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THE FIRST ENERGY INDICATORS REPORT OF THE REPUBLIC OF LEBANON

LEBANESE REPUBLIC
MINISTRY OF ENERGY AND WATER

LCEC
LEBANESE CENTER FOR ENERGY CONSERVATION
المركز اللبناني لحفظ الطاقة

Credits

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List of symbols

BDL	Central Bank for Lebanon
CAS	Central Administration of Statistics
CDD	Cooling degree day
DHW	Domestic Hot Water
EDL	Electricite du Liban
GDP	Gross Domestic Product
GEF	Global Environmental Facility
HDD	Heating degree day
LARI	Lebanese Agricultural Research Institute
LCEC	Lebanese Center for Energy Conservation
MENA	Middle East and North Africa
MER	Market Exchange Rate
MEW	Ministry of Energy and Water
MoE	Ministry of Environment
NEEAP	National Energy Efficiency Action Plan
NREAP	National Renewable Energy Action Plan
OEA	Order of Engineers and Architects
PD	Petroleum Directorate at MEW
UNDP	United Nations Development Programme

Definitions

Mohafaza: Lebanon is divided into six administrative regions called Mohafaza

Caza: Each Mohafaza is divided into districts called Caza

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INTRODUCTION AND CONTEXT OF THE REPORT

In 2009, the Lebanese Government committed to reducing the country's energy consumption through energy efficiency policies and initiatives. The Government also committed to increasing the share of renewable energy to 12% of the total electricity and heating demand by the year 2020.

This commitment is reiterated in several publications of the Lebanese Ministry of Energy and Water, namely the policy paper of the electricity sector published in 2010, the First National Energy Efficiency Action Plan (NEEAP) 2011–2015; NEEAP 2016-2020; and the National Renewable Energy Action Plan (NREAP) 2016–2020.

However, to be able to monitor and control progress toward meeting the national objectives, a clear methodology needs to be applied. In addition, international organizations and bodies have set a number of indicators for measuring energy production and consumption, as well as energy efficiency. The First Energy Indicators Report of the Republic of Lebanon is written to address all the indicators needed to reflect energy consumption in Lebanon in all its different aspects. The report also discusses a number of energy efficiency indicators that inform and influence the development of national policies year after year.

The First Energy Indicators Report of the Republic of Lebanon shows how the intensity of energy use and its components are changing. It raises public awareness about how and why energy intensity has changed over the years. The report complements other inputs to policy and program analyses, including improved understanding of the impact of program and policy choices on energy intensity. It also sheds light on the role of efficiency improvements in changing energy markets.

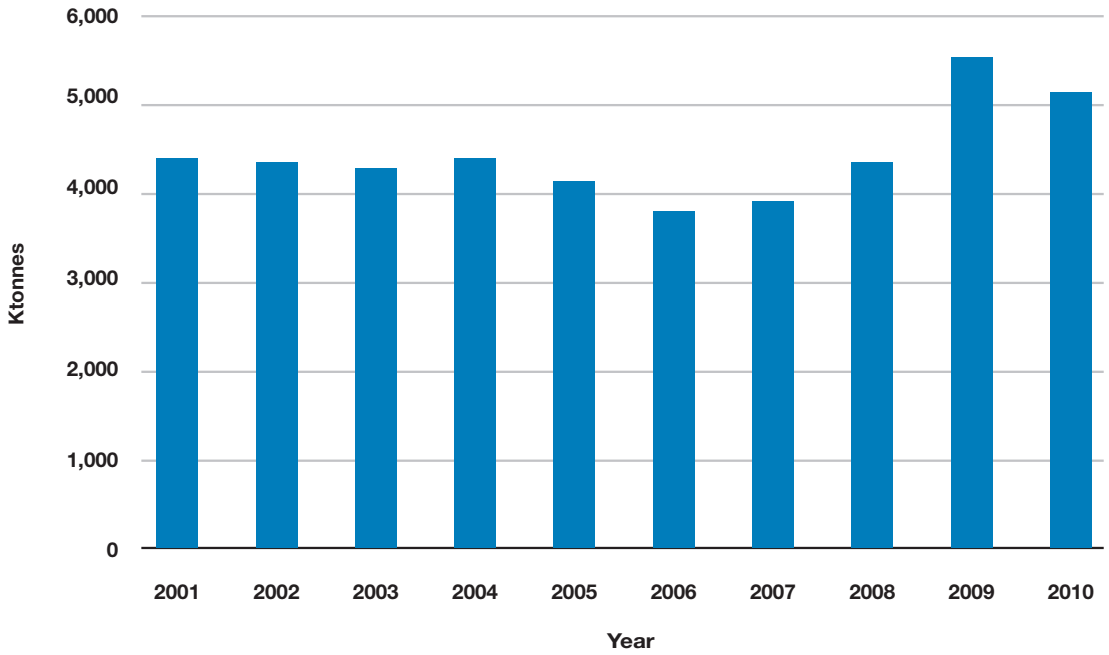
This report is divided into four main sections. The first section shows the history of energy consumption between 2001 and 2010. The second section explains the methodology used to extrapolate missing data regarding climatic zoning and the building sector in Lebanon. The third section details the results and analyses of energy demand in each sector, and the final section includes the energy indicators as per the International Energy Agency template.

1. A BRIEF HISTORY 2001–2010

This section presents a brief overview of energy consumption in Lebanon for the years 2001–2010. Lebanon's national energy bill is the total cost paid annually by the Lebanese Republic for all fuel imports to Lebanon (fuel oil, gas oil, kerosene, liquid gas, gasoline and asphalt). The values used in this section are supplied by the Ministry of Energy and Water's Directorate of Oil and Electricite du Liban.

The annual total petroleum consumption is the total annual consumption of different petroleum derivatives in Lebanon and it is shown in figure 1 for the years 2001-2010.

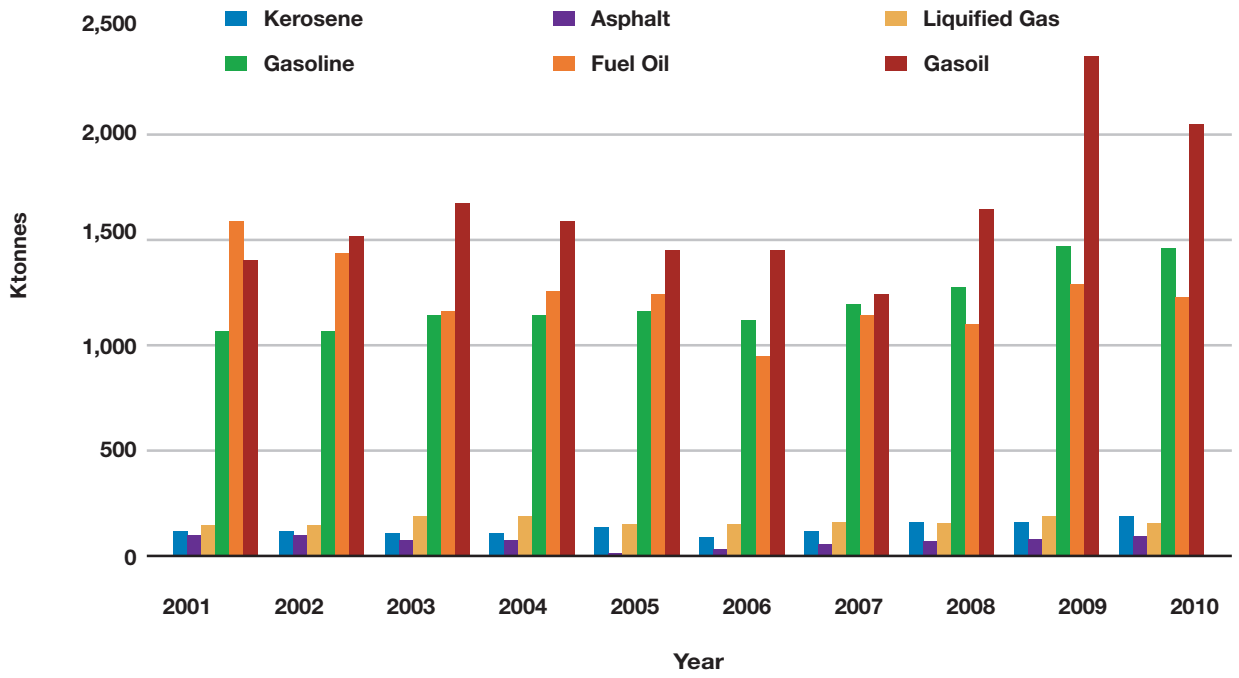
Figure 1:
Total annual petroleum consumption (ktonnes) 2001–2010



Source: MEW

The petroleum derivatives imported include gas oil, fuel oil, gasoline, liquefied gas, asphalt and kerosene. The quantity imported of each of these derivatives is shown in figure 2, below.

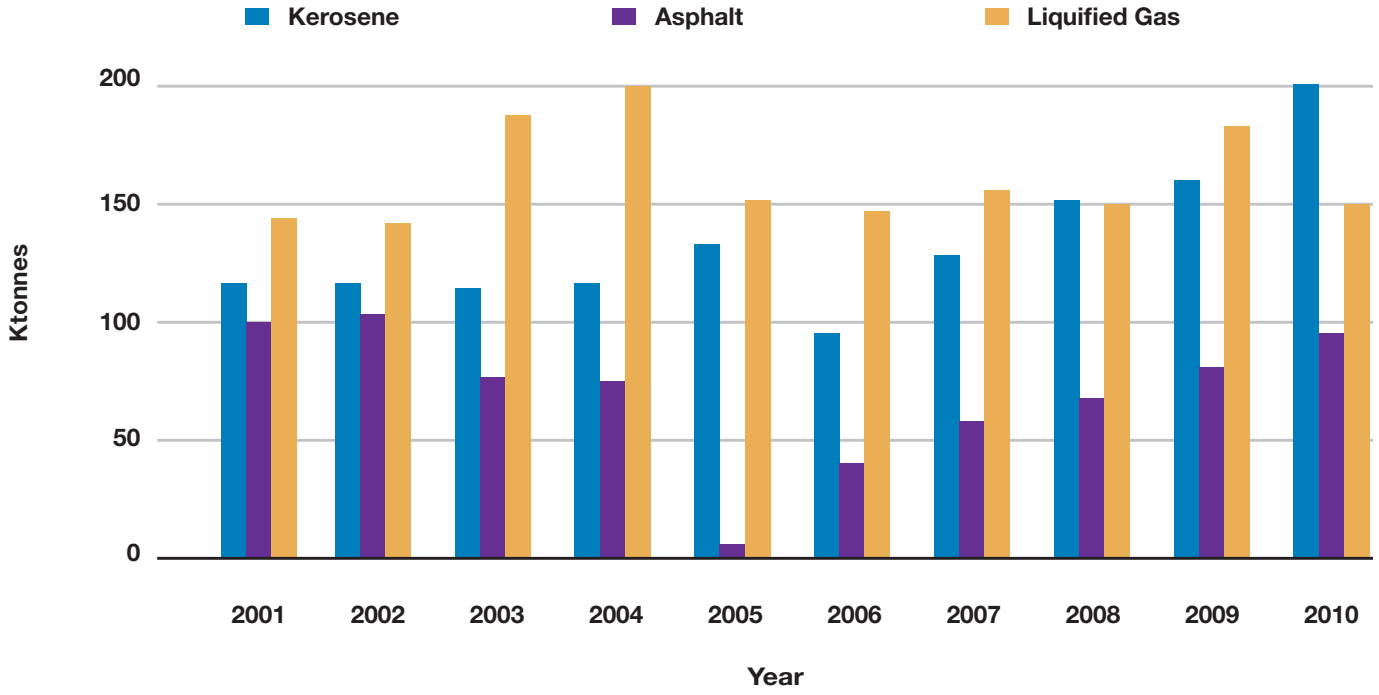
Figure 2:
The quantity imported (ktonnes) of each petroleum derivative 2001–2010



Source: MEW

Figure 3 shows the quantities imported (ktonnes) of kerosene, asphalt and liquefied gas.

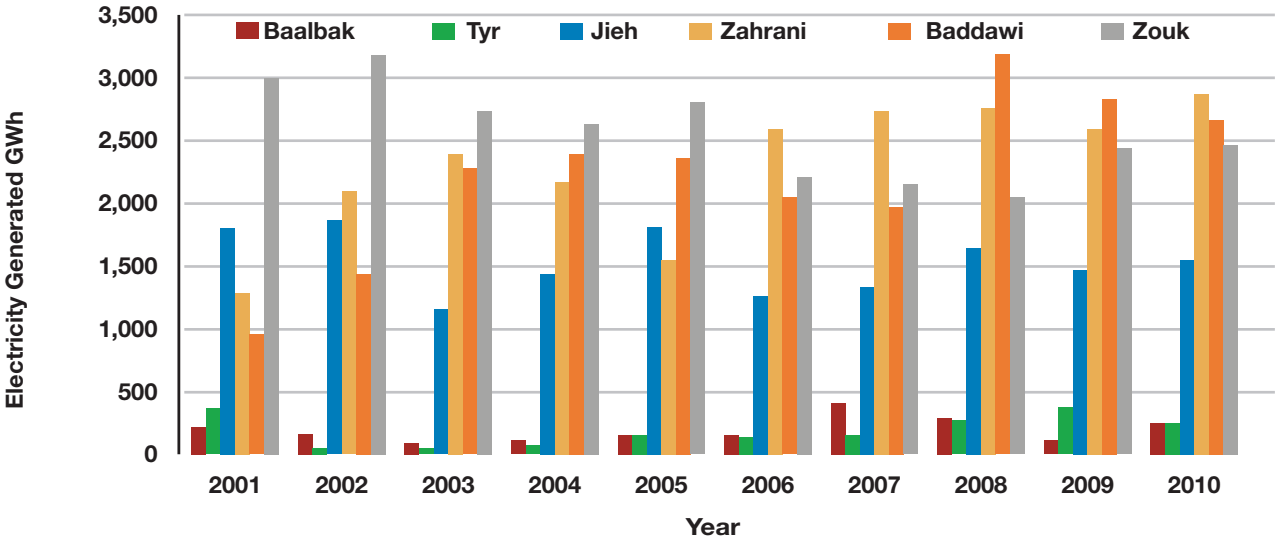
Figure 3:
Quantity imported (ktonnes) of kerosene, liquefied gas and asphalt 2001–2010



Source: MEW

Part of the imported energy is used for electricity generation. The electrical energy generated by conventional thermal power plants is detailed per power plant in figure 4. Zouk power plant was the largest producer of conventional electricity in Lebanon until 2005. It was surpassed by the Badawi power plant, which reached a peak of 3,169 GWh in 2008.

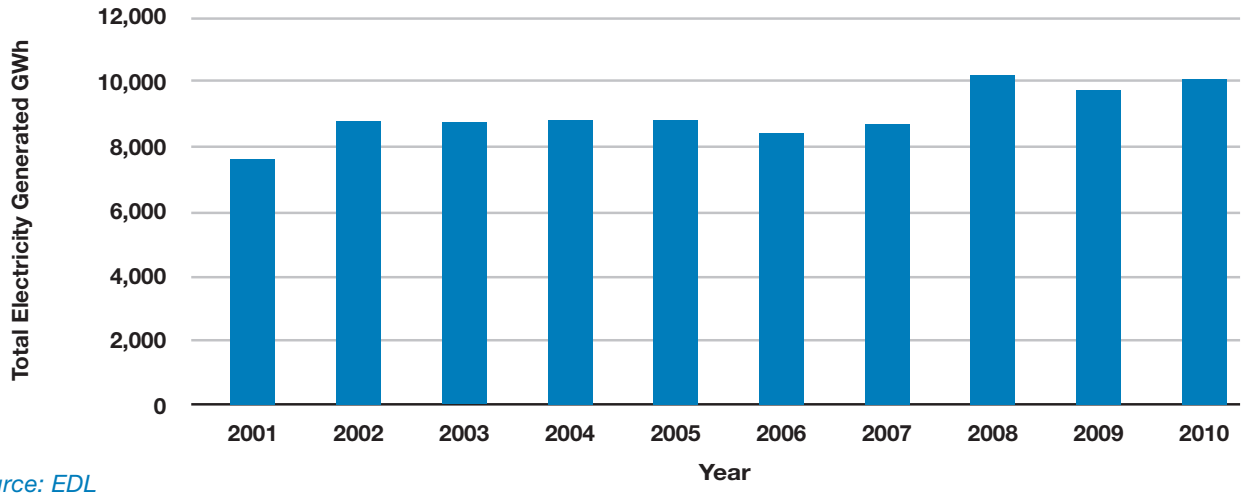
Figure 4:
Electricity generated (GWh) at each thermal power plant 2001–2010



Source: EDL

Figure 5 represents the total annual amount of electricity (measured in GWh) generated by power plants owned and operated by EDL. Total electricity generation reached its highest level in that period, 10,140 GWh, in 2008.

