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ENERGY AUDITING AND CAPACITY BUILDING FOR SIX MINISTRIES IN JORDAN

[Ministry Of Social Development– Energy Audit Report]

APRIL 2016

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ENERGY AUDITING AND CAPACITY BUILDING FOR SIX MINISTRIES IN JORDAN

[MINISTRY OF SOCIAL DEVELOPMENT]

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
MoSD	Ministry Of Social Development
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

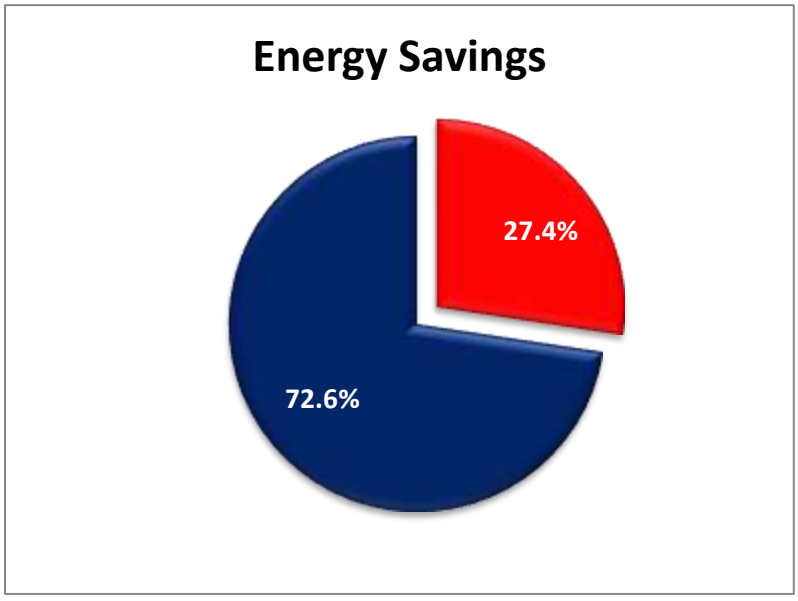
1.0 EXECUTIVE SUMMARY

This Energy Audit Report contains detailed data and analysis about energy aspects at "Ministry Of Social Development – MoSD" located at Amman, Jordan which is based on ASHRAE Level II Energy Audit conducted during April 2016.

The Energy Audit showed that the MOSD is sharing the electricity supply with National Aid Fund where one electricity meters is installed for the two buildings. The electricity consumption breakdown showed that the MOSD consumes about 65% of the meter readings and the rest is being consumed by the National Aid Fund. The total electricity meter reading in the past year was **JD 233,593** where the MoSD consumes **JD 151,835**. New electricity tariff was applied at the beginning of Jan 2016; this would lead the energy bills for the ministry to be **JD 163,585**.

Implementing the recommended energy management opportunities [EMOs] addressed in this report will help the Ministry in reducing energy bills, where the report recommended the implementation of Fourteen EMO's; that would lead to monetary savings of **JD 51,491 /year** equivalent to **27.4 %** of the annual energy bill. The required investment to implement the EMOs is about **JD 41,578**, which would be returned back in **9.7 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 2x36 Watt by New High Efficiency T8 LED Lamps 2x18 Watt in some Selected Areas.

L.2 Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas.

L.3 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.4 Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors

L.5 Replace the Existing External Sodium Street Light 150 Watt by new High Efficiency LED Street Light 90 Watt

AC.1 Improve the heat transfer Efficiency at the water chiller by Condenser Cleaning Program

AC.2 Improve the heat Transfer Efficiency at the Water Chiller by Adding Heat Transfer Additives

AC.3 Improve the Heat Transfer Efficiency at the Water Chiller by Shell and Tube Cleaning program

AC.4 Optimizing Temperature Set Point of AC System in Both Summer and Winter According to International Standards

AC.5 Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System

P.1 Control The Operation of Chilled Water Pump using VFD

O.1 Switch Off the Water Coolers During Night Time by Programmable Timer

O.2 Increase Energy Conservation Awareness among the Ministry Staff.

F.1 Improve the Combustion Efficiency of Space Heating Diesel Boiler.

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 **128.2 %**. While the saving to investment ratio is **4.5**, the net present value NPV is **JD 126,565** and finally, the simple payback period is **0.81 years**.

The total expected reduction in CO2 equivalent is around **179.5 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 Ministry 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 the Ministry, 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 2x36 Watt by New High Efficiency T8 LED Lamps 2x18 Watt in some Selected Areas.	56,433	16,375	10.0%	**11,176**	8
L.2	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	58,849	17,076	10.4%	**4,644**	3
L.3	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.	5,618	1,630	1.0%	**1,223**	9
L.4	Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors	2,600	755	0.5%	**2,430**	39
L.5	Replace the Existing External Sodium Street Light 150 Watt by new high efficient LED Street Light 90 Watt	9,331	2,708	1.7%	**7,200**	32
Air Conditioning System's Energy Management Opportunities						
AC.1	Improve the heat transfer Efficiency at the water chiller by Condenser Cleaning Program	2,186	634	0.4%	**750**	14
AC.2	Improve the heat Transfer Efficiency at the water chiller by adding heat transfer additives	7,286	2,114	1.3%	**3,800**	22
AC.3	Improve the heat transfer Efficiency at the water chiller by shell and Tube Cleaning program	5,829	1,691	1.0%	**1,750**	12
AC.4	Optimizing Temperature Set Point of AC System in Both Summer and Winter According to International Standards	8,385	2,433	1.5%	**1,140**	6
AC.5	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	5,893	1,710	1.0%	**5,375**	38
Pumping System's Energy Management Opportunities						

P.1	Control The Operation of Chilled Water Pump using VFD	1,162	337	0.2%	425	15
Other Energy Management Opportunities						
O.1	Switch Off the Water Coolers During Night Time by Programmable Timer	3,819	1,108	0.7%	465	5
O.2	Increase Energy conservation awareness among the Ministry employees	5,638	1,636	1.0%	500	4
Total		173,029	50,207	30.7%	40,878	10

No.	Fuel System Energy Management Opportunities	Saving in [Liters]	Saving in JDs	% of saving	Investment JDs	Pay-Back Months
F.1	Improve the Combustion Efficiency of Diesel Boilers	3,132	1,284	6.5%	700	7
Total		3,132	1,284	6.5%	700	7

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 12.1 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 the Ministry. 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 the Ministry of Social Development Building and the Adjacent National Aid Fund (NAF) Building supplied by electricity form the same meter. According to the analysis and the information supplied by the technical technical team of the ministry, MoSD consumes 65% of the total electrical bill and NAF consumes the other 35% 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
MoSD Building	**65%**	**563,766 kWh**	**151,835 JD**
NAF Building	**35%**	**303,567 kWh**	**81,758 JD**
Total Electrical Energy Bill	**100%**	**867,333 kWh**	**233,593 JD**

- All calculations and analysis in this report conducted based on consumption of MoSD Building only (the 563,766 kWh/year)

The total annual electrical bill for MoSD 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 (Nov 2014 to Oct 2015)
Electrical Energy Consumption [kWh]	**563,766**
Electrical Energy Cost based on 2015 Tariff [JD]	**151,835**
Electrical Energy Cost based on 2016 Tariff [JD]	**163,585**

- **Electrical Tariff System**

The electrical tariff applied to the ministry 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 ministry Building during the period from Nov-2014 till Oct-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
Nov-14	41,666	10,964	12,040
Dec-14	41,666	10,964	12,040
Jan-15	46,031	12,121	13,315
Feb-15	42,536	11,619	12,294
Mar-15	47,496	13,048	13,742
Apr-15	40,869	11,038	11,807
May-15	41,559	11,226	12,009
Jun-15	29,249	7,877	8,414
Jul-15	54,376	14,711	15,751
Aug-15	44,419	12,004	12,844
Sep-15	64,184	17,379	18,615
Oct-15	69,715	18,884	20,230
Total	**563,766**	**151,835**	**163,585**
Average	**46,981**	**12,653**	**13,592**
Minimum	**29,249**	**7,877**	**8,414**
Maximum	**69,715**	**18,884**	**20,230**

From the above table, the following could be noted:

1. The annual electrical consumption [kWh] in the past year for MoSD Building was **563,766 kWh** and the annual electricity cost was **JD 151,835** 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 **163,585**.

3. The maximum bill was in **October 2015** with a monetary amount of **JD 18,884**.

4. The minimum electrical bill was in (**July 2015)** with a monetary amount of **JD 7,877.**

5. The average electrical tariff was **0.2691 JD/kWh** during the year 2015 and it was increased to **0.2902 JD/kWh** at the beginning of 2016.

The below figures illustrate the annual electricity consumption and cost graphically

Figure 2: Electricity Consumption [kWh] from Nov 2014 to Oct 2015

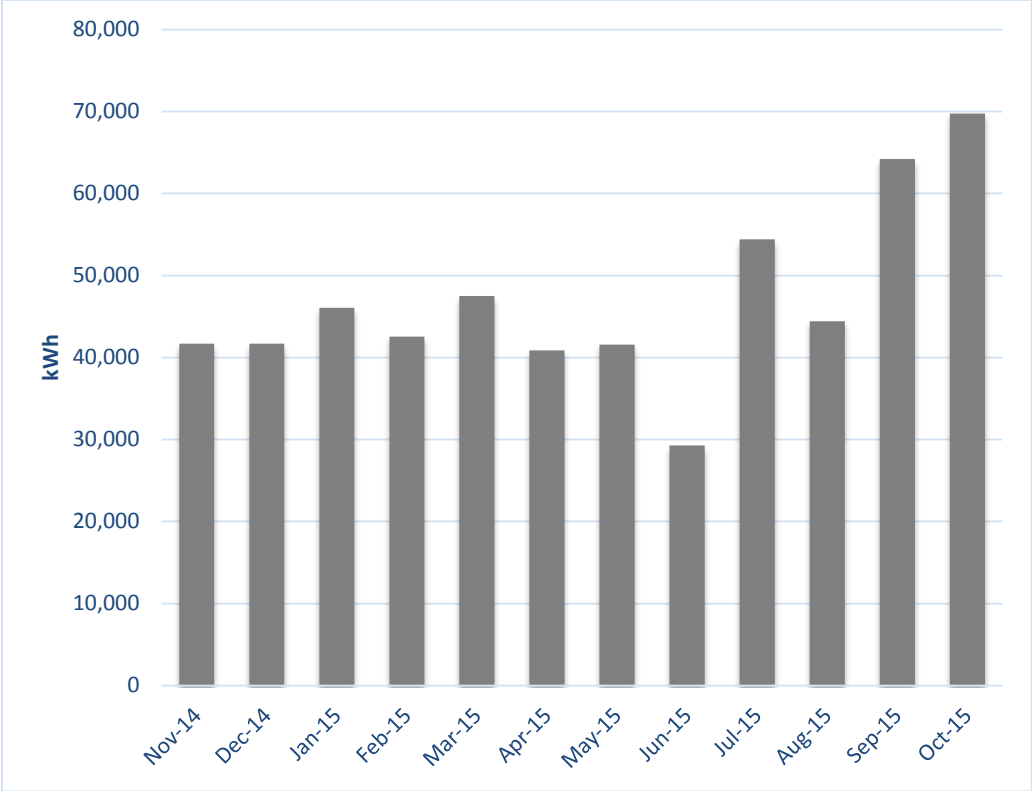
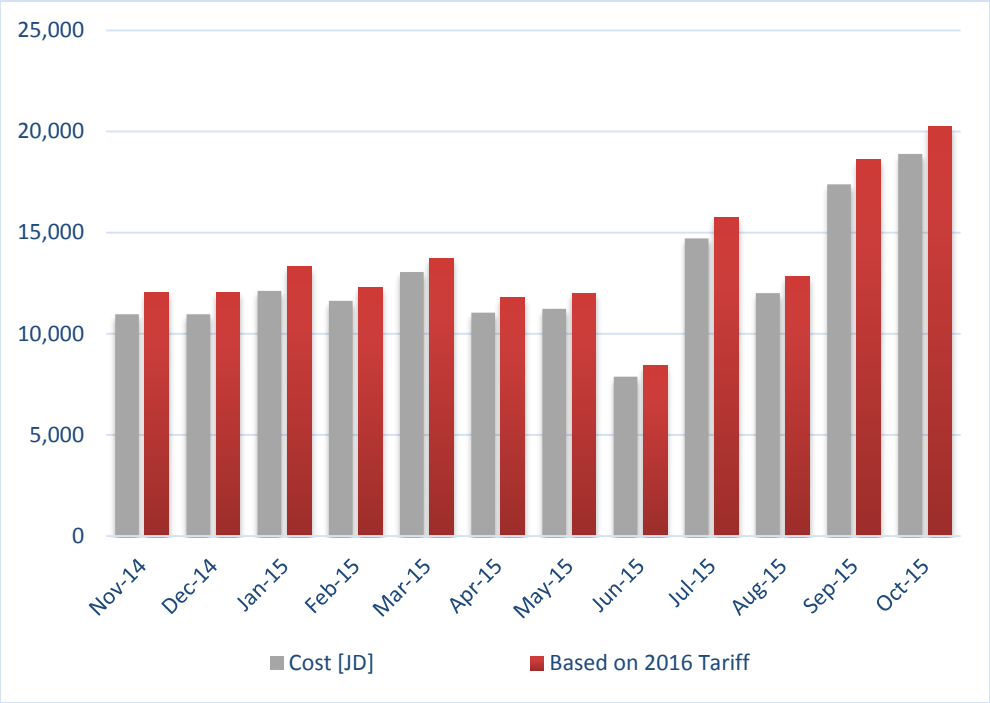
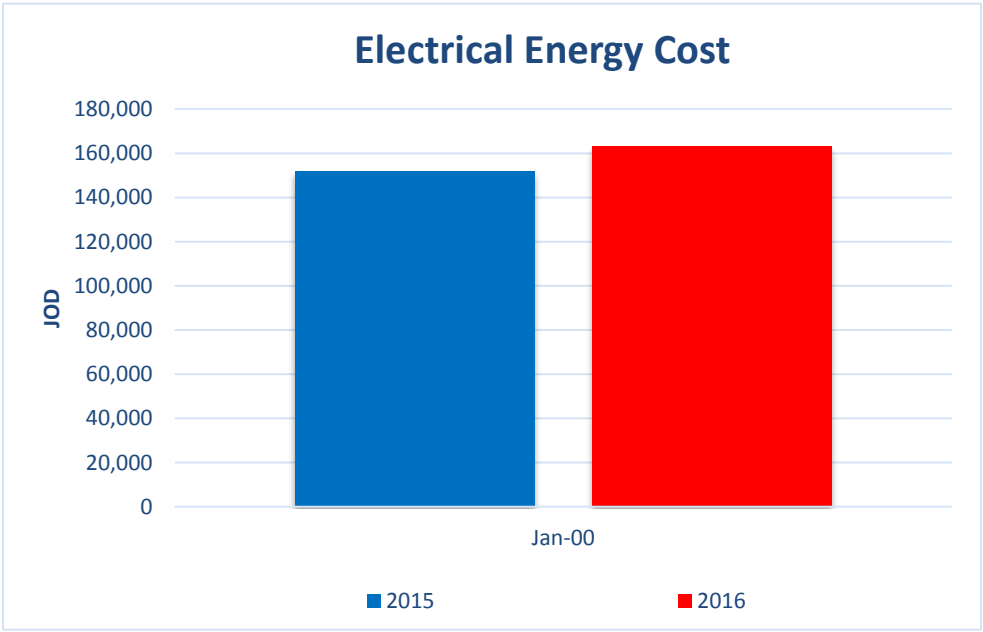


Figure 3: Comparison of Electrical Bills based on the Past and New Tariff in JDs



Note: the significant increase in energy consumption during Sep and Oct 2015 is due to un-traditional working conditions where many departments at the ministry worked for long hours during those two months.

