United Nations Development Programme

Sustainable Oil and Gas Development in Lebanon, "SODEL"

COST BENEFIT ANALYSIS FOR THE USE OF NATURAL GAS AND LOW CARBON FUELS

FINAL REPORT

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TABLE OF CONTENTS

FIGURES

TABLES

TERMS AND DEFINITIONS

In the present document the following definitions are used. Their meanings are explained in the Table 1.

Definition	Explanation
Client	The United Nations Development Programme (UNDP)
Consultant	ILF Business Consult GmbH (ILF)
Project	Sustainable Oil & Gas Development in Lebanon “SODEL”
Sub-consultant	Infrastructure Development Partnership LLP (IDP) Earth Link & Advanced Resources Development (ELARD) Infrastructure Development Partnership LLP (IDP)
Study	Complete study for the sustainable Oil& Gas development in Lebanon
Third Party	Any legal entity except the Client, Consultant and Contractor

Table 1: List of terms and definitions

ABBREVIATIONS

In the present document the following abbreviations are used. Their meanings are explained in the Table 2.

Abbreviation	Explanation
AC	Air Conditioning
APIC	Association of Petroleum Importing Companies
Bbl	Barrels
BCM	Billion Cubic Meters
Bln	Billions
BOO	Build Own Operate
BOOT	Build Own Operate and Transfer
bpd	Barrels Per Day
CAPEX	Capital Expenditure

Abbreviation	Explanation
CAS	Central Administration for Statistics
CBA	Cost Benefit Analysis
CCGT	Combined Cycle Gas Turbine
CCU	Climate Change Unit
CGP	Coastal Gas Pipeline
CH4	Methane
CO2	Carbon Dioxide
COM	Council of Ministers
DN400, DN200, DN100	Nominal Diameter 400, 200, 100 Millimetres
DO	Diesel Oil
EDL	Electricité du Liban
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
ELARD	Earth Link & Advanced Resources Development
ESCO	Energy Service Company
EU	European Union
FEED	Front End Engineering Design
FSRU	Floating Storage and Regasification Unit
ft	foot
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GOL	Government of Lebanon
GTL	Gas to Liquids
GW	Gigawatts
GWh	Gigawatt hours

Abbreviation	Explanation
HFO	Heavy Fuel Oil
HSE	Health, Safety and Environment
IB	International Bunker
IDP	Infrastructure Development Partnership LLP, UK
ILF	ILF Business Consult GmbH
IPP	Independent Power Producer
JV	Joint Venture
km	Kilometres
KOM	Kick Off Meeting
LCEC	Lebanese Center for Energy Conservation
LCF	Low Carbon Fuel
LCPC	Lebanese Cleaner Production Center
LIBNOR	Lebanese Standards Institution
LLC	Lebanon Chemicals Company
LNG	Liquefied Natural Gas
LOI	Lebanese Oil Installations
LPA	Lebanese Petroleum Administration
LPG	Liquid Petroleum Gas
MMBTU	Million British Thermal Unit
MMCFD	Millions standard cubic feet per day
MMCM	Million Cubic Meter
MMscf/d	Millions standard cubic feet per day
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water in Lebanon
MoF	Ministry of Finance
MoIM	Ministry of Interior and Municipalities

Abbreviation	Explanation
MW	Mega Watts
N2O	Nitrous Oxide
NATGAZ	National Distributing Gas Company
NEEAP	National Energy Efficiency Action Plan for Lebanon
NEEREA	National Energy Efficiency and Renewable Energy Action
NERB	National Electricity Regulatory Body
NG	Natural Gas
NOx	Nitrogen Oxides
NPV	Net Present Value
OCGT	Open Cycle Gas Turbine
OE	Office Equipment
OPEX	Operational Expenditure
p.a.	Per annum
PM 2.5	Particle Matters (< 2.5 Microns)
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PRMS	Pressure reduction metering system
S1 – S5	Scenario 1 – Scenario 5
SEA	Strategic Environmental Assessment
SH	Space Heating
SIDACO	Société Industrielle pour le Remplissage et la Distribution du Gaz
SNC	Second National Communication
SODEL	Sustainable Oil & Gas Development in Lebanon
SOx	Sulphur Oxides
ST	Steam Turbine
TCF	Trillion Cubic Feet

Abbreviation	Explanation
TNC	Third National Communication to the UNFCCC
TOI	Tripoli Oil Installations
ToR	Terms of Reference
TPES	Total Primary Energy Supply
TPP	Thermal Power Plant
UNDP	The United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
USD	United States Dollar
VAT	Value Added Tax
Vent	Ventilation
WH	Water Heating
ZOI	Zahrani Oil Installations

Table 2: List of abbreviations

1 INTRODUCTION

1.1 Authorization

The

United Nations Development Programme

3rd Floor Arab African International Bank Building

Riad El-Solh St., Nejmeh, Beirut 20115211, Lebanon

Appointed

ILF Business Consult GmbH

Joseph-Wild-Strasse 16

81829, Munich, Germany

To perform consultant services for

The preparation of a CBA for the use of natural gas and LCFs in the commercial, industrial, institutional and residential sectors in Lebanon (Contract Ref.: 15/105).

1.2 Project Description

The Government of Lebanon has initiated the process to launch the first licensing round for the offshore oil and gas exploration and production in the Lebanese waters. In preparation for this and future rounds, a SEA was carried out in 2012 to determine priority environmental policies that are needed based on the requirements of the Offshore Petroleum Resource Law (Law 132/2010).

The SEA identified a number of recommendations for forming an action plan for the next phases of work. The main recommendations of the action plan have created the foundation for the Sustainable Oil and Gas Development in Lebanon “SODEL” Project, with 2 components.

Through the first component, SODEL is supporting the LPA in developing and implementing an action plan and improving the governance of HSE aspects in the emerging oil and gas sectors.

Through the second component, SODEL undertakes technical studies that set policy recommendations for uses of the potential natural gas resources and LCFs in Lebanon. Particular focus is on the use of alternative fuels for private electricity generation and in the industrial and transport sectors. A policy paper based on feasibility assessments to be undertaken by the SODEL Project is prepared to maximize economic benefit to Lebanon while safeguarding the environment. Ultimately, the goal of SODEL is to promote the consideration of environmental and social aspects in the upstream and downstream petroleum sectors.

The Client has awarded ILF to carry out a CBA (as part of the 2^{nd} component of SODEL) for the use of natural gas and LCFs in the residential, institutional, commercial and industrial sectors in Lebanon.

This is the final and complete report with all the deliverables included, which were done by ILF.

1.3 Work Methodology for the Project

1.3.1 Task 1: Overview of the current hydrocarbons in the energy sector in Lebanon

The main outcome of this Task is to establish a comprehensive understanding of the energy consumption patterns in the target sectors, the current fuel mixes, and forecasts of fuel consumption developments (taking into consideration possible climate change influence based on the SNC study).

Upon coordination with UNDP, and after a comprehensive review of existing studies, the Consultants prepared bespoke questionnaires for specific target sectors / types of installations to aid interviews. In addition, the Consultant thoroughly reviewed existing studies and data, which can be publicly accessed or which have been made available during conduct of the work for this project.

The main issues that were addressed include:

- Understanding the quantity of fuel being imported and used in Lebanon: This information is primarily gained from existing studies (CCU has gathered much of this information to develop GHG inventories) and is complemented with data requested from Lebanese customs, private companies importing and handling fuel, and the Directorate of Petroleum/Lebanese Oil Installations;
- Understanding in which sectors the fuel is being used and for what purpose: The information was obtained from the private companies distributing fuels, from existing studies (primarily from CCU) and from owners/operators of installations; and
- Understanding the rationale for using a specific fuel and the preparedness to switch fuel: Meetings with main representatives of energy consumers in the target sectors were conducted for this purpose.

1.3.2 Task 2: Assess the existing infrastructure in Lebanon and provide recommendations to implement a new fuel mix in the target sectors

Existing gas infrastructure is rather limited in Lebanon, and often non-existent. However there is significant storage, handling and distribution infrastructure for liquid and solid fuels. The existing infrastructure was mapped along the entire logistics chain including:

- Import facilities in ports (e.g. marine import tank terminals);
- Production / bottling facilities in Lebanon (if any);

- Distribution within the country (mainly by road tanker);
- Intermediate storages;
- Outlets to customers: wholesale facilities, retail, delivery to the sites; and
- Storage / handling at customer premises prior to use.

The objective is to understand what import, storage and transport capacities exist for what fuels and to analyse, which additional logistical elements may be needed / which infrastructure elements may need to undergo modifications in case of a change of fuel mix.

Sources of information are private companies which are involved in fuel logistics in Lebanon, customers, and the Directorate of Petroleum/Lebanese Oil Installations.

1.3.3 Task 3: Conduct Cost benefit Analysis on the possible use of natural gas and LCFs in the target sectors

The analysis of costs and benefits based on the incremental cash flow principle considers a comparison between the existing situation (and fuel use) and a potential new set-up where natural gas and LCFs are more intensively used. The analysis starts with some basic qualitative/local related observations, and further calculations are performed based on pro and con arguments.

The CBA and the results are structured by Governorate and proposed sector, using both a top-level approach (macro-level) and a bottom-level approach (micro-level).

In particular, the top level approach considers the current and future (proposed) use of fuels at country level and by Governorate, mapping the fuel consumption/demand and characterizing the current and future possible supply scenarios of natural gas and alternative fuels. In particular, two future supply scenarios are considered.

The Supply Scenario 1 assumes the coastal pipeline is built and gas is available along the coast in a few years' time.

The Supply Scenario 2 assumes that two FSRUs for the main power plants (Zahrani and Beddawi) and potentially a third one for the Beirut area will be built if sufficient demand exists. In this latter scenario, the LNG would need to be transported by LNG tankers and re-gasification stations built at local level. This was technically investigated from the technical and cost perspective, as well as from the perspective of the geographical distance to the LNG import terminals (FSRUs). Not building the coastal pipeline reduces the potential for gas distribution.

For the longer term perspective (after 15 years), the location of offshore gas supply pipeline(s) was approximated.

The bottom-level approach (micro-level) includes an analysis of particular cases such as:

- For one typical household (in each Governorate), what would be the cost difference between the currently used fuels and the proposed fuels;

- For one typical institution (i.e. army or hospital), one small and one large commercial establishment (mall or hotel) in each Governorate as existing; and
- Several industrial establishments based on size (large/medium/small consumption) such as a cement factory, iron and steel manufacturing, etc. The most energy intensive industries will be considered here. About 70% of the industrial establishments are located along the sea coast, with a high concentration in the Beirut area.

Understanding the customer side is of particular importance for developing regulatory incentives for switching to LCFs and also for the design of the Pilot Study.

The costs/cost savings estimated during the analysis include:

- Investment costs for new distribution infrastructure and for new equipment at the sites (or for modification of the currently existing installations i.e. conversion costs for gas at plants) considering the existing and the proposed new set-up;
- Costs for fuel (the current conventional high carbon fuel vs. LCFs);
- Costs for transportation and distribution of fuel for the existing and proposed new set-up including i.e. capital and operational costs for the current type of HFO/diesel tankers, additional pipelines or LNG tanker fleet and their corresponding operational costs, maintenance and operation of existing (including replacement) and proposed fuel storage and distribution facilities;
- Environmental impacts of the existing and proposed new set-up in terms of public health costs resulting from air pollution and greenhouse gas emissions and of the relevant road transport.

As a result of changing the set-up, several stakeholder categories are expected to be positively affected and the effects distributed to:

- Consumers in the analysed Sectors through lower fuel costs and increased competiveness for the industry;
- Society, with a different employment structure in case of the existing situation (existing employment in fuel distribution) and new proposed set-up (less employment in fuel distribution, increased competiveness and triggered economic / industrial growth and employment); and
- Society, with healthier environment and consequently some public health costs reduction.

Data from existing studies gathered during Tasks 1 and 2, ILF calculations regarding infrastructure costs for NG and LCFs, surveys and interviews with owners/operators of certain facilities/plants were used to feed Excel spreadsheet calculations. The following inputs, outputs and structure elements were included:

- Estimated quantitative demand (mapping) for natural gas/LNG/alternative fuel at macro level and consumption of currently used fuels by sector (and main industries), with geographical conditions and concentrations being considered;
- Supply infrastructure in each governorate (mapping of the existing and possible new gas/LNG/ LCFs storage and distribution infrastructure and equipment such as existing fuel tankers or LNG transporting tankers) and relevant distribution costs;
- Resulting end-user costs for natural gas/LNG/alternative fuels and current fuels. In principle, the price of currently imported fuels is composed of import prices, fuel taxes, import terminal and distribution costs (warehouses or tank storage, road transport costs, fuel stations distribution costs). The cost of natural gas to end-users are estimated based on entry points and the proposed distribution solution i.e. LNG terminal (including or excluding re-gasification) costs, pipeline transport costs or alternatively LNG tankers transport related costs plus re-gasification costs onsite;
- Several cases are assumed for world prices of gas (LNG) and crude oil based fuels, with prices of different fuels being converted into USD/MMBTU;
- An analysis period of 45 years is used. The time start and the port location of LNG imports (FSRUs) for the first 15 analysis years are considered. Also, the entry point for the Lebanese offshore gas during the next 30 years are approximated. It is assumed the offshore gas will be cheaper or at least not more expensive than imported LNG;
- The potential gas demand for own electricity generation is estimated and deducted for each sector (especially for the industrial sector), since private local generation is expected to be phased out in 5 years;
- The governorates of Lebanon considered are Beirut, Mount Lebanon (Baabda), North (Tripoli), Bekaa (Zahleh), Nabatiye and South (Sidon); and
- The GTL, CNG conversion costs and production of other alternative fuels were researched (based on process and source of gas, etc.).

1.3.4 Task 4: provide recommendations to update or develop new legislation to implements the new fuel mix in the target sectors

In anticipation of Lebanon developing its domestic gas resources, it has taken a policy decision to start converting the country's power generation sector to gas fired power generation and renewable energy sources. This will have the twin benefit of environmental sustainability and eventually security of energy supplies. In order for this policy to be properly implemented and supported, appropriate legislation (including implementing regulations), will need to be developed.

The Study carefully reviews legislation and implementing regulations applicable to the energy supply sector in Lebanon (the "Applicable Laws"). In particular, the Study undertakes a 'gap analysis' to determine which provisions of the Applicable Laws are capable of being adapted to support the new fuel mix within the targeted sector. Based upon the results of the gap analysis, the Study develops draft legislation and implementing regulations to appropriately support usage of the desired fuel mix within the targeted sectors. The Study worked closely with local counsel to determine the parameters of existing legislation and to ensure that recommended legislative adjustments are fit-for-purpose.

1.3.5 Task 5: Provide policy recommendations

Based upon a careful review of the preliminary outputs from the CBA undertaken in Task 3, the Study discussed with the Client the legal, technical, fiscal, environmental and social impacts based upon the various scenarios analysis undertaken. The Study identified the scenario most likely to deliver the objectives set for SODEL. Based upon the foregoing analysis, the Study prepared a Draft Policy paper supporting the foregoing analysis and the Government's objectives.

1.3.6 Task 6: Conduct consultation workshop to verify the attained results

The Team supported the UNDP in organizing and delivering a consultation workshop to discuss and validate the findings of the assessment.

The planned workshop was a 1-day highly interactive workshop to reach tangible outcomes and obtain concrete recommendations from the stakeholders.

1.3.7 Task 7: Design a pilot study on the use of natural gas and LCFs in an identified zone in Lebanon

Based on the identified results and recommendations from the previous tasks, the Project Committee determined a specific identified sector/zone/region for which a pilot study shall be conducted. The objective of the Pilot Study is to find out under which conditions fuel users are prepared to switch to natural gas or LCFs.

ILF developed a concept and prepared a proposal for the scope of work of a Pilot Study for the use of natural gas and LCFs in the selected sector/zone/region. The scope of work forms the basis for tendering the pilot study to a qualified company.

The pilot study is envisaged to be a combination of information campaign and data gathering. Addressees of the Pilot study shall be potential customers for natural gas and LCFs, which will be informed on the advantages of switching fuel and of a proposed potential frame work of regulatory/financial incentives. It will then be tested by use of questionnaires and/or interviews under which conditions/incentives fuel switching would result.

2 OVERVIEW OF THE CURRENT HYDROCARBONS IN THE ENERGY SECTOR IN LEBANON

2.1 Stakeholders

Various stakeholders are interested in the outcome of the CBA. In order to create a reliable source for the studied sectors and infrastructure development a consultation process through the entire project shall be implemented.

The following stakeholders are considered to be of primary relevance given their interest and potential influence on the project:

- Lebanese Petroleum Administration: policy maker, responsible for upstream offshore hydrocarbons exploration and production; interested in optimizing possible use of potential indigenous gas in Lebanon;
- Directorate of Petroleum – Ministry of Energy and Water: responsible for downstream activities in the hydrocarbon sector as well as for on-shore exploration and production; responsible for regulating the import, storage, distribution and use of hydrocarbons in Lebanon as well as related infrastructure; interested in promoting low-carbon fuels in various sectors;
- Lebanese Oil Installations of Zahrani and Tripoli – Ministry of Energy and Water: responsible for the management of the installations in Zahrani and Tripoli which include refineries (currently obsolete) and storage facilities;
- Electricité du Liban: responsible for generation, transmission and distribution of electricity; operates several power plants and electricity infrastructure; represents a major energy consumer in Lebanon with main interest in acquiring cheaper (and cleaner) sources of fuel;
- Directorate of Land Transport – Ministry of Public Works and Transport: responsible for planning and regulation of land transportation; another major energy consumer in Lebanon;
- Ministry of Industry: responsible for planning and regulation of the industrial sector, with potential interest in promoting cheaper and cleaner fuel to increase the competitiveness and sustainability of industries in the country;
- Ministry of Environment: responsible for the protection of the environment, has major interest in switching energy consumption of various sectors to gas or other LCFs. Such switch would have significant contribution in improving air quality in Lebanon as well as reducing the country's contribution to greenhouse gas emissions, MoE would be a major supporter of the project and could drive policies to promote the introduction of such fuels;
- Ministry of Finance: responsible for management of the financial resources and for the fiscal policies in Lebanon; any policy that can affect the revenues of the central government needs to be approved by the MoF; and

- Municipalities and Union of Municipalities: responsible for local governance; any decision to build local infrastructure (such as gas pipelines) should be coordinated with local authorities.

In addition to these major public sector stakeholders, various private sector stakeholders play a potentially important role in the context of this project. These include:

- Private companies that import, store, and distribute fuel in the country; these companies would be influenced (possibly negatively) by any policy shifting the use of LCFs that would replace liquid hydrocarbons which are imported and sold by them; they also manage important storage, handling and distribution infrastructure primarily for liquid hydrocarbons; these include:

    1. Uniterminals (largest terminal company in Lebanon);
    2. Medco;
    3. Total;
    4. MPC/HYPCO (part of BB Energy);
    5. IPT; and
    6. Liquigas.

- Distributers of LPG such as Natgas: these companies already provide LPG for use primarily in the residential sector;
- Syndicate of petrol stations: these stations rely mainly on the sales of gasoline; while mainly related to the transport sector which is not directly included in the scope of this Study, these stakeholders can have a major influence in lobbying against the promotion of fuels that could replace gasoline;
- Association of industrialists and representatives of major industries: these represent some of the main potential users of LCFs; in the absence of specific policy incentives, these industrialists will only switch or invest in lower carbon fuels if the investment has a decent return or relatively low pay-back period; and
- Owners of major commercial and institutional establishments: same rationale as for industrialists applies.

Other relevant stakeholders are:

- Climate Change Unit (UNDP): responsible for supporting the Ministry of Environment in planning and implementing climate change adaptation and mitigation strategies in various sectors in Lebanon; the CCU has undertaken various studies of relevance to this activity and is an important data holder with high interest in the outcomes of this Study;

- CEDRO (UNDP): this is another project promoting the introduction of renewable energy and energy efficiency in Lebanon; important data holder with high interest in the Study;
- Lebanese Center for Energy Conservation (LCEC): responsible for the promotion of energy efficiency strategies in Lebanon; important data holder with relations with various commercial and institutional stakeholders and with possible interest in the outcome of the Study;
- Lebanese Cleaner Production Center (LCPC): responsible to promote cleaner production particularly in the industrial sector; some of the data and assessments conducted at industrial establishments could be of interest to this assessment;
- Central Administration for Statistics (CAS): responsible for collecting and maintaining vital statistics in the country; and
- Lebanese customs: holder of information on quantities and types of fuels imported in the country.

2.2 Literature Review

2.2.1 Studies

Many reports, presentations, and other deliverables have already been produced as the outcome of different projects studying the Lebanese Oil and Gas and Energy sector. Among the received and collected information, the following documents have been recognized to be relevant to the Team's work:

- LNG Supply for Lebanon's Power Sector in light of the Pending offshore gas Discoveries and the World's Falling Oil Prices;
- The National Bioenergy Strategy for Lebanon, 2012 (CEDRO);
- Policy Paper for the Electricity Sector in Lebanon;
- Energy Efficiency Study in Lebanon, World Bank;
- Optimal Renewable Energy Mix of the Power Sector by 2020 in Lebanon;
- Technology Needs Assessment (TNA) Mitigation for the Energy and Transport Sectors;
- SNC Vulnerability and Adaption Electricity Summary (Arabic);
- Lebanon's Second National Communication to the UNFCCC on Climate Change;
- The Power Sector in Lebanon; and Lebanese Gas Potential: National Demand and Export Options dated 21 October 2014;
- The Hydrocarbon Strategy Outline;

- Relevant information from the "Scenario Analysis" which is still work in progress (in its early stages); and
- The latest information about the "FSRU" project.

2.2.2 Relevant Laws, Policies and Plans

An initial legal review is provided in this section. Further regulatory review has been performed by the legal expert, hired by UNDP.

Electricity and Renewable Energy

Decree No. 16878 of 1964 established the EDL as an autonomous state-owned entity under the authority of the MoEW. This legislative text entrusts the generation, transmission and distribution of electricity across Lebanon to EDL. Article 4 of the Decree provides that no license, concession or permit generation, transmission or distribution of electricity may be granted to another entity. Pursuant to this Decree, EDL benefits from a monopoly on the production, transfer and distribution of electric power in Lebanon.

As such the private sector may not enter the market of electricity and sell its production, whether through conventional or renewable resources, except through the project tenders organized from time to time by the MoEW, subject to the availability of necessary funding. Projects financing is mainly governed by EDL Investment System Regulation through **Decree No. 7580 of 1974,** and Tender Regulation through **Decree No. 2866 of 1959**.

Alongside EDL, four (4) private concessions (Zahle, Jbeil, Aley and Bhamdoun) and three (3) private/semi-private hydroelectric power plants (Nahr Ibrahim, Kadisha, and Al Bared) are generating electricity.

In 2002, the parliament adopted **Law No. 462 of 2002** on the Organization of the Electricity Sector which sets an updated legal framework for regulating the electricity sector in Lebanon. The main provisions of this legal text are as follows:

1. Provision for the privatization of all or some of the distribution and production activities of the electricity sector (transmission to remain with the public sector). The proposed privatization model starts with the Council of Ministers (COM) creating joint stock companies, called "privatized companies" and subject to the commercial law licensing procedures. Two years following the establishment of a privatized company, the government may offer up to 40% of the share of the privatized company, through public auction or tender. In addition, the law provides for the licensing of Independent Power Producers[1] (IPPs).

1 An Independent Power Producer is an entity, which is not a public electric utility, but which owns and/or operates facilities to generate electric power for sale to a utility, central government buyer and end users.

2. Creation of an independent sector regulatory body: the 'National Electricity Regulatory Body' (NERB) to regulate and monitor the electricity sector and to issue licenses to the Privatized Companies established pursuant to the law and IPPs.
3. Defining the NERB roles and responsibilities, which include:
   a. Preparing studies, decrees and regulations' projects;
   b. Promoting investment and encouraging competition in the electricity sector; and fixing the ceiling of prices of production services, tariffs, subscription and service fees, fines, etc.;
   c. Setting technical and environmental standards relevant to the electricity sector;
   d. Issuing, renewing, suspending, amending and cancelling licenses or authorizations;
   e. Controlling and monitoring the compliance of the licenses and authorization holders with the laws and regulations; and
   f. Corporatization/restructuring of EDL and enhancing its overall resources and capabilities.

In 2006, **Law No. 462** was amended by **Law No. 775 of 2006** (no longer relevant) and recently replaced by Law No. 288 of 2014 as a temporary measure for "one year" and "two years" respectively during which the Council of Ministers shall be in charge of granting the production permits and licenses upon the proposal of the MoEW and the MoF, this until the members of the regulatory commission, described under Law No. 462, are appointed and start carrying out with their tasks. The main strengths of Law No. 462 of 2002 is that it allows for the establishment of a regulatory commission in charge of elaborating the important details pertaining to the introduction of renewable energy and energy conservation. Nevertheless, the lack of political agreement has prevented the establishment of the NERB, and hence the implementation of Law 462. The main gaps and weaknesses of Law 462 are that it does not directly nor specifically include feed-in tariffs[2], except by the authority given to the NERB in the preparation of Transaction Dossiers, and does not promote or regulate specific aspects of renewable energy in a comprehensive manner. Complementary laws and decrees are needed to complete the legal framework related to renewable energy.

The LCEC prepared in 2010 the 'Energy Conservation Draft Law' for the promotion of energy efficiency and renewable energy in Lebanon. This draft law has not yet been approved by the Lebanese Parliament. The draft law offers a legal framework for energy audits, energy efficiency stand-

2 A feed-in tariff is a policy mechanism designed to accelerate investment in renewable energy technologies. It achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology.

ards and labels, financial incentives for energy efficient appliances and net-metering and the institutionalization of the LCEC.

In terms of private electricity provision, an informal structure for electricity subscription (private generators) is provided by the private sector in the status quo of electricity supply shortage and governed by **Circular No. 10/1 issued in 19/03/2011** issued by the Ministry of Environment, for the monitoring of the operation of electric generators.

The National Policy Paper for the Electricity Sector

This policy paper was proposed in 2010 by the Minister of Energy and Water and tackles the addition of generation capacity to cover the existing gap and commits to meeting these additions through at least 12% renewable energy. This policy paper was approved by the Council of Ministers' Decision No. 1 dated 21 June 2010 consists of ten integrated and correlated strategic initiatives which are focused on remedying the problems of the energy sector in respect to infrastructure, supply and demand, and the legal framework.

The National Policy Paper is a realistic implementation program for the essential rehabilitation and improvement of the electricity sector to respond to the economic, social and political Lebanese needs. This Paper considers corporatization to be the best solution for the revitalization of EDL. The objective of this policy was to set norms and standards for the provision of safe and fair electric services with greatest quality and at lowest cost. The policy will progressively rearrange and increase the existing tariff to eradicate the financial deficit in the electricity sector and establish a balanced budget for EDL to eventually reduce the financial burden on the citizens.

This policy is committed to launch, support and reinforce all public, private and individual initiatives to adopt the utilization of renewable energies to reach 12% of electric and thermal supply. The policy's main points, with regards to the restructuring of the legal framework for the Energy Sector and the development of renewable energy and energy efficiency initiatives are:

- Initiating the process of revising and amending Law 462 with concerned parties;
- Beginning with the current legal status of EDL governed by Decree 4517 in order to avoid delays in the execution of the strategy;
- Adopting a Law for the establishment of new power plants with all possible technologies and encouraging all kinds of Public Private Partnership to facilitate the transition and ensure proper continuity between the current and future legal status;
- Corporatization/restructuring of EDL and enhancing its overall resources and capabilities, through the amendment of Law 462;
- Setting norms and standards for the provision of electric services that are safe, equitable and fair with the best quality and lowest cost;
- Adoption of the Energy Conservation Law;

- Modification of legislation to allow feed-in tariffs for individual renewable energy Power Producers; and
- Implementation of the Lebanese Thermal Standards for buildings as a mandatory law.

National Energy Efficiency Action Plan for Lebanon 2011-2015 (NEEAP)

The NEEAP was developed in September 2010 by LCEC and adopted by the MoEW in December 2010. It is based on the Arab Energy Efficiency Guidelines. It was officially adopted by the COM in Decision No. 26 of year 2011. It includes 14 independent but interrelated national initiatives of energy efficiency and renewable energy. Among these, five initiatives include proposals for enhancing the legal and regulatory framework; these include:

- Adopting the draft Energy Conservation Law that was prepared by LCEC experts and discussed in a national workshop in 2010[3];
- Institutionalizing the LCEC as the National Energy Agency for Lebanon;
- Adopting a Lebanese Building Code that would include energy performance standards set for both existing and new buildings. In addition to reviewing and updating the thermal standards for Lebanese buildings and setting mechanisms to incorporate these codes in practice;
- Promoting Energy Audits and ESCO Business. The policy paper proposes the set-up of the National Energy Efficiency and Renewable Energy Action (NEEREA) as a national financing mechanism to provide the ESCOs with financial, fiscal, and technical incentives to promote energy audit activities. NEEREA is also providing subsidies for energy efficiency and renewable energy investments;
- Promoting the use of energy efficient equipment in households and other commercial buildings; this includes focusing on electrical equipment and establishing a national energy efficiency standard. In 2010, mandatory standards for the Compact Fluorescent Lamp and the Solar Water Heating were outlined in Decree No. 5305 dated 28 November 2010, approved as per Decision No. 38 of 21 September 2010 by the Council of Ministers. Enforcement status of these standards is not clear.

A draft National Hydrocarbon strategy is currently under preparation with the leadership of the LPA.

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3 This information was selected from the NEEAP 2011-2015 document. The document mentions (i) the following statement from the parliamentary workshop on March 1 and 2, 2010: "[…] emphasis on the importance of producing the energy conservation law and presenting it to the parliament for approval […]", and (ii) that "a committee of 4 experts has drafted the energy conservation law, which was then debated and updated in a national workshop in 2010.", and "a national workshop to discuss the draft energy conservation law was held on July 2, 2010 including more than 30 participants representing all concerned parties."

3 EXISTING HYDROCARBONS INFRASTRUCTURE

A description of the existing hydrocarbon infrastructure in Lebanon is presented in this section. It describes the status of hydrocarbon production in Lebanon, transportation infrastructure, terminals and storage facilities, status of local refineries and an overview of fuel stations in the country.

3.1 Hydrocarbons Production

At present, Lebanon neither produces nor are there any proven hydrocarbon deposits. However, it is understood that initial 2-D and 3-D seismic surveys that have been undertaken off the coast of Lebanon suggest that there could be significant natural fields of oil and gas resources within its offshore Exclusive Economic Zone (EEZ). The US Geological Survey estimates (2010) that there may be 1.7 billion barrels of recoverable oil and 122 TCF of recoverable gas resources[4] in the Levant basin.

However at the moment the Lebanese government has not yet launched its first licensing round which is pending the adoption of two decrees by the council of ministers. From the time the licensing round is launched, it could take an average of 10 to 15 years until hydrocarbons reach consumers, assuming exploration activities confirm the presence and commerciality of such resources.

It can therefore be assumed that indigenous resources are not likely to be available for domestic use before 2030.

3.2 Transport

In general, there are four main means of transporting petroleum products utilized by oil and gas producers and distributors: marine (including inland waterways), pipelines, motor carriers (road transport), and rail. Many distribution networks consist of a combination of these transportation means. For example, oil may be pumped through a pipeline to a waiting ship for transport to a refinery, and from there transferred to trucks that transport gasoline to retailers or heating oil to consumers.

Currently, Lebanon imports all its needs of petroleum products by sea via tankers, arriving at its public and private terminals (Chapter 3.3) after which these products are distributed to the end users within the country only through road transport. This chapter presents a summary of the existing (operative and non-operative) infrastructure related to the logistics of petroleum products in Lebanon as well as infrastructure used elsewhere but which is not available in Lebanon (such as navigable rivers channels).

4 Baalbaki Int'l. "Oil and Gas Prospects in Lebanon-2015". July 2015. http://de.slideshare.net/baalbaki/lebanon-oil-gas-2015

3.2.1 Inland Water Transport

Inland water transportation system primarily in the form of navigable water channels does not exist in Lebanon. Other than receiving all its needs of petroleum products via marine tankers, the country does not have any commercially navigable river channels usable by mechanised boats for the transport of bulky commodities from the marine import terminals to end user locations within the country. Inland water transport of hydrocarbons is therefore not available for consideration in future plans given the characteristics of the permanent rivers in Lebanon, which are not suitable for commercial navigation.

3.2.2 Import Pipelines

There exist two (2) oil pipelines and one (1) gas pipeline in Lebanon. These are described in the paragraphs below.

3.2.2.1 Iraq Petroleum Company (IPC) Pipeline

Constructed in the 1930s, the IPC pipeline is a 833 km long crude oil pipeline which transported oil produced in Kirkuk-Iraq through three (3) pipelines (12", 16", 30/32") across Syria and to a terminal and a refinery in Tripoli, north of Lebanon (Figure 1). The IPC pipeline has not been operational since 1976 as Iraq ceased pumping crude to the main Syrian export terminal at Banias and thus halted direct supplies to Lebanon.[5]

The IPC pipeline is composed of three major sections namely (i) 376 km across Iraq, (ii) 424 km across Syria and (iii) only 33 km across Lebanon, with 4 major pump stations along the Iraqi territories, 3 in Syria and none in Lebanon.

In 1960, the average receipts and exports of the installations at the Tripoli terminal are said to have been at the rate of 445,000 bpd.

Based on consultations with the Lebanese Oil Installations, there is no recent published information about the condition of the pipeline.

5 Ostfold College, The Levant webserver, "Iraq Petroleum Company" (http://almashriq.hiof.no/lebanon/300/380/388/ipc/)

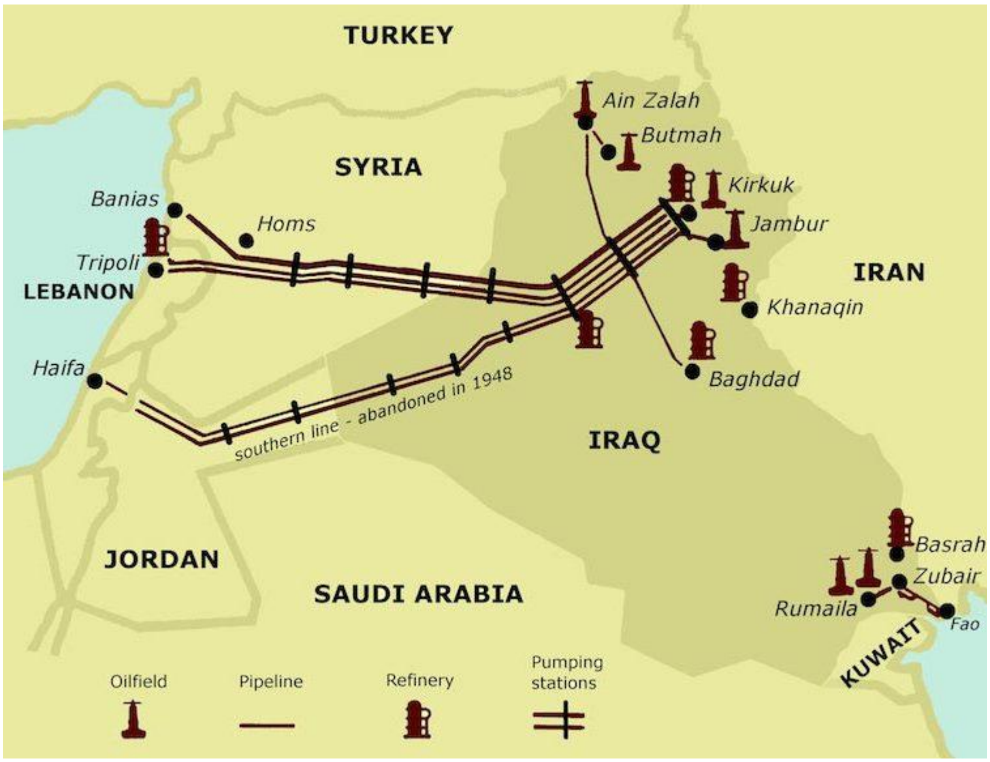

Figure 1: The IPC pipeline route
Source: www.geoexpro.com

3.2.2.2 Trans-Arabian Pipeline (TAPLINE)

Constructed by Bechtel Co. in the late 1940s, the TAPLINE is a 1,213 km long, 31" diameter crude oil pipeline which transported light crude oil from the Abqaiq fields in Saudi Arabia across Jordan and southern Syria to an export terminal and a refinery in Zahrani near Sidon, in the south of Lebanon (Figure 2). Oil was then shipped from the export terminal to markets in Europe and Eastern United States. At the time, the TAPLINE was the world's largest oil pipeline system, and was considered groundbreaking and innovative. It had a nameplate capacity of 500,000 bpd.[6]

Due to disagreements on transit fees between Saudi Arabia, Syria and Lebanon, continuous sabotage of the pipeline, as well as increasing competition from sea transport by supertankers, all transportation operations on the Syrian and Lebanese portions of the pipeline stopped in 1976. In 1990, Saudi Arabia also stopped oil transportation to Jordan (around 65,000 bpd) on the Jordanian portion of the pipeline in response to Jordan's support of Iraq during the First Gulf War.

