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ENERGY SAVING ACTION PLANNING FOR GOVERNMENT BUILDINGS IN JORDAN

Energy Auditing and Capacity Building For Six Ministries In Jordan

JULY 2016

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ENERGY SAVING ACTION PLANNING FOR GOVERNMENT BUILDINGS IN JORDAN

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Table of Contents

List of Figures

List of Tables

List of Acronyms

USAID	United States Agency for International Development
ESCB	Energy Sector Capacity Building
MEMR	Ministry of Energy and Mineral Resources
EMRC	Energy and Mineral Regulatory Commission
MOICT	Ministry of Information and Communication Technology
MOITS	Ministry of Industry , Trade and Supply
MOFA	Ministry of Foreign Affairs
MOSD	Ministry of Social Development
MOPWH	Ministry of Public Works and Housing
JREEF	Jordan Renewable Energy and Energy Efficiency Fund
JNEEAP	Jordan National Energy Efficiency Action Plan
Governmental Buildings	A building that is used as office building excluding (Hospitals , Schools , universities ,…etc)
ASHRAE	American Society of Heating Refrigeration and Air Conditioning Engineers
ESCO	Energy Service Company
EE	Energy Efficiency
RE	Renewable Energy
EMO	Energy Management Opportunity
ECM	Energy Conservation Measure
BCR	Benefit to Cost Ratio
NPV	Net Present Value
EUI	Energy Use Intensity
ECI	Energy Cost Index
kWh	Kilo Watt Hour
WWR	Windows to Wall Ratio

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2. **Ministry of Foreign Affairs**
   H.E Amb. Mohammad Taisir Bani Yassin, Secretary General
   Mr. Mohammad Al-Askar, Engineering Department

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   H.E Eng. Nader Al-Thneibat, Secretary General
   Eng. Ahmad Jaber, Engineering Department Head
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   H.E Eng. Wejdan Al-Rabadi, Commissioner
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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 in support of renewable energy and energy efficiency technologies and practices. ESCB also places a high priority on addressing gender issues in the energy sector, especially promoting women's inclusion and advancement 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.

The activities and results described here were part of ESCB's effort to increase the capacity of the Ministry of Energy and Mineral Resources and its sister ministries and agencies to plan and implement energy-saving measures on their physical facilities.

1.0 EXECUTIVE SUMMARY

This energy saving action plan was developed based on ASHRAE level II energy audits conducted for six government buildings in Amman, Jordan. The objective of this report is to present the energy conservation measures identified through these audits, and describe an energy saving roadmap which can be followed by other Jordanian ministries and agencies.

ASHRAE level II energy audits were conducted for the Ministry of Energy and Mineral Resources (MEMR), Ministry of Information and Communication Technology (MOICT), Ministry of Industry, Trade and Supply (MOITS), Ministry of Foreign Affairs (MOFA), Ministry of Social Development (MOSD) and the Energy and Minerals Regulatory Commission (EMRC). The audit results presented in Table ES-1 indicate significant energy and financial savings, from 27 to 40 percent, can be achieved with modest investment and pay-back periods of one year or less.

Table ES-1: Energy and Cost Savings from Energy Conservation Measures.

Ministry/ Agency	% of Saving in Electricity Consumption	% of Saving in Fuel Consumption	Overall % of energy bill savings	Savings [JD]	Implementation Cost [JD]	Simple Pay-Back [Years]	Benefit-Cost Ratio
MEMR	39.7%	12.5%	40.3%	37,430	22,860	0.61	6.0
MOFA	32.3%	8.5%	32.6%	80,880	45,500	0.56	6.5
MOITS	35.5%	7.0%	33.3%	122,220	133,100	1.0	3.3
MOSD	30.7%	6.5%	27.4%	51,500	41,600	0.81	4.5
MOICT	31.2%	6.1%	29.6%	63,000	32,540	0.52	7.0
EMRC	33.0%	19.5%	31.3%	41,000	37,250	0.9	4.0

Significant savings, short pay-back periods and high Benefit to Cost Ratios (BCRs) indicate a high financial feasibility for investing in energy saving projects for governmental buildings.

The energy audits recommended similar energy conservation measures (ECMs) across all six of the government buildings audited (see Table ES-2). This finding suggests that these ECMs and their overall potential savings can be generalized to other governmental buildings in Jordan. Results for each ministry/agency are presented in Section 3.

Table ES-2: Recommended ECMs Common to All Audited Buildings

Recommended ECMs	Average % of end-use savings	Average Pay-back [Years]
Retrofit lighting with equivalent LED lamps	70% - 85%	0.4 – 0.7
Occupancy-sensing lighting controllers	20% - 25%	1 – 2
Optimise the Temperature Set point on AC units	3% - 5%	0.1 – 0.4
Periodic maintenance to improve AC system efficiency	3% - 8%	1 – 2
Ambient heat exchange for server room AC units	30% – 35%	2 - 3
Heating boiler combustion efficiency improvements	5% - 8%	0.5 - 1

An Energy Use Intensity (EUI) index was calculated for the six government buildings. The EUI index is a useful tool for understanding why energy consumption differs between buildings. It also provides a benchmark for estimating the potential energy savings from implementing ECMs. The results from the six energy audits show that the EUI index is very sensitive to the amount of air conditioned space

within a given building. By combining data across buildings it was possible to derive a rough relationship between the percentage of air conditioned space and the potential impact of a standard package of ECMs on the EUI index. The EUI before and after implementing the six most-common ECMs across the six governmental buildings according to the percentage of area served by air conditioning system at summer time is shown in Table ES-3. More air conditioned presents higher savings opportunities; however, the percentage savings achievable with the six most-common ECMs are around 30% regardless of the percentage of building space served by AC.

Table ES-3: Impact of % Air Conditioned Space on EUI and Energy Savings

% of Areas Served by AC	EUI [kWh/ Sq.meter/ Yr] without EE	EUI [kWh/ Sq.meter/ Yr] After implementing EE measures
30%	56	39
40%	69	49
50%	84	58
60%	101	71
70%	136	95
80%	165	115
90%	191	134
100%	223	156

Energy saving action plans were developed for each ministry and agency, providing a roadmap for realizing the potential energy savings of the recommended ECMs. The energy saving actions listed in Table ES-4 are described in more detail in Section 4.0.

Table ES-4: Recommended Energy Saving Actions

1. Form a ministerial or agency Energy Committee, with representation from key departments
2. Appoint, assign or hire an Energy Manager, to supervise the energy audit and carry out planning and implementation of ECMS
3. Conduct an ASHRAE Level II (or equivalent) energy audit
4. Use the audit results to set energy-saving goals and formulate a monitoring and evaluation plan to track progress towards goals
5. Implement no-cost and low-cost ECMs (with payback period of less than one year)
6. Evaluate progress, including financial results
7. Consider implementing higher-cost ECMs with longer payback periods
8. Conduct energy audit ASHRAE level I every three Years

Energy saving efforts should be an ongoing effort. Once the non-cost and low-cost ECMs are implemented the Energy Committee should consider longer-term energy saving actions, including ECMs with longer payback periods as well as other energy-saving actions including renewable energy. These longer-term energy-saving actions are also detailed in Section 4.

The impressive energy-saving potential found for these six ministries suggest a government-wide effort would have a significant impact on energy consumption in the public sector. Government-wide initiatives to save energy have proven effective in the US, Canada, Mexico, and elsewhere. A Jordanian energy-saving initiative for government buildings could be tailored to fit the needs of individual ministries and might include activities such as:

1. Collecting the basic information (energy consumption and physical dimensions) needed to benchmark the energy performance of government buildings.
2. Encouraging ministries to procure energy audit services from a licensed energy auditor.
3. Providing technical support to the Energy Committees and Energy Managers established in individual ministries and agencies;
4. Establishing an incentives scheme that encourages ministries and agencies to pursue energy saving opportunities
5. Recognizing and rewarding ministries and government employees who implement energy-saving measures.

2.0 ENERGY AUDIT APPROACH AND OVERVIEW OF RESULTS

2.1 Introduction

Jordan's National Energy Efficiency Action Plan (JNEEAP), issued in 2007 and updated in 2013, sets a target of reducing energy consumption among all energy consuming sectors by an average 20% (compared with 2007) by 2020. Included is a goal to reduce electricity consumption in public buildings, estimated at 350 GWh in 2012, by 10%.[1] Recognizing that the government should lead the way in reducing energy use, instructions were issued by H.E. the Prime Minister and H.E. the Minister of Energy and Mineral Resources that government offices should achieve a 50% reduction in lighting usage and an overall 20% reduction in energy usage.

