MINARET

NETWORKING FOR THE FUTURE

ENERGY EFFICIENCY ASSESSMENT– LEBANON

Sweden Sverige

FUTURE PIONEERS Empowering Communities

IUCN

NERC National Energy Research Center

Royal Scientific Society

Contents

List of Figures

List of Tables

1. Executive Summary

An energy assessment was conducted for Jdaidet Al-Chouf Municipality in Lebanon by the Royal Scientific Society (RSS) / National Energy Research Center (NERC) to assess the energy status of the Municipality. The RSS / NERC team exerted huge efforts to compile all the provided data, measurements and outcomes that took place during the assessment in order to come up with the final assessment report.

The energy assessment of Jdaidet Al-Chouf Muncipality mainly targeted facilities under municipality administration to evaluate the energy situation and recommend energy saving measures for these facilities. The energy assessment targeted the following facilities:

- Municipality building
- Wastewater treatment plant
- Solid waste separation plant
- Water pumping station
- Street lighting
- Football playground

The assessment indicates that the municipality depends on two sources to cover its needs of electricity: the national public grid for national electricity company and private companies using diesel generators to generate electricity to cover the electricity interruption by the national electricity company.

The assessment uncovered energy saving opportunities within municipal facilities by evaluating the electric and mechanical energy consumptions. Through the assessment, several energy saving recommendations were suggested to achieve reduction in energy consumption for facilities in the municipality. Through these recommendations the municipality can achieve energy saving of about **253,326 KWh** per year if it implements all these recommendations, as per the distribution shown in Figure 1 for energy saving distribution in Jdaidet Al-Chouf Municipality.

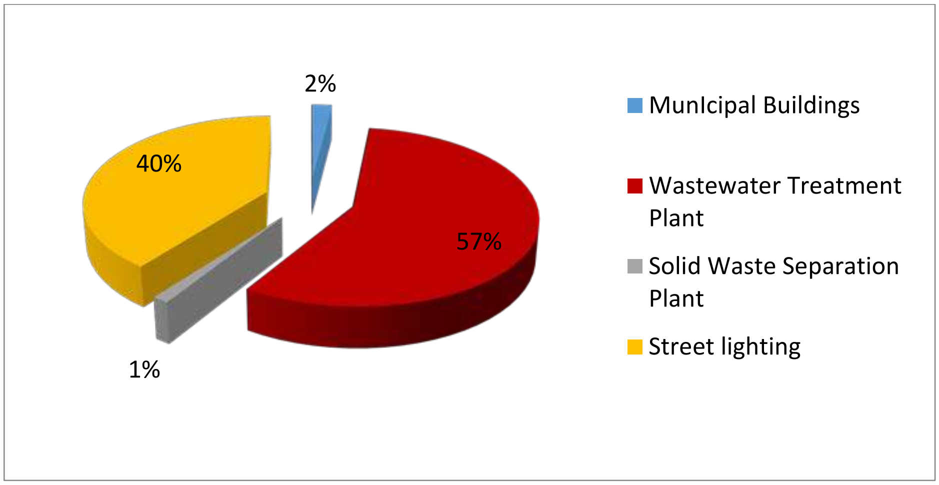


Figure 1: Energy savings distribution in percent for municipal buildings and facilities

Through the analyses of the Jdaidet Al-Chouf municipality facilities, Table 1 below summarizes the final energy saving recommendations for each building and facility:

Table 1 *:Energy saving recommendations for municipal buildings and facilities in Jdaidet Al-Chouf.*

Energy Saving Measure	No. of Units	Annual Energy Saving (kWh/yr)	Annual Cost Saving (LBP)	Required Investment (LBP)	Payback Period (Years)
Municipal Building					
Replacing halogen light 100w with LED 18w	78	3748	1,124,416	1,174,290	1
Replacing CFL 85w with LED round panel 24w	12	429	128,685	280,020	2
Replacing CFL 24w LED round panel 12w	4	28	8,438	45,164	5.4
Replacing spot lights 30w with LED spot lights 6w	16	225	67,507	84,272	1.2
Install solar water heater	1	710	213,000	602,196	2.8
Wastewater Treatment Plant					
Replace compressor rather than aerobic mixture	1	140,160	35,040,000	7,527,511.18	1
Build receiving tank with capacity 500 m^3	1	4320	1,296,000	7,527,511.18	5.8
Solid Waste Separation Plant					
Replacing metal halide lamps (400W) with LED flood light fixture (180W)	4	3258	977448	1705956	2
Street Lighting					
Replacing high pressure sodium lamps (HPS) 250W with LED fixtures 100W	172	100,448	32,919,442	103,200,000	3.1

There are some recommendations for some facilities of the municipality that do not directly affect the energy consumption, but they can improve the energy systems in those facilities, as follows:

1. Water pumping: it is recommended that a Computerized Maintenance Management System (CMMS) is set up to keep track of maintenance issues.
2. Water pumping: it is recommended to install energy & water meters in the lower and upper pumping stations.

3. Water pumping: nomination of a technical staff member at the pumping station to spearhead energy management activities.
4. Use the timer instead of the cells to turn on and switch off the lighting units.
5. Conduct an awareness campaign in areas of energy efficiency and waste management.

2. Introduction

2.1 About MINARET Project

The MENA Region Initiative as a model of the NEXUS Approach to Renewable Energy Technologies" (MINARET), is a project aimed to address the following three key issues: renewable energy technology and energy efficiency, water management and food security with various cross cutting themes: gender equality, women empowerment and socio-economy.

Many **MENA** countries, including Jordan, Lebanon and Tunisia are facing several challenges. These include a global economic downturn, regional upheavals and instability (such as the ongoing Syrian crisis), acute scarcity of energy and water resources, growing energy needs and a fast-growing population that is demanding a better standard of living and adequate solutions to rising prices and unemployment. All of these challenges are significantly impacted by near total dependency on imported hydrocarbon energy sources as well as the arid and extremely variable climate, which are putting huge pressures on available energy, water and food resources.

2.2 About Jdaidet Al-Chouf

Jdaidat (Baqaata) Al-Chouf is a town located in the Chouf District of the Mount Lebanon Governorate, about 45 kilometers (28 mi) southeast of Beirut. Its altitude ranges between 800 m (1,824 ft) - 1000 m (3,280 ft) high. Bordering towns include Symkanieh, Ain wa Zein and Mokhtara.[1] Figure 2 shows Jdaidat Al-Chouf location map.

Figure 2: Jdaidat Al-Chouf map

One of the most important tourist attractions in the Chouf area is the Al-Chouf Cedar Reserve, which is managed by the Al-Chouf Cedar Society in cooperation with the Lebanese Ministry of Environment, UNDP and the World Conservation Union. The reserve is located on the tops of the central part of the West Lebanon mountain range. It is one of the largest reserves in Lebanon, accounting for 80% of protected areas. It covers an area of 550 km^2, 50 km long and 11 km wide and its height ranges from 1200 meters to 1984 meters; 70% of which are located in the Chouf area and 30% in the western Bekaa. [2]

Figure 3: Al-Chouf Cedar Reserve

Jdaidat (Baqaata) Al-Chouf city is known for its National Park (Marytyrs' Cemetry, 1958's Revolution), which constitutes an important part of the architectural heritage in Chouf Region. The site has a spiritual and intellectual significance, in addition to its artistic, cultural, symbolic and architectural value. [3] A characteristic picture of the national park is presented in Figure 3.

Figure 4: National Park (Marytyrs' Cemetry) - Baqaata

2.3 Energy situation in Lebanon

Lebanon is among the highest in the world in dependency on foreign energy sources, with 96.8% (NEEAP 2016-2020) of the country's energy needs coming from imported oil and natural gas from

Gulf countries and neighboring oil countries. This complete reliance on foreign oil imports consumes a significant amount of Lebanon's Gross Domestic Product (GDP).

The country's primary energy imports cover essentially the following types of oil products:
- Liquid gas
- Gasoline
- Gas Oil
- Fuel Oil
- Kerosene
- Asphalt

According to the baseline for Lebanon NEEAP (2016-2020); all these types of oil products are consumed by electricity and local market.

The total primary energy consumption in 2010 is 6,069,301 toe, out of which 96.8% were imported from outside Lebanon and the remaining (3.2%) were locally produced. Figure (5) illustrates the distribution for the primary energy consumption in Lebanon.

