CLIMATE CHANGE

Energy consumption in the commercial and institutional sector

2015

This document should be referenced as:

MoE/GEF/UNDP(2015). Energy consumption in the commercial and institutional sector. Beirut, Lebanon

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Energy consumption in the commercial and institutional sector. Beirut, Lebanon

Reference project

Lebanon's First Biennial Update Report

Executed by

Ministry of Environment

Funded by

Global Environment Facility

Implemented by

United Nations Development Programme, Lebanon

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LIST OF ACRONYMS

ADNRC	Annual Data of New Registered Companies
C&I	Commercial & Institutional
CAS	Central Administration of Statistics
CBDE	Census of Buildings Dwellings and Establishments
CDD	*Cooling Degree Day*
EDL	Electricité du Liban
EEG	Energy Efficiency Group
ELARD	Earth Link and Advanced Resources Development
GDP	Gross Domestic Product
GHG	Green House Gases
HDD	Heating Degree Day
LBP	Lebanese Pounds
LCEC	Lebanese Center for Energy Conservation
LPG	Liquefied Petroleum Gas
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MOJ	Ministry of Justice
UPS	Uninterruptible Power Supply
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
USEK	Holy Spirit University of Kaslik
VAT	Value Added Tax

ACKNOWLEDGMENT

This report is a collaborative effort of a team of experts and professionals from different disciplines, purring in together their knowledge and experience in the energy sector and environmental assessment field in Lebanon to present a reliable reference for energy and environmental studies in the country.

This report could not be possible without joint collaboration and valuable support from different institutions. They are to be thanked and appreciated for their input and contributions.

As such we wish to extend our gratefulness and gratitude to:

- Mr. Albert Khalil, CAS

- Dr. Hassan Harajli, CEDRO/UNDP; and

- Every company, individual, and institution that cooperated in providing energy data about and electricity consumption patterns.

1. INTRODUCTION AND BACKGROUND

In 2000, more than 41% of the GHG emissions in Lebanon came from the energy sector (excluding transport), making it the largest contributor to the national's GHG emissions [5]. More than 60% of the energy produced is through EDL power plants which are 95% of the thermal type and 5% of the hydroelectric type. The remaining share is produced by decentralized onsite generators.

The residential and commercial sectors are reported to consume more than 80% of the electricity in Lebanon [6] and accordingly have a large impact on GHG emissions in the country. Previous technical studies and reports on the sectorial shares of electricity usage provided large variances in values ranging from 16% to more than 60% for the commercial sector. None of these studies was based on a nation-wide census and accurate data.

ELARD and EEG were appointed by the Ministry of Environment/UNDP in 2014 to conduct an assessment of energy consumption and mitigation initiatives in the commercial and institutional sectors in Lebanon. This will enable the calculation of greenhouse gas emissions from both sectors; this information will be reported in Lebanon's next inventory submission to the UNFCCC.

This report provides an overview of the survey methodology and results including classification and categorization of institutions, baseline identification of total population size, sampling methodology, data treatment, assumptions, and extrapolation, in addition to analysis and interpretation of results and information on methodologies and assumptions used in data analysis.

2. METHODOLOGY

The present study offers a first-of-a-kind assessment of energy consumption and its patterns among the commercial and institutional sectors in Lebanon for the period from 2005 to 2012, as it is backed by accurate field data from a large number of technical studies and censuses that were gathered from a variety of sources.

The adopted methodology is based on using the Central Administration of Statistics (CAS) sectorial and economic classification, which provides an accurate count of registered establishments and institutions in Lebanon, coupled with data from the Ministry of Justice on the number of registered establishments every year. Both yielded the number of commercial and institutional energy users across the country.

Following the validation of the total number of energy end users in the targeted sectors, the energy consumption and operational patterns of a selected sample of 868 establishments and facilities was assessed through the field data gathering. Facilities considered covered both the different sub-sectors under the Commercial and Institutional ones and the geographical locations. Data was then extrapolated following statistically reliable and representative methods that are further developed in the following subsections related to the methodology part.

The questionnaires designed and used for large commercial and institutional establishments, and for small retail shops can be found in Appendix A.

2.1 SOURCE OF DATA

Energy consumption trends and patterns were collected using a variety of sources that provide a wide range of relevant information with representative geographic and scale coverage. The main sources of energy data used in study are found in Table 2-1

Table 2-1   Sources of Energy Data

Source	Data Collected
CEDRO Project	Energy consumption in public hospitals and health institutions
MoE	Energy consumption in large commercial buildings and institutions
MoEW	Energy consumption in large commercial and institutional buildings
EEG	Energy consumption in large commercial and institutional buildings
Field survey	Energy consumption in small to medium scale commercial facilities

For baseline identification, extrapolation, and other economic variables, official data was retrieved mainly from the CAS and other official bodies as shown in Table 2-2 below.

Table 2-2   Sources of Statistical and Economic Data

Source	Data Collected
CAS	Number of commercial and institutional establishments

Source	Data Collected
Chamber of Commerce	Commercial facilities and establishments
World Bank	Economic indicators

2.2 APPROACH

The quantification of energy consumption in the commercial and institutional sector in Lebanon is conducted following a bottom-up approach, working at the establishments level and moving up to the sector as a whole.

The approach and all inputs are presented in Figure 2-1   Methodology   and   InputsFigure 2-1, with small establishments referred to as S and larger establishments as L.
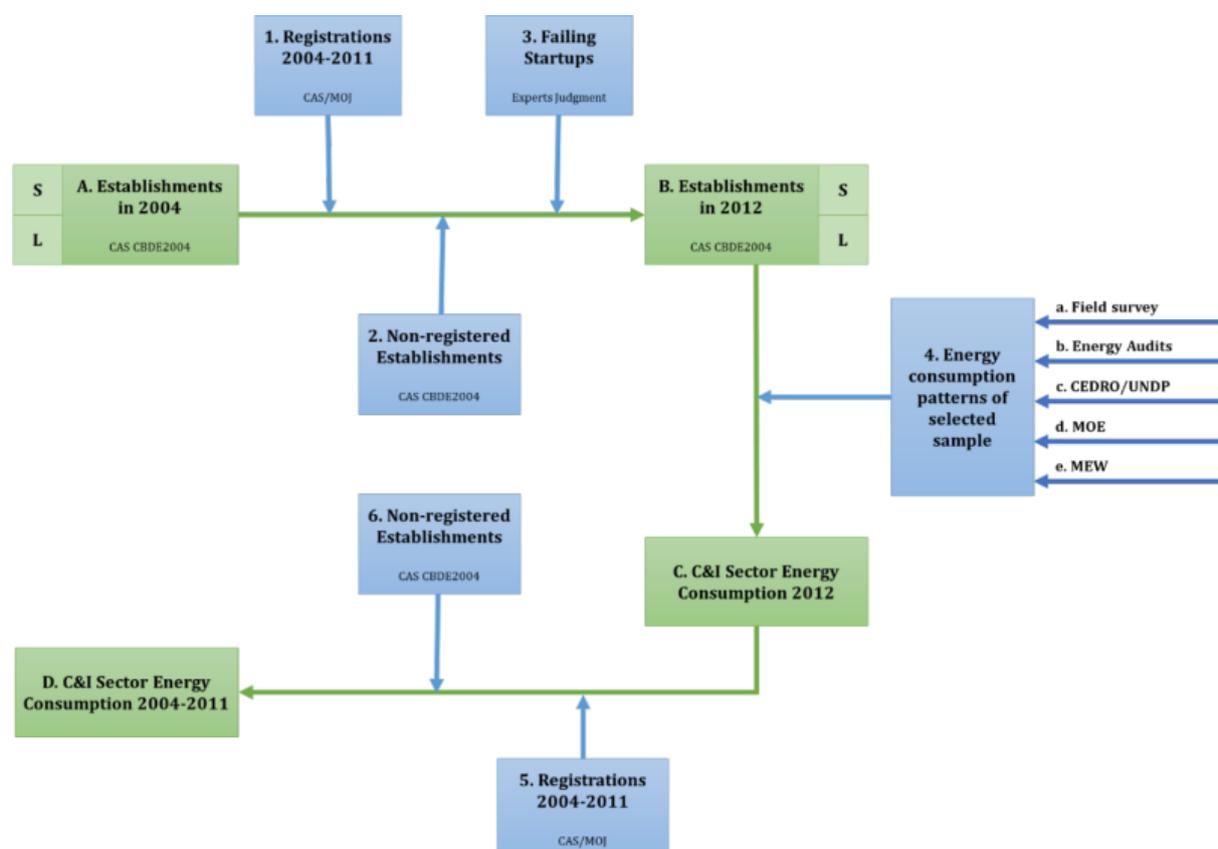
Figure 2-1   Methodology and Inputs

A-B: Estimating the number of commercial establishment in Lebanon starts with the figures published by CAS in The Census of Buildings, Dwellings and Establishments (CBDE) for the year 2004. These were further classified into economic sectors as presented in the Lebanese Economic Activity Classification published by CAS in 2008, and divided among districts. The number of both registered and non-registered commercial and institutional establishments is provided and used as a 2004 baseline (*A. Establishments in Lebanon 2004*).

As the above was the last census performed in the country, estimating the number of related establishments in Lebanon for the year 2012 starts from the 2004 data and then integrates

additional information collected from CAS, the Ministry of Justice, and experts' judgment to perform the annual growth analysis.

Establishments are classified into 'small' and 'large' in order to achieve a more realistic extrapolation. This is further developed in Table 2-4.

1. **Registrations 2004-2011:** data about the registered establishments is collected from the Ministry of Justice and published on CAS monthly data matrix webpage. The registration numbers are presented on a monthly basis and by district. On another hand, data about the growth by economic sector is provided separately, allowing for a more defined growth calculation. It has to be noted that this accounts for registered establishments only; in order to quantify the real number of establishments, further extrapolation needs to be performed in order to cater the non-registered entities (2. *Non-registered Establishments*).

2. **Non-registered Establishments:** CBDE of 2004 provided the number of registered establishments with an estimate of the non-registered ones in each district. Accordingly, the share of the registered entities per district was calculated from the total number of entities. The same percentages were applied to the overall growth of the registered entities in order to find the number of non-registered ones for the years through 2012. .

3. **Failed Startups:** a large number of companies are established every year, but a much lower number actually are still operational a year later according to local experts and business consultants. According to experts and professionals in the field [7], 50% of startups are to fail due to a variety of reasons. Considering the fact that many newly registered companies have already available offices or locations from sister companies, a rate of 40% is used as a start-up failure to be on the safe side. In addition, an annual shutdown rate of 1% is considered based on experts' judgment. This is considered based on business growth and economic situation evolution during the past year.

B-C: having the number of both registered and non-registered companies in the Commercial and Institutional sectors, along with their classification by economic activity, scale, and geographical location, it is possible to perform statistical extrapolation and accordingly quantify all the related energy consumption. For this purpose, data was collected from different sources to cover 868 facilities and institutions.

Data collected includes but is not limited to:

- Electricity bill
- Genset diesel consumption
- Boiler diesel consumption
- LPG consumption
- Working hours per week
- Type of backup power supply
- Facility surface area
- Benchmark unit when possible (e.g., Beds in hospitals, rooms in hotels, students in schools, etc...)
- Energy consumption breakdown
- Location.