The USAID Energy Sector Capacity Building Project is supporting ministries and agencies in achieving their energy saving targets. This support is being provided in cooperation with ESCB's main counterpart, the Ministry of Energy and Mineral Resources and the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF). The USAID-ESCB contracted Eco Engineering and Energy Solutions (EcoSol), an Energy Services Company, to develop energy saving action plans for selected governmental buildings. The scope of work called for EcoSol to conduct ASHRAE Level II energy audits for six governmental buildings: the Ministry of Energy and Mineral Resources (MEMR), Ministry of Information and Communication Technology (MOICT), Ministry of Foreign Affairs (MOFA), Ministry of Industry and Trade (MOITS), Ministry of Social Development (MOSD) and the Energy and Minerals Regulatory Commission (EMRC). The scope of work also called for EcoSol to build the capacity of ministry and agency employees to develop and implement their own energy saving action plan to achieve their 20% energy saving target.

2.2 Approach

ESCB and MEMR worked together to identify the candidates ministries and agencies to be audited. A workshop was held for the energy officers appointed at each of the 25 ministries and agencies subject to the Prime Minister's Decree on Saving Energy in Government Buildings. Ministries and agencies were invited to express their interest. Those ministries and agencies able to mobilize the necessary background information (energy bills, facility layouts, engineering drawings) were selected for participation.

ESCB's consultant EcoSol visited each of the selected ministries and agencies to introduce the project and collect all necessary data. Ecosol conducted a walk-through audit at which time data loggers were installed to collect pertinent information on energy consumption and other variables. The walk-through audit was used to prepare and deliver a training for local facilities and engineering staff on how to identify and implement energy conservation measures. The next step was a full ASHRAE Level II audit, a process which included documenting the physical characteristics of the building, collecting electricity and fuel consumption and expenditures for a minimum of one year, making an inventory of the type and condition of all major energy-consuming systems in the buildings

[1] Jordan National Energy Efficiency Plan, 2013. http://www.rcreee.org/sites/default/files/plans_jordanian_neeap_summery_2013.pdf

(lighting, air conditioning, pumping, IT equipment, space and water heating, and miscellaneous). The audit process then identified potential energy conservation measures, along with their costs and savings. Potential ECMs were rank-ordered according to parameters including benefit-cost ratio and payback period. The audit process concluded with the preparation of a detailed energy audit report actionable by local staff.

2.3 Energy Audit Results

This project focused on six government buildings considered representative of most buildings found in Jordan. The Energy Conservation Measures (ECMs) identified in these buildings are likely to be applicable to other buildings with similar characteristics. This section describes the energy audit results, including an analysis of the achievable energy savings taking into consideration economic factors and reasonable return on the energy-saving investment.

Table 1 summarizes the achievable savings in the six government buildings. Section 3 provides a more detailed description of the audit findings for each ministry, while Section 3 provides a complete list of the energy saving opportunities for each governmental building.

The achievable reductions in electricity consumption ranges between 30 and 40 percent, while the corresponding fuel usage reduction potential is between 5 and 20 percent. The overall cost savings was between 27 and 40 percent. The variations between buildings and energy savings by type were driven by differences in building characteristics, notably the efficiency of existing heating and cooling systems and the percentage of building space which is air conditioned. The financial savings varied by a factor of 3, according to the relative size of the six buildings.

Table 1: Summary – Energy Saving from Implementing Economical ECM

Ministry/ Agency	% of Saving in Electricity Consumption	% of Saving in Fuel Consumption	Over all percentage of saving out of energy bills	Savings [JD]
MEMR	39.7%	12.5%	40.3%	37,430
MOFA	32.3%	8.5%	32.6%	80,880
MOITS	35.5%	7.0%	33.3%	122,220
MOSD	30.7%	6.5%	27.4%	51,500
MOICT	31.2%	6.1%	29.6%	63,000
EMRC	33.0%	19.5%	31.3%	41,000

The information in Table 1 is presented graphically in Figures 1 and 2. The similarity in the achievable percent of energy consumption reduction and energy bill reduction is striking, suggesting that there are very significant and persistent energy savings potential across the government buildings sector.

Figure 1: Achievable and Economical Electricity and Fuel Savings by Ministry

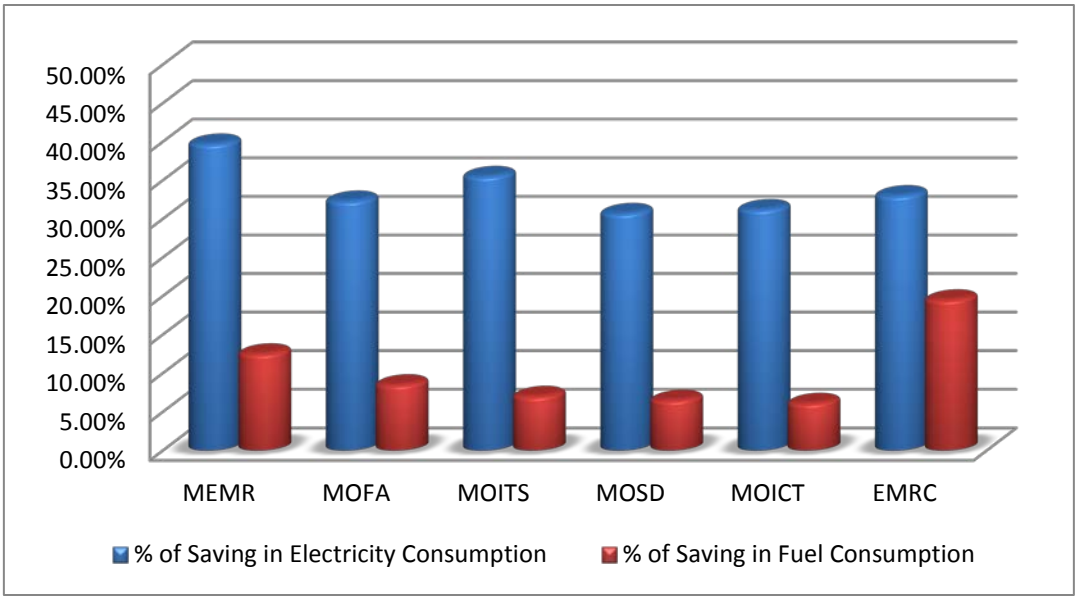


Figure 2: Achievable and Economical Energy Cost Savings by Ministry

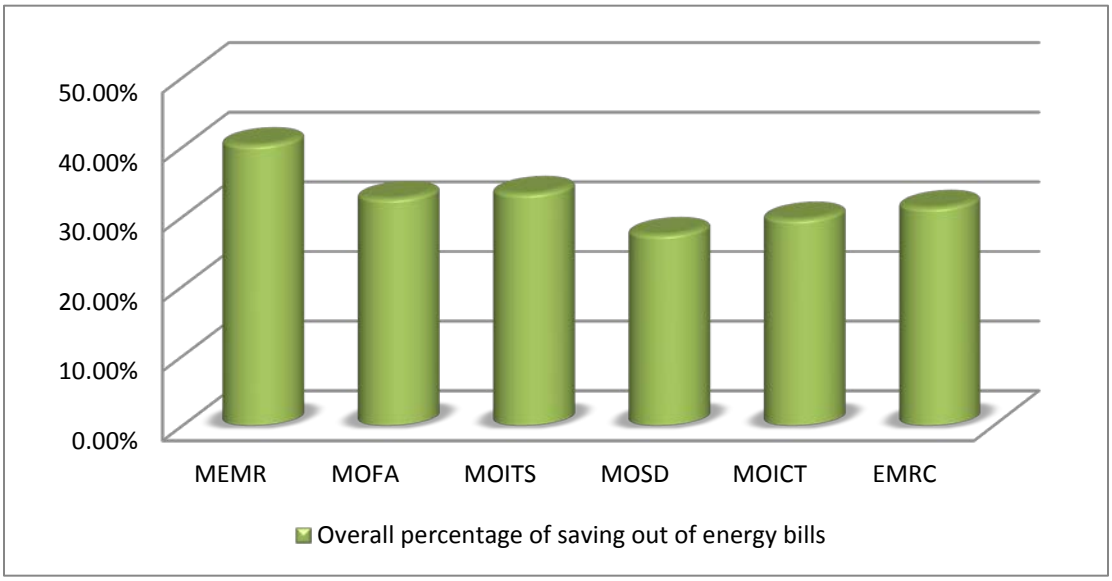


Table 2 summarizes the financial parameters of achievable and economical ECMs for each of the governmental buildings. The recommended package of ECMs is highly attractive from a financial perspective, with simple paybacks of less than 1 year and benefit-cost ratios of more than 3. A payback period of less than one year means that ministries can self-finance the ECM investment and recover the costs through energy bill savings in the same year.

