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ENERGY AUDITING AND CAPACITY BUILDING FOR SIX MINISTRIES IN JORDAN

[Energy and Minerals Regulatory Commission– Energy Audit Report]

MAY 2016

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ENERGY AUDITING AND CAPACITY BUILDING FOR SIX MINISTRIES IN JORDAN

[ENERGY AND MINERALS REGULATORY COMMISSION]

Program Title:	**Energy Auditing and Capacity Building For Six Ministries In Jordan**
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PREFACE

The USAID Energy Sector Capacity Building (ESCB) Activity works with Jordanian energy sector partners to cultivate effective policies and decision-making in the energy sector; and to build sustainable institutional and organizational capacity to increase the adoption of renewable energy and energy efficiency technologies and practices. ESCB places a high priority on addressing gender issues in the energy sector, including promotion of women in energy-related careers.

ESCB started in July 2013 and runs for four years. It applies a broad, adaptable approach to meet the energy sector's evolving needs, including:

1. Successful development and adoption of a utilities incentive mechanism to promote energy efficiency, including a robust monitoring, evaluation, and validation system;
2. Increased institutional capacity of the Jordanian energy sector partners including the Ministry of Energy and Mineral Resources, Electricity Regulatory Commission, and electricity production, distribution, and transmission companies;
3. Strengthened presence, capacity and regulation of energy services companies through market research, business development services, accreditation of those companies, and the creation of a coalition of energy services association; and
4. Flexible response mechanism for emergent energy sector needs and opportunities on a demand-driven basis.

ABBREVIATIONS

ESCB	Energy Sector Capacity Building
EMRC	Energy and Minerals Regulatory Commission
EE	Energy Efficiency
EMO	Energy Management Opportunity
IRR	Internal Rate of Return
NPV	Net Present Value
EUI	Energy Use Intensity
FL	Fluorescent Lamp
LED	Light Emitting Diode
CFL	Compact Fluorescent Lamp
AC	Air Conditioning System
kW	Kilo-Watt
kWh	Kilo-Watt Hour
BTU	British Thermal Unit
COP	Coefficient of Performance
AHU	Air Handling Unit
MDB	Main Distribution Board
ASHRAE	American Society for Heating Refrigeration and Air-conditioning Engineers
ECM	Energy Conservation Measure
BMS	Building Management System
PPM	Parts Per Million
IPMVP	International Performance Measurement and Verification Protocol

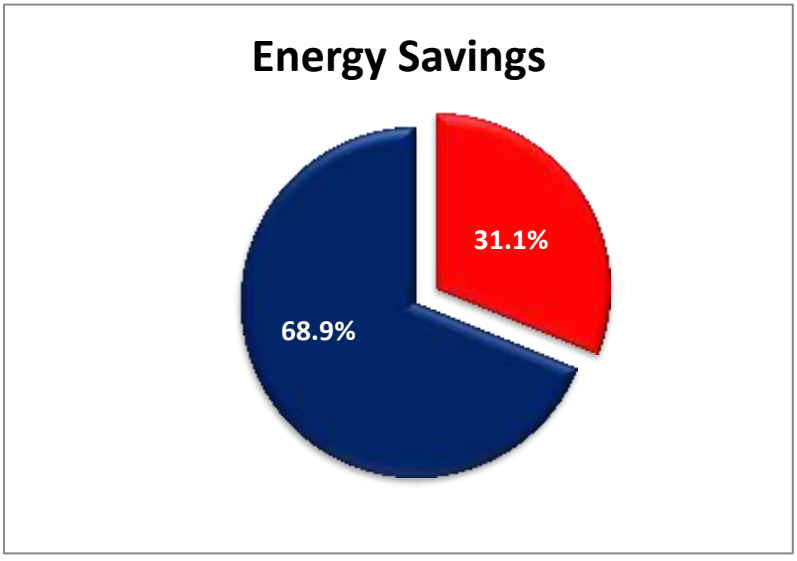
1.0 EXECUTIVE SUMMARY

This Energy Audit Report contains detailed data and analysis about energy aspects at "Energy and Minerals Regulatory Commission – EMRC" located at Amman-Jordan, which is based on ASHRAE Level II Energy Audit conducted during April-May 2016.

The Energy Audit showed that EMRC is sharing the electricity supply with Seismic Monitoring Building where one electricity meters is installed for the two buildings. The electricity consumption breakdown showed that EMRC consumes about 75% of the meter readings and the rest is being consumed by the Seismic Monitoring Building. The total electricity meter reading in the past year was **JD 135,308** where the EMRC consumes **JD 101,481**. New electricity tariff was applied at the beginning of Jan 2016; this would lead the electrical energy bills for the EMRC to be **JD 113,534**.

Implementing the recommended energy management opportunities [EMOs] addressed in this report will help EMRC in reducing energy bills, where the report recommended the implementation of Twelve EMO's; that would lead to monetary savings of **JD 41,051 /year** equivalent to **31.1 %** of the annual energy bill. The required investment to implement the EMOs is about **JD 37,248**, which would be returned back in **10.9 months**. It is worth to be mentioned here that the calculations in this report were developed based on the applied electrical tariff which was assumed to be applied at the beginning of 2016. However, if energy prices were kept the same as of 2015, section 11.1 shows the energy audit results based on 2015 electricity tariff.

Figure 1: Expected Percentage of Saving by Implementing the Energy Management Project



This Energy Audit Report presents the following energy management opportunities to achieve the aforementioned monetary savings:

L.1 Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas.

L.2 Replace the Existing Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt in some Selected Areas.

L.3 Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors.

L.4 Control the Operation of Lighting system in Some Selected Areas using Day Lighting Sensor.

L.5 General Recommendations on Lighting System in Some Areas.

AC.1 Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.

AC.2 Relocate the Outdoor Units of the Server Room AC's to a Well Ventilated Location.

AC.3 Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System.

O.1 Improve and Optimize Existing Heating System and Prohibit Use of Electric Space Heaters.

O.2 Switch Off the Water Coolers During Night Time by Programmable Timer.

O.3 Increase Energy conservation awareness among the EMRC employees.

F.1 Effect of Boiler Replacement in EMO (O.1) on Heating System Efficiency.

The report provided an eye about some vital financial figures as presented in section 7. The analysis yielded in encouraging results by which the Internal Rate of Return IRR for the project was **113.6 %**. While the saving to investment ratio is **4.0**, the net present value NPV is **JD 97,410** and finally, the simple payback period is **0.91 years**.

The total expected reduction in CO2 equivalent is around **148.0 tons** provided that all energy management opportunities were implemented

2.0 INTRODUCTION

2.1 BACKGROUND AND RATIONALE

Energy bill in Jordan is posing a huge burden on the Jordanian economy since it represented around 20% of GDP in 2014. This had created serious challenge for governments, developers, industries and individuals to conserve energy and improve the efficiency of energy use.

The efficiency of energy use helps all energy consumers to cut down their energy bills resulting into continuous growth and development by providing lower risks form the increment of energy prices and more competitiveness.

Moreover, any energy efficiency enhancements would count and at the end of the day, the overall cumulative figure will contribute to minimizing the burden on national economy noticeably. The improvement of energy efficiency will not only save energy, but will also increase in the awareness of the stockholders about the importance of energy saving. What would make the situation even more challenging is the expected rise in oil prices. Thus the need for enhancing the efficiency use in Jordan will become more urgent since Jordan imports almost all its energy requirement to satisfy local demand.

Any enhancement in energy efficiency will not only reduce the cost of bills but it will also result in improving the surrounding environment by reducing the greenhouse gases GHG associated with fossil fuel burning and energy production.

Energy management programs are a systematic strategy for controlling a building's energy consumption pattern, and reducing it to an acceptable minimum without compromising production levels and quality, comfort, operations and other factors. It establishes and maintains an efficient balance between a building's annual functional energy requirements and its annual actual energy consumption.

Generally; energy management programs have several advantages including but not limited to the following: Lower energy bills; Maximizes the efficiency of the electromechanical equipment (HVAC, lighting, pumping, Thermal system, etc.); Reduces maintenance cost; Decreases greenhouse Gases (GHG) footprint; Provides solutions to any existing power or energy problems; Conserves the resources and improve comfort and productivity.

In terms of water, Jordan's primary sources of water are aquifers and basins fed and recharged through annual rainfall. The Yarmouk Basin is the largest in the country. Water from ground, surface, and non-traditional sources, exhibits short- and long-term variations, and this requires that decision-makers in charge of planning and development be informed and advised on the general and specific data. Jordan's

water supply suffers because about 85% of the total amount of water is lost to evaporation annually, which leaves only a small amount of surface and groundwater to enter the water supply.

Many methods have been suggested to increase the water supply, including intensive capturing of rainwater through the use of micro- and macro-domes, desalination of sea water, and importation of water from neighbouring countries, as well as other alternatives. However, all these are subject to cost–benefit analyses and geopolitical constraints.

Water in Jordan is used primarily for agriculture. Agriculture accounts for 62% of all water consumed, the rest being for domestic and industrial use. Annual growth in demand for water in Jordan is estimated at 25 Mm3/year. This growth is related to urbanization and industrial expansion, as well as to increased domestic use, mainly as a result of population growth.

The current situation of water supply and demand in Jordan raises serious concerns about the country's water balance, as well as about the qualitative deterioration of water. The picture is so gloomy that any water researcher would observe that it is all too easy for the country to "cross the red line" when faced with annual water deficits, overuse, resource depletion or contamination, and human errors. Projections of water resources to 2025 demonstrate that there will be persistent shortage. Several methods are in place to help alleviate the shortage, with reduced consumption at the top of the list. Appropriate pricing is a preferred alternative for achieving this goal. Money saved and funds generated may justify installing and using new technologies more efficient in terms of cost–benefit analyses.

2.2 PROJECT OBJECTIVES

The main objectives of this energy assessment are the following:

1. Implementing ASHRAE Level II energy Audit at Six Ministries in Jordan.
2. Conduct a complete billing analysis for the building to establish the energy balance.
3. Identifying energy efficiency enhancement opportunities, supported by a complete technical, financial and environmental analysis.
4. Prioritize the implementation of the EMOs based on its economic feasibility.
5. Preparing Action Plan for EMO's implementation.
6. Increasing the levels of awareness of the Staff and stack holders about the importance of energy management for the Governmental Sector on the first level and the Jordanian economy on higher level through Conducting Two-Days Training for selected ministries staff.

3.0 KEY FINDINGS

This Section addresses the proposed Energy Management Opportunities EMOs at EMRC, those EMOs were selected as they proved to be the most economically feasible and simple to be implemented. Table (1) below shows the proposed energy management opportunities, the associated energy savings, implementation costs and the simple pay-back period.

Table 1: Summary of Energy Management Opportunities in Electrical Systems

No.	Electrical Systems Energy Management Opportunities	Saving in kWh	Saving in JDs	% of saving	Investment JDs	Pay-Back Months
Lighting System's Energy Management Opportunities						
L.1	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	22,306	6,447	5.7%	**1,527**	3
L.2	Replace the Existing Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt in some Selected Areas.	4,293	1,241	1.1%	**1,300**	13
L.3	Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors	7,080	2,046	1.8%	**1,575**	9
L.4	Control the Operation of Lighting system in Some Selected Areas using Day Lighting Sensor	3,601	1,041	0.9%	**1,200**	14
L.5	General Recommendations on Lighting System in Some Areas	7,687	2,222	2.0%	**436**	2
Air Conditioning System's Energy Management Opportunities						
AC.1	Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.	5,280	1,526	1.3%	**525**	4
AC.2	Relocate the Outdoor Units of the Server Room AC's to a Well Ventilated Location	8,991	2,599	2.3%	**750**	3
AC.3	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	16,965	4,904	4.3%	**8,165**	20
Other Energy Management Opportunities						
O.1	Improve and Optimize Existing Heating System and Prohibit Use of Electric Space Heaters	47,520	13,736	12.1%	**20,000**	17
O.2	Switch Off the Water Coolers During Night Time by Programmable Timer	2,217	641	0.6%	**270**	5

O.3	Increase Energy conservation awareness among the EMRC employees	3,940	1,139	1.0%	1,500	16
Total		129,880	37,542	**33.0%**	**37,248**	12

No.	Fuel System Energy Management Opportunities	Saving in Liter	Saving in JDs	% of saving	Investment JDs	Pay-Back Months
F.1	Effect of Boiler Replacement in EMO (O.1) on Heating System Efficiency	8,022	3,509	19.5%	**0**	**0**
Total		8,022	3,509	**19.5%**	**0**	**0**

The above table was updated based on 2016 electricity tariff issued by the GoJ , if the prices were kept the same as of 2015 , the above table has to reconsider this slight change in electricity tariff , this table was attached in section 11.1 at the end of report and developed based on 2015 electricity tariff

4.0 ENERGY BILL ANALYSIS AND BASELINE ENERGY CONSUMPTION

This section addresses the energy performance and the baseline analysis for EMRC. This section serves the analysis of the existing energy consumption, energy bills over the past year, energy consuming systems, efficiency and characteristics of energy systems.

4.1 ELECTRICAL ENERGY CONSUMPTION

The Analysis of Electricity Bills for the baseline year showed that EMRC Building and the Adjacent Seismic Monitoring Building supplied by electricity form the same meter. According to the analysis and the information supplied by the technical team, EMRC consumes 75% of the total electrical bill and Seismic Monitoring Building consumes the other 25% of the bill. The following table shows the electrical energy bill breakdown per building:

Table 2: Annual Electricity Consumption and Costs

Building	Percentage of the Total Bill	Energy Consumption Nov 2014 to Oct 2015	Energy Cost Nov 2014 to Oct 2015
EMRC Building	**75%**	**394,016 kWh**	**101,481 JD**
Seismic Monitoring Building	**25%**	**131,338 kWh**	**33,827 JD**
Total Electrical Energy Bill	**100%**	**525,354 kWh**	**135,308 JD**

- All calculations and analysis in this report conducted based on consumption of EMRC Building only (the 394,016 kWh/year)

The total annual electrical bill for EMRC Building was analysed over the past year; the annual electrical consumption was as follows:

Table 3: Annual Electricity Consumption and Costs

Description	Annual Electrical Bills (Jan 2015 to Dec 2015)
Electrical Energy Consumption [kWh]	**394,016**
Electrical Energy Cost based on 2015 Tariff [JD]	**101,481**
Electrical Energy Cost based on 2016 Tariff [JD]	**113,534**

- **Electrical Tariff System**

The electrical tariff applied to the building is the regular tariff system. Below are the details of the applied electrical tariff for years 2014 to 2017:

Table 4: Electrical Tariff Details for the Regular Sector in Jordan as announced by GoJ

Consumption [kWh]	JD/kWh			
	2014	2015	2016	2017
1-160	0.040	0.044	0.048	0.053
161-300	0.087	0.096	0.105	0.116
301-500	0.104	0.114	0.126	0.139
501-600	0.138	0.152	0.167	0.184
601-750	0.163	0.175	0.188	0.202
751-1000	0.185	0.194	0.204	0.214
more than 1000	0.259	0.272	0.286	0.300
Total cost of the first 1000 kWh	**123.88**	**133.23**	**143.48**	**154.72**

The following table shows the actual electricity consumption with the associated costs for the EMRC Building during the period from Jan-2015 till Dec-2015 as well as the expected energy costs during this year (2016) if the energy management opportunities were not implemented.

Table 5: Total Annual Electricity Consumption and Costs during Past Year and the expected Costs during the 2016 year as announced by GoJ

Month	Energy Consumption [kWh]	Cost [JD]	
		based on 2015 Tariff	Based on 2016 Tariff
Jan-15	36,788	9,485	10,615
Feb-15	34,003	8,760	9,802
Mar-15	31,768	8,179	9,150
Apr-15	29,138	7,496	8,382
May-15	23,591	6,053	6,762
Jun-15	31,022	7,985	8,932
Jul-15	33,128	8,533	9,547
Aug-15	43,228	11,159	12,496
Sep-15	32,515	8,374	9,368
Oct-15	33,255	8,566	9,584
Nov-15	28,493	7,328	8,193
Dec-15	37,090	9,563	10,704
Total	**394,016**	**101,481**	**113,534**
Average	**32,835**	**8,457**	**9,461**
Minimum	**23,591**	**6,053**	**6,762**
Maximum	**43,228**	**11,159**	**12,496**

From the above table, the following could be noted:

1. The annual electrical consumption [kWh] in the past year for EMRC Building was **394,016 kWh** and the annual electricity cost was **JD 101,481** based on electrical tariff applied during 2015.

2. New electricity tariff was applied in Jan 2016; the total expected electrical cost for the same energy consumption will be JD **113,534**.

3. The maximum bill was in (**Aug 2015)** with a monetary amount of **JD 11,159**.

4. The minimum electrical bill was in (**May 2015)** with a monetary amount of **JD 6,053.**

5. The average electrical tariff was **0.2691 JD/kWh** during the year 2015 and it was increased to **0.2890 JD/kWh** at the beginning of 2016.