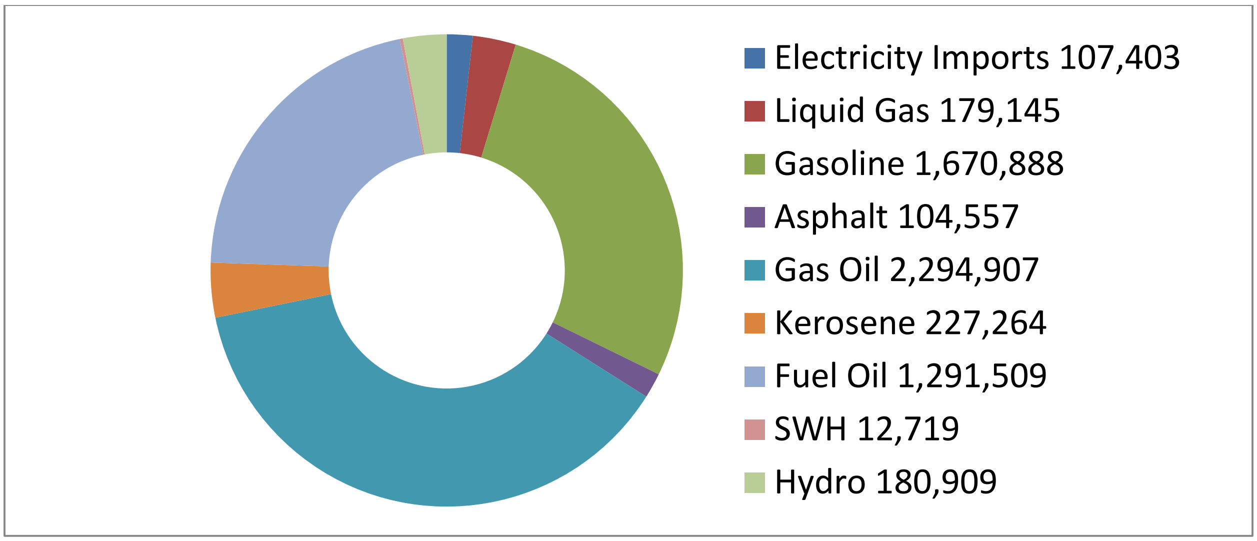


Figure 5: The distribution for the primary energy consumption in Lebanon. NEEAP (2016-2020) [4].

Lebanon faces several problems in the energy sector, especially in electricity generation and distribution. The electricity gets interrupted twice a day for more than 6 hours and the shortage of electricity supply is covered by alternative energy sources (diesel generators); most of the owners of the generators are private companies and some people have their own generators. The generators cover the shortage of electricity, but it doubles the energy tariff. In addition to the electricity shortage the electricity transmission is weak and the grid is over the headline.

2.4 Energy regulatory framework

The Ministry of Energy and Water is responsible for energy regulation in Lebanon. The Ministry of energy and water has three general directions for water and energy sectors in Lebanon as follows:

- Hydraulic and electric resources

- Exploitation
- The petroleum

The Lebanese Center for Energy Conservation (LCEC) was created in 2002 as a subsidiary of the Ministry of Energy and Water; it addresses end-use energy conservation and renewable energy in Lebanon. It supports the government in Lebanon to develop and implement national strategies that promote the development of efficient and rational usages of energy and the use of renewable energy on the consumer's level. LCEC operates under the direct supervision of the Minister. The LCEC is involved in a range of pilot projects, covers the solar water heating market, conducts the Energy Audit Program and provides financial and tax incentives to consumers to promote energy efficiency. The LCEC has developed - in cooperation with the Lebanese Standards Institution, energy efficiency standards for the following five household appliances: solar water heaters, compact fluorescent lamps, refrigerators, AC split units, electrical and gas water heaters.[5]

2.5 Energy situation in Jdaidet Al-Chof

Jdaidet Al-Chof suffers from electricity interruptions twice a day for more than 6 hours and the shortage of electricity supply is covered by alternative energy sources (Diesel Generators).

Five companies cover the shortage of electricity in Jdaidet Al-Chouf in addition to the diesel generators which are owned by some families. The electricity tariffs differ based on their sources, be it the national electricity company or a local private company. Table 2 below illustrates the electricity tariffs in Jdaidet Al-Couf.

Table 2: *Electricity Tariff In Jdaidet AlChouf.*

Source	Class	Consumption (kWh)	Cost (LBP)
Public Grid	A	1-200	35
	B	201-500	55
	C	501-750	80
	D	750-1000	120
Diesel Generator	E	Greater than 1000	200
	Fixed fees	Less than 40	40000
	per KWh	Greater than 40	400

On the other hand, there are five oil stations in Jdaidet Al-Chof that provide different types of fuel oil for local communities and companies.

3. NERC Energy Assessment Methodology

The energy assessment in Jdaidet Al-Chouf municipality in Lebanon was conducted by the RSS/NERC team to evaluate the current situation of several municipal facilities and to identify the possible energy saving measures through the improvement of the energy efficiency in these facilities. Also, the RSS / NERC team has identified the possible renewable energy systems that can be installed in these facilities.

Several meetings have been conducted with different stakeholders and the main entities within the municipality in order to collect the needed information to evaluate the energy situation of the municipality.

4. Analysis and Findings

4.1 Facilities under municipality administration

The following facilities are under the municipal administration:

1. Municipality building
2. Wastewater treatment plant
3. Solid waste separation plant
4. Water pumping station
5. Street lighting
6. Football playground

4.2 Municipality building

General description

Jdaidet Al-Chouf Municipality building is located in the middle of Al-Jdaideh city. The building consists of only one main building and the utilized area equals **(835 m^2)** including three floors and twelve offices. The total number of employees working at the municipality is five. There are many facilities under the municipality administration within its boundaries, including the municipality building, street lighting, water pumping station, waste water treatment station, solid waste separation plant and football playground. Figure 6 shows the municipality building.

Figure 6: Jdaideh Al-Chouf Municipality building

Energy consumption distribution

The building of the municipality uses electrical and thermal (diesel) energy in order to meet its energy demands. According to meter readings the annual electrical consumption was **9,432** kWh equivalent to **2,829,600** LBP, while the annual thermal consumption was **1,100** kWh equivalent to **825,000** LBP. Figure 7 shows the distribution of energy consumption of the municipality building.

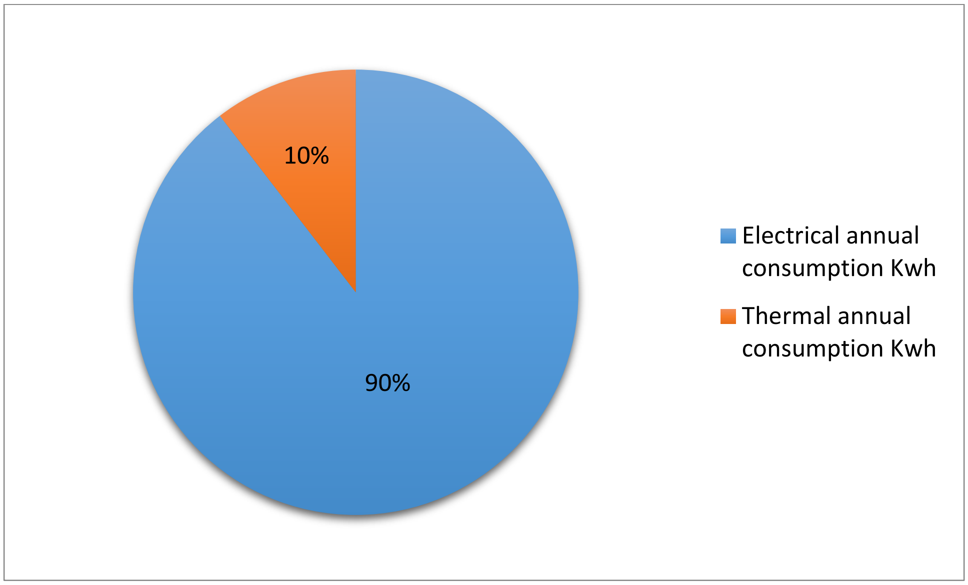


Figure 7: Distribution of energy consumption for the municipality building.

Electrical system

The electrical power for the municipal building is fed by two sources; the public grid and diesel generators. Both sources have a single meter.

Equipment breakdown

The NERC team surveyed the municipality building's energy consumers where Table (3) shows the electric energy consumers and their expected annual energy consumption distribution. Also, Figure 8 illustrates the electrical energy consumption proportionally for each type of electrical system in the municipality building.

Table 3: *Energy consumers and their expected consumption distribution in the municipality building*

Area of Consumption	Annual Energy Consumption (KWh)	Consumption Percentage %
Equipment	5,261	35.55%
Lighting system	9,539	64.45%

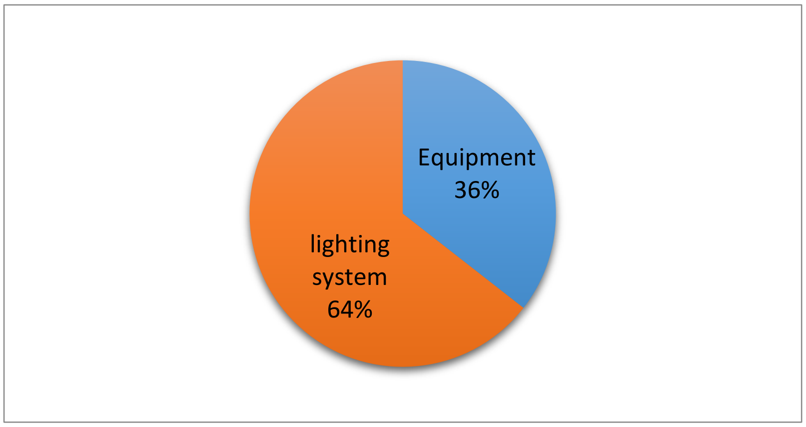


Figure 8: Electrical Energy Consumption Proportionality

Lighting system

Lighting is one of the main energy consuming systems at the municipality building. There are several types of lighting systems in order to meet lighting requirements during working hours. Table 4 and the Figure hereunder illustrate the number of lamps, connected loads and respective energy consumptions according to each type of lighting fixture; Figure 9 illustartes the energy consumption distrepution for lighting in the municipal building.

