MINARET

NETWORKING FOR THE FUTURE

ENERGY EFFICIENCY ASSESSMENT – JORDAN

Sweden
Sverige

FUTURE PIONEERS
Empowering Communities

IUCN

NERC
National Energy Research Center

Amman Jordan 1970
Royal Scientific Society

Table of Contents

1. Executive summary

Under the Framework of the MINARET Project, the Royal Scientific Society (RSS) / National Energy Research Center (NERC) carried out an energy efficiency assessment to assess the energy consumption at the Greater Karak Municipality. The RSS/NERC team spent huge efforts to collect all the needed data and carry out all required measurements to identify energy efficiency saving measures potentials.

Table 1 shows the results obtained from the detailed analysis on the collected data and measurements for the air-conditioning system, building envelope and lighting systems that would attain savings up to **60,986 kWh/year** from the electrical energy consumption (equivalent to **10,849.4 JOD/year**) by using energy conservation and energy efficiency measures. The required investment is around **JOD 42,250** requiring a **3.9** years payback period.

Table (1): Energy savings recommendations

Energy Saving Opportunity	No.	Annual Savings in costs (JOD)	Annual Energy Savings (KWh)	Required Investment (JOD)	Payback Period (Years)
Lighting Systems Energy Saving Opportunities					
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	417	15287	2106	3753	1.78
Replacing (T8 fluorescent linear tube 18W) with (LED tube 9W)	444	9395	1815	3108	1.71
Replacing (Circular fluorescent tube 32W) with (LED round panel 18W)	29	592	110	348	3.18
Replacing (CFL lamps 60W) with (LED round panel 18W)	21	971	138	252	1.83
Replacing (CFL lamps 27W) with (LED round panel 18W)	193	2322	434	2316	5.33
Replacing (CFL lamps 11W) with (LED Bulb 5W)	34	90	6	170	27.42
Replacing (Halogen lamps 60W) with (LED round panel 18W)	44	1017	94	528	5.63
Replacing (Halogen Spot Lamp) 14W with (LED spot 5W)	73	841	201	365	1.81
Replacing (Incandescent lamps 100W) with (LED round panel 18W)	50	1545	212	600	2.84
Replacing (Flood light MH 250W) with (LED Flood light 180W)	11	1431	132	1650	12.47
Replacing (Flood light MH 150W) with (LED Flood light 50W)	9	1534	170	360	2.11
Total		5418	35026	13450	2.48
Energy Savings Opportunities in Air-conditioning Systems					
Replacing old Acs with inverter ACs	44	5431	25959	28800	5.3

2. Introduction

2.1 About the MINRET Project

The "**MENA** Region Initiative as a model of the NEXUS Approach to Renewable Energy Technologies" (MINARET), is a project that aims 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-economic dimensions.

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 fast-growing populations that demand 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 place huge pressures on available energy, water and food resources.

2.2 Objective and scope

- Build the municipality's resilience to climate change by adopting renewable energy resources (RER) and energy efficiency (EE) applications, water management techniques and food security approaches.
- Strengthen institutional capacities of relevant government authorities involved in the project by promoting policy dialogue and implementing various capacity-building programs.
- Promote inter-municipal regional cooperation to enhance good governance and equitably dealing with needs and human rights particularly for refugee's survival in and around municipalities.
- Reinforce roles of women, youth and marginalized groups in developing and implementing the NEXUS approach.
- Develop a **MENA** dialogue platform focusing on knowledge sharing, education and lessons learned on national and regional policy levels.

2.3 The Energy Situation in Jordan

The Hashemite Kingdom of Jordan covers an area of 88,974[1] km² on the northern Arabian Peninsula. It borders with Syria, Iraq, Saudi Arabia and the West Bank (Palestine). The climate is semi-arid in summer and cool in winter. Jordan is a middle-income county shaped by its geography, history, geopolitics and scarcity in natural resources.

Like many developing countries, Jordan is under a number of constraints due to insufficient natural resources. However, realizing the importance of electric energy in socio-economic development, the government has exerted significant efforts to ensure the provision of secure and reliable supply of electricity at minimum cost to the Jordanian population and to different sectors of the economy. In order to achieve this goal, the government has adopted a strategy since 1967 which focuses on building a modern and reliable electricity system based on large central power plants, reliable high voltage networks, supplying electricity to all suburbs, villages and rural areas and inter-connections among areas.

The electricity sector in Jordan is structured as follows:

- Generation Sector: This sector generates electricity via power plants for the Transmission Grid. The sector incorporates government entities: Central Electricity Generation Company (CEGCO) and Samra Electricity Power Company (SEPCO); private sector Independent Power Producers (IPP's) that include: AES Jordan 370MW, Amman Asia 573MW, Qatrana Power Company (QEPCO), Korean South Power Company (KOSPO) 373MW, AES Levant 241MW and Mega-Scale PV plants.

- Transmission Sector: This sector includes the National Electric Power Company (NEPCO) only which is a 100% state-owned company. NEPCO is responsible for power system safe and economic operations (System Operator), transmission system construction, ownership and maintainance (Transmission Network Owner), planning, developing the power system, purchasing electricity from different sources and selling it to distribution companies, procuring the required fuel for power plant operation, importing and exporting electricity with neighboring countries and contracting new generation capacity to meet future demand.

[1] https://www.citypopulation.de/Jordan-Cities.html?admid=1276

- Distribution Sector: This sector is responsible for distributing electricity to the final consumer or end-user (households, commercial, industrial users, etc.). This includes the following companies:

    i. Jordan Electric Power Company (JEPCO) which distributes electricity in the central region of Jordan.

    ii. Irbid District Distribution Company (IDECO) which distributes electricity in the northern region of Jordan.

    iii. Electricity Distribution Company (EDCO) which distributes electricity in the southern region of Jordan.

2.4 About Karak

The Karak Governorate is located 120 km south of Amman and 1000 meters above sea level with a total area of 3,500[2] km^2. The Governorate consists of ten districts with an overall population of approximately 325,500[3]. Figure 1 shows the location of Karak in Jordan, while Figure 2 demonstrates the distribution of the 10 regions.

Figure (1): Karak Governorate

[2] City population website: https://www.citypopulation.de/Jordan-Cities.html?admid=1276
[3] City population website: https://www.citypopulation.de/Jordan-Cities.html?admid=1276

Figure (2): Karak municipalities

The Karak Greater Municipality is the largest Municipality in the Governorate. The Municipality consists of the main building located in the central area of Karak in addition to 18 facilities that are distributed around the Municipality borders. NERC'S team has conducted site assessments of all those facilities. Table 2 below shows the coordinates for each location, area of each building and the number of its employees (where available).

Table (2): Distribution of facilities under municipality responsibility

Name	Location	Area (M^2)	No. of Employees
Central municipality building	31°10′56.7″N 35°42′09.7″E	700	-
Health center building	31°11′02.9″N 35°42′29.8″E	290	-
Workshops	31°10′30.2″N 35°42′11.8″E	300	-
Al-Thanya municipality building	31°10′08.4″N 35°43′28.7″E	188	16
Zahoum municipality building	31°10′06.8″N 35°45′44.2″E	NA	-
Manshiet Abo-Hammour municipality building	31°11′30.5″N 35°44′20.9″E	450	-
Ader municipality building	31°11′57.1″N 35°45′31.3″E	400	38
Al-Shahabye Municipality building	31°10′28.7″N 35°41′12.2″E	210	14
Rakien municipality building	31°13′20.5″N 35°42′44.9″E	200	-
Al-Ghwier municipality building	31°08′26.6″N 35°45′16.1″E	140	15
Zaid Iben-Harthe municipality building	31°06′07.9″N 35°43′17.6″E	130	-
Al-Jdaydeh municipality building	31°15′11.5″N 35°48′29.0″E	400	18
Al-Adnaniya municipality building	31°07′16.5″N 35°41′48.1″E	230	17
Wadi **Karak municipality building**	31°13′20.5″N 35°42′44.9″E	200	19
Baddan and Barda municipality building	31°12′42.3″N 35°40′39.9″E	160	-
Al-Marj municipality building	31°10′48.8″N 35°42′42.9″E	120	32
Al-Hawieh municipality building	31°09′05.8″N 35°42′02.5″E	NA	-

3. RSS/NERC Energy Assessment Methodology

The energy assessment in Karak municipality in Jordan was conducted by RSS/NERC team to evaluate the current situation for several municipality facilities and to identify the possible energy saving measures by improving energy efficiency at these facilities. Also, RSS/NERC team has identified the possible renewable energy systems that can be installed for these facilities.

Several meetings have been conducted with different stakeholders and main entities at the municipality to collect needed information for evaluating energy status at the municipality.

4. Analysis and findings

4.1. Energy consumption distribution

Electricity and fuel are the most common energy sources used in public, commercial, industrial and residential constructions. All constructions/buildings under municipality administration use electricity and fuel (kerosene and LPG) sources to operate utilized end-user energy. The analysis of available electricity bills for these buildings showed that the annual electrical consumption in 2016 was **161,475 kWh** which is equivalent to **28,871 JOD;** based on the electric tariff structure of the *National Electrical Power Company (NEPCO)*[4] listed under retail (domestic) tariffs, the categories of this tariff are listed in Table 3 below. The analysis also revealed that the annual fuel consumption was **117,068.3 kWh** which is equivalent to **4,636.9 JOD.**

Table (3): Categories of electrical tariffs

Electrical Tariff	kWh/ Month	Fills/ kWh
First category	1-160	42
Second category	161-300	92
Third category	301-500	109
Fourth category	501-600	145
Fifth category	601-750	169
Sixth category	751-1000	190
Seventh category	Above 1000	256

[4] NEPCO website: http://www.nepco.com.jo/en/electricity_tariff_en.aspx

Figure 3 shows the distribution of energy consumption for municipality buildings.

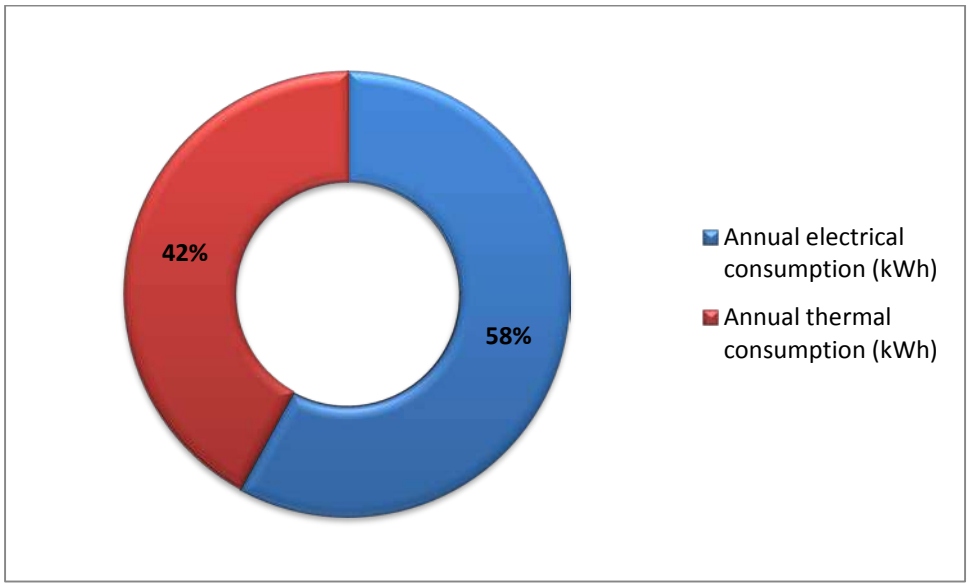


Figure (3): Thermal and electrical energy consumption distribution

4.2. Electrical Systems Description per Building

4.2.1. Central municipality building

The Central Municipality building shown in Figure 4 is the main municipal building located beside the Karak Castle and responsible of all 18 facilities. The building consists of two floors with a total utilized area of 700 m^2. The total utilization of the building based on electricity bills of 2016 is approximately **84,264 kWh,** which is equivalent to **20,170 JOD.**

Figure (4): Karak central municipal building

The main energy consumers are the lighting units, air-conditioning system and office equipment. Table 4 illustrates the type of all lighting units, their wattage, numbers and annual consumption; whereas Table 5 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 5 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (4): Details on the existing lighting system in central municipal building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	120	6.00	7680
T8 fluorescent linear tube 18W	0.025	316	7.90	10112
Circular fluorescent tube 32W	0.046	10	0.46	589
Compact fluorescent Lamp (CFL) 60W	0.060	6	0.36	461
Compact fluorescent Lamp (CFL) 27	0.027	126	3.40	4355
Halogen Spot lamp 14W	0.014	73	1.02	1308
Incandescent lamp 100W	0.100	6	0.60	768
LED Bulb 5W	0.005	6	0.03	38
LED Round Panel 12W	0.012	2	0.02	31
LED Round Panel 18W	0.018	46	0.83	1060
Total		**711**	**20.63**	**26401**

Table (5): Details on existing office equipment and Ac system in central municipal building

Electric appliances	No.	Total connected load (kW)	Total equipment consumption (kWh)
Office Equipment			
PC	64	**34.38**	**16632**
Printer	21		
Laptop	1		
Copier	9		
TV	2		
Water cooler	4		
Stand fan	26		
Fridge	1		
Water heater	2		
Exhaust fan	14		
Electric heater	2		
Air-conditioning System			
Air-condition 1 ton	1	**193.27**	**41231**
Air-condition 1.5 tons	4		
Air-condition 2 tons	24		

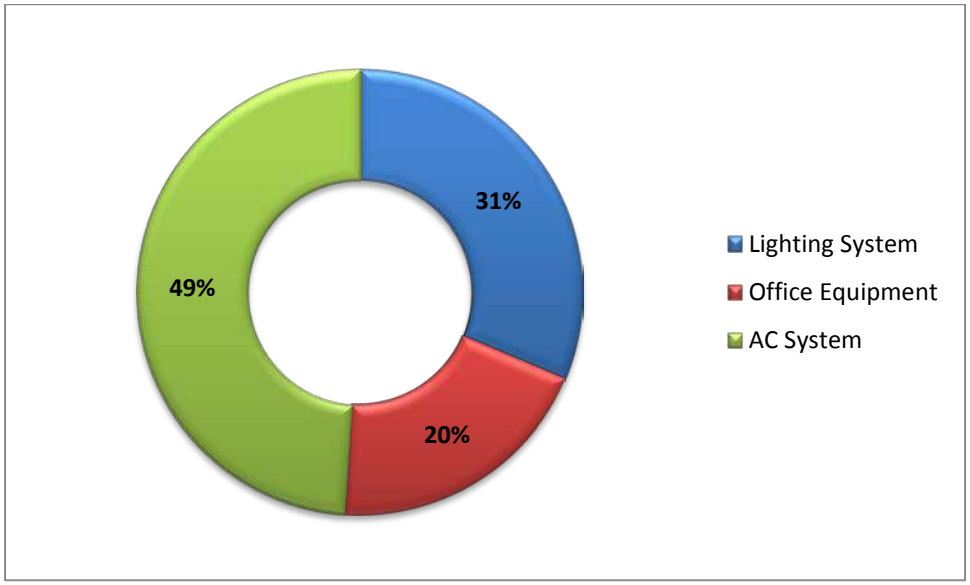


Figure (5): Energy consumption distribution of lighting system and office equipment (kWh) in the central municipality building

4.2.2. Health care center

The health center - shown in Figure 6, is divided into two buildings (old & new one) with a total utilized area of 290 m^2 for both buildings. It is located close to the Karak Castle. The total utilization of the building - based on electricity bills of 2016, is approximately **4,704 kWh** which is equivalent to **402 JOD**.