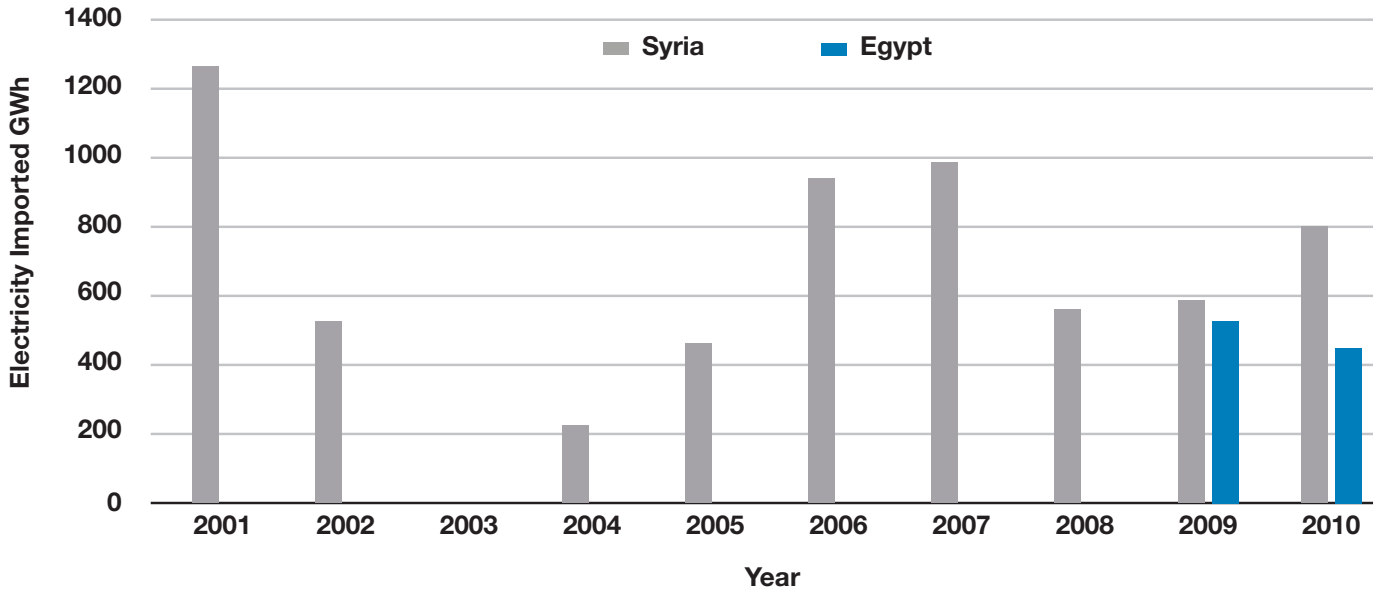
Figure 5:
Total electricity generated annually (GWh) by EDL 2001–2010



Source: EDL

Lebanon also imports electricity from Syria and Egypt, and figure 6 below shows that the amount of power imported from Syria has decreased from 1,271 GWh in 2001 to 563 GWh in 2008.

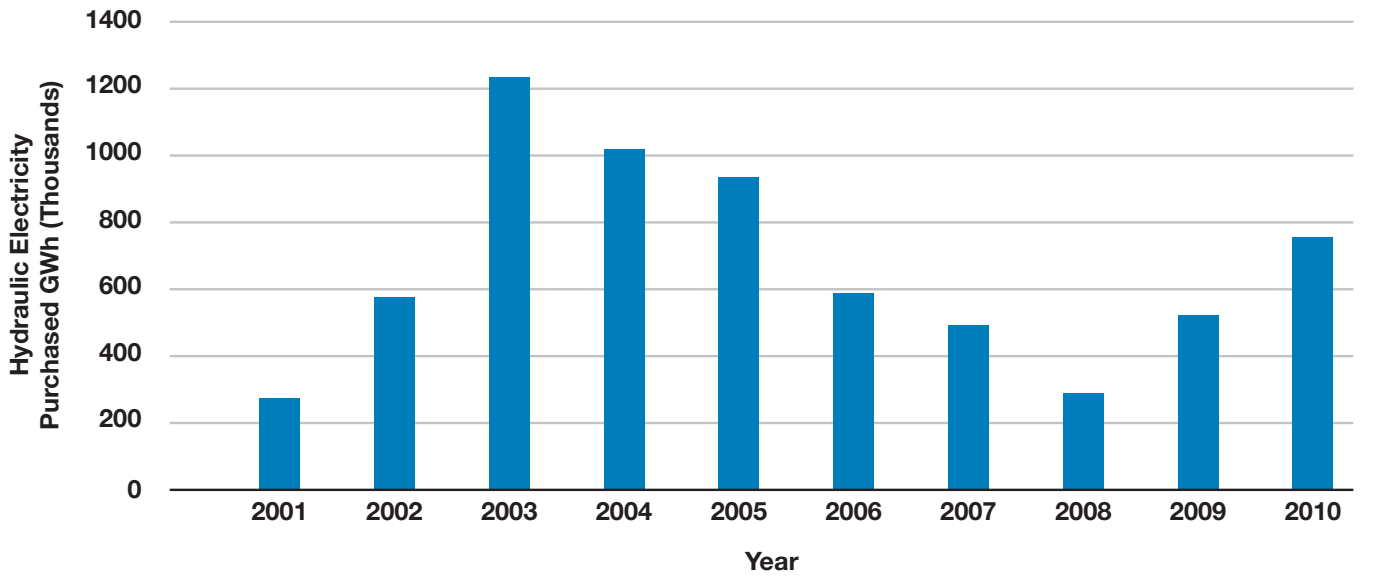
Figure 6:
Electricity imported (GWh) 2001–2010



Source: EDL

Total hydraulic electricity represents the total electrical energy generated from hydraulic power plants. In Lebanon, this covers the electricity generated by EDL and the electricity purchased by EDL from different national producers (Litani, Nahr Ibrahim, Bared, Safa). A peak of 1,280.33 GWh was recorded in 2003. Figure 7 shows the total hydraulic electricity purchased, which is the electrical energy generated from hydraulic power plants in Lebanon and purchased from different national producers (Litani, Nahr Ibrahim, Bared).

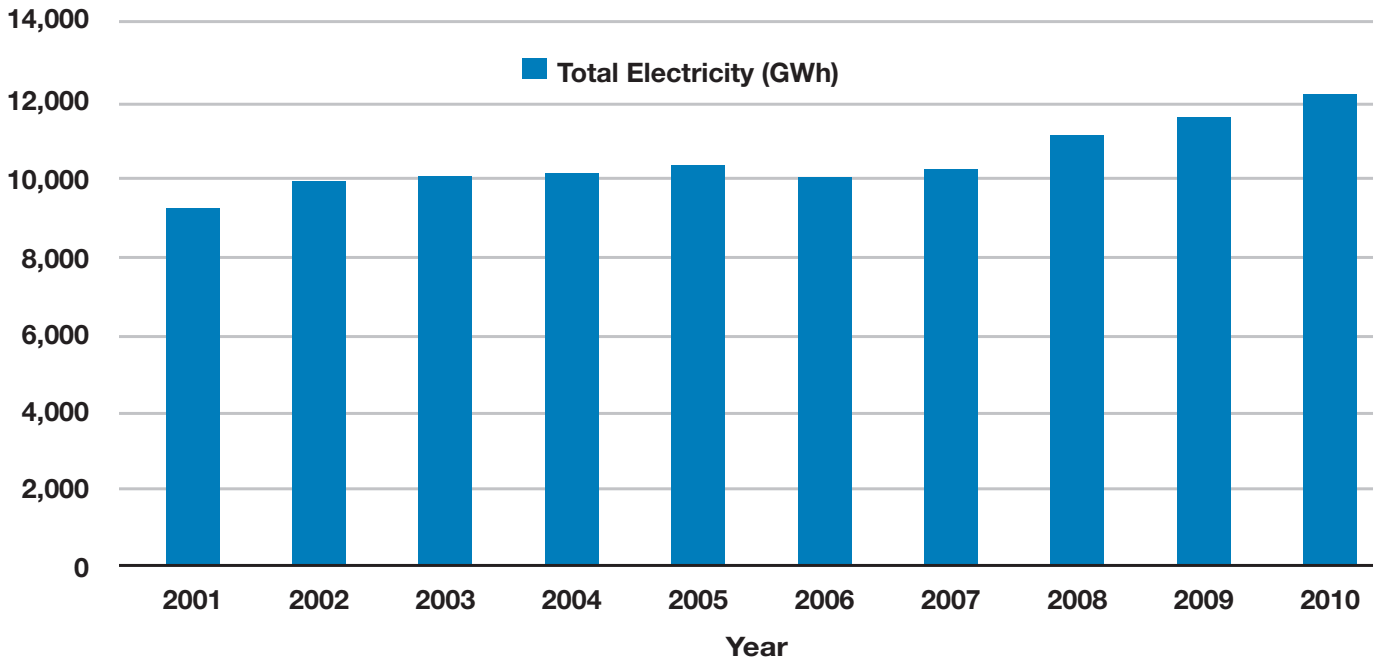
Figure 7:
Hydraulic electricity purchased (GWh) by EDL 2001–2010



Source: EDL

Total electricity generation, shown in figure 8, is the total electrical consumption in Lebanon, covering both the electricity generated by EDL and the electricity purchased by EDL from both national and international producers (Hrayche station is excluded due to a lack of data).

Figure 8:
Total electricity generation (GWh) 2001–2010



Source: EDL

2. METHODOLOGY

A bottom-up approach is used to define Lebanon's energy balance in recent years (2010–2015). First, the final energy demands for electricity and heat are calculated by sector. The primary energy demand is then calculated.

The final consumption of electricity and heat represents the sum of electricity and heat consumed in industry, transport, agriculture, commercial/public services and residential sectors.(1)

Lebanon, like most MENA countries, suffers from lack of data and statistics. Thus, the methodology of calculations is based on assumptions correlated to real data.

This chapter addresses the final energy demand in electricity and heat. This demand is directly related to the climatic data, especially for the main five usages: heating and humidification, cooling and dehumidification, ventilation, lighting and domestic hot water.

The first part of this section discusses the update of the Lebanese climatic data by climatic zone. It is followed by a building sector data update, regarding the number of units and dwellings as well as square meters constructed between 2005 and 2015.

Then, it discusses the energy consumption and usage in each climatic zone, drawing on previous studies and updated data.

2.1 Climatic data

The Climatic Zoning Study performed in 2005 resulted in the definition and delineation of four climatic zones that represent the range of thermal energy requirements for buildings in Lebanon. Lebanon includes four zones. The coastal zone is divided into two subzones, one subzone above and the other below 200 m.(2)

Table 1: Approximate altitude and degree-day threshold for four zones [2]

Climatic zone	Approximate altitude range	Approximate HDD (18) and CDD (21) thresholds
Zone 1 (coastal)	**0–700 m**	**300 < HDD < 1 200 120 < CDD < 1 050**
Zone 2 (western mid-mountain)	**700–1 400 m**	**1 200 < HDD < 2 000 0 < CDD < 600**
Zone 3 (inland plateau)	**700–1 150 m**	**1 200 < HDD < 1 800 120 < CDD < 600**
Zone 4 (high mountain)	**Littoral side +1 400 m**	**HDD > 200 CDD=0**
	Inland side +1 150 m	**HDD > 1 800 0 < CDD < 120**

The Lebanese Agricultural Research Institute (LARI) owns 17 stations across Lebanon that measure weather indicators such as temperature, relative humidity and windspeeds. LARI's files for the years 2009–2014 were processed, and the processing indicated that some files are complete whereas others contain only limited information, especially regarding wind speed and humidity indicators.

The LCEC also acquired 2014 and 2015 weather data from three stations: Beirut Airport, Tripoli and Hoch El Omara.

The heating degree days HDD (18) and the cooling degree days CDD (21) were then calculated for each of the aforementioned 20 weather stations. The highest and lowest values of HDD and CDD were identified for each of the four Lebanese climatic zones.

Figure 9 shows the variation of HDD (18) and CDD (21) for the years 2009–2014 for the Markaba, Tyr and Fanar weather stations in the coastal climatic zone.

Figure 9:
HDD (18) and CDD (21) for three stations in zone 1

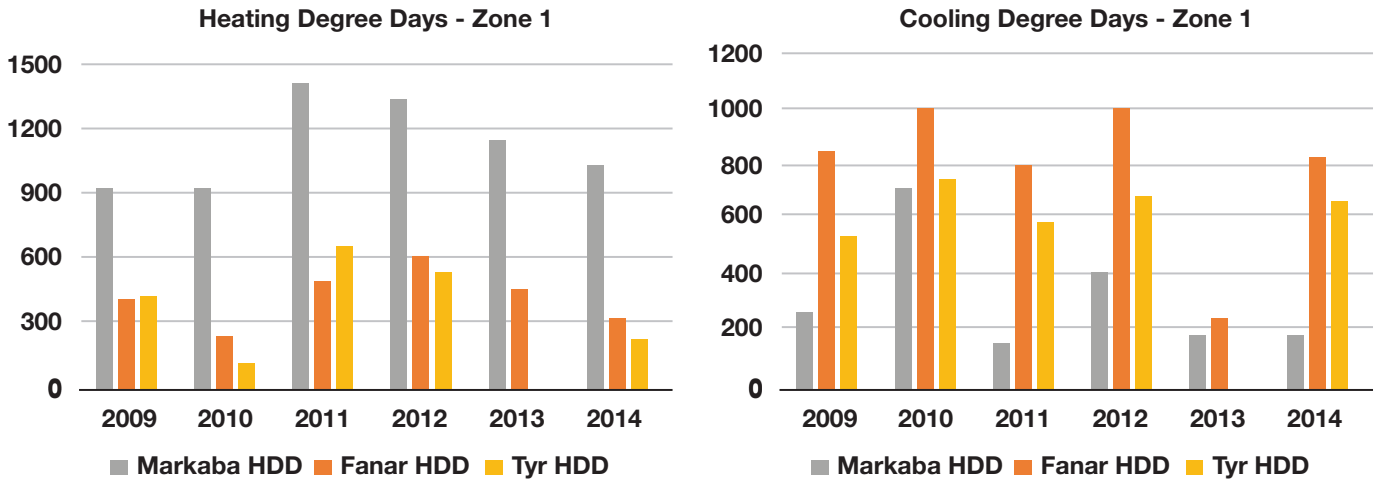


Table 2 and table 3 show the HDD (18) and CDD (21), respectively, for all weather stations in Lebanon from 2009–2015.

Table 2: HDD (18) of all weather stations in Lebanon

Zone 1 (coastal)						
	Fanar	Markaba	Tyr	Nabatiyi	Beirut Airport	Tripoli
2009	403.26	919.76	419.44	844	..	..
2010	246.73	847.65	112.57	613.18	..	..
2011	488.07	1 403.22	646.21	..	..	..
2012	591.3	1 326.74	530.07	1 004.98	..	..
2013	447.4	1 138.61	..	810.43	78.85	163.6
2014	323.1	1024.1	222.3	741.6	170.15	379.45
2015					283	536.3

Zone 2 (Western mid-mountain)				
	Aamatour	Baakline	Ghazir	Mymis
2010	786.71	993.17	760.52	966.14
2011	1 346.55	1 620.74	1 142.93	1 563.41
2012	1 252.30	1 406.82	997.42	1 423.12
2013	880.54	1 297.15	1 045.60	865.63
2014	952.30	1 239	980.70	442.3

Zone 3 (inland plateau)							
	Doures	Hoch Elomara	Jabboule	Kaa	Mashghara	Mansoura	Tal Amara
2010	0	1 477.33	1 221.11	1 108.63	1 235.34	1 104.72	1 449.39
2011	1 883.83	1 002.74	1 752.53	1 628.01	1 628.01	1 600.44	1 940.41
2012	1 880.87	1 250.43	1 607.06	1 154.11	1 677.78	1 474.56	1 796.03
2013	1 879.59	1 092.52	1 639.37	1 438.84	1 598.83	1 403.28	1 637.53
2014	1 313.4	1 585.6	906.7	1 308.5	1 484.6	1 285.9	1 630.7
2015	1 959.1	1 793.8	1 350.1	1 129.4	1 731.3	1 469.9	1 887.7

Zone 4 (High mountain)	
	Akoura
2010	1 603.95
2011	2 491.63
2012	2 247.69
2013	2 051.97
2014	1 769.5

Table 3 : CDD (21) of all weather stations in Lebanon

Zone 1 (coastal)						
	Fanar	Markaba	Tyr	Nabatiyi	Beirut Airport	Tripoli
2009	844.36	259.05	537.62	456.79	..	..
2010	991.92	408.15	744.69	632.19	..	..
2011	796.28	150.28	585.29	..	..	..
2012	991.83	414.92	672.67	549.2	..	..
2013	254.99	182.75	..	435.55	64.75	4.95
2014	830.4	177.7	664.5	422.9	1015.2	799.5
2015					1 811.55	1 454.95

Zone 2 (Western mid-mountain)				
	Aamatour	Baakline	Ghazir	Mymis
2010	501.46	343.73	338.41	485.99
2011	266.81	179.12	183.57	243.22
2012	437.83	307.6	297.57	454.5
2013	267.93	172.02	181.77	72.55
2014	275.6	163	197.4	225

Zone 3 (inland plateau)							
	Doures	Hoch Elomara	Jabboule	Kaa	Mashghara	Mansoura	Tal Amara
2010	0	231.7	539.83	503.5	350.96	659.46	364.82
2011	262.75	347.07	648.35	349.18	349.18	468.34	191.01
2012	322.58	140.94	471.53	542.1	280.36	617.62	306.8
2013	251.83	180.92	360.82	426.92	186.73	496.99	215.98
2014	283	219.7	419.9	448.8	189.7	500.4	257.4
2015	331.5	308.5	411.1	506.7	273.2	607.3	302.9

Zone 4 (High mountain)	
	Akoura
2010	1 603.95
2011	2 491.63
2012	2 247.69
2013	2 051.97
2014	1 769.5

2.2 Statistics on the building sector

The latest data on the building sector dates to 2005 when the Central Administration of Statistics (CAS) published the Census of Buildings, Dwellings and Establishments (CBDE 2004) (3). The census details the types of buildings in each Mohafaza and Caza and the number of buildings for each type.

It also allows for reasonable estimates of the amount that residential construction increased over time in each Caza. However, while it is possible to estimate growth, it is impossible to estimate the residential area absent data on the amount of residential space already present in each Caza.