Table 4: *Details about existing lighting units in the municipal building.*

Type of Lighting Units	Number of Lighting Units	Total Connected Load (kW)	Energy Consumption (kWh)
Halogen lamps (100W)	78	7.8	4570.8
Compact fluorescent lamps 85w (CFL)	12	1.02	597.7
Compact fluorescent lamps 24w (CFL)	4	0.096	56.3
LED candles (4W)	24	0.096	56.3
LED (100W)	3	0.3	175
LED Floodlights bulbs (30W)	1	0.03	17.6
LED (2 Round panel/4 flood Light) (20W)	6	0.12	70

LED square panel lights (18W)	31	0.558	327
LED round panel lights (12W)	6	0.072	42
Spot lights (30W)	16	0.48	281
LED tube lights (14W)	20	0.28	164
Total		**10.852**	**6357.7**

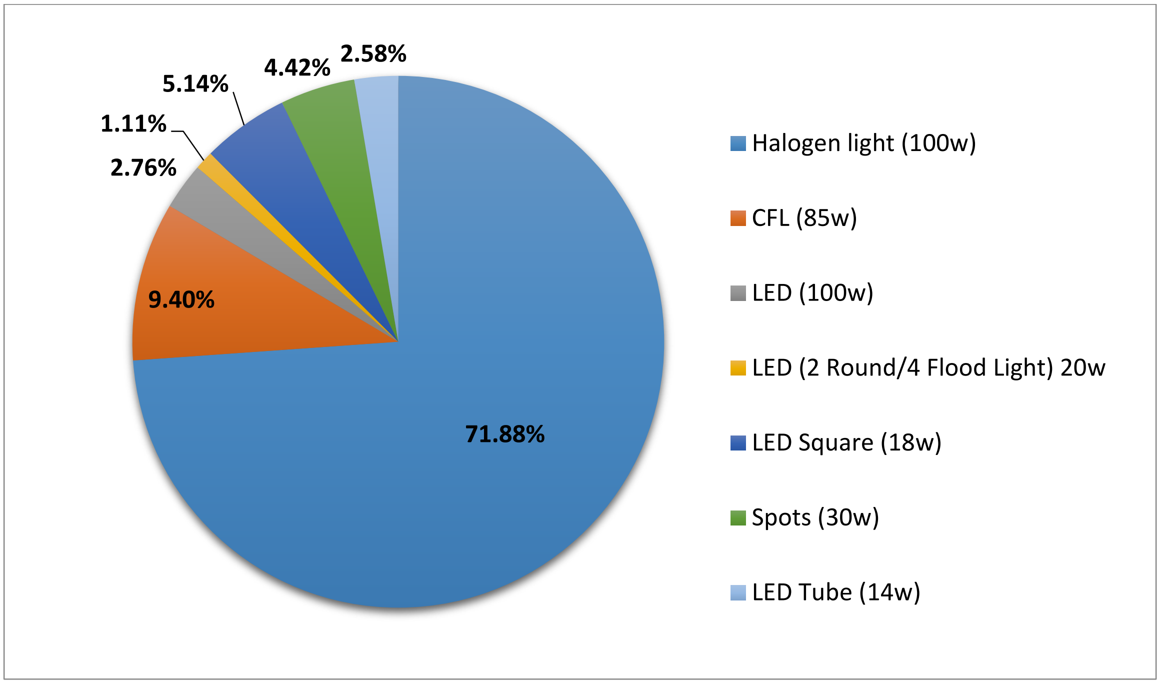


Figure 9: Energy consumption distrepution for lighting in the municipal building

Mechanical Systems, building envelope, heating and cooling Systems

After site investigation and discussions with responsible staff at the Municipality, it was noted that the municipality building envelope had double wall construction, considering its composition as follows: air, plaster, 10 cm concrete, 5 cm insulation air cavity, 15 cm concrete, 2 cm plaster and air; the overall U-value is 1.57 W/m^2 .K., which is more efficient than the single wall construction (U-value of 2.76 W/m^2 .K.) by 43% [1]. Additionally, the windows in the building envelope were double glazed and well sealed, which reduce heat losses coming from infiltration.

The municipality building uses different diesel heaters as a source of heating in winter, which are distributed as follows:

- Mayor’s Office: One diesel heater with burner, with capacity of 115 kcal/hr (diesel rate of 0.0145 Lit/hr, electricity rate of 80W).
- Meetings Room: One diesel heater with burner, with capacity of 115 kcal/hr (diesel rate of 0.0145 Lit/hr and electricity rate of 80W).
- Martyr Hall: Two diesel heaters with burner, with capacity of 13,000 kcal/hr each (diesel rate of 1.24 Lit/hr and electricity rate of 80W).

- Treasurer Office: One diesel heater with burner, with capacity of 115 kcal/hr (diesel rate of 0.0145 Lit/hr and electricity rate of 80W).
- Municipal Clerk Office: One diesel heater without burner, with capacity of 2,000 kcal/hr (diesel rate of 0.25 Lit/hr).
- Waiting & Copying Room: One diesel heater without burner, with capacity of 2,000 kcal/hr (Diesel rate of 0.25 Lit/hr).

Figure 10: Different diesel heaters with pump in the municipality building.

Figure 11: Diesel Heater in the municipality building.

As for Cooling, the municipality building has one split air-condition in the meetings room and 7 stand fans in the offices, the cooling energy in the summer is minor with annual consumption about 1,000 kWh.

Annual diesel consumption for space heating in the municipality building is 110 Liters with annual cost of 82,500 LBP (equivalent to 24 USD) (according to the municipality staff who provided this information). The total heated area in the municipality building (heated offices and rooms) is around 260 m^2, whereas the total energy consumed is 1,242 kWh (1 Liter Diesel = 10 kWh plus the electrical energy consumed by the burners). Thus, the specific energy for space heating in the municipality building is (4.78 kWh/m^2), which is lower than the average specific energy in the zone (17 kWh/m2)[1] by 71% and this is due to the good building envelope with double wall construction and double-glazed windows.

Moreover, the building consists of two electric water heaters with capacity of 50 lit each, that operate in winter with total daily hot water demand of 100 Lit/day and annual electrical energy consumption of 710 kWh.

4.3 Street lighting

Importance of street lighting

Street lighting is a key public service provided by public authorities at the local and municipal level. Good lighting is essential for road safety, personal safety and urban ambience. Street lighting ensures visibility in the dark for motorists, cyclists and pedestrians, thereby reducing road accidents. Street lighting also indirectly facilitates crime prevention by increasing the sense of personal safety, as well as the security of adjacent public and private properties. Street lighting effects can also boost the appeal of cities, towns and communities as commercial and cultural centers by highlighting attractive local landmarks or accentuating the atmosphere during important public events.

However, many street lighting facilities are outdated and therefore highly inefficient. This leads to higher energy requirements and levels of maintenance.

Municipality’s Street lighting

Jdaidet Al-Chouf municipality has installed street lighting facilities all around its boundaries to acquire the desired visibility and safety for the inhabitance. The mayor of Al-Jdaideh municipality stressed on the fact that they are looking forward to improving the standards of living of the municipality’s residents and provide all the comforts and safety for them; this is why they put “upgrading the street lighting” in their priorities list.

[1] According to the Second National Energy Efficiency Action Plan for The Republic of Lebanon (NEEAP 2016-2020) “Page 86-89”

Subsequently, the municipality's maintenance staff confirmed their decision to take a step forward, so that they have already started to replace old inefficient lighting units with more efficient and higher technology units using “trial and error” methodology to attain the optimum replacement.

Energy consumption

The street lighting systems are almost similar to other electrical energy consumers within the municipality boundaries in its power supply sources, since most of these lighting units are directly connected to the electrical grid, but they’re also connected to the private generators network as a backup source because of the frequent power outages and electrical faults in the electrical grid in general.

Furthermore, a street lighting system is considered as the main significant energy user (SEU) of the whole energy consumers which is located within the boundaries of Jdaidet Al-Chouf municipality, where the annual electrical energy consumption “from the electrical grid only” as an average for the years (2012, 2013 and 2014) “according to the electricity bills which were submitted by municipality’s management staff” is about 58,358 kWh (equivalent to 16,861,333 L.L.). It should be noted that the average calculated electricity tariff for street lighting facilities according to the electricity bills for the same mentioned period is (**328 L.L./kWh**).

However, as there were no bills from the private generators’ companies to be submitted to the RSS/ NERC team and while the operating time for the mentioned two power sources is almost equal (12 hours each); it would be the best scenario to assume that the annual electrical energy consumption “from the two sources” for the street lighting units is about **116,716 kWh** (equivalent to **33,722,667 L.L.**).