4. *Energy consumption patterns of selected sample:* To undertake the energy consumption and related pattern analysis, data was collected in two ways. First, for the smaller facilities with a rather limited electricity consumption (i.e., small retailers/restaurants/offices…), a field survey was conducted in which surveyors targeted a number of these companies covering different economic activities in various geographical locations. Then, data about larger properties from the private and public sectors was gathered from different sources, mainly through energy audit reports completed during the last 10 years by EEG and other companies/organizations.

C-D: with no significant variation in the power supply system in Lebanon (in type, capacity, and intermittency), backward quantification is performed to estimate the sector energy consumption and breakdown from 2012 back to 2004. This is performed based on the number of establishments in each district, sector, and economic activity.

2.3 CLASSIFICATION, CATEGORIZATION, AND BUILDING

The census was primarily based on the classification followed by the CAS and then categorized in a manner that bundles similar categories together.

The Lebanese Economic Activity Classification published by CAS in 2008 classifies commercial activities under 21 main categories as listed in Table 2-3 (CAS, 2008). This classification was followed throughout the census as it is considered the only one that features a validated and accurate population of facilities.

Table 2-3 **Classification of Commercial Activities in Lebanon (Source: CAS, 2008)**

Code	Description
50	Sale & maintenance of vehicles & fuel
51	Wholesale
52	Retail trade except vehicles
55	Hotels (5510) & Restaurants (5520)
63	Supporting transport activities
64	Mail & telecom
65	Financial intermediaries
66	Insurance
67	Financial intermediaries
70	Real estate
71	Renting equipment & machines for personal & labor use
72	computer & related rental
73	R&D

Code	Description
74	Other commercial
75	Public administration, army, social security
80	Schools, Universities, & education institutions
85	Health & social work
90	Wastewater
91	Institutions not classified with memberships
92	Entertainment, sports, & cultural activities
99	Embassies & consulates

These classifications were further categorized in terms of similarity of the nature and type of operation. For instance, activities under classifications 63, 66, and 70 were combined under a category that features office work. Results are summarized in Table 2-4 that presents the scale ('small' v/s 'large') classification under each category. This method is used to ensure more realistic extrapolation distinguishing between large facilities such as a 6-storey shopping area as compared to a small retail shop of less than 300 m^2.

Table 2-4   Classification of Commercial Activities in Lebanon Based on Types of Operation

Category	Activities	Includes	Scale	
			Large	**Small**
(A) Sales & Other Services	50. Sale & maintenance of vehicles & fuel 51. Wholesale 52. Retail trade except vehicles 92. Entertainment, sports, & cultural activities	Retail shops, malls, wholesale shops, showrooms, movie theatres, entertainment grounds, etc…	Malls, supermarkets, retails shopping larger than 2,500 m^2	All others
(B) Hotels	5510. Hotels	Hotels, motels, resorts, etc…	Large hotels & resorts	All others
(C) Restaurants	5520. Restaurants	Restaurants, pubs, nightclubs, etc…	Large restaurants	All others
(D) Offices	63. Supporting transport activities 64. Mail & telecom 65. financial intermediaries 66. Insurance 67. Financial intermediaries supporting 70. Real estate 71. Renting equipment & machines 72. Computer & related rental 73. R&D 74. Other commercial	Engineering services, banks, insurance, brokers, shipping, design, and telecom services, etc…	Headquarters and large office buildings	All others
(E) Public Service	75. Public administration, army, social security 90. Wastewater 91. Institutions not classified with memberships 99. Embassies & consulates	Ministries, office buildings, public service, embassies, international organizations	Headquarters	All others
(F) Education	80. Schools, Universities & educational institutions	Schools, universities, academies, learning centers, etc…	Universities & large schools (> 1,000 students)	All others
(G) Healthcare	85. Health & social work	Hospitals, healthcare, orphanages, beauty salons, laundry, etc…	Hospitals and large healthcare centers	All others

2.4 ASSUMPTIONS

In order to build all the needed extrapolation and data analysis, a set of assumptions were made to achieve accurate and reliable results.

2.4.1 Emission Factors

The emission factors used in the environmental analysis in this report are provided by the Climate Change Unit at the Ministry of Environment, and are presented as follows:

- EDL Grid: 0.657 tCO_2/MWh

- Diesel Oil: 3.18 tCO_2/tonne

- LPG: 2.95 tCO_2/tonne

2.4.2 Generator, Boiler, and LPG Consumption

In order to have a common quantification unit, conversion factors are used to estimate the energy production based on liters of diesel and kilograms of LPG consumed.

From more than 200 energy audits performed, the following factors have been identified and applied in this report.

- Diesel generator: 3.8 kWh/ liter

- Diesel boiler: 8.0 kWh/ liter

- LPG: 10.8 kWh/ liter

2.4.3 EDL Cutoff/Power Failure

In order to ensure accuracy and avoid any discrepancy from survey respondents, the EDL power failure was taken from EDL directly, which publishes the timeline on its website divided by its different zones as follows:

- Beirut: includes Beirut area

- North Lebanon: includes the North area and Amchit

- Bekaa: incudes Bekaa and Marjeyoun area

- South: includes Nabatieh and South excluding Marjeyoun

- Chiah: includes areas from Beirut river to Damour and from Bdadoun to Jamhour east

- Antelias: includes areas from Nahr Al Kalb north to Beirut and Monteverde, Daishounieh, Mansourieh, Fanar, and Zouk Khrab east.

- Mount Lebanon: includes the rest of Mount Lebanon

According to EDL, the average daily supply hours were reported to be 21 hours in Beirut, 18.5 hours in Chiah, 16.25 in Antelias, 16 hours in Mount Lebanon and Bekaa, 16.5 hours in the North, and 17 hours in the South.

2.4.4 Backup/ Onsite Generator Use

In a large number of existing facilities, there are no private backup generators installed as they rely on local generators' subscription, UPS, or do not have any backup.

Surveyed establishments reported their type of backup power which helped estimating the off-EDL energy consumption.

1. For facilities reporting the use of EDL and those reporting no availability of backup power, only EDL bill was considered for electricity consumption analysis.

2. For those subscribed to a back-up power system, their electricity consumption was measured based on the frequency of power failure in their region. For instance, a facility consuming 100 kWh in a zone with an EDL failure rate of 25% would be consuming 33 kWh from subscribed back-up.

3. For those with available private generators, the reported diesel consumption is used.

2.4.5 Fuel Mass Density

The following factors are used to convert from liters to metric tonnes:

- Diesel: 0.885 t/ 1,000 liter

- LPG: 1.908 t/ 1,000 liter

2.5 DATA TREATMENT

2.5.1 EDL Bill Electricity Consumption

During the electricity consumption data collection, several answers were provided in LBP or USD rather than kWh. In order to calculate the electricity bill in kWh, the following variables are accounted for:

- Type of tariff: Residential, Industrial, or Institutional

- Subscribed power: In Amperes; this affects the subscription fee

- Value Added Tax: Currently at 10%

The VAT, subscription fee, and additional expenses are discounted at first. After that the net electricity consumption value is broken down based on the type of tariff applied. Eventually, the net kWh consumption is quantified.

2.6 Sample Characteristics

Energy data was collected from 868 commercial facilities and establishments, distributed over the different regions of the country. The geographical and climatic zoning distribution of data collected is presented in Figure 2-2 while the distribution of all commercial establishments in Lebanon in 2012 is found in Figure 2-3.

In terms of climatic zoning, it was ensured that facilities from the different zones were selected in order to present different climatic conditions. As seen in Figure 2-4 and Table 2-5, Lebanon can be divided into four climatic zones: Beirut and coastal areas; Western Mid-Mountain (with an altitude higher than 700m); the eastern Anti-Mount Lebanon and part of the western Mount Lebanon range; and the Bekaa, that have different cooling and heating requirements.
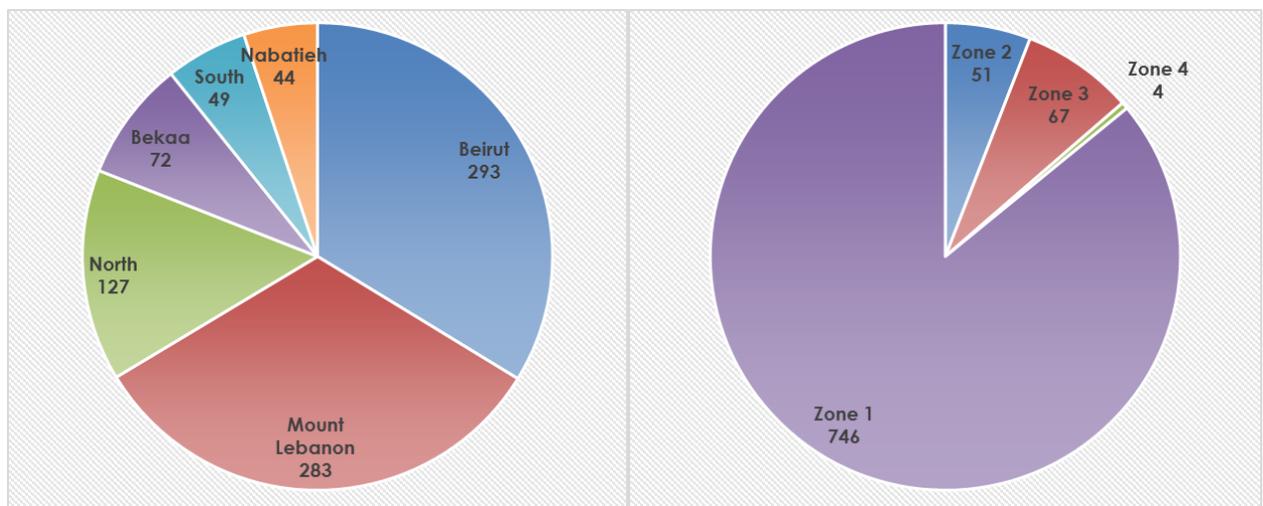

**Figure 2-2   Geographic and Climatic Zoning Distribution of Collected Data**
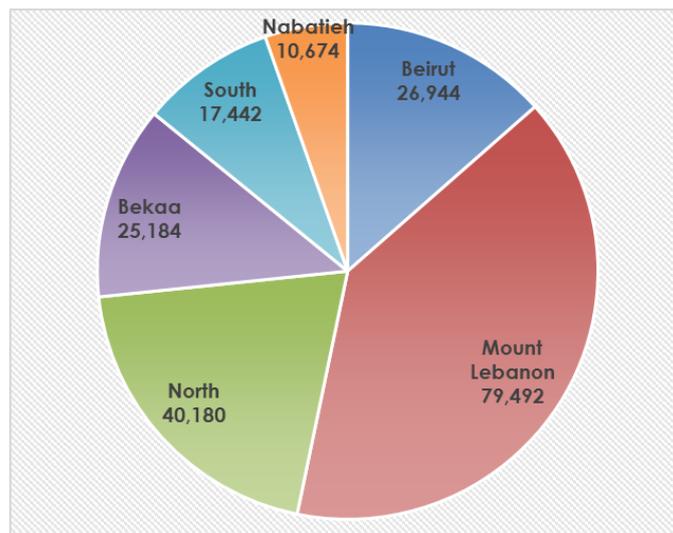
Figure 2-3   Geographic Distribution of Commercial Establishments in Lebanon (2012)
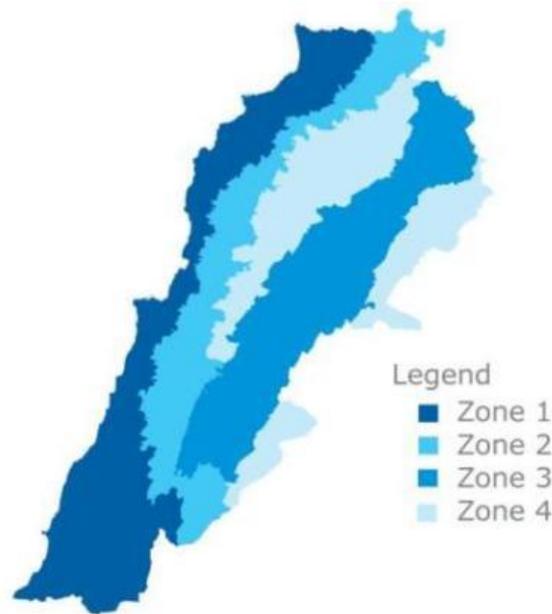
Figure 2-4   **Proposed Climatic Zones in Lebanon [4]**

Table 2-5   **Climatic Zones in Lebanon with Average Heating and Cooling Degree Days [4]**

Zone	Reference weather station	Characteristic HDD	Characteristic CDD
Zone 1: Coastal	Beirut	379	882
Zone 2: Western Mid-Mountain	Qartaba	1514	105
Zone 3: Inland plateau	Zahle	1600	390
Zone 4 : High mountain	Cedars	3330	0

Source: UNDP/GEF and MoPWT/DGUP, 2005

HDD (Heating Degree Day) and CDD (Coolind Degree Day) are indicative measurements designed to reflect the demand for energy needed to heat and cool a building respectively. These values are derived from measurements of outside air temperature

The total number of surveyed establishments is shown in Table 2-6.