The objective of this section is to calculate the constructed area per type of building and per Lebanese climatic zone. For the first part, yearly construction permits published by the Order of Architects and Engineers in Beirut and Tripoli (OEA) were used to generate correlations between the number of buildings and the constructed areas to deduce the constructed area for 2004. For the second, the number of square meters for which OEA granted construction permits are added to the year following the construction permit date.

The construction permits given by OEA are divided by usage type: residential, commercial, health and education, hotels, offices (other) and industrial.(4)

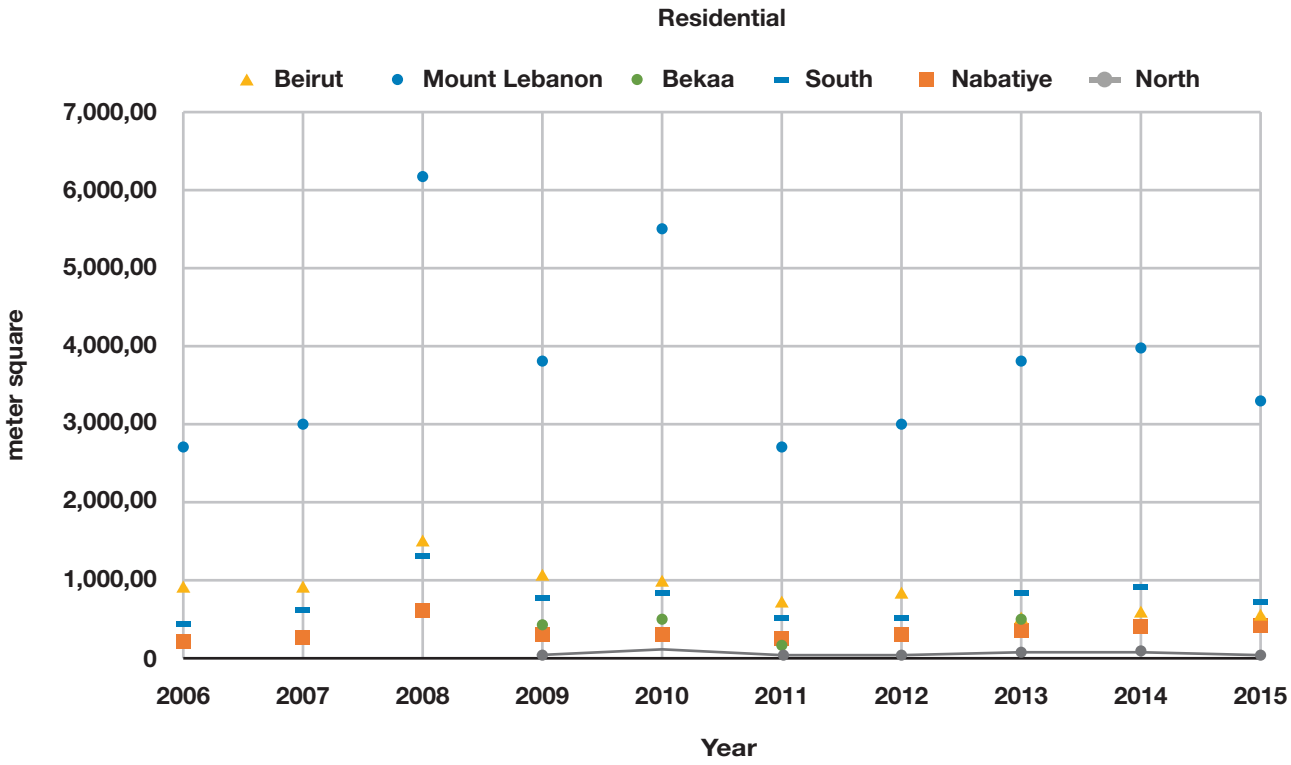
Data on construction permits awarded for residential construction are given in number of units and square meters, and this data was used to find an equivalence between the number of units and the constructed area in each Mohafaza, and to convert the CBDE data from number of buildings into square meters.

The existing area of the other types of buildings is based on the percentages of construction permits of each type, as well as proposed correlations that state the yearly variations in these percentages.

2.2.1 Residential buildings

Figure 10 shows the construction permits given by OEA for residential use in each Mohafaza for the years 2006– 2015. The North of Lebanon data are limited to the construction permits given by OEA Beirut. The area for the North of Lebanon is deduced from the BdL yearly data and the OEA data for later use.(5)

Figure 10:
Construction permitted by OEA for residential use (m²)



Source: OEA

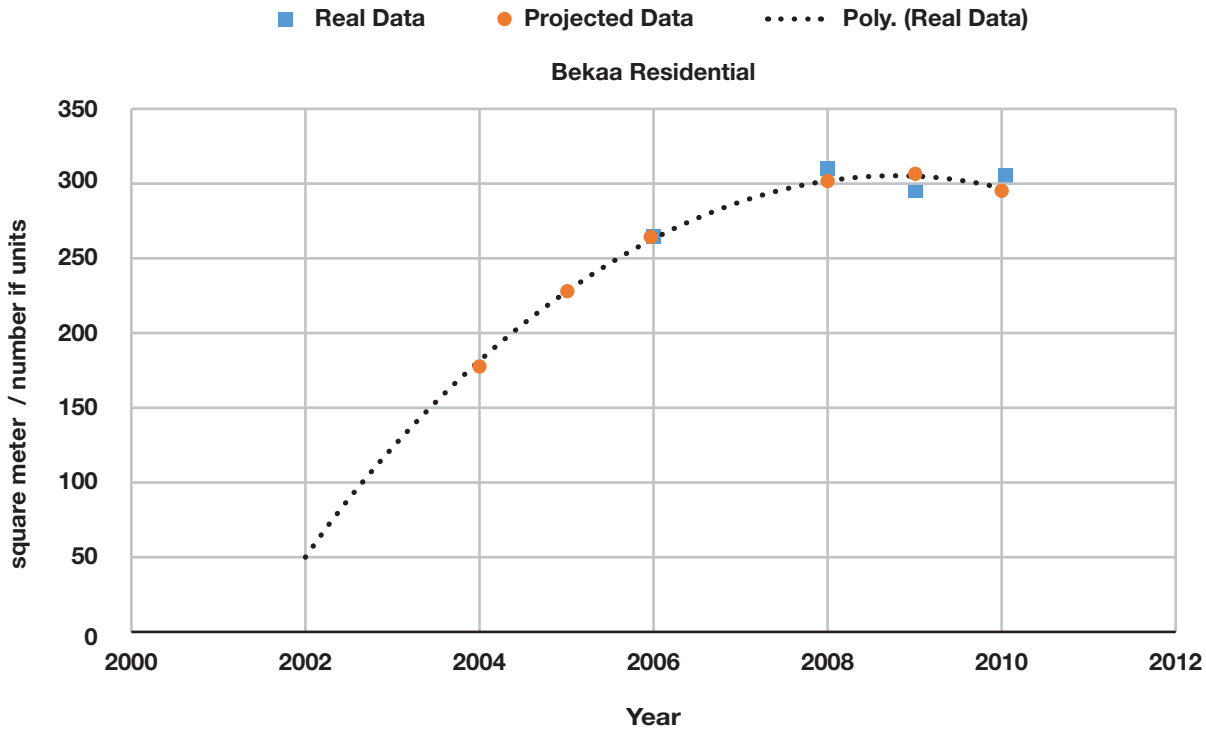
Table 4 shows data published by OEA on construction for residential purposes, including the number of units per Mohafaza that were approved for construction as well as the total area of the units approved. The pattern of equivalence for each Mohafaza is generated from this data.

Table 4 : Number of units granted construction permits in 2013 in each Mohafaza (OEA data)

Unit	Beirut	Mount Lebanon	Bekaa	South	Nabatiye	Total
< 100 m²	66	1 185	39	115	53	1 458
101–150 m²	782	7 177	551	1 422	1 075	11 007
151–200 m²	637	4 073	319	1 082	483	6 594
201–300 m²	419	1 474	93	246	128	2 360
301–400 m²	273	253	6	20	7	559
>400 m²	93	60	----	4	3	160
Individual houses	----	135	71	112	152	470
Villas	----	259	16	75	64	414
Palace	----	----	----	1	----	1
Total area (m²)	391 093	3 795 903	509 573	827 642	371 237	5 895 448

These data are available for the year 2006–2011. A regression for this range of years in each Mohafaza is extended back through 2003 (see figure 11 for Bekaa). The North of Lebanon equivalence is assumed to be similar to the South of Lebanon given that no data (except that on the total area of construction permitted) is available.

Figure 11:
Projected and real data for the equivalence between the number of units and the area for Bekaa



Source: OEA

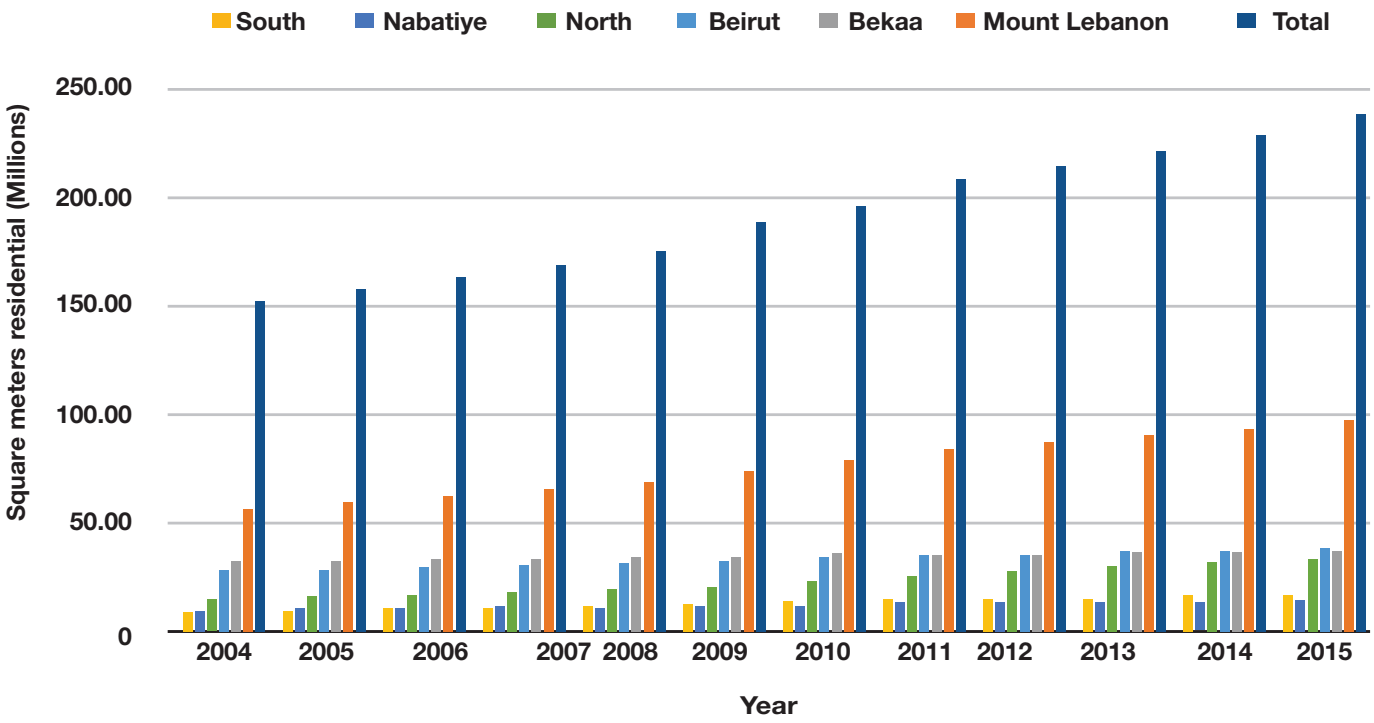
The equivalence between the number of residential units and square meters is calculated using the construction permits. The number of existing residential units is translated into area in table 5, below.

Table 5 : Existing residential area in 2004

Mohafaza/Caza	Units (CAS 2004) (3)	m^2
Beirut	156 801.0	27 918 109.15
North/Mount Lebanon	498 252.0	56 284 977.39
Administrative North Lebanon and Akkar	263 497.0	14 799 604.12
Bekaa	183 041.0	32 833 954.98
South Lebanon	161 786.0	9 086 891.89
Administrative Nabatiyeh	114 068.0	10 056 072.90
Lebanon	1 377 445.0	150 979 610.44

The residential area in 2004 approached 150.9 square kilometers, and the numbers from yearly construction permits are added to the baseline year for each Mohafaza to show the residential built area for each year between 2004 and 2015 in figure 12, below.

Figure 12:
Built area of residential buildings (square meters) in each Mohafaza 2004–2015



2.2.2 Other types of buildings

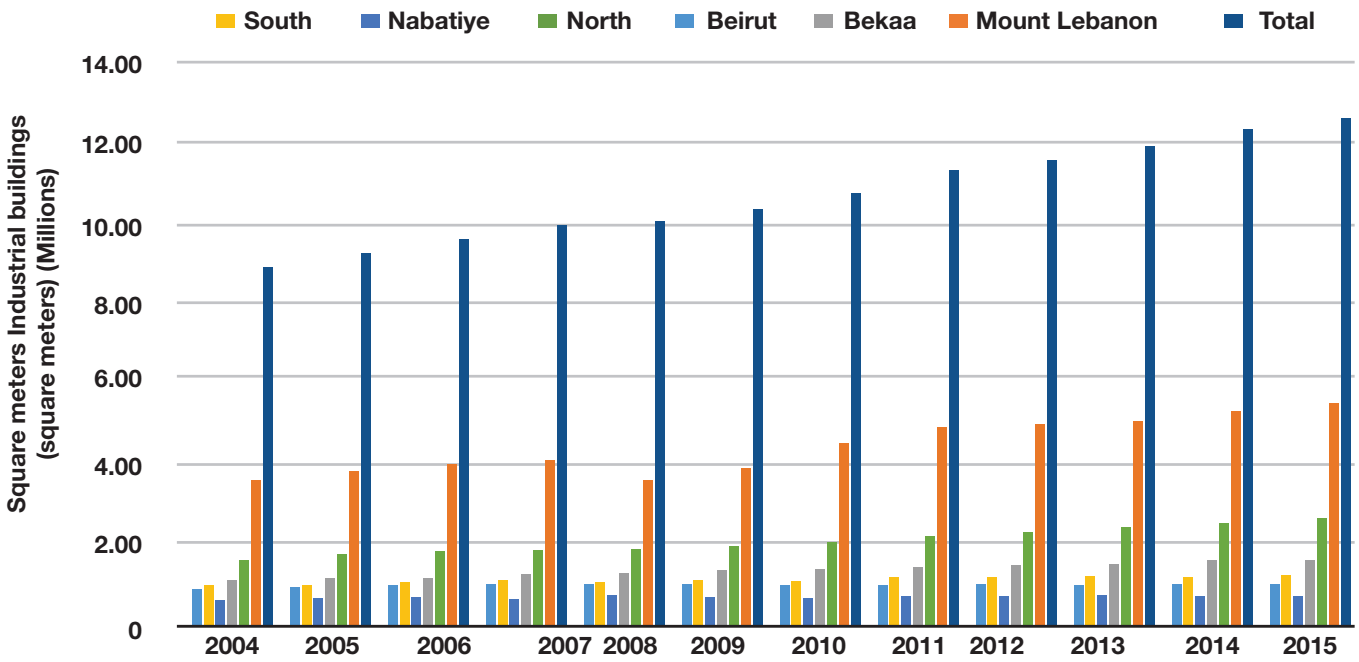
Calculations of the industrial sector built area use the OEA yearly construction permits. The industrial sector permits varied between 2% of the total area in 2007 to 4.7% in 2010. An extrapolation using the data between 2006 and 2015 indicates that the industrial building represented 3.9% of the building sector in 2004. OEA data are used to define the distribution of this area in each Mohafaza in table 6, below.

Table 6 : Repartition of the industrial building in each Mohafaza (OEA)

Beirut	Mount Lebanon	Bekaa	South	Nabatiye	North
10%	41%	13%	11%	7%	19%

Figure 13 shows the distribution of the built area of industrial buildings in all Lebanese Mohafazat.

Figure 13:
Industrial buildings area (square meters) distribution in each Mohafaza 2004–2015



The same procedure is used for calculating the built area of all other types of buildings.
Table 7 below shows remaining building types distribution per Mohafaza based on OEA construction permits.