The below figures illustrate the annual electricity consumption and cost graphically

Figure 2: Electricity Consumption [kWh] from Jan 2015 to Dec 2015

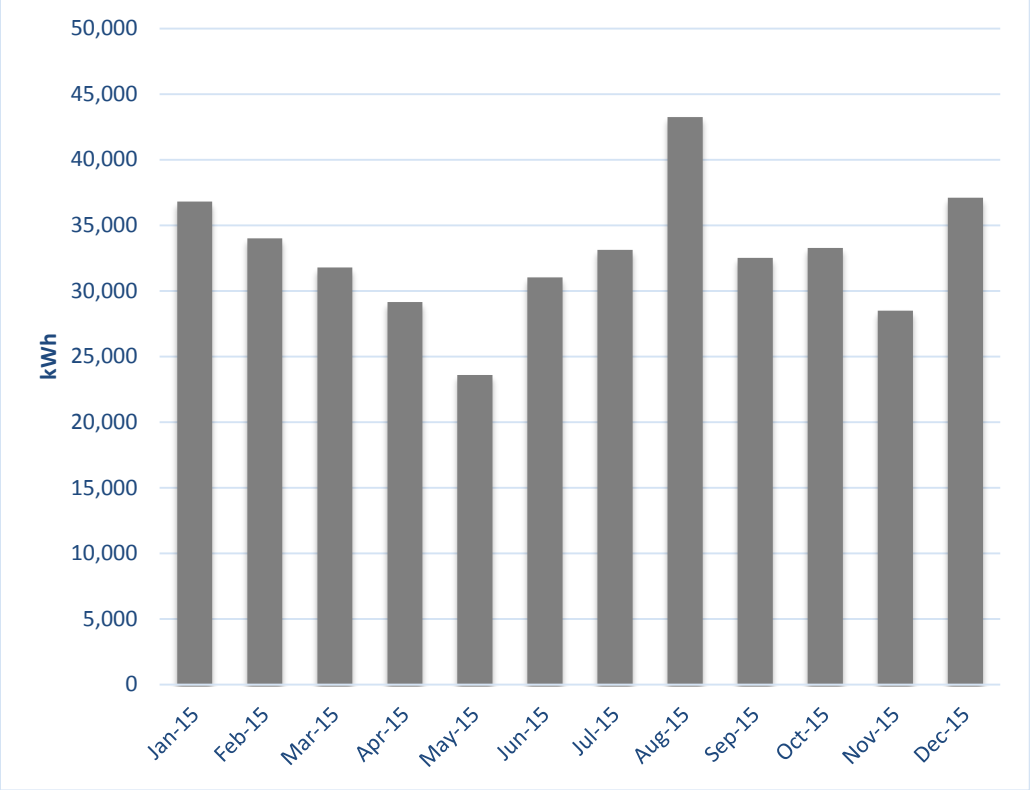
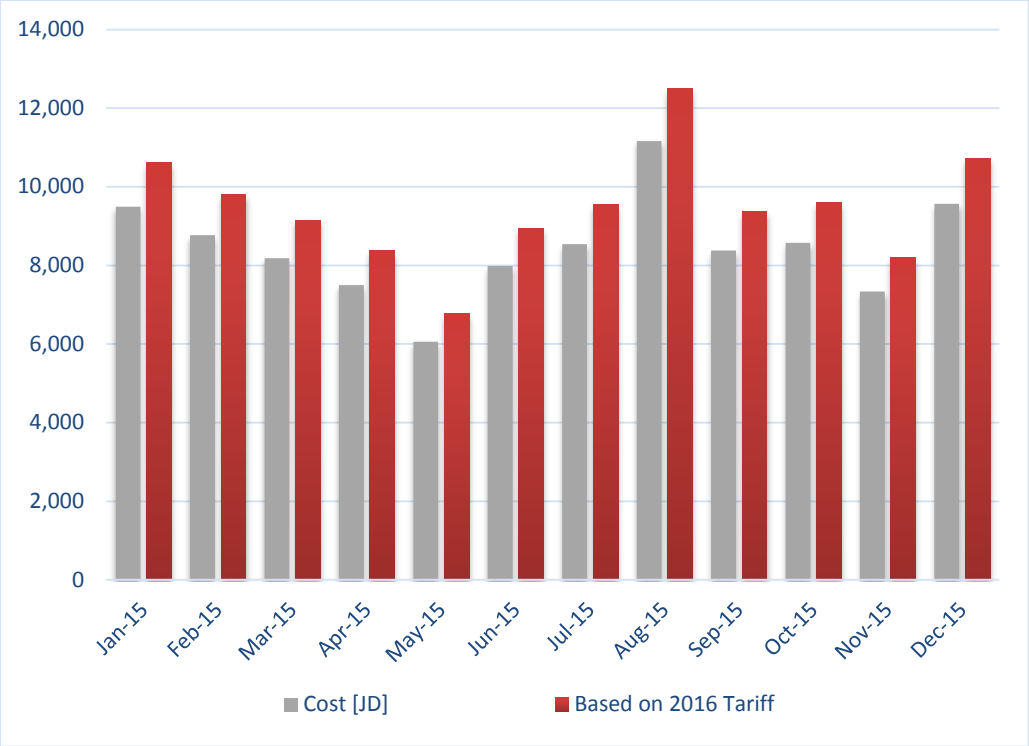
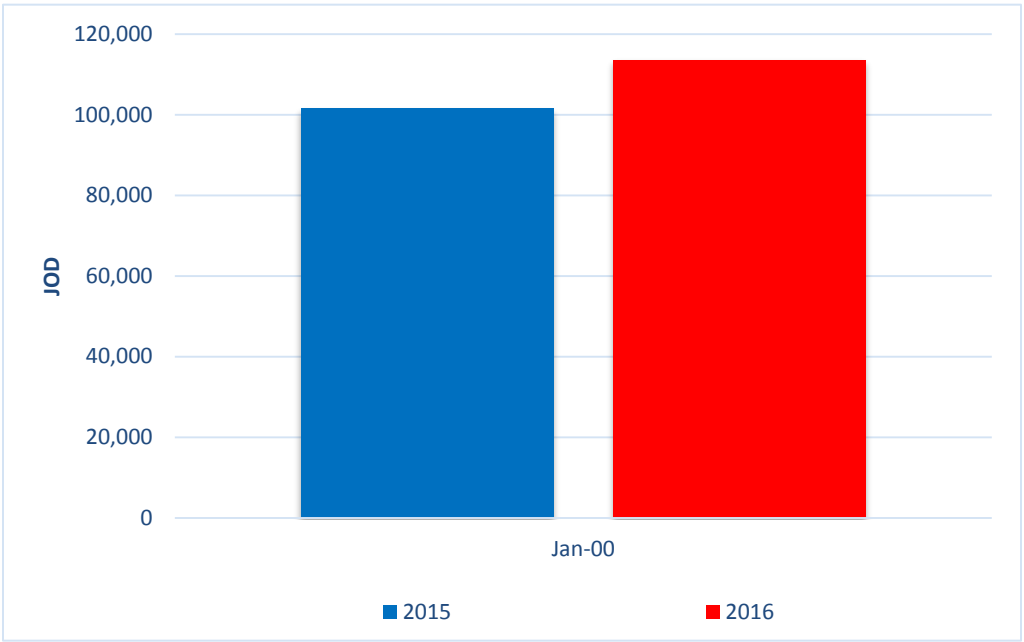


Figure 3: Comparison of Electrical Bills based on the Past and New Tariff in JDs



Note: it could be noticed that the energy consumption during winter season is high, due to that the fact that most employees use electric space heaters.

Figure 4: Annual Electrical Tariff Inflation in JDs



4.2 BASELINE ELECTRICAL MEASUREMENTS

Continuous monitoring over different periods of time were conducted on the main power supply and other main loads at the building, the total electrical load at the building and other measured parameters are illustrated in the following figures:

Figure 5: Electrical Load [kW] as Measured on the MDB (Mar 22, 2016 – Mar 28, 2016)

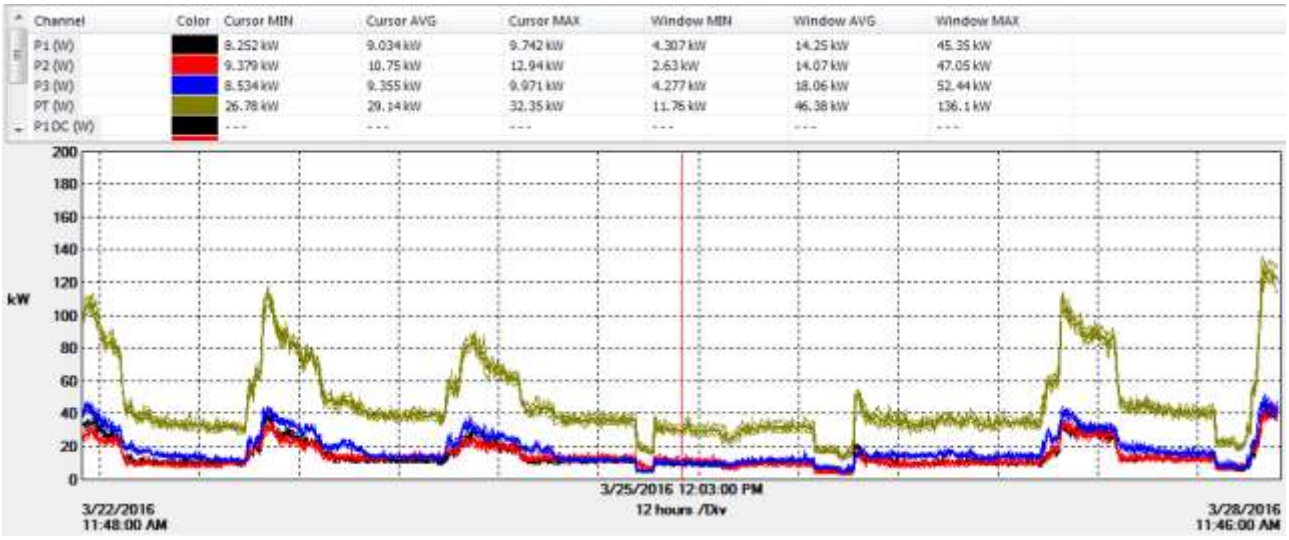


Figure 6: Electrical Current [Amp] as Measured on the MDB (Mar 22, 2016 – Mar 28, 2016)

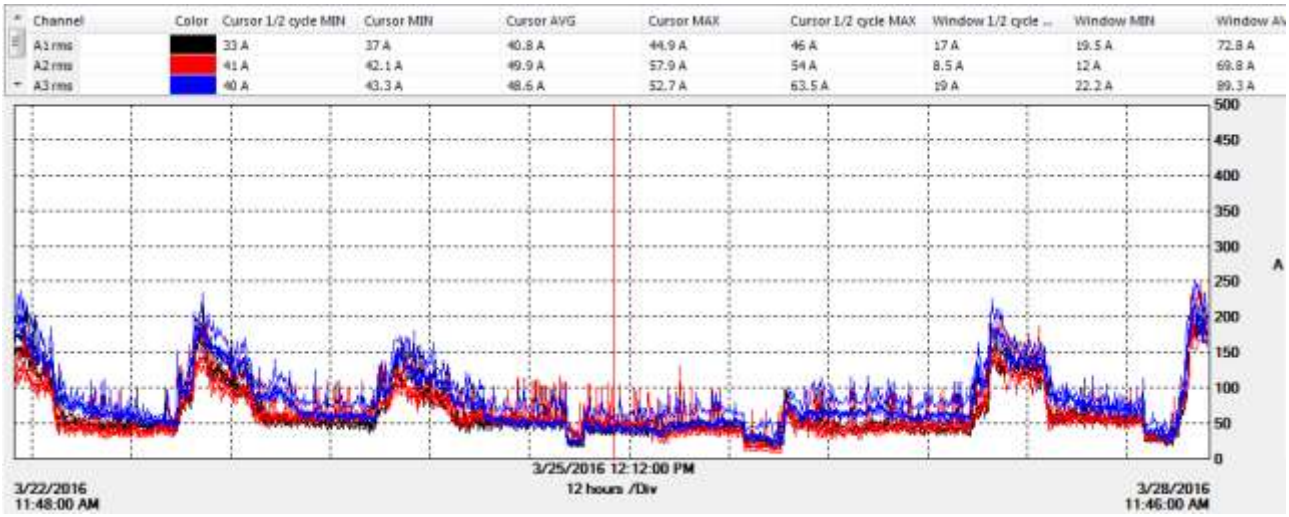


Figure 7: Electrical Voltage [V] as Measured on the MDB (Mar 22, 2016 – Mar 28, 2016)

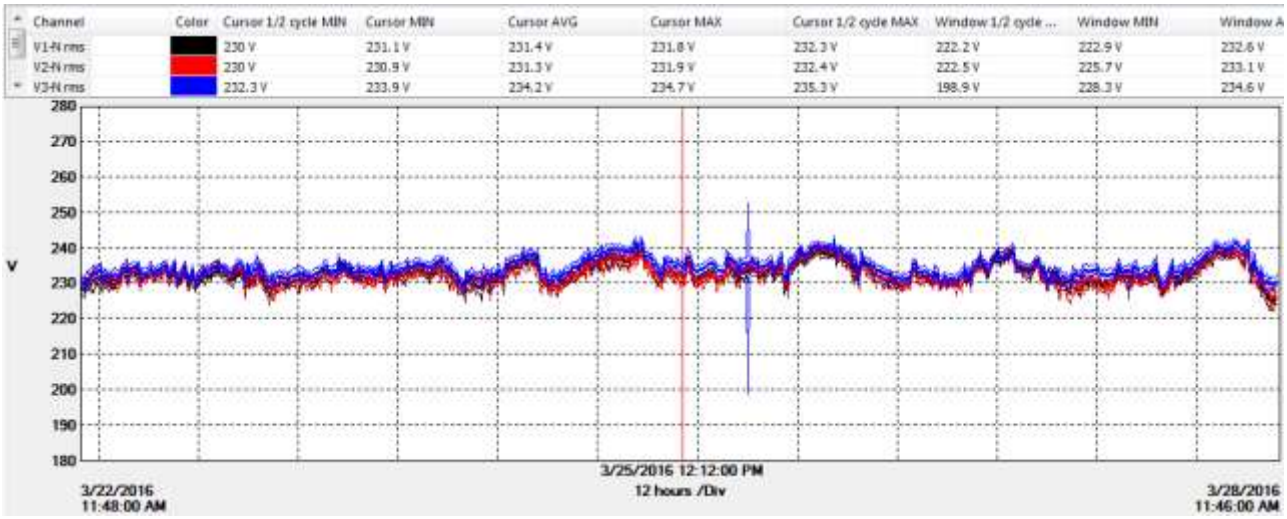


Figure 8: Electrical Current [Amp] as Measured GF and First Floor Circuit Breaker (Mar 17, 2016 – Mar 30, 2016 – Two Weeks)

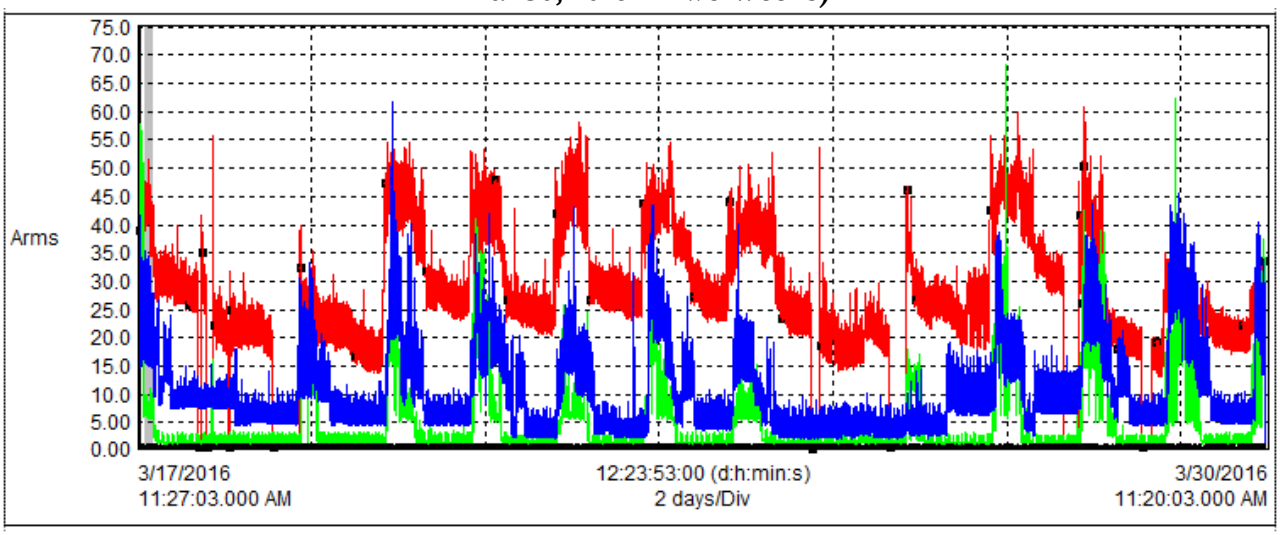


Figure 9: Electrical Current [Amp] as Measured on the Second Floor Circuit Breaker (Mar 17, 2016 – Mar 30, 2016 – Two Weeks)

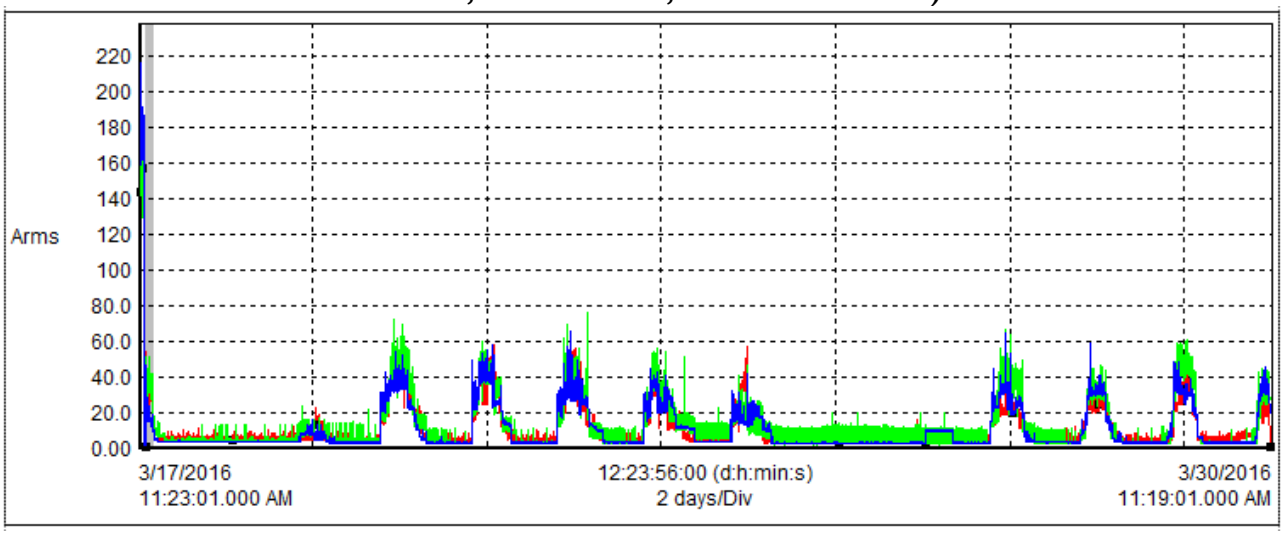


Figure 10: Electrical Current [Amp] as Measured on the Circuit Breaker of the Elevator (Mar 17, 2016 – Mar 30, 2016 – Two Weeks)

