The Impact of the Syrian Crisis on the Lebanese Power Sector and Priority Recommendations

FINAL REPORT
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Note: The information contained within this document has been developed within a specific scope, and might be updated in the future.

Acknowledgments

The Ministry of Energy and Water and the United Nations Development Programme (UNDP) would like to thank the Kingdom of the Netherlands for the grant that enabled this study and other crucial energy interventions for host communities in Lebanon.

Foreword

H.E. Cesar Abi Khalil, Minister of Energy and Water

Since the onset of the Syrian crisis in 2011, Lebanon has been hosting displaced Syrian nationals reaching 1.5 million in 2015 when the Government of Lebanon decided to close its borders. The number has remained relatively stable since then.

In 2015, the Government of Lebanon took the lead in setting a multi-sectoral strategy, the Lebanon Crisis Response Plan (LCRP), with the aim of mitigating the impact of the Syrian crisis on its territories. The LCRP is a joint effort between the GoL's relevant ministries on one hand and the UN agencies, local and international NGO's and international donors on the other. The LCRP incorporates several affected sectors, not the least of which is the Energy sector, stated as a stand-alone sector in the LCRP 2017-2020.

Prior to putting a medium term strategy under LCRP 2017-2020, MoEW was keen in 2016 to obtain realistic numbers of the electricity consumed by the displaced Syrians based on a household survey. Financed by the Kingdom of the Netherlands, and in collaboration with our partners UNDP, both of whom I thank deeply, the study "The Impact of the Syrian Crisis on the Lebanese Power Sector and Priority Recommendations" provided us with clear results and tangible indicators that highlight the areas where urgent action is needed.

Overall, the study shows that the displaced Syrians require a power generation of almost 480 MW, exceeding the additional production of 443MW added to the national grid by the Ministry since 2012. It also shows that the percentage of illegal connections to the grid vary between 36% in the North of Lebanon, to 82% in Beirut and Mount Lebanon, with an average of 45%. These facts result in a financial burden on the national economy exceeding $330 million per year.

Therefore, in order to tackle this problem, the energy team at MoEW proposed to target several axes simultaneously: the first is the electricity generation aspect, the second focuses on the demand side, while the third deals with the transmission and distribution systems. These are further developed in this study as well as in our Energy chapter under LCRP 2017-2020.

MoEW will put all the necessary effort to respond to the impact of the Syrian crisis on the Energy sector. Yet, we count on our partners of the international community to support us in providing assistance to the Energy sector to ease the burden on Lebanon as a hosting country carrying a burden above its capacities. By doing so, Lebanon will continue to cater for the needs of the displaced Syrian citizens who had to fled their homeland in spite of their will.

Cesar Abi Khalil

Minister of Energy and Water

Foreword UNDP

Philippe Lazzarini, UNDP Resident Representative

The power sector in Lebanon is known for chronic inefficiencies and shortages in supply reaching up to nine hours per day in some regions, and even more during the peak summer months. Over the past few years, the Government of Lebanon has worked on improving the energy supply by upgrading some of the power utilities and purchasing electricity from temporary facilities, namely barges. However, with the massive influx of refugees caused by the Syrian conflict, the surge in demand for power has surpassed most efforts made to improve supply, leaving the country with a higher energy deficit than in 2012.

The present study, undertaken in partnership with the Ministry of Energy and Water, with the generous funding from the Government of the Netherlands, assesses the impact of the Syrian crisis on the energy sector in Lebanon and is based on extensive surveys. Results indicate an overall increase of 480 Megawatts in energy consumption; nearly equivalent to the current deficit in supply which means the electricity gap is now double that of 2010.

More importantly, the study identifies short and medium term recommendations to overcome these problems. The recommendations focus on demand-side energy management options, prioritize renewable energy and energy efficiency and also highlight the need to upgrade the transmission and distribution infrastructure to ultimately lessen the impact of the crisis. The findings of this study were used to formulate the strategy of the energy sector within the Lebanon Crisis Response Plan (2017–2020), which was adopted at the end of last year.

Adequate, sustainable and affordable power supply for all people residing in Lebanon is a matter that requires urgent attention. In parallel to the continued efforts of the Government of Lebanon to pursue the structural reforms needed to implement the national electricity agenda, technical and financial support are needed to overcome the additional challenges faced by this sector as a result of the Syrian crisis.

ACRONYMS AND ABBREVIATIONS

3RP:	The Regional Refugee and Resilience Plan
AEMS:	Advance Engineering & Management Services
BDL:	Banque Du Liban (Central Bank of Lebanon)
BLOM:	Banque du Liban et Outre Mer
BUS:	BUTEC Utility Services
CDR:	Council for Development and Reconstruction
DER:	Distributed Energy Resources
DESS:	Distributed Energy Storage System
DGGS:	Directorate General of General Security
DSP:	Distribution Service Provider at EDL
EDL:	Électricité Du Liban
EU:	European Union
GDP:	Gross Domestic Product
GIS:	Geographic Information System
GOL:	Government of Lebanon
GS:	General Security
HV:	High Voltage
IMF:	International Monetary Fund
INDC:	Intended Nationally Determined Contribution
IOM:	International Organization for Migration
IS:	Informal Settlement
KVA:	K & A JV (Joint Venture)
KW:	Kilowatt
KWH:	Kilowatt Hour
LCEC:	Lebanese Center for Energy Conservation
LCRP:	Lebanon Crisis Response Plan
LV:	Low Voltage
ML:	Mount Lebanon
MEHE:	Ministry of Education and Higher Education
MoEW:	Ministry of Energy and Water
MoIM:	Ministry of Interior and Municipalities
MoPH:	Ministry of Public Health
MoSA:	Ministry of Social Affairs
MV:	Medium Voltage
MW:	Megawatt
MWH:	Megawatt Hour
NEC:	National Electrical Code
NEEREA:	The National Energy Efficiency and Renewable Energy Action
NEUC:	National Electrical Utility Company
NGO:	Non-Governmental Organization
Non IS:	Non Informal Settlement
OHTL:	Overhead Transmission Lines
PF:	Power Factor
PRL:	Palestinian Refugees in Lebanon
PRS:	Palestinian Refugees from Syria
PV:	Photovoltaic
RCREE:	Regional Centre for Renewable Energy and Energy Efficiency
SISSAF:	Support Program for Infrastructure Sector Strategies and Alternative Financing
TCL:	Total Connected Load
ToR:	Terms of Reference
UN:	United Nations
UNDP:	United Nations Development Programme
UNHCR:	United Nations High Commissioner for Refugees
UNICEF:	The United Nations International Children's Emergency Fund
UNRWA:	United Nations Relief and Works Agency for Palestinian Refugees in the Near East
WFP:	World Food Programme

TABLE OF CONTENTS

ANNEXES

LIST OF FIGURES

LIST OF TABLES

1. EXECUTIVE SUMMARY

Prior to the onset of the Syrian crisis, Lebanon was, and still is, suffering from serious and persistent issues in its energy sector. The limited generation capacities and the increasing demand impede Électricité du Liban (EDL), the national utility, from meeting the country's electricity demand. The gap between EDL's electricity production and total electricity consumption increases every year. Ageing power plants in Lebanon operate below their rated capacity. This results in power outages of at least three hours per day in Beirut and up to twelve hours outside of Beirut. EDL generates about 61% of the electricity consumption. Efforts have been made to improve the situation through the rehabilitation of some generation plants and through rented generation barges that increased the generation capacity by about 440 MW. However, power outages remained the same across the country because additional capacities are equated by an almost similar demand by the displaced Syrians.

The Ministry of Energy and Water (MoEW), in partnership with the United Nations Development Programme (UNDP) and with funding from the Kingdom of the Netherlands, initiated a project to study the additional power consumption as a result of the displaced Syrians in Lebanon. This report quantifies the power consumption of the displaced Syrians in Lebanon, assesses their direct and indirect impact on the electricity sector in Lebanon, and recommends interventions that are in line with the government's Policy Paper, Lebanon Crisis Response Plan (LCRP) and Lebanon's Intended Nationally Determined Contribution (INDC). The data produced in this report was also used to prepare the Energy Sector of the LCRP 2017 – 2020.

The power consumption of the displaced Syrians in Lebanon is calculated using two pathways. The first is based on the UNHCR figures as of June 30, 2016, which amounts to 1,032,589 registered persons. The second is based on Directorate General of General Security (DGGS) figures which estimate the official number of displaced Syrians in Lebanon at 1,500,000 persons. The recommendations and interventions presented in this report have been identified based on data made available by governmental authorities such as MoEW and EDL, as well as data gathered from an official survey of the displaced Syrians communities across all regions in Lebanon, and best practices in other countries with similar profiles. The recommendations and interventions were based on discussions with key representatives and were subsequently classified into short-, medium-, and long-term priorities.

Electricity demand of the displaced Syrians in Lebanon should be looked at primarily as a humanitarian need that affects the well-being of the individuals and the proper operation of other humanitarian sectors, in addition to its impact on the overall economy and electricity sectors. Similar to the Lebanese, most displaced Syrians in Lebanon, whether living in Non Informal Settlements (Non IS) or in Informal Settlements (IS), are not obtaining the minimum required electricity to operate basic household appliances due to insufficient generation capacities and overloaded transmission and distribution networks.

The assessment calculates that the additional direct and indirect power generation needed to cater for the demand of the displaced Syrian amounts to approximately 486 MW. This impact has major implications on the EDL network, and action has to be taken to alleviate its impact. Rehabilitation of the ageing power plants and construction of new power plants, underway by MoEW, are not sufficient nor quick enough to cover the rapidly increasing electricity demand. In 2010, Lebanon put forward a target for the energy sector by committing to 12% renewable energy use by 2020 (Climate Change, 2016), but Lebanon is still far from meeting this target. Therefore, recommendations and priorities are given to renewable energy to increase generated capacity and to participate in achieving ensure that 12% of total supply comes from renewable energy sources.

The short-term priority includes encouraging the use of energy saving bulbs and solar water heaters in the residential sector to reduce power demand on EDL's network.

The medium-term priorities comprise interventions that would require a period of at least five years to complete. Decentralized solutions such as Distributed Generation Resources (DER), or Distributed Energy, is recommended for areas of medium power demand (up to 10 MW) such as Hermel, Rachaya, and West Bekaa. Street lighting retrofit is another medium-term recommendation; high (or low) pressure sodium lamps (SHP) can be changed for LED fixtures, with dimming of lighting in times of low night traffic.

Other recommendations and interventions vary from using solar kits with a small rated capacity (up to 2.5 KW) in areas where households are considered "vulnerable" or where the EDL grid does not exist, to centralized solutions such as grid-tied PV plants or Wind Turbines. To further encourage the use of renewable energy, it is recommended to support the agricultural sector and water establishments to use renewable energy technology for irrigation and water distribution, respectively. This can be done by using PV-Direct Water Pumping technology.

To upgrade and rehabilitate the distribution network so that it accommodates the additional load and hence improve the quality of the electricity supplied, installation of new medium voltage/low voltage (MV/LV) substations and/or upgrade of the existing MV/LV substations is required. This solution requires the reinforcement of EDL's distribution network as well as the rehabilitation and upgrading of the transmission network through upgrading the transmission capacity of the high voltage/medium voltage (HV/MV) substations and by reinforcing the overhead transmission lines (OHTL).

2. BACKGROUND

The United Nations Development Programme, initiated the "Lebanon-Support to Economic Recovery, Community Security and Social Cohesion in Lebanese Communities Affected by the Syrian Project: Renewable Energy Project" funded by the Netherlands Ministry for Foreign Trade and Development Cooperation, in partnership with the Ministry of Energy and Water. A private energy services company, Advanced Engineering Management Services (AEMS) S.A.L., was hired to conduct a detailed assessment during 2016 of the actual impacts and implications of the current Syrian refugee crisis on the Lebanese electricity sector. The aim of this assessment is to better align international assistance with the Lebanese Government and the Ministry of Energy and Water's programmes and plans.

Since the beginning of the Syrian crisis on March 15, 2011, the number of Syrian displaced persons have fluctuated, the highest number recorded being 1,174,830 persons (287,321 families) on June 30, 2015 (UNHCR, 2015). For almost four years, the Government of Lebanon (GoL) adopted an "Open Border Policy" allowing displaced Syrians to settle freely across the country until January 2015 when it took a firm decision to close its borders. As of June 30, 2016, the number of displaced Syrians registered with the UNHCR was 1,032,589 persons (247,454 Families) dispersed across 1,298 villages in Lebanon, while the official number of displaced Syrians in Lebanon adopted by GoL and issued by the Directorate General of General Security (DGGS) is 1,500,000 persons. Although most of the displaced Syrians are living in rented accommodations or hosted within the Lebanese communities, there are 4,231 Informal Settlements comprising 223,965 individuals living in 39,856 tents spread out across 344 villages in Lebanon where the majority have settled in the Bekaa and North regions (UNHCR, 2016).

The Syrian crisis has impacted many sectors in Lebanon, not least of which is the electricity sector. Therefore, it was deemed necessary to conduct a study to measure and quantify the power consumption of displaced Syrians in Lebanon and assess its implications on the electricity sector, which is already facing chronic issues in meeting the continuously increasing power demand.

The current situation is, however, receiving substantial attention from the international community to assist Lebanon in its ability to cater for the large number of displaced Syrians and at the same time to ensure that its own population is not negatively impacted. However, to ensure that scarce resources are used effectively, this assessment aims to align the assistance of the international community where it is most needed and in line with the energy policies of the Government of Lebanon.

3. PROJECT DESCRIPTION AND METHODOLOGY

The project initiated by the MoEW and the UNDP explores the implications of the current Syrian crisis on the electricity sector in Lebanon through sample surveys, it then provides and prioritizes interventions. The study aims to accurately assess the impacts on electricity use, in terms of time-of use, additional quantity of use, and regional variations in use, of the displaced Syrians in Lebanon. The assessment is anticipated to prioritize interventions and actions required to meet the additional electricity demand in Lebanon from the Syrian crisis while ensuring that these interventions are technically, financially, and environmentally sustainable.

The project is divided into different methodology tracks allowing for data validation and cross check:

- Data gathering
- Site survey
- Data validation and analysis
- Power and energy calculation
- Recommendations and prioritization of interventions

3.1 Data Gathering

A review of the latest reports/publications and literature on the electricity and energy sector in Lebanon has been carried out, including but not limited to studies such as the Ministry of Energy and Water's Policy Paper for Electricity (2010) as well as the National Energy Efficiency Action Plan for Lebanon (NEEAP 2016 – 2020) and the National Renewable Energy Action Plan for Lebanon (NREAP 2016 – 2020), the World Bank Economic and Social Impact of the Syrian Crisis (2013), the GoL's Lebanon Crisis Response Plan (2016 and 2017 - 2020), Ministry of Environment/ EU/ UNDP Environmental Assessment of the Syrian Crisis on Lebanon (2014 and update of 2015). Data gathering also included interviews of key stakeholders, the Ministry of Energy and Water (MOEW), Ministry of Social Affairs (MOSA), UNHCR, Ministry of Public Health (MOPH), Ministry of Education and Higher Education (MEHE), and Electricity du Lebanon (EDL), to gather additional information on the sector.

Data gathered from the UNHCR in the form of published lists of the "Number of Syrian Refugee Families and Individuals per Cadastral in Lebanon" and number of displaced Syrians living in Informal Settlements (available in Annex 01), have been used in the power consumption calculation as shown in section 4.3 Data Analysis.

As of June 30, 2016, the number of displaced Syrians registered with the UNHCR was 1,032,589 persons (247,454 Families) dispersed across 1,298 villages in Lebanon (UNHCR by CAS, 2016). Table 1 and Figures 1, 2 below illustrate the number of displaced Syrians in Lebanon at different intervals and the geographic distribution across all regions in Lebanon.

No. of the Displaced Syrians in Lebanon Registered with the UNHCR

Region	Category	July 19, 2013	December 31, 2013	December 31, 2014	June 30, 2015	December 30, 2015	March 31, 2016	June 30, 2016
Beirut & ML	Person	99,212	176,196	304,771	343,923	311,098	305,687	298,487
	Family	23,460	45,864	79,332	91,469	82,425	80,617	77,329
North	Person	180,489	233,666	345,908	412,200	371,809	365,555	363,297
	Family	37,601	60,824	90,040	93,802	98,511	96,405	81,558
Bekaa	Person	185,513	236,448	283,677	280,691	260,932	256,126	252,219
	Family	45,724	61,548	73,842	71,258	65,406	64,037	62,110
South	Person	67,770	96,197	135,646	138,016	125,272	120,907	118,586
	Family	15,120	21,462	30,263	30,792	27,949	26,975	26,457
Total	**Person**	**532,984**	**742,507**	**1,070,002**	**1,174,830**	**1,069,111**	**1,048,275**	**1,032,589**
	Family	**121,905**	**189,697**	**273,477**	**287,321**	**274,291**	**268,034**	**247,454**

Table 1: Displaced Syrians in Lebanon Registered with UNHCR - Historical Data

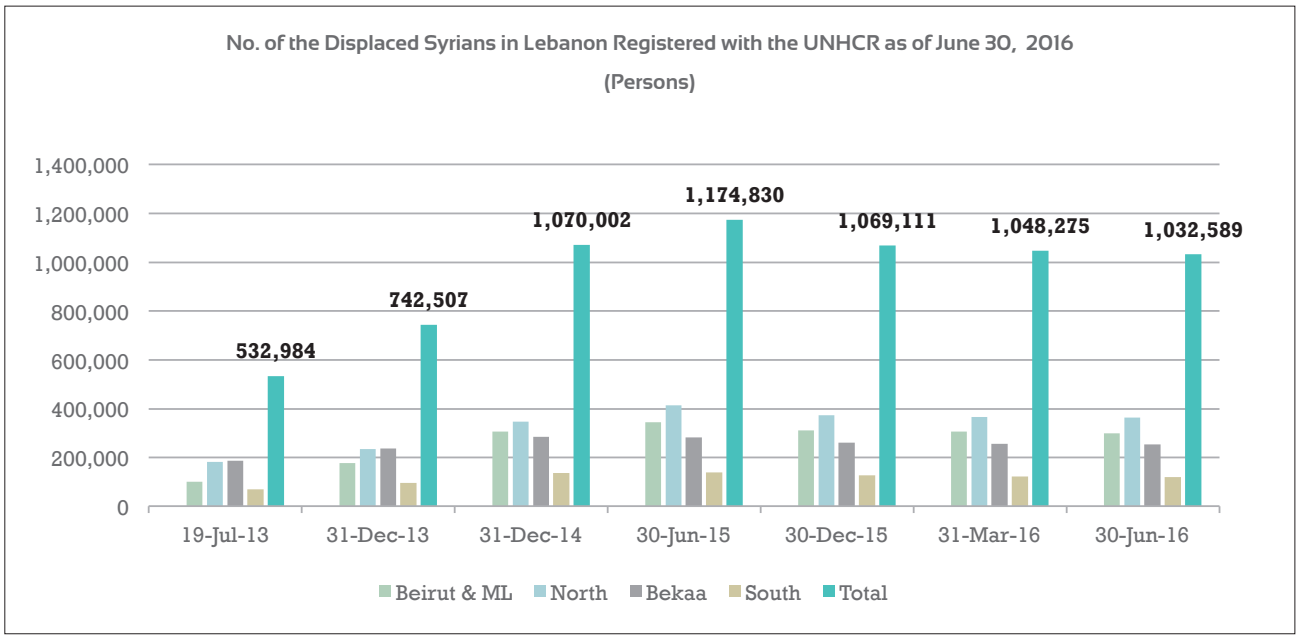


Figure 1: No. of the Displaced Syrians in Lebanon Registered with the UNHCR (Persons) - Historical Data

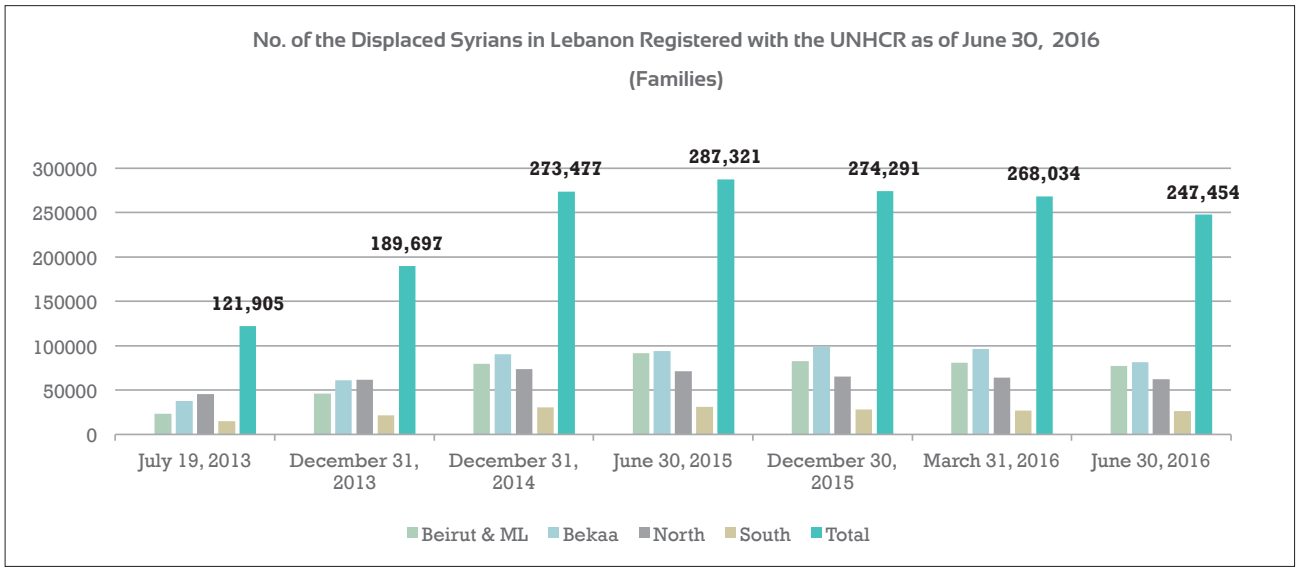


Figure 2: No. of the Displaced Syrians in Lebanon Registered with the UNHCR (Families) - Historical Data

Although most of the displaced Syrians are living in rented accommodations or hosted within Lebanese communities, there are 4,231 Informal settlements comprising 223,965 individuals living in 39,856 tents or shelter units spread out across 344 villages in Lebanon where the majority have settled in the Bekaa and North regions (UNHCR, 2016). However, as per the UNHCR, there is an estimated 7% displaced Syrians living in Informal Settlements (IS) that are not registered with the UNHCR and must be considered in the power consumption calculation.

The updated number of displaced Syrians in Lebanon registered with the UNHCR as of June 30, 2016, in addition to the number of Informal Settlements as of August 31, 2016, is depicted in Table 2, Figure 3, and Figure 4.

