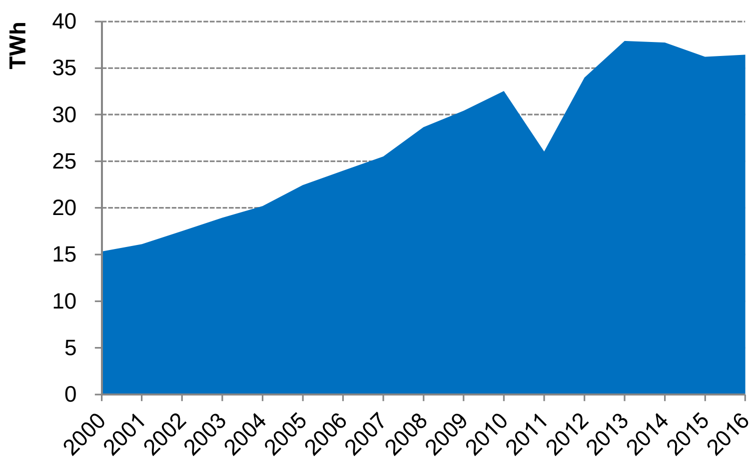
Source: Own elaboration based on PwC/GECOL/NOC

Three areas in which the more efficient power plants are located can be identified:

- To the West, from Aboukammash to Zawia where existing and planned power plants add up approximately 4,000 MW.
- In Misurata, with ~1,500 MW of efficient combined cycles.
- To the east, in Zwetina and Benghazi which account for 3,400 MW.

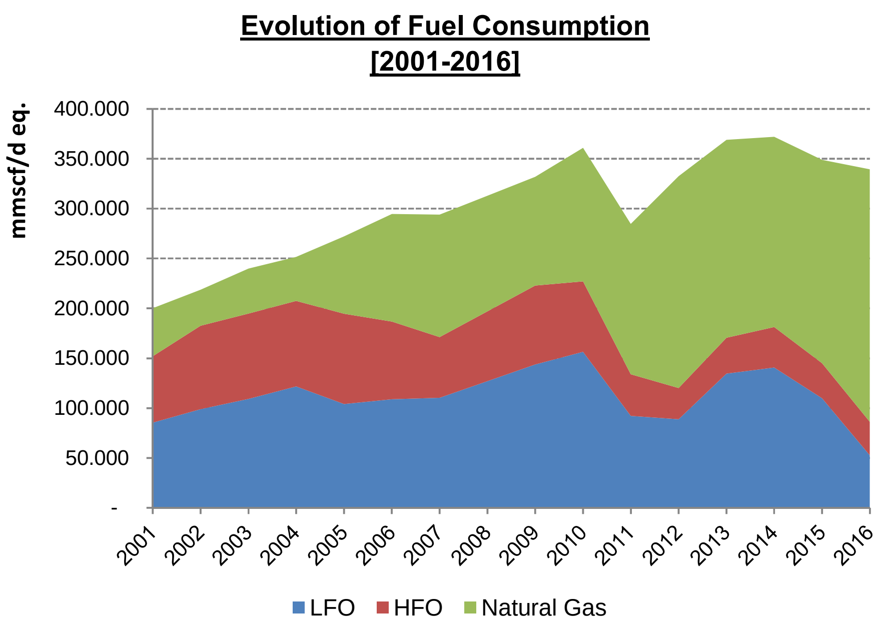
After the sharp fall in generation in 2011, electricity generation has remained stable since 2012. In 2016, power generation reached 36,429 GWh (~4,150 MWavg). Its growth has been approximately ~3% p.a. over the last 6 years, much lower than before 2011 when annual growth was ~ 8% p.a.

Evolution of Power Generation [2000-2016]



Source: GECOL

Libya's electricity market relies entirely on the O&G sector for electricity production. Most of the energy generation in 2016 was natural gas-fuelled (75%), while the rest was fuelled by light fuel oil – LFO (16%) and heavy fuel oil – HFO (10%) mainly imported by NOC at international prices.

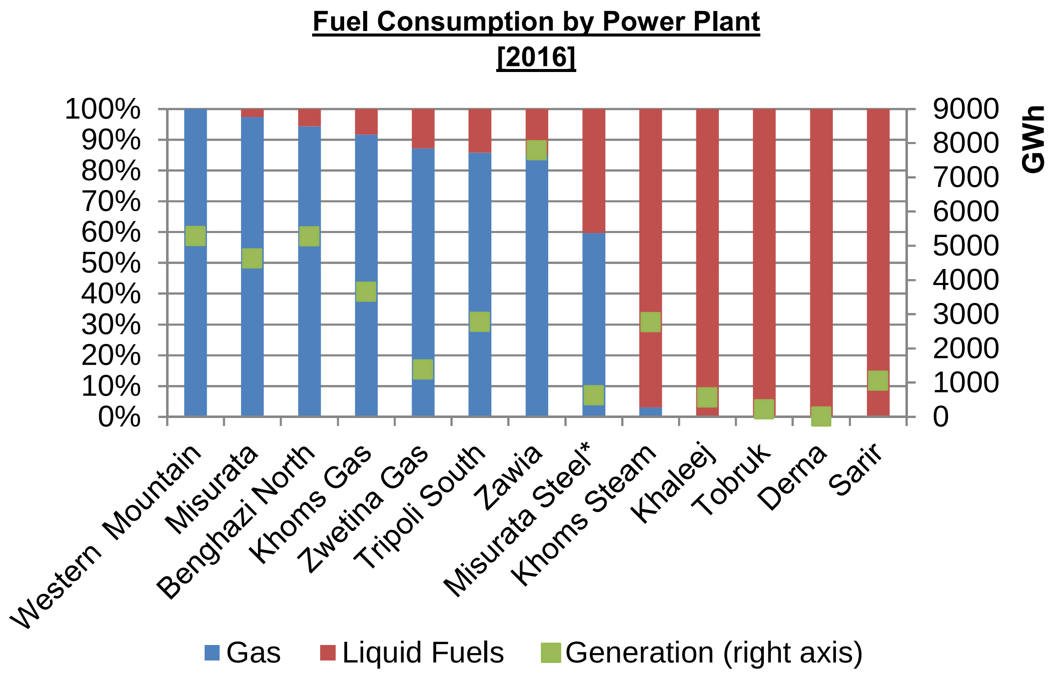


Source: GECOL

According to the information provided by GECOL, most of the existing or under construction power plants were designed for dual fuel operation, meaning that they could run either on natural gas or on LFO/HFO. Two power plants are able to run just on HFO (i.e. not dual): Derna (130 MW) and Tobruk (130MW) (both in the far East of the country).

In addition to these two plants, Sarir, Ubari, Khaleej (or Gulf) and Tripoli West[13] are not currently connected to the Coastal pipeline and are not fuelled with natural gas. The first two are located in the interior of the country; while the other two are located near the Costal pipeline but do not have gas connections yet. Sarir and Khaleej power plant are expected to be connected to the gas network soon. The first one, by the end of the first quarter 2018 and the second one by 2019. West Mountain, although not connected to the Coastal Pipeline, is connected to the pipeline going from the El Wafaa field to the Mellitah treatment plant and mostly uses natural gas.

[13] The last two under construction, Ubari and Tripoli West, were not online during 2016; thus, are not included in the "Fuel Consumption by Power Plant" chart.



Source: GECOL

Although over the last years gas has been increasing its penetration in the generation mix (substituting fuel oil and gas oil) and contributing to reducing generation cost, there is still room for improvements. Taking into consideration liquid fuel consumption at power plants that could have burned natural gas (~240 mmscf/d eq.) approximately 200 MUSD could have been saved by using LNG instead of LFO/HFO during 2016[14].

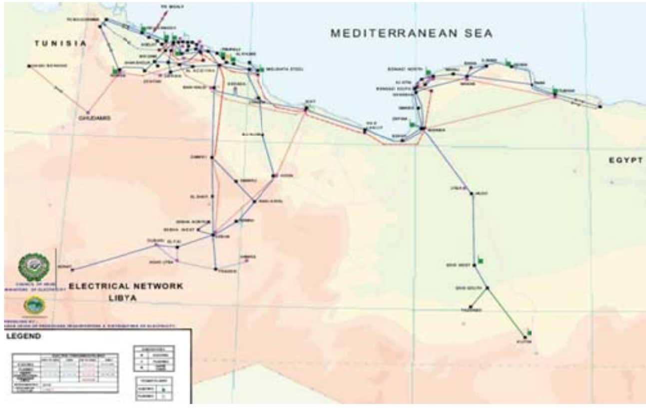
2.3.2. Transmission:

The transmission network accounts for 2,290 km of 400 kV lines, 13,706 km of 220 kV and 25,453 km of other lines (< 66 kV). The network has suffered from substantial damage in the recent years, which have caused inefficiencies to the grid operation and maintenance.

The most important transmission bottlenecks occur near Bengazi, actually splitting the network between eastern and western regions. As a result, surplus generation in the east side does not flow to the west regions. In a similar way as to the gas market, the East and the West essentially operate as independent systems. GECOL is pursuing plans to reinforce the transmission system with 400kV lines, but the status of implementation is uncertain and seems to lag behind.

[14] The estimation assumes that the 240 mmscf/d of LFO/HFO consumed are replaced by LNG. LFO/HFO price correspond to the paid by NOC in 2016 (400 USD/ton and 280 USD/ton respectively), while LNG price to the average spot price (5.5 USD/MBTU). Required new infrastructure to meet power plants demand is not considered in the calculation. Also, saving from power plants having higher efficiency and lower O&M costs when fired with gas are not included in the calculation.

Libya's electricity infrastructure



Source: GECOL

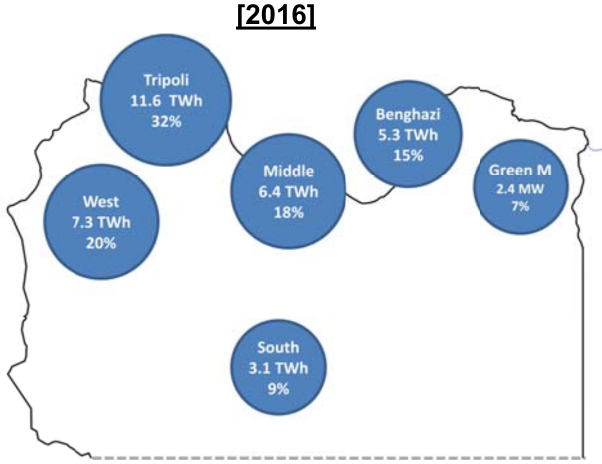
2.3.3. Demand:

Since 2012, electricity consumption has grown at lower rates than during the 2000-2010 decade (3% vs. 8% CAGR). Peak demand has grown at a rate of 4% (CAGR) since 2012 and reached ~7 GW in 2016[15], although this rate has decreased compared to levels before 2011 (8% CAGR).

However, an additional 1 to 2 GW of the demand is not met. Moreover, the main cities are suffering 3 to 4 hours of load shedding every day. There also were days during last year with 10-hour power cuts and even some blackouts.

Tripoli, the West and the Middle region together account for approximately 70% of the electricity load. Both, peak and average demand growth are concentrated in these regions.

Power Consumption by Region [2016]

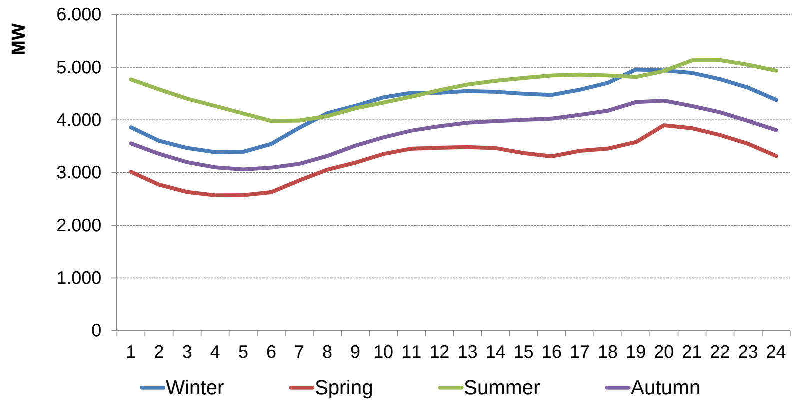


Source: GECOL

[15] Peak demand occurs both in summer and winter.

Summer and winter are the seasons with the highest average demand, while during autumn and spring, demand is below average.

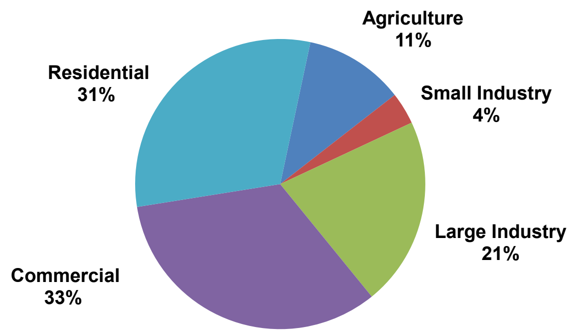
Average Seasonal Hourly Loads [2012]



Source: GECOL

According to GECOL, power demand is equally split among Residential, Commercial and Industry (Agriculture, Small and Large Industry).

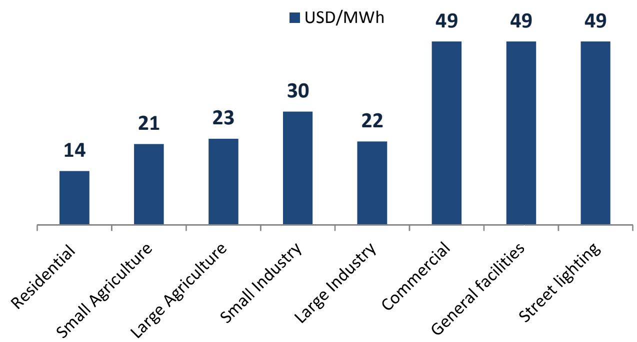
Demand by Customer [2015]



Source: GECOL

The ability of the consumer to pay is not enough to cover the full prices. On the one hand, energy prices are relatively low. On the other hand, payment collection is one of the main challenges for GECOL together with illegal connections. "Even before the revolution, the share of unpaid bills was high and commonly around 40%. However, post-revolution the situation has worsened significantly. In 2012, the share of unpaid bills reached more than 70%. Additionally, commercial losses accounted for 30% in the domestic sector alone in 2012, mainly due to a large number of illegal connections. Technical losses are also high at around 17%. Electricity bills are issued and delivered quarterly to households who then have to pay them at one of the 188 commercial centers all around the country. A small percentage of around 10% of customers does pay their invoices through state bank transfers. However, there are no clear procedures for the enforcement of non-payment"[16].

Libya Electricity Prices by Sector [2015]

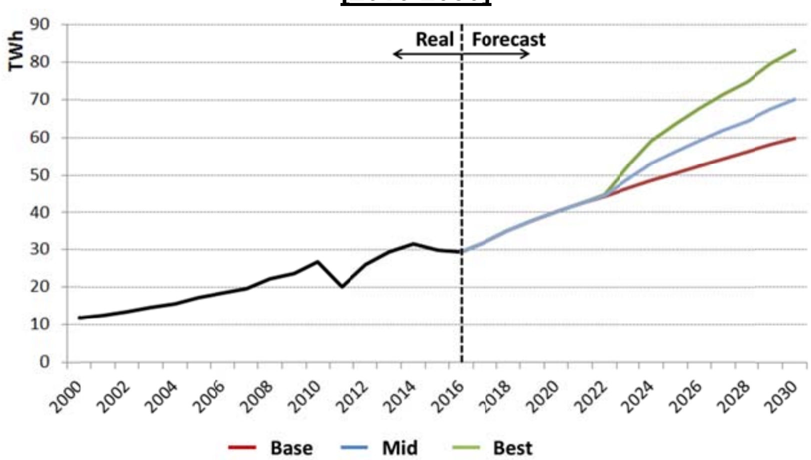


Source: GECOL

Since energy prices are heavily subsidized for all economic sectors in Libya, it is difficult to foster renewable energies and energy efficiency on a cost-effective basis.

According to PwC's[17] (documents v03 of 17th June 2017), demand is expected to grow at a CAGR of 4.9% (CAGR) until 2030 under a scenario dubbed "Base", 6.2% (CAGR) in an alternative scenario called "Mid" and 7,6% (CAGR) in a third scenario identified as "Best", reaching circa 60 TWh ,70 TWh and 83 TWh (i.e. a 40% difference by 2030), respectively. The three scenarios assume similar growth rates until 2022 when they detach due to the inclusion of "mega-projects" demand. The "Best" scenario includes the original mega-projects curve that remains the only official curve available today, while the "Mid" scenario assumes a revised "mega-projects" development curve.

Electricity Demand Forecast [2016-2030]



Source: PwC's Rapid Assessment

[16] Libya-Electricity Sector Reform Technical Assistance, World Bank, 2014

[17] The "Base" scenario corresponds to the "Continuous Political Instability" scenario in PwC's documents, the "Mid" scenario to the "Slow Political Stability (Updated)" scenario and the "Best" scenario to the "Continuous Political Stability" scenario.

In regard to power generation plants operational features (to be taken into account in the following section "3. Natural Gas Supply Alternatives for Power Generation), the "Base" scenario considers low installed capacity, low plant availability, high technical losses and low generation efficiency. On the contrary, "Mid" and "Best" scenarios would include high installed capacity, high plant availability, low technical losses and high generation efficiency[18].

[18] See Annex 7.4 for the detail of the electricity market assumptions used in the models.

3. NATURAL GAS SUPPLY ALTERNATIVES FOR POWER GENERATION.

The following sections of the report will focus on the analysis of different potential options to reduce power generation costs and greenhouse gas emissions while increasing the reliability of the system through the increase of natural gas availability.

3.1. METHODOLOGY.

In order to analyze the different alternatives to improve natural gas supply, the Consultant will run two models: a simplified electricity dispatch model and a natural gas flow. Both models are run for each alternative and the three electricity demand scenarios previously detailed.

First, the simplified electricity dispatch model determines the demand for natural gas or liquid fuels by power plant. This linear programing tool, optimize the dispatch of the power plants (minimum cost) to meet the expected demand throughout the study time horizon. In every case, the electricity demand is fully supplied (i.e. the simulations do not consider electricity curtailments).