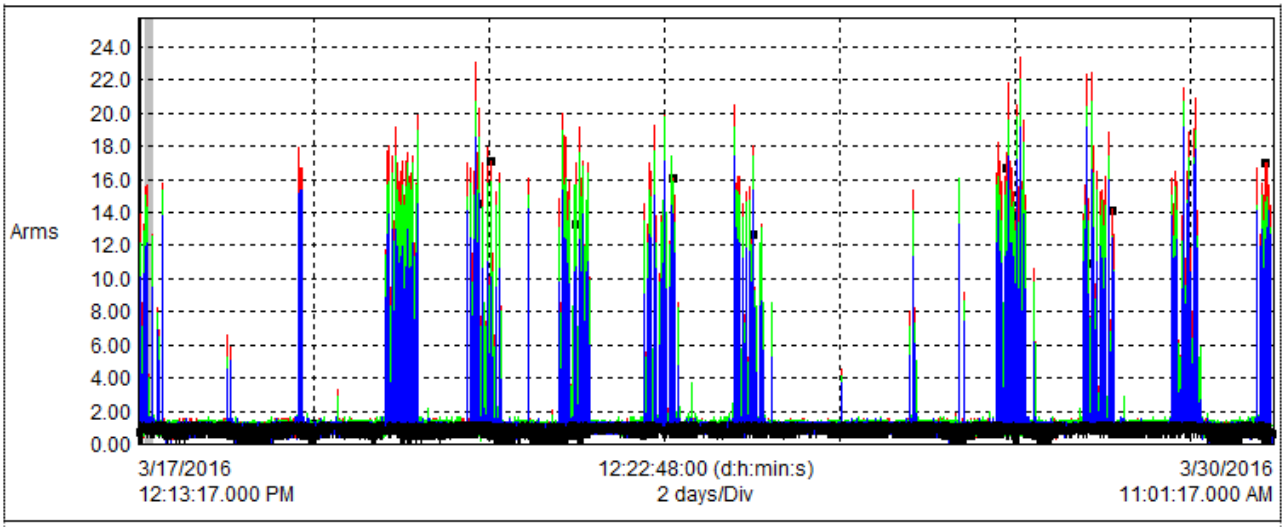
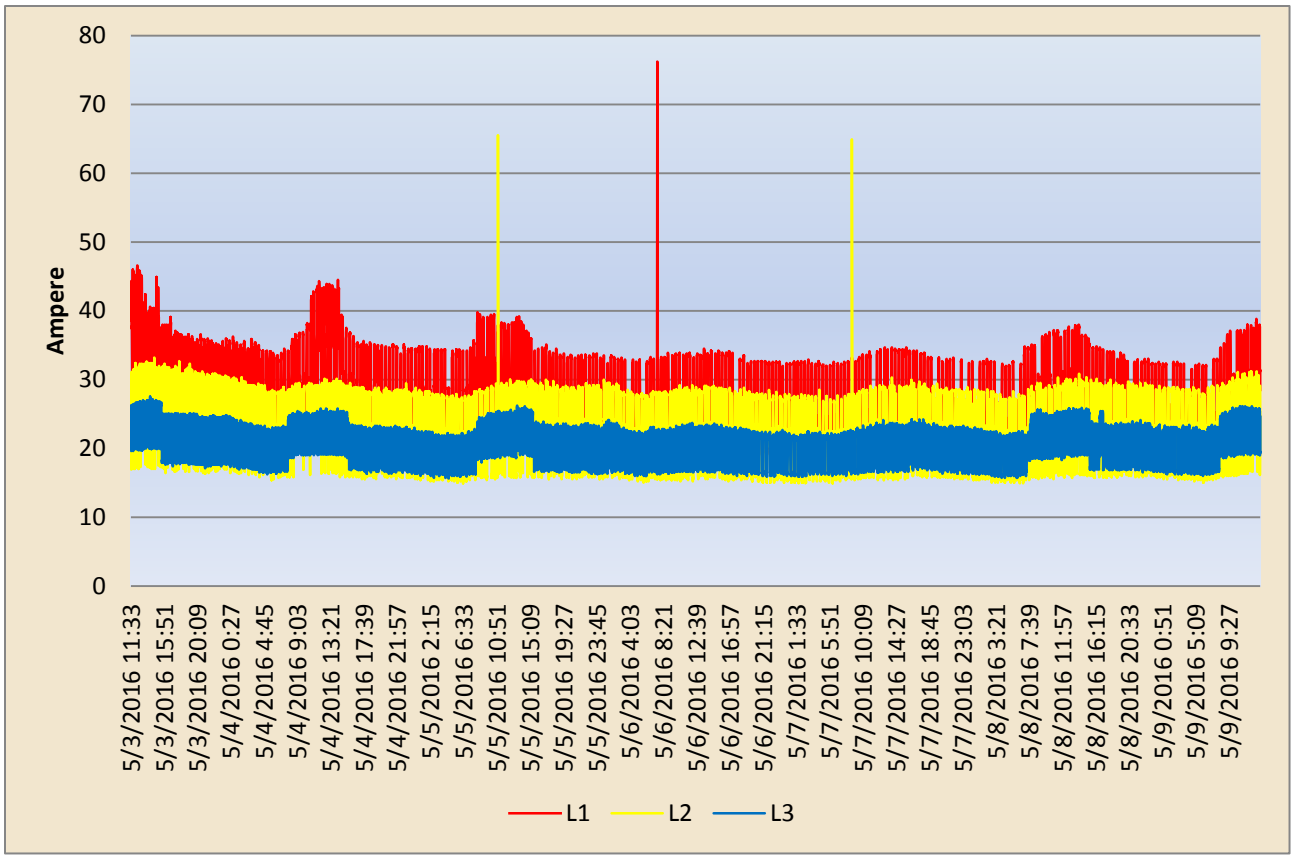


Figure 11: Electrical Current [Amp] as Measured on the Circuit Breaker of Servers and Servers AC (May 3, 2016 – May 9, 2016 – One Week)



4.3 ELECTRICITY CONSUMPTION BREAKDOWN

During the site visits at the energy audit phase, the previously mentioned continuous electrical measurements were carried out at the electrical loads and electrical energy consumers to establish the electrical consumption and cost breakdown. All the electrical measurements yielded in the following electrical breakdown

Table 6: Detailed Electricity Consumption [kWh] and Costs [JOD] Breakdown

No.	Load Description	Annual Consumption and Cost		% of the Total Consumption
		kWh	JDs	
1	IT Equipment	97,044	28,050	24.63%
2	Lighting System	80,014	23,128	20.31%
3	Split Air Conditioners	54,756	15,827	13.90%
4	Server Room Air Conditioners	53,622	15,499	13.61%
5	Electric Space Heaters	47,520	13,736	12.06%
6	Elevator	9,504	2,747	2.41%
7	Water Coolers	8,748	2,529	2.22%
8	Electric Water Heaters	7,260	2,098	1.84%
9	Heating Water Pump	3,939	1,139	1.00%
10	Fans	3,105	897	0.79%
11	Others	28,504	8,239	7.23%
	Total	394,016	113,890	100%

The following figure shows the detailed electrical load breakdown graphically

Figure 12: Detailed Electrical Consumption [kWh] Breakdown at EMRC

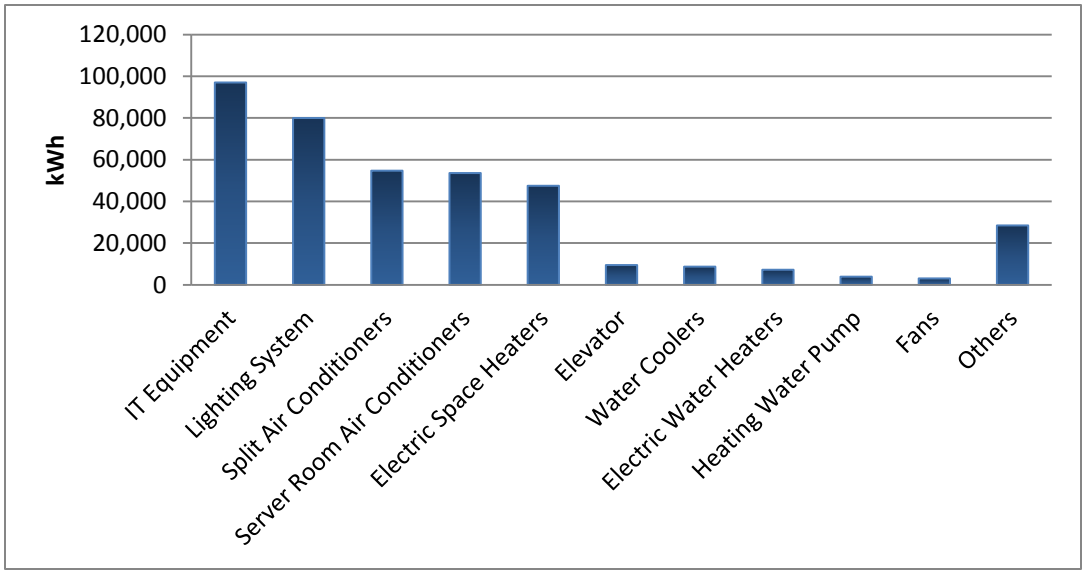
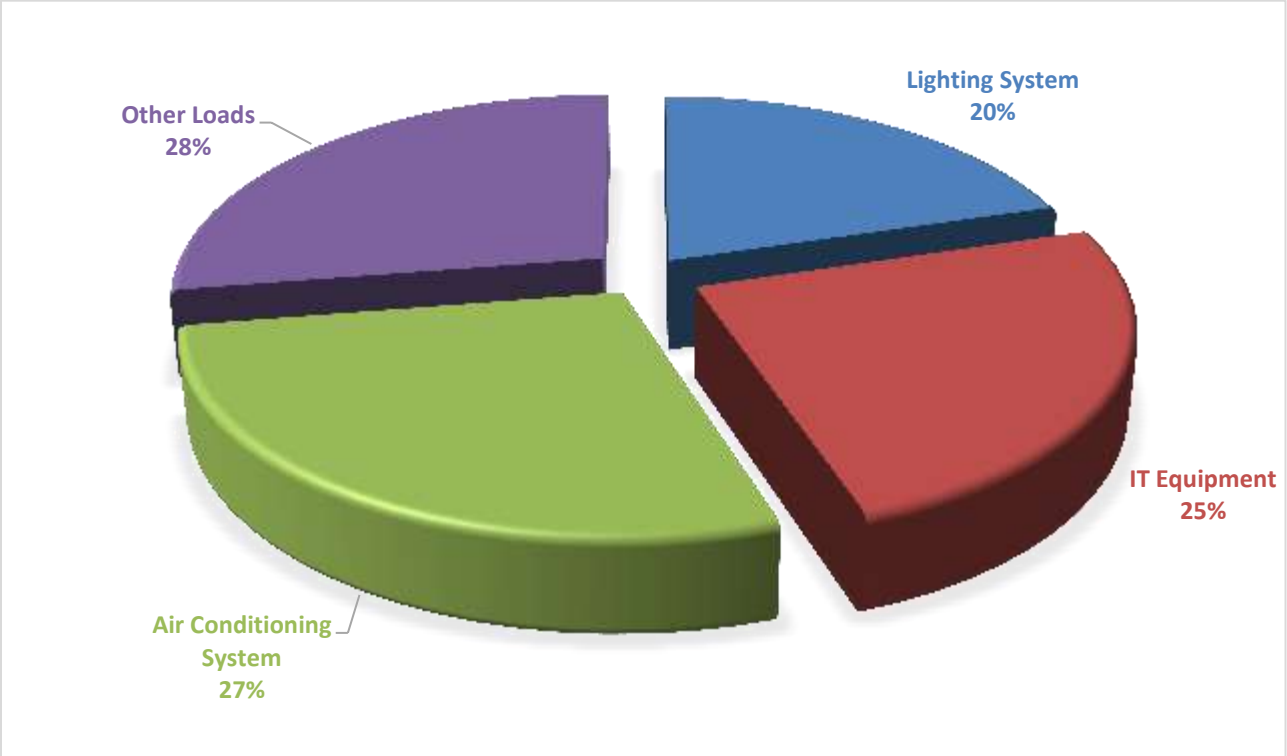


Table 7: Electricity Consumption [kWh] and Costs [JOD] Breakdown for main Electrical Consumers

Energy Consuming System	Annual Consumption kWh	Annual Cost JDs	% of Total Consumption
Lighting System	80,014	23,128	20%
IT Equipment	97,044	28,050	25%
Air Conditioning System	108,378	31,326	28%
Other Loads	108,580	31,385	28%
Total	394,016	113,890	100%

Figure 13: Electricity Bill Breakdown



4.4 FUEL CONSUMPTION

The total annual Fuel bills at EMRC were analysed over 2015. The main fuel consumed at the building is Diesel fuel for a purpose of heating **(Space Heating)**. EMRC invoices showed that the total fuel consumption during 2015 was **41,055** litres with an associated cost of **17,959 JD** the below table presents the monthly fuel consumption with the associated costs paid by the EMRC. It is obvious that actual monthly fuel consumption is not available as no fuel meters are installed at the Building. The only way available to know fuel consumption is from the Diesel Fuel filling invoices shown in the table below.

Table 8: Total Annual Fuel Consumption in Liters, Associated with their Costs in JD

Month	Fuel Consumption [Liters]	Cost [JD] based on 2014Tariff
Jan-15	6,330	2,880.2
Feb-15	7,440	3,385.2
Mar-15	6,840	3,112.2
Apr-15	6,045	2,750.5
May-15		0.0
Jun-15		0.0
Jul-15		0.0
Aug-15		0.0
Sep-15		0.0
Oct-15		0.0
Nov-15	7,050	2,890.5
Dec-15	7,350	2,940.0
Total	**41,055**	**17,959**
Average	**6,843**	**1,497**
Minimum	**6,045**	**0**
Maximum	**7,440**	**3,385**

From the above table, the following could be noted:

1. The monthly fuel consumption was in winter only; this is mainly due to operation of heating boilers only
2. The average fuel tariff during the past year was 0.44 JD/lit, since fuel tariff in Jordan is adjusted on monthly basis.

4.5 ENERGY USE INTENSITY

Energy Use Intensity (EUI) or Energy Use Index is a measure used by Energy Auditors to enable comparison of audited building to similar buildings in the same country or universally or to compare the building consumption with reference benchmark data according to a standard.

The strength of the EUI comparisons is their ease of use and widespread familiarity to find a benchmark reference data and compare similar buildings in the same climate zone within the country with similar energy consumption behaviour, similar schedule and building function.

In this project; six ministries' main buildings are being audited with reference to ASHRAE level II energy Audit, and the EUI shall be found for these ministries, then compare results to each other to set a benchmark reference data about governmental buildings in Jordan

EUI can be defined as the total amount energy consumed annually [kWh] divided by the gross utilized area [m^2]. In the international units, EUI is presented in [$kWh/m^2/year$].

EcoSol had examined and calculated EUI for EMRC building taking into consideration that most of the Area and offices at the building are Un-conditioned, the following table shows the details of EUI calculation for EMRC:

Table 9: Energy Use Intensity (EUI)

Parameter	Value
Total Building Built Up Area [m^2]	**6,300**
Total EMRC Electrical Energy Consumption [kWh/year]	**394,016**
Total EMRC Fuel Consumption [Liters/year]	**41,055**
Total EMRC Fuel Consumption [kWh/year]	**311,324**
Total EMRC Energy Consumption (Electricity and Fuel) [kWh/year]	**705,340**
Electrical Energy Use Intensity [$kWh/m^2/year$]	**112**

To provide indicative values only, and according to IEA (International Energy Agency, 2004), the average international EUI is 265 $kWh/m^2/year$ for commercial and offices buildings (Governmental Buildings could be considered as commercial buildings).

As shown above, EUI of EMRC is lower than the average world EUI, this is due to many factors:

- Common areas such as corridors, reception, most offices at the building…etc. are not air conditioned.
- Low lighting level in different areas.
- Using Electrical Water Heaters in winter only.
- Differences in weather conditions and general moderate weather conditions in Jordan.

However, this simple and direct way of benchmarking should be treated in more depth considering the different factors in a country like Jordan. Saving Energy must consider other factors like comfort levels, staff productivity and general buildings and facility operational conditions.

5.0 FINDINGS AND RECCOMENDTAIONS

This section provides in depth the findings and recommendations that shall be implemented to reduce energy consumption by 31.1%, the below recommendations were quoted as they proved to be the most economically feasible:

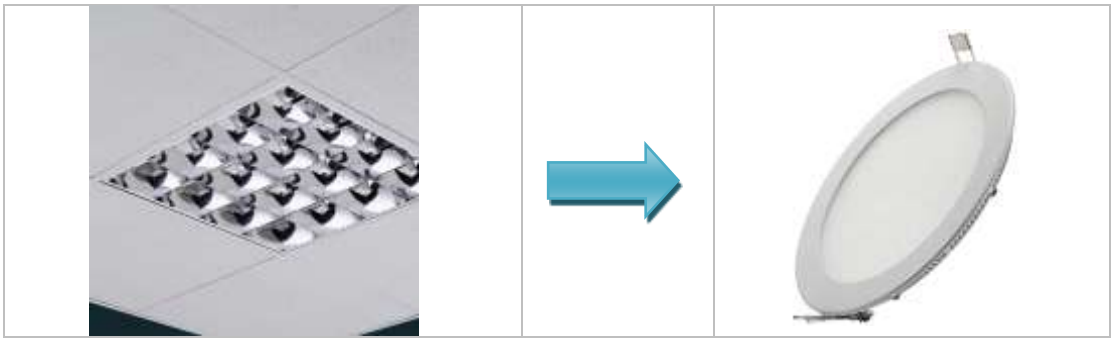
L.1: Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas

Finding Description and Recommendations:

During the energy audit stage, a detailed lighting survey was carried out to identify lamps type, energy consumption and the illumination levels in the various areas at the building. The energy audit showed that many offices and open spaces in building is being served Fluorescent lamps 4X18 Watt.

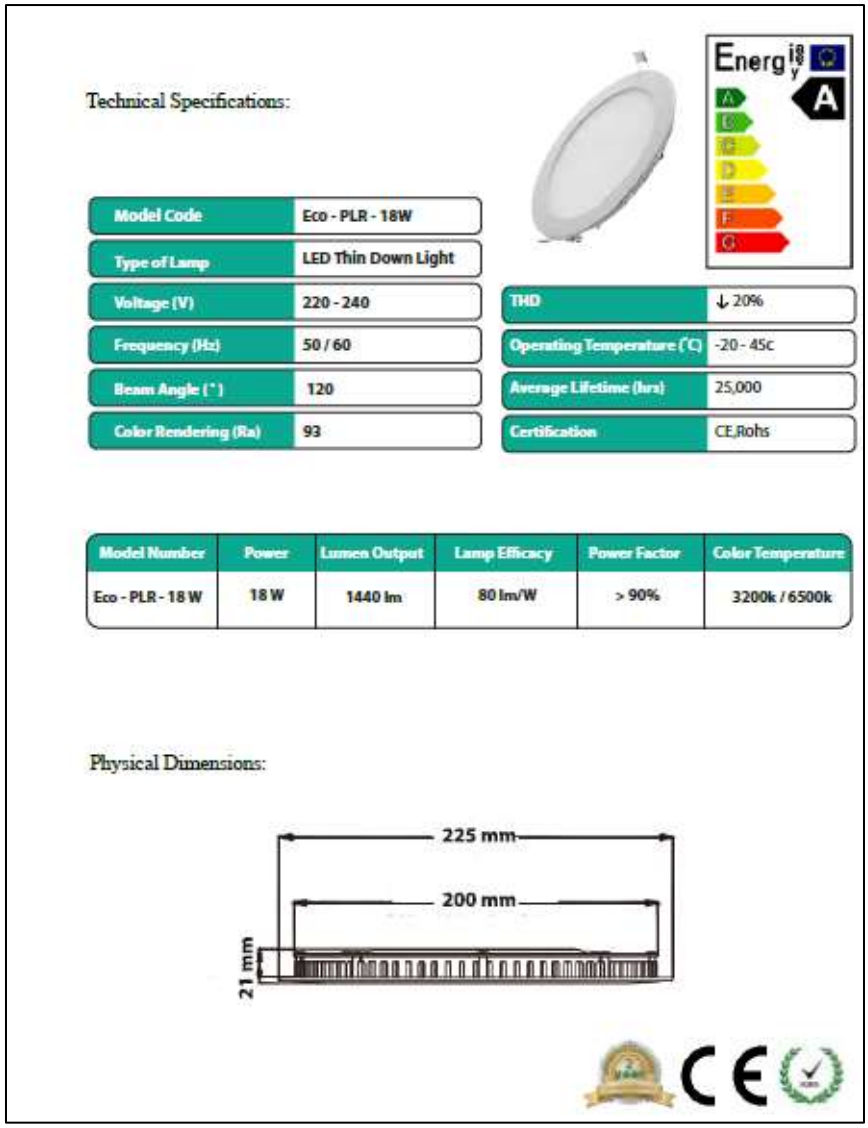
Fluorescent lamps are considered as one of the medium efficiency lamps if compared to the other lamps. Conversely, new revolution of the lighting technology had introduced new lamps which relays on a semi-conductor technology called LED lamps.

To assist in reducing the lighting system energy consumption at EMRC, it is recommended to replace the fluorescent lamps FL 4X18 Watt by LED Round Panel 18 Watt.



Special attention must be given to the specifications of the new LED fixtures by choosing those with suitable lumens and quality. Following is one recommended example

Figure 14: Proposed LED Round Panel Specifications



Technical Specifications:

Model Code	Eco - PLR - 18W
Type of Lamp	LED Thin Down Light
Voltage (V)	220 - 240
Frequency (Hz)	50 / 60
Beam Angle (°)	120
Color Rendering (Ra)	93

THD	↓ 20%
Operating Temperature (°C)	-20 - 45c
Average Lifetime (hrs)	25,000
Certification	CE,Rohs

Model Number	Power	Lumen Output	Lamp Efficacy	Power Factor	Color Temperature
Eco - PLR - 18 W	18 W	1440 lm	80 lm/W	> 90%	3200k / 6500k

Physical Dimensions:

Lumen output of LED round panel 18 watt (**1400-1500 lumen/lamp**) is less than lumen output of Fluorescent lamps 4X18 Watt (**700 lumen/lamp, or 2800 lumen/fixture**), but Replacing Fluorescent lamps by ultra-high efficient LED Lamps will provide almost the same lux level due to the following factors

- The fluorescent lamps fixture's efficiency is about 0.5 to 0.7, this will reduce the gross lumen reaching the task areas to be about 1400 to 1960 lumens which is in the range of the LED lumen output.
- Rapid lumen depreciation of fluorescent lamps over operational life time if compared to LED lamps.