No. of the Displaced Syrians in Lebanon Registered with the UNHCR as of June 30, 2016 including 7% for Unregistered Displaced Syrians living in Informal Settlements

Region	Category	Displaced Syrians as of June 30, 2016	Non Informal Settlements	Informal Settlements as of August 31, 2016	Informal Settlements +7% of Unregistered IS	Total No. of Displaced Syrians in Lebanon
Beirut & ML	Person	298,487	295,410	3,077	3,292	298,702
	Family	77,329	76,747	582	623	77,370
Bekaa	Person	363,297	191,652	171,645	183,660	375,312
	Family	81,558	51,088	30,470	32,603	83,691
North	Person	252,219	209,726	42,493	45,468	255,194
	Family	62,110	54,571	7,539	8,067	62,638
South	Person	118,586	111,836	6,750	7,223	119,059
	Family	26,457	25,192	1,265	1,354	26,546
Total	**Person**	**1,032,589**	**808,624**	**223,965**	**239,643**	**1,048,267**
	Family	**247,454**	**207,598**	**39,856**	**42,647**	**250,245**

Table 2: No. of the Registered and Unregistered Displaced Syrians in Lebanon as per the UNHCR Figures

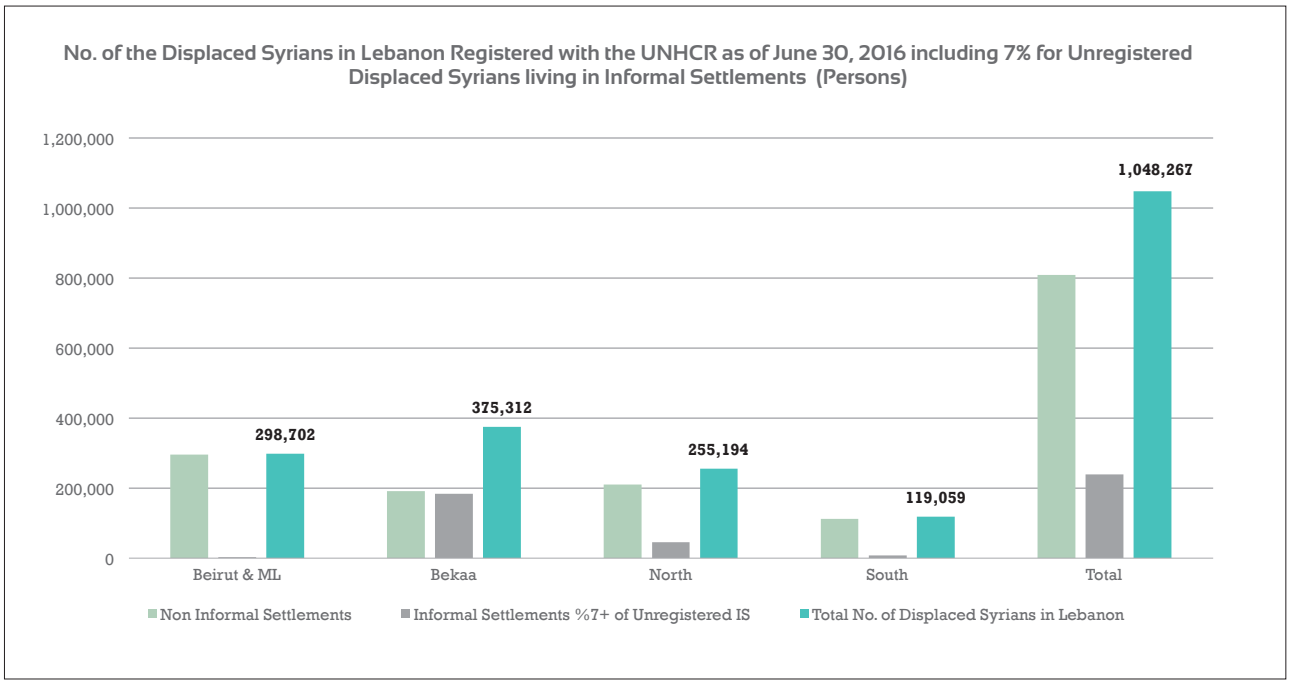


Figure 3: No. of the Registered and Unregistered Displaced Syrians in Lebanon as per the UNHCR Figures (Persons)

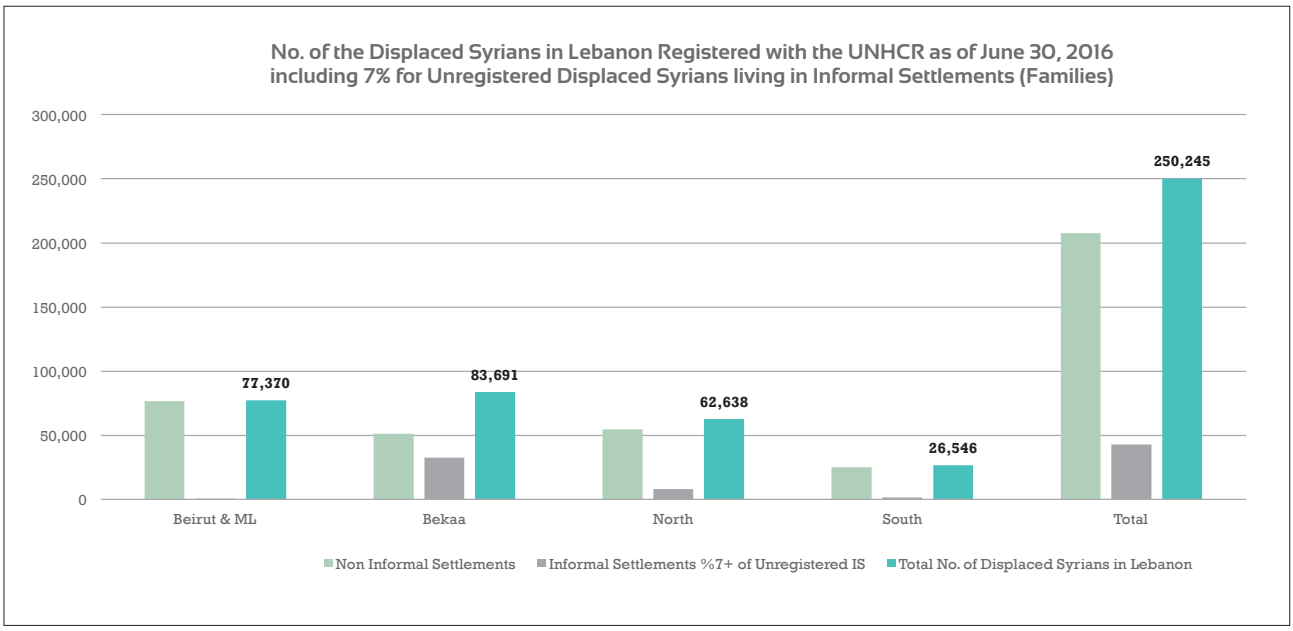


Figure 4: No. of the Registered and Unregistered Displaced Syrians in Lebanon as per the UNHCR Figures (Families)

As per the UNHCR data, the majority of displaced Syrians are living in Beirut, Mount Lebanon, and Bekaa regions. Based on definitions adopted by the UNHCR, displaced Syrians living in Non Informal Settlements refer to those in rented accommodations or hosted within the Lebanese communities, which make up around 78% of the displaced Syrian population, while the remaining 22% live in Informal Settlements. Table 3, Figure 5, and Figure 6 below represent the geographic distribution of the displaced Syrians in Lebanon as of June 30, 2016 including the 7% of unregistered displaced Syrians living in IS shelters.

Geographic Distribution of the Displaced Syrians in Lebanon Registered and Unregistered with the UNHCR

Region	Category	No. of Non Informal Settlements	% of Non IS from Total No. of Displaced Syrians	No. of Informal Settlements	% of IS from Total No. of Displaced Syrians	Total No. of Displaced Syrians	% of Non IS from Total No. of Displaced Syrians
Beirut & ML	Person	295,410	28.18%	3,292	0.31%	298,702	28.49%
	Family	76,747	30.67%	623	0.25%	77,370	30.92%
Bekaa	Person	191,652	18.28%	183,660	17.52%	375,312	35.80%
	Family	51,088	20.42%	32,603	13.03%	83,691	33.44%
North	Person	209,726	20.01%	45,468	4.34%	255,194	24.34%
	Family	54,571	21.81%	8,067	3.22%	62,638	25.03%
South	Person	111,836	10.67%	7,223	0.69%	119,059	11.36%
	Family	25,192	10.07%	1,354	0.54%	26,546	10.61%
Total	**Person**	**808,624**	**77.14%**	**239,643**	**22.86%**	**1,048,267**	**100.00%**
	Family	**207,598**	**82.96%**	**42,647**	**17.04%**	**250,245**	**100.00%**

Table 3: Geographic Distribution of the Displaced Syrians in Lebanon as of June 30, 2016

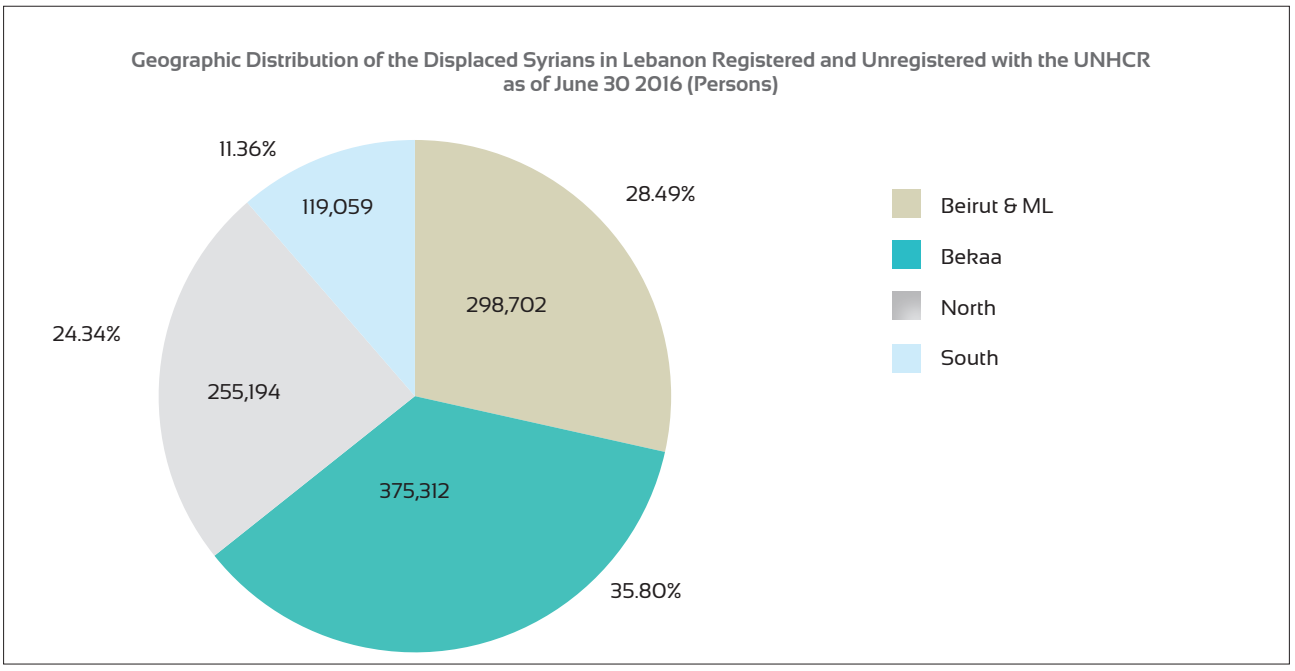


Figure 5: Geographic Distribution of the Displaced Syrians in Lebanon as of June 30, 2016

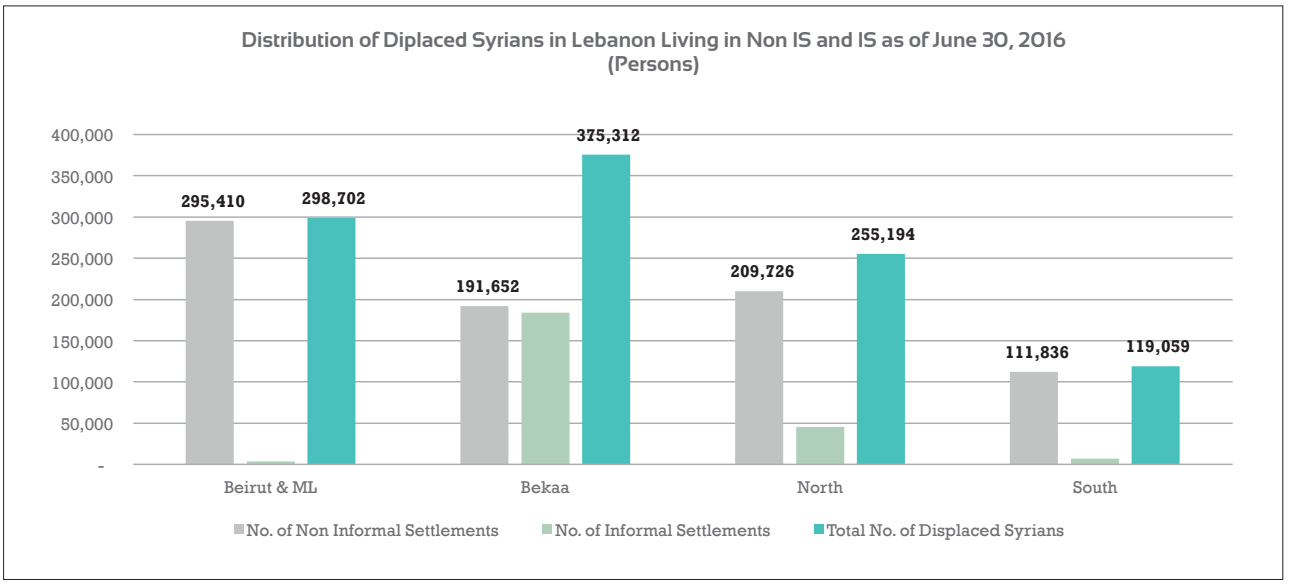


Figure 6: Distribution of the Displaced Syrians in Lebanon Living in Non IS and IS as of June 30, 2016 (Persons)

EDL data is provided by the three Distribution Service Provider (DSP's): BUTEC Utility Service (BUS) covers Antelias area and North region, K&A Joint Venture (KVA) covers part of Beirut and Bekaa region, and National Electrical Utility Company (NEUC) covers part of Beirut, Mount Lebanon, and the South. Data collection proved to be challenging, as it was either incomplete (mainly missing GIS data which prevents cross referencing feeders and geographical locations) or rather general containing only annual peak loads (hence no insight as to detailed seasonal or time changes in demand).

3.2 Site Survey

From the information collected, a representative survey to 340 Syrian families and 60 institutions across the country was undertaken in July 2016 to quantify the direct and indirect electricity consumption of the displaced Syrians in Lebanon. As of June 30, 2016, displaced Syrians registered with the UNHCR amounted to 1,032,589 persons spread across 247,454 families and dispersed in 1,298 villages. Survey samples were selected based on the number of registered displaced Syrians in each village in different regions as well as the shelter type (Non IS or IS) to calculate the power consumption of each shelter type as shown in Tables 4 and 5 below.

Region	Population	% of Total	No. of Samples
Beirut & ML	298,487	28.91%	110
Bekaa	363,297	35.18%	100
North	252,219	24.43%	80
South	118,586	11.48%	60

Institution Type	Expected Sample Size
Health-care	20
Education	20
Other	20

Table 4: No. of Displaced Syrians in Lebanon and No. of Survey Samples

Area	Start Date	End Date	Duration	No. of Teams	No. of Samples
Beirut & ML	7/20/16	8/20/16	28	2	110
Bekaa	7/18/16	8/17/16	27	2	100
North	7/11/16	8/10/16	27	2	80
South	7/12/16	8/18/16	33	2	60
Health-Care	7/11/16	8/12/16		1	20
Education	6/30/16	8/16/16		1	20
Others	7/11/16	8/24/16		1	20
Total					410

Table 5: Survey Schedule

Different Survey Forms were developed for each type of institution type to gather the required information. Mainly power consumption was assessed in hospitals, schools, and other institutions such as municipalities and by displaced Syrians themselves.

3.3 Survey Findings

3.3.1 Beirut & Mount Lebanon Governorate

There are 295,410 persons (76,747 families) living in Non IS shelter and 3,292 persons (623 families) living in IS. 110 samples were surveyed in different areas such as Achrafieh, Ain El Mraissy, Mazraa, Naameh, and Choueifat to verify the power consumption of different shelter types in different areas.

In general, about 86% of the visited samples have one family per shelter unit, 10% have two families per shelter unit, and 4% have three or more families per shelter unit. With regards to power connection, the majority of the displaced Syrians have Non-Metered power connections. Power consumption for Non IS shelter unit is almost the same for all visited samples irrespective of the number of persons or number of families living in each shelter unit. The same applies to displaced Syrians living in IS. The average connected load of household appliances was calculated to be 2.777 KW per shelter unit for Non IS samples and 0.661 KW per shelter unit for IS samples. Tables 6 and 7 below summarize the survey findings of the visited samples in Beirut & Mount Lebanon.

	UNHCR Data		Survey Data						Calculated Data	
Shelter Type	No. of Persons	No. of Families	No. of Visited Shelters	Total No. of Units in Visited Shelters	Total No. of Persons in Visited Shelter Units	Total No. of Families in Visited Shelter Units	Total Connected Load of Household Appliances of Visited Shelter Units (kW)	Average No. of Supply Hours/ Day	Average Connected Load of Household Appliances/ Shelter Unit (kW)	Average Power Consumption per Shelter Unit (kW)
Non IS	295,410	76,747	83	148	428	91	230.450	8	2.777	1.388
IS	3,292	623	27	85	185	38	17.850	6	0.661	0.661
Total	298,702	77,370	110	233	613	129	248.300			

Table 6: Survey Data of Visited Displaced Syrian Shelter Units in Beirut & Mount Lebanon Governorate

Shelter Type	UNHCR Data		Survey Data						
	No. of Persons	No. of Families	No. of Visited Shelters	Total No. of Units in Visited Shelters	One Family/ Shelter Unit	Two Families/ Shelter Unit	Three Families/ Shelter Unit	Four Families/ Shelter Unit	Five Families/ Shelter Unit
Non IS	295,410	76,747	83	148	77	4	2	0	0
IS	3,292	623	27	85	18	7	2	0	0
Total	298,702	77,370	110	233	95	11	4	0	0
			% of Visited Samples		86.36%	10.00%	3.64%	0.00%	0.00%

Table 7: No. of Families per Shelter Unit of Displaced Syrians in Beirut & Mount Lebanon Governorate

3.3.2 Bekaa Region

The majority of displaced Syrians in Lebanon (35.80%) had settled in the Bekaa region of which 51% (191,652 persons/ 51,088 families) are living in rented accommodations (Non IS) while the remaining 49% (183,660 persons or 32,603 families) are living in IS.

As per the survey data, the majority of the displaced Syrians have one family per shelter unit. The average supply hours per day in the Bekaa region is the highest among all regions (15 hours per day) due to the fact that almost 43% of the displaced Syrians in the Bekaa live in Zahle and have 24 hours of power supply per day. Additional information of displaced Syrians in the Bekaa region is illustrated in the Tables 8 and 9 below.

Shelter Type	UNHCR Data		Survey Data						Calculated Data	
	No. of Persons	No. of Families	No. of Visited Shelters	Total No. of Units in Visited Shelters	Total No. of Persons in Visited Shelter Units	Total No. of Families in Visited Shelter Units	Total Connected Load of Household Appliances of Visited Shelter Units (kW)	Average No. of Supply Hours/ Day	Average Connected Load of Household Appliances/ Shelter Unit (kW)	Average Power Consumption per Shelter Unit (kW)
Non IS	**191,652**	**51,088**	**38**	**130**	**226**	**58**	**78.750**	**12**	**2.072**	**1.036**
IS	**183,660**	**32,603**	**62**	**1,002**	**484**	**72**	**68.150**	**15**	**1.099**	**1.099**
Total	**375,312**	**83,691**	**100**	**1,132**	**710**	**130**	**146.900**			

Table 8: Survey Data of Visited Displaced Syrian Shelter Units in Bekaa Region

Shelter Type	UNHCR Data		Survey Data						
	No. of Persons	No. of Families	No. of Visited Shelters	Total No. of Units in Visited Shelters	One Family/ Shelter Unit	Two Families/ Shelter Unit	Three Families/ Shelter Unit	Four Families/ Shelter Unit	Five Families/ Shelter Unit
Non IS	191,652	51,088	39	130	26	7	3	1	1
IS	183,660	32,603	61	1,002	53	8	1	0	0
Total	375,312	83,691	100	1,132	79	15	4	1	1
			% of Visited Samples		79.00%	15.00%	4.00%	1.00%	1.00%

Table 9: No. of Families per Shelter Unit of Displaced Syrians in Bekaa Region

3.3.3 North Region

Although the majority of the displaced Syrians in the Akkar and North regions are living in rented accommodations (Non IS) or hosted within the Lebanese communities; the average power consumption per shelter unit for Non IS turned out to be the lowest among other regions due to the fact that most of the displaced Syrians living in Non IS shelters have the same living conditions of those living in IS shelters. Detailed information of displaced Syrians in the Northern region is depicted in Tables 10 and 11 below.

Shelter Type	UNHCR Data		Survey Data						Calculated Data	
	No. of Persons	No. of Families	No. of Visited Shelters	Total No. of Units in Visited Shelters	Total No. of Persons in Visited Shelter Units	Total No. of Families in Visited Shelter Units	Total Connected Load of Household Appliances of Visited Shelter Units (kW)	Average No. of Supply Hours/ Day	Average Connected Load of Household Appliances/ Shelter Unit (kW)	Average Power Consumption per Shelter Unit (kW)
Non IS	209,726	54,571	56	580	427	76	106.850	9	1.908	0.954
IS	45,468	8,067	24	623	169	37	18.400	8	0.767	0.767
Total	255,194	62,638	80	1,203	596	113	125.250			

Table 10: Survey Data of Visited Displaced Syrian Shelter Units in North Region

Shelter Type	UNHCR Data		Survey Data						
	No. of Persons	No. of Families	No. of Visited Shelters	Total No. of Units in Visited Shelters	One Family/ Shelter Unit	Two Families/ Shelter Unit	Three Families/ Shelter Unit	Four Families/ Shelter Unit	Five Families/ Shelter Unit
Non IS	209,726	54,571	56	580	46	3	4	3	0
IS	45,468	8,067	24	623	19	2	1	0	2
Total	255,194	62,638	80	1,203	65	5	5	3	2
			% of Visited Samples		81.25%	6.25%	6.25%	3.75%	2.50%

Table 11: No. of Families per Shelter Unit of Displaced Syrians in North Region

3.3.4 South Region

As per the survey data, the average power consumption per shelter unit in the South region is the highest among all regions. As noticed during the survey, the majority of the displaced Syrians in the Southern region have Non-Metered power connection and high current carrying capacity cables connected directly to the nearest power source and therefore, electricity is used for water heating and operating more household appliances compared to other shelters in other regions. Details of the displaced Syrians in the South are shown in Tables 12 and 13.

	UNHCR Data		Survey Data						Calculated Data	
Shelter Type	No. of Persons	No. of Families	No. of Visited Shelters	Total No. of Units in Visited Shelters	Total No. of Persons in Visited Shelter Units	Total No. of Families in Visited Shelter Units	Total Connected Load of Household Appliances of Visited Shelter Units (kW)	Average No. of Supply Hours/ Day	Average Connected Load of Household Appliances/ Shelter Unit (kW)	Average Power Consumption per Shelter Unit (kW)
Non IS	111,836	25,192	31	143	162	31	81.050	6	2.615	1.307
IS	7,223	1,354	29	64	154	31	54.050	5	1.864	1.864
Total	119,059	26,546	60	207	316	62	135.100			

Table 12: Survey Data of Visited Displaced Syrian Shelter Units in South Region

Shelter Type	UNHCR Data		Survey Data						
	No. of Persons	No. of Families	No. of Visited Shelters	Total No. of Units in Visited Shelters	One Family/ Shelter Unit	Two Families/ Shelter Unit	Three Families/ Shelter Unit	Four Families/ Shelter Unit	Five Families/ Shelter Unit
Non IS	111,836	25,192	31	143	31	0	0	0	0
IS	7,223	1,354	29	64	27	2	0	0	0
Total	119,059	26,546	60	207	58	2	0	0	0
			% of Visited Samples		96.67%	3.33%	0.00%	0.00%	0.00%

Table 13: No.of Families per Shelter Unit of Displaced Syrians in North Region

3.3.5 Healthcare Centers

Twenty healthcare centers have been surveyed to assess the indirect impact of the Syrian crisis on the electricity sector in Lebanon. The survey covered seventeen (17) governmental hospitals and three (3) private hospitals to evaluate the additional power consumption each hospital is bearing due to the displaced Syrians in the area.

As expected, there is no quantitative impact on the electricity bill of the hospitals because most hospitals already operate 24 hours at full capacity. However, there is a qualitative impact resulting from the additional power consumption of the displaced Syrians in the areas close to the supply points of the respective hospitals. The impact is in the form of overloading of the distribution network. This results in poor power quality and voltage drop (180V - 190V) in many areas, and therefore hospitals are forced to run on diesel generators even during power supply hours because most office machines and appliances do not function when the voltage levels are low. Additional information of hospitals survey is available in Annex 02 - Survey Data.

3.3.6 Education Centers

As per information provided by the Ministry of Education and Higher Education (MEHE), there are 238 public schools in Lebanon hosting 85,487 displaced Syrian students across all regions. Details of schools and number of students are given in Table 14 below.

Area	No. of Schools	No. of Students
Beirut & ML	71	28,776
Bekaa	59	22,704
North	68	20,783
South	40	13,224
Total	238	85,487

Table 14: No. of Schools Hosting Displaced Syrian Students in Each Region

Schools normally work six hours a day but schools that are hosting displaced Syrian students are working an additional four-hour shift. This in turn increased both electricity and fuel oil bills of the schools. Moreover, due to the poor power quality and high voltage drop in some areas as a result of the overloaded MV feeders or MV/LV substations, some schools operate on diesel generators even during power supply hours because office machines do not function when voltage levels are low. Additional information of schools survey is available in Annex 02 - Survey Data.

The additional four-hour shift constitutes the indirect impact of displaced Syrian students on the power consumption of hosting schools. The power consumption of each school was calculated from their respective electricity bills based on 22 working days per month. The additional four-hour shift is evaluated for the calculation of the indirect impact of the displaced Syrian students on the hosting schools' energy consumption as detailed in Table 15. The collected data show a total increase of 10,895KWh in energy consumption as indirect impact of the displaced Syrians, almost 50% of which is in Beirut and Mount Lebanon.