Table 2: Financial Parameters of Achievable and Economical ECMs.

Ministry/ Agency	Annual Monetary Saving [JD]	Needed Investment [JD]	Simple Pay Pack [Years]	Savings [JD]	Benefit-Cost Ratio
MEMR	37,400	22,850	0.61	37,430	6.0
MOFA	80,850	45,500	0.56	80,880	6.5
MOITS	122,200	133,000	1.0	122,220	3.3
MOSD	51,500	41,500	0.81	51,500	4.5
MOICT	63,000	32,500	0.52	63,000	7.0
EMRC	41,000	37,250	0.9	41,000	4.0

2.3 Energy Use and Energy Cost Intensity

The calculated Energy Use Intensity (EUI) of a building or facility, expressed as annual energy consumption divided by usable area (kWh/m^2 per year), provides a quick and easy benchmark for evaluating and comparing the energy savings potential for buildings with similar use and complexity. Governmental buildings share many characteristics of construction and use which makes benchmarking and comparison a useful tool. Common characteristics of the governmental buildings audited, described in Section 2.4, include operating hours, lighting systems, HVAC design, and building envelope.

Differences in building characteristics are reflected in the EUI – notably the percentage of air-conditioned space, and the age and efficiency of building systems. Buildings with a higher percentage of air conditioned space will tend to have a higher energy use intensity, as can be seen by comparing an EUI of 85 for MOSD (13 % air conditioned) and an EUI of 56 for MEMR (30% air conditioned) with an EUI of 146 for MOITS (73 % air conditioned) and an EUI of 108 for MOICT (62 % air conditioned). However even buildings with a low percentage of air conditioned space can have a high EUI if other factors are in play, notably low efficiency. Only 19 % of EMRC's building is air conditioned, but it still has a relatively high EUI of 112. This is due to many factors, including the old age, poor condition and low efficiency of the equipment and the building. The EUI thus gives a big picture but the details of each building still need to be evaluated to understand what makes a building consume more or less energy.

The Energy Cost Index (ECI) is also a calculated figure (JD/m^2 per year) for a building or facility, expressed as an annual total energy expenditures divided by usable area. It provides a useful benchmark for evaluating the expenditures associated with the energy consumption in a building. The fuel oil consumption has been expressed in kWh units to see the effect of energy consumption by type on energy costs. Because electricity is considerably more expensive on an equivalent per unit basis, buildings with a higher share of electricity in overall energy consumption will tend to have a higher ECI. This can be seen by comparing an ECI of 37 for MOITS (electricity 93% of total energy consumption) with an ECI of 15 for MOSD (electricity 69% of total energy consumption).

Tables 2 and 3 show the EUI and the ECI for each of the audited buildings.

Table 3: Energy Use Intensity (EUI) Index

Ministry	Building Total area [m²]	% air conditioned area	Total Annual Energy Consumption (Electricity and Fuel)					% electricity use/total energy use	Energy Use Intensity (EUI) [kWh/m²]
			Electrical Energy Consumption [kWh/year]	Fuel Consumption			Total Annual Energy Consumption [kWh/year		
				Diesel Oil Consumption [Ltr/year]	Heating Boiler Efficiency	Diesel Oil Consumption [kWh/year][2]			
MEMR	8,100	30.37%	320,060	14,502	85.8%	134,792	454,852	77.1%	56
MoFA	16,654	47.56%	835,580	54,990	84.2%	501,585	1,337,165	73.0%	80
MoITS	9,300	73.44%	1,252,368	10,937	89.2%	105,625	1,357,993	92.8%	146
MoSD	12,000	13.30%	563,766	48,000	87.4%	454,466	1,018,232	69.1%	85
MoICT	8,216	61.92%	709,997	18,867	86.5%	176,794	886,791	83.4%	108
EMRC	6,300	18.89%	394,016	41,055	70.0%	311,324	705,340	69.4%	112

Table 4: Energy Cost Index (ECI)

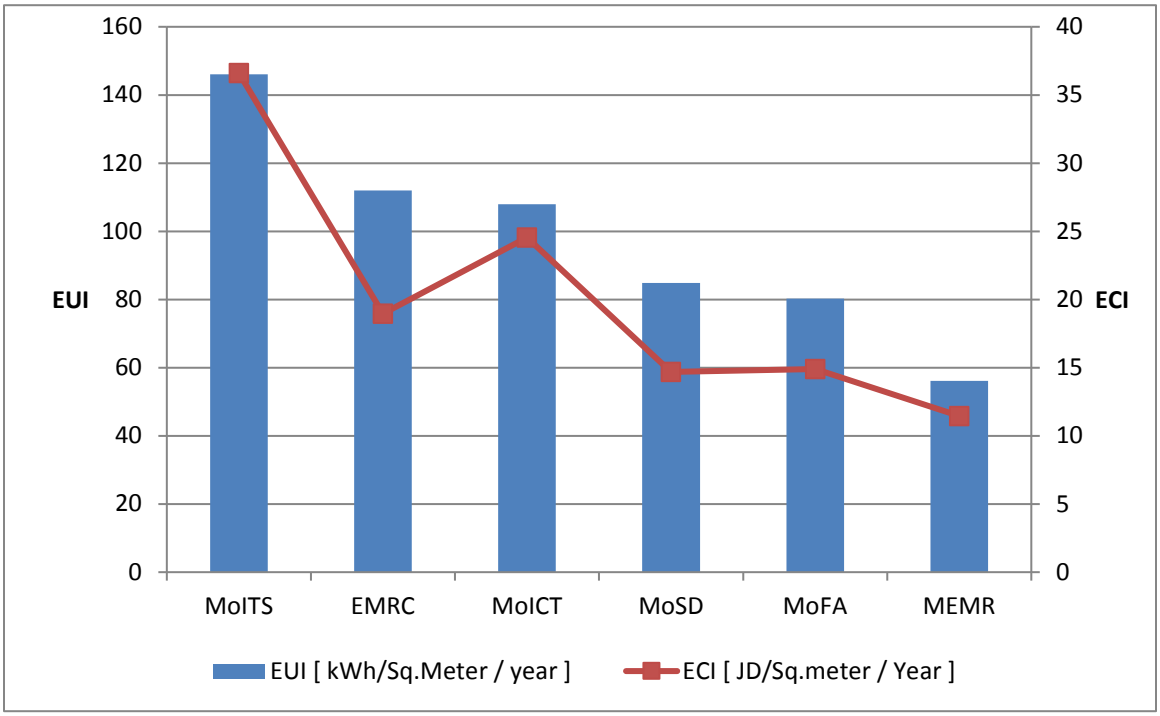
Ministry	Building Total area [m²]	Total Air Conditioned Area [m²]	Total Non Air Conditioned Area [m²]	Energy Use Intensity (EUI) [kWh/m²]	Total Annual Energy Cost			% electricity cost/total energy cost	Energy Cost Index (ECI) [JD/m²]
					Electrical Energy Cost [JOD/year]	Fuel Cost [JOD/year]	Total Energy Cost [JOD/year]		
MEMR	8,100	2,460	5,640	454,852	85,467	7,321	92,788	92%	11
MoFA	16,654	7,920	8,734	1,337,165	225,558	22,546	248,104	91%	15
MoITS	9,300	6,830	2,470	1,357,993	335,999	4,484	340,483	99%	37
MoSD	12,000	1,596	6,874	1,018,232	151,835	24,480	176,315	86%	15
MoICT	8,216	5,087	3,124	886,791	189,426	12,193	201,619	94%	25
EMRC	6,300	1,190	5,110	705,340	101,481	17,959	119,440	85%	19

[2] One liter of diesel oil contains about 9.7 kWh of energy

Figure 3 compares the EUI and ECI for each ministry graphically. Generally speaking a high EUI is associated with a high ECI, but the specific characteristics of a building can introduce variations to this general pattern. The differences in EUI and ECI between ministries result from many factors – among them building characteristics, fuel mix, air conditioned space, and heating boiler efficiency. MOITS has both the highest EUI and ECI, because its building has the highest percentage of air conditioned space. In this case the higher EUI also meant a higher ECI, since electricity has a higher price per unit of consumption. MEMR is on the other end of scale, showing both the lowest EUI and ECI. This is due to the relatively limited air conditioned spaces and a higher consumption of fuel oil relative to electricity.