Figure (6): Health care center buildings

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 6 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 7 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 7 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (6): Details on the existing lighting system in Health care center

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	12	0.60	336
T8 fluorescent linear tube 18W	0.025	4	0.10	56
Compact fluorescent lamp (CFL) 27	0.027	4	0.11	60
LED Round Panel 18W	0.018	145	2.61	1462
Total		**165**	**3.42**	**1914**

Table (7): Details on existing office equipment and AC system in health care center

Electric appliances	No.	Total connected load (kW)	Total equipment consumption (kWh)
Office Equipment			
PC	3	**3.72**	**354**
Printer	2		
Water Cooler	2		
Stand fan	4		
Water Heater 50 ltr.	1		
Exhaust Fan	1		
Air-conditioning System			
Air-condition 1 ton	-	**22.84**	**2436**
Air-condition 1.5 ton	3		
Air-condition 2 ton	1		

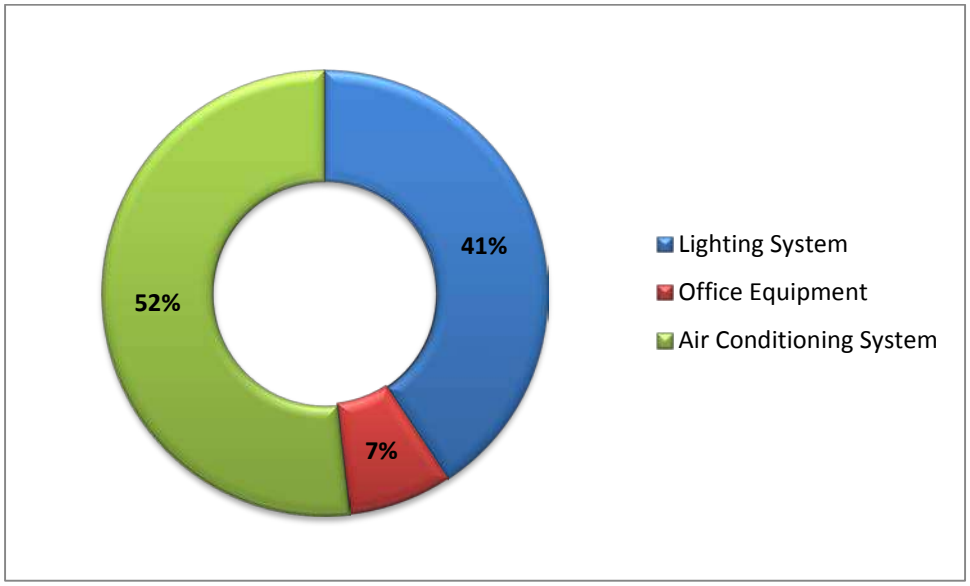


Figure (7): Energy consumption distribution of lighting system and office equipment (kWh) in health care center building

4.2.3. Workshop Buildings

Workshops (maintenance garages) shown in Figure 8 are responsible for operations and maintenance of garbage trucks, with a total utilized area of 300 m^2. The total usage of the building - based on electricity bills of 2016, is approximately **9,426 kWh** which is equivalent to **1,107 JOD**.

Figure (8): Workshops buildings

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 8 shows the types of all lighting units, their wattage, numbers and annual

consumption; whereas Table 9 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 9 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (8): Details on the existing lighting system in workshop buildings

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	7	0.35	644
Compact fluorescent Lamp (CFL) 60W	0.060	4	0.24	442
Compact fluorescent Lamp (CFL) 27	0.027	7	0.19	348
Flood light metal halide 250W	0.290	1	0.29	534
Flood Light Mercury 150W	0.190	5	0.95	1748
LED (120x30cm) 30W	0.030	4	0.12	221
LED High Bay 100W	0.100	11	1.10	2024
LED Flood Light 75W	0.075	3	0.23	414
Total		**42**	**3.46**	**6374**

Table (9): Details on existing office equipment in workshop buildings

Equipment	No.	Total connected load (kW)	Total equipment consumption (kWh)
PC	1	**5.83**	**3052**
Printer	1		
TV	1		
Water Cooler	2		
Stand fan	3		
Server	1		
Water Heater 50 ltr.	1		
Water Pump	1		
Exhaust Fan	2		
Electric heater	1		

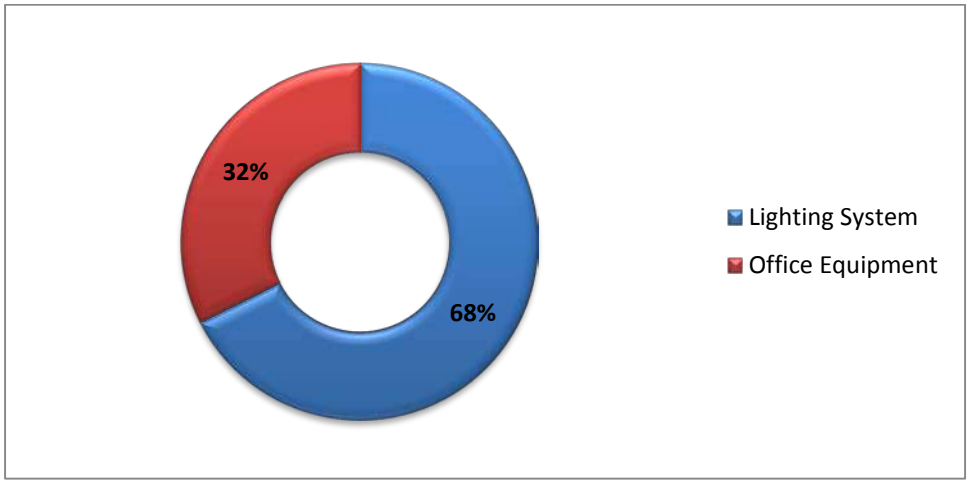


Figure (9): Energy consumption distribution of lighting system and office equipment (kWh) in workshop buildings

4.2.4. Al-Thanya administrative building

Al-Thanya administrative building, shown in Figure 10, is affiliated with the Central Municipality. The building consists of one floor with an area of 188 m^2. The total energy consumption of the building, based on the electricity bills of 2016, is approximately **5,292 kWh** which is equivalent to **463.3 JOD**.

Figure (10): Al-Thanya administrative building

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 10 shows the types of all lighting units, their wattage, numbers and

annual consumption; whereas Table 11 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 11 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (10): Details on the existing lighting system in Al-Thanya administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	16	0.80	1472
Compact florescent Lamp (CFL) 27	0.027	4	0.11	199
Halogen lamp 60W	0.060	1	0.06	110
Total		**21**	**0.97**	**1781**

Table (11): Details on existing office equipment and the AC system in Al-Thanya administrative building

Electric appliances	No.	Total connected load (kW)	Total equipment cons. (kWh)
Office Equipment			
PC	6	**4.24**	**925**
Printer	3		
Copier	2		
Water Cooler	1		
Stand fan	4		
Fridge	1		
Air-conditioning System			
Air-condition 1 ton	-	**5.27**	**2586**
Air-condition 1.5 ton	1		
Air-condition 2 ton	-		

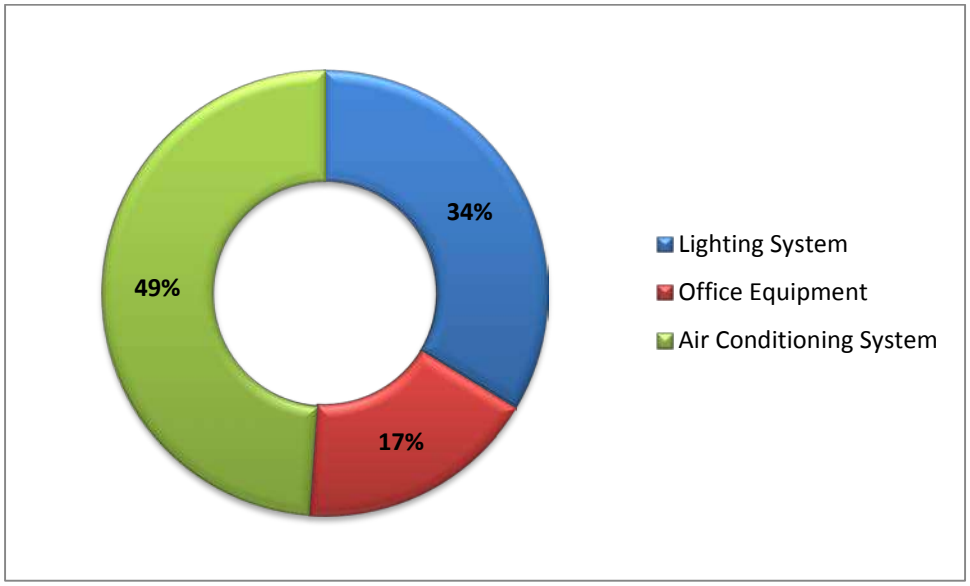


Figure (11): Energy consumption distribution of the lighting system and office equipment (kWh) in Al-Thanya administrative building

4.2.5. Zahoum administrative building

Zahoum administrative building - Figure 12, is also affiliated with the Central Municipality. The building consists of one floor with annual energy consumption **708 kWh** equivalents to **68.5 JOD** in 2016.

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 12 shows the types of all lighting units, their wattage, numbers and annual consumptions; whereas Table 13 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 13 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Figure (12): Zahoum administrative building

Table (12): Details on the existing lighting system in the Zahoum administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	1	0.05	30
Circular fluorescent tube 32W	0.046	13	0.60	359
Compact fluorescent Lamp (CFL) 27	0.027	5	0.14	81
Total		**19**	**0.78**	**470**

Table (13): Details on the existing office equipment in the Zahoum administrative building

Equipment	No.	Total connected load (kW)	Total equipment cons. (kWh)
PC	1	**1.89**	**238**
Printer	1		
Copier	1		
Water Cooler	1		
Stand fan	4		

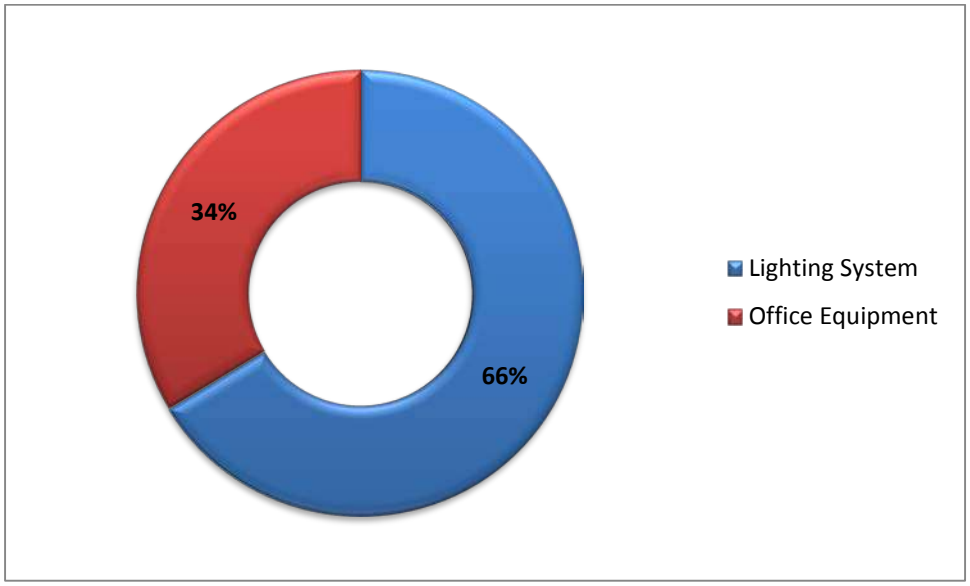


Figure (13): Energy consumption distribution of the lighting system and office equipment (kWh) in the Zahoum administrative building

4.2.6. Manshiet Abo-Hammour administrative building

Manshiet Abo-Hammour is located in the north of the Karak Governorate with a total area[5]of 2 km^2 and overall population of 10,000[6] approximately. Manshiet Abo-Hammour administrative building, shown in Figure 14, consists of two floors; hall and offices with a total utilized area of 450 m^2. The total utilization of the building, based on the electricity bills of 2016 is approximately **7,464 kWh** which is equivalent to **765 JOD**.

[5] http://www.karak.gov.jo/Default.aspx?Lng=1&P=D&T=1&S=1&Q=6&ID=51
[6] http://www.karak.gov.jo/Default.aspx?Lng=1&P=D&T=1&S=1&Q=6&ID=51

Figure (14): Manshiet Abo-Hammour administrative building

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 14 shows the types of all lighting units, their wattages, numbers and annual energy consumptions; whereas Table 15 shows office equipment types, numbers and total annual energy consumptions (kWh). Figure 15 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (14): Details on the existing lighting system in Manshiet Abo-Hammour administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	19	0.95	1026
Compact fluorescent lamp (CFL) 27	0.027	6	0.16	175
Halogen lamp 60W	0.060	6	0.36	389
LED round panel 12W	0.012	72	0.86	933
Total		**103**	**2.34**	**2523**

Table (15): Details on existing office equipment and the AC system in Manshiet Abo-Hammour administrative building

Electric appliances	No.	Total connected load (kW)	Total equipment consumption (kWh)
Office Equipment			
PC	13	**4.39**	**893**
Printer	4		
Scanner	1		
Water Cooler	1		
Stand fan	6		
Air-conditioning System			
Air-condition 1 ton	-	**31.63**	**4048**
Air-condition 1.5 ton	6		
Air-condition 2 ton	-		

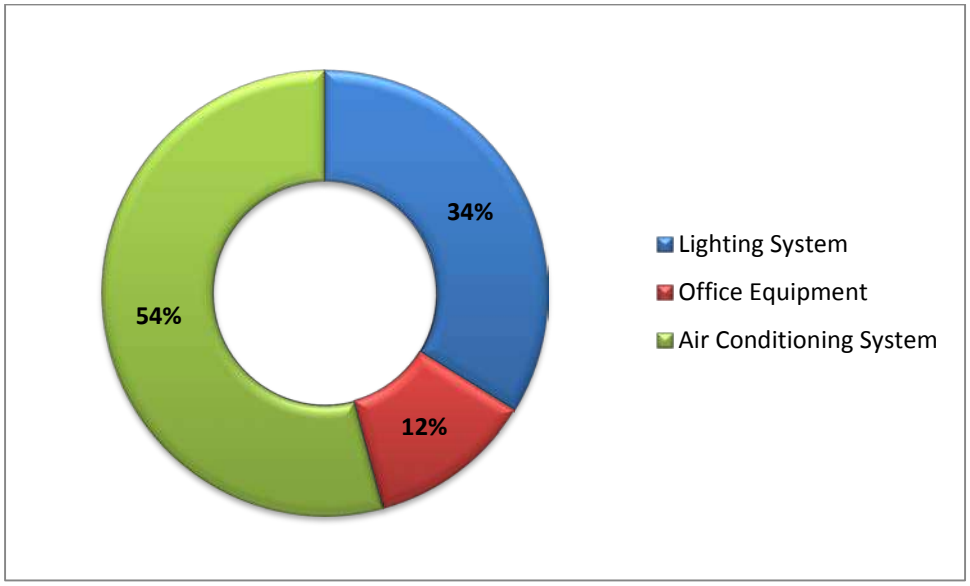


Figure (15): Energy consumption distribution of the lighting system and office equipment (kWh) in Manshiet Abo-Hammour administrative building

4.2.7. Ader administrative building

Ader is located in the northeast of Karak Governorate. The Ader municipality building was built in 1968 with a total area of 800 m^2, consists of two floors and nine offices. The total utilization of the building, based on the electricity bills of 2016, is approximately **5,076 kWh** which is equivalent to **443 JOD**.