	Survey Data				Calculated Data								
Region	**School Name**	Energy Consumption (KWH) as per Electricity Bill	No. of Months	Energy Consumption per Month (KWH/ Month)	Energy Consumption per Day (KWH/Day)	No. of Supply Hours per Day	No. of Working Hours per Day	No. of Working Hours per Day on EDL Supply	Average Power Consumption of School (KW)	Average Power Consumption per School (KW)	**No. of Schools**	Total Power Consumption (KW)	Additional Energy Consumption of the 4 Hour Shift (KWH)
Beirut & ML	Omar Fakhoury	27,618	4	6,905	314	12	10	10	31.384	20.112	71	1,428	5,712
	Ibtihaj Kadora	7,779	4	1,945	88	12	10	10	8.840				
Bekaa	Bar Elias	1,412	1	1,412	64	24	10	10	6.418	9.185	59	542	2,168
	Qob Elias	1,134	2	567	26	8	10	6	4.295				
	Salim Haidar	4,446	2	2,223	101	8	10	6	16.841				
North	Al Tarbyah Al Hadiyha	3,595	3	1,198	54	8	10	6	9.078	7.381	68	502	2,008
	Solaiman Al Bostani	2,222	3	741	34	8	10	6	5.611				
	Motawasetat Al Baddawi	4,540	2	2,270	103	8	10	6	17.197				
	Al Fadilah	1,516	3	505	23	8	10	6	3.828				
	Dahr Al Ain	472	3	157	7	8	10	6	1.192				
South	Zibdine Intermediate	432	1	432	20	6	10	6	3.273	6.301	40	252	1,008
	Masaken Al Shaabieh	2,463	2	1,232	56	6	10	6	9.330				
									Total		238	2,724	10,895

1. The number of working days is 22 days per month
2. Average power consumption per school is calculated on the No. of EDL supply hours the school benefits from
3. Omar Fakhoury School, Ibtihaj Kadora School, and two other schools have the same electricity bill
4. The share of Omar Fakhoury School is 54.2% of the total bill (50,956 KWH for four months)

Table 15: Indirect Additional Power Consumption of Public Schools Hosting Displaced Syrian Students as per Survey Data

3.3.7 Other Institutions

The other institutions covered in the survey were municipalities in different regions. Some municipalities have updated records of the displaced Syrians in the area, where in some areas, the municipalities' actual reported numbers of displaced Syrians is much higher than the figure given by the UNHCR.

According to some municipalities, the electricity bill increased because water pumps are running for longer hours to cover the additional water consumption caused by the displaced Syrians in the area (pumps and systems, 2016 and Washington State University, 2016). Although legally, the Regional Water Establishments and the Ministry of Energy and Water are responsible for the supply of domestic water, for the purpose of this study, municipalities were surveyed as a means to shed light on the issue.

Furthermore, some municipalities had to install streetlights near displaced Syrian shelters for security reasons. The additional working hours of water pumps as well as the new street lights represent the indirect impact on the power consumption resulting from the displaced Syrians in each area. Assuming that the operation of water pumps has increased by 50%, the estimated indirect power consumption of is calculated in Table 16 below.

No. of Villages Hosting Displaced Syrians	Assumed No. of Municipalities using Water Pumps for Additional Hours	Average Rated Capacity per Water Pump (HP)	Average Rated Capacity per Water Pump (KW)	Average Rated Capacity per Water Pump at 75% Efficiency (KW)	Additional Power Consumption of Municipalities (KW)
1,298	649	100	74.57	55.9275	36,297

Table 16: Indirect Additional Power Consumption of Municipalities as per Survey Data

The other concern of some municipalities is the frequently burnt out distribution transformers due to the over-load, the low power quality, and voltage drop caused by the additional power consumption of the displaced Syrians that forces the municipality to operate the water pumps and other service machinery on diesel generator.

3.3.8 General Findings

- Power consumption of IS and Non IS shelters is independent of the number of persons or number of families living in each shelter unit.
- In most areas, people are complaining about voltage drop that prevents them from operating most of the household appliances.
- Most of the visited shelters do not have a fridge or a washing machine because they cannot use it due to the limited power capacity (1A to 1.5A per shelter unit).
- Schools hosting displaced Syrian students have an indirect impact on the power consumption resulting from the additional four-hour shift the schools are providing. This additional power requirement is estimated at around 10 MW as shown in table 15.
- Other institutions have shown increase in indirect power consumption as a result of the longer operating hours of water pumping to cover the additional water demand of the displaced Syrians. This is estimated at 36 MW as indicated in table 16.

Details of the UNHCR data are available in Annex 02 - Survey Data.

3.4 Data Validation & Analysis

The data validation process aims at ensuring the accuracy of the achieved results of the gathered data, managed, and analyzed. The correlation between these results and the real status of the displaced Syrians in Lebanon will be used to generate the analysis base lines of the final report.

The data validation and analysis are intended to give the maximum possible guarantees for the accuracy and consistency of the outputs of gathered data and prove the reliability of the components of this study. This will secure correctness of the results of the impact of the Syrian crisis on the power sector in Lebanon. The process of data validation and analysis is described in annex 03.

Table 17 here after provides a sample of the calculated average connected load for Non IS and IS using the average of the TCL for each shelter type of the visited samples in each region. For validation purposes, the power consumption is then calculated again using the econometric and statistical methods to calculate the increase in load on the MV feeders supplying the South region and correlating it to the number of the displaced Syrians in the villages supplied by these feeders taking into consideration the increase in load due to the increase in the number of EDL customers resulting from the normal Lebanese population growth.

DISPLACED SYRIAN SHELTERS SURVEY DATA
GOVERNORATE OF SOUTH LEBANON (60 SAMPLES)

City / Village	Visited Shelter Name	No. of Family Members	Shelter Type	No. of Families in Visited Unit Shelter	No. of Persons in Visited Unit Shelter	No. of Units in Visited Unit Shelter	Available Household Appliances (W)								Total Connected Load (KW)	Average Power Consumption (KW)
							Light	Fridge	TV	Fan	Washing Machine	Water Heater	Iron	A/C		
							100	300	150	100	1,000	1,500	1,000	1,100		
Bissarieh	Mounir Hmaidan	5	IS	1	5	11	2	1	1	1	0	0	0	0	0.75	0.75
		3	IS	1	3		2	1	1	0	1	0	0	0	1.65	1.65
		4	IS	1	4		3	0	1	1	0	0	0	0	0.55	0.55
		4	IS	1	4		2	1	1	0	0	0	0	1	1.75	1.75
Sarafand	Manana Building	5	Non IS	1	5	74	2	0	1	0	1	0	1	0	2.35	1.175
		5	Non IS	1	5		2	0	1	0	1	0	0	0	1.35	0.675
		8	Non IS	1	8		2	0	1	0	1	0	0	0	1.35	0.675
		3	Non IS	1	3		2	0	1	0	1	0	0	0	1.35	0.675
		7	Non IS	1	7		2	0	1	0	1	0	0	0	1.35	0.675
		7	Non IS	1	7		2	0	1	0	1	0	0	0	1.35	0.675
		9	Non IS	1	9		2	0	1	0	1	0	0	0	1.35	0.675

Non IS: Non Informal Settlement IS: Informal Settlement

Table 17: Sample of Survey Data Sheet

4. Econometrics and Statistical Analysis

4.1 Introduction

The econometrics and statistical methods employed to analyze and validate the primary and secondary data are presented along with their results, as well as their interpretation and implications. The site survey data is considered herewith as the primary data, while the secondary data consists of data related to the distribution of the displaced Syrians obtained from various sources such as the UNHCR and the DGGS, as well as GIS and MV feeder loads shared by EDL and the MOEW.

The data related to the distribution of the displaced Syrians obtained from the UNHCR is used to calculate the average number of persons per family for each of the four regions considered in this study (Beirut & Mount Lebanon, Bekaa, North, and South).

The results of the site survey data provide the basis for calculating the power consumption of displaced Syrians in Lebanon. Descriptive and inferential statistical methods are conducted to analyze the demographic variables of the displaced Syrians in Lebanon. These results, along with those obtained by analyzing the power consumption of household appliances of the visited samples, are used to calculate the power consumption of the displaced Syrians in Lebanon.

Power consumption calculated using the survey data is validated by comparing it to the monthly power consumption calculated using EDL data (GIS data and MV feeders load). Data analysis and calculation are based on the monthly load on the MV feeders and the historical data of the number of displaced Syrians provided by the UNHCR.

4.2 Methodology

As per EDL data, 10 HV/MV primary substations supply the South region. Other details of the South region are exhibited in Table 18 below.

Category	2012	2013	2014	2015	2016
No. of MV Feeders	81	87	89	92	98
No. of Villages Hosting Displaced Syrians		283	305	303	306
No. of Displaced Syrians (Persons)		96,197	135,646	125,272	118,586

Table 18: Details of South Region

Validation of the data is carried out using the seasonal index method on a quarterly basis. Seasonal indices are computed in order to remove the seasonal variation in consumption and then values are used to calculate the average yearly load. In order to account for the increase in load due to the displaced Syrians, the calculated loads are adjusted using the Lebanese population growth rate. The total load from the displaced Syrians is then divided by the number of families for time period required; details on the method are available in Annex 04.

This analysis is conducted for the South region alone since it was the region where data (GIS and load) were provided as mentioned above in section 3.1.

4.3 Determining the Seasonal Indices and Deseasonalized Loads for the Entire South Region

- To calculate the average power consumption per family, the MV feeders' quarterly loads for the South region are analyzed using time series techniques to calculate the moving averages, seasonal indices, and deseasonalized quarterly loads. Calculating the average power consumption per family is based on the deseasonalized quarterly loads.
- The moving-average method is useful in smoothing a time series to observe its trend. Additionally, it is the basic method used in measuring seasonal fluctuation. This is accomplished by "moving" the arithmetic mean values through the time series.
- Seasonal variation is one of the components of a time series. The monthly loads and the quarterly loads have above-average load and below-average load periods each year. One of the reasons for analyzing seasonal fluctuations is to have a sufficient supply of power to meet the varying seasonal demand. An analysis of seasonal fluctuations over a period of years is also helpful in calculating the power consumption of displaced Syrians in Lebanon.
- A typical set of quarterly indices consists of four indices that are representative of the data for a four-quarter period. Each index is a percentage, with the average for the year equal to 100.0; that is, each quarterly index indicates the level of loads in relation to the annual average of 100.0. A typical index of 97.0 for the winter quarter indicates that loads are usually three percent below the average for the year in the winter season. Similarly, an index of 104.1 for the summer quarter means that the variable is typically 4.1 percent above the annual average in the summer season.
- There are several methods to measure the typical seasonal fluctuation in a time series. The most commonly used method to compute the typical seasonal pattern is called the ratio-to-moving-average method. It eliminates the trend, cyclical, and irregular components from the original data.

Year	Load in Amps (Voltage Level is 15 kV)				
	Q1	Q2	Q3	Q4	Annual
	Winter	Spring	Summer	Fall	Average
2012	20,162	18,993	22,739	19,810	20,426
2013	22,638	22,051	26,270	23,731	23,673
2014	21,707	24,301	24,543	22,476	23,257
2015	23,214	21,393	24,167	18,390	21,791
2016	22,745	24,027			23,386

Table 19: South Region Quarterly Loads (Amp)

Figure 7 depicts the quarterly loads for the South region over the five-year period, highlighting the seasonal nature of the loads. For each year, the third-quarter loads are the highest; while the loads for the second and the fourth quarters are lower. In addition, there is a significant increase in the loads from 2012 to 2013.

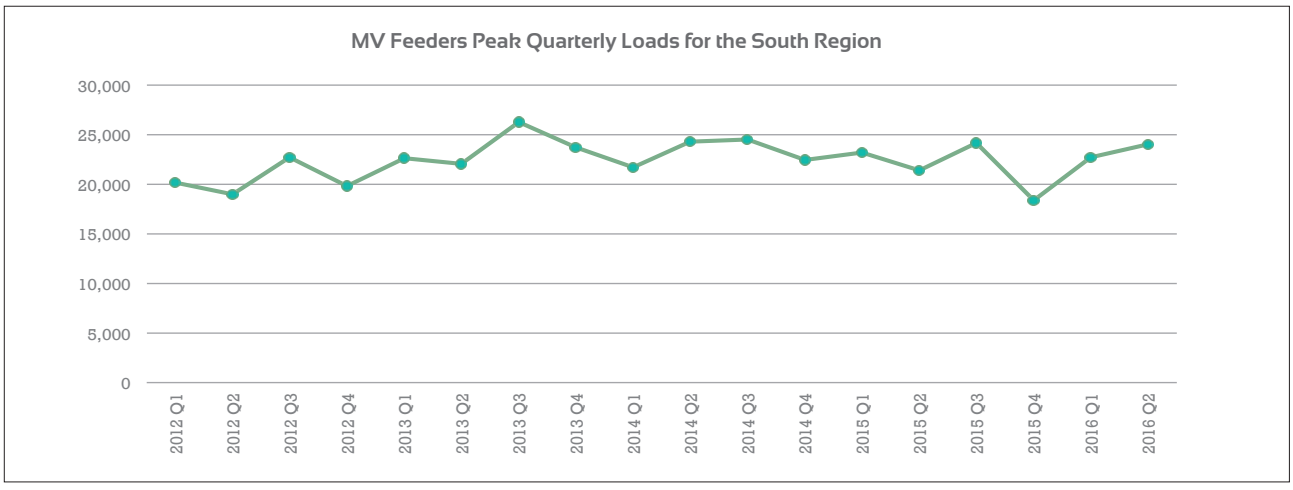


Figure 7: MV Feeders Quarterly Loads for the South Region

The quarterly seasonal indices are determined in seven steps. A detailed explanation of the steps is given in Annex 10 - Statistics and Econometrics (South Region Data - Consumption per Family Estimate Validation) and the results are listed in . Columns 1 and 2 of Table 20 list the quarters of years 2012 to 2016 and the corresponding quarterly loads in Amps.

Column 1 Year & Quarter	Column 2 Loads (Amp)	Column 3 Four Quarter Total	Column 4 Four Quarter Moving Average	Column 5 Centered Moving Average	Column 6 Specific Seasonality	Column 7 Seasonal Index	Column 8 Adjusted Seasonal Index	Column 9 De-Seasonalized Load (Amp)
2012 Q1	20,162							
2012 Q2	18,993						0.9855	19,272
		81,703	20,426					
2012 Q3	22,739			20,735	1.0966	1.0927	1.0957	20,753
		84,180	21,045					
2012 Q4	19,810			21,427	0.9245	0.9317	0.9342	21,204
		87,238	21,809					
2013 Q1	22,638			22,251	1.0174	0.9818	0.9846	22,993
		90,768	22,692					
2013 Q2	22,051			23,182	0.9512	0.9828	0.9855	22,375
		94,690	23,672					
2013 Q3	26,270			23,556	1.1152		1.0957	23,975
		93,759	23,440					
2013 Q4	23,731			23,721	1.0004		0.9342	25,402
		96,009	24,002					
2014 Q1	21,707			23,786	0.9126		0.9846	22,048
		94,283	23,571					
2014 Q2	24,301			23,414	1.0379		0.9855	24,659
		93,027	23,257					
2014 Q3	24,543			23,445	1.0468		1.0957	22,399
		94,534	23,633					
2014 Q4	22,476			23,270	0.9659		0.9342	24,058
		91,625	22,906					
2015 Q1	23,214			22,859	1.0155		0.9846	23,578
		91,250	22,812					
2015 Q2	21,393			22,302	0.9592		0.9855	21,707
		87,164	21,791					
2015 Q3	24,167			21,732	1.112		1.0957	22,057
		86,696	21,674					
2015 Q4	18,390			22,003	0.8358		0.9342	19,685
		89,330	22,332					
2016 Q1	22,745						0.9846	23,102
2016 Q2	24,027						0.9855	24,380
2016 Q3							1.0957	
2016 Q4							0.9342	

Table 20: South Region Quarterly Deseasonalized Loads (AMP)

4.4 Average Power Consumption per Family Based on EDL Data for the Entire South Region

The number of displaced Syrian families provided by the UNHCR is in annual figures except for the year 2016. In order to have a common time reference, average annual loads are calculated (Column 2 of Table 27) based on the deseasonalized loads listed in Table 26 (Column 9). The trend in the average annual loads (Figure 9) is expected population growth and the additional

consumption by displaced Syrians. The average annual loads are then adjusted to account for a population growth of 1.222%, 1.180%, 1.182%, and 1.182% per year for 2013, 2014, 2015 and 2016, respectively (Trading Economies, 2016 and World Bank, 2016).

The remaining trend is the power consumption of the displaced Syrians in the area. Calculations of all figures in Table 21 are available in Annex 10 - Statistics and Econometrics (South Region Data - Consumption per Family Estimate Validation).

Column 1 Year	Column 2 Average Loads (AMP)	Column 3 Population Growth	Column 4 Estimated Loads Base Year 2012 (AMP)	Column 5 Load Growth Base Year 2012 (AMP)	Column 6 Adjusted Average Loads Per Quarter (AMP)	Column 7 Change in Adjusted Average Annual Loads (AMP)	Column 8 Change in Adjusted Average Annual Load (KW)	Column 9 Change in Number of Families (Base Year 2012)	Column 10 Average Consumption per Family (KW with Base Year 2012)
2012	20,427		20,427	0	20,427				
2013	23,686	1.222%	20,676	250	23,437	3,010	62,558	21,462	2.915
2014	23,291	1.180%	20,920	494	22,797	2,371	49,269	30,263	1.628
2015	21,757	1.182%	21,301	874	20,882	455	9,466	27,949	0.339
2016	23,741	1.182%	21,689	1,262	22,479	2,052	42,654	26,457	1.612
								Average	1.623

Table 21: Average Peak Power Consumption per Family

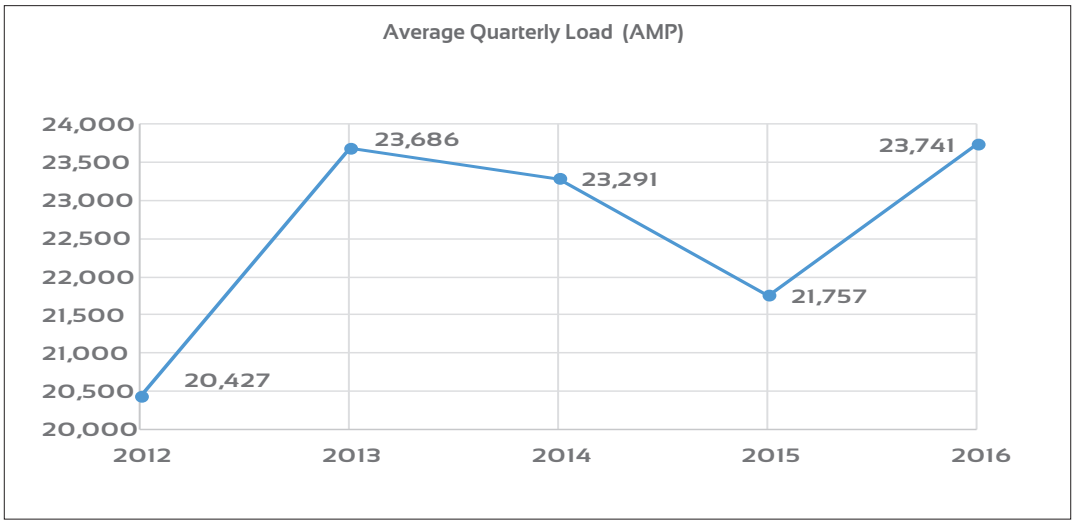


Figure 8: Quarterly Load for the South Region (Amp)

4.5 Analysis of Survey Data

Survey data was collected in order to:

- Examine the distribution of the average number of persons per family.
- Determine the distribution of family per shelter type (Non IS, IS).
- Determine the power consumption per shelter unit.
- Determine the number of displaced Syrian families living in each village.

Descriptive and inferential statistical methods were conducted to analyze the survey data. In particular, the survey data are analyzed to estimate the average number of persons per family. This information along with collected data on power consumption will be used to calculate the additional power consumption due to the displaced Syrians in Lebanon.

Sample selection was based on the distribution of the displaced Syrians in various geographic locations, the concentration of displaced Syrians in these locations and the proportion of the displaced Syrians living in Non IS shelters and IS shelters. A summary of the distribution of families surveyed is presented in Table 22 below and the corresponding bar chart depicted in Figure 9. Note that the distribution of surveyed families is consistent with the actual distribution of displaced Syrians in Lebanon.

Region	Beirut & ML	Bekaa	North	South	Total
No. of Families	110	100	80	60	350
% of Families	31.43%	28.57%	22.86%	17.14%	100.00%

Table 22: Distribution of Families as per Survey Data

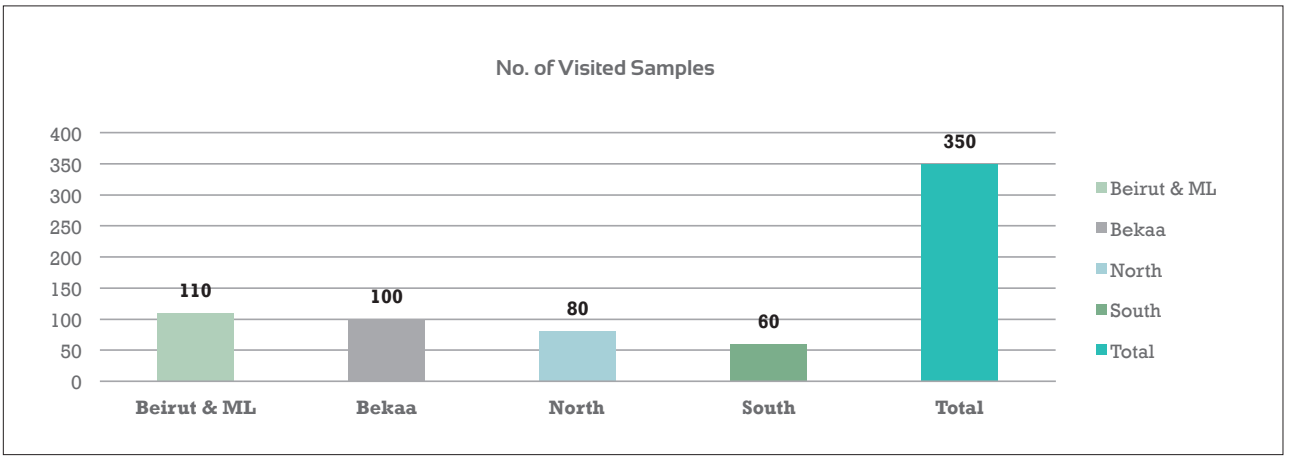


Figure 9: Distribution of Families as per Survey Data

In Table 23 below, the surveyed families are cross-classified according to location and residency type (Non IS and IS).

Region	Beirut & ML	Bekaa	North	South	Total
Non IS	83	38	43	31	195
IS	27	62	37	29	155
Total	37	100	80	60	350

Table 23: Cross-Tabulation of Families Residency Type vs. Region

Most of the visited shelter units, whether Non IS or IS, are occupied by a single family; few are found to host more than one family. Since power consumption is calculated per shelter unit, the distribution of residency units hosting one or more family was evaluated and results can be seen in Table 24 below.

		Frequency	Percentage	Cumulative %
Valid	1	297	84.9	84.9
	2	33	9.4	94.3
	3	13	3.7	98.0
	4	4	1.1	99.1
	5	2	0.6	99.7
	6	1	0.3	100.0
	Total	350	100.0	

Table 24: No. of Families per Shelter Unit

The distribution of number of persons per shelter unit was further analyzed. First, the frequency distribution was constructed in the table below. The result showed that the number of persons per shelter unit varied across a wide range, extending from 1 to 25 persons. Descriptive and inferential analyses were then used to estimate the distribution of the average number of persons per shelter unit for the various geographic regions. In each case, a point estimate for the average is calculated along with a 95% confidence interval for the true average. The results are shown in Table 25.

	No. of Persons per Shelter Unit	Frequency	Percent	Cumulative Percent
Valid	1	7	2.0	2.0
	2	23	6.6	8.6
	3	26	7.4	16.0
	4	58	16.6	32.6
	5	45	12.9	45.4
	6	48	13.7	59.1
	7	36	10.3	69.4
	8	35	10.0	79.4
	9	20	5.7	85.1
	10	20	5.7	90.9
	11	11	3.1	94.0
	12	3	0.9	94.9
	13	5	1.4	96.3
	14	3	0.9	97.1
	15	3	0.9	98.0
	16	1	0.3	98.3
	18	1	0.3	98.6
	19	1	0.3	98.9
	20	2	0.6	99.4
	24	1	0.3	99.7
	25	1	0.3	100.0
	Total	350	100.0	

Table 25: No. of Persons per Shelter Unit

Region	Descriptive Statistics		Statistic
Beirut	Mean		4.78
	95% Confidence Interval for Mean	Lower Bound	4.11
		Upper Bound	5.46
Mount Lebanon	Mean		5.01
	95% Confidence Interval for Mean	Lower Bound	4.55
		Upper Bound	5.48
Bekaa	Mean		6.44
	95% Confidence Interval for Mean	Lower Bound	5.86
		Upper Bound	7.02
North	Mean		6.1
	95% Confidence Interval for Mean	Lower Bound	5.43
		Upper Bound	6.77
South	Mean		5.18
	95% Confidence Interval for Mean	Lower Bound	4.5
		Upper Bound	5.86

Table 26: Number of Persons per Family

The mean represents the average number of persons per family in each region obtained from the sample data as detailed in Table 26 above. The 95% confidence interval is a range for the overall mean within that region.