Today, the entire line is understood to be unfit for oil transport.[7]

6 International Business Publications, Inc. "Middle East Mining and Mineral Industry Handbook, Volume I: Strategic Information and Regulations". May 2015.
7 Ostfold College, The Levant webserver, Tapline (http://almashriq.hiof.no/lebanon/300/380/388/tapline/)

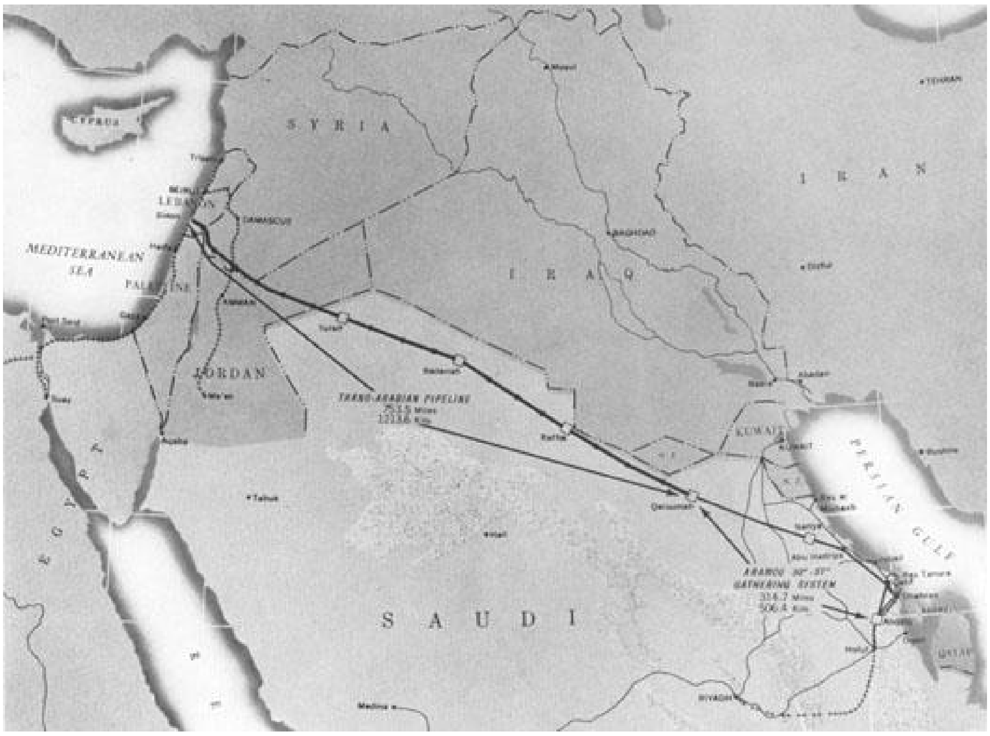

Figure 2: The TAPLINE route
Source: Ostfold College, The Levant webserver (www.almashriq.hiof.no)

3.2.2.3 *The Lebanese Gas Pipeline (GASYLE) [8]*

The Lebanese Gas Pipeline or GASYLE[9] is the only gas pipeline in Lebanon (Figure 3). It was built between 2003 and 2007 to deliver gas from Egypt to the Deir Ammar CCGT power plant in the north of Lebanon through swap arrangements with Syria. It was first activated in 2009 in co-operation with the Egyptian Company for Natural Gas-GASCO.

Running from the Syrian border (coming from Homs) to Tripoli for about 30 km, the underground 24” GASYLE is a spur of the Arab Gas Pipeline (AGP), which is a 1,200 km long trans-regional gas export pipeline, built to carry gas from Egypt to Jordan, Syria and Lebanon.[10]

8 Lebanese Oil Installations. 2016. www.leboilinst.com
9 Originally referred to as GASYLE 1 since more connections were planned but not developed
10 Hydrocarbons-technology.com. “Arab Gas Pipeline (AGP), Jordan, Syria, Lebanon, Egypt. http://www.hydrocarbons-technology.com/projects/arab-gas-pipeline-agp/

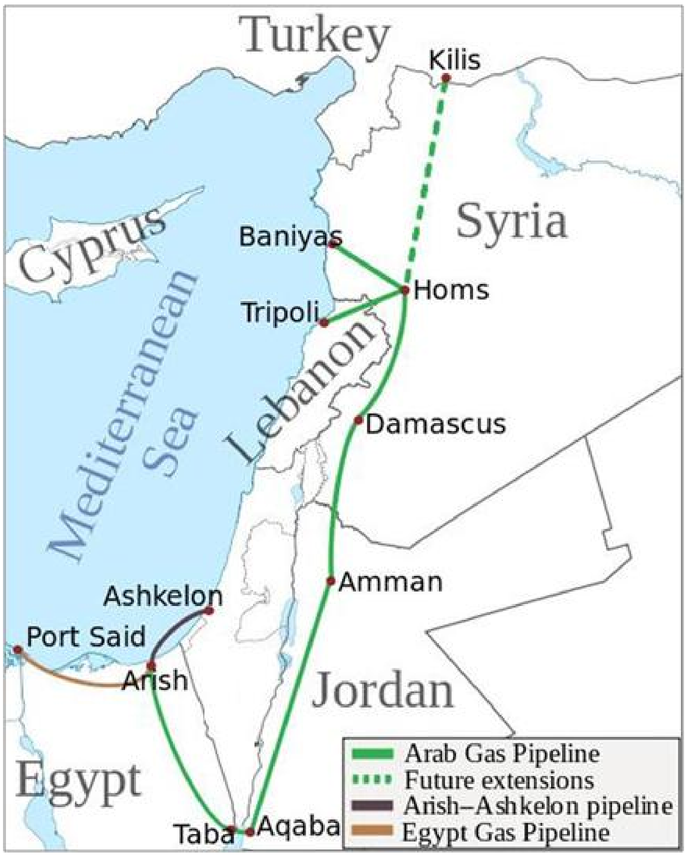

Figure 3: Arab Gas Pipeline and GASYLE
Source: www.hydrocarbons-Technology.com

The design capacity of GASYLE is 6 MMCM/d (2.2 BCM/y). The pipeline is equipped with:

1. A cathodic protection through four solar-energy stations along its course;
2. An optical cable which transmits all signals and required information between stations for work facilitation;
3. A pigging launcher station which is used to sweep and clean the pipeline and to insert nitrogen in order to launch gas. The station is also used for operation and maintenance;
4. A filtration and measurement station which receives and filters the natural gas in addition to calculating quantities and controlling quality. The maximum power for the process of filtration and measurement in the station is 250,000 m^3/h, equivalent to 6 MMCM/d; and
5. A 1.3 km and 10” interconnector pipeline transmitting NG from the filtration and measurement station at the terminal to the pressure reduction chamber in the Deir Ammar power plant consisting of filtration and measurement equipment and boilers. This station is responsible for increasing the gas’s temperature and reducing its pressure then supplying the turbine units in the power plant.

It is understood that both Lebanon and Syria had entered into an agreement under which Syria would provide Lebanon with Natural Gas (NG) in quantities that are at least sufficient for one of its combined cycle power plants. The NG would have been delivered from the Syrian northern gas fields, until the Damascus-Homs section of the AGP pipeline was ready. However, gas could not be supplied from Syria. Hence, in September 2009, a gas swapping agreement was signed between the Egyptian and Syrian officials and the Lebanese Ministry of Energy and Water (MoEW) (as a witness) to transport Egyptian gas to Lebanon through Syria. Under this agreement, the GASYLE pipeline came to commercial operation on 11 November 2009.[11] NG Quantities received were 26.3 MMCM/month (0.32 BCM/y) which were enough to fire one of the two gas turbines of the Deir Ammar power plant on natural gas.

The Deir Ammar power plant ceased receiving NG from Egypt by the beginning of November 2010 due to the riots that took place in Egypt and the geo-political problems extended from Egypt, Syria, Jordan and Israel. The lines and stations supplying NG to the AGP were bombed several times and the Egyptian crisis had a great impact on the supply of NG to Lebanon and on the export to the neighboring countries.

The substitution of diesel oil by natural gas in the Deir Ammar power plant has given an economic return to the Lebanese economy of about 125 US$ million in 2010.[12]

Currently, the Deir Ammar power plant is not receiving any natural gas through GASYLE. There are currently no publically discussed plans about the recommissioning of the pipeline in the near future.

3.2.3 Road Transport

Lebanon is heavily dependent on its roads for all kinds of freight and passenger transport. Road transportation is the only means for transporting and distributing the imported petroleum products within the country.

Information differs between sources as to the total length of the Lebanese road network. Some sources state the network to be around 8,000 km including a highway network linking Lebanon with Syria[13], whereas others state it at 6,600 km[14], 7,000 km[15] or 7,200 km[16]. The Ministry of Public Works and Transport (MoPWT) has not issued any recent publication about the road network in Lebanon.

For this report, the Consultant Team adopts the information provided in Chapter 5 of the State of the Environment Report prepared by ECODIT on behalf of the Ministry of Environment in 2002 as

11 Arab Republic of Egypt , Ministry of Petroleum. 2016. www.petroleum.gov.eg
12 Personal communication with Mr. Karim Osseiran at the Ministry of Energy and Water on 10 September 2015
13 WFP Logistics. “Lebanon Road Network”. December 2014. http://dlca.logcluster.org/display/public/DLCA/2.3+Lebanon+Road+Network
14 ECODIT. “Lebanon State of the Environment Report”. 2002
15 Central Intelligence Agency. “The World Factbook: Lebanon”. 2016. https://www.cia.gov/library/publications/the-world-factbook/fields/2085.html
16 The Investment Development Authority of Lebanon (IDAL). “Transportation: Roads, Highways and Border Crossing”. http://investinlebanon.gov.lb/en/lebanon_at_a_glance/infrastructure_logistics/transportation

well as the more recent facts and numbers provided in the National Greenhouse Gas Inventory Report and Mitigation Analysis for the Transport Sector in Lebanon, dated May 2015.

3.2.3.1 General Overview

Most parts of Lebanon are connected by good but narrow roads (Table 3). Primary roads connect the major cities and towns. Secondary roads connect the mountain villages with the primary roads. Many of the local roads in particular the mountain roads have steep grades and sharp curves but are generally well maintained. Due to Lebanon's relatively small size, all areas are accessible in one day's drive. Security on the road is considered good.

Classified road network category	Road width (meters)	Length (km)	% of the total network
International roads	10-14	548	8.3
Primary roads	8-10	1,799	27.3
Secondary roads	5-8	1,474	22.3
Tertiary/Local roads	4-6	2,770	42.0
Total		**6,591**	

Table 3: Classified Lebanese road network in 2001
Source: MoE, 2002, Lebanon State of the Environment Report

Mount Lebanon Governorate has the largest total road network in the country at around 33% of the total network, followed by North Lebanon and Bekaa at around 24% each (Table 4). South Lebanon and the Nabatiyeh Governorates combined host the shortest road network in Lebanon at around 20%. A general overview of the Lebanese road network is shown in Figure 4.

Governorate	Classified road network (km)	% of the total network
North Lebanon and Akkar	1,558	23.6
Mount Lebanon	2,156	32.7
Baalbeck Hermel and South Bekaa	1,555	23.6
South Lebanon and Nabatiyeh	1,322	20.0
Total	**6,591**	

Table 4: Geographical distribution of the classified road network in Lebanon, by governorate
Source: MoE, 2002, Lebanon State of the Environment Report

Figure 4: General overview map of the road network in Lebanon
Source: www.dlca.logcluster.org

It is understood that Lebanon has one of the highest car to people ratios in the world with one car for every three people, burdening the country with a rapidly increasing traffic volume. In 2012, passenger cars constituted 85% of the total vehicle fleet distribution, whereas light duty[17] and heavy duty[18] vehicles constituted around 10% (Figure 5). The remaining 5% was for motorcycles. In the CBA report, it is assumed that heavy duty vehicles are the type used to distribute liquid fuels in Lebanon and would be used to distribute LNG in the future.

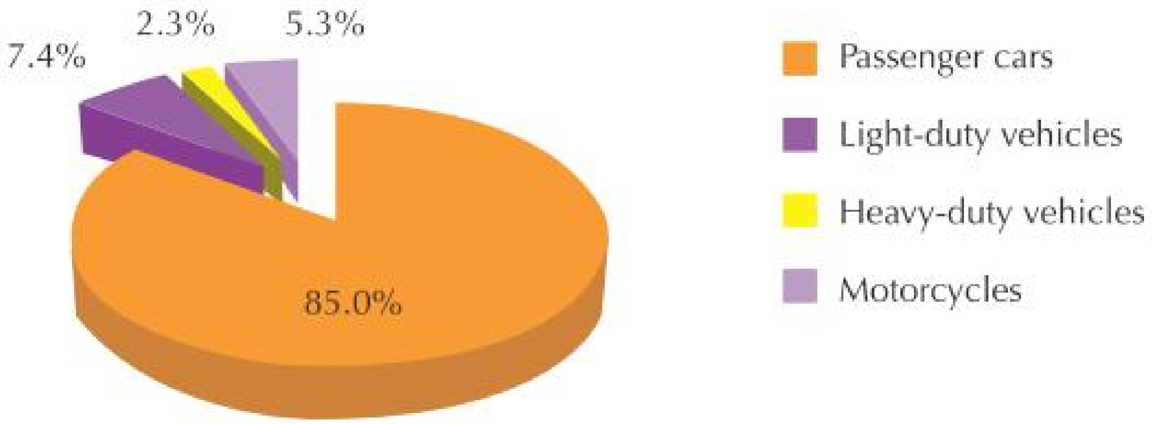

Figure 5: Vehicle fleet distribution in Lebanon in 2012
Source: National Greenhouse Gas Inventory Report and Mitigation Analysis for the Transport Sector in Lebanon, MoE, 2015

After banning the use of diesel for vehicles with gross weight lower than 3,500 kg (law 341 dated 6-08-2001 and decree no. 341/2002), passenger cars, light duty vehicles and motorcycles run only on gasoline, where heavy duty vehicles run on gas/diesel oil. About 14% is the average percentage of diesel oil consumption of the vehicle fleet in Lebanon for the period between 2005 and 2012. About 71 % of the vehicle fleet (public and private) are older than 10 years. Older models typically consume more fuel, emit more pollutants, are prone to more breakdowns, and use more lubricating oils on a per kilometer basis.

The contribution of the different vehicle categories to GHG emission is shown in Figure 6. Light and heavy duty vehicles contribute around 40%, 24% and 21% to CO2, methane, and nitrous oxide emissions, respectively.

17 Light duty vehicles are gasoline fired vehicles with gross weight < 3,500kg including light trucks and coaches, designed to transport cargo or passengers.

18 Heavy duty vehicles are diesel fired vehicles with gross weight > 3,500kg including heavy trucks and coaches, designed to transport cargo or passengers.

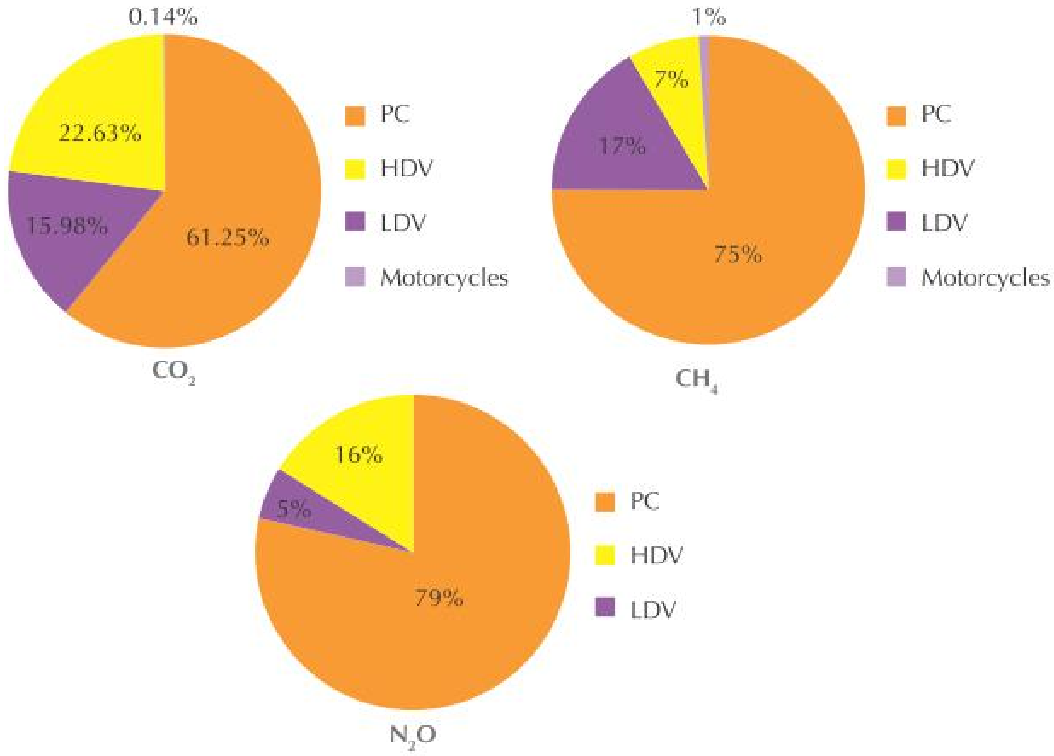

Figure 6: Contribution of the different vehicle categories to the direct GHG emissions in 2005
Source: National Greenhouse Gas Inventory Report and Mitigation Analysis for the Transport Sector in Lebanon, MoE, 2015

3.2.3.2 Key Routes

There are three key road routes in the country, each radiating from Beirut:

1. To the north is the road to Tripoli, Lebanon's second largest city, a coastal route that also passes through such major towns as Jouniyeh and Byblos. It is a 2-way, 83 km long route with 4 lanes (2 and 3 lanes at some points) in each direction.
2. To the east, crossing the Lebanon Mountains is the highway to Damascus, which connects Beirut directly to the Bekaa valley, Lebanon's main agriculture zone. The road passes through the key town of Chtaura and continues all the way to the Lebanese-Syrian border at Al-Masnaa. It is a 2-way, 53 km long mountainous route with 4 lanes in each direction.
3. To the south is the coastal road to Saida and Tyr and further to Naqoura. It is a 2-way, 104 km long route with 3 lanes.

Lebanon also possesses a second north-south road axis, running along the length of the Bekaa Valley. Roads in the northern valley converge on the Beirut-Damascus highway at Chtaura and link the important market towns of Baalbek and Zahle with the primary road network. The southern valley's local road network also centers on Chtaura at its northern end.

Cross-mountain routes, which link the northern Bekaa Valley with Jouniyeh and Tripoli, and the southern valley with Saida, are of importance during times of conflict or adverse weather conditions.

3.2.3.3 Transport Corridors

The only way into and from Lebanon by land is through Syria via 4 official border crossings, ranked according to the daily vehicle traffic these crossing handle (highest to lowest) (Figure 7):

1. Al Masnaa- Al-Jdeideh border entry point (at the eastern part of Lebanon) located 60 km from Damascus and 53 km from Beirut. This is the main corridor that connects the Lebanese and Syrian capitals.

   During winter months, road challenges due to heavy snow temporarily affect the use of the international highway leading to the Al Masnaa Crossing, particularly at Dahr al Baidar area. However, this is usually cleared within a maximum of one day. On a few occasions the Beirut-Damascus highway has also been closed due to security reasons, but overall remains the most consistent transport corridor from Lebanon to Syria.

2. Al-Abboudiyeh border entry point (at the northeast end of Lebanon) which connects Homs from the Syrian side with Tripoli from the Lebanese side. It is widely used for cargo transportation, especially in-transit cargo to Iraq.

3. Al-Aarida-Tartous border entry point (at the northwest end of Lebanon) located at the coastal area and widely used for cargo transportation between Syria and Lebanon. It is 45 km far from Tartous on the Syrian side and 170 km far from Beirut on the Lebanese side.

   Civil unrest that can erupt at any time around the Tripoli area can disrupt transportation through this border crossing.

4. Al-Qaa entry point at the northern end of the Bekaa Valley.

Figure 7: Border crossings between Lebanon and Syria
Source: www.investinlebanon.gov.lb

These four (4) border crossings with Syria do not meet international standards as they are located far from the border (except for Al-Aarida), poorly equipped and ill coordinated. Their insufficiencies leave the border region ripe for smuggling, especially the smuggling of cheap fuel from Syria as the winter months draw near.[19]

19 NOW. “Lebanon-Syria Borders 2009 Report”. 2009.

3.2.4 Railway Transport

Lebanon used to operate four rail lines (Figure 8): Beirut-Damascus (Syria), Naqoura-Tripoli (coastal railway), Tripoli-Homs (Syria) and Rayak-Aleppo (Syria), but today the country has a derelict rail network of around 400 km due to the considerable damage inflicted on it by the Lebanese civil war in the mid-1970s.[20] Hence, Lebanon is entirely cut off from a railway system that still operates from Syria to Istanbul, Tehran and Baghdad.

The Ministry of Public Works and Transport (MoPWT) is currently undertaking a feasibility study for the Beirut-Tripoli section of the old coastal railway with the financial support from the European Investment Bank (EIB). The study considers having the section Beirut-Tabarja operational by 2023 and the section Tabarja-Tripoli operational by 2030. Both sections would include freight and passenger transport. The Council for Development and Reconstruction (CDR) is also initiating a feasibility study for the railway section between Tripoli and the Syrian border.

Both the EU and the European Investment Bank have expressed their readiness to provide loans to the Lebanese state to execute public railway projects.[21] If and when railway freight becomes operational along these sections of the coast, they could offer an opportunity to transport hydrocarbons to potential users.

20 Global Security.org. “Southwest Asia: Military Capabilities, history, weather, terrain, and lines of communication data”. (http://www.globalsecurity.org/military/library/policy/army/accp/is3009/lsn2.html)

21 Wehbe, Mouhamad. “Lebanon: Dreaming of a railway between Beirut and Tabarja”. June 2014. (http://english.al-akhbar.com/node/20359)

Figure 8: Railway routes of Lebanon
Source: www.nowlebanon.com

3.2.5 Export Infrastructure

Lebanon's priority is to use its oil and gas resources, should they be proven and made available, to supply its increasing domestic energy demand, mostly driven by the growing demand for electricity generation.

Assuming that Lebanon's hydrocarbon reserves (see section 3.1) are much larger than the domestic demand, then oil and gas exports could be an option for Lebanon.

This section presents what Lebanon might be able to do with its existing infrastructure, and will not advise on other infrastructure or export options.

3.2.5.1 Pipelines

3.2.5.1.1 Oil Pipelines

Reference is made to section 3.2.2.

Other than the IPC pipeline and the TAPLINE, there is no other current infrastructure in Lebanon that is connected to the oil transport network in Syria and its neighboring countries.

Since these two (2) pipelines are non-operative and they are unfit for oil transport at the moment, thorough technical and economic analyses should be undertaken to study the rehabilitation possibilities and requirements of these pipelines (assuming they are in a minimum needed condition to be considered for rehabilitation) as well as their ability to connect to the network of the neighboring countries and to major oil exporting hubs of the Eastern Mediterranean in the future.

3.2.5.1.2 Gas Pipelines

The GASYLE gives Lebanon the option of exporting gas in the future through the existing AGP pipeline and connecting to the neighboring networks of Syria as well as the European and Eurasian network through the Turkish pipeline network.

3.2.5.2 Roads

Reference is made to Section 3.2.3 which lists the transport corridors which could be used for export, if deemed feasible.

3.2.5.3 Railways

Reference is made to Section 3.2.4. Lebanon’s railway system is unfit for any kind of rail transport at the moment. If the coastal railway stretch from Beirut to the Northern border with Syria is revived, it could then serve as a possible means to transport liquid hydrocarbons.

3.3 Terminals and Storage Facilities

Lebanon has oil and gas terminals and storage facilities which are owned and managed by the Lebanese Oil Installations, as well as private terminals and storage facilities owned and managed by the private Lebanese companies which import and distribute petroleum products to end users in the country.

3.3.1 Public Oil Infrastructure

The public oil infrastructure consists of the facilities at the Tripoli Oil Installations and the Zahrani Oil Installations.

3.3.1.1 Tripoli Oil Installations (TOI)[22]

3.3.1.1.1 General

The Tripoli Oil Installations (TOI) consists of a terminal and a closed refinery and is connected to the IPC pipeline (Figure 9).

Figure 9: Tripoli oil installations components (yellow) and Deir Ammar power plant
Source: Ostfold College, The Levant webserver (www.almashriq.hiof.no)

The current activities of the TOI consist of importing fuel oil and gas oil through the terminal and storing it in the reservoirs of the installations, then treating and distributing these derivatives to EDL and in the local market through distribution companies. A laboratory also exists in the vicinity of the refinery that is used to examining all oil derivative samples to ensure they are in line with the Lebanese specifications as set by LIBNOR.

3.3.1.1.2 Technical details and condition of the facilities

The terminal covers an area of 1,000,000 m^2 and includes:

1. five (5) loading berths at Tripoli Terminal, approximately 2.5 km away from the shore line. The berths are located at the contour depths between 10 and 20 meters. The maximum size of vessel acceptable is approximately 250,000 DWT, and/or within limits of 60ft (18.3 m) Draft and 1,110 ft. (338 m) length of vessel.

   TOI's berth number 5 has been reserved lately by the MoEW to be used for the berthing of the planned FSRU[23;] and

22 Lebanese Oil Installations. 2016. www.leboilinst.com

2. There are eleven (11) reservoirs with a storing capacity of 100,000 tons of fuel oil and 100,000 tons of Gas Oil.

3.3.1.2 Zahrani Oil Installations (ZOI)[24]

3.3.1.2.1 General

The Zahrani Oil Installations (ZOI) consists of a terminal and a closed refinery and used to receive light crude oil from Saudi Arabia through the TAPLINE (Figure 10).

Figure 10: Zahrani oil installations components (yellow) and Zahrani power plant
Source: Ostfold College, The Levant webserver (www.almashriq.hiof.no)

The current activities of the ZOI consist of importing fuel oil, gas oil and gasoline through the terminal and storing it in the reservoirs of the installations and distributing these derivatives to EDL and in the local market through distribution companies.

3.3.1.2.2 Technical description and condition of the facilities

The terminal covers an area of 2,200,000 m^2 and includes:

1. Lower zone which consists of marine department and shore operation. In the marine department only one of the four existing sea berths is operational; it extends over 1,800 m from the shore and has 3 sub-sea lines at a depth of 20 m. The shore control area includes three booster pumps in operation for unloading tankers; and

23 Personal communication with Mr. Karim Osseiran at the Ministry of Energy and Water on 10 September 2015.
24 Lebanese Oil Installations. 2016. http://www.leboilinst.com

2. Upper zone which is the tank farm area located 113 meters above sea level. It has 25 tanks with floating roofs, with a total combined capacity of 4.5 million barrels (around 550,000 MT). The tank farms are divided as follows:

   a) Three (3) for gasoline with a total capacity of 475,398 Bbl (61,135 MT);

   b) Ten (10) for gasoil with a total capacity of 1,685,837 Bbl (228,845 MT). Three (3) of these tanks have been rehabilitated in 2009, one (1) tank needs rehabilitation, one tank is kept for emergency cases, and another one is a special tank for stripping cargo from tanker to shore; and

   c) Twelve (12) for fuel oil with a total capacity of 2,694,908 Bbl (402,742 MT). It is understood that two (2) tanks are already out of service and four (4) need repair of floating roof.

3.3.2 Private Oil Infrastructure

Data provided in this section was mainly collected through the Association of Petroleum Importing Companies (APIC).

There are 13 private fuel import terminals in Lebanon with a total holding capacity of approximately 440,500 Liters.

All of these terminals are located along the Lebanese coastline, ten (10) being concentrated on Mount Lebanon’s seaside with 77% of the total storage capacity, two (2) on the seaside of the North Governorate, and one (1) on the seaside of the South Governorate (Table 5 and Figure 11). Selected infrastructure is shown in Figure 12.

No.	Name	Location	Storage Capacity (liters)
1	Arabian Petroleum Co. APEC	Tripoli, Baddawi , Sea Road North Governorate	19,365
2	Gefco	Anfeh, Koura North Governorate	9,800
3	IPT	Amchit Industrial Area Mount Lebanon Governorate	16,649
4	United Petroleum Co.	Amchit, Sea Road Mount Lebanon Governorate	16,050
5	Uniterminals	Dora, Seaside Road Mount Lebanon Governorate	45,751
6	Wardieh / Mobil	Bouchrieh, Seaside Road Mount Lebanon Governorate	44,450
7	Medco	Dora, Seaside Road Mount Lebanon Governorate	50,223
8	Total Lebanon	Dora, Seaside Road Mount Lebanon Governorate	48,000
9	Hypco / MPC	Antelias, Facing Sultan Ibra-him Mount Lebanon Governorate	25,142
10	Coral Oil Co. Ltd	Karantina, Sea Road Mount Lebanon Governorate	69,386
11	HIF	Zahrani, Saida, South Leba-non Governate	14,383
12	Liquigaz	Dora, Seaside Road Mount Lebanon Governorate	30,617
13	Cogico / Levant Oil	El- Jiyeh , Coastal Road Mount Lebanon Governorate	50,640
		Total	**440,456**

Table 5: Fuel import terminal locations and storage capacities
Source: APIC

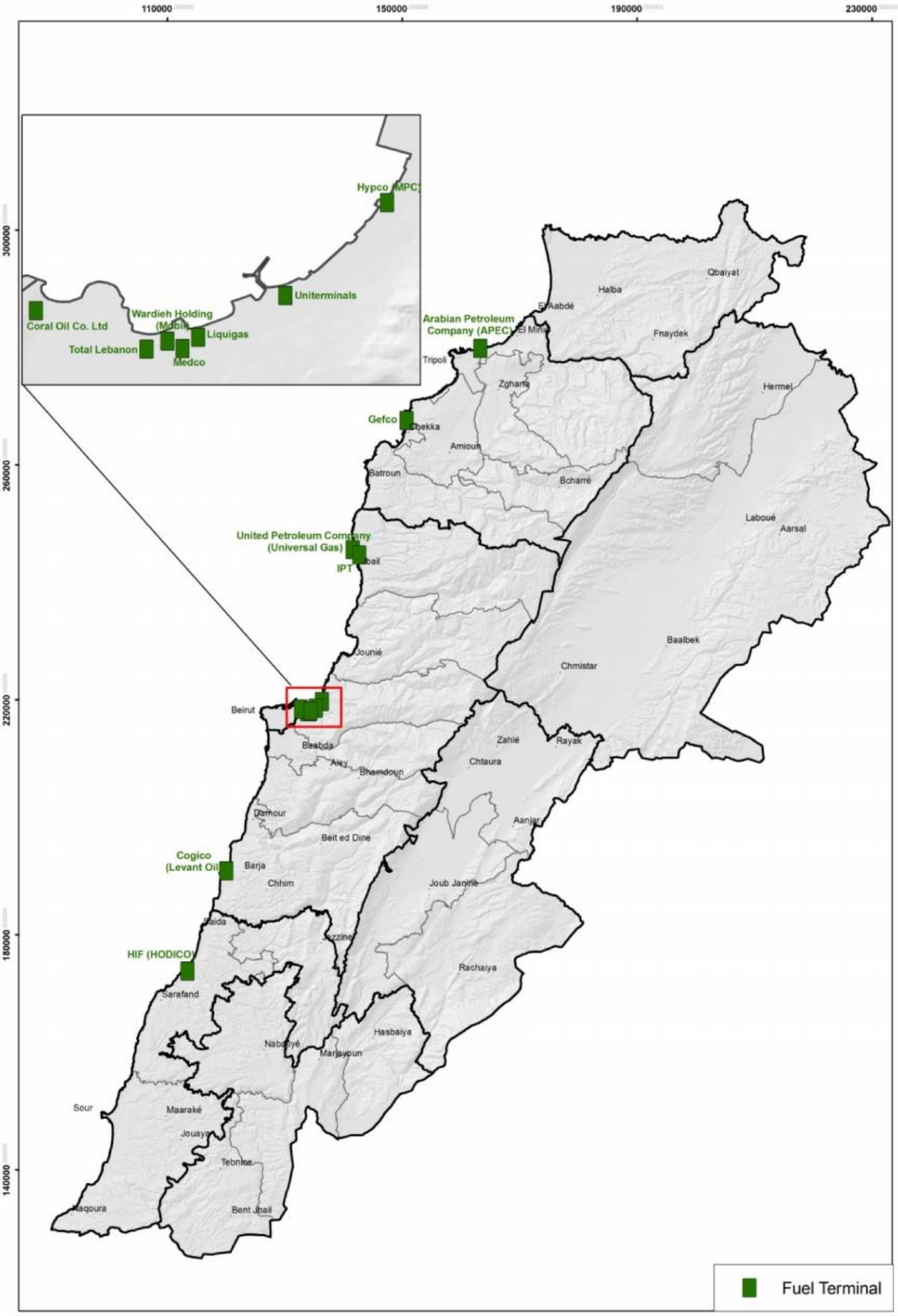

Figure 11: Location of the private fuel import terminals in Lebanon
Source: prepared by ELARD based on APIC's information

According to APIC (unless otherwise specified below), in 2014, the main fuels imported by these companies were (with no limitations on quotas):

- Gasoline 95 and 98, with a total annual import of approximately 1.7 MT;
- Diesel Oil, with imported quantities reaching 1.45 MT;
- Jet A1, with about 0.22 MT per year, used solely in the aviation sector;
- Bitumen (asphalt) of about 54,000 tons;[25]
- Light Fuel Oil for industries of about 0.17 MT; and
- LPG of about 0.24 MT.

Figure 12: Examples of private sector fuel storage tanks

3.3.3 Public Gas Infrastructure

There is currently no public gas infrastructure in Lebanon.

3.3.4 Private Gas Infrastructure

Data provided below on the private gas infrastructure was mainly collected through the Association of Petroleum Importing Companies (APIC).

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25 Directorate General of Petroleum. 2015. 2014-2010 المشتقات النفطية المستوردة طن متري

There are 6 private gas import terminals in Lebanon with a total holding capacity of 44,668 m^3.

All of these terminals are located along the Lebanese coastline, five (5) being concentrated on Mount Lebanon's seaside with 92.6 % of the total storage capacity, and one (1) in Tripoli, on the seaside of the North Governorate (Table 6 and Figure 13).

The top gas importer and distributor in terms of size and capacity is Natgaz.

No.	Terminal	Location	Total Capacity (m^3)
1	Nourgaz	Tripoli North Governorate	3,313
2	Natgaz	Nahr El Mott Mount Lebanon Governorate	21,340
3	Sidaco	Zahrani-Jiyeh Mount Lebanon Governorate	7,485
4	Phoenicia	Dora Mount Lebanon Governorate	2,586
5	Unigaz	Dora Mount Lebanon Governorate	2,944
6	Gazorient	Nahr El Mott Mount Lebanon Governorate	7,000
		Total	**44,668**

Table 6: Location and capacity of gas import terminals
Source: APIC

These importers have LPG bottling activities and services (Figure 13). Three (3) companies provided more details about their activities:

- Natgaz: operates 3 gas filling and distribution plants covering Beirut and Mount Lebanon located in Fanar (main filling station), Daoura, and Choueifat. Natgaz provides 10 kg and 35 kg cylinders and serves the residential, industrial, and commercial sectors.
- Sidaco: has nine LPG filling plants, 1 in Beirut (Jinah), 2 in Mount Lebanon (Aley and Kfarnabrakh), 2 in Bekaa (Teanayel and Nabi Ayla), and 4 in South Lebanon (Zahrani, Abbassieh, Ansar and Kosaibeh), and provides services in more than 50% of the Lebanese territory. Two types of cylinders are available: 12.5 kg and 35 kg; both dealers and individuals can buy and/or fill gas cylinders from Sidaco's filling stations network. Sidaco also provides autogas.
- Unigaz: operates one (1) plant in Bourj Hammoud and provides services in terms of cylinder filling, bulk supply, central gas heating, and trading of gas accessories. Their clients include a range of hotels, resorts, restaurants, and hospitals. Unigaz has been installing central gas systems in resorts and malls (such as Zeituna Bay, ABC malls, Beirut Mall) for cooking purposes. It includes a central liquid gas storage tank with a small regasification

unit and gas is connected through pipes to the various restaurants. Each restaurant pays a bill based on its consumption.

Figure 13: LPG bottling

According to APIC, imported LPG is 90% Butane and 10% Propane and its consumption has increased from 120,000 tons in 2006 to 220,000 tons in 2014; the main reasons for such increase are the shift from diesel (diesel oil and gasoil) to LPG mostly for environmental reasons, increase in illegal use of LPG in transportation, and lately due to presence of Syrian refugees; also in 2013 and 2014 about 20,000 tons were exported to Syria. Main uses are heating, cooking and (illegal-retrofitting) transport.

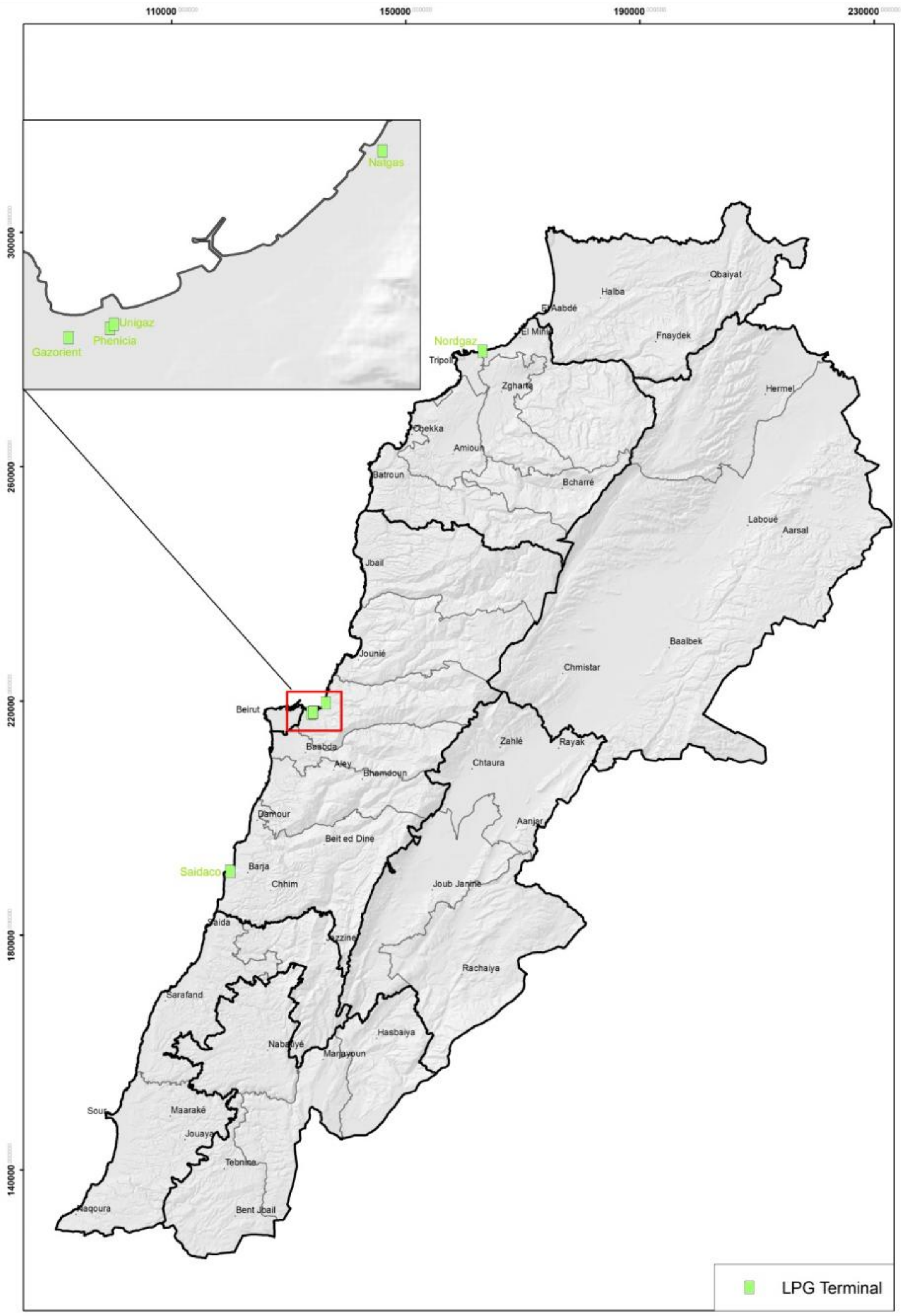

Figure 14: Location of private LPG import terminals in Lebanon
Source: prepared by ELARD based on data provided by APIC

3.4 Local Refineries

Lebanon was among the first countries in the Middle East to build oil refineries in the 1940s and 1950s, but both coastal refineries in Tripoli and Zahrani had to be closed down in 1989 and 1992 respectively, due to damage and general instability caused by the Lebanese civil war.