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 16 shows the types of all lighting units, their wattage, numbers and annual consumptions; whereas Table 17 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 16 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (16): Details on the existing lighting system in Ader administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	91	4.55	2503
Halogen lamp 60W	0.060	33	1.98	1089
Flood light metal halide 250W	0.290	3	0.87	479
Total		**127**	**7.40**	**4070**

Table (17): Details on existing office equipment in Ader administrative building

Equipment	No.	Total connected load (kW)	Annual consumption (kWh)
PC	4	**2.46**	**1006**
Printer	2		
Laptop	1		
Water Cooler	1		
Stand fan	9		
Fridge	1		

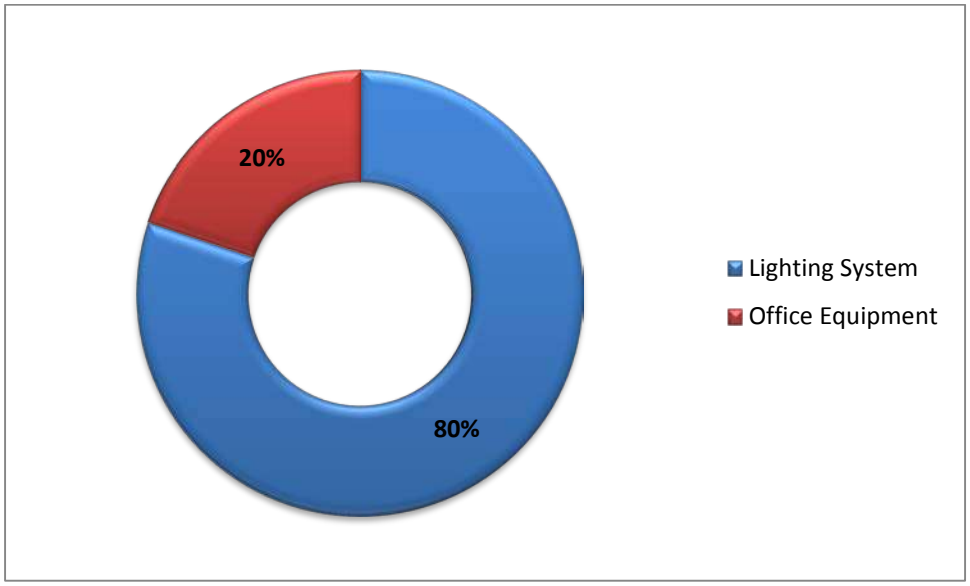


Figure (16): Energy consumption patterns of the lighting system and office equipment (kWh) in Ader administrative building

4.2.8. Al-Shahabye administrative building

Al-Shahabye is located in the west of Karak, it has a population of 6,000 approximately and an area of 6 Km^2. Al-Shahabye administrative building - Figure 17, consists of one floor divided into seven offices with a 210 m^2 total area. The total utilization of the building, based on the electricity bills of 2016, is approximately **2,568 kWh** which is equivalent to **181 JOD**.

Figure (17): Al-Shahabye administrative building

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 18 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 19 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 18 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (18): Details on the existing lighting system in Al-Shahabye administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	14	0.70	1120
Compact fluorescent lamp (CFL) 60W	0.060	4	0.24	384
Compact fluorescent lamp (CFL) 27	0.027	7	0.19	302
Total		**25**	**1.13**	**1806**

Table (19): Details on the existing office equipment in Al-Shahabye administrative building

Equipment	No.	Total connected load (kW)	Annual consumption (kWh)
PC	3	**1.71**	**762**
Printer	1		
Water Cooler	1		
Stand fan	6		

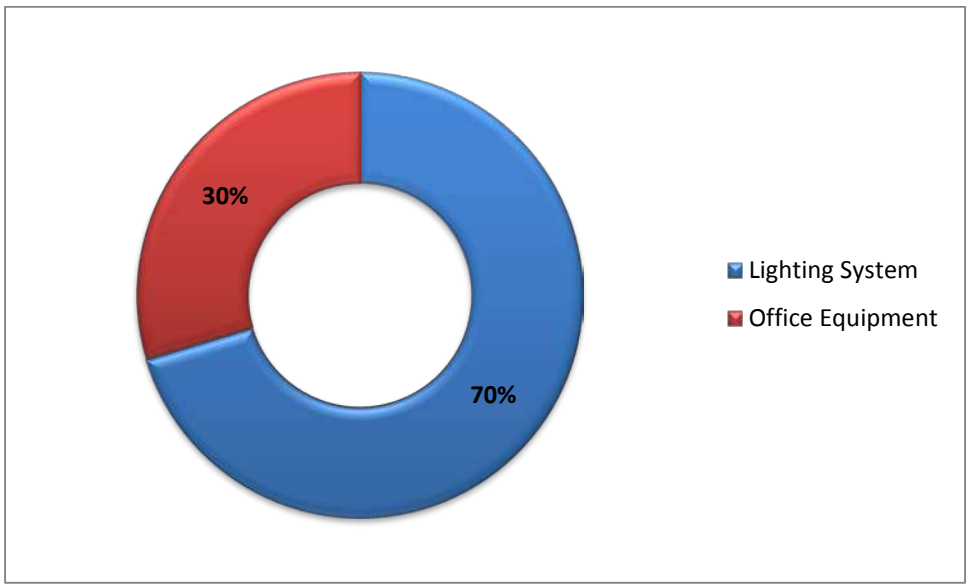


Figure (18): Energy consumption patterns of the lighting system and office equipment (kWh) in Al-Shahabye administrative building

4.2.9. Rakien administrative building

Rakien is one of the regions that are located at the Karak municipality borders, 15 km away from the center of the Karak Governorate and 1050[7] meters above sea level. Rakien administrative building - Figure 19, consists of one floor with a total of 200 m^2 utilized area.

Figure (19): Rakien administrative building

The total utilization of the building, based on the electricity bills of 2016, is approximately **1,572 kWh** which is equivalent to **110 JOD**.

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 20 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 21 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 20 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (20): Details on the existing lighting system in Rakien administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	16	0.80	576

[7] http://www.karak.gov.jo/Default.aspx?Lng=1&P=D&T=1&S=1&Q=6&ID=53

Circular fluorescent tube 32W	0.046	6	0.28	199
Halogen lamp 60W	0.060	3	0.18	130
Total		**25**	**1.26**	**904**

Table (21): Details on existing office equipment in Rakien administrative building

Equipment	No.	Total connected load (kW)	Annual consumption (kWh)
PC	4	**5.59**	**668**
Printer	3		
Copier	1		
TV	1		
Stand fan	5		
Server	1		
Fridge	1		
Water Heater 30 ltr.	2		

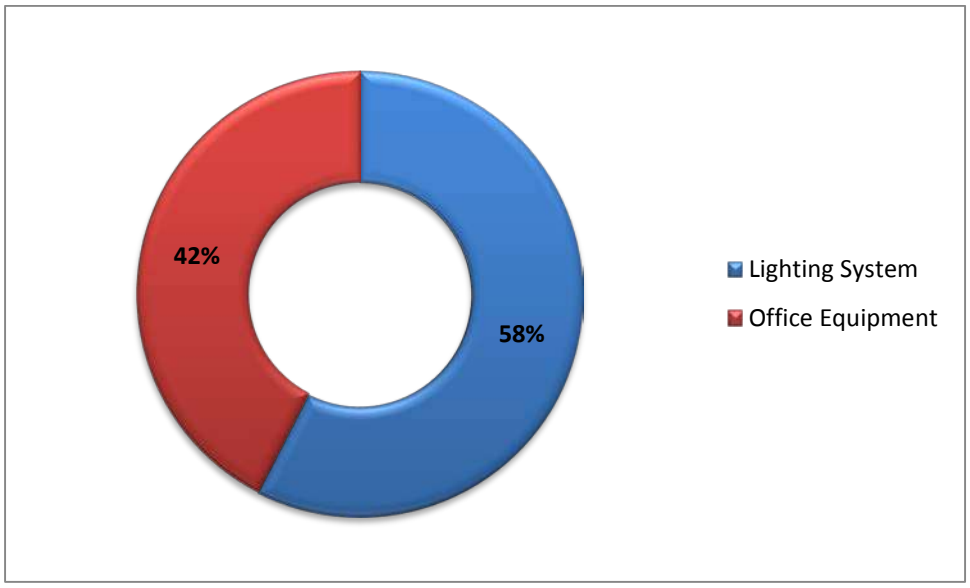


Figure (20): Energy consumption pattern of lighting system and office equipment (kWh) in Rakien administrative building

4.2.10. Al-Ghwier administrative building

Al-Ghwier is located at the east of Karak governorate; it has an administrative building at the center of Al-Ghwier region with 140 m^2 total utilized area divided to four offices. The total utilization of the building based on the electricity bills of 2016 is approximately **1,056 kWh** which is equivalent to **84 JOD**.

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 22 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 23 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 21 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (22): Details on the existing lighting system in Al-Ghwier administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	13	0.65	416
Compact fluorescent Lamp (CFL) 27	0.027	3	0.08	52
Flood Light Mercury 150W	0.190	2	0.38	243
Total		**18**	**1.11**	**711**

Table (23): Details on existing office equipment in Al-Ghwier municipality administrative building

Equipment	No.	Total connected load (kW)	Annual consumption (kWh)
PC	3	**3.51**	**345**
Printer	3		
TV	1		
Water Cooler	1		
Stand fan	7		
Water Heater 50 ltr.	1		

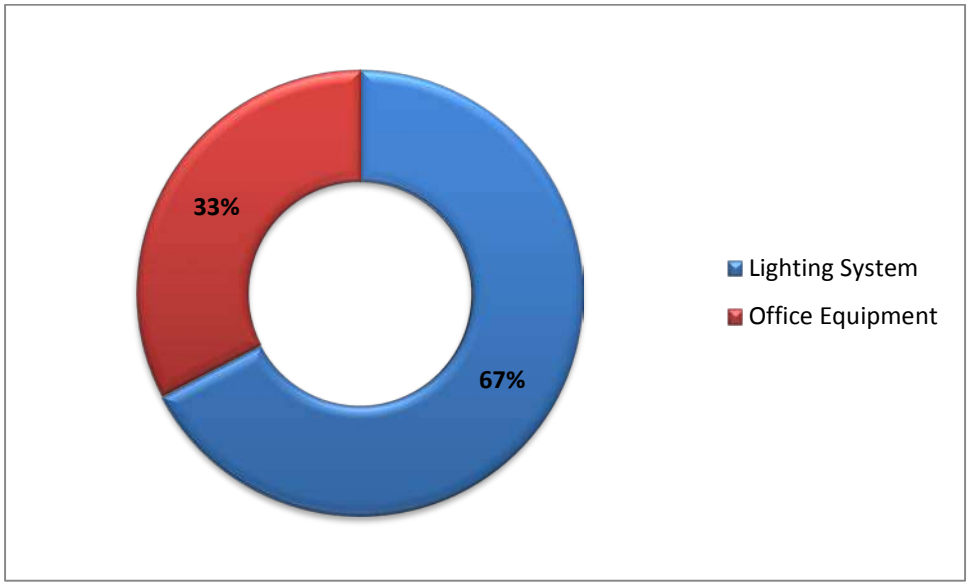


Figure (21): Energy consumption distribution of lighting systems and office equipment (kWh) in Al-Ghwier administrative building

4.2.11. Zaid Iben-Harthe administrative building

Zaid Iben-Harthe region is located near Mutah University with a population of 5,000[8] approximately; Zaid Iben-Harthe administrative building - Figure 22, has a utilized area of 130 m^2. The total utilization of the building, based on electricity bills of 2016, is approximately **6,204 kWh** which is equivalent to **571 JOD**.

[8] http://www.karak.gov.jo/Default.aspx?Lng=1&P=D&T=1&S=1&Q=6&ID=50

Figure (22): Zaid Iben-Harthe administrative building

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 24 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 25 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 23 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (24): Details on the existing lighting system in Zaid Iben-Harthe administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	32	1.60	3840
Compact fluorescent lamp (CFL) 27	0.027	12	0.32	778
Total		**44**	**1.92**	**4618**

Table (25): Details on existing office equipment in Zaid Iben-Harthe administrative building

Equipment	No.	Total connected load (kW)	Annual consumption (kWh)
PC	4	**3.69**	**1586**
Printer	4		
TV	1		
Water Cooler	1		
Stand fan	5		
Water Heater 50 ltr.	1		

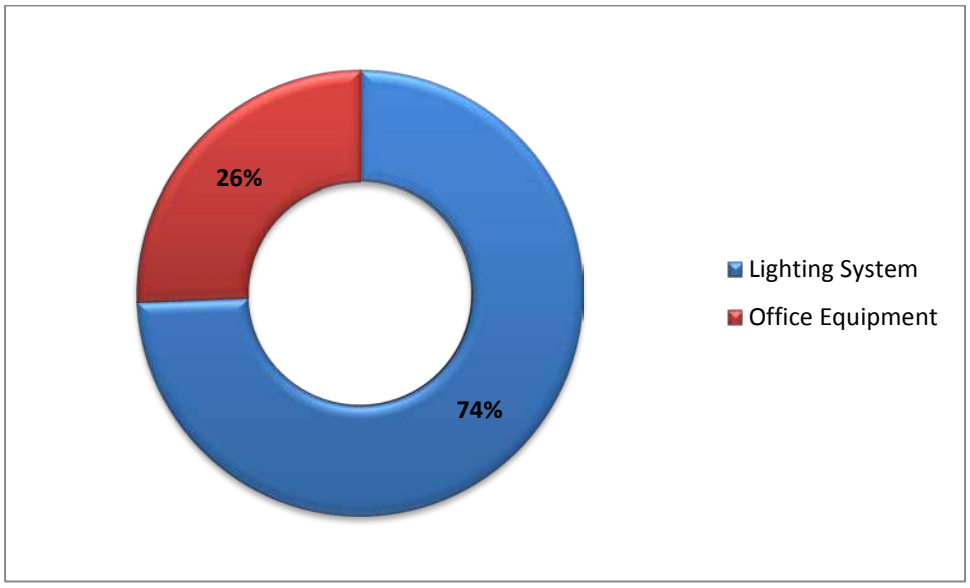


Figure (23): Energy consumption patterns of the lighting systems and office equipment (kWh) in Zaid Iben-Harthe administrative building

4.2.12. Al-Jdaydeh administrative building

Al-Jdaydeh administrative building is one of the buildings that fall under the central municipality responsibility; it consists of five offices in one single floor with an area of 400 m^2. The total utilization of the building, based on the electricity bills of 2016, is approximately **1,800 kWh** which is equivalent to **120 JOD**.