4.6 Validation of Estimates

The average load per family for the years 2012 - 2016 based on averaging the additional load for the entire South region is compared to the value obtained from the survey data. The average peak power consumption per family based on EDL data for the South region is 1.623 KW per family. Since EDL figures are obtained using peak load, the South region estimate of 1.623 kW per family is divided by 1.21 (the average ratio of peak load / average load for the South region) and the result is 1.341 kW per family. To compare this average with the survey-based estimation, a weighted mean for the average of 1.307 KW per shelter unit for Non IS and 1.864 KW per shelter unit for IS with weights of 69% and 31% respectively was calculated resulting in a consumption of 1.479 KW per shelter unit. The average power consumption per shelter unit in the South region calculated using the survey data is slightly higher than that obtained using the EDL data mainly due to:

- The value of the factor (Demand Factor 0.7 * Diversity Factor 0.7) used in the survey data to calculate the average power consumption for Non IS shelter type is higher than the actual.
- The value of the power factor (pf=0.80) used in EDL data to calculate the average power consumption is lower than the actual value found in the field in areas with a severe voltage drop (180V – 190V).
- The total load of the MV feeders in 2015 is less than the total load in 2014. This is due to the reinforcement of several MV feeders in the South region and/or some displaced Syrian families having moved to other areas but are still registered in the old location, or the fact that EDL data obtained would also include institutions in the area such as schools, municipalities, etc.

Details of the calculations of the average power consumption per family in the South using EDL data are presented in "Section 5 - Econometrics and Statistical Analysis".

5. POWER CONSUMPTION CALCULATION

Power consumption is calculated using the survey data which provided the connected load from the accommodation walk through and the shelter unit details (number of families / individuals residing per shelter unit – as shown in Table 36 in annex 05); detailed steps of the methodology is provided in Annex 05.

5.1 Demand Factor

Demand factor is the ratio of the maximum demand of a system to the total connected load on the system. Demand factor is always less than one. The lower the demand factor, the less system capacity is required to serve the connected load (Electrical Engineering Portal, 2016).

As per National Electrical Code (NEC), a demand factor may be applied to the total connected load to calculate the sizing of a power generation system and/or select the proper conductor size of an MV feeder to avoid over-loading the feeder. Care must be taken when selecting the value of the demand factor. Using a low demand factor ends up in having insufficient generation capacity to supply the connected load. Demand factor for residential load ranges between 0.50 and 0.80 of the total connected load. To be on the safe side and avoid over-sizing the required system, a 0.70 Demand Factor is used to calculate the power consumption of the displaced Syrians living in Non IS shelter type. For incandescent-lighting and small residential loads <0.25 KW, the demand factor always equals 1. Therefore, a 1.00 demand factor is applied when calculating the power consumption of the displaced Syrians living in IS shelter (Electrical Engineering Portal, 2016 and Electrical Contractor: Power & Integrated Building Systems, 2016 and Electricity Notes, 2011).

5.2 Diversity Factor

Diversity factor and load factor are closely related. Diversity factor is the ratio of the sum of the individual maximum demand of the various subdivisions of a system to the maximum demand of the whole system. Diversity factor is usually more than one. EDL values for Diversity Factor as per EDL Memo 226 - Page 3 (Annex 06 - Diversity Factor) are inversely given in Table 27 below.

Category	Diversity Factor
Offices	0.70
Luxury Buildings	0.60
Medium Standard Buildings without A/C	0.50
Popular Residential Complexes	0.80

Table 27: EDL Values of Diversity Factor (Inversed)

5.3 Calculations and Scenarios

While assessing the impact of the Syrian Crisis on the electricity sector the main variables are the total power consumption and the number of end users benefiting from it (refer to Annex 06 for number of Registered Syrian Refugees and the different values).

The total power consumption in KW and the total energy consumption in KWH of the displaced Syrians in Lebanon are calculated in four scenarios:

- Scenario 1: This scenario takes into account the total number of displaced Syrians in Lebanon

as of June 30, 2016 as provided by the UNHCR, in addition to the 7% estimate for the displaced Syrians living in IS shelters and are still not registered with the UNHCR. These will be calculated using the average number of supply hours per day and per region as per the collected survey data.

- Scenario 2: This scenario takes into account the total number of displaced Syrians in Lebanon as of June 30, 2016 as provided by the UNHCR, in addition to the 7% estimate for the displaced Syrians living in IS shelters that are still not registered with the UNHCR. As for the second variable, supply hours, these will be calculated using the average number per day and per region as per EDL's data.
- Scenario 3: This scenario takes into account the total number of displaced Syrians in Lebanon as provided by the DGGS (1,500,000 persons). As for the second variable, supply hours, these will be calculated using the average number per day and per region as per the collected survey data.
- Scenario 4: This scenario takes into account the total number of displaced Syrians in Lebanon as provided by the DGGS (1,500,000 persons). As for the second variable, supply hours, these will be calculated using the average number per day and per region as per EDL's data.

Detailed calculation of the total power consumption in KW and total energy consumption in KWH of the displaced Syrians in Lebanon of all four scenarios is available in Annex 07 - Total Power Consumption and in Annex 08 - Total Energy Consumption.

6. MAIN RESULTS

The main results of the four scenarios of the total power consumption and total energy consumption are presented in Tables 28 to 31 and in Figures 10 to 17 below. Detailed calculations and results are available in Annex 07 - Total Power Consumption and in Annex 08 - Total Energy Consumption.

		UNHCR Data			Calculated Data		Energy Consumption Using Average No. of Supply Hours as per the Survey Data		
Region	Shelter Type	No. of Registered Displaced Syrians in Lebanon as of June 30, 2016			Total Power Consumption per Shelter Type	Total Power Consumption	Average No. of Supply Hours	Total Energy Consumption per Shelter Type (KHW)	Total Energy Consumption (KWH)
		Person	Family	Shelter Unit	KW	KW			
Beirut & ML	Non IS	295,410	76,747	71,047	98,632	99,043	8	789,053	791,522
	IS	3,292	623	622	412		6	2,469	
	Total	298,702	77,370	71,670	99,043			791,522	
Bekaa	Non IS	191,652	51,088	45,102	46,734	82,571	12	560,810	1,098,365
	IS	183,660	32,603	32,603	35,837		15	537,555	
	Total	375,312	83,691	77,705	82,571			1,098,365	
North	Non IS	209,726	54,571	47,966	45,760	51,945	9	411,841	461,318
	IS	45,468	8,067	8,067	6,185		8	49,478	
	Total	255,194	62,638	56,033	51,945			461,318	
South	Non IS	111,836	25,192	24,773	32,384	34,908	6	194,305	206,923
	IS	7,223	1,354	1,354	2,524		5	12,618	
	Total	119,059	26,546	26,127	34,908			206,923	
Total	**Non IS**	**808,624**	**207,598**	**188,888**	**223,510**	**268,467**		**1,956,008**	**2,558,128**
	IS	**239,643**	**42,647**	**42,647**	**44,957**			**602,120**	
Grand Total		**1,048,267**	**250,245**	**231,535**	**268,467**			**2,558,128**	

IS: Informal Settlement Non IS: Non Informal Settlement

Table 28: Total Power Consumption (KW) and Energy Consumption of The Displaced Syrians in Lebanon - Scenario 1

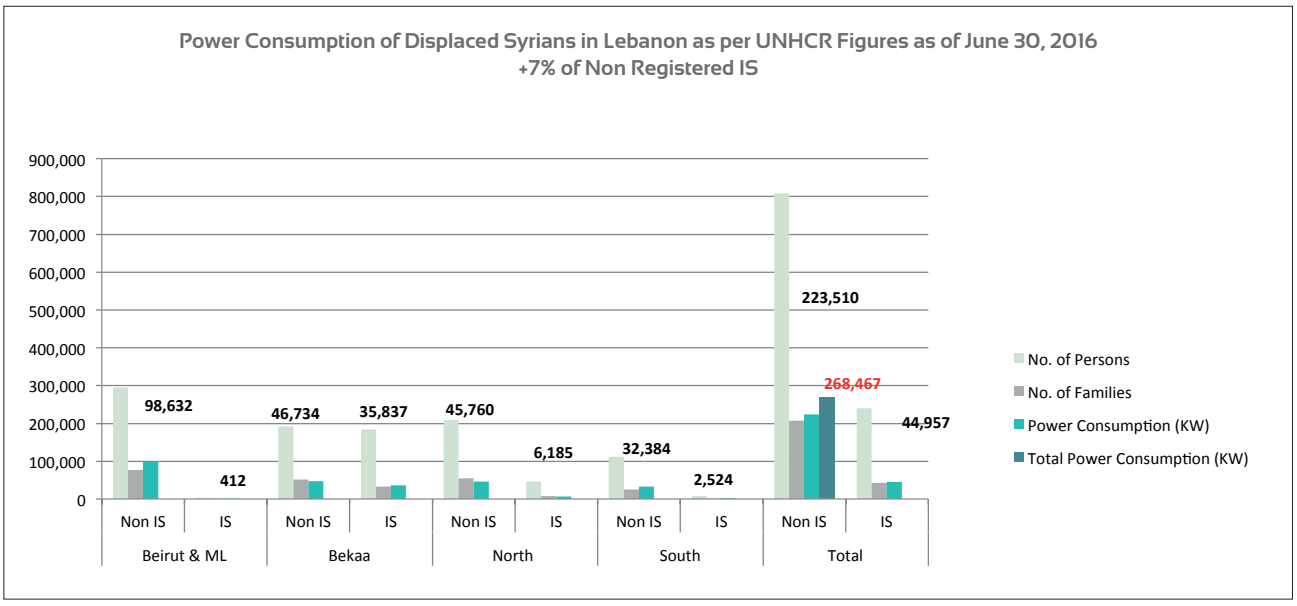


Figure 10: Total Power Consumption (KW) of The Displaced Syrians in Lebanon - Scenario 1

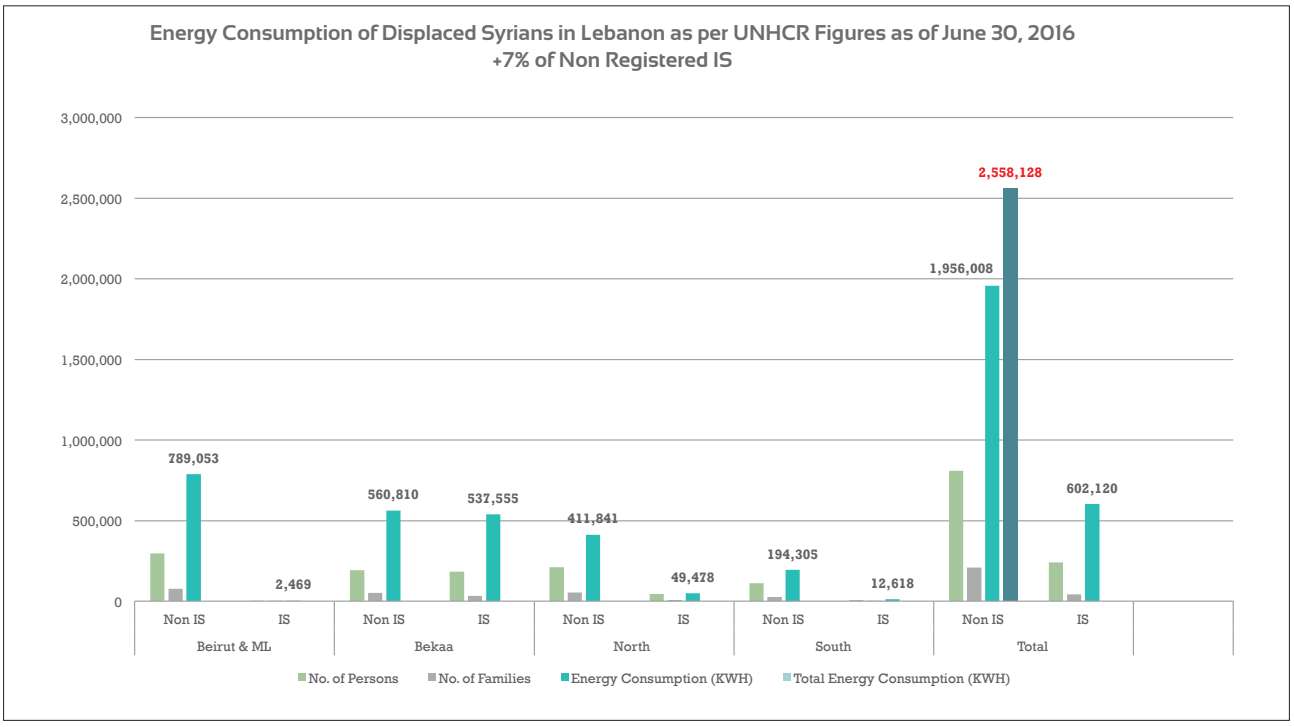


Figure 11: Total Energy Consumption (KWH) of The Displaced Syrians in Lebanon - Scenario 1

Region	Shelter Type	UNHCR Data			Calculated Data		Energy Consumption Using Average No. of Supply Hours as per EDL		
		No. of Registered Displaced Syrians in Lebanon as of June 30, 2016			Total Power Consumption per Shelter Type	Total Power Consumption			
					Average No. of Supply Hours	Total Energy Consumption per Shelter Type (KHW)	Average No. of Supply Hours	Total Energy Consumption per Shelter Type (KHW)	Total Energy Consumption (KWH)
		Person	Family	Shelter Unit	KW	KW			
Beirut & ML	Non IS	295,410	76,747	71,047	98,632	99,043	16	1,601,777	1,608,460
	IS	3,292	623	622	412		16	6,683	
	Total	298,702	77,370	71,670	99,043			1,608,460	
Bekaa	Non IS	191,652	51,088	45,102	46,734	82,571	13	613,620	1,084,160
	IS	183,660	32,603	32,603	35,837		13	470,540	
	Total	375,312	83,691	77,705	82,571			1,084,160	
North	Non IS	209,726	54,571	47,966	45,760	51,945	13	609,982	692,424
	IS	45,468	8,067	8,067	6,185		13	82,442	
	Total	255,194	62,638	56,033	51,945			692,424	
South	Non IS	111,836	25,192	24,773	32,384	34,908	12	384,400	414,354
	IS	7,223	1,354	1,354	2,524		12	29,955	
	Total	119,059	26,546	26,127	34,908			414,354	
Total	**Non IS**	**808,624**	**207,598**	**188,888**	**223,510**	**268,467**		**3,209,778**	**3,799,398**
	IS	**239,643**	**42,647**	**42,647**	**44,957**			**589,620**	
Grand Total		**1,048,267**	**250,245**	**231,535**	**268,467**			**3,799,398**	

IS: Informal Settlement Non IS: Non Informal Settlement

Table 29: Total Power Consumption (KW) and Energy Consumption of The Displaced Syrians in Lebanon - Scenario 2

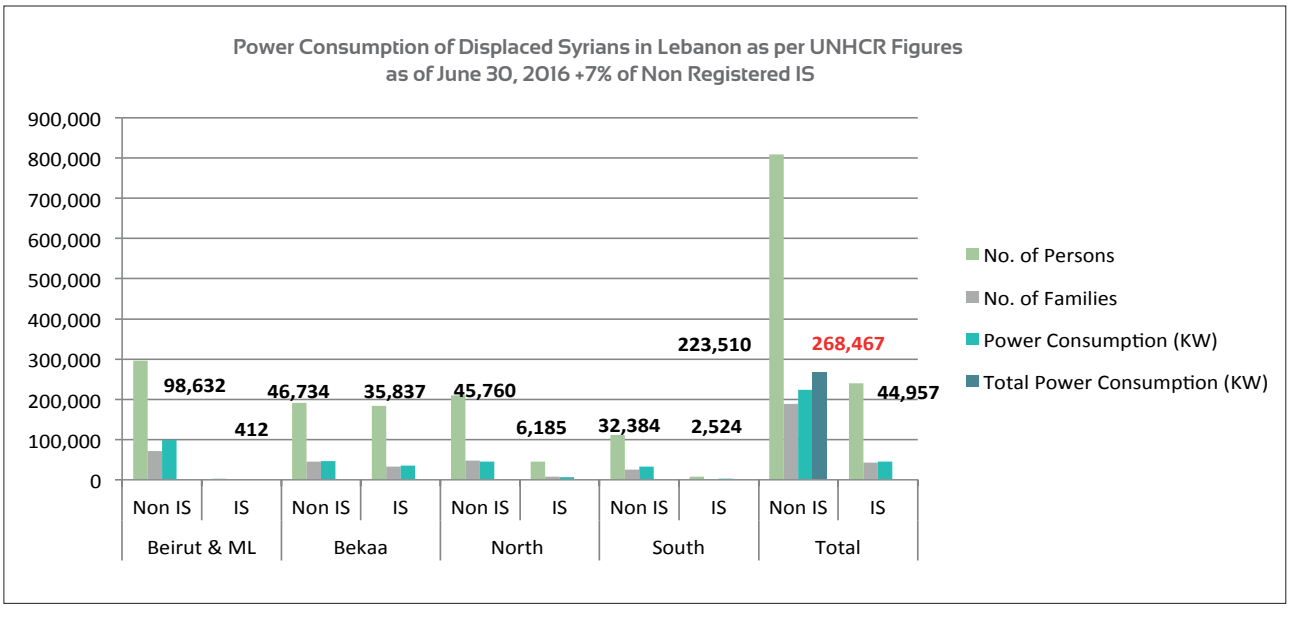


Figure 12: Total Power Consumption (KW) of The Displaced Syrians in Lebanon - Scenario 2

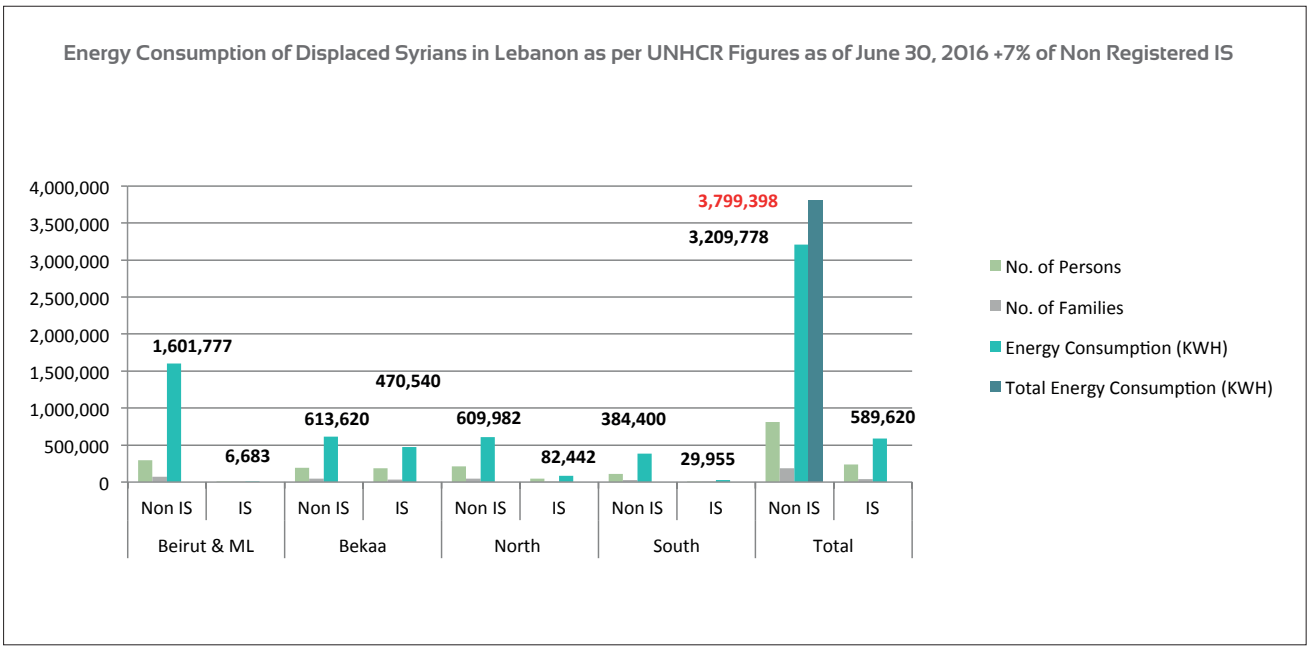


Figure 13: Total Energy Consumption (KWH) of The Displaced Syrians in Lebanon - Scenario 2

Region	Shelter Type	UNHCR Data			Calculated Data		Energy Consumption Using Average No. of Supply Hours as per the Survey Data		
		No. of Registered Syrian Refugees in Lebanon as per the Official Numbers of the DGGS up to the Closure of the Borders			Total Power Consumption per Shelter Type	Total Power Consumption	Average No. of Supply Hours '	Total Energy Consumption per Shelter Type (KHW)	Total Energy Consumption (KWH)
		Person	Family	Shelter Unit	KW	KW			
Beirut & ML	Non IS	424,131	110,182	101,999	141,601	142,012	8	1,132,805	1,135,276
	IS	3,292	623	623	412		6	2,471	
	Total	427,423	110,805	102,622	142,012			1,135,276	
Bekaa	Non IS	353,387	93,665	82,691	85,683	121,520	12	1,028,192	1,565,747
	IS	183,660	32,603	32,603	35,837		15	537,555	
	Total	537,047	126,268	115,294	121,520			1,565,747	
North	Non IS	319,697	83,037	72,986	69,630	75,815	9	626,670	676,148
	IS	45,468	8,067	8,067	6,185		8	49,478	
	Total	365,165	91,104	81,053	75,815			676,148	
South	Non IS	163,142	36,696	36,085	47,172	49,696	6	283,035	295,652
	IS	7,223	1,354	1,354	2,524		5	12,618	
	Total	170,365	38,050	37,439	49,696			295,652	
Total	**Non IS**	**1,260,357**	**323,580**	**293,761**	**344,086**	**389,043**		**3,070,702**	**3,672,824**
	IS	**239,643**	**42,647**	**42,647**	**44,957**			**602,122**	
Grand Total		**1,500,000**	**366,227**	**336,408**	**389,043**			**3,672,824**	

Table 30: Total Power Consumption (KW) and Energy Consumption of the Displaced Syrians in Lebanon - Scenario 3

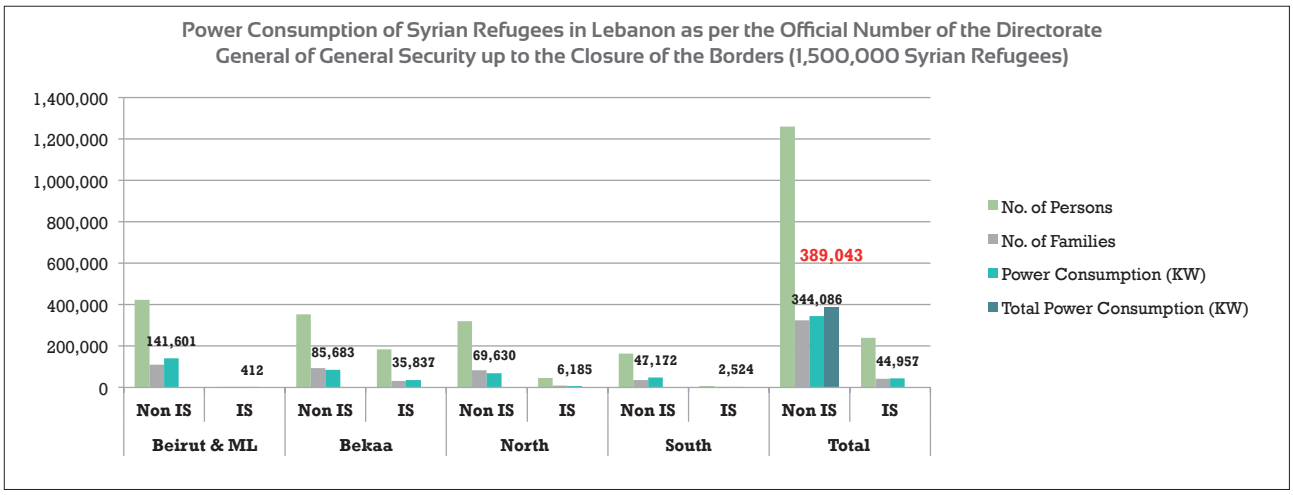


Figure 14: Total Power Consumption (KW) of The Displaced Syrians in Lebanon - Scenario 3