Lebanon is currently one of the only countries in the region with no refining capacity, and consequently entirely dependent on imported fuel sources. Since 1989, the private sector began importing the local market needs of oil derivatives by virtue of advance importing licenses granted by the Ministry of Industry and Petroleum to the importing companies. However, the Ministry of Industry and Petroleum resumed in early 1993 the import of gasoline and gasoil, without prejudice to the private sector freedom of importation. This intervention resulted in the control of oil derivatives prices in the local market.

In 1997, the Ministry of Industry and Petroleum was split into two ministries: The Ministry of Industry and the Ministry of Petroleum (Law No. 642 of 02/06/1997). The Ministry of Petroleum was later on cancelled and its responsibilities handed over to the Ministry of Energy and Water as the Directorate General of Petroleum (Law 247 of 07/08/2000).

3.4.1 Tripoli Refinery

The currently inoperative refinery at the Tripoli Oil Installations was established in 1940 to refine the crude oil imported through the IPC pipelines from the fields of Karkuk- Iraq.

The Iraq Petroleum Company took the refinery from the French Authorities and controlled it until 1973, when the Lebanese Government took charge of its management and the related oil installations.

The refinery's maximal storage capacity was 34,500 bpd of crude oil, but did not exceed 30,000 barrels a day. Before its breakdown, the refining capacity was virtually 21,000 bpd.

The main refined products were fuel oil (50%), gas oil (22%) and gasoline (21%).

The total surface of the refinery is 114,875 m².

The Lebanese domestic market need exceeds 140,000 bpd. Studies showed that from an economic point of view, it is not economically feasible to rehabilitate the Tripoli refinery in its current capacity (21,000 barrels a day)[26]. However, a study conducted by MoEW concludes that it might be feasible to renovate the refinery in Tripoli under some low oil price scenario and increase in capacity. This would require a thorough engineering inspection and studies to evaluate its technical and economic viability.[27]

26 Lebanese Oil Installations. 2016. http://www.leboilinst.com
27 Personal communication with Mr. Karim Osseiran at the Ministry of Energy and Water on 10 September 2015

3.4.2 Zahrani Refinery

The currently inoperative refinery in Zahrani was commissioned in 1950 and was owned by CALTEX under the name of (MEDRECO - MEDITERRANEAN REFINERY CO). In 1983 the Government of Lebanon took charge of the management of the refinery and the oil related facilities.

The refining capacity reached 17,500 bpd until the refinery was shut down in 1989. It used to produce LPG, gasoline, kerosene, gas oil and fuel oil.

The total land area occupied by the refinery is 313,000 m².

All refinery units and equipment's need comprehensive over haul and maintenance. Some do not have spare parts. A study conducted by MoEW concludes that it will not be viable to renovate the smaller refinery at Zahrani (having 17,500 barrels per day capacity) under any oil price.[28]

3.5 Fuel Stations

In terms of fuel stations, there are about 3,000 licensed gas stations in Lebanon (Table 7 and Figure 15). Typical gas stations in Lebanon are shown in Figure 16.

No.	Governorate	Number of Gas Stations
1	Baalbek-Hermel	241
2	Bekaa	345
3	Beirut	108
4	Mount Lebanon	1,185
5	South Lebanon	335
6	North Lebanon	603
7	Nabatieh	233
	Total	**3,050**

Table 7: Number and locations of licensed gas stations
Source: Directorate General of Petroleum. 2015. عدد محطات توزيع المحروقات السائلة

28 Personal communication with Mr. Karim Osseiran at the Ministry of Energy and Water on 10 September 2015

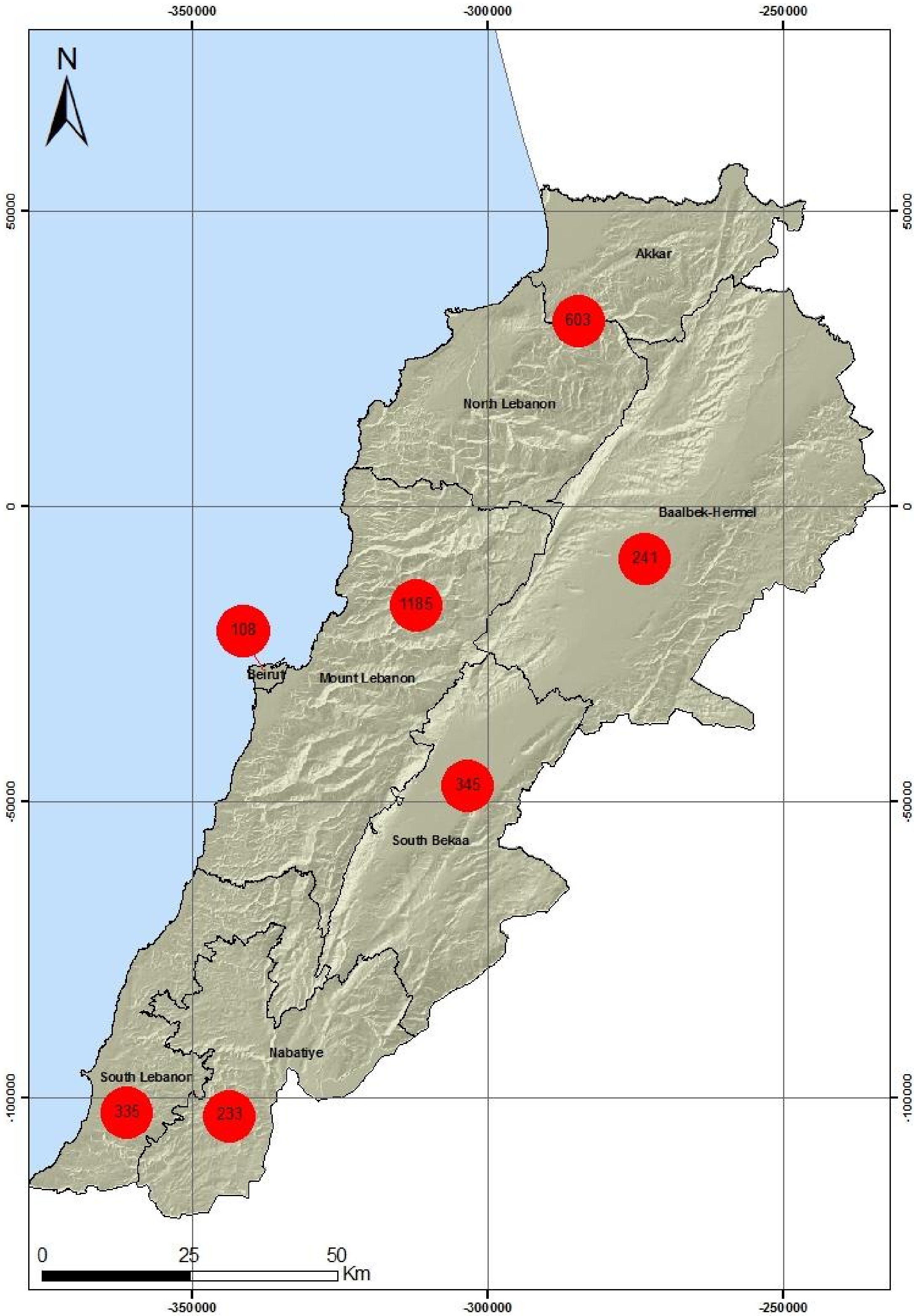

Figure 15: Licensed gas stations in Lebanon
Source: prepared by ELARD based on data from the Directorate General of Petroleum

Figure 16: Typical gas stations in Lebanon

3.6 Local Power Plants

Only thermal and hydroelectric power plants currently operate in Lebanon.

3.7 Thermal Power Plants

There are seven (7) thermal power plants in Lebanon, all of them located on the coastline except for the Baalbek power plant located inland east of the country, around 70 km from Beirut (Table 8 and Figure 17).

Overall the seven (7) thermal power plants in Lebanon have a total installed capacity of 2,038 MW (2010) of which about 78% is available.

No	Power Plant	Year Commissioned	Retirement Year[29]	Installed Capacity (MW)	Available Capacity (MW)	Fueling Method	Fuel Type	Plant Type	Totals (MW)
1	Zouk	1984/ 1986	2015	607	410	Sea line	HFO	ST	Steam 1,028
2	Jieh	1970/ 1981	2010	346	195	Sea line	HFO	ST	
3	Hreicheh	1975	2010	75	30	Trucks	HFO	ST	
4	Zahrani	1998/ 2001	2025-2031	435	412	Sea line	Diesel Oil	CCGT	CCGT 870
5	Deir Ammar	1998/ 2002	2015-2031	435	410	Sea line	Diesel Oil	CCGT	
6	Tyr	1996	2021	70	70	Trucks	Diesel Oil	OCGT	OCGT 140
7	Baalbek	1996	2021	70	70	Trucks	Diesel Oil	OCGT	
Total				**2,038**	**1,597**				

Table 8: Thermal power plants in Lebanon
Sources: Bassil, Gebran. "Policy Paper for the Electricity Sector". June 2010
MoE, 2010, State of the Environment Report
EDL website, www.edl.gov.lb
Personal communication with Mr. Karim Osseiran at the MoEW on 10 September 2015

29 Tannous, Naji. "State of Environment Report (SOER), Chapter 9: Energy Crisis". 2010

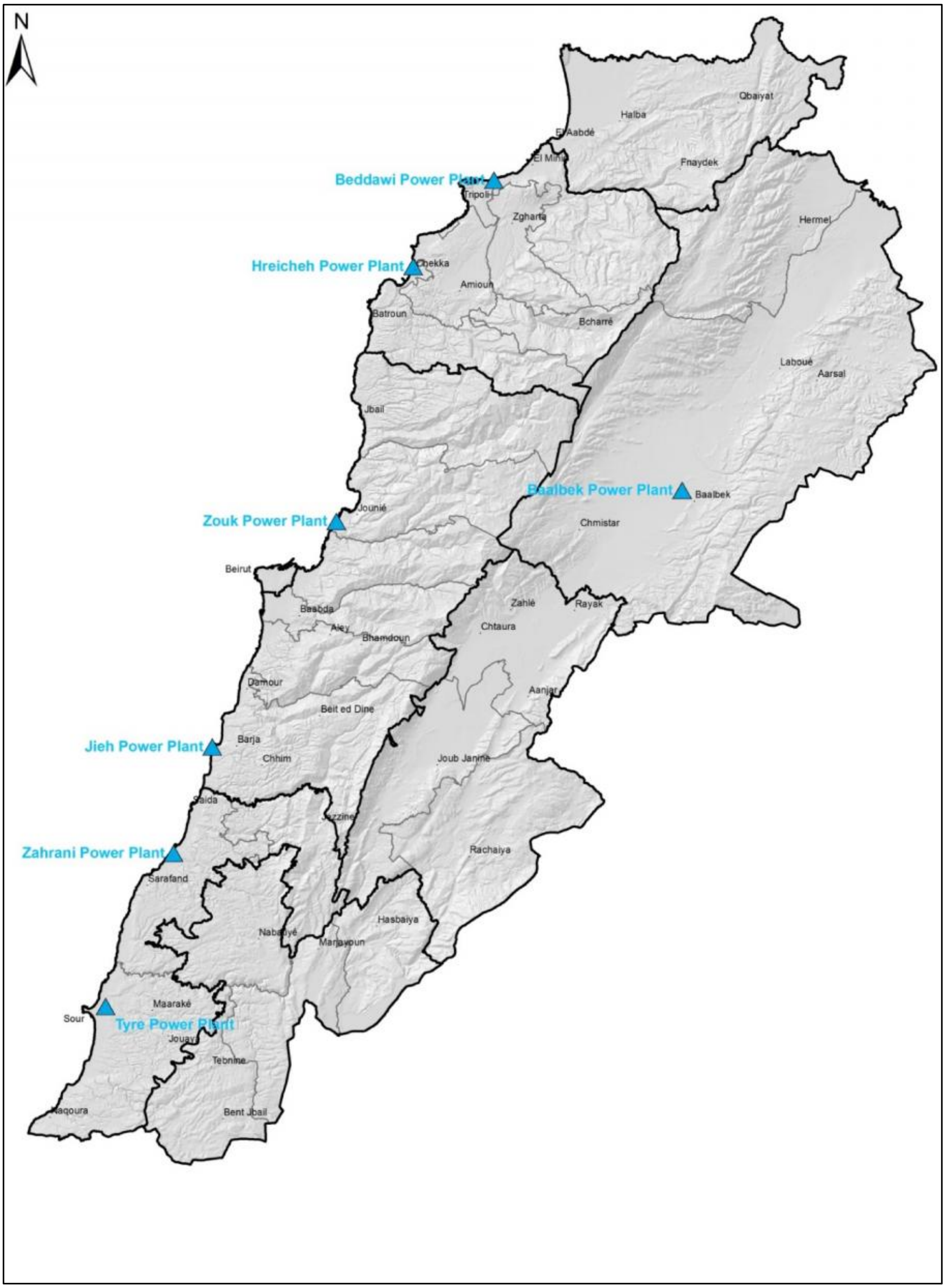

Figure 17: Location of the power plants in Lebanon

3.7.1 Zouk Power Plant

The Zouk power plant is the largest power plant in Lebanon, situated inside the highly populated residential town of Zouk, Mount Lebanon Governorate, 18 km north of Beirut (Figure 18).

Commissioning of the plant started in 1984 and was completed in 1986 with a total installed capacity of 607 MW; the plant's available capacity is 410 MW with a potential capacity of 607 MW. Sea line is used for fuelling.

The thermal energy at Zouk power plant is generated by four (4) HFO-fired steam-turbines. Those units are old and cannot be operated with natural gas. EDL plans to rehabilitate the plant; a tender was launched and contractor commissioned, however the project is currently on-hold due to contractual problems.

Figure 18: Zouk power plant

3.7.2 Jiyeh Power Plant

The Jiyeh power plant, the oldest operating thermal plant in the country, is located 30 km south of Beirut (Figure 19). Commissioning of the plant was started in 1970 and completed in 1981 after gradual commissioning of its turbines to reach a total installed capacity of 346 MW; the plant's available capacity is 195 MW with a potential capacity of 327 MW. Sea line is used for fuelling.

The thermal energy at Jiyeh power plant is generated by HFO-fired steam-turbines. Those units are old and cannot be operated with natural gas. EDL plans to completely decommission the plant since it is not economically feasible to rehabilitate it. Decommissioning is however delayed until asbestos containing material is safely removed from the plant.

Figure 19: Jieh power plant

3.7.3 Deir Ammar Power Plant

Deir Ammar power plant is located at around 90 km north of Beirut. Commissioning of the plant started in 1998 and ended in 2002 with a total installed capacity of 435 MW.

The thermal energy at Deir Ammar power plant is generated by a diesel-fired Combined Cycle Gas Turbine (CCGT) that is fit and ready to be operated with natural gas. The plant consists of two gas turbines and a steam turbine, which uses the residual heat as thermal input. However, the plant continues to be fuelled by diesel rather than by natural gas. Sea line is used for fuelling.

The plant’s available capacity is currently 410 MW. The plant is connected to the currently un-operational GASYLE pipeline.

Figure 20: Deir Ammar power plant

3.7.4 Hrayche Power Plant

Hrayche power plant is located at around 64 km north of Beirut. The total installed capacity, the available capacity, and the potential capacity of Hrayche power plant are 75 MW, 30 MW, and 70 MW respectively. Trucks are used for fuelling. The thermal energy at Hrayche power plant is generated by HFO-fired steam-turbines. Those units are old and cannot be operated with natural gas.

3.7.5 Zahrani Power Plant

Zahrani power plant is located at around 48 km south of Beirut. Commissioning of the plant started in 1998 and ended in 2001 with a total installed capacity of 435 MW (Figure 21).

The thermal energy at Zahrani power plant is generated by a diesel-fired Combined Cycle Gas Turbine (CCGT) that is fit and ready to be operated with natural gas. The plant consists of two gas turbines and a steam turbine, which uses the residual heat as thermal input. However, the plant continues to be fuelled by diesel rather than by natural gas. Sea line is used for fuelling. The plant's available capacity is currently 412 MW and it is not connected to any gas infrastructure.

Figure 21: Zahrani power plant

3.7.6 Tyr Power Plant

Tyr power plant is located at around 75 km south of Beirut. The total installed capacity and the available capacity of Tyr power plant are both equal to 70 MW. The plant is currently operating on diesel oil, trucks are used for fuelling. The thermal energy at Tyr power plant is generated by diesel-fired Open Cycle Gas Turbine (OCGT). With some minor modifications, this OCGT can operate with natural gas.

3.7.7 Baalbek Power Plant

Baalbek power plant is located at around 68 km north-east of Beirut. The total installed capacity and the available capacity of Baalbek power plant are both equal to 70 MW. The potential capacity of the plant is 64 MW. The plant is currently operating on diesel oil; trucks are used for fuelling. The thermal energy at Baalbek power plant is generated by diesel-fired Open Cycle Gas Turbine (OCGT). With some minor modifications, this OCGT can operate with natural gas.

3.7.8 Power Ships

In 2013, the Lebanese government signed a three-year, $370 million deal with the Turkish energy company Karadeniz Holding for the lease of two "power ships" (Figure 22). Accordingly, two Turkish power-generating ships have arrived and started operating in Lebanon; both operating on heavy fuel oil:

- Karadeniz Powership Fatmagül Sultan has been operational since April 2013 in Jiyeh supplying a total capacity of 82 MW.
- Karadeniz Powership Orhan Bey which has been operating since September 2013 in Zouk and supplying a total capacity of 188 MW.

Figure 22: Turkish power ships In Jieh and Zouk

According to the MoEW, the power ships do not represent an ultimate solution to the electricity problem, but a temporary solution to allow the rehabilitation of the existing conventional power plants at Jiyeh and Zouk.

The temporary solutions were planned until September 2016 and are still operational to date. The contract may be extended since the rehabilitation of the existent power plants is significantly delayed.

3.8 Hydro Power Plants[30]

There are three (3) hydro power plants in Lebanon, with a total combined installed capacity of about 280 MW. The actual generation capacity is 190 MW since many of the plants have been in service for several decades, some of them for 50-100 years. Therefore, the potential for new capacity from hydropower generation will only exist either from the rehabilitation of the existing plants or by constructing new ones. In the Electricity Policy Paper (2010) this has been quantified to range between 40 MW and 120 MW.

The energy produced from hydropower plants has been variable in the last years, ranging from 4.5% of the total production (Litani, Nahr Ibrahim and Bared) to 8.7% in 2012 primarily due to the rehabilitation of TPPs in place, as shown in Table 9.

No	River/Plant	Establishment	Capacity (MW)	Year of Construction	2012 Yearly Production	Rehabilitated Plant Yearly Production (GWh)	Production increase from rehabilitation (%)
1	Kadisha Valley / Bcharreh, Mar Licha, Blaouza II, Abu-Ali	La Kadisha - Société Anonyme d'Electricité du Liban Nord	21	1924, 1932, 1957, 1961	72	82	14
2	Litani-Awali/ Markaba, Awali, Joun	Litani Water Authority	199	1961, 1964, 1967	680	775	14
3	Nahr Ibrahim/ Chouane, Yahchouch, Fatri	Société Phénicienne des Forces de Nahr Ibrahim des Eaux et Electricité	32	1951, 1955, 1961	92	105	14
4	Nahr Al Bared/ Al Bared 1, Al Bared 2	Al Bared Concession	17	1936	54	62	15
5	Safa Spring /Richmaya-Safa	Electricité du Liban	13	1931	20	23	15

30 MoEW, Schéma Directeur Hydroélectrique du Liban, Sogreah, 2012.
UNDP. "Hydropower from Non-River Sources, the potential in Lebanon, 2013."
MoEW, The National Energy Efficiency Action Plan for Lebanon, NEEAP, 2011-2015, January 2012.
Karim Osseiran, General Advisor to the MoEW, Hydropower in Lebanon, History and Prospects, CEDRO Exchange Issue No 4, February 2013

No	River/Plant	Establish-ment	Capacity (MW)	Year of Construc-tion	2012 Yearly Produc-tion	Rehabilitat-ed Plant Yearly Pro-duction (GWh)	Produc-tion in-crease from re-habilita-tion (%)
	Total Hydro		**282**		**918**	**1,047**	**14**
	% of Total Energy				**8.70%**	**7.91%**	**-**

Table 9: Hydro power plants in Lebanon

3.8.1 Future developments or expansion plans

Potential for the development of hydro power in Lebanon refers to either the rehabilitation of the existing plants or the construction of new ones.

Rehabilitation of existing plants:

It has been estimated that at least 15% of additional generation capacity is possible from rehabilitating the existing hydropower plants in Lebanon. This corresponds to additional electricity generation of about 129 GWh per year and an increase of the average capacity factor of all plants to 42.3% (from the current 37.2%).

New plants:

A Master Plan Study for the hydroelectric potential of Lebanon along the main river streams has been prepared by Sogreah, which identified the potential arising from 32 new sites, split into two categories:

Run of river schemes: potential capacity of 263 MW (1,271 GWh/y);

Peak schemes (with dams): potential capacity of 368 MW (1,363 GWh/y).

Analysis of these sites in terms of financial viability resulted in the selection of the most promising ones and allocation into three major categories as shown in Figure 23.

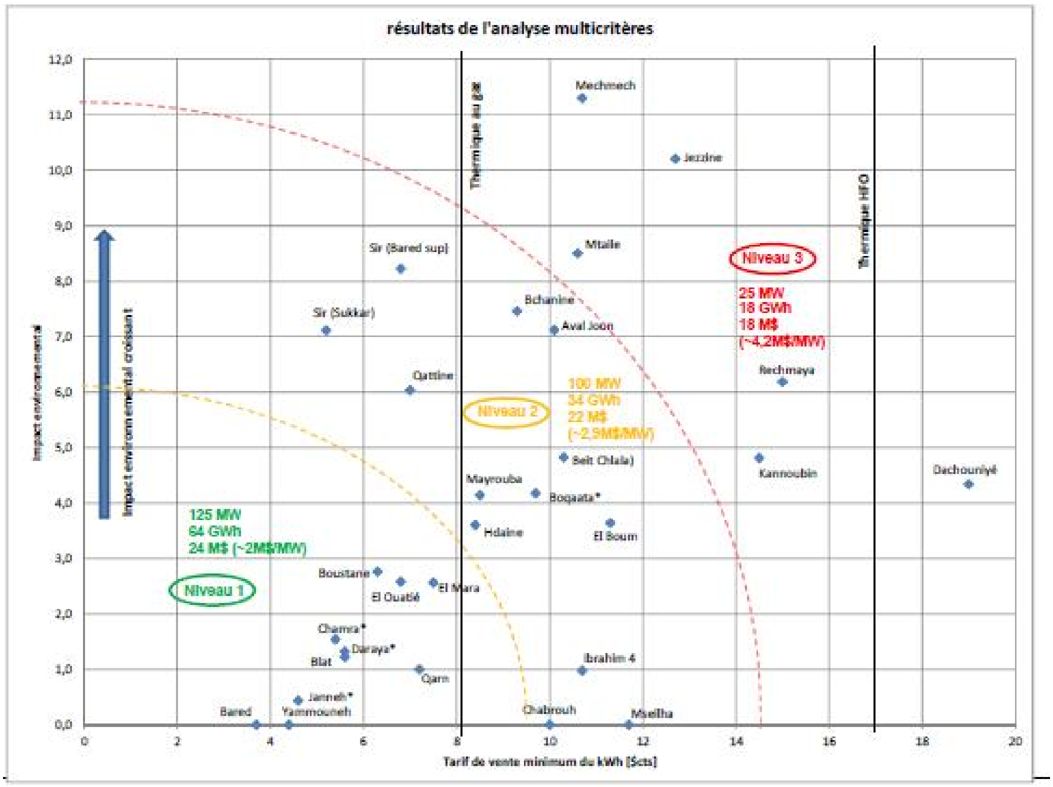

Figure 23: Potential new hydro power plants in Lebanon categorized according to financial viability

In brief, this analysis concluded that additional 250 MW of new hydro power plants, producing about 1200 GWh/y, can be financially viable:

- Approximately 125 MW of new hydropower supply is viable at exceptionally favorable locations with low environmental impact and relatively low levelised costs;
- 100 MW are additionally available and viable, yet relatively less favorable than the first trench;
- 25 MW that also exist require special attention to the environmental impacts; and
- All three trenches have levelised costs lower than current average generation costs of EDL.

4 OVERVIEW OF THE MAIN ENERGY CONSUMING SECTORS IN LEBANON

Historically, and as presented in the previous sections, the primary energy supplies in Lebanon rely on imported fossil fuels (Figure 24). In particular, most of the generated electricity in the power sector is produced in power plants using fuel oil and diesel. The industrial, commercial and the residential sector use oil based products for space and water heating, private power generation as well as production processes. In addition, LPG is used for cooking purposes as well as for heating. The share of other types of energy supplies is relatively low. In addition to oil products, cement factories use coal/pet coke for production processes, petcock consumption not being usually accounted for in published statistics (such as those published by IEA or ALMEE).

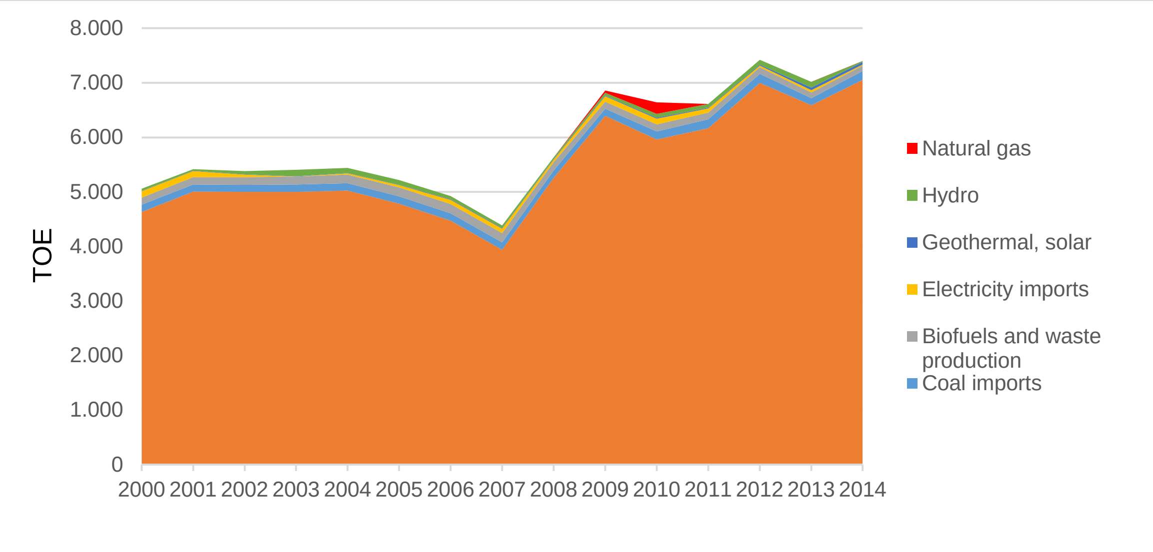

Figure 24: Historical total primary energy supply in Lebanon (TPES) in tons of oil equivalent
Source: ILF based on IEA and ALMEE (2013-2014); indicatively only 250,000 tons of coal included

A summary of the main fuels used in Lebanon is shown in Table 10.

No.	Fuel type	Importer	Consumer Sectors	Usage
1	HFO	MoEW	Energy, Industry	Electricity production in the thermal power plants, and energy production in some manufacturing industries
2	Gasoil	MoEW	Energy, local market	Electricity production in the thermal power plants Space heating in residential, commercial and institutional sectors
3	Diesel oil	Private Companies	Local Market	Road transport, electricity generation (private generators)
4	Gasoline	Private Companies	Transportation	Road transport, air transport
5	Kerosene Jet A1	Private Companies	International Bunkers	Air transportation
6	Pet Coke / Coal	Industry	Industry (cement only)	Energy production
7	LPG	Private Companies	Residential, Commercial, Institutional, Industrial	Mainly cooking and heating, and energy production in some manufacturing industries
8	Natural Gas	MoEW	Energy	Electricity production in the thermal power plants[31]

Table 10: Summary of importers and consumers of main fuels used in Lebanon
Source: Adapted from MoE, 2010, State of Environment Report

4.1 The Power Sector

The power sector is the main consumer of fuels in Lebanon. As the Lebanese economy started recovering from the Civil War in the early 1990s, demand grew substantially and surpassed the supply capacity of the power plants installed. Accordingly, the Lebanese electricity sector is in a chronic state of crisis where extensive power shortages became the norm with some regions barely receiving 12 hours of electricity supply on some days such as in North Lebanon, South Lebanon and Bekaa region. From around 7,800 GWh in 2000, the electricity demand was estimated at 15,000 GWh in 2009[32] and at 22,000 GWh[33] in 2014. In total, EDL provided about 12,500 GWh in 2014, including imported electricity (138 GWh) and hydro generation (190 GWh).

31 Natural gas was only delivered for 1 year through the GASYLE pipeline through the GASYLE pipeline to the Deir Ammar CCGT power plant
32 Chaaban, Farid. "Technology Needs Assessment for Climate Change, 2012. Chapter 4: The Power Sector"
33 ALMEE. "Les Bilans Energétiques au Liban en 2014". 2014. Including EDL electricity supplies, estimations for private power generation and estimations for demand not met by any means

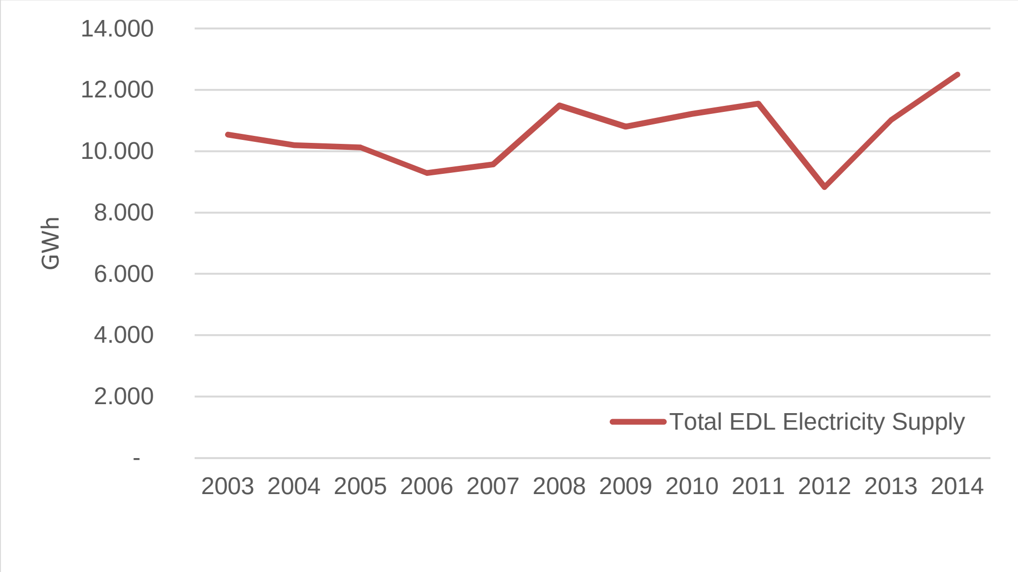

Figure 25: Historical electricity supply in Lebanon between 2003 and 2014
Source: ILF, based on ALMEE. "Les Bilans Energetiques au Liban en 2014"

EDL operates all the main 7 thermal power plants (TPPs), all currently fueled either by HFO or by diesel oil due to lack of natural gas supplies. In particular, two CCGT plants (Deir Ammar and Zahrani) as well as two open cycle plants can function on natural gas.

4.1.1 Existing Challenges in the Power Sector

The key obstacles in the Lebanese power sector preventing sufficient volumes of electricity being delivered to end users are spread across the whole power system value chain and set up. These are summarized below.

There is an indisputable shortage of power supply reflected in frequent power cuts around the year. Peak demand in summer in the order of 2,450 MW[34], i.e. almost 50% above the available capacity was recorded in 2009. Private power self-generation for industry, residential, institutional and commercial sectors has become rather common i.e. installed capacity approximated 500 MW[35] in 2009. Therefore, private power is available but is less efficient and with elevated pollution levels within residential areas. Nevertheless, a significant share of the electricity demand is not met either way.

Furthermore tariffs are highly subsidized and do not cover generation costs and the grid requires upgrade to increase geographical coverage. The share of losses in the transmission and distribution networks is also substantially high compared with international best practice. Technical losses average 15% compared to the world average of 8% and non-technical losses is about 18%

34 Bassil, Gebran "Policy Paper for the Electricity Sector". Lebanese Republic's Ministry of Energy and Water, June 2010
35 Chaaban, Farid. "Technology Needs Assessment for Climate Change, 2012. Chapter 4: The Power Sector"

(non-billed consumption of electricity)[36]. In addition, the collection rate of bills is low and results in significant deficits to EDL.

Inefficiencies occur since the CCGT Deir Ammar and Zahrani are not functioning on natural gas as primarily planned and the Zouk and Jieh plants have already reached the end of their design lifetime. Zouk, Lebanon's largest thermal power plant, fires HFO and its fuel efficiency design value varies from 37% to 39%. The actual efficiency is below the design value by as much as 30%. The deviation from the design value has a significant impact on the fuel bill, reflecting an increase in fuel cost. In Jieh, the oldest operating thermal plant, the actual value of fuel efficiencies compared to the design value varies by as much as 35%. Similarly, the deviation represents an increase in fuel cost.

Aiming to overcome the constant power shortages, the MoEW has set through the Policy Paper for the Electricity Sector in 2010 the ambitious target of increasing installed capacity to 4,000 MW in 2014 and 5,000 MW immediately after 2015, primarily through new gas fired plants. Unfortunately these targets were not met till date and very few initiatives from the paper have actually been implemented so far. The policy paper also aimed at enhancing the institutional and regulatory framework as well as tariffs in order to attract the private sector to finance and operate the future power plants.

The following relevant initiatives described below materialized in the 2010-2015 timeframe. The remaining planned capacity additions remain to be implemented. There are currently three (3) power plants under construction:

- Zouk 2, which is expected to become operational May/June 2016, with a capacity of 194 MW on natural gas / HFO;
- Jieh 2, which should be ready by end of 2016, with a capacity of 94 MW on natural gas / HFO (78.2 MW);
- Deir Ammar 2, which is a combined cycle plant with a capacity of 538 MW on natural gas / HFO (535 MW). This project is "on hold" due to a problem with the contractor.

The engines at the new Zouk and Jieh plants are designed to run on tri-fuel basis of HFO, diesel oil, and natural gas when available. The plant at Deir Ammar II is designed to run on a dual fuel basis and shall fire HFO at a de-rated capacity of 525MW until natural gas is available to the plant. This additional capacity is expected to be operational by the end of 2018.

Moreover, as part of an operation and maintenance contract, the gas turbines at Zahrani and Deir Ammar power plants were upgraded by the end of 2013; the works resulted in a capacity addition of 63 MW as well as enhancements in efficiency and lifetime extension of the power plants.[37]

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36 Chaaban, Farid. "Technology Needs Assessment for Climate Change, 2012. Chapter 4: The Power Sector"
37 Personal communication with Mr. Karim Osseiran at the Ministry of Energy and Water on 10 September 2015

4.1.2 Future plans

In addition to the capacity under construction, the Policy Paper for the Electricity Sector (2010) included three IPPs of 500 MW each to become operational by 2015. However only the feasibility study was completed so far and the implementation of the projects has faced significant delays.

These plants, once and if built, will contribute to the national demand for natural gas. The natural gas demand for the power sector has an impact on the studied sectors in case the coastal pipeline is built, since the transported gas volumes have an impact on the unit transport costs for natural gas.

Two more IPPs (1,000 MW) mentioned in the Policy Paper for the Electricity Sector (2010) as planned to be built immediately after 2020 are assumed to be built after 2030 given the current delays in initiating the first 1,500 MW IPPs.

The development of the power sector would also impact the need for private power generation in the studied sectors. Given the experienced delays in implemented the 2010 Electricity Policy Paper, private power generation demand is considered for the relevant sectors as a first step of estimated maximum potential demand for natural gas in this study assuming that diesel / fuel oil fired generators could be potentially replaced by natural gas fired generators if natural gas is available.

4.2 The Industrial Sector

Industry uses fuel for direct production processes (ovens, heating boilers) as well as for private power generation. In particular, fuel oil, diesel, gas oil, LPG (in a very limited extent) and coal/pet coke are used.