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 ministry, the total electrical load at the ministry and other measured parameters are illustrated in the following figures:

Figure 5: Electrical Load [kW] as Measured on the MDB (Feb 16, 2016 – Feb 23, 2016)

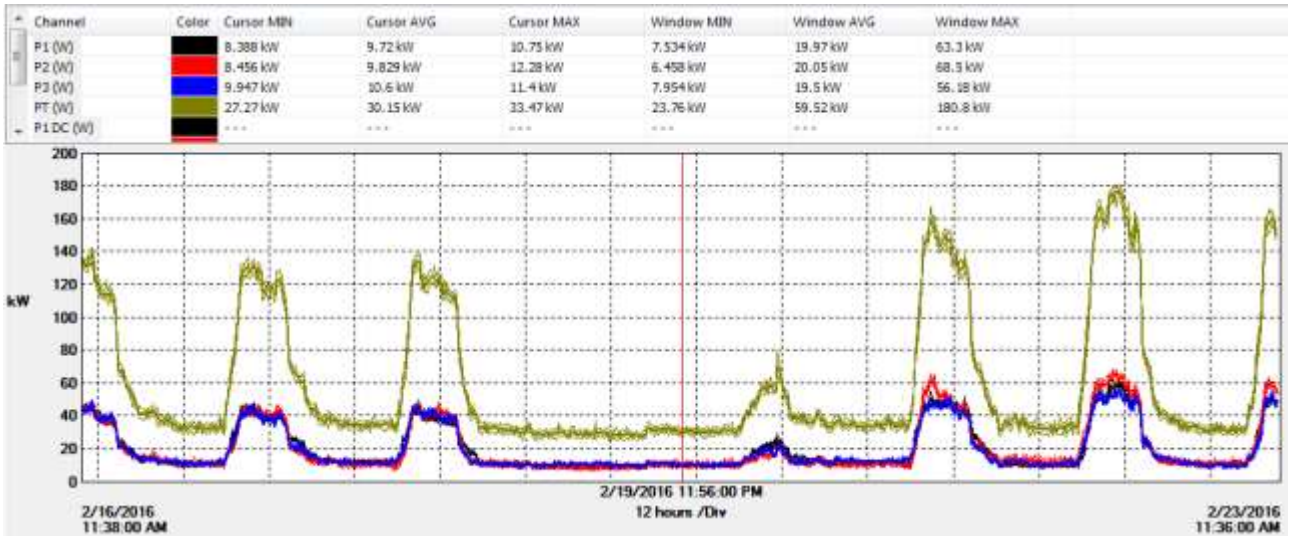


Figure 6: Electrical Current [Amp] as Measured on the MDB (Feb 16, 2016 – Feb 23, 2016)

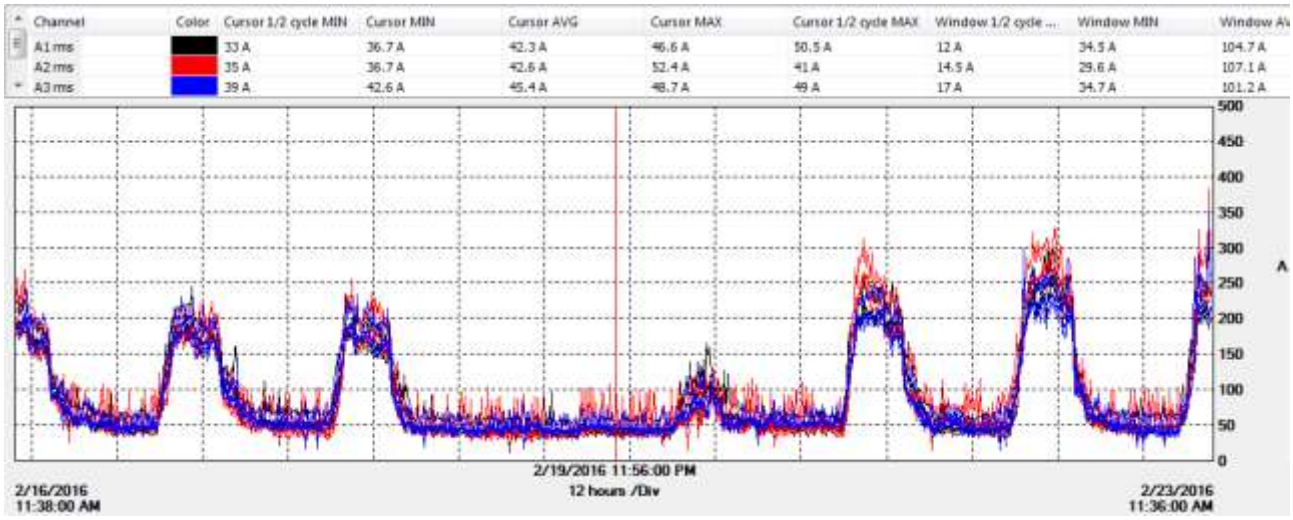


Figure 7: Electrical Voltage [V] as Measured on the MDB (Feb 16, 2016 – Feb 23, 2016)

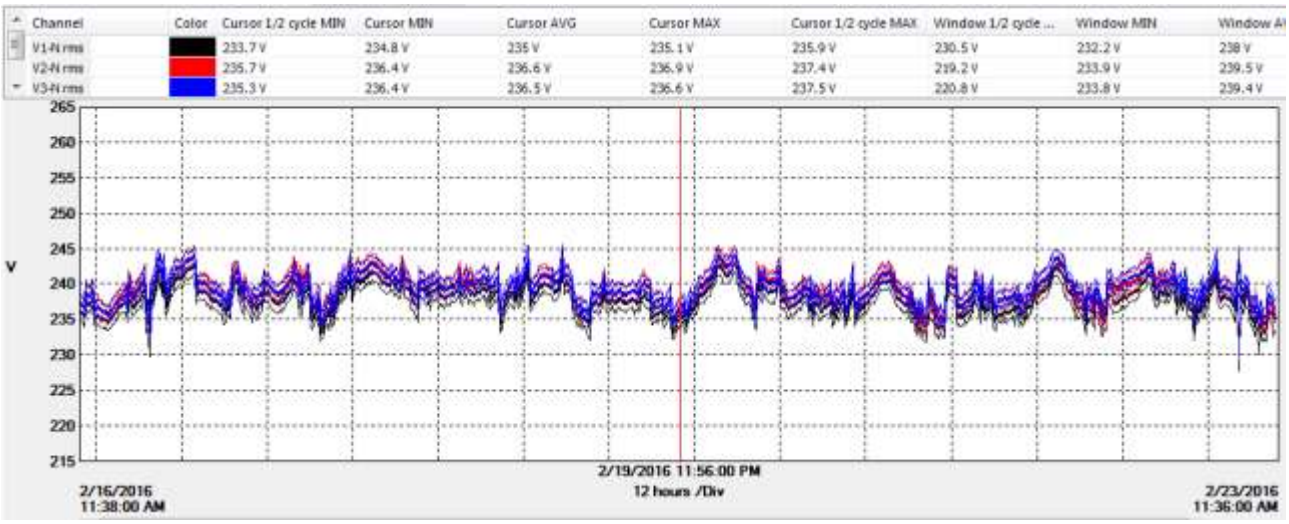


Figure 8: Electrical Current [Amp] as Measured on the Servers Air Condoning (Feb 16, 2016 – Feb 23, 2016)

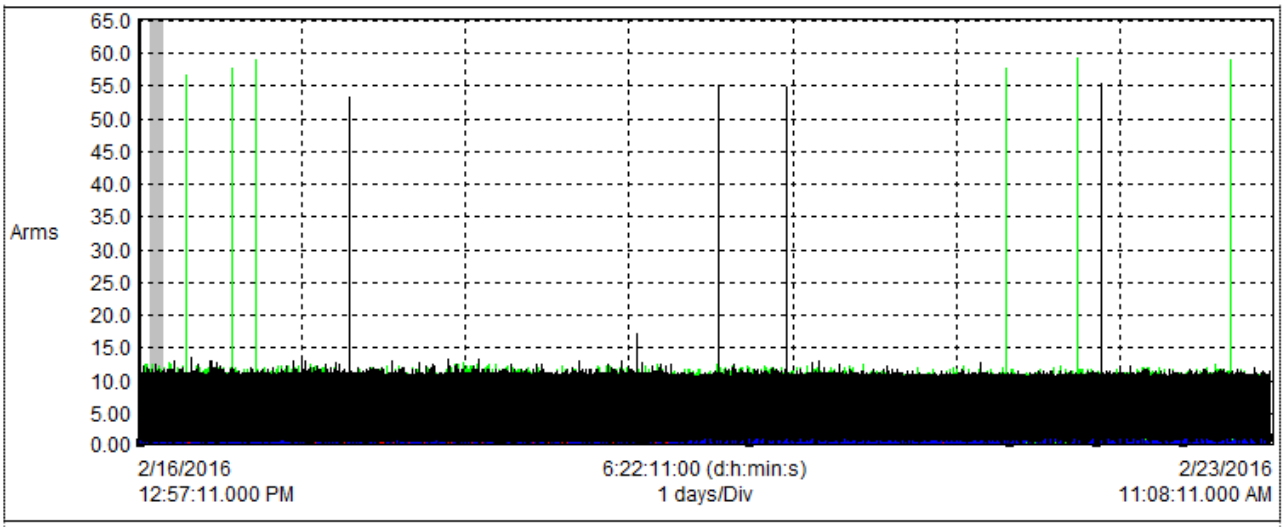


Figure 9: Electrical Current [Amp] as Measured on the Circuit Breaker of Server and Server AC (Feb 16, 2016 – Feb 23, 2016)

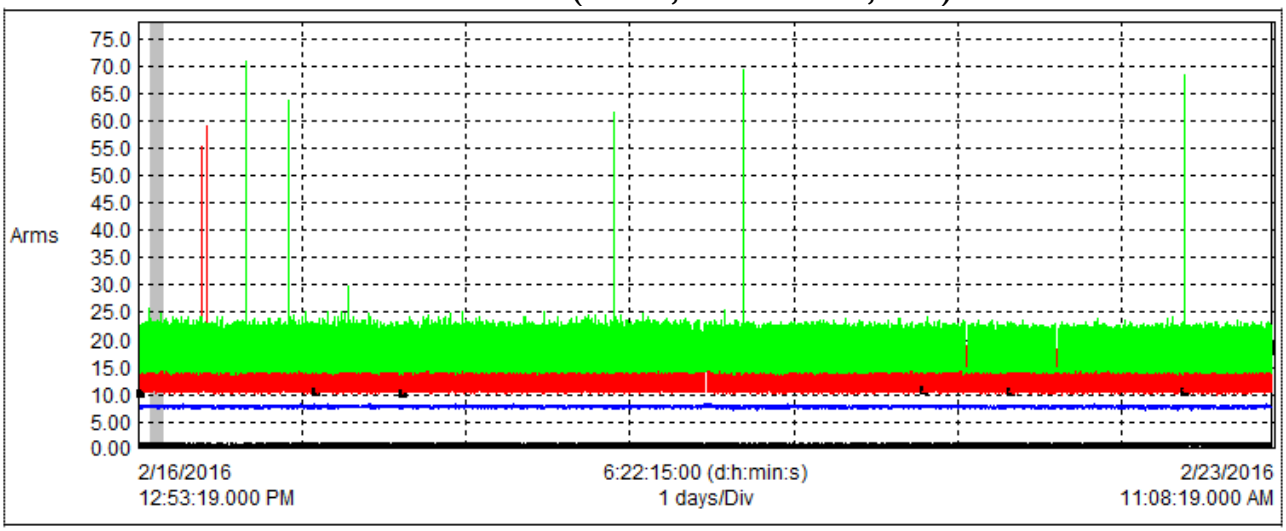


Figure 10: Electrical Current [Amp] as Measured on the Circuit Breaker Boiler Number 1

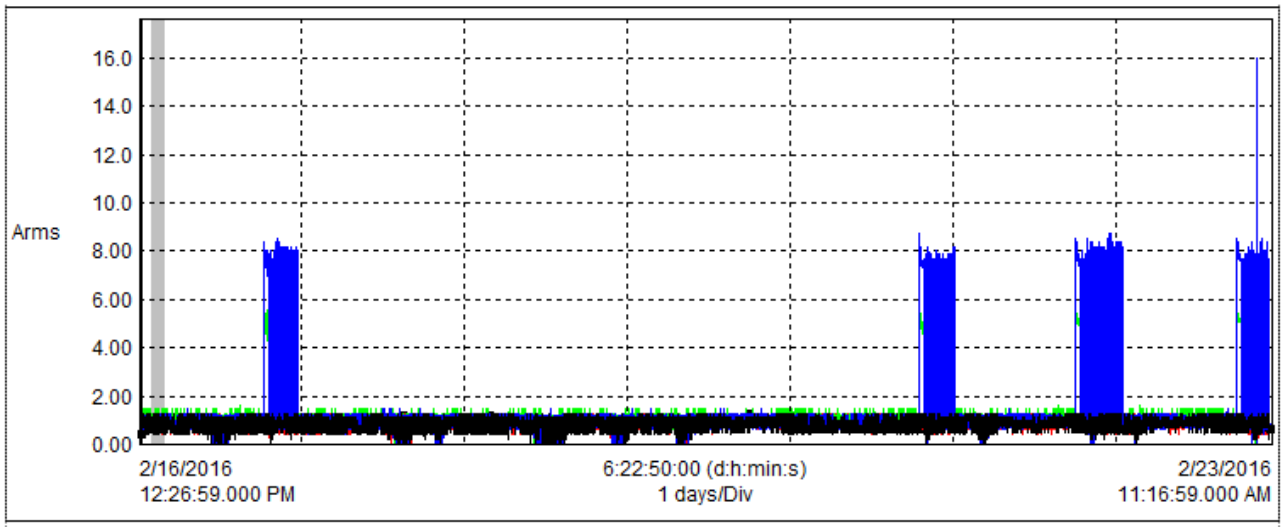
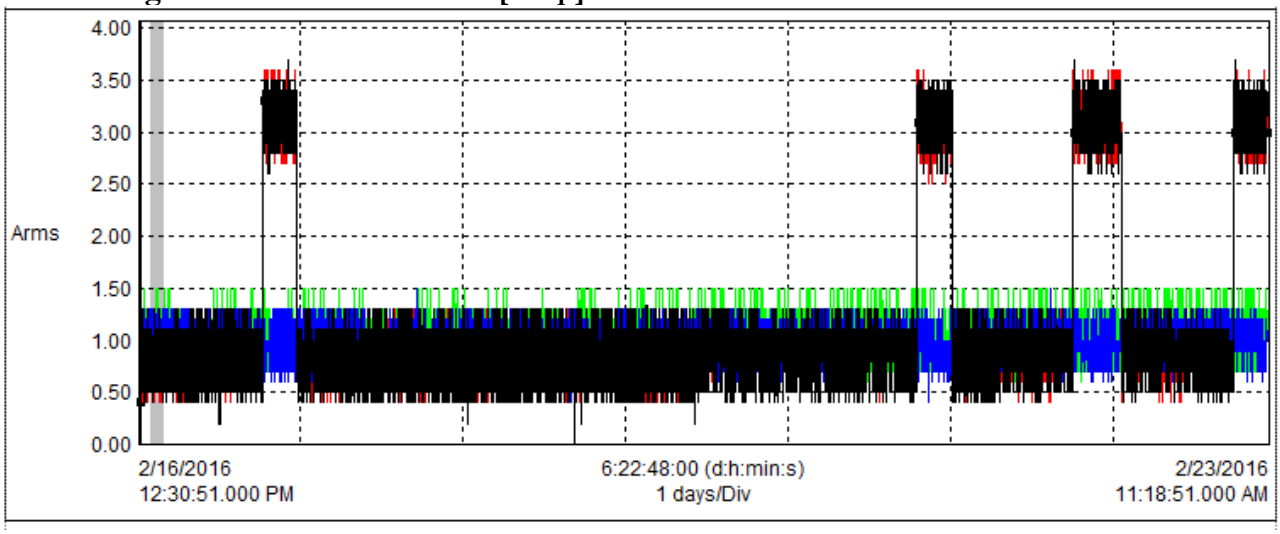


Figure 11:Electrical Current [Amp] as Measured on the Circuit Breaker of Boiler 2



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	Lighting System	199,317	57,835	35.35%
2	IT Equipment	142,058	41,220	25.20%
3	Water Chiller	72,864	21,143	12.92%
4	Server Room Air Conditioners	31,164	9,043	5.53%
5	Split Air Conditioners	24,426	7,087	4.33%
6	Elevators	31,680	9,912	5.60%
7	Water Cooler	15,066	4,372	2.67%
8	Fans	8,752	2,540	1.55%
9	Pumping System	8,096	2,349	1.44%
10	Others	30,344	8,805	5.4 %
	Total	563,766	163,585	100%

The following figure shows the detailed electrical load breakdown graphically

Figure 12: Detailed Electrical Consumption [kWh] Breakdown at the Ministry

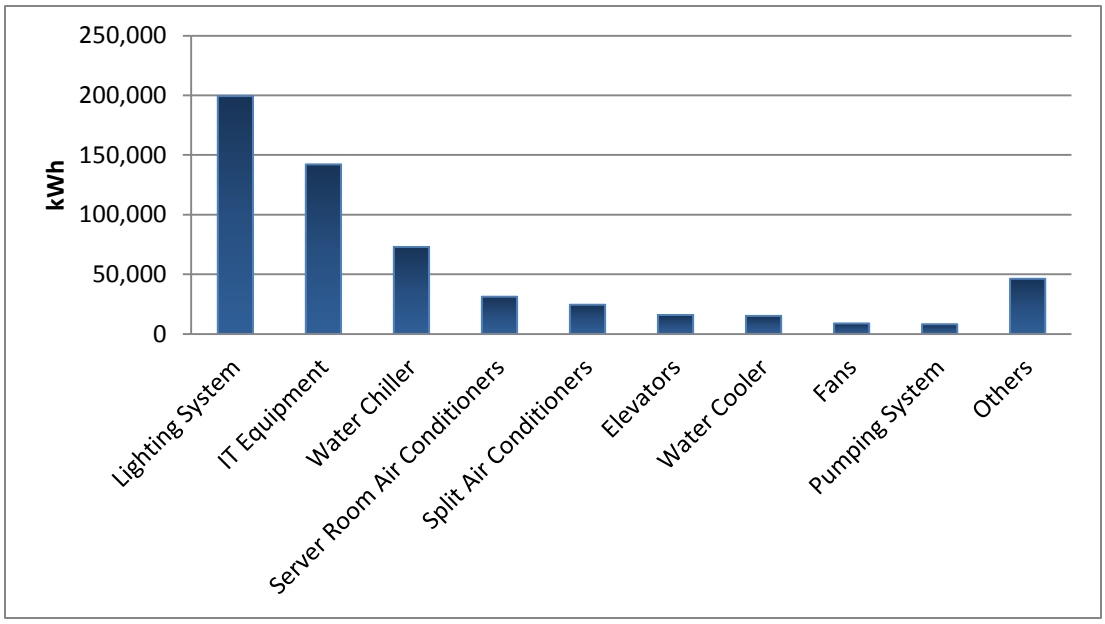
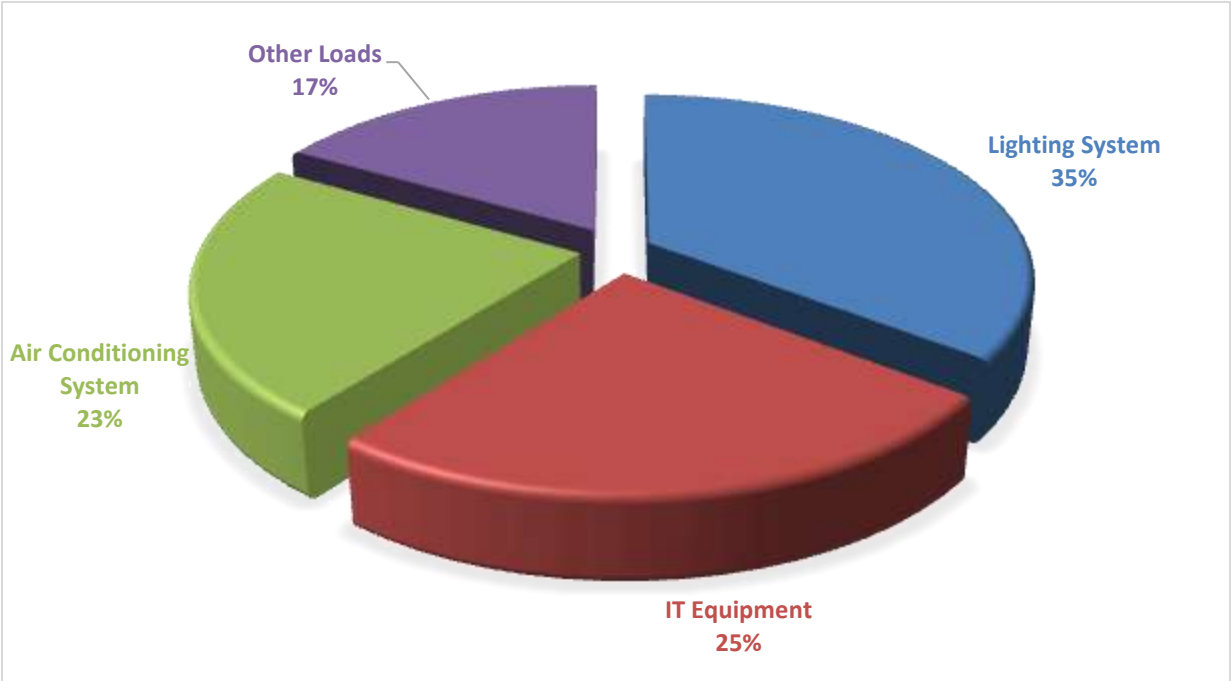


