ENERGY AUDIT REPORT

Ministry of Education
Republic of the Marshall Islands

Prepared by

William Reiher

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Ministry of Education – Republic of the Marshall Islands

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1. EXECUTIVE SUMMARY

The Ministry of Education (here on referred to as MOE) consumed 1.96 GWh of electricity in the 2012 Fiscal year – a twelve month period from October 2011 – September 2012, at a total cost of approximately $980,000. This equates to an annual greenhouse gas emissions equivalent to 1.7 Million kilograms (or 3.66 Million lbs) of CO_2. An estimated breakdown of this energy consumption is shown in Figure A1 below.

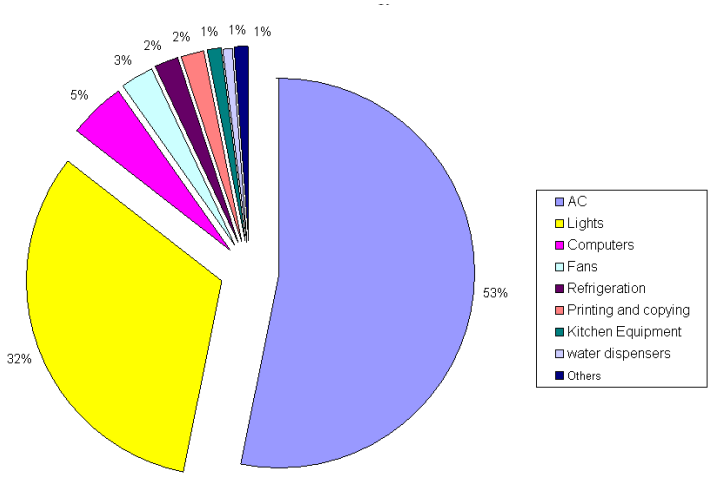


Figure A1: Estimated Breakdown of Energy Consumption

The audit of the Ministry of Health identified energy efficiency cost savings worth approximately $275,000 per annum. These savings represent approximately 45% of the energy currently used by the audited buildings (calculated at today's Government energy tariff of $0.50/kWh). It is recommended that the energy efficiency projects mentioned herein should be implemented over the next year.

In addition to the above energy efficiency works, it is recommended that a utilities metering system be implemented across all MOE facilities to provide monitoring, metering and apportioning of energy use and efficiency as required under the Energy Savings Action Plan and to carry out the other functions required under MOE's energy management programs. The monitoring equipment should be installed and energy monitoring and control implemented immediately to provide cost recovery. This initiative is included with the cost-effective projects in Table 8.1.

Notes on savings quoted above and in the report:
(1) Savings for items are based on the average energy for the October 2011-September 2012 months
(2) Refer to the body of the report for additional notes and qualifications on the above estimates
(3) All costs and savings estimates are based on information available and investigations possible at the time of the audit. Each requires confirmation in subsequent feasibility studies.

2. Introduction

2.1 Background

Due to rising electrical costs in 2011, MOE decided to undertake an Energy Audit to identify cost saving potentials through an Energy Savings Action Plan.

The steps taken in preparing the Energy Action Plan are:

- Determine baseline energy use
- Conduct an Energy Management Review
- Undertake a Technical Review, in the form of a Level 3 Energy Audit in accordance with AS/NZS 3598:2000
- Complete an Energy Savings action plan

2.2 Audited Buildings

This report and the data herein pertains only to the following buildings and spaces shown below:

1. MOE Main Office
2. Laura High School
3. Laura Elementary School
4. Woja Elementary School
5. Ajeltake Elementary School
6. Rairok Elementary School
7. Delap Elementary School
8. DUD Kindergarten
9. Marshall Islands High School
10. Majuro Middle School
11. Rita Elementary School

The audited buildings account for around 45% of MOE's total electricity bill during the active school periods and around 70% during the summer months. The following MOH facilities are not included in this audit and account for the remaining 30% of electrical expenditure in total.:

- Jaluit High School
- Northern Islands High School
- RMI-USP
- NVTI
- MIHS Staff House
- MIHS New Staff House (World Teach)
- Special Ed.

2.3 Scope of Works

This report only covers the electrical energy usage by the audited MOE buildings, which have been identified in section 2.2 of this report.

This report includes the determination of baseline energy use, the technical review, and the Energy Management Review.