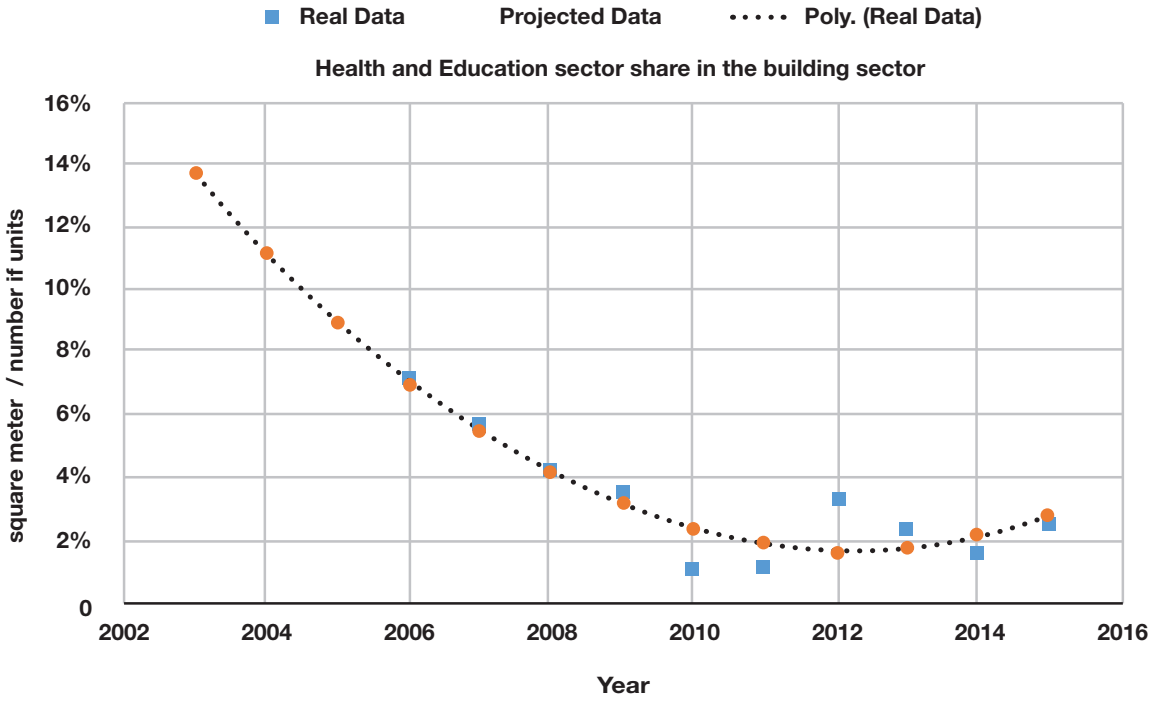
Table 7 : Distribution of several types of buildings per in each Mohafaza (OEA)

Type	Beirut	Mount Lebanon	Bekaa	South	Nabatiye	North
Commercial	13%	35%	20%	15%	11%	6%
Offices	14%	37%	19%	12%	10%	7%
Hotels	24%	38%	18%	8%	8%	4%
Health and education	23%	35%	17%	9%	10%	6%

The share of each type of buildings was calculated using OEA data. Using extrapolations, the data is extended to 2004 in order to calculate the existing area of each type of building.

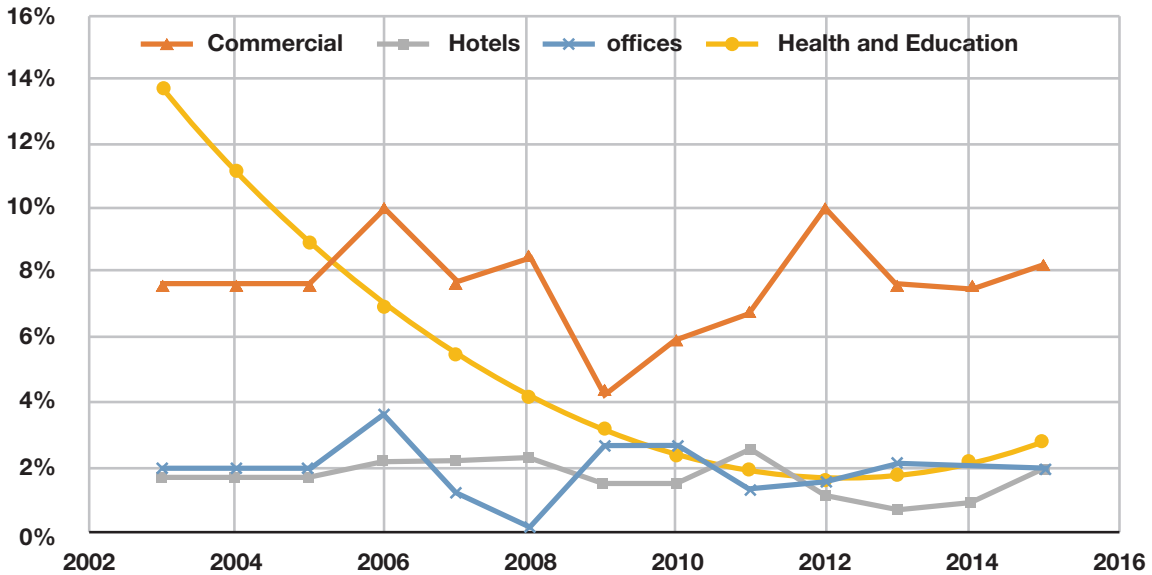
Figure 14 shows an example calculation of the share of health and education buildings from the building sector in Lebanon.

Figure 14:
Share of health and education buildings in the building sector 2003–2015



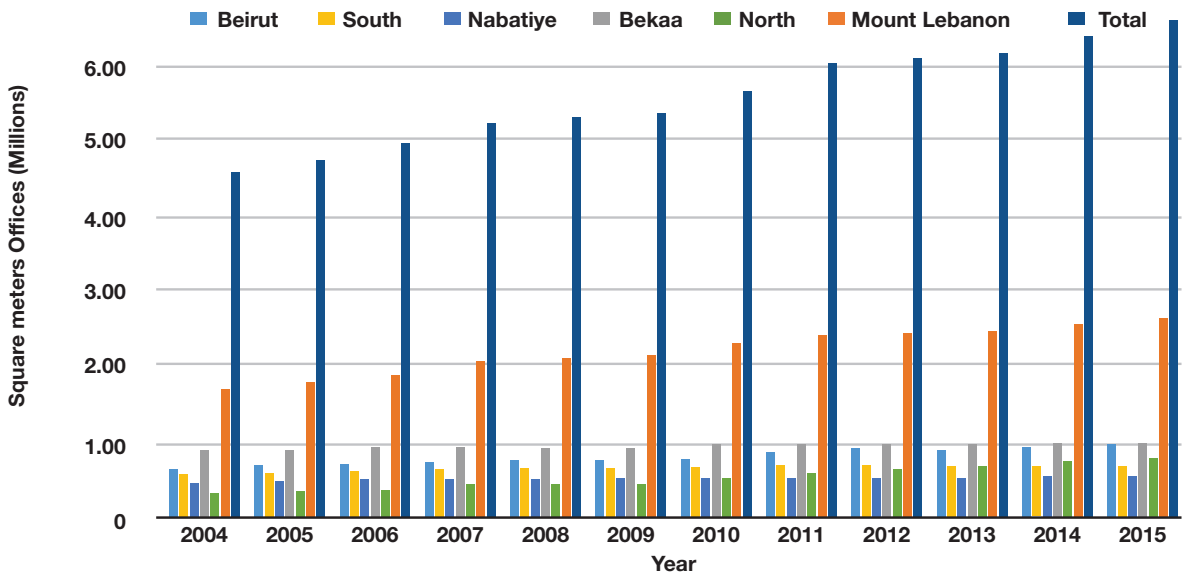
The share of each type of building is shown in figure 15, below, for 2003–2015.

Figure 15:
Share of several types of building from the total building area 2003–2015



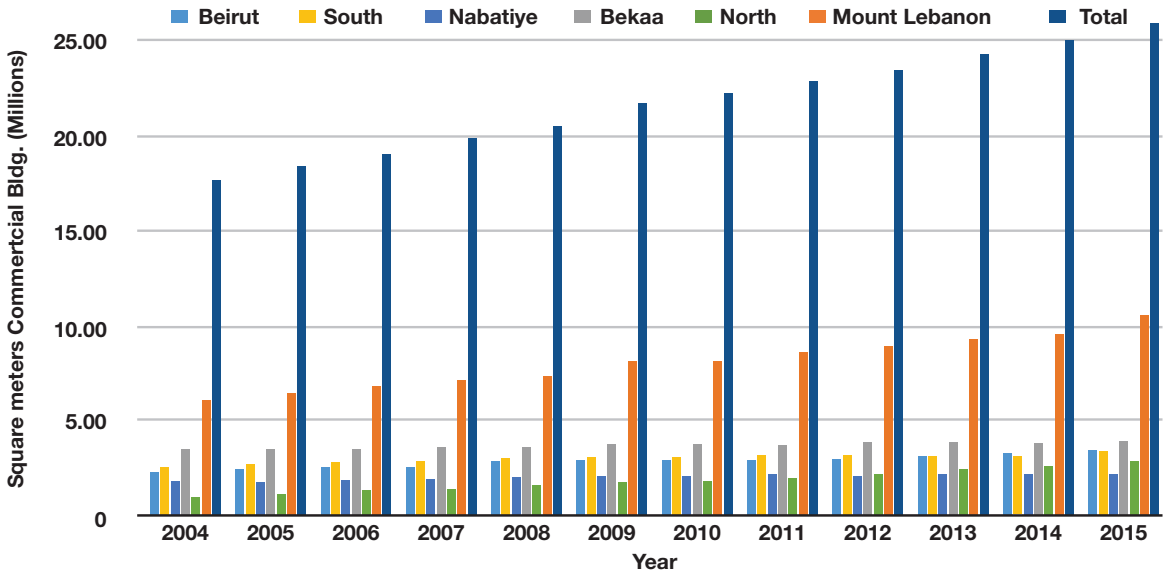
Using the aforementioned data, the existing area of buildings between 2004 and 2015 is calculated in all Lebanese Mohafazat (see figure 16 to 19). The total area of office buildings increased about 30% from 4,580,698.78 square meters in 2004 to reach 6,578,586.63 square meters in 2015. Office built area reached the highest level in Mount Lebanon Mohafaza.

Figure 16:
Office Buildings area (square meters) distribution in each Mohafaza 2004–2015



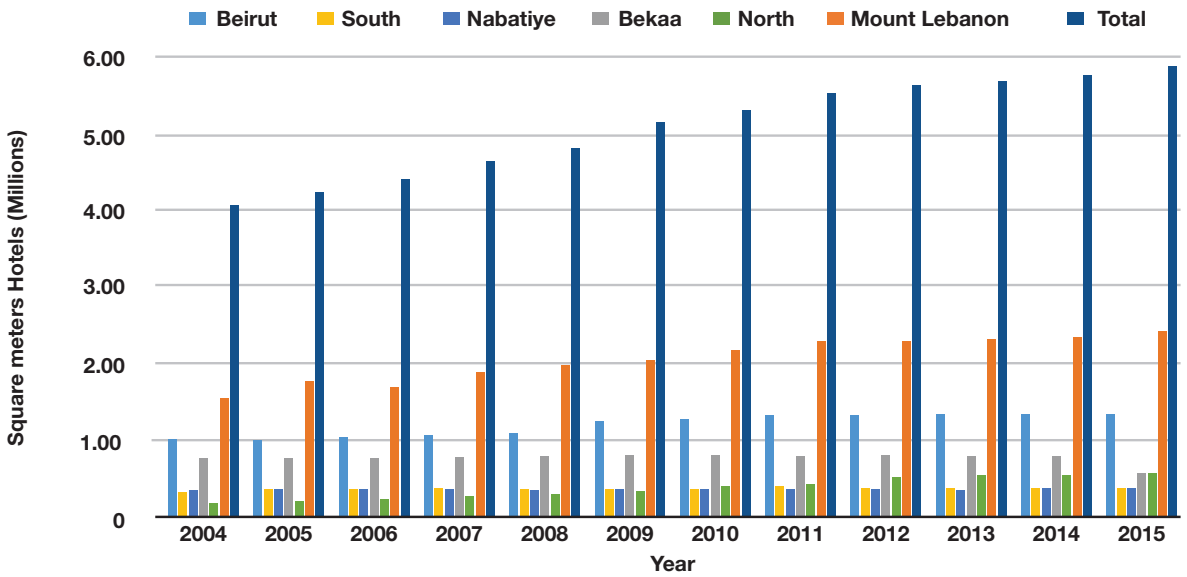
Mount Lebanon Mohafaza also has the highest rate of commercial built area, followed by the Bekaa region, as shown in figure 17. The total commercial built area for all of Lebanon approximated 25,867,482 square meters in 2015.

Figure 17:
Commercial Buildings area (square meters) distribution per Mohafaza 2004-2015



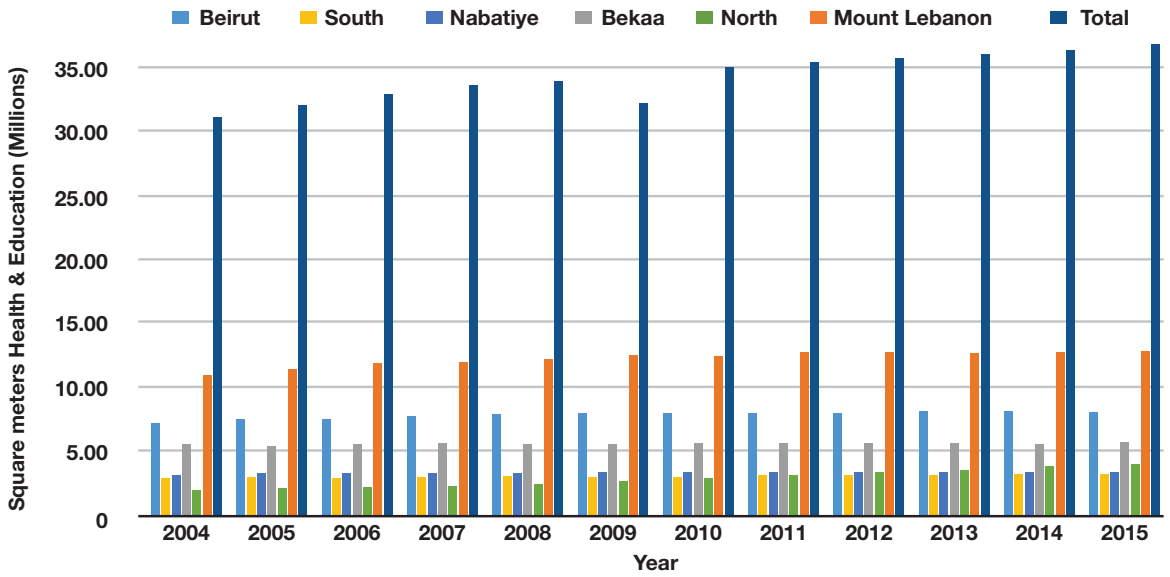
Again, Mount Lebanon presents the highest share of hotels built area for the years 2004–2015, followed by Beirut. The total hotels built area varied between 4,068,631 square meters in 2004 and 5,856,282 square meters in 2015, corresponding to an increase of 30.5%.

Figure 18:
Hotels built area (square meters) distribution by Mohafaza 2004-2015



Mount Lebanon represents 35% of the share of health and education buildings in Lebanon, followed by Beirut with 23%. Figure 19 shows the existing area of health and education sector in each Lebanese Mohafaza. The total area approximated 36,599,807 square meters in 2015.

Figure 19:
Health and education built area (square meters) distribution by Mohafaza 2004–2015



2.2.3 Occupancy rates

In order to calculate the energy demand of the building sector, it is necessary to determine the occupancy rate of each building type. The residential sector is the first to be affected by economic, security and political circumstances. Kamal Hamdan, managing director of the Consultation and Research Institute, reported in an interview with Al-Akhbar that 50% of the residential area was vacant in 2009. In fact, these 50% belong to expatriates.(6) In 2015, 20 to 25% of the residential units were reported to be vacant.(7) Unsold residential units were accounted for in this report, and figures for Lebanon's energy demand were adjusted accordingly. BlomInvest bank reported that 18%, 22% and 24% of the residential units were unsold in years 2012, 2013 and 2014 respectively.(8)

Fifteen percent of Lebanese families own two or more residences (including standard and seasonal). Calculations for the energy demand of the residential buildings take these parameters into consideration, alongside the behavior effect. In fact, occupants can reduce the energy consumption of a residence by 25% through their behavior.(9) In Lebanon, occupants periodically switch between EDL and private generators to meet their electricity needs. This affects electricity consumption, especially when generator subscription is low (5 and 10 Amperes in the residential case).

Occupancy rates for the other building types used in this report are shown in table 8, below.

Table 8 : Occupancy rate for all building types

Type	Occupancy rate
Commercial	90% (10)
Offices	80% (11)
Hotels	Between 72% in 2010 and 51% in 2012 (12)
Health and education	85% (13)

2.3 Transport sector

The transport sector in Lebanon suffers from inefficiency and poor organization. In addition, the public transport sector suffers from disorganization and a lack of structure.

There were around 1.55 million registered vehicles in Lebanon in 2007. Private passenger cars constitute around 80% of this number (See table 9)(14), which implies an ownership rate of 3 cars per person.

Table 9 : Registered vehicles in Lebanon in 2007

Passenger cars	1,247,572
Red plate cars	47, 707
Heavy duty vehicles	183,428
2/3-wheelers	70,699
Agricultural vehicles	210
Total	**1,549,616**

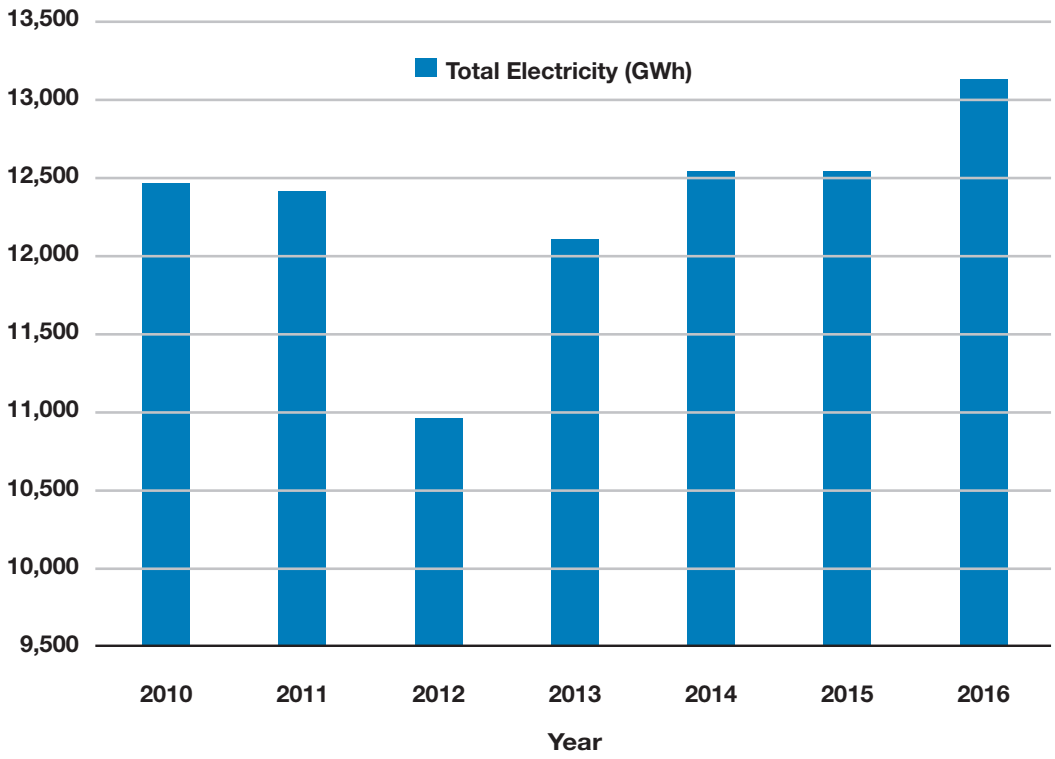
Energy data on the Lebanese transport sector is detailed in the next section.