Table 7: Electricity Consumption [kWh] and Costs [JOD] Breakdown for main Electrical Consumers

Energy Consuming System	Annual Consumption kWh	Annual Cost JDs	% of Total Consumption
Lighting System	199,317	57,835	35%
IT Equipment	142,058	41,220	25%
Air Conditioning System	128,453	37,273	23%
Other Loads	93,939	27,258	17%
Total	563,766	163,585	100%

Figure 13: Electricity Bill Breakdown



4.4 FUEL CONSUMPTION

The total annual Fuel bills at MoSD were analysed over 2015. The main fuel consumed at the building is Diesel fuel for a purpose of Heating **(Space Heating, and Water Heating)**. MoSD invoices showed that the total fuel consumption during 2015 was **48,000** litres with an associated cost of **24,280 JD** the below table presents the monthly fuel consumption with the associated costs paid by the MoSD. It is obvious that actual monthly fuel consumption is not available as no fuel meters are installed at the Ministry. 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	16,000	8,160
Feb-15	16,000	8,160
Mar-15		
Apr-15		
May-15		
Jun-15		
Jul-15		
Aug-15		
Sep-15		
Oct-15		
Nov-15	16,000	8,160
Dec-15		
Total	**48,000**	**24,480**
Average	**16,000**	**8,160**
Minimum	**16,000**	**8,160**
Maximum	**16,000**	**8,160**

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 0.51 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 MoSD building taking into consideration that most of the Area and offices at the Ministry building are Un-conditioned, the following table shows the details of EUI calculation for MoSD:

Table 9: Energy Use Intensity (EUI)

Parameter	Value
Total Building Built Up Area [m^2]	**14,800**
Total Ministry Electrical Energy Consumption [kWh/year]	**563,766**
Total Ministry Fuel Consumption [Liters/year]	**48,000**
Total Ministry Fuel Consumption [kWh/year]	**520,000**
Total Ministry Energy Consumption (Electricity and Fuel) [kWh/year]	**1,083,766**
Electrical Energy Use Intensity [$kWh/m^2/year$]	**73**

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 MoSD is lower than the average world EUI, this is due to many factors:

- Absence of domestic hot water system, where MoSD Building depends on diesel boilers to obtain hot water, and used in winter months only.
- Common areas such as corridors, lift lobbies, most offices at the building…etc. are not air conditioned.
- 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 27.4%, the below recommendations were quoted as they proved to be the most economically feasible:

L.1: Replace the Existing T8 Fluorescent Lamps 2x36 Watt by New High Efficiency T8 LED Lamps 2x18 Watt in some Selected Areas.

Finding Description and Recommendations:

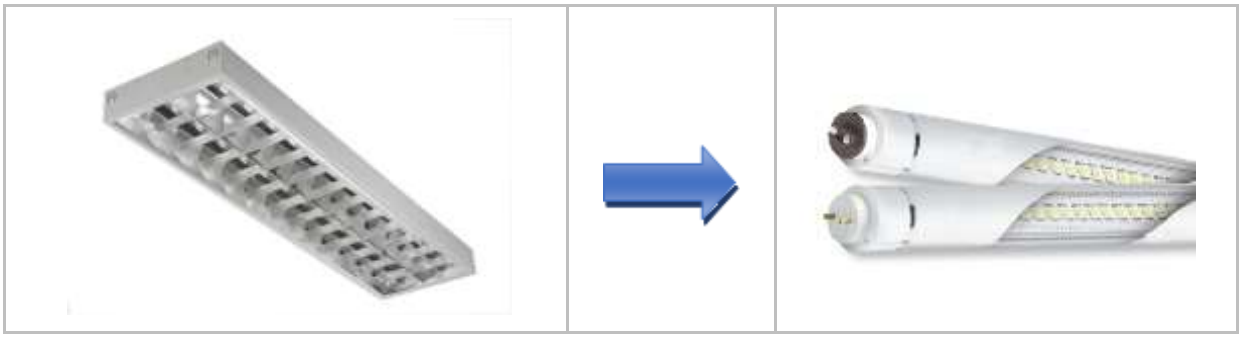
During the energy audit stage, a detailed lighting survey was carried out to identify lamps type, energy consumption and the illumination levels in the various areas and offices at the ministry. The energy audit showed that some of the ministry offices were served by Fluorescent Lamps 2x36 Watt powered by electromagnetic ballast.

The artificial lighting and natural lighting were investigated and examined using accurate measurements obtained by utilizing special lighting measuring tool (lux meter); a sample of lux measurements were carried out for some typical offices at all ministry where it was obvious that the light level is higher than international standards. **(More details could be found in the annexes)**

The standard lighting level in offices of typing and computer usage activities is (300-500 Lux) according to CIBSE Code. Lighting level in MoSD offices measured and found above these values, due to a good amount of natural lighting passes through windows, and when the natural lighting effect were not considered, lighting level in these offices measured and found within the standard values. Few offices examined and found has low lighting level due to burned lamps.

Existing fluorescent lamps are categorized among medium efficiency lamps if compared to the other lamps. However, recent developments in LED Lighting technologies made it possible and economically feasible to replace these lamps by new LED fixtures and saving about 60 % of energy consumption while improving the existing illumination levels by about 15%, by which the lighting level would be improved more.

To save energy and improve illumination levels at the ministry, it is recommended to replace the fluorescent lamps FL 2x36 Watt, by LED Tube 2x18 Watt.



The following table highlights the areas where this ECM is recommended;

Table 10: Areas in which the existing Fluorescent 2x36 Lamps to be replaced by LED 2x18 Watt Tube

Area	fixture type	fixture wattage	Q'ty	Annual Consumption		% of saving	Annual Saving	
				Consumption kWh/yr	cost / yr		kWh saving	cost saving
طابق التسوية								
حمام رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
مخزن 003	FL 2X36	90	3	143	41	60%	85.5	24.8
مخزن 004	FL 2X36	90	4	190	55	60%	114.0	33.1
مقسم رئيسي	FL 2X36	90	2	104	30	60%	62.2	18.1
الطابق الأرضي								
مدير الشؤون الإدارية 001	FL 2X36	90	6	1,140	331	60%	684.3	198.6
خدمة الجمهور 003	FL 2X36	90	4	760	221	60%	456.2	132.4
مدير خدمة الجمهور 004	FL 2X36	90	2	380	110	60%	228.1	66.2
مكتب خدمات 005	FL 2X36	90	1	190	55	60%	114.0	33.1
باحث اجتماعي 006	FL 2X36	90	4	760	221	60%	456.2	132.4
حمام الجناح الأيمن - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيمن - سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
التمويل الأجنبي 007	FL 2X36	90	3	570	165	60%	342.1	99.3
مدير التمويل الأجنبي 008	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس قسم اللوازم 009	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم اللوازم 010	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس قسم التزويد 011	FL 2X36	90	3	570	165	60%	342.1	99.3
مدير الدفاع الاجتماعي (السكرتيرة) 012	FL 2X36	90	3	570	165	60%	342.1	99.3
مدير الدفاع الاجتماعي 012	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس قسم الأحداث 013	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم الاتجار بالبشر 014	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم الاتجار بالبشر 015	FL 2X36	90	3	570	165	60%	342.1	99.3
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
قسم الأحدث 027	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم الحماية الاجتماعية 028	FL 2X36	90	4	760	221	60%	456.2	132.4
مكاتب 017	FL 2X36	90	4	760	221	60%	456.2	132.4
الصادر 019	FL 2X36	90	6	1,140	331	60%	684.3	198.6
الوارد 020	FL 2X36	90	4	760	221	60%	456.2	132.4
الوارد 021	FL 2X36	90	3	570	165	60%	342.1	99.3
الديوان 022	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس الديوان 023	FL 2X36	90	3	570	165	60%	342.1	99.3

الطابق الأول								
قسم الرقابة المالية 101	FL 2X36	90	4	760	221	60%	456.2	132.4
مدير الموارد المالية (السكرتيرة) 102	FL 2X36	90	4	760	221	60%	456.2	132.4
مدير الموارد المالية 102	FL 2X36	90	4	760	221	60%	456.2	132.4
حمام الجناح الأيمن - رجال	FL 2X36	90	3	570	165	60%	342.1	99.3
حمام الجناح الأيمن - سيدات	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس قسم الرواتب 103	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم الرواتب 104	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم الرواتب 105	FL 2X36	90	4	760	221	60%	456.2	132.4
رئيس قسم التدقيق 107	FL 2X36	90	2	380	110	60%	228.1	66.2
رئيس قسم المحاسبة 108	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم المحاسبة 109	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم الصرف و الأمانات 110	FL 2X36	90	10	1,901	552	60%	1140.5	330.9
قسم التدقيق 112	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم الصرف 113	FL 2X36	90	3	570	165	60%	342.1	99.3
المراقب المالي 114	FL 2X36	90	3	570	165	60%	342.1	99.3
المراقب المالي 115	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس قسم شؤون الموظفين 116	FL 2X36	90	3	570	165	60%	342.1	99.3
شؤون الموظفين 117	FL 2X36	90	3	570	165	60%	342.1	99.3
شؤون الموظفين 118	FL 2X36	90	4	760	221	60%	456.2	132.4
مدير الموارد البشرية (السكرتيرة) 119	FL 2X36	90	3	570	165	60%	342.1	99.3
مدير الموارد البشرية 119	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم التخطيط 120	FL 2X36	90	4	760	221	60%	456.2	132.4
الموارد البشرية 121	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم التدريب 122	FL 2X36	90	4	760	221	60%	456.2	132.4
أرشيف الموارد البشرية	FL 2X36	90	3	570	165	60%	342.1	99.3
أرشيف الوزارة	FL 2X36	90	13	2,471	717	60%	1482.6	430.2
حمام الجناح الأيسر - رجال	FL 2X36	90	3	570	165	60%	342.1	99.3
حمام الجناح الأيسر- سيدات	FL 2X36	90	3	570	165	60%	342.1	99.3
الطابق الثاني								
مستشار الأمين العام لشؤون الأشخاص المعوقين 202	FL 2X36	90	3	570	165	60%	342.1	99.3
حمام الجناح الأيمن - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيمن - سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
رئيس قسم الرقابة الفنية 212	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس قسم الرقابة الداخلية (سكرتيرة) 213	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس قسم الرقابة الداخلية 213	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم التأهيل الاجتماعي 214	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم المتابعة و التقييم الاداري 215	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم المراكز و المؤسسات 216	FL 2X36	90	3	570	165	60%	342.1	99.3

مدير شوؤن الأشخاص ذوي الإعاقة (السكرتيرة) 217	FL 2X36	90	3	570	165	60%	342.1	99.3
مدير شوؤن الأشخاص ذوي الإعاقة 217	FL 2X36	90	3	570	165	60%	342.1	99.3
مصلى النساء 220	FL 2X36	90	3	570	165	60%	342.1	99.3
مصلى الرجال 221	FL 2X36	90	6	1,140	331	60%	684.3	198.6
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
قسم الاشراف التربوي 222	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم الرقابة الادارية 223	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم الرقابة الفنية 224	FL 2X36	90	4	760	221	60%	456.2	132.4
رئيس قسم المتابعة و الشكاوي 225	FL 2X36	90	4	760	221	60%	456.2	132.4
الطابق الثالث								
مديرية الأسرة و الطفولة 301	FL 2X36	90	6	1,140	331	60%	684.3	198.6
مديرية الأسرة و الطفولة 302	FL 2X36	90	4	760	221	60%	456.2	132.4
حمام الجناح الأيمن - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيمن - سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
سكرتيرة مدير مديرية الأسرة و الطفولة 303	FL 2X36	90	4	760	221	60%	456.2	132.4
مدير مديرية الأسرة و الطفولة 304	FL 2X36	90	4	760	221	60%	456.2	132.4
مديرية الأسرة و الطفولة 305	FL 2X36	90	8	1,521	441	60%	912.4	264.7
مديرية الأسرة و الطفولة 306	FL 2X36	90	3	570	165	60%	342.1	99.3
مديرية تعزيز الإنتاجية 307	FL 4X18	90	6	1,140	331	60%	684.3	198.6
مديرية تعزيز الإنتاجية 308	FL 2X36	90	4	760	221	60%	456.2	132.4
مديرية تعزيز الإنتاجية 309	FL 2X36	90	6	1,140	331	60%	684.3	198.6
مديرية تعزيز الإنتاجية 310	FL 2X36	90	4	285	83	60%	171.1	49.6
مديرية تعزيز الإنتاجية 311	FL 2X36	90	6	1,140	331	60%	684.3	198.6
مديرية تعزيز الإنتاجية 312	FL 2X36	90	3	570	165	60%	342.1	99.3
سكرتيرة مدير مديرية الجمعيات 314	FL 2X36	90	3	570	165	60%	342.1	99.3
مدير مديرية الجميعات 314	FL 2X36	90	4	760	221	60%	456.2	132.4
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
مديرية الجمعيات 321	FL 2X36	90	4	760	221	60%	456.2	132.4
مديرية تكنولوجيا المعلومات 322	FL 2X36	90	8	1,521	441	60%	912.4	264.7
الطابق الرابع								
مديرية الشؤون القانونية (السكرتارية)	FL 2X36	90	4	760	221	60%	456.2	132.4
مدير مديرية الشؤون القانونية	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم الاتفاقيات و العقود	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم الاستشارات القانونية	FL 2X36	90	4	760	221	60%	456.2	132.4
مديرية السياسات و التطوير المؤسسي	FL 2X36	90	4	760	221	60%	456.2	132.4
مدير السياسات	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم التخطيط الاستراتيجي	FL 2X36	90	3	570	165	60%	342.1	99.3

قسم تحسين الخدمات	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم المتابعة و التقييم	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم الاتصال	FL 2X36	90	4	760	221	60%	456.2	132.4
قسم العلاقات العامة	FL 2X36	90	4	760	221	60%	456.2	132.4
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
قسم التوعية و التثقيف	FL 2X36	90	3	570	165	60%	342.1	99.3
مدير مديرية الاتصال	FL 2X36	90	3	570	165	60%	342.1	99.3
مكتب جائزة الملك عبد الله الثاني للتميز	FL 2X36	90	3	104	30	60%	62.2	18.1
الطابق الخامس								
كافيتيريا	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيمن - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيمن - سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
سكرتيرة أمين عام سجل الجمعيات	FL 2X36	90	3	570	165	60%	342.1	99.3
أمين عام سجل الجمعيات	FL 2X36	90	4	760	221	60%	456.2	132.4
قاعة اجتماعات	FL 2X36	90	4	138	40	60%	82.9	24.1
مدير مكتب أمين عام سجل الجمعيات	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم الدراسات و التطوير	FL 2X36	90	2	380	110	60%	228.1	66.2
رئيس قسم وحدة القيد و الاشهار	FL 2X36	90	2	380	110	60%	228.1	66.2
سكرتيرة القائم بأعمال مدير مديرية سجل الجمعيات	FL 2X36	90	3	570	165	60%	342.1	99.3
القائم بأعمال مدير مديرية سجل الجمعيات	FL 2X36	90	4	760	221	60%	456.2	132.4
رئيس قسم متابعة الأنظمة السياسية	FL 2X36	90	4	760	221	60%	456.2	132.4
صندوق دعم الجمعيات	FL 2X36	90	4	760	221	60%	456.2	132.4
مدير الأبنية و المساكن	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم المساكن 510	FL 2X36	90	2	380	110	60%	228.1	66.2
قسم الأبنية و الصيانة 509	FL 2X36	90	3	570	165	60%	342.1	99.3
رئيس قسم الدراسات و التعاون الخارجي 508	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم الاعلام 507	FL 2X36	90	3	570	165	60%	342.1	99.3
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	60%	228.1	66.2
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	60%	228.1	66.2
قسم الاراضي و الاستملاك 506	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم الأبنية و المساكن 505	FL 2X36	90	3	570	165	60%	342.1	99.3
قسم الأبنية و المساكن 504	FL 2X36	90	4	760	221	60%	456.2	132.4
رئيس قسم الأراضي و الاستملاك 503	FL 2X36	90	4	760	221	60%	456.2	132.4
صندوق دعم الجمعيات 502	FL 2X36	90	3	570	165	60%	342.1	99.3
صندوق دعم الجمعيات / المحاسبة 501	FL 2X36	90	4	760	221	60%	456.2	132.4
مناطق أخرى								
الحضانة	FL 2X36	90	14	2,661	772	60%	1596.7	463.3
مكتب الحركة	FL 2X36	90	7	1,663	483	60%	997.9	289.6
Total				**94,055.0**	**27,291.4**	**60%**	**56,433.0**	**16,374.9**

- **Please refer to annex to section 11.2 for more information about lighting system operating hours, and lux level.**

It is worth to be mentioned that replacing the Fluorescent Lamps FL 2x36 Watt by LED 2x18 will not require the replacement of the existing lighting fixture, as these lamps are direct replacement of the regular florescent lamps with minor modification on lamps wiring and removing the ballasts and starters.