The dispatch model allocates liquid fuels and natural gas by merit order (i.e. the least generation cost expressed in USD/MWh) in order to minimize the total system cost[19]. As a result, the optimal fuel mix is obtained.

The input data for the model are: the electricity demand scenarios, the power plant features (installed capacity, availability, losses, and heat rates or efficiencies of the power plants), the fuel costs[20], and the availability of natural gas.

It is worth noting that power plants in the interior of the country (i.e. Ubari and Sabha[21]) and in the East Mountains (i.e. Tobruk and Derna) are assumed as still fuelled with HFO or LFO. The latter stems from the long distances that make pipeline connection not economically viable[22]. Also, the model does not consider electricity transmission restrictions.

Second, natural gas flow simulations are performed. The input data for the model are: natural gas demand resulting from the dispatch model, the transportation capacity and natural gas availability. Through this model, the gas system optimal operation at every section of the pipeline (direction and volume) is understood and the required size of the transportation expansions and additional natural gas is obtained.

Both models are run under two electricity demand conditions. First, for summer electricity demand in order to dimension the natural gas supply and transportation infrastructure requirements. Summer is the season with higher demand (approximately 15% higher than the year's average); thus, the natural gas system configuration resulting would allow meeting demand under tight situations. Second, models are run for the yearly average electricity demand, in order to determine the average fuel

[19] This type of dispatch corresponds to a centralized operation in which only one entity decides which plant uses the fuel in order to reduce as much as possible the generation cost.
[20] See "4.2 Fuel Costs"
[21] Natural gas supply directly from the wells might be possible, but not under review during this study.
[22] See Annex "7.2 Preliminary Analysis on Tobruk"

consumption, which along with the investments of new infrastructure, will result on the system's cost.

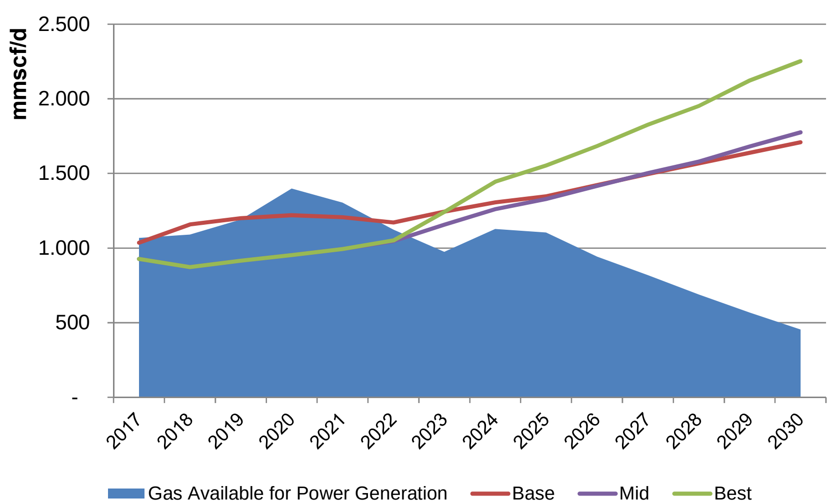
These model results would then be used to help focus on the areas where technical viability of required changes to the gas distribution system needs to be assessed or preferred location of LNG injection points can be reviewed for the LNG Options report.

3.2. FORECAST UNDER CURRENT CONDITIONS.

Before moving forward with the supply alternatives it is important to review what the forecast for Libya could be maintaining the status quo (i.e. not additional gas supply or transportation expansions). As explain in detail below, under these conditions, **the country would suffer gas curtailments first due to transportation bottlenecks and then due to insufficient supply.** This scenario will serve as the base line case for comparison and to determine the potential savings.

Considering the natural gas supply forecast prepared by NOC, a simplified Supply-Demand balance for power generation was prepared. As can be observed, without taking into account the transportation capacity, natural gas supply will not be enough to meet the average power demand as of 2017/2018 under the "Base" scenario, and as of 2022, the "Mid" and "Best" scenarios[23]. This situation would worsen during summer and winter seasons when electricity demand is higher than the average. It is worth mentioning that "Mid" and "Best" cases show lower gas demand in the short term as, in this scenario, it is assumed that power plant availability, efficiency and capacity is higher than in the "Base" scenario.

Simplified Natural Gas Supply-Demand Forecast [2017-2030]

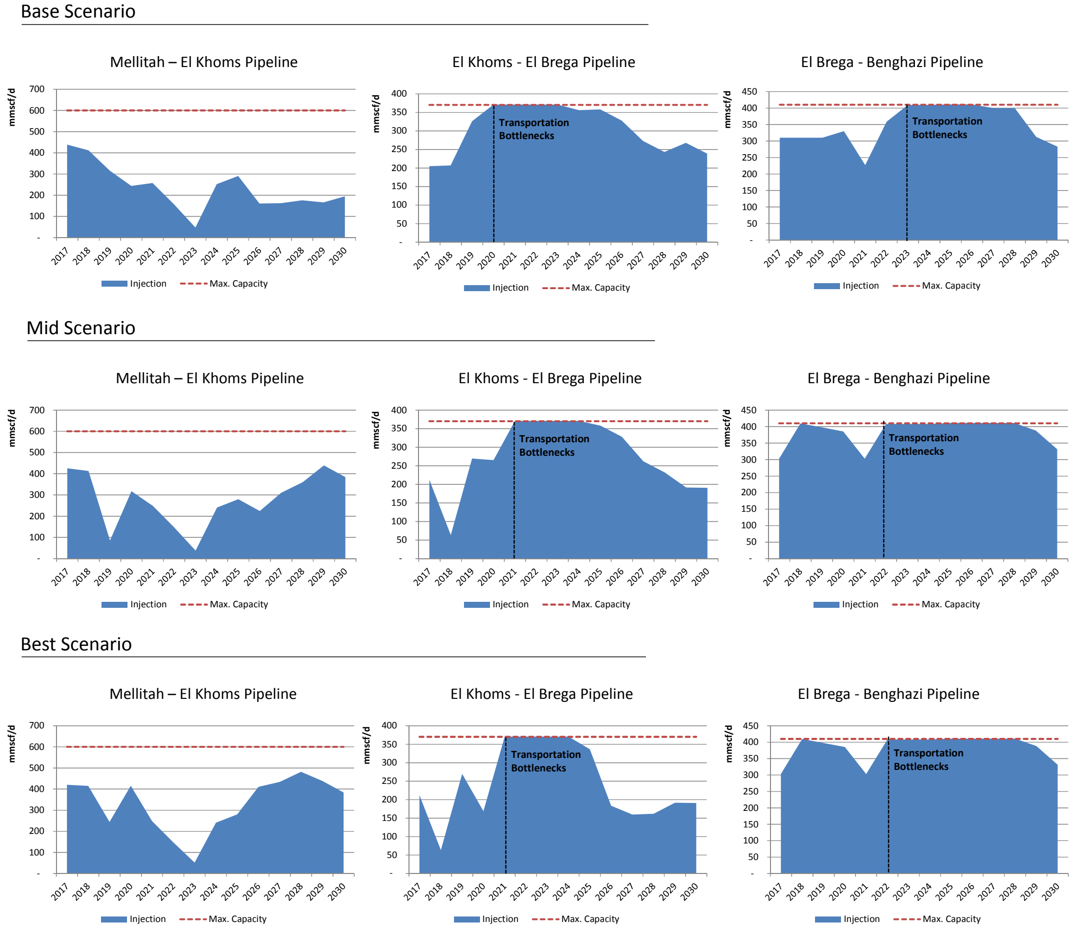


Source: Own elaboration based on PwC and NOC

[23] Note that since the figures that support the blue-area under the graph above (i.e. "Gas Available for Power Generation") refer to "availability" instead of "actual supply", it could be argued that the gas available but not supplied during low demand periods may be effectively supplied when the gas deficit arises in 2022/2023 (according to the Scenario analysed) so deferring such deficits to about 2024 for both Scenarios. Such analysis though is out of the scope of this Study since it would depend on a detailed scrutiny of the features and performance of every Libyan gas field feeding the system.

When taking into consideration the transportation capacity, only part of the available gas volume would be injected to the system due to bottlenecks. As a result, in order to meet electricity demand, liquid fuels would be required.

Coastal Pipeline Transportation Utilization[24]
[2017-2030]

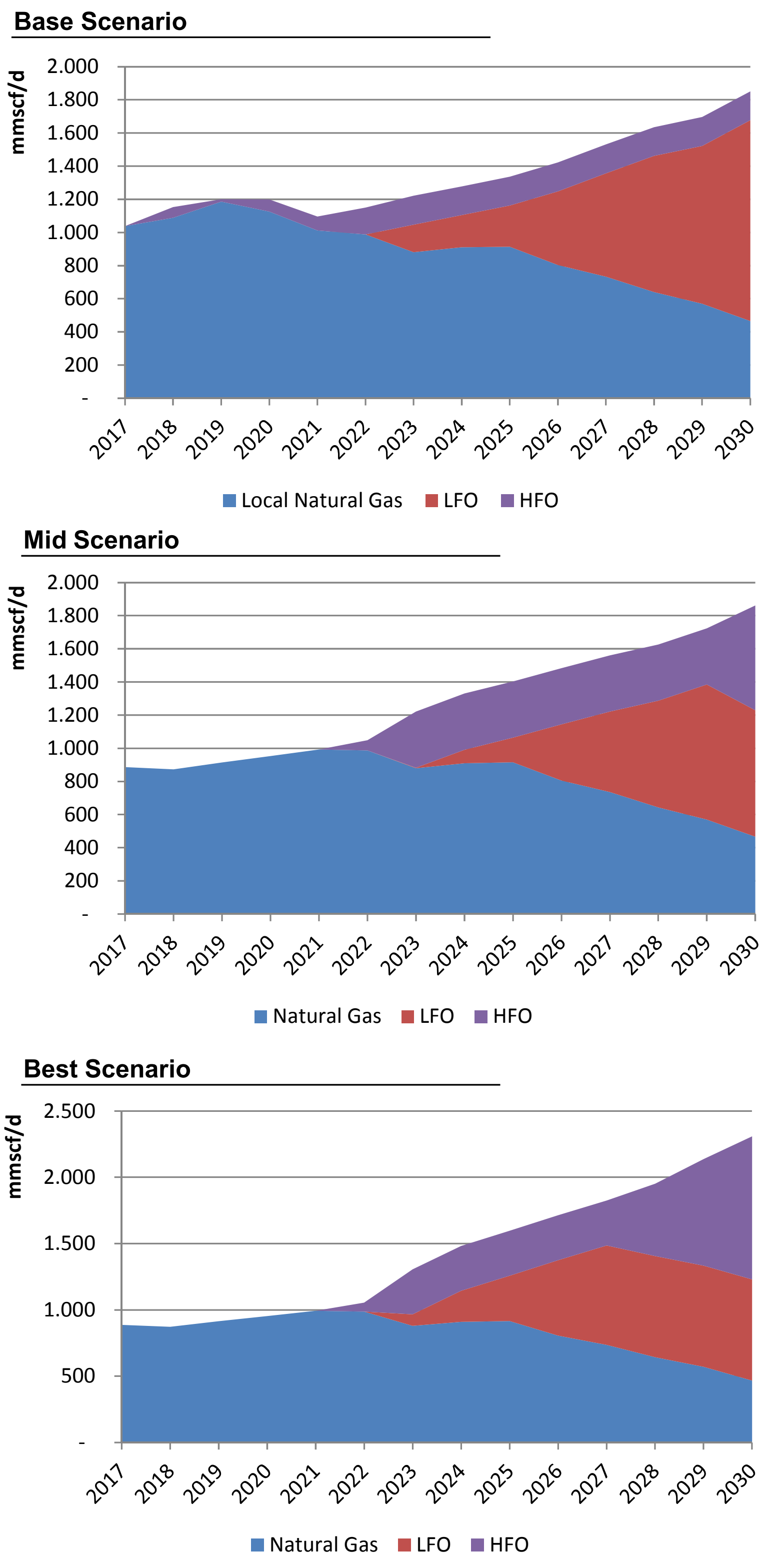


Source: Own elaboration

By 2030, taking into consideration the current transportation capacity, natural gas supply and the expected demand growth, the system would be affected by a shortfall of gas for power generation of around 1,250 mmscf/d to over 1,800 mmscf/d that should be covered by liquid fuels, as shown in the following figures.

[24] Pipeline utilization includes in addition to power generation gas demand, industrial and residential consumption.

Fuel Utilization for Power Generation Forecast [2017-2030]



Source: Own elaboration

This large amount of liquid fuels would probably be imported, resulting in a significant cost for the system[25]. The following table summarizes the yearly cost of power generation under this “do nothing” scenario (for fuel prices used for this estimation see “4.2 Fuel Prices”).

Total Fuel Utilization for Power Generation Yearly Cost [2017-2030]

Scenario	Fuel Costs / Year (MUSD)													
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Base	1.585	1.900	1.871	2.036	1.926	2.274	3.236	3.488	3.927	5.163	6.366	7.639	8.566	10.500
Mid	1.352	1.331	1.395	1.455	1.515	1.814	3.022	2.555	3.061	4.507	5.787	7.019	8.401	10.137
Best	1.352	1.331	1.395	1.455	1.515	1.849	3.561	3.510	4.318	6.210	7.607	8.992	10.613	12.289

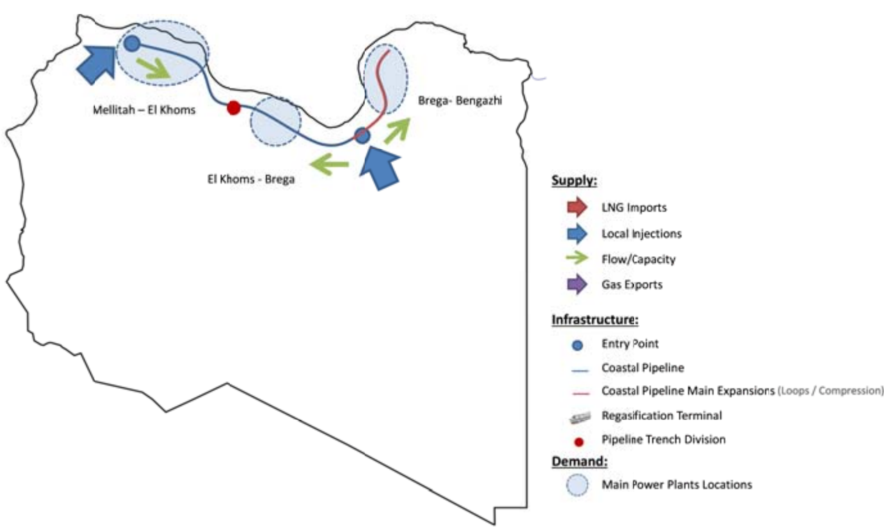
Source: Own elaboration

3.3. ALTERNATIVES TO IMPROVE NATURAL GAS AVAILABILITY.

Given the situation described above, alternatives to improve natural gas availability for power generation should include additional natural gas supply and transportation expansion. In this regard, the Consultant has identified four different alternatives:

1. **Short Term Solution:** considers the utilization of all the local gas production for power generation by expanding[26] the Coastal pipeline and reducing gas exports when necessary.

Schematic Diagram of the “Short Term Solution” Alternative

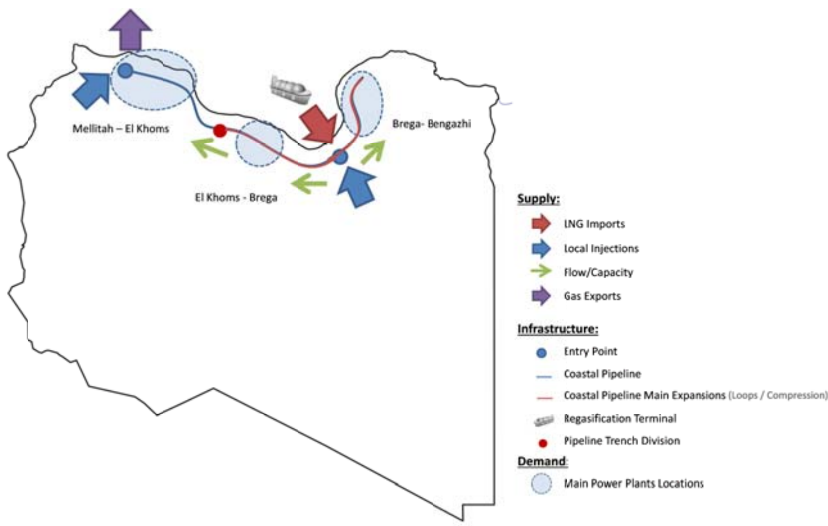


Source: Own elaboration

[25] It is worth noting, that all analyses in this report are made from Libya’s point of view; thus, real cost of fuels were considered in the system cost estimation.
[26] In this report expanding the pipeline could either be additional compression or loops not new pipeline trenches. In the LNG Option Report the most appropriate solution for expanding the pipeline to meet demand will be studied.

2. **LNG in El Brega:** assumes the conversion of the on-shore liquefaction terminal in Marsa El Brega to regasification and the expansion of the Coastal pipeline to meet natural gas demand.

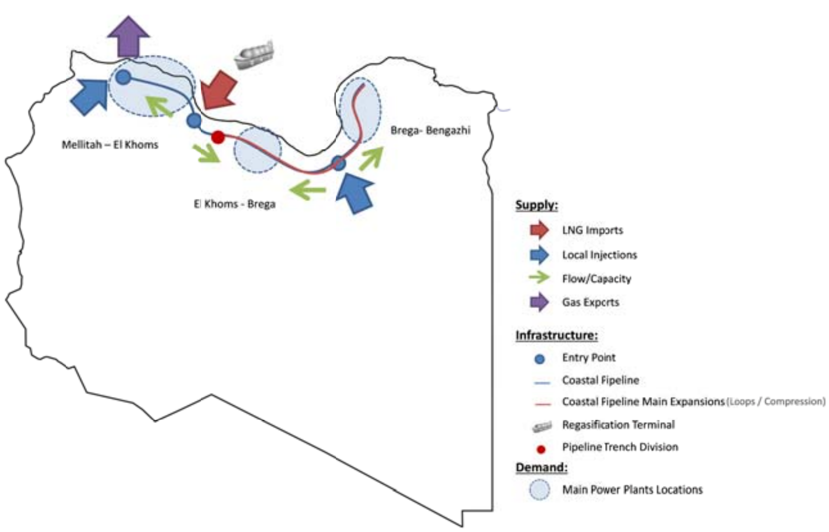
<u>Schematic Diagram of the "LNG in Brega" Alternative</u>



Source: Own elaboration

3. **LNG in the West:** includes the construction of an off-shore regasification and storage terminals to next to Khoms to supply gas and expanding the transportation system if required.