Table 2-6   **Surveyed Establishments**

Category	Existing	Surveyed	Percentage
Sale & Entertainment	155,093	364	0.23%
Hotels	684	26	3.80%
Restaurants	6,474	66	1.02%
Offices	15,607	171	1.10%
Public Service	1,039	43	4.14%
Education	1,722	130	7.55%
Healthcare	19,295	68	0.35%

2.7 BASELINE FEATURES

The baseline year on which all the analysis work of the present report was focused is 2012. This is the year analyzed and reviewed for energy consumption baseline, from which conclusions on the energy trends is drawn.

The CBDE is considered one of the key activities of CAS as it is a compilation of data collected from different sources such as the Ministry of Justice, syndicates, and official registration records (CAS, 2004). CBDE leads to two databases, the first provides the population of dwellings and the second provides the population of establishments. These databases were used to draw all samples for the economic and social surveys.

The publication issued in 2004 is the last one that gives a reliable count of establishments in Lebanon. Another census was planned to take place in 2014 but has not been implemented to date as per the CAS representative.

According to CBDE (2004), under section 10 (Economic activity of the establishments in Lebanon in 2004), there were 159,784 establishments (registered and not registered) in Lebanon. The CBDE (2004) data provided a good basis for the current project; however, the study needed to consider the growth of the numbers of establishments through the years (2005-2012). The growth was calculated based on the Annual Data of New Registered Companies (ADNRC) as per the Ministry of Justice (CAS, 2015). This data is publicly available and published on a yearly basis on the CAS website under the monthly data matrix, which offers registrations per month per district. The GDP growth by sector over the years from the World Bank publications on economic growth and the Central Administration of Statistics reports was also considered in order to ensure a reasonable growth rate estimation of various economical activities in each district.

The approximate annual number of existing registered establishments was therefore calculated for the mentioned years considering the following assumptions:

- A startup failure rate of 40%
- An average of 1% yearly shut down rate of existing establishments.

It is important to note that ADNRC provides only the count of registered companies. The number of non-registered companies was extrapolated based on the ratio of registered to non-registered as found in CBDE (2004). This ratio was used for each respective district and applied to the growth rate. The ratio for each district is shown in Table 2-7. The ratios for Chouf and Aley are not available from the source, and thus the average governorate ratio was applied.

Table 2-7   Ratio of Registered to Non-registered Establishments in Different Districts

Governorate/District	Registered Establishments %
Beirut	**51%**
Baabda	21%
Chouf & Aley	N/A
Metn	46%

Governorate/District	Registered Establishments %
Kesserouan	53%
Jbeil	29%
Mount	**37%**
Tripoli	24%
Koura	13%
Zghorta	11%
Batroun	15%
Aakkar	4%
Bcharreh	3%
Minieh-Dennieh	6%
North Lebanon	**15%**
Zahleh	15%
West Bekaa	7%
Baalbeck	7%
Hermel	5%
Rachaya	9%
Bekaa	**11%**
Saida	29%
Tyre	14%
Jezzine	10%
South Lebanon	**21%**
Nabatieh	31%
Bent Jbeyl	12%
Marjaayoun	10%
Hasbaya	4%
Nabatieh	**21%**

To illustrate the approach used to establish the baseline year in terms of sector size, the following real-life example shows the process starting with the number of establishments in 2004 to reach the final number for 2012.

In 2004, according to the CBDE 2004 and the detailed data provided by the CAS, there were 22,326 establishments in Beirut, among which 51% were registered and 49% were not.

Following the ADNRC over the period 2004-2011, there were 1843 registrations in 2004, followed by 1,685 in 2005, 1,451 in 2006, 1,309 in 2007 and so on. In order to have a real count of the establishments starting in the covered years, it is essential to take into account the parallel growth of non-registered establishments, and the start-up failure rate of 40%. Applying the various ratios listed in Table 2-7 leads to the total values found in Table 2-8.

The number of newly established companies is added to that of existing ones in 2004 (22,326), then a shut-down rate of 1% is applied to reach the total of 28,058 commercial establishments in Beirut by the year 2012.

The number of newly established companies is distributed over economic activities. In order to judge the distribution of newly established companies over the different economic sectors, yearly economic activities growth data is used. For example in 2005, 5.33% of registered establishments were classified under the hotels and restaurants activity. Accordingly, in that year 5.33% of the 2,022 surviving establishments were in this activity. The same methodology was used for other economic activities and subsectors.

Table 2-8   Number of Registered and Non-registered Establishments From 2004 to 2011

Year	Registered	Non-registered	Total	Surviving Establishments
2004	1,843	1,806	3,649	2,189
2005	1,685	1,651	3,336	2,002
2006	1,451	1,422	2,873	1,724
2007	1,309	1,283	2,592	1,555
2008	1,473	1,443	2,916	1,750
2009	2,031	1,990	4,021	2,413
2010	2,392	2,344	4,736	2,842
2011	1,600	1,568	3,168	1,901

2.8   EXTRAPOLATION

Extrapolation was performed based on the number of commercial establishments in each district and the energy patterns in the surveyed facilities. Each district is dealt with separately, and when insufficient data is found in a certain district, the overall average of the governorate is used.

To better illustrate the above point, the example of large restaurants in the district of Jbeil was considered. The data available for Jbeil and Keserwan, both located in the Governorate of Mount Lebanon, is presented below:

- Number of large facilities in Jbeil: 30   Surveyed: 0
- Number of large facilities in Keserwan: 177   Surveyed: 3
- Number of large facilities in Mount Lebanon: 420   Surveyed: 7
- EDL kWh consumption of large facilities in Mount Lebanon: 2,684,172 kWh
- EDL kWh consumption of large facilities in Keserwan: 635,498 kWh

In order to perform the extrapolation for the district of Keserwan for large facilities, the average consumption per surveyed facility is calculated to be 211,832.66 kWh. Extrapolation over the number of existing large facilities in Keserwan provided an annual energy consumption of 37,494,382 kWh.

For the district of Jbeil, where no large restaurant was surveyed, the average consumption per surveyed facility is calculated based on the governorate average, which is 383,453 kWh. The extrapolation over the number of existing large facilities in Jbeil leads to an annual total energy consumption of 11,503,594 kWh.

3. RESULTS

3.1 EDL ELECTRICITY CONSUMPTION

According to the electricity utility (EDL), the electricity supplied to customers is estimated at 10,969 GWh in 2012, of which 327 GWh was supplied from Syria and 1,177 GWh from hydraulic power.

This study has shown that the commercial and institutional sectors represent a substantial share of the country's electricity consumption with 4,802 GWh of EDL supply and 2,817 GWh from private generation, with a total of 7,620 GWh per year. On another hand, the EDL power consumed by the commercial and institutional sectors accounted for 3.1 million tonnes of CO_2 emissions annually.

Looking at the sub sector levels, it is seen that 'Sales and other services' represent 32% of the electricity consumed by the commercial and institutional sectors from EDL power which, combined with the healthcare category would top the 50%. Offices consume 18%, while hotels and restaurants make up 16% and 12% respectively. Education and public services are the lowest with 5% and 1% respectively as shown in Figure 3-1.
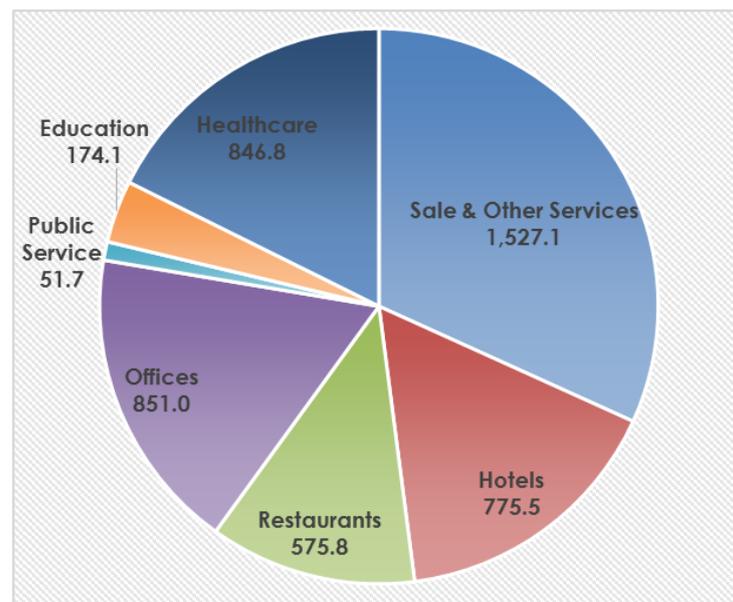
Figure 3-1   Commercial and Institutional EDL electricity Consumption by Economic Category in GWh (2012)

Hosting the majority of business and commercial facilities, the governorates of Mount Lebanon and Beirut represent together 70% of EDL's produced power consumed by the commercial and institutional sectors. Mount Lebanon's near 80,000 commercial and institutional facilities consume alone 2,226 GWh per year, while Beirut's 27,000 consume 1,125 GWh. These numbers show Beirut with a higher EDL consumption rate with an average of 41.8 MWh per establishment per year compared to 28 MWh per establishment per year in Mount Lebanon. This variation is due to two major factors, the first being the lower EDL rationing rate in Beirut area, and the second being the centralization of large facilities in the capital. Figure 3-2**Error! Reference source not found.** shows the EDL electricity consumption per governorate.
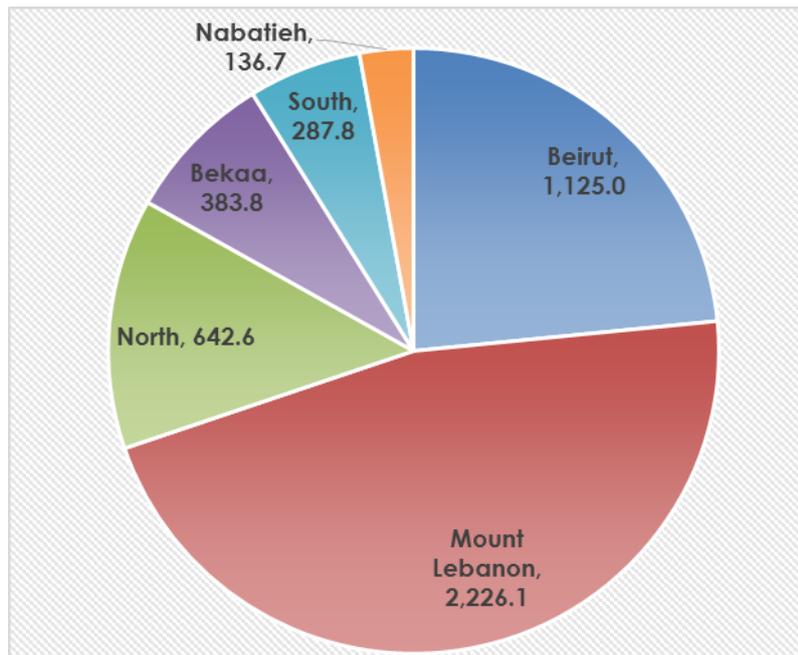
Figure 3-2   Commercial and Institutional EDL electricity Consumption by Governorate in GWh (2012)

3.2   GENERATORS DIESEL CONSUMPTION

Whether the facility is using its private generator or a public generator subscription, diesel is being consumed to provide electricity during EDL's power cut-off time. The amount consumed by the commercial and institutional sectors in Lebanon in the year 2012 turned out to be 656,265 tonnes of diesel oil, providing a total of 2,817 GWh. This leads to an overall carbon emission of more than 2 million tonnes of CO_2.