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 26 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 27 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 24 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (26): Details on the existing lighting system in Al-Jdaydeh administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	6	0.30	72
Compact fluorescent lamp (CFL) 60W	0.060	7	0.42	101
Incandescent lamp 100W	0.100	41	4.10	984
Flood Light Mercury 150W	0.190	2	0.38	91
Total		**56**	**5.20**	**1248**

Table (27): Details on existing office equipment and AC system in Al-Jdaydeh administrative building

Electric Appliance	No.	Total connected load (kW)	Total energy consumption(kWh)
Office Equipment			
PC	4	**4.48**	**271**
Printer	4		
Copier	1		
TV	1		
Stand fan	4		
Server	1		
Water Heater 50 ltr.	1		
Air-conditioning System			
Air-condition 1ton	1	**3.51**	**281**
Air-condition 1.5 ton	-		
Air-condition 2 ton	-		

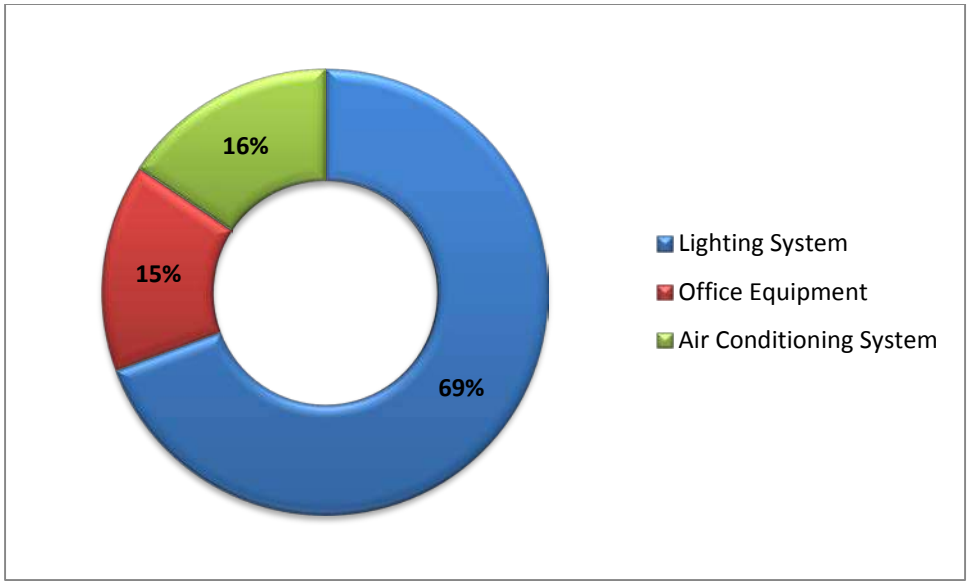


Figure (24): Energy consumption distribution of lighting systems and office equipment (kWh) in Al-Jdaydeh administrative building

4.2.13. Al-Adnaniya administrative building

Al-Adnaniya administrative building - Figure 25, consists of seven offices and 17 employees (2-3 in each office) with a total area of 230 m^2. The total utilization of the building, based on the electricity bills of 2016, is approximately **2,244 kWh** which is equivalent to **151 JOD**.

Figure (25): Al-Adnaniya administrative building

The
main energy consumers are the lighting system, air-conditioning system and office equipment. Table 28 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 29 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 26 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (28): Details on the existing lighting system in Al-Adnaniya administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	8	0.40	176
Compact fluorescent lamp (CFL) 27W	0.027	3	0.08	36
Compact fluorescent lamp (CFL) 11W	0.011	34	0.37	165
Incandescent lamp 100W	0.100	3	0.30	132
Flood light metal halide 250W	0.290	2	0.58	255
Total		**50**	**1.74**	**763**

Table (29): Details on existing office equipment and AC system in Al-Adnaniya administrative building

Electric Appliance	No.	Total connected load (kW)	Total energy consumption(kWh)
Office Equipment			
PC	3	**4.18**	**356**
Printer	2		
TV	1		
Water Cooler	1		
Stand fan	4		
Server	2		
Water Heater 30 ltr.	1		
Air-conditioning System			
Air-condition 1 ton	-	**17.57**	**1124**
Air-condition 1.5 ton	2		
Air-condition 2 ton	1		

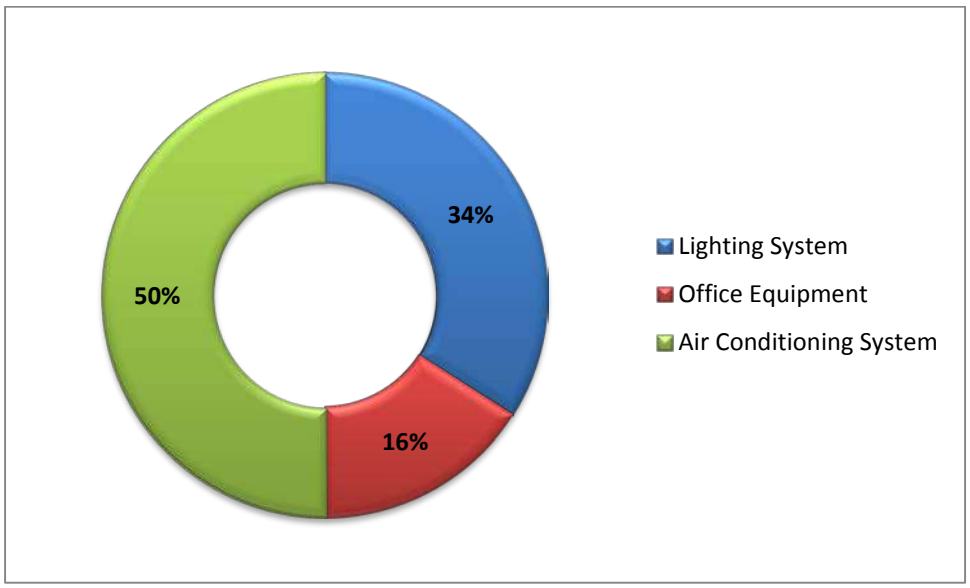


Figure (26): Energy consumption distribution of lighting systems and office equipment (kWh) in Al-Adnaniya administrative building

4.2.14. Wadi Karak administrative building

Wadi Karak administrative building - Figure 27, is one of the buildings under central municipal responsibility; it consists of four offices with an area of 200 m^2. The total utilization of the building, based on the electricity bills of 2016, is approximately **2,400 kWh** which is equivalent to **168 JOD**.

Figure (27): Wadi Karak administrative building

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 30 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 31 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 28 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (30): Details on the existing lighting system in Wadi Karak administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	20	1.00	1280
Compact fluorescent lamp (CFL) 27W	0.027	3	0.08	104
Flood light metal halide 250W	0.290	1	0.29	371
Total		**24**	**1.37**	**1755**

Table (31): Details on existing office equipment in Wadi Karak administrative building

Equipment	No.	Total connected load (kW)	Total energy consumption(kWh)
PC	2	**1.63**	**645**
Water Cooler	1		
Stand fan	3		
Fridge	2		

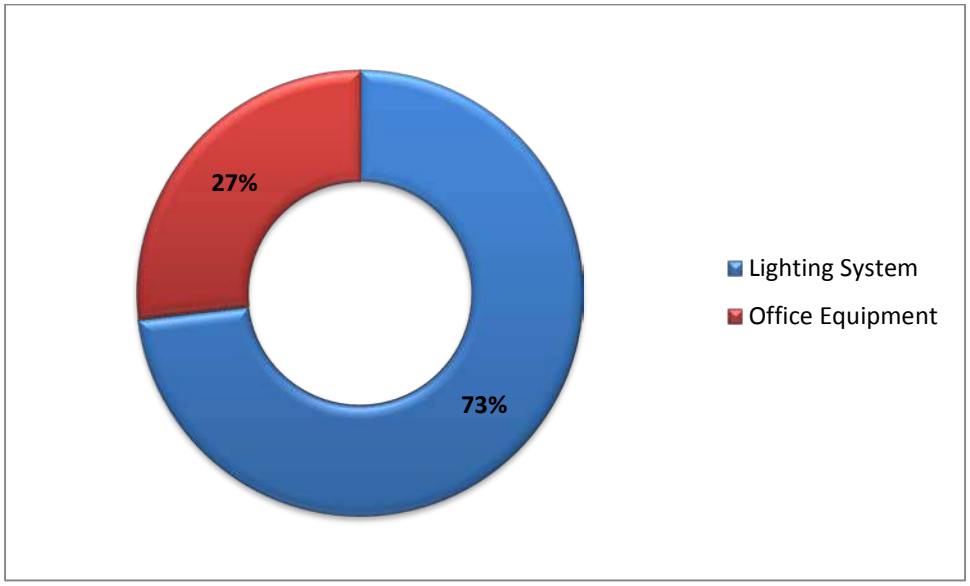


Figure (28): Energy consumption distribution of lighting systems and office equipment (kWh) in Wadi Karak administrative building

4.2.15. Baddan and Barda administrative buildings

Baddan and Barda administrative buildings - Figure (29), consists of one floor with a total area of 160 m^2. The total utilization of the building, based on the electricity bills of 2016, is approximately **1,656 kWh** which is equivalent to **110 JOD**.

Figure (29): Baddan and Barda administrative buildings

The main energy consumers are the lighting system and, air-conditioning system and office equipment. Table 32 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 33 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 30 shows electricity consumption breakdown of the lighting system and office equipment in kWh

Table (32): Details on the existing lighting system in Baddan and Barda administrative buildings

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	8	0.40	640
Flood light metal halide 250W	0.290	1	0.29	464
Total		**9**	**0.69**	**1104**

Table (33): Details on existing office equipment in Baddan and Barda administrative buildings

Equipment	No.	Total connected load (kW)	Total energy consumption(kWh)
PC	2	**0.82**	**552**
Stand fan	2		
Fridge	1		

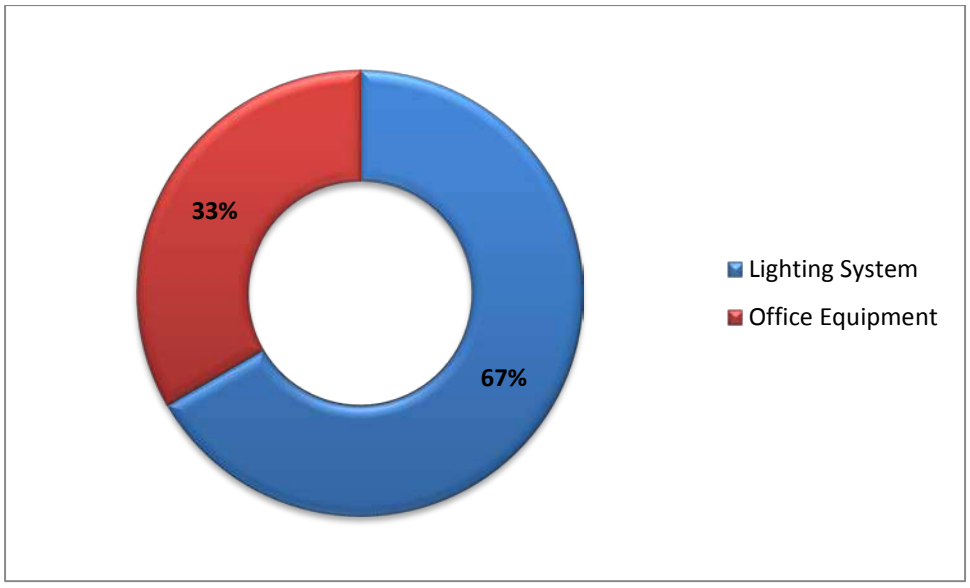


Figure (30): Energy consumption distribution of lighting systems and office equipment (kWh) in Baddan and Barda administrative buildings

4.2.16. Al-Marj administrative building

Al-Marj is located east of Karak Governorate with a population of 18,000[9]; it has an administrative building - Figure 31, at the center of Al-Marj, with a 130 m^2 total area. The total utilization of the building, based on the electricity bills of 2016, is approximately **15,890 kWh** which is equivalent to **2,910 JOD**.

Figure (31): Al-Marj administrative building

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 34 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 35 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 32 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (34): Details on the existing lighting system in Al-Marj administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	26	1.30	2496
T8 fluorescent linear tube 18W	0.025	4	0.10	192
Compact fluorescent lamp (CFL) 27W	0.027	10	0.27	518

[9] http://www.karak.gov.jo/Default.aspx?Lng=1&P=D&T=1&S=1&Q=6&ID=22

Halogen lamp 60W	0.060	1	0.06	115
Flood light metal halide 250W	0.290	3	0.87	1670
Total		**44**	**2.60**	**4992**

Table (35): Details on existing office equipment in Al-Marj administrative building

Equipment	No.	Appliance load (kW)	Total appliances load (kW)	Total connected load (kW)	Total energy consumption(kWh)
PC	4	0.25	1.00	**4.69**	**2328**
Printer	3	0.05	0.15		
TV	2	0.14	0.28		
Water Cooler	2	0.55	1.10		
Stand fan	1	0.06	0.06		
Server	1	0.60	0.60		
Water Heater 50 ltr.	1	1.50	1.50		

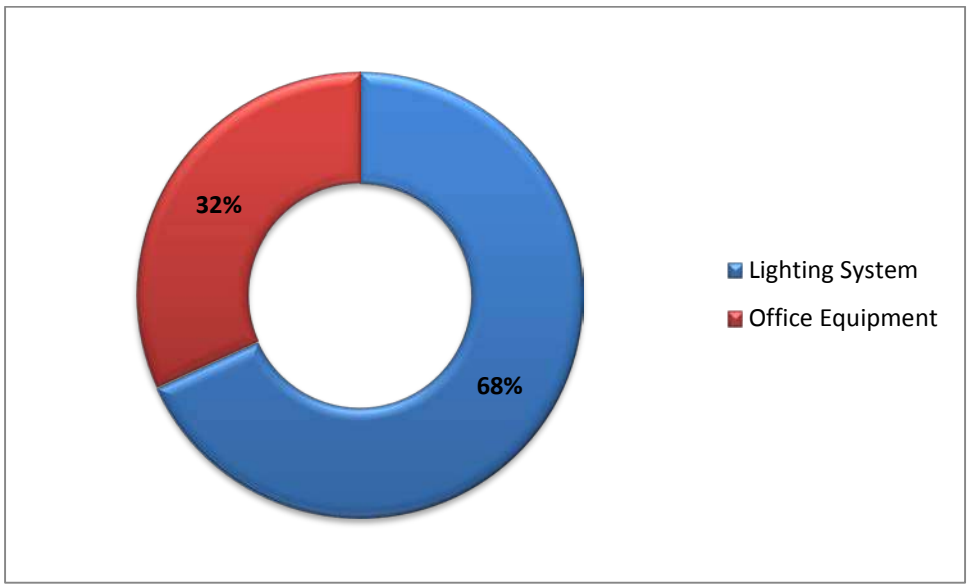


Figure (32): Energy consumption distribution of lighting systems and office equipment (kWh) in Al-Marj administrative building

4.2.17. Al-Hawieh administrative building[10]

Al-Hawieh is located in the south of Karak Governorate, with a population of 7,000[11]. It has a municipality building - Figure 33, at the center of Al-Hawieh.