Due to the interrupted supply of electricity, most of the industrial establishments generate their own electricity, at least partially, through private power generators.

Information obtained from the study “The Lebanese Industrial Sector – Facts and Findings 2007“ and from energy and environmental audits conducted in various industrial establishments, were useful to estimate industrial energy demand.

The total number of surveyed establishments in 2007 was 4,033; surveyed industries had more than five employed workers, a surface area of at least 100-m^2 and energy consumption of at least five Amps.

Most of the industries are located in Mount Lebanon, especially in the coastal area of Metn, Baabda and Alley near Beirut (Figure 26). Other industrial clusters are located in the coastal areas of Keserwan and Jbeil, Sidon in the South and Tripoli in the North. Close to Tripoli, there are the two largest cement factories and a chemicals manufacturer (Lebanon Chemicals Company). In the inland regions the main industrial clusters are located in Zahle and Arsal regions.

Mount Lebanon dominates the textile, pulp and paper industry, printing industry as well as furniture and metal products manufacturing. Another, more recent industry census from 2013-2014, for establishments with more than eight workers (but using different activity classifications), validates the results of the 2007 survey with 3,343 establishments surveyed.

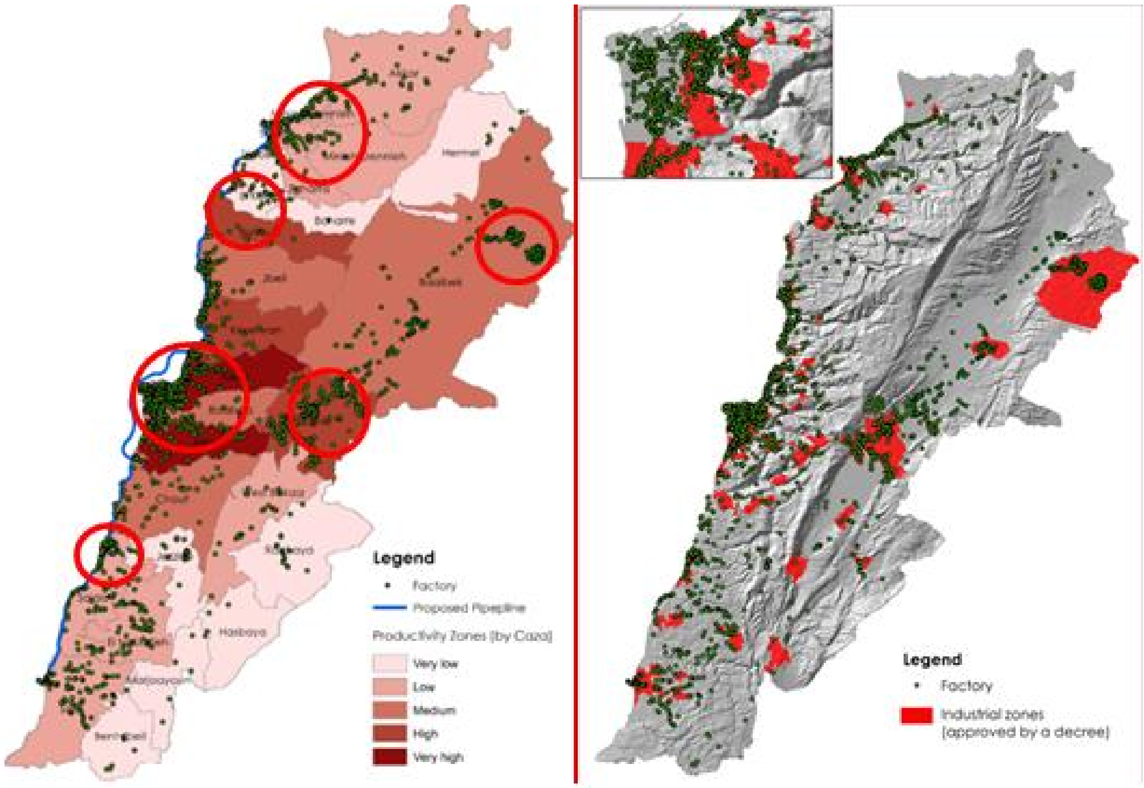

Figure 26: Concentration of industries (within red circles) and coastal pipeline in Lebanon
Source: UNIDO, 2007

There are many small industrial establishments and very few large ones, as illustrated in Figure 27. This higher concentration of small size industrial units is valid for all types of industries.

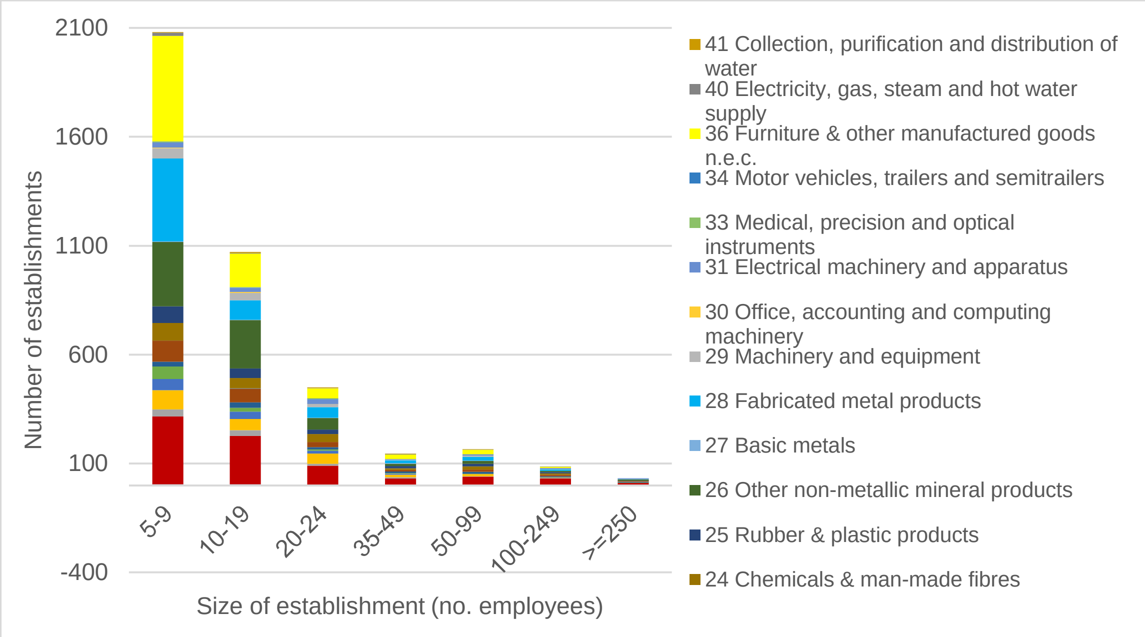

Figure 27: Total industrial establishments in Lebanon by category and size
Source: based on UNIDO 2007 survey

A more detailed example showing the concentration of small industrial units is shown in Figure 28, for the specific case of pulp and paper industry.

Main energy intensive industries in Lebanon, based on the EDL electricity supplies, and total fuel consumption for power generation and production processes are:

- Manufacturing of metal products – mineral industries (cement);
- Chemical industries (mainly Lebanon Chemicals Company);
- Pulp and paper;
- Food and beverage industries;
- Manufacturing of fabricated metal products, except machinery.

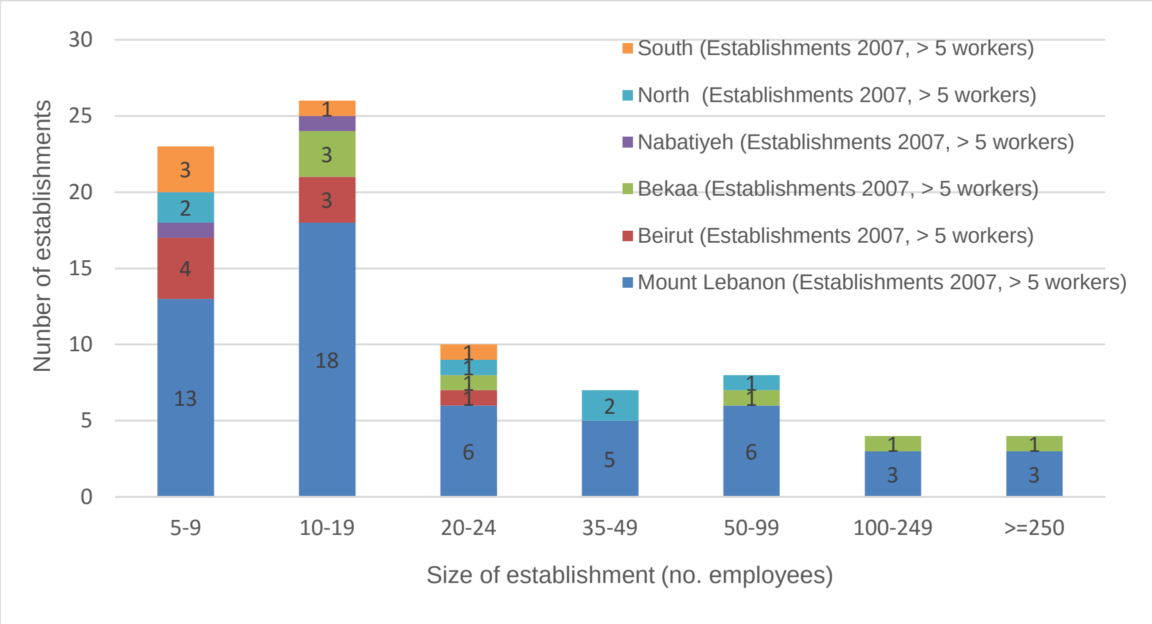

Figure 28: Pulp and paper industry establishments by caza and size
Source: based on UNIDO 2007 survey

According to the calculations derived from the UNIDO study, the surveyed establishments (excluding coal and pet coke energy supplies) used in 2007 about:

- 1,700 GWh as primary consumption for production processes (93,000 tons fuel oil and 49,000 tons diesel);
- 4,300 GWh for private generation purposes from liquid fuels (126,000 tons fuel oil and 216,000 tons diesel).

The coal/pet coke consumption in the cement manufacturing companies is additional to the above.

In total, 220,000 tons[38] of fuel oil are estimated to have been consumed by the industry in 2007, along with 266,000 tons of diesel. The corresponding equivalent gas consumption and therefore maximum potential demand is around 300 MMCM (10.6 BCF) for private power generation and 200 MMCM (7.1 BCF) for the production processes (about 500 MMCM / 17.7 BCF in total). A separate estimation by caza indicates approximately 62% of such consumption to be in Mount Lebanon. A 15% discrepancy between the UNIDO study and total imported quantity of fuel oil in 2007 was noticed, and the consumption figures were adjusted accordingly.

38 188,000 tons of fuel oil were imported in 2007 for market / industry (plausibility check of the estimates based on calculations)

4.2.1 Growth of industry 2007-2014

Based on World Bank (World Development Indicators, October 2015), an average annual growth of 3.9%[39] in the period between 2007 and 2013 has been recorded.

4.2.2 Cement industry in Lebanon

There are three cement plants in Lebanon (with a fourth plant, White Cement, with a production of 100,000 tons p.a., being a subsidiary of Holcim) with a total capacity of 6.4 million tons in 2013. Two of the plants are located in Chekka (Holcim, 2.2 million tons and White Cements; Cementerie Nationale 2.8 million tons) and one is located in South of Beirut (Sibline, 1.2 million tons). Sibline has a special tariff and power supply arrangements with EDL and does not use self-generation.

The cement production for the local Lebanese market was about 3.9 million tons in 2007 and reached 5.3 million tons in 2012, stabilizing at around 5.8 million tons in 2013 and 2014 (plants operate close to the capacity level, the surplus being exported but with difficulty due to the market closure in Syria and Iraq). Syria and Iraq are traditional export markets for Lebanese cement with about 1 million tons of cement being exported to these countries in 2008. However the cement market decreased by 4.5% in 2014 due to instability in the region. Cement domestic deliveries had increased by 125% between 1993 and 2013 to reach 5.8 million tons in 2013, in line with the boom of the real estate sector. The prices remained stable, despite decreases in energy prices and slow down of the real estate sector (2013).[40]

The domestic demand for cement depends primarily on the construction sector, in particular residential developments (real estate), but also on major public infrastructure investments. A huge potential for cement export to Syria (and Iraq) exists once and if the conflict in Syria ceases given major need for reconstruction.

Cement production is an energy intensive industry that significantly depends on traditional energy sources such as coal and pet coke. Currently, most of the process related energy for all cement manufacturing plants is supplied by coal and pet coke (about 600,000 tons p.a.). These are traditionally low priced fuels. Natural gas could become attractive only in a low price scenario i.e. of 4 US$/MMBTU in relation to own gas discoveries and sufficient supplies to the domestic market.

The plants in Chekka also use fuel oil for private power generation as well as production processes:

- Holcim - White cements (Chekka): 1,700 tons fuel oil for process, 19,000 tons for private power generation;

39 Manufacturing, value added (annual % growth), 2005 USD constant prices
40 Blominvest Bank, “Lebanon´s Cement Sector - A Progress to Continue”. May 2014. http://blog.blominvestbank.com/wp-content/uploads/2014/10/2014-05-Lebanon%E2%80%99s-Cement-Sector-a-Progress-to-Continue.pdf

- Holcim (Chekka) - fuel oil for private generation about 43,000 tons p.a. and no supplies from EDL;
- Cimenterie Nationale (Chekka) - 12,000 tons of fuel oil for production process and 42,000 tons of fuel oil for power generation.

4.2.3 Chemical industry

Lebanon Chemicals Company (LCC) produces phosphate fertilizers, phosphoric acid, and sulfuric acid[41] (mainly used for the production of fertilizers). About half of the fertilizer production (52%, 2013) is exported (World Bank World Development Indicators, October 2015). In general the market for fertilizers, and respectively their use in agriculture, has grown in Lebanon during the last decade. The plant has the capacity to produce 300,000 tons of fertilizers, 145,000 tons of phosphoric acid, 600,000 tons sulfuric acid and 30,000 tons of aluminum sulphate per year.

The plant is estimated to use about 12,400 tons of fuel oil during the manufacturing process and about 8,400 tons for self-power generation.[42]

4.2.4 New steel and petrochemical industries (2030)

Based on potential market demand and recent trends, the following development areas are estimated to be possible:

- Aluminum and steel production;
- Ethanol, polyethylene, ethylene;
- PVC; and
- Fertilizers.

However, only low price linked to natural gas from potential own discoveries might allow such industries to be competitive. Development of such industries is also highly related to market demand at the time gas becomes available and therefore any estimate made would only be highly uncertain at this stage.

Historically, Lebanon already has a track record of steel production. However, this industry was negatively affected by high energy costs leading to inefficiencies. The only steel mill in Lebanon (Amchit) closed in 2003 due to high production costs, mainly related to fuel and electricity. The production of iron and steel was 80,000 tons in 2001 further decreasing to 40,000 tons in 2002 before closure of the plant[43]. This historical production volume indicates a potential of around 100,000 tons even during the 2000‘s. A company producing rolled steel operates in the Beirut

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41 From 1996 to 2001, Lebanon's consumption of sulphuric acid increased to 400,000 tons from 207,000 tons. More than ¾ was consumed in the production of fertilizers
42 ILF calculations based on energy related data from environmental audits
43 2012 Minerals Yearbook, USGS

region (200,000 tons p.a.). A pipe manufacturing company is located in Southern Metn with a production of 300,000 tons p.a. heavy melting for scrap (200,000 tones capacity) is located in Mkalles (Metn).

The Middle East petrochemical industry experienced high growth based on the availability of low-price gas feedstock. Capturing the gas flows associated with oil production previously flared and using them as very low-priced feedstock for chemical production made possible a large and highly profitable industry[44].

The expansion in petrochemicals has made an important contribution to the region's economies, diversifying them away from their dependence on oil production. The scale of expansion in the Gulf countries in petrochemicals, energy-intensive industries, and in gas-fired power generation leads the region to move from a gas surplus to a shortage in the near future. The expectation is that there will not be enough gas available to sustain further petrochemical expansion across the region over the medium term.

A further opportunity for additional feed stock for petrochemical production, given expected gas unavailability, is using naphtha instead of current feedstock. Shifting to naphtha from low-priced ethane represents a major challenge to the cost position and competitiveness of the Middle East petrochemical industry. If the only feedstock available is market-priced naphtha, the only new production that could compete on costs with other regions would be plants that supply the immediate region – and therefore offering a very limited opportunity. Therefore, the required level of competitiveness required for potential petrochemical production in Lebanon is very high and crucially depends on the availability of cheap feed stock.

Another petrochemical product that could be considered to be produced in Lebanon, should petrochemical industry be developed, is ethylene. The total ethylene demand is projected to increase by more than 40 million tons per year to around 175 million tons by 2020, and to 210 million tons by 2025, with most of the end-use demand growth coming from China and other emerging economies. New North American capacity and other advantaged feedstock-based producers are expected to cover only around half of new demand, leaving extensive scope for companies located in other regions.

In summary, the market potential for petrochemicals is high, but crucial factors such as price of feedstock and geographical proximity to user markets are crucial for developing production facilities in Lebanon. Also, high investments for developing such industries are necessary. The overall impact for Lebanon, given potential negative effects on other sectors such as tourism, as well as on society, including increased environmental pressures from this industry, should be assessed as well. A clear government policy needs to be established regarding promotion of a petrochemical industry in Lebanon. In the CBA analysis, impact of different potential demand levels from future petrochemical industries shall be assessed to guide policy makers.

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44 Mckinsey. "When Gas Gets Tight: Next Steps for the Middle East Petrochemical Industry". April 2014.

4.2.5 Fuel consumption and potential gas demand

The estimated fuel consumption and potential gas demand has been derived mainly based on the UNIDO 2007 survey and the consumption benchmarks from cement factories. The value share of each caza (%) after eliminating Batroun caza (hosting Seelata Chemical company and two cement manufacturing plants) has been applied to the estimated consumption (corrected by 85% in case of fuel oil) after deducting the consumption of the two cement companies in the North. The values estimated for 2007 have been extrapolated to 2014 based on the historical growth of the manufacturing sector. For the future growth of industries other than cement, 3-5% growth p.a. was estimated until 2020 based on the IMF projection of real GDP growth of 3-4% during 2015-2020 for Lebanon (World Economic Outlook, October 2015) as well as an elasticity factor of 1.2 of manufacturing growth in relation to GDP growth. The elasticity factor has been derived using historical GDP and manufacturing growth during 1994-2013 as provided by the World Bank (World Development Indicators, October 2015). After 2020, growth factors of 2.4% (low growth) and 4.8% (high growth) have been applied in two scenarios using the elasticity factor of 1.2 and annual GDP growth rates of 2% and 4%, respectively. The base values for 2007 are:

- 216,000 tons diesel/gasoil for private power generation and 50,000 tons for production processes;
- 19,000 fuel oil for power generation and 68,000 tons fuel oil for production processes.

For the cement industries, two scenarios have been considered: 2% growth and 4% growth p.a. respectively from 2014 to 2030, with a 0.5% p.a. assumed during 2031-2050 in both cases. The average annual growth of cement consumption and respectively production in Lebanon has been around 4% during 1993-2014. This growth rate has been used for a high growth case, while a more conservative growth rate of 2% has been considered for the low growth case. In periods of stagnation, such as 1999-2005, the growth has been around 0.5% p.a. As such a growth of 0.5% has been assumed for 2030-2050, the cement consumption being assumed to become stable. Sufficient production capacity is assumed to be available in line with each scenario, given there are some capacity expansion plans already announced[45]. The energy consumption based on the 2012 production levels was about 14,000 tons fuel oil for production and another 105,000 tons fuel oil for power generation for the plants located in Chekka. In addition to electricity and fuel oil, the cement industry consumed about 600,000 tons of coal/pet coke, with 135,000 tons in Sibline and the remaining 465,000 tons in Chekka.

Table 11 summarises the maximum expected demand for the industrial sector for each scenario.

45 Cimenterie Nationale intending to increase its production capacity by 2 million tons by 2017

Governorate	Total 2014	Total 2018-Low growth	Total 2018-High growth	Total 2030-Low growth	Total 2030-High growth	Total 2050-Low growth	Total 2050-High growth
Beirut	15	17	17	23	29	38	75
Mount Lebanon	444	494	496	675	854	1,019	1,940
North	504	520	529	668	857	781	1,104
Bekaa	98	112	112	156	196	250	501
South	21	23	23	33	41	52	105
Nabatieh	6	7	7	10	12	16	32
Total (MMCM)	**1,088**	**1,173**	**1,184**	**1,564**	**1,990**	**2,156**	**3,757**
Total (BCF)	**38**	**41**	**42**	**55**	**70**	**76**	**133**

Table 11: Expected maximum demand in the industrial sector
Source: ILF

4.3 The Residential Sector

In the residential sector, diesel oil is consumed for space heating, LPG for cooking purposes and kerosene for space heating and cooking. Due to electricity shortages, the use of private power generators is common. The residential sector uses electricity supplied by EDL as well as private power generation (directly own generators or subscription to residential private power providers i.e. 5 Amps subscriptions). The cost of EDL supplied electricity (0.08 US$ / KWh) is significantly cheaper since it is provided at subsidized tariffs (lower than generation costs). The private power subscriptions are expensive i.e. fixed monthly fees and provide limited electricity, the connection not being able to support sufficiently the normally used electrical appliances.

4.3.1 Existing population and households size; geographical distribution by caza

According to Lebanese statistics[46] data by caza, population in Lebanon was 4.14 million in 2007. The main population clusters are in the Beirut region and in Tripoli. Based on IMF statistics (World Economic Outlook, October 2015), population in 2012 was estimated at 4.4 million persons, projecting a growth of 1% p.a. and 4.7 million persons by 2020. About 50% of the population lives in Beirut and the Mount Lebanon. Another 21% lives in the North Lebanon governorate. Additionally, 1.4 million Syrian refugees were estimated for Lebanon in January 2015, with the number expected to rise to 1.8 million by end of 2015 (United Nations, UNHCR 2015 planning figures for Lebanon 2015[47]). The UNHCR planning projections for December 2016, include 5.9 million people living in Lebanon, out of which 1.5 million displaced from Syria and 0.3 million Palestinian refugees[48].

46 Ministry of Public Health Lebanon. “Epidemiological Surveillance & Department of Statistics”
47 UNHCR. “Country Operations Profile – Lebanon”, 2015. (http://www.unhcr.org/pages/49e486676.html)
48 UNHCR. “ Lebanese Crisis Response Plan 2015-2016”. December 2015

The distribution of population by governorate and caza are shown respectively in Figure 29 and Figure 30.

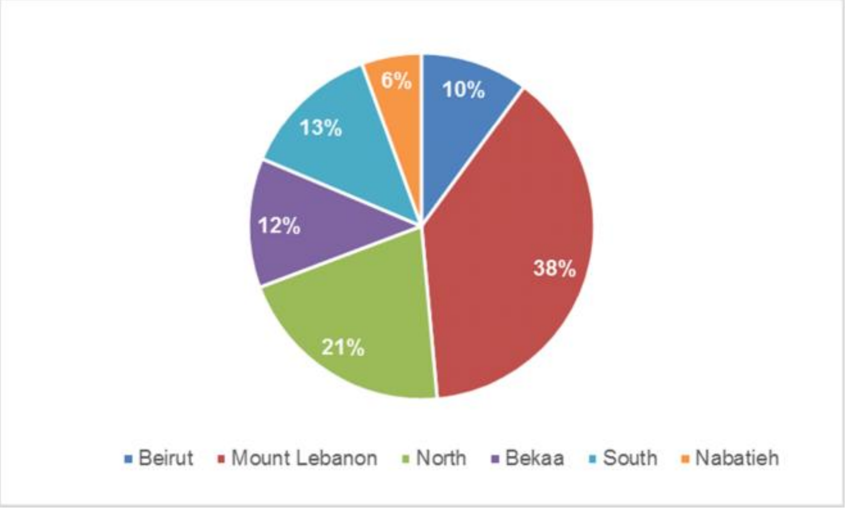


Figure 29: Distribution of Lebanese population by governorate
Source: Ministry of Public Health Lebanon, Epidemiological Surveillance & Department of Statistics (4.14 million persons)

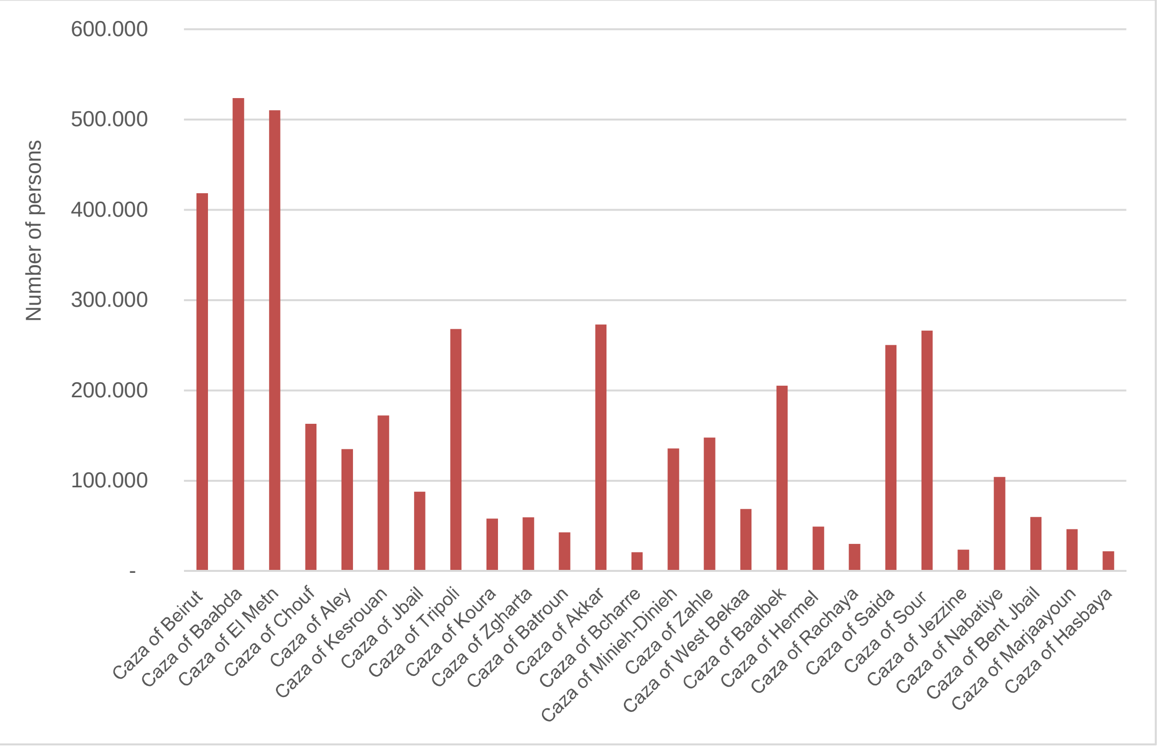


Figure 30: Size of population by caza
Source: Ministry of Public Health Lebanon, Epidemiological Surveillance & Department of Statistics (4.14 million persons)

The average number of household members in Lebanon is around 4, which at the 4.1-4.5 million population would be translated into about 1 million initial potential gas connections including both rural and urban areas. However, there are many small cities and villages, which make the provision of natural gas potentially unfeasible.

4.3.2 Estimated fuel consumption and potential gas demand

The residential sector uses diesel/gasoil for water and space heating, as well as private power generation and LPG mainly for cooking purposes. The maximum demand to be potentially substituted by natural gas includes initially all these fuel uses. Following other qualitative, technical and cost considerations, the demand would be further limited to feasible options within the cost-benefit analysis. At this stage, the maximum potential demand before applying such criteria is indicated in order to define a maximum size infrastructure requirement.

The potential demand of natural gas for this sector is estimated based on the consumption of existing fuels, using 2012 as a reference year due to data availability and methodology considerations and further extrapolations to 2014 based on several assumptions. Population growth rates have been used as growth factors for the period 2012-2014 and 2015-2060.

In order to estimate the total existing consumption of diesel and gas oil in the sector from the annual total consumption during 2012-2014, the following quantities have been deducted:

- Estimated use of diesel (20%) and gasoil (5%) in the transport sector;
- Estimated use of diesel in the industry;
- Estimated diesel for boilers in the commercial and institutional sector;
- Estimated diesel for private generation in the commercial and institutional sector.

As a next step, the diesel and gas oil consumption used for heating has been assessed in order to split the estimated consumption by fuel use, respectively for heating and private power generation. The diesel/gasoil consumption for heating has been estimated based on the following:

- Considering APIC estimates that 30% of the diesel and gas oil is used for heating, and applying this percentage to the 2012 total diesel/gasoil consumption in Lebanon;
- Deducting the 2012 survey estimates for diesel used for boilers in the commercial and institutional sectors (based on ELARD's study on energy consumption in the institutional and commercial sectors);
- The result (170,000 tons for 2012) has been extrapolated to 2014 based on the percent growth of population. This result is further distributed by caza based on the distribution of population.

In order to estimate the quantities consumed for private power generation in the residential sector, the estimated diesel used for heating has been deducted from the total consumption calculated for the sector in 2012-2014. This results in a consumption of 312,000 tons for private generation in the residential sector for 2014. The quantity is further distributed by the power shortages by governorate and then by the population share of each caza in the respective governorate.

The amount of LPG used by the residential sector is estimated by deducting from the total consumption, the quantities estimated as being consumed by the commercial and institutional sector. This is further distributed by caza based on the concentration of the population.

Further growth of the demand of natural gas for the residential sector is estimated based on a population growth of around 1% p.a. during 2015-2050 based on IMF projections for 2012-2020 (World Economic Outlook, October 2015) extrapolated to 2050.

Table 12 summarizes the maximum expected demand for this sector in each scenario. In this case, only one growth scenario has been used, therefore the low and high growth scenarios coincide.

Governorate	Total 2014	Total 2018-Low growth	Total 2018-High growth	Total 2030-Low growth	Total 2030-High growth	Total 2050-Low growth	Total 2050-High growth
Beirut	71	77	77	84	84	96	96
Mount Lebanon	350	382	382	414	414	477	477
North	159	173	173	188	188	217	217
Bekaa	117	127	127	138	138	159	159
South	111	121	121	131	131	152	152
Nabatieh	58	63	63	68	68	79	79
Total (MMCM)	**865**	**943**	**943**	**1,023**	**1,023**	**1,179**	**1,179**
Total (BCF)	**31**	**33**	**33**	**36**	**36**	**42**	**42**

Table 12: Expected maximum demand in residential sector
Source: ILF

4.4 The Commercial and Institutional Sectors

The commercial and institutional sector includes the following:

- Sales / commercial shops and commercial centers;
- Hotels;
- Restaurants;
- Public institutions;
- Offices;
- Educational sector (schools and universities); and
- Healthcare (hospitals).

The study undertaken by ELARD in 2015 entitled “Assessment of energy consumption and mitigation initiatives in the commercial and institutional sector” was used in order to estimate the potential demand of natural gas. It included the survey for estimating the diesel consumption for private power generation and heating (boilers) as well as for estimating the LPG consumption in this sector. The estimations are already available at caza level for 2012.

4.4.1 Consumption by Economic Category (Boilers, Private Power, LPG)

About 656,000 tons of diesel are estimated having been used in 2012 for private power generation, considering an electricity (EDL) consumption of 4,800 GWh in the commercial and institutional sector. Most of the consumption originates from the commercial / sales establishments. Breakdown of diesel use for power generation by category is shown in Figure 31.

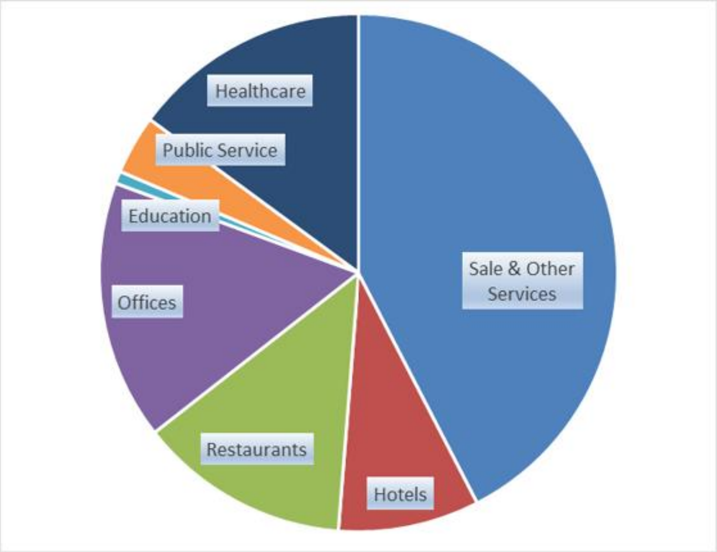


Figure 31: Consumption of diesel for private power generation in 2012
Source: ILF, based on ELARD Study (2015)

About 170,000 tons of diesel are estimated having been used for heating boilers during 2012 by the commercial and institutional sector. The main consumers are the sales & commercial establishments as well as the hotels (Figure 32).

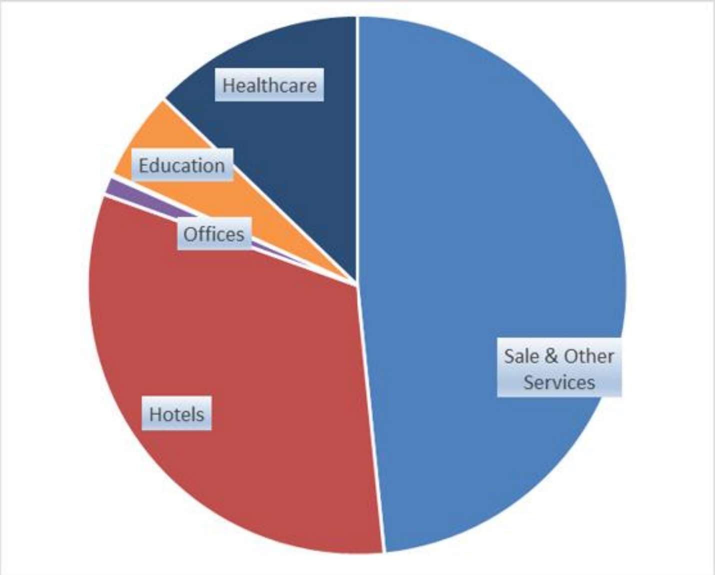


Figure 32: Consumption of diesel for heating boilers in the commercial and institutional sector in 2012
Source: ILF, based on ELARD Study (2015)

About 30,000 tons of LPG are estimated to have been used for heating boilers during 2012 by the commercial and institutional sector. The leading consumers are the restaurants, since LPG is used mainly for cooking purposes (Figure 33).

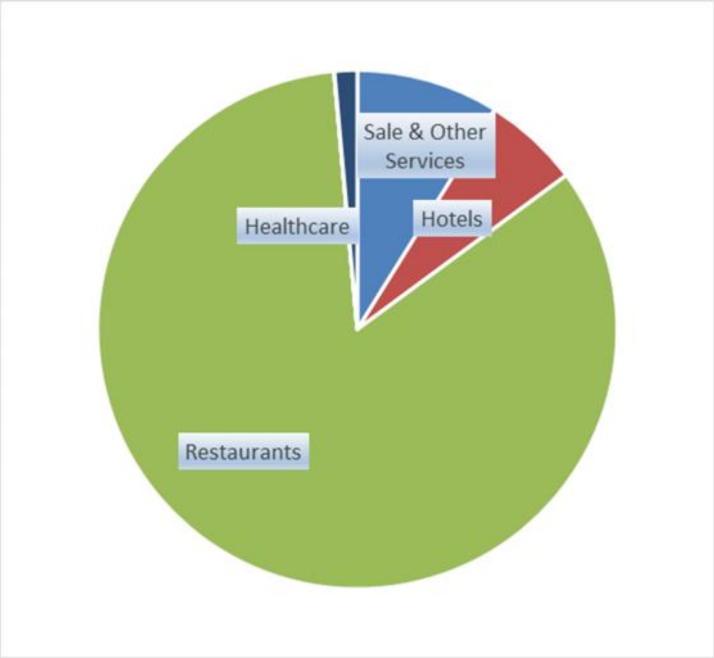


Figure 33: Consumption of LPG in the commercial and institutional sectors in 2012
Source: ILF, based on ELARD Study 2015

Table 13 provides a summary of the results regarding fuel consumption as obtained by ELARD at governorate level as part of the "Assessment of energy consumption and mitigation initiatives in the commercial and institutional sector", as well as an equivalent consumption of natural gas.

Governorate	EDL (MWh)	Diesel Boilers (Tons)	Diesel Power (Tons)	LPG (Tons)	Equivalent MMCM gas
Beirut	1,125	12,782	57522	1,702	85
Mount Lebanon	2,226	101,760	386914	17,715	595
North	647	18,551	73629	3,234	112
Bekaa	384	17,420	71549	3,114	108
South	288	13,693	43062	3,298	70
Nabatyieh	137	6,378	23588	989	36
Total	**4,807**	**170,584**	**656,264**	**30,052**	**1,006**

Table 13: Fuel Consumption in the Commercial and Institutional Sectors by Governorate in 2012
Source: ILF, based on ELARD Study (2015)

4.4.2 Consumption and potential gas demand

The estimated consumption for 2012 at caza level has been extrapolated to 2014 by adding the annual growth (%) in the services sector in Lebanon (World Bank, World Development Indicators, October 2015). Further growth rates of around 3-4% are assumed till 2020. From 2020, two growth scenarios of 2% p.a. (low growth) and 4% p.a. (high growth) have been considered for 2020-2050. The growth rates during 2015-2020 have been derived based on the IMF projection of real GDP growth of 3-4% during 2015-2020 for Lebanon (World Economic Outlook, October 2015) as well as an elasticity factor of 1.1 of service sector growth in relation to GDP growth. The elasticity factor has been derived using historical GDP and service sector growth during 1994-2014 as provided by the World Bank (World Development Indicators, October 2015). After 2020, growth factors of 2.2% (low growth) and 4.4% (high growth) have been applied in two scenarios using the elasticity factor of 1.1 and annual GDP growth rates of 2% and 4%, respectively.

Table 14 summarises the maximum expected demand for this sector in each growth scenario.