It is noticed that in small facilities, public subscription is more common than private generation. The second is mainly used in large facilities and establishments as presented in **Error! Reference source not found.**.
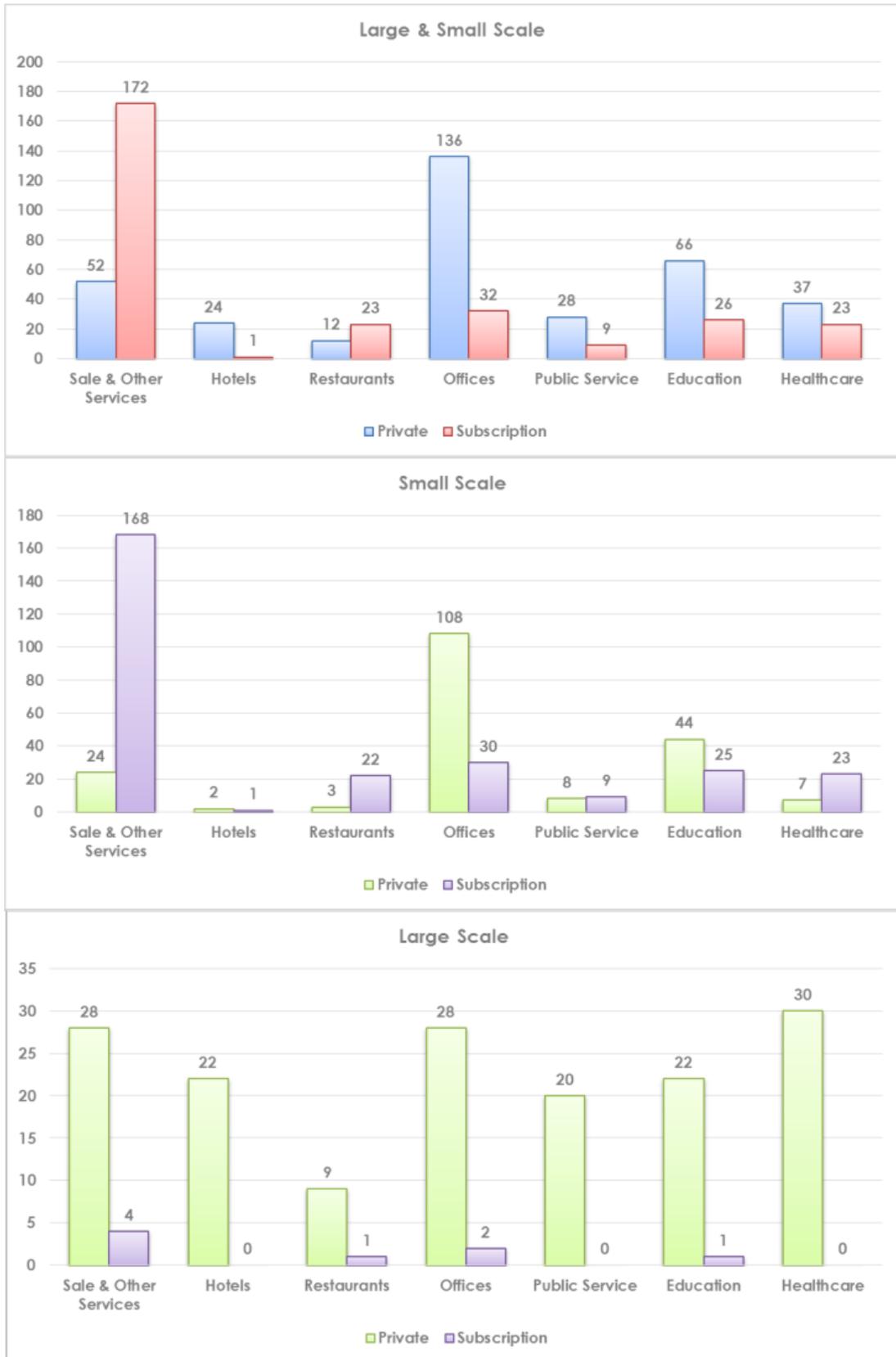
Figure 3-3   Number of Facilities by Source of Backup Power

Sales and other services also appeared to make up the biggest share with 42% of the consumed commercial and institutional sectors' diesel oil for backup generators operation, followed by offices with 16%, healthcare with 15% and restaurants with 13%. Hotels make up to 9%, education and public services are the lowest with 4% and 1% respectively as shown in Figure 3-4.
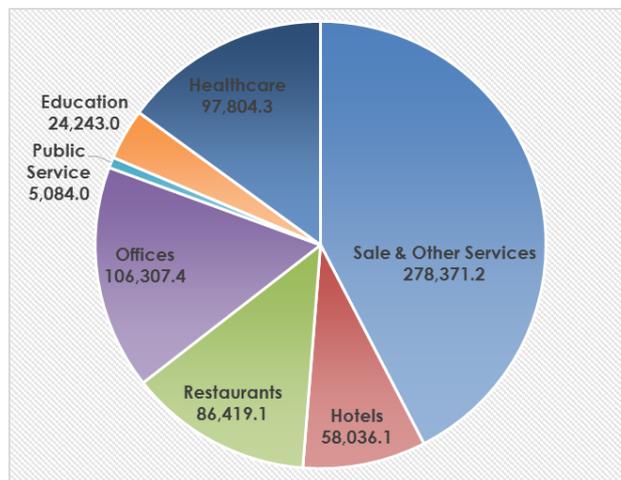
Figure 3-4   Commercial and Institutional Backup Power Diesel Consumption by Economic Category in Tonnes (2012)

With high rationing rates and high density of commercial and institutional facilities, Mount Lebanon consumes by far the largest amount of diesel oil used for back-up generators, with almost 387,000 tonnes per year. Beirut ranks fourth after both the North and the Bekaa that have much higher blackout hours than the capital.

In terms of density, Mount Lebanon is on top followed by Bekaa, the South, Nabatieh and then Beirut. Figure 3-5**Error! Reference source not found.** shows the diesel consumption used for power generation in the commercial and institutional sectors per governorate.
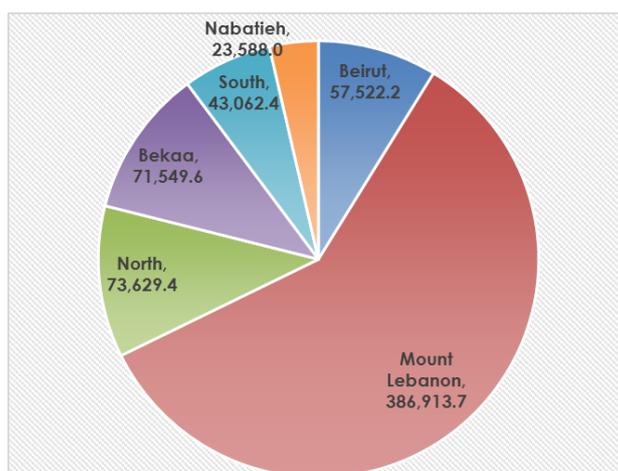
Figure 3-5   Commercial and Institutional Backup Power Diesel Consumption by Governorate in Tonnes (2012)

3.3   BOILER DIESEL CONSUMPTION

Hot water boilers are used in a number of large facilities for water heating and central space heating purposes. Almost all boilers utilized in Lebanon are diesel powered with only a few using other fuels such as LPG, biomass, solar energy and others.

The commercial and institutional sector in Lebanon consumes 170,584 tonnes of diesel oil per year for thermal energy production, emitting around 542,458 tonnes of CO_2. The sales and other services sector still make up the lion's share, mainly because of the enormous number of facilities and establishments it covers. It is noticeable that the share of hotels has increased when comparing diesel usage for boiler usage as compared to other electricity consumption to make up more than 25% of the commercial an institutional sector water heating diesel consumption. Detailed breakdown is shown in Figure 3-1   Commercial and Institutional EDL electricity Consumption by Economic Category in GWh (2012)Figure 3-6.
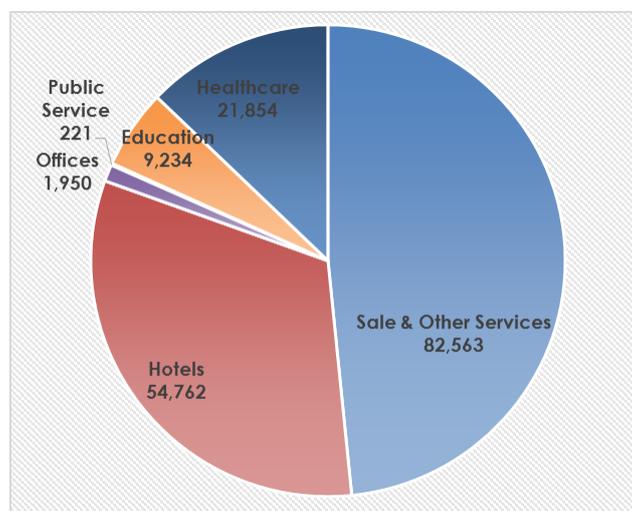
Figure 3-6   Commercial and Institutional Boiler Diesel Consumption by Economic Category in tonnes (2012)