Data gathering and analysis

The municipality’s maintenance staff has recently conducted a survey to collect all the needed data in order to fill out the Table 5; which includes the types of street lighting units, their electric power, numbers, operating hours, the average distance between lighting poles and their height according to the last updated data and statistics.

Table 5: *Types of street lighting units, wattages, numbers, operating hours and poles information*

Area	Type of lamp	Power (W)	No. of connected lamps	Operating Hours	Distance between poles (m)	Height (m)
Al-Jdaideh - Al-Day'ah	Sodium	250	50	8	30-50	7-10
	Fluorescent	100	24	8	30-50	7-10
Alshuhada -Mun. Building	Sodium	100	13	8	30-50	7-10
	Sodium	250	4	8	30-50	7-10
	LED	50	50	8	30-50	7-10
Baqaata Market	Fluorescent	100	23	8	30-50	7-10
Baqaata - Aljadideh	LED	100	24	8	30-50	7-10
	LED	40	10	8	30-50	7-10
	Fluorescent	100	3	8	30-50	7-10
	LED	100	15	8	30-50	7-10

Aljdaideh-Alkahlotiah	LED	50	2	8	30-50	7-10
	Fluorescent	100	11	8	30-50	7-10
Opposite & Behind Nasr-Allah	Fluorescent	100	5	8	30-50	7-10
	Sodium	250	24	8	30-50	7-10
	LED	100	18	8	30-50	7-10
Ein & Zain Way	Fluorescent	100	74	8	30-50	7-10
	Sodium	250	49	8	30-50	7-10
Hai Alshuhada	Sodium	250	45	8	30-50	7-10
	Fluorescent	100	26	8	30-50	7-10

Calculations and outcomes

Electrical Energy consumption for the existed street lighting system could be calculated based on the collected data in the Table 5, while taking into consideration the following:

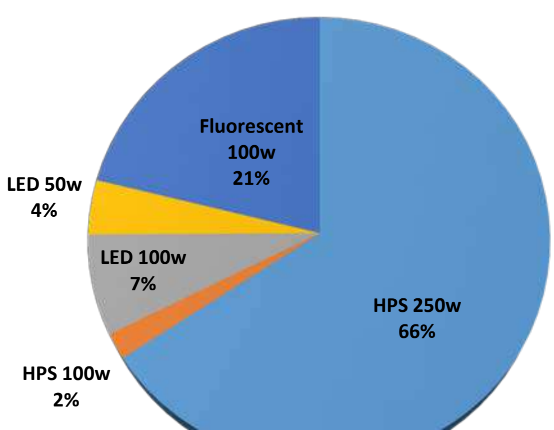
- Number of working connected lamps.
- Total connected load for each type of lamps including the power dissipated by the ballast.
- The average operating period of 8 hours per day and 365 days/year for all street lighting units.

The annual energy consumption for each type of lamp is shown in the Table 6; it is resulted by multiplying the total connected load for each type of lamp by the annual operating hours.

Table 6: *Types of street lighting units, wattages, numbers, operating hours and poles information*

Type of lamp	Lamp Power (w)	No. of lamps	Total Connected load (Kw)	Annual operating Hours	Annual energy consumption (Kwh)
High Pressure Sodium HPS	250	172	51.6	2920	150,672
	100	13	1.5	2920	4,365
LED	100	57	5.7	2920	16,644
	50	62	3.1	2920	9,052
Fluorescent	100	166	16.6	2920	48,472
Total		470	78		229,205

Figures 12 and 13 show the patterns of the installed types of street lighting units' distributions according to their numbers and their energy consumption, respectively.



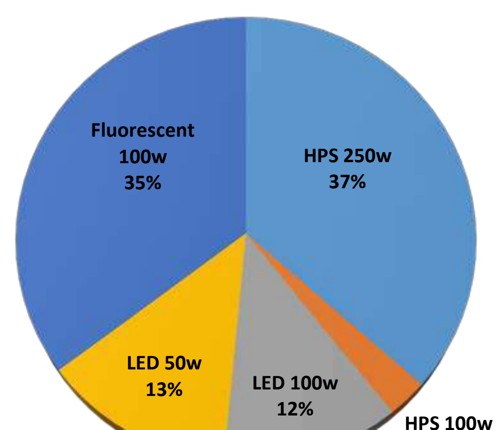


Figure 13: Proportions of lighting units' types according to their numbers

Figure 12: Proportions of lighting units' types according to their energy consumption

Measurements and Findings

NERC/RSS team has conducted a quick assessment for several locations and took the required measurements to assess the illuminance and efficacy for these lighting units, thereby they found that most of the street lighting units located within the municipality's boundaries are inefficient units that don't meet the lighting standards and require a frequent maintenance.

Figure 14: NERC/RSS team while conducting lux measurement for street lighting

Throughout conducting the illumination measurements, various locations with different types of street lighting units have been selected in order to obtain comprehensive results, Table 7 summarizes these results illustrating the average measured lux for each type of street lighting unit. Figure 14 illustrates NERC/RSS team while conducting lux measurement for street lighting

However, Since it is highly recommended to achieve an average illuminance of 15 lux for street lighting in order to fulfill the adequate illumination for the street; it is obvious to figure out that the last three types of lighting units (LED fixture 50W, CFL 100W and LED lamp 35W) in Table 7 below couldn't meet the minimum requirement of street lighting standards.

Table 7: *Average measured lux for different types of street lighting units*

Type of Lighting Unit	**Pole height (m)**	**Power (w)**	**Average measured Luminance (Lux)**
High Pressure Sodium (HPS)	8	250	29
LED fixture	8	100	23
LED fixture	8	50	11
CFL	8	100	1

LED Lamp	8	35	4

Moreover, street lighting lamps within Al-Jdaideh boundaries are all connected with light-sensitive photocells that get activated automatically when light is or is not needed: dusk, dawn, or the onset of dark weather.

Furthermore, it should be noticed that some of these light detectors require immediate maintenance to avoid turning on these lights within the daylight hours as shown in the Figure 15 below, which is a basic measure to reduce wasted energy that can be used for other energy consumers and contribute to more security in energy supply.

Figure 15: actual example on the result of photocells failures

4.4 Pumping water station

General description

Municipalities are spending large amounts of their revenue on purchasing energy for providing local public services such as street lighting and water supply. Water pumping being a 24 hour operation tends to be a more energy intensive process. Through effective energy management practices and periodic energy audits, much energy savings can be realized in pumping systems.

A municipal water pumping system that incorporates energy, reliability and economic benefits of optimum pumping systems can reduce costs, gain pumping efficiency, improve opportunities and gain confidence to move ahead with essential capital upgrades that are deemed necessary for water services provision. These measures will play a role in meeting the challenges of rising energy prices, since the population increase is apt to lead to an increased demand for water in the city.

Jdaidat Al-Chouf pumping station

The pumping station that was assessed is the Jdaidat Al-Chouf pumping station. It is located in Jdaidat Al-Chouf about 1 km from the city center.

The pumping station delivers an average of 0.406 million liters per day (MLD) or 12.18 million liters per month to Jdaidah reservoirs, while consuming about 9,790 kWh of electricity per month. The static head, which is defined as the height difference between the pumping station and the reservoir is around 160 meters. The length of the pipeline is around 1400 meters while the water pipe diameter is 8".

The Pumping station process

The water is sourced from Barouk's water pumping station, which flows to the Jdaidah receiving tanks, where it is pumped to boost supply to high level tanks for filtration pumping to two large reservoirs where the reservoirs serve the city center and surrounding areas by gravity. Figure 20 shows a schematic of the pumping process and configuration at the station.