In making comparison between ministries it is important to note that a higher EUI and ECI does not mean that energy is being wasted. However it does suggest there may be more energy-saving opportunities in some buildings than in others.

Figure 3: Comparison of EUI and ECI across Six Ministries / Agencies

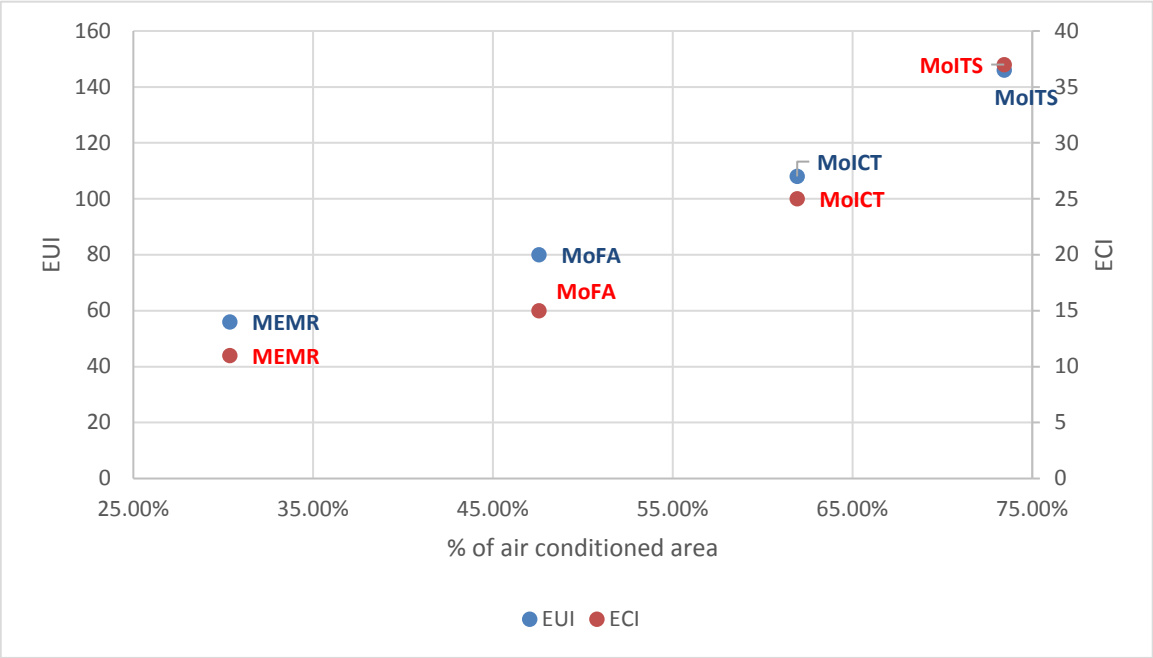


An analysis was conducted to correlate EUI with building characteristics. The analysis focused on the pattern of EUI values and the percent of air conditioned space in the buildings audited. The analysis also looked at the effect of achievable and economical ECMs on before-and-after EUIs.

Figure 5 presents a scatter plot of both the calculated EUI and ECI as function of the air conditioned space for four of the six buildings audited. Two buildings – EMRC and MOSD – were dropped from this analysis because their electricity consumption is estimated. Both EMRC and MOSD share a metered power supply with other entities. Their monthly electricity consumption is therefore an

estimated value and thus unsuitable for combining with the data from other buildings with accurate metered data.

Figure 4: EUI and ECI of Four Ministries as a Function of % of Air Conditioned areas



A linear curve fit imposed on these four data points suggests a relationship between air conditioned area and EUI ($R^2 = 0.9887$). However there are not enough data points to draw a firm conclusion. If additional data can be collected from other government buildings, it may be possible to suggest a general guideline for energy savings potential as a function of air conditioned space. Such a guideline table might look like Table 5.

Table 5: EUI estimator based on Air Conditioned Areas in Governmental Buildings

% of Areas Served by AC	EUI [kWh/ Sq.meter/ Yr] without EE	EUI [kWh/ Sq.meter/ Yr]After implementing EE measures
30%	56	39
40%	69	49
50%	84	58
60%	101	71
70%	136	95
80%	165	115
90%	191	134
100%	223	156

2.4 Common Characteristics and Common Recommended ECMs

This project conducted ASHRAE level II energy audits for six governmental buildings to identify common ECMs and analyze the costs associated with each ECM. The result was a complete list of

energy-saving and cost-reducing recommendations submitted to each ministry and agency. The complete list of energy management opportunities at each building may be found in Section 3.

The audits found broad similarities in characteristics between the six governmental building, such as:

1. **Working Hours**: all government buildings in Jordan operate from 8 AM till 3:30 PM Sunday through Thursday. There is little or no activity during nights and weekends.
2. **Lighting system**: more than 90% of occupied areas were lit with fluorescent tube lamps. Lighting levels were generally below international standards.
3. **HVAC System**: only MOICT was constructed with a central AC system and a closed building envelope. The other buildings were found to have split units installed to serve selected spaces, mostly for management and executives.
4. **Space and Water Heating Systems:** hot water boilers are used for space heating purposes during winter months while domestic hot water is provided with small electric water heaters distributed throughout the buildings.
5. **Server Rooms:** server rooms with dedicated AC systems operating 24 hours a day, 365 days a year were found at each governmental building.
6. **Building envelope:** the building envelope design and the windows-to-wall ratio (WWR) were found to be almost identical. All the audited buildings were constructed more than 10-15 years ago, with little or no thermal insulation.
7. **Building openings (Fenestration)**: except for MOSD, all the windows found in these buildings were single glaze with very low efficiency.
8. **Electricity metering:** there was no electricity sub-metering in any of the buildings. MoSD and EMRC were both found to share a single electricity meter with other entities, greatly complicating the energy audit process.
9. **Automated Controls**: except for the MOICT, all energy consuming systems are controlled manually with no centralized energy management system (EMS) or automated controls.

The audits also produced very similar recommendations for ECMs across all six governmental buildings. These energy conservation measures were identified and recommended in each of the audited buildings and are presented in Table 6. These ECMs address the three major types of energy consumption found in government buildings – electricity for lighting, heating fuel oil, and electricity for air conditioning. Some buildings had other energy-saving opportunities according to their usage characteristics, e.g., electric water heating. The measures themselves produce varying amounts of savings relative to current consumption. The largest energy reduction can be achieved with lighting, through retrofitting of existing fixtures with LED lamps and by installing occupancy-sensing lighting controllers. The combination of these two ECMs can reduce electricity consumption for lighting by as much as 75-80%. The second largest electricity savings can be achieved by improving the performance of AC units, both by adjusting set points, improving maintenance, and boosting the efficiency of server room AC units through ambient heat recovery system. Finally, modest fuel oil savings (5-8%) can be achieved by improving the combustion efficiency of space heating boilers.

Table 6: Common Energy Conservation Measures for Government Buildings

Common ECM	Average % of saving [3]	Average Pay-back [Years]
Retrofit lighting with equivalent LED lamps	70% - 80%	0.4 – 0.7
Occupancy-sensing lighting controllers	20% - 25%	1 – 2
Optimise the Temperature Set point on AC units	3% - 5%	0.1 – 0.4
Periodic maintenance to improve AC system efficiency	3% - 8%	1 – 2
Ambient heat recovery system for server room AC units	30% – 35%	2 - 3
Heating boiler combustion efficiency improvements	5% - 8%	0.5 - 1

These common energy conservation opportunities are found across all six of buildings examined in this study, and the same energy conservation opportunities are likely to be found in many other governmental buildings through similar energy audit process.

The audit process also identified barriers which can impede the identification of energy conservation opportunities. The biggest barrier encountered in this study was the lack of separate metering for two of the six government buildings. To be effective an energy audit must be able to match the energy bills in a government building with an audit of the physical characteristics of the building itself. No energy conservation opportunities can be confirmed without the presence of proper metering.

[3] Out of the respective system energy consumption

3 ENERGY AUDIT FINDINGS BY MINISTRY

This section provides further details about each of the six buildings audited during this study, including the complete list of energy conservation measures by ministry/agency.

3.1 Ministry of Energy and Mineral Resources (MEMR)

The Ministry of Energy and Mineral Resources MEMR has a built up area of 8,100 m^2, of which 30% (2,460 m^2) is air conditioned. The building was constructed in 2003 and is occupied by 350 government employees.