Mount Lebanon, North Lebanon, and the Bekaa region consume the most when it comes to thermal energy. In Mount Lebanon alone, more than 100,000 tonnes of diesel oil are consumed in boilers in commercial and institutional facilities, representing more than 50% of the overall C&I share. Beirut's share is low due to the lower heating requirement in this coastal region. Further details are shown in Figure 3-7.
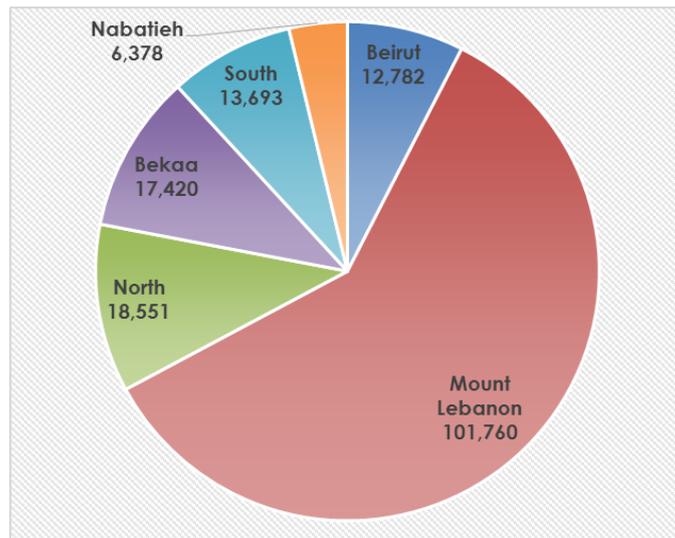
Figure 3-7   Commercial and Institutional Boiler Diesel Consumption by Governorate in tonnes (2012)

3.4   LPG Consumption

LPG is mainly used in kitchens in restaurants, hotels, and hospitals. Around 30,053 tonnes of LPG are consumed in the C&I sector per year, with restaurants contributing to 84% of the sector's consumption, followed by sales and other services and hotels as shown in Figure 3-8. The total CO_2 emissions from the use of LPG in the sector is 87,603 tonnes.
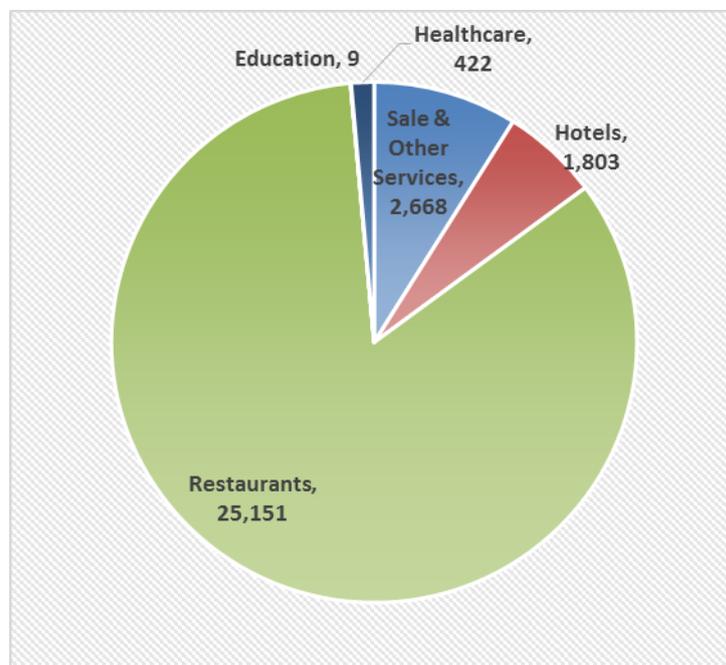

Figure 3-8   Commercial and Institutional LPG Consumption by Economic Category in tonnes (2012)

Mount Lebanon alone consumes around 17,715 tonnes of LPG for commercial and institutional facilities. This is followed by the South, North, Bekaa, Beirut, and lastly Nabatieh as shown in Figure 3-9. This accounts for 51,638 tCO2 emissions per year in the governorate of Mount Lebanon.
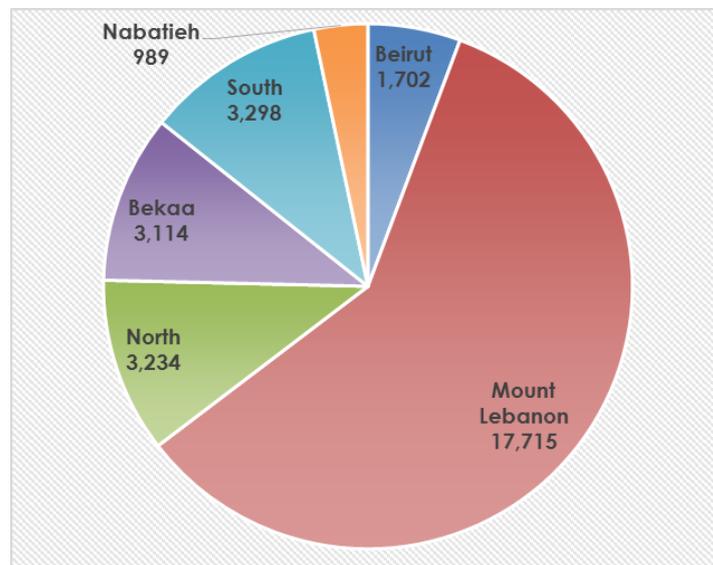
Figure 3-9   **Commercial and Institutional LPG Consumption by Governorate in tonnes (2012)**

4. ANALYSIS AND INDICATORS

4.1 ELECTRICITY CONSUMPTION
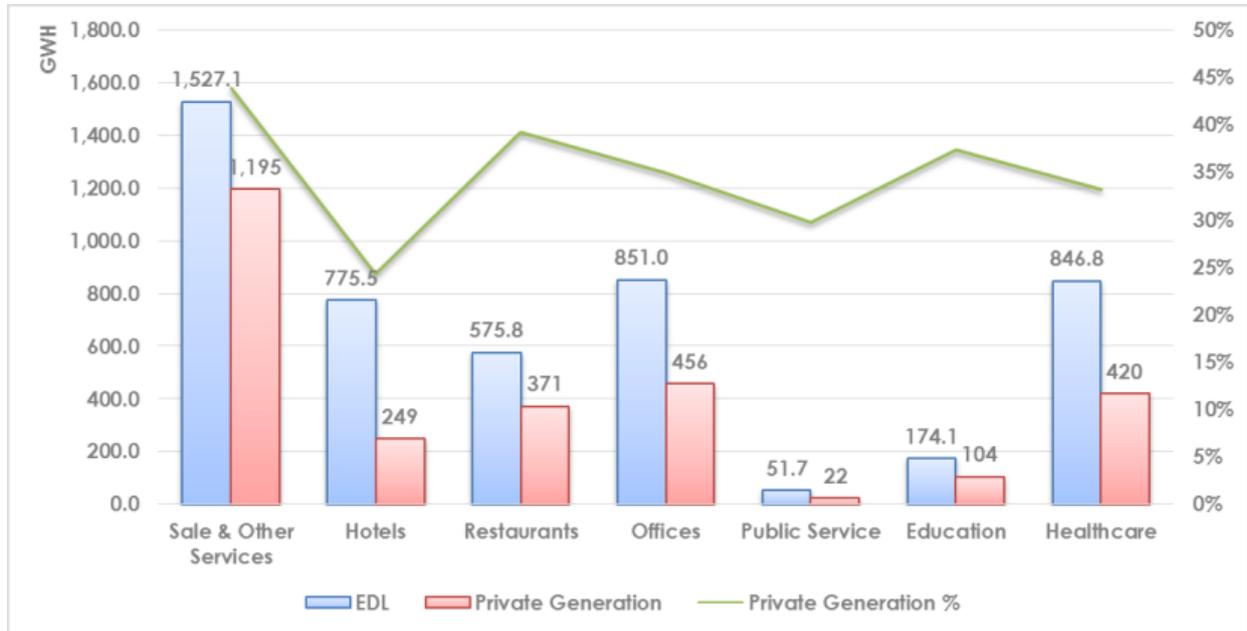
Figure 4-1   Electricity Consumption by Source and Economic Activity (2015)

More than 44% of the energy consumed in sales and other services comes from private generators, making this share the highest among economic activities. Restaurants and office buildings also have high reliance on private power generation with 39% and 35%.

4.2 DIESEL CONSUMPTION
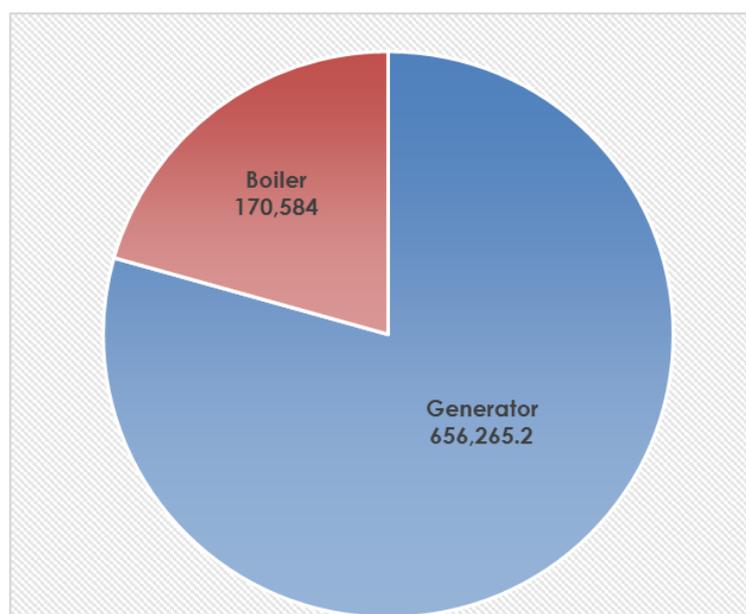
Figure 4-2   Diesel Consumption by End Use Activity in tonnes (2012)

The annual diesel consumption in the commercial and institutional sector sector is 826,849 tonnes of diesel oil, more than 75% of which is for backup power generation. This contributes to the emission of 2,629,381 tonnes of CO_2.
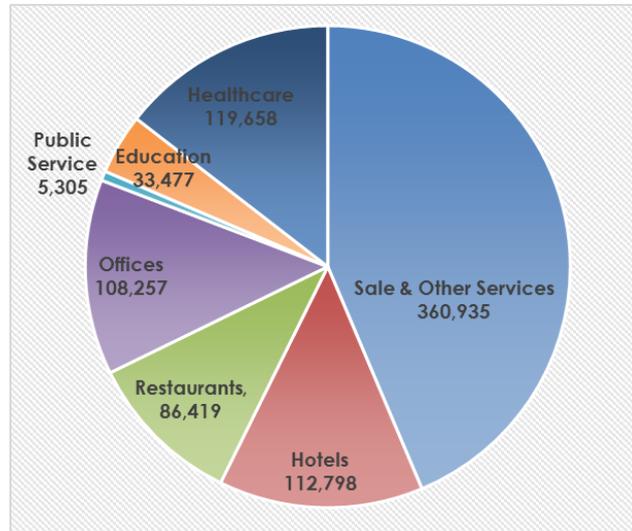
Figure 4-3   Diesel Consumption by Economic Activity (2012)

The sales and other services economic category consumes on average more than 375,000 tonnes of diesel oil per year, which is the highest share, contributing to 1,194,948 tonnes of CO_2.