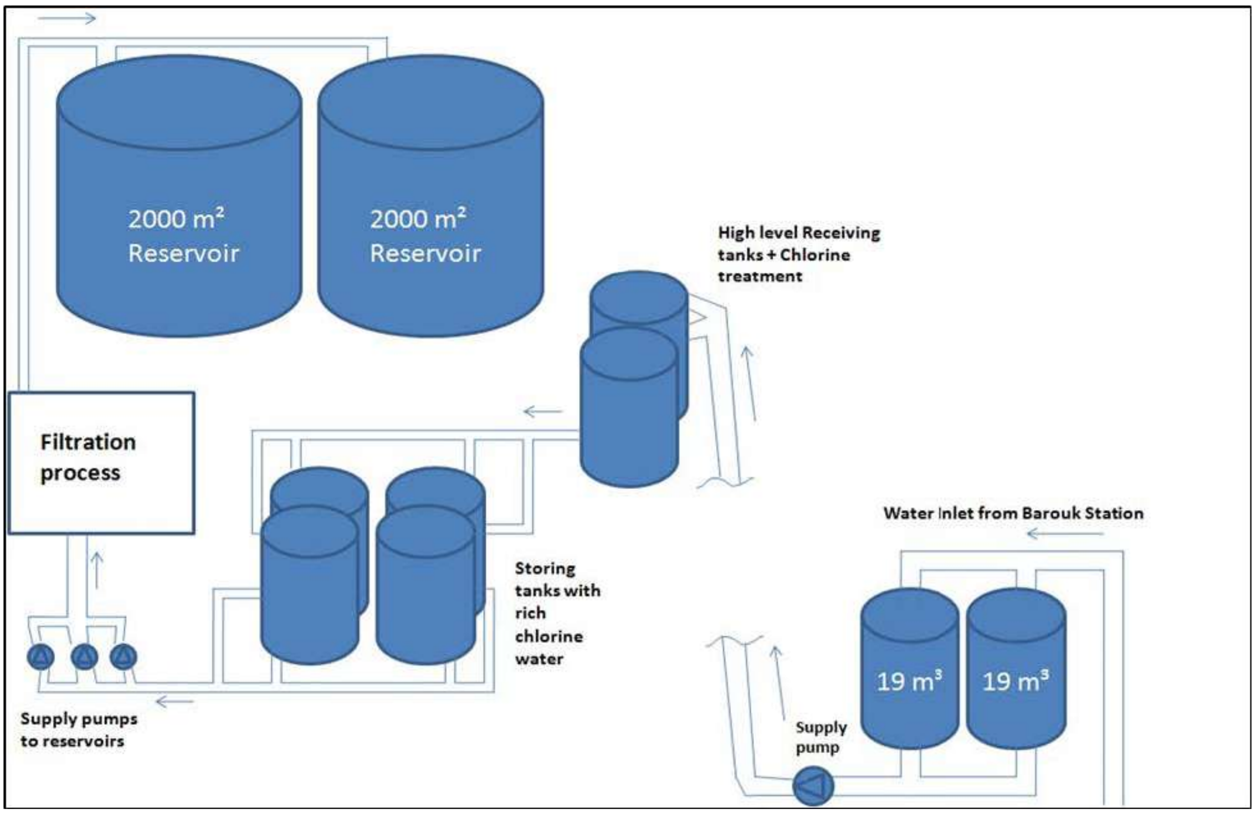


Figure 16: Pumping station schematic

The water pumping system at the Jdaidah plant consists of two reservoir tanks with a capacity of 2,000 cubic meters each, where there are 3 centrifugal pumps (one of them is stand by) operate to transfer water from the high level tanks to the reservoirs passing through filtration units.

The Jdaidah pumping station is a high energy intensity facility with high inductive motor loads. The lower supply pump was commissioned before more than 20 years, which runs 6 hours per day throughout the year because of the fact that the electricity supply from the grid is not continuous and there is no stand-by generator to cover the electricity outage period. Consequently, the remaining pumps at the high level ground operates when the tanks are full with water, which renders some delay in the pumping process between the lower and upper pumps.

It is worthwhile mentioning that the Jdaidah pumping station was noted not to have an organized system in place to adequately check measure and record the power, flow and pressure readings that are crucial for evaluating the energy performance of a pumping system.

Pumping operations

The pumping stations in Jdaidah use one submersible pump with a power of 42 kW in the lower level and three centrifugal pumps with a power of 7.5 kW each in the upper level. The lower level pump was installed before more than 20 years. Unfortunately over the years the pump manuals and pump curve charts were misplaced and as a result no nameplate information was available during the assessment of the pumps, because it is submersed underground.

During the pump efficiency test, readings of the ampere from the distribution panel were taken when the pump was running, where the electricity source voltage is 11 kV. Water flow rate was measured by measuring the difference in the water levels in the upper receiving tanks within known time period, where the suction and discharge pressures were estimated by knowing the water level in the tanks before the pump, in addition to the elevation between the lower and upper level tanks. Figures 21 to 27 illustrate NERC/RSS team through the energy assessment for water pumping station and equipment.

Figure 17**:** The submersible lower level pump

Figure 18: Ampere readings for the lower pump

Figure 19: Lower level receiving tanks

Figure 20**:** upper level receiving tanks and the two large reservoirs

Figure 21**:** upper level supply pumps to the reservoirs

Figure 22**:** Water filtration units after the supply pumps

Figure 23**:** Main electricity distribution panel for the three supply pumps

Energy index of pumping operations

After conducting site measurements for the flow rate and power of the pumps, it was found that the supplied water flow rate in the lower pump is around 70 m^3/hr and the operating time was around 174 hours per month, where the monthly energy consumption is 7325 kWh, then the monthly amount of supplied water is 12,180 m^3. Therefore, the specific energy for supplying water to the upper level tanks is 0.601 kWh/m^3. On the other hand, the measured flow rate for the upper level pumps was 69 m^3/hr, where the measured input power was 13.5 kW; thus the specific energy for the upper pumps is 0.196 kWh/m^3. Therefore, the overall specific energy for the pumping station including lower and upper pumps is 0.797 kWh/m^3.

Pump and pumping system efficiency

1) Pump efficiency

Pump efficiency is defined as the ratio of the hydraulic pump output power of the pumped liquid to the mechanical pump shaft input power and is expressed as a percentage. The equation is shown below:

$$\eta_P = \frac{P_W}{P_P} \times 100$$

$$P_W = \frac{Q \times H \times \rho}{367}$$

P_P = Measure electrical input power (kW)

$$P_D = \rho \times g \times H$$

Where;

H = Total head (m)

Q = Flow rate (m^3/h) – Flow measurements taken at discharge side of pump. ρ = Density (1000 kg/m^3)

P_D = Discharge pressure (N/m^2), P_S = Suction pressure (N/m^2) P_W = Hydraulic pump output power (kW) η_P = Pump efficiency (%),g = Gravitational acceleration (9.81 m/s^2)

2) Pump Efficiency for Pump No.1 (Lower level pump)

Flow rate Q of each pump running = 70 m^3/h

Discharge Pressure P_D = 15.9 bar = 159000 N/m^2

Suction Pressure P_S = 0.49 bar = 49,050 N/m^2

H = Pd-Ps = 15.41 bar =157 m

Measured input power P_P = 42 kW

Hydraulic power $P_W = \frac{70 \times 157}{367} = \mathbf{29.9\ kW}$

Pump efficiency $\eta_P = \frac{P_W}{P_P} = \frac{29.9}{42} = \mathbf{71.2}\%$

Pump specific energy= 42 kW/ 70 m^3/hr = 0.60 kWh/m^3

3) Pump efficiency for Pumps Numbers 2 and 3 (upper level pumps)

Flow rate Q of each pump running = 40 m^3/h

Discharge Pressure P_D = 4 bar = 600,000 N/m^2

Suction Pressure P_S = 0.49 bar = 49,050 N/m^2

H = Pd-Ps = 3.51 bar =35.8 m

Measured input power P_P = 6.75 kW

Hydraulic power P_W = $\frac{40 \times 35.8 \times 1000}{367000} = \mathbf{3.9\ kW}$

Pump efficiency $\eta_P = \frac{P_W}{P_P} = \frac{3.90}{6.75} = \mathbf{57.7}\%$

Specific energy = 6.75 kW / 40 m^3/hr = 0.168 kWh/m^3

4) Pump characteristic chart

A pump curve is a graphical representation describing the operation of a pump for a range of flows. Every pump has a point on the pump curve where its efficiency is highest; this point is known as the Best Efficiency Point (BEP). Operating a pump on or close to the BEP utilizes the least amount of energy and minimizes vibrations that can damage the pump impeller and bearings.

The pump curve for the lower pump is not available, while it is available for the upper level pumps and shown in Figure 28. From the flow rate test of the pump, the flow rate for the single pump is 40 m^3/hr and about 80 m^3/hr for the two parallel flow pumps.

From the pump curve, we see the system curve representing the pipeline intersecting at the point (A). This point is the duty point of the pump operating at upper level pumping station. A pump efficiency of 65% was attained when operating at the duty point (A). Pump efficiency tests done indicate the efficiency of the upper pumps to be 57.7%. This difference can be attributed to adjustments to field operating conditions. The duty points (A) is located at the best efficiency point (BEP) region with respect to the pump curve. Thus the performance of upper pumps is satisfactory.

On the other hand, for the lower level pump, a pump curve for new pump was given from catalogues of one of the pumps companies' (shown in Figure 30), which the water flow rate and total head were taken in consideration to be the same with needed requirements for the supply pump. It can be noted that the mechanical power of the new pump will be 36.5 kW, with hydraulic efficiency of 75 %, which the input power is 42 kW (PF for new pumps is 0.87) which is the same power of the existing submersible pump. Therefore, the existing submersible pump can be considered at a good state.

Figure 24: Nameplate for one of the upper level pumps.