3. ENERGY DEMAND 2010–2015

3.1 Electricity generation

Figure 20 shows the total electricity generated by EDL for the years 2010–2015. The lowest amount of electricity was generated in 2012 (15).

Figure 20:
Total electricity generated in Lebanon 2010–2015



Source: BDL

3.2 Final energy needs

This section details the final energy needs of the industrial, building and transport sectors based on the data presented in the previous section.

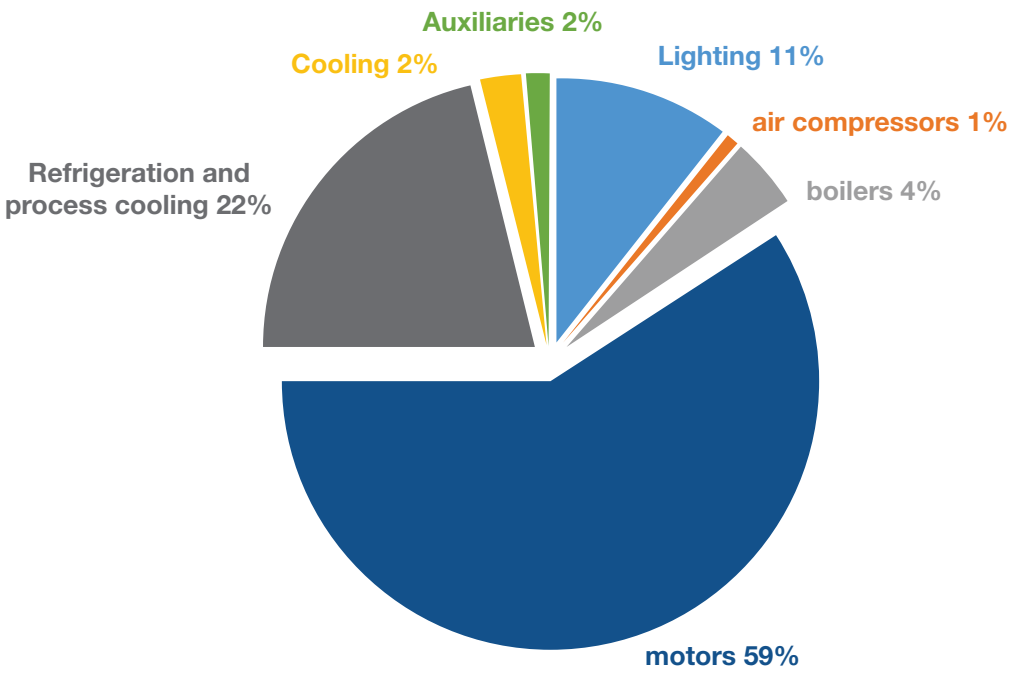
National energy action plans NEEAP and NREAP adopted the year 2010 as a baseline year. Thus, the energy demand calculations for all sectors detailed in this section also use 2010 as a baseline year.

3.2.1 Industrial sector energy demand

The Lebanese industrial sector is made of 4,033 factories employing five workers or more, with energy consumption higher than 10 kVA(50A/220V), and operating areas of more than 100 m^2. These industrial facilities are distributed over 22 industrial sectors (16). Energy consumption of the industrial buildings is based on the energy audits performed by LCEC. In the industrial sector, generators consume the most energy (61%), followed by thermal energy (23%) and EDL electricity (16%).

The electricity load breakdown in industrial processes, based on LCEC audits in 2015, is shown in figure 21. Motors account for around 59% of the total electricity demand.

Figure 21:
Electricity consumption breakdown in industry 2015 (LCEC audits)



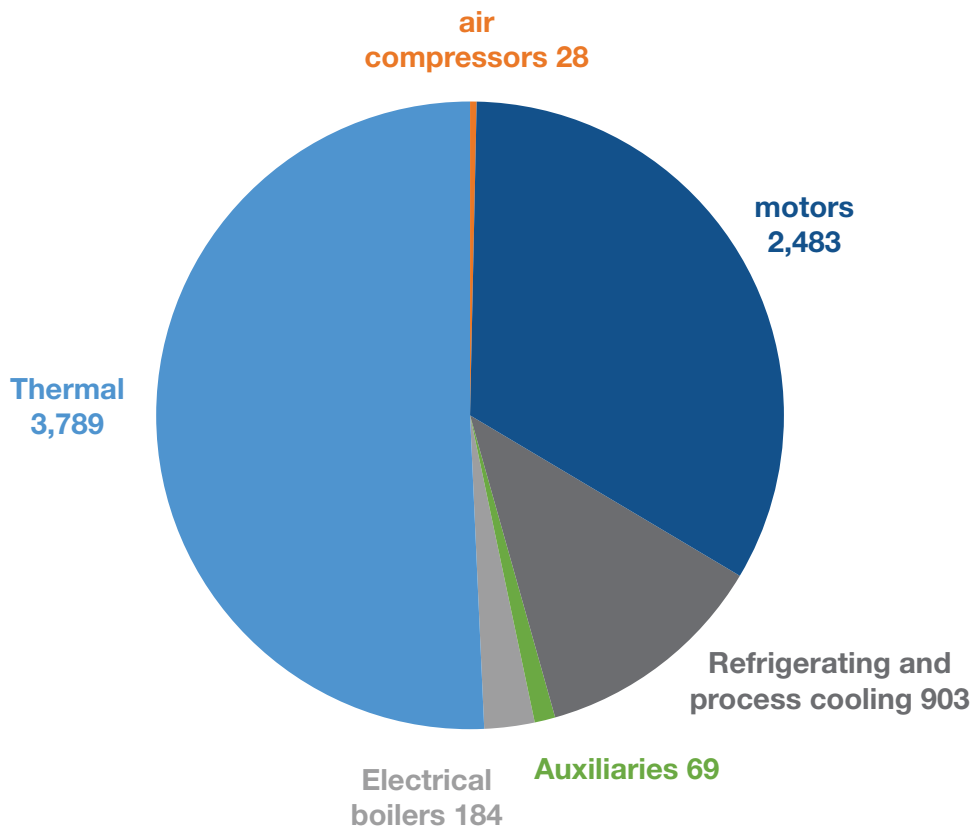
Based on surveys conducted in 2015 by the LCEC, the industrial sector's total electricity consumption was 4,201 GWh in 2010. The electrical consumption of a large industry is around 3,850 MWh/year, compared to around 650 MWh/year for a medium industry. Considering 500 large industries and 3,500 medium ones, the average electrical consumption of Lebanese industries is around 4,201 GWh/year.

Total thermal energy consumption in the Lebanese industries was found to be around 4,210 GWh, with a large industry consuming around 4,360 MWh/year and a medium one consuming 580 MWh/year.

Electric and thermal energy demand related to the heating, cooling, ventilation, lighting and domestic hot water usages are considered part of industrial building energy demand, the remainder of which comes from the industrial process itself. These usages corresponded to around 956 GWh in 2015, with 421 GWh coming from thermal energy and 535.63 GWh from electric energy.

The energy consumption of the industrial process is then around 3,668 GWh from electrical energy and 3,789 GWh from thermal energy. Figure 22 shows the distribution of electrical energy consumption.

Figure 22:
Energy load distribution (GWh) in industrial processes (excluding industrial building demand) (17)



3.2.2 Building sector energy demand

The EU-funded project on Energy Efficiency in the Construction Sector of the Mediterranean (MED-ENEC) conducted a study in July 2013 titled *A roadmap for developing energy indicators for buildings in Lebanon*. Using 2005 climatic data for Beirut, this study defines the energy demand for each type of building (except hospitals) and for each essential usage in the coastal zone. The essential usages are five: heating and humidification, cooling and dehumidification, ventilation, lighting and domestic hot water. For instance, the average energy demand for cooling in buildings of all types is about 100 kWh $_{FE}$/m^2.year for the coastal zone. This value varies from 64 kWh $_{FE}$ /m^2.year for seasonal residences to 193 kWh $_{FE}$ /m^2.year for retail, and varies depending on the climatic zone. (18)

Hospital data were extracted from several energy audits performed by LCEC, where cooling includes also dehumidification and heating includes humidification.

Table 10 shows the energy demand for all building types, except the industrial buildings addressed in the MED-ENEC study and several energy audits for hospitals.

Table 10: Energy demand (kWh/m².yr) of several types of buildings in Beirut

	Residential standard	Residential seasonal	Hotel	Office	Retail	Hospital
Heating	3	6	4	0	1	11.4
Cooling	78	64	95	82	193	81
Ventilation	7	7	12	5	8	38
Lighting	13	3	21	17	125	32
DHW	10	2	46	0	0	102.6
Humidification	1	1	2	1	3	
Dehumidification	36	32	55	24	63	
Total	148	115	235	129	393	265

Note that the educational sector will be treated as office buildings in the energy demand specifications.

The building-type data is divided by Mohafaza. Buildings in each Mohafaza are divided by climatic zone in table 11, below.

Table 11: Climatic Zones by Mohafaza

Mohafaza	Zone 1 (coastal)	Zone 2: (mid-mountain)	Zone 3 (inland)	Zone 4 (high mountain)
Beirut	100%	0%	0%	0%
Mount Lebanon	30%	50%	0%	20%
North Lebanon	40%	40%	0%	20%
Bekaa	0%	0%	80%	20%
South	50%	50%	0%	0%
Nabatiye	50%	50%	0%	0%

Calculations of the total energy demand (thermal and electrical) of all building types assume that the same building envelope is used for all climatic zones, and use the heating degree and cooling degree days for each climatic zone, the built area of each type of building, and the occupancy rates.

All building types, except for industrial buildings, consumed around 13,251 GWh in 2010. The energy consumption of 956 GWh for industrial buildings, detailed in the previous section excluding the industrial processes, constitutes around 10% of the total energy consumption for the building sector, which was 14,207 GWh in 2010. The 10% rate was used to calculate the yearly energy consumption of industrial buildings for the years 2009–2014.

Figure 23 shows the electrical and thermal energy demand in Lebanon for the building sector (including all types of buildings). The residential sector share of the building sector energy demand varied between 30% in 2009 and 37% in 2015. The commercial sector consumed between 30% and 32% of the total building sector demand, followed by the health and education sector, which consumed between 21% and 24% of the total building sector demand.

Figure 23:
Energy demand (GWh) of the building sector 2009–2014

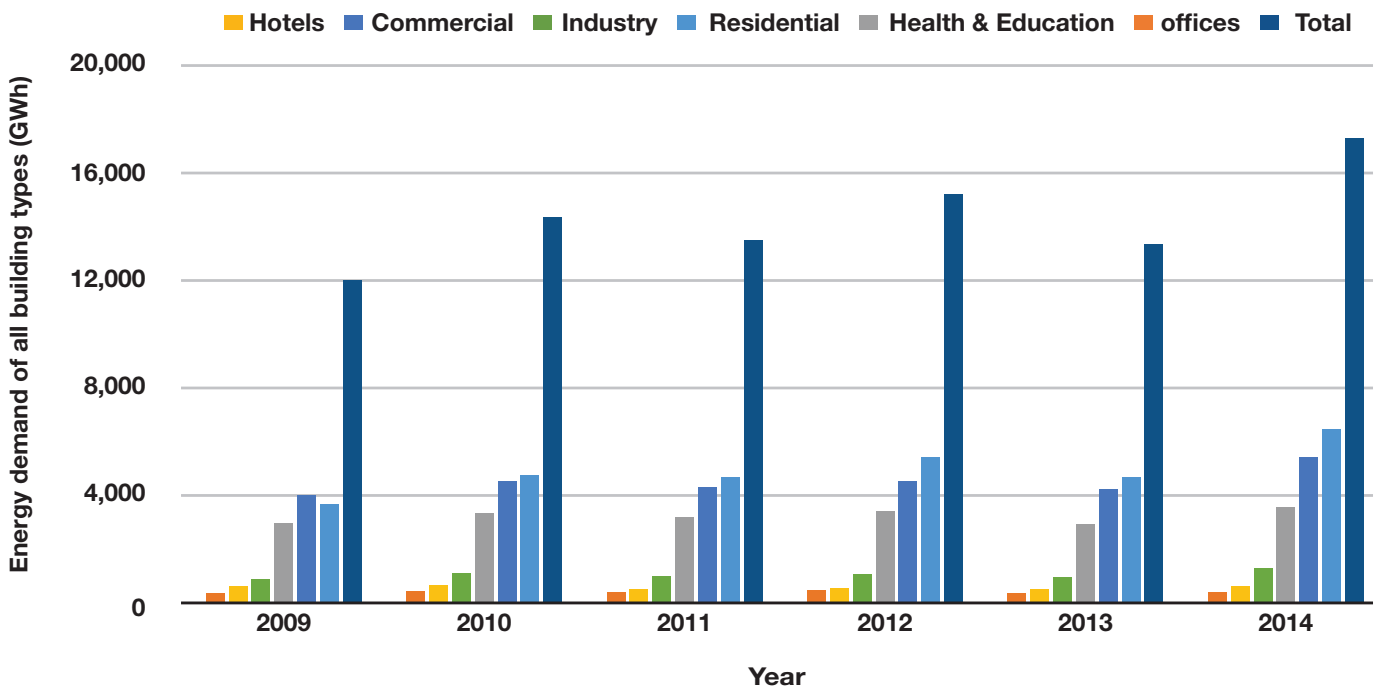
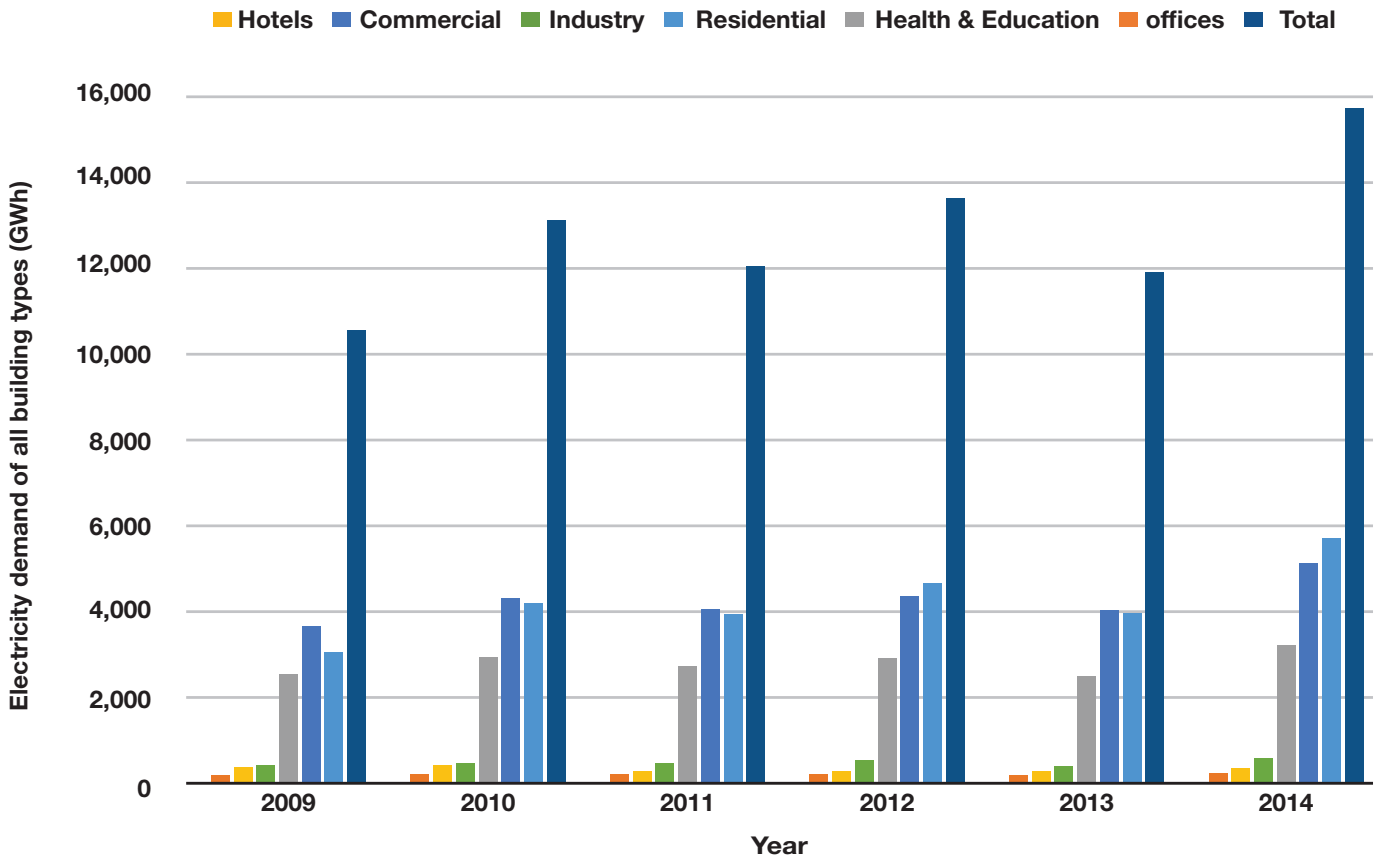


Figure 24 shows the electricity demand for all types of buildings. The residential sector demand for electricity has increased from 3,080 GWh in 2009 to 5,750.8 GWh in 2014. This increase could be related to the massive population increase caused by the migration of more than 1.5 million Syrian refugees to Lebanon.