Furthermore, Color rendering index of LED lamps is better than the color rendering index of fluorescent lamps which improves the lighting characteristics.

Implementing this measure will result in reducing energy consumption for fluorescent lamps by about 80%.

It's worth to be mentioned here that the life time of the proposed LED lamps is about 25,000 hours which is much higher than the existing fluorescent lamps (about 6000 – 8000 hours). This will reduce the replacement cost and maintenance cost for the existing lamps. Maintenance cost savings were not considered at this stage and left as an extra benefit for implementing this measure.

The below table illustrates the replacement of FL 4X18 Watt by LED Round Panel 18 Watt.

Table 10: Details of Replacing Fluorescent Lamps 4x18 Watt by LED Round Panel 18 Watt down Lights

Area	fixture type	fixture wattage	Q'ty	Annual Consumption		Annual Saving	
				Consumption [kWh/year]	Cost [JD/year]	kWh saving	Cost Saving
الطابق الأرضي							
قسم المختبرات الاشعاعية	FL 4X18	90	4	760	220	608.3	175.8
الديوان	FL 4X18	90	4	760	220	608.3	175.8
قسم ادراة الموارد البشرية	FL 4X18	90	10	1,901	549	1520.6	439.5
مدير مديرية الموارد البشرية	FL 4X18	90	3	570	165	456.2	131.9
الدائرة القانونية	FL 4X18	90	2	380	110	304.1	87.9
قسم الشؤون القانونوية	FL 4X18	90	4	760	220	608.3	175.8
قسم التراخيص	FL 4X18	90	2	380	110	304.1	87.9
الممر الرئيسي	FL 4X18	90	45	12,830	3,709	10264.3	2966.9
الطابق الأول							
مدير مكتب الرئيس التنفيذي	FL 4X18	90	4	950	275	760.3	219.8
ممر جنوبي	FL 4X18	90	7	1,996	577	1596.7	461.5
ممر شمالي	FL 4X18	90	7	1,331	385	1064.4	307.7
المكتبة	FL 4X18	90	14	2,661	769	2128.9	615.4
الطابق الثاني							
غرفة السيرفر	FL 4X36	180	6	2,281	659	1824.8	527.4
ممر	FL 1X36	45	3	428	124	256.6	74.2
Total			**115.0**	**27,989.3**	**8,090.3**	**22,305.9**	**6,447.5**

- **Please refer to annex to section 11.2 for more information about lighting system operating hours, and Lux levels**

It is worth to be mentioned that the replacement of Fluorescent Lamps FL 4X18 Watt by recessed LED Round Panel 18 Watt requires installing new false ceiling panel. The cost of the new false ceiling panel is included in the implementation cost.

To examine the proposed replacement, EcoSol had simulated the existing illumination level in some selected offices during the Audit phase and the expected illumination level after carrying out the proposed replacement of the existing lamps by LED lamps, output results are provided in **Annex 11.3**.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**22,306**	**6,447**	**5.7%***	**1,527**	**2.8**

** The above saving percentage is out of the total annual electrical energy bill*

L.2: Replace the Existing Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt in some Selected Areas.

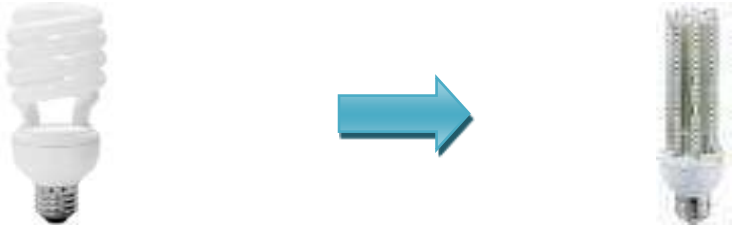
Finding Description and Recommendations:

During Lighting Survey, several details about Lighting system were observed and investigated, these details covering lighting fixtures types, distribution and number of lighting fixtures. Some Areas and offices were served by Compact fluorescent lamps CFL 2X26 Watt and CFL2X23 Watt.

Generally, Compact Fluorescent Lamps (CFLs), or energy saving lamps, are considered as one of the most efficient lamps if compared to other lighting families.

LED lamps revolution, which is spreading the lighting world rapidly, has covered most designs, applications and requirements. One of LED products is the Bulb LED light, that designed specially to replace compact fluorescent lamps, and available in wide range of shapes, colors and wattage to meet several application needs

Therefore, to assist in reducing energy consumption; it is recommended to replace the CFL lamps 26 watt and CFL 23 watt by new technology LED U-Bulb 12 Watt.



Implementing this measure will save around 50 % of those lamps energy consumption, and about 1% of the total annual electrical Bill.

The below table shows the proposed areas and the details of implementing this measure.

Table 11: Details of Replacing of Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt

Area	fixture type	fixture wattage	Q'ty	Annual Consumption		Annual Saving	
				Consumption kWh/yr	Cost JD/yr	kWh saving	Cost saving
طابق التسوية							
غرفة الخدمات	CFL 40	40	2	225	65	134.8	39.0
الطابق الأرضي							
وحدة الضبط و التفتيش	CFL 2X23 Watt	46	3	291	84	139.4	40.3
الدائرة القانونية	CFL 2X23 Watt	46	8	777	225	371.7	107.4
وحدة المناجم و المقالع	CFL 2X23 Watt	46	22	2,137	618	1022.2	295.5
قسم الرقابة و التفتيش و الجودة	CFL 2X23 Watt	46	19	1,846	534	882.8	255.2
قسم التراخيص	CFL 2X23 Watt	46	9	874	253	418.2	120.9
الاستقبال	CFL 2X23 Watt	46	16	2,332	674	1115.1	322.3
الطابق الأول							
حمام الرئيس التنفيذي	CFL 2X23 Watt	46	3	437	126	209.1	60.4
Total			**82.0**	**8,919.7**	**2,578.2**	**4,293.3**	**1,241.0**

- **Please refer to annex to section 11.2 for more information about lighting system operating hours**

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**4,293**	**1,241**	**1.1%***	**1,300**	**12.6**

***** *The above saving percentage is out of the total annual electrical energy bill*

L.3: Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors.

Finding Description and Recommendations:

The energy audit revealed that the light is put ON in some offices and Toilets even if they are un-occupied. A simple and smart way to reduce lighting consumption is to switch off these lighting when nobody exists automatically by using occupancy sensors; either presence or motion sensors.

Presence sensors which are more sensitive than motion sensors are being used widely to control lighting fixtures according to the detected human presence within intermittently occupied areas. It turns the lights off, instead of conventional toggle switch when nobody is in the area after a certain period of time. This period of time could be adjusted by the staff using these areas. Presence sensors could be installed in offices and other areas where humans exist.

Conversely, Motion sensors are being used widely to control lighting fixtures' operation according to the detected human movement at areas which hosts not productive humans with any permanent stay such as toilets, corridors, pathways, etc.

Therefore, to help in reducing energy consumption at the building, it is recommended to control the lighting operation in some selected areas by occupancy sensors (presence / motion) to switch off the light when nobody exists instead of conventional toggle switches. Where presence sensors are proposed to control the lighting operation at offices, the motion sensors are proposed to control the lighting operation at toilets.

The below table shows the proposed areas and the details of implementing this measure.

Table 12: Control Lighting Fixtures in Some Selected Areas Using Presence/Motion Sensors

Area	fixture type	fixture wattage	Q'ty	Annual Consumption		ECM	Annual Saving	
				Consumption kWh/yr	Cost JD/ yr		kWh saving	Cost saving
طابق التسوية								
غرفة الكهرباء	FL 2X36	90	4	3,110	899	Motion Sensor	2799.4	809.2
الطابق الأرضي								
قسم الخدمات الادارية	LED PLR 18	18	6	228	66	Occupancy Sensor	68.4	19.8
مدير مديرية الموارد البشرية	FL 4X18	90	3	570	165	Occupancy Sensor	34.2	9.9
مدير مديرية البترول و الصخر الزيتي	LED PLR 18	18	6	228	66	Occupancy Sensor	68.4	19.8
مدير وحدة المناجم و المقالع	LED PL 40	40	6	507	147	Occupancy Sensor	169.0	48.8
حمام رجال	LED PLR 18	18	5	190	55	Motion Sensor	57.0	16.5
حمام سيدات	LED PLR 18	18	5	190	55	Motion Sensor	57.0	16.5
ممر	FL 4X18	90	45	12,830	3,709	Motion Sensor	855.4	247.2
الطابق الأول								
ممر	LED PL 40	40	13	2,246	649	Motion Sensor	576.0	166.5
مدير مكتب الرئيس التنفيذي	FL 4X18	90	4	950	275	Occupancy Sensor	57.0	16.5
الرئيس التنفيذي	LED PL 40	40	12	1,521	440	Occupancy Sensor	456.2	131.9
ممر	FL 4X18	90	7	1,996	577	Motion Sensor	133.1	38.5
حمام رجال	LED PLR 18	18	4	622	180	Motion Sensor	186.6	53.9
المدير المالي	LED PLR 18	18	4	152	44	Occupancy Sensor	45.6	13.2
حمام سيدات	LED PLR 18	18	4	152	44	Motion Sensor	45.6	13.2
ممر	FL 4X18	90	7	1,331	385	Motion Sensor	88.7	25.6
الطابق الثاني								
مدير وحدة ضبط الجودة	LED PLR 18	18	6	228	66	Occupancy Sensor	68.4	19.8
حمام رجال	LED PLR 18	18	6	228	66	Motion Sensor	68.4	19.8
غرفة السيرفر	FL 4X36	180	6	2,281	659	Occupancy Sensor	380.2	109.9
حمام سيدات	LED PLR 18	18	6	228	66	Motion Sensor	68.4	19.8
مدير تكنولوجيا المعلومات	LED PLR 18	18	10	380	110	Occupancy Sensor	114.0	33.0
المستشار 2	LED PLR 18	18	6	228	66	Occupancy Sensor	68.4	19.8
نائب الرئيس التنفيذي	LED PLR 18	18	4	152	44	Occupancy Sensor	45.6	13.2
المفوض م. وجدان الربضي	LED PLR 18	18	4	152	44	Occupancy Sensor	45.6	13.2
المفوض د. مجد الهواري	LED PLR 18	18	4	152	44	Occupancy Sensor	45.6	13.2
المفوض بشير السرور	LED PLR 18	18	4	152	44	Occupancy Sensor	45.6	13.2
مصلى	LED PLR 18	18	6	228	66	Occupancy Sensor	136.9	39.6
ممر	LED PLR 18	18	31	1,178	341	Motion Sensor#4	294.6	85.2
Total			**228.0**	**32,412.7**	**9,368.8**		**7,079.5**	**2,046.3**

- **Please refer to annex to section 11.2 for more information about lighting system operating hours**

Implementing this measure reduces the lighting system's energy consumption at offices by up to 10% based on the occupancy type of these areas, while motion sensors (proposed in toilets) reduces lighting system's energy consumption by about 40%.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**7,080**	**2,046**	**1.8%***	**1,575**	**9.2**

***** *The above saving percentage is out of the total annual electrical energy bill*

L.4: Control the Operation of Lighting system in Some Selected Areas using Day Lighting Sensor

Finding Description and Recommendations:

During the energy audit stage, it was observed that the most southern offices lamps are in operation even if the sunlight is passing through the window and sufficient light level is obtained, knowing that the architecture of the building allows the trespass of natural lighting through windows that represent about 60% of the southern façade.

Natural day lighting improves human comforts and saves energy if it was harvested successfully. Daylight harvesting is a concept of utilizing the light of sky or sun inside the building through a control system uses a signal for daylight sensor that measures brightness or luminance to switch the artificial lighting system ON or OFF, in order to reduce energy consumption.

It was observed that the light level in southern offices are served by a high level of natural lighting while the artificial light was turned ON. The conducted lighting level measurements showed that those areas have a lighting level of more than 500 lux with the artificial lighting is ON and it was reduced to 330 - 400 lux (average) when artificial lighting was switched OFF, which is in the range of the international standards which requires 300-500 Lux for offices as per the CIBSE code (Chattered Institution of Building Service Engineers - London / UK).

Therefore, to assist in reducing energy consumption at EMRC; it is recommended to install Daylight Sensors to control Lighting fixtures' operation in southern offices. Energy savings result from the installation of a day lighting sensors are considerably high in Jordan since there are about 330 sunny days a year providing a great potential of harvesting the natural lighting and saving energy. It is worth to be mentioned here that one day light sensor is capable of controlling the lighting system in the southern areas which they are all exposed to the same building orientation and thus the same day light level.

The below table shows the proposed areas and the details of implementing this measure.

Table 13: Control Lighting Fixtures in Some Selected Areas Using Daylight Sensors

Area	fixture type	fixture wattage	Q'ty	Light Level [Lux]		Annual Consumption		ECM	Annual Saving	
				Actual	Standard	Consumption kWh/yr	Cost JD /yr		kWh saving	cost saving
الطابق الأرضي										
قسم ادراة الموارد البشرية	FL 4X18	90	10	750	300-500	1,901	549	Daylight Control of all units	237.6	68.7
خدمة الجمهور	LED PLR 18	18	6	1200	300-500	228	66	Daylight Control of all units	171.1	49.4
وحدة المناجم و المقالع	CFL 2X23	46	22	800	300-500	2,137	618	Daylight Control of all units	697.0	201.5
قسم الرقابة و التفتيش و الجودة	CFL 2X23	46	19	700	300-500	1,846	534	Daylight Control of all units	601.9	174.0
قسم التراخيص	CFL 2X23	46	9	820	300-500	874	253	Daylight Control of all units	285.1	82.4
الطابق الأول										
مديرية الأمن النووي	LED PLR 18	18	14	-	300-500	532	154	Daylight Control of all units	399.2	115.4
الطابق الثاني										
مديرية الكهرباء و الطاقة المتجددة	LED PLR 18	18	35	600	300-500	1,331	385	Daylight control on 14 units	372.6	107.7
وحدة ضبط الجودة	LED PLR 18	18	15	1000	300-500	570	165	Daylight control on 10 units	266.1	76.9
مديرية التعرفة و تحليل الأداء المالي	LED PLR 18	18	6	1000	300-500	228	66	Daylight Control of all units	171.1	49.4
قسم الحاسوب	LED PLR 18	18	26	750	300-500	988	286	Daylight control on 15 units	399.2	115.4
Total			**162.0**			**10,636.0**	**3,074.3**		**3,600.7**	**1,040.8**

Implementing this measure is estimated to save about 35% of the lighting system's energy consumption at the proposed areas.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**3,601**	**1,041**	**0.9%***	**1,200**	**13.8**

***** *The above saving percentage is out of the total annual electrical energy bill*

L.5: General Recommendations on Lighting System in Some Areas

Finding Description and Recommendations:

During Lighting Survey, several details about Lighting system were observed and investigated, these details covering lighting fixtures distribution, number of lighting fixtures and wiring of Lighting fixtures.

In many locations, it was found that the number of lighting fixtures is overdesigned and causing Lighting level to exceed international standards which lead to an excessive and un-justified energy consumption.

On the other hand, the wiring of fixtures series in some areas was not suitable for working environment, resulting in switching un-needed lighting simply because it is powered from the same source of the needed lighting.

This measure recommends for several actions includes the reduction of installed number of lighting fixtures in some selected areas which found to be illuminated by more than the international standards, turn off unneeded lighting fixture in some selected areas that found over lighted without justified reason, and replace old lighting fixtures with new efficient LED lamps.

The following table shows the details of implementing this measure

Table 14: General Recommendations on Lighting System in Some Areas

Area	fixture type	fixture wattage	Q'ty	Annual Consumption		ECM	Annual Saving	
				Consumption kWh/yr	cost JD/ yr		kWh saving	cost saving
الطابق الأرضي								
قسم المختبرات الاشعاعية	FL 2X36	90	2	380	110	LED Tube 2X18 Watt	228.1	65.9
مدير وحدة المناجم و المقالع	LED PL 40	40	6	507	147	reduce by 2 Fixture	253.4	73.3
مدير وحدة المناجم و المقالع	CFL 2X23 Watt	46	1	97	28	Turn Off	97.2	28.1
إنارة ديكور	FL 1X18	23	48	2,332	674	LED Tube 8 Watt	1520.6	439.5
إنارة ديكور	INC R80 75	75	32	5,069	1,465	Turn Off	5068.8	1465.1
ممر	LED PL 40	40	13	2,246	649	reduce by 3 Fixtures	518.4	149.8
Total			**89.0**	**10,631.0**	**3,072.9**		**7,686.5**	**2,221.8**

- **Please refer to annex to section 11.2 for more information about lighting system operating hours**

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**7,687**	**2,222**	**2.0%***	**436**	**2.4**

***** *The above saving percentage is out of the total annual electrical energy bill*

AC.1: Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.

Finding Description and Recommendations:

During the energy audit phase, it was noticed that the air conditioners' (Split Units) set-points on the thermostat does not comply with the international standards where it was noted that the average set point is about 28 °C (heating mode) while the optimum temperature for human comfort and energy efficiency is 25 °C according to ASHRAE recommendations, knowing that audit was conducted in April.

At the same time, it was advised that the set point at summer time (cooling mode) is adjusted to be between 18 °C – 20 °C while the optimum temperature is 23 °C.

Decreasing/increasing the set point to the lower / higher value posts extra load on the AC compressor, resulting in consuming and wasting more energy and depreciating the A/C system as well.

Therefore, to assist in reducing the air conditioning system's energy consumption, it is recommended to optimize the set-point values of all air conditioners to be 23 °C at winter time and 24 °C at summer time. This will keep the conditioned areas with optimum comfort level and reduce the AC system energy consumption.

The set point of the AC system can be re-programmed to limit the set point to the optimum values.

Implementing this measure will save around 10% of AC System electrical energy consumption, and 1.3 % of the total electricity bill, the actual savings from appling this measures is higher than 10% as we consider a facotr of 25% as saftey factor to be conservative in the analysis.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**5,280**	**1,526**	**1.3%***	**525**	**4.1**

***** *The above saving percentage is out of the total annual electrical energy bill*

The above investment was calculated based on purchasing new remote controls programmed to limit the set point to the above mentioned values, the cost of each remote control is JD 15. And to reprogram control thermostats of central AC system

AC.2: Relocate the Outdoor Units of the Server Room AC's to a Well Ventilated Location.

Finding Description and Recommendations:

The correct installation of AC system is one of the important issues to ensure high running efficiency of any air conditioning system where a well-ventilated location away from obstacles and preferably shaded is the optimum place to install the outdoor unit of the AC system.

The outdoor unit of split AC (which contains key components of split AC like compressor, condenser, fan motor etc.) should be installed in a location free from obstacles to allow the air to pass freely on the heat exchanger which help the heat transfer process in the outdoor unit to be at the optimum rates.

During the energy audit stage, the server room Air Conditioning was studied intensively; two AC split units each is 4 RT were installed to serve the server room by its need from cooling.

The outdoor units, are installed on the roof of the building, found installed in almost closed space as illustrated in the above photo.

Installation outdoor unit in closed space will affect the efficiency of the unit significantly since the heat rejected from the condenser will increase the temperature of the air surrounding the unit, and this hot air will be circulated in the same space and entering the condenser again, causing less heat transfer in the condenser and decreasing the efficiency of the cycle.