MEMR's 2015 electricity bill was **JD 85,456.** Table 7 shows the electricity and cost breakdowns. Almost half the consumption serves building lighting needs, while another one-third of electricity consumption is required for air conditioning of occupied space and server rooms. Note that MEMR has installed a 33 kW solar PV system on its rooftop, which provides about 11% of MEMR's total electricity needs.

Table 7: Electricity Consumption & Costs Breakdown at MEMR

No.	Load Description	Annual Consumption and Cost		% of the Total Consumption
		kWh	JDs	
1	Lighting System	150,382	40,152	46.99%
2	IT Equipment (Computers, Printers, etc.)	69,340	18,514	21.66%
3	Split Air Conditioning Units	54,966	14,676	17.17%
4	Server Rooms Air Conditioning	51,840	13,841	16.20%
6	Elevators	13,860	3,701	4.33%
7	Heating Pumps	1,848	493	0.58%
8	PV System	-34,600	-9,238	-10.81%
9	Others	12,425	3,317	3.88%
	Total	320,060	85,456	100%

The energy audit showed an encouraging **40.3%** savings potential by implementing 12 ECMs leading to reduced electricity and fuel expenditures totalling **JD 37,430/year**. Almost 90% of the electricity savings come from lighting ECMs, with air conditioning ECMs contributing most of the remainder.

The needed investment to implement the recommended ECMs is estimated at **JD 22,864** which would be returned back in **8 months**. Table 8 shows the full list of ECMs, including energy savings, bill savings, ECM investment costs, and the estimated simple pay-back period.

Table 8: ECMs for the MEMR

No.	Electrical Systems Energy Conservation Measures	Savings (kWh)	Savings (JD)	Savings (%)	Cost (JD)	Pay-Back (Months)
Lighting System Energy Conservation Measures						
L.1	Replace the Existing Fluorescent Lamps 2x36 by New High Efficiency LED 2x18 Watt	33,473	9,603	10.5%	7,371	9
L.2	Replace the Existing Fluorescent Lamps FL 4x18 by New High Efficiency LED 18 Watt	68,942	19,778	21.5%	4,860	3
L.3	Replace the Existing Low efficient Compact Fluorescent Lamps 2x26 Watt by New High Efficiency LED U-Bulb Lamps 16 Watt	2,984	856	0.9%	952	13
L.4	Replace the Existing Halogen Spot Lamps by New High Efficiency LED 7 Watt	2,543	729	0.8%	196	3
L.5	Control the Lighting Operation in the Lift lobby Area Using Day Lighting Sensor	852	244	0.3%	525	26
L.6	Control the Lighting Operation in Car Parks and Corridors Using Occupancy Sensors	3,682	1,056	1.2%	1,690	19
Air Conditioning System's Energy Conservation Measures						
AC.1	Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.	5,300	1,521	1.7%	360	3
AC.2	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System.	6,039	1,732	1.9%	4,990	35
AC.3	Insulate the external walls of the Sever room at the 3rd floor	234	67	0.1%	220	39
Other Energy Conservation Measures						
O.1	Increase Energy Conservation Awareness among the Ministry Staff	3,201	918	1.0%	500	7
Total		127,250	36,505	39.7%	21,664	7

No.	Fuel System Energy Conservation Measures	Savings (l)	Savings (JD)	Savings (%)	Investment (JD)	Pay-Back (Months)
F.1	Improve the Combustion Efficiency of Space Heating Diesel Boiler	1,320	673	9.1%	700	12
F.2	Maintain and Re-operate the Existing Solar Water Heaters	493	251	3.4%	500	24
Total		1,813	925	12.5%	1,200	16

3.2 Ministry of Foreign Affairs (MOFA)

The Ministry of Foreign Affairs MOFA has a built up area of 16,654 m^2, of which 48% (7,920 m^2) is air conditioned. The building was constructed in 1999 and is occupied by 370 government employees.

MOFA's 2015 electricity bill was JD **225,523**. Table 9 shows the electricity consumption and cost breakdown by end-use. Lighting accounts for just over 40% of electricity consumption, with air conditioning requiring another one-third of total consumption. Water heater demand is also significant.

Table 9: Electricity Consumption Costs Breakdown at MOFA

No.	Load Description	Annual Consumption and Cost		% of the Total Consumption
		kWh	JDs	
1	Lighting System	341,367	92,135	40.85%
2	IT Equipment (Computers, Printers, etc.)	128,700	34,736	15.40%
3	Split Air Conditioning Units	214,013	57,762	25.61%
4	Servers Rooms Air Conditioning	49,896	13,467	5.97%
5	Electric Water Heaters	55,440	14,963	6.63%
6	Elevators	13,860	3,741	1.66%
7	Heating Pumps	2,770	748	0.33%
8	Others	29,535	7,971	3.53%
	Total	835,580	225,523	100%

The energy audit showed an encouraging **32.6%** savings potential by implementing 10 ECMs leading to electricity and fuel expenditure reductions totalling **JD 81,882/year**.

The investment required to implement the recommended ECMs is estimated at **JD 45,494**, with a payback period of just **7 months.** Table 10 shows the full list of ECMs, including energy savings, bill savings, ECM investment costs, and the estimated simple pay-back period. Lighting accounts for over 80% of the total savings, with air conditioning improvements contributing another 15 %.

TABLE 10: ECMs for the MOFA

No.	Electrical Systems Energy Management Opportunities	Saving in kWh	Saving in JDs	% of saving	Cost JDs	Pay-Back Months
Lighting System's Energy Management Opportunities						
L.1	Replace the Existing Fluorescent Lamps 2x36 by New High Efficiency LED 2x18 Watt in some Selected Areas.	79,805	22,655	9.6%	**15,257**	**8**
L.2	Replace the Existing Fluorescent Lamps FL 4x18 and CFL 2x26 by New High Efficiency LED 18 Watt ,in some Selected Areas	91,647	26,016	11.0%	**7,500**	**3**
L.3	Replace the Existing Low efficient Incandescent Lamps 75 Watt and Compact Fluorescent Lamps 24 Watt by New High Efficiency LED U-Bulb Lamps 12 Watt in some Selected Areas.	14,328	4,067	1.7%	**1,752**	**5**
L.4	Replace the existing low efficient external lighting (Street Lighting, and Flood Lights) by new high efficient LED lights	12,007	3,408	1.4%	**7,575**	**27**
L.5	Replace the Existing Hal Spot Lamps by New High Efficiency LED 7 Watt in some Selected Areas.	34,442	9,777	4.1%	**2,365**	**3**
L.6	Control the Lighting Operation in the Lift lobby Area by Day Lighting Sensor	772	219	0.1%	**300**	**16**
Air Conditioning System's Energy Management Opportunities						
AC.1	Optimizing Temperature Set Point of all AC's in Both Summer and Winter According to International Standards.	20,637	5,858	2.5%	**3,195**	**7**
AC.2	Install Heat Recovery System to Provide Free Cooling to Support the Server Room AC System.	16,965	4,816	1.4%	**6,650**	**17**
Other Energy Management Opportunities						
O.1	Increase Energy Conservation Awareness among the Ministry Staff	8,356	2,372	0.7%	**500**	**3**
Total		278,187	78,970	**32.3%**	**44,794**	**7**

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 Boiler	4,662	1,912	8.5%	**700**	**4**
Total		4,662	1,912	**8.5%**	**700**	**4**

3.3 Ministry of Industry, Trade and Supply (MOITS)

The Ministry of Industry, Trade and Supply MOITS has a built up area of 9,300 m^2, of which 73% (6,830 m^2) is air conditioned. The building was constructed in 1975 and is occupied by 780 government employees.

The MOITS electricity bill in 2015 was **JD 331,516.** Table 11 shows the electricity and cost breakdown by end-use. Electricity consumption is quite diverse, with lighting only making up one-quarter of total consumption. Air conditioning for occupied space and server rooms makes up another one-third, and IT equipment consumption accounting for fully one-quarter of consumption.

MOITS has a small (30 kW) solar PV system which offsets 3% of its large electricity consumption.

Table 11: Electricity Consumption Costs Breakdown at MOITS

No.	Load Description	Annual Consumption and Cost		% of the Total Consumption
		kWh	JDs	
1	Lighting System	320,202	85,907	25.91%
2	IT Equipment (Computers, Printers, etc.)	308,456	82,756	24.96%
3	Split Air Conditioning Units	255,180	68,462	20.65%
4	Servers Rooms Air Conditioning	95,040	25,498	7.69%
5	Cooling Chillers	53,975	14,481	4.37%
6	Electric Space Heaters	51,870	13,916	4.20%
7	Electric Water Heaters	42,240	11,333	3.42%
8	Elevators	30,788	8,260	2.49%
9	Water Coolers	20,529	5,508	1.66%
10	Air Handling Units (AHU)	16,973	4,554	1.37%
11	Heating and Chilled Water Pumps	12,650	3,394	1.02%
12	PV System	-36,512	-9,796	-2.95%
13	Others	64,269	17,243	5.20%
	Total	1,235,658	331,516	100%

The energy audit showed an encouraging **33.3%** savings potential by implementing 10 ECMs leading to electricity and fuel savings totalling **JD 122,227/year**.