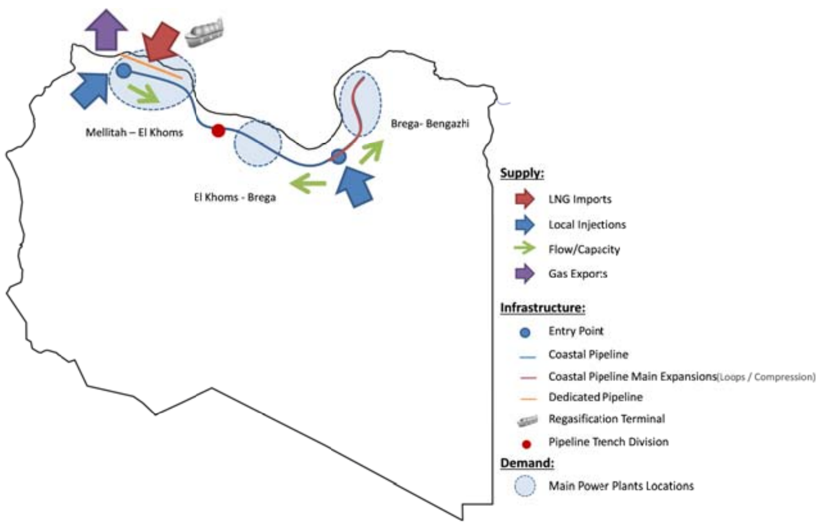
<u>Schematic Diagram of the "LNG in the West" Alternative</u>



Source: Own elaboration}

4. **Focused LNG:** considers the construction of an off-shore regasification and storage terminal to connect directly to Mellitha, Zawia and Aboukammash power plants[27].

Schematic Diagram of the "Focused LNG" Alternative



Source: Own elaboration

Next, the results of the simulations underlining fuel consumption volumes, transportation expansion requirements and additional natural gas supply are presented for the three electricity demand scenarios under analysis.

3.3.1. Short Term Solution.

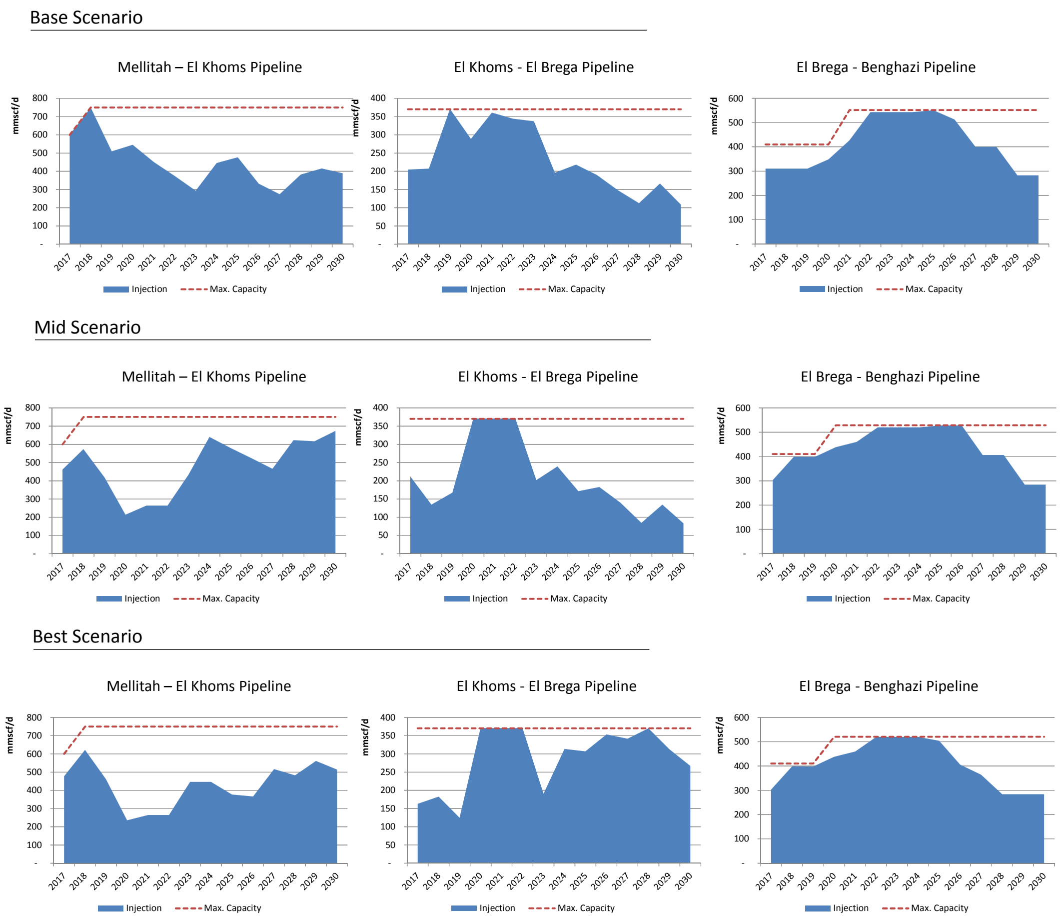
The "Short Term Solution" alternative, as its name implies, reduces liquid fuel requirements in the short term (in comparison with the current situation forecast) by modifying the Coastal pipeline and using local gas production originally planned to be exported (injecting it in the West Entry Point). This alternative does not consider the increase of gas supply through imports; but maximizes the utilization of production locally. The underlining assumption for this alternative is that it is preferable to increase gas supply from reducing exports than expand the Coastal pipeline. In this way, large investments are minimized.

As explained in "3.1 Methodology", in order to dimension the transmission expansion and additional supply requirements models are run under summer electricity demand conditions. Under the latter, in 2018 and 2023 in the "Base" and in the "Mid" and "Best" scenarios respectively, exports are reduced gradually until finally suspended to avoid using liquid fuels. It is worth noting that a study of the commercial impact of suspending exports to Italy has not been carried out.

[27] This alternative was based on the discussion with NOC during the KOM and further discussions, in order to simplify the expansion of the transmission system and allowing higher natural gas availability.

In order to use as much local production as possible and allow more efficient power plants to be dispatch, additional transportation capacity in the Brega – Zwetina section of the pipeline would be required all three scenarios. Also, additional transportation capacity would be required from Brega to the West.

<u>Coastal Pipeline Transportation Utilization [2017-2030]</u>



Source: Own elaboration

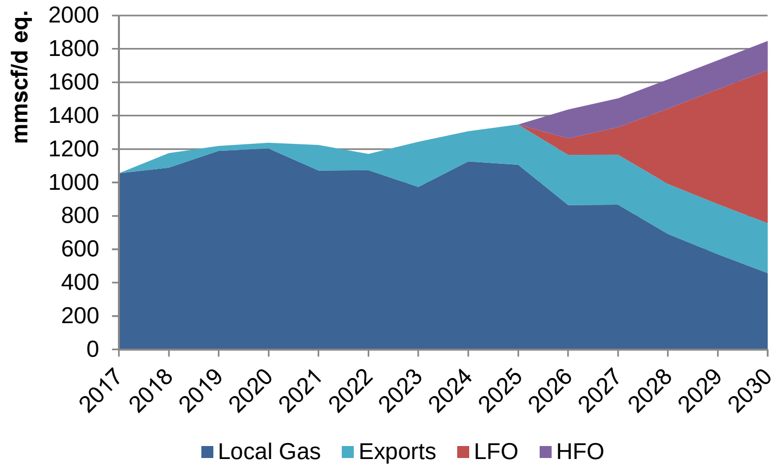
It is worth noting that, although exports increases supply at the West Entry Point it would only be necessary a minor expansion in the Mellitah - Tripoli - El Khoms pipeline to meet summer demand in the “Base” scenario[28].

Taking in consideration the yearly average demand, it can be observed in the graphs below that **<u>after undergoing the expansion previously mentioned and using all local gas production, liquid fuels required would be delayed until 2025/2026 in all three scenarios</u>**

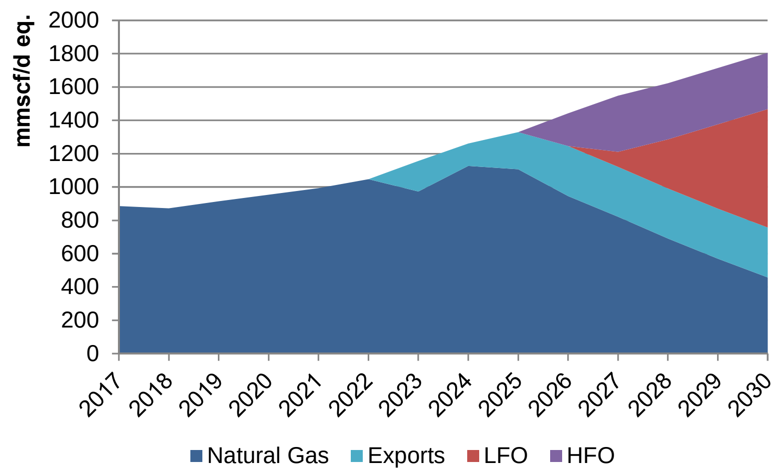
[28] This expansion is currently been pursued by NOC and not considered as an extra cost for this solution.

Fuel Utilization for Power Generation Forecast [2017-2030]

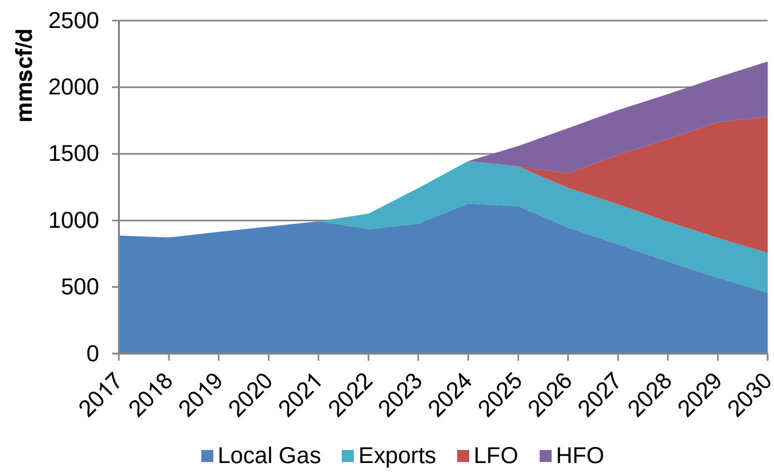
Base Scenario



Mid Scenario



Best Scenario



Source: Own elaboration

3.3.2. LNG in Brega.

The "LNG in Brega" alternative consists of increasing gas injection in Brega by converting the on-shore liquefaction terminal in Marsa El Brega and debottlenecking the Coastal pipeline.

The table below indicates the maximum send-out capacity requirements for each scenario in order to fully meet summer average demand[29].

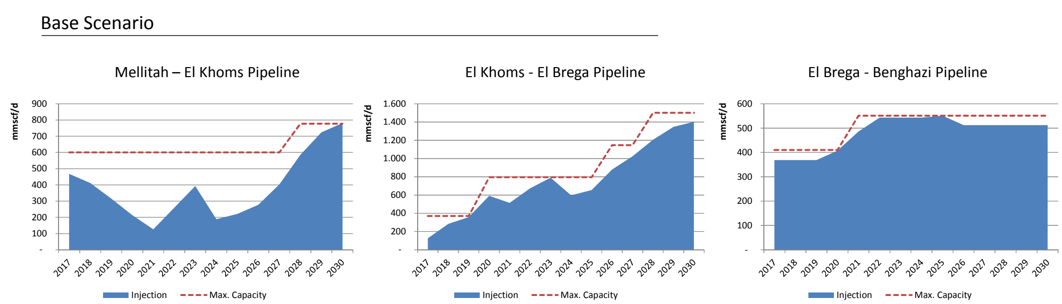
LNG Import Terminals
[2017-2030]

Scenario	Brega Conversion		1st Expansion		2nd Expansion		3rd Expansion	
	COD	Max. Send Out (bcm/y)	COD	Max. Send Out (bcm/y)	COD	Max. Send Out (bcm/y)	COD	Max. Send Out (bcm/y)
Base	2022	5,5	2026	5,5	2028	5,5	-	-
Mid	2022	5,5	2026	5,5	2028	5,5	-	-
Best	2022	5,5	2024	5,5	2026	3,7	2028	5,5

Source: Own elaboration

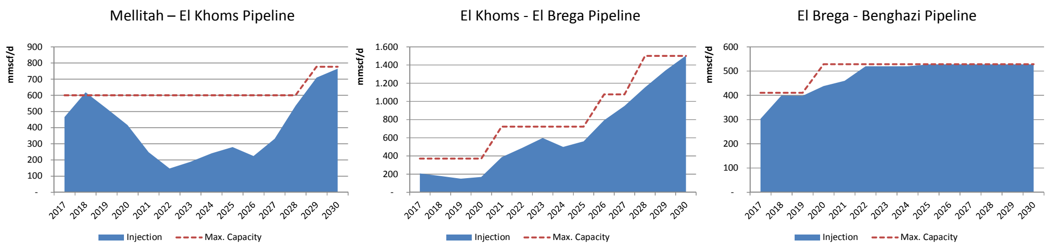
Given that the most efficient power plant (existing and planned) and that the highest fall in natural gas production would be located in the west, large pipeline expansions would be required in order to allow regasified LNG flow from Brega to consumption centers in the West. Also, it would be necessary to expand the Brega-Zwetina pipeline section in order to exploit all local gas production. The maximum transportation utilization for each pipeline including expansions requirements of this alternative are showed in the following table.

Coastal Pipeline Transportation Utilization
[2017-2030]

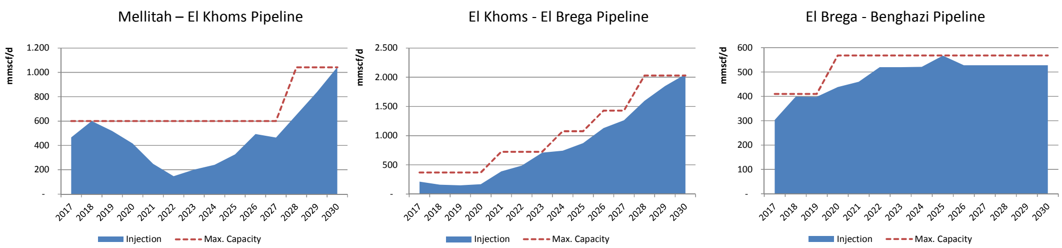


[29] Although LNG terminal plant would be required before 2022, it would be difficult to have the import terminal online before this date.

Mid Scenario



Best Scenario

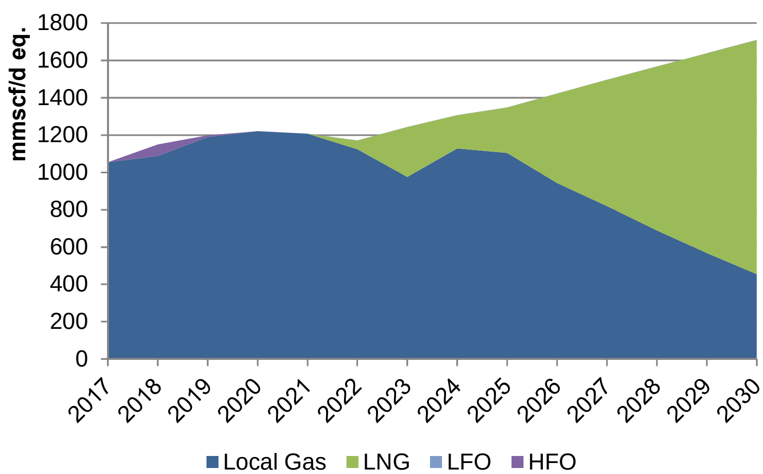


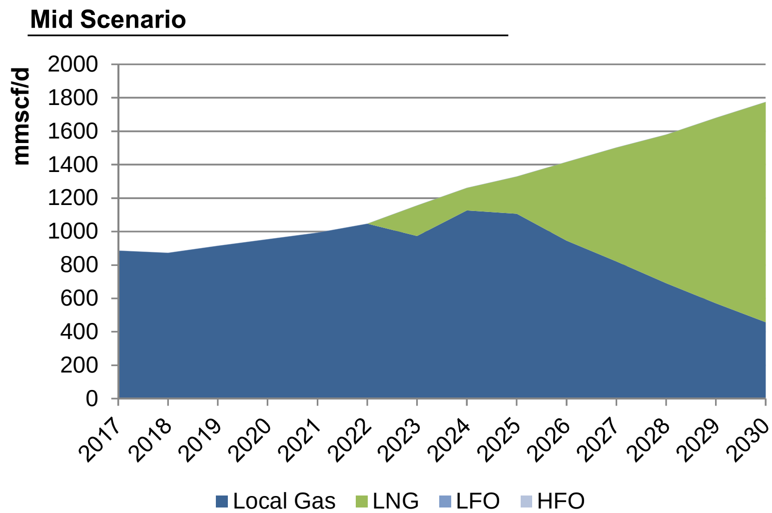
Source: Own elaboration

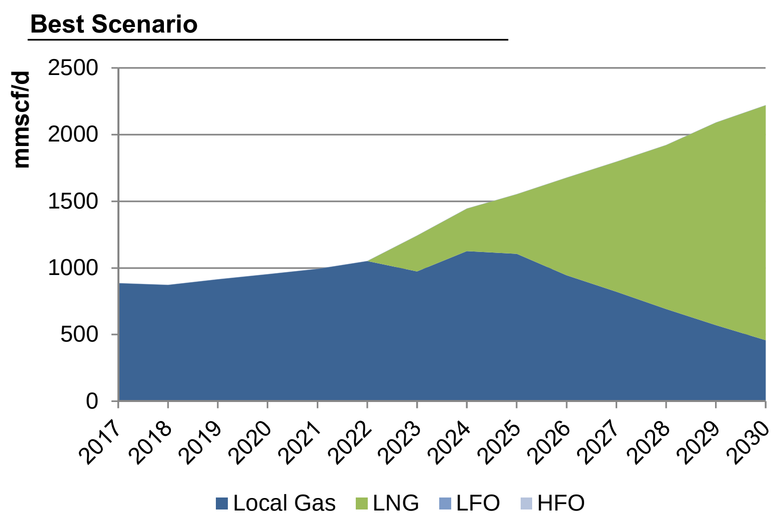
Taking in consideration the yearly average demand, it can be observed in the figure below, that this alternative fully meets average natural gas demand during the whole period.