EcoSol has measured the actual temperatures of the air entering and leaving the condenser of outdoor units, and the ambient temperature at the same time. The ambient temperature was 35.5 C, and the temperature of air entering the condensers of the units was 44 C for the first unit (which is partially surrounded by walls) and 47 C for the second one (that almost surrounded by walls and the first unit).

By referring to the manufacturer performance table for similar product, it was found that increasing the temperature of the air entering the condenser will increase the power consumed by the AC.

The following figure shows screenshot from the performance table of the manufacturer.

Figure 15: Screenshot from the Performance Table of the Server Room AC Split unit

MODEL	EVAPORATOR			OUTDOOR ENTERING TEMPERATURE (°F)											
	AFR	ON COIL		85			95			105			115		
		DB	WB	T.Cap	S.Cap	PI	T.Cap	S.Cap	PI	T.Cap	S.Cap	PI	T.Cap	S.Cap	PI
DSP 24+CMD 10X3	1048	76	62	26.4	21.1	2.3	25.1	20.6	2.4	23.8	20.1	2.6	22.4	19.5	2.7
		78	65	27.4	21.0	2.3	26.1	20.5	2.5	24.7	20.0	2.6	23.3	19.5	2.8
		80	67	28.7	21.0	2.4	27.4	20.5	2.5	26.0	20.1	2.7	24.5	19.6	2.9
	876	76	62	25.7	19.2	2.3	24.5	18.7	2.4	23.2	18.2	2.6	21.8	17.7	2.7
		78	65	26.6	19.1	2.3	25.4	18.6	2.5	24.1	18.1	2.6	22.7	17.6	2.8
		80	67	27.9	19.1	2.3	26.6	18.7	2.5	25.3	18.2	2.7	23.9	17.7	2.8
	682	76	62	24.6	16.9	2.2	23.4	16.4	2.4	22.2	15.9	2.5	21.0	15.5	2.7
		78	65	25.5	16.9	2.3	24.3	16.4	2.4	23.1	15.9	2.6	21.8	15.4	2.7
		80	67	26.7	16.9	2.3	25.5	16.4	2.5	24.2	16.0	2.6	22.9	15.5	2.8
DSP 30+CMD 10X3	1048	76	62	28.4	21.8	2.5	27.0	21.3	2.7	25.5	20.7	2.8	23.8	20.1	3.0
		78	65	29.5	21.8	2.6	28.0	21.2	2.7	26.5	20.6	2.9	24.8	20.0	3.0
		80	67	30.9	21.8	2.6	29.5	21.3	2.8	27.9	20.7	3.0	26.1	20.1	3.1
	876	76	62	27.6	19.9	2.5	26.2	19.4	2.6	24.8	18.8	2.8	23.2	18.2	2.9
		78	65	28.6	19.9	2.5	27.2	19.3	2.7	25.7	18.8	2.8	24.1	18.2	3.0
		80	67	30.0	19.9	2.6	28.6	19.4	2.7	27.1	18.8	2.9	25.4	18.2	3.1
	682	76	62	26.2	17.6	2.4	25.0	17.1	2.6	23.7	16.5	2.7	22.2	16.0	2.9
		78	65	27.2	17.6	2.5	25.9	17.0	2.6	24.6	16.5	2.8	23.1	15.9	2.9
		80	67	28.5	17.6	2.5	27.2	17.1	2.7	25.8	16.5	2.8	24.3	16.0	3.0
DSP 36+CMD 16X3	1688	76	62	35.1	31.1	2.2	33.6	30.6	2.5	32.1	30.1	2.8	30.5	29.5	3.2
		78	65	36.3	31.0	2.2	34.8	30.5	2.5	33.3	30.0	2.8	31.7	29.4	3.2
		80	67	38.1	31.1	2.3	36.6	30.6	2.6	35.0	30.0	2.9	33.3	29.5	3.2
	1343	76	62	34.1	27.4	2.2	32.7	26.9	2.5	31.3	26.3	2.8	29.7	25.7	3.1
		78	65	35.3	27.3	2.2	33.9	26.8	2.5	32.4	26.3	2.8	30.8	25.7	3.2
		80	67	37.0	27.4	2.3	35.5	26.8	2.5	34.0	26.3	2.9	32.4	25.7	3.2
	1106	76	62	33.1	24.7	2.2	31.8	24.2	2.4	30.5	23.7	2.8	28.9	23.1	3.1
		78	65	34.3	24.6	2.2	33.0	24.1	2.5	31.6	23.6	2.8	30.0	23.0	3.2
		80	67	35.9	24.6	2.2	34.5	24.1	2.5	33.1	23.6	2.8	31.5	23.0	3.2
DSP 48+CMD 16X3	1688	76	62	48.2	36.2	3.6	46.3	35.4	4.0	44.5	34.7	4.5	42.8	34.1	5.1
		78	65	49.7	36.0	3.6	47.9	35.2	4.1	46.1	34.6	4.5	44.3	33.9	5.1
		80	67	51.9	35.9	3.7	50.1	35.3	4.1	48.2	34.6	4.6	46.4	33.9	5.2
	1343	76	62	46.4	32.3	3.5	44.7	31.7	3.9	43.0	30.9	4.4	41.3	30.3	5.0
		78	65	48.0	32.2	3.6	46.2	31.5	4.0	44.5	30.8	4.5	42.8	30.1	5.1
		80	67	50.0	32.1	3.6	48.2	31.5	4.1	46.5	30.8	4.6	44.8	30.2	5.2
	1106	76	62	44.7	29.5	3.5	43.1	28.9	3.9	41.5	28.1	4.4	39.9	27.5	5.0
		78	65	46.2	29.3	3.5	44.6	28.7	3.9	42.9	28.0	4.4	41.3	27.3	5.0
		80	67	48.2	29.4	3.6	46.5	28.7	4.0	44.9	28.1	4.5	43.2	27.4	5.1

LEGEND

T.CAP: Total Capacity [MBH]
S.CAP: Sensible Capacity [MBH]
PI: Power Input for compressors only [kW]
AFR: Evaporator air flow rate [CFM]
DB: Dry Bulb temperature [°F]
WB: Wet Bulb temperature [°F]

From the above figure, it could be noticed that increasing the outdoor entering temperature from 95 Fahrenheit (35 C) to 115 Fahrenheit (46 C) will increase the input power from 4.1 kW to 5.2 kW.

To assist in reducing energy consumption of the server room AC, it is recommended to relocate the outdoor units of the AC's to a well-ventilated location (preferably shaded).

Implementing this measure will save about 16% of those AC's power consumption and about 2.3% of the total annual electrical energy bill.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**8,991**	**2,599**	**2.3%***	**750**	**3.5**

***** *The above saving percentage is out of the total annual electrical energy bill*

AC.3: Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System.

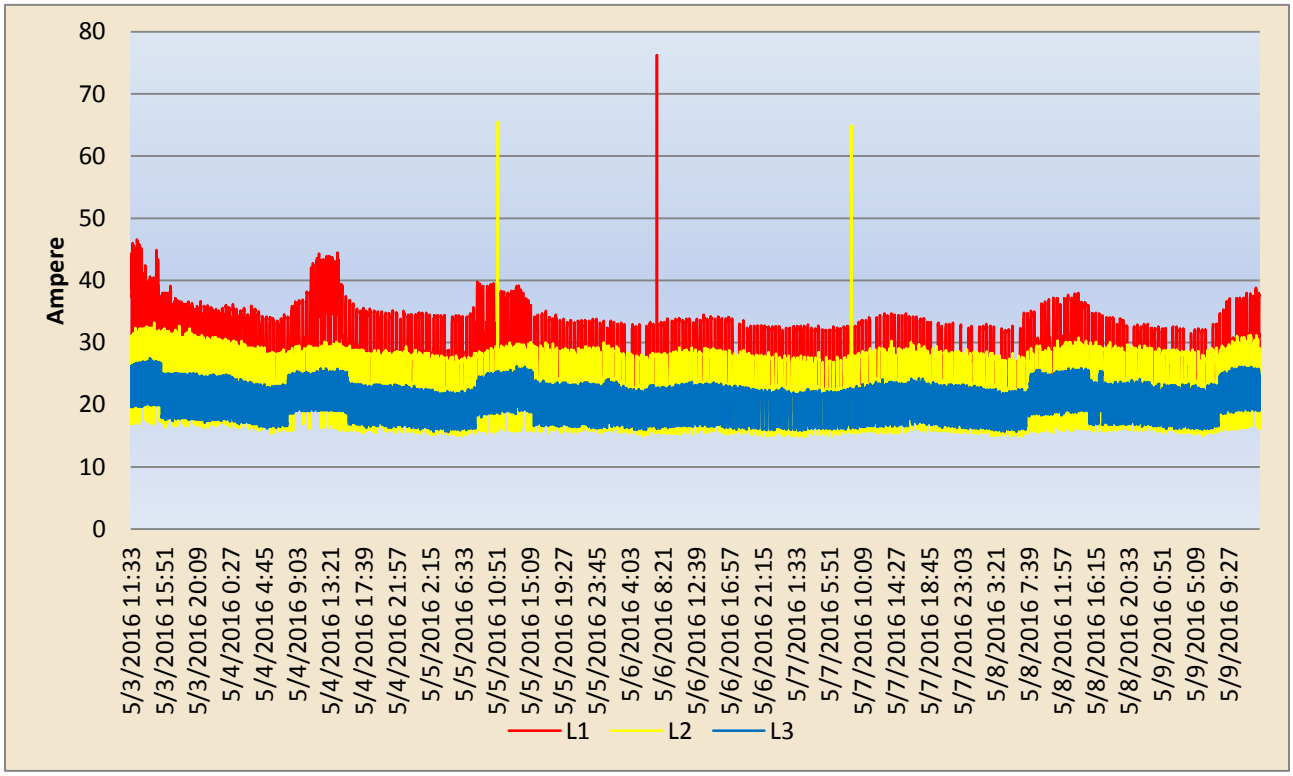
Finding Description and Recommendations:

The Server Rooms at EMRC Building is considered as a major load on AC system due to the huge amount of rejected heat, this AC system represents about 14% of the electrical energy consumers at the building.

Server room is supplied by its need from cooling by two AC Split units; each of 4.0 RT (Refrigeration Ton) capacities as in the previous measure, both of them are operational.

EcoSol had monitored the work trend of Server room air conditioning using special current data loggers. The following figure illustrates working trend of server room AC at EMRC.

Figure 16: Electrical Current [Amp] as Measured on the Air Conditioning of Server Room and Server AC (May 3, 2016 – May 9, 2016



From the above figure it could be noticed that AC was running continuously to provide the required cooling for server room.

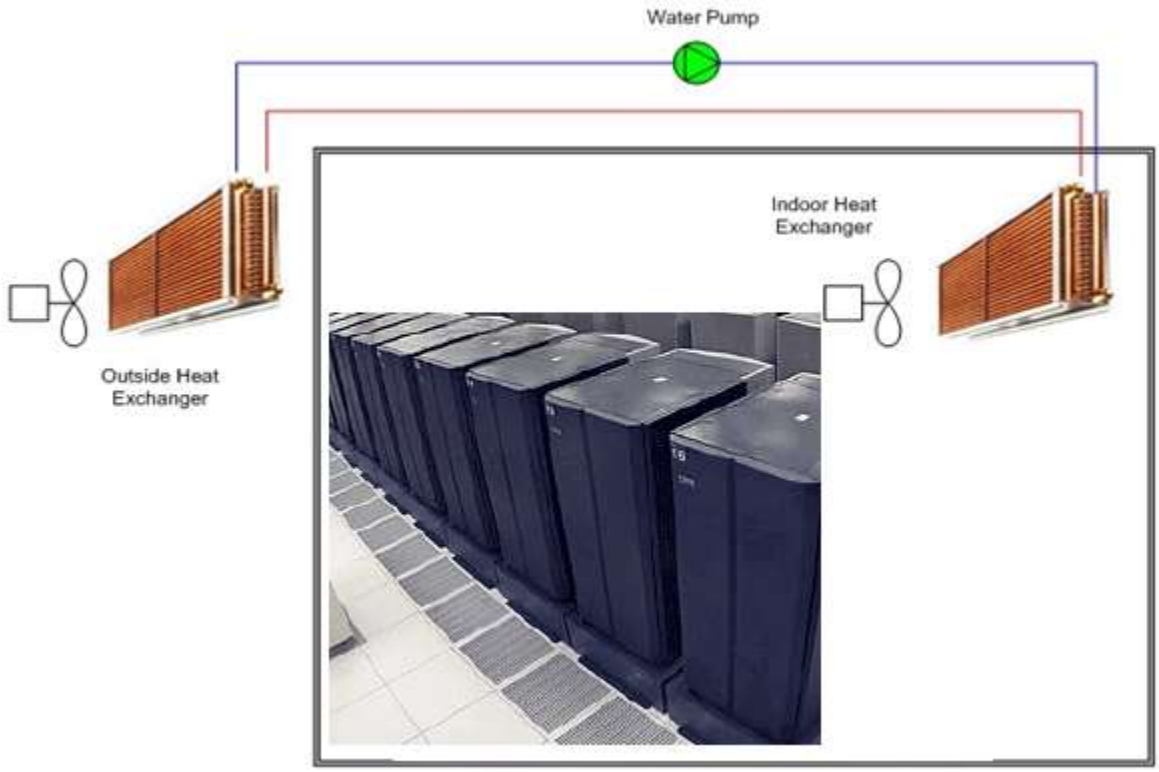
The cooling design for this area is based on circulating the room air through the AC heat exchanger to provide the required cooling and keeping the temperature inside the server room in the range of 19 - 20°C with no outside air compensation to maintain the humidity at the acceptable levels which was found to be in the range of (40-60%).

Jordan climate is chilly at winter time as many days had recorded an ambient temperature lower than 19°C as per the Jordan Meteorological Department. This provides an opportunity to utilize the low ambient air temperature to provide "free cooling" for server room by introducing a heat recovery system.

EcoSol had studied this measure intensively during the audit phase, where it was found that utilizing the low temperature ambient is suitable and satisfy the energy efficiency requirement without affecting the operation and the safety of the instrument.

For this purpose and to reduce energy consumption at the server room, it is recommended to install a run around coil heat exchanger working as a heat recovery system to utilize the ambient air temperature when it falls below 19°C mainly at winter time and in some nights at summer time. the run around coil heat exchanger consists of two cooling coils (heat exchangers) one to be located inside the room and the other one to be located outside the building, those two coils will be connected to each other by a copper pipe which allows the coolant liquid (water or glycol ethylene) to be circulated in both coils by small pump, each coil will be equipped by a fan for heat exchanging purposes.

The below figure illustrates the proposed system graphically.



The following table highlights the specifications of the main parts in the system:

Table 15: Heat Recovery System Specifications

Part	Specifications	Q'ty
Inside Heat Exchanger	Fan Coil Unit with Cooling Capacity of 45,000 BTU/Hr.	2
Outside Heat Exchanger	Air Handling Unit with Cooling Capacity of 88 MBH (M BTU/Hr.)	1
Water Pump	50 Watt Circulating Water Pump	1

The control of this system should be based on two temperature sensors; one is located inside the room and the other one is located outside the room to measure the difference of the temperature and to switch ON the system when the outside air temperature is less than the indoor temperature. The indoor sensor will switch off the system when the server room temperature falls below 13 degrees.

Implementing this measure is expected to provide the required cooling for around 2940 hours per year and can save around 30% of the AC consumption at the server room.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**16,965**	**4,904**	**4.3%***	**8,165**	**20.0**

** The above saving percentage is out of the total annual electrical energy bills*

O.1: Improve and Optimize Existing Heating System and Prohibit Use of Electric Space Heaters

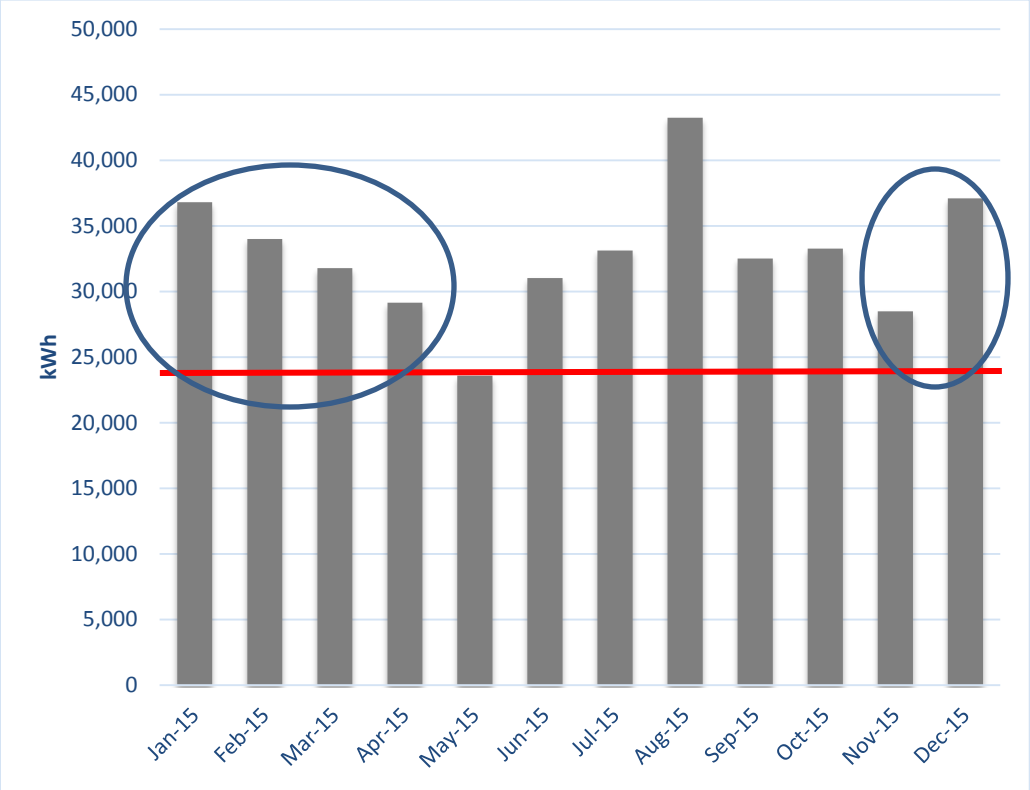
Finding Description and Recommendations:

Heating System is one of the main energy systems in the EMRC building that was fully investigated during the energy audit. EMRC heating is mainly provided through a Diesel Fuel Boilers through a big network of pipes and radiators distributed in all spaces and offices of the building.

During the energy audit, it was noticed that electric space heaters (54 units as advised by EMRC technical team) are also used by EMRC employees as heating source, while in other offices Split AC Units used in heating mode also, knowing that audit was conducted in April. The staff reported that conventional fuel heating system through radiators was not working properly.

The following figure shows monthly electrical energy bills over the base line period.

Figure 17: Electricity Consumption [kWh] from Jan 2015 to Dec 2015



From the above figure, it could be noticed clearly that the electrical energy consumption during winter season is high and close to summer energy consumption, this due to the use of electric space heaters.

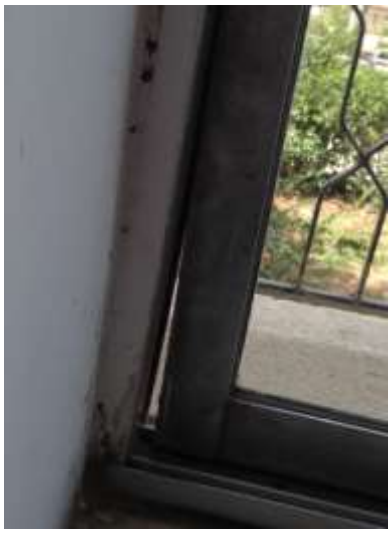
EMRC issued an official notification to all employees that electric heaters are prohibited and must not be used, but the employees still use them.