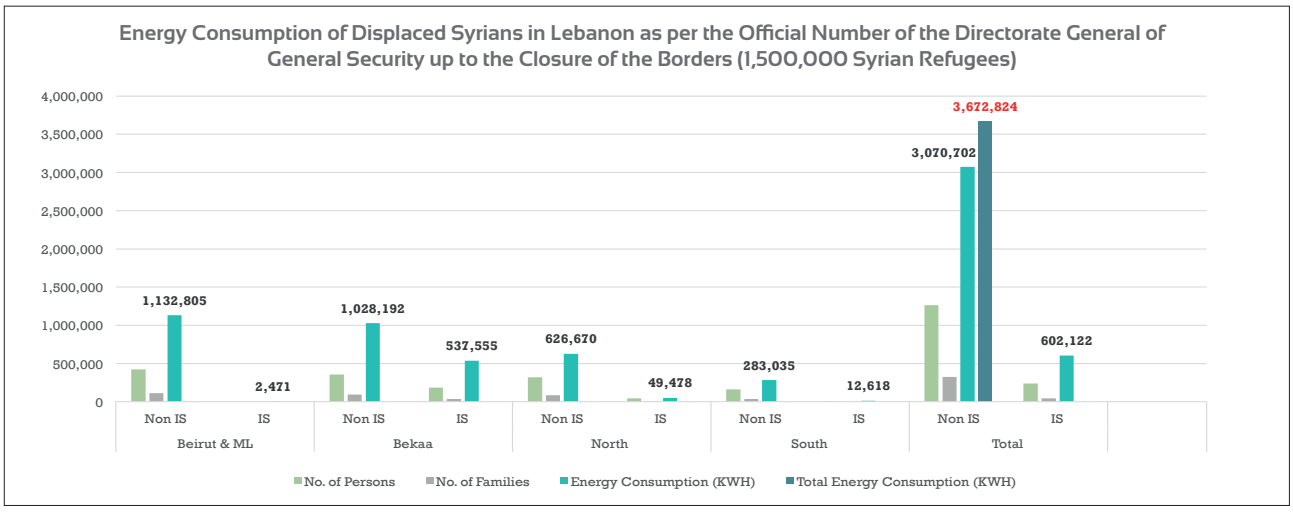


Figure 15: Total Energy Consumption (KWH) of The Displaced Syrians in Lebanon - Scenario 3

Region	Shelter Type	UNHCR Data			Calculated Data		Energy Consumption Using Average No. of Supply Hours as per EDL		
		No. of Registered Syrian Refugees in Lebanon as per the Official Numbers of the DGGS up to the Closure of the Borders			Total Power Consumption per Shelter Type	Total Power Consumption	Average No. of Supply Hours	Total Power Consumption per Shelter Type (kW)	Total Energy Consumption (KWH)
		Person	Family	Shelter Unit	KW	KW			
Beirut & ML	Non IS	424,131	110,182	101,999	141,601	142,012	16	2,299,594	2,306,283
	IS	3,292	623	623	412		16	6,689	
	Total	427,423	110,805	102,622	142,012			2,306,283	
Bekaa	Non IS	353,387	93,665	82,691	85,683	121,520	13	1,125,014	1,595,553
	IS	183,660	32,603	32,603	35,837		13	470,540	
	Total	537,047	126,268	115,294	121,520			1,595,553	
North	Non IS	319,697	83,037	72,986	69,630	75,815	13	928,168	1,010,610
	IS	45,468	8,067	8,067	6,185		13	82,442	
	Total	365,165	91,104	81,053	75,815			1,010,610	
South	Non IS	163,142	36,696	36,085	47,172	49,696	12	559,937	589,891
	IS	7,223	1,354	1,354	2,524		12	29,955	
	Total	170,365	38,050	37,439	49,696			589,891	
Total	**Non IS**	**1,260,357**	**323,580**	**293,761**	**344,086**	**389,043**		**4,912,712**	**5,502,338**
	IS	**239,643**	**42,647**	**42,647**	**44,957**			**589,626**	
Grand Total		**1,500,000**	**366,227**	**336,408**	**389,043**			**5,502,338**	

IS: Informal Settlement Non IS: Non Informal Settlement

Table 31: Total Power Consumption (KW) and Energy Consumption of The Displaced Syrians in Lebanon - Scenario 4

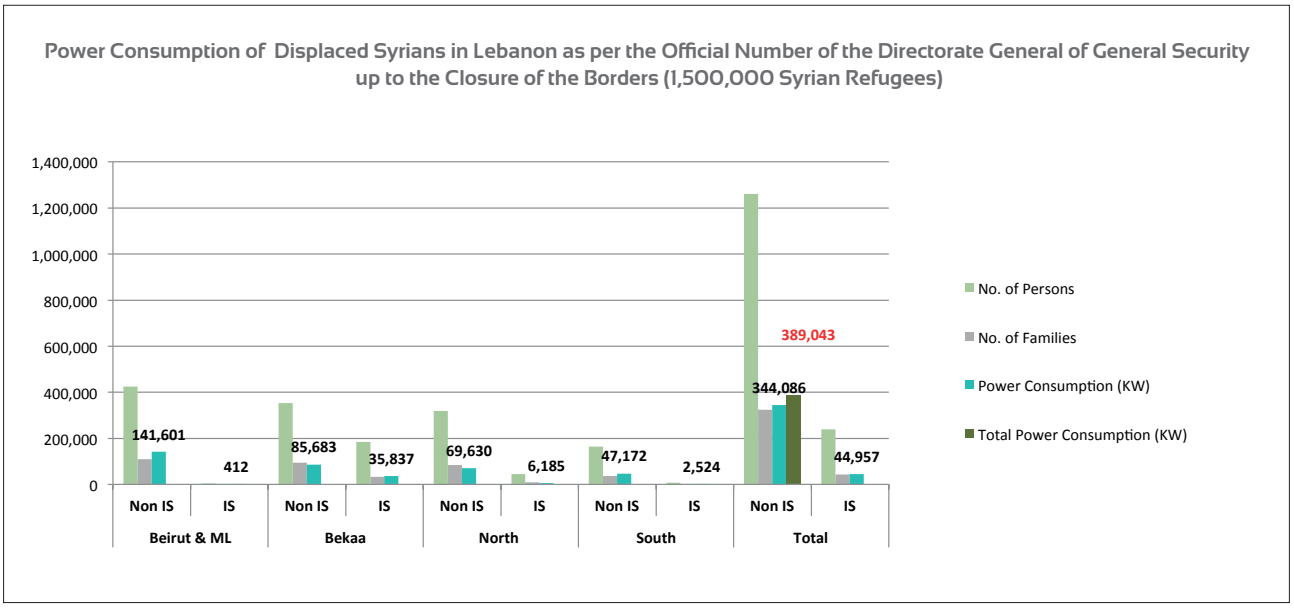


Figure 16: Total Power Consumption (KW) of The Displaced Syrians in Lebanon - Scenario 4

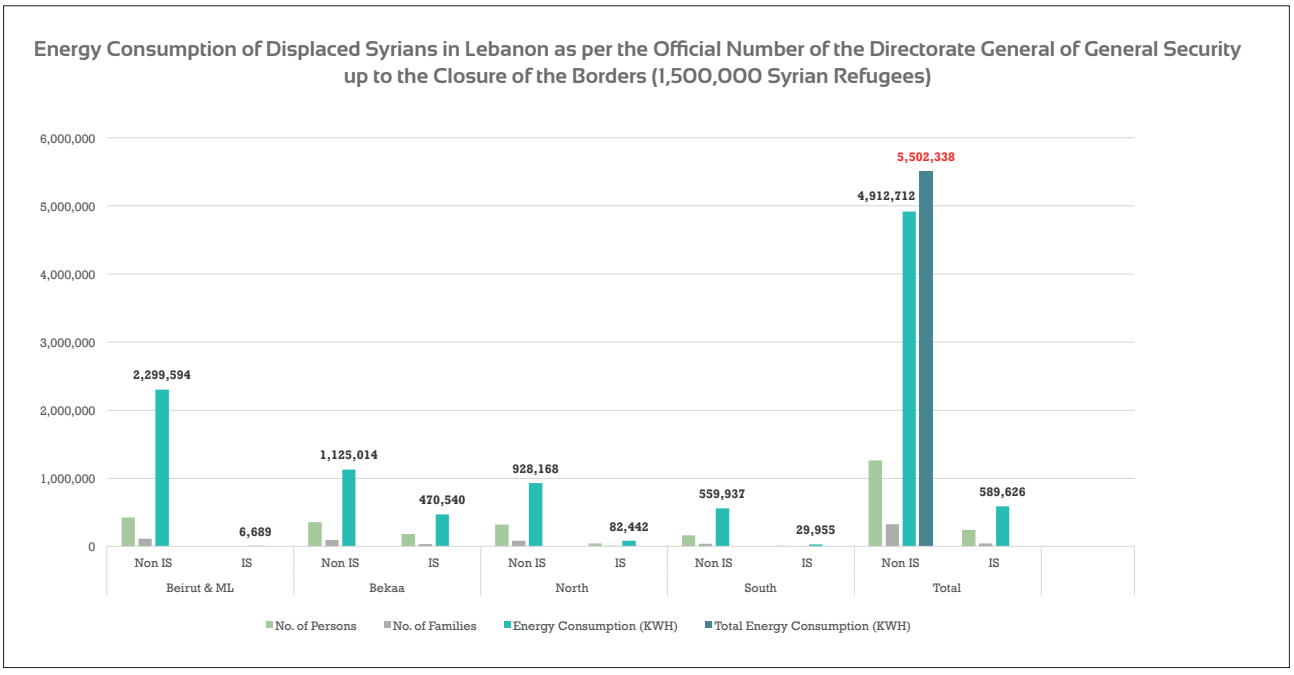


Figure 17: Total Energy Consumption (KWH) of The Displaced Syrians in Lebanon - Scenario 4

In order to recommend appropriate interventions, power consumption and energy consumption are calculated per caza as well. Results are given in Table 32 below and in Figures 18 to 27. Detailed calculations and results are available in Annex 09 - Power Consumption per Caza.

		No. of Displaced Syrians as per UNHCR Data as of June 30, 2016 +7% of Non Registered Persons Living in IS					No. of Displaced Syrians as per DGGS Data up to the Closure of the Borders (1,500,000)				
Region	Caza Name	Total No. of Persons	Total No. of Families	Total No. of Non IS Shelter Units	Total No. of IS Shelter Units	Total Power Consumption/ Caza (kW)	Total No. of Persons	Total No. of Families	Total No. of Non IS Shelter Units	Total No. of IS Shelter Units	Total Power Consumption/ Caza (KW)
Beirut & ML	Aley	59,315	14,522	13,344	107	18,593	84,876	20,789	19,146	107	26,645
	Baabda	88,572	21,943	20,308	6	28,191	126,741	31,399	29,061	6	40,341
	Beirut	25,617	7,436	6,872	13	9,546	36,656	10,642	9,839	13	13,666
	Chouf	50,509	11,875	10,824	183	15,144	72,275	17,016	15,583	183	21,750
	El Meten	51,909	15,261	14,078	54	19,575	74,278	21,848	20,176	54	28,039
	Jbeil	6,455	1,725	1,535	67	2,175	9,237	2,486	2,239	67	3,152
	Kesrwane	16,326	4,608	4,087	193	5,800	23,361	6,639	5,968	193	8,411
	Total	298,702	77,370	71,047	623	99,025	427,423	110,818	102,011	623	142,003
Bekaa	Baalbak	123,788	28,466	11,943	14,938	28,790	177,276	43,424	25,189	14,938	42,513
	El Hermel	6,039	1,269	864	290	1,214	8,669	1,818	1,347	290	1,714
	Rachaya	9,926	2,272	1,964	47	2,087	14,189	3,248	2,831	47	2,985
	West Bekaa	64,476	14,108	8,288	4,720	13,773	92,098	21,002	14,412	4,720	20,118
	Zahle	171,083	37,576	22,043	12,608	36,692	244,814	56,565	38,911	12,608	54,168
	Total	375,312	83,691	45,102	32,603	82,556	537,046	126,056	82,691	32,603	121,498
North	Akkar	100,944	24,843	16,824	5,702	20,424	144,444	36,604	27,161	5,702	30,285
	Bcharre	2,719	620	540	6	520	3,883	887	776	6	745
	El Batroun	13,971	3,209	2,759	70	2,685	20,020	4,604	3,980	70	3,850
	El Dennie	56,892	13,593	10,426	1,731	11,274	81,398	19,817	15,899	1,731	16,496
	El Koura	16,007	3,844	3,131	282	3,203	22,901	5,530	4,613	282	4,617
	Tripoli	52,350	13,644	11,969	27	11,439	74,906	19,521	17,135	27	16,368
	Zgharta	12,311	2,884	2,317	248	2,401	17,611	4,141	3,422	248	3,455
	Total	255,194	62,638	47,966	8,067	51,946	365,165	91,104	72,986	8,067	75,816
South	Bent Jbeil	7,780	1,635	1,608	0	2,101	11,133	2,334	2,295	0	3,000
	El Nabatieh	24,883	5,363	5,274	0	6,893	35,606	7,662	7,535	0	9,848
	Hasbaya	5,555	1,393	1,259	113	1,857	7,956	2,012	1,865	113	2,649
	Jezzine	3,006	661	634	17	859	4,303	943	912	17	1,223
	Marjeyoun	7,358	1,572	923	634	2,388	10,536	2,292	1,629	634	3,311
	Saida	43,213	9,881	9,249	476	12,975	61,822	14,152	13,453	476	18,469
	Sour	27,263	6,040	5,825	116	7,829	39,011	8,654	8,396	116	11,189
	Total	119,059	26,546	24,773	1,355	34,901	170,366	38,049	36,085	1,355	49,688
Grand Total		**1,048,267**	**250,244**	**188,888**	**42,647**	**268,429**	**1,500,000**	**366,027**	**293,773**	**42,647**	**389,006**

Table 32: Power Consumption of Displaced Syrians in Lebanon per Caza

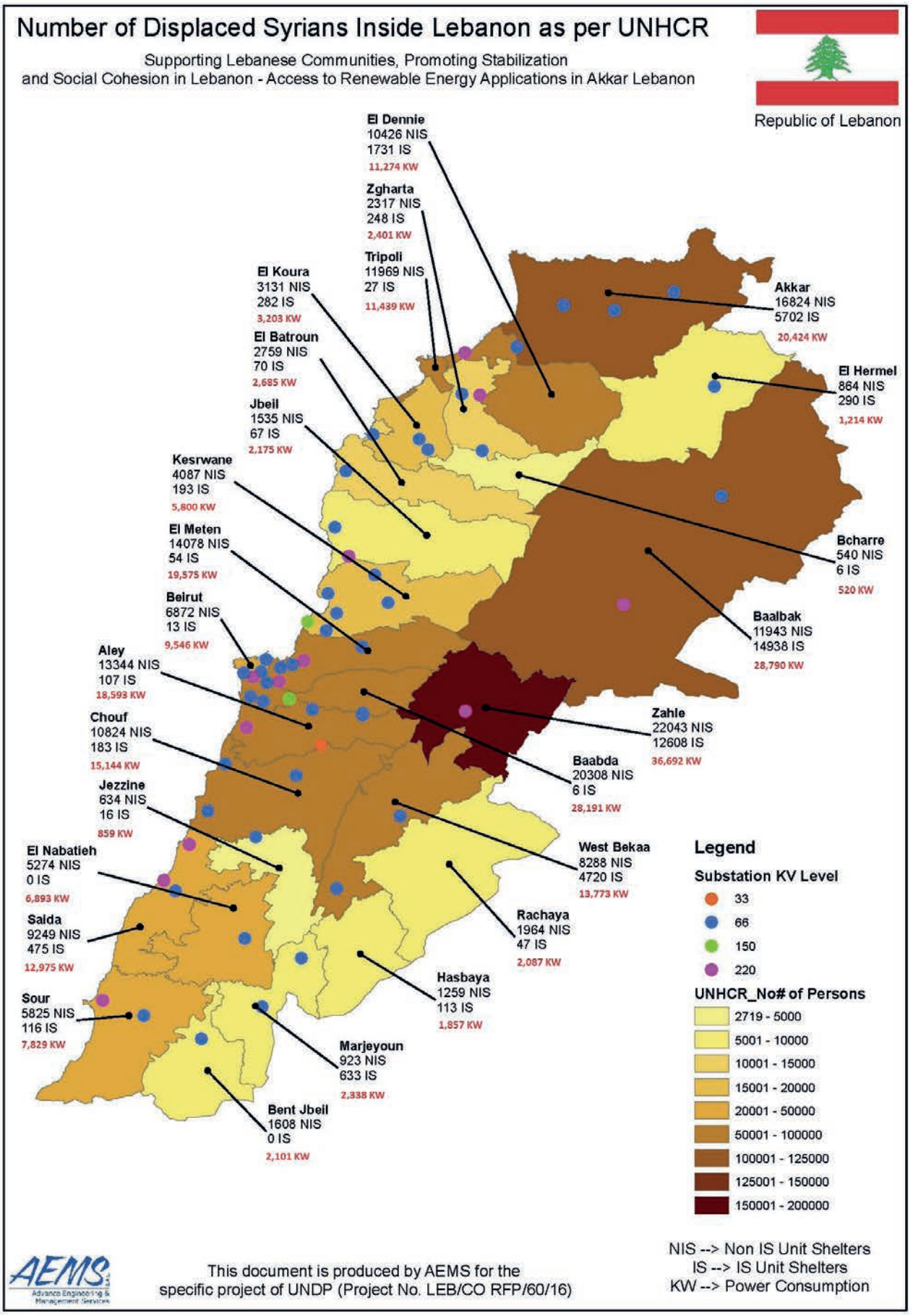


Figure 18: Power Consumption of Displaced Syrians in Lebanon per Caza using UNHCR Data