The investment needed to implement the recommended ECMs is estimated at **JD 133,100**, with an overall payback period of **13 months.** Table 12 shows the full list of ECMs, including energy savings, bill savings, ECM investment costs, and the estimated simple pay-back period.

The diversity of MOITS' energy consumption results in a diverse set of recommended ECMs. Lighting ECMs account for almost half of total savings, and air conditioning improvements just 10%. However installing solar water heaters to replace electric water heaters and optimizing space heating by eliminating isolated electric space heating units saves an impressive 30% of total electricity consumption.

Table 12: ECMs for the MOITS

No.	Electrical Systems Energy Conservation Measures	Savings (kWh)	Savings (JD)	Savings (%)	Cost (JD)	Pay-Back (Months)
Lighting System's Energy Conservation Measures						
L.1	Replace Existing Fluorescent Lamps FL 4x18 and CFL 2x26 by LED 18 Watt	163,638	47,383	13.1%	14,124	4
L.2	Replace Existing Fluorescent Tube Lamps 2x36 by LED Tube Lamps 2x18 Watt	37,644	10,900	3.0%	5,948	7
L.3	Replace Halogen Spot Lamps by LEDs	8,015	2,321	0.6%	345	2
L.4	Occupancy sensors for Lighting System Control	2,258	654	0.2%	1,390	26
Air Conditioning System Energy Conservation Measures						
AC.1	Clean Water Chiller Condensers	1,619	469	0.1%	500	13
AC.2	Water Chiller Heat Transfer Additives	5,397	1,563	0.4%	4,000	31
AC.3	Optimizing Temperature Set Point of all AC's	24,121	6,985	1.9%	2,250	4
AC.4	Ambient Heat Recovery System for the Server Room AC System.	16,965	4,913	1.4%	6,650	16
AC.5	Optimizing Temperature Set Point at the Server Rooms	3,564	1,032	0.3%	0	0
AC.6	Variable Frequency Drives [VFD's] for the Air Handling Units and Water Pumps	8,116	2,350	0.6%	5,900	30
Other Energy Conservation Measures						
O.1	Increase Energy Conservation Awareness	12,524	3,626	1.0%	500	2
O.2	Thermal Insulation of Fifth Floor Metal Roof in Buildings 1 and 2	11,716	3,392	0.9%	7,785	28
O.3	Solar Energy for Hot Water Needs	13,378	3,874	1.1%	8,000	25
O.4	Eliminate Electric Space Heaters	116,555	27,000	9.3%	60,000	27
O.5	Split AC Unit Replacements	18,824	5,451	1.5%	15,000	33
Total		444,335	121,912	35.5%	132,392	13

No.	Fuel System Energy Conservation Measures	Savings (l)	Savings (JD)	Savings (%)	Investment (JD)	Pay-Back (Months)
F.1	Boiler Improved Combustion Efficiency	768	315	7.0%	700	27
Total		768	315	7.0%	700	27

3.4 Ministry of Information and Communication Technology (MOICT)

The Ministry of Information and Communication Technology MOICT has a built up area of 8,216 m^2, of which 62% (5,087 m^2) is air conditioned. The building was constructed in 1985 and is occupied by 190 government employees.

MOICT's 2015 electricity bill was **JD 189,426.** Table 13 shows the electricity and cost breakdowns. Over half of MOICT's electricity demand is for air conditioning, reflecting the high percentage of air conditioning in this building. Lighting accounts for less than one-quarter of consumption in this building.

Table 13: Electricity Consumption Costs Breakdown at MOICT

No.	Load Description	Annual Consumption and Cost		% of the Total Consumption
		kWh	JDs	
1	Floors Air Cooled Water Chillers	220,196	58,748	31.00%
2	Fourth Floor Air Cooled Water Chiller	41,097	10,965	5.80%
3	Split Air Conditioning System	38,940	10,389	5.50%
4	Server Room Air Conditioning	56,242	15,005	7.90%
5	Lighting System	152,977	40,814	21.50%
6	IT Equipment	89,383	23,847	12.60%
7	Pumping System	25,778	6,878	3.60%
8	Elevators	17,516	4,673	2.50%
9	Electric Water Heaters	5,940	1,585	0.80%
10	Water Coolers	1,663	444	0.20%
11	Others	60,265	16,079	8.50%
	Total	709,997	189,426	100%

The energy audit showed an encouraging **29.6%** savings potential by implementing 10 ECMs leading to electricity and fuel cost savings totalling **JD 63,023 /year**.

The investment needed to implement the recommended ECMs is estimated at **JD 32,540** which would be returned back in around **6 months.** Table 14 shows the full list of ECMs, including energy savings, bill savings, ECM investment costs, and the estimated simple pay-back period. The savings from ECMs are evenly split between lighting and air conditioning, with the remainder coming from improvements and optimization of water pumping requirements.

Table 14: ECMs for the MOICT

No.	Electrical Systems Energy Conservation Measures	Savings (kWh)	Savings (JD)	Savings (%)	Cost (JD)	Pay-Back (Months)
Lighting System Energy Conservation Measures						
L.1	Replace Existing Fluorescent Lamps 4x18 and 2x36 Watt by New High Efficiency 18 W LEDs	62,840	17,771	8.9%	5,342	4
L.2	Redesign some Lighting Systems Using LED Round Panel 18 Watt	24,984	7,065	3.5%	502	1
L.3	Occupancy sensor for lighting system Control	3,534	999	0.5%	1,350	16
L.4	Replace Existing Lighting with LED Lighting	6,938	1,962	1.0%	1,483	9
Air Conditioning System Energy Conservation Measures						
AC.1	Improve the heat transfer Efficiency at the Water Chiller by Condenser Cleaning Program	7,839	2,217	1.1%	750	4
AC.2	Improve the heat Transfer Efficiency at the Water Chiller by adding heat transfer additives	26,129	7,389	3.7%	8,750	14
AC.3	Water Chiller Shell & Tube Cleaning program	20,903	5,911	2.9%	3,500	7
AC.4	Optimize the A/C Thermostat Set-Point to meet international Standards	25,949	7,338	3.7%	1,813	3
AC.5	Install Ambient Heat Recovery System for Server Room AC System	16,965	4,798	2.4%	6,650	17
Pumping System Energy Conservation Measures						
P.1	Control Chilled Water Pumps using VFD	2,140	605	0.3%	1,200	24
P.2	Turn off B1 Chilled Water Pump (18.5 kW)	15,873	4,489	2.2%	0	0
Other Energy Conservation Measures						
O.1	Energy conservation awareness for employees	7,100	2,008	1.0%	500	3
Total		221,195	62,553	31.2%	31,840	6

No.	Fuel System Energy Conservation Measures	Savings (l)	Savings (JD)	Savings (%)	Investment (JD)	Pay-Back (Months)
F.1	Improve the Combustion Efficiency of Diesel Boiler	1,148	471	6.1%	700	18
Total		1,148	471	6.1%	700	18

3.5 Ministry of Social Development (MOSD)

The Ministry of Social Development MOSD has a built up area of 12,000 m^2, of which 13% (1,596 m^2) air conditioned. The building was constructed in 2008 and is occupied by 320 government employees.

MOSD's 2015 energy bill was **JD 151,835.** Table 15 shows the electricity and cost breakdowns. Lighting makes up more than one-third of electricity consumption, followed by one-quarter for IT equipment and almost one-quarter for air conditioning.

Table 15: Electricity Consumption Costs Breakdown at MOSD

No.	Load Description	Annual Consumption and Cost		% of the Total Consumption
		kWh	JDs	
1	Lighting System	199,317	53,681	35.35%
2	IT Equipment	142,058	38,259	25.20%
3	Water Chiller	72,864	19,624	12.92%
4	Server Room Air Conditioners	31,164	8,393	5.53%
5	Split Air Conditioners	24,426	6,578	4.33%
6	Elevators	31,680	8,532	5.62%
7	Water Cooler	15,066	4,058	2.67%
8	Fans	8,752	2,357	1.55%
9	Pumping System	8,096	2,180	1.44%
10	Others	30,344	8,172	5.38%
	Total	563,766	151,835	100%

The energy audit showed an encouraging **27.4%** savings potential by implementing 14 ECMs, resulting in electricity and fuel cost savings totalling **JD 51,491/year**.