The energy auditing team has investigated the heating system intensively and discussed the above issues with EMRC technical team and the following notes were identified;

- EMRC has 4 working boilers, new one (installed in Dec 2015) and three heating boilers suffering from several problems due to the age (about 25 years). No combustion test was conducted for those boilers since it was dangerous even to operate them at currents conditions, but depending on Ecosol past experience and due to that fact that boilers are very old and suffering lack of maintenance, they have an efficiency of maximum 70% or even less than that.

- It was noticed also that network has many problems like aging, insulation problems, piping design problems…etc.

- Building envelope also investigated; where many air infiltration points were identified as well.



Due the above situation, and to save energy, it is highly recommended to conduct a complete retrofitting and maintenance of the whole heating system at EMRC building including boilers replacement, conducting a full maintenance for the network and its design to give a better efficiency for the heating system, and maintain the leaks and infiltration of windows.

EcoSol had conducted a Heating load simulation on special simulation program HAP (Hourly Analysis Program) to identify the actual optimal Heating density in terms of thermal kW. The simulation results showed that the Heating load for one floor of EMRC building is 195,250 KW thermal, hence 585,750 kW thermal for the three floors.

Therefore, it is recommended to replace the existing old three boilers by new three boilers each of 225 – 250 KW (taking into account the system losses and the combustion efficiency).

The below sheet shows the simulation results as generated by the software

Figure 18: EMRC Heating Load simulation results

Air System Design Load Summary for EMRC system

Project Name: EMRC
Prepared by: EcoSol

05/16/2016
12:33PM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1500 COOLING OA DB / WB 35.0 °C / 18.3 °C			HEATING DATA AT DES HTG HEATING OA DB / WB 0.6 °C / -2.5 °C		
ZONE LOADS	Details	Sensible (W)	Latent (W)	Details	Sensible (W)	Latent (W)
Window & Skylight Solar Loads	424 m²	58927	-	424 m²	-	-
Wall Transmission	184 m²	2791	-	184 m²	4841	-
Roof Transmission	0 m²	0	-	0 m²	0	-
Window Transmission	424 m²	25054	-	424 m²	56651	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	1900 m²	0	-	1900 m²	4122	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	11875 W	9322	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	222300 W	200976	-	0	0	-
People	70	3677	4206	0	0	0
Infiltration	-	0	0	-	114624	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	300747	4206	-	180238	0
Zone Conditioning	-	310672	4206	-	178651	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	28934 L/s	0	-	28934 L/s	0	-
Ventilation Load	745 L/s	8534	-3685	745 L/s	16599	0
Supply Fan Load	28934 L/s	0	-	28934 L/s	0	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	-	319205	520	-	195250	0
Central Cooling Coil	-	319205	0	-	0	0
Central Heating Coil	-	0	-	-	195250	-
>> Total Conditioning	-	319205	0	-	195250	0
Key:	Positive values are clg loads Negative values are htg loads			Positive values are htg loads Negative values are clg loads		

Implementing this measure will save around 12% of the total electrical energy bill where electric spaces heaters should be strictly prohibited.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**47,520**	**13,736**	**12.1%***	**20,000**	**17.5**

** The above saving percentage is out of the total annual electrical energy bills*

O.2: Switch Off the Water Coolers during Night Time by Programmable Timer

Finding Description and Recommendations:

During audit stage, all electrical appliances in EMRC studied and investigated, 18 water coolers of 150 Watt/cooler found serving 200 employees in addition to the Commission visitors.

These coolers found working for 24 hours; about 9 hours during working time working continuously at loading factor of 90%, and the rest 15 hours working at 15% loading factor to compensate losses in heating and cooling compartments inside the machine.

When calculating the electrical energy consumption of those water cooler after official working hours over the year resulting that they consumes about 2,217 kWh/year. (18 coolers * 0.15 kW/cooler * 15% * 15hr's/day * 365 days/year).

If those water coolers controlled and turned off after official working days, then the 2,217 kWh/year will be saved.

Therefore, to help in reducing energy consumption at the EMRC, it is recommended to control the operation of water coolers by switching them off during night time using programmable timers.

Implementing this measure will save about 0.6% of the total annual electrical energy bill of the EMRC building.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**2,217**	**641**	**0.6%***	**270**	**5.1**

***** *The above saving percentage is out of the total annual electrical energy bill*

O.4: Increase Energy conservation awareness among the EMRC employees

Finding Description and Recommendations:

THE SUCCESS OF AN ENERGY EFFICIENCY PROJECT depends on people as much as or even more than technology and technical solutions. To maximize the energy savings potential of any facility, it is important to make the effort to raise the awareness of everyone involved, including staff, managers, executives, tenants and suppliers through an Energy Efficiency Awareness Program.

The overall success of the program depends on the cooperation, acceptance and involvement of everyone who uses the facilities – whether employees in the Commission or visitors; and, of course, maintenance and operations personnel.

The first step to increase the energy conservation awareness is to designate an Energy management program leader from the EMRC (from technical department), who will be responsible about preparing communication plan in cooperation with public relation department to identify communication tools with employees.

Following some recommended actions to be considered to increase the energy conservation awareness:

- Take the support from the Executive manager of the commission by developing internal energy management policy.
- Develop a messages for EMRC employees with different ways and communication tools in which all information about energy management could be delivered easily.
- Consider new and innovative ways to reach employees such as printed materials (posters, press release, ministry yearly book), internet based products (commission homepage, emails signatures, e-newsletter), public channels (displays inside the building)
- Issuing some required regulations to save energy.
- Encourage and reward creative suggestions about energy management.
- Ask employees to design and produce an energy efficiency poster, a poem, a song or a jingle, a mascot or an energy efficiency awareness character.
- Promote energy-efficient transportation by rewarding departments that have the highest number of people who carpool or take public transit.
- Nominate maintenance engineers to attend sessions and courses about energy management, and encourage them to have the accreditation of some important certifications such as CEM: Certified Energy Manager.
- Adapt excellent maintenance plans (preventive maintenance of all electromechanical systems)

- Adapt using new technology systems to control the operation of electromechanical utilities.
- Consider procure energy efficient equipment, labeled with Energy Star and energy efficiency mark.
- Tracking the behavior of employees periodically and measure the effect of actions.

This measure will help to maintain energy saving and improve it, as well as motivating employees to consider energy efficiency in their daily practice. To be conservative, we assumed 1% energy saving could be achieved from the total annual energy bill.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**3,940**	**1,139**	**1.0%***	**1,500**	**15.8**

** The above saving percentage is out of the total annual electrical energy bill*

F.1: Effect of Boiler Replacement in EMO (O.1) on Heating System Efficiency

Finding Description and Recommendations:

Diesel Fuel is used in EMRC building for heating purposes, (**Space Heating**). And as mentioned in previously in this report that there are 4 boilers, new one of 70 kW thermal and very old three boilers with unknown capacities due to the absence of nameplates. The three old boilers are usually operated in winter for 5 Month to provide heating needs, while the new one that serving about 10% of the building is working around 24 hours during winter since it serves the emergency and control centre and the executive manager office.

During the energy audit phase, as mentioned in EMO O.1, no combustion test was conducted for those boilers since it was dangerous even to operate them at currents conditions and assumed that those old boilers have an efficiency of 70% or less.

EMO O.1 recommended improving and optimizing existing heating system by conducting a complete retrofitting and maintenance of the whole heating system at EMRC building including boilers replacement, conducting a full maintenance for the network and its design to give a better efficiency for the heating system, and maintain the leaks and infiltration of windows.

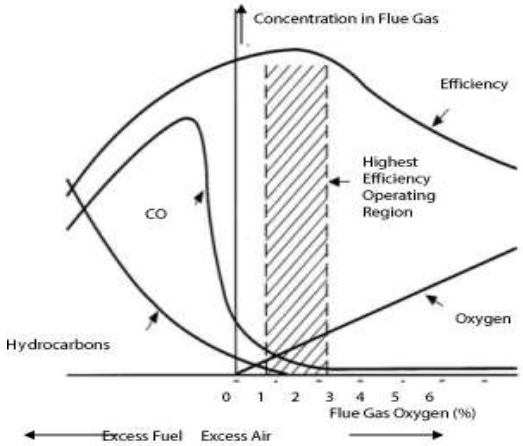
The existing new boiler has efficiency range of 85-87%, due to the fact the most technicians calibrate the air/fuel ratio based on experience (visually), not based on testing and measurement; hence, no actual figures about the boiler could be achieved and no losses could be minimized.

It is crucial to keep the heat losses to a minimum so that efficiency is maximized and more energy is utilized. Heat losses are inevitable, especially through the stack, but great amounts of heat losses may be prevented with the proper measurement and control procedures.

Stack losses will combine the sensible heat losses or dry gas losses and the latent heat losses. Sensible heat losses relate to the heat used to heat the combustion gases exiting the stack; the higher the volume and temperature of the flue gases the larger the dry gas heat losses. Latent heat losses are due to the water vapor in the flue gases (a large amount of energy is used as water evaporates)

Skin/shell losses, which are the losses due to radiation from the boiler walls, can be minimized with proper insulation and in general are relatively small. The figure below shows the highest combustion efficiency operating region, the region specified by the interaction between the optimum values of many parameters such as flue gas oxygen, hydrocarbons, oxygen, carbon monoxide, etc…

Figure 19: Highest Boiler Combustion Efficiency Operating Region



Improving heating system by replacing old boilers by new boilers with an efficiency of 87% at least, in addition that maintenance of hot water network and eliminate leaks and infiltrations in windows, is expected to save about 20% at least of diesel fuel.

Energy Saving:

Type of Saved Energy	Fuel Saving [Liter]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Fuel	**8,022**	**3,509**	**19.5%***	**0**	**0.0**

** The above saving percentage is out of the total annual Fuel bill*

6.0 ENVIRONMENTAL IMPACTS OF THE PROPOSED ENERGY MANAGEMENT OPPORTUNITIES

The combustion of fossil fuel to generate energy is being considered the largest contributing factor to the release of greenhouse gases GHG into the atmosphere. Combustion of fossil fuels not only realizes carbon dioxide and the GHG into the air, it also releases many other harmful acidic substances like sulphuric acid and carbonic acid and cause air pollution. These gases undergo some chemical changes and return to the surface of the earth in the form of acid rain. This has a huge impact on the entire environment affecting the plant life and causes water pollution also.

The major effect of the increment of the GHG in the atmosphere is their contribution to the global warming.

The global warming has much negative effect on the climate of earth. The weather conditions of various places of the earth will change drastically. Droughts and floods will occur more frequently in many areas that have extreme weather condition which will badly affect the agriculture. All the glaciers of the earth will be melting at a much faster pace. As a result, the areas nearby the water bodies like the coastal regions and the banks of the river will get submerged under water. Many deltas, islands, thickly populated cities are likely to go under water.

Environmental Benefits by implementing the Energy Saving Program:

Energy saving has positive consequences on the environment adopting energy conservation programs does not only save energy costs, but also protect the environment, reduce the risks of the global warming and improves the quality of life.

Implementing the energy management opportunities at this project will contributes to reduce the realized greenhouse gases from the fossil fuel combustion needed to generate electricity. The following table highlights the effect of implementing each energy management opportunity from an environmental perspective

Table 16: Reductions in Greenhouse Gases as a Result of Implementing the Proposed Energy Management Opportunities

No.	Energy Management Opportunities	Savings kWh or Liters	Nox Kg	CO2 Kg	SO2 Kg	CO Kg	SO3 Kg	VOC Kg	CO2 equiv Kg
L.1	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	22,306	46	22,400	132	42	1.68	0.2	22,418
L.2	Replace the Existing Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt in some Selected Areas.	4,293	9	4,312	25	8	0.32	0.0	4,315
L.3	Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors	7,080	15	7,110	42	13	0.53	0.1	7,115
L.4	Control the Operation of Lighting system in Some Selected Areas using Day Lighting Sensor	3,601							
L.5	General Recommendations on Lighting System in Some Areas	7,687	16	7,719	45	14	0.58	0.1	7,725
AC.1	Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.	5,280	11	5,302	31	10	0.40	0.1	5,307
AC.2	Relocate the Outdoor Units of the Server Room AC's to a Well Ventilated Location	8,991	19	9,030	53	17	0.68	0.1	9,037
AC.3	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	16,965	35	17,037	100	32	1.28	0.2	17,051
O.1	Improve and Optimize Existing Heating System and Prohibit Use of Electric Space Heaters	47,520	98	47,721	281	89	3.57	0.5	47,759
O.2	Switch Off the Water Coolers During Night Time by Programmable Timer	2,217	5	2,227	13	4	0.17	0.0	2,229
O.3	Increase Energy conservation awareness among the EMRC employees	3,940	8	3,957	23	7	0.30	0.0	3,960
F.1	Effect of Boiler Replacement in EMO (O.1) on Heating System Efficiency	8,022	43	21,033	17	39	0.22	0.2	21,049
Total		137903	304	147847	763	276	10	1.6	147963

7.0 TECHN-ECONOMINC ANALYSIS OF IMPLEMENTING THE ENERGY MANAGEMENT OPPORTUNITIES

Implementing energy efficiency projects are the most attractive investments with internal rate of returns usually above 20%. This section addresses a financial evaluation of implementing the energy management opportunities EMO, the analysis considered the initial investment and the annual increment in energy prices.

Some further financial figures were presented also such as the internal rate of return, the net present value and the simple pay back.

Table (17) below shows the above mentioned figures by implementing the energy saving program.

Table 17: Financial Analysis of Implementing Energy Management Opportunities

Project Inputs and Details							
Implementation Cost JDs	**37,248**	**Annual Savings JDs**	**41,051**	**Annual Increment in energy prices:**	**3%**	**Discount rate :**	**15%**
Energy Saving - Financial Analysis							
Energy Saving Analysis	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	**Total**
Existing Value		41,051	41,051	41,051	41,051	41,051	**205,255**
Escalated value		42,282	43,551	44,857	46,203	47,589	**224,483**
Annual Cash flow (undiscounted)	-37,248	42,282	43,551	44,857	46,203	47,589	**224,483**
Annual Cash flow (Discounted)		36,767	32,931	29,494	26,417	23,660	**149,270**
Financial Results							
Saving to Investment Ratio	**4.0**	**Internal Rate of Return IRR**	**113.6%**	**Net Present Value NPV in JDs**	**97,410**	**Simple Pay back [years]**	**0.91**

8.0 MEASUREMENT AND VERIFICATION OF SAVINGS

Table (18) includes the methodologies/approaches for monitoring and verification of savings. The suggested methodologies/approaches in the table were extracted from the International Performance Measurement and Verification protocol IPMVP.

Table 18: Measurement and Verification Procedure for Each EMO

#	Description	Measurements Before	Measurements After	Savings in kWh /Liter/ m^3	Savings in JDs
L.1	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	Lighting Fixtures Load in kW	Lighting Fixtures Load in kW	(kW before - kW after) x (Operational hours)	(Saving in kWh) x (Elec. Tariff)
L.2	Replace the Existing Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt in some Selected Areas.	Lighting Fixtures Load in kW	Lighting Fixtures Load in kW	(kW before - kW after) x (Operational hours)	(Saving in kWh) x (Elec. Tariff)
L.3	Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors	Average Working Hours before	Average Working Hours After	(Reduction in working hours) x (the electrical load in kW)	(Saving in kWh) x (Elec. Tariff)
L.4	Control the Operation of Lighting system in Some Selected Areas using Day Lighting Sensor	Average Working Hours before	Average Working Hours After	(Reduction in working hours) x (the electrical load in kW)	(Saving in kWh) x (Elec. Tariff)
L.5	General Recommendations on Lighting System in Some Areas	Lighting Fixtures Load in kW	Lighting Fixtures Load in kW	(kW before - kW after) x (Operational hours)	(Saving in kWh) x (Elec. Tariff)
AC.1	Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.	Average Working Hours before	Average Working Hours After	Difference in working hours x electric load in kW	(Saving in kWh) x (Elec. Tariff)
AC.2	Relocate the Outdoor Units of the Server Room AC's to a Well Ventilated Location	Server Room AC consumption before (kWh)	Server Room AC consumption after (kWh)	Reduction of energy consumption in kWh	(Saving in kWh) x (Elec. Tariff)
AC.3	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	Server Room AC consumption before (kWh)	Server Room AC consumption after (kWh)	Reduction of energy consumption in kWh	(Saving in kWh) x (Elec. Tariff)
P.1	Improve and Optimize Existing Heating System and Prohibit Use of Electric Space Heaters	Electric space Heaters consumption before (kWh)	Electric space Heaters consumption after (kWh)	Reduction of energy consumption in kWh	(Saving in kWh) x (Elec. Tariff)

P.2	Switch Off the Water Coolers During Night Time by Programmable Timer	Average Working Hours before	Average Working Hours After	Difference in working hours x electric load in kW	(Saving in kWh) x (Elec. Tariff)
O.1	Increase Energy conservation awareness among the EMRC employees	Energy Consumption before (Energy Bill)	Energy Consumption After (Energy Bill)	Reduction of energy consumption in kWh	(Saving in kWh) x (Elec. Tariff)
F.1	Effect of Boiler Replacement in EMO (O.1) on Heating System Efficiency	Boiler Efficiency Before implementation	New Boiler Efficiency After implementation	((New boiler efficiency – Old boiler efficiency)/(New efficiency)) * (annual fuel consumption liters)	(Saving in Liter) x (Fuel Tariff)

9.0 MAINTENANCE OF SAVINGS

Continuous follow up and maintenance of savings is a crucial factor in ensuring the success over time of any particular project. Energy saving could be degraded over time if not maintained or managed properly, reducing the net positive cash-flow and the benefits the owner can realize.

The maintenance of savings could be ensured by different procedures and approaches staring from personal follow up and periodical inspection, and ends by automated monitoring systems which triggers an alarm in case of malfunctioning. The selection of the proper methodology depends in many factors as it is mentioned below:

1- The ability of the local stuff to monitor and report any negative variance in energy saving by the available expertise and tools.

2- The existence of an electronic monitoring system which is able to additionally monitor and record energy saving and to trigger an alarm in case of low or no saving which could be happened due to several reasons such as; malfunctioning of energy saving equipment, improper use of equipment,…etc (note: the associated cost should be considered)

3- The installation of a new electronic monitoring system to create a data base for energy saving and to trigger an alarm in case of low or no saving which could be happened due to several reasons as mentioned above.

To maintain savings at this project, the following approach is proposed:

Form an Energy Committee from one of the engineers and two technicians (preferably electrical and mechanical) to follow up the installed energy saving equipment and to ensure the effectiveness of their operation. The main duties of this committee can be summarized as follows:

1. Make sure that the implementation of energy savings measures are all in place.

2. Make sure that the implemented measures are all functional.

3. Prepare monthly reports, to be submitted to the management, on the overall situation with regard to status of implemented measures, functionality of them, and any misuse or malfunctioning.

4. Take corrective actions to make sure that all implementation measures are in place.

5. Create a data base for energy consumption by documenting the monthly bills, then make comparisons with previous similar months to identify savings.

6. Organize a quarterly meeting with all the employees and the owner to report on savings and educate them about the importance of energy management.

10.0 IMPLEMENTATION PRIORITIES

The prioritization of the energy management opportunities is subjective, but based on an overall evaluation with consideration given to the criteria of energy savings, project cost, and likelihood of being implemented, indoor air quality, safety, and comfort. This will assist the project owner in determining the order in which to implement these findings. The following table shows the proposed priority list of the recommended energy management opportunities, the prioritization list was classified into high / medium priority, where the high priority was given to EMOs with less than 12 months of pay-back; otherwise medium priority will be introduced.