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	**56,433**	**16,375**	**10.0%***	**11,176**	**8.2**

** The above saving percentage is referenced to the total annual electrical energy bill*

L.2: Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas

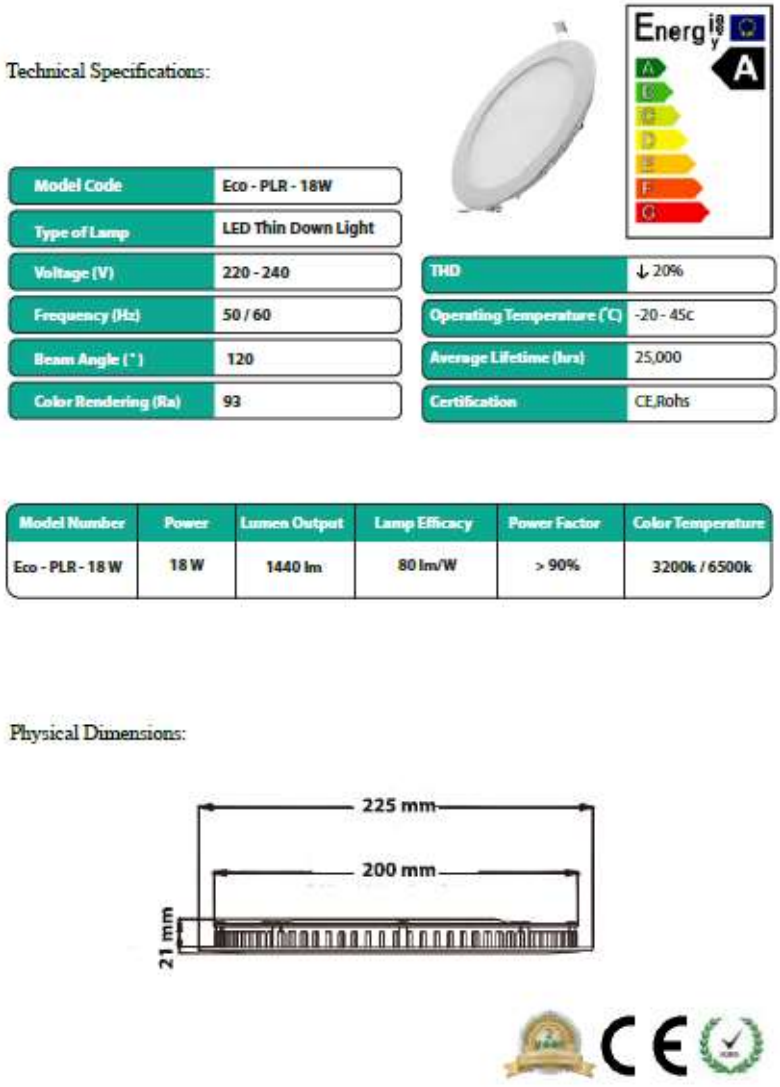
Finding Description and Recommendations:

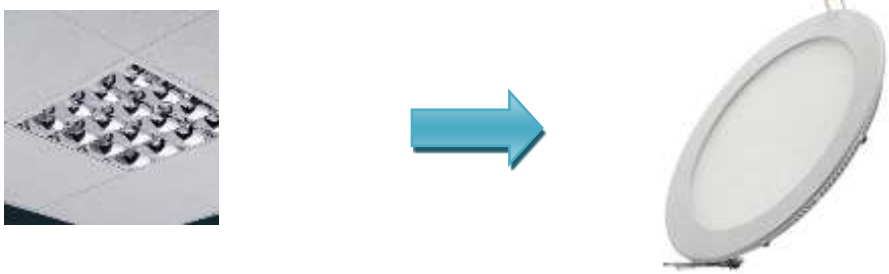
During the energy audit stage, a detailed lighting survey was carried out to identify lamps type, energy consumption and the illumination levels in the various areas at the ministry. The energy audit showed that all of the ministry corridors, open spaces, and some offices are being served by Fluorescent lamps 4X18 Watt.

To assist in reducing the lighting system energy consumption at the ministry, 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





Lumen output of LED round panel 18 watt (**1400-1500 lumen/lamp**) in 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 11: 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/yr	cost / yr	kWh saving	cost saving
طابق التسوية							
ممر رئيسي	FL 4X18	90	8	1,521	441	1216.5	353.0
الطابق الأرضي							
مدخل الوزارة	FL 4X18	90	26	4,942	1,434	3953.7	1147.2
خدمة الجمهور 003	FL 4X18	90	2	380	110	304.1	88.2
غرفة تصوير	FL 4X18	90	2	380	110	304.1	88.2
ممر - الجناح الايسر	FL 4X18	90	33	6,273	1,820	5018.1	1456.1
الطابق الأول							
ممر	FL 4X18	90	29	5,512	1,599	4409.9	1279.6
الطابق الثاني							
ممر	FL 4X18	90	26	4,942	1,434	3953.7	1147.2
الدمج الأسري 200	FL 4X18	90	6	1,140	331	912.4	264.7
المستشارين 201	FL 4X18	90	6	1,140	331	912.4	264.7
سكرتاريا المساعدين	FL 4X18	90	5	950	276	760.3	220.6
مساعد الأمين العام للتطوير	FL 4X18	90	6	1,140	331	912.4	264.7
مساعد الأمين العام للتنمية و الرعاية	FL 4X18	90	6	1,140	331	912.4	264.7
وحدة الانتاج التلفزيوني 218	FL 4X18	90	2	380	110	304.1	88.2
الطابق الثالث							
ممر	FL 4X18	90	30	5,702	1,655	4561.9	1323.7
مديرية الجمعيات 313	FL 4X18	90	8	1,521	441	1216.5	353.0
مديرية الجمعيات 315	FL 4X18	90	6	1,140	331	912.4	264.7
مديرية تكنولوجيا المعلومات 316	FL 4X18	90	6	1,140	331	912.4	264.7
سكرتيرة مدير مديرية تكنولوجيا المعلومات 317	FL 4X18	90	3	570	165	456.2	132.4
مدير مديرية تكنولوجيا المعلومات 317	FL 4X18	90	4	760	221	608.3	176.5
مديرية تكنولوجيا المعلومات 318	FL 4X18	90	14	2,661	772	2128.9	617.7
مختبر الحاسوب 319	FL 4X18	90	6	1,140	331	912.4	264.7
قاعة تدريب 320	FL 4X18	90	10	1,901	552	1520.6	441.2
الطابق الرابع							
ممر	FL 4X18	90	20	3,802	1,103	3041.3	882.5
جناح الوزير	FL 4X18	90	45	8,554	2,482	6842.9	1985.6
الطابق الخامس							
ممر	FL 4X18	90	30	5,702	1,655	4561.9	1323.7
كافيتيريا	FL 4X18	90	8	1,521	441	1216.5	353.0
سجل الجمعيات / القيد و الاشهار	FL 4X18	90	14	2,661	772	2128.9	617.7

المكتبة	FL 4X18	90	21	3,992	1,158	3193.3	926.6
مناطق أخرى							
الحضانة	FL 4X18	90	5	950	276	760.3	220.6
Total				**73,561.0**	**21,344.8**	**58,848.8**	**17,075.8**

- **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 11.4**.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**58,849**	**17,076**	**10.4%**	**4,644**	**3.3**

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

L.3: 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.

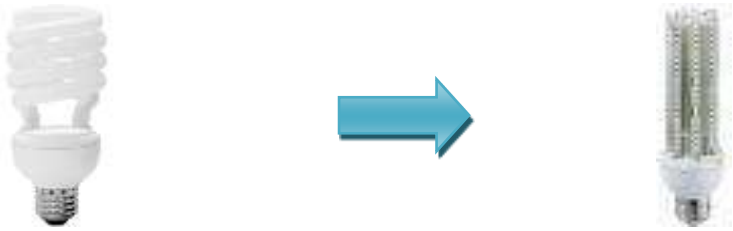
Finding Description and Recommendations:

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 26 Watt, and polar lighting of CFL 23 Watt found serving the external areas of the ministry

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 69 % of those lamps energy consumption, the below table shows the proposed areas and the details of implementing this measure.

Table 12: Details of Replacing of Compact Fluorescent Lamps 26 Watt and 23 Watt by New High Efficiency LED U-Bulb Lamps 16 Watt

Area	fixture type	fixture wattage	Q'ty	Annual Consumption		Annual Saving	
				Consumption kWh/yr	cost / yr	kWh saving	cost saving
الطابق الثاني							
جناح الأمين العام / السكرتاريا	CFL 1X26	28	8	473	137	270.3	78.4
مدير مكتب الأمين العام	CFL 1X26	28	10	591	172	337.9	98.1
الأمين العام	CFL 1X26	28	24	1,419	412	811.0	235.3
الطابق الرابع							
جناح الوزير	CFL 1X26	28	102	6,032	1,750	3446.8	1000.1
مناطق أخرى							
إنارة خارجية (Lighting Polar)	CFL 1X23	23	19	1,573	456	752.4	218.3
Total				**10,088.8**	**2,927.4**	**5,618.4**	**1,630.3**

- **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	**5,618**	**1,630**	**1.0%***	**1,223**	**9.0**

***** *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 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 ministry, 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.

Table 13: Control Lighting Fixtures in Some Selected Areas Using Presence/Motion Sensors

Area	fixture type	fixture wattage	Q'ty	Annual Consumption		ECM	% of saving	Annual Saving	
				Consumption kWh/yr	cost / yr			kWh saving	cost saving
طابق التسوية									
ممر رئيسي	FL 4X18	90	8	1,521	441	Motion Sensor	7%	106.4	30.9
حمام رجال	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
حمام سيدات	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
الطابق الأرضي									
حمام الجناح الأيمن - رجال	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
حمام الجناح الأيمن - سيدات	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
مدير الدفاع الاجتماعي 012	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
رئيس قسم الأحداث 013	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
الطابق الأول									
مدير الموارد المالية 102	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
حمام الجناح الأيمن - رجال	FL 2X36	90	3	570	165	Motion Sensor	10%	57.0	16.5
حمام الجناح الأيمن - سيدات	FL 2X36	90	3	570	165	Motion Sensor	10%	57.0	16.5
رئيس قسم الرواتب 103	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
رئيس قسم التدقيق 107	FL 2X36	90	2	380	110	Occupancy Sensor	8%	30.4	8.8
رئيس قسم المحاسبة 108	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
رئيس قسم شؤون الموظفين 116	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
مدير الموارد البشرية 119	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
حمام الجناح الأيسر - رجال	FL 2X36	90	3	570	165	Motion Sensor	10%	57.0	16.5
حمام الجناح الأيسر- سيدات	FL 2X36	90	3	570	165	Motion Sensor	10%	57.0	16.5
الطابق الثاني									
مستشار الأمين العام لشؤون الأشخاص المعوقين 202	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
حمام الجناح الأيمن - رجال	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
حمام الجناح الأيمن - سيدات	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
رئيس قسم الرقابة الفنية 212	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2

رئيس قسم الرقابة الداخلية (سكرتيرة) 213	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
رئيس قسم الرقابة الداخلية 213	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
مدير شوؤن الأشخاص ذوي الإعاقة 217	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
مصلى النساء 220	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
مصلى الرجال 221	FL 2X36	90	6	1,140	331	Occupancy Sensor	8%	91.2	26.5
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
رئيس قسم المتابعة و الشكاوي 225	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
الطابق الثالث									
حمام الجناح الأيمن - رجال	FL 2X36	90	2	380	110	Motion Sensor	12%	45.6	13.2
حمام الجناح الأيمن - سيدات	FL 2X36	90	2	380	110	Motion Sensor	12%	45.6	13.2
مدير مديرية الأسرة و الطفولة 304	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
مدير مديرية الجميعات 314	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
مدير مديرية تكنولوجيا المعلومات 317	FL 4X18	90	4	760	221	Occupancy Sensor	4%	30.4	8.8
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	Motion Sensor	12%	45.6	13.2
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	Motion Sensor	12%	45.6	13.2
الطابق الرابع									
مدير مديرية الشؤون القانونية	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
مدير السياسات	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
الطابق الخامس									
حمام الجناح الأيمن - رجال	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
حمام الجناح الأيمن - سيدات	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
أمين عام سجل الجمعيات	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
مدير مكتب أمين عام سجل الجمعيات	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
رئيس قسم وحدة القيد و الاشهار	FL 2X36	90	2	380	110	Occupancy Sensor	8%	30.4	8.8
القائم بأعمال مدير مديرية سجل الجمعيات	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6

رئيس قسم متابعة الأنظمة السياسية	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
مدير الأبنية و المساكن	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
رئيس قسم الدراسات و التعاون الخارجي 508	FL 2X36	90	3	570	165	Occupancy Sensor	8%	45.6	13.2
حمام الجناح الأيسر - رجال	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
حمام الجناح الأيسر- سيدات	FL 2X36	90	2	380	110	Motion Sensor	10%	38.0	11.0
رئيس قسم الأراضي و الاستملاك 503	FL 2X36	90	4	760	221	Occupancy Sensor	8%	60.8	17.6
Total				**30,222.7**	**8,769.6**		**9%**	**2,600.3**	**754.5**

- **Please refer to annex to section 11.3 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	**2,600**	**755**	**0.5%**	**2,430**	**38.6**

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

L.5: Replace the Existing External High Street Light 150 Watt by New High Efficient LED Street Light 90 Watt

Finding Description and Recommendations:

The conducted lighting survey showed that the external lighting fixtures are from the High Pressure Sodium Light street light (HPS 150 Watt)

LED Streetlight is the optimum choices in this case to replace existing HPS Streetlight, as they are able to light external areas with higher color rendering index and better color characteristics.

To assist in reducing energy consumption at the Ministry; it is recommend to replace the existing HPS Streetlight 150 Watt by LED Streetlight 90 Watt.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**9,331**	**2,708**	**1.7%***	**7,200**	**31.9**

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

AC.1: Improve the Heat Transfer Efficiency at the Water Chiller by Condenser Cleaning Program

Finding Description and Recommendations:

The Chiller's condenser is part of the refrigeration cycle where the heat absorbed by the refrigerant is dissipated to the atmosphere. When the surface of the condenser is blocked with foreign materials the heat exchange between the refrigerant and ambient air becomes less and accordingly the cooling effect of the refrigeration system decreases.

The condenser of the water chillers at the ministry were intensively examined; a layer of dust, mud and sand had built up on the condenser fins surface of these chillers, reducing its heat transfer efficiency and thus reducing the water chiller's efficiency.

Based on our past experience and similar international practices , For every 1 C decrease in the temperature of the refrigerant leaving the condenser, the chiller efficiency improves by 2%- 3%.

To assist in reducing energy consumption of the water chiller, it is recommended to conduct a chemical cleaning program for the condenser water chillers to remove the dust, mud and sands from the fins and improving the heat transfer efficiency. By implement this measure on water chiller, at minimum of 3% of the chiller consumption could be saved. The cleaning process of the water chiller could be done by high pressure water pump, pumping water with special cleaning chemicals to remove the dirty from the fins.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**2,186**	**634**	**0.4%***	**750**	**14.2**

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

AC.2: Improve the Heat Transfer Efficiency at the Water Chiller by Adding Heat Transfer Additives

Finding Description and Recommendations:

during the life time of any water chiller, some of the lubrication oil from the refrigeration compressors get in the gas side and spread in the refrigeration cycle making a layer of oil inside the gas pipes and then reducing the heat transfer efficiency of the overall system, the amount of oil get in the gas side is being increased by the aging of the water chiller and during the maintenance of the chiller.

A very efficient method to remove the layer of oil inside the gas side is to add some additives that can absorb this layer result in improving the heat transfer efficiency of the water chiller. This additives are called "Polarized Refrigerant Oil Additives" (PROA).

The main benefit of these additives is to improve the heat transfer in the evaporator and condensing coils. On the other hand, it increases lubricity of the refrigerant oil and can extend equipment life.

To assist in reducing energy consumption of the water chiller, it is recommended to add the PROA to the gas side of the water chiller; this should be done by qualified engineer or technician. Adding this refrigerant oil additive saves about 8% - 15% of the water chiller energy consumption depending on the amount of oil being penetrated in the gas side. From our previous experience impressive results were obtained where savings in some cases exceeded 15%. Based on our past experience in similar systems, implementing this measure will achieve considerable savings due to the age of the chiller (7 years). To be conservative in the calculations a saving of 10% was assumed.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**7,286**	**2,114**	**1.3%***	**3,800**	**21.6**

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

AC.3: Improve the heat transfer Efficiency at the Water Chiller by Shell and Tube Cleaning Program

Finding Description and Recommendations:

The energy efficiency of the water chiller is expressed in the term Coefficient of Performance (COP). The COP is defined as the amount of thermal energy produced by water chillers divided by the consumed electrical energy. The higher COP value, the more energy efficient water chiller.

The COP value depreciates over time due to many reasons such as scaling in the shell & tube water circuit and make it dirty, then chilled water coils just become less and less efficient until they reach a point where they cannot deliver enough capacity to cool the space, resulting in reducing the COP of the water chiller, and consequently reducing it's working efficiency.

Due to the aging of chiller (7 years), it is expected that a layer of mud and scaling started to be built in the inner side of the shell and tube of water chiller, thus decreasing its heat transfer efficiency at the water side.

Therefore, to help in reducing energy consumption at the ministry, it is recommended to conduct a chemical treatment for the water chiller's network to flush out the shell and tube circuit from any scaling inside. This will improve the COP of the water chiller to be close to the optimum value.

Based on our past experience and the technical assessment of the water chiller, implementing this measure is expected to save at least 8% of chillers electrical energy consumption.

Note: During the energy auditing phase, the chiller was un-operational and no temperature measurements carried out. It is preferred to conduct temperature measurements on the water chiller during its operation to measure the difference in the inlet and outlet temperature and to compare it with the manufacturer data to check the exact percentage of saving.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**5,829**	**1,691**	**1.0%**	**1,750**	**12.4**

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

AC.4: Optimizing Temperature Set Point of AC System in Both Summer and Winter According to International Standards

Finding Description and Recommendations:

During the energy audit phase conducted in the beginning of April 2016, 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 during Winter season is about 27-28 °C (heating mode) while the optimum temperature for human comfort and energy efficiency is 25 °C according to ASHRAE recommendations.