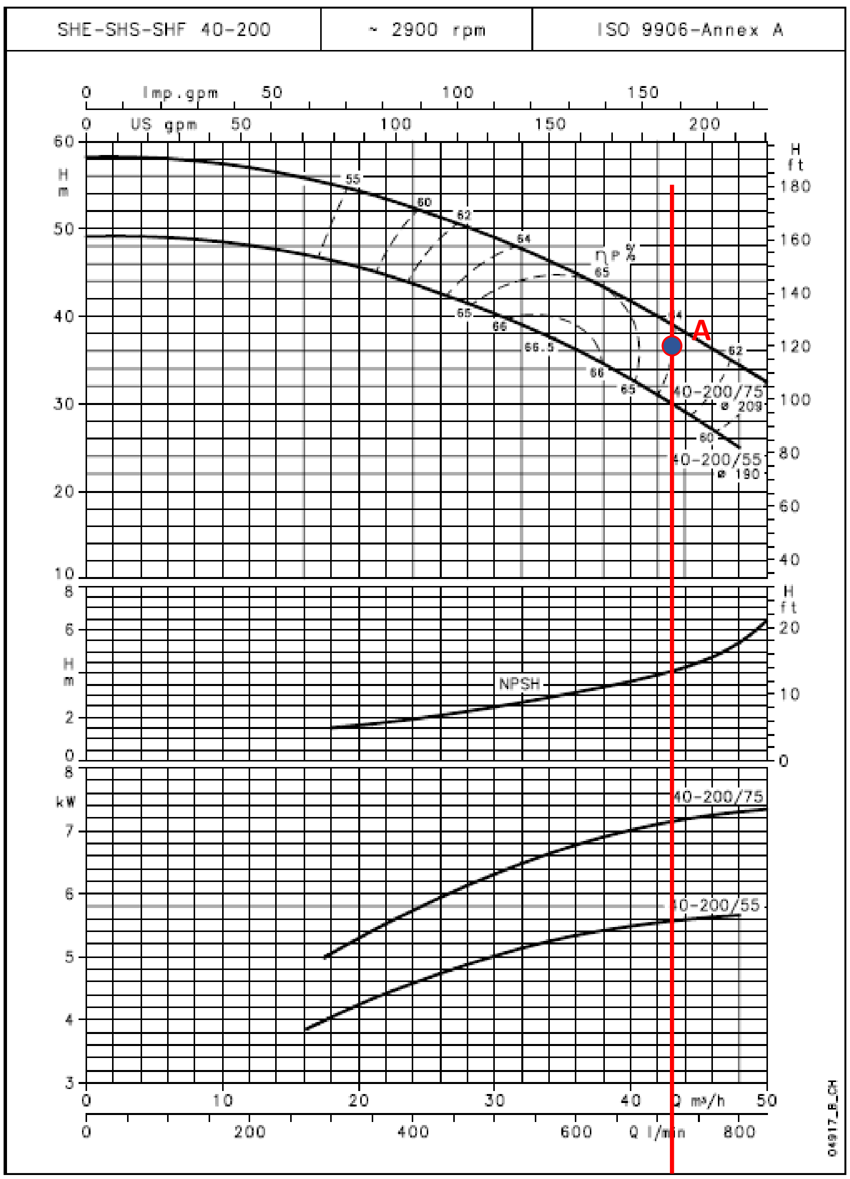


Figure 25**:** Pumping characteristic curve for the upper pumps

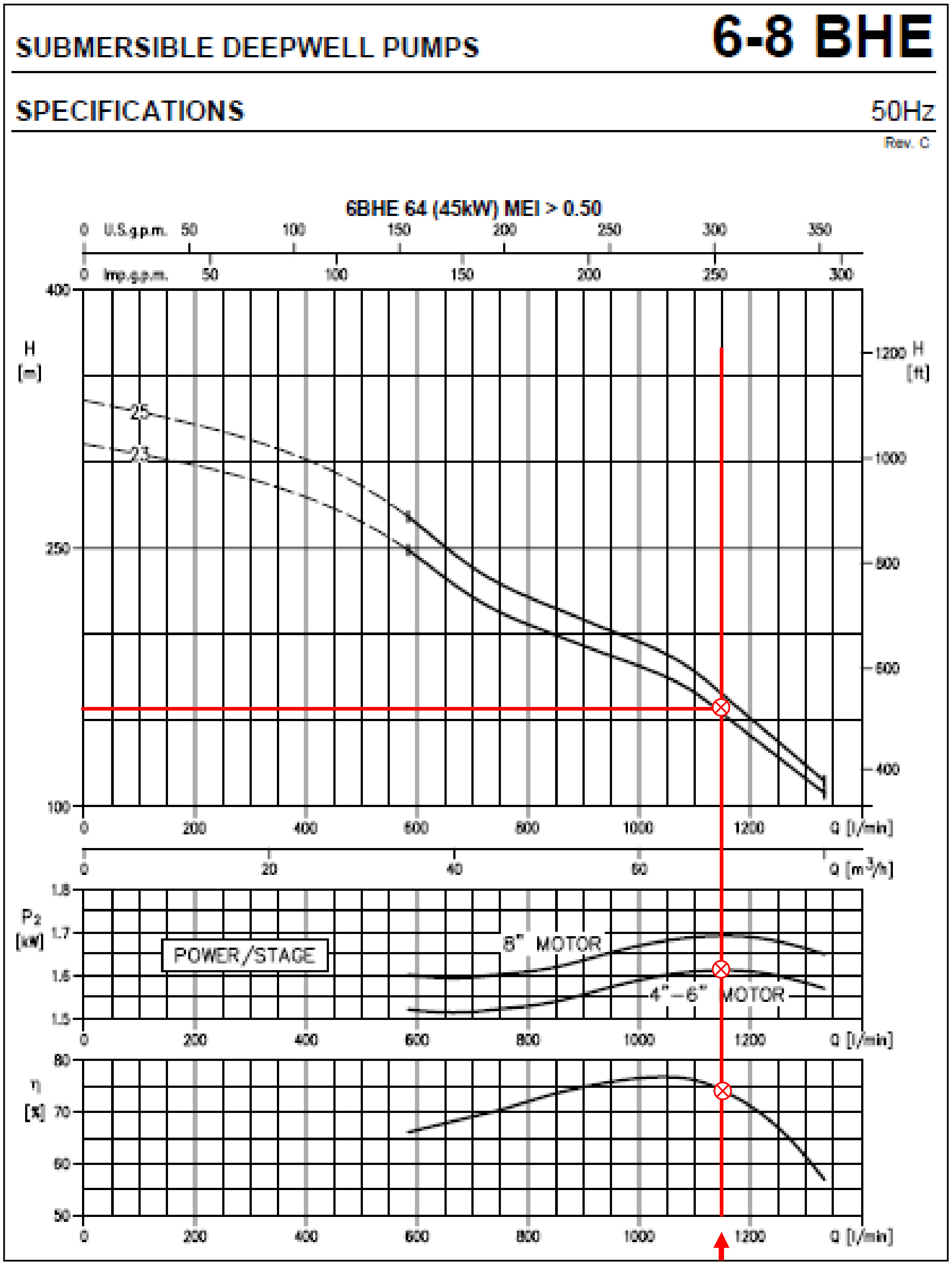


Figure 26**:** Pumping characteristic curve for the upper pumps

5) System efficiency

Pumping system efficiency is defined as the minimum hydraulic power needed to fulfill the process or operational demands divided by the input power to the pump drive system. The minimum hydraulic power corresponds to the design /duty flow rate. Flow measurements were taken at the receiving tanks where the pipeline ends.

5-1 System efficiency for the lower level pump

Estimation of pipe friction losses for the pipeline and the static head

Length of pipeline = 1400 m

Pipe diameter = 8”

Elevation between the lower and upper stations = 160 m

The friction head losses are equal around 2 m, where the static head is 160 meters , with total discharge head of 162 m, then when taking the suction head 5m , thus the total head is 157 m.

5-2 System Efficiency with lower Pump Running

Single pump flow rate Q $= 70\ m^3/hr$

Hydraulic power, $P_W = \frac{Q \times H \times \rho}{367000} = \frac{\mathbf{70 \times 157 \times 1000}}{\mathbf{367000}} = \mathbf{29.94\ kW}$

Input power P_P = 42 kW

System efficiency $\eta_S = \frac{P_W}{P_P} = \frac{\mathbf{29.94}}{\mathbf{42.0}} = \mathbf{71.2}\%$

System specific energy = 42 kW/70 m^3/hr = 0.60 kWh/m^3

5-3 System efficiency with upper pumps running

Estimation of pipe friction losses for the pipeline and the static head

Length of pipeline = 15 m

Pipe diameter = 2"

Number of elbows 90° in the single line= 12

Sand filters prusser losses = 17 m

Ultraviolet filters pressure losses = 5m

The friction head losses are equal around 26 m, where the static head is 6 meters, with total discharge head of 32 m, then when taking the suction head 5m, thus the total head is 27 m.

System Efficiency with upper Pumps Running

Parallel pump flow rate Q $= 69.37\ m^3/hr$

H = Pd-Ps = 5.1 bar =27 m

Input power P_P = 13.5 kW

Hydraulic power $P_W = \frac{69.37 \times 27 \times 1000}{367000} = 5.10\ kW$

System efficiency $\eta_P = \frac{P_W}{P_P} = \frac{5.10}{13.5} = 37.7\%$

System specific energy = 13.5 kW / 69.37 m^3/hr = 0.194 kWh/m^3

Note: System specific energy is lower than the pump specific energy and this is due to some water leakages in the network.

4.5 Waste water treatment station

General description

The waste water treatment plant (WWTP) was established in 2012 to treat the waste water of the residential sector in the Jdaedet Al-Chof Municipality. The Plant receives the wastewater from Al-Chof region and Jdedet Al-Chof Municipality provides the WWTP with about 80% of the total daily amount of received wastewater.