Table 19: Prioritization of implementing the proposed Energy Management Opportunities

No.	Electrical Systems Energy Management Opportunities	Saving in kWh	Saving in JDs	% of saving	Investment JDs	Pay-Back Months	Implementation priority
L.1	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	22,306	6,447	5.7%	1,527	3	High
L.2	Replace the Existing Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt in some Selected Areas.	4,293	1,241	1.1%	1,300	13	Medium
L.3	Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors	7,080	2,046	1.8%	1,575	9	High
L.4	Control the Operation of Lighting system in Some Selected Areas using Day Lighting Sensor	3,601	1,041	0.9%	1,200	14	Medium
L.5	General Recommendations on Lighting System in Some Areas	7,687	2,222	2.0%	436	2	High
AC.1	Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.	5,280	1,526	1.3%	525	4	High
AC.2	Relocate the Outdoor Units of the Server Room AC's to a Well Ventilated Location	8,991	2,599	2.3%	750	3	High
AC.3	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	16,965	4,904	4.3%	8,165	20	Medium
O.1	Improve and Optimize Existing Heating System and Prohibit Use of Electric Space Heaters	47,520	13,736	12.1%	20,000	17	Medium
O.2	Switch Off the Water Coolers During Night Time by Programmable Timer	2,217	641	0.6%	270	5	High
O.3	Increase Energy conservation awareness among the EMRC employees	3,940	1,139	1.0%	1,500	16	Medium
F.1	Effect of Boiler Replacement in EMO (O.1) on Heating System Efficiency	8,022	3,509	19.5%	0	0	High

11.0 APPENDIXES

11.1 ECM TABLE BASED ON 2015 ELECTRICTY TARIFF

No.	Energy Management Opportunities	Saving in kWh / Liter	Saving in JDs	% of saving	Investment JDs	Pay-Back Months
E	**Energy Management Opportunities in Electrical Systems**	129,880	33,445	33.0%	37,248	13.4
F	**Energy Management Opportunities in Fuel Systems**	8,022	3,509	19.5%	0	0.0
	Total		36,954	30.9%	37,248	12.1

No.	Electrical Systems Energy Management Opportunities	Saving in kWh	Saving in JDs	% of saving	Investment JDs	Pay-Back Months
Lighting System's Energy Management Opportunities						
L.1	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	22,306	5,744	5.7%	1,527	3
L.2	Replace the Existing Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt in some Selected Areas.	4,293	1,106	1.1%	1,300	14
L.3	Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors	7,080	1,823	1.8%	1,575	10
L.4	Control the Operation of Lighting system in Some Selected Areas using Day Lighting Sensor	3,601	927	0.9%	1,200	16
L.5	General Recommendations on Lighting System in Some Areas	7,687	1,979	2.0%	436	3
Air Conditioning System's Energy Management Opportunities						
AC.1	Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.	5,280	1,360	1.3%	525	5
AC.2	Relocate the Outdoor Units of the Server Room AC's to a Well Ventilated Location	8,991	2,315	2.3%	750	4
AC.3	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	16,965	4,369	4.3%	8,165	22
Other Energy Management Opportunities						
O.1	Improve and Optimize Existing Heating System and Prohibit Use of Electric Space Heaters	47,520	12,237	12.1%	20,000	20

O.2	Switch Off the Water Coolers During Night Time by Programmable Timer	2,217	571	0.6%	270	6
O.3	Increase Energy conservation awareness among the EMRC employees	3,940	1,015	1.0%	1,500	18
Total		129,880	33,445	**33.0%**	**37,248**	13

No.	Fuel System Energy Management Opportunities	Saving in Ltr	Saving in JDs	% of saving	Investment JDs	Pay-Back Months
F.1	Effect of Boiler Replacement in EMO (O.1) on Heating System Efficiency	8,022	3,509	19.5%	0	0
Total		8,022	3,509	**19.5%**	**0**	0

11.2 ELECTRICAL LOAD LIST AND REFERENCE DATA

Electrical Load List

Load Description	Total Installed Power [kW]	Measured Power [kW]	Operating Hours				Annual Consumption and Cost		% of the Total Consumption
			Hrs/Day	Day/M	M/Year	Hrs/Yr	kWh	JDs	
IT Equipment	79.98	-	8	22	12	2112	97,044	28,050	24.6%
Lighting System	31.44	-	8	22	12	2112	80,014	23,128	20.3%
Split Air Conditioners	69.00	-	5	22	5	550	54,756	15,827	13.9%
Server Room Air Conditioners	8.80	6.21	24	30	12	8640	53,622	15,499	13.6%
Electric Space Heaters	108.00	-	4	22	5	440	47,520	13,736	12.1%
Elevator	7.50	4.50	8	22	12	2112	9,504	2,747	2.4%
Water Coolers	2.70	-	9	30	12	3240	8,748	2,529	2.2%
Electric Water Heaters	13.20	-	5	22	5	550	7,260	2,098	1.8%
Heating Water Pump	7.46	5.97	6	22	5	660	3,939	1,139	1.0%
Fans	2.94	-	8	22	6	1056	3,105	897	0.8%
Others	13.5						28,504	8,239	7.2%
Total							394,016	113,890	100%

Lighting System Reference Data

Area	fixture type	fixture wattage	Q'ty	Light Level [Lux]		H/D	D/M	M/Y	kW	Annual Consumption	
				Actual	Standard					Consumption kWh/yr	Cost JD/ yr
طابق التسوية											
غرفة الكهرباء	FL 2X36	90	4	-	200	24	30	12	0.360	3,110	899
غرفة الخدمات	CFL 40	40	2	-	200	9	26	12	0.080	225	65
الطابق الأرضي											
قسم الحركة	LED PLR 18	18	6	310	130-400	8	22	12	0.108	228	66
قسم المختبرات الاشعاعية	LED PLR 18	18	12	200	500	8	22	12	0.216	456	132
قسم المختبرات الاشعاعية	FL 4X18	90	4	230	500	8	22	12	0.360	760	220
قسم المختبرات الاشعاعية	FL 2X36	90	2	230	500	8	22	12	0.180	380	110
مديرية المختبرات و الرصد الاشعاعي	LED PLR 18	18	12	270	300-500	8	22	12	0.216	456	132
مراقب الدوام	LED PLR 18	18	4	240	300-500	8	22	12	0.072	152	44
قسم الخدمات الادارية	LED PLR 18	18	6	420	300-500	8	22	12	0.108	228	66
الديوان	FL 4X18	90	4	300	300-500	8	22	12	0.360	760	220
قسم ادراة الموارد البشرية	FL 4X18	90	10	750	300-500	8	22	12	0.900	1,901	549
مدير مديرية الموارد البشرية	FL 4X18	90	3	700	300-500	8	22	12	0.270	570	165
خدمة الجمهور	LED PLR 18	18	10	325	300-500	8	22	12	0.180	380	110
خدمة الجمهور	LED PLR 18	18	6	1200	300-500	8	22	12	0.108	228	66
مديرية الاتصال و التعاون الدولي	LED PLR 18	18	4	380	300-500	8	22	12	0.072	152	44
مديرية البترول و الصخر الزيتي	LED PLR 18	18	18	500	300-500	8	22	12	0.324	684	198
مدير مديرية البترول و الصخر الزيتي	LED PLR 18	18	6	500	300-500	8	22	12	0.108	228	66
وحدة الضبط و التفتيش	CFL 2X23 Watt	46	3	380	300-500	8	22	12	0.138	291	84
الدائرة القانونية	CFL 2X23 Watt	46	8	500	300-500	8	22	12	0.368	777	225
الدائرة القانونية	FL 4X18	90	2	500	300-500	8	22	12	0.180	380	110
قسم الشؤون القانونية	FL 4X18	90	4	400	300-500	8	22	12	0.360	760	220
وحدة المناجم و المقالع	CFL 2X23 Watt	46	22	800	300-500	8	22	12	1.012	2,137	618
مدير وحدة المناجم و المقالع	LED PL 40	40	6	890	300-500	8	22	12	0.240	507	147

مدير وحدة المناجم و المقالع	CFL 2X23 Watt	46	1	890	300-500	8	22	12	0.046	97	28
قسم الرقابة و التفتيش و الجودة	CFL 2X23 Watt	46	19	700	300-500	8	22	12	0.874	1,846	534
قسم التراخيص	CFL 2X23 Watt	46	9	820	300-500	8	22	12	0.414	874	253
قسم التراخيص	FL 4X18	90	2	820	300-500	8	22	12	0.180	380	110
حمام رجال	LED PLR 18	18	5	130	100-150	8	22	12	0.090	190	55
حمام سيدات	LED PLR 18	18	5	165	100-150	8	22	12	0.090	190	55
ممر	FL 4X18	90	45	110	100-150	12	22	12	4.050	12,830	3,709
الاستقبال	CFL 2X23 Watt	46	16	330	200	12	22	12	0.736	2,332	674
إنارة ديكور	FL 1X18	23	48		-	8	22	12	1.104	2,332	674
إنارة ديكور	INC R80 75	75	32		-	8	22	12	2.400	5,069	1,465
الطابق الأول											
ممر	LED PL 40	40	13	260	100-150	12	30	12	0.520	2,246	649
مدير مكتب الرئيس التنفيذي	FL 4X18	90	4	310	300-500	10	22	12	0.360	950	275
سكرتاريا	LED PLR 18	18	2	1000	300-500	8	22	12	0.036	76	22
ممر جناح الرئيس التنفيذي	LED PLR 18	18	2	160	100-150	12	22	12	0.036	114	33
قاعة إجتماعات	LED PL 40	40	10	700	300-500	2	4	12	0.400	38	11
الرئيس التنفيذي	LED PL 40	40	12	1200	300-500	12	22	12	0.480	1,521	440
حمام الرئيس التنفيذي	CFL 2X23 Watt	46	3	-	100-150	12	22	12	0.138	437	126
مركز المراقبة و الطوارئ	LED PLR 18	18	10	220	300-500	24	30	12	0.180	1,555	450
مدير مركز المراقبة و الطوارئ	LED PLR 18	18	6	-	300-500	24	30	12	0.108	933	270
ممر	FL 4X18	90	7	-	100-150	12	22	12	0.630	1,996	577
حمام رجال	LED PLR 18	18	4		100-150	24	30	12	0.072	622	180
الدائرة المالية	LED PLR 18	18	32	-	300-500	8	22	12	0.576	1,217	352
المدير المالي	LED PLR 18	18	4	600	300-500	8	22	12	0.072	152	44
قسم المشتريات	LED PLR 18	18	8	300	300-500	8	22	12	0.144	304	88
الرقابة و التدقيق الداخلي	LED PLR 18	18	17	200	300-500	8	22	12	0.306	646	187

حمام سيدات	LED PLR 18	18	4	-	100-150	8	22	12	0.072	152	44
مديرية الرقابة الاشعاعية الحدودية	LED PLR 18	18	23	180	300-500	8	22	12	0.414	874	253
مديرية الأمن النووي	LED PLR 18	18	14	-	300-500	8	22	12	0.252	532	154
مديرية الأمن النووي 2	LED PLR 18	18	10	-	300-500	8	22	12	0.180	380	110
مديرية الأمان / قسم المفاعلات البحثية	LED PLR 18	18	14	900	300-500	8	22	12	0.252	532	154
مديرية الوقاية الإشعاعية	LED PLR 18	18	28	550	300-500	8	22	12	0.504	1,064	308
ممر	FL 4X18	90	7	125	100-150	8	22	12	0.630	1,331	385
المتحف الجيولوجي	LED PLR 18	18	6	530	500	8	22	12	0.108	228	66
المكتبة	FL 4X18	90	14	540	500	8	22	12	1.260	2,661	769
الطابق الثاني											
مديرية الكهرباء و الطاقة المتجددة	LED PLR 18	18	35	300-600	300-500	8	22	12	0.630	1,331	385
وحدة ضبط الجودة	LED PLR 18	18	15	1000	300-500	8	22	12	0.270	570	165
مدير وحدة ضبط الجودة	LED PLR 18	18	6	880	300-500	8	22	12	0.108	228	66
مدقق مالي	LED PLR 18	18	4	-	300-500	4	22	12	0.072	76	22
ديوان المحاسبة	LED PLR 18	18	4	-	300-500	4	22	12	0.072	76	22
المراقب المالي	LED PLR 18	18	4	-	300-500	4	22	12	0.072	76	22
مستشار	LED PLR 18	18	4	-	300-500	4	22	12	0.072	76	22
مديرية التعرفة و تحليل الأداء المالي	LED PLR 18	18	13	600	300-500	8	22	12	0.234	494	143
مديرية التعرفة و تحليل الأداء المالي	LED PLR 18	18	6	1000	300-500	8	22	12	0.108	228	66
مدير مديرية التعرفة و تحليل الأداء المالي	LED PLR 18	18	8	800	300-500	8	22	12	0.144	304	88
حمام رجال	LED PLR 18	18	6	-	100-150	8	22	12	0.108	228	66
قسم الحاسوب	LED PLR 18	18	26	750	300-500	8	22	12	0.468	988	286
غرفة السيرفر	FL 4X36	180	6	-	500	8	22	12	1.080	2,281	659
رئيس قسم الحاسوب	LED PLR 18	18	6	330	300-500	8	22	12	0.108	228	66
حمام سيدات	LED PLR 18	18	6	-	100-150	8	22	12	0.108	228	66
وحدة المعلومات المركزية	LED PLR 18	18	15	270	300-500	8	22	12	0.270	570	165
قسم المعرفة و المعلومات	LED PLR 18	18	4	400	300-500	8	22	12	0.072	152	44
مدير تكنولوجيا المعلومات	LED PLR 18	18	10	650	300-500	8	22	12	0.180	380	110

المستشار 2	LED PLR 18	18	6	450	300-500	8	22	12	0.108	228	66
ممر	FL 1X36	45	3	-	100-150	12	22	12	0.135	428	124
نائب الرئيس التنفيذي	LED PLR 18	18	4	700	300-500	8	22	12	0.072	152	44
سكرتيرة نائب الرئيس التنفيذي	LED PLR 18	18	2	680	300-500	8	22	12	0.036	76	22
المفوض م. وجدان الربضي	LED PLR 18	18	4	300	300-500	8	22	12	0.072	152	44
المفوض د. مجد الهواري	LED PLR 18	18	4	300	300-500	8	22	12	0.072	152	44
المفوض بشير السرور	LED PLR 18	18	4	320	300-500	8	22	12	0.072	152	44
غرفة اجتماعات	FL 4X18	90	6	-	300-500	8	22	12	0.540	1,140	330
مصلى	LED PLR 18	18	6	-	200	8	22	12	0.108	228	66
ممر	LED PLR 18	18	31	120	100-150	8	22	12	0.558	1,178	341
كافيتيريا	LED PLR 18	18	3	-	200	8	22	12	0.054	114	33
إنارة خارجية											
إنارة خارجية	LED Floodlight	50	28			10	30	12	1.400	5,040	1,457
Total			**873.0**						**31.4**	**80,014.2**	**23,128.0**

Split Air Conditioning System Reference Data

Area Name	Area	Unit Capacity [RT]	Units Q'ty	Working Hours			Total Capacity [RT]	[m²/RT]	Total Power [kW]	Consumption [kWh/year]	Cost [JOD/year]
				H/D	D/M	M/Y					
الطابق الأرضي											
قسم المختبرات الاشعاعية	48.00	1.50	2	5	22	9	3	16.0	3.6	2,317	670
قسم المختبرات الاشعاعية	24.00	1.00	1	24	30	12	1	24.0	1.2	6,739	1,948
مديرية المختبرات و الرصد الاشعاعي	54.00	2.50	1	5	22	5	2.5	21.6	3	1,073	310
الديوان	48.00	2.00	1	5	22	5	2	24.0	2.4	858	248
مدير مديرية الموارد البشرية	24.00	1.50	1	5	22	5	1.5	16.0	1.8	644	186
خدمة الجمهور	48.00	2.00	2	5	22	5	4	12.0	4.8	1,716	496
وحدة الضبط و التفتيش	24.00	1.00	1	5	22	5	1	24.0	1.2	429	124
الدائرة القانونية	30.00	2.00	1	5	22	5	2	15.0	2.4	858	248
الشؤون القانونية	16.00	2.00	1	5	22	5	2	8.0	2.4	858	248
مدير وحدة المناجم و المقالع	24.00	1.50	1	5	22	5	1.5	16.0	1.8	644	186
الطابق الأول											
مدير مكتب الرئيس التنفيذي	24.00	2.00	1	5	22	5	2	12.0	2.4	858	248
قاعة اجتماعات	60.00	2.50	1	2	4	9	2.5	24.0	3	140	41
الرئيس التنفيذي	72.00	2.00	2	10	26	9	4	18.0	4.8	7,301	2,110
مركز المراقبة و الطوارئ	48.00	2.00	1	24	30	9	2	24.0	2.4	10,109	2,922
مركز المراقبة و الطوارئ	36.00	1.50	1	24	30	9	1.5	24.0	1.8	7,582	2,191
الدائرة المالية	96.00	1.50	1	5	22	5	1.5	64.0	1.8	644	186
المدير المالي	24.00	2.00	1	5	22	5	2	12.0	2.4	858	248
الرقابة و التدقيق الداخلي	96.00	1.00	2	5	22	5	2	48.0	2.4	858	248
مديرية الرقابة الاشعاعية الحدودية	54.00	1.00	2	5	22	5	2	27.0	2.4	858	248
المتحف الجيولوجي	18.00	1.00	1	5	22	5	1	18.0	1.2	429	124
الطابق الثاني											
وحدة ضبط الجودة	48.00	1.00	1	5	22	5	1	48.0	1.2	429	124
قسم الحاسوب	54.00	1.50	2	5	22	5	3	18.0	3.6	1,287	372
رئيس قسم الحاسوب	16.00	1.00	1	5	22	5	1	16.0	1.2	429	124
مدير تكنولوجيا المعلومات	36.00	2.00	1	5	22	5	2	18.0	2.4	858	248
المستشار	27.00	1.50	1	2	22	5	1.5	18.0	1.8	257	74

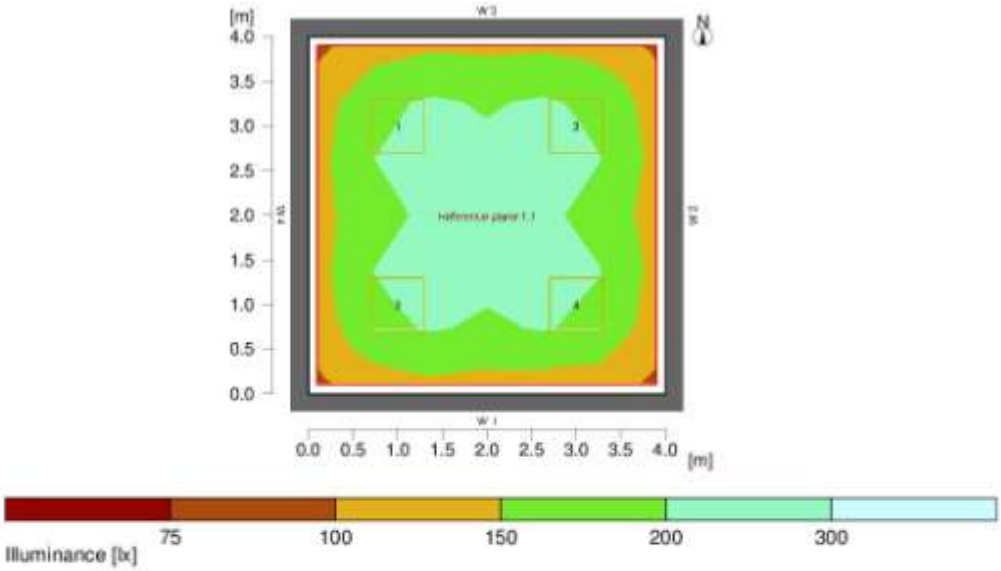
نائب الرئيس التنفيذي	36.00	2.00	1	5	22	5	2	18.0	2.4	858	248
المفوض م. وجدان الربضي	36.00	2.00	1	8	26	5	2	18.0	2.4	1,622	469
المفوض د. مجد الهواري	36.00	2.00	1	8	26	5	2	18.0	2.4	1,622	469
المفوض بشير السرور	36.00	2.00	1	8	26	5	2	18.0	2.4	1,622	469
Total			**35**				**57.5**		**69**	**54,756**	**15,827**