At the same time, it was advised that the set point at summer time (cooling mode) for both AC split units and Central AC thermostat 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 (split units and water chiller), 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 split air conditioners to be 23 °C at winter time, and optimize the set-point of those units and central system thermostat to be 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 the split AC's electrical energy consumption and about 8% of water chiller electicity consumption, resulting 1.5 % of the total electricity bill, the actual savings from appling this measures is higher than this value 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	**8,385**	**2,433**	**1.5%**	**1,140**	**6**

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

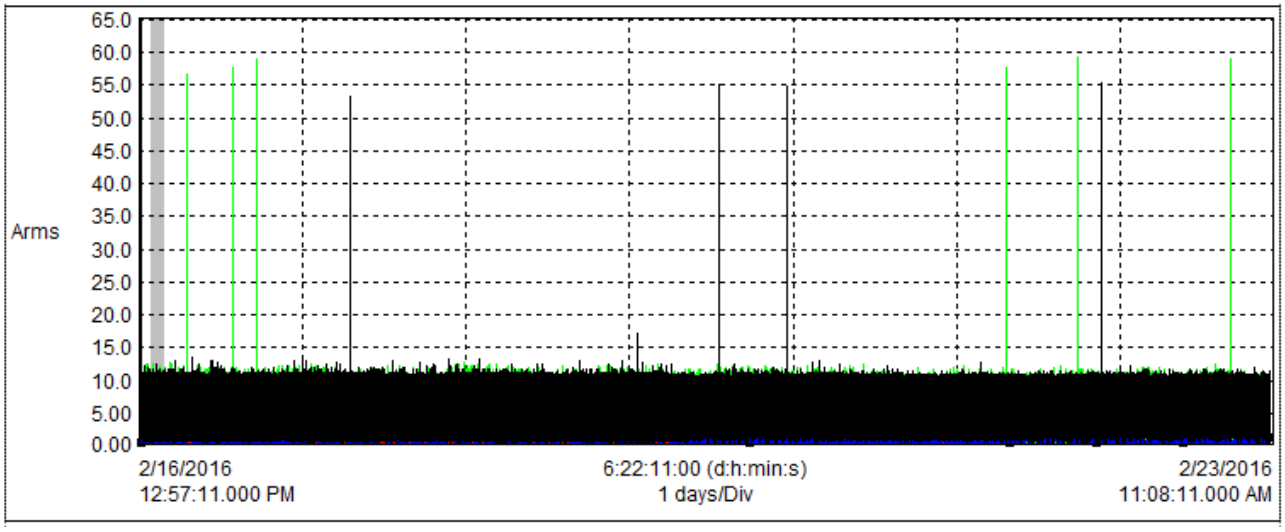
Finding Description and Recommendations:

The Server Rooms at MoSD Building is considered as a major load on AC system due to the huge amount of rejected heat, and its represent about 16% of the electrical energy consumers at the ministry building.

Server room is supplied by its need from cooling by two stand-alone units; each of 5.6 RT (Refrigeration Ton) capacities, one in duty and the other one is stand-by.

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 MoSD.

Figure 15: Electrical Current [Amp] as Measured on the Air Conditioning of Server Room (February 16, 2016 – February 23, 2016)



From the above figure it could be noticed that AC was running continuously to provide the required cooling for server room, knowing that measurement conducted during February.

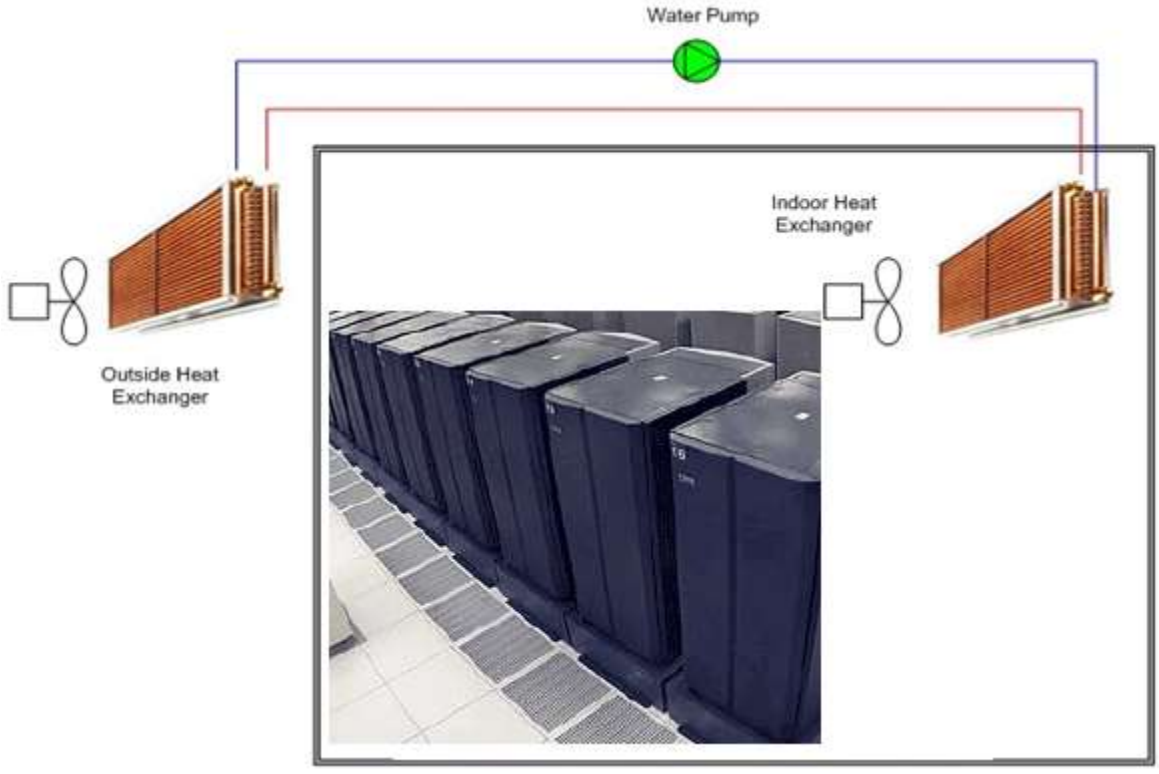
The cooling design for this area is based on circulating the room air through the AC heat exchanger to provide the required cooling and keeping the temperature inside the server room in the range of 19 - 20°C with no outside air compensation to maintain the humidity at the acceptable levels which was 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 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 14: Heat Recovery System Specifications

Part	Specifications	Q'ty
Inside Heat Exchanger	Fan Coil Unit with Cooling Capacity of 45,000 BTU/Hr.	1
Outside Heat Exchanger	Air Handling Unit with Cooling Capacity of 33 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	**5,893**	**1,710**	**1.0%***	**5,375**	**37.7**

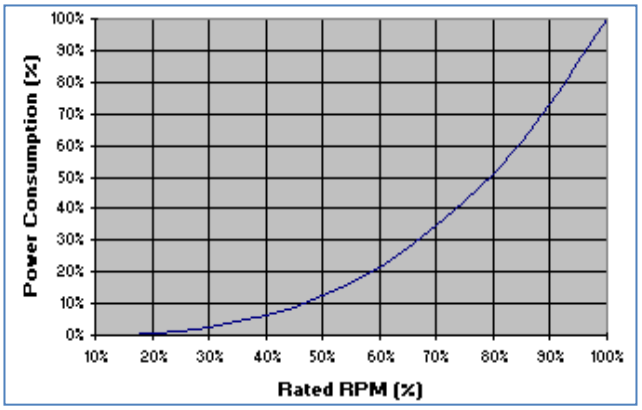
** The above saving percentage is out of the total annual electrical energy bills*

P.1: Control The Operation of Chilled Water Pumps using VFD

Finding Description and Recommendations:

A simple method of reducing motor energy consumption and running cost is to reduce the motor's speed. Energy consumption of pumps and fans varies according to the speed based on cubic relation. Therefore, small change in speed reflects into high change in power consumption. Figure (16) below shows the relationship between the fan speed in (RPM %) and power consumption.

Figure 16: Motors Power Consumption V.s. Speed for Fans



From the above figure, it can be noticed that a reduction in speed (flow) of 10 % could be translated into 27% power saving, and a reduction of 20% reflects on 50% saving in power consumption.

The most common and easy method to control motor's speed utilizing modern technologies is to install a variable frequency drive (VFD) on the fan or pump's motor, the VFD offers a smooth wide range of speeds, higher motor performance, as well as the energy conservation purposes.

During the audit stage, the HVAC system was studied intensively. Chilled water pumps were investigated and found three of 5.5 kW; one of them found operational and the other two pumps are stand by. These set of chilled water pumps are being operated at full speed all the time regardless of the actual cooling needs.

Therefore, to help in reducing energy consumption at the ministry, it is recommended to control the operation of the chilled water pump using variable frequency drive VFD by temperature feedback signal, by which the VFD automatically decrease / increase the fan speed based on the actual needs where the inverter reduces the fan speed

when the return air temperature are close to the set point or below the set point and vice versa.

Implementing this measure can reduce the pump motor speed by 10% - 15% resulting in saving about (27% - 43%) of the chilled water pump energy consumption. The below calculations were based on 30% savings

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**1,162**	**337**	**0.2%**	**425**	**15.1**

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

O.1: Switch Off the Water Coolers during Night Time by Programmable Timer

Finding Description and Recommendations:

During audit stage, all electrical appliances in MoSD studied and investigated, 31 water coolers of 150 Watt/cooler found serving 320 employees in addition to the ministry 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 3,819 kWh/year. (31 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 3,819 kWh/year will be saved.

Therefore, to help in reducing energy consumption at the ministry, 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 0.7% of the total annual electrical energy bill of the MoSD building.

Energy Saving:

Type of Saved Energy	Energy Saving [kWh]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Electricity	**3,818.8**	**1,108**	**0.7%***	**465**	**5.0**

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

O.2: Increase Energy conservation awareness among the Ministry 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 ministry 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 ministry (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 minister and SG of the ministry by developing internal energy management policy.
- Develop a messages for ministry 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 (ministry homepage, emails signatures, e-newsletter), public channels (displays inside the ministry)
- 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	**5,638**	**1,636**	**1.0%***	**500**	**3.7**

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

F.1: Improve the Combustion Efficiency of Space Heating Diesel Boiler

Finding Description and Recommendations:

Diesel Fuel is used in the Ministry for heating purposes, (**Space Heating, and Domestic Hot Water**). There are three boilers in the Ministry, Two of them for the offices and employees areas Space Heating and the other for ministry nursery three boilers are usually operated in winter for 5 Month to provide heating needs.

During the audit phase, a combustion efficiency test was conducted for existing Boilers and found that one of the Boilers is in a good conditions and has a high efficiency (around 92 %), while the other two Boilers need some maintenance to improve their Combustion Efficiency.

The test was done by special combustion gas analyzer, the below table shows the combustion efficiency test results for each boiler in MoSD, in addition to combustion efficiency test the insulation of hot water pipes in the Boiler rooms was visually investigated and It was in a good condition and well insulated, and the set point of the Diesel Boiler within the standards (60-70) Degree Celsius.

Table 15: Combustion Test Results

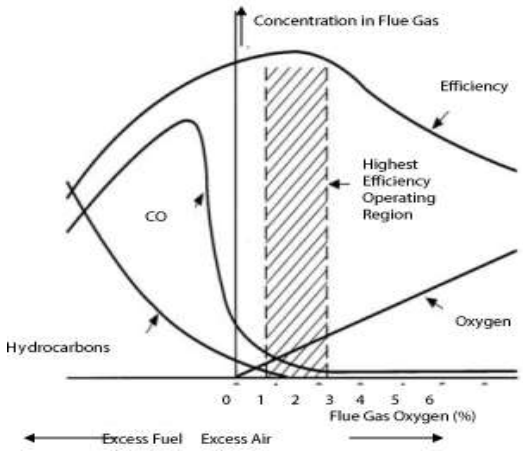
Boiler	O2	CO2	CO(PPM)	Flue Temp	Net Stack Temp	Current Efficiency
Left Boiler	9.1	8.8	17	338.3	319.4	85.5%
Right Boiler	9.1	8.7	8	160.6	141.4	91.8%
Nursery Boiler	5.5	11.4	296	356.1	337.2	85.0%

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 17: Highest Boiler Combustion Efficiency Operating Region



As shown in **table (16),** the boilers combustion efficiencies could be improved more to the optimum values by a fuel/air calibration and optimization. The following table shows the proposed optimum values.

Table 16: Proposed Optimum Values for Efficient Combustion

Boiler	O2	CO2	CO(PPM)	Flue Temp	Net Stack Temp	Current Efficiency
Boilers	5	11	24	180	160	91%

Energy Saving:

Type of Saved Energy	Fuel Saving [Liter]	Cost Saving [JD]	% of Saving	Implementation Cost [JD]	Pay Back [Months]
Fuel	**3,132**	**1,284**	**6.5%***	**700**	**7**

** 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 17: 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 2x36 Watt by New High Efficiency T8 LED Lamps 2x18 Watt in some Selected Areas.	56,433	117	56,672	333	106	4.24	0.6	56,717
L.2	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	58,849	122	59,098	347	110	4.43	0.6	59,145
L.3	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.	5,618	12	5,642	33	11	0.42	0.1	5,647
L.5	Replace the Existing External Sodium Street Light 150 Watt by new high efficient LED Street Light 90 Watt	9,331	19	9,371	55	17	0.70	0.1	9,378
AC.1	Improve the heat transfer Efficiency at the water chiller by Condenser Cleaning Program	2,186	5	2,195	13	4	0.16	0.0	2,197
AC.2	Improve the heat Transfer Efficiency at the water chiller by adding heat transfer additives	7,286	15	7,317	43	14	0.55	0.1	7,323
AC.3	Improve the heat transfer Efficiency at the water chiller by shell and Tube Cleaning program	5,829	12	5,854	34	11	0.44	0.1	5,858
AC.4	Optimizing Temperature Set Point of AC System in Both Summer and Winter According to International Standards	8,385	17	8,421	50	16	0.63	0.1	8,428
AC.5	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	5,893	12	5,917	35	11	0.44	0.1	5,922
P.1	Control The Operation of Chilled Water Pump using VFD	1,162	2	1,167	7	2	0.09	0.0	1,167
O.1	Switch Off the Water Coolers During Night Time by Programmable Timer	3,819	8	3,835	23	7	0.29	0.0	3,838
O.2	Increase Energy conservation awareness among the Ministry employees	5,638	12	5,662	33	11	0.42	0.1	5,666
F.1	Improve the Combustion Efficiency of Diesel Boilers	3,132	17	8,211	7	15	0.09	0.1	8,217
Total		173561	369	179362	1013	335	13	1.9	179503

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

Table 18: Financial Analysis of Implementing Energy Management Opportunities

Project Inputs and Details							
Implementation Cost JDs	**41,578**	**Annual Savings JDs**	**51,491**	**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		51,491	51,491	51,491	51,491	51,491	**257,455**
Escalated value		53,036	54,627	56,266	57,954	59,692	**281,574**
Annual Cash flow (undiscounted)	-41,578	53,036	54,627	56,266	57,954	59,692	**281,574**
Annual Cash flow (Discounted)		46,118	41,306	36,996	33,135	29,678	**187,232**
Financial Results							
Saving to Investment Ratio	**4.5**	**Internal Rate of Return IRR**	**128.2 %**	**Net Present Value NPV in JDs**	**126,656**	**Simple Pay back [years]**	**0.81**

8.0 MEASUREMENT AND VERIFICATION OF SAVINGS

Table (19) 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 19: 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 2x36 Watt by New High Efficiency T8 LED Lamps 2x18 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 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.3	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.4	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.5	Replace the Existing External Sodium Street Light 150 Watt by new high efficient LED Street Light 90 Watt	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	Improve the heat transfer Efficiency at the water chiller by Condenser Cleaning Program	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	Improve the heat Transfer Efficiency at the water chiller by adding heat transfer additives	Average Working Hours before	Average Working Hours After	Difference in working hours x electric load in kW	(Saving in kWh) x (Elec. Tariff)
AC.3	Improve the heat transfer Efficiency at the water chiller by shell and Tube Cleaning program	Average Working Hours before	Average Working Hours After	Difference in working hours x electric load in kW	(Saving in kWh) x (Elec. Tariff)
AC.4	Optimize the A/C Thermostat Set-point to meet 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.5	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	Control The Operation of Chilled Water Pump using VFD	Power Consumption before in kW	Power Consumption after in kW	Reduction of Power consumption in kW X Working hours	(Saving in kWh) x (Elec. Tariff)
P.2	Switch OFF the Loop Chilled Water Pump (18.5 kW) Located at the B1 Level	Power Consumption before in kW	Power Consumption after in kW	Reduction of Power consumption in kW X Working hours	(Saving in kWh) x (Elec. Tariff)
O.1	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.2	Increase Energy conservation awareness among the Ministry 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	Improve the Combustion Efficiency of Diesel Boiler	Boiler Efficiency Before implementation	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 20: 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
Lighting System's Energy Management Opportunities							
L.1	Replace the Existing T8 Fluorescent Lamps 2x36 Watt by New High Efficiency T8 LED Lamps 2x18 Watt in some Selected Areas.	56,433	16,375	10.0%	**11,176**	8	**High**
L.2	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	58,849	17,076	10.4%	**4,644**	3	**High**
L.3	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.	5,618	1,630	1.0%	**1,223**	9	**High**
L.4	Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors	2,600	755	0.5%	**2,430**	39	**Medium**
L.5	Replace the Existing External Sodium Street Light 150 Watt by new high efficient LED Street Light 90 Watt	9,331	2,708	1.7%	**7,200**	32	**Medium**
Air Conditioning System's Energy Management Opportunities							
AC.1	Improve the heat transfer Efficiency at the water chiller by Condenser Cleaning Program	2,186	634	0.4%	**750**	14	**Medium**
AC.2	Improve the heat Transfer Efficiency at the water chiller by adding heat transfer additives	7,286	2,114	1.3%	**3,800**	22	**Medium**
AC.3	Improve the heat transfer Efficiency at the water chiller by shell and Tube Cleaning program	5,829	1,691	1.0%	**1,750**	12	**High**