The investment required to implement the recommended ECMs is estimated at **JD 41,578** with a payback period of **10 months.** Table 16 shows the full list of ECMs, including energy savings, bill savings, ECM investment costs, and the estimated simple pay-back period. Over three-quarters of the energy savings come from lighting system improvements with most of the remainder resulting from air conditioning systems optimization.

Table 16: ECMs for the MOSD

No.	Electrical Systems Energy Conservation Measures	Saving (kWh)	Savings (JD)	Savings (%)	Cost (JD)	Pay-Back (Months)
Lighting System Energy Conservation Measures						
L.1	Replace T8 Fluorescent Lamps 2x36 W w/ LED Lamps 2x18 W	56,433	16,375	10.0%	**11,176**	8
L.2	Replace T8 Fluorescent Lamps 4x18 W w/ LED Downlight 18 W	58,849	17,076	10.4%	**4,644**	3
L.3	Replace CFLs and 23 Watt w/ LED U-Bulb Lamps 12 W	5,618	1,630	1.0%	**1,223**	9
L.4	Occupancy Sensor Light Controls	2,600	755	0.5%	**2,430**	39
L.5	Replace Sodium Street Light 150 Watt w/ LED Street Light 90 Watt	9,331	2,708	1.7%	**7,200**	32
Air Conditioning System Energy Conservation Measures						
AC.1	Water chiller Condenser Cleaning	2,186	634	0.4%	**750**	14
AC.2	Water chiller heat transfer additives	7,286	2,114	1.3%	**3,800**	22
AC.3	Water chiller shell & Tube Cleaning	5,829	1,691	1.0%	**1,750**	12
AC.4	Optimizing AC system Set Points	8,385	2,433	1.5%	**1,140**	6
AC.5	Ambient Heat Recovery for Server Room AC System	5,893	1,710	1.0%	**5,375**	38
Pumping System Energy Conservation Measures						
P.1	VFDs for Chilled Water Pump	1,162	337	0.2%	**425**	15
Other Energy Conservation Measures						
C.1	Timer control of Water Coolers	3,819	1,108	0.7%	**465**	5
O.2	Energy conservation awareness	5,638	1,636	1.0%	**500**	4
Total		173,029	50,207	**30.7%**	**40,878**	10

No.	Fuel System Energy Conservation Measures	Savings (l)	Savings (JD)	Savings (%)	Investment (JD)	Pay-Back Months
F.1	Boiler Combustion Efficiency	3,132	1,284	6.5%	**700**	7
Total		3,132	1,284	**6.5%**	**700**	7

3.6 Energy and Minerals Regulatory Commission (EMRC)

The Energy and Minerals Regulatory Commission EMRC has a built up area of 6,300 m^2, of which 19% (1,190 m^2) is air conditioned. The building was constructed in 1973 and is occupied by 200 government employees.

EMC's 2015 energy bill was **JD 101,481.** Table 17 shows the electricity and cost breakdowns. Consumption is evenly split between lighting (20%), IT equipment (25%), air conditioning (27.6%), and miscellaneous end uses.

Table 17: Electricity Consumption Costs Breakdown at EMRC

No.	Load Description	Annual Consumption and Cost		% of the Total Consumption
		kWh	JDs	
1	IT Equipment	97,044	24,994	24.63%
2	Lighting System	80,014	20,608	20.31%
3	Split Air Conditioners	54,756	14,103	13.90%
4	Server Room Air Conditioners	53,622	13,811	13.61%
5	Electric Space Heaters	47,520	12,239	12.06%
6	Elevator	9,504	2,448	2.41%
7	Water Coolers	8,748	2,253	2.22%
8	Electric Water Heaters	7,260	1,870	1.84%
9	Heating Water Pump	3,939	1,014	1.00%
10	Fans	3,105	800	0.79%
11	Others	28,504	7,341	7.23%
	Total	394,016	101,481	100%

The energy audit showed an encouraging **31.1%** savings potential by implementing 14 ECMs leading to electricity and fuel savings totalling **JD 41,051 /year**.

The investment needed to implement the recommended ECMs is estimated at **JD 37,248**, with a payback period estimated at **11 months.** Table 18 shows the full list of ECMs, including energy savings, bill savings, ECM investment costs, and the estimated simple pay-back period. Over three-quarters (76.7%) of the savings potential comes from improved lighting, with another 17% resulting from air conditioner system optimization.

Table 18: ECMs for the EMRC

No.	Electrical Systems Energy Conservation Measures	Savings (kWh)	Savings (JD)	Savings (%)	Cost [JD]	Pay-Back (Month)
Lighting System's Energy Conservation Measures						
L.1	Replace T8 Fluorescent Lamps 2x36 W w/LED Lamps 2x18 W	56,433	16,375	10.0 %	11,176	8
L.2	Replace T8 Fluorescent Lamps 4x18 Watt w/LED Down lights	58,849	17,076	10.4 %	4,644	3
L.3	Replace CFLs w/ LED U-Bulb Lamps 12 W	5,618	1,630	1.0%	1,223	9
L.4	Occupancy Sensor Lighting Controls	2,600	755	0.5%	2,430	39
L.5	Replace Sodium Street Light 150 W by LED Street Light 90 W	9,331	2,708	1.7%	7,200	32
Air Conditioning System's Energy Conservation Measures						
AC. 1	Water chiller Condenser Cleaning Program	2,186	634	0.4%	750	14
AC. 2	Water chiller heat transfer additives	7,286	2,114	1.3%	3,800	22
AC. 3	Water chiller shell and Tube Cleaning program	5,829	1,691	1.0%	1,750	12
AC. 4	Optimizing Temperature Set Point of AC Systems	8,385	2,433	1.5%	1,140	6
AC. 5	Ambient Heat Recovery System for Server Room AC System	5,893	1,710	1.0%	5,375	38
Pumping System's Energy Conservation Measures						
P.1	VFD control of Chilled Water Pump	1,162	337	0.2%	425	15
Other Energy Conservation Measures						
O.1	Water Coolers Timer Control	3,819	1,108	0.7%	465	5
O.2	Energy conservation awareness for employees	5,638	1,636	1.0%	500	4
Total		173,029	50,207	30.7 %	40,878	10

No.	Fuel System Energy Conservation Measures	Savings (l)	Savings (JD)	Savings (%)	Investment (JD)	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

4.0 ENERGY SAVING ACTION PLANNING

4.1 Energy Saving Action Planning Process

The energy audit results contained in this report show the potential for electricity and fuel cost savings for government buildings of between 35% and 40% with payback periods of one year or less. These findings suggest that government ministries and agencies can not only meet the energy savings targets set in the 2013 National Energy Efficiency Action Plan but can self-finance the ECMs recommended here using savings on their electricity and fuel oil expenditures.

The potential benefits have been presented in the preceding sections. This section presents recommendations for how ministries and agencies can organize themselves to realize these savings.

This study recommends that every ministry or agency establish an energy saving action planning process. The recommended process consists of several steps as described below.

1. **Form an Energy Committee:** An Energy Committee should be commissioned by the Minister or the Secretary General (S.G.) of the ministry, or the Chief Commissioner or Head of Agency in case of other governmental agencies, e.g. the EMRC. This committee should include representatives from each department with an interest in or responsibility for planning and implementing energy saving measures – Procurement, Facilities, Accounting, and Public Affairs. The Committee should report to senior management on a regulator basis.
2. **Assign an energy manager:** The commissioner of that committee should assign or appoint or hire an Energy Manager. The Energy Manager will have day-to-day responsibilities for identifying energy saving opportunities and planning and implementing energy conservation measures (ECMs). The Energy Manager should be technical qualified and partially or wholly dedicated to implementing the energy saving plan.
3. **Conduct an ASHRAE Level II (or equivalent) Audit.** The Energy Committee and Energy Manager should work together to mobilize a professional energy auditor to conduct a thorough energy audit for the buildings under the purview of the ministry or agency. As described in Section 2.2, the energy audit process should include documenting the physical characteristics of the building, electricity and fuel consumption and expenditures for the past two years, and type and condition of all major energy-consuming systems in the buildings (lighting, air conditioning, pumping, IT equipment, space and water heating, and miscellaneous). The audit process should include identification of energy conservation measures, along with their costs and savings. The audit process should include a rank-ordering of potential ECMs according to parameter including benefit-cost ratio and payback period. The result should be a detailed and actionable energy audit recommendations report.
4. **Use the results of the energy audit to set energy saving goals, identify the ECMs needed to meet these goals, and establish a monitoring and evaluation program to track progress.** The Monitoring and evaluation (M&E) plan identifies key indicators (e.g., implementation progress, electricity and fuel oil consumption and expenditures) that the Energy Committee can use to track energy saving progress. Progress should be evaluated after each implementation activity to ensure that results are consistent with expectations. Benchmarking is an easy and quick tool to track improvements in energy efficiency as ECMs are implemented. Benchmarks include the Energy Use Intensity (EUI) index and the Energy

Cost Index (ECI). Each governmental building can easily benchmark themselves for quick evaluation and to check whether the expected improvements in energy performance from implementing ECMs have materialized.