Fuel Utilization for Power Generation Forecast [2017-2030]

Base Scenario







Source: Own elaboration

3.3.3. LNG in the West.

In this alternative, as well as the previous one, the objective would be to avoid burning liquid fuels for power generation.

In order to meet summer average demand across all users, at least three FSRU's would be required to cover all scenarios[30]. The table below indicates the maximum send-out capacity requirements for each scenario.

[30] The expansion of the regasification capacity would depend on the certainty that all new power plants are in line by the expected dates.

LNG Import Terminals
[2017-2030]

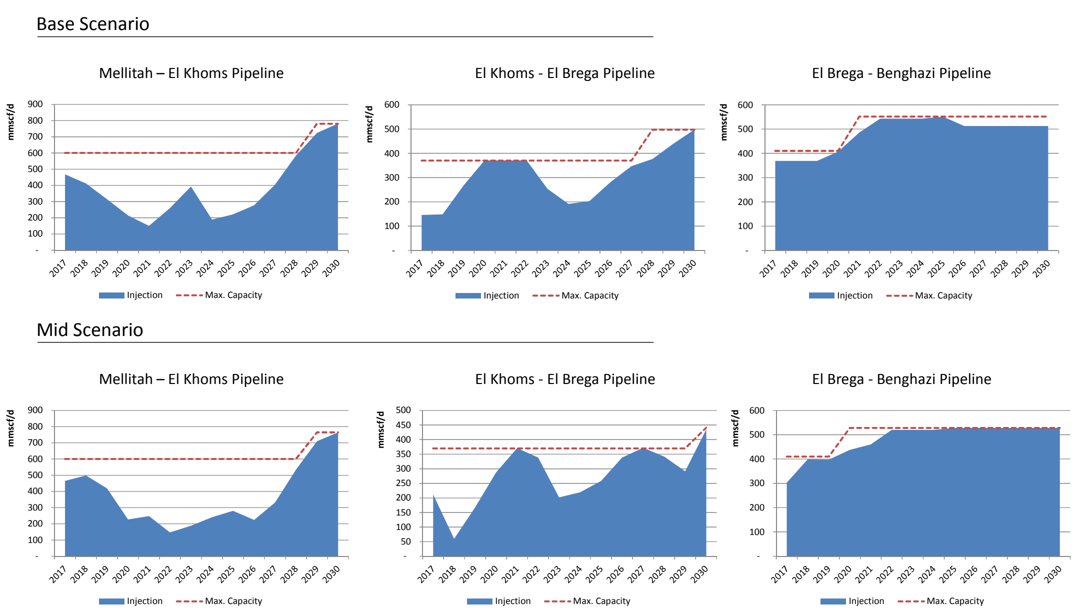
Scenario	FSRU		1st Expansion		2nd Expansion		3rd Expansion	
	COD	Max. Send Out (bcm/y)	COD	Max. Send Out (bcm/y)	COD	Max. Send Out (bcm/y)	COD	Max. Send Out (bcm/y)
Base	2022	5,5	2026	5,5	2028	5,5	-	-
Mid	2022	5,5	2026	5,5	2028	5,5	-	-
Best	2022	5,5	2024	5,5	2026	3,7	2028	5,5

Source: Own elaboration (COD = Commercial Operations Date)

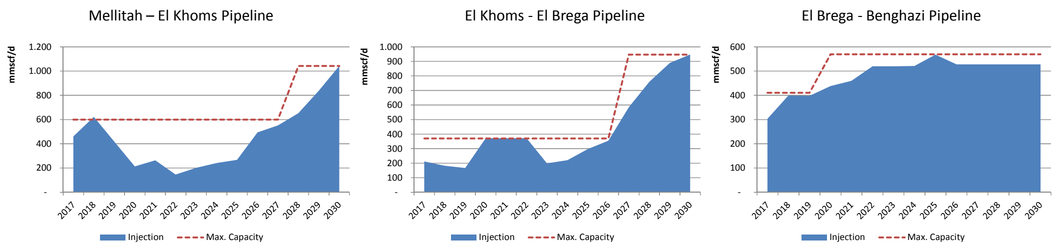
FSRU type import terminals would be installed in the west next to Khoms, near the demand and replacing the fall in injections at the West Entry Point. Although the LNG amount required would be the same as in the previous alternative, transportation system expansions should be much smaller. Thus this alternative would have lower costs than the previous one. It's worth mentioning that, results would be similar if facilities were located along the coast in the West from Khoms to Mellitah. If the terminals were to be located east of Khoms, transportation expansions should be larger as the pipeline only has a capacity of 370 mmscf/d.

In all three scenarios, pipeline expansions will be required in the Brega-Zwetina section and from Brega to the West in order to leverage on local gas production. Also some expansion could be necessary by the end of the period under analysis in the Tripoli-Khoms and Tripoli pipeline.

Coastal Pipeline Transportation Utilization
[2017-2030]



Best Scenario

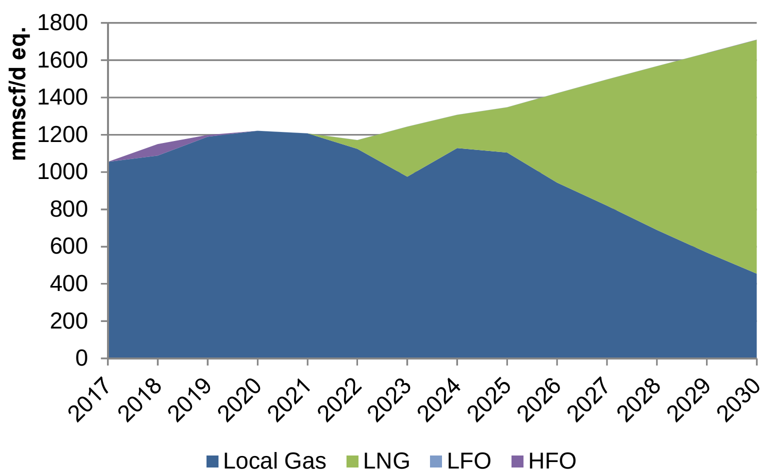


Source: Own elaboration

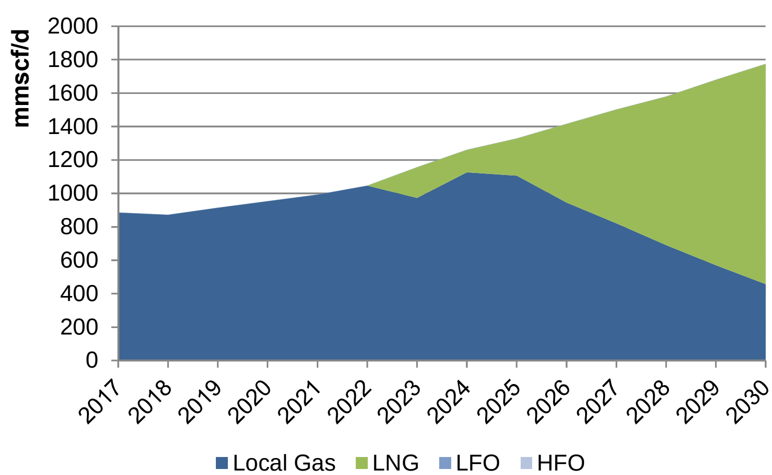
Taking in consideration the average yearly demand, it can be observed in the figure below, that this alternative fully meets average natural gas demand during the whole period.

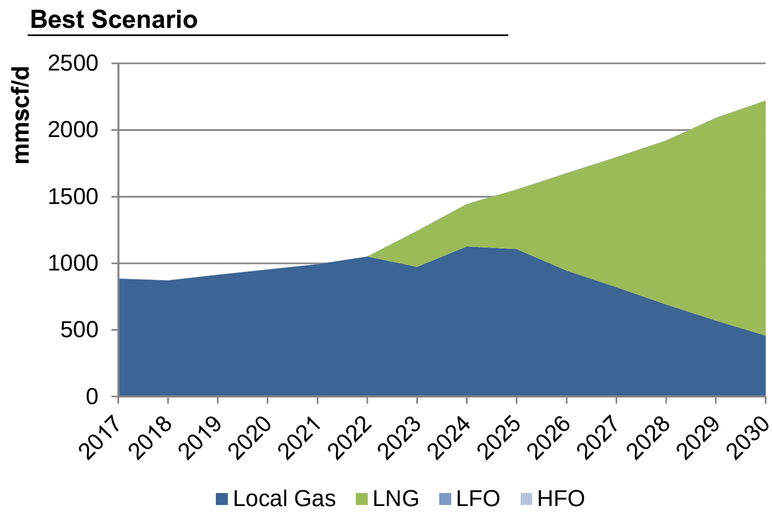
Fuel Utilization for Power Generation Forecast [2017-2030]

Base Scenario



Mid Scenario





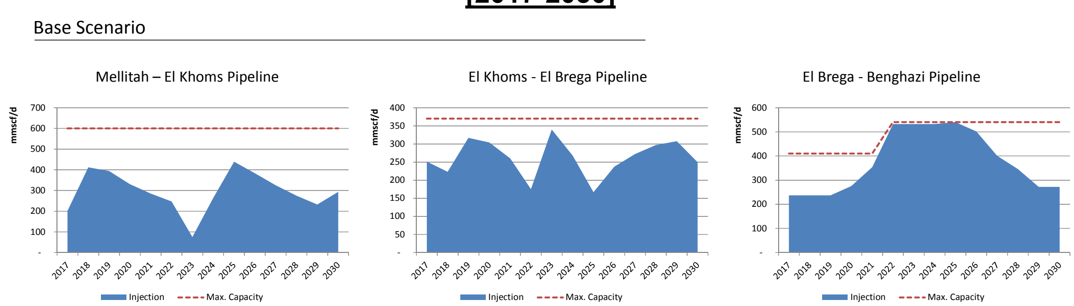
Source: Own elaboration

3.3.4. Focused LNG.

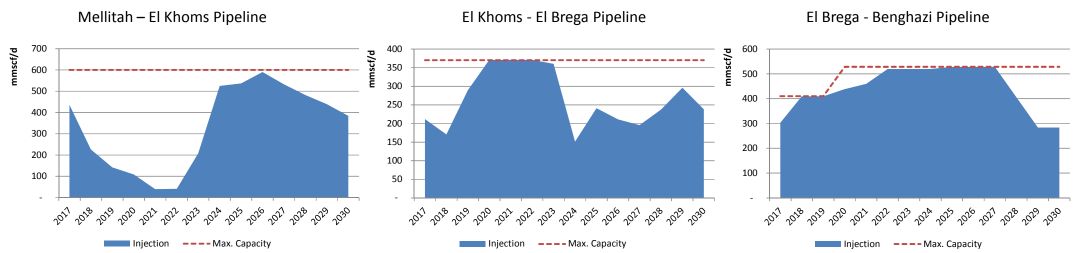
Last, the alternative “Focused LNG” consists in connecting directly, through a new pipeline, a LNG terminal (FRSU) with power plants near Mellitah and Zawia, which according to their efficiency would have high dispatch. The underlining assumption of this scenario is that power plants grouped with a dedicated LNG terminal and pipeline (rather than being connected to the coastal pipeline) would be dispatch with first priority.

The new pipeline, of around 100 km, would allow supplying directly the power plants leaving idle capacity to meet the rest of the demand. However, by the end of the period under study (2027) due to the fall in local production, liquid fuels would be again required. In order to meet these power plants summer natural gas consumption, the FSRU would need to be ~ 6 bcm/y (within international standards). Given that in this alternative the LNG would be supplied through a dedicated pipeline, transportation expansion would be minor.

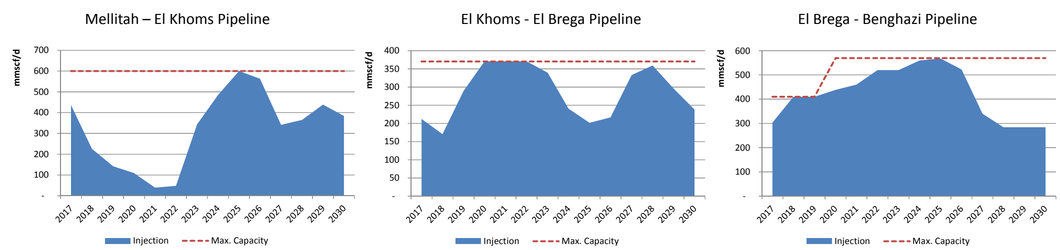
Coastal Pipeline Transportation Utilization
[2017-2030]



Mid Scenario



Best Scenario

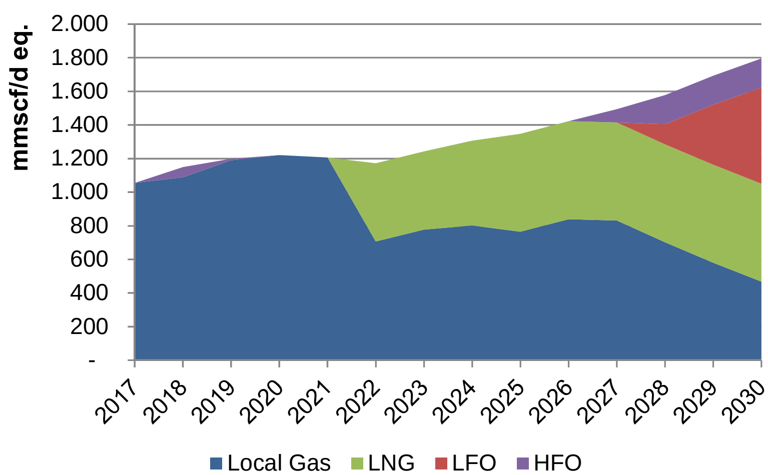


Source: Own elaboration

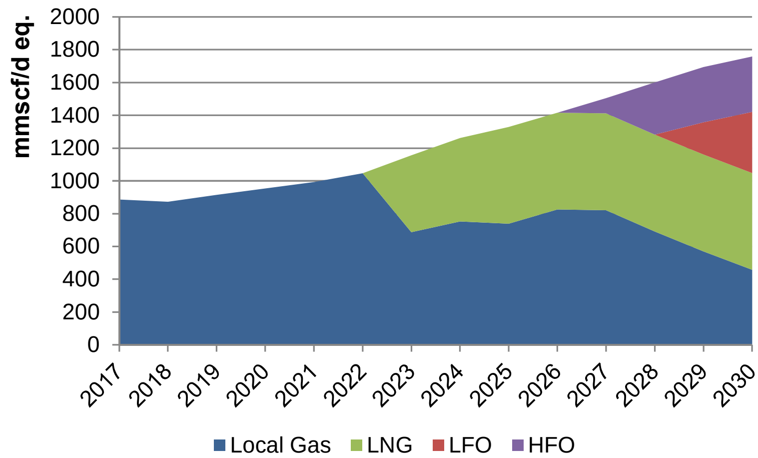
Taking into consideration the average yearly demand, it can be observed in the figure below, that this alternative fully meets average natural gas demand during the whole period.

Fuel Utilization for Power Generation Forecast [2017-2030]

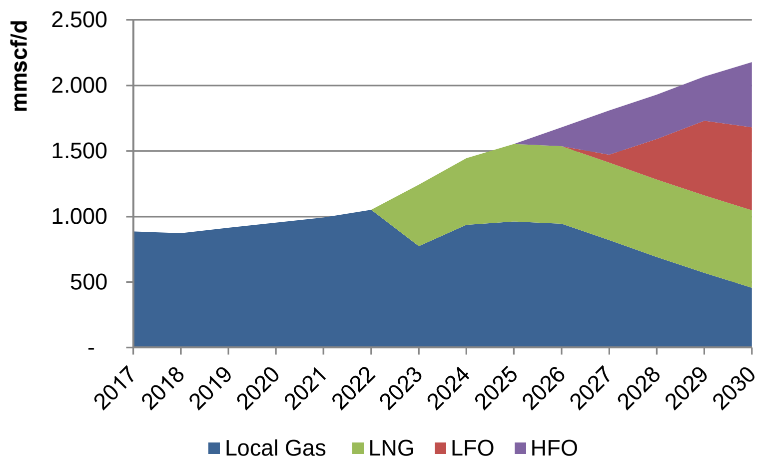
Base Scenario



Mid Scenario



Best Scenario



Source: Own elaboration

4. COMPARISON OF SUPPLY ALTERNATIVES.

In order to compare the different alternatives and determine the possible savings of using the optimal fuel, in this section the total power generation fuel costs are estimated based on the investment and operational costs - CAPEX and OPEX - of the new infrastructure (regas terminals and transport capacity expansion) and fuel prices.

4.1. CAPEX & OPEX.

Subsequently, all new infrastructure costs included in the model analysis are detailed.

First, the Consultant assumes that the pipeline CAPEX costs would be 105 USD/inch/meter either if it loops or compression stations. Further analysis on which is the best alternative (especially if the pipeline route is difficult) will be undertaken after the site visit in the LNG Option Report. Additionally, transport OPEX is estimated as 4% of CAPEX. These assumptions are considered in all alternatives under study[31].

Second, for the conversion of the liquefaction terminal in Marsa El Brega involved in Alternative “LNG in Brega”, the CAPEX is assumed as 500 MUSD. Although the terminal already has two LNG storage tanks and a harbor with a breakwater and jetty, initial assessment shows that little plant and equipment could be saved from using this location (the full analysis is being prepared separately for inclusion within the LNG Options Report). OPEX would be 13 MUSD/y. When required, expansions of the regasification terminal required are estimated as 150 MUSD.