[10] The electricity bills are not available

[11] http://www.karak.gov.jo/Default.aspx?Lng=1&P=D&T=1&S=1&Q=6&ID=52

Figure (33): Al-Hawieh administrative building

The main energy consumers are the lighting system, air-conditioning system and office equipment. Table 36 shows the types of all lighting units, their wattage, numbers and annual consumption; whereas Table 37 shows office equipment types, numbers and total annual energy consumption (kWh). Figure 34 shows electricity consumption breakdown of the lighting system and office equipment in kWh.

Table (36): Details on the existing lighting system in Al-Hawieh administrative building

Lighting unit type	Unit load (kW)	No. of connected lamps	Total connected load (kW)	Annual consumption (kWh)
T8 fluorescent linear tube 36W	0.050	8	0.40	576
T8 fluorescent linear tube 18W	0.025	120	3.00	4320
Compact fluorescent lamp (CFL) 27W	0.027	3	0.08	117
Total		**131**	**3.48**	**5013**

Table (37): Details on existing office equipment in Al-Hawieh administrative building

Equipment	No.	Total connected load (kW)	Total energy consumption(kWh)
PC	1	**1.96**	**960**
Stand fan	3		
Water Heater 50 ltr.	1		
Exhaust Fan	1		

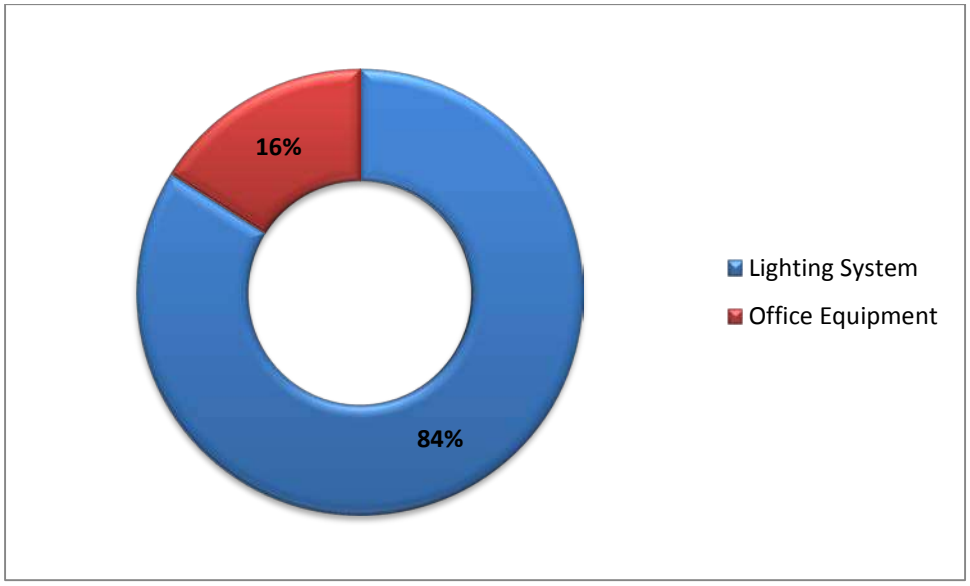


Figure (34): Energy distribution patterns of lighting systems and office equipment (kWh) in Al-Hawieh administrative building

4.3. Street lighting

4.3.1. Importance of Street Lighting

Street lighting is a key public service provided by public authorities on the local and municipal levels. Good lighting is essential for road safety and safety of pedestrians. Street lighting ensures visibility in the dark for drivers, cyclists and pedestrians, therefore, reducing road accidents. It indirectly contributes to crime prevention by increasing the sense of personal safety and security of public and private properties. Street lighting may boost the appeal of cities, towns and communities as commercial and cultural centers by highlighting attractive local landmarks or accentuating an attractive 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. For a number of municipalities which have outdated systems, street lighting can account for as much as 30-50% of their entire power consumption.

4.3.2. Municipality's Street lighting

Karak municipality has installed street lighting around its boundaries, thus reaching the desired visibility & safety of citizens. The municipality cadre has listed "upgrading street lighting" at the top of their priorities. Indeed, they look forward to improving the standards of living of municipality residents by providing them with comfort and safety.

Subsequently, the municipality's maintenance team followed suit and decided to take this matter one step further by (already) starting to replace old inefficient lighting units with more efficient and higher technology units (LED). So far, they have succeeded in installed about **1,699** units.

4.3.3. Energy Consumption

A street lighting system is as essential as other electric devices within municipal boundaries. Most of Karak Municipality energy consumption is coming from street lighting. Since the only available electricity bill was dated November 2017, a team estimated the annual energy consumption of 2017 by calculating the working hours for the street lights using the average nighttime hours for each month in 2017[12].

According to the available bill of November 2017, the energy consumption was **654,039 kWh (equivalent to 71,944 JOD)**. Based on the aforementioned methodology, the estimated energy consumption of 2017 was **7,957,482 kWh (equivalent to 875,323 JOD)**. It should be noted that the average calculated electricity tariff for street lighting facilities according to electricity bills for the same mentioned year was (**0.11 JOD/kWh**).

4.4. Building envelope and thermal systems

The building envelope relates to structural elements materials (walls, roofs, windows and foundations) within exposed system areas (e.g. insulation); it provides the thermal barrier between the indoor and outdoor environments; its elements are key determinants of the building's energy requirements to maintain a dry, heated or cooled indoor environment.

4.4.1. Main Municipality Building

After site investigations and discussions with the responsible staff at the Municipality, the municipal building envelope was found to have a single wall construction and a single glazed window which results in large amounts of heat loss due to infiltrations.

4.4.2. Air-conditioning Systems

[12] https://www.timeanddate.com/sun/south-korea/seoul?month=1&year=2017

The main building is air-conditioned by one type of split air-conditioning wall mounted units; there are 31 split units (out of which nine were very old and meriting replacements), with an average thermal capacity of 1.5 ton. It was noted that the set temperatures for heating in winter varied between 23°C and 30°C for different areas; this is not compliant with the recommended/standard of 21°C; similarly, the average set temperature for cooling in summer was around 16°C (according to the staff in charge); again, this does not comply with the recommended/standard temperature of 24°C, in summer.

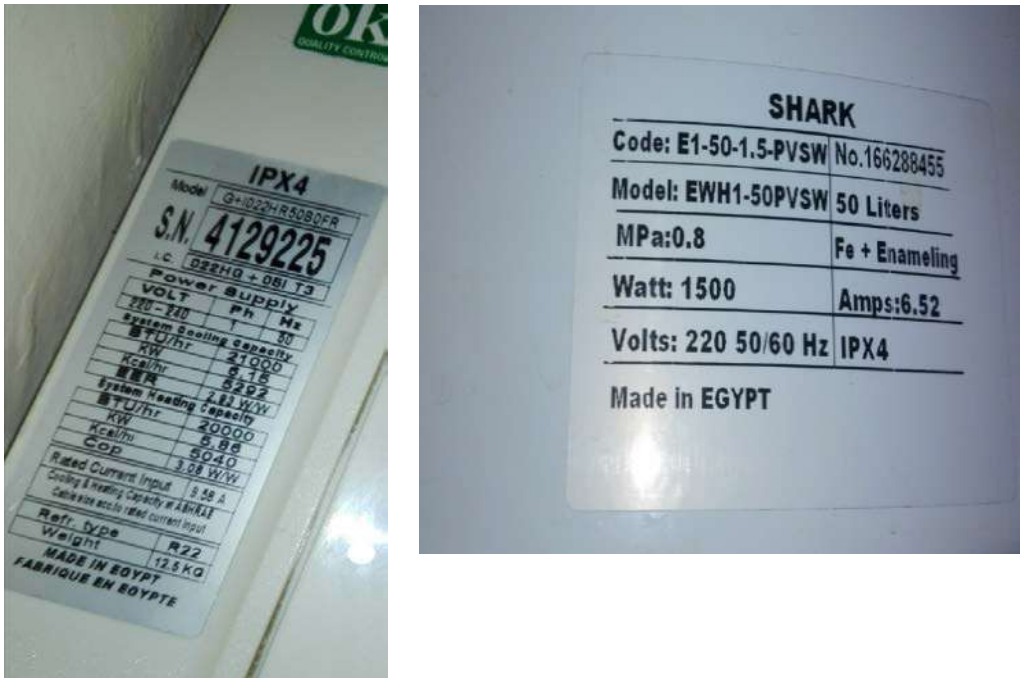


Figure (35): Electric heater and AC name plates at the Municipality building

4.4.3. Buildings under municipal administration

After site investigations and discussions with responsible staff in the Municipality buildings, the municipal building envelope was found to have a single wall construction, with a less efficient U-value of 2.76 (W/m^2 K) than a double wall construction by 43%. Furthermore, the windows in the building envelope are single glazed and not well sealed, which causes huge amounts of heat loss due to infiltration.

Municipality buildings are using spilt units as a source of heating in winter with a set temperature of 23° C.

Table 39 shows LPG & kerosene fuel consumption in Municipality buildings.

Table (38): LPG & kerosene fuels consumption in Municipality buildings

	LPG			Kerosene	
Location	**Consumption (Kg/yr)**	**KWh**	**No.**	**Consumption (ltr/yr)**	**KWh**
Central municipality Building	1781	24221.6			
Workshop buildings	416	5657.6			
Rakien administrative building	346.7	4714.7			
Baddan and Barda administrative buildings	416	5657.6			
Wadi Karak administrative building	624	8486.4	3.0	30.0	300
Al-Shahabye administrative building	416	5657.6	3.0	120.0	1,200
Al-Thanya administrative building	156	2121.6			
Zahoum administrative building	104	1414.4			
Ader administrative building	208	2828.8			
Manshiet Abo-Hammour administrative building	156	2121.6			
Al-Jdaydeh administrative building	260	3536			
Health care center	52	707.2			
	156	2121.6			
Al-Adnaniya administrative building	936	12729.6			
Zaid Iben-Harthe administrative building	1300	17680			
Al-Ghwier administrative building	520	7072			
Al-Marj administrative building	650	8840			

5. Recommendations

After assessing of the energy status of Karak municipality main facilities, recommendations were put forth to improve the energy efficiency of the main systems within those facilities.

5.1. Energy saving of the lighting system

As mentioned above, the lighting system is the main energy consumer, hence, it can be replaced by opting for more efficient technology such as the lighting emitting diode (LED) technology that has low power consumption, high reliability and a long lifespan. This renders a more energy-efficient and cost-effective technology, when compared to traditional lighting units.

5.2. Street lighting

The main goal of implementing energy efficiency measures is to save energy and achieve cost savings. As for street lighting systems, the utilization of more efficient lamps with lower energy consumption instead of old inefficient lamps, would significantly reduce the lighting load, which in turn leads to a substantial energy savings.

LED lights have two main benefits: energy efficiency and long service life, which - at around 50,000 hours - is three to five times longer than conventional lighting technology. From a lifecycle perspective, the majority of costs related to conventional street lighting stem 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.

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

- <u>Replacing all inefficient street lighting units with LED street lighting units</u>

It should be noticed that both high pressure sodium lamps (250, 125W) and LED fixtures (80W, 60W) are the best types of installed lighting units in municipality streets that can achieve the minimum required average illuminance (15 lux), unlike other installed lighting lamps or fixtures that are quite far from achieving this goal.

The NERC/RSS team recommends that all street lighting units (except LED fixtures 80W, 60W) that had been installed in Karak streets should be replaced by **LED fixtures (80W).**

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.

5.3. Central Municipality Building

Table 40 illustrates recommendations to replace each type of existing lighting unit at the central municipality building with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 37 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (39): Energy & cost saving potentials in Central Municipality Building

Energy Saving Opportunity	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual energy saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting systems energy saving opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	120	2.16	4915	1177	1080	0.92
Replacing (T8 fluorescent linear tube 18W) with (LED tube 9W)	0.009	316	2.84	6472	1549	2212	1.43
Replacing (Circular fluorescent tube 32W) with (LED round panel 18W)	0.018	10	0.18	358	86	120	1.40
Replacing (CFL lamps 60W) with (LED round panel 18W)	0.018	6	0.11	323	77	72	0.93
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	126	2.27	1452	347	1512	4.35
Replacing halogen spot lamps 14W with LED spot 5W	0.005	73	0.37	841	201	365	1.81
Replacing (Incandescent lamps 100W) with (LED round panel 18W)	0.018	6	0.11	630	151	72	0.48
Total			**8.03**	**14990**	**3588**	**5433**	**1.5**
Thermal Systems Energy Savings Opportunities							
Replacing old ACs with inverter ACs	**Unit Load (Ton)**	**No. of ACs to be replaced**	**Total Connected Load (kW)**	**Annual energy saving (kWh)**	**Annual cost saving (JOD)**	**Investment (JOD)**	**Simple payback period (yr)**
Replacing old ACs with new inverter ACs	1	1	193.3	20700	4955	19700	4
Replacing old ACs with new inverter ACs	1.5	4					
Replacing old ACs with new inverter ACs	2	24					

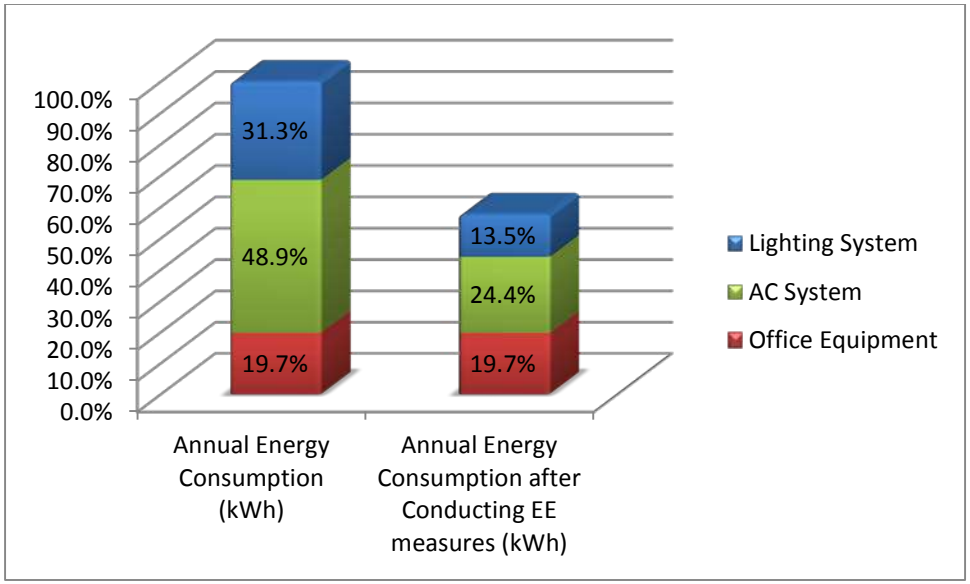


Figure (36): Annual electric energy consumption before & after retrofitting in the central municipality building

5.4. Health care center building

Table 41 illustrates the recommendations to replace each of the following types of existing lighting units, with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 38 shows the annual energy consumption of the lighting system before and after applying the recommendations.