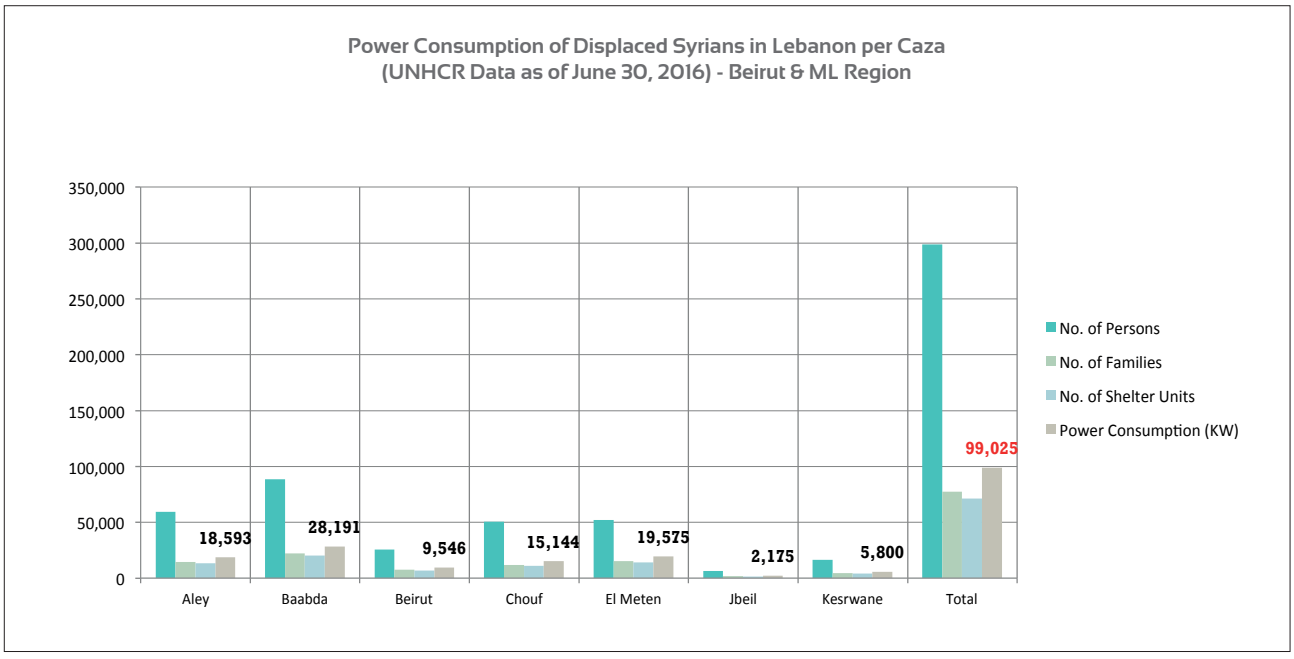


Figure 19: Power Consumption (KW) per Caza using UNHCR Data - Beirut & ML Region

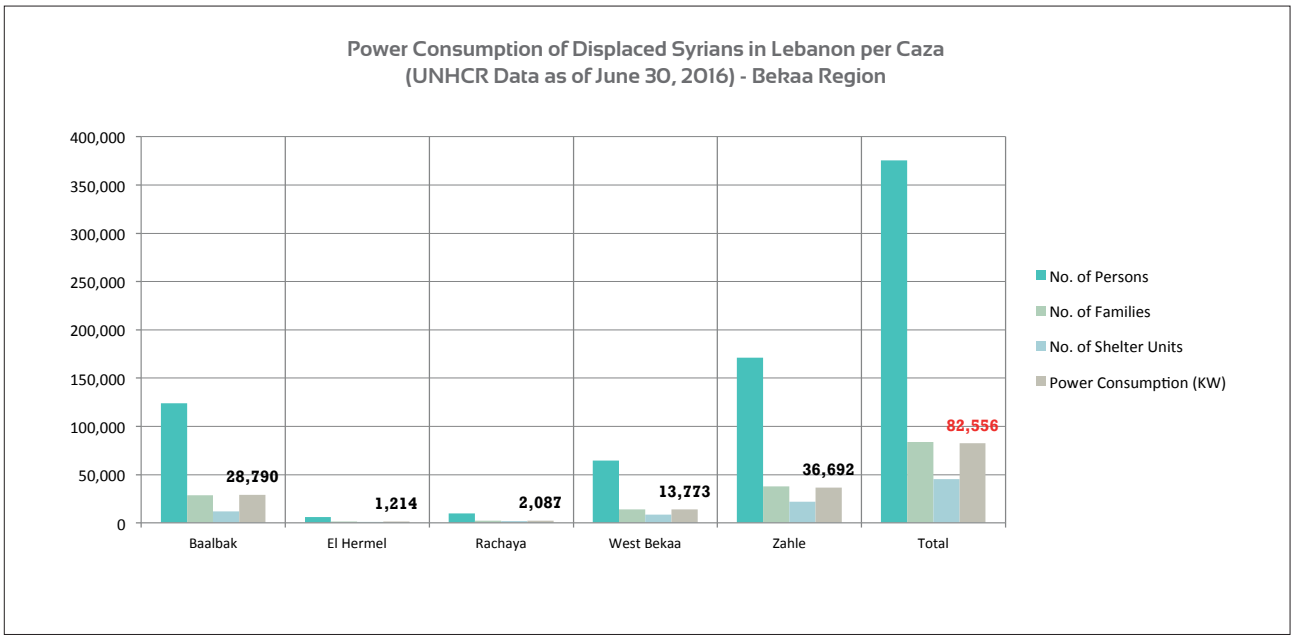


Figure 20: Power Consumption (KW) per Caza using UNHCR Data - Bekaa Region

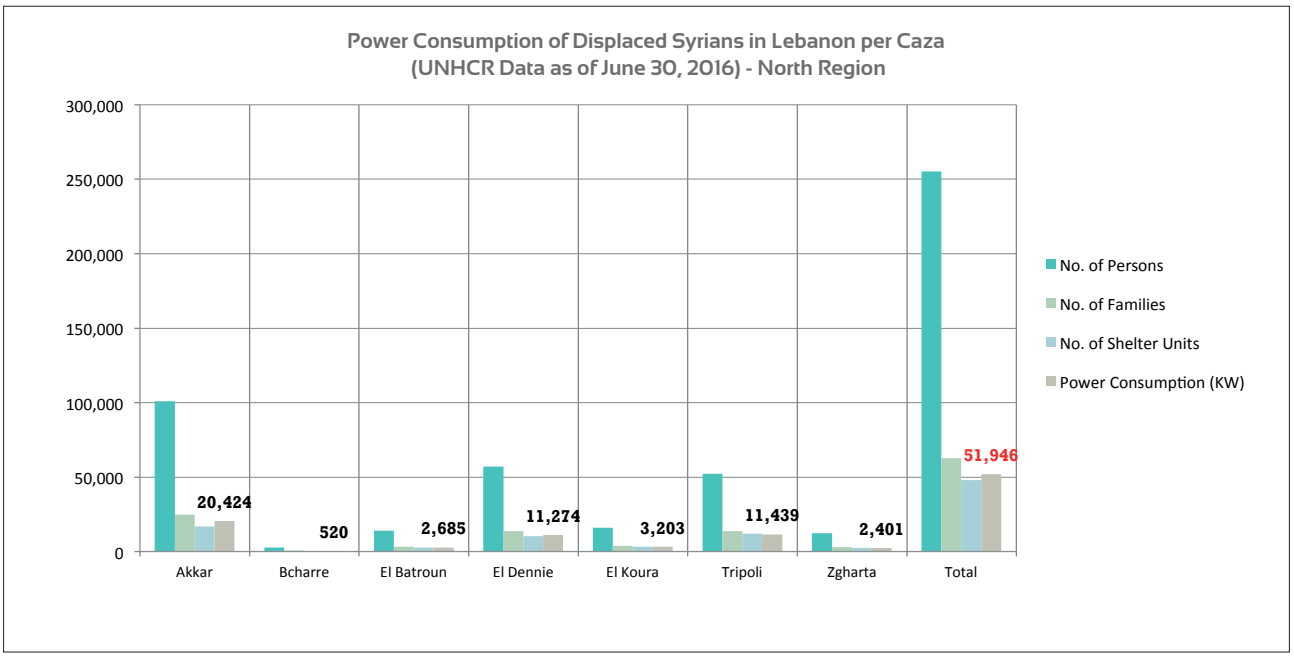


Figure 21: Power Consumption (KW) per Caza using UNHCR Data - North Region

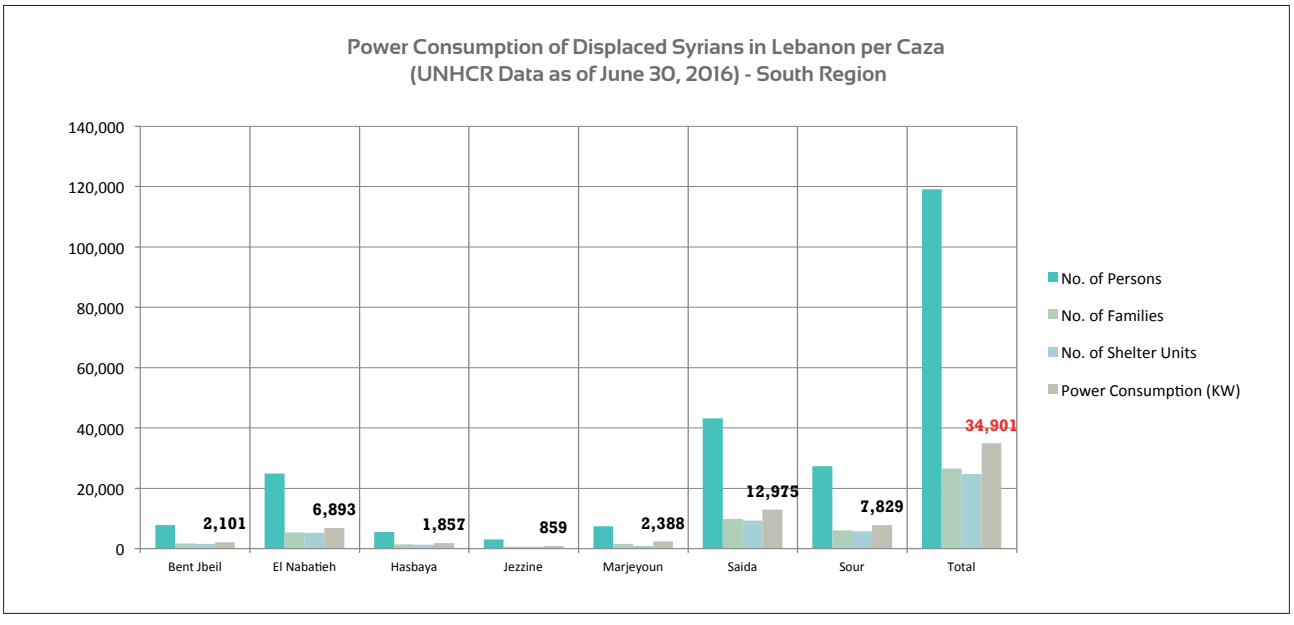


Figure 22: Power Consumption (KW) per Caza using UNHCR Data - South Region

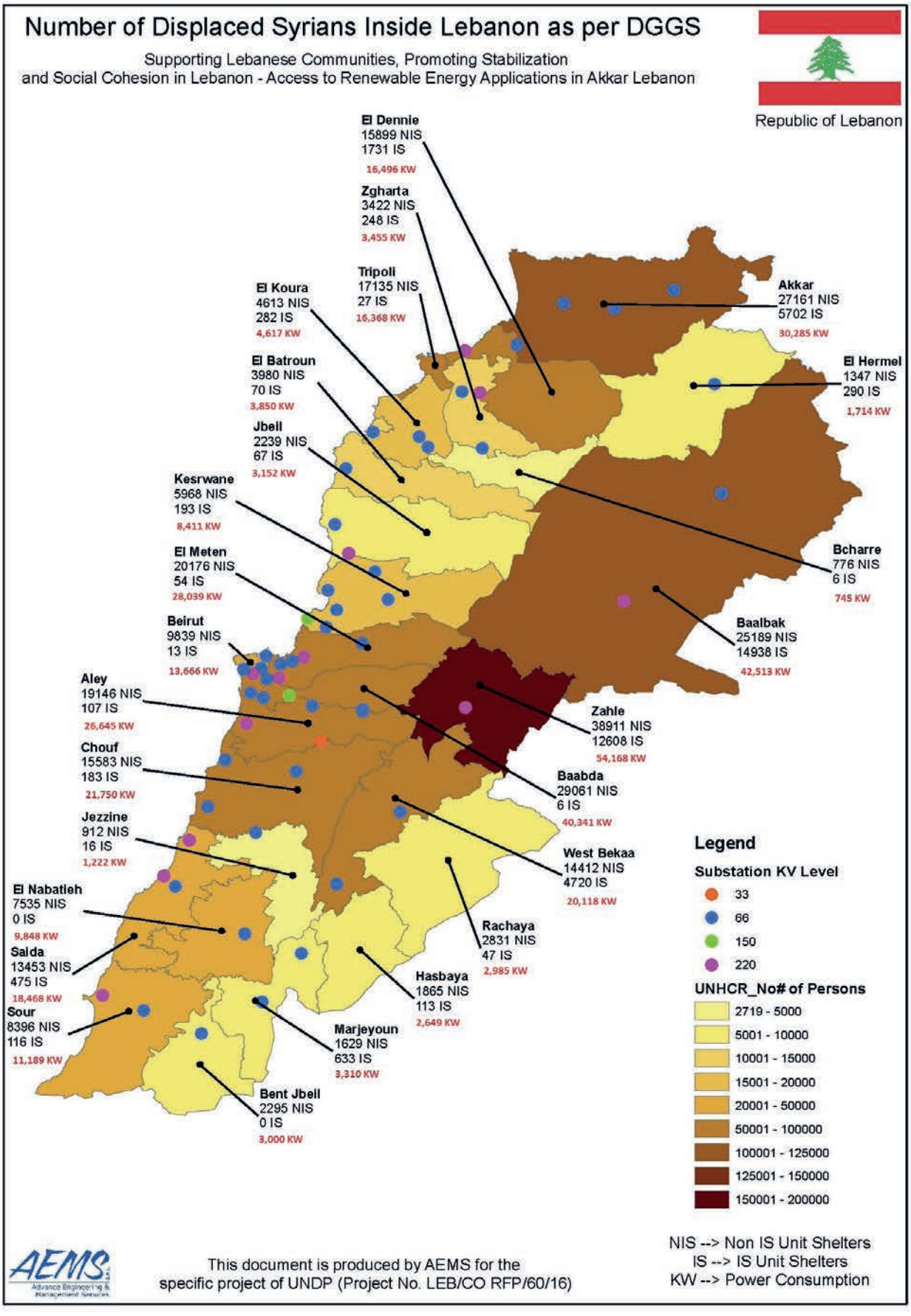


Figure 23: Power Consumption of Displaced Syrians in Lebanon per Caza using DGGS Data

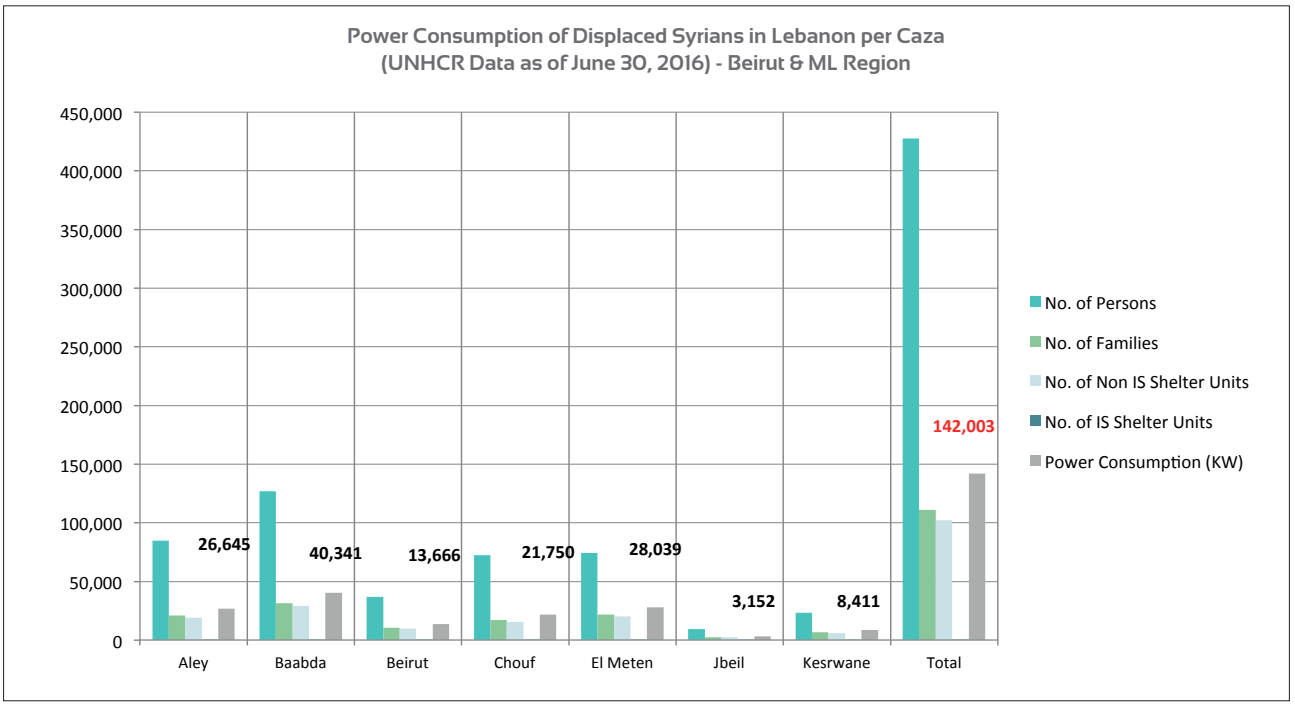


Figure 24: Power Consumption (KW) per Caza using DGGS Data - Beirut & ML Region

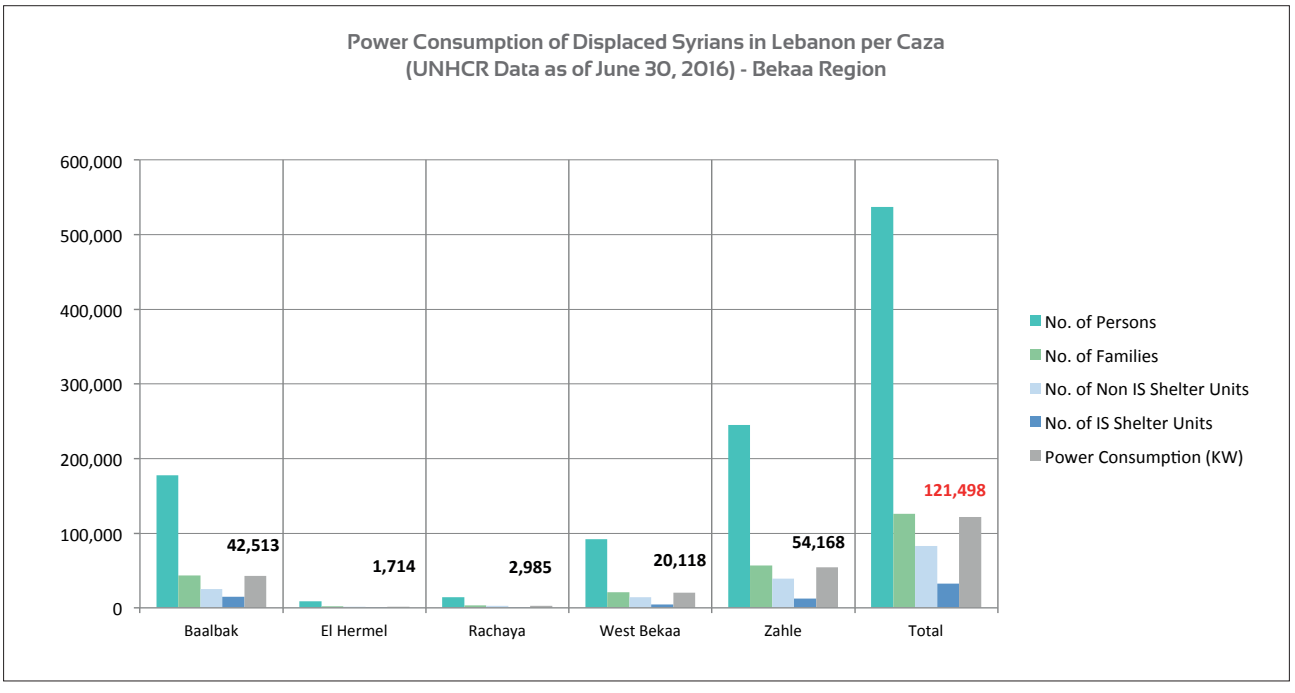


Figure 25: Power Consumption (KW) per Caza using DGGS Data - Bekaa Region

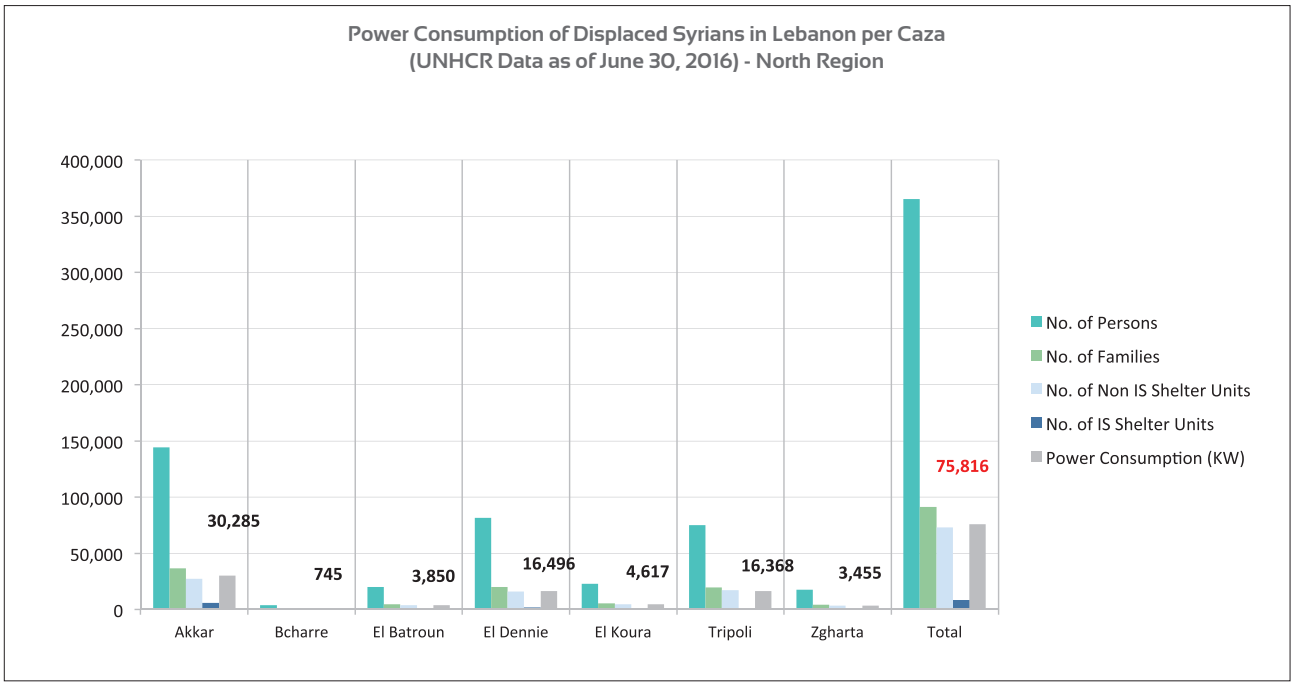


Figure 26: Power Consumption (KW) per Caza using DGGS Data - North Region

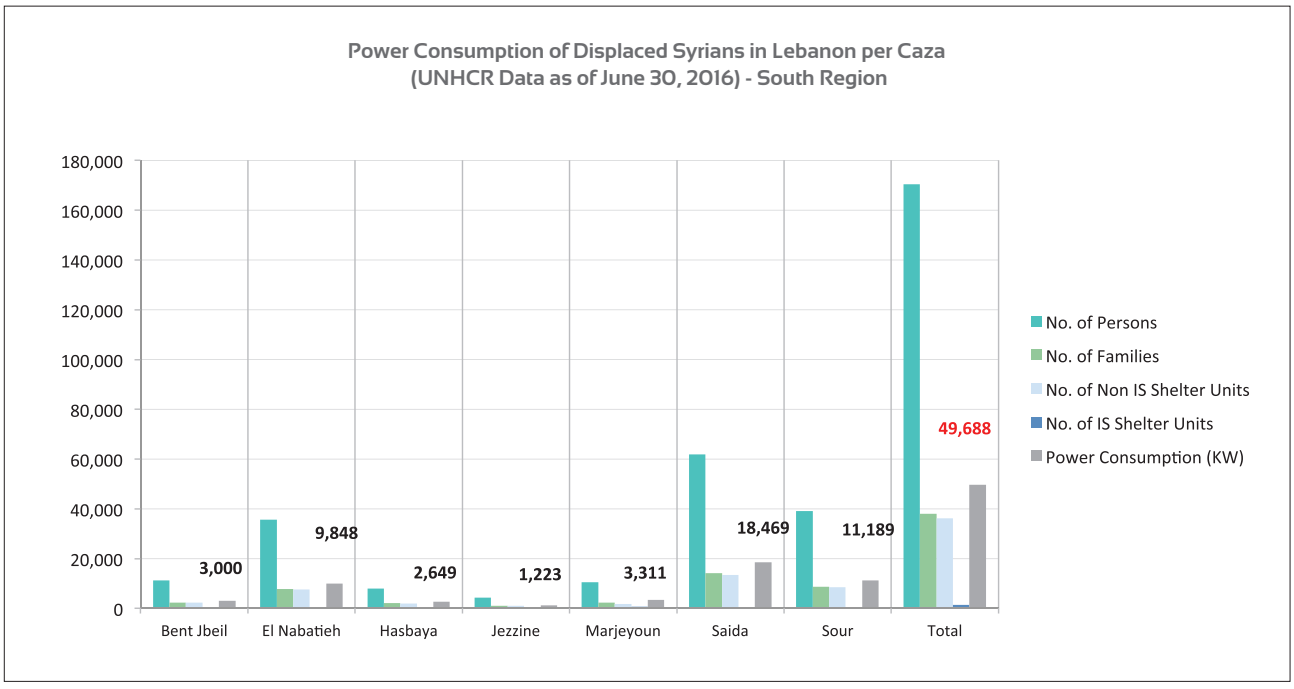


Figure 27: Power Consumption (KW) per Caza using DGGS Data - South Region

As mentioned previously, power consumption (KW) is calculated using the UNHCR data and the DGGS data and energy consumption (KWH) is calculated using average supply hours per day as per the collected survey data and EDL data.

Through the survey findings it was noted that most of the surveyed families, mainly those living in IS, do not have the basic household appliances such as a fridge or a washing machine due to insufficient electrical power capacity. On the other hand, a large number of the surveyed displaced Syrians living in Non IS, mainly in the Bekaa and North regions, have the same living conditions as those living in IS shelters (no fridge or washing machine). Therefore, it is worth highlighting that the power consumption will increase if sufficient capacity of power supply is provided to the displaced Syrians in Lebanon.

It was also noted during the survey that a large number of displaced Syrians, mainly in Beirut, ML, and the South regions, do not have metered connections. Based on the number of visited shelters in different regions, about 44.61% of the displaced Syrians (46.15% for Non IS and 43.74% for IS) do not have metered connections. This value ranges from 36% with no metered connections in the North of Lebanon to approximately 82% in Beirut and Mount Lebanon. This is reflected in the average power consumption per shelter unit in the South (1.307 KW per shelter unit for Non IS and 1.864 KW per shelter unit for IS), where most displaced Syrians use electric water heaters and electric heating household appliances in winter. If meters are installed, the power consumption in the South region is expected to go down.

Moreover, there is an indirect power consumption caused by schools hosting displaced Syrian students because they work an additional four-hour shift and by municipalities/water establishments due to water pumps having to operate for longer hours to cover the increase in water demand in each area. This power consumption, although low, cannot be neglected and must be taken into consideration in the total power consumption (Table 15: Indirect Additional Power Consumption of Public Schools Hosting Displaced Syrian Students as per Survey Data).

Another important factor that has to be considered in calculating power consumption is the technical losses of the transmission and distribution networks. As per the National Electricity Policy Paper, these losses are estimated to be 15%. Tables 33 and 34 below summarize the total power consumption (KW) and energy consumption (KWH) including the 15% technical losses.

Power Consumption of Displaced Syrians in Lebanon as per UNHCR Data as of June 30, 2016

		UNHCR Data			Calculated Data		
Region	Shelter Type	Total No. of Registered Displaced Syrians in Lebanon as of June 30, 2016			Total Power Consumption per Shelter Type	Total Power Consumption	Total Power Consumption Including 15% for Technical Losses
		Person	Family	Shelter Unit	KW	KW	KW
Beirut & ML	Non IS	295,410	76,747	71,047	98,632	99,043	113,900
	IS	3,292	623	622	412		
	Total	298,702	77,370	71,670	99,043		
Bekaa	Non IS	191,652	51,088	45,102	46,734	82,571	94,957
	IS	183,660	32,603	32,603	35,837		
	Total	375,312	83,691	77,705	82,571		
North	Non IS	209,726	54,571	47,966	45,760	51,945	59,736
	IS	45,468	8,067	8,067	6,185		
	Total	255,194	62,638	56,033	51,945		
South	Non IS	111,836	25,192	24,773	32,384	34,908	40,144
	IS	7,223	1,354	1,354	2,524		
	Total	119,059	26,546	26,127	34,908		
Total	Non IS	808,624	207,598	188,888	223,510	268,467	308,737
	IS	239,643	42,647	42,647	44,957		
Grand Total		1,048,267	250,244	231,534	268,467		

IS: Informal Settlement Non IS: Non Informal Settlement

Table 33: Power Consumption of Displaced Syrians in Lebanon using UNHCR Data including 15% for Technical Losses

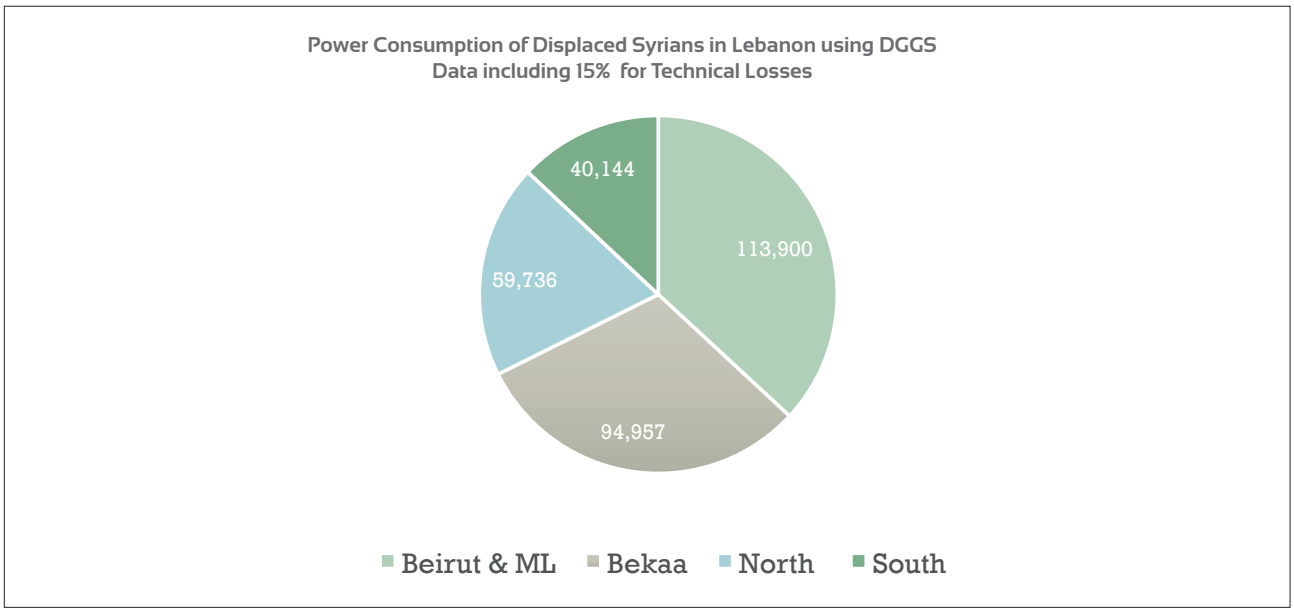


Figure 28: Power Consumption of Displaced Syrians in Lebanon using UNHCR Data including 15% for Technical Losses