Governorate	Total 2014	Total 2018-Low growth	Total 2018-High growth	Total 2030-Low growth	Total 2030-High growth	Total 2050-Low growth	Total 2050-High growth
Beirut	81	91	91	123	29	190	360
Mount Lebanon	567	639	639	866	854	1,338	2,535
North	107	120	120	163	857	252	478
Bekaa	103	116	116	157	196	243	461
South	67	76	76	103	41	159	301
Nabatieh	35	39	39	53	12	82	155
Total (MMCM)	**960**	**1,082**	**1,082**	**1,466**	**1,990**	**2,265**	**4,290**
Total (BCF)	**34**	**38**	**38**	**52**	**70**	**80**	**151**

Table 14: Expected maximum demand in commercial and institutional sectors
Source: ILF

5 POTENTIAL NEW INFRASTRUCTURE FOR DELIVERING NATURAL GAS TO THE TARGET SECTORS

The methodology for developing new infrastructure scenarios for the potential use of NG and alternative low carbon fuels (LCF) in the industrial, residential, commercial and institutional sectors in Lebanon is based on the following main elements:

- The power sector is the main consumer of primary fuel in Lebanon. The analysis considers the use of gas as feedstock for the production of electric power based on existing generation capacity able to use NG, as well as several assumptions highlighted in sections 4.1.1 (plants under construction) and 4.1.2 (future plans). In particular, the demand for natural gas for existing and planned power plants functioning on gas is estimated based on maximum generating capacity (80% load).
- The analysis considers the use of gas for production processes and for private power generation in the cement industries as well as in the other industrial establishments, based on maximum possible demand for NG irrespective of cost or technical, or logistics criteria;
- The analysis considers that gas for the residential, commercial and institutional sectors is sold as an end-fuel to be distributed and consumed directly in these sectors;
- The starting point is the analysis of the current demand (consumption) and supply in the studied sectors for the various fuels segregated, to the extent possible, based on geographical distribution and final use.

The infrastructure scenarios in Lebanon consider the geographical zones in the country from an accessibility point of view.

In order to obtain geographical distribution estimates of the demand, after a high level assessment, in relation with each sector, each caza was assigned a percentage (shares totaling 100%) estimating the distribution of the estimated demand in the considered sectors as coastal, inland or mountainous area. The geographical distribution of the demand was assessed for the residential and commercial sectors by using approximate distribution of population (municipality level) in living in coastal (0-300 m), inland (300-800 m) and mountain areas (>800 m). The geographical split is relevant in order to estimate the maximum demand in the coastal zone and in rather less accessible areas where distribution pipelines are not possible / very expensive to be built to reach the potential energy consumers. Distribution of industries is based on the UNIDO survey (2007) results and approximately 800 major industries (Class I, II and III industries as per ISIC 3[49]) displayed on the map using data from National Physical Masterplan of the Lebanese Territory pub-

49 Class I industries include tanneries, leather dressing, cement, lime, plaster, pulp, paper (from pulp), paperboard, fertilizer, ammunition production plants and gas products, production of animal feed; Class II industries include mining, construction materials (gypsum, building blocks, etc.), certain types of food and beverage production. Class III industries include certain types of food and beverage, food and beverage packaging, tobacco, carpets.

lished in 2005, and geographical zoning map[50]. It is important to highlight, that the percentages do not represent the geographical distribution of land areas (square km), but of maximum NG demand by geographical characteristics. Results are shown in Table 15.

Gover-norate	Caza	Residential			Commercial			Industrial		
		Coastal	Inland	Moun-tain	Coastal	Inland	Moun-tain	Coastal	Inland	Moun-tain
North Lebanon	Akkar	50%	0%	50%	50%	0%	50%	80%	0%	20%
	Tripoli	100%	0%	0%	100%	0%	0%	100%	0%	0%
	Minie-Danniye	0%	0%	100%	0%	0%	100%	0%	0%	100%
	Bcharre	0%	0%	100%	0%	0%	100%	0%	0%	100%
	Koura	50%	50%	0%	50%	50%	0%	20%	80%	0%
	Zgharta	85%	10%	5%	85%	10%	5%	100%	0%	0%
	Batroun	60%	20%	10%	60%	20%	10%	95%	5%	0%
Bekaa -		0%	0%	100%	0%	0%	100%	0%	0%	100%
	Baalbek	0%	60%	40%	0%	60%	40%	0%	60%	40%
	Zahle	0%	70%	30%	0%	70%	30%	0%	80%	20%
	Bekaa West	0%	70%	30%	0%	70%	30%	0%	70%	30%
	Rachaiya	0%	0%	100%	0%	0%	100%	0%	0%	100%
Mount Lebanon	Jbail	50%	0%	50%	50%	0%	50%	90%	10%	0%
	Kesrouane	50%	10%	40%	50%	10%	40%	90%	10%	0%
	El Metn	65%	10%	25%	65%	10%	25%	80%	10%	10%
	Baabda	85%	7%	8%	85%	7%	8%	85%	10%	5%
	Aley	50%	20%	30%	50%	20%	30%	80%	10%	10%
	Chouf	30%	30%	40%	30%	30%	40%	40%	30%	30%
Beyrouth	Beyrouth	100%	0%	0%	100%	0%	0%	100%	0%	0%
South Lebanon	Jezzine	0%	0%	100%	0%	0%	100%	0%	0%	100%
	Saida	50%	50%	0%	50%	50%	0%	90%	10%	0%
	Sour	80%	20%	0%	80%	20%	0%	50%	50%	0%
Nabatiye	Hasbaiya	0%	0%	100%	0%	0%	100%	0%	0%	100%
	Marjay-oun	0%	95%	5%	0%	95%	5%	0%	80%	20%
	Nabatiye	0%	100%	0%	0%	100%	0%	0%	100%	0%
	Bent Jbail	0%	100%	0%	0%	100%	0%	0%	100%	0%

Table 15: Approximate percent distribution of energy demand based on geographical area and sector.
Source: ILF

Figure 34 shows the resulting distribution of energy demand per geographical area. The year 2018 is used as a base year assuming natural gas starts to be available for use that year in case LNG import plans materialize by that time. The figure clearly shows that majority of the demand is in the coastal area (about 60 percent). Only 7 cazas show a demand in 2018 of nearly 200

50 Criteria: Coastal: 0-300 m elevation; Inland: 300 -800 m elevation; Mountain: above 800 m

MMCM (7 BCF) and above. Figure 35 shows that the majority of the energy demand is in the Mount Lebanon Governorate (about 1500 MMCM / 54 BCF), followed by the North Governorate with about half of Mount Lebanon's demand (about 800 MMCM / 29 BCF). The remaining governorates have around 870 MMCM (31 BCF) estimated energy demand in 2018.

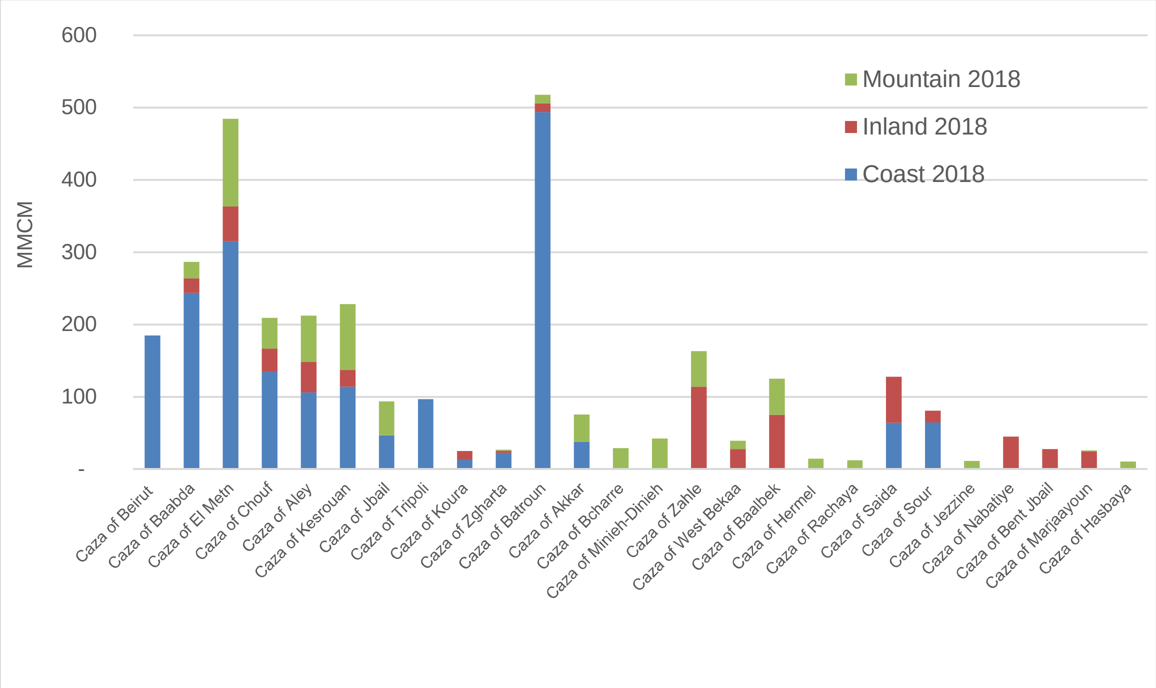


Figure 34: Distribution of demand by geographical area and caza in the relevant sectors for a low growth scenario, for year 2018 and in MMCM
Source: ILF

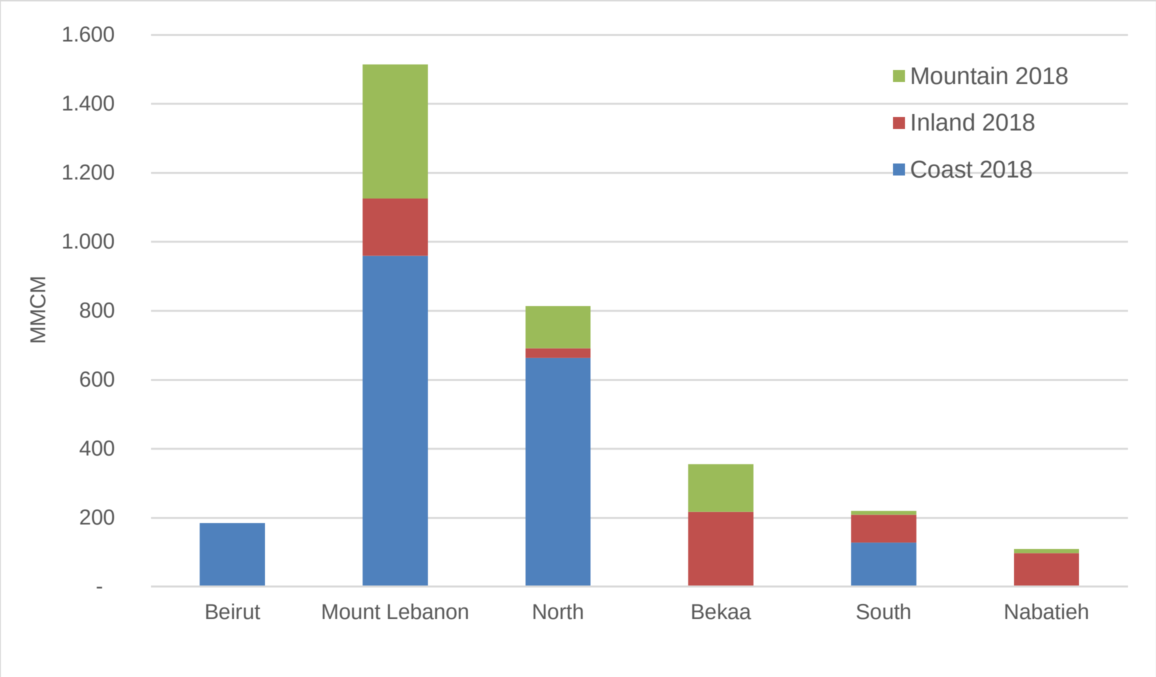


Figure 35: Distribution of demand by geographical area and governorate in the relevant sectors for a low growth scenario, for year 2018 and in MMCM
Source: ILF

For the year 2018, the results in the low growth and high growth scenarios are similar. The next figures show the total potential NG demand by caza and governorate in the relevant sectors for the years 2030 and 2050, considering low growth and high growth scenarios as well as geographical zones.

The maximum NG gas demands in the two governorates with the highest potential are Mount Lebanon and the North. Mount Lebanon is estimated to have a potential of around 2,000-2,300 MMCM, while the North governorate (mostly due to cement and chemical industries located in Batroun) of receiving 1,000-1,200 MMCM of NG by 2030.

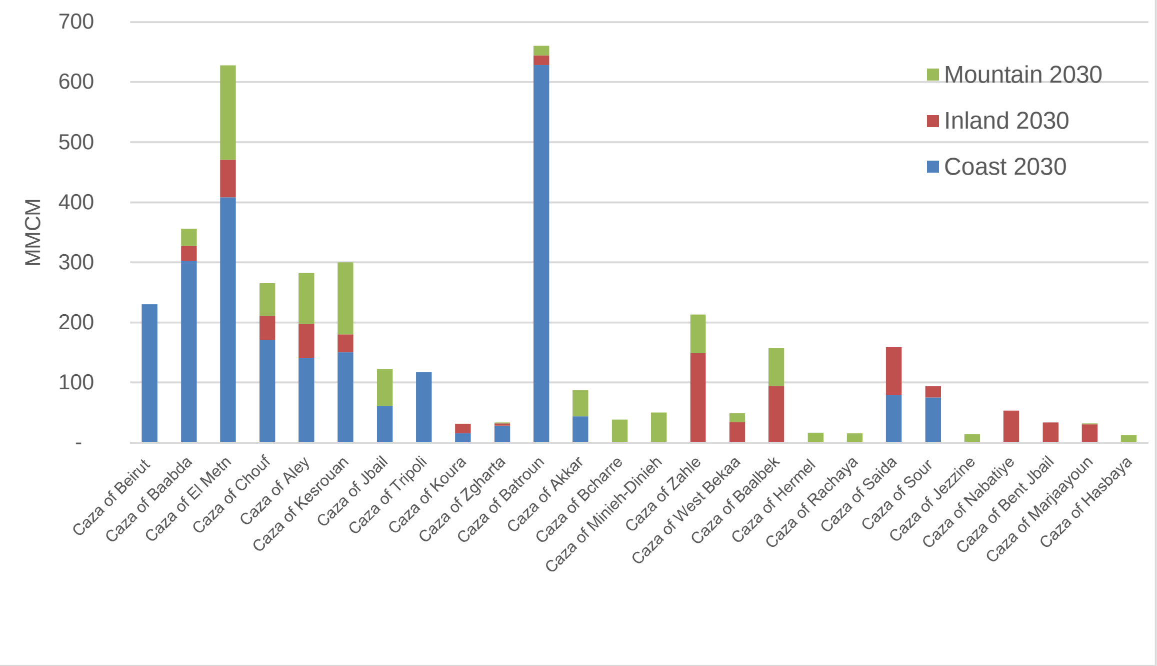


Figure 36: Distribution of demand by geographical area and caza in the relevant sectors for a low growth scenario, for year 2030 and in MMCM
Source: ILF

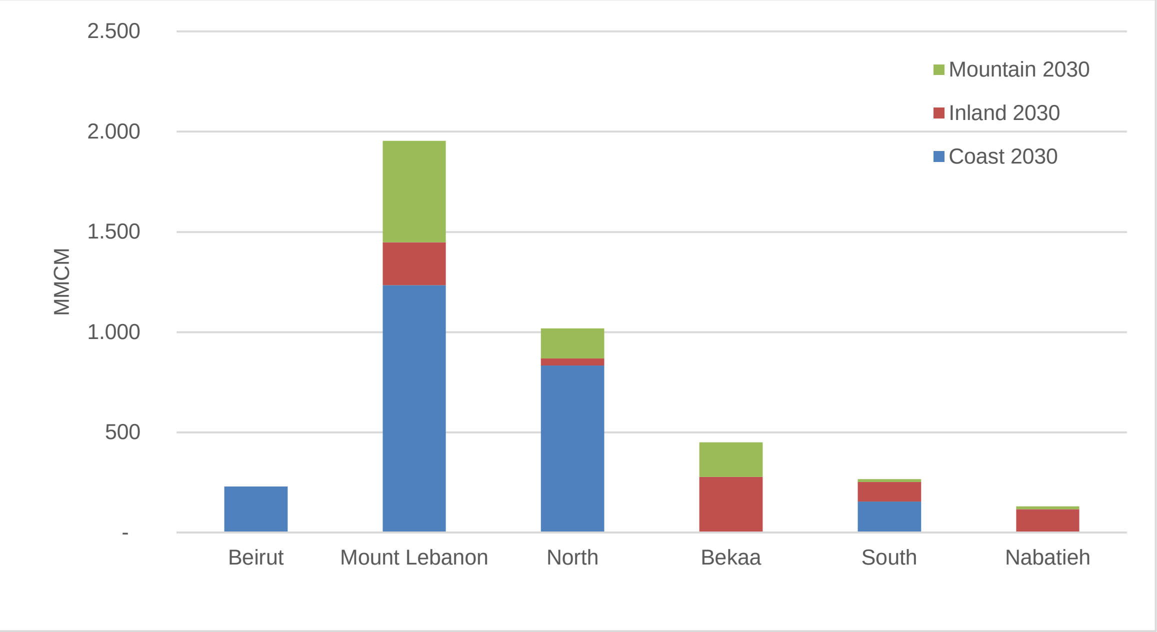


Figure 37: Distribution of demand by geographical area and governorate in the relevant sectors for a low growth scenario, for year 2030 and in MMCM
Source: ILF

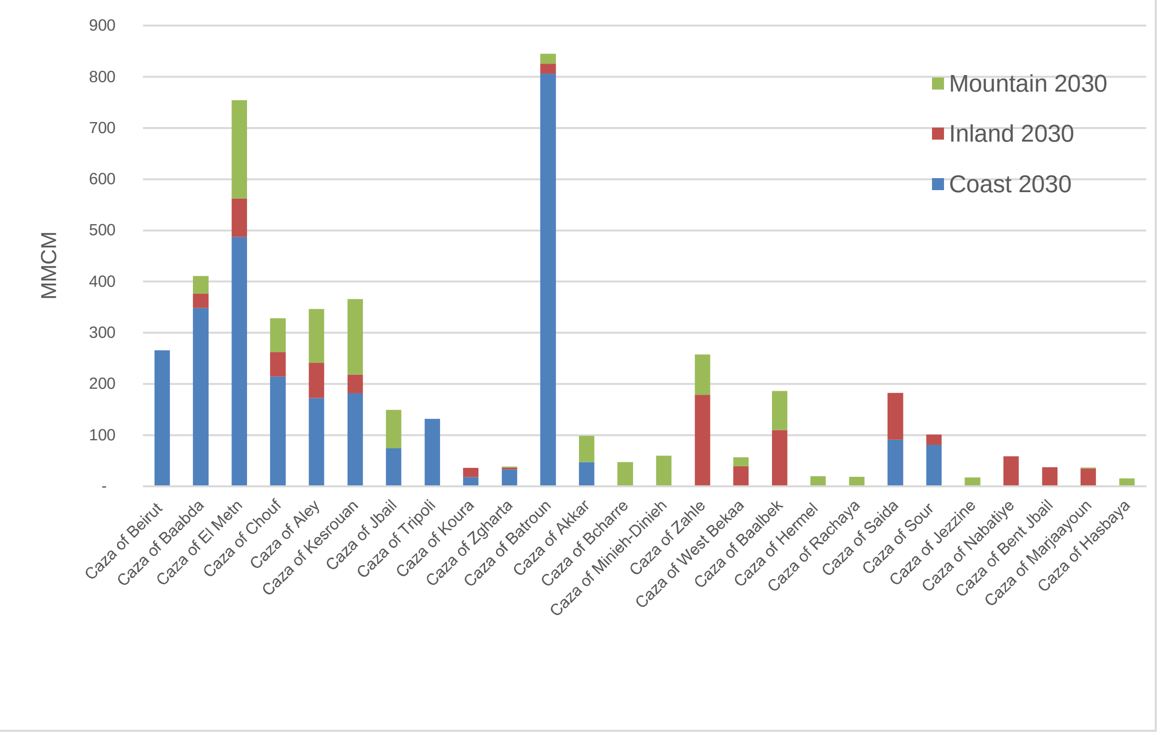


Figure 38: Distribution of demand by geographical area and caza in the relevant sectors for a high growth scenario, for year 2030 and in MMCM
Source: ILF

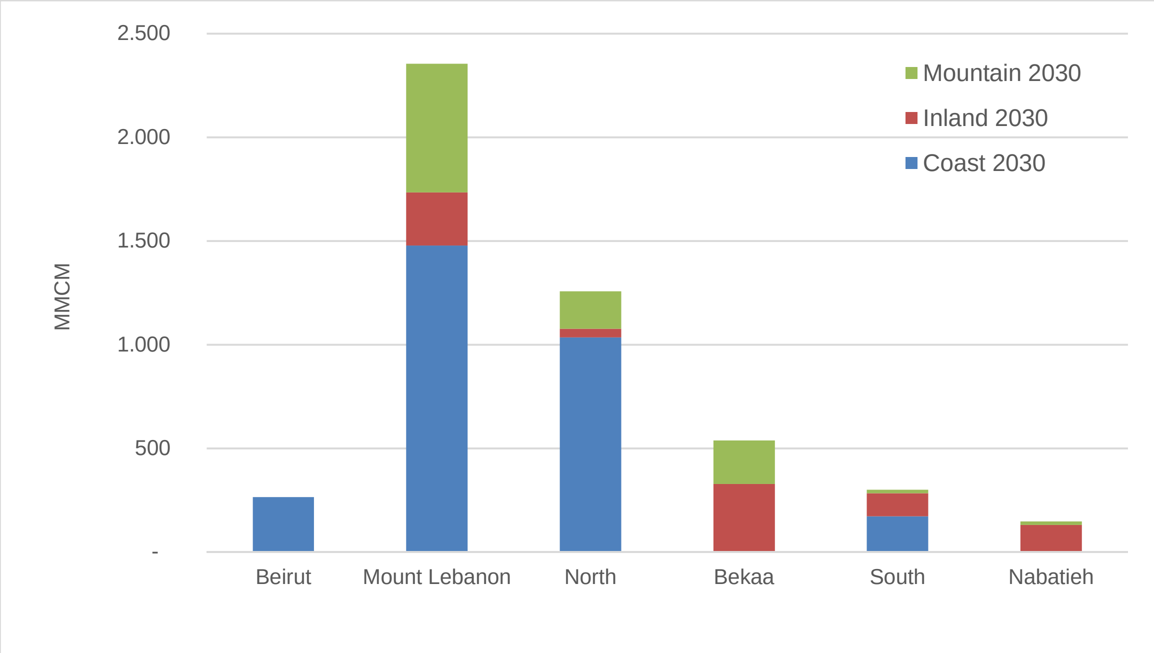


Figure 39: Distribution of demand by geographical area and governorate in the relevant sectors for a high growth scenario, for year 2030 and in MMCM
Source: ILF

Mount Lebanon is estimated to have a potential of around 2,800-4,900 MMCM, while the North governorate of receiving 1,300-1,800 MMCM of NG by 2050.

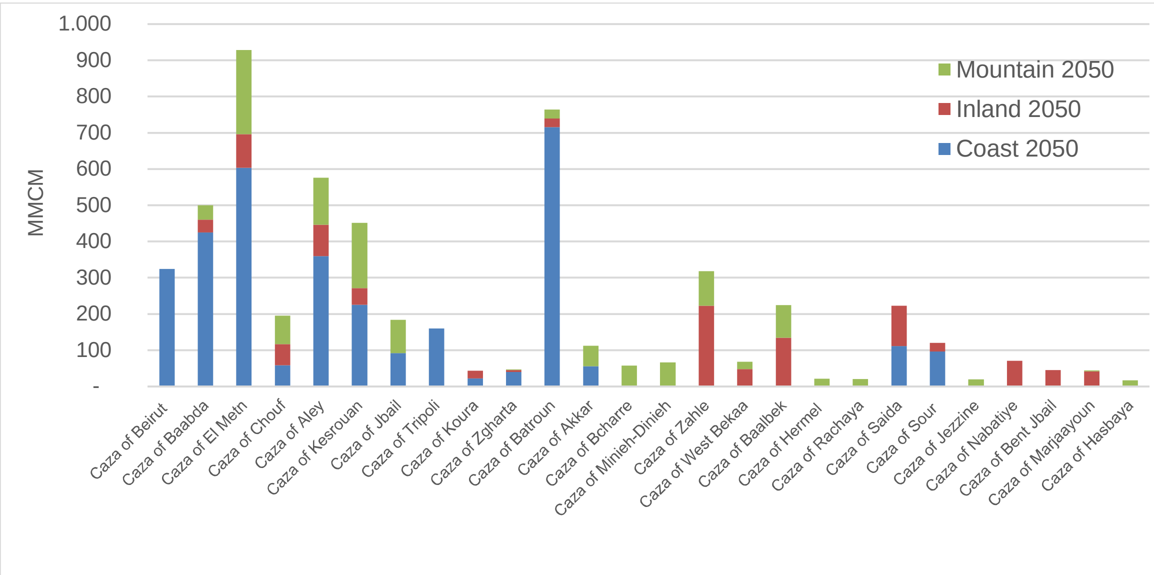


Figure 40: Distribution of demand by geographical area and caza in the relevant sectors for a low growth scenario, for year 2050 and in MMCM
Source: ILF

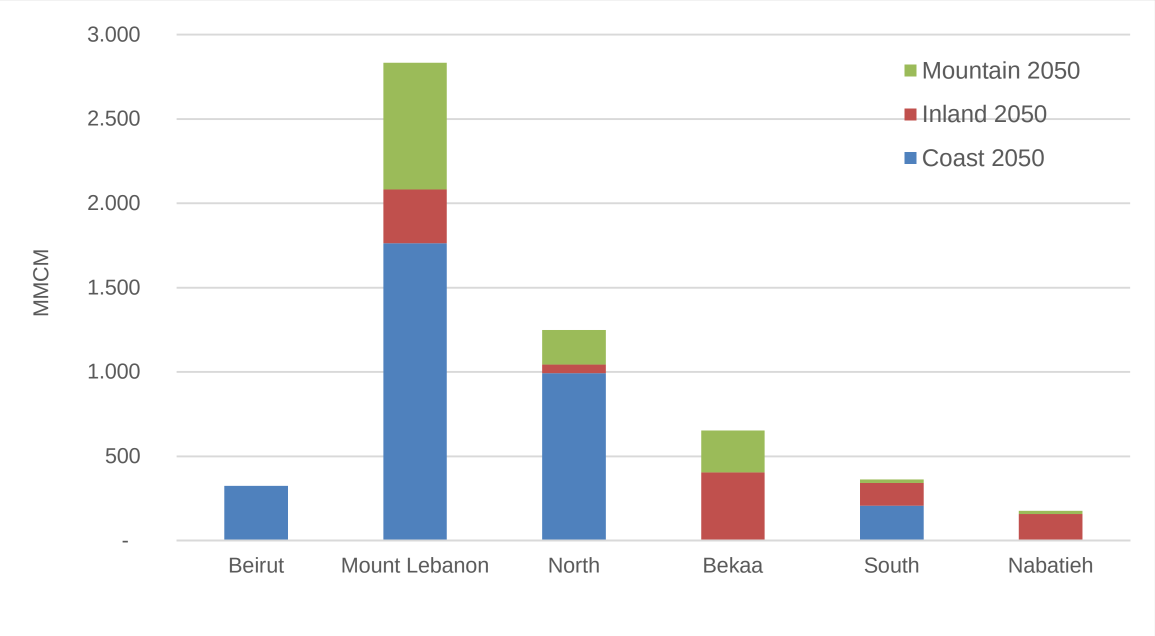


Figure 41: Distribution of demand by geographical area and governorate in the relevant sectors for a low growth scenario, for year 2050 and in MMCM
Source: ILF

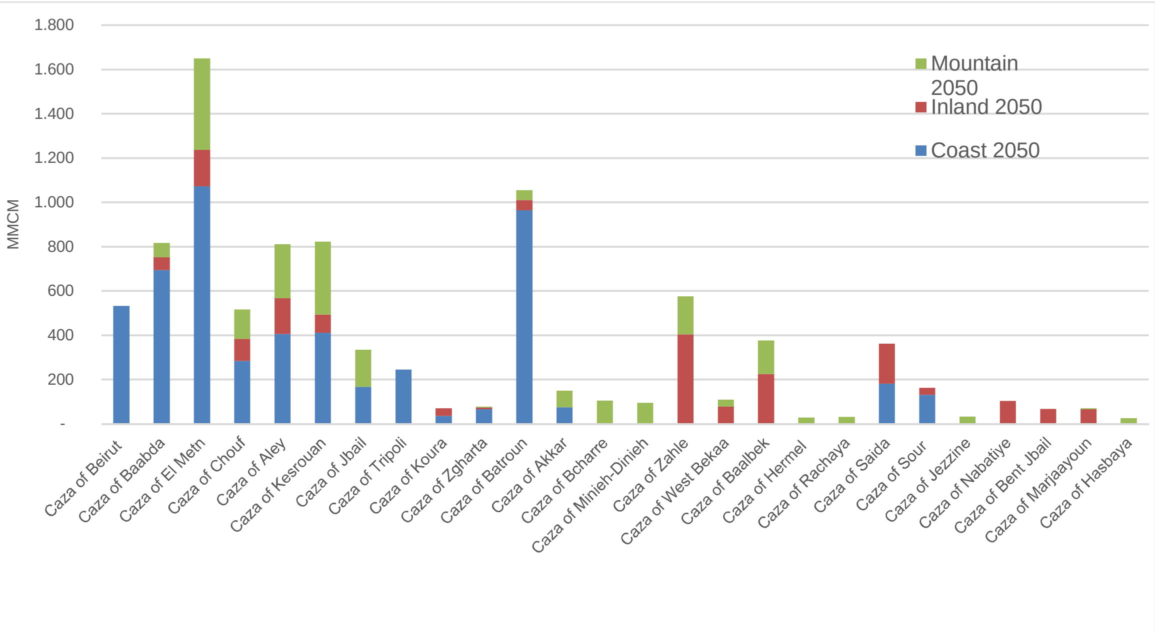


Figure 42: Distribution of demand by geographical area and caza in the relevant sectors for a high growth scenario, for year 2050 and in MMCM
Source: ILF

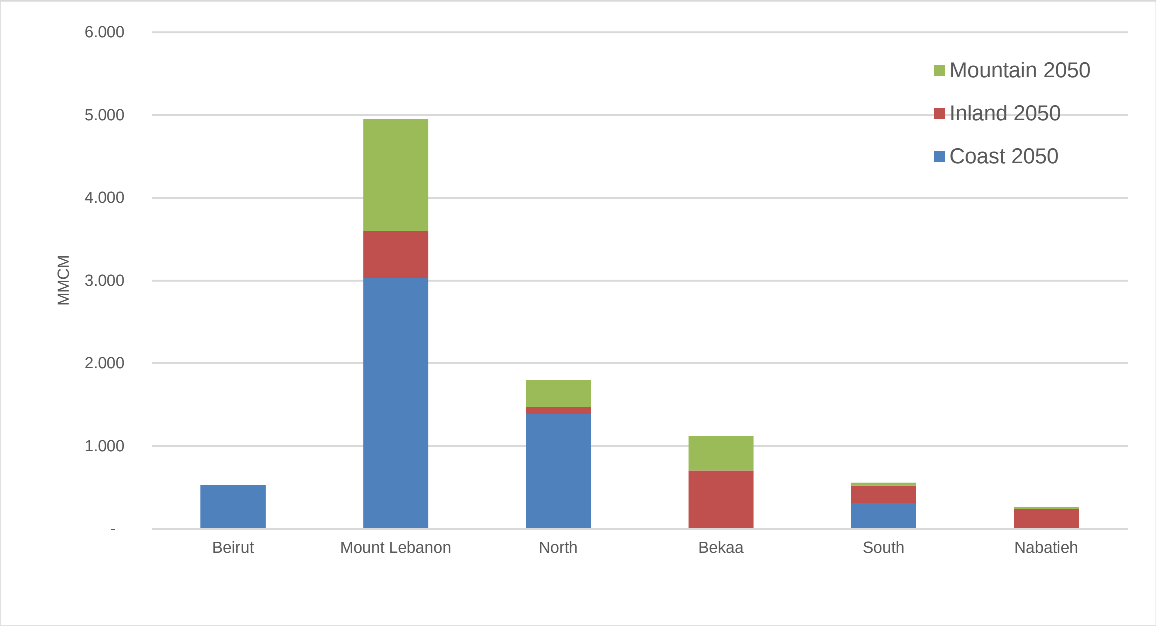


Figure 43: Distribution of demand by geographical area and governorate in the relevant sectors for a high growth scenario, for year 2050 and in MMCM
Source: ILF

A summary of the estimated results (in MMCM and BCF) for the low growth and high growth scenarios for each of the relevant sectors are displayed in Tables 16 to 19.