Table (40): Energy & cost saving potentials at the health care center building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual energy saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting systems energy saving opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	12	0.22	215	18	108	5.88
Replacing (T8 fluorescent linear tube 18W) with (LED tube 9W)	0.009	4	0.04	36	3	28	9.14
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	4	0.07	20	2	48	27.86
Total			**0.32**	**271**	**23**	**184**	**7.9**
Thermal systems energy savings opportunities							
Replacing old ACs with inverter ACs	**Unit Load (Ton)**	**No. of ACs to be replaced**	**Total Connected Load (kW)**	**Annual energy saving (kWh)**	**Annual cost saving (JOD)**	**Investment (JOD)**	**Simple payback period (yr)**
Replacing old ACs with new inverter ACs	**1.5**	**3**	**22.8**	**1223**	**105**	**2500**	**23.9**
Replacing old ACs with new inverter ACs	**2**	**1**					

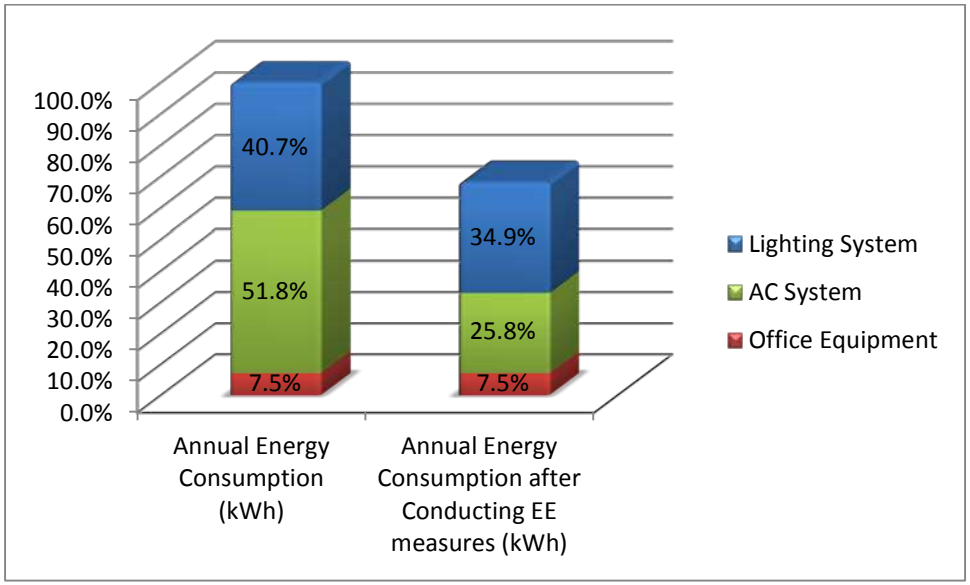


Figure (37): Annual electric energy consumption before & after conducting EE measures at the health care center building

5.5. Workshop buildings

Table 42 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy savings, annual cost savings, the required investment cost, the expected life time of the system and simple payback period for those recommendations. Figure 39 shows the annual energy consumption of the lighting system before and after applying the recommendations.

Table (41): Energy & cost saving potentials in the workshop buildings

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual energy saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting systems energy saving opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	7	0.13	412	48	63	1.30
Replacing (CFL lamps 60W) with (LED round panel 18W)	0.018	4	0.07	309	36	48	1.32
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	7	0.13	116	14	84	6.17
Replacing (Flood light MH 250W) with (LED Flood light 180W)	0.180	1	0.18	202	24	150	6.31
Replacing (Flood light Mercury 150W) with (LED Flood light 50W)	0.050	5	0.25	1288	151	200	1.32
Total			**0.75**	**2328**	**273**	**545**	**2.0**

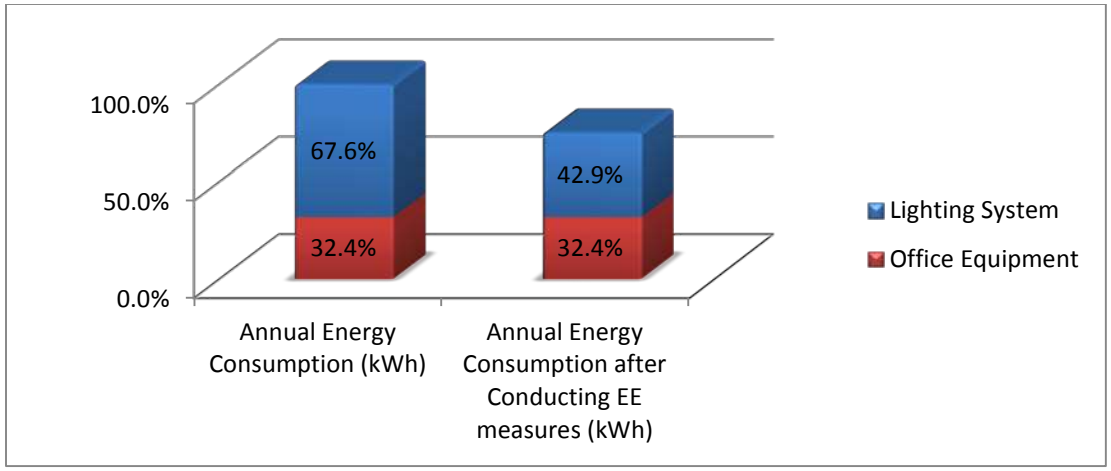


Figure (38): Annual electric energy consumption before & after conducting EE measures in the workshops buildings

5.6. Al-Thanya administrative building

Table 43 illustrates the recommendations to replace each type of the existing lighting units, with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 40 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (42): Energy & cost saving potentials in Al-Thanya administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual energy saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting systems energy saving opportunities							

Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	16	0.29	942	83	144	1.73
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	4	0.07	66	6	48	8.21
Replacing (Halogen lamps 60W) with (LED round panel 18W)	0.018	1	0.02	77	7	12	1.76
Total			**0.38**	**1086**	**96**	**204**	**2.1**
Thermal systems energy savings opportunities							
Replacing old ACs with inverter ACs	**Unit Load (Ton)**	**No. of ACs to be replaced**	**Total Connected Load (kW)**	**Annual energy saving (kWh)**	**Annual cost saving (JOD)**	**Investment (JOD)**	**Simple payback period (yr)**
Replacing old ACs with new inverter ACs	**1.5**	**1**	**5.3**	**1298**	**115**	**600**	**5.2**

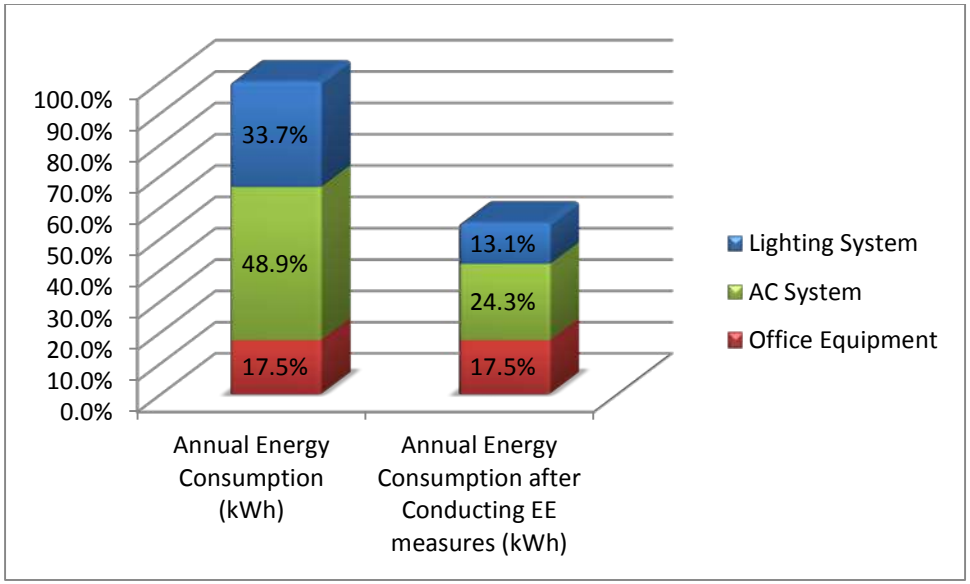


Figure (39): Annual electric energy consumption before & after retrofitting in Al-Thanya administrative building

5.7. Zahoum administrative building

Table 44 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 41 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (43): Energy & cost saving potentials in Zahoum administrative building

Replacing lighting units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							

Replacing(T8fluorescentlinearttube36W)	0.018	1	0.02	19	2	9	4.61

with(LEDtube18W)							
Replacing(Circularflu	0.016	13	0.21	234	24	156	6.56

orescentstube32W)with(LEDroundpanel18							

W)							
Replacing(CFLlamps27W)with(LEDround	0.018	5	0.09	27	3	60	21.85

panel 180 W)							
Total			**0.32**	**280**	**28**	**225**	**7.9**

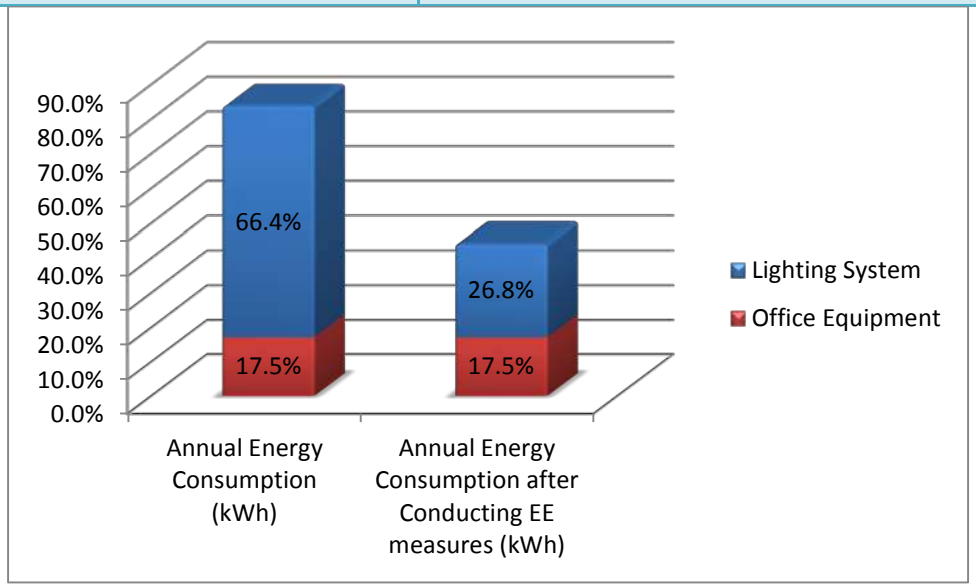


Figure (40): Annual electric energy consumption before & after retrofit in Zahoum administrative building

5.8. Manshiet Abo-Hammour administrative building

Table 45 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 42 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (44): Energy & cost saving potentials in Manshiet Abo-Hammour administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting systems energy saving opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	19	0.34	657	67	171	2.54

Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	6	0.11	58	6	72	12.05
Replacing (Halogen lamps 60W) with (LED round panel 18W)	0.018	6	0.11	272	28	72	2.58
Total			**0.56**	**987**	**101**	**315**	**3.1**
Thermal systems energy savings opportunities							
Replacing old ACs with inverter ACs	**Unit Load (Ton)**	**No. of ACs to be replaced**	**Total Connected Load (kW)**	**Annual Saving (kWh)**	**Annual cost saving (JOD)**	**Investment (JOD)**	**Simple payback period (yr)**
Replacing old ACs with inverter ACs	**1.5**	**6**	**31.4**	**2032**	**208**	**3600**	**17**

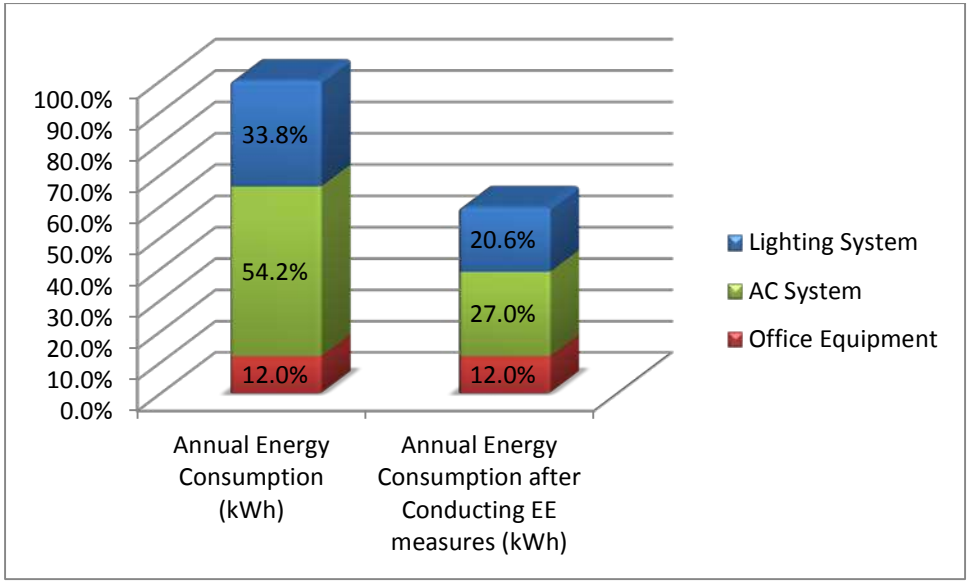


Figure (41): Annual electric energy consumption before & after retrofit in Manshiet Abo-Hammour administrative building

5.9. Ader administrative building

Table 46 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 43 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (45): Energy & cost saving potentials in Ader administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	91	1.64	1602	140	819	5.86
Replacing (Halogen lamps 60W) with (LED round panel 18W)	0.018	33	0.59	762	67	396	5.95
Replacing (Flood light MH 250W) with (LED Flood light 180W)	0.180	3	0.54	182	16	450	28.41
Total			2.77	2545	222	1665	7.5

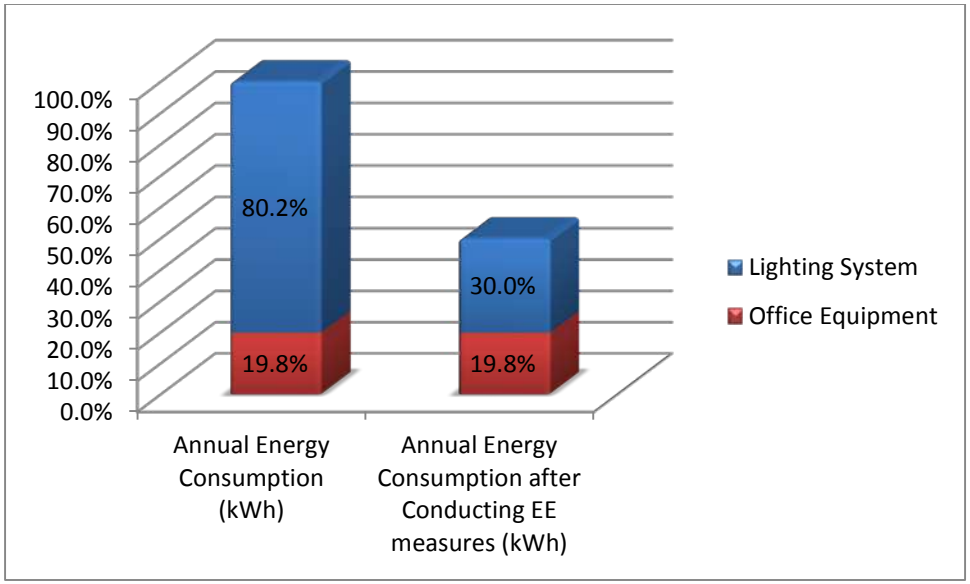


Figure (42): Annual electric energy consumption before & after retrofit in Ader administrative building