AC.4	Optimizing Temperature Set Point of AC System in Both Summer and Winter According to International Standards	8,385	2,433	1.5%	1,140	6	High
AC.5	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	5,893	1,710	1.0%	5,375	38	Medium
Pumping System's Energy Management Opportunities							
P.1	Control The Operation of Chilled Water Pump using VFD	1,162	337	0.2%	425	15	Medium
Other Energy Management Opportunities							
O.1	Switch Off the Water Coolers During Night Time by Programmable Timer	3,819	1,108	0.7%	465	5	High
O.2	Increase Energy conservation awareness among the Ministry employees	5,638	1,636	1.0%	500	4	High
Total		173,029	50,207	30.7%	40,878	10	
No.	**Fuel System Energy Management Opportunities**	**Saving in [Liters]**	**Saving in JDs**	**% of saving**	**Investment JDs**	**Pay-Back Months**	
F.1	Improve the Combustion Efficiency of Diesel Boilers	3,132	1,284	6.5%	700	7	High
Total		3,132	1,284	6.5%	700	7	

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**	173,029	46,562	30.7%	40,878	10.5
F	**Energy Management Opportunities in Fuel Systems**	3,132	1,284	6.5%	700	6.5
	Total		47,846	27.2%	41,578	10.4

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 2x36 Watt by New High Efficiency T8 LED Lamps 2x18 Watt in some Selected Areas.	56,433	15,186	10.0%	11,176	9
L.2	Replace the Existing T8 Fluorescent Lamps 4x18 Watt by New High Efficiency LED Down light 18 Watt in some Selected Areas	58,849	15,836	10.4%	4,644	4
L.3	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.	5,618	1,512	1.0%	1,223	10
L.4	Control the Operation of Lighting System in Some Selected Areas Using Occupancy Sensors	2,600	700	0.5%	2,430	42
L.5	Replace the Existing External Sodium Street Light 150 Watt by new high efficient LED Street Light 90 Watt	9,331	2,511	1.7%	7,200	34
Air Conditioning System's Energy Management Opportunities						
AC.1	Improve the heat transfer Efficiency at the water chiller by Condenser Cleaning Program	2,186	588	0.4%	750	15
AC.2	Improve the heat Transfer Efficiency at the water chiller by adding heat transfer additives	7,286	1,961	1.3%	3,800	23
AC.3	Improve the heat transfer Efficiency at the water chiller by shell and Tube Cleaning program	5,829	1,569	1.0%	1,750	13
AC.4	Optimizing Temperature Set Point of AC System in Both Summer and Winter According to International Standards	8,385	2,257	1.5%	1,140	6

AC.5	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System	5,893	1,586	1.0%	5,375	41
Pumping System's Energy Management Opportunities						
P.1	Control The Operation of Chilled Water Pump using VFD	1,162	313	0.2%	425	16
Other Energy Management Opportunities						
C.1	Switch Off the Water Coolers During Night Time by Programmable Timer	3,819	1,028	0.7%	465	5
O.2	Increase Energy conservation awareness among the Ministry employees	5,638	1,517	1.0%	500	4
Total		173,029	46,562	**30.7%**	**40,878**	11

No.	Fuel System Energy Management Opportunities	Saving in Ltr	Saving in JDs	% of saving	Investment JDs	Pay-Back Months
F.1	Improve the Combustion Efficiency of Diesel Boilers	3,132	1,284	6.5%	700	7
Total		3,132	1,284	**6.5%**	**700**	7

11.2 ELECTRICAL LOAD LIST AND REFERENCE DATA

Electrical Load List

Load Description	Qty	Total Installed Power [kW]	Operating Hours				Annual Consumption and Cost		Percentage %
			Hrs	Days	Months	Hrs/Year	kWh	JDs	
Lighting System	1100	91.07	8	22	12	2112	199,317	57,835	35.4%
IT Equipment	455	153.60	8	22	12	2112	142,058	41,220	25.2%
Water Chiller	1	103.50	8	22	5	880	72,864	21,143	12.9%
Server Room Air Conditioners	3	7.20	24	30	12	8640	31,164	9,043	5.5%
Split Air Conditioners	36	69.60	5	22	5	550	24,426	7,087	4.3%
Elevators	4	30.00	8	22	12	2112	31,680	9,912	5.6%
Water Cooler	31	4.65	9	30	12	3240	15,066	4,372	2.7%
Fans	74	5.18	8	22	12	2112	8,752	2,540	1.6%
Pumping System	4	11.50	8	22	5	880	8,096	2,349	1.4%
Others		21.9					30,344	8,805	5.38%
Total							563,766	163,585	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											
ممر رئيسي	FL 4X18	90	8	225	100-150	8	22	12	0.720	1,521	441
حمام رجال	FL 2X36	90	2	60	100-150	8	22	12	0.180	380	110
حمام سيدات	FL 2X36	90	2	85	100-150	8	22	12	0.180	380	110
مخزن 003	FL 2X36	90	3	370	100	2	22	12	0.270	143	41
مخزن 004	FL 2X36	90	4	330	100	2	22	12	0.360	190	55
مقسم رئيسي	FL 2X36	90	2	235	200	4	12	12	0.180	104	30
الطابق الأرضي											
مدخل الوزارة	FL 4X18	90	26	300	100-150	8	22	12	2.340	4,942	1,434
مدير الشؤون الإدارية 001	FL 2X36	90	6	330	300-500	8	22	12	0.540	1,140	331
خدمة الجمهور 003	FL 2X36	90	4		300-500	8	22	12	0.360	760	221
خدمة الجمهور 003	FL 4X18	90	2		300-500	8	22	12	0.180	380	110
مدير خدمة الجمهور 004	FL 2X36	90	2		300-500	8	22	12	0.180	380	110
مكتب خدمات 005	FL 2X36	90	1		300-500	8	22	12	0.090	190	55
باحث اجتماعي 006	FL 2X36	90	4	270	300-500	8	22	12	0.360	760	221
غرفة تصوير	FL 4X18	90	2	270	500	8	22	12	0.180	380	110
حمام الجناح الأيمن - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيمن - سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
ممر - الجناح الايسر	FL 4X18	90	33	190	100-150	8	22	12	2.970	6,273	1,820
التمويل الأجنبي 007	FL 2X36	90	3	900	300-500	8	22	12	0.270	570	165
مدير التمويل الأجنبي 008	FL 2X36	90	3	600	300-500	8	22	12	0.270	570	165
رئيس قسم اللوازم 009	FL 2X36	90	3		300-500	8	22	12	0.270	570	165
قسم اللوازم 010	FL 2X36	90	3	600	300-500	8	22	12	0.270	570	165
رئيس قسم التزويد 011	FL 2X36	90	3	780	300-500	8	22	12	0.270	570	165
مدير الدفاع الاجتماعي (السكرتيرة) 012	FL 2X36	90	3		300-500	8	22	12	0.270	570	165
مدير الدفاع الاجتماعي 012	FL 2X36	90	3		300-500	8	22	12	0.270	570	165
رئيس قسم الأحداث 013	FL 2X36	90	3		300-500	8	22	12	0.270	570	165
قسم الاتجار بالبشر 014	FL 2X36	90	3	460	300-500	8	22	12	0.270	570	165
قسم الاتجار بالبشر 015	FL 2X36	90	3	450	300-500	8	22	12	0.270	570	165
حمام الجناح الأيسر - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيسر - سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
قسم الأحدث 027	FL 2X36	90	4	300	300-500	8	22	12	0.360	760	221
قسم الحماية الاجتماعية 028	FL 2X36	90	4	320	300-500	8	22	12	0.360	760	221
مكاتب 017	FL 2X36	90	4	480	300-500	8	22	12	0.360	760	221
الصادر 019	FL 2X36	90	6	480	300-500	8	22	12	0.540	1,140	331

الوارد 020	FL 2X36	90	4	290	300-500	8	22	12	0.360	760	221
الوارد 021	FL 2X36	90	3	360	300-500	8	22	12	0.270	570	165
الديوان 022	FL 2X36	90	3	300	300-500	8	22	12	0.270	570	165
رئيس الديوان 023	FL 2X36	90	3	280	300-500	8	22	12	0.270	570	165
الطابق الأول											
ممر	FL 4X18	90	29	130	100-150	8	22	12	2.610	5,512	1,599
قسم الرقابة المالية 101	FL 2X36	90	4	355	300-500	8	22	12	0.360	760	221
مدير الموارد المالية (السكرتيرة) 102	FL 2X36	90	4	450	300-500	8	22	12	0.360	760	221
مدير الموارد المالية 102	FL 2X36	90	4	330	300-500	8	22	12	0.360	760	221
حمام الجناح الأيمن - رجال	FL 2X36	90	3		100-150	8	22	12	0.270	570	165
حمام الجناح الأيمن - سيدات	FL 2X36	90	3		100-150	8	22	12	0.270	570	165
رئيس قسم الرواتب 103	FL 2X36	90	3		300-500	8	22	12	0.270	570	165
قسم الرواتب 104	FL 2X36	90	4	450	300-500	8	22	12	0.360	760	221
قسم الرواتب 105	FL 2X36	90	4	510	300-500	8	22	12	0.360	760	221
رئيس قسم التدقيق 107	FL 2X36	90	2	280	300-500	8	22	12	0.180	380	110
رئيس قسم المحاسبة 108	FL 2X36	90	3	180	300-500	8	22	12	0.270	570	165
قسم المحاسبة 109	FL 2X36	90	4	290	300-500	8	22	12	0.360	760	221
قسم الصرف و الأمانات 110	FL 2X36	90	10	500	300-500	8	22	12	0.900	1,901	552
قسم التدقيق 112	FL 2X36	90	4	690	300-500	8	22	12	0.360	760	221
قسم الصرف 113	FL 2X36	90	3	420	300-500	8	22	12	0.270	570	165
المراقب المالي 114	FL 2X36	90	3	580	300-500	8	22	12	0.270	570	165
المراقب المالي 115	FL 2X36	90	3	650	300-500	8	22	12	0.270	570	165
رئيس قسم شؤون الموظفين 116	FL 2X36	90	3	800	300-500	8	22	12	0.270	570	165
شؤون الموظفين 117	FL 2X36	90	3	790	300-500	8	22	12	0.270	570	165
شؤون الموظفين 118	FL 2X36	90	4	580	300-500	8	22	12	0.360	760	221
مدير الموارد البشرية (السكرتيرة) 119	FL 2X36	90	3	530	300-500	8	22	12	0.270	570	165
مدير الموارد البشرية 119	FL 2X36	90	3	600	300-500	8	22	12	0.270	570	165
قسم التخطيط 120	FL 2X36	90	4	480	300-500	8	22	12	0.360	760	221
الموارد البشرية 121	FL 2X36	90	4	460	300-500	8	22	12	0.360	760	221
قسم التدريب 122	FL 2X36	90	4	580	300-500	8	22	12	0.360	760	221
أرشيف الموارد البشرية	FL 2X36	90	3	390	200	8	22	12	0.270	570	165
أرشيف الوزارة	FL 2X36	90	13	285	200	8	22	12	1.170	2,471	717
حمام الجناح الأيسر - رجال	FL 2X36	90	3		100-150	8	22	12	0.270	570	165
حمام الجناح الأيسر- سيدات	FL 2X36	90	3		100-150	8	22	12	0.270	570	165
الطابق الثاني											
ممر	FL 4X18	90	26	100	100-150	8	22	12	2.340	4,942	1,434
الدمج الأسري 200	FL 4X18	90	6	630	300-500	8	22	12	0.540	1,140	331
المستشارين 201	FL 4X18	90	6	580	300-500	8	22	12	0.540	1,140	331
مستشار الأمين العام لشؤون الأشخاص المعوقين 202	FL 2X36	90	3		300-500	8	22	12	0.270	570	165

حمام الجناح الأيمن - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيمن - سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
جناح الأمين العام / السكرتاريا	CFL 1X26	28	8	160	300-500	8	22	12	0.224	473	137
مدير مكتب الأمين العام	CFL 1X26	28	10	200	300-500	8	22	12	0.280	591	172
الأمين العام	CFL 1X26	28	24	260	300-500	8	22	12	0.672	1,419	412
سكرتاريا المساعدين	FL 4X18	90	5	650	300-500	8	22	12	0.450	950	276
مساعد الأمين العام للتطوير	FL 4X18	90	6	350	300-500	8	22	12	0.540	1,140	331
مساعد الأمين العام للتنمية و الرعاية	FL 4X18	90	6	1000	300-500	8	22	12	0.540	1,140	331
رئيس قسم الرقابة الفنية 212	FL 2X36	90	3	870	300-500	8	22	12	0.270	570	165
رئيس قسم الرقابة الداخلية (سكرتيرة) 213	FL 2X36	90	3	670	300-500	8	22	12	0.270	570	165
رئيس قسم الرقابة الداخلية 213	FL 2X36	90	3	580	300-500	8	22	12	0.270	570	165
قسم التأهيل الاجتماعي 214	FL 2X36	90	3	850	300-500	8	22	12	0.270	570	165
قسم المتابعة و التقييم الاداري 215	FL 2X36	90	3	550	300-500	8	22	12	0.270	570	165
قسم المراكز و المؤسسات 216	FL 2X36	90	3	540	300-500	8	22	12	0.270	570	165
مدير شوؤن الأشخاص ذوي الإعاقة (السكرتيرة) 217	FL 2X36	90	3	520	300-500	8	22	12	0.270	570	165
مدير شوؤن الأشخاص ذوي الإعاقة 217	FL 2X36	90	3	530	300-500	8	22	12	0.270	570	165
وحدة الانتاج التلفزيوني 218	FL 4X18	90	2	480	300-500	8	22	12	0.180	380	110
الاستوديو 218	LED PLR 18	18	6			8	22	12	0.108	228	66
مصلى النساء 220	FL 2X36	90	3		200-300	8	22	12	0.270	570	165
مصلى الرجال 221	FL 2X36	90	6		200-300	8	22	12	0.540	1,140	331
حمام الجناح الأيسر - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيسر - سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
قسم الاشراف التربوي 222	FL 2X36	90	4	650	300-500	8	22	12	0.360	760	221
قسم الرقابة الادارية 223	FL 2X36	90	4	710	300-500	8	22	12	0.360	760	221
قسم الرقابة الفنية 224	FL 2X36	90	4	620	300-500	8	22	12	0.360	760	221
رئيس قسم المتابعة و الشكاوي 225	FL 2X36	90	4	690	300-500	8	22	12	0.360	760	221
الطابق الثالث											
ممر	FL 4X18	90	30	105	100-150	8	22	12	2.700	5,702	1,655
مديرية الأسرة و الطفولة 301	FL 2X36	90	6	700	300-500	8	22	12	0.540	1,140	331
مديرية الأسرة و الطفولة 302	FL 2X36	90	4	400	300-500	8	22	12	0.360	760	221
حمام الجناح الأيمن - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيمن - سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
سكرتيرة مدير مديرية الأسرة و الطفولة 303	FL 2X36	90	4	800	300-500	8	22	12	0.360	760	221
مدير مديرية الأسرة و الطفولة 304	FL 2X36	90	4	700	300-500	8	22	12	0.360	760	221
مديرية الأسرة و الطفولة 305	FL 2X36	90	8	700	300-500	8	22	12	0.720	1,521	441
مديرية الأسرة و الطفولة 306	FL 2X36	90	3	350	300-500	8	22	12	0.270	570	165
مديرية تعزيز الإنتاجية 307	FL 4X18	90	6	450	300-500	8	22	12	0.540	1,140	331

مديرية تعزيز الإنتاجية 308	FL 2X36	90	4	410	300-500	8	22	12	0.360	760	221
مديرية تعزيز الإنتاجية 309	FL 2X36	90	6	430	300-500	8	22	12	0.540	1,140	331
مديرية تعزيز الإنتاجية 310	FL 2X36	90	4	830	300-500	3	22	12	0.360	285	83
مديرية تعزيز الإنتاجية 311	FL 2X36	90	6		300-500	8	22	12	0.540	1,140	331
مديرية تعزيز الإنتاجية 312	FL 2X36	90	3	600	300-500	8	22	12	0.270	570	165
مديرية الجمعيات 313	FL 4X18	90	8	730	300-500	8	22	12	0.720	1,521	441
سكرتيرة مدير مديرية الجمعيات 314	FL 2X36	90	3	700	300-500	8	22	12	0.270	570	165
مدير مديرية الجميعات 314	FL 2X36	90	4	480	300-500	8	22	12	0.360	760	221
مديرية الجمعيات 315	FL 4X18	90	6	630	300-500	8	22	12	0.540	1,140	331
مديرية تكنولوجيا المعلومات 316	FL 4X18	90	6	700	300-500	8	22	12	0.540	1,140	331
سكرتيرة مدير مديرية تكنولوجيا المعلومات 317	FL 4X18	90	3	800	300-500	8	22	12	0.270	570	165
مدير مديرية تكنولوجيا المعلومات 317	FL 4X18	90	4	680	300-500	8	22	12	0.360	760	221
مديرية تكنولوجيا المعلومات 318	FL 4X18	90	14	500	300-500	8	22	12	1.260	2,661	772
حمام الجناح الأيسر - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيسر- سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
مختبر الحاسوب 319	FL 4X18	90	6	900	300	8	22	12	0.540	1,140	331
قاعة تدريب 320	FL 4X18	90	10	750	300	8	22	12	0.900	1,901	552
مديرية الجمعيات 321	FL 2X36	90	4	750	300-500	8	22	12	0.360	760	221
مديرية تكنولوجيا المعلومات 322	FL 2X36	90	8	490	300-500	8	22	12	0.720	1,521	441
الطابق الرابع											
ممر	FL 4X18	90	20	200	100-150	8	22	12	1.800	3,802	1,103
جناح الوزير	CFL 1X26	28	102	500-800	300-500	8	22	12	2.856	6,032	1,750
جناح الوزير	FL 4X18	90	45	500-800	300-500	8	22	12	4.050	8,554	2,482
مديرية الشؤون القانونية (السكرتارية)	FL 2X36	90	4	460	300-500	8	22	12	0.360	760	221
مدير مديرية الشؤون القانونية	FL 2X36	90	4	660	300-500	8	22	12	0.360	760	221
قسم الاتفاقيات و العقود	FL 2X36	90	4	600	300-500	8	22	12	0.360	760	221
قسم الاستشارات القانونية	FL 2X36	90	4	900	300-500	8	22	12	0.360	760	221
مديرية السياسات و التطوير المؤسسي	FL 2X36	90	4	700	300-500	8	22	12	0.360	760	221
مدير السياسات	FL 2X36	90	4	920	300-500	8	22	12	0.360	760	221
قسم التخطيط الاستراتيجي	FL 2X36	90	3	610	300-500	8	22	12	0.270	570	165
قسم تحسين الخدمات	FL 2X36	90	3	580	300-500	8	22	12	0.270	570	165
قسم المتابعة و التقييم	FL 2X36	90	3	550	300-500	8	22	12	0.270	570	165
قسم الاتصال	FL 2X36	90	4	400	300-500	8	22	12	0.360	760	221
قسم العلاقات العامة	FL 2X36	90	4	550	300-500	8	22	12	0.360	760	221
حمام الجناح الأيسر - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيسر- سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
قسم التوعية و التثقيف	FL 2X36	90	3	480	300-500	8	22	12	0.270	570	165