Third, regarding the new off-shore regasification and storage terminals (FSRU type), involved in Alternatives “LNG in the West” and “Focused LNG”, the cost (CAPEX and OPEX) is based on a standard FSRU with jetty/trestle facility (90 MUSD) assuming that connection to the grid is not too far away or complicated (such as horizontal drilling being required) and that no breakwater or extensive dredging is required at the FSRU berthing point. FSRU daily fees are estimated at 160 kUSD/day (140 kUSD/day vessel lease and 20 kUSD/day crew costs).

Last, the reversion of the Coastal pipeline flow is not included as an additional cost. It is noteworthy that, based on the Consultant’s international experience, the potential flow reverse does not imply significant investments, since an annexation of external new tubing allows the shift. Additionally, the pipeline cost to connect new power plants and regasification terminals to the Coastal pipeline are not included in this analysis.

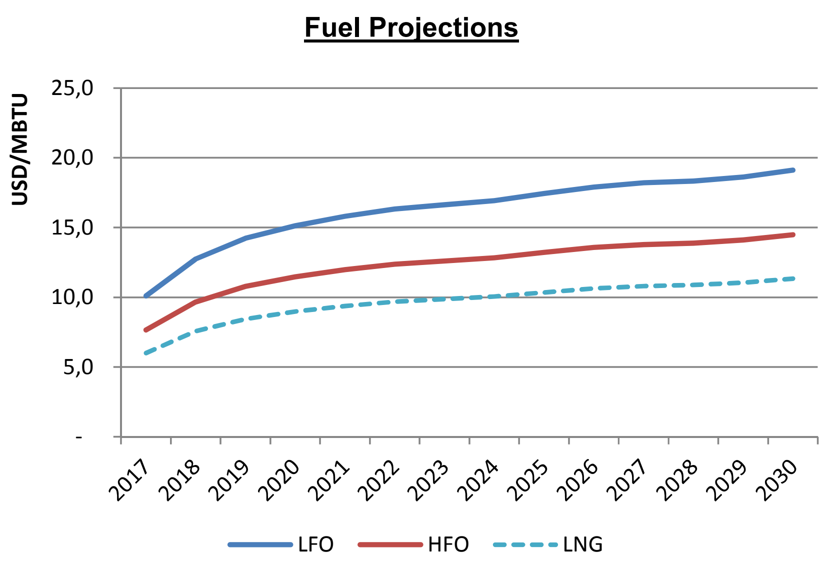
Given that this was a first preliminary valuation of the different alternatives, the costs are assumed based on information available and therefore were subjected to further analysis in the second report of Task B, LNG Options Report.

In order to allow new infrastructure COD in the year required, investments are assumed to be executed two years in advance.

[31] For scenario comparison only additional OPEX to the existing infrastructure will be considered.

4.2. FUEL PRICES.

Fuel prices used for the estimation of the cost for power generation, were projected based on the EIA January 2017 forecast. The following figure shows the projected prices.



Source: Own elaboration

In particular:

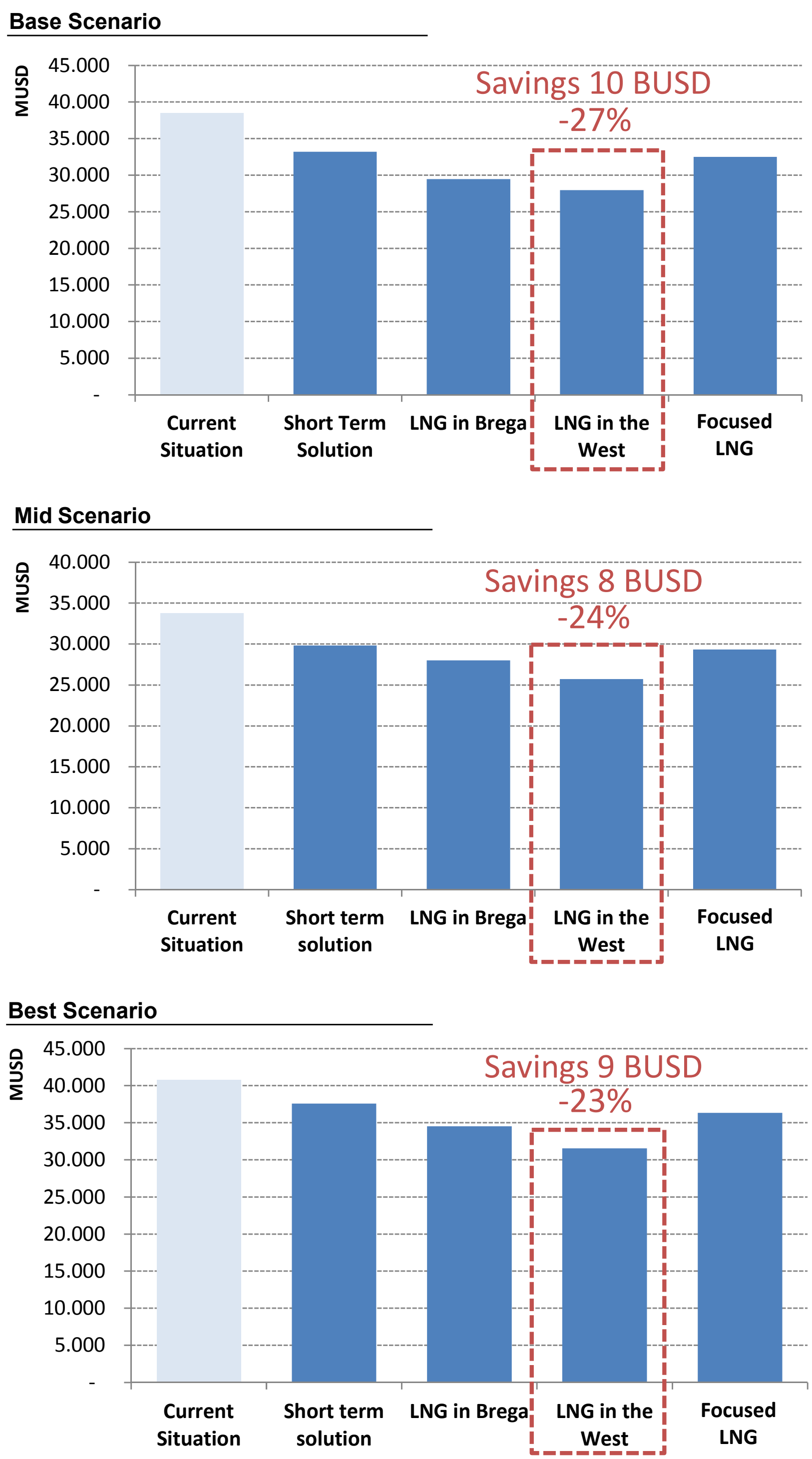
- LNG was projected based on the prices from Egypt and Pakistan that recently singed short and long term LNG supply contracts at 12% of Brent price.
- The liquid fuels forecast was based on the historical spread between international liquids fuel price and WTI.
- Exports price, to be considered in the "Short Term Solution" alternative, as an opportunity cost of not selling the gas to Italy is forecasted at 11% of Brent price similar to other prices sold in continental Europe.
- Local gas, although it would not have any impact on the study as all alternatives contemplate the utilization of all local gas (with higher priority than more expensive fuels), is estimated at 4 USD/MBtu.

4.3. EXPECTED SAVING FROM USING OPTIMAL FUEL.

Based on CAPEXs and OPEXs and considering an estimated discount rate of 10%, the present value of cost of each alternative under the different scenarios is exposed in the following figure. In all cases, Alternative "LNG in the West", shows the higher level of savings (with a net present value of 8 to 10.5 BUSD depending on the scenario) compared with maintaining the current situation due to two reasons: liquid fuels are replaced by LNG which is cheaper and there is no need for large gas transportation system expansions.

Total saving of this alternative in relation to the different scenarios[32] are:

Cost Present Value of the Alternatives



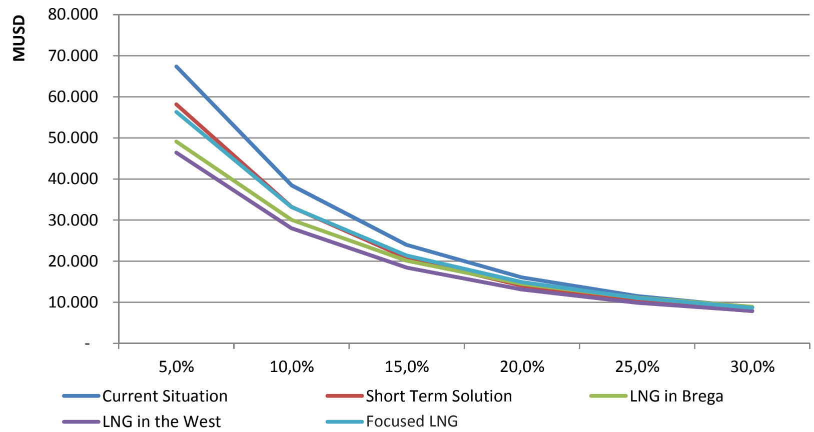
Source: Own elaboration

[32] Note all scenarios consider the same electricity scenarios. All power plants are included in all scenarios.

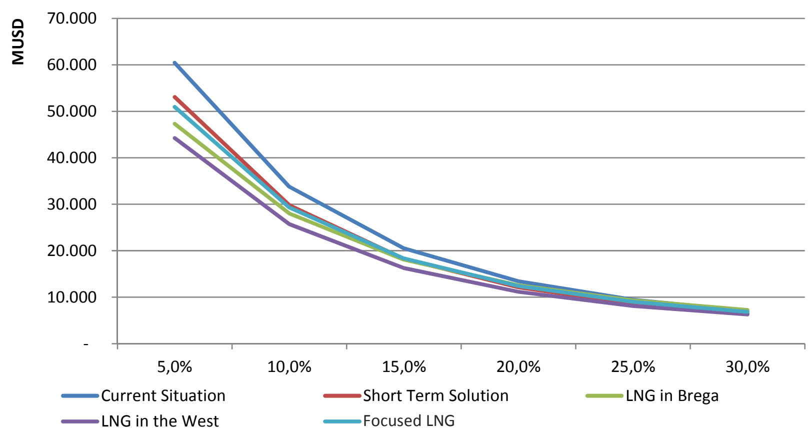
It is worth noting, that the discount rate has a significant impact on the present value of the total savings of each alternative. The following graphs show the different cost present value at different discount rates.

Cost Present Value Sensitivity at Different Discount Rates

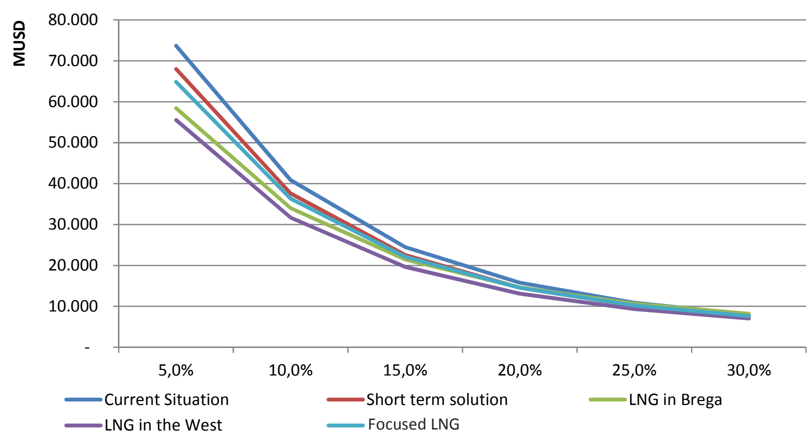
Base Scenario



Mid Scenario



Best Scenario

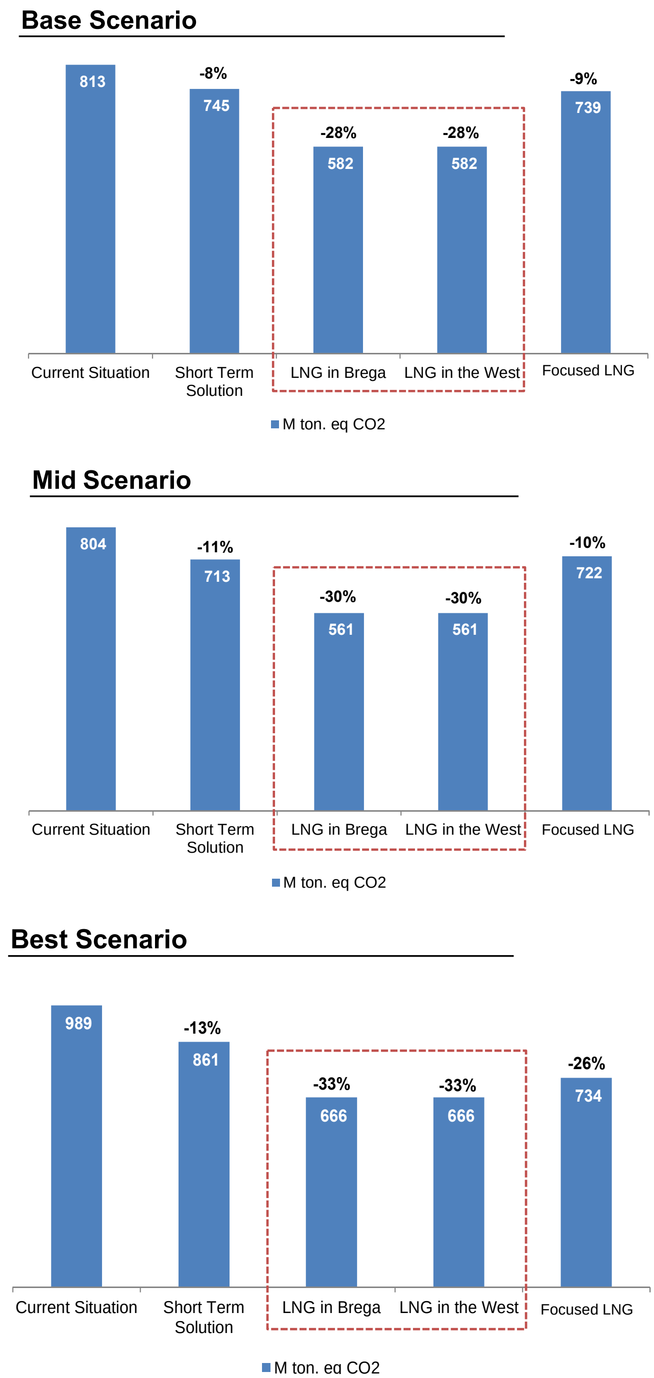


Source: Own elaboration

4.4. POTENTIAL REDUCTION OF CO_2 EMISSIONS.

The following figures summarize the reduction of CO_2 emissions in comparison to the case under current conditions (i.e. neither additional supply nor transportation expansions). As could be expected, Alternatives LNG in Brega" and "LNG in the West" presents the largest reduction as liquid fuels are not used in either of the scenarios.

CO_2 Emission Reduction



Source: Own elaboration

5. GUIDELINES TO PRIORITIZE THE USE OF GAS FOR GENERATION.

Before addressing this point specifically, it is important to highlight that as a matter of a national energy policy level a first assessment should be made in regard to where a “molecule” of natural gas is more valuable for the country or in other words, identify which final consumer or sector has the highest opportunity cost for such a molecule. In the context of this study for the Libyan case this assessment has been implicitly made since the natural gas on which the power sector can count on is the “reminder” one; that is, after having fully supplied the other sectors (i.e. upstream usage, industry, and exports)[33].

So, the next question is: “with the natural gas available for power generation, how should it be prioritized among the existing and future power plants?”

The first consideration is to guarantee a tight coordination among NOC and GECOL plans not just in terms of both the location of the natural gas supply to pipeline and power production (generation), but also in regards to the development of each sector’s infrastructure. As previously mentioned the local gas non-thermoelectric demand is low compared with power generation, thus the latter would probably be the driver for gas transportation expansions and additional supply (either new local production or imports). Thus, the decision of moving forward with an LNG import terminal should be an integrated decision and should contemplate potential resulting local gas production (even though currently there is no exploration, if the political situation improves, an increase in production could be expected leveraging from the countries significant potential). Regarding infrastructure, especially that of transportation, it is necessary to identify the optimal capacities of each one (or even to make comparisons like gas-by-pipeline vs gas-by-wire in case a power plant is to be built near to a gas field, etc.).

Another point to take into account is the efficiency of the power plants: if there is the alternative and the necessity to supply them with either liquid fuels or natural gas, the liquids should be allocated to the most efficient plants so as to minimize the generation costs by supplying the most expensive fuel to the plant that requires less of it to generate the same amount of electricity.

Generally speaking, it is cheaper to transport liquid fuels than natural gas when it is done by pipelines, so the long distances from a fuel supply to a power plant make liquid fuels the obvious choice provided there are actually pipelines in place; otherwise, if the fuels ought to be transported by other means (by ship or truck, for instance), an analysis of the transportation costs should be made.

[33] See

6. HIGHLIGHTS.

In the **short term**, reducing the exports to Europe and expanding the Coastal Pipeline is a good immediate solution to reduce liquid fuels consumption for power generation. However, it is not enough to offset the fall in local gas production in the mid/long term.

In the **mid-term** (i.e. next 10 years), replacing liquid fuels by LNG seems to be an alternative that would allow significant savings in generation costs. However, the required expansion in existing transportation and import infrastructure would reduce the savings.

Given that: the fall in production will be greater in the West Entry Point, a large part of the efficient power generation is located in the West, and, the Mellitah – El Khoms pipeline has the largest capacity the most economical alternative is to place the LNG import terminals in the west somewhere near Khoms.

This alternative would also increase flexibility and reduce investment costs. The former by allowing the adaptation of the solution to the evolution of the country's political situation and/or the development of a new local gas supply. FRSU type import terminals, could be built in the short term in case gas demand is not expected to be met or dismantled when there is higher local gas supply. The latter because FRSU usually do not require high investment, as the vessel is not built or purchased by the user but leased.

In the **long term**, the country could either move forward with an onshore terminal or end LNG imports depending on the evolution in the natural gas E&P. The decision would need to be taken around 2026/2027.