Power Consumption of Displaced Syrians in Lebanon as per the Official Number of the Directorate General of General Security up to the Closure of the Borders (1,500,000 Syrian Refugees)

		UNHCR Data			Calculated Data		
Region	**Shelter Type**	**Total No. of Registered Displaced Syrians in Lebanon up to the Closure of the Borders**			**Total Power Consumption per Shelter Type**	**Total Power Consumption**	**Total Power Consumption Including 15% for Technical Losses**
		Person	**Family**	**Shelter Unit**	**KW**	**KW**	**KW**
Beirut & ML	Non IS	424,131	110,182	101,999	141,601	142,012	163,314
	IS	3,292	623	623	412		
	Total	427,423	110,805	102,622	142,012		
Bekaa	Non IS	353,387	93,665	82,691	85,683	121,520	139,748
	IS	183,660	32,603	32,603	35,837		
	Total	537,047	126,268	115,294	121,520		
North	Non IS	319,697	83,037	72,986	69,630	75,815	87,187
	IS	45,468	8,067	8,067	6,185		
	Total	365,165	91,104	81,053	75,815		
South	Non IS	163,142	36,696	36,085	47,172	49,696	57,150
	IS	7,223	1,354	1,354	2,524		
	Total	170,365	38,050	37,439	49,696		
Total	**Non IS**	**1,260,357**	**323,580**	**293,761**	**344,086**	**389,043**	**447,399**
	IS	**239,643**	**42,647**	**42,647**	**44,957**		
Grand Total		**1,500,000**	**366,227**	**336,408**	**389,043**		

IS: Informal Settlement Non IS: Non Informal Settlement

Table 34: Power Consumption of Displaced Syrians in Lebanon using DGGS Data including 15% Technical Losses

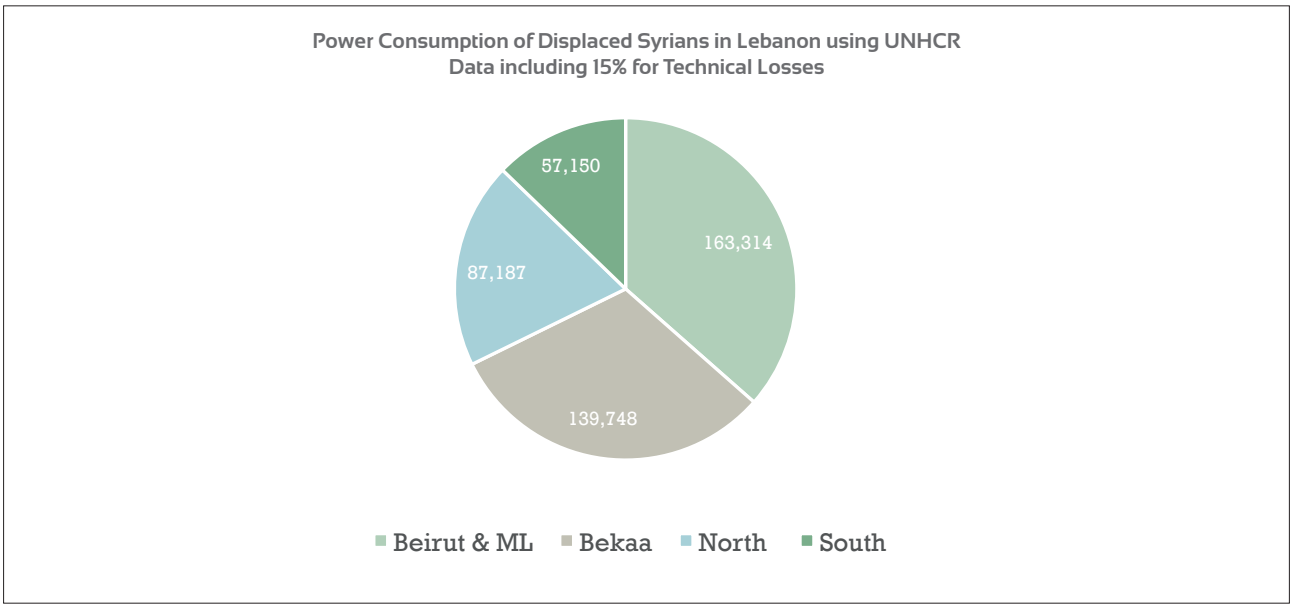


Figure 29: Power Consumption of Displaced Syrians in Lebanon using DGGS Data including 15% for Technical Losses

7. IMPLICATIONS OF THE SYRIAN CRISIS ON THE ELECTRICITY IN LEBANON

The implications of the Syrian Crisis on the electricity sector in Lebanon can be summarized as follows:

- Additional burden on the already deteriorated electricity network as a result of the increased demand.
- Impact on quality of the supplied power due to the increased load in some areas where people are suffering from voltage drop and are forced to use their diesel generators even during supply hours.
- Indirect impact of the additional power consumption of the schools hosting displaced Syrian students caused by the additional four-hour shift the schools need to work.
- Additional power consumption of some municipalities/water establishments that are operating their water pumps for longer hours to cover the additional water demand as a result of the displaced Syrians.
- Damage of the distribution transformers and/or MV and LV cables due to overload.
- Increase of the non-technical losses and damage to the distribution network caused by the Non-Metered connections of a large portion of the Syrian shelters.
- The 486 MW caused by the direct and indirect additional power consumption illustrated in Tables 15, 16, and 34 has a major implication on EDL's grid that is already suffering from a shortage in generation capacities.

8. RECOMMENDATIONS AND PRIORITIZATION OF INTERVENTIONS

Lebanese citizens have been suffering from extensive load shedding of at least three hours in the Beirut governorate and up to twelve hours a day outside of Beirut. In addition to the shortage in the installed generation capacity, the increased electricity demand caused by the Syrian crisis has put an additional burden on the transmission and distribution networks. MOEW, in collaboration with EDL, managed to increase the generation capacity by about 440 MW through the rehabilitation of one generation plant and rental of two power barges. These power plants are operational since 2012. Lebanese citizens did not benefit from this improvement and load shedding hours remained the same because the additional generation capacity is being consumed by the displaced Syrians in Lebanon.

From the calculated results of power consumption of the displaced Syrians in Lebanon per caza, preliminary recommendations and prioritization of interventions to alleviate the implications on electricity in Lebanon from the current Syrian Crisis are listed below.

8.1 General Recommendations

1. Demand side management through projects that help reduce power demand such as energy efficiency measures across various Lebanese sectors. Examples of such projects are:
    - Replacing existing high (or low) pressure sodium street lighting bulbs with energy saving bulbs (example LED lighting with lightning and voltage-surge protection).
    - Distributing energy-saving light bulbs to the displaced Syrians to reduce their power consumption.
    - Using solar water heaters.
    - Encouraging the use of solar powered water pumps.
2. Installation of solar water heater systems in households of vulnerable Lebanese and displaced Syrians living in Non IS (where applicable and/or technical feasible), in line with NEEAP 2016 (initiative 4).1
3. Across Lebanon, large scale grid-connected photovoltaic (PV) Plants would be an optimal intervention.
4. Refurbishment of the existing hydro plants and/or construction of new hydro plants to increase generation capacity (CEDRO, 2013).
5. Encourage Net-Metering by supporting mainly industrial and commercial bulk customers to go for Renewable Energy (PV or Wind). The adopted net-metering context in Lebanon allows the rollover of exported electricity within billing months of any one year, yet nulls any exports after the 1-year term. It is a low-cost and easily administered means of promoting direct customer investment and involvement in renewable energy.Moreover, the voltage level on the low voltage network is low in many areas. In a previous study conducted in 2014 (AEMS, 2014), under voltage was also observed on the Medium Voltage network, mainly outside of Beirut and Mount Lebanon Areas. The situation is more critical in remote areas, especially

1 For example, solar hot water systems can only apply to homes that use running water, heat water for bathing using electrical heaters, and/or have the roof space and structural integrity to accommodate these types of equipment.

in Nabatieh, North of Bekaa, Akkar, and Halba. It is strongly recommended to encourage the use of capacitor banks at the customer end, mainly bulk industrial customers. Capacitor banks help in improving the power factor by reducing the reactive power (VAR) consumed by these customers (hence help them reduce their electricity bills) and in maintaining an overall better voltage level in the nearby area. Detailed studies should be conducted, on a case-by-case basis, for each area.

6. Reinforcement of EDL distribution network through the installation of new MV/LV substations, and/or upgrading the existing MV/LV substations is also required in some areas to reduce technical losses and improve power quality and voltage level. Upgrading and reinforcement of the distribution network also requires the rehabilitation and upgrading of the transmission network firstly by upgrading the transmission capacity of the HV/MV substations (adding more power transformers and related bays), and secondly by reinforcing the overhead transmission lines (OHTL), either by creating new lines or upgrading the existing ones. The two actions (for distribution and transmission) are inter-related. Working on one sector while disregarding the other sector will not lead to the required results in the long run.

8.2 Recommendations Specific to Water Pumping

1. Support the agricultural sector and the national Water Establishments to use renewable energy technology for irrigation (only when sources are legal and environmentally-sound2) and water distribution, respectively. Using PV-Direct Water Pumping technology can do this. PV-direct technology is a simple PV system that supplies the load directly from a PV module or array and operates only when the sun is shining, which is very suitable for the agricultural sector and water establishments. The advantage of a PV-direct system is that it is much less expensive and easier to install than battery-based or grid-tied designs. No batteries, charge controllers, or inverters are required which reduces cost and increases efficiency.

   The most common PV-direct application is solar water pumping for irrigation and domestic use. Since water tanks are much cheaper than battery banks and have a longer lifespan, no batteries are required because water tanks can be filled on sunny days. A PV-direct system works well if enough water is stored to cover the demand on days without sun.

   In the case of most Lebanese areas, and because of intermittent load shedding, citizens tend to run the water pumps during EDL grid power supply, which causes a further deterioration of the power quality, mainly lower voltages at the end of the medium voltage lines. Hence, PV water pumping will not only serve to supply water for required use, but will also indirectly help in maintaining an improved voltage level.

   It is important to note that PV-direct pumping cannot be used to provide domestic water pressure, but can be used to fill a tank. Domestic water pressure requires a water pressure-pump system that is used to push stored water to the houses.

2 The feasibility and applicability of solar pumping for irrigation has to be carefully studied since most sources of water used for irrigation are groundwater which is not a sustainable practice and therefore encouraging the use of solar power for pumping may have negative environmental impacts. Furthermore, this type of technology must be used with caution.

8.3 Recommendations Specific to Decentralized Power Generation

1. For areas with small and medium power demand (up to 10 MW), decentralized solutions such as Distributed Generation Resources (DER) is recommended. Conventional power stations and large-scale solar power plants are considered centralized and often require electricity to be transmitted over long distances. DER systems are decentralized and flexible technologies located close to the load they serve. It is a demand-side technology driven by consumers and can be tailored to meet the end user needs without having to worry about the entire system (Newcomb, J. and Paulos, B. 2013).

   DER, also known as distributed energy or On-Site Generation, is a new technology that includes energy efficiency, demand response, and distributed generation and storage. It is basically generating renewable energy, using PV Plants or Wind Farms or can be a Hybrid power system that comprises multiple generation and storage components, within a community to avoid the expensive and inefficient transmission of power and to reduce losses both in transmission and distribution networks. This is mainly because the most affected areas are those where the transmission sector is weak and high voltage substations are overloaded.

   DER technology increases the efficiency and reliability of the power system and reduces costs and losses.15 DER systems can be installed on LV networks to serve a single customer, support delivery of clean and reliable power, and reduce the technical losses, or it can be installed on the MV network and be part of the grid to serve multiple customers or a major industrial facility. The disadvantage of DER systems is their limited capacities of up to 10 megawatts (MW) (Wikipedia).

   In the residential sector, common DER systems may include one or more of the following resources:

   » Solar photovoltaic panels

   » Small wind turbines

   » Natural-gas-fired fuel cells

   In the commercial and industrial sectors, distributed generation can include resources such as:

   » Combined heat and power systems

   » Solar photovoltaic panels

   » Wind Farms

   » Hydropower

   » Biomass combustion

   » Municipal solid waste incineration

   Recommended areas to install DER systems are Hermel, Rachaya, West Bekaa, and other cazas where total power consumption of displaced Syrians is less than 10 MW.

2. In some regions like West Bekaa and Akkar, wind farms are recommended to produce the required power demand per caza where the minimum wind speed required to start rotating the smallest wind turbines is maintained most of the time.

3. Areas of small power demand where the EDL grid does not exist and households are considered "vulnerable," solar kits can be used to generate the required power.

   Solar kits are small systems (capacities up to 2.5 KW) composed of high efficiency crystalline cells, back-up batteries, and inverters that can power light, household appliances that have a small load, and small pumps.

   Solar kits can also be used to support the demand side by reducing the power demand when they are grid tied. Grid tie systems can be integrated with the existing utility company connection and can also be coupled with net-metering to reduce the power bill, hence eliminating the need for the battery backup system that stand alone systems need; therefore, cost will be considerably lower (Solar Home).

Table 35 below summarizes the specific recommendations per power consumption per caza.

The Specific Recommendations as per the Power Consumption per Caza

Region	Caza Name	Total No. of Persons	Total Power Consumption (KW)	Energy Saving Bulbs	Solar Water Heater	Replace Street Lights	Solar Water Pumps	Solar Kits	Distributed Generation Resource (DER)	Grid-connected PV Plant	Reinforcement of EDL Network	Refurbishment of Hydro Plants
Beirut & ML	Aley	84,876	26,645	✓	✓	✓	✓			✓		
	Baabda	126,741	40,341	✓	✓	✓					✓	
	Beirut	36,656	13,666	✓	✓	✓					✓	
	Chouf	72,275	21,750	✓	✓	✓	✓			✓		
	El Meten	74,278	28,039	✓	✓	✓					✓	
	Jbeil	9,237	3,152	✓	✓	✓			✓			
	Kesrwane	23,361	8,411	✓	✓	✓			✓			
Bekaa	Baalbak	177,276	42,513	✓	✓	✓	✓	✓		✓	✓	
	El Hermel	8,669	1,714	✓	✓	✓	✓		✓			
	Rachaya	14,189	2,985	✓	✓	✓	✓		✓			
	West Bekaa	92,098	20,118	✓	✓	✓	✓	✓		✓		✓
	Zahle	244,814	54,168	✓	✓	✓	✓			✓	✓	
North	Akkar	144,444	30,285	✓	✓	✓	✓	✓		✓	✓	
	Bcharre	3,883	745	✓	✓	✓			✓			
	El Batroun	20,020	3,850	✓	✓	✓			✓			
	El Dennie	81,398	16,496	✓	✓	✓	✓	✓		✓		
	El Koura	22,901	4,617	✓	✓	✓	✓		✓			
	Tripoli	74,906	16,368	✓	✓	✓	✓			✓		✓
	Zgharta	17,611	3,455	✓	✓	✓			✓			
South	Bent Jbeil	11,133	3,000	✓	✓	✓	✓		✓			
	El Nabatieh	35,606	9,848	✓	✓	✓	✓		✓			
	Hasbaya	7,956	2,649	✓	✓	✓	✓		✓			
	Jezzine	4,302	1,223	✓	✓	✓	✓		✓			
	Marjeyoun	10,536	3,311	✓	✓	✓	✓		✓			
	Saida	61,822	18,469	✓	✓	✓	✓			✓		
	Sour	39,010	11,189	✓	✓	✓	✓			✓		
Total		**1,499,999**	**389,006**									

Table 35: The Specific Recommendations as per the Power Consumption per Caza

8.4 Prioritization

- Prioritization of the interventions should be given to the most vulnerable areas such as:
- Areas of high concentration of affected residents where there is no EDL grid and/or have insufficient capacity to operate the basic household appliances such as a fridge or a washing machine. Examples are Akkar, West Bekaa, and El Dennie.
- Areas of high concentration of displaced Syrians such as Baalbak, West Bekaa, Akkar, Tripoli, El Dennie, and Saida.
- Areas where recommended interventions are easy to install, such as solar kits and solar water heaters, to reduce the power demand on the grid. Examples are Baalbak, El Hermel, Rachaya, West Bekaa, Zahle, Akkar, El Dennie, Tripoli, En Nabatieh, Saida, and Sour.

ANNEXES

Annex 01 - UNHCR Data
(more data available on CD)

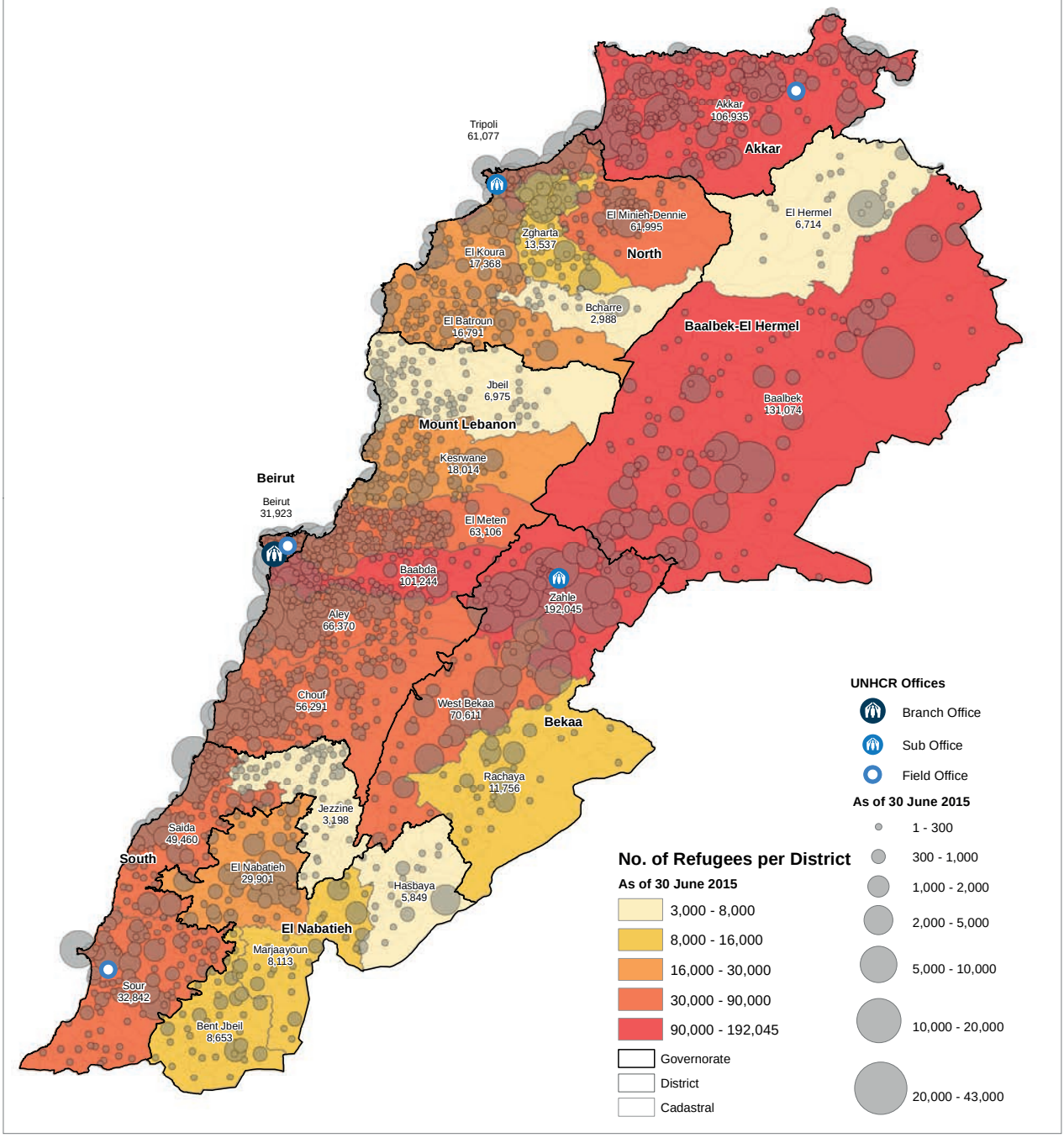
SYRIA REFUGEE RESPONSE

LEBANON Syrian Refugees Registered

30 June 2015

UNHCR Lebanon - Beirut
Country Office

Total No. of Refugees	1,174,830
Refugees Registered	1,174,830
Refugees Awaiting	0



This map has been produced by UNHCR based on maps and material provided by the Government of Lebanon for UNHCR operational purposes. It does not constitute an official United Nations map. The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Data Sources:
- Refugee population and location data by UNHCR 30 June 2015. For more information on refugee data, contact Rana G. Ksaifi at ksaifi@unhcr.org

GIS and Mapping by UNHCR Lebanon. For further information on map, contact Jad Ghosn at ghosn@unhcr.org or Aung Thu WIN at wina@unhcr.org

Annex 02 - Survey Data
(more data available on CD)

Annex 03 – Data Validation

- The UNHCR data is used in calculating the average number of persons per family in each region and the total power consumption of the displaced Syrians. Furthermore, the list of the number of displaced Syrians living in Informal Settlements is utilized to segregate the number of displaced Syrians living in Non IS and IS and the percentage of the displaced Syrians living in each shelter type. Power consumption is then calculated for the total number of displaced Syrians living in Non IS and IS respectively in each region.

- The extrapolated data obtained in step 1 above is then used to calculate the total power consumption of the displaced Syrians using the DGGS figure of 1,500,000 persons.

- Survey data is used in calculating the total connected load (TCL) of the household appliances in each visited sample as per the standard power consumption values of typical household appliances (Daftlogic).

- The average connected load for Non IS and IS is then calculated by taking the average of the TCL for each shelter type of the visited samples in each region. A sample of the survey data sheet is shown in Table 17 (featured in chapter 3 section 3.4 Data Validation & Analysis).

- Since power consumption is calculated per shelter unit irrespective of the number of persons or the number of families living in it, the survey data is also used to convert the number of families living in Non IS into number of shelter units based on the number of families living in each shelter unit in each region.

- The alternative approach to calculate power consumption of the displaced Syrians in Lebanon was supposed to be done by calculating the increase in load on the MV feeders of EDL distribution network in all areas taking the year 2012 as the base year and correlating the increase in load on each MV feeder with the number of displaced Syrians living in the villages supplied by each MV feeder all the while taking into account the increase in number of EDL customers resulting from the normal Lebanese population growth using GIS data to identify the villages supplied by each MV feeder. Due to incompleteness of EDL data, this approach was implemented in the South region only where data, to some extent, was found complete. This is done using the econometric and statistical methodologies to calculate the increase in load on the MV feeders supplying the South region and correlating it to the number of the displaced Syrians in the villages supplied by these feeders taking into consideration the increase in load due to the increase in the number of EDL customers resulting from the normal Lebanese population growth. Details and results of this approach are presented in "Section 4: Econometrics and Statistical Analysis".

Annex 04 – Econometric Analysis (Methodology)

- Actual peak load quarterly data, for the years 2012 - 2015 and two quarters of 2016, are used to validate the power consumption calculated using the survey data.
- Data for the entire South region is analyzed to calculate the average peak load and the average peak power consumption per family.
- In each case, the quarterly data is used to calculate a seasonal index for each quarter.
- The seasonal indices are used to remove the seasonality from the quarterly data as described in the following section.
- The quarterly data is then adjusted to continuous rather than seasonal operation (deseasonalized) (Econometrics for Dummies and Merriam Webster) and used to calculate the average load for each year.
- The average annual loads are then adjusted to account for population growth in Lebanon. The population growth rate per year is based on World Bank estimates that were last measured at 1.18% in 2014 (Trading Economies, 2016 and Index Mundi, 2016). A study, approved by EDL (Network Load Forecast - 2013_02_28 NLF_Rev02), was compiled in 2013 in order to forecast the load growth in the distribution network of new forecasted customers for the purpose of load flow analysis, feeder utilization, and network reinforcement.
- Using 2012 as a base year, the changes in the adjusted average annual loads are considered along with the number of families in the villages powered by each MV feeder, or by all MV feeders in the South region, to calculate the average peak power consumption per family for the years 2013 - 2016.

Annex 05 – Power Consumption Calculation Methodology

- The average power consumption for Non IS and IS shelter types is calculated using the survey data and validated using EDL data.
- The average connected load of household appliances per shelter unit is calculated based on the available household appliances in each visited shelter unit in each region using the standard values of power consumption of typical household appliances as shown in "Table 17: Sample of Survey Data Sheet."
- Since average power consumption is calculated per shelter unit, irrespective of the number of persons or number of families in each shelter unit, the number of families of displaced Syrians living in Non IS shelter type had to be converted to the number of shelter units using the survey data shown in Tables 6 to Tables 13 of section "3.3 Survey Findings."
- The number of families and number of persons, as of June 30, 2016, provides UNHCR data of displaced Syrians in Lebanon. The number of families of displaced Syrians living in Non IS shelter type is converted to the number of shelter units using the percentages calculated in Tables 6 to Tables 13 of section "3.3 Survey Findings." The results are given in Table 36 below.