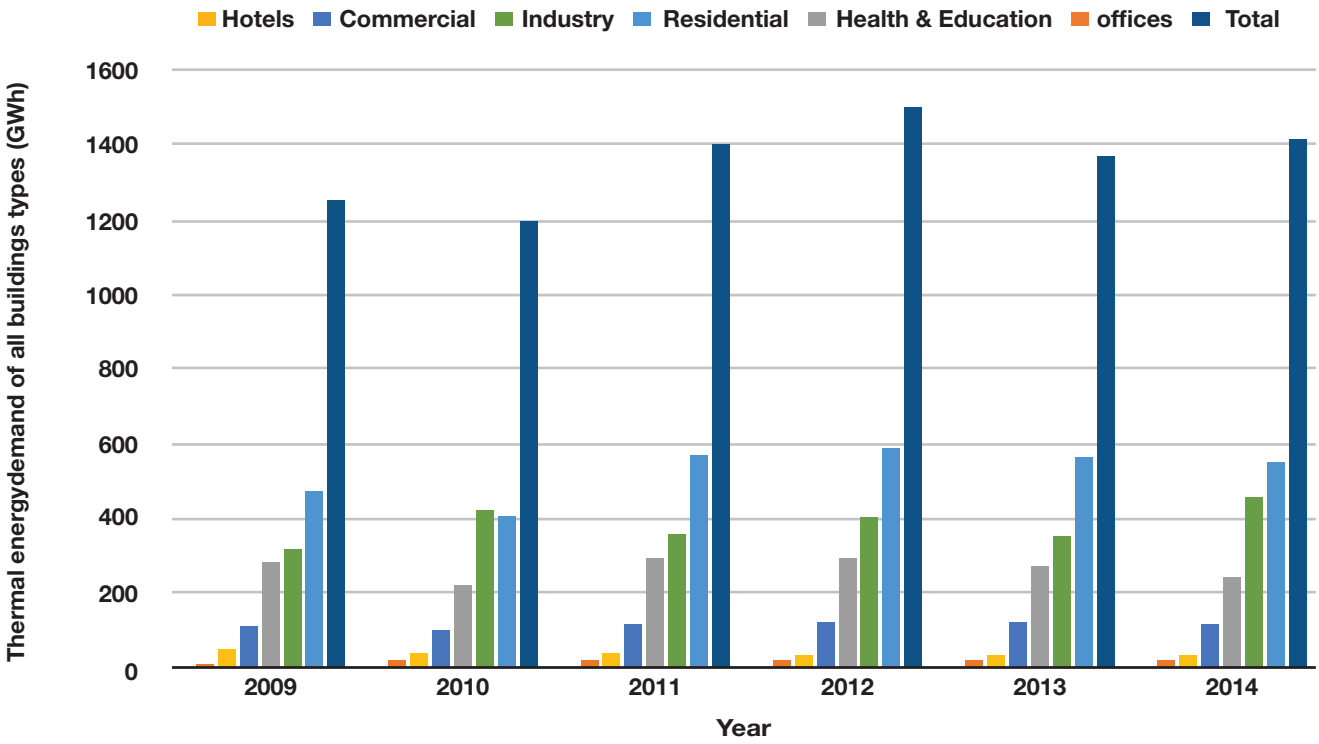
Figure 24:
Electricity demand (GWh) of the building sector 2009–2014



The thermal energy demand of the building sector is shown in figure 25. It is clear that the greatest demand for thermal energy comes from the residential sector, where demand was approximately 468.4 GWh in 2009 and 553.1 GWh in 2014, with peak demand for thermal energy recorded at 587.6 GWh in 2012.

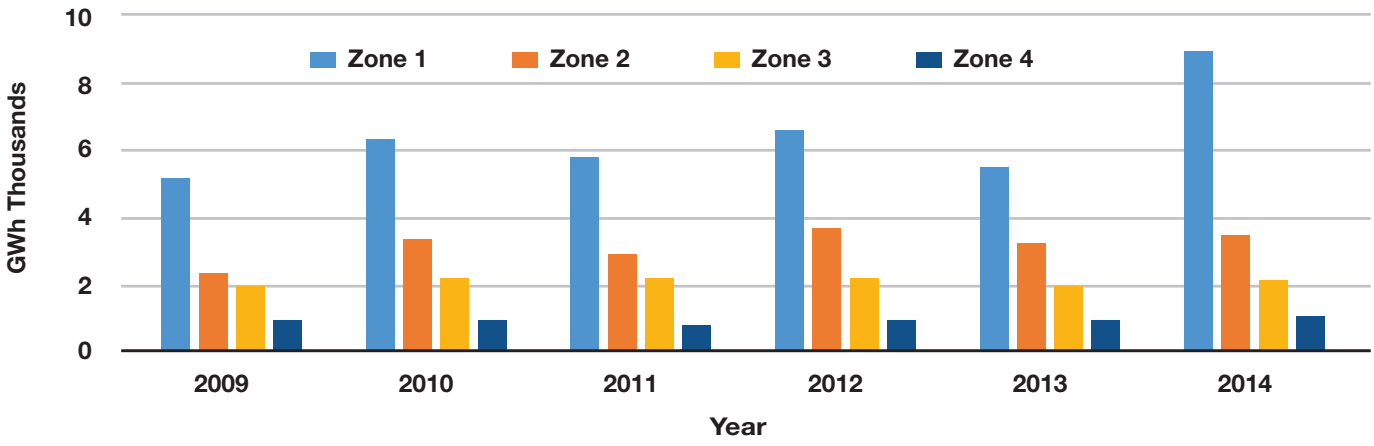
The residential sector is followed by the industrial sector (building only), and then the health and education sector.

Figure 25:
Thermal energy demand (GWh) of the building sector 2009–2014



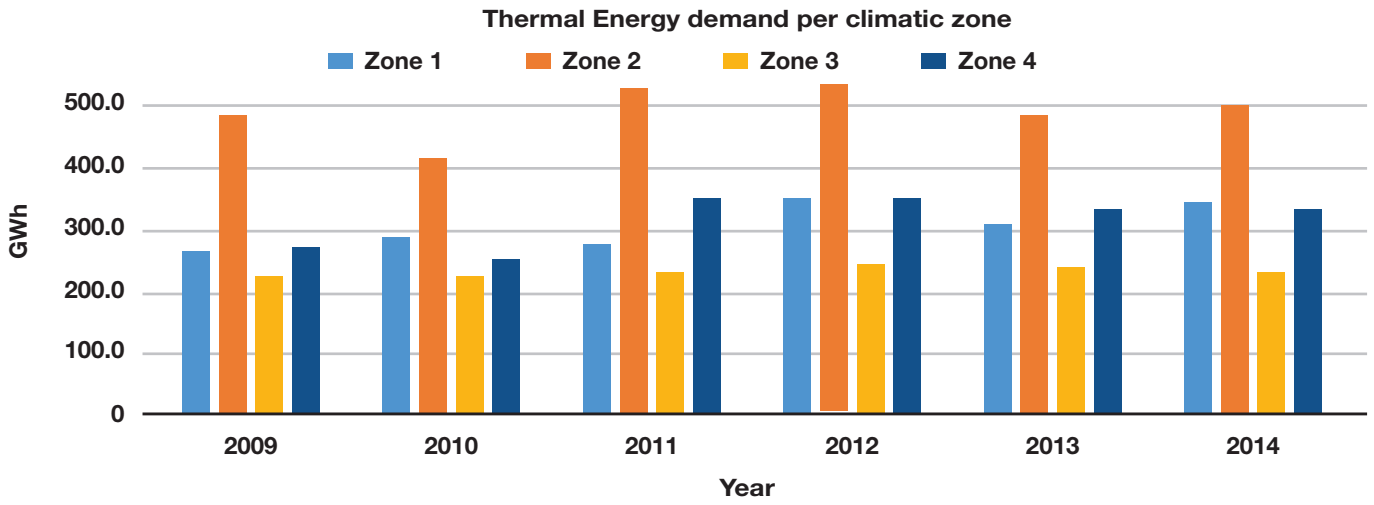
The electricity demand varied across climatic zones in the years 2009–2014. Figure 26 shows that the largest demand was recorded in zone 1, where it reached around 8,942 GWh in 2014.

Figure 26:
Electricity demand (GWh) of the building sector by climatic zone 2009-2014



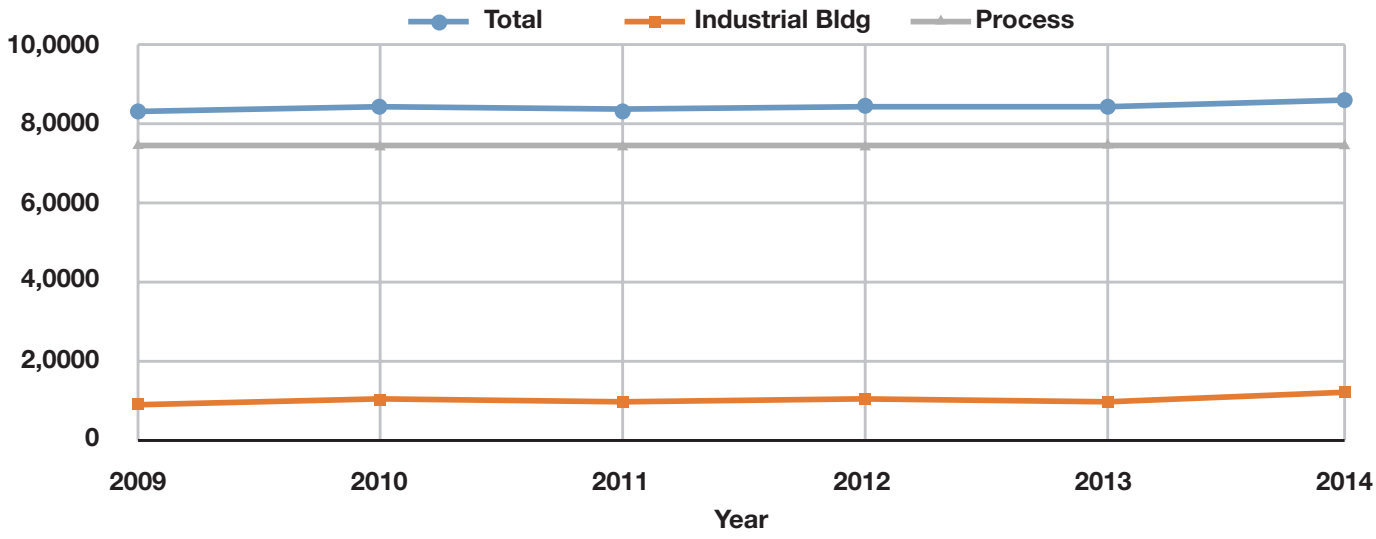
Thermal energy demand also varied by climatic zone in the years 2009–2014 (see figure 27). Zone 2 had the highest demand for thermal energy, recording a peak of 542.6 GWh in 2012.

Figure 27:
Thermal demand (GWh) of the building sector by climatic zone 2009–2014



The industrial sector energy demand varies as shown in figure 28. The numbers shown assume that process demand in the industrial sector remains constant, and incorporate building demand for heating, cooling, ventilation, lighting and hot water.

Figure 28:
Industrial sector energy demand (GWh) 2009–2015



3.2.3 Baseline electricity demand

As mentioned earlier, NEEAP 2016-2020 and NREAP 2016-2020 fix the year 2010 as the baseline year, based on the recommendation of the Arab Renewable Energy Framework published by the League of Arab States. In 2010, electricity demand was around 15,934 GWh, according to EDL.

Table 12 shows the energy demand of the building and industrial sectors in 2010.

Table 12: Energy demand in the building and industrial sectors 2010

	Building sector		Industrial sector		**Total**	
	Electrical	Thermal	Electrical	Thermal	**Electrical**	**Thermal**
GWh	13 012.1	1 195.8	3 665.4	3 789.0	**16 677**	**4 984.84**

The total electricity demand calculated is around 16,677 GWh. An error of 4.4% compared to EDL's demand announced for the year 2010 could be related to several parameters, including:

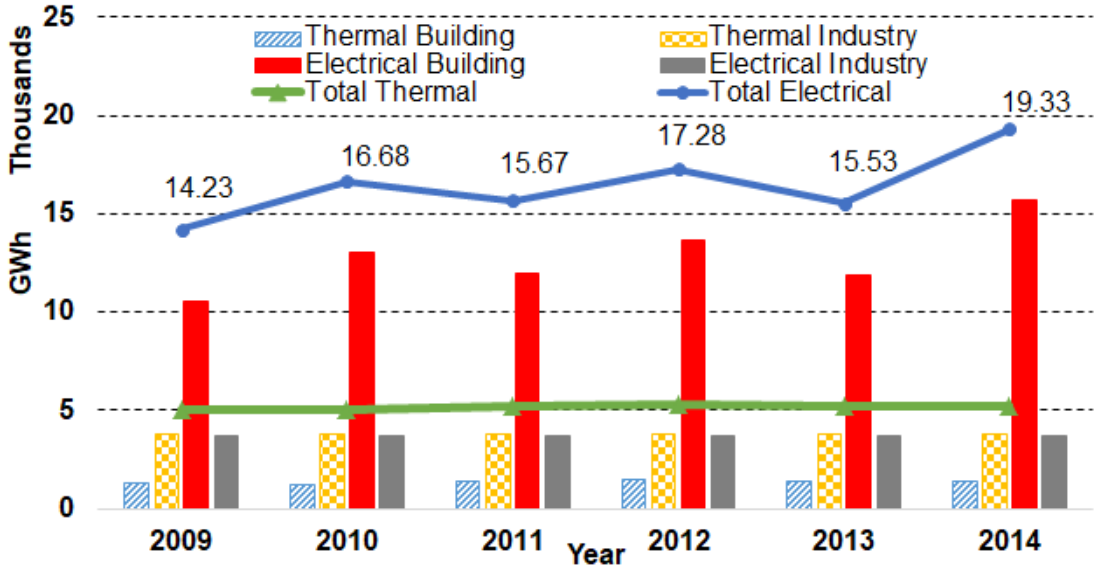
- Occupancy rates used in this report
- Baseline energy consumption of MED-ENEC study which is based on ideal case of thermal comfort
- End-user behavior that highly affects electricity consumption patterns

3.2.4 Shares of building and industrial sectors

a. Thermal and electrical energy in building and industrial sectors 2009–2014

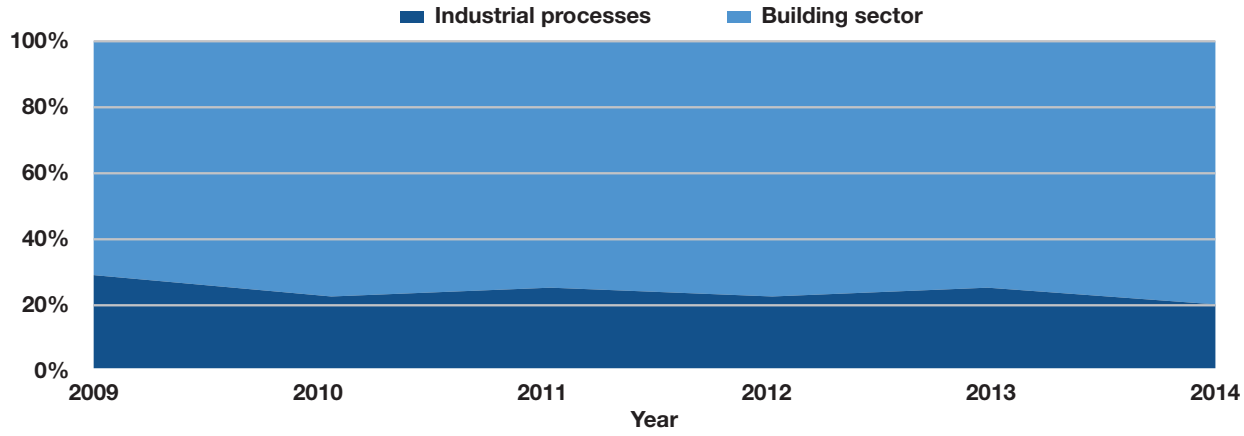
Electrical consumption in the building sector increased from 10,563 GWh in 2009 to 13,617 GWh in 2012. This increase was followed by a decrease to 11,816 GWh in 2013, as shown in figure 29. Electrical consumption in the building sector reached 15,667 in 2014.

Figure 29:
Thermal and electrical energy in the building and industrial sectors 2009–2014



The building sector is consuming around 78% of the overall electricity generated in Lebanon, as shown in figure 30.