IT Equipment Reference Data

#	Area Name	Unit Power Consumption [kW]	Qty	Working Hours			Total Power [kW]	Diversity Factor	Annual Consumption and Cost	
				H/D	D/M	M/Y			Consumption [kWh/year]	Cost [JOD/year]
1	Personal Computers	0.140	198	6	22	12	27.7	0.5	21,954	6,346
2	Printers	0.430	73	1	22	12	31.4	0.5	4,143	1,198
4	Scanners	0.520	2	0.5	22	12	1.0	1.0	137	40
5	Copiers	2.400	5	1	22	12	12	1.0	3,168	916
7	Servers			24	30	12	7.8	1.0	67,641	19,551
Total			**278**				**80**		**97,044**	**28,050**

11.3 SIMULATION OUTCOMS FOR REPLACING FL 4X18 W BY LED PLR 18 W

- Existing lighting level **(from simulation) using FL 4X18 Watt Fixtures :**



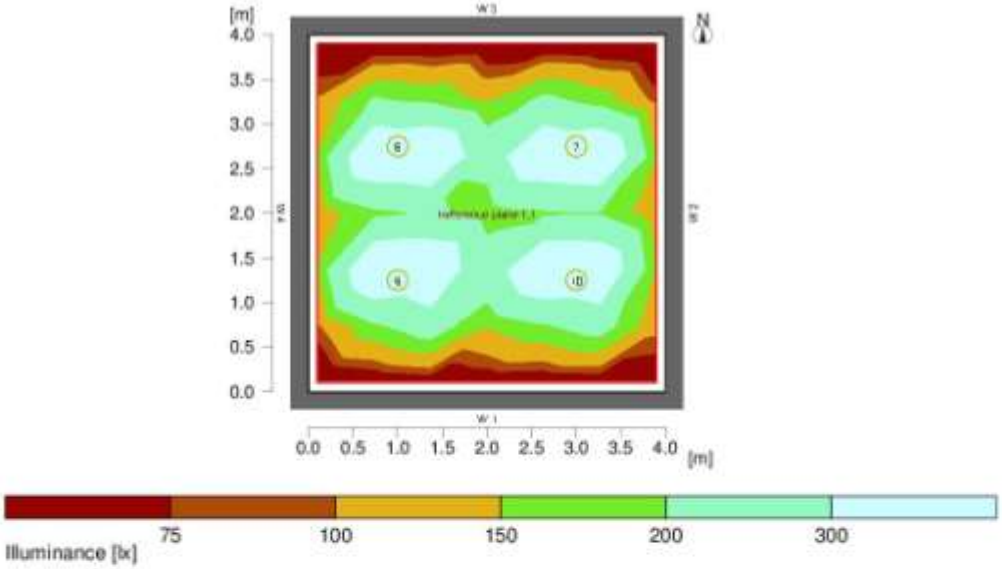
General

Calculation algorithm used	Average indirect fraction
Height of luminaire plane	2.50 m
Maintenance factor	0.50
Total luminous flux of all lamps	11200 lm
Total power	360.0 W
Total power per area (16.00 m²)	22.50 W/m² (13.70 W/m²/100lx)

Evaluation area 1	**Reference plane 1.1** Horizontal
Em	164 lx
Emin	88 lx
Emin/Eav (Uo)	0.53
Emin/Emax (Ud)	0.40
UGR (3.1H 3.1H)	<=15.3
Position	0.70 m

Major surfaces	Em	Uo
m 1.5 (Ceiling)	30 lx	0.60
m 1.1 (Wall)	74 lx	0.28
m 1.2 (Wall)	67 lx	0.31
m 1.3 (Wall)	75 lx	0.28
m 1.4 (Wall)	66 lx	0.31

- Expected lighting level **(from simulation) Using LED PLR 18 Watt Fixtures:**



General

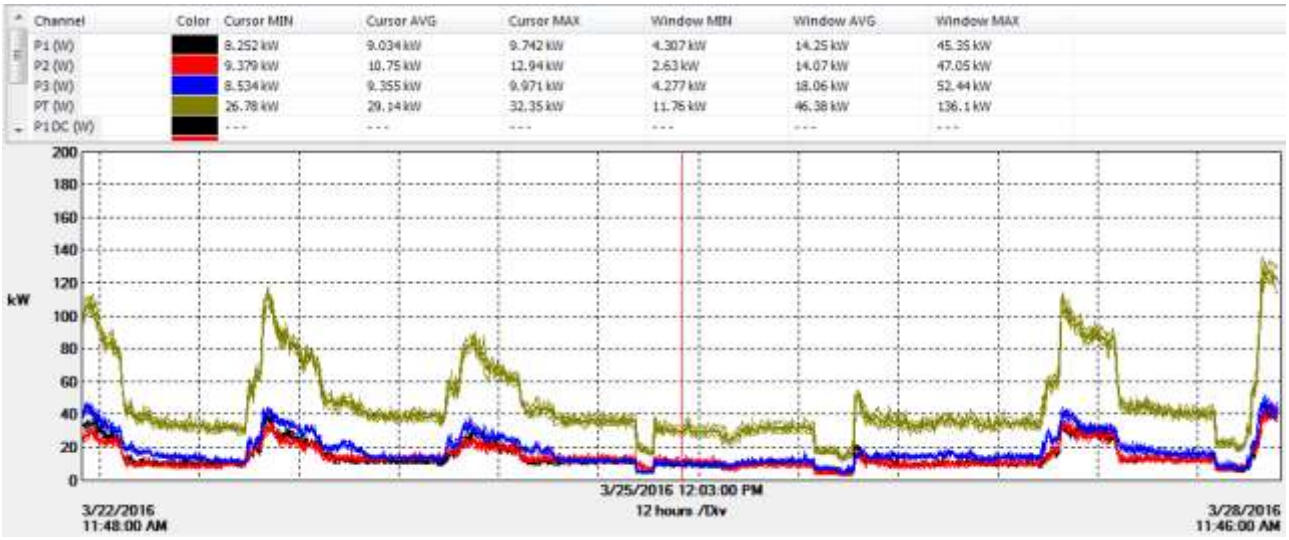
Calculation algorithm used	Average indirect fraction
Height of luminaire plane	2.50 m
Maintenance factor	0.80
Total luminous flux of all lamps	6000 lm
Total power	72.0 W
Total power per area (16.00 m²)	4.50 W/m² (2.60 W/m²/100lx)

Evaluation area 1	**Reference plane 1.1** Horizontal
Em	173 lx
Emin	22 lx
Emin/Eav (Uo)	0.13
Emin/Emax (Ud)	0.05
UGR (3.1H 3.1H)	<=12.5
Position	0.70 m

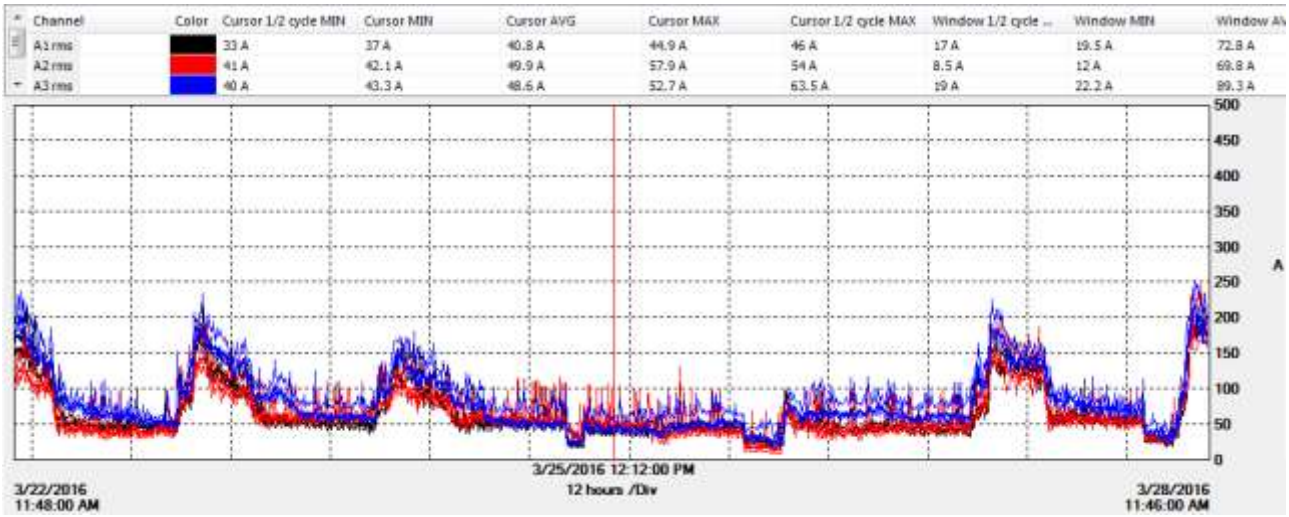
Major surfaces	Em	Uo
m 1.5 (Ceiling)	22 lx	0.61
m 1.1 (Wall)	30 lx	0.45
m 1.2 (Wall)	43 lx	0.32
m 1.3 (Wall)	29 lx	0.46
m 1.4 (Wall)	44 lx	0.31

11.4 BASELINE ELECTRICAL MEASUREMENTS

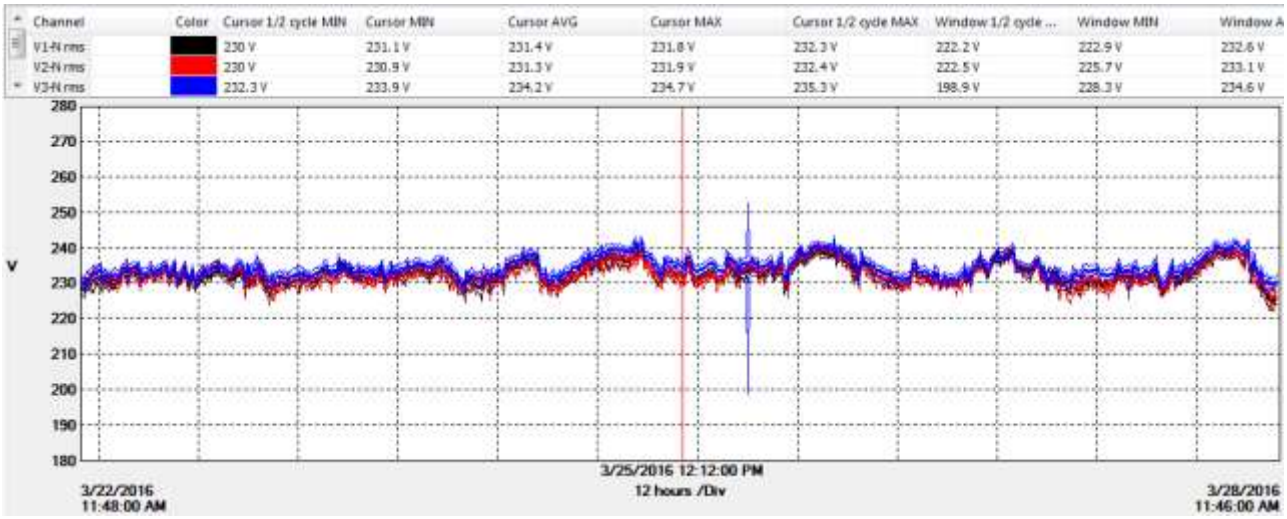
Electrical Load [kW] as Measured on the MDB (Mar 22, 2016 – Mar 28, 2016)



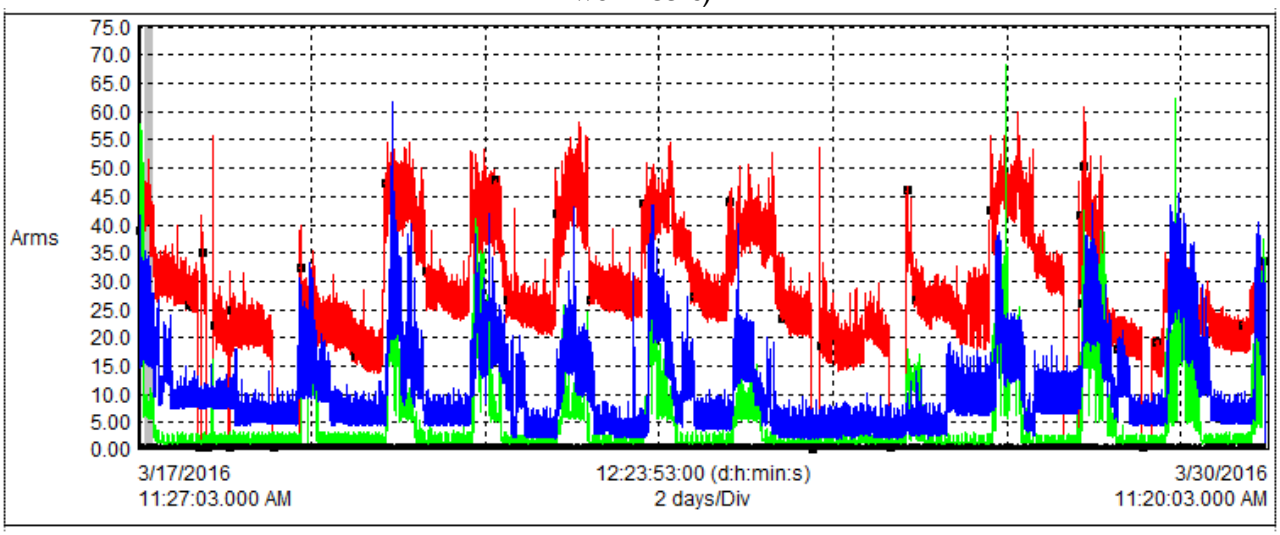
Electrical Current [Amp] as Measured on the MDB (Mar 22, 2016 – Mar 28, 2016)



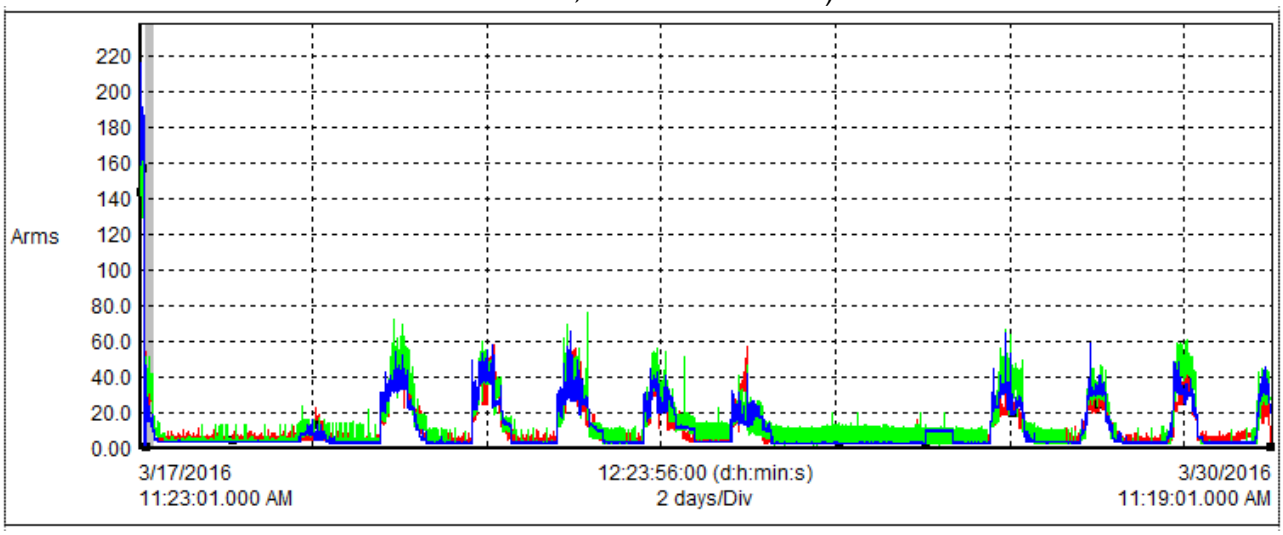
Electrical Voltage [V] as Measured on the MDB (Mar 22, 2016 – Mar 28, 2016)



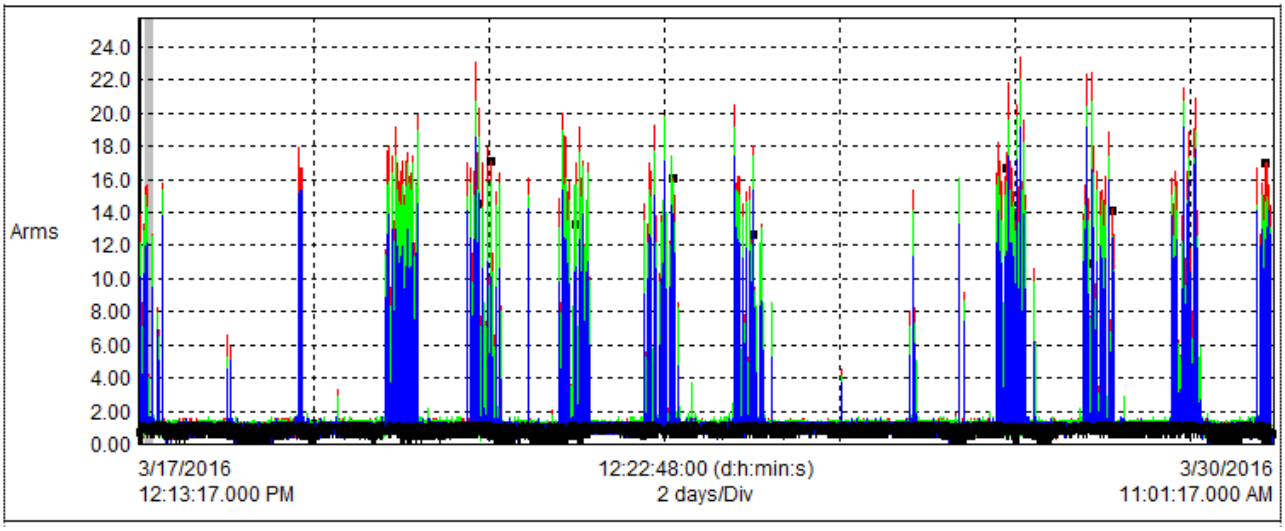
Electrical Current [Amp] as Measured GF and First Floor Circuit Breaker (Mar 17, 2016 – Mar 30, 2016 – Two Weeks)



Electrical Current [Amp] as Measured on the Second Floor Circuit Breaker (Mar 17, 2016 – Mar 30, 2016 – Two Weeks)



Electrical Current [Amp] as Measured on the Circuit Breaker of the Elevator (Mar 17, 2016 – Mar 30, 2016 – Two Weeks)



Electrical Current [Amp] as Measured on the Circuit Breaker of Servers and Servers AC (May 3, 2016 – May 9, 2016 – One Week)