5.10. Al-Shahabye administrative building

Table 47 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 44 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (46): Energy & cost saving potentials in Al-Shahabye administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	14	0.25	717	52	126	2.44
Replacing (CFL lamps 60W) with (LED round panel 18W)	0.018	4	0.07	269	19	48	2.48
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	7	0.13	101	7	84	11.57
Total			**0.45**	**1086**	**78**	**258**	**3.3**

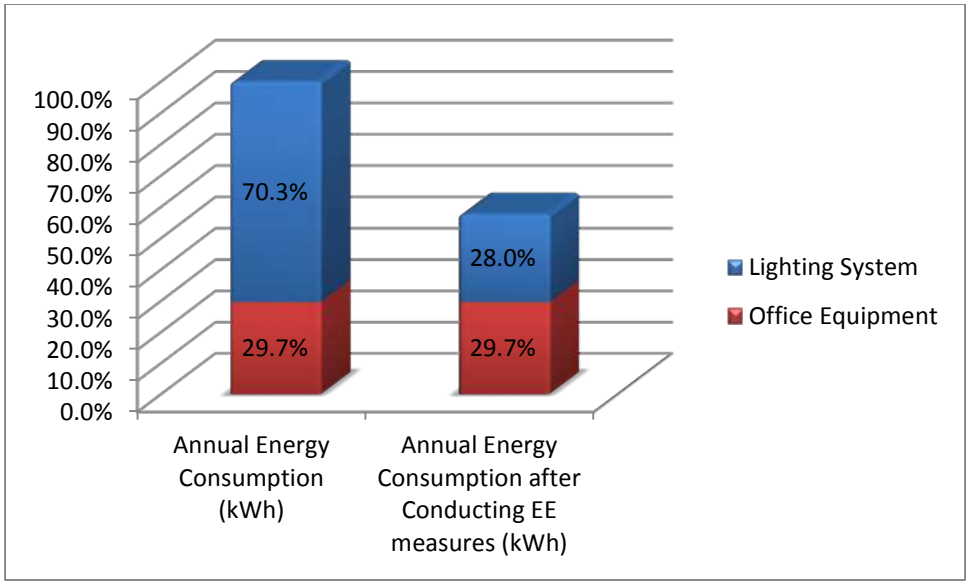


Figure (43): Annual electric energy consumption before & after conducting EE measures in Al-Shahabye administrative building

5.11. Rakien administrative building

Table 48 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 45 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (47): Energy & cost saving potentials in Rakien administrative y building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	16	0.29	369	26	144	5.58
Replacing (Circular fluorescent tube 32W) with (LED round panel 18W)	0.016	6	0.10	130	9	72	7.94
Replacing (Halogen lamps 60W) with (LED round panel 18W)	0.018	3	0.05	91	6	36	5.67
Total			**0.44**	**589**	**41**	**252**	**6.1**

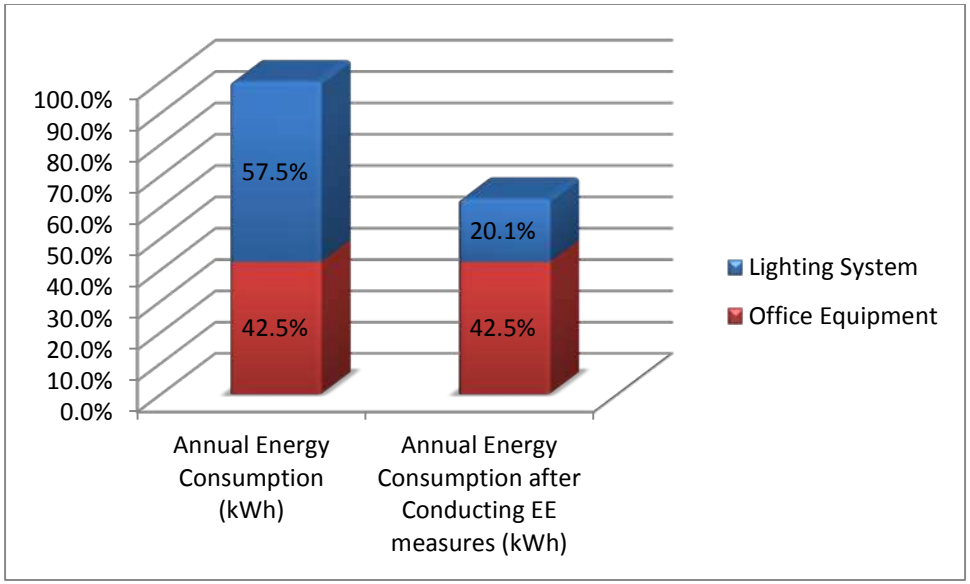


Figure (44): Annual electric energy consumption before & after conducting EE measures in Rakien administrative building

5.12. Al-Ghwier administrative building

Table 49 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 46 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (48): Energy & cost saving potentials in Al-Ghwier administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	13	0.23	266	22	117	5.33
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	3	0.05	17	1	36	25.29
Replacing (Flood light Mercury 150W) with (LED Flood light 50W)	0.050	2	0.10	179	15	80	5.42
Total			**0.39**	**463**	**38**	**233**	**6.1**

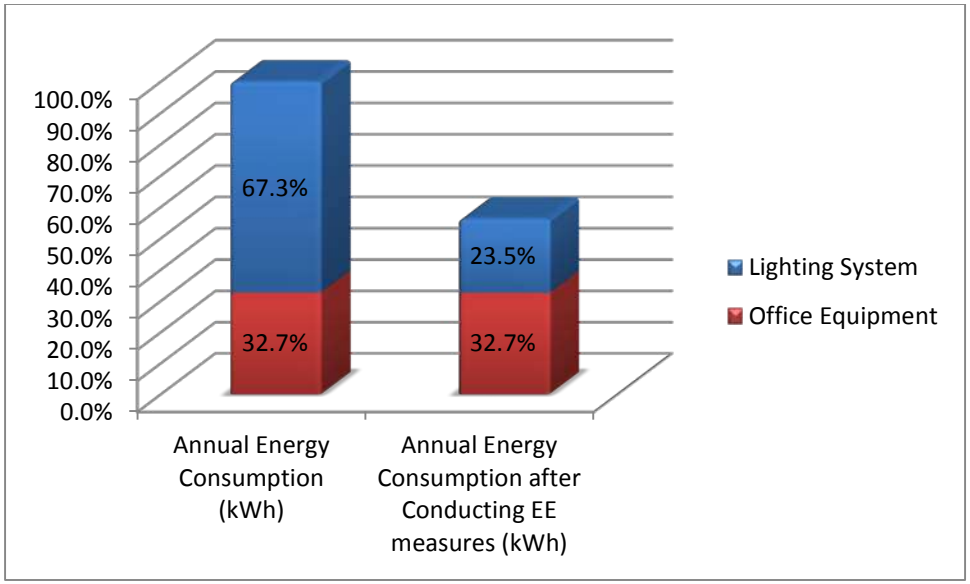


Figure (45): Annual electric energy consumption before & after conducting EE measures in Al-Ghwier administrative building

5.13. Zaid Iben-Harthe administrative building

Table 50 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 47 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (49): Energy & cost saving potentials in Zaid Iben-Harthe administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	32	0.58	2458	228	288	1.26
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	12	0.22	259	24	144	5.99
Total			**0.79**	**2717**	**252**	**432**	**1.7**

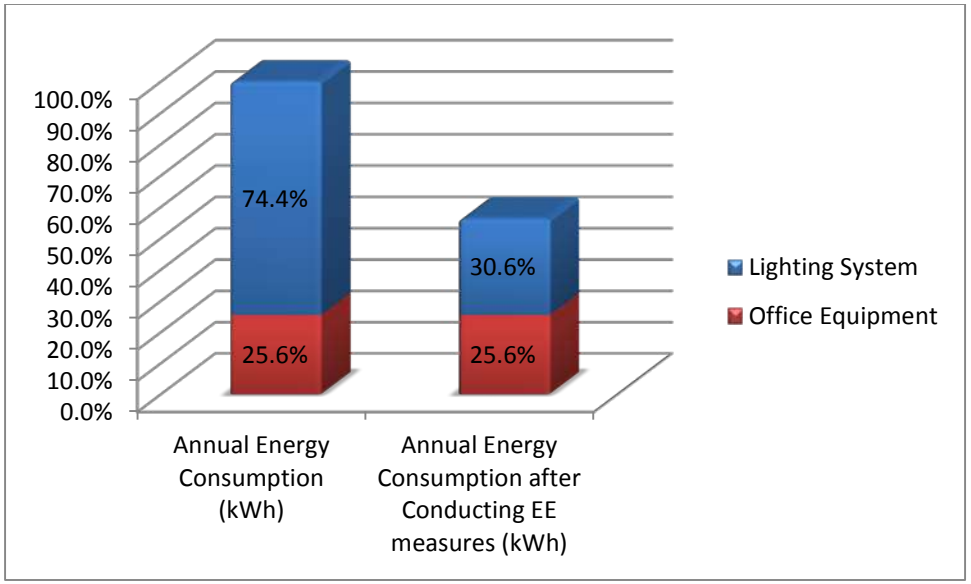


Figure (46): Annual electric energy consumption before & after conducting EE measures in Zaid Iben-Harthe administrative building

5.14. Al-Jdaydeh administrative building

Table 51 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 48 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (50): Energy & cost saving potentials in Al-Jdaydeh administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Expected CO_2 reduction (ton/yr)
Lighting systems energy saving opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	6	0.11	46	3	54	26
Replacing (CFL lamps 60W) with (LED round panel 18W)	0.018	7	0.13	71	5	84	40
Replacing (Incandescent lamps 100W) with (LED round panel 18W)	0.018	41	0.74	807	53	492	452
Replacing (Flood light Mercury 150W) with (LED Flood light 50W)	0.050	2	0.10	67	4	80	38
Total			**1.07**	**991**	**65**	**710**	**555**
Thermal systems energy savings opportunities							
Replacing old ACs with inverter ACs	**Unit Load (Ton)**	**No. of ACs to be replaced**	**Total Connected Load (kW)**	**Annual Energy Saving (kWh)**	**Annual cost saving (JOD)**	**Investment (JOD)**	**Simple payback period (yr)**
Replacing old ACs with inverter ACs	**1**	**1**	**3.51**	**141**	**9**	**500**	**53.6**

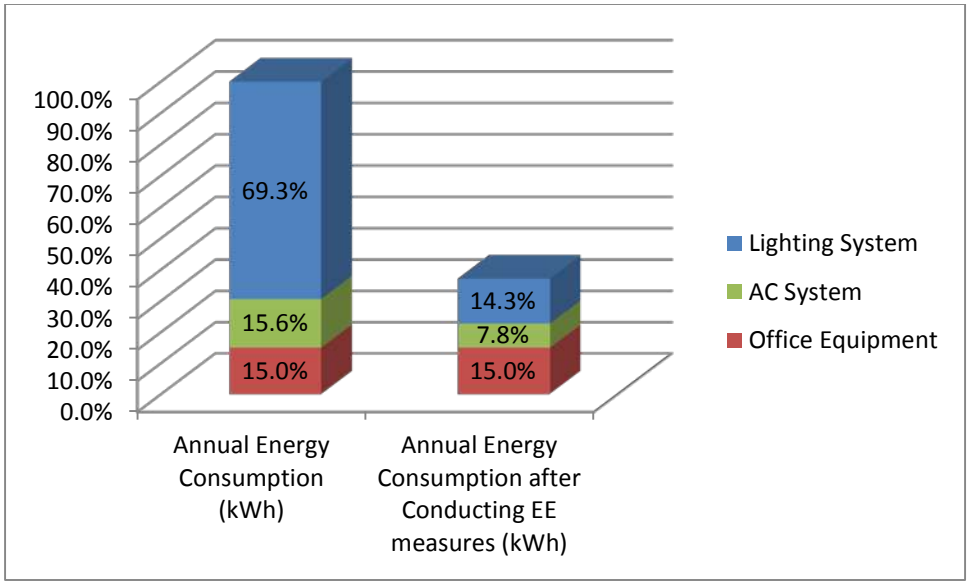


Figure (47): Annual electric energy consumption before & after conducting EE measures in Al-Jdaydeh administrative building

5.15. Al-Adnaniya administrative building

Table 52 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 49 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (51): Energy & cost saving potentials in Al-Adnaniya administrative building

Replacing lighting units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual energy saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)

Lighting systems energy saving opportunities							
Replacing (T8 fluorescent linear tube 36W	0.018	8	0.14	113	8	72	9.25

)with(LEDtube18W)							
Replacing(CFLlamps27	0.018	3	0.05	12	1	36	43.87

W) with (LED round panel 18W)							
Replacing (CFL	0.005	34	0.17	90	6	408	65.81

lamps11W)with(LEDBulb5W)							
Replacing(Inc	0.018	3	0.05	108	7	36	4.82

andescentlamps100W)withLEDroundpanel							

18W)							
Replacing(FloodlightMH250W)with(L	0.180	2	0.36	97	7	300	44.87

EDFloodlight180W)							
Total			0.78	419	29	852	29.4
Thermal systems energy savings opportunities							
Replacing old AC	Unit Load (Ton)	No. of AC to be re	Total Connected Load (kW)	Annual Energy Saving (kWh)	Annual cost savi	Investment (JOD)	Simple payback period (yr)

switch inverter ACs		**placed**			**ng (JOD)**		
Replacing old ACs with in	1.5	2	17.6	565	39	1900	48.7

verterACs							
ReplacingoldACswithinverterA	2	1					

Cs							

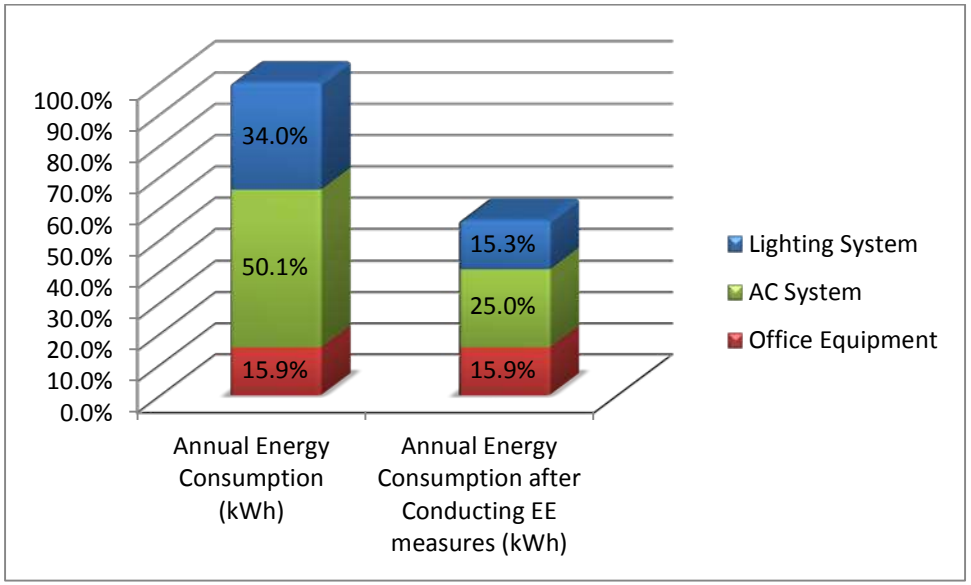


Figure (48): Annual electric energy consumption before & after conducting EE measures in Al-Adnaniya administrative building