The WWTP has an area 2500m^2 with capacity about 1450 m^3 . The WWTP receives about 90 m^3 of waste water per hour. The treatment system has several treatment stages to treat the wastewater and produce clean water for irrigation. Figure 31 illustrates the Jdaidet Al-Chouf Waste Water Treatment Plant.

Figure 27: Waste water treatment plant

Energy sources

The energy consumption form at the plant is electrical energy. The electrical energy is provided for the WWTP from two sources; the national electricity grid and diesel generators.

The average daily consumption of electricity from the diesel generator is 9.5 kWh/ day which is 258 kWh/Month. The amount of energy consumed from the national electricity grid is unknown because there is no electricity meter at the site.

The treatment process

The treatment process consists of several mechanical and chemical treatment stages to treat the waste water which can be summarized as follows:

- **Preliminary screening**

Preliminary screening at the WWTP is accomplished through the use of one mechanically cleaned bar screen, which removes large material and debris from the wastewater flow.

- **Influent wastewater tank (anoxic tank)**

The picture below illustrates the influence flow as it enters a huge tank to prepare the wastewater for the aerobic treatment process and removal of nitrogen from the wastewater. Through this stage the organic polymeric flocculants is used in water purification processes – as it has been used for several decades as coagulant aids or floc builders. The major advantages in polyelectrolyte use generally is to expedite the process with and much greater operational stability and reliability. Figure 32 illustrate the influent wastewater tank.

Figure 28: Influent wastewater tank

- **Aerobic treatment reactor**

Effluents from the influent tank enter into the aerobic treatment reactor which is a high-purity oxygen reactor. Through the aerobic process the organic matter gets oxidized. At the upper side of the aerobic reactor, there is an aerobic mixer that has an energy of 19 KWp. Figure 33 shows the Aerobic reactor.

Figure 29 Aerobic reactor

The reactor is connected with two circulation pumps (each pump has 3 kWp) where the anaerobic/anoxic tank repeats the treatment process if the quality of the treatment process is less than the standard.

- **Solid contact clarification**

The effluent from the aerobic reactor flows into the solid contact clarifier. The original purpose of the solid contact clarifier was to remove the solid content of the wastewater by precipitation. The products from the clarification unit are sewage sludge and clear water. Figure 34 below shows the solid content classification.

Figure 30: Solid content clarification

The Clarifier connects with pass pump to pour the wastewater before the anoxic tank to repeat the treatment process if the quality of the treatment process is less than the standard.

- **Chlorine disinfection**

Cleared water discharges to the nearest river through the WWTP outfall pipe. Chlorine gas is used to provide disinfection at the WWTP and is added upstream of the Parshall flume in the effluent channel.

- **Solid tank (sewage sludge holiding tank)**

The solid sewage sludge is collected in the tank and then send to another treatment plant to get rid of it. On the other hand, the WWTP has 6 pumps and motors distributed in the WWTP parts. Through the energy assessment the power for each pump and motor was measured as in Table 8:

Table 8: *Motors in the waste water treatment plant*

Name of Pump or Motor	Power (KW)
Anoxic mixer	3
Anoxic recirculation pump (2 pumps)	3*2=6
Clirfier rotating bridge	1
Serface aerator for aerobic digester	19
Pump to load tanker	3

4.6 Solid waste separation plant

General description

The solid waste separation plant was established in 2009 with the capacity of 40 ton per day to separate the component of the municipal solid waste (plastic, metal, paper, carton, biomass...) from each other, it receives all the waste of the Federation of Municipalities and Jdedet Al-Chof represents about 80% of the total daily amount of received solid waste.

The factory consists of moderate hanger with an area of 2000 m^2 and receives the waste from the Waste fans and produces separated solid waste. The waste receives from the waste bins and empties at the entrance, then the waste put on an electrical conveyor while the laborers collect the different component of the solid waste separately and then the sepearated waste is sold to the recycling factories. The biomass is shredded and then collected to be distributed to the farmers and used as fertilizer. Figure 35 illustrate the waste separation plant.

Figure 31 :The waste separation plant

Energy sources

The solid waste separation plant uses electrical energy in order to be operated. The electrical energy is covered by two sources; national electricity company via the national electricity grid and electricity generators that use diesel fuel. The factory uses the diesel fuel to operate the diesel generator and bulldozers.

The total amount of diesel that was monthly consumed in 2016 is show in Table 9.

__Table 9:__ Annual Diesel consumption for waste separation plant.

Month	**Diesel consumed (Litre/month)**
Jan	2080
Feb	2000
Mar	2120
Apr	2095
May	2100
Jun	2200
Juli	2170
Aug	2150
Sep	2000
Oct	1980
Nov	2090
Dec	2100
Total	**25085**

Electrical system description

Electrical energy consumption analysis

The electrical power for solid waste separation plant is fed by two sources; the public grid and the diesel generator. The working staff at the solid waste separation plant did not provide the NERC team with electricity bills for the plant due to logistical issues, so the energy tariff for the factory has not been identified and the amount of the electrical energy consumed by the public grid is not available.

Lighting system

Lighting is one of the main energy consuming systems at the solid waste separation plant. There are several types of lighting systems in order to meet its lighting requirements through working time. The Table 10 illustrates the number of lamps and connected loads:

Table 10: Details about Existing Lighting Units in the Municipality Building.

Type of Lighting Units	Number of Lighting Units	Connected Load (W/unit)	Energy Consumption (kWh)
Replacing metal halide lamps (480W) with LED flood light fixture (180W)	4	480	5606
Total	4	480	5606

Equipment

The process in the factory is simple, it consists of one conveyor working on two motors that have a capacity of 1 hp; the crusher for the biomass has a capacity of 2 hp. Figures 36 illustrates the process in the factory.

Figure 32: Solid waste separation plant.

Energy saving opportunities

Energy saving opportunities on the level of equipments are negligent because the capacity of the machines is suitable for the amount of solid waste which is daily separated.

4.7 Football playground

General description

The football stadium was established in 2016. It is currently used by the local football teams and hosts some of the national teams. The stadium has only one lighting system which is an energy consumer. Figure 37 illustrates the football playground.

Figure 33: Football Playground

Lighting System

The lighting system consists of four poles, each pole contains six metal-halide lamps. The power of each lamp is 1000W**.** Figure 34 illustrates the lighting system at the football playground in Jdaidet Al-Chouf

Figure 34: The lighting system at the football playground in Jdaidet Al-Chouf.

The existing lighting system is efficient and there is no need for retrofitting.

5. Recommendations

After the assessment of the energy status of Al-Chof Municipality main facilities, this section includes the recommendations to improve the energy efficiency of the main systems within these facilities.

5.1 Municipality building

Energy Saving in lighting systems can be achieved by either switching lights off when they are not needed or utilizing efficient lighting equipment. Lighting energy savings can also lead to improvements in lighting quality. As shown in Table 11, these are some measures that can be adopted to realize energy savings in lighting system.

Table 11: *Lighting systems energy saving opportunities.*

Energy Saving Opportunity	No. of Lamps	Annual Energy Saving (kWh/yr)	Annual Cost Saving (LBP)	Required Investment (LBP)	Payback Period (Years)
Replacing halogen light 100w with LED 18w	78	3748	1,124,416	1,174,290	1
Replacing CFL 85w with LED Round Panel 24w	12	429	128,685	280,020	2
Replacing CFL 24w LED round panel 12w	4	28	8,438	45,164	5.4
Replacing spot lights 30w with LED Spot lights 6w	16	225	67,507	84,272	1.2

It is also recommended to install a solar water-heating system with a capacity of 100 Lit/day to cover the domestic hot water demand. This measure will save 710 kWh per year with cost saving of 213,000 LBP.

The investment cost of the solar system is around (602,196 LBP), with simple payback period of 2.8 years.

5.2 Street lighting

The main goal of implementing energy efficiency measures is to gain energy and cost savings. As for the street lighting systems, the utilization of more efficient lamps with lower energy consumption instead of old inefficient lamps, will lead to a significant reduction in the lighting load, which in turn leads to substantial energy savings.

Therefore, it is highly recommended to perform the following measures:

Replacing all inefficient street lighting units with LED street lighting units

LED lights have two key benefits: energy efficiency and long service life, which - at around 50,000 hours - is three to five times longer than the conventional lighting technology. From a lifecycle perspective, the majority of costs related to conventional street lighting systems are not from the investment itself, but from post-installation costs (i.e. energy, maintenance and upkeep costs). As a longer expected service life means considerable reductions in maintenance costs, LEDs' higher upfront costs can become more economic than those of typical conventional lights in roughly three years.

Taking the findings shown in measurements and findings about the street lighting , it should be noticed that both high pressure sodium lamps (250W) and LED fixtures (100W) are the majority types of the installed lighting units in the municipality streets that could achieve the minimum required average illuminance (15 lux), while other installed lighting lamps or fixtures are quite far from achieving this required average illuminance. After accomplishing many successful projects (inclusive similar LED units replacing) with best results that fulfill the road lighting standards (**CIE 140 / EN 13201**) by performing each of the illumination measurements and simulation modeling on professional lighting software - see the next title "modelling and simulation of LED street lighting", RSS /NERC team recommends that all street lighting units (except LED fixtures 100W) that had been installed in Al-Jdaideh streets should be replaced by **LED fixtures (100W)**, Figure 35 illustrates a sample of LED street lighting fixture (100W).