4.3 OVERALL ENERGY CONSUMPTION
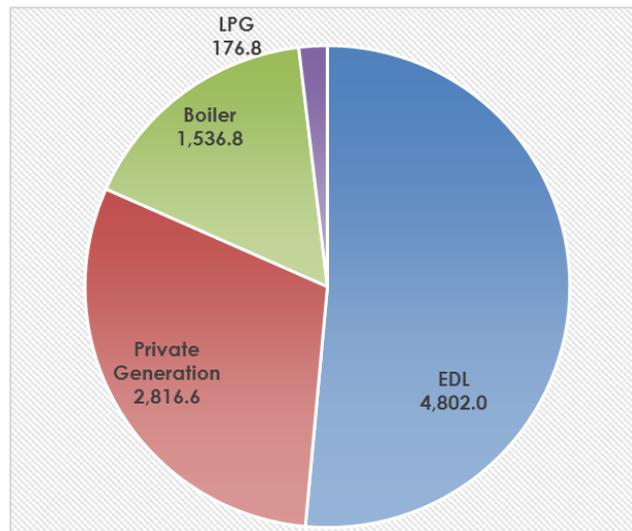
Figure 4-4   Overall Energy Consumption in GWh in the C&I Sector by Source (2012)

Around 9,332 GWh is consumed annually by the commercial and institutional sectors, including EDL electricity, privately generated electricity, thermal energy for boilers, and LPG. Electricity consumption has the largest share with more than 80% of the overall sectors'

consumption (7,619 GWh). On the other hand, thermal energy consumed 1,536.8 GWh while LPG had a consumption of only 176.8 GWh. The combined sectors' energy consumption lead to about 5.703 million tonnes of CO_2.
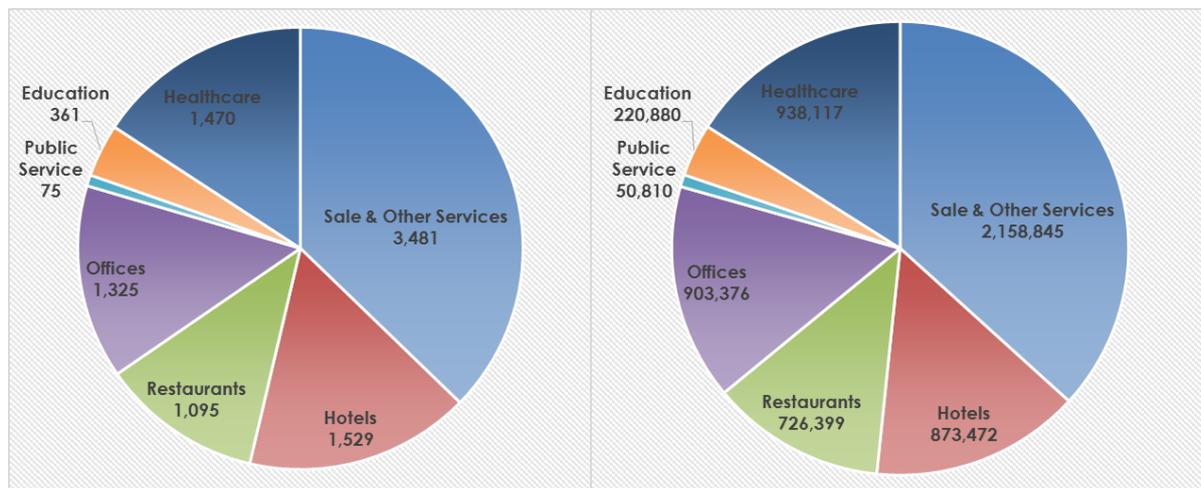
Figure 4-5   Overall Energy Consumption in GWh (left) and Carbon Emissions in tCO$_2$ (right) in C&I Sector by Economic Category (2012)

The sales and other services economic category is the largest consumer with an average of 3,481 GWh per year, contributing to 2,158,845 tonnes of CO_2.

Analyzing the above figure, it is seen that both the energy consumption and CO_2 emissions pie charts have similar pattern with slight changes in shares. As an example, the health care sector represented 15.75% of the total energy consumption and 15.98% of the CO_2 emissions, while offices had an increase of the percentage from 14.19% to 15.38%, restaurants also increased from 11.72% to 12.37%, while hotels dropped from 16.37% to 14.88%.

These changes and trends are directly linked to the levels of boiler's fuel consumption in facilities as the boiler's emission rate per kWh is much lower (around 0.35 tCO$_2$ per MWh) compared to those of diesel generators (0.74 tCO$_2$ per MWh) and EDL (0.66 tCO$_2$ per MWh). Accordingly, facilities consuming more fuel oil for boiler usage will have a lower emission rate per energy production. This is clearly reflected in health care and hotels that are known to have higher consumption rates of diesel for water heating and steam boiler applications.

4.4 ENERGY CONSUMPTION PER HOUR OF OPERATION

Considering the operational profile of studied facilities including operating hours and weekly schedule, a consumption per operating hours analysis is performed for the different economic activities related to electricity consumption including EDL and private generation, and also related to diesel boiler and LPG consumption.

Analysis is performed differentiating between small scale and large scale facilities to give more representative results.

Offices might not be the highest consumers of electricity as a whole, but because of their limited operating hours, their consumption per hour turns out to be the highest. Comparing

this to healthcare facilities that mainly operate 24/7, a large-scale office consumes more than 4 times what a hospital normally consumes.
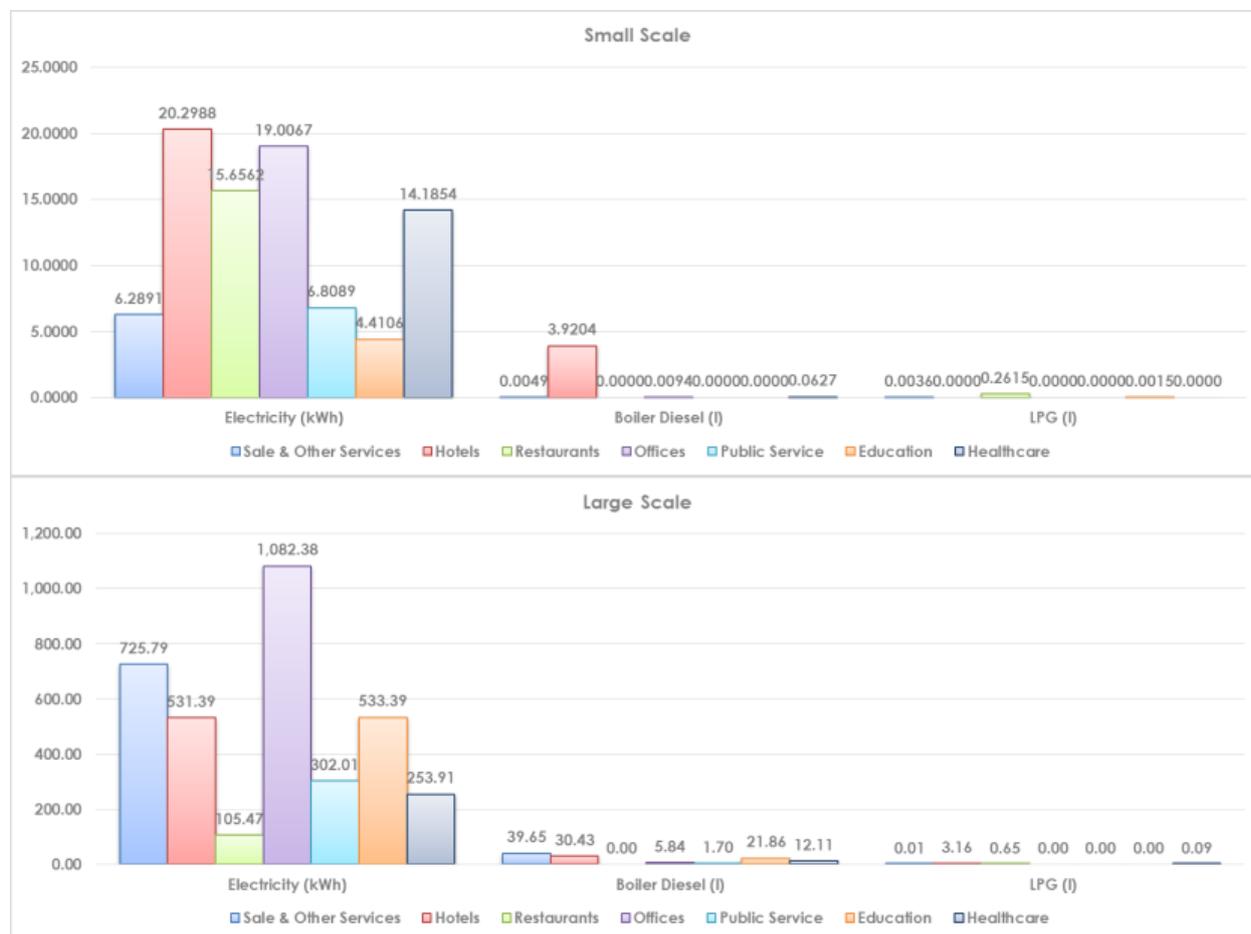

Figure 4-6   Energy Consumption per Operational Hours for Different Economic Categories and Different Scales

4.5 INDICATORS

This study allows for the establishment of energy performance indicators for the Lebanese commercial and institutional sector. Three main facility types are considered and analyzed to achieve benchmarking indicators.

- Hotels: analyzed against number of rooms

- Hospitals: analyzed against number of beds

- Universities: Analyzed against number of students.

For hotels, 26 facilities in different regions were considered, leading to an average consumption of 36.24 MWh per year per room. However, it is to be noted that there are large variations among properties with some reaching more than 100 MWh per room per year while others had related values as low as 1 MWh.

This large variation among hotels properties was seen to be correlated with their ratings; 5-star hotels were noticed to have the highest energy consumption per unit as compared to 4- and 3-star hotels.
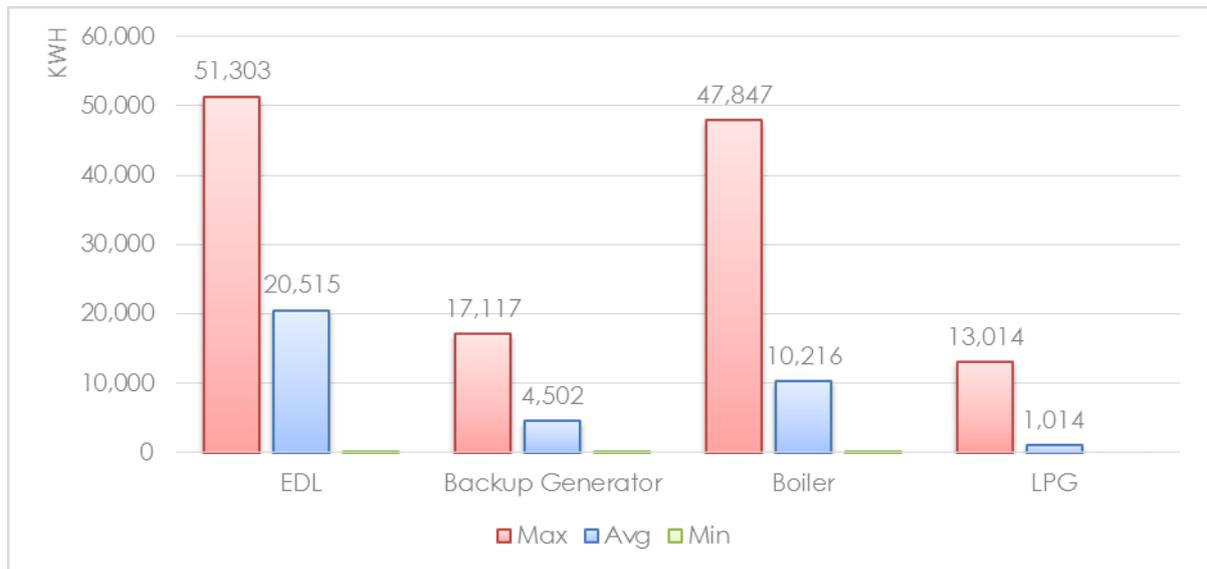
Figure 4-7   Average Energy Consumption per Room in Hotels (2012)

As for hospitals, a total of 24 facilities were analyzed with capacities ranging from 20 to more than 500 beds.