	2018				2030				2050			
	Total	Coast	Inland	Mountain	Total	Coast	Inland	Mountain	Total	Coast	Inland	Mountain
Industrial Sector	**1,173**	848	153	173	**1,564**	1,111	213	240	**2,156**	1,428	342	386
Beirut	**17**	17	-	-	**23**	23	-	-	**38**	38	-	-
Mount Lebanon	**494**	322	53	119	**675**	435	74	166	**1,019**	635	119	266
North	**520**	496	9	15	**668**	634	13	21	**781**	726	20	35
Bekaa	**112**	-	75	37	**156**	-	104	52	**250**	-	167	83
South	**23**	13	9	1	**33**	18	13	1	**52**	29	21	2
Nabatieh	**7**	-	7	0	**10**	-	10	0	**16**	-	15	0
Commercial Sector	**1,082**	590	214	277	**1,466**	800	290	375	**2,265**	1,236	449	580
Beirut	**91**	91	-	-	**123**	123	-	-	**190**	190	-	-
Mount Lebanon	**639**	393	69	177	**866**	533	94	239	**1,338**	824	145	370
North	**120**	66	9	45	**163**	90	13	61	**252**	139	20	94
Bekaa	**116**	-	71	45	**157**	-	96	61	**243**	-	149	95
South	**76**	40	31	5	**103**	54	42	7	**159**	83	64	11
Nabatieh	**39**	-	34	5	**53**	-	46	7	**82**	-	71	10
Residential Sector	**943**	499	221	223	**1,023**	541	240	242	**1,179**	624	276	279
Beirut	**77**	77	-	-	**84**	84	-	-	**96**	96	-	-
Mount Lebanon	**382**	245	44	93	**414**	265	48	101	**477**	306	55	116
North	**173**	102	9	63	**188**	110	9	68	**217**	127	11	78
Bekaa	**127**	-	72	56	**138**	-	78	60	**159**	-	90	70
South	**121**	76	40	5	**131**	82	44	6	**152**	95	50	7
Nabatieh	**63**	-	57	7	**68**	-	61	7	**79**	-	71	8
Total	**3,198**	**1,937**	**588**	**673**	**4,052**	**2,452**	**743**	**858**	**5,600**	**3,288**	**1,067**	**1,245**
Beirut	**185**	185	-	-	**230**	230	-	-	**324**	324	-	-
Mount Lebanon	**1,515**	960	166	389	**1,955**	1,234	215	506	**2,834**	1,764	318	752
North	**814**	664	27	123	**1,018**	834	35	150	**1,250**	992	51	206
Bekaa	**355**	-	217	138	**451**	-	278	173	**653**	-	405	248
South	**220**	129	80	12	**267**	154	98	14	**363**	207	135	20
Nabatieh	**109**	-	98	12	**131**	-	117	14	**176**	-	157	19

Table 16: Estimated maximum potential NG demand in MMCM by geographical zone and sector for a low growth scenario
Source: ILF

	2018				2030				2050			
	Total	Coast	Inland	Mountain	Total	Coast	Inland	Mountain	Total	Coast	Inland	Mountain
Industrial Sector	**41**	30	5	6	**55**	39	8	8	**76**	50	12	14
Beirut	**1**	1	-	-	**1**	1	-	-	**1**	1	-	-
Mount Lebanon	**17**	11	2	4	**24**	15	3	6	**36**	22	4	9
North	**18**	18	0	1	**24**	22	0	1	**28**	26	1	1
Bekaa	**4**	-	3	1	**5**	-	4	2	**9**	-	6	3
South	**1**	0	0	0	**1**	1	0	0	**2**	1	1	0
Nabatieh	**0**	-	0	0	**0**	-	0	0	**1**	-	1	0
Commercial Sector	**38**	21	8	10	**52**	28	10	13	**80**	44	16	20
Beirut	**3**	3	-	-	**4**	4	-	-	**7**	7	-	-
Mount Lebanon	**23**	14	2	6	**31**	19	3	8	**47**	29	5	13
North	**4**	2	0	2	**6**	3	0	2	**9**	5	1	3
Bekaa	**4**	-	3	2	**6**	-	3	2	**9**	-	5	3
South	**3**	1	1	0	**4**	2	1	0	**6**	3	2	0
Nabatieh	**1**	-	1	0	**2**	-	2	0	**3**	-	3	0
Residential Sector	**33**	18	8	8	**36**	19	8	9	**42**	22	10	10
Beirut	**3**	3	-	-	**3**	3	-	-	**3**	3	-	-
Mount Lebanon	**13**	9	2	3	**15**	9	2	4	**17**	11	2	4
North	**6**	4	0	2	**7**	4	0	2	**8**	4	0	3
Bekaa	**4**	-	3	2	**5**	-	3	2	**6**	-	3	2
South	**4**	3	1	0	**5**	3	2	0	**5**	3	2	0
Nabatieh	**2**	-	2	0	**2**	-	2	0	**3**	-	2	0
Total	**113**	**68**	**21**	**24**	**143**	**87**	**26**	**30**	**198**	**116**	**38**	**44**
Beirut	**7**	7	-	-	**8**	8	-	-	**11**	11	-	-
Mount Lebanon	**53**	34	6	14	**69**	44	8	18	**100**	62	11	27
North	**29**	23	1	4	**36**	29	1	5	**44**	35	2	7
Bekaa	**13**	-	8	5	**16**	-	10	6	**23**	-	14	9
South	**8**	5	3	0	**9**	5	3	1	**13**	7	5	1
Nabatieh	**4**	-	3	0	**5**	-	4	0	**6**	-	6	1

Table 17: Estimated maximum potential NG demand in BCF by geographical zone and sector for a low growth scenario
Source: ILF

	2018				2030				2050			
	Total	**Coast**	**Inland**	**Mountain**	**Total**	**Coast**	**Inland**	**Mountain**	**Total**	**Coast**	**Inland**	**Mountain**
Industrial Sector	**1,184**	859	153	173	**1,990**	1,419	268	303	**3,757**	2,298	684	774
Beirut	**17**	17	-	-	**29**	29	-	-	**75**	75	-	-
Mount Lebanon	**494**	322	53	119	**854**	552	93	209	**1,940**	1.169	238	533
North	**520**	496	9	15	**857**	814	16	27	**1,104**	995	40	69
Bekaa	**112**	-	75	37	**196**	-	131	65	**501**	-	334	167
South	**23**	13	9	1	**41**	23	16	2	**105**	59	41	4
Nabatieh	**7**	-	7	0	**12**	-	12	0	**32**	-	31	1
Commercial Sector	**1,082**	590	214	277	**1,813**	990	359	464	**4,290**	2,342	850	1,099
Beirut	**91**	91	-	-	**152**	152	-	-	**360**	360	-	-
Mount Lebanon	**639**	393	69	177	**1,072**	660	116	296	**2,535**	1,561	274	701
North	**120**	66	9	45	**202**	111	16	75	**478**	263	37	177
Bekaa	**116**	-	71	45	**195**	-	119	76	**461**	-	282	179
South	**76**	40	31	5	**127**	67	52	9	**301**	158	122	21
Nabatieh	**39**	-	34	5	**66**	-	57	8	**155**	-	135	20
Residential Sector	**943**	499	221	223	**1,023**	541	240	279	**1,179**	624	276	279
Beirut	**77**	77	-	-	**84**	84	-	-	**96**	96	-	-
Mount Lebanon	**382**	245	44	93	**414**	265	48	116	**477**	306	55	116
North	**173**	102	9	63	**188**	110	9	78	**217**	127	11	78
Bekaa	**127**	-	72	56	**138**	-	78	70	**159**	-	90	70
South	**121**	76	40	5	**131**	82	44	7	**152**	95	50	7
Nabatieh	**63**	-	57	7	**68**	-	61	8	**79**	-	71	8
Total	3,209	1,948	588	673	4,826	2,950	867	1,046	9,227	5,264	1,811	2,152
Beirut	**185**	185	-	-	**265**	265	-	-	**532**	532	-	-
Mount Lebanon	**1,515**	960	166	389	**2,339**	1,477	256	621	**4,952**	3,035	566	1,350
North	**814**	664	27	123	**1,247**	1,036	41	180	**1,799**	1,385	89	325
Bekaa	**355**	-	217	138	**529**	-	328	211	**1,121**	-	705	416
South	**220**	129	80	12	**300**	172	111	17	**557**	311	214	32
Nabatieh	**109**	-	98	12	**81**	46	80	8	**266**	-	237	29

Table 18: Estimated maximum potential NG demand in MMCM by geographical zone and sector for a high growth scenario
Source: ILF

	2018				2030				2050			
	Total	Coast	Inland	Mountain	Total	Coast	Inland	Mountain	Total	Coast	Inland	Mountain
Industrial Sector	**41**	30	5	6	**70**	50	9	11	**133**	81	24	27
Beirut	**1**	1	-	-	**1**	1	-	-	**3**	3	-	-
Mount Lebanon	**17**	11	2	4	**30**	19	3	7	**68**	41	8	19
North	**18**	18	0	1	**30**	29	1	1	**39**	35	1	2
Bekaa	**4**	-	3	1	**7**	-	5	2	**18**	-	12	6
South	**1**	0	0	0	**1**	1	1	0	**4**	2	1	0
Nabatieh	**0**	-	0	0	**0**	-	0	0	**1**	-	1	0
Commercial Sector	**38**	21	8	10	**64**	35	13	16	**151**	83	30	39
Beirut	**3**	3	-	-	**5**	5	-	-	**13**	13	-	-
Mount Lebanon	**23**	14	2	6	**38**	23	4	10	**90**	55	10	25
North	**4**	2	0	2	**7**	4	1	3	**17**	9	1	6
Bekaa	**4**	-	3	2	**7**	-	4	3	**16**	-	10	6
South	**3**	1	1	0	**4**	2	2	0	**11**	6	4	1
Nabatieh	**1**	-	1	0	**2**	-	2	0	**5**	-	5	1
Residential Sector	**33**	18	8	8	**36**	19	8	10	**42**	22	10	10
Beirut	**3**	3	-	-	**3**	3	-	-	**3**	3	-	-
Mount Lebanon	**13**	9	2	3	**15**	9	2	4	**17**	11	2	4
North	**6**	4	0	2	**7**	4	0	3	**8**	4	0	3
Bekaa	**4**	-	3	2	**5**	-	3	2	**6**	-	3	2
South	**4**	3	1	0	**5**	3	2	0	**5**	3	2	0
Nabatieh	**2**	-	2	0	**2**	-	2	0	**3**	-	2	0
Total	**113**	**69**	**21**	**24**	**170**	**104**	**31**	**37**	**326**	**186**	**64**	**76**
Beirut	**7**	7	-	-	**9**	9	-	-	**19**	19	-	-
Mount Lebanon	**53**	34	6	14	**83**	52	9	22	**175**	107	20	48
North	**29**	23	1	4	**44**	37	1	6	**63**	49	3	11
Bekaa	**13**	-	8	5	**19**	-	12	7	**40**	-	25	15
South	**8**	5	3	0	**11**	6	4	1	**20**	11	8	1
Nabatieh	**4**	-	3	0	**5**	-	5	1	**9**	-	8	1

Table 19: Estimated maximum potential NG demand in BCF by geographical zone and sector for a high growth scenario
Source: ILF

In conclusion, the estimated potential maximum NG demands are expected to increase from around 3,200 MMCM (113 BCF) in 2018 to 4,000-4,800 MMCM (140-170 BCF) in 2030. Thereof, about 1,900 MMCM (68 BCF) in 2018 and 2,400-2,900 MMCM (87-104 BCF) in 2030 are estimated as originating from coastal areas. By 2050, the maximum total demand[51] reaches 5,600-9,200 MMCM (198-326 BCF), including 3,300-5,300 MMCM (116-186 BCF) in coastal areas.

51 Including potential amounts for private power generation as per the current set up growing demand

5.1 Potential New Infrastructure for the delivery of natural gas

All cost estimates, benchmark cost figures and sizes have been extracted from the ILF internal database specifically for this project. As detailed information is subject to confidentiality, it is not possible to provide further insight into this database. The accuracy of the cost estimate applies to the recommendations of AACE International (Association for the Advancement of Cost Engineering), which is generally applied for projects within the process and construction industry. Reference is made to the AACE Recommended Practice No. 18R-97 for more information. Based on the level of design, the appropriate estimating class is class 5 (Figure 44). The selected accuracy ranges between -30% to +50% of the estimate is located well within the range of AACE recommended accuracies. A quality assurance and benchmark of the results has been performed by comparison of costs with other projects resulting in costs for the different topics.

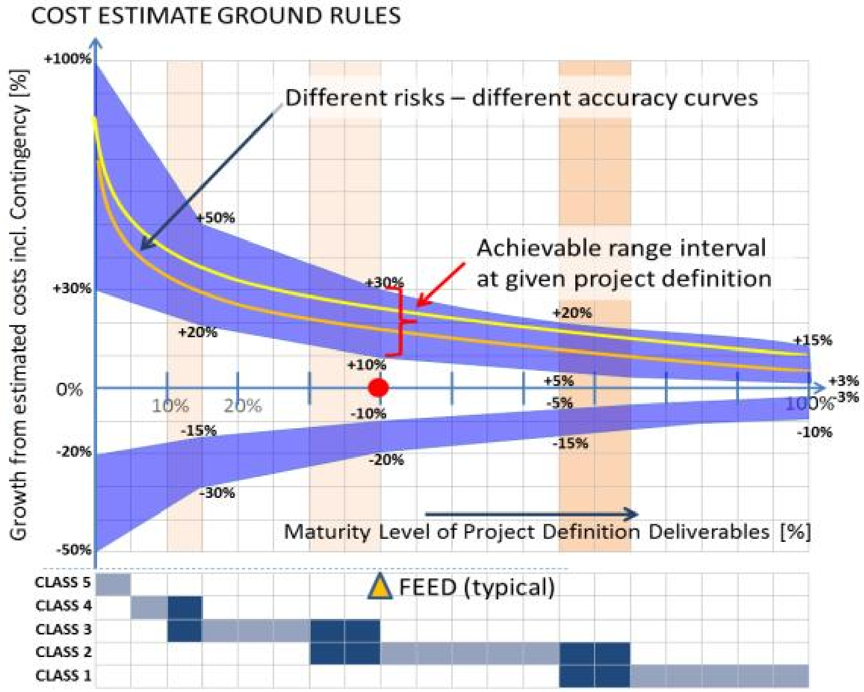


Figure 44: Cost estimate ground rules
Source: ILF

5.2 The Coastal Pipeline

5.2.1 General

Information presented in this section was provided by the Lebanese Oil Installations. The Lebanese Coastal Gas Pipeline (CGP) project is planned from Deir Ammar to Tyr, for a length of 175 km and a pipeline diameter of 36”.

This project constitutes the backbone for the distribution of natural gas along the Lebanese coastline, since it can be connected to the AGP pipeline which is tied to the Deir Ammar power plant. This project is of particular importance to this study. It is considered as a base infrastructure from which additional infrastructure would spin off to supply gas to the target sectors considered in this study. In the absence of this backbone infrastructure, the feasibility of supplying gas to the target sectors could be compromised and shall be assessed based on the CBA results. At the moment the project is on-hold.

The CGP would give Lebanon the possibility to get connected to the Turkish network and then to European and Eurasian countries, as well as to connect with any LNG plant on the coastline and with the national gas fields once/if they are found and developed. The CGP was planned to be laid under the Right of Way of the coastal railway based on an agreement between the Railway and Public Transport Authority and the Lebanese Oil Installations. However such agreement could be compromised given that the Ministry of Public Works and Transport is now conducting a feasibility study to re-establish the coastal highway between Beirut and Tripoli.

The project was planned to be executed in parts:

- the 1st part is an onshore pipeline from Deir Ammar power plant to Selaata for a distance of 36 km. Execution period is said to be 24 months. It will connect the Deir Ammar plant with Harisha power plant;
- the 2nd part is an onshore pipeline extending from Selaata to Zouk power plant with a length of 42 km. Execution period is 26 months. It will provide the Zouk power plant with natural gas;
- the 3rd part is an offshore pipeline passing through Beirut with a length of 36km;
- the 4th part is an onshore pipeline from the town of Neeme to the Zahrani power plant for 33 km. Execution period is 21 months. This will feed the Jiyeh and Zahrani power plants with natural gas; and
- the 5th part is an onshore line from Zahrani to Tyr for feeding the Tyr power plant for a length of 30 km. Execution period is 19 months.

5.2.2 CAPEX

All stages of the CGP project from Deir Ammar to Tyr were estimated to cost about 455 US$ million.

5.2.3 OPEX

Operating expenditures are estimated at 2% of Capex per year at around 9 US$ million.

5.3 City Gas Distribution Network for the industrial, commercial, institutional and residential sectors

5.3.1 Technical Infrastructure Requirements

The main technical infrastructure requirements for piped distribution of natural gas are described in this section.

Transmission pipeline

For Lebanon the Coastal Pipeline will take over the functionality of the transmission pipeline.

Pressure reduction and metering station

Strategically positioned off take stations need to be located in the areas of Tripoli, Beirut, Mount Lebanon, and the power plants.

Distribution network

The development of a distribution network shall be implemented around large industrial consumers and future new residential areas. E.g. for the Mount Lebanon area a medium pressure (MP) distribution pipeline with a length of approximately 40 km is considered for industrial customers. A low pressure distribution (LP) network for residential use shall be connected to the MP system. Within the CBA only connection of new residential areas are considered to be connected to the gas distribution network.

The connection of a new gas distribution network to existing housing areas in Lebanon is considered to be a challenging objective to be achieved. In the absence of underground infrastructure information and maps, and given the high density in most urban areas along the coast, implementation of such gas distribution would be costly and challenging from a safety point of view.

Connections of end customers to the gas distribution network

Each domestic gas consumer has to be connected to the gas distribution network. The gas consumption of each consumer has to be measured separately; therefore a gas metering device has to be installed at each consumer location. Currently two different types of gas meters are available on the market, namely mechanical meters and smart meters. Mechanical meters require manual handling while smart meters allow remote control.

5.3.2 CAPEX

The following tables show typical CAPEX cost for the different infrastructure measures related to a gas distribution network.

Type of pipeline connection	Technical Data	Typical CAPEX
Transport Pipeline (HP)[52]	DN 300 / PN 70	800 US$ / m
Distribution Pipeline (MP)	DN 100 / PN 4	600 US$ / m
Distribution Pipeline (LP)	DN 40 / PN 0.04	400 US$ / m
House Connection		1500 - 3000 US$ / connection
End Consumer connection		400 - 1000 US$ / connection

Table 20: CAPEX costs for pipeline connections
Source: ILF

Pressure Reduction and Metering Station (PRMS):

Construction Item	Size/ Capacity	Typical Cost
PRMS A Station (70 bar)	150,000 m³/h	2,000,000 US $ / unit
PRMS A Station (70 bar)	25,000 m³/h	600,000 US $ / unit
PRMS B Station (4 bar)	5,000 m³/h	40,000 US $ / unit

Table 21: Station CAPEX costs
Source: ILF

Smart Metering Devices:

Smart Meter	Nominal Flow Rate [m³/h]	Capacity [kW]	Typical Cost
G4	4	37.8	400 US$ / unit
G6	6	56.7	450 US$ / unit
G10	10	94.5	600 US$ / unit
G16	16	151.2	700 US$ / unit
G25	25	236.3	850 US$ / unit
G40	40	378.0	2500 US$ / unit
G65	65	614.3	3500 US$ / unit

Table 22: Smart metering CAPEX costs
Source: ILF

5.3.3 OPEX

A typical benchmark value for operational expenditures OPEX for a gas distribution network is 5000-8000 US$/km for large gas distribution networks. Higher expenditures are usually incurred in the early life of the network.

52 Note: Considered is a pipeline to connect the Coastal (transportation) pipeline with the gas distribution pipelines

5.4 LNG Trucking

LNG trucking can also support delivery of LNG / Natural Gas to rural areas of Lebanon. Consumers of gas which cannot be cost-effectively connected to a piped gas distribution network, could be reached via LNG trucking.

5.4.1 Technical Infrastructure Requirements

At the LNG import terminals / FSRU, the truck loading is done through a specific LNG refueling station. The LNG is loaded on tank trucks which transport the LNG in smaller quantities from the point of delivery to the consumers.

The trucks are weighted prior to filling and afterwards get connected manually to the loading arm filling and vapor return lines. The time for filling one truck is estimated at around one hour including all the paperwork; depending on the needs the truck loading facility could be extended easily for parallel operation to achieve e.g. a loading rate for around 50 trucks a day.

At the point of delivery / at the site of the customer the LNG needs to be regasified. Therefore a so called LNG satellite / regasification plant must be installed.

5.4.2 CAPEX

For a recently conducted similar assignment and the transport of LPG via trucks in Saudi Arabia, the Consultant assumed the following CAPEX:

Construction Item	Size/ Capacity	Typical Cost
LNG Truck loading facility	approx. 3.800 m^3/day or 50 trucks per day	approx. 600,000 US$ / estimated with 30% of the costs for a regasification plant as there are no storage tanks required
LNG Truck Head	-	110,000 US$
LNG Trailer incl. tank	18 m^3	250,000 US$
LNG Trailer incl. tank	50 m^3	340,000 US$
LNG satellite / regasification plant	60 m^3	approx. 900,000 US$
LNG satellite / regasification plant	250 m^3	approx. 1,800,000 US$

Table 23: Typical cost indications for LNG trucking equipment
Source: ILF

5.4.3 OPEX

In general the transportation costs for LNG are in the same range as for alternative goods such as for Diesel of Heavy Fuel Oil (HFO), therefore the transport of LNG could be easily achieved by switching part of the existing truck fled to the requirements of LNG transportation.

For a similar assignment and the transport of LPG via trucks in Saudi Arabia the Consultant assumed the following OPEX for road transport by trucks:

- Personnel and administration costs at 0.52 US$ / vehicle-km. For verification purposes, this has been benchmarked against a high side salary for drivers of 10 US$ / hour and the cost levels are comparable.
- Fuel cost of 0.07 US$ / Liter and 0.5 Liter per travelled vehicle-km;
- Maintenance costs of 0.14 US$ / vehicle-km;
- Additional to the listed costs, which are based on LPG transportation, approximately 30% on top for the special treatment and to minimize the boil-off for the LNG are to be considered.

According to Cerasis, a US based provider for transportation management, the following categories represent a major portion of a carrier’s operating cost and a shipper’s direct transportation cost; the average cost per mile for the industry over the last year, according to industry experts is as follows:

- Less than truckload –1.11 US$ per km
- Specialized – 1.07 US$ per km
- Truckload – 0.94 US$ per km

In addition, experts figure that on average for carriers:

- Fuel costs represent 39% of a total carrier’s cost
- Driver wages represent 26% of costs
- Payments on leased/purchased trucks and trailers represent 11% of costs
- Maintenance repair represents 24% of costs

6 COST BENEFIT ANALYSIS

As mentioned initially the primary energy supplies in Lebanon rely on imported fossil fuels. In particular, most of the generated electricity in the power sector is produced in power plants using fuel oil and diesel. The commercial, industrial, institutional and residential sectors (Study target sectors) use mineral oil based products for space and water heating, private power generation as well as production processes. In addition, Liquefied Petroleum Gas (LPG) is used for cooking and heating. In addition to oil products, the cement factories in Lebanon use coal/pet coke. The share of other types of energy supplies is relatively low.

As part of the consultancy services for “The preparation of a CBA[53] for the use of Natural Gas (NG) and Low Carbon Fuels (LCFs) in the commercial, industrial, institutional and residential sectors[54] in Lebanon”, ILF jointly with ELARD have analysed the financial, environmental and employment related costs and benefits of replacing liquid and solid fossil fuels used in the Study target sectors by LCFs. During the analysis, it has been concluded that the potential of introducing Low Carbon Fuels other than natural gas is minor, and as a consequence, the further analysis has exclusively focused on natural gas.

The analysis was undertaken for a medium (2016-2030) as well as a long term (2016-2060) perspective, in order to study the impact of LNG introduction on the medium term as well the combined impact of introducing LNG till 2030 with the potential supply from discoveries of Lebanese natural gas starting with 2031. The period until 2030 is characterised by the need to import Liquified Natural Gas (LNG), while in the long term it is assumed that domestic offshore gas fields are developed and are considered to produce enough NG quantities to replace LNG imports. The analysis timeframe includes an initial period necessary for starting and completing investments in the NG related infrastructure during 2016-2018, the first LNG supplies being available in January 2019.

6.1 Characterization of Target Sectors and Fuel Demand

The key driver for potential future natural gas use in Lebanon is the power sector. Demand of fuels in the Study target sectors is significantly lower and the development of costly gas import and distribution infrastructure cannot be triggered by the Study target sector offtakers alone. The best solution for Lebanon (“Country Level”) should ideally maximize the benefits for both the Study target sectors and the key demand creating power sector and minimize the costs of the combined NG supplies for all end users.

The national electricity provider EDL operates the seven (7) thermal power plants (TPPs) in the country. All are currently fueled either by Heavy Fuel Oil (HFO) or by diesel oil. Two Combined

53 Cost Benefit Analysis
54 Study target sectors

Cycle Gas Turbine (CCGT) plants (Deir Amar I and Zahrani) as well as two (Open Cycle Gas Turbine) OCGT plants could, however, use natural gas as fuel if available. Other plants able to use NG are under construction or planned.

The Lebanese electricity sector is in a prolonged state of crisis with frequent power cuts. The key obstacles in the Lebanese power sector preventing sufficient electricity supply to end users are actually spread across the whole power system value chain and set up. As a consequence, substantial electricity is generated privately, primarily fueled by diesel.

Industries in Lebanon use fuel for direct production processes (ovens, heating boilers) as well as for private power generation at industrial plant premises. In particular, fuel oil, diesel, gas oil, LPG (in a very limited extent) and coal/pet coke are used.

Most of the industrial activities are located in Mount Lebanon, especially in the coastal part of the areas of Metn, Baabda and Alley near Beirut. Other industrial clusters are located in the coastal areas of Keserwan and Jbeil (also part of the Mount Lebanon governorate), in Sidon in the south and Tripoli in the north of Lebanon. Close to Tripoli are the two largest cement factories and a chemicals manufacturer (Lebanon Chemicals Company). In the inland areas the main industrial cluster is located in Zahle in the Bekaa Valley, accessible from Beirut via a narrow winding mountain road.

In the residential sector, diesel / gas / oil is consumed for space heating, and LPG for cooking purposes. Due to electricity shortages, the use of private power generators is common. For households, mainly community-based back-up generators are used when the public electricity provider is not able to meet the demand.

The commercial and institutional sector includes sales, commercial shops and commercial centers, hotels, restaurants, public institutions, offices, the educational and the healthcare sectors.

Potential NG demand in the Study target sectors and power sector of Lebanon

A previous study /7/ has been used as basis in order to estimate the potential demand of NG for the commercial sector. The study included a survey for estimating the diesel consumption for private power generation and heating (boilers) as well as for estimating the LPG consumption

The maximum NG demand would be achieved in case of 100% substitution of the existing fuels in the Study target sectors. In the Study target sectors[55] the demand of NG would increase from around 3,200 MMCM (113 BCF) in 2018 to ca. 3,800 to 4,600 MMCM (136 to 163 BCF) in 2030. Thereof, about 1,900 MMCM (70 BCF) in 2018 and 2,400 to 2,900 MMCM (85 to 103 BCF) in 2030 relate to coastal and lower altitude areas. By 2060, the maximum total demand reaches 5,400 to 9,000 MMCM (191 to 319 BCF), thereof 3,300 to 5,300 MMCM (116 to 190 BCF) in coastal areas. The estimates are based on historical consumption and growth rates by sector irre-

55 Including private power generation

spective of technological improvements and co-generation aspects that would increase energy efficiency.

The potential total NG demand in Lebanon has been estimated for a low growth and a high growth case, both derived from GDP and demographic forecasts. Today, about 47% of the potential NG demand of 2018 is concentrated in the area of Mount Lebanon; the share of this region is forecast to be growing to 52-53% by 2050.

Sector / Governorate	Low growth			High Growth		
	2018	2030	2060	2018	2030	2060
Industrial Sector	1.173	1.564	2.156	1.184	1.990	3.757
Commercial Sector	1.082	1.466	2.265	1.082	1.813	4.290
Residential Sector	935	813	977	935	814	979
Total	**3.190**	**3.842**	**5.395**	**3.201**	**4.617**	**9.207**
Beirut	185	214	309	185	249	517
Mount Lebanon	1.512	1.871	2.754	1.511	2.256	4.873
North and Akkar	812	979	1.212	813	1.207	1.761
Bekaa	352	421	623	353	499	1.092
South	220	240	337	220	273	532
Nabatieh	109	117	163	108	132	252

Table 24: Maximum NG demand by Study target sector and governorate (MMCM)

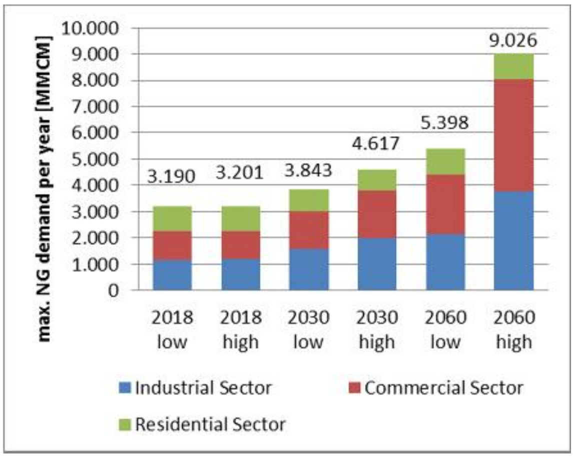


Figure 45: Max. NG demand by Study target sector

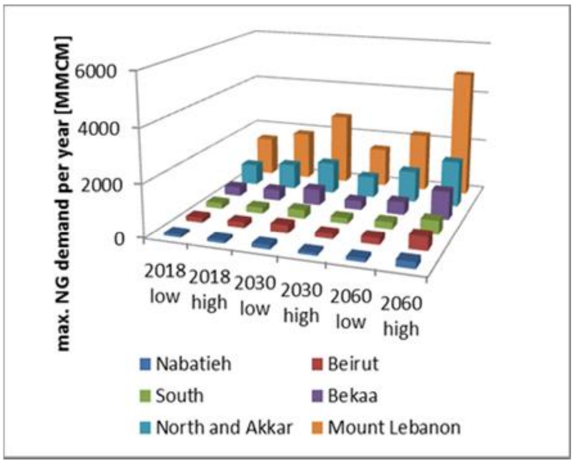


Figure 46: Max. NG demand by governorate

For the public power supply related NG demand, the existing, under construction and planned power plants suitable for the use of NG have been considered. About 990 MW of the existing power sector capacity (excluding the inland Baalbeck plant) can be fueled by NG. Further power plant capacity of 828 MW able to use NG is under construction. Assuming a 3rd CCGT plant to be built in Deir Amar and another 2 CCGT units to be built in Zahrani by 2027, in total 3,318 MW of plant capacity in Lebanon could eventually use NG for power generation. This leads to a potential demand for NG growing from 2,585 MMCM p.a. by 2019 (with Deir Amar II completed) to 4,594 MMCM by 2027. It is evident from Table 24, that the potential Study target sector NG demands are dwarfed by the potential power sector demand.

6.2 NG Demand Clusters for the Study Target Sectors

Demand clusters have been developed for the Study target sectors. These clusters have been analysed for the following criteria:

- Is potential NG demand high enough to justify costly gas transportation / distribution infrastructure?
- Are location of the cluster and conditions favourable for the construction of gas transportation / distribution infrastructure or do terrain conditions pose material obstacles (e.g. this precludes the Bekaa Valley from NG supply)?
- Do road infrastructure and traffic conditions (e.g. narrow winding mountain roads, congestion around Beirut) pose material obstacles for trucking of LNG?

Clusters, which were found not to create sufficient demand or clusters difficult or impossible to supply with LNG and/or NG were excluded from further considerations. Also there are severe limitations to establish gas transportation/distribution infrastructure in already built-up residential and commercial areas. From the analysis, it has been concluded, that only coastal areas of the clusters qualify for LNG and NG supplies.

6.3 NG Infrastructure Scenarios

Five LNG / NG supply scenarios (S1 to S5) have been developed during previous tasks of the overall Project and are documented in /3/. Table 25 provides an overview of the 5 scenarios and their key elements. The above described analysis of the clusters has then been used to further refine the scenarios before proceeding with the CBA.

Until 2030, the scenarios are primarily characterized by a different amount and location of LNG import and regasification units, e.g. one, two or three offshore Floating Storage and Regasification Units (FSRUs), and different NG transportation and distribution infrastructure configurations. Until the use of LNG is discontinued, further transport of regasified LNG can occur via pipelines, e.g. via the so-called Coastal pipeline (considered in scenarios S1 and S3) stretching from near Tripoli in the North across most of Lebanon to the South, or via direct smaller size and shorter distance pipelines from the individual FSRUs (scenarios S2, S4 and S5). Alternatively, LNG can also be trucked to power plants with no pipeline connection (scenarios S2, S4 and S5).

Core NG Infrastruc-ture Scenario	Description	Medium Term (LNG) (2019-2030)	Long term supply (NG field initial years, 2031-2040)	Long term supply (NG field maturity 2041- 2060 years)
Scenario 1	1 FSRU in the North **Combined with Coastal Pipeline**	4.900	22.663[56]	31.161
Scenario 2	1 FSRU in the North **without Coastal Pipeline**	4.900	22.663	31.161
Scenario 3	2 FSRUs - North and South **Combined with Coastal Pipeline** excluding the off-shore section around Beirut	9.800 (4.900 x 2 FSRUs)	11.333[57] (available) equally divided to 2 processing plants	36.827 (available) equally divided at 2 processing plants
Scenario 4	2 FSRUs - North and South **without Coastal Pipeline**	9.800 (4.900 x 2 FSRUs)	11.333 (available) equally divided to 2 processing plants	36.827 (available) equally divided to 2 processing plants
Scenario 5	3 FSRUs – North, South and around Beirut (Zouk) **without Coastal Pipeline**	14.700 (4.900 x 3 FSRUs)	11.333[58] (available) divided to 3 plants of max. 12.748 MMCM p.a. each	36.827 (available) divided to 3 plants of max 12.748 MMCM p.a. each

Table 25: NG Infrastructure and available NG supply (MMCM p.a.)

After 2030, it has been assumed that Lebanese NG supply will suffice to fully meet the forecast NG demand.

For Scenario 1, the FSRU located in the North of Lebanon becomes a supply constraint until 2030, preventing Lebanon from supplying the maximum demand of the power sector and selected clusters. In each of the other scenarios potential demand until 2030 as reached by the NG proposed infrastructure is fully met NG resource availability restrictions. However, from 2031 onward the power plants assumed to be supplied by LNG trucking under Scenarios 2, 4 and 5 will no longer be able to receive gas due to lack of pipeline connections and unavailability of LNG, the FSRUs being assumed discontinued as NG supplies become available.

Scenarios 1 and 3 involving the coastal pipeline or S5 with three FSRUs/ supply points are characterized by a much larger geographical outreach than S2 and S4. For the S2 and S4 scenarios, the strong industry and demand growth region of Beirut cannot receive NG as there will neither be the Coastal pipeline nor an FSRU nearby. If, however, the forecast industrial growth can be shift-

56 1.1 TCF p.a. (ramp up – 0.8 TCF p.a. in the first 10 years; 1.1 TCF in the next years; starts decreasing after 40 years).
57 1.3 TCF p.a. (ramp up – 0.4 TCF p.a. in the first 7 years; 1.3 TCF in the next years; starts decreasing after 40 years). Two process plants of 0.9 TCF/ year capacity per plant (1 in the North and 1 in the South of Lebanon).
58 1.3 TCF p.a. (ramp up – 0.4 TCF p.a. in the first 7 years; 1.3 TCF p.a. in the next years; starts decreasing after 40 years).). One process plant in the North (0.45 TCF), one process plant in the South (0.45 TCF), one process plant in an unidentified onshore location (0.45 TCF).

ed more to other Northern or more Southern areas of Lebanon, the disadvantage of S2 and S4 is likely to decrease.

Oil Price Dependency

Petroleum product import prices as well as LNG/NG prices are considered to be oil price indexed. Historical correlation factors have been applied. Two oil price development cases have been considered over the entire analysis period (2016 to 2060): 60 USD/Bbl and 120 USD/Bbl. The price cases have been combined with low and a high demand growth demand cases.

The CBA two stage simulation process

Initially, for each scenario, supply chain delivery costs of NG have been calculated for each cluster, Study target sector and the power plants. This has been done for the medium term set up until 2030 and the long term until 2060, under consideration of the switch from LNG to domestic NG.

Cost estimates for the infrastructure investments have been based on the assumption that the infrastructure capacities shall be sufficient to meet all potential demand (100% replacement of liquid and solid fossil fuels) for a high and a low demand case. For comparison, also supply chain costs have been determined for the currently used coal and oil based products.

Also externalities have been monetarized, e.g. environmental impacts have been considered and priced using an internationally acknowledged methodology. The employment effects resulting from substitution of the currently used fuels have been analysed and quantified; however, they were found to be of minor relevance for the overall assessment.

As an outcome of the initial analysis (during the first CBA model simulation) it has been concluded that due to a significant financial cost advantage but also due to production process related reasons, coal / pet coke is not likely to be replaced by NG.

6.4 Results of the second CBA model simulation

As a consequence of the outcome of CBA model simulation I, replacements of liquid fuels only have been considered further in a second CBA model simulation. The resulting potential coastal NG demand per cluster is summarized in Table 26 for the low growth case. Private power generation is assumed to continue in the Study target sectors and even grow further with 100% substitution of the diesel / HFO fueled generators by NG fired generators. The share of private power generation is about 70 to 80% of the total NG demand.

Sector / Cluster	2030					2060				
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Industrial Sector	536	322	579	332	579	862	448	862	466	862
Residential Sector	2	2	4	3	4	16	8	16	12	16
Commercial Sector	9	9	30	13	30	30	9	30	13	30
Total	**547**	**333**	**613**	**348**	**613**	**908**	**465**	**908**	**490**	**908**
Tripoli	31	31	31	31	31	56	56	56	56	56
Chekka	143	146	146	146	146	161	161	161	161	161
Selaata	39	40	40	40	40	64	64	64	64	64
Jbeil-Keserwan	113	115	115	115	115	184	184	184	184	184
Beirut	214	-	265	-	265	417	-	417	-	417

Table 26: Supplied NG demand by cluster and Study target sectors, low growth, S1 to S5 in 2030 and 2060 (MMCM p.a.)

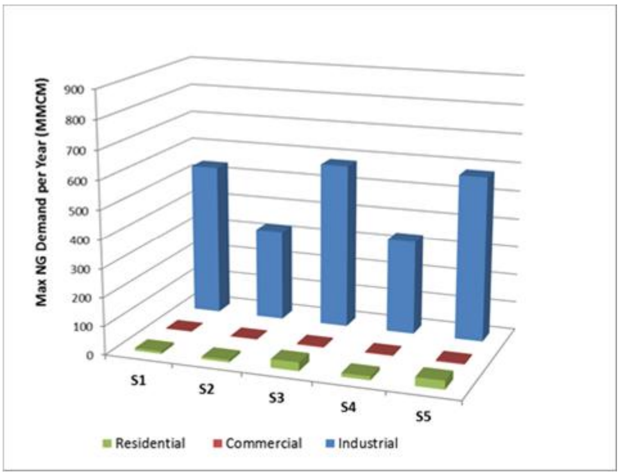


Figure 47: NG demand by Study target sectors 2030

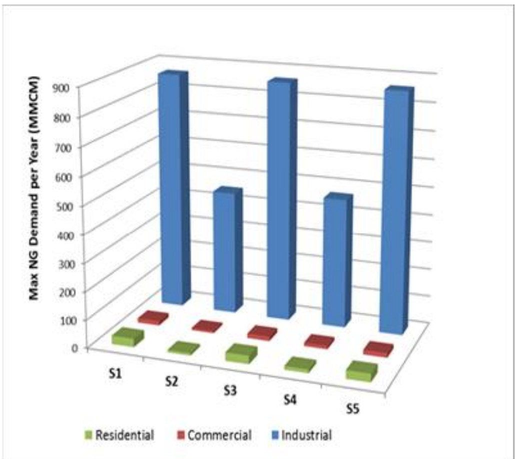
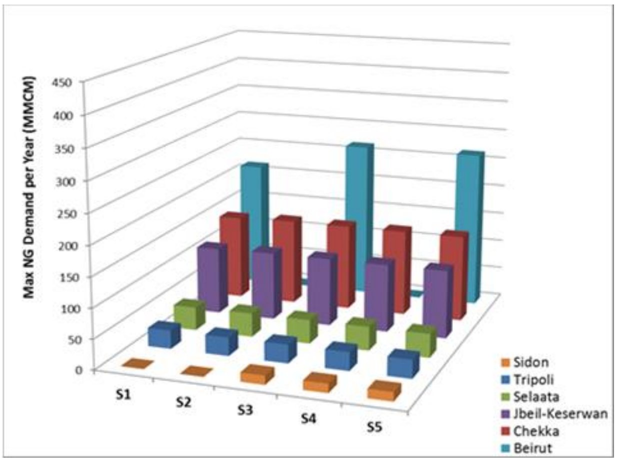


Figure 48: NG demand by Study target sectors 2060



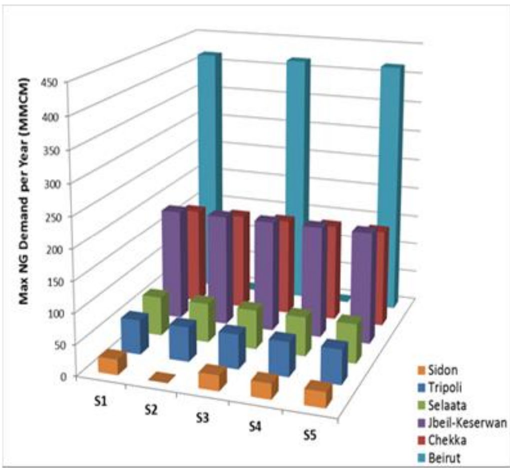


Figure 49: NG demand by cluster, low growth, in 2030

Figure 50: NG demand by cluster, low growth, in 2060

For the power sector, the plants listed in Table 27 are supplied with NG in the medium (2030) and long term (2060) under the given scenarios.

Plant	S1	S2	S3	S4	S5
Deir Amar	1,958 Direct supply	1,958 Direct supply	1,958 Direct supply	1,958 Direct supply	1,958 Direct supply
Zouk	253 Coastal pipeline	253 LNG truck Discontinued in 2031	253 Coastal pipeline	253 LNG truck Discontinued in 2031	253 Direct supply
Zahrani	1,906 Direct supply	1,906 Direct supply	1,906 Direct supply	1,906 Direct supply	1,906 Direct supply
Jieh	123 Coastal pipeline	Not supplied	123 Coastal pipeline	123 LNG truck Discontinued in 2031	123 LNG truck Discontinued in 2031
Tyre	114 Coastal pipeline	Not supplied	114 Coastal pipeline	114 LNG truck Discontinued in 2031	114 LNG truck Discontinued in 2031

Table 27: Supplied NG Demand by power plant S1 to S5 (MMCM p.a.)