مدير مديرية الاتصال	FL 2X36	90	3	540	300-500	8	22	12	0.270	570	165
مكتب جائزة الملك عبد الله الثاني للتميز	FL 2X36	90	3		300-500	4	8	12	0.270	104	30
الطابق الخامس											
ممر	FL 4X18	90	30	160	100-150	8	22	12	2.700	5,702	1,655
كافيتيريا	FL 4X18	90	8	490	200	8	22	12	0.720	1,521	441
كافيتيريا	FL 2X36	90	2	490	200	8	22	12	0.180	380	110
حمام الجناح الأيمن - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيمن - سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
سكرتيرة أمين عام سجل الجمعيات	FL 2X36	90	3	785	300-500	8	22	12	0.270	570	165
أمين عام سجل الجمعيات	FL 2X36	90	4	630	300-500	8	22	12	0.360	760	221
قاعة اجتماعات	FL 2X36	90	4	670	300	2	16	12	0.360	138	40
مدير مكتب أمين عام سجل الجمعيات	FL 2X36	90	3	530	300-500	8	22	12	0.270	570	165
قسم الدراسات و التطوير	FL 2X36	90	2	500	300-500	8	22	12	0.180	380	110
رئيس قسم وحدة القيد و الاشهار	FL 2X36	90	2	800	300-500	8	22	12	0.180	380	110
سجل الجمعيات / القيد و الاشهار	FL 4X18	90	14	700	300-500	8	22	12	1.260	2,661	772
المكتبة	FL 4X18	90	21	560	300-500	8	22	12	1.890	3,992	1,158
سكرتيرة القائم بأعمال مدير مديرية سجل الجمعيات	FL 2X36	90	3	500	300-500	8	22	12	0.270	570	165
القائم بأعمال مدير مديرية سجل الجمعيات	FL 2X36	90	4	500	300-500	8	22	12	0.360	760	221
رئيس قسم متابعة الأنظمة السياسية	FL 2X36	90	4	780	300-500	8	22	12	0.360	760	221
صندوق دعم الجمعيات	FL 2X36	90	4	830	300-500	8	22	12	0.360	760	221
مدير الأبنية و المساكن	FL 2X36	90	3	800	300-500	8	22	12	0.270	570	165
قسم المساكن 510	FL 2X36	90	2	425	300-500	8	22	12	0.180	380	110
قسم الأبنية و الصيانة 509	FL 2X36	90	3	600	300-500	8	22	12	0.270	570	165
رئيس قسم الدراسات و التعاون الخارجي 508	FL 2X36	90	3	450	300-500	8	22	12	0.270	570	165
قسم الاعلام 507	FL 2X36	90	3	850	300-500	8	22	12	0.270	570	165
حمام الجناح الأيسر - رجال	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
حمام الجناح الأيسر- سيدات	FL 2X36	90	2		100-150	8	22	12	0.180	380	110
قسم الاراضي و الاستملاك 506	FL 2X36	90	3	430	300-500	8	22	12	0.270	570	165
قسم الأبنية و المساكن 505	FL 2X36	90	3	620	300-500	8	22	12	0.270	570	165
قسم الأبنية و المساكن 504	FL 2X36	90	4	800	300-500	8	22	12	0.360	760	221
رئيس قسم الأراضي و الاستملاك 503	FL 2X36	90	4	380	300-500	8	22	12	0.360	760	221
صندوق دعم الجمعيات 502	FL 2X36	90	3	520	300-500	8	22	12	0.270	570	165
صندوق دعم الجمعيات / المحاسبة 501	FL 2X36	90	4	820	300-500	8	22	12	0.360	760	221
مناطق أخرى											
الحضانة	FL 4X18	90	5		300	8	22	12	0.450	950	276
الحضانة	FL 2X36	90	14		300	8	22	12	1.260	2,661	772
مكتب الحركة	FL 2X36	90	7		300-500	10	22	12	0.630	1,663	483

Polar) إنارة خارجية (Lighting	CFL 1X23	23	19			10	30	12	0.437	1,573	456
Street) إنارة خارجية (Lighting	HPS 150	165	36			10	30	12	5.940	21,384	6,205
Total			**1,100.0**						**91.1**	**199,316.9**	**57,834.7**

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/yr]	Cost [JD/yr]
				H/D	D/M	M/Y					
الطابق الأرضي											
مدير الشؤون الإدارية 001	39.60	2.00	1	5	22	5	2	19.8	2.4	858	249
خدمة الجمهور 003	20.25	1.50	1	5	22	5	1.5	13.5	1.8	644	187
مدير خدمة الجمهور 004	16.00	1.50	1	5	22	5	1.5	10.7	1.8	644	187
باحث اجتماعي 006	38.00	2.00	1	5	22	5	2	19.0	2.4	858	249
غرفة تصوير	11.20	1.50	1	5	22	5	1.5	7.5	1.8	644	187
مدير التمويل الأجنبي 008	21.60	2.00	1	5	22	5	2	10.8	2.4	858	249
رئيس قسم اللوازم 009	20.25	1.50	1	5	22	5	1.5	13.5	1.8	644	187
قسم الحماية الاجتماعية 028	16.80	1.50	1	5	22	5	1.5	11.2	1.8	644	187
الصادر 019	70.00	2.00	1	5	22	5	2	35.0	2.4	858	249
الطابق الأول											
قسم الرقابة المالية 101	36.00	1.50	1	5	22	5	1.5	24.0	1.8	644	187
مدير الموارد المالية 102	37.80	2.00	1	5	22	5	2	18.9	2.4	858	249
قسم الرواتب 104	24.00	1.00	1	5	22	5	1	24.0	1.2	429	124
قسم الصرف و الأمانات 110	66.50	1.50	2	5	22	5	3	22.2	3.6	1,287	373
مدير الموارد البشرية 119	25.00	1.50	1	5	22	5	1.5	16.7	1.8	644	187
الطابق الثاني											
المستشارين 201	24.00	2.00	1	5	22	5	2	12.0	2.4	858	249
مكتب الأمين العام	42.00	4.00	1	5	22	5	4	10.5	4.8	1,716	498
مدير الرقابة الداخلية 213	20.25	1.50	1	5	22	5	1.5	13.5	1.8	644	187
مدير شؤون الأشخاص ذوي الاعاقة	20.25	1.50	1	5	22	5	1.5	13.5	1.8	644	187
وحدة الإنتاج التلفزيوني	23.00	1.50	1	5	22	5	1.5	15.3	1.8	644	187
الطابق الثالث											
مدير مديرية الأسرة و الطفولة 304	24.00	1.50	1	5	22	5	1.5	16.0	1.8	644	187
مديرية الأسرة و الطفولة 306	12.25	1.00	1	5	22	5	1	12.3	1.2	429	124
مديرية تكنولوجيا المعلومات 322	24.00	1.00	1	5	22	5	1	24.0	1.2	429	124
الطابق الرابع											
مكتب الوزير	60.00	4.00	1	5	22	5	4	15.0	4.8	1,716	498
الطابق الخامس											
أمين عام سجل الجمعيات	10.50	1.00	1	5	22	5	1	10.5	1.2	429	124

قاعة اجتماعات	17.50	1.50	1	2	16	5	1.5	11.7	1.8	187	54
مدير مكتب أمين عام سجل الجمعيات	12.25	1.00	1	5	22	5	1	12.3	1.2	429	124
قسم الدراسات و التطوير	16.00	1.00	1	5	22	5	1	16.0	1.2	429	124
رئيس قسم وحدة القيد و الاشهار	20.00	1.00	1	5	22	5	1	20.0	1.2	429	124
القائم بأعمال مدير مديرية سجل الجمعيات	25.00	1.50	1	5	22	5	1.5	16.7	1.8	644	187
مدير الأبنية	45.00	2.50	1	5	22	5	2.5	18.0	3	1,073	311
قسم الأبنية و المساكن 504	17.50	1.00	1	5	22	5	1	17.5	1.2	429	124
مناطق أخرى											
الحضانة		2.00	1	5	22	5	2	0.0	2.4	858	249
الحضانة		1.00	3	5	22	5	3	0.0	3.6	1,287	373
Total			**36**				**58**		**69.6**	**24,426**	**7,087**

IT Equipment Reference Data

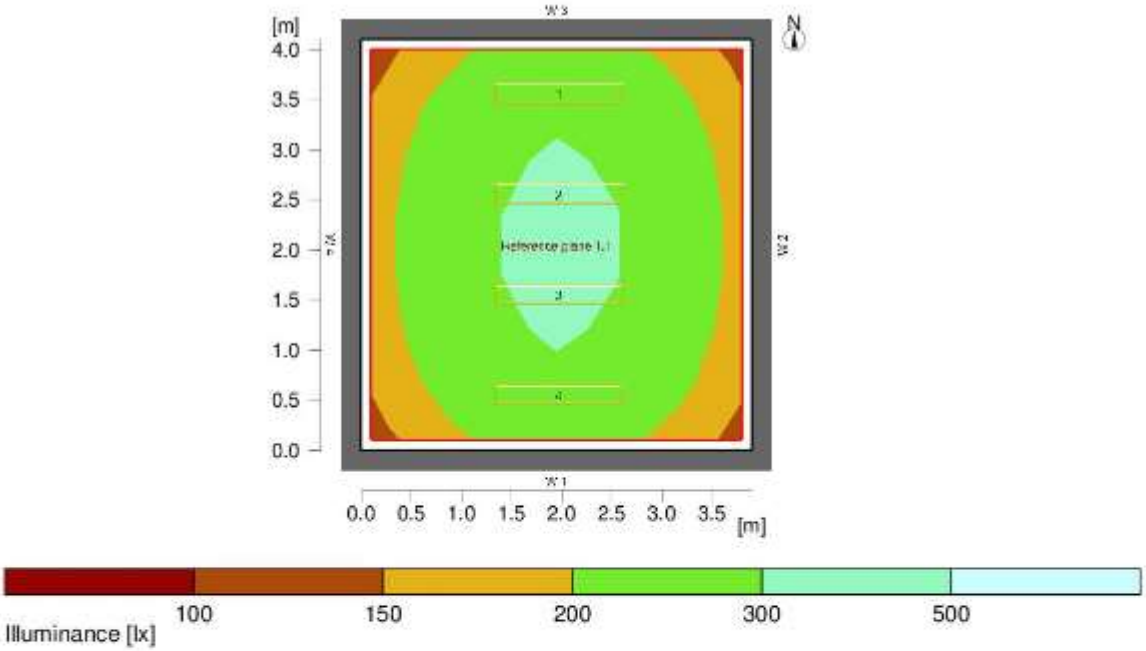
Area Name	Unit Power Consumption [kW]	Qty	Working Hours			Total Power [kW]	Annual Consumption and Cost	
			H/D	D/M	M/Y		Consumption [kWh/year]	Cost [JOD/year]
All ministry - Personal Computers	0.140	262	6	22	12	36.7	58,101	16,859
All ministry - Printers	0.410	98	2	22	12	40.2	21,215	6,156
All ministry - Printers	0.480	67	1	22	12	32.2	8,490	2,464
All ministry - Scanners	0.520	13	0.5	22	12	6.8	892	259
All ministry - Copiers	2.400	9	1	22	12	21.6	5,702	1,655
All ministry - Copiers	1.900	6	2	22	12	11.4	6,019	1,747
Servers			24	30	12	4.8	41,637	12,082
Total		**455**				**154**	**142,058**	**41,220**

Pumping System Reference Data

Pump	Working Hours			Rated Power [kW]	Measured Power [kW]	Annual Consumption and Cost	
	H/D	D/M	M/Y			Consumption [kWh/year]	Cost [JOD/year]
Chilled Water Pump	8	22	5	**5.5**	4.4	3,872	1,124
Hot Water Pump 1	8	22	5	**3**	2.4	2,112	613
Hot Water Pump 2	8	22	5	**1.5**	1.2	1,056	306
Hot Water Pump 3	8	22	5	**1.5**	1.2	1,056	306
Total				**11.5**	**9.2**	**8,096**	**2,349**

11.3 SIMULATION OUTCOMS FOR FL 2X36 BY LED 2X18

- Existing lighting level **(from simulation) using FL 2x36 Watt Fixtures :**

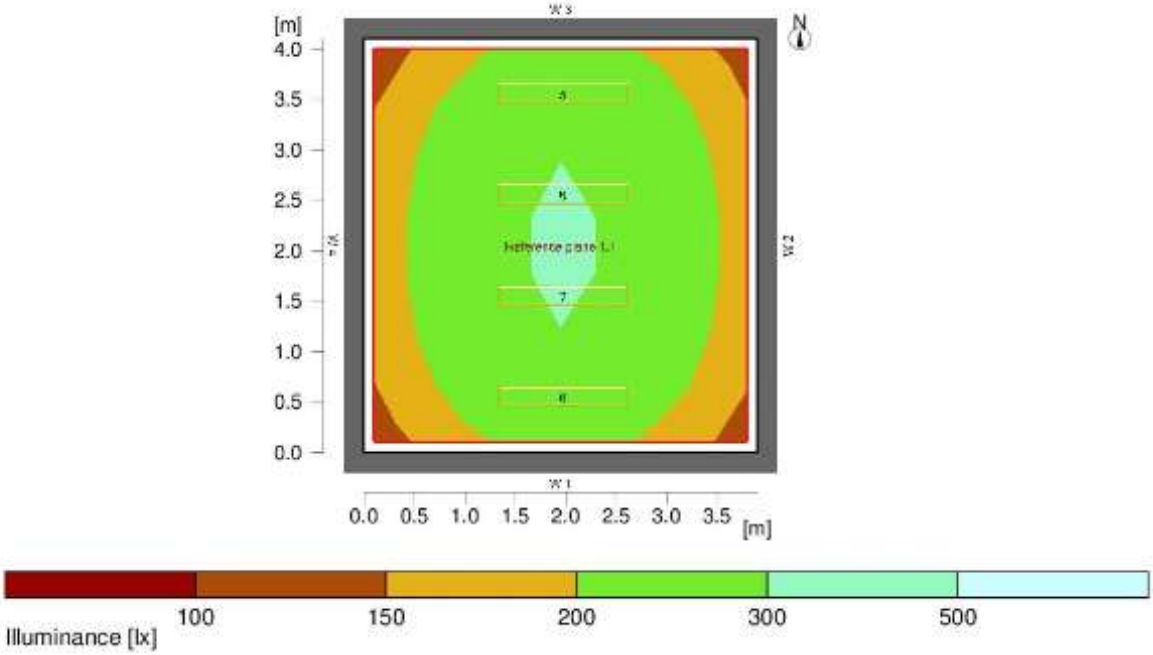


General

Calculation algorithm used	Average indirect fraction
Height of luminaire plane	3.10 m
Maintenance factor	0.50
Total luminous flux of all lamps	24000 lm
Total power	360.0 W
Total power per area (15.99 m²)	22.51 W/m² (10.06 W/m²/100lx)

Evaluation area 1	**Reference plane 1.1**
	Horizontal
Em	224 lx
Emin	129 lx
Emin/Eav (Uo)	0.58
Emin/Emax (Ud)	0.40
UGR (2.1H 2.2H)	<=15.6
Position	0.75 m

- Expected lighting level **(from simulation) Using LED 2x18 Watt Fixtures:**



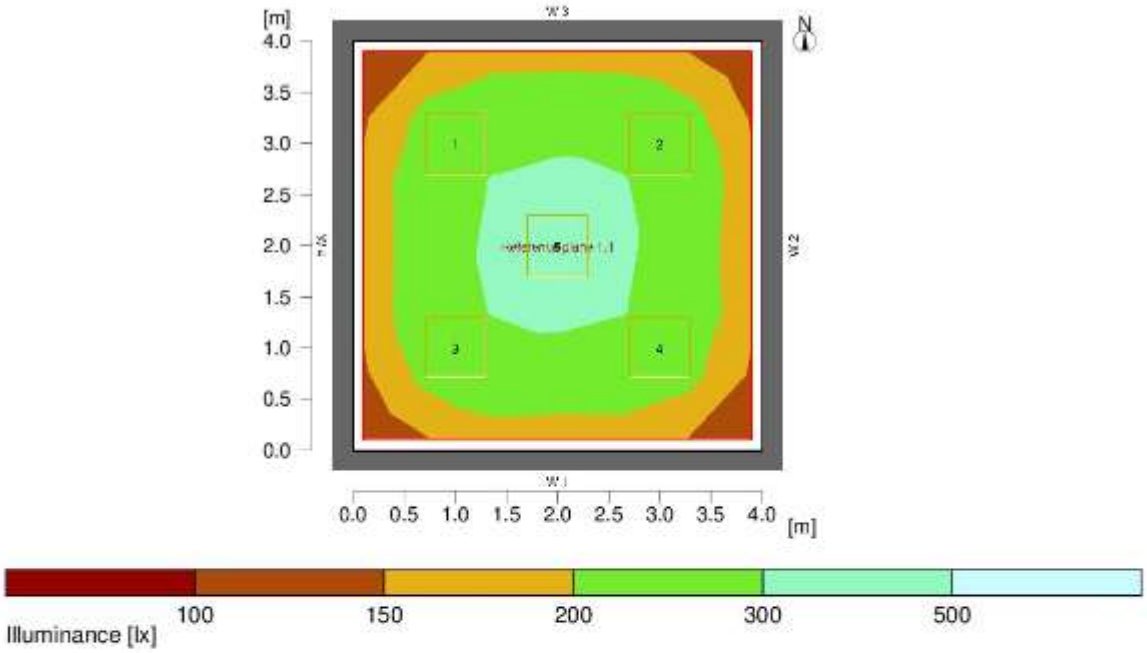
General

Calculation algorithm used	Average indirect fraction
Height of luminaire plane	3.10 m
Maintenance factor	0.80
Total luminous flux of all lamps	14400 lm
Total power	144.0 W
Total power per area (15.99 m²)	9.01 W/m² (4.19 W/m²/100lx)