The analysis showed an average energy consumption of around 20 MWh per year distributed among diesel, EDL, and LPG.

There is no pattern in the consumption rates by climatic zoning or geographic location, but it is obvious that hospitals with large service areas and advanced facilities hit the top of the range with highest consumption rates per bed.
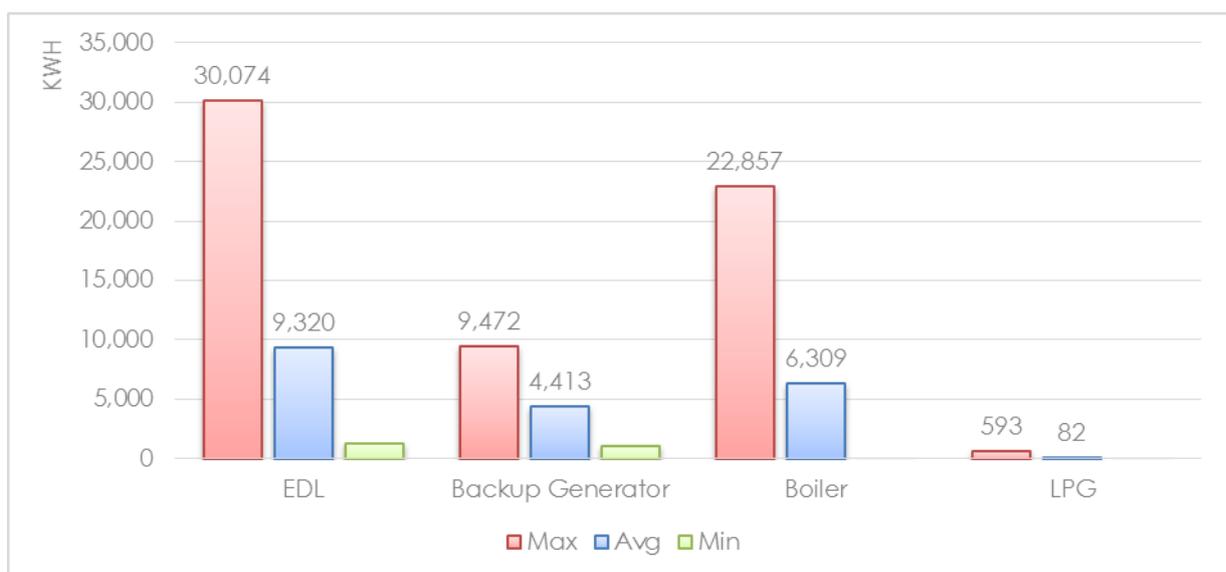
Figure 4-8   Average Energy Consumption per Bed in Hospitals (2012)

Seven universities were studied, namely the Lebanese Univeristy (LU) - Agriculture Branch in Dekwaneh, Alba University, Notre-Dame University (NDU) in Zouk Mosbeh, Université Antonine, Université du Saint Esprit Kaslik (USEK), Lebanese University- Hadath Campus, and Beirut Arab University (BAU). These host all together more than 45 thousand students according to 2011 data published by CAS.

Universities have a lower energy consumption rate per unit as compared to hospitals and hotels, with a yearly average of 714 kWh per student.
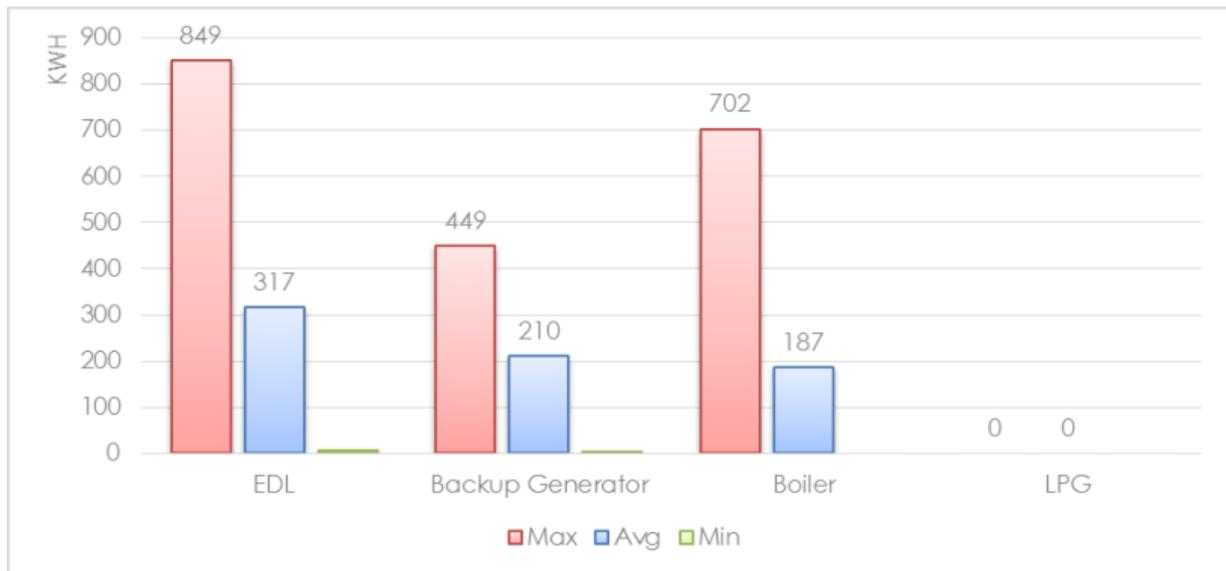
Figure 4-9   Average Energy Consumption in kWh per Student per year in Universities (2012)

When it comes to diesel consumption per unit, hotels have the highest rate with 2,183 liters of diesel per room, and emit around 21 tonnes of CO_2 from diesel, LPG and EDL. A hospital emits 11.6 tonnes of CO_2 per bed and requires 1,729 liters of diesel per year per bed on average.
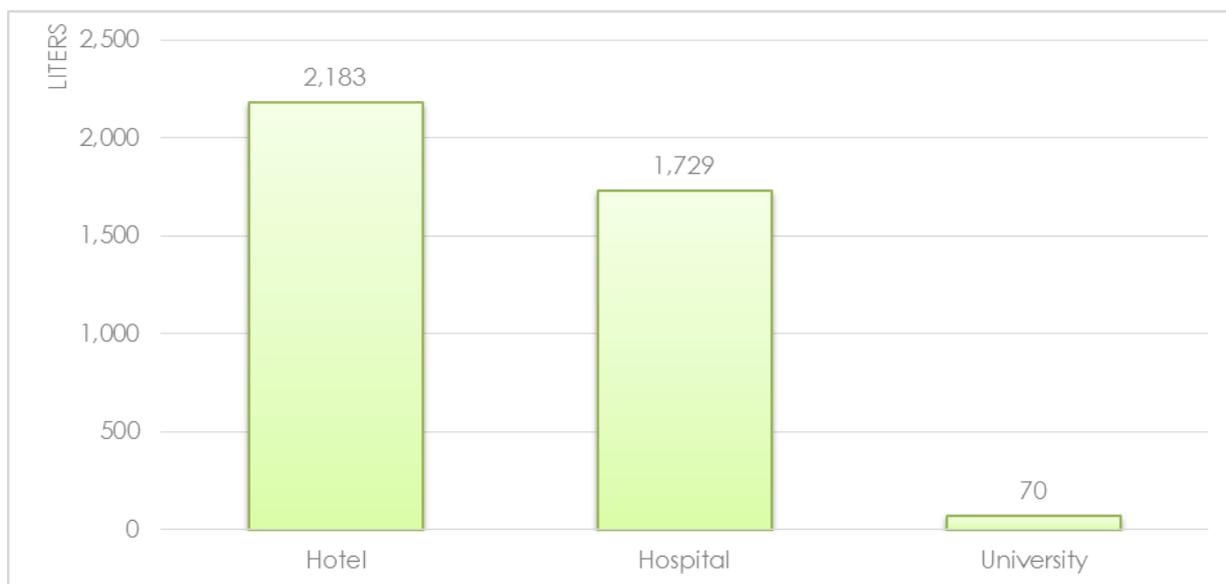
Figure 4-11   Average CO2 Emissions per Working Unit in tonnes per Year

As for the heating and cooling loads, it has been obvious that the cooling load is the highest in the coastal climatic zone, which also features low heating load compared to other zones; Heating peaks in zone two followed by zone three.
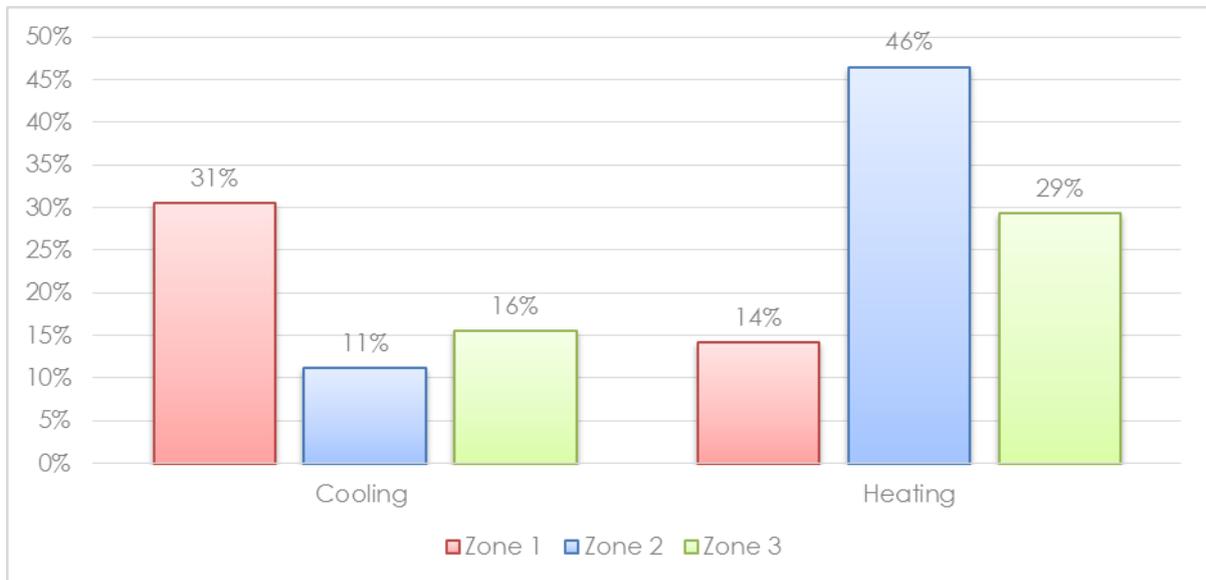
Figure 4-12   Cooling & Heating Load Share of Overall Energy Consumption for Different Climatic Zones

5. TREND ANALYSIS

Energy consumption growth trend is studied reversely, starting with the results reached for 2012 and going back by years to reach 2004.

Building on the same methodology followed in the extrapolation part, reverse analysis is performed to achieve the energy consumption and GHG emissions based on the number of establishments in each district and economic activity category (Figure 5-1).