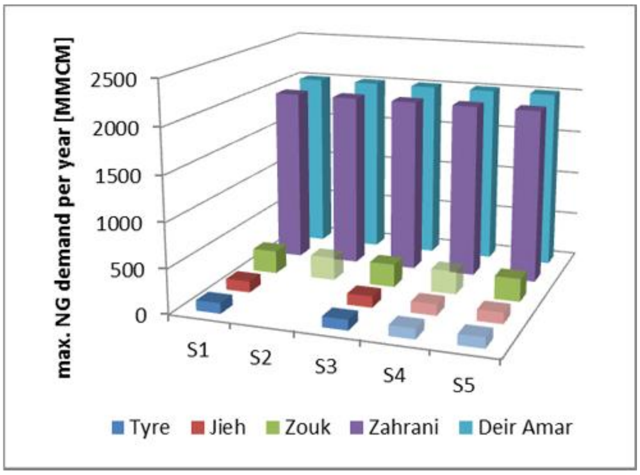


Figure 51: Supplied NG Demand by power plant S1 to S5 (MMCM p.a.)

A summary of the financial and economic impact expressed as net present value[59] (NPV) by Study target sector is compiled in the next tables. The best solution for each category in terms of financial and environmental NPV is highlighted in green and the least favourable in red.

In the medium term scenarios S1 and S3 seem preferable due to their higher geographical out-reach, followed by S5. S1 has the disadvantage that one FSRU limits the volumes to be delivered till 2030, with Beirut for example receiving only 87% of the 2030 required volumes in S1 at low demand growth and 40% of volumes in case of high growth. S2 offers the lowest opportunities

59 Discount rate 12%

due to limited geographical reach, being especially disadvantageous at high oil prices. At high demand and high oil prices, S3 becomes significantly better than S1 due to the supply restrictions till 2030 for S1, S5 being the second best in this case.

Medium Term (2016-2030)	Unit	S1	S2	S3	S4	S5
Low oil price, Low demand growth						
TOTAL Study target sectors – Financial NPV	Million USD	168	36	73	46	34
TOTAL Study target sectors – Environmental NPV	Million USD	274	158	289	165	289
TOTAL Study target sectors – Total NPV	**Million USD**	442	194	363	211	323
High oil price, Low demand growth						
TOTAL Study target sectors – Financial NPV	Million USD	449	156	380	178	343
TOTAL Study target sectors – Environmental NPV	Million USD	274	158	289	239	289
TOTALStudy target sectors – Total NPV	**Million USD**	723	314	669	416	632
Low oil price, High demand growth						
TOTAL Study target sectors – Financial NPV	Million USD	118	47	94	58	57
TOTAL Study target sectors – Environmental NPV	Million USD	244	176	317	183	317
TOTAL Study target sectors – Total NPV	**Million USD**	361	223	411	241	374
High oil price, High demand growth						
TOTAL Study target sectors – Financial NPV	Million USD	340	177	426	200	391
TOTAL Study target sectors – Environmental NPV	Million USD	244	176	317	183	317
TOTAL Study target sectors – Total NPV	**Million USD**	584	353	743	383	708

Table 28: Summary of financial and environmental impact for the Study target sectors, 2016-2030

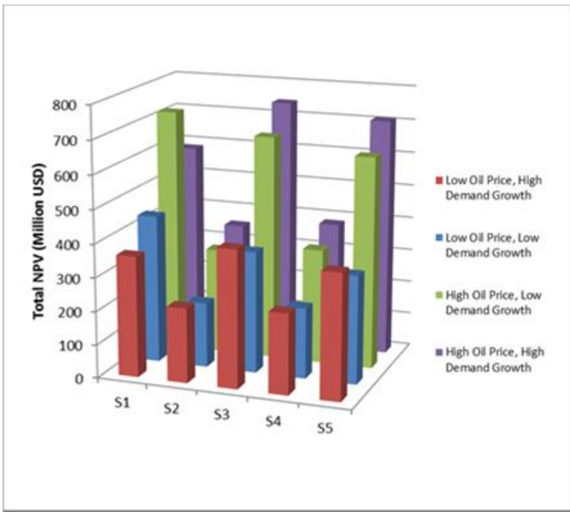


Figure 52: Total NPV of target sectors, 2016-2030

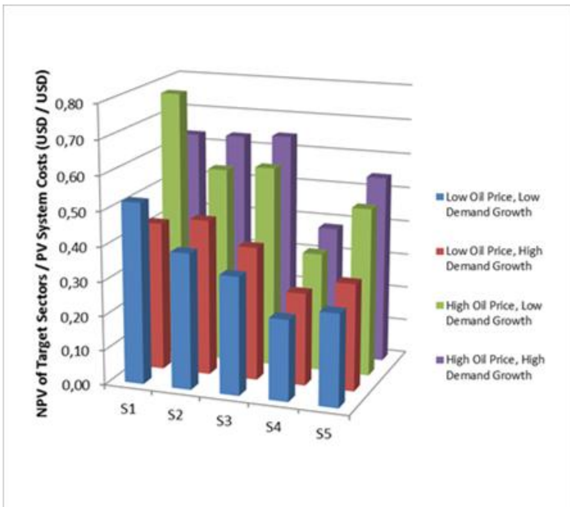


Figure 53: NPV of target sectors divided by the total system costs, 2016-2030

In the long term, the limiting factor of NG supply in S1 becomes less relevant. The results for S3 and S5 are quite similar in range.

Long Term (2016-2060)	Unit	S1	S2	S3	S4	S5
Low oil price, Low demand growth						
TOTAL Study target sectors – Financial NPV	Million USD	435	155	313	176	304
TOTAL Study target sectors – Environmental NPV	Million USD	405	229	421	239	421
TOTALStudy target sectors – Total NPV	**Million USD**	840	383	735	416	725
High oil price, Low demand growth						
TOTAL Study target sectors – Financial NPV	Million USD	868	336	771	376	766
TOTAL Study target sectors – Environmental NPV	Million USD	405	229	421	239	421
TOTALStudy target sectors – Total NPV	**Million USD**	1.273	564	1.192	416	1.187
Low oil price, High demand growth						
TOTAL Study target sectors – Financial NPV	Million USD	521	233	473	259	476
TOTAL Study target sectors – Environmental NPV	Million USD	438	277	512	289	512
TOTAL Study target sectors – Total NPV	**Million USD**	960	510	985	548	988
High oil price, High demand growth						
TOTAL Study target sectors – Financial NPV	Million USD	972	455	1.031	502	1.039
TOTAL Study target sectors – Environmental NPV	Million USD	438	277	512	289	512
TOTAL Study target sectors – Total NPV	**Million USD**	1.411	732	1.544	791	1.551

Table 29: Summary of financial and environmental impact for the Study target sectors, 2016-2060

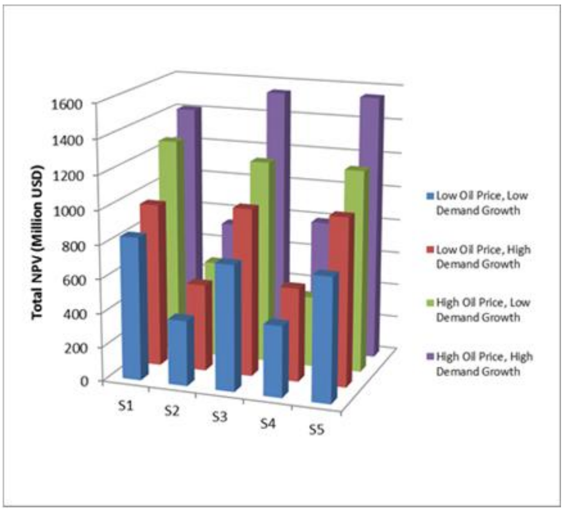


Figure 54: Total NPV of target sectors, 2016-2060

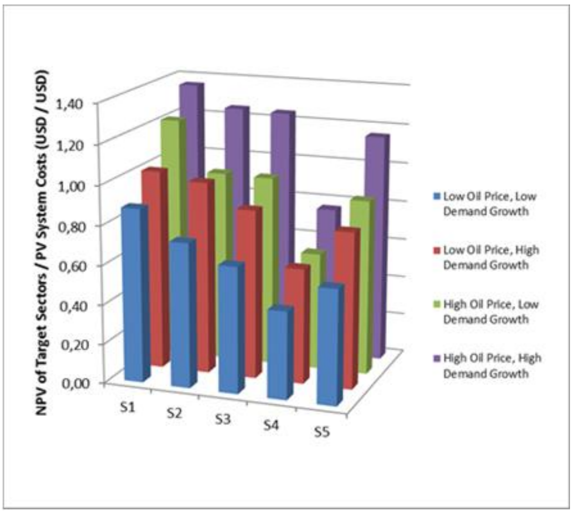


Figure 55: NPV of target sectors divided by the total system costs, 2016-2060

A summary of the financial and economic impact for Lebanon at country level, including the power and the Study target sectors, for medium and long term are included in the next tables. The range of results in case of low growth / high growth and low / high oil prices may be observed. Employment related impact is also added, but is – as said previously - of low relevance.

Considering therefore also the impact estimated for the power sector, the best solution on the medium term is S1 and even S3 in case of high prices and high demand. In case of a high growth demand and high oil price case, S3 becomes better from the economic point of view, with S1 and S5 as followers. The less favourable scenario is by far S2.

Medium Term (2016-2030)	Unit	S1	S2	S3	S4	S5
Low oil price, Low demand growth						
COUNTRY LEVEL – Financial NPV	Million USD	2.468	1.216	2.281	2.275	2.139
COUNTRY LEVEL – Environmental NPV	Million USD	1.023	625	1.038	915	1.038
COUNTRY LEVEL – Employment NPV	Million USD	35	16	47	33	40
COUNTRY LEVEL – Total NPV	**Million USD**	3.526	1.857	3.366	3.222	3.218
High oil price, Low demand growth						
COUNTRY LEVEL – Financial NPV	Million USD	5.146	2.507	4.986	4.789	4.840
COUNTRY LEVEL – Environmental NPV	Million USD	1.023	625	1.038	1.295	1.038
COUNTRY LEVEL – Employment NPV	Million USD	34	16	47	33	40
COUNTRY LEVEL – Total NPV	**Million USD**	6.203	3.148	6.071	5.763	5.919
Low oil price, High demand growth						
COUNTRY LEVEL – Financial NPV	Million USD	2.405	1.231	2.313	2.293	2.171
COUNTRY LEVEL – Environmental NPV	Million USD	993	642	1.066	932	1.066
COUNTRY LEVEL – Employment NPV	Million USD	35	16	47	33	40
COUNTRY LEVEL – Total NPV	**Million USD**	3.432	1.889	3.426	3.258	3.278
High oil price, High demand growth						
COUNTRY LEVEL – Financial NPV	Million USD	5.024	2.532	5.043	4.819	4.897
COUNTRY LEVEL – Environmental NPV	Million USD	993	642	1.066	932	1.066
COUNTRY LEVEL – Employment NPV	Million USD	34	16	46	33	40
COUNTRY LEVEL – Total NPV	**Million USD**	6.051	3.190	6.156	5.784	6.004

Table 30: Summary of financial, employment and environmental impact for Country Level, 2016-2030

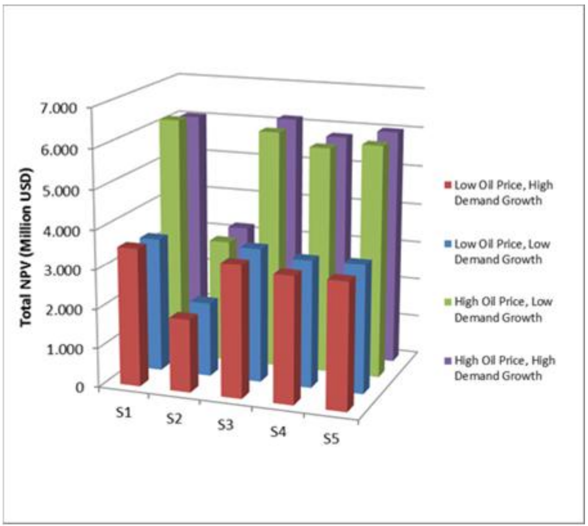


Figure 56: Total NPV, Country level, 2016-2030

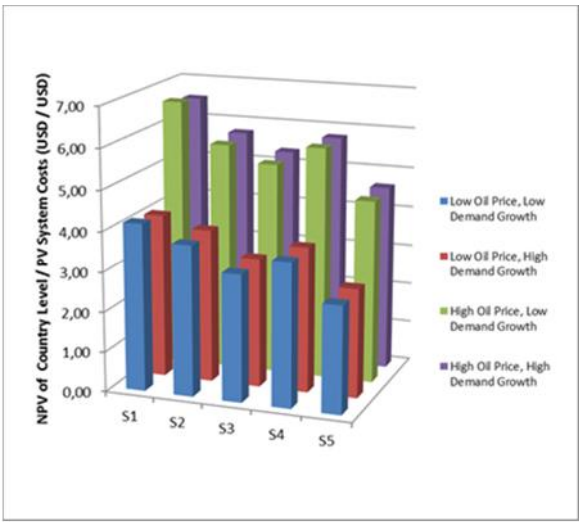


Figure 58: Total NPV divided by Total system costs, Country level, 2016-2030

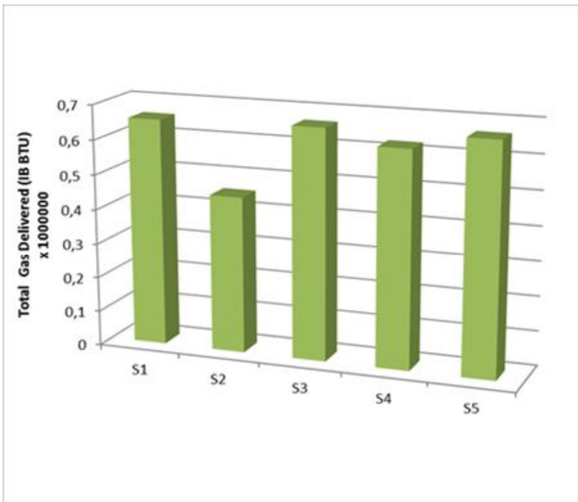


Figure 57: Total delivered gas, Country level, 2016-2030, exemplary for the high oil, low demand case

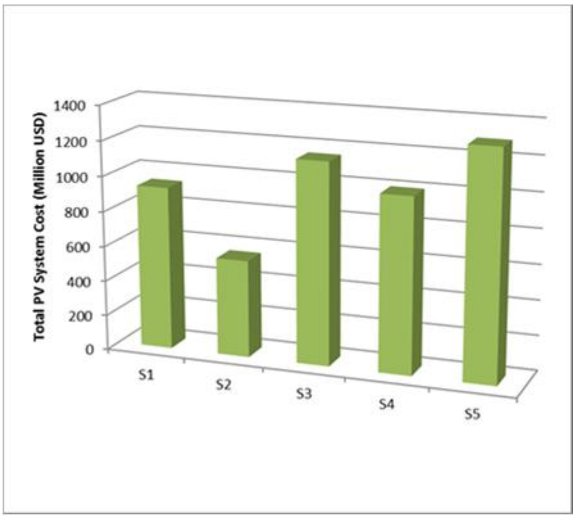


Figure 59: Total system costs, Country level, 2016-2030, exemplary for the high oil, low demand case

For the long term perspective and the entire analysis period, S1 is the best scenario, followed by S3.

Long Term (2016-2060)	Unit	S1	S2	S3	S4	S5
Low oil price, Low demand growth						
COUNTRY LEVEL – Financial NPV	Million USD	4.858	2.235	4.695	4.435	4.502
COUNTRY LEVEL – Environmental NPV	Million USD	1.501	851	1.516	1.295	1.497
COUNTRY LEVEL – Employment NPV	Million USD	42	16	54	32	40
COUNTRY LEVEL – Total NPV	**Million USD**	6.400	3.101	6.266	5.763	6.039
High oil price, Low demand growth						
COUNTRY LEVEL – Financial NPV	Million USD	8.981	4.089	8.846	8.260	8.604
COUNTRY LEVEL – Environmental NPV	Million USD	1.501	851	1.516	1.295	1.497
COUNTRY LEVEL – Employment NPV	Million USD	41	16	54	33	40
COUNTRY LEVEL – Total NPV	**Million USD**	10.523	4.955	10.416	9.588	10.141
Low oil price, High demand growth						
COUNTRY LEVEL – Financial NPV	Million USD	4.942	2.317	4.876	4.524	4.683
COUNTRY LEVEL – Environmental NPV	Million USD	1.534	899	1.608	1.346	1.589
COUNTRY LEVEL – Employment NPV	Million USD	42	15	54	32	39
COUNTRY LEVEL – Total NPV	**Million USD**	6.517	3.231	6.538	5.902	6.311
High oil price, High demand growth						
COUNTRY LEVEL – Financial NPV	Million USD	8.972	4.311	8.903	8.368	8.705
COUNTRY LEVEL – Environmental NPV	Million USD	1.351	832	1.488	1.233	1.401
COUNTRY LEVEL – Employment NPV	Million USD	37	16	54	34	41
COUNTRY LEVEL – Total NPV	**Million USD**	10.361	5.160	10.445	9.635	10.146

Table 31: Summary of financial, employment and environmental impact for Country Level, 2016-2060

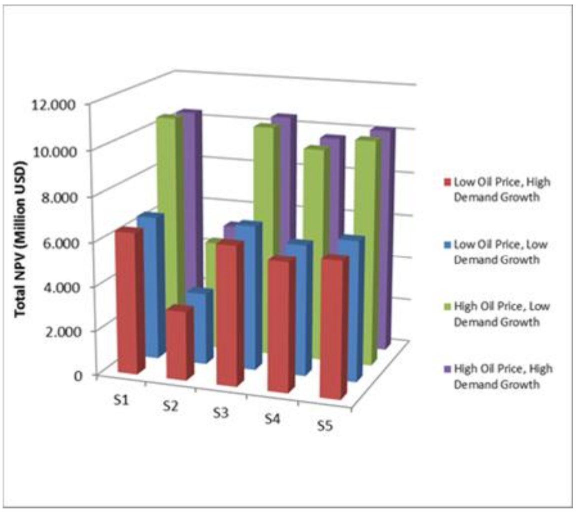


Figure 60: Total NPV, Country level, 2016-2060

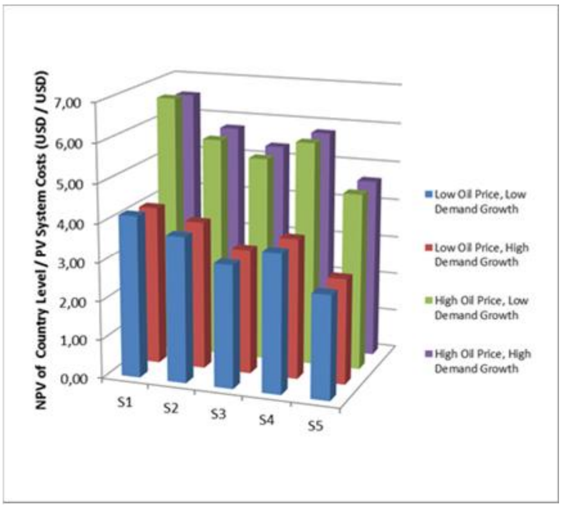


Figure 61: Total NPV divided by Total system costs, Country level, 2016-2060

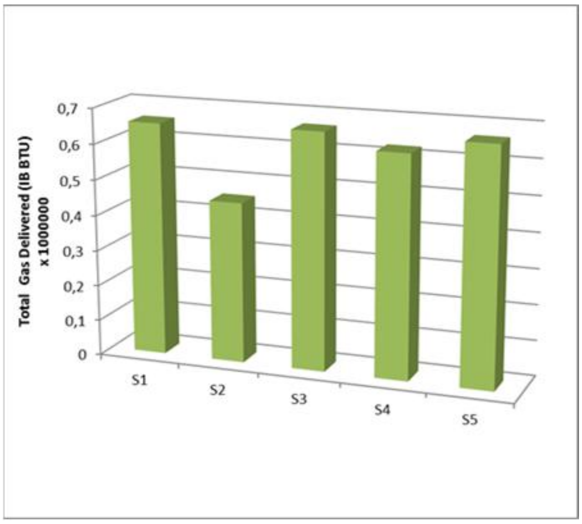


Figure 62: Total delivered gas, Country level, 2016-2060, exemplary for the high oil, low demand case

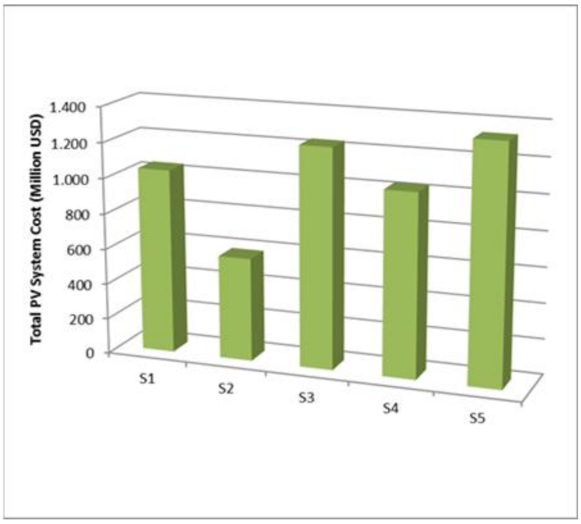


Figure 63: Total system costs, Country level, 2016-2060, exemplary for the high oil, low demand case

Conclusions

The results are quite different for each of the NG demand development cases (low, high) and very much influenced by the oil price assumptions. Scenarios with a lower geographical outreach, with less clusters and power plants that can be delivered with NG become even less advantageous at increasing oil prices, because less benefits are grasped by substituting lower quantities from the currently used fuels.

In principle, it does appear that all scenarios are beneficial. Taking no action in terms of providing supply of NG to Lebanon would therefore not be a good option. However, for the Study target sectors the results needs to be treated with care because private power generation is assumed to continue and increase, which may not hold true. Also the assumption has been that 100% of oil based generators in the selected clusters[60] will eventually be replaced by NG generators. This significantly contributes to a high NG demand. Without such private power and conversion to NG, NG supply to several clusters would become less economic or could even move below the economic viability threshold.

HFO in several cases remains cheaper than NG, which would prevent the switch to NG; however, such price disadvantage may be counter-balanced by a suitable pricing / taxation / subsidy policy.

The positive environmental effects related to the substitution of oil based products by NG are considerable, leading to a positive economic impact for the country even when excluding the assumed private power generation – with the exception of S5 in case of low oil prices and low demand growth.

A considerable impact on what scenario to realize will be from the following factors:

- Industrial growth of the Beirut cluster relative to others;
- Difficulties to build the Coastal pipeline;
- Implementation of NG power plants and their construction schedules; and
- The ability to develop the Lebanese offshore gas fields and to connect them to the shore.

A gradual approach to establishing NG supplies for the country is probably prudent. This could start with setting up an FSRU in the North near Tripoli and supplies to the Northern region. In case the Coastal pipeline cannot be built or only part of it, scenarios S2 / S4 / S5 should be considered. Boosting development in the regions away from Beirut may be desirable and such development support could well be provided by the LNG / NG supplies, which become available in the North, or perhaps also in the South, where another FSRU could be deployed.

The CBA model can be used as a tool to run additional and/or more detailed analyses i.e. a third simulation round considering lower NG demands due to a lower switching potential. The model also enables sensitivity analysis by changing various parameters.

60 Coastal located part of the industrial demand of the selected clusters and new residential and commercial projects nearby

7 PILOT STUDY, TERMS OF REFERENCE

7.1 INTRODUCTION

The Government of Lebanon intents to introduce the use of natural gas as the main source of fuel for the country´s power production for the next 5 – 10 years in order that i) power shortages are addressed, ii) pollution from HFO / diesel is reduced, iii) security and diversity of fuel supply sources are secured. In addition to the fuelling of the power sector with gas the GoL intends to extend it´s objectives to the residential, commercial and institutional and industry sectors.

The Consultant shall identify the three most energy intensive industry types within the Chekka, Batroun industrial cluster analyse the production processes and prepare a report describing effort, costs and constraints and benefit of a fuel switch from the current type of energy to natural gas.

7.2 OBJECTIVE OF THE STUDY

The goal of this work is to develop a cost benefit analysis for different types of industry. The study shall provide the different companies an overview on advantages and disadvantages of switching their current type of energy supply to natural gas.

The document shall identify and describe details of a fuel switch considering the production processes of each of the selected industries for the industry, but also on environment, traffic and employment. In line with the before mentioned analysis the potential for energy efficiency measures shall be identified and addressed.

The work involves developing a cost-effective fueling option for the type of industry usinf natural gas, design and performance criteria to address environmental impact mitigative requirements and provide cost-effective production processes.

7.3 SCOPE OF THE STUDY

Task 1: Analysis of the industrial cluster of Chekka, Batroun

The Consultant shall review and analyse the energy consumption of the existing industries within the industrial cluster of Chekka, Batroun. As part of the analysis the preparation of an overview over type, location and energy consumption of the different industries shall be provided. Based on this analysis the three (3) main enrgy consuming types of industries shall be identified and recommended for further investigation.

Task 2: Analysis of typical production processes for the selected types of industries

The Consultant shall prepare a desktop study analysing typical production processes for the selected target industries considering natural gas as energy supply source. The analysis shall describe typical production processes in Lebanon but also international best practice.

Task 3: Analysis of the production process of the target industries

The Consultant shall compare the use of energy within the target companies´ production processes with similar companies in Lebanon and international best practice. Based on natural gas as energy source required adoptions on the process shall be described. Beside the technical aspects of a fuel switch to natural gas the economic aspects e.g. CAPEX estimate, cost savings resulting of reduced fuel cost and potential variations on productivity shall be described. For the development of this analysis the discussion with lead target companies staff is assumed being mandatory.

Task 4: Analysis of the energy efficiency of the target industries

The Consultant shall prepare an energy efficiency analysis for the target industries. For the development of this analysis the discussion with lead target companies staff is assumed being mandatory. The Consultant is expected to visualize energy flows within the production process by preparation of a Sankey Diagram[61]. Potential energy efficiency targets shall be developed using a "Pinch Analysis"[62]. CAPEX and potential cost savings when realizing the energy efficiency measures shall be analysed.

Task 5: Preparation of a Cost benefit Analysis for the target industries

The results of Task 3 and Task 4 shall be summarized in three (3) separate CBA reports for the target industries.

Task 6: Preparation of an analysis on Health, Safety and Environment for the industrial cluster of Chekka, Batroun

The Consultant shall prepare a high level Environmental, Health and Safety analysis for the industrial cluster of Chekky, Batroun. The analysis shall include the effects of a fuel switch to natural gas on local pollution (air and noise), traffic, impact of single industries on productivity of the industrial cluster.

61 Sankey diagram is a graphical type of flow diagram in which the width of the arrows is shown proportionally to the flow quantity. Sankey diagrams are typically used to visualize energy flows.

62 Pinch analysis is a methodology for minimising energy consumption of industrial processes by calculating thermodynamically feasible energy targets (or minimum energy consumption) and achieving them by optimising heat recovery systems, energy supply methods and process operating conditions. It is also known as heat integration, process integration, energy integration or pinch technology.

8 STAKEHOLDERS CONSULTATION WORKSHOP

The consultation workshop took place on the 19th of July 2016 at the Ministry of Energy and Water (MoEW) from 10:00 am to 12:30 PM. The number of participants reached 31 persons with a good representation of the different stakeholders including members of MoEW, LPA, Ministry of Environment (MoE), Electricité du Liban (EDL), Ministry of Finance (MoF), Directorate General of Petroleum, Lebanese Oil Installations, Association of Lebanese Industrialists (ALI), Association of Petroleum Importing Companies (APIC), Higher Council for Privatization (HCP), Railway Authority, Lebanese Green Building Council (LGBC), and UNDP. The list of attendees is provided in Appendix 1.

The consultation workshop was structured in three sessions that consisted of:

- Session 1: Welcome Note by UNDP, MoEW and LPA
- Session 2: Part 1 – Work Methodology and Estimates of Natural Gas demand in the electricity, industrial, residential, commercial and institutional sectors in Lebanon. This part was presented by the Consultant ELARD. Comments and questions were received and discussed throughout the session.
- Session 3: Part 2 – Results of the CBA evaluation and discussion of current policy situation and way forward recommendations for the target sectors. This session was presented by the Consultant ILF. Comments and questions were received and discussed throughout the session.

9 POLICY CONSIDERATIONS

The Republic of Lebanon's fuel supply sources are overwhelmingly concentrated in liquid hydrocarbon products both for the generation of power by the country's power utility (EdL) as well by individuals within the SODEL Target Study Sectors. The Government of Lebanon is seeking to shift the country's fuel supply source away from liquid hydrocarbon products and towards the use of natural gas as the main source of fuel within next 5-10 years such that. In so doing, the Government of Lebanon hopes to achieve the following objectives:

- To address the country's chronic power shortages;
- To eliminate pollution from HFO / diesel; and
- To diversify and secure the country's fuel supplies.

In order to enable supplies of natural gas to be used within the Lebanese markets, and for the Government of Lebanon to thereby achieve its objectives, a number of important financial commitments will need to be made including the following:

- Commitments to procure relatively large quantities of LNG under long-term gas sales and purchase agreements;
- Commitments to (lease / purchase) one or more FSRUs to process the LNG into NG;
- Commitment to develop, finance, construct, commission and operate terrestrial gas transportation infrastructure; and
- Commitments from larger-scale creditable off-takers prepared to pay for the NG and all costs associated with the foregoing (including an appropriate return.

At present, there are simply no larger-scale creditable off-takers within the Study Target Sectors that would be in a position to underpin the commitments required. The only off-takers capable of undertaking the foregoing commitments are the Government of Lebanon in combination with the future IPP owners and operators of the power plants. Indeed, the scale of projected NG utilization by the public power sector outweighs the Study Target Sector by a ratio of approximately 8.8:1.

Given the fact that the Government of Lebanon currently lacks the funds to self-finance the aforementioned commitments, Lebanon will require third party funding and finance. We therefore believe that the key to achieving the overarching fuel supply objectives, a strategy which focuses upon anchoring the initial gas procurement and associated infrastructure to the public power sector should be prioritized. Once concrete steps have been taken to ensure that funding is in place to flow NG to the power sector, efforts to extend utilization of NG within the Study Target Sectors may then be pursued as a secondary priority. Accordingly, this Policy Paper provides an estimate on Capex requirements for the gas infrastructure, the likely funding and financing requirements to implement the Gas-to-Power value chain and the policy measures that should be put into place as a matter of priority in order to attract investors, allocate and manage associated risks and otherwise facilitate the delivery of the aforementioned infrastructure. As agreed with the client, a draft scope of work is also provided to guide the Government of Lebanon in tendering for additional analysis and work that will be required in order to fully implement and deliver the MoEW's objectives for the Lebanese energy sector.

9.1 Funding and financing the gas-to-power value chain

According to the June 2010 MoEW Policy Paper for the Electricity Sector, total estimated funding required to implement the various infrastructure components of the proposed gas to power value chain identified therein was estimated at between US $5,770 Bln and $6,005 Bln. Of this amount, US $4,513 to $4,739 Bln was allocated for power generation; US$791M to $801M for transmission and US $466M for distribution. Of the total amount, approximately 20% was assumed to be funded by the Government of Lebanon and the balance was assumed to be financed via private sector equity and via international debt financing. This section offers high-level guidance on key financing considerations for MoEW to take into account in seeking to finance the gas infrastructure options that have been evaluated within the 2016-2030 timeframe as set out above. The core recommendation here is that the power plants are the anchor off-takers that will support the implementation of the gas infrastructure needed to bring gas to Lebanon and therefore constitute the GoL's strategic priority. Once investment has been secured in the gas-to-power value chain, converting off-takers within the Study Target Sectors will be enabled; however, achieving this latter goal should be considered a secondary priority.

The Gas-to-Power Versus the Gas-to-End-User Value Chain

In offering this guidance, it is important to note that any investor and / or lender will require line of sight to the flow of funds across the entire gas to power and gas to end-user value chains. It is also important to note that until the Lebanese market for gas can be established, the gas to power value chain (where gas is procured as a feedstock for power generation) will operate on the basis of a commercial model that is fundamentally distinct from the gas to end-user (gas as direct off-take by consumer) value chain for the following reasons:

- Establishing a gas to power value chain fundamentally requires the large-scale procurement and subsequent re-delivery of gas to a fixed, small number of larger-scale, creditable off-takers who use the gas as feedstock to generate power. With the exception of large-scale industrial off-takers in Lebanon (such as the cement factories), the creditability of the single off-takers can more easily be established and long-term arrangements put into place to enable stable and predictable cash flows to be modeled over a number of years. In the case of a debt financing, this is essential to ensure that *inter alia* appropriate debt service coverage ratios may be maintained for the life of the loans;
- The existing LPG market and the establishment of a market for off-take from a City Gas Distribution Network will operate on a fundamentally different commercial model. Here, the number of individual small-scale (consumer) off-takers is much larger than the gas to

power value chain. While the cash flows generated across this value chain can certainly be modeled, it is not common for investors in and / or lenders to green field gas transportation infrastructure to secure the respective investments with contracts entered into with numerous small-scale consumer off-takers.

Accordingly, it will be important for the MoEW to prioritize how it intends to achieve its core objectives by developing a private sector investment and debt financing strategy. Such a strategy will require that the MoEW take into account its answers to *inter alia* the following questions:

- Does the MoEW plan to privatize the existing components of the gas to power value chain (e.g. the power plants)?
- If so, will the privatization occur only in respect of one or more of the CCGT power plants or will all of the plants be privatized? Will the private sector be asked to complete the process of retrofitting the existing HFO plants to fire on gas? Will the power plants be privatized before or after the gas import infrastructure is put into place? In what sequence will the MoEW privatize the power plants?
- If not, will private sector participation be concentrated on investment in /debt financing of a green fields Coastal Pipeline and related downstream infrastructure with the Government of Lebanon procuring LNG through long-term agreements and process the LNG through a facility it either owns and / or leases?
- Who will own and operate the FSRU? Does it make sense for the Government of Lebanon to assume this cost and risk or is it more sensible to bundle this into the ownership and operation of the Coastal Pipeline?
- When does the MoEW plan to institute key market reforms to enable the proper regulation of the markets for gas and power off-take across the various target sectors?
- Will the development of the Coastal Pipeline and related gas transportation infrastructure be tendered by concession? Will the gas off-take infrastructure (e.g. the City Gas Networks) be tendered by concession in conjunction with the foregoing larger magnitude gas to power infrastructure or will it be tendered separately? Will such tenders take place before or after the appropriate market reforms are undertaken?
- What infrastructure components comprising the gas to power value chain will the Government of Lebanon be prepared to fund itself? Will the Government seek to participate up to a certain percentage in most components or not at all? If not at all, which components will be left to the private sector?

In answering these questions, the MoEW will need to take account of the fact that developing a strategy to mobilize private sector investment and debt financing into the various infrastructure components will require a holistic approach (in essence a gas sector Master Plan).

9.2 Some Initial Observations on Investment and Debt Financing of the Infrastructure Scenarios

As an asset class, infrastructure (even within developed markets) is generally considered a higher risk investment (pre-completion) as it involves long-lead times and large capital expenditures. This entails that investors commit large magnitude sunk costs up-front during the build-out period (often several years) before the infrastructure is operational, generating cash and repaying investment. Within emerging markets, green field infrastructure investment is considered particularly ‘risky’ due to *inter alia* higher levels of actual and/or perceived security, political, legal and regulatory risk factors that are by definition not present in developed markets.

As referenced in the Preliminary Risk Identification and Risk Allocation Analysis, developing a commercial and bankable FSRU / gas supply scenario for Lebanon without anchoring tariff payments (and / or payments for gas off-take) to large-scale and creditable shippers and / or gas off-takers, is not considered realistic for investment or debt financing of the respective infrastructure components. Accordingly, aside from the cement factories (in particular), the role of the target sectors is largely irrelevant to an evaluation of investment or debt financing for the gas infrastructure at this juncture. Once again, this is due to the fact that any potential off-takers within these sectors are individually too small to function as shippers (customers) for the gas infrastructure.

While, the cement factories may represent sufficiently large-scale off-take (the cement industry in Lebanon takes in excess of 25% of the total fuel required by the Lebanese public power sector), evaluating the creditability of the cement factories is outside the scope of this exercise and, in any event, will unnecessarily complicate commercial and financing considerations for purposes of this analysis.

Accordingly, the Preliminary Risk Identification and Risk Allocation Matrix assumes there is a single (state-owned) purchaser and shipper of gas (the Lebanese gas Supply Company) through the FSRU and gas transportation infrastructure (the Lebanese gas Transportation Company). It is our understanding that the Government of Lebanon has contemplated also leasing one or more FSRU units. This would not change the fundamental allocation of risk other than to shift responsibility for delivering the dry gas to the owner/operator of the pipeline onto the shoulders of the Government.

The combination of currently prevailing high levels of political, legal and regulatory risk in Lebanon (for example Moodys, Fitch and S&P all rate Lebanon’s credit risk as ‘Highly Speculative’), and the absence of a liquid and efficiently functioning power market, may have a deterring impact on private and international institutional investment. Specifically, the certainty with which fees generated from the distribution of electricity (and gas) to end-users in the target markets in amounts sufficient to cover all costs associated with generating and delivering the power to the target sectors will be questioned by prospective investors and lenders. These costs will include *inter alia* all financing, Capex, Opex and administration costs associated with each of the grid, the power generation facilities, the fuel import (FSRU) and transportation facilities and the procurement of the fuel itself.

As referenced above, the gas to power and the gas to end-user value chains are underpinned by distinct commercial models. Attempting to 'bolt' the City Gas Distribution Network, LNG Trucking or LPG, onto the gas transportation infrastructure unnecessarily complicates the task of attracting investment and /or international debt financing into the main gas to power generation infrastructure.