A Level 3 Energy Audit provides a detailed analysis of energy usage, the savings that can be made and the cost of achieving these savings. A Level 3 Energy Audit is expected to provide a firm estimate of savings and cost. Accuracy of figures would be within +10% for costs and -10% for benefits. However, refer to section 2.4 for factors which affect the accuracy of these estimates.

2.4 Methodology

Baseline Energy Use

Baseline energy use was established from monthly electricity consumption and cost for the period October 2011 – September 2012.

Energy Management Review

Technical Review

Surveys of the building loads were undertaken by MOE Maintenance staff, and the data collected was compiled by a private Energy Auditor to construct a model of the energy use across the buildings and obtain a breakdown of energy consumption and demand levels.

The validity of the model was checked against historical electricity consumption.

Energy related greenhouse gas emission factors used in the report were obtained from the Australian Greenhouse Office "AGO Factors and Method Workbook, December 2005" – and adjusted to take into account MEC's older generators, along with inefficient transmission systems to correspond to the following for Diesel generation:

Electricity – 0.85 kg CO2-e/kWh or 1.87 lbs CO2-e/kWh

The energy savings action plan is the result of the aggregation of initiatives identified in the Technical Reviews of the individual buildings and the MOE-wide initiatives covered in this report.

2.5 Sources of Information, Assumptions and Qualifications

The information contained in this report is based on a range of sources that have selectively been evaluated; these sources include site historical energy consumption data, production data, daily plant run time and lost time records, individual plant electrical readings, site observations, and discussions with site personnel.

Site drawings and operating and maintenance manuals have been reviewed, where available, to gain an understanding of the installed plant and equipment. Where practical and appropriate, information has been confirmed by inspection of the installed plant.

Recommendations and observations are based on visual inspections of plant and equipment. Dismantling of plant or carrying out detailed technical inspections was outside the brief of this audit.

The information and recommendations stated in this report are based on the above techniques and limitations. However these estimates can be affected by a multitude of external factors, which are subject to change. As a result, each recommendation should be reviewed at the time of consideration, to ensure that its relevance and economics are still acceptable. Some of these factors include:

- Variations in production requirements
- Addition or deletion of energy consuming equipment;
- Variation in activity levels;
- Variations in process settings;
- Changes in energy tariff rates; and
- Other relevant changes.

2.6 Acknowledgements

Throughout the conductance of the Technical Review, the assistance and cooperation of the Ministry of Education's Maintenance staff of MOH have been invaluable.

I would like to especially thank the following whose cooperation has been a significant contribution towards completion of this report.

- Cassiano Jetnil – Assistant Secretary, Maintenance division
- Bradenson Soram – Management Information System

3. Buildings and Equipment

3.1 General Description of Buildings and Activity Levels

3.2 Air Conditioning Systems

Air conditioning systems used at MOE facilities are mostly 12,000 BTU split units for office spaces, and 18,000 – 24,000 BTU units for classroom spaces. All of the air conditioning units surveyed are highly inefficient units, and many of these are in need of replacement.

3.3 Lighting

Lighting systems are mostly linear fluorescent 4 feet double lamp fixtures (40 watts). Usage of incandescent was rare.

All lights are switch operated; there are no automatic/motion detection type lighting. Many lighting fixtures at the old hospital require some cleaning of the prismatic covers for better light output.

3.4 Computers

Many MOE computers still use the old CRT monitors which are found to be highly energy inefficient. Flat screen monitors and Laptops are not common at MOE, however these are more energy efficient than the older CRT monitors.

4. Energy Load Profiles and Energy Consumption Patterns

4.1 Summary of Energy Consumption and Performance

The audited MOE buildings consumed a total of 1.96 GWh of energy for the twelve months ending September 2012. This consumption level resulted in Greenhouse gas emissions of 1.7 Million kilograms (or 3.66 Million lbs) of Carbon Dioxide.

The corresponding energy performance indices were:

- 388kWh or $194 per High School Student per year
- 100kWh or $50 per Elementary/Kindergarten Student
- 300 kWh or $150 per Equivalent Full TIME Enrolled Students (EFTS)
- 1,719 kWh or $860 per Administration staff

The maximum electricity demand, based on the recorded monthly maximum and minimum for the combined audited buildings, was 141,768 kWh in November 2011 and 212,134 kWh respectively (a 50% increase), in March 2012.

Figure 4.1 below shows total monthly electricity costs by the MOE facilities