7. ANNEX.

7.1. POTENTIAL SWITCH OF POWER PLANTS TO NATURAL GAS.

As detailed in “2. Country Overview”, Derna and Tobruk power plants are the only ones not designed to run on a dual fuel basis (i.e. only on fuel oil.). These power stations are located at the North-Eastern part of the country. Both are based on the conventional steam units of 65 MWe, i.e. sub-critical steam turbines and HFO-fired steam boilers. Tobruk power station was commissioned in 1983, and Derna in 1985.

According to the Expansion Plan, it can be observed that the plants are due to be decommissioned in 2019, and that the available capacity is limited to 30 MW. The reported heat rate evidences the poor performance of these power stations, which are obviously not well suited for long term and base-load operation in terms of energy efficiency.

The conversion of steam plants from HFO-firing to NG-firing is technically possible. It would consist of installing a natural gas supply system including associated gas control and safety systems, and to install a gas firing system into the existing boilers with associated mechanical, electrical and process control adaptations.

However it is expected that the pay-back period of such works would be incompatible with the remaining operational lifetime of the plants (less than 2 years of operation are planned) and expected dispatch.

Moreover, the performance indicators mentioned above show that additional works might be required to recover the original plants’ performances. More generally, a lifetime extension assessment might be undertaken to ascertain that the steam turbine generators are still in good condition, as well as to address other ageing issues, boiler corrosion issues, and I&C obsolescence which are generally concerns for similar older plants.

7.2. PRELIMINARY ANALYSIS ON TOBRUK.

7.2.1. Expanding the Pipeline to Tobruk.

In order to determine if existing and planned power plants located in Derna and Tobruk the Consultant has undertaken a desktop study to identify a route technically feasible to connect the cities with a new pipeline.

Route Survey

Source: Own elaboration

Two routing are possible and have been checked and compared. The first is along the coast and the second is south from the mountain area. Laying the pipeline along the coast would be very difficult due to the fact that the pipeline would go through the cities in the coast and laying in a cliff (altitude ± 250m). Thus, the second option seems to be the most favourable.

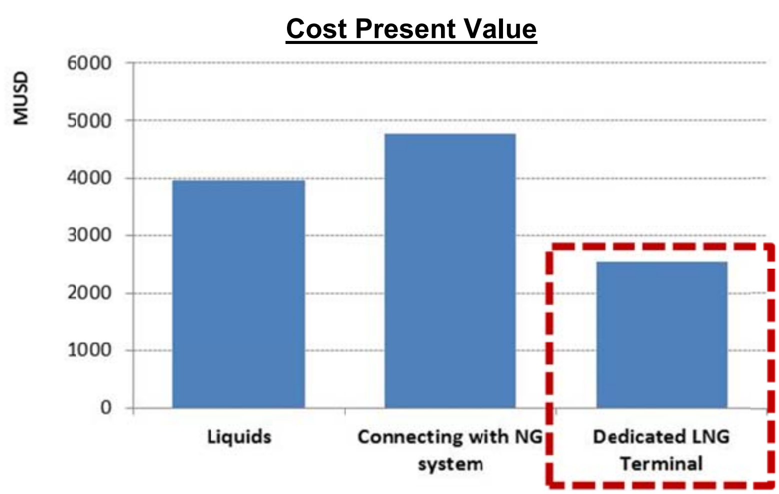
Based on a preliminary estimate, the required 34 inch / 430 km pipeline would have a cost of approximately 1,540 BUSD (uncertainty + 40%). In addition to the new pipeline, to supply gas from Marsa El Brega to the new pipeline, the existing Coastal pipeline should be expanded to supply power plants located in these cities.

Given the long distances from the Costal pipeline and the expected dispatch for existing and planned power plants in Derna and Tobruk, it would be more economically advantageous to use liquid fuels (during peaks) than to expand the pipeline to this location[34].

7.2.1. Tobruk Standalone.

If Tobruk power plant is analyzed independent from the system a dedicated LNG could prove to be an economically feasible alternative.

Considering the full dispatch of the new CCGT in Tobruk, fuel saving could be around 330 MUSD/y in the 2021-2030 period[35]. If the full dispatch of new power plants in Derna and other local units saving would be even bigger.



Source: Own elaboration

[34] It is assumed that Libya only would be installing one regasification terminal.
[35] If Tobruk is dispatched below 30% it would be more economically to use liquid fuels.

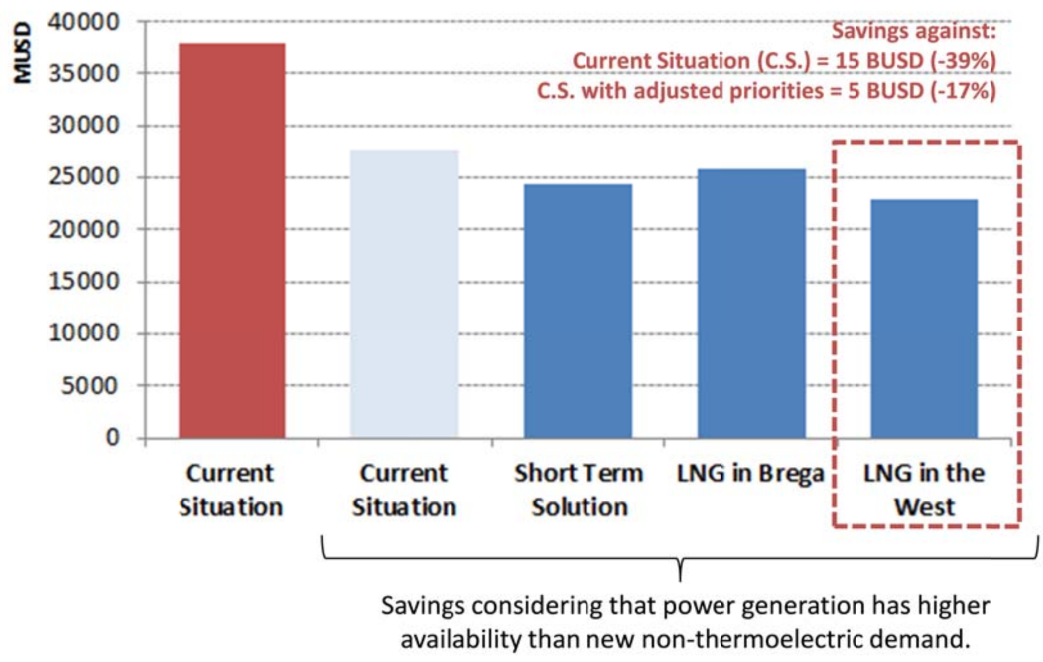
7.3. SENSITIVITY WITH ADJUSTED GAS PRIORITIES.

The alternative for higher gas availability analysis assumes that gas available for power generation is the remainder after deducting upstream usage and non-thermoelectric demand. However, it could be discussed (as highlighted in section "5. Guidelines to Prioritize the Use of Gas for Generation") where a "molecule" of natural gas is more valuable for the country.

As non-thermoelectric demand is currently small (~150 mmscf/d), but it is expected to grow to ~650 mmscf/d according to NOCs projection, the Consultant run a sensitivity assuming that power plants have higher priority than new non-thermoelectric demand based on 2016 levels).

Adjusting the priorities of natural gas will increase gas availability for power generation; thus reduces the fuel cost in all alternatives, even in the case of maintaining the status quo. However, given that non-thermoelectric demand is small compared to power generation, the higher availability is still not enough to meet demand in the long run. Thus, as well as in all the other scenarios studied, the LNG terminal near Khoms alternative maximizes savings.

Cost Present Value of the Alternatives



Source: Own elaboration

7.4. ELECTRICITY MARKET ASSUMPTIONS USED IN THE PROJECTIONS.

For the projection the Consultant used the information regarding the approach for demand projection and operational features provided by PwC through its Rapid

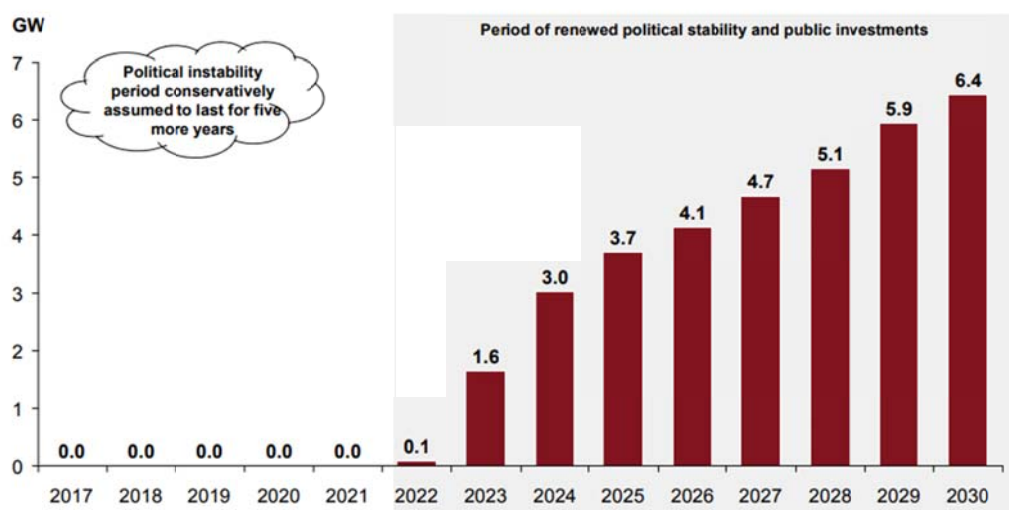
Assessment of the Electricity Sector. The following tables summarize the availability and thermal efficiency for base and best case scenarios:

Electricity Demand Projections main Drivers

Scenario	Consumption forecast	Demand (peak) forecast
Continuous political instability scenario	• Regression analysis of historical consumption[1] vs. GDP and population • Projections based on new IHS and BMI GDP and population estimates[2] (each consumer category estimated separately[3]) • No mega-projects assumed to kick-in	Forecast built separately for each scenario according to the following methodology: • Correlation of historical peak load and actual electricity consumption[1] (estimated based on electricity generation and net import, net of own consumption and technical losses) • Demand (peak) forecast based on consumption forecast growth rate
Slow political stability scenario	• Regression analysis of historical consumption[1] vs. GDP and population • Projections based on IHS and BMI GDP and population estimates (each consumer category separately estimated) • Mega-projects assumed to kick-in in 2022.	
Mid Scenario (Updated Slow political stability scenario)	• Same projections as the “Slow Political Stability Scenario”, with a reviewed projection of mega-projects (with a more realistic estimation)	

Source: PwC’s Rapid Assessment

“Mega Projects” Ramp-up Projections



Source: PwC’s Rapid Assessment

Operational Features Assumptions

Variable	Scenario name (2017-2030)	Simplified assumptions on **Existing plants**	Simplified assumptions on **Under construction, contracted and proposed plants**
1 **Installed capacity/ Suspended units** (MW)	Best	All units suspended in 2016 recovered in 2017	No suspended units
	Base	All units suspended in 2016 recovered in 2022	No suspended units
2 **Availability** (%)	Best	GECOL data collection ID23 capacity projections	GECOL data collection ID23 capacity projections
	Base	Average 2010-2016 GECOL actual availability (%) by plant	Average 2010-2016 GECOL actual availability (%) by plant technology
3 **Thermal efficiency** (%)	Best	Max 2010-2016 GECOL actual efficiency (%) by plant	Max 2010-2016 GECOL actual efficiency (%) by plant technology
	Base	Average 2010-2016 GECOL actual efficiency (%) by plant	Average 2010-2016 GECOL actual efficiency (%) by plant technology
4 **Technical losses** (%)	Best	Min 2010-2016 GECOL actual T&D network technical losses (%)	
	Base	Average 2010-2016 GECOL actual T&D network technical losses (%)	

Source: PwC's Rapid Assessment

Base Case Installed Capacity

Type of plant		Power station	Inst. cap	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing	Various	Small / rented	N/A	N/A	135														
	Steam	Khoms Steam	480	4ST	480	480	480	480	480										
		Derna	130	2ST	0	0	0												
		Tobruk	130	2ST	65	65	65												
		Misurata Steel	507	6ST	169	169	169	169	169	169	85								
	Gas	Tripoli South	500	5GT	500	500	500	500	500	500	500	500	500	500					
		Zwetina Gas	200	4GT	50	50	50	50	50	50	200	200	200	200					
		Khoms Gas	600	4GT	600	600	600	600	600	600	600	600	600	600					
		West Mountain	936	6GT	936	936	936	936	936	936	936	936	936	936	936	936	936	936	936
		Sarir	820	3GT	570	570	570	570	570	570	820	820	820	820	820	820	820	820	820
	CC	Zawia	1.485	6GT	780	990	990	990	990	990	990	990	990	990	990	990	990	990	990
				3ST	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495
		Benghazi North	945	4GT	155	465	465	465	465	465	635	635	635	635	635	635	635	635	635
				2ST	310	0	0	0	0	0	310	310	310	310	310	310	310	310	310
		Misurata CC	820	2GT	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570
				1ST	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
		Benghazi North II	820	2GT	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570
				1ST	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
		Zwetina	820	2GT	285	285	285	285	285	285	570	570	570	570	570	570	570	570	570
				1ST	0	0	0	0	0	0	250	250	250	250	250	250	250	250	250
Under contr. / contracted	Steam	Khaleej (Gulf)	1.400	4ST	350	350	700	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
		Tripoli West	1.400	4ST				1.050	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
	Gas	Ubari	624	4GT		156	624	624	624	624	624	624	624	624	624	624	624	624	624
		Khoms II	524	2GT		524	524	524	524	524	524	524	524	524	524	524	524	524	524
		Units of (PIAG)	235	5GT		235	235	235	235	235	235	235	235	235	235	235	235	235	235
Proposed	Steam	Tripoli East	1.400	4ST				350	700	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
		Tubrok	700	2ST					350	700	700	700	700	700	700	700	700	700	700
		Darna	700	2ST							700	700	700	700	700	700	700	700	700
		Benghazi West	1.400	4ST									350	700	1.400	1.400	1.400	1.400	1.400
	Gas	Sabha	855	3GT					285	855	855	855	855	855	855	855	855	855	855
		Tripoli South II	855	3GT							285	855	855	855	855	855	855	855	855
	CC	Misurata	750	2GT				250	500	500	500	500	500	500	500	500	500	500	500
				1ST					250	250	250	250	250	250	250	250	250	250	250
		Mellitah	1.640	4GT				550	550	1.090	1.090	1.090	1.090	1.090	1.090	1.090	1.090	1.090	1.090
				2ST					270	550	550	550	550	550	550	550	550	550	550
		Zwetina II	820	2 GT					270	550	550	550	550	550	550	550	550	550	550
				1 ST						270	270	270	270	270	270	270	270	270	270
		Tubrok	820	2 GT						270	550	550	550	550	550	550	550	550	550
				1 ST							270	270	270	270	270	270	270	270	270
		Aboukammash	820	2 GT									270	550	550	550	550	550	550
				1 ST										270	270	270	270	270	270

Source: PwC's Rapid Assessment

Best Case Installed Capacity

Type of plant		Power station	Inst. cap	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing	Various	Small / rented	N/A	N/A	135														
	Steam	Khoms Steam	480	4ST	480	480	480	480	480										
		Derna	130	2ST	0	0	0												
		Tobruk	130	2ST	65	65	65												
		Misurata Steel	507	6ST	169	169	169	169	169	169	85								
	Gas	Tripoli South	500	5GT	500	500	500	500	500	500	500	500	500	500					
		Zwetina Gas	200	4GT	50	50	200	200	200	200	200	200	200	200					
		Khoms Gas	600	4GT	600	600	600	600	600	600	600	600	600	600					
		West Mountain	936	6GT	936	936	936	936	936	936	936	936	936	936	936	936	936	936	936
		Sarir	820	3GT	570	570	820	820	820	820	820	820	820	820	820	820	820	820	820
	CC	Zawia	1.485	6GT	780	990	990	990	990	990	990	990	990	990	990	990	990	990	990
				3ST	495	495	495	495	495	495	495	495	495	495	495	495	495	495	495
		Benghazi North	945	4GT	155	465	635	635	635	635	635	635	635	635	635	635	635	635	635
				2ST	310	0	310	310	310	310	310	310	310	310	310	310	310	310	310
		Misurata CC	820	2GT	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570
				1ST	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
		Benghazi North II	820	2GT	570	570	570	570	570	570	570	570	570	570	570	570	570	570	570
				1ST	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
		Zwetina	820	2GT	285	285	570	570	570	570	570	570	570	570	570	570	570	570	570
				1ST	0	0	250	250	250	250	250	250	250	250	250	250	250	250	250
Under contr. / contracted	Steam	Khaleej (Gulf)	1.400	4ST	350	350	700	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
		Tripoli West	1.400	4ST				1.050	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
	Gas	Ubari	624	4GT		156	624	624	624	624	624	624	624	624	624	624	624	624	624
		Khoms II	524	2GT		524	524	524	524	524	524	524	524	524	524	524	524	524	524
		Units of (PIAG)	235	5GT		235	235	235	235	235	235	235	235	235	235	235	235	235	235
Proposed	Steam	Tripoli East	1.400	4ST				350	700	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
		Tubrok	700	2ST					350	700	700	700	700	700	700	700	700	700	700
		Darna	700	2ST							700	700	700	700	700	700	700	700	700
		Benghazi West	1.400	4ST									350	700	1.400	1.400	1.400	1.400	1.400
	Gas	Sabha	855	3GT					285	855	855	855	855	855	855	855	855	855	855
		Tripoli South II	855	3GT							285	855	855	855	855	855	855	855	855
	CC	Misurata	750	2GT				250	500	500	500	500	500	500	500	500	500	500	500
				1ST					250	250	250	250	250	250	250	250	250	250	250
		Mellitah	1.640	4GT				550	550	1.090	1.090	1.090	1.090	1.090	1.090	1.090	1.090	1.090	1.090
				2ST					270	550	550	550	550	550	550	550	550	550	550
		Zwetina II	820	2 GT					270	550	550	550	550	550	550	550	550	550	550
				1 ST						270	270	270	270	270	270	270	270	270	270
		Tubrok	820	2 GT						270	550	550	550	550	550	550	550	550	550
				1 ST							270	270	270	270	270	270	270	270	270
		Aboukammash	820	2 GT									270	550	550	550	550	550	550
				1 ST										270	270	270	270	270	270