Region	Shelter Type	No. of Displaced Syrians in Lebanon Registered with UNHCR as of June 30, 2016		% of IS from Total Displaced Syrians in Lebanon		Additional 7% of Non Registered Displaced Syrians Living in IS		Total No. of Displaced Syrians in Lebanon Registered with UNHCR as of June 30, 2016		
		Person	Family	Person	Family	Person	Family	Person	Family	Shelter Unit
Beirut & ML	Non IS	295,410	76,747			0	0	295,410	76,747	71,047
	IS	3,077	582	0.30%	0.24%	215	41	3,292	623	623
	Total	298,487	77,329			215	41	298,702	77,370	71,670
Bekaa	Non IS	191,652	51,088			0	0	191,652	51,088	45,102
	IS	171,645	30,470	16.62%	12.31%	12,015	2,133	183,660	32,603	32,603
	Total	363,297	81,558			12,015	2,133	375,312	83,691	77,705
North	Non IS	209,726	54,571			0	0	209,726	54,571	47,966
	IS	42,493	7,539	4.12%	3.05%	2,975	528	45,468	8,067	8,067
	Total	252,219	62,110			2,975	528	255,194	62,638	56,033
South	Non IS	111,836	25,192			0	0	111,836	25,192	24,773
	IS	6,750	1,265	0.65%	0.51%	473	89	7,223	1,354	1,354
	Total	118,586	26,457			473	89	119,059	26,546	26,127
Total	**Non IS**	**808,624**	**207,598**			**0**	**0**	**808,624**	**207,598**	**188,888**
	IS	**223,965**	**39,856**	**21.69%**	**16.11%**	**15,678**	**2,790**	**239,643**	**42,647**	**42,647**
	Total	**1,032,589**	**247,454**					**1,048,267**	**250,244**	**231,534**

Table 36: Number of Displaced Syrian Families, Persons, and Shelter units in Lebanon as of June 30, 2016

- UNHCR data of displaced Syrians living in IS as of August 31, 2016 is already given by the number of tents and number of individuals. Since average power consumption is calculated per shelter unit, the number of tents in UNHCR data is considered to be the number of shelter units in each region regardless of the number of persons living in each tent.
- In this case study, a Diversity Factor of 0.70 and a Demand Factor of 0.7 is used to calculate the power consumption of the displaced Syrians living in Non IS shelter type. For small residential loads <0.25 KW, a unity Diversity Factor and unity Demand Factor is applied to calculate the power consumption of the displaced Syrians living in IS shelter. Power consumption of the displaced Syrians in Lebanon living in Non IS is the product of the Demand Factor, the Diversity Factor, and the Total Connected Load.

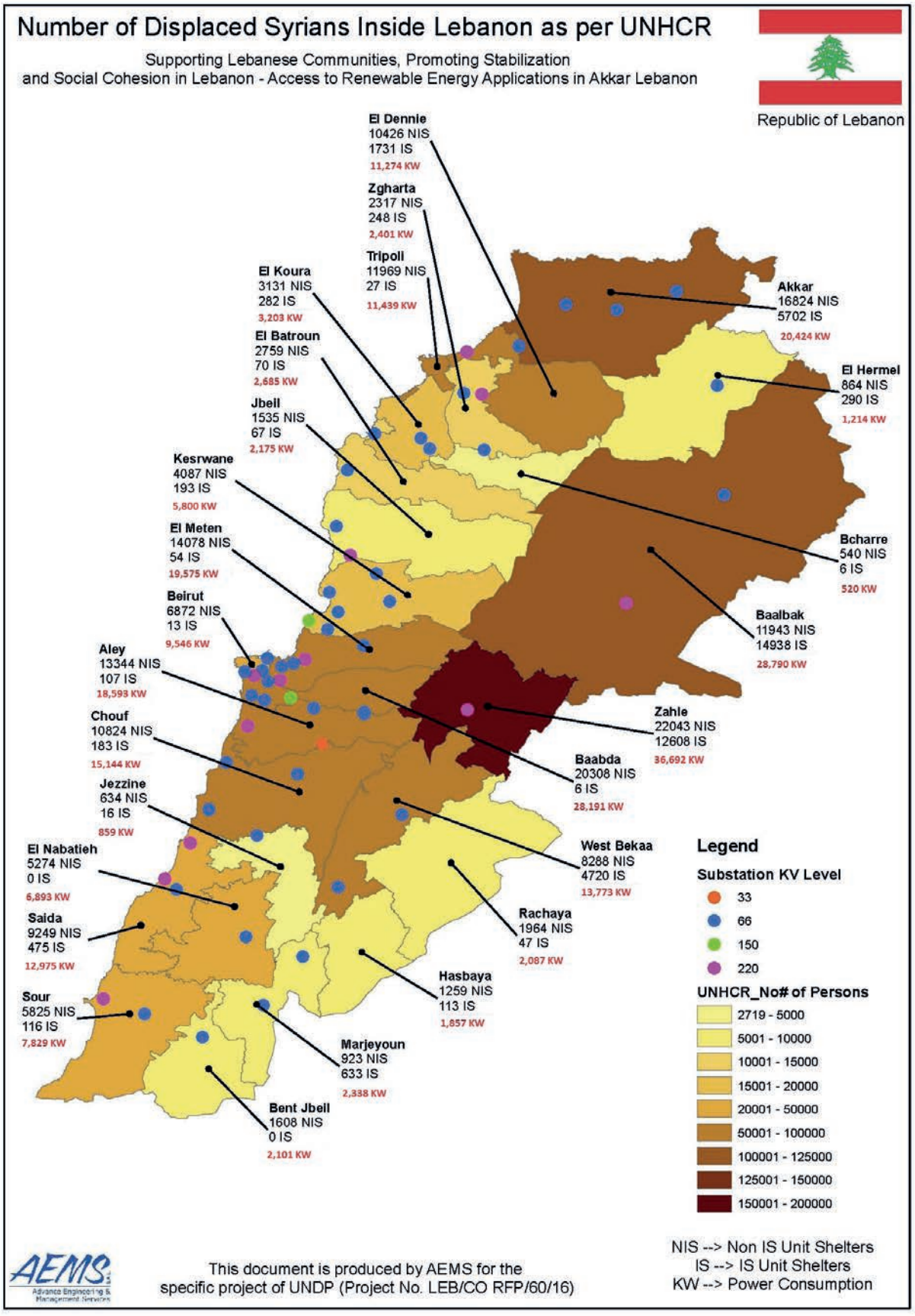
Annex 06 – Diversity Factor (EDL MEMO)
(more data available on CD)

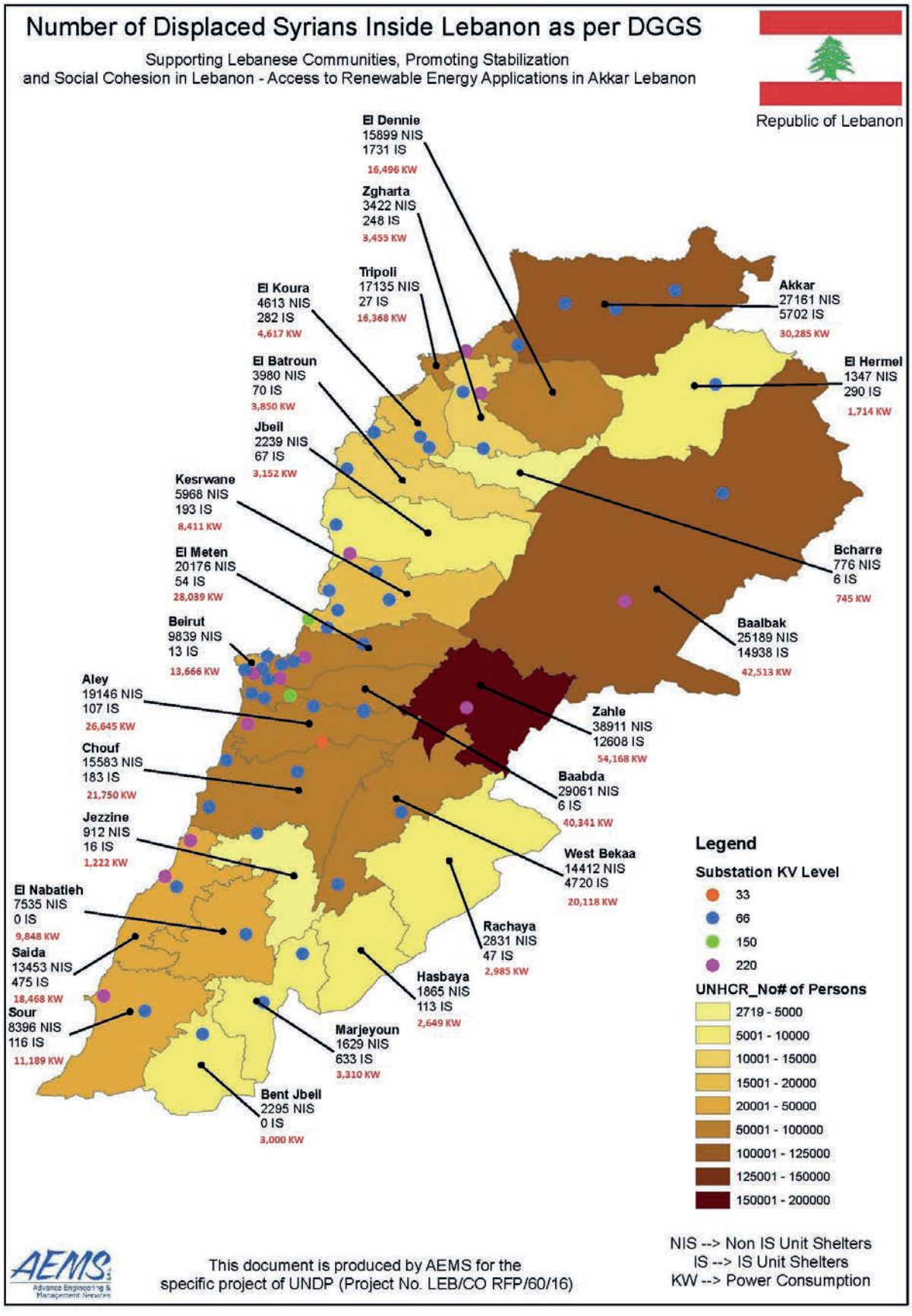
Annex 07 - Total Power Consumption
(more data available on CD)

- The power consumption in KW of the displaced Syrians in Lebanon for Non IS and IS in each region is the product of the average power consumption per shelter unit and the number of units in each shelter type in each region.
- Number of displaced Syrians in Lebanon as per the UNHCR data is 1,032,589 persons as of June 30, 2016 with an additional estimate of 7% of displaced Syrians living in IS shelters who are still not registered with the UNHCR. Hence, the total number of the displaced Syrians in Lebanon is 1,048,267 persons.
- The actual number of displaced Syrians in Lebanon as per the Directorate General of General Security (DGGS) is 1,500,000 persons. Some governmental sources estimate +10% to +23% in illegal entrances, but there is no official counting at the borders to verify them.
- The number of displaced Syrians in Lebanon provided by DGGS (1,500,000) is broken down into number of families and number of shelter units both in Non IS and IS using the extrapolated data obtained from both the UNHCR and the survey data.
- The total power consumption in KW of the total displaced Syrians in Lebanon for Non IS and IS is calculated by summing up the power consumption of each region.
- The total energy consumption in KWH of the total displaced Syrians in Lebanon for Non IS and IS is the product of the total power consumption calculated in step 5 multiplied by the average number of supply hours per day in each region.

Annex 08 - Total Energy Consumption
(more data available on CD)

Annex 09 - Power Consumption per Caza
(more data available on CD)




Number of Displaced Syrians Inside Lebanon as per DGGS
Supporting Lebanese Communities, Promoting Stabilization
and Social Cohesion in Lebanon - Access to Renewable Energy Applications in Akkar Lebanon
Republic of Lebanon
El Dennie
15899 NIS
1731 IS
16,496 KW
Zgharta
3422 NIS
248 IS
3,455 KW
Tripoli
17135 NIS
27 IS
16,368 KW
El Koura
4613 NIS
282 IS
4,617 KW
Akkar
27161 NIS
5702 IS
30,285 KW
El Batroun
3980 NIS
70 IS
3,850 KW
El Hermel
1347 NIS
290 IS
1,714 KW
Jbeil
2239 NIS
67 IS
3,152 KW
Kesrwane
5968 NIS
193 IS
8,411 KW
Bcharre
776 NIS
6 IS
745 KW
El Meten
20176 NIS
54 IS
28,039 KW
Beirut
9839 NIS
13 IS
13,666 KW
Baalbak
25189 NIS
14938 IS
42,513 KW
Aley
19146 NIS
107 IS
26,645 KW
Zahle
38911 NIS
12608 IS
54,168 KW
Chouf
15583 NIS
183 IS
21,750 KW
Baabda
29061 NIS
6 IS
40,341 KW
Jezzine
912 NIS
16 IS
1,222 KW
West Bekaa
14412 NIS
4720 IS
20,118 KW
El Nabatieh
7535 NIS
0 IS
9,848 KW
Rachaya
2831 NIS
47 IS
2,985 KW
Saida
13453 NIS
475 IS
18,468 KW
Hasbaya
1865 NIS
113 IS
2,649 KW
Sour
8396 NIS
116 IS
11,189 KW
Marjeyoun
1629 NIS
633 IS
3,310 KW
Bent Jbeil
2295 NIS
0 IS
3,000 KW
Legend
Substation KV Level
33
66
150
220
UNHCR_No# of Persons
2719 - 5000
5001 - 10000
10001 - 15000
15001 - 20000
20001 - 50000
50001 - 100000
100001 - 125000
125001 - 150000
150001 - 200000
AEMS
Advance Engineering & Management Services
This document is produced by AEMS for the
specific project of UNDP (Project No. LEB/CO RFP/60/16)
NIS --> Non IS Unit Shelters
IS --> IS Unit Shelters
KW --> Power Consumption

Annex 10 - Statistics and Econometrics Data
(more data available on CD)

Methodology

- Actual peak load quarterly data, for the years 2012 - 2015 and two quarters of 2016, are used to validate the power consumption estimate based on the survey data.
- Data for the entire South region as well as four representative feeders are analyzed to calculate the average consumption per family.
- In each case, the quarterly data are used to calculate a seasonal index for each quarter.
- The seasonal indices are used to remove the seasonality from the quarterly data.
- The average load for each year is calculated based on the deseasonalized quarterly data.
- The average annual loads are then adjusted to account for the population growth in Lebanon. The population growth rate per year are based on World Bank estimates.
- Using 2012 as a base year, the changes in the adjusted average annual loads are considered along with the number of families in the villages powered by a feeder, or by all feeders in the South region, to calculate the average power consumption per family for the years 2013 - 2016.

The quarterly seasonal indexes are determined in seven steps. A detailed explanation of the steps is given below and the results are listed in Table 20. Columns 1 and 2 of Table 20 list the quarters of years 2012 to 2016 and the corresponding quarterly loads.

Step 1. The four-quarter moving total for 2012 is first determined. Starting with the first quarter of 2012, the loads 20,162, 18,993, 22,739 and 19,810 are added. The total is 81,703 AMP. Moving along, the four-quarter total is computed for the spring, summer, and fall loads of 2012 to the winter load of 2013. The total is 84,180 AMP. This process is repeated for the remaining quarterly loads. Column 3 of Table 20 lists all of the moving totals. Note that the moving total 81,703 Amps is centered between the spring and summer of 2012. The next moving total, 84,180 Amps, is positioned between loads for summer and fall of 2012, and so on.

Step 2. Each quarterly moving total in column 3 is divided by 4 to give the four-quarter moving average. The four-quarter moving averages are presented in column 4. Note that all the moving averages are still positioned between the quarters. For instance, the first moving average, 20,426 Amps, is positioned between spring and summer of 2012.

Step 3. Next, the moving averages are centered. The first centered moving average is calculated by averaging (20,426 + 21,045)/2 = 20,735 and centered opposite summer 2013. The second moving average is found by (21,045 + 21,809)/2 = 21,427. The others are found in a similar way and listed in column 5. Note that a centered moving average is now positioned on a particular quarter.

Step 4. The specific seasonal index for each quarter is then computed (column 6) by dividing the load in column 2 by the centered moving average in column 5. The specific seasonal reports the ratio of the original time series value to the moving average. The specific seasonal for the summer quarter of 2012 is calculated to be 1.0966 (22,739/20,735).

Step 5. The specific seasonal indexes are organized in column 6. This column helps in locating the specific seasonality for the corresponding quarters. The values 1.0966, 1.1152, 1.0468, and 1.1120 all represent estimates of the typical seasonal index for the summer quarter. A reasonable method to find a typical seasonal index is to average these values. So the typical index for the summer quarter is calculated by (1.0966 + 1.1152 + 1.0468 + 1.1120)/4 = 1.0927. The typical seasonal indices for the fall, winter, and spring quarters are calculated in a similar way and the results are listed in column 7.

Step 6. The four quarterly means (1.0927, 0.9317, 0.9818, and 0.9828) should theoretically total 4.00 because the average is set at 1.0. The total of the four quarterly means may not be exactly equal to 4.00 due to rounding. In this case, the total of the means is 3.9889. A correction factor of 4/3.9889 is therefore multiplied by each of the four means to force them to total 4.00. The adjusted quarterly seasonal indices (1.0957, 0.9342, 0.9846, and 0.9855), now totaling to exactly 4.000, are listed in column 8 and repeated for each year.

Step 7. The deseasonalized loads, listed in column 9, are calculated by dividing each quarterly load in column 2 by the corresponding actual seasonal index in column 8. After removing the seasonality from each quarterly data, the trend in the quarterly loads is analyzed.

Column 1 Year & Quarter	Column 2 Loads (Amp)	Column 3 Four Quarter Total	Column 4 Four Quarter Moving Average	Column 5 Centered Moving Average	Column 6 Specific Seasonality	Column 7 Seasonal Index	Column 8 Adjusted Seasonal Index	Column 9 De-Seasonalized Load (Amp)
2012 Q1	20,162							
2012 Q2	18,993						0.9855	19,272
		81,703	20,426					
2012 Q3	22,739			20,735	1.0966	1.0927	1.0957	20,753
		84,180	21,045					
2012 Q4	19,810			21,427	0.9245	0.9317	0.9342	21,204
		87,238	21,809					
2013 Q1	22,638			22,251	1.0174	0.9818	0.9846	22,993
		90,768	22,692					
2013 Q2	22,051			23,182	0.9512	0.9828	0.9855	22,375
		94,690	23,672					
2013 Q3	26,270			23,556	1.1152		1.0957	23,975
		93,759	23,440					
2013 Q4	23,731			23,721	1.0004		0.9342	25,402
		96,009	24,002					
2014 Q1	21,707			23,786	0.9126		0.9846	22,048
		94,283	23,571					
2014 Q2	24,301			23,414	1.0379		0.9855	24,659
		93,027	23,257					
2014 Q3	24,543			23,445	1.0468		1.0957	22,399
		94,534	23,633					
2014 Q4	22,476			23,270	0.9659		0.9342	24,058
		91,625	22,906					
2015 Q1	23,214			22,859	1.0155		0.9846	23,578
		91,250	22,812					
2015 Q2	21,393			22,302	0.9592		0.9855	21,707
		87,164	21,791					
2015 Q3	24,167			21,732	1.112		1.0957	22,057
		86,696	21,674					
2015 Q4	18,390			22,003	0.8358		0.9342	19,685
		89,330	22,332					
2016 Q1	22,745						0.9846	23,102
2016 Q2	24,027						0.9855	24,380
2016 Q3							1.0957	
2016 Q4							0.9342	

Table 20: South Region Quarterly Deseasonalized Loads (AMP)

Average Power Consumption Per Family Based on EDL Data for the Entire South Region

The number of displaced Syrian families provided by the UNHCR are annual figures, except 2016. In order to have a common time reference, average annual loads are calculated (Column 2 of Table 21) based on the deseasonalized loads listed in Table 20. The trend in the average annual loads (Figure 8) is due to growth in the population and to additional consumption of the displaced Syrians. The average annual loads are then adjusted to account for a population growth of 1.222%, 1.180%, 1.182%, and 1.182%, per year for 2013, 2014, 2015 and 2016, respectively (Source: World Bank http://data.worldbank.org/indicator/SP.POP.GROW). The remaining trend is the power consumption of the displaced Syrians in the area. Calculations of all figures in Table 21 are detailed below.

Column 1 Year	Column 2 Average Loads (AMP)	Column 3 Population Growth	Column 4 Estimated Loads Base Year 2012 (AMP)	Column 5 Load Growth Base Year 2012 (AMP)	Column 6 Adjusted Average Loads Per Quarter (AMP)	Column 7 Change in Adjusted Average Annual Loads (AMP)	Column 8 Change in Adjusted Average Annual Load (KW)	Column 9 Change in Number of Families (Base Year 2012)	Column 10 Average Consumption per Family (KW with Base Year 2012)
2012	20,427		20,427	0	20,427				
2013	23,686	1.222%	20,676	250	23,437	3,010	62,558	21,462	2.915
2014	23,291	1.180%	20,920	494	22,797	2,371	49,269	30,263	1.628
2015	21,757	1.182%	21,301	874	20,882	455	9,466	27,949	0.339
2016	23,741	1.182%	21,689	1,262	22,479	2,052	42,654	26,457	1.612
								Average	1.623

Table 21: Average Peak Power Consumption per Family

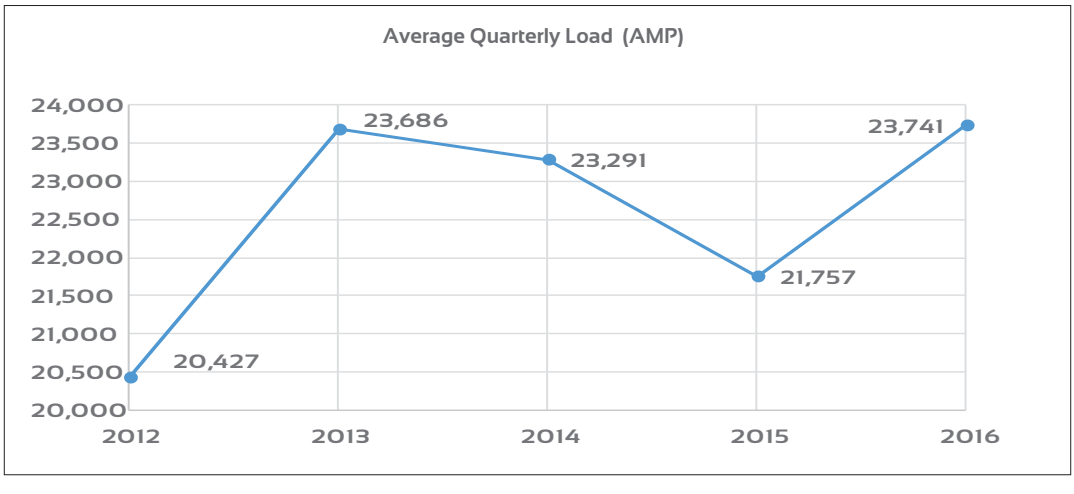


Figure 8: Quarterly Load for the South Region (Amp)

The calculations of values listed in Table 21 above are as follows:

Step 1. For each year, the quarterly deseasonalized loads (column 9 of Table 20) are averaged. The average load for 2012 is (20,478 + 19,272 + 20,753+ 21,204)/4 = 20,427. The calculated average loads are listed in column 2. The average for 2016 is based on the first two quarters.

Step 2. Column 3 shows the population growth rates for the years 2013, 2014, and 2015 (Source: World Bank http://data.worldbank.org/indicator/SP.POP.GROW). For 2016, the most recent rate is used.

Step 3. Using 2012 as a base year, the average load for each year is estimated based on the population growth rate. For instance, the estimate for 2013 is 20,427 + 1.222% (20,427) = 20,676. Similarly, the estimate for 2013 is the 20,676+ 1.180% (20,676) = 20,920, and so on. The results are shown in column 4.

Step 4. The annual increase due to population growth, with 2012 as a base year, is listed in column 5. These values are obtained by subtracting the estimate average load for each year from the load of 2012 in column 5.

Step 5. Subtracting each additional load due to population growth from the corresponding load in column 2 yields the adjusted loads. Increase in these adjusted loads is due to the power consumption of the displaced Syrians in the area. The calculated results are listed in column 6.

Step 6. The increase in loads (in AMP) relative to year 2012 are calculated by subtracting each load in column 7 from the load of 2012 in column 7.

Step 7. In column 8, the increase in loads (in AMP) is converted to KW using:

$P\ (KW) = V*I*pf*\sqrt{3}$ where V = 15KV and pf = 0.85

Step 8. The number of families of the displaced Syrians based on UNHCR data is listed in column 9.

Step 9. The average power consumption per family for the years 2013 to 2016 are presented in column 9.

Step 10. Averaging the values in column 9 to obtain a single estimate for the average power consumption of 1.6001 KW per family.

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