5. **Implement easy and low cost ECMs.** Many of the ECMs identified in this report are simple "good housekeeping" measures – cleaning condenser coils, adding additives to improve heat transfer characteristics. Other ECMs, such as replacing CFLs and fluorescent tube lamps with LED equivalents, can be financed with the energy savings from a few months of operation. The Energy Committee and the Energy Manager should mobilize internal and external resources to implement no-cost and low-cost ECMs not only to get immediate saving with low cost but to build practical experience for local staff. Implementation of more-ambitious and higher-cost ECMs should come gradually as the local staff builds their capability.
6. **Begin Implementing higher cost ECMs:** once the local staff has completed the installation of low cost and easy ECMs, their practical experience and capacity can enable them to install higher cost and more complex EE equipment.

4.2 Additional, Longer-Term Energy Saving Actions

This report has focused on ECMs which can be implemented easily at no or low-cost and which yield significant savings (one-quarter to one-third of energy costs) that pay for themselves within one year. There are additional significant energy savings which can be realized with longer-term and higher-cost ECMs. This report recommends that each ministry should maintain its Energy Committee and Energy Manager even after completing the initial energy saving actions. The Committee should consider longer-term energy saving actions including ECMs that are not feasible or hard to be implemented as of today, renewable energy investments, and introduction of energy efficiency considerations in procuring equipment. Several recommended longer-term energy saving actions are briefly described below:

- **Invest in Renewable Energy**. Many governmental buildings are installing renewable energy systems, both solar PV and solar water heaters. In buildings with electric water heating, such as MOITS, a solar water heater is recommended as a short-term ECM. Solar PV at today's prices has a 3-5 year payback period, less economical than other ECMs. In the future, as solar PV prices come down, solar PV will likely become more economical.
- **Develop and Implement an Energy Efficient Procurement Policy**. Life-cycle cost studies have shown that the initial cost of lighting, air conditioning, refrigeration and pumping devices are only about 10%-15% of the total operating costs over the life of the equipment. Adopting an energy efficient procurement policy will make it possible to consider the life-cycle costs of new energy consuming systems instead of just the initial purchase cost. Recommended guidelines for government purchasing agents include:
  - **HVAC System:** all new AC system and split units shall be from the variable speed drive type (commercially known as Variable refrigerant flow /volume) or (Inverter Driven AC). These AC equipment are rated at A+ or more on the energy efficiency labelling scale.
  - **Heating Boilers:** heating boilers shall have high combustion efficiency regardless of the fuel type being used. High efficiency heating boilers are equipped with a monitoring system that measures the real time combustion efficiency and automatically adjust the air/fuel ratio to keep the combustion efficiency as high as possible

- **Lighting system:** all new installed lighting system should be LED type
- **IT Equipment:** Energy Star qualified IT equipment such as PCs, laptops, IT servers, and photocopiers.

- **Conduct ASHRAE energy audit level I every three years.**[4] Energy efficient end-use technology is advancing at a rapid pace. A periodic Level I energy audit can check whether new technologies have emerged which could benefit a particular building. A periodic quick-check audit can also reconsider ECMs which were identified during the Level II audit but found to be unachievable or uneconomic**.** ECMs with long pay-back periods today can be economically feasible in the future, due to rising energy prices or falling EE equipment prices.

4.3 Develop an Initiative to Save Energy in Government Buildings

Extrapolating the results of this study suggests that there is a large potential for low-cost energy savings across the public buildings sector. Based on public sector consumption estimates, implementing ECMs could save as much as 100 GWh in energy and reduce government spending by 25-30 million JD per year. This report suggests an initiative be undertaken to identify energy savings measures and support ministries and agencies to implement them. Such initiatives to save energy in government buildings have proven effective in the US, Canada, Mexico, and elsewhere. The initiative could be tailored to fit the needs of individual ministries and could include activities such as:

1. Collecting the basic information (energy consumption and physical dimensions) needed to benchmark the energy performance of government buildings.
2. Encouraging ministries to procure energy audit services from a licensed energy auditor.
3. Providing technical support to the Energy Committees and Energy Managers established in individual ministries and agencies;
4. Establishing an incentives scheme that encourages ministries and agencies to pursue energy saving opportunities
5. Recognizing and rewarding ministries and government employees who implement energy-saving measures.

[4] An ASHRAE Level I energy audit is less rigorous than a Level II energy audit. Typically a Level I, or walk-through, energy audit is more like a check-up than a thorough exam of the building characteristics and equipment.

Such an initiative could be undertaken through collaboration among the organizations already supporting energy saving in government buildings. For example, the Ministry of Public Works and Housing (MOPWH) is implementing an *Energy Efficiency in Public Buildings* activity with the support of the German donor KfW. The Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) under MEMR is supporting energy efficiency and renewable energy investments across all consuming sectors. The quasi-public National Energy Research Center (NERC) has significant technical capability and experience in conducting energy audits. Finally, the Ministry of Finance has a vested interest in rationalizing all public expenditures, including energy expenditures. All of these entities would be important participants in the development of a government-wide initative to realize energy savings in public buildings.

5.0 FINANCING ENERGY CONSERVATION MEASURES

The energy audits of six government buildings found that between one-quarter and one-third of energy consumption could be saved by implementing no-cost and low-cost energy conservation measures. The package of ECMs recommended for each ministry and agency studied here had payback periods of one year or less and benefit-cost ratios of over 3 and in some cases as much as 7. Based on these results financing should be easily available from several sources. This section briefly reviews the options for financing such highly economical energy saving projects.

5.1 Self-Financing

The most obvious financing is self-financing. The results presented here show that a package of ECMs optimal for each building were economically very attractive. Table 19 shows the financial indicators for each building audited. All of these projects could be financed entirely from the reduced electricity and fuel oil expenditures over the course of one year.

The potential savings were in the range of 1/3 of the annual energy bill for each ministry, while the cost was in the range of few tens of thousands (less than 50,000 JD in most cases). Because the cost of implementing all ECMs does not exceed the savings achieved within the first year, and the costs are modest compared to ministry budgets, self-financing should be achievable simply by reallocating the items in the energy budget for a single year. Most savings will persist for over 10 years, assuming the ECMs are maintained.

Table 19: Financial Figures of Merit for the Six Buildings Audited

Ministry/ Agency	Percentage of Potential Savings	Annual Energy Saving Potential [JD]	Implementation Cost [JD]	Simple Pay-Back [Years]
MEMR	40.3%	37,430	22,860	0.61
MOFA	32.6%	80,880	45,500	0.56
MOITS	33.3%	122,220	133,100	1.1
MOSD	27.4%	51,500	41,600	0.81

MOICT	29.6%	63,000	32,540	0.52
EMRC	31.3%	41,000	37,250	0.9

5.2 Financing through JREEEF

The Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) was established under the umbrella of the Ministry of Energy and Mineral Resources to assist implementing energy saving and/or renewable energy projects.

JREEEF has considerable latitude in supporting renewable energy and energy efficiency projects. JREEEF has just established an agreement with commercial banks whereby JREEEF beneficiaries can access low-cost financing. JREEEF could also provide support to ASHRAE Level II audits for government buildings to reduce the risk to ministries of pursuing energy efficiency opportunities.

5.3 Financing through the Energy Service Companies

Some energy services providers offer financing schemes by which the ESP finances the cost of energy efficiency improvements in exchange for a percentage of the actual savings for a certain period of time. This has several advantages over other financing mechanisms, as it addresses any government budget limitation while providing guarantees to the government that the installation will be according to international standards and the actual savings will be as listed in the energy audit report.

5.4 Financing through MoPWH's Energy Efficiency in Public Buildings Program

This program is currently focused on two ministries – Education and Health. However the program could be expanded to provide short-term working capital to implement low-cost ECMs for government buildings of other ministries and agencies.

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