Source: PwC’s Rapid Assessment

Base Case Availability

Type of plant		Power station	Inst. cap	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing	Various	Small / rented	N/A	N/A	100%														
	Steam	Khoms Steam	480	4ST	70%	78%	78%	78%	78%										
		Derna	130	2ST		67%	67%												
		Tobruk	130	2ST	62%	39%	39%												
		Misurata Steel	507	6ST	71%	71%	71%	71%	71%	71%	71%								
	Gas	Tripoli South	500	5GT	85%	83%	83%	83%	83%	83%	83%	83%	83%	83%					
		Zwetina Gas	200	4GT	50%	71%	71%	71%	71%	71%	71%	71%	71%	71%					
		Khoms Gas	600	4GT	82%	79%	79%	79%	79%	79%	79%	79%	79%	79%					
		West Mountain	936	6GT	80%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%	79%
		Sarir	820	3GT	58%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%	55%
	CC	Zawia	1.485	6GT 3ST	71%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%
		Benghazi North	945	4GT 2ST	84%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
		Misurata CC	820	2GT 1ST	78%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%	76%
		Benghazi North II	820	2GT 1ST	65%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
		Zwetina	820	2GT 1ST	88%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%	71%
Under contr. / contracted	Steam	Khaleej (Gulf)	1.400	4ST	43%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
		Tripoli West	1.400	4ST				65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
	Gas	Ubari	624	4GT		74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
		Khoms II	524	2GT		74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
		Units of (PIAG)	235	5GT		74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
Proposed	Steam	Tripoli East	1.400	4ST				65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
		Tubrok	700	2ST					65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
		Darna	700	2ST							65%	65%	65%	65%	65%	65%	65%	65%	65%
		Benghazi West	1.400	4ST									65%	65%	65%	65%	65%	65%	65%
	Gas	Sabha	855	3GT					74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
		Tripoli South II	855	3GT							74%	74%	74%	74%	74%	74%	74%	74%	74%
	CC	Misurata	750	2GT 1ST				74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
		Mellitah	1.640	4GT 2ST				74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
		Zwetina II	820	2 GT 1 ST					74%	74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
		Tubrok	820	2 GT 1 ST						74%	74%	74%	74%	74%	74%	74%	74%	74%	74%
		Aboukammash	820	2 GT 1 ST									74%	74%	74%	74%	74%	74%	74%
				Average	**73%**	**74%**	**73%**	**71%**	**70%**	**70%**	**70%**	**70%**	**70%**	**70%**	**70%**	**70%**	**70%**	**70%**	**70%**

Source: PwC’s Rapid Assessment

Best Case Availability

Type of plant		Power station	Inst. cap	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing	Various	Small / rented	N/A	N/A	100%														
	Steam	Khoms Steam	480	4ST	70%	83%	83%	83%	83%										
		Derna	130	2ST		46%	46%												
		Tobruk	130	2ST	62%	46%	46%												
		Misurata Steel	507	6ST	71%	71%	71%	71%	71%	71%	71%								
	Gas	Tripoli South	500	5GT	85%	80%	80%	80%	80%	80%	80%	80%	80%	80%					
		Zwetina Gas	200	4GT	50%	80%	80%	80%	80%	80%	80%	80%	80%	80%					
		Khoms Gas	600	4GT	82%	80%	80%	80%	80%	80%	80%	80%	80%	80%					
		West Mountain	936	6GT	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
		Sarir	820	3GT	58%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
	CC	Zawia	1.485	6GT 3ST	71%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%
		Benghazi North	945	4GT 2ST	84%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%
		Misurata CC	820	2GT 1ST	78%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
		Benghazi North II	820	2GT 1ST	65%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
		Zwetina	820	2GT 1ST	88%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
Under contr. / contracted	Steam	Khaleej (Gulf)	1.400	4ST	43%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Tripoli West	1.400	4ST				100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Gas	Ubari	624	4GT		65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%	65%
		Khoms II	524	2GT		80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
		Units of (PIAG)	235	5GT		80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Proposed	Steam	Tripoli East	1.400	4ST				100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Tubrok	700	2ST					100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Darna	700	2ST							100%	100%	100%	100%	100%	100%	100%	100%	100%
		Benghazi West	1.400	4ST									100%	100%	100%	100%	100%	100%	100%
	Gas	Sabha	855	3GT					81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%
		Tripoli South II	855	3GT							81%	81%	81%	81%	81%	81%	81%	81%	81%
	CC	Misurata	750	2GT 1ST				80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
		Mellitah	1.640	4GT 2ST				84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
		Zwetina II	820	2 GT 1 ST					84%	84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
		Tubrok	820	2 GT 1 ST						84%	84%	84%	84%	84%	84%	84%	84%	84%	84%
		Aboukammash	820	2 GT 1 ST									84%	84%	84%	84%	84%	84%	84%
				Average	**73%**	**82%**	**82%**	**85%**	**86%**	**86%**	**86%**	**86%**	**87%**	**87%**	**88%**	**88%**	**88%**	**88%**	**88%**

Source: PwC's Rapid Assessment

Base Case Thermal Efficiency with Natural Gas

Type of plant		Power station	Inst. cap	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing	Various	Small / rented	N/A	N/A	10%														
	Steam	Khoms Steam	480	4ST	20%	21%	21%	21%	21%										
		Derna	130	2ST	/	/	/												
		Tobruk	130	2ST	/	/	/												
		Misurata Steel	507	6ST	31%	31%	31%	31%	31%	31%	31%								
	Gas	Tripoli South	500	5GT	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%					
		Zwetina Gas	200	4GT	31%	32%	32%	32%	32%	32%	32%	32%	32%	32%					
		Khoms Gas	600	4GT	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%					
		West Mountain	936	6GT	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
		Sarir	820	3GT	/	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
	CC	Zawia	1.485	6GT 3ST	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
		Benghazi North	945	4GT 2ST	46%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%
		Misurata CC	820	2GT 1ST	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%
		Benghazi North II	820	2GT 1ST	46%	30%	30%	30%	30%	30%	41%	41%	41%	41%	41%	41%	41%	41%	41%
		Zwetina	820	2GT 1ST	31%	30%	30%	30%	30%	30%	45%	45%	45%	45%	45%	45%	45%	45%	45%
Under contr. / contracted	Steam	Khaleej (Gulf)	1.400	4ST	/	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
		Tripoli West	1.400	4ST				21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
	Gas	Ubari	624	4GT		30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
		Khoms II	524	2GT		30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
		Units of (PIAG)	235	5GT		30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
Proposed	Steam	Tripoli East	1.400	4ST				21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
		Tubrok	700	2ST					21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
		Darna	700	2ST							21%	21%	21%	21%	21%	21%	21%	21%	21%
		Benghazi West	1.400	4ST									21%	21%	21%	21%	21%	21%	21%
	Gas	Sabha	855	3GT					30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
		Tripoli South II	855	3GT							30%	30%	30%	30%	30%	30%	30%	30%	30%
	CC	Misurata	750	2GT 1ST				45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
		Mellitah	1.640	4GT 2ST				45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
		Zwetina II	820	2 GT 1 ST					45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
		Tubrok	820	2 GT 1 ST						45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
		Aboukammash	820	2 GT 1 ST									45%	45%	45%	45%	45%	45%	45%
				Average	**36%**	**34%**	**33%**	**32%**	**32%**	**33%**	**34%**	**34%**	**34%**	**34%**	**34%**	**34%**	**34%**	**34%**	**34%**

Source: PwC's Rapid Assessment

Best Case Thermal Efficiency with Natural Gas

Type of plant		Power station	Inst. cap	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing	Various	Small / rented	N/A	N/A	10%														
	Steam	Khoms Steam	480	4ST	20%	23%	23%	23%	23%										
		Derna	130	2ST	/	/	/												
		Tobruk	130	2ST	/	/	/												
		Misurata Steel	507	6ST	31%	31%	31%	31%	31%	31%	31%								
	Gas	Tripoli South	500	5GT	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%					
		Zwetina Gas	200	4GT	31%	35%	35%	35%	35%	35%	35%	35%	35%	35%					
		Khoms Gas	600	4GT	29%	30%	30%	30%	30%	30%	30%	30%	30%	30%					
		West Mountain	936	6GT	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
		Sarir	820	3GT	/	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%
	CC	Zawia	1.485	6GT 3ST	45%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
		Benghazi North	945	4GT 2ST	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
		Misurata CC	820	2GT 1ST	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%
		Benghazi North II	820	2GT 1ST	46%	37%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
		Zwetina	820	2GT 1ST	31%	37%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%
Under contr. / contracted	Steam	Khaleej (Gulf)	1.400	4ST	/	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
		Tripoli West	1.400	4ST				31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
	Gas	Ubari	624	4GT		37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%
		Khoms II	524	2GT		37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%
		Units of (PIAG)	235	5GT		37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%
Proposed	Steam	Tripoli East	1.400	4ST				31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
		Tubrok	700	2ST					31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%
		Darna	700	2ST							31%	31%	31%	31%	31%	31%	31%	31%	31%
		Benghazi West	1.400	4ST									31%	31%	31%	31%	31%	31%	31%
	Gas	Sabha	855	3GT					37%	37%	37%	37%	37%	37%	37%	37%	37%	37%	37%
		Tripoli South II	855	3GT							37%	37%	37%	37%	37%	37%	37%	37%	37%
	CC	Misurata	750	2GT 1ST				49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%
		Mellitah	1.640	4GT 2ST				49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%
		Zwetina II	820	2 GT 1 ST					49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%
		Tubrok	820	2 GT 1 ST						49%	49%	49%	49%	49%	49%	49%	49%	49%	49%
		Aboukammash	820	2 GT 1 ST									49%	49%	49%	49%	49%	49%	49%
				Average	**36%**	**37%**	**38%**	**38%**	**38%**	**39%**	**39%**	**39%**	**39%**	**40%**	**40%**	**40%**	**40%**	**40%**	**40%**

Source: PwC's Rapid Assessment

Base Case Thermal Efficiency with Liquid Fuels

Type of plant		Power station	Inst. cap	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing	Various	Small / rented	N/A	N/A	23%														
	Steam	Khoms Steam	480	4ST	29%	29%	29%	29%	29%										
		Derna	130	2ST	19%	23%	23%												
		Tobruk	130	2ST	24%	17%	17%												
		Misurata Steel	507	6ST	20%	22%	22%	22%	22%	22%	22%								
	Gas	Tripoli South	500	5GT	28%	26%	26%	26%	26%	26%	26%	26%	26%	26%					
		Zwetina Gas	200	4GT	24%	25%	25%	25%	25%	25%	25%	25%	25%	25%					
		Khoms Gas	600	4GT	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%					
		West Mountain	936	6GT	/	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
		Sarir	820	3GT	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
	CC	Zawia	1.485	6GT 3ST	40%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%
		Benghazi North	945	4GT 2ST	31%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
		Misurata CC	820	2GT 1ST	32%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%	41%
		Benghazi North II	820	2GT 1ST	31%	27%	27%	27%	27%	27%	28%	28%	28%	28%	28%	28%	28%	28%	28%
		Zwetina	820	2GT 1ST	24%	27%	27%	27%	27%	27%	36%	36%	36%	36%	36%	36%	36%	36%	36%
Under contr. / contracted	Steam	Khaleej (Gulf)	1.400	4ST	30%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%	32%
		Tripoli West	1.400	4ST				24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%	24%
	Gas	Ubari	624	4GT		27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
		Khoms II	524	2GT		27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
		Units of (PIAG)	235	5GT		27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
Proposed	Steam	Tripoli East	1.400	4ST				21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
		Tubrok	700	2ST					21%	21%	21%	21%	21%	21%	21%	21%	21%	21%	21%
		Darna	700	2ST							21%	21%	21%	21%	21%	21%	21%	21%	21%
		Benghazi West	1.400	4ST									21%	21%	21%	21%	21%	21%	21%
	Gas	Sabha	855	3GT					27%	27%	27%	27%	27%	27%	27%	27%	27%	27%	27%
		Tripoli South II	855	3GT							27%	27%	27%	27%	27%	27%	27%	27%	27%
	CC	Misurata	750	2GT 1ST				36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
		Mellitah	1.640	4GT 2ST				36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
		Zwetina II	820	2 GT 1 ST					36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
		Tubrok	820	2 GT 1 ST						36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
		Aboukammash	820	2 GT 1 ST									36%	36%	36%	36%	36%	36%	36%
				Average	**30%**	**31%**	**31%**	**31%**	**30%**	**30%**	**30%**	**30%**	**30%**	**30%**	**30%**	**30%**	**30%**	**30%**	**30%**

Source: PwC's Rapid Assessment

Best Case Thermal Efficiency with Liquid Fuels

Type of plant		Power station	Inst. cap	Unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing	Various	Small / rented	N/A	N/A	23%														
	Steam	Khoms Steam	480	4ST	29%	30%	30%	30%	30%										
		Derna	130	2ST	19%	29%	29%												
		Tobruk	130	2ST	24%	24%	24%												
		Misurata Steel	507	6ST	20%	26%	26%	26%	26%	26%	26%								
	Gas	Tripoli South	500	5GT	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%					
		Zwetina Gas	200	4GT	24%	26%	26%	26%	26%	26%	26%	26%	26%	26%					
		Khoms Gas	600	4GT	28%	30%	30%	30%	30%	30%	30%	30%	30%	30%					
		West Mountain	936	6GT	/	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%	29%
		Sarir	820	3GT	27%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
	CC	Zawia	1.485	6GT 3ST	40%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%	43%
		Benghazi North	945	4GT 2ST	31%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%
		Misurata CC	820	2GT 1ST	32%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
		Benghazi North II	820	2GT 1ST	31%	30%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%	34%
		Zwetina	820	2GT 1ST	24%	30%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
Under contr. / contracted	Steam	Khaleej (Gulf)	1.400	4ST	30%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%	36%
		Tripoli West	1.400	4ST				33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
	Gas	Ubari	624	4GT		30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
		Khoms II	524	2GT		30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
		Units of (PIAG)	235	5GT		30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
Proposed	Steam	Tripoli East	1.400	4ST				33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
		Tubrok	700	2ST					33%	33%	33%	33%	33%	33%	33%	33%	33%	33%	33%
		Darna	700	2ST							33%	33%	33%	33%	33%	33%	33%	33%	33%
		Benghazi West	1.400	4ST									33%	33%	33%	33%	33%	33%	33%
	Gas	Sabha	855	3GT					30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
		Tripoli South II	855	3GT							30%	30%	30%	30%	30%	30%	30%	30%	30%
	CC	Misurata	750	2GT 1ST				46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
		Mellitah	1.640	4GT 2ST				46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
		Zwetina II	820	2 GT 1 ST					46%	46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
		Tubrok	820	2 GT 1 ST						46%	46%	46%	46%	46%	46%	46%	46%	46%	46%
		Aboukammash	820	2 GT 1 ST									46%	46%	46%	46%	46%	46%	46%
				Average	**30%**	**34%**	**35%**	**35%**	**36%**	**37%**	**37%**	**37%**	**37%**	**37%**	**37%**	**37%**	**37%**	**37%**	**37%**

Source: PwC's Rapid Assessment

Technical Losses

Scenario	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	17.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%
	17.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%	18.6%

Source: PwC's Rapid Assessment

7.5. MODELING RESULTS.

7.5.1. Pipeline Expansions.

The following tables summarizes the transportation system expansions requirements (based on an initial configuration[36]) for each alternative and scenario.

[36] To be updated after the site visit and further the technical study of aspects of the gas transportation system and High Level Conceptual Design of the LNG import option.

Short Term Solution

Scenario	Mellitah - Zawia		Zawia - Tripoli		Tripoli - Khoms		Khoms - Misurata		Misurata - Gulf (PP)		Gulf - Brega		Brega-Zwetina		Zwetina-Benghazi	
	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d
Base	-	-	-	-	-	-	-	-	-	-	-	-	2021	+141	-	-
Mid	-	-	-	-	-	-	-	-	-	-	-	-	2020	+118	-	-
Best	-	-	-	-	-	-	-	-	-	-	-	-	2020	+113	-	-

LNG in Brega

Scenario	Mellitah - Zawia		Zawia - Tripoli		Tripoli - Khoms		Khoms - Misurata		Misurata - Gulf (PP)		Gulf - Brega		Brega-Zwetina		Zwetina-Benghazi	
	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d
Base	-	-	-	-	2029	+177	2023 2028	+353 +353	2020 2026 2028	+353 +353 +353	2020 2026 2028	+424 +353 +353	2021	+141	-	-
Mid	-	-	-	-	2029	+177	2026 2028	+194 +431	2021 2026 2028	+353 +353 +353	2021 2026 2028	+353 +353 +424	2020	+118	-	-
Best	-	-	-	-	2028	+441	2024 2028	+353 +530	2021 2024 2026 2028	+353 +353 +353 +247	2021 2024 2026 2028	+353 +353 +353 +600	2020	+158	-	-

LNG in the West

Scenario	Mellitah - Zawia		Zawia - Tripoli		Tripoli - Khoms		Khoms - Misurata		Misurata - Gulf (PP)		Gulf - Brega		Brega-Zwetina		Zwetina-Benghazi	
	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d
Base	-	-	-	-	2028	+180	2028	+127	2020	+71	2020	+71	2021	+141	-	-
Mid	-	-	-	-	2029	+177	2028	+353	-	-	-	-	2020	+118	-	-
Best	-	-	-	-	2028	+442	2027	+565	-	-	-	-	2020	+159	-	-

Dedicated LNG

Scenario	Mellitah - Zawia		Zawia - Tripoli		Tripoli - Khoms		Khoms - Misurata		Misurata - Gulf (PP)		Gulf - Brega		Brega-Zwetina		Zwetina-Benghazi	
	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d	COD	Δmmscf/d
Base	-	-	-	-	-	-	-	-	-	-	-	-	2022	+131	-	-
Mid	-	-	-	-	-	-	-	-	-	-	-	-	2020	+118	-	-
Best	-	-	-	-	-	-	-	-	-	-	-	-	2020	+159	-	-

7.5.2. Fuel consumption by Power Plant.

The following tables summarize the fuel consumption (natural gas, LFO and HFO) by power plant in order to fully supply the average electricity demand.