5.16. Wadi Karak administrative building

Table 53 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 50 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (52): Energy & cost saving potentials in Wadi Karak administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	20	0.36	819	58	180	3.12
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	3	0.05	35	2	36	14.79
Replacing (Flood light MH 250W) with (LED Flood light 180W)	0.180	1	0.18	141	10	150	15.13
Total			**0.59**	**995**	**70**	**366**	**5.2**

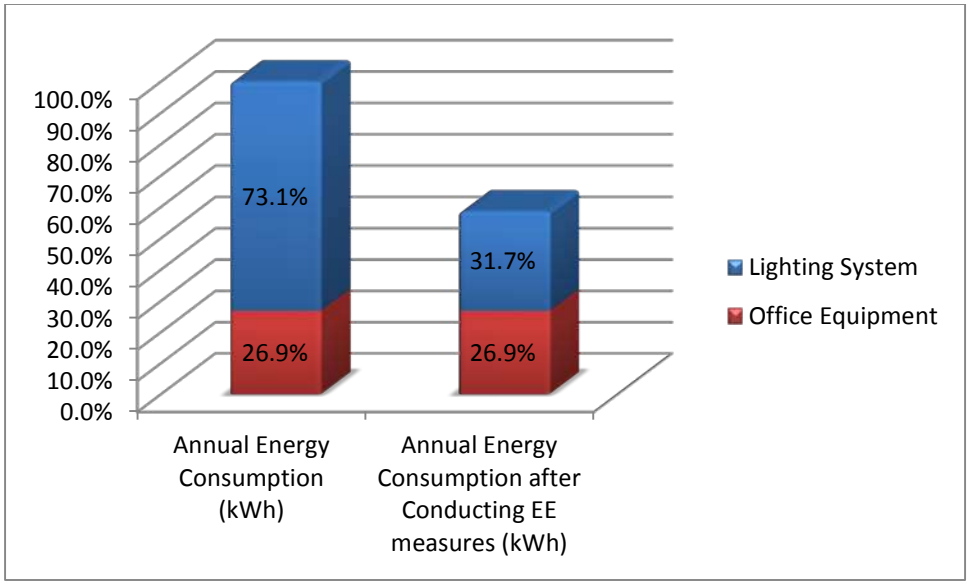


Figure (49): Annual electric energy consumption before & after conducting EE measures in Wadi Karak administrative building

5.17. Baddan and Barda administrative buildings

Table 54 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 51 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (53): Energy & cost saving potentials in Baddan and Barda administrative buildings

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual energy saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	8	0.14	410	28	72	2.58
Replacing (Flood light MH 250W) with (LED Flood light 180W)	0.180	1	0.18	176	12	150	12.49
Total			**0.32**	**586**	**40**	**222**	**5.6**

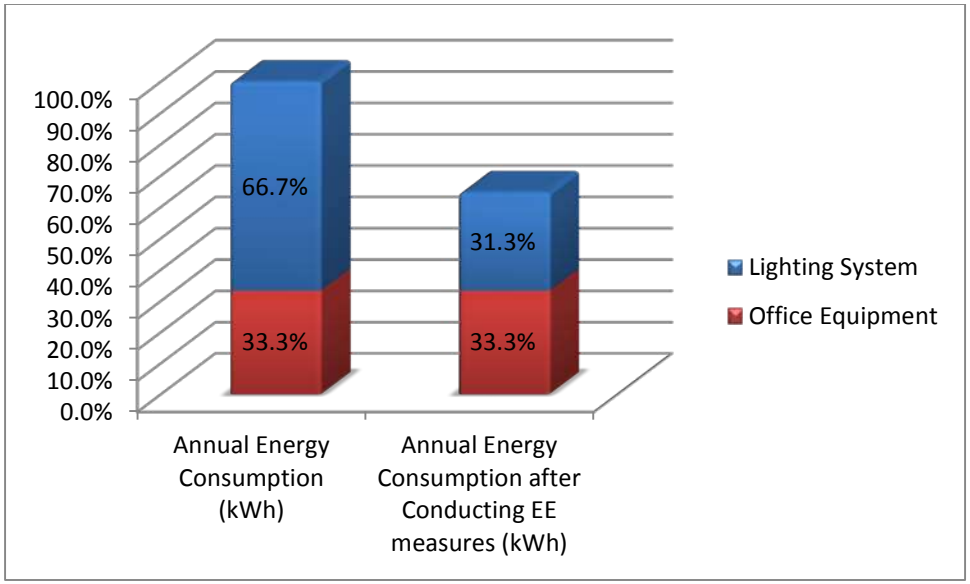


Figure (50): Annual electric energy consumption before & after conducting EE measures in Baddan and Barda administrative buildings

5.18. Al-Marj administrative building

Table 55 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 52 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (54): Energy & cost saving potentials in Al-Marj administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual energy saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	26	0.47	1597	161	234	1.45
Replacing (T8 fluorescent linear tube 18W) with (LED tube 9W)	0.009	4	0.04	123	12	28	2.25
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	10	0.18	173	17	120	6.87
Replacing (Halogen lamps 60W) with (LED round panel 18W)	0.018	1	0.02	81	8	12	1.47
Replacing (Flood light MH 250W) with (LED Flood light 180W)	0.180	3	0.54	634	64	450	7.03
Total			**1.24**	**2607**	**264**	**844**	**3.2**

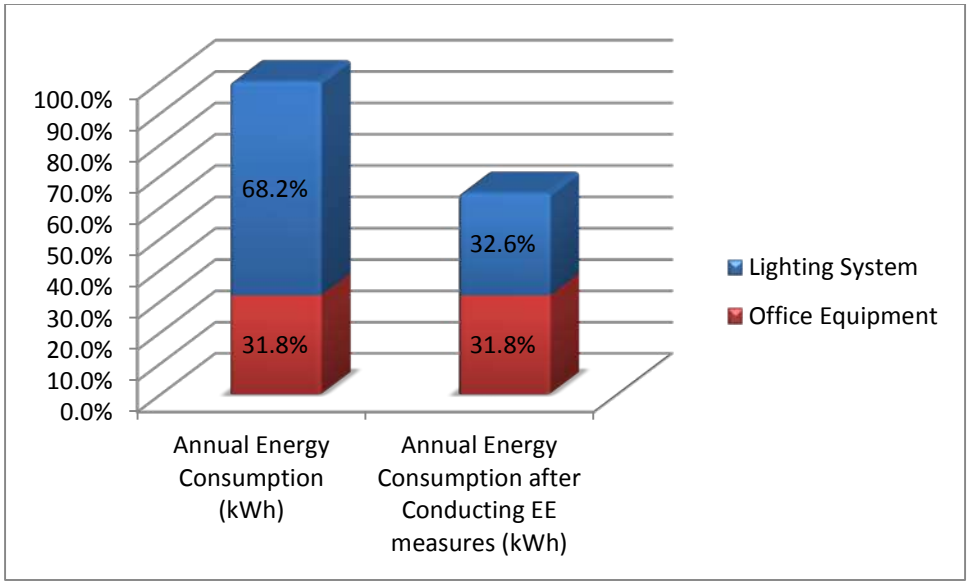


Figure (51): Annual electric energy consumption before & after conducting EE measures in Al-Marj administrative building

5.19. Al-Hawieh administrative building

Table 56 illustrates the recommendations to replace each type of the existing lighting units with their wattage, annual expected energy saving, annual cost saving, the required investment cost, the expected life time for the system and simple payback period for these recommendations. Figure 53 shows the annual energy consumption of the lighting system before and after applying these recommendations.

Table (55): Energy & cost saving potentials in Al-Hawieh administrative building

Replacing lightning units	Unit load (kW)	No. of lamps to be replaced	Total connected Load (kW)	Annual energy saving (kWh)	Annual cost saving (JOD)	Investment (JOD)	Simple payback period (yr)
Lighting Systems Energy Saving Opportunities							
Replacing (T8 fluorescent linear tube 36W) with (LED tube 18W)	0.018	8	0.14	369	33	72	2.15
Replacing (T8 fluorescent linear tube 18W) with (LED tube 9W)	0.009	120	1.08	2765	251	840	3.35
Replacing (CFL lamps 27W) with (LED round panel 18W)	0.018	3	0.05	39	4	36	10.20
Total			**1.28**	**3172**	**288**	**948**	**3.3**

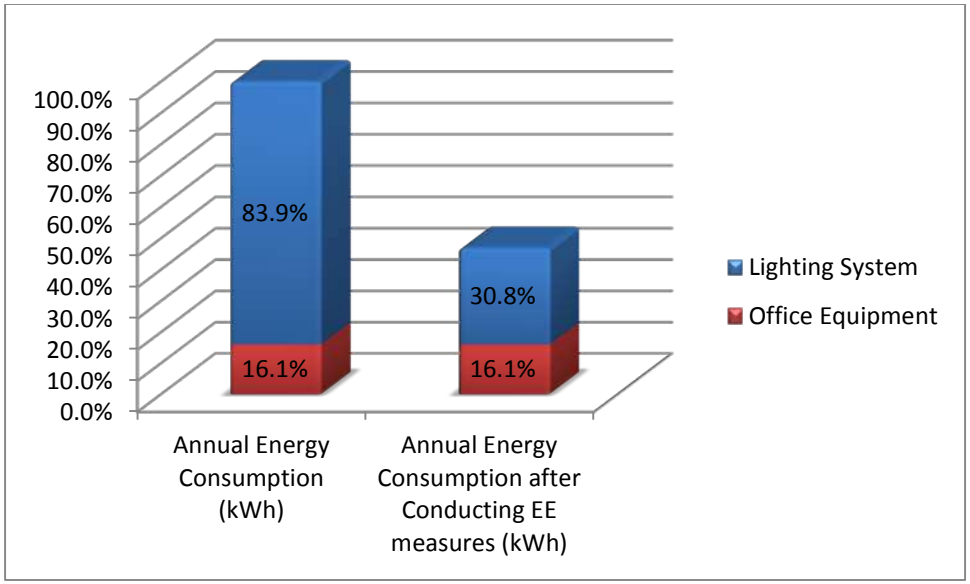
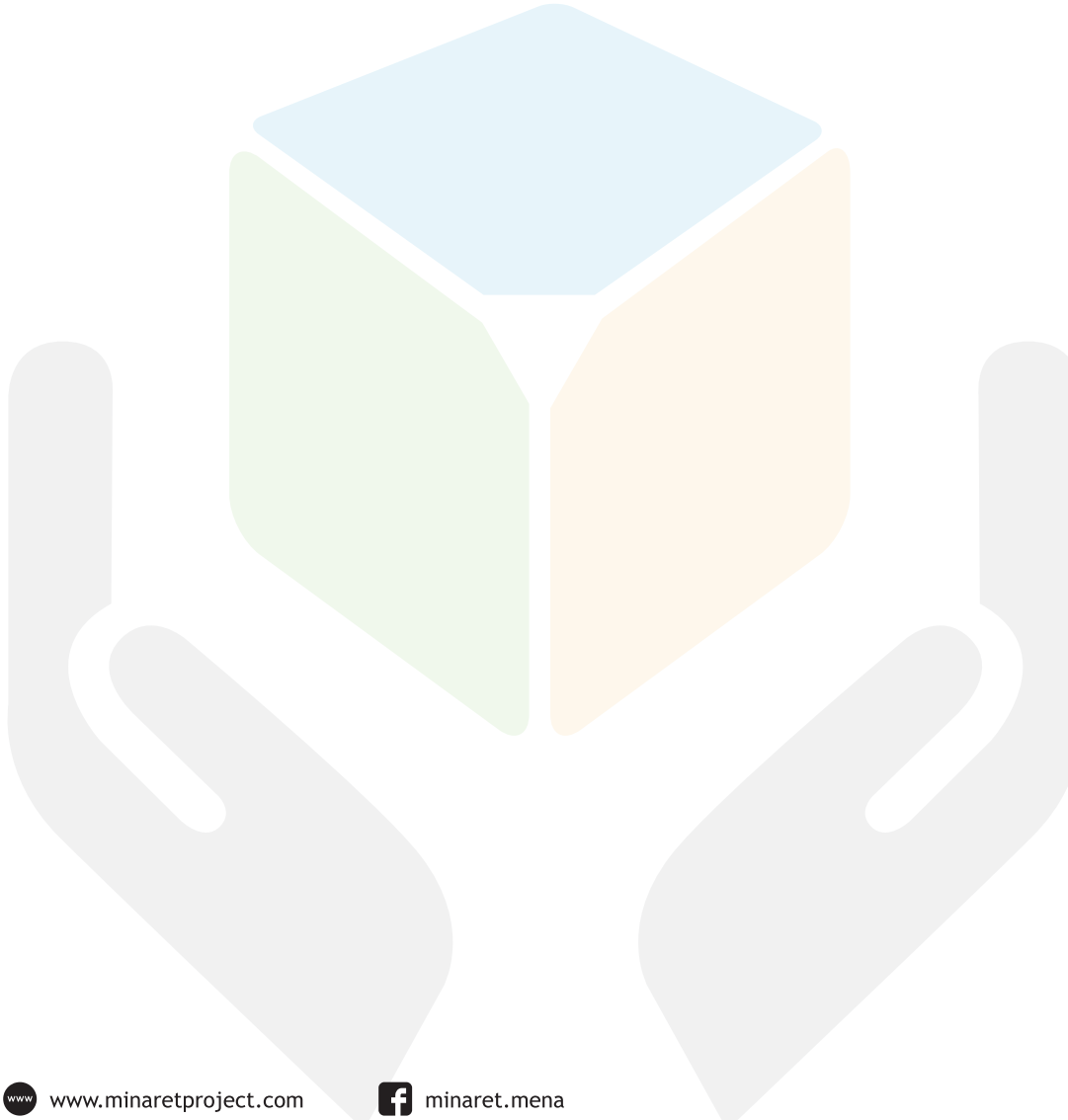


Figure (52): Annual electric energy consumption before & after conducting EE measures in Al-Hawieh administrative building



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

Sweden
Sverige

FUTURE
PIONEERS
Empowering Communities

IUCN

NERC
National Energy Research Center

Royal Scientific Society