	2004	2005	2006	2007	2008	2009	2010	2011	2012
LPG	177	178	179	181	182	183	184	185	186
Boiler	1403	1429	1454	1479	1505	1530	1555	1581	1606
Private Generation	2542	2592	2641	2691	2740	2789	2839	2888	2938
EDL	4406	4481	4556	4631	4707	4782	4857	4932	5007

	2004	2005	2006	2007	2008	2009	2010	2011	2012
LPG	87850	88383	88916	89448	89981	90514	91047	91580	92112
Boiler	495385	504324	513262	522199	531137	540074	549010	557946	566882
Private Generation	1883727	1920340	1956953	1993565	2030177	2066789	2103401	2140013	2176624
EDL	2894696	2944082	2993467	3042850	3092232	3141612	3190991	3240368	3289744

Figure 5-1   Energy Consumption (Top) and GHG Emissions (Bottom) in the C&I Sector (2004-2012)

The energy consumption is growing annually, at rates varying from 1.6% to 1.8% as presented in Figure 5-3.
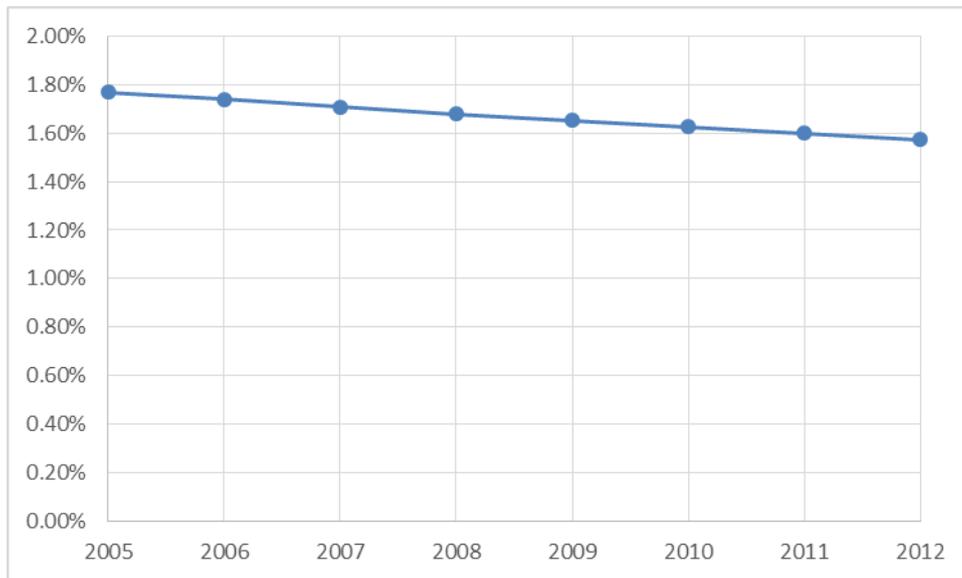
Figure 5-2   Energy Consumption Growth per Annum in the C&I Sector (2004-2012)

The energy consumption in the commercial and institutional sector has grown by 14.15% from 2004 to 2012, with variations among sub sectors' activities.

Sales and Other services share increased from 32.4% to 37.2%, while offices increased from 13.8% to 14%. The remaining economic activities decreased in the related share as compared to the overall energy consumption in the C&I sector. Numbers and shares are presented in Figure 5-3 and Figure 5-4.

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Healthcare	1,502	1,507	1,513	1,518	1,523	1,529	1,534	1,540	1,545
Education	379	379	379	380	380	380	380	380	380
Public Service	76	76	76	76	76	76	76	76	76
Offices	1,176	1,199	1,222	1,246	1,269	1,292	1,316	1,339	1,362
Restaurants	1,122	1,126	1,129	1,133	1,136	1,140	1,144	1,147	1,151
Hotels	1,518	1,529	1,540	1,551	1,561	1,572	1,583	1,594	1,604
Sale & Other Services	2,761	2,869	2,976	3,084	3,192	3,300	3,407	3,515	3,623

Figure 5-3   **Energy Consumption in the Different C&I Sector Economic Categories (2004-2012)**
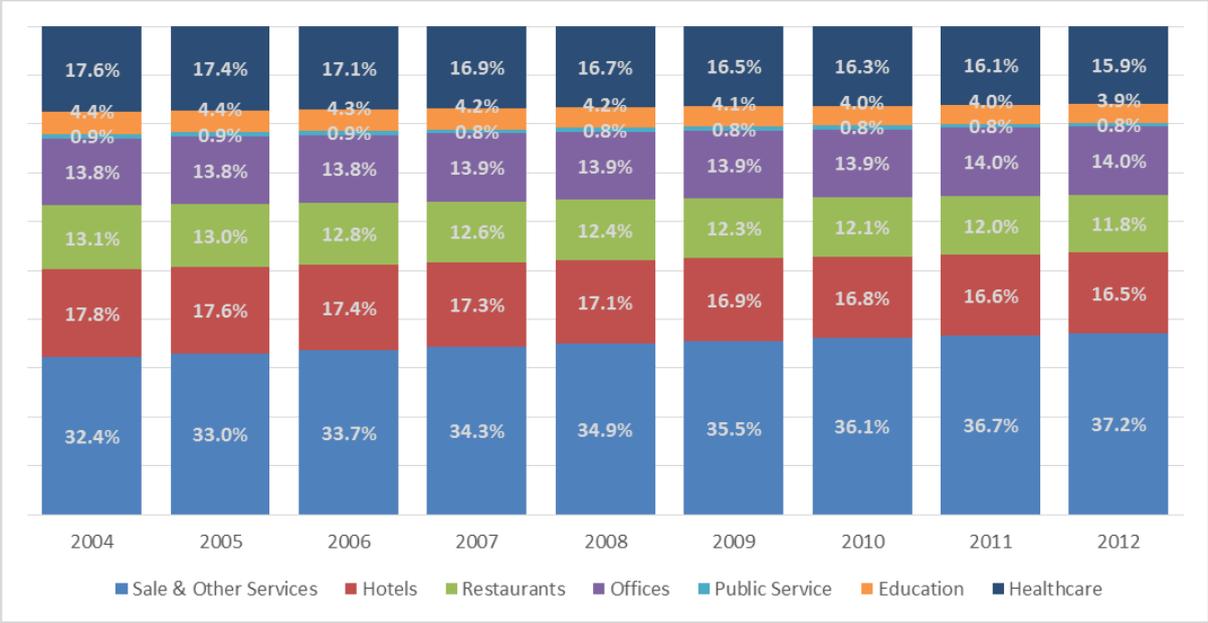
Figure 5-4   **Energy Consumption Share Evolution in the Different C&I Sector Economic Categories (2004-2012)**

6. REFERENCES

[1] CAS (2004). Census of Buildings Dwellings and Establishments 2004. Accessed on January 2015 at: http://www.cas.gov.lb/images/Excel/CBDE-2004.xls

[2] Central Administration of Statistics. (2015). Monthly data Matrix Webpage. Accessed on January 2015 at: http://www.cas.gov.lb/index.php/monthly-data-matrix

[3] Central Administration of Statistics (2008). Lebanese Economic Activity Classification. Accessed on January 2015 at: http://www.cas.gov.lb/images/PDFs/ISIC.zip

[4] UNDP/GEF and MoPWT/DGUP. Thermal Standard for Buildings in Lebanon. 2005.

[5] United Nations Climate Change Secretariat (2000). Emissions Summary for Lebanon..

[6] ALMEE (2001).   Energy in Lebanon: Facing the 3rd millennium.   A bulletin published by ALMEE in July 2001.

[7] Matar, G. (2014, July 20). التخطيط الدقيق والدراسة الموسعة أساس النجاح :جاد داغر. Retrieved from http://www.ra2ed.com/رواد-الاعمال/أساس-النجاح رواد-الاعمال-الموسعة-والدراسة-الدقيق-التخطيط-داغر-جاد/24740/

7. APPENDICES
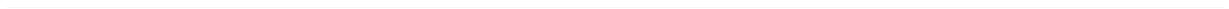
APPENDIX A: QUESTIONNAIRE
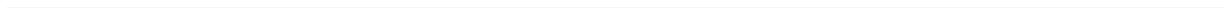
R	Reference	

General Information

Name of institution			
City/Village		Type of property	1. Hospital 2. Healthcare 3. Educational 4. Governmental 5. Other:_____
Contact person			
Phone number			
Built up surface of property (m^2)			

Regular Working Hours per Season

	Winter	Summer
Weekdays		
Saturdays		
Sundays		

Energy Consumption

1. Energy: Electricity and Thermal

EDL
What is the type of EDL tariff used?
1. Residential tariff
2. Triple tariff
3. Special tariff for Public sector/ small hotels
Annual electricity consumption from EDL (KWh or LBP)
2011 _____
2012 _____
Subscribed power at EDL:_____

Total Annual Fuel/Gas Consumption

		2011	2012
1. Diesel consumed on owned generators			
2. Fuel/Gas consumed on boilers			
3. Gas (LPG) consumed for other services (e.g., Kitchen …)	Number of gas tanks used per year		
	Size of gas tank (10 kg or 50 kg?)		

Approximate daily hours of power failure by season

Summer	_____ hours
Rest of the Year	_____ hours

Generator

Onsite own installation

1. No
2. Yes, Please specify:
   Number:_____
   Power Rating (kVA):_____

Subscribed generators

1. No
2. Yes, Please specify:
   Subscribed power (Amps):_____

2. Transportation

Do you have your own fleet of cars or buses?

1. No
2. Yes, Please specify Number of Buses: _____
   Number of Cars: _____

Total fuel consumed for the fleet service by type of fuel:

	2011	2012
Gasoline for vehicles		
Diesel for vehicles		
Diesel for On-site machinery/equipment (forklifts, cranes, etc)		

3. Energy Efficiency Measures Undertaken

Have you tried to implement measures to reduce your electricity /fuel costs?

1. No

2. Yes, Please select the measures from the list below and specify year, budget and source of funding

Measure undertaken to reduce the company/ institution's electricity bill	Year undertaken	Budget (USD)	Source of funding
1. Lighting retrofit (installation of CFL or LED)			
2. A/C retrofit (replacing old A/C by more efficient one)			
3. Installation of Solar Hot Water Systems			
4. Other: please specify:			

What are the barriers that have prevented you from investigating or implementing energy efficiency measures?

1. None   2. Financial   3. Technical   4.Other: _____

Are you aware of Energy and Green loans available through local banks?

1. No   2. Yes

4. Reporting Energy Consumption

Are you willing/ capable to participate in a voluntary external reporting system of energy consumption to the Ministry of Environment on a yearly basis?

1. No   2. Yes

What are your preferred methods of reporting your establishment/ institution's energy consumption?

1. Online
2. By hand
3. Along with other reporting mechanisms
4. In a stand-alone process
5. Other:_____

From the below measures for enhancing the collaboration with public sector, which would you select?

1. Establish a hotline and online system to handle questions and complaints and track progress
2. Establish an Energy Council to enhance collaboration and action between the public and private sectors
3. Organize regular formal/informal roundtable discussions between stakeholders from the public and private sectors to discuss energy and environmental issues and potential solutions
4. Ensure effective compliance and enforcement
5. Promote environmental awareness
6. Other: _____

Which incentives would you suggest for encouraging commercial and institutional establishments to report their energy consumption to the Ministry of Environment?

1. Award certifications
2. Publish a list of all green-friendly establishments for their reporting efforts
3. Grant financial incentives in the form of tax deductions
4. Grant deductions on electricity tariffs
5. Other:_____
   _____
   _____
   _____