"Base" scenario:

Short Term Solution

Power Plant	Fuel	Consumption (mmscf/d eq.)													
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	10	10	10	10	-	39	39	39	-	-	-	-	-
Khoms Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	15	-	-	-	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	207	207	207	207	207	-	24	49	11	-	19	87	155	207
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	99	166	254	254	254
	Natural Gas	232	232	232	232	232	232	232	232	232	141	82	-	-	-
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	74	74	74	74	74	150	150	150	150	150	150	150	150	150
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	131	131	131
	Natural Gas	110	110	110	110	110	110	110	110	110	110	110	-	-	-
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	161	161	161	161	-	109	118	118	118	76	118	118	118	118
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	64	141	141
	Natural Gas	59	59	59	40	-	112	112	112	112	112	112	61	-	-
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	112	112	108	-	-	-	-	-	-	-	-	-	-	-
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	38	50	-	-	-	-	-	-	-	-	-	-	-	-
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	134	134
	Natural Gas	-	-	36	107	107	107	107	107	107	107	107	107	-	-
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	28	254
	Natural Gas	-	-	78	117	234	234	234	234	234	234	234	234	213	30
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	39	117	117	117	117	117	117	117	117	117	117
Khaleej (Gulf)	Liquid Fuels	-	-	-	-	-	-	-	-	-	173	173	173	173	173
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	91	91	91	83	-	-	-	-	-	-	-	-	18
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	34	34	34	34	-	-	-	-	-	-	-	-	-
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	39	117	117	117	117	117	117
Total Liquids Fuels		-	-	-	-	-	-	-	-	-	272	339	621	862	1.088
Total Natural Gas		1.037	1.154	1.199	1.221	1.207	1.171	1.243	1.306	1.347	1.165	1.166	991	870	757
Total		1.037	1.154	1.199	1.221	1.207	1.171	1.243	1.306	1.347	1.437	1.505	1.612	1.732	1.844

LNG in Brega

Power Plant	Fuel	Consumption (mmscf/d eq.)													
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	10	10	10	10	-	39	39	39	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	34	34	34	34	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	207	207	207	207	207	-	24	49	11	125	199	207	207	207
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	199	199	199	199	199	232	232	232	232	232	232	232	232	232
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	74	74	74	74	74	150	150	150	150	150	150	150	150	150
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	110	110	110	110	110	110	110	110	110	110	110	110	110	110
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	161	161	161	161	41	109	118	118	118	118	118	118	118	118
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	117	117	117	89	-	112	112	112	112	112	112	112	112	112
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	112	112	99	-	-	-	-	-	-	-	-	-	3	74
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	29,1	50,3	-	-	-	-	-	-	-	-	-	-	-	-
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	36	107	107	107	107	107	107	107	107	107	107	107
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	78	117	234	234	234	234	234	234	234	234	234	234
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	39	117	117	117	117	117	117	117	117	117	117
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	91	91	91	91	-	-	-	-	-	-	63	130	130
Khaleej (Gulf)	Liquid Fuels	-	65	15	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	39	117	117	117	117	117	117
Total Liquids Fuels		-	65	15	-	-	-	-	-	-	-	-	-	-	-
Total Natural Gas		1.053	1.165	1.215	1.237	1.223	1.171	1.243	1.306	1.347	1.422	1.496	1.567	1.637	1.709
Total		1.053	1.230	1.230	1.237	1.223	1.171	1.243	1.306	1.347	1.422	1.496	1.567	1.637	1.709

LNG in the West

Power Plant	Fuel	Consumption (mmscf/d eq.)													
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	10	10	10	10	-	39	39	39	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	34	34	34	34	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	207	207	207	207	207	-	24	49	11	125	199	207	207	207
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	199	199	199	199	199	232	232	232	232	232	232	232	232	232
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	74	74	74	74	74	150	150	150	150	150	150	150	150	150
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	110	110	110	110	110	110	110	110	110	110	110	110	110	110
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	161	161	161	161	41	109	118	118	118	118	118	118	118	118
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	117	117	117	89	-	112	112	112	112	112	112	112	112	112
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	112	112	99	-	-	-	-	-	-	-	-	-	3	74
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	29,1	50,3	-	-	-	-	-	-	-	-	-	-	-	-
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	36	107	107	107	107	107	107	107	107	107	107	107
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	78	117	234	234	234	234	234	234	234	234	234	234
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	39	117	117	117	117	117	117	117	117	117	117
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	91	91	91	91	-	-	-	-	-	-	63	130	130
Khaleej (Gulf)	Liquid Fuels	-	65	15	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	39	117	117	117	117	117	117
Total Liquids Fuels		-	65	15	-	-	-	-	-	-	-	-	-	-	-
Total Natural Gas		1.053	1.165	1.215	1.237	1.223	1.171	1.243	1.306	1.347	1.422	1.496	1.567	1.637	1.709
Total		1.053	1.230	1.230	1.237	1.223	1.171	1.243	1.306	1.347	1.422	1.496	1.567	1.637	1.709

Dedicated LNG

Power Plant	Fuel	Consumption (mmscf/d eq.)													
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	10	10	10	10	-	39	39	39	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	34	34	-	-	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	207	207	207	207	207	-	24	49	11	125	117	87	155	199
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	199	199	199	199	199	232	232	232	232	232	232	232	232	232
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	74	74	74	74	74	141	150	150	150	150	150	150	150	150
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	120	132	132
	Natural Gas	110	110	110	110	110	110	110	110	110	110	110	10	-	-
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	161	161	161	161	117	108	108	108	108	108	108	108	108	108
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	140	140
	Natural Gas	117	117	117	59	-	112	112	112	112	112	112	112	-	-
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	112	112	99	107	-	-	-	-	-	-	-	-	-	-
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	29	50,3	-	-	-	-	-	-	-	-	-	-	-	-
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	84	134
	Natural Gas	-	-	36	107	107	107	107	107	107	107	107	107	40	-
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	78	117	234	234	234	234	234	234	234	234	234	234
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	146
	Natural Gas	-	-	-	39	117	117	117	117	117	117	117	117	117	-
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	91	91	-	-	-	-	-	-	-	-	-	-	-
Khaleej (Gulf)	Liquid Fuels	-	65	15	-	-	-	-	-	-	-	79	175	175	175
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	39	117	117	117	117	117	117
Total Liquids Fuels		-	65	15	-	-	-	-	-	-	-	79	294	531	727
Total Natural Gas		1.053	1.165	1.215	1.189	1.175	1.161	1.233	1.296	1.337	1.412	1.404	1.274	1.153	1.040
Total		1.053	1.230	1.230	1.189	1.175	1.161	1.233	1.296	1.337	1.412	1.483	1.568	1.683	1.767

“Mid” scenario:

Short Term Solution

Power Plant	Fuel	Consumption (mmscf/d eq.) 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	-	-	-	-	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	67	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	135	60	-	-	-	-	11	-	-	-	-	13	92
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	68	139	139	139	52	106	139	139	139	139	139	139	139	139
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	88	131	131	131
	Natural Gas	122	122	122	122	122	122	122	122	122	122	38	-	-	-
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	162	130	130	77	-	-	76	130	127	43	3	65	130	130
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	131	131	131
	Natural Gas	56	122	122	122	122	122	122	122	122	122	122	-	-	-
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	98	-	-	-	-	-	-	-	-	-	-	-	-	-
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	44,1	-	-	-	-	-	-	-	-	-	-	-	-	-
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	35	113	113
	Natural Gas	-	-	35	106	106	106	106	106	106	106	106	74	-	-
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	134	261
	Natural Gas	-	-	82	122	244	244	244	244	244	244	244	244	119	-
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	78
	Natural Gas	-	-	-	40	122	122	122	122	122	122	122	122	122	49
Khaleej (Gulf)	Liquid Fuels	-	-	-	-	-	-	-	-	-	198	339	339	339	339
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	40	122	122	122	122	122	122
Total Liquids Fuels		-	-	-	-	-	-	-	-	-	198	427	636	847	1.052
Total Natural Gas		886	873	915	954	993	1.047	1.156	1.261	1.329	1.245	1.121	991	870	757
Total		886	873	915	954	993	1.047	1.156	1.261	1.329	1.443	1.548	1.626	1.717	1.809

LNG in Brega

Power Plant	Fuel	Consumption (mmscf/d eq.) 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	162	60	-	-	-	-	11	-	84	162	162	162	162
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	67	-	-	-	-	-	-	-	-	-	-	-	-	-
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	68	139	139	139	52	106	139	139	139	139	139	139	139	139
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	122	122	122	122	122	122	122	122	122	122	122	122	122	122
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	162	102	130	77	-	-	76	130	127	130	130	130	130	130
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	56	122	122	122	122	122	122	122	122	122	122	122	122	122
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	98	8	-	-	-	-	-	-	-	-	9	86	98	98
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	44	-	-	-	-	-	-	-	-	-	-	-	44	44
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	35	106	106	106	106	106	106	106	106	106	106	106
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	82	122	244	244	244	244	244	244	244	244	244	244
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	40	122	122	122	122	122	122	122	122	122	122
Tripoli South	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	38	117
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	40	122	122	122	122	122	122
Total Liquids Fuels		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Natural Gas		886	879	915	954	993	1.047	1.156	1.261	1.329	1.416	1.502	1.580	1.673	1.752
Total		886	879	915	954	993	1.047	1.156	1.261	1.329	1.416	1.502	1.580	1.673	1.752

LNG in the West

Power Plant	Fuel	Consumption (mmscf/d eq.)													
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	162	60	-	-	-	-	11	-	84	162	162	162	162
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	67	-	-	-	-	-	-	-	-	-	-	-	-	-
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	68	139	139	139	52	106	139	139	139	139	139	139	139	139
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	122	122	122	122	122	122	122	122	122	122	122	122	122	122
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	162	102	130	77	-	-	76	130	127	130	130	130	130	130
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	56	122	122	122	122	122	122	122	122	122	122	122	122	122
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	98	8	-	-	-	-	-	-	-	-	9	86	98	98
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	44	-	-	-	-	-	-	-	-	-	-	-	44	44
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	35	106	106	106	106	106	106	106	106	106	106	106
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	82	122	244	244	244	244	244	244	244	244	244	244
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	40	122	122	122	122	122	122	122	122	122	122
Tripoli South	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	38	117
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	40	122	122	122	122	122	122
Total Liquids Fuels		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Natural Gas		886	879	915	954	993	1.047	1.156	1.261	1.329	1.416	1.502	1.580	1.673	1.752
Total		886	879	915	954	993	1.047	1.156	1.261	1.329	1.416	1.502	1.580	1.673	1.752

Dedicated LNG

Power Plant	Fuel	Consumption (mmscf/d eq.)													
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	112	135	60	-	-	-	-	11	-	84	80	-	13	92
Khoms Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	68	139	139	139	52	106	139	139	139	139	139	139	139	139
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	131	131
	Natural Gas	122	122	122	122	122	122	122	122	122	122	122	122	-	-
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	162	130	130	77	-	-	76	130	127	130	130	80	130	131
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	67	131
	Natural Gas	56	122	122	122	122	122	122	122	122	122	122	122	60	-
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	98	-	-	-	-	-	-	-	-	-	-	-	-	-
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	44	-	-	-	-	-	-	-	-	-	-	-	-	-
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	113
	Natural Gas	-	-	35	106	106	106	106	106	106	106	106	106	106	0
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	82	122	244	244	244	244	244	244	244	244	244	244
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	40	122	122	122	122	122	122	122	122	122	122
Tobruk CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Khaleej (Gulf)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	92	318	339	339
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	40	122	122	122	122	122	122
Total Liquids Fuels		-	-	-	-	-	-	-	-	-	-	92	318	537	713
Total Natural Gas		887	873	915	954	993	1.047	1.156	1.261	1.329	1.416	1.412	1.282	1.161	1.074
Total		887	873	915	954	993	1.047	1.156	1.261	1.329	1.416	1.503	1.599	1.698	1.787

"Best" scenario:

Short Term Solution

Power Plant	Fuel	Consumption (mmscf/d eq.) 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	-	-	-	-	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	67	-	-	-	-	-	-	-	-	-	-	-	-	-
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	68	139	139	139	52	110	139	139	139	139	139	139	139	139
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	109	131	131	131	131
	Natural Gas	122	122	122	122	122	122	122	122	122	19	-	-	-	-
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	162	130	130	77	-	-	130	130	130	130	130	130	130	130
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	131	131	131	131
	Natural Gas	56	122	122	122	122	122	122	122	122	122	-	-	-	-
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	98	-	-	-	-	-	-	34	-	-	-	79	93	98
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	44	-	-	-	-	-	-	-	-	-	-	-	-	4
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	109	113	113	113
	Natural Gas	-	-	35	106	106	106	106	106	106	106	3	-	-	-
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	247	261	261
	Natural Gas	-	-	82	122	244	244	244	244	244	244	244	13	-	-
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	131	131
	Natural Gas	-	-	-	40	122	122	122	122	122	122	122	122	-	-
Tripoli West	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	74
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tobruk CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	102	131
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Khaleej (Gulf)	Liquid Fuels	-	-	-	-	-	-	-	-	152	339	339	339	339	339
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	135	60	-	-	-	33	162	74	16	136	162	162	162
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	131
	Natural Gas	-	-	-	-	-	-	-	40	122	122	122	122	122	-
Total Liquids Fuels		-	-	-	-	-	-	-	-	152	448	710	960	1.208	1.441
Total Natural Gas		886	873	915	954	993	1.051	1.243	1.445	1.406	1.245	1.121	991	870	757
Total		886	873	915	954	993	1.051	1.243	1.445	1.558	1.693	1.831	1.952	2.078	2.198

LNG in Brega

Power Plant	Fuel	Consumption (mmscf/d eq.) 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	-	-	-	-	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	67	-	-	-	-	-	-	-	-	-	-	123	210	210
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	68	139	139	139	52	110	139	139	139	139	139	139	139	139
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	122	122	122	122	122	122	122	122	122	122	122	122	122	122
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	162	102	130	77	-	-	130	130	130	130	130	130	130	130
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	56	122	122	122	122	122	122	122	122	122	122	122	122	122
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	98	8	-	-	-	-	-	34	60	98	98	98	98	98
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	44	-	-	-	-	-	-	-	-	44	44	44	44	44
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	35	106	106	106	106	106	106	106	106	106	106	106
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	82	122	244	244	244	244	244	244	244	244	244	244
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	40	122	122	122	122	122	122	122	122	122	122
Khaleej (Gulf)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	83	213
Tripoli South II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	41	160	162	162	162
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	162	60	-	-	-	33	162	162	162	162	162	162	162
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	40	122	122	122	122	122	122
Total Liquids Fuels		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Natural Gas		886	879	915	954	993	1.051	1.243	1.445	1.553	1.676	1.796	1.921	2.091	2.220
Total		886	879	915	954	993	1.051	1.243	1.445	1.553	1.676	1.796	1.921	2.091	2.220

LNG in the West

Power Plant	Fuel	Consumption (mmscf/d eq.)													
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Misurata Steel	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	34	-	-	-	-	-	-	-	-	-	-	-	-	-
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	67	-	-	-	-	-	-	-	-	-	-	123	210	210
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	68	139	139	139	52	110	139	139	139	139	139	139	139	139
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	122	122	122	122	122	122	122	122	122	122	122	122	122	122
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	162	102	130	77	-	-	130	130	130	130	130	130	130	130
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	56	122	122	122	122	122	122	122	122	122	122	122	122	122
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	98	8	-	-	-	-	-	34	60	98	98	98	98	98
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	44	-	-	-	-	-	-	-	-	44	44	44	44	44
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	35	106	106	106	106	106	106	106	106	106	106	106
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	82	122	244	244	244	244	244	244	244	244	244	244
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	40	122	122	122	122	122	122	122	122	122	122
Khaleej (Gulf)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	83	213
Tripoli South II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	-	-	41	160	162	162	162
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	162	60	-	-	-	33	162	162	162	162	162	162	162
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	40	122	122	122	122	122	122
Total Liquids Fuels		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Natural Gas		886	879	915	954	993	1.051	1.243	1.445	1.553	1.676	1.796	1.921	2.091	2.220
Total		886	879	915	954	993	1.051	1.243	1.445	1.553	1.676	1.796	1.921	2.091	2.220

Dedicated LNG

Power Plant	Fuel	Consumption (mmscf/d eq.)													
		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Zwetina Gas	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Sarir	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	135	60	-	-	-	33	162	162	162	136	162	162	162
West Mountain	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	67	-	-	-	-	-	-	-	-	-	-	-	-	-
Zawia	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Benghazi North	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	68	139	139	139	52	110	139	139	139	139	139	139	139	139
Misurata CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	60	131	131	131
	Natural Gas	122	122	122	122	122	122	122	122	122	122	66	-	-	-
Benghazi North II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	162	130	130	77	-	-	130	130	130	130	130	130	130	130
Zwetina	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	131	131	131
	Natural Gas	56	122	122	122	122	122	122	122	122	122	122	-	-	-
Khoms II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	98	-	-	-	-	-	-	34	60	42	-	79	98	27
Units of (PIAG)	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	44	-	-	-	-	-	-	-	-	-	-	-	41	-
Misurata	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	49	113	113
	Natural Gas	-	-	35	106	106	106	106	106	106	106	106	59	-	-
Mellitah	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	82	122	244	244	244	244	244	244	244	244	244	244
Zwetina II	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	131	131
	Natural Gas	-	-	-	40	122	122	122	122	122	122	122	122	-	-
Tobruk CC	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	67	131
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Khaleej (Gulf)	Liquid Fuels	-	-	-	-	-	-	-	-	-	145	339	339	339	339
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tripoli West	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	159
	Natural Gas	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aboukammash	Liquid Fuels	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Natural Gas	-	-	-	-	-	-	-	40	122	122	122	122	122	122
Total Liquids Fuels		-	-	-	-	-	-	-	-	-	145	399	650	911	1.133
Total Natural Gas		852	873	915	954	993	1.051	1.243	1.445	1.553	1.536	1.412	1.282	1.161	1.048
Total		852	873	915	954	993	1.051	1.243	1.445	1.553	1.680	1.811	1.932	2.072	2.181