Evaluation area 1	**Reference plane 1.1**
	Horizontal
Em	215 lx
Emin	124 lx
Emin/Eav (Uo)	0.58
Emin/Emax (Ud)	0.40
UGR (2.1H 2.2H)	<=13.8
Position	0.75 m

11.4 SIMULATION OUTCOMS FOR FL 4X18 BY LED PLR 18 WATT

- Existing lighting level **(from simulation) using FL 4x18 Watt Fixtures**

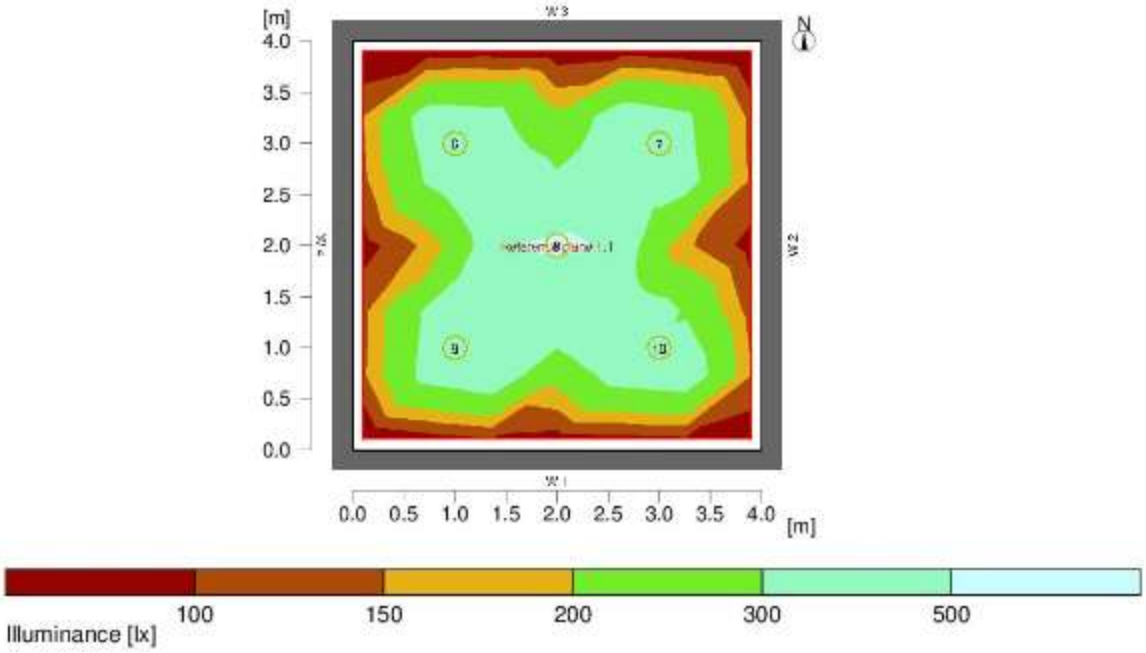


General

Calculation algorithm used	Average indirect fraction
Height of luminaire plane	2.50 m
Maintenance factor	0.50
Total luminous flux of all lamps	14000 lm
Total power	450.0 W
Total power per area (16.00 m²)	28.13 W/m² (13.39 W/m²/100lx)

Evaluation area 1	**Reference plane 1.1**
	Horizontal
Em	210 lx
Emin	99 lx
Emin/Eav (Uo)	0.47
Emin/Emax (Ud)	0.28
UGR (3.1H 3.1H)	<=15.3
Position	0.70 m

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



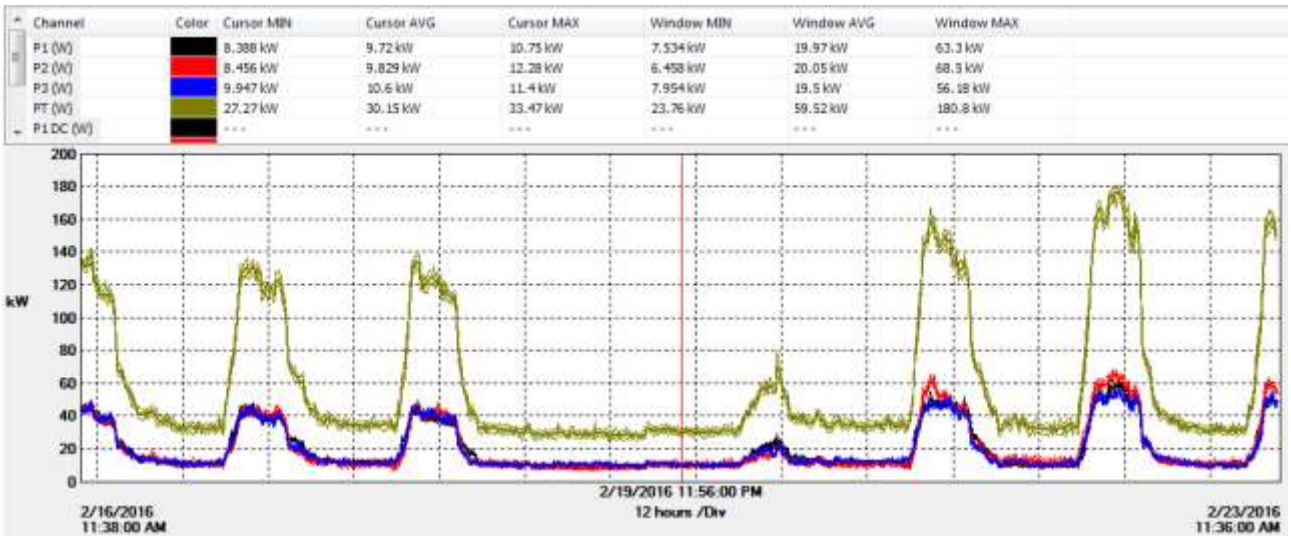
General

Calculation algorithm used	Average indirect fraction
Height of luminaire plane	2.50 m
Maintenance factor	0.80
Total luminous flux of all lamps	7500 lm
Total power	90.0 W
Total power per area (16.00 m²)	5.63 W/m² (2.61 W/m²/100lx)

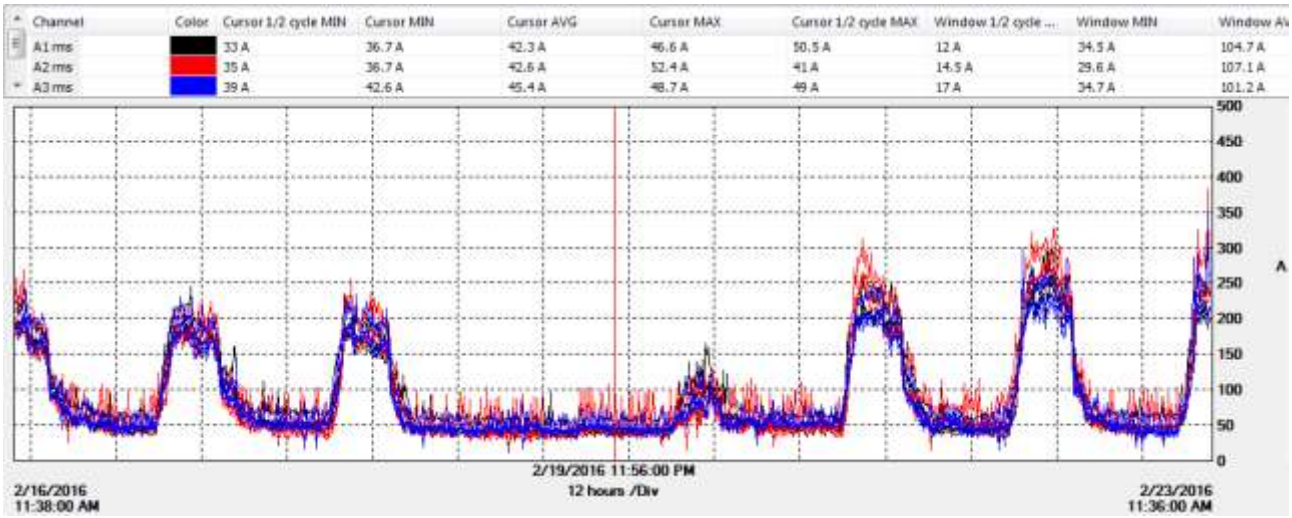
Evaluation area 1	**Reference plane 1.1**
	Horizontal
Em	216 lx
Emin	38 lx
Emin/Eav (Uo)	0.18
Emin/Emax (Ud)	0.07
UGR (3.1H 3.1H)	<=12.5
Position	0.70 m

11.5 BASELINE ELECTRICAL MEASUREMENTS

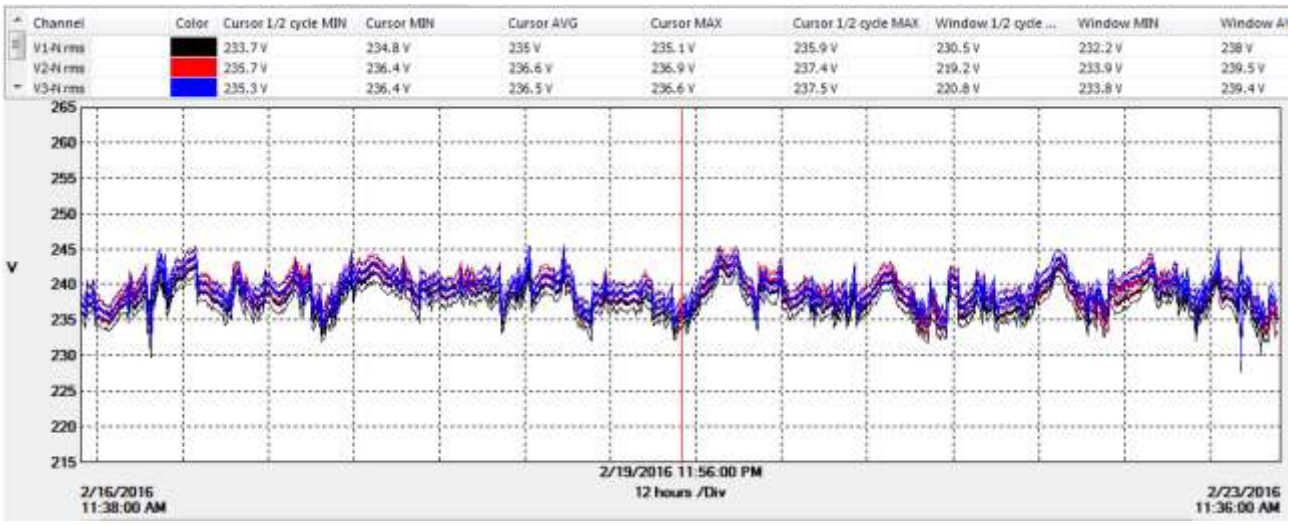
Electrical Load [kW] as Measured on the MDB (Feb 16, 2016 – Feb 23, 2016)



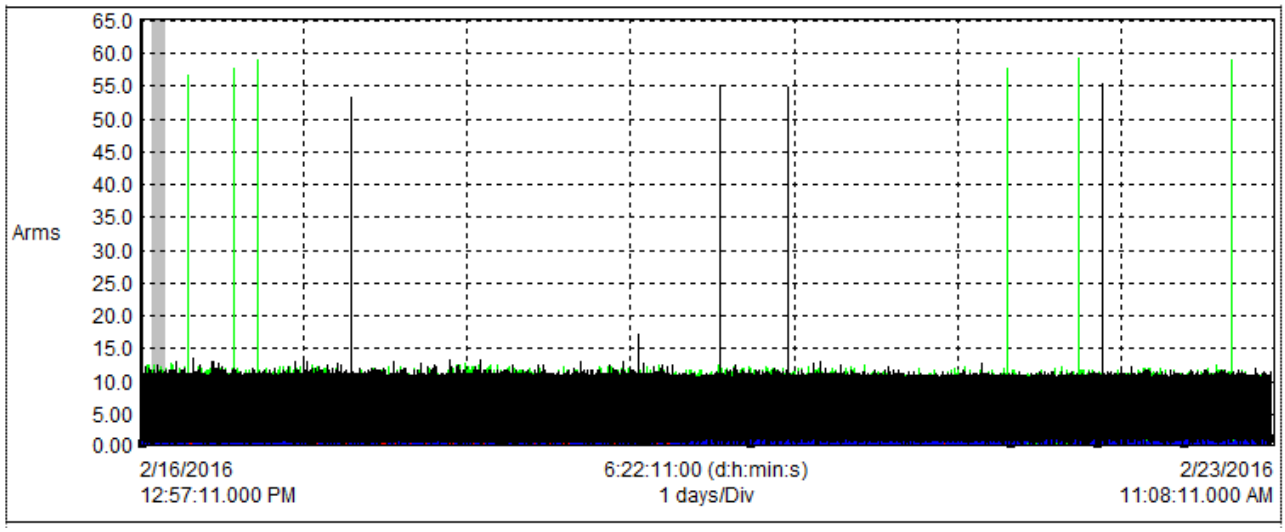
Electrical Current [Amp] as Measured on the MDB (Feb 16, 2016 – Feb 23, 2016)



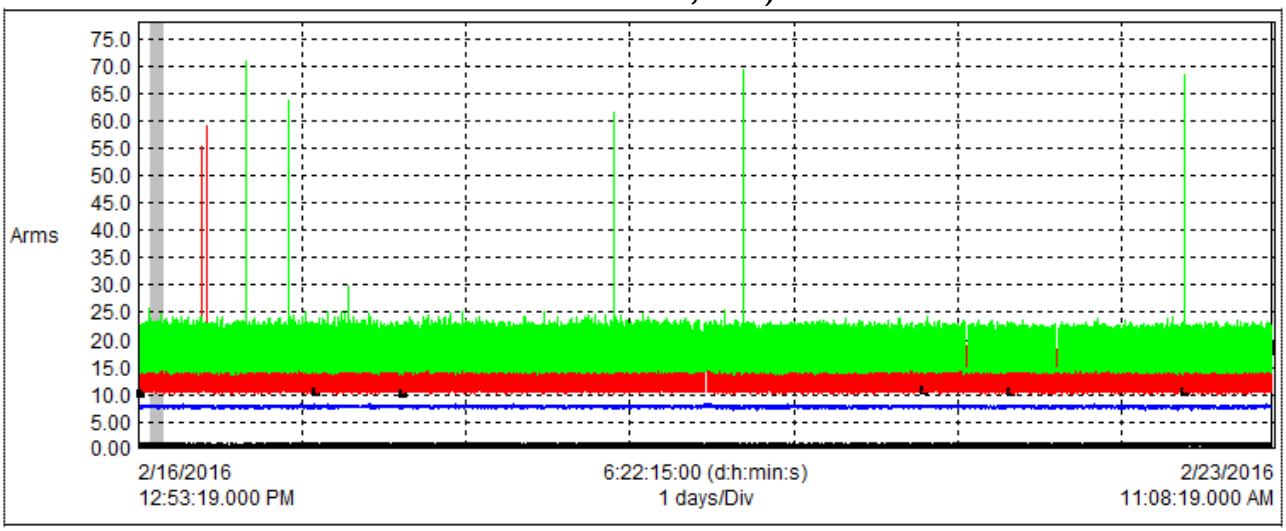
Electrical Voltage [V] as Measured on the MDB (Feb 16, 2016 – Feb 23, 2016)



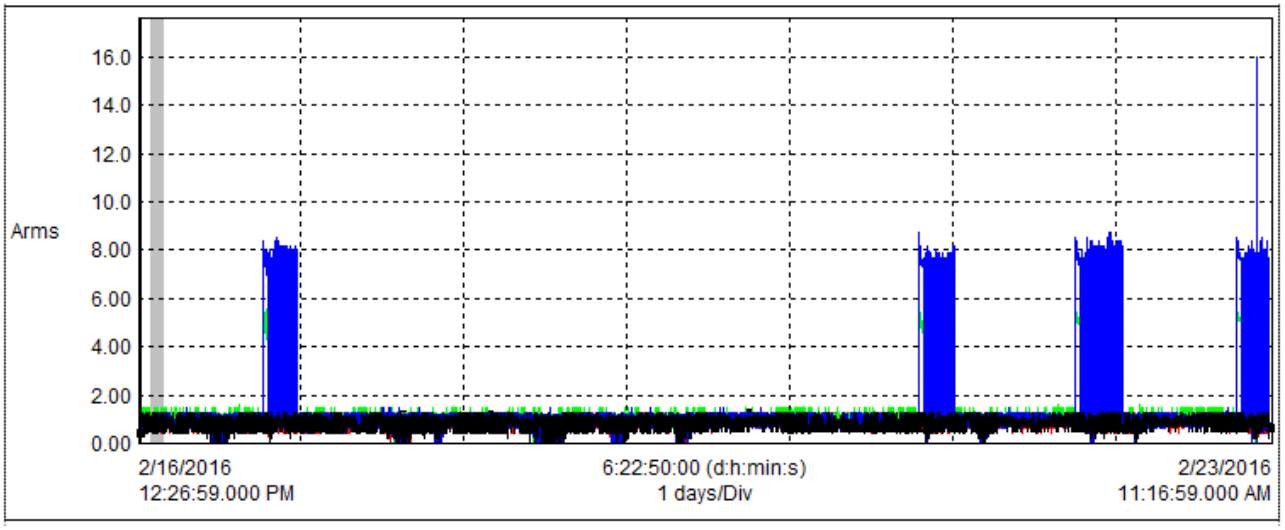
Electrical Current [Amp] as Measured on the Servers AC (Feb 16, 2016 – Feb 23, 2016)



Electrical Current [Amp] as Measured on the Circuit Breaker of Server and Server AC (Feb 16, 2016 – Feb 23, 2016)



Electrical Current [Amp] as Measured on the Circuit Breaker of Boiler No. 1 (Feb 16, 2016 – Feb 23, 2016)



Electrical Current [Amp] as Measured on Current measured on the Circuit Breaker of Boiler No. 2 (Feb 16, 2016 – Feb 23, 2016)