Finally, it is also important to note that the prevailing LNG market circumstances strongly favor buyers at this time. Currently, approximately 150 billion cubic metres per year (bcma) of LNG has been added to global supplies since 2014 (largely from Australia) and an additional 75 bcma is awaiting a final investment decision between 2018-20 (a large amount of this is from the US). The supply situation has also exacerbated the landed price for LNG prevailing globally. The drop in estimated world landed LNG prices between May 2013 and January 2016 as summarized in the table below (calculated in $/MMBtu) has been precipitous:

Country	May 2013	May 2016
India	$14.40	$4.50
Korea	$14.95	$4.55
China	$14.55	$4.40
Japan	$14.95	$4.55
Spain	$11.78	$4.46
US	$3.79	$1.78

Table 32: LNG prices in USD/MMBtu May 2013 – Jan 2016
Source: FERC https://www.ferc.gov/market-oversight/mkt-gas/overview/ngas-ovr-lng-wld-pr-est.pdf

In view of the foregoing market dynamics, opportunities to source and negotiate long-term supply of LNG together with an FSRU facility (whether leased or purchased) are favourable and should be further explored by MoEW.

The challenge for Lebanon will be to secure investment in the gas transportation infrastructure required to take the gas from the FSRU(s) and re-deliver it to gas off-takers. As noted herein, and more completely in the Risk Identification and Risk Allocation Matrix, much will depend upon the ability of the Government of Lebanon to offer various forms of guarantees when considering investment and bankability. Accordingly, the Government of Lebanon is encouraged to pursue the additional elements of the proposed work scope set forth in the Annex hereto. In addition, MoEW would be well advised to explore forms of credit enhancements offered through international granting and financial institutions such as *inter alia* the World Bank Partial Risk Guarantee. On the other hand, the Government of Lebanon may wish to focus its efforts on private sector investment and international debt financing of the power plants and fund the long-term procurement of LNG, the FSRU (leased or purchased) and the financing of the Coastal Pipeline and related gas transportation infrastructure through public sources.

9.3 Project Risk, Emerging Markets and De-Risking Options

For purposes of this Report, third party investment and financing solutions associated with developing, constructing and operating gas infrastructure in Lebanon would need to consider (a) who would purchase and pay for the gas and all costs associated with the services provided by the FRSU unit and (b) who would pay the transportation costs associated with shipping gas through the facilities, i.e. from the FSRU unit to the main off-takers via a coastal pipeline (in the first instance, this is assumed to be the power plants and potentially the cement factories).

A key conclusion drawn from the Infrastructure Report is that the largest single off-takers of gas are the power plants (0.08 TCF). Accordingly, this section will focus upon a single large-scale, creditable off-taker / shipper -- the State of Lebanon (whether acting through EdL or the hypothetical Lebanese gas Supply Company as referenced in the Preliminary Risk Identification and Risk Allocation Matrix (**See Annex 1**).

Apart from the elevated political, legal and regulatory risk factors present within Lebanon, there are fundamental commercial risk factors that need to be identified and allocated including the following:

- The owner of the FSRU, coastal pipeline and downstream transmission infrastructure would likely need to have assurances from the customer (the shipper of gas) that the gas to be shipped through the infrastructure will be delivered in accordance with agreed specifications (quality) at the time agreed in order to anticipate commencement of payment for the service provided by the infrastructure;
- If the gas is not delivered to the FSRU, coastal pipeline owner, then the pipeline owner cannot generate the tariff agreed for providing the service (shipping gas) and therefore cannot pay back the investment costs associated with constructing and operating the facilities and earn a fair return;
- On the other hand, the owner of the gas cannot deliver the gas to the customer (the off-taker), unless the FSRU unit is in place and the coastal pipeline is completed on time and in accordance with the agreed specifications, in order to be able to ship the gas and provide the service; and
- Accordingly, if the owner of the gas cannot deliver the gas to its customer, then the owner will not be able to collect payment and in turn will either not be able to pay the seller of the gas or will have to finance the cost of the gas at a loss.

Note that a more complete statement of the pre and post-completion risk factors present in the relationship between LNG supply, storage and processing; gas transportation; and gas off-take, is set forth in the Preliminary Risk Identification and Risk Allocation Matrix (see **Annex 1**). The Matrix also includes suggested risk management and other policy considerations that the MoEW may choose to take into account.

Leaving aside for the moment, what individual risk factors may present to owners and operators of the FSRU and gas transportation infrastructure, there is a single question for every single owner and operator of each component in the gas to power value chain: who will pay for the halting, interruption, curtailment, non-payment or any other event that results in the erosion of value to the owner of the infrastructure?

Answering this question involves a complex process of identifying risk factors and designing 'de-risking' solutions for the infrastructure investment. Within an emerging market where the project seeks to attract private sector participation and/or commercial debt, answering this question will generally require the use of enhanced de-risking instruments in the forms of concession agreements ratified with the force of law, government performance and payment guarantees, subsidies and the participation of bilateral and multilateral lending institutions.

9.4 Financing Options

Pure financial investment, commercial debt and infrastructure bonds are generally not feasible pre-completion in emerging markets although these types of financings are more common post-completion. In view of the foregoing, questions of 'finance-ability' and 'bankability' can only be answered in respect of individual projects and after full financial models have been developed for each. This assumes that the MoEW and the Government of Lebanon has formulated an appropriate Gas and Gas to Power Master Plan. It also assumes that key decisions have been taken in respect of policy on *inter alia* privatization and market regulation. In addition, more will need to be known about the Lebanese market including country risk particularly at the time that the individual Projects move to their respective final investment decisions (FID). Accordingly, the following is an attempt to offer some preliminary thoughts on equity and financing options for the MoEW to consider.

9.4.1 Equity Investment by a Strategic Investor

In the first instance, the project scope will be important to define as some of the infrastructure options will be seen as more immediately commercial than others. For example, assuming LNG trucking and on-site regasification were commercially viable, a strategic investor would be an obvious candidate to fund this infrastructure alternative. In theory, trucking would involve less up-front Capex and, could be operationalized more quickly. In addition, the LPG gas off-take market is another example of an investment ideally suited to a strategic investor on an equity basis. Assuming demand is in place, credible (and creditable players) are involved in the value chain, the market for licensing and regulating the wholesale and downstream market is appropriate and forms of government support are available (e.g. a concession agreement together with legal, regulatory and fiscal protections) and other forms of performance and payment guarantees are in place, an investment could be attractive. Typically, a strategic investor would seek to partner locally in order to leverage a greater level of understanding of the market environment and legal and regulatory conditions.

9.4.2 Debt Financing and PPP Arrangements

As the scale of the Capex required for the investment grows and lead times to implement become longer, the need for the Lebanese Government and /or a strategic investor to leverage debt will grow. Within an emerging markets context like Lebanon, the ability to mobilize debt will depend upon strong government support in the form of a concession agreement and various forms of payment and performance guarantees as well as the participation of bilateral and multilateral lending institutions. Accordingly, two additional forms of financing are briefly outlined below: (a) Project Financing and (b) a PPP arrangement together with a project financing.

9.4.2.1 Non-Recourse / Limited Resource Project Financing

A non-recourse or limited recourse project financing typically involves a private sector strategic investor forming a Special Purpose Vehicle (SPV) – usually a corporation. In the event of a private sector investment only, the very first step is the negotiation of a concession agreement with the Government to enable the full licensing and investment protection required to implement the infrastructure project. Often, the private investor (if foreign) will enter into a JV with a local sponsor or the government (or state-owned entity). If the latter, the JV is usually referred to as a form of public private partnership or (PPP).

The SPV will in turn enter into a commercial arrangement (typically with industrial off-takers) to pay for the service on a 'take or pay' basis. In other words, in the event that the service or end product is not taken, the off-taker will guarantee payment thereof. The commercial contract is then used to underpin the equity financing and eventually the debt that can be raised with lenders. The SPV will also need to enter into an Engineering Procurement and Construction (EPC) Contract for the construction of the infrastructure and an operating and maintenance agreement (O&M) contract with an operator.

In the event of a debt financing, the Concession Agreement, EPC Contract, O&M Contract and Sale and Purchase or Service Contract will all be pledged by the SPV to the lenders as security for the loans. In the event of a default on the repayment of loans by the SPV, the banks will be able to 'step-in' and take over the project from the SPV. Finally, to ensure the project is delivered and capable of generating cash to repay the debt, lenders will typically ask the sponsors to provide 'completion guarantees' to ensure that the loan amounts can be repaid in the event that the project is not completed. However, once the project is operational, and generating agreed cash flows, the lenders will release the completion guarantees and the project will be allowed to go 'non-recourse'.

Figure 64 provides an outline of a simple non-recourse project finance structure:

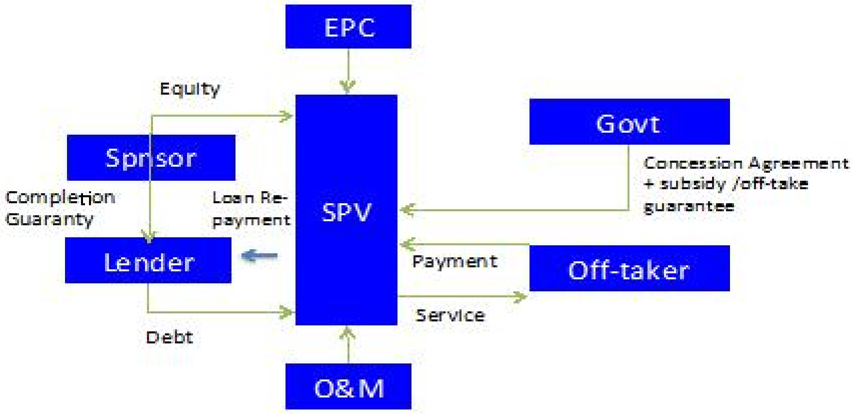


Figure 64: Basic Non-Recourse Project Finance Arrangement.

Note, the gas supply component of this structure has not been included here to avoid over-complicating the above Figure. Please see the diagram included in the Preliminary Risk Identification and Risk Allocation Matrix for a more complete view of the gas supply side and associated guarantees.

Provided that an acceptable combination of de-risking instruments can be mobilized, private sector investment and commercial debt can in principle be mobilized for the construction and operation of infrastructure projects within emerging markets on a project finance basis. However, as noted above, as the scale of the infrastructure project expands from a single unit (e.g. a power plant) to the construction and operation of countrywide infrastructure with multiple components requiring different commercial structures (e.g. gas import and distribution infrastructure as currently being contemplated for Lebanon) a PPP arrangement may become more appropriate. Through a PPP arrangement, the private sector investor establishes a working, inter-dependent relationship with the Government (either directly or through a state-owned entity) that enables project risk to be more appropriately allocated.

9.4.2.2 PPP Finance Structure (Equity and Debt)

PPP arrangements may be entered into between one or more private sector sponsors / operators, a State-Owned Company or directly with the Government (or Ministry). Once again, assuming sufficient demand and market capacity for the infrastructure, a Concession Agreement, subsidies and other forms of de-risking instruments become critical to generating appetite for such an investment. Finally, market appetite for Lebanese country risk will also be an important factor for investors and banks to take into consideration at the time such investments are made.

Figure 65 provides a simple outline of a simple PPP finance structure:

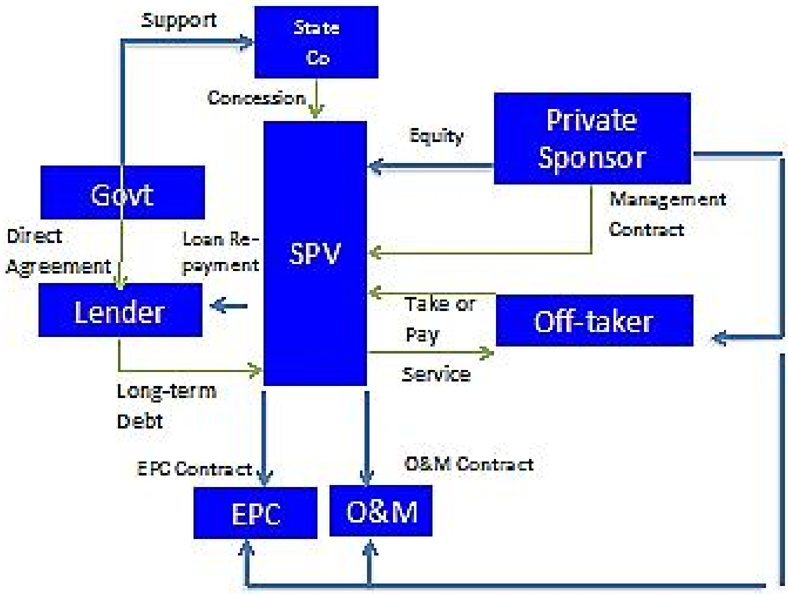


Figure 65: PPP Arrangement

Once again, note that the gas supply component of this structure has not been included here to avoid over-complicating the above Figure. Please see the diagram included in the Preliminary Risk Identification and Risk Allocation Matrix for a more complete view of the gas supply side and associated guarantees.

Once private sector investment is successfully secured into the broader gas to power value chain, PPP arrangements may be considered in reference to developing, financing, constructing and operating components of the gas to end-user (consumer) value chain, e.g. the City Gas Distribution Network. As long as the investor in such infrastructure can be insulated from the various risk associated with gas supply delivery and the risk of gas not being taken and / or paid for, it is possible that private sector investment and /or international debt financing can be secured. However, due to the fact that the gas to end-user of gas value chain is highly unlikely to underpin the financing of gas import and transportation infrastructure (more typical in the gas to power value chain), the financing of infrastructure associated with distributing gas to end-users (e.g. the City Gas Distribution Network) would more logically follow once the import and transportation infrastructure has been successfully operationalized.

9.5 Master Plan, Strategy and Priority Focus

In putting together a strategy and plan for delivering its objectives for implementing a gas infrastructure solution for Lebanon (a Gas Master Plan), the MoEW will need to take account of the respective value chains and commercial models referenced above. This entails implementing infrastructure solutions across the entire gas to power value chain as well as the gas to end-user value chain. Accordingly, this will transcend the more limited task of analyzing the FSRU and related gas transportation infrastructure. More importantly, Lebanon does not appear to have the public finances required to implement all of the required infrastructure upgrades without private sector investment and / or debt financing.

At present, none of the existing power generation facilities is privately owned. While four of the seven existing facilities are capable of producing power using gas as feedstock, only two of these plants are large-scale (450 MW) although the 2010 Policy Paper anticipates 3 additional IPPS with 500 MW each. Accordingly, a significant percentage of Lebanon's overall public power generation capacity is yet to be converted to gas.

In addition, there are other infrastructure components (e.g. upgrades to the existing grid) as well as legal and regulatory changes that will be required to ensure that the market for power in Lebanon is sufficiently efficient to support private sector investment and debt financing. As referenced at the outset, the MoEW will, therefore, need to carefully consider at what stage it makes sense for it to start implementing the appropriate market reforms in anticipation of inward investment into this sector.

The June 2010 Policy underscores the importance that MoEW assigns to private sector investment in the gas to power value chain in Lebanon. Accordingly, the MoEW should also consider whether it might make sense to privatize the power generation facilities and link their conversion to gas to the implementation of the FSRU and related gas transportation infrastructure. Development of such a strategy and plan is beyond the scope of the current assignment. However, with a proper value chain analysis, as recommended in Section 5 below the MoEW would be able to update the conclusions it has reached in its June 2010 Policy Paper for the Energy Sector and to take additional steps that may be required to revise its forward strategy and planning for implementing its key objectives for this important sector.

9.6 Indicative Recommendation on Funding and Financing Gas-to-Power Infrastructure

As referenced in the Conclusion to Section 2 above, in order to enable Lebanon to properly convert its fuel sourcing from liquid hydrocarbons to natural gas, specific funding and financial commitment will need to be made including in reference to the following:

- Commitments to procure relatively large quantities of LNG under long-term gas sales and purchase agreements;
- Commitments to (lease / purchase) one or more FSRUs to process the LNG into NG;
- Commitment to develop, finance, construct, commission and operate terrestrial gas transportation infrastructure; and
- Commitments from larger-scale creditable off-takers prepared to pay for the NG and all costs associated with the foregoing (including an appropriate return.

Before the GOL can formulate a funding and finance strategy, there are few considerations that will need to be taken into account;

- Which of the foregoing commitments will the Government of Lebanon be in a position to undertake and self-fund?
- What will third parties expect / require from the Government of Lebanon in order to fund / finance various scenarios / components?
- Third will third parties expect / require from other private sector parties in order to finance various scenarios components and for the market?

In order to attract potential investors / financiers to make the range of commitments required in order to ensure NG may be introduced as a fuel source into the Lebanese, the following principles should be considered;

- A single creditable counter-party whether that party is functioning as an off-taker buying the gas and / or a shipper shipping the gas through transportation and infrastructure and paying a tariff is more likely to secure finance / funding than multiple smaller-scale counterparties that lack creditability (e.g. smaller-scale stakeholders in the Study Target Sectors);
- The financial “plumbing” linking the various components of the gas-to-power value chain should be transparent, certain and predictable;
- The willingness of the government of Lebanon to step in and provide guarantees and /or fund critical infrastructure, in case the private sector is unwilling to do so, in order to achieve strategic objectives; and
- A clear identification and understanding of the risks, and the need to allocate the risks to the party which will be best to manage or mitigate those risks

The Preliminary Risk Identification and Risk Allocation Matrix (**Annex 1**) was developed in order to identifies and explain key risk elements within the transportation component of the Gas-to-Power value chain. Please note, that we strongly recommend that the Government of Lebanon complete the risk allocation analysis to incorporate the gas sales and purchase as well as the off-take components of the value chain as provided for in **Annex 1** herein. The Preliminary Risk Identification and Risk Allocation Matrix, identifies the primary stakeholders to whom the risk would be allocated and the likely stakeholder who would be the residual holder of the risk together with recommended mitigations.

105 risk factors were identified, 46 sourced risks that involve and require the Government of Lebanon to take primary or secondary risk allocation.

The core funding and financing risk factors that should be considered are;

- Infrastructure risks: cost overrun, construction delay, opex increase, capacity reduction and interruption or stoppage;
- Supply risks: delay in delivery and reduction in throughput delivered;
- Demand risks: delay in ability to off-take and reduction in off-take; and
- Creditability of all counter-parties in the value chain.

In order to better inform the thinking of the Government of Lebanon in formulating its funding and finance strategy, 8 possible owner/ user gas infrastructure configurations are considered, of which 2 stand out as presenting a sensible approach for attracting third party funding/financing as noted in the table below:

No.	Indicative Infrastructure Owner and User Configuration Under Funding and Finance Considerations	
1	GOL buys gas and owns and operates FSRU and Coastal Pipeline and GOL is shipper of gas directly to gas off-takers (power plants)	
2	GOL buys gas and owns and operates FSRU and Coastal Pipeline but off-taker is shipper through Coastal Pipeline	
3	GOL buys gas, Private sector owns and operates FSRU and Coastal Pipeline, GOL is shipper	
4	GOL buys gas, Private sector owns and operates FSRU and Coastal Pipeline, off-takers are shippers	
5	GOL buys gas and operates FSRU and off-takers build connection pipelines directly to power plants	
6	GOL buys gas and owns and operates LNG infrastructure including LNG Trucking and ships to off-takers	
7	GOL buys gas and ships to off-takers using LNG trucking owned and operated by private sector	
8	GOL buys gas and resells to off-takers, off-takers ship gas to power plants using private sector LNG trucking	

Table 33: Possible owner/user gas infrastructure configurations

Under each configuration, the above table assumes that it is sensible for the Government of Lebanon to enter into the long-term sales and purchase agreement to buy the gas required. The only other creditable buyer of gas would be the individual power plants. In the event that the public power plants proceeded, the gas seller(s) would in any event require a Government or Lebanon payment guarantee. Moreover, it would make sense for the public power plants to aggregate their off-take requirements and to enter into one gas sales and purchase agreement to meet their collective requirements. In effect, this would in any event mean that the Government of Lebanon would be the purchaser of the gas. If on the other hand, it is assumed that the individual IPPs would be the direct off-takers of the gas, then they would in effect be asked to assume responsibility for the entire gas-to-power value chain and this is simply not realistic.

Given that the private sector would be unlikely to take the risk and assume commitments over the entire gas-to-power value chain, it is unlikely that the Government of Lebanon would be in a position to fund and finance the entire value chain. For this reason configurations 6-8 have all been discounted.

While configurations 1, 2 and 4 take incremental commitments off the shoulders of the Government of Lebanon and the private sector respectively, our analysis suggests that these configurations are discounted as they fail to strike the correct risk allocation balance. Configuration 1 assumes that the Government of Lebanon would be the purchaser and shipper of gas to the power plants. While this configuration would remove the midstream risk from the private sector, it would place the cost of transportation on the shoulders of the Government and expose the Government to transportation performance risk *vis a vis* the power plants. While this might be acceptable to the power plants, it would likely load additional commitments onto the Government. However, the real ‘elephant in the room’ is who would build, own and operate the midstream transport infrastructure. Based upon the observations in reference to Configurations 6 and 7 above, the only viable party would be private sector. If this is the case, then the private sector midstream operator would have the Government of Lebanon as a shipper and the midstream (as well as the power plants) would be exposed to Government of Lebanon performance risk. For this reason Configurations 1 and 3 have been discounted.

On the other hand, if the midstream is private sector and the power plants are public and private sector, then the power plants and midstream are all exposed to broader counter-party risk that none are likely to feel comfort with. The midstream would be exposed to both Government of Lebanon gas delivery risk and power plant off-take and payment risk. The power plants, on the other hand, would be exposed to gas supply risk that would have to be allocated between two separate counter-parties the Government of Lebanon and the midstream transporter. It is simply not realistic to expect that the additional complexity presented would be acceptable to the private sector in this circumstance. For this reason Configuration 2 has also been discounted.

Accordingly, the two configurations that appear to satisfy all of the basic risk allocation principles are Configurations 3 and 5. Both configurations present a single creditable counter-party which enables and certain and predictable means to link payments with the Government of Lebanon positioned to provide the requisite guarantees.

9.7 Lebanese Energy Policy Context

9.7.1 Policy Considerations

The individual risk matrices that the Government of Lebanon is urged to develop for the remaining components of the gas-to-power value chain as well as each project within the individual components of the value chain must be understood against a broader country risk profile for Lebanon. This profile is comprised of the following risk elements:

- Speculative Lebanese sovereign credit rating;
- Political risk across risk evaluation sources;
- Regional security risks due to proximity of Lebanon to Syria and Israel;
- Perception of corruption and political instability;
- Thefts and losses in the power sector;
- Subsidies that betray the uneconomic and unsustainable nature of the sector;
- Perceived inconsistency in the application of rules and regulations and / or an unstable fiscal regime;
- Anti-competitive environment; and
- Credibility of potential commercial counter-parties.

Addressing the foregoing risk elements should be a critical aspect of the Government of Lebanon's energy policy priorities. While the Government of Lebanon may be able to address a number of these risk elements in reference to specific projects by providing guarantees (i.e. attracting investment and / or raising debt secured *inter alia* by guarantees as noted in the Preliminary Risk Identification and Risk Allocation Matrix), there may be a maximum threshold for the amount of investment / debt that may guaranteed beyond which the International Monetary Funds (IMF) may raise concerns. Accordingly, an important set of questions to be answered includes the need to evaluate the amount of additional debt the country can handle, whether this debt is sufficient to deliver the funding and finance needed to implement the various components accommodate the desired investment and / or debt required to achieve the objectives and how much additional contingent liability can Lebanon take on. Other risk elements may be mitigated through the provision of various rights, privileges and exemptions within the context of a concession agreement.

Over the last 15 years, the Government of Lebanon has taken a variety of energy policy reforms in an effort to address many of the key problems vexing the country's fuel supply. These measures include the following:

- In 2002, Law No 462 was adopted and included a plan to reform the energy. Adoption of the law was advanced at the time by the World Bank which advocated the privatization of the Lebanese energy sector. Unfortunately, and notwithstanding several very significant initiatives, very little actual reforms have been implemented;
- In 2002, the Lebanese Center for Energy Consumption was a joint project of UNDP and MoEW and addresses renewable energy and end-use energy conservation. It has carried out several pilot projects in the production of clean energy;

- In a009, the Lebanese Prime Minister pledged at the Copenhagen Climate Change Conference in that Lebanon's share of energy from renewable resources would rise to 12% until 2020;
- In 2009, Lebanon joined the International Renewable Energy Agency (IRENA)
- In 2010, a comprehensive Policy Paper on the Electricity Sector was adopted;
- On an initiative of the current Minister for Energy and Water, Gebran Bassil, and after a lengthy debate, an electricity bill was passed September 22, 2011. It will give 1,2 billion USD to the Ministry of Energy and Water, in installments. It aims at providing an additional 700 MW energy output, which is needed in order to satisfy the national demand; and
- In 2011, the National Energy Efficiency Action Plan was developed (2011-2015 under the MED-EMIP project (initiated by EU) and the Regional Center for Renewable Energy and Energy Efficiency (RCREEE). It contains 14 measures to be taken in the realm of energy efficiency, energy conservation and renewable energy.

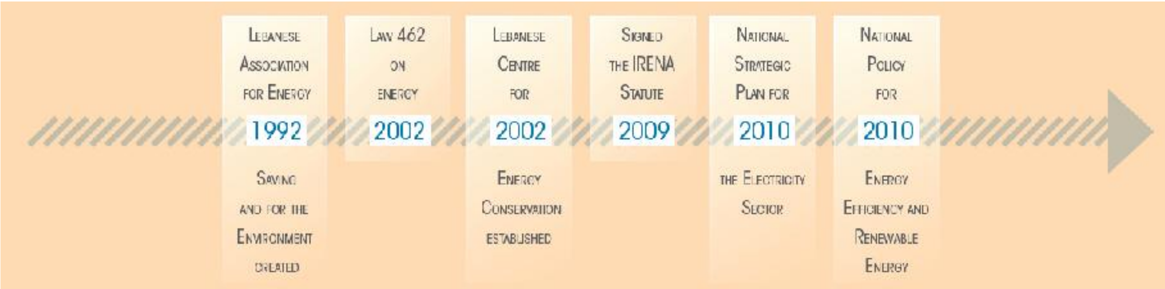


Figure 66: Policies in Place to Promote Renewable Energy since the Rio Conference 1992
Source: IRENA, 2012

Unfortunately, as noted above, very little concrete progress has been made to implement the foregoing policy recommendations and plans. Consequently, investment in power generation infrastructure is still lacking leaving much of Lebanon's consumers subject to power shortages, the country remains heavily reliant on liquid hydrocarbons, the country's air quality is seriously compromised by unacceptable levels of air pollution and Lebanon lacks security and diversity of fuel supplies.

9.7.2 Lebanese Policy Recommendations

In order for Lebanon to proactively improve the likelihood of addressing its fuel supply challenges and achieving its objectives, we recommend that the Government of Lebanon adopt the take of the following policies and take specific actions to implement them:

1. Formulate a Gas Master Strategy and Deliverable Implementation Plan

The Government of Lebanon should prioritize the gas-to-power sector and implement the components of critical infrastructure needed to complete the value chain by

- Focusing on sourcing, procuring and supplying gas to existing CCGT Power Plants as a matter of priority;
- Enter into arrangements with IPPs within a structure that positions the power plants (and IPPs) to function as the anchor off-takers for the gas;
- Accordingly, the IPPs should be agreed subject to
  - Gas procurement by the Government of Lebanon and
  - The successful implementation of the FSRU(s) and the associated gas transportation infrastructure to link the delivery of the gas from the FSRU to the power plants;
- Arrange for the privatization of the existing Power Plants – the goal should be to place the entire power sector into the hands of recognized investors / operators. This will also require the development of a standard PPA Agreement and EdL should be prepared to provide a guaranteed price at which it will purchase the power;
- A Government of Lebanon commitments to:
  - Enter into long term gas sales and purchase agreements for the procurement of gas;
  - Provide appropriate performance and payment guarantees (as may be needed) in order to
    - Procure (whether purchasing or leasing) appropriate FSRU(s); and
    - Develop, fund, construct and operate the required transportation infrastructure
- The Government of Lebanon should assess existing legislation to determine whether it is fit-for-purpose to support third party investment and finance (see Section XX below); and
- In the event that the gas and FSRU and infrastructure cannot be funded and financed in the first instance, then the Government of Lebanon should consider sourcing international institutional support and allocating sufficient funds to undertake the foregoing commitments and implement the requisite infrastructure with a view towards privatizing it to strategic and / or financial investors post-completion.

2. Develop a full value chain risk identification/ risk allocation matrix for each of the following components of the gas-to-power value chain to complete the analysis already commenced in reference to the midstream.
   - Upstream: Gas sales and purchase (a) identify each risk that could impede, halt or curtail the sale, purchase or delivery of gas from seller to buyer (b) identify primary and residual

stakeholders to whom this risk may be allocated and (c) take other risk mitigation measures

- Downstream: Power off-taker to end user

Each infrastructure scenario / project should be reviewed against the foregoing to enable an informed selection. Attention should be focused on ownership, evaluation of the commercial structure and forward market development objectives. In parallel, attention should also be focused on implementing least costly policy options.
Select the desired infrastructure scenario according to political considerations and funding and financing considerations;

3. Identify potential strategic investors and other third party funders and financers for the project; and
4. Develop appropriate draft legislation to enable appropriate support t third parties funders and financiers.

9.7.3 Legal Framework

The Government of the Republic of Lebanon should review its existing legislative, fiscal and regulatory structure to ensure that it is fit-for-purpose to support third party funding and finance of the various components of the gas-to-power. As a secondary priority, the Government of Lebanon should take steps to ensure that the gas-to-end-user value chain (the value chain that will support the Study Target Sectors) is supported by appropriate policies designed to achieve *inter alia* the following objectives:

- The elimination of thefts and losses;
- To ensure that the market for access to gas is transparent, fair and competitively priced;
- To ensure access to all transportation and tolling infrastructure is ensured on a transparent, fair and regulated price;
- To ensure that all components of the value chain are operated on a transparent, fair and competitive basis; and
- To ensure that subsidies are in place (as necessary) to ensure that participants in the target sector are properly incentivized to make the switch from liquid hydrocarbon fuels to gas.

9.7.3.1 Investment Agreements

The Government of Lebanon should ensure that an appropriate privatization law and associated tendering process is in place to attract the highest quality IPPs who will be able to efficiently operate the existing public power sector infrastructure at a price that is appropriate for the Lebanese market conditions. With reference to all new-build infrastructure, the Government of Lebanon should ensure that it has in place an appropriate concessions law providing for the MoEW (or other Ministry as appropriate) to enter into PPP and / or concession arrangements with private sector strategic investors to implement the requisite infrastructure projects. Many of the key provisions in the concession / PPP agreements should focus on addressing 'government risk' factors as set forth in the Preliminary Risk Identification and Risk Allocation Matrix. To be clear, government risk is most properly addressed by allocating it back to the Government. Accordingly, provisions addressing the following should be considered:

- General commitments to support and facilitate the timely implementation of projects;
- Protection against expropriation (direct, indirect and creeping)
- Stability of legal and regulatory environment through change of law provisions (as appropriate);
- Other forms of investment protection;
- Assurances in respect of licenses, permits authorizations and other requirements needed to construct and operate the facilities;
- Access to the requisite rights to land;
- Clear process and timings in respect of the conduct of environmental and social impact assessments that ensure appropriate central, regional and local stakeholder participation; and
- Fiscal stability and, where appropriate, incentives.

The policies formerly mentioned should be more completed developed and elaborated in appropriate laws and regulations. There should be Coordination between the Ministries of Energy and Water and Industry for the planning of new industrial areas and with the Directorate General of Urban Planning and Order of Engineers for new residential areas.

9.7.3.2 Guarantees

As referenced above, it is critically important that the Government of Lebanon is prepared to provide appropriate payment and performance guarantees to the investors and lenders as needed. Nevertheless, the Government of Lebanon should be careful in how these guarantees are entered into to ensure that the IMF is comfortable. It is recommended that any and all Government of Lebanon guarantees entered into are logged with the Ministry of Finance (or such other Ministry as appropriate in accordance with the Laws of Lebanon. For details on specific performance and payment guarantees that may be required please see the Preliminary Risk Identification and Risk Allocation Matrix (**Annex 1)** A sample of the guarantees that might be required in connection with the transportation component of the gas-to-power value chain is set forth in the commercial contracting structure (below).

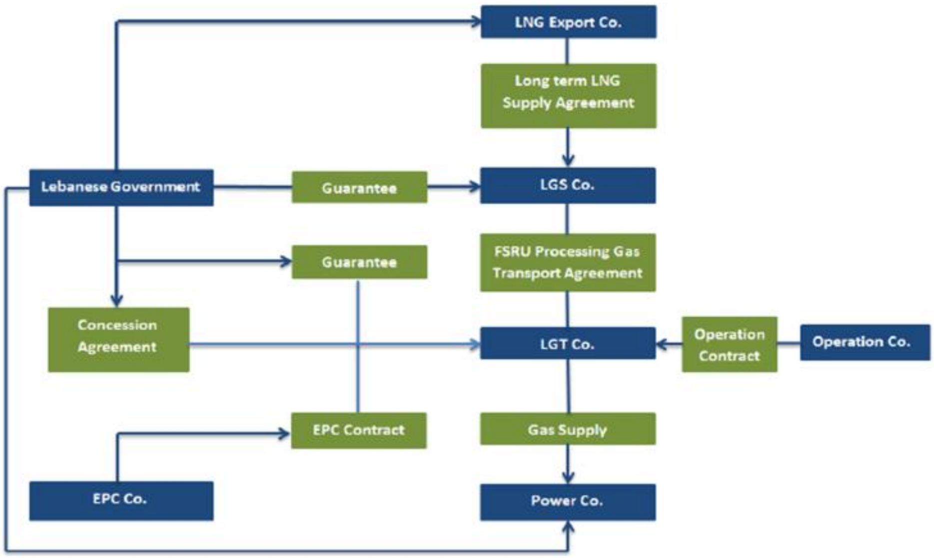


Figure 67: Indicative Infrastructure Owner / User Configurations and Funding and Finance Considerations

9.8 Subsequent Scope of Work

Phase I

Phase one of the Scope of work shall involve developing the Risk Allocation Matrices required in order to complete the Gas-to-Power value chain as set forth below.

Risk Allocation

The Risk allocation matrix ("RAM") is critical to identifying the key considerations which Third Party Funders / Financiers will want to understand before taking decisions on Investment / Finance.

In addition to the gas transport RAM already produced and delivered, two additional RAMS will be needed to complete the full value chain from gas procurement to gas transport to power and the value chain from Generator to end-user.

In other words, with the addition of the two additional RAMs, the risk position of every stakeholder in that value chain will be identified, understood and appropriately allocated and/or mitigated.

The allocation and mitigations identified in the RAMs will form the core basis of the Policy recommendations. The "TWO" additional (RAMS) are described below:

RAM (1) will look at the full range of risks that the GoL will need to consider in negotiating and concluding an appropriate Long Term Gas Sales and Purchase Agreement with prospective gas sellers. The key benefits of this RAM are as follows:

Gas Sellers will seek to push all risks to the buyer (the GoL);

While some of these risks should be accepted by the buyer others should be heavily negotiated and reallocated to the Seller; and

The RAM will serve as a fundamental tool to assist the GoL to better understand and to leverage key points in the negotiation – essentially preventing the GoL from getting screwed.

RAM (2) will focus upon all of the risks that

1. The GoL will need to consider in entering a PPA Arrangement with the IPP; and

2. All of the risks that an IPP would likely consider in attempting to recover the costs associated with a BOO (Build Own Operate) or BOOT (Build Own Operate and Transfer) of the new build Power Generation Facility or to otherwise take over and operate existing facilities.

The idea is to structure an assignment in four parts as follows:

PART ONE will involve the Consultant in developing appropriate risk allocation matrix to understand the risk position of each of the core stakeholders in the Gas to Power Value chain.

PART TWO will involve the Consultant in developing an appropriate risk allocation matrix to understand the risk posed on the GoL in paying for power (pursuant to a PPA). The core risk will center upon, on the one hand, the GoL's inability to recover the cost of the Power and, on the other hand, the range of risks posed to an IPP involved in a BOO / BOOT of the power generation facilities and centering upon the inability of the IPP to recover the Capex associated with developing and constructing the power generation facilities.

PART THREE will be based upon the results of the CBA and the decision of the MoEW on the particular GAS-TO-END-USER Value Chain(s) to prioritize. Given the ancillary nature of these value chains, it is likely that they will involve the deployment of a combination of Government Investment as well as Third Party Funding and Finance. Accordingly, Part three will involve the development of a broader range of Policy Tools to ensure that the correct risk mitigations and incentives are in place to July 19, 2016 **Risk Allocation** appropriately support third party investment and finance and ultimately the delivery of the MoEW objectives.

PART FOUR will involve a written report and a slide deck summary that will be presented at the conclusion of the assignment.

<u>**Phase II**</u>

Phase Two of the Scope of work shall involve developing appropriate policy positions to support the delivery of the Government of Lebanon's objectives in reference to the Study Target Sectors as set forth below.

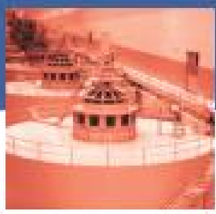
Appropriate policies should be developed to ensure that the gas-to-end-user value chain (the value chain that will support the Study Target Sectors) is designed to achieve *inter alia* the following objectives:

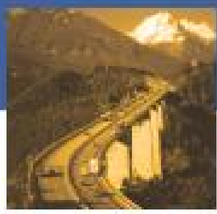
- The elimination of thefts and losses;
- To ensure that the market for access to gas is transparent, fair and competitively priced;

- To ensure access to all transportation and tolling infrastructure is ensured on a transparent, fair and regulated price;
- To ensure that all components of the value chain are operated on a transparent, fair and competitive basis; and
- To ensure that subsidies are in place (as necessary) to ensure that participants in the target sector are properly incentivized to make the switch from liquid hydrocarbon fuels to gas.

10 SCHEDULE OF DELIVERABLES

Deliverable	Name	Date (DD.MM.YYYY)
DI	Inception Report	22.07.2016
DII	Infrastructure Analysis Report	23.03.2016
DIII	Cost Benefit Analysis Report	28.07.2016
DIV	TOR Case Study	28.07.2016
DV	Report of the consultation workshop	28.07.2016
DVI	Lebanon Policy Paper	02.08.2016



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