Figure 35 :A sample of LED street lighting fixture (100W)

Table 12 states that; by replacing the HPS lamps, more than **30,000,000 L.L.** (Equivalent to **100,488 kWh**) could be obtained annually; meanwhile it will have a short payback period of around 3 years.

Table 12: *Energy & cost saving potentials*

Energy Saving Opportunities	**No. of lamps to be replaced**	**Annual Electric Energy Saving (kWh)**	**Annual Electrical Saving (L.L)**	**Required Investment (L.L.)**	**Simple Payback Period (Years)**

Replacing high pressure sodium lamps (HPS) 250W with LED fixtures 100W	172	100,448	32,919,442	103,200,000	3.1

With rising energy prices, energy efficient street lighting is becoming a progressively more attractive proposition, which also contributes to the security of energy supply and tackling climate change.

The financial savings from efficient street lighting are based on the underlying technology and the related reduction of energy used and maintenance costs, relative to older street lighting models. The majority of costs stem from the operation of the lighting system and not from the investment itself. The total cost of a typical street lighting installation over a period of 25 years is split approximately as follows: 85% maintenance/operation (including power supply) and 15% capital cost.

Performing a periodic maintenance for the lighting control system

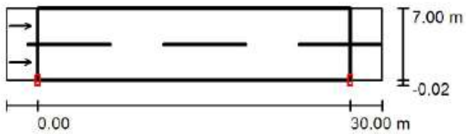
One of the NERC/RSS findings, was that some of the street lighting units were turned on during the sunlight hours, which is considered a direct indication on photocell or one of its component failures, it is highly recommended to perform periodic preventive maintenance on all control points to avoid any operational faults that could decrease lamps life-time or any energy waste.

Modelling and simulation of LED street lighting

As mentioned previously, all street lighting units should be replaced by LED street lighting fixtures (100W). As a first step RSS /NERC team used "DIALux software" to calculate and design a street lighting model in order to implement and validate that a (100W) LED fixture will produce the desired amount of illumination. Figure 36 illustrate a picture of 3D modelling using DIALux.

Figure 36: A picture of 3D modelling using DIALux

Assuming the following technical specifications and components of the street lighting system: 100W LED lamp, 13000 lumens output, 30m between poles, 9m height pole and 7m street width; Figures (37and 38) ensure that the recommended units shall fulfill the lighting requirements according to the road lighting standards (CIE 140/ EN 13201) with an average output illumination of (**21 lux**).



Maintenance factor: 0.67 Scale 1:500

Grid: 10 x 6 Points
Accompanying Street Elements: S. Roadway.
tarmac: R3, q0: 0.070, tarmac (wet): W3, q0 (wet): 0.200
Selected Lighting Class: MEW4 (All lighting performance requirements are met.)

	L_{av} [cd/m²]	U0	Ul	TI [%]	SR	U0 (wet)
Calculated values:	1.17	0.65	0.92	8	0.58	0.18
Required values according to class:	≥ 0.75	≥ 0.40	/	≤ 15	≥ 0.50	≥ 0.15
Fulfilled/Not fulfilled:	✓	✓	✓	✓	✓	✓

Assigned Observer (2 Pieces):

No.	Observer	Position [m]	L_{av} [cd/m²]	U0	Ul	TI [%]	U0 (wet)
1	Observer 1	(-60.000, 1.750, 1.500)	1.17	0.66	0.95	8	0.20
2	Observer 2	(-60.000, 5.250, 1.500)	1.27	0.65	0.92	8	0.18

Figure 37: Screenshot of results overview from DIALux output sheets

6.417	22	20	18	15	14	14	15	18	20	22
5.250	26	23	19	16	14	14	16	19	23	26
4.083	31	26	20	16	14	14	16	20	26	31
2.917	34	28	21	16	13	13	16	21	28	34
1.750	35	28	21	15	12	12	15	21	28	35
0.583	34	27	18	12	9.93	9.93	12	18	27	34
m	**1.500**	**4.500**	**7.500**	**10.500**	**13.500**	**16.500**	**19.500**	**22.500**	**25.500**	**28.500**

Attention: The coordinates refer to the image above. Values in Lux.

Grid: 10 x 6 Points

E_{av} [lx]	E_{min} [lx]	E_{max} [lx]	u0	E_{min} / E_{max}
21	9.93	35	0.481	0.280

Figure 38: Screenshot of a lux table showing (10x6) grid and the lux in each point

5.3 Water pumping station

Introduction

In this section, energy costs saving opportunities are analyzed. These opportunities are found in the following areas:

(i) Water leakages from the pipeline.
(ii) Relative sources of electricity for the pumping stations.

Water leakages from the pipeline

After site investigations for the upper pumping station, it was noted that there are water leakages due to some cracks in the network (after the third pump and in one of the sand filters). Once pumping takes place, the water exits from the cracks with high flow rate. This was observed and noted as loss of water resources, but water loss has energy implications, which is lost due to leaks. Flow tests revealed that 10.63 meter cubes of water were lost per hour in the upper pumping station.

If the water leakages were fixed and stopped:

Total water saving per day $= 10.63\frac{m^3}{hr} \times 6\ hours = 63.78\ m^3/day$

Total annual water saving $= 63.78\frac{m^3}{day} \times 365 = 23{,}280\ m^3$

As mentioned in the entitled section "Energy Index of Pumping Operations", the average specific energy of the pumping process is **0.777 kWh /m³**.

Potential annual energy savings $= 23{,}280\ m^3 \times 0.777\frac{kWh}{m^3} = 18{,}088\ kWh$

CO_2 Reduction due to this measure =7.15 tones/year (based on CO_2 emission factor of 0.948 ton CO_2/MWh [2]).

Investment

Cost of replacing the sand filter =2500 USD
Cost of fixing the pumps leakage= 500 USD
Total investment = 3000 USD

Relative sources of electricity for the pumping stations

Due to the daily electricity cut-off from the Grid, the lack of water supply has been progressively the case, since the electricity from the grid network is the only source of energy to run the pumping stations.The availability of water and electricity supplies at the same time in the pumping station is critical since unavailability of one of them will stop the operation of the station, which will affect the water security for the people and for the agricultural sector. Based on this, securing another source of electricity and water would solve this problem.

Other recommendations

- Due to the numerous routine maintenance requirements, it is recommended that a Computerized Maintenance Management System (CMMS) be acquired to keep track of maintenance issues. This will aid in identifying energy related breakdowns and maintenance events more accurately.
- It is recommended to install energy and water meters in the lower and upper pumping stations to monitor and indicate the amount of energy consumed per cubic meter of supplied water.
- Nomination of technical staff members at the pumping station to spearhead energy management activities. Energy issues are largely overlooked as a result of lack of awareness and proper recording of operations data.

[2] According to NEEAP 2016-2020 - Page 52

5.4 Waste water treatment station

The energy saving opportunities in the WWTP are represented in the equipment and the process; the following points show the saving opportunities in the WWTP:

1- Replace air compressor unit (3KWp) for air pumping and distribution rather than aerobic mixture; this step will increase the efficiency of the treatment process, so it will reduce the dependency on the circulation pumps and pass pump in aerobic reactor and clarifier.
2- Build a receiving tank with a volume of 500 m^3 for wastewater to receive the overload wastewater at the peak time and treat it at the low wastewater production time, which will reduce the dependency on the circulation pumps and pass pump in aerobic reactor and clirefier.

Table 13 illustrates the summary of the energy saving opportunities in Al-Chof WWTP.

Table 13*: Summary of the energy saving opportunities in Al-Chof WWTP.*

Energy Saving Opportunity	**Annual Saving (kWh/yr)**	**Saving Percentage of Energy Consumption (%)**
Replace compressor (3KWp) rather than aerobic mixture	140,160	84%
Build receiving tank with capacity 500 m^3	4,320	90%

5.5 Solid waste separation plant

Energy Saving in lighting systems can be achieved by either switching lights off when they are not needed or utilizing efficient lighting equipment. Lighting energy savings can also lead to improvements in lighting quality. As shown in Table 14, these are some measures that can be implemented to realize energy savings in the lighting system.

Table 14: *Lighting system energy saving opportunities.*

Energy Saving Opportunity	**Annual Saving (kWh/yr)**	**Saving Percentage of Energy Consumption (%)**
Replacing Metal halide 480w with FloodLight 180w	3258	0.43

6. References

[1] Wikepedia: https://en.wikipedia.org/wiki/.

[2] Historvius: https://www.historvius.com/

[3] Climate-data.org: https://en.climate-data.org/

[4] National Energy Efficiency Action Plan (NEEAP 2016-2020), Lebanon.

[5] Ministry of Energy and Water-Lebanon

www.minaretproject.com minaret.mena

National Energy Research Center / Royal Scientific Society (NERC/RSS) P.O.Box: 1945 Jubeiha, Amman 11941 Jordan Tel: +962 6 5338014/42 Fax: +962 6 5338043