Figure 30:
Building and industrial sector shares of total Lebanese electricity consumption 2009–2014

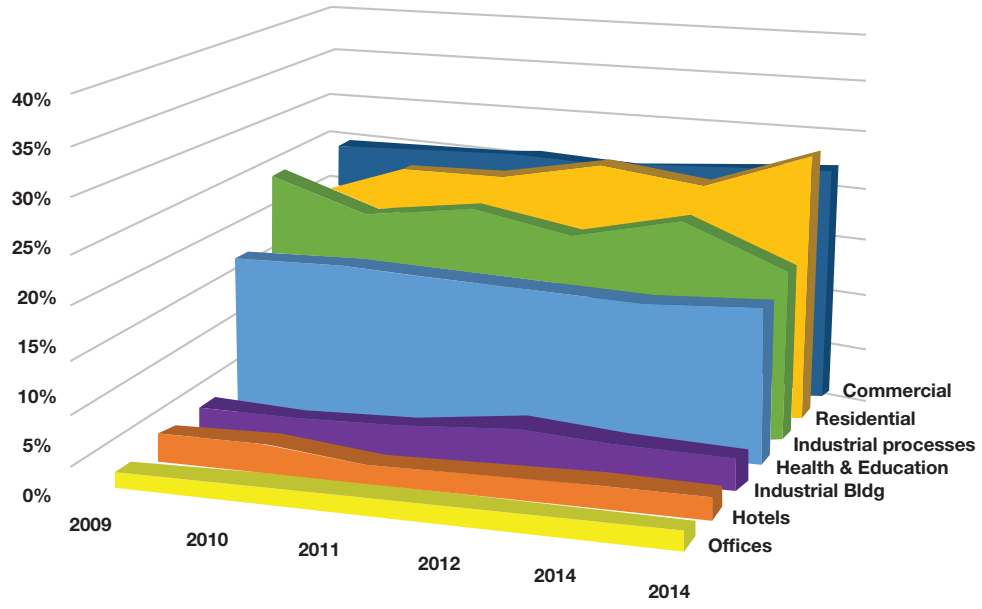


b. Share of each sector in the electricity demand 2009-2014

The share of electricity demand of each sector is presented in figure 31 for the years 2009-2014. In recent years, the residential sector has been the largest consumer of electricity, generating approximately 30% of Lebanon's overall electricity demand in 2014. The increase in Syrian refugees in Lebanon since 2011 might account for some of this increase in demand.

The residential building sector is followed by the commercial sector, which accounted for 27% of demand in 2014, then by the industrial sector (processes without building demand), which accounted for 19% of Lebanon's total demand for electricity in 2014.

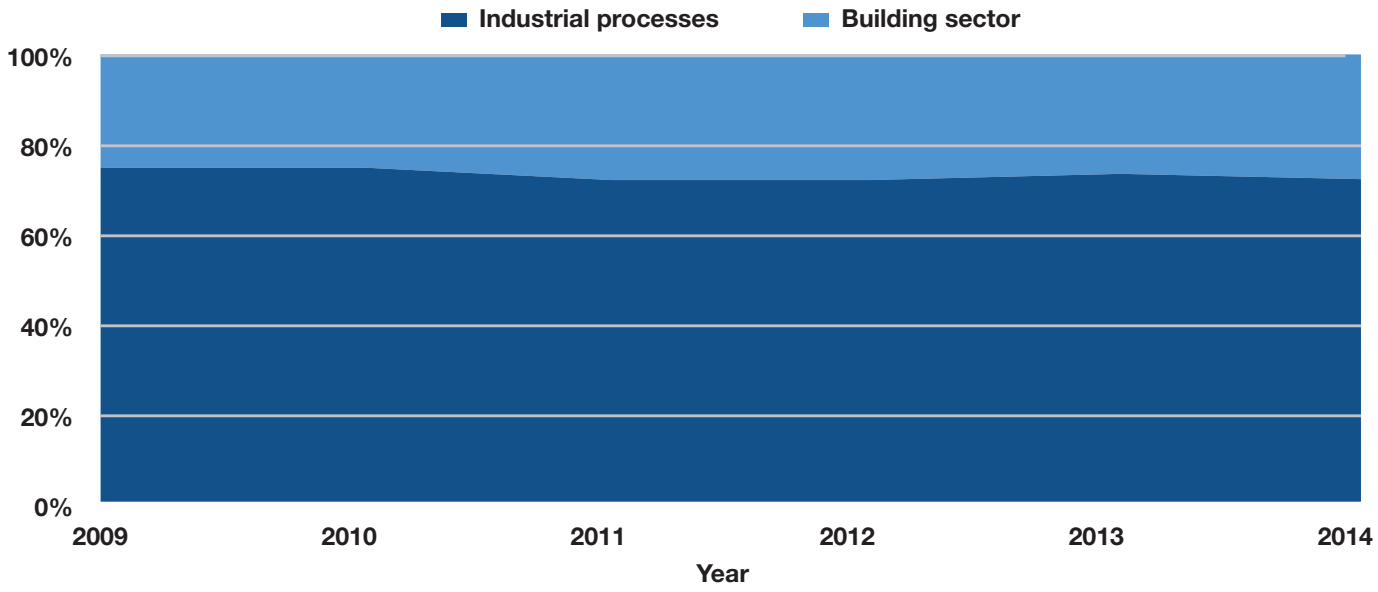
Figure 31:
Share (%) of the building and industry sectors in overall electricity demand 2009-2014



c. Share of each sector in the total Lebanese thermal demand 2009–2014

Figure 32 shows that industrial processes dominate thermal consumption, with a share varying between 72% and 76% of Lebanon's total thermal energy consumption.

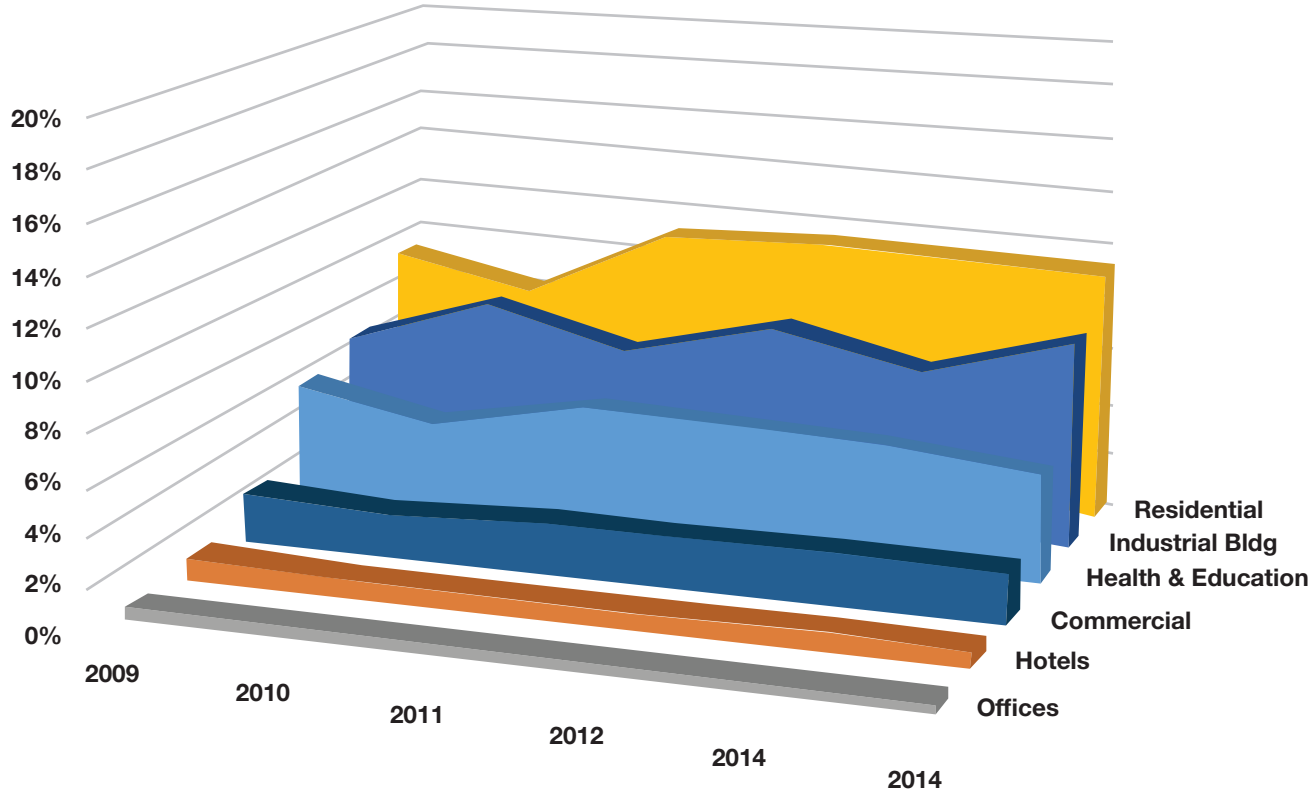
Figure 32:
Share of industrial process and the building sector in total Lebanese thermal energy demand 2009–2014



Source: LCEC, 2017

Figure 33 shows the thermal energy consumption for all building types as a percentage of total Lebanese thermal energy consumption. The residential sector accounted for around 11% of total demand in 2014, followed by industrial buildings at 9%, then the health and education sector at 5% of total Lebanese thermal energy consumption.

Figure 33:
Building sector thermal consumption by type of building as a percentage of total Lebanese thermal energy consumption

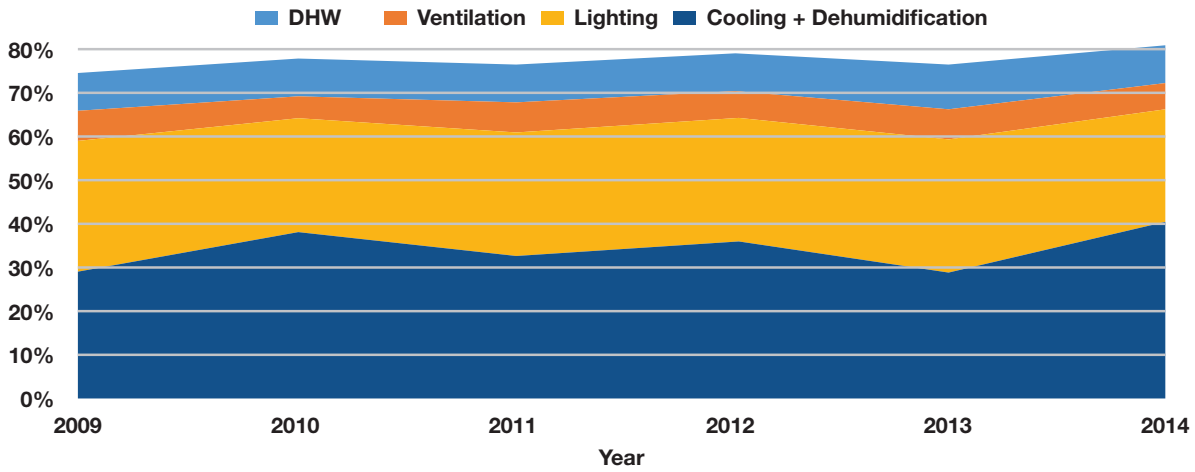


Source: LCEC, 2017

d. Building sector usages shares of the total Lebanese electricity demand 2009–2014

The total demand of the building sector is broken down by usage in figure 34, below. Cooling and dehumidification are the highest-consuming usages in the building sector. Cooling and dehumidification combined constituted 29% of the total electricity demand in Lebanon in 2009, and reached 40% in 2014. Cooling is followed by the lighting, the second highest-consuming usage in the building sector, which accounted for 31% of total Lebanese electricity demand in 2013.

Figure 34:
The building sector's share of total Lebanese electricity demand, by usage 2009–2014

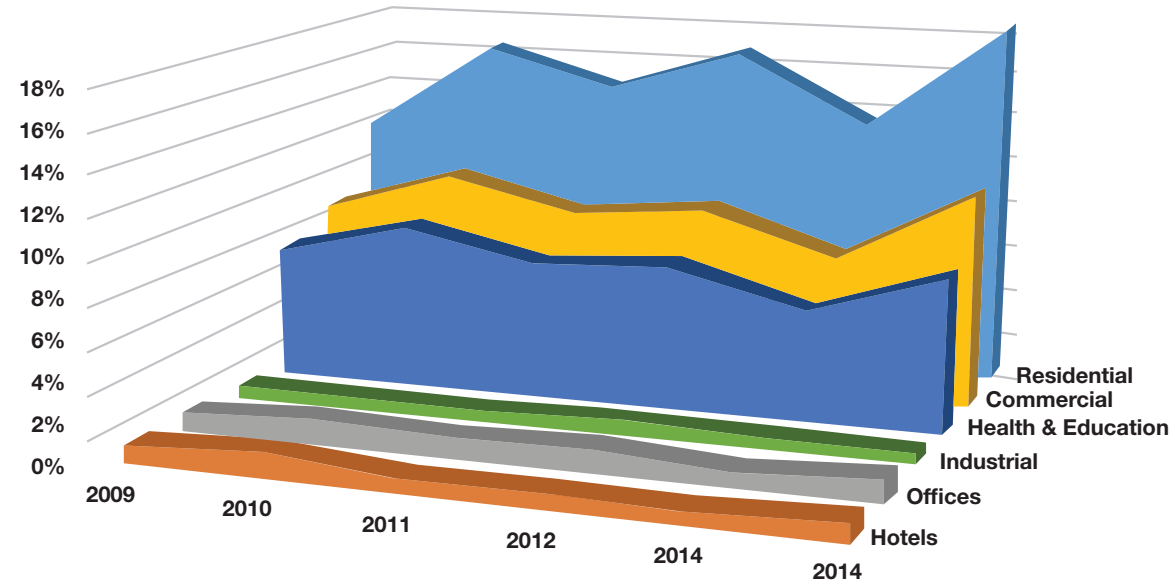


Source: LCEC, 2017

e. Building sector lighting share of the total Lebanese electrical consumption

Cooling and dehumidification, along with lighting, are the usages that consume the most electricity in Lebanon. Figure 35 presents the cooling share in various types of buildings. In 2014, the residential sector cooling share reached 19%, followed by the commercial sector with 11%, and the health and education sector, which accounted for 8% of the total Lebanese electrical consumption.

Figure 35:
Building sector cooling share in the total Lebanese electrical consumption

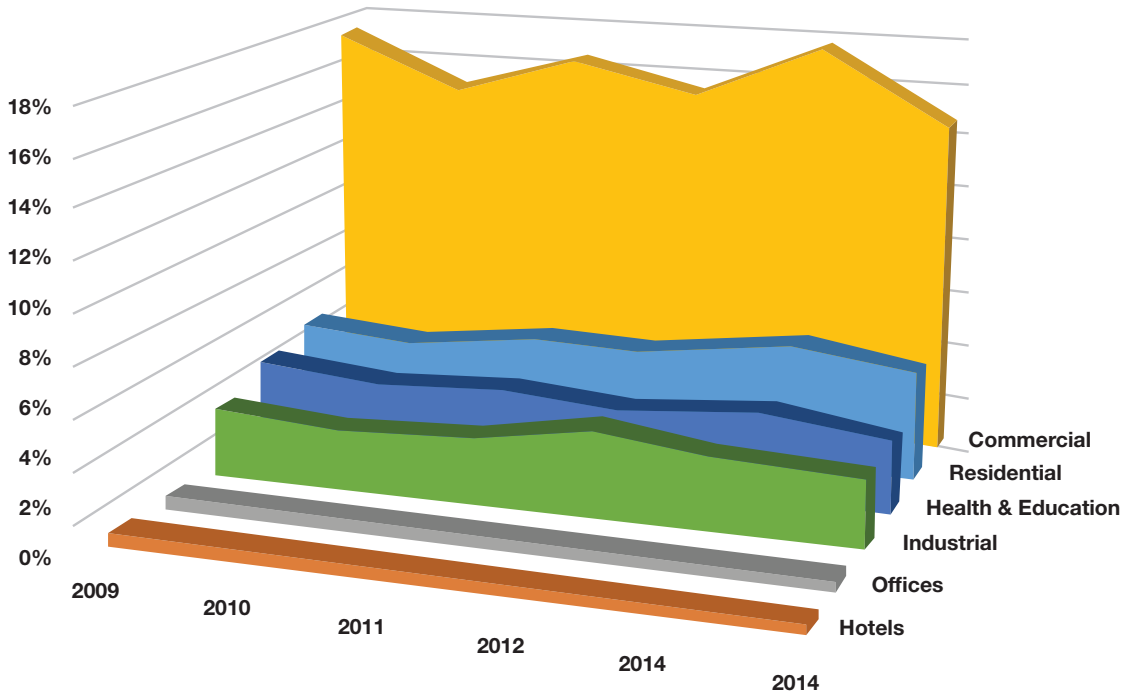


Source: LCEC, 2017

f. Building sector lighting share of the total Lebanese electrical consumption

Figure 36 shows the share represented by lighting for all buildings types in the total Lebanese electrical consumption. The commercial sector is dominant, with an average share of 16% represented by lighting, followed by the residential sector, where 5% is an average share of lighting consumption in the total Lebanese consumption.

Figure 36:
Building sector lighting share in the total Lebanese electrical consumption

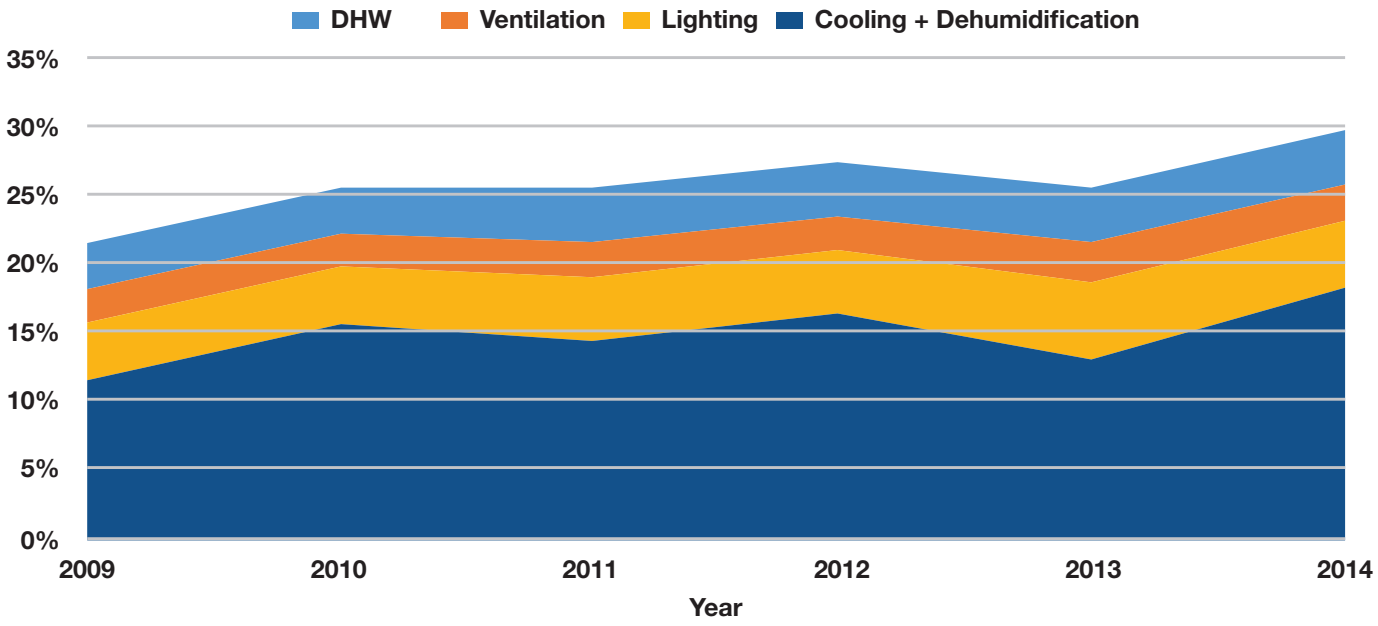


Source: LCEC, 2017

g. Residential sector usages share of the total Lebanese electricity demand

The residential sector electrical demand is mainly composed of cooling and dehumidification, ventilation, lighting and domestic hot water. Figure 37 shows the variation of these usages in the residential sector as a percentage of the total electricity demand in Lebanon for the years 2009–2014.

Figure 37:
Residential sector usages as shares of the total Lebanese electricity demand

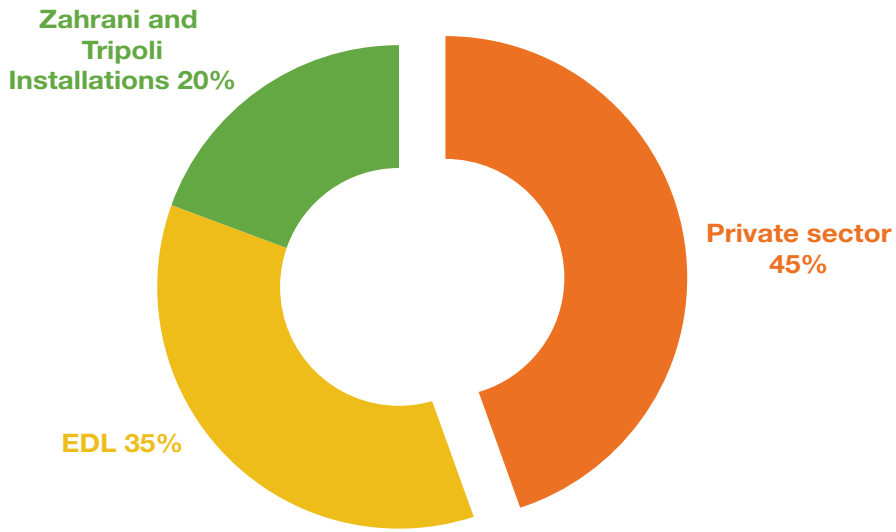


Source: LCEC, 2017

3.2.5 Transport sector

The objective of this section is to estimate the energy use in the Lebanese transport sector. It merits mention that the Lebanese energy bill includes the import of gasoline and diesel oil, and that imported gasoline is strictly used in the transport sector. Figure 38 shows how imported gas oil is distributed.

Figure 38:
Distribution of imported gas oil in Lebanon 2015

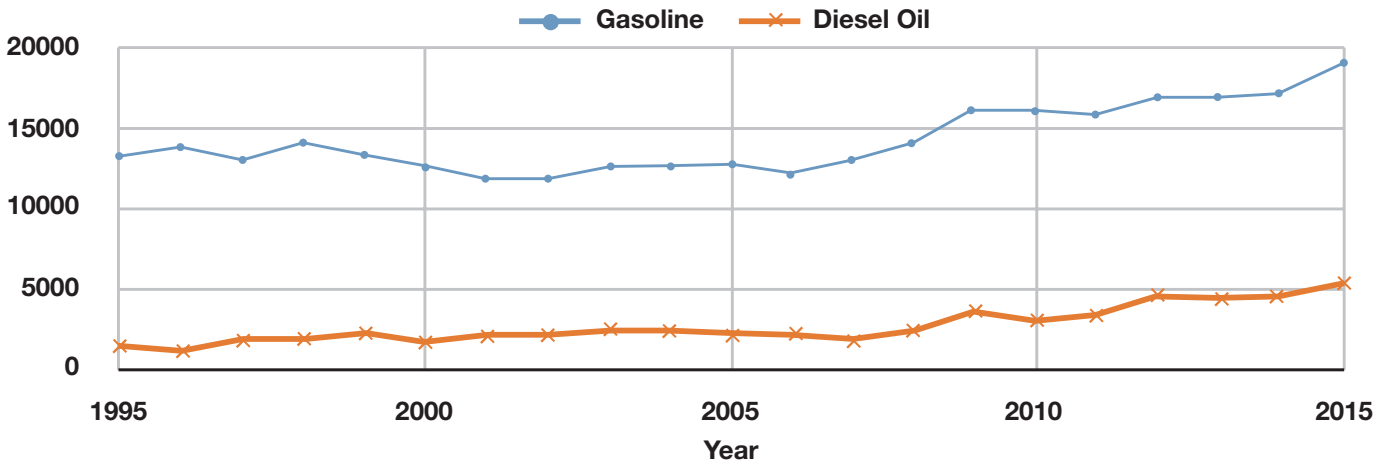


Source: Petroleum directorate, MEW

The private sector share includes the diesel oil used in the Lebanese transport sector.

The climate change unit at the Ministry of Environment has published several reports on diesel oil consumption in Lebanon's transport sector ((19), (20), (21)). Figure 39 shows estimates of gasoline and diesel oil consumption using these data, and the energy bill for the years 2014–2015 provided by the petroleum directorate at MEW.

Figure 39:
Fuel (ktonnes) used in the transport sector (1995–2015)



Source: MoE, Petroleum directorate

Table 13, below, shows the amounts of gasoline and diesel oil consumed by the Lebanese transport sector.

Table 13 : Gasoline and diesel oil consumed by the transport sector 2010-2015

Year	Gasoline (ktonnes)	Diesel oil (ktonnes)
2010	1 592	315
2011	1 595	343
2012	1 682	457.63
2013	1 694	448.49
2014	1 719	455.25
2015	1 905	513.91

4. INDICATORS AS PER IEA TEMPLATE

4.1 Macroeconomic data

Activity and structure Indicators							
	units	2010	2011	2012	2013	2014	2015
Total population	10^6 persons	4.34	4.59	4.92	5.29	5.61	5.85
Share of population living in urban area	%	87.18%	87.30%	87.43%	87.55%	87.67%	87.79%
Share of population living in rural area	%	12.82%	12.70%	12.57%	12.45%	12.33%	12.21%
Total number of dwellings[1]	10^6 dw	1.79	1.88	1.94	2.00	2.08	2.15
Occupied dwellings	10^6 dw	0.77	0.85	0.91	0.96	1.06	1.08
New dwellings	10^6 dw	0.09	0.06	0.06	0.07	0.08	0.06
Percent of urban households without electricity	%	0	0	0	0	0	0
Percent of rural households without electricity	%	0	0.18	0.04	0.004	0	0
Total residential area	10^6 m^2	196.53	206.80	213.55	220.52	228.50	236.96
Annual heating degree-days	dd°C	1 050.43	1 534.11	1 468.55	1 335.35	1 154.46	1 560.37
Annual cooling degree-days	dd°C	429.85	259.77	379.37	200.33	321.13	502.72
Currency conversion to US$1	LBP	1 507.50	1 507.50	1 507.50	1 507.50	1 507.50	1 507.50
Consumer price index (2010= US$100)	US$	100	..	111.881	118.084	118.969	114.509
Household final consumption expenditure/PPP (in constant 2011 international US$)	$ PPP	59 832 703 531	60 059 481 254	61 464 252 347	60 675 565 724	59 496 251 577	63 741 230 351
Total services area	10^6 m^2	68.01	69.63	70.74	72.05	73.47	74.90
New services area	10^6 m^2	1.62	1.11	1.31	1.42	1.43	1.41

[1] *Building sector information is based on calculations presented elsewhere in this report.*

Gross domestic							
	units	2010	2011	2012	2013	2014	2015
At current prices and current exchange rates	billions of US$	38	40.07	43.2	44.35	45.73	47.08
At 2010 price levels and exchange rates		38	38.76	39.61	39.97	40.69	41.22

GDP deflator							
	units	2010	2011	2012	2013	2014	2015
Deflator for GDP at market prices		100	103.393	109.05	110.95	112.3	114.2

Value-added in US$ MER 2010 $ (at 2010 price levels and MER)							
	units	2010	2011	2012	2013	2014	2015
ISIC Rev.4 Division		4.34	4.59	4.92	5.29	5.61	5.85
01 - 03: Agriculture, forestry and fishing	billions of US$ (2010)	1.46	1.56	1.64	1.75	1.83	1.84
10 - 32: Manufacturing		2.81	2.85	3.02	3.13	3.47	3.50
33 - 99: Services		27.55	28.76	28.97	29.13	29.29	30.13
GDP MER 2010		**38**	**38.76**	**39.61**	**39.97**	**40.69**	**41.22**

[2] *MER=Market Exchange Rate, GDP=Gross Domestic Product*

4.2 Service sector

The service sector encompasses those services enumerated under “Commerce and Public Services” in the United Nations International Recommendations on Energy Statistics. It is also referred to as the tertiary sector. It covers a large number of economic activities, which can be private, public or a combination of the two. Service sector activities are grouped into the following categories: offices, retail space, public administration, health care, education, warehousing, food service and sales and lodging, arts, entertainment and recreation. (22)

Total energy use in services sector						
	units	2010	2011	2012	2013	2014
Heat	PJ	1.36	1.70	1.69	1.59	1.46
Electricity	PJ	29.59	26.92	29.17	26.12	33.22
Total	**PJ**	**30.94**	**28.62**	**30.85**	**27.72**	**34.68**
Energy intensity (using GDP at MER)	MJ/US$	1.12	0.99	1.07	0.95	1.18
Energy use per floor area	GJ/m2	0.45	0.41	0.44	0.38	0.47
Space heating						
Oil and petroleum products	PJ	1.36	1.70	1.69	1.59	1.46
Total	**PJ**	**1.36**	**1.70**	**1.69**	**1.59**	**1.46**
Total (climate corrected for 1990–2011)	PJ	1.74	1.50	1.55	1.61	1.71
Space cooling						
Electricity	PJ	12.76	9.95	11.83	8.22	14.87
Total	**PJ**	**12.76**	**9.95**	**11.83**	**8.22**	**14.87**
Total (climate corrected for 1990–2011)	PJ	10.36	13.36	10.88	14.32	16.15
Lighting						
Electricity	PJ	11.57	11.84	12.12	12.53	12.88
Total	**PJ**	**11.57**	**11.84**	**12.12**	**12.53**	**12.88**
Other building energy use in services sector						
Electricity	PJ	5.26	5.13	5.21	5.37	5.47
Total	**PJ**	**5.26**	**5.13**	**5.21**	**5.37**	**5.47**
Total building energy use in services sector						
Oil and petroleum products	PJ	1.36	1.70	1.69	1.59	1.46
Electricity	PJ	29.59	26.92	29.17	26.12	33.22
Total	**PJ**	**30.94**	**28.62**	**30.85**	**27.72**	**34.68**
Total (climate corrected for 1990–2011)	PJ	28.92	31.83	29.77	33.83	36.21

Total energy use in services sector						
	units	2010	2011	2012	2013	2014
Energy intensity (using GDP at MER —not climate corrected)	MJ/US$	1.12	0.99	1.07	0.95	1.18
Energy intensity (using GDP at MER— climate corrected)	MJ/US$	1.05	1.11	1.03	1.16	1.24
Energy use per floor area (not climate corrected)	**GJ/m2**	**0.45**	**0.41**	**0.44**	**0.38**	**0.47**
Energy use per floor area (climate corrected)	GJ/m2	0.43	0.46	0.42	0.47	0.49
Total energy use in services sector						
Oil and petroleum products	PJ	1.36	1.70	1.69	1.59	1.46
Electricity	PJ	29.59	26.92	29.17	26.12	33.22
Total	**PJ**	**30.94**	**28.62**	**30.85**	**27.72**	**34.68**
Total (climate corrected for 1990–2011)	PJ	28.92	31.83	29.77	33.83	36.21
Energy intensity (using GDP at MER - not climate corrected)	MJ/US$	1.12	0.99	1.07	0.95	1.18
Energy intensity (using GDP at MER - climate corrected)	MJ/US$	1.05	1.11	1.03	1.16	1.24
Energy use per floor area (not climate corrected)	**GJ/m2**	**0.45**	**0.41**	**0.44**	**0.38**	**0.47**
Energy use per floor area (climate corrected)	GJ/m2	0.43	0.46	0.42	0.47	0.49

4.3 Residential sector

Total energy use in residential sector						
	units	2010	2011	2012	2013	2014
Heat	PJ	2.10	2.73	3.05	2.94	2.93
Electricity	PJ	31.65	30.70	35.30	30.02	46.72
Space heating						
Oil and petroleum products	PJ	2.10	2.73	3.05	2.94	2.93
Total	**PJ**	**2.10**	**2.73**	**3.05**	**2.94**	**2.93**
Total (climate corrected for 1990–2011)	PJ	2.70	2.41	2.81	2.97	3.42
Space cooling						
Electricity	PJ	20.94	18.93	22.65	16.7	32.05
Total	**PJ**	**20.95**	**18.93**	**22.65**	**16.70**	**32.06**
Total (climate corrected for 1990–2011)	PJ	17.00	25.43	20.83	29.09	34.83
Water heating						
Electricity	PJ	3.56	3.92	4.21	4.43	4.88
Total	**PJ**	**3.57**	**3.92**	**4.22**	**4.44**	**4.89**
Lighting						
Electricity	PJ	4.64	5.10	5.48	5.77	6.35
Total	**PJ**	**4.64**	**5.10**	**5.48**	**5.77**	**6.35**

Total energy use in services sector						
	units	2010	2011	2012	2013	2014
Other energy use in residential sector						
Electricity	PJ	2.50	2.74	2.95	3.11	3.42
Total	**PJ**	**2.50**	**2.74**	**2.95**	**3.11**	**3.42**
Total energy use in residential sector						
Oil and petroleum products	PJ	2.10	2.73	3.05	2.94	2.93
Electricity	PJ	31.65	30.70	35.30	30.02	46.72
Total	**PJ**	**33.76**	**33.43**	**38.35**	**32.96**	**49.64**
Total (climate corrected for 1990–2011)	PJ	30.41	39.60	36.28	45.37	52.91
Fuel use per floor area (not climate corrected)	GJ/m2	0.17	0.16	0.18	0.15	0.22
Fuel use per floor area (climate corrected)	**GJ/m2**	**0.15**	**0.19**	**0.17**	**0.21**	**0.23**
Fuel use per capita (not climate corrected)	GJ/cap	7.78	7.28	7.79	6.23	8.85
Fuel use per capita (climate corrected)	GJ/cap	7.01	8.62	7.37	8.58	9.43
Fuel use per household (not climate corrected)	**GJ/dw**	**43.94**	**39.51**	**42.03**	**34.25**	**46.86**
Fuel use per household (climate corrected)	GJ/dw	39.58	46.80	39.76	47.15	49.94

4.4 Transport sector

The conversion of fuel derivatives are as follows:

- Motor gasoline: 46.4 GJ/tonne
- Diesel oil: 45.6 GJ/tonne
- Aviation Gasoline: 49.6 GJ/tonne

Total energy use in transport sector							
	units	2010	2011	2012	2013	2014	2015
Motor gasoline (including biofuels)	PJ	73.92	74.01	78.00	78.60	79.79	88.39
Diesel and light fuel oil	PJ	**14.36**	**15.64**	**20.86**	**20.45**	**20.75**	**23.43**
Jet fuel and aviation gasoline	PJ	..	..	..	..	11.36	10.19
Total	**PJ**	**88.28**	**89.65**	**98.86**	**99.05**	**111.90**	**122.01**

4.5 Electricity generation

Electricity generation from combustible fuels and other inputs							
	units	2010	2011	2012	2013	2014	2015
Inputs to all plants generating only electricity							
Oil and petroleum products	TJ	..	..	..	..	144 043	154 083
Total	**TJ**	**..**	**..**	**..**	**..**	**144 043**	**154 083**
Electricity output from all plants generating only electricity							
Oil and petroleum products	GWh	12 458	12 397	10 966	12 096	12 522	12 520
Total	**GWh**	**12 458**	**12 397**	**10 966**	**12 096**	**12 522**	**12 520**
Efficiency of all plants							
Oil and petroleum products	%	..	..	..	..	31.3	29.3
Total	**%**	**..**	**..**	**..**	**..**	**31.3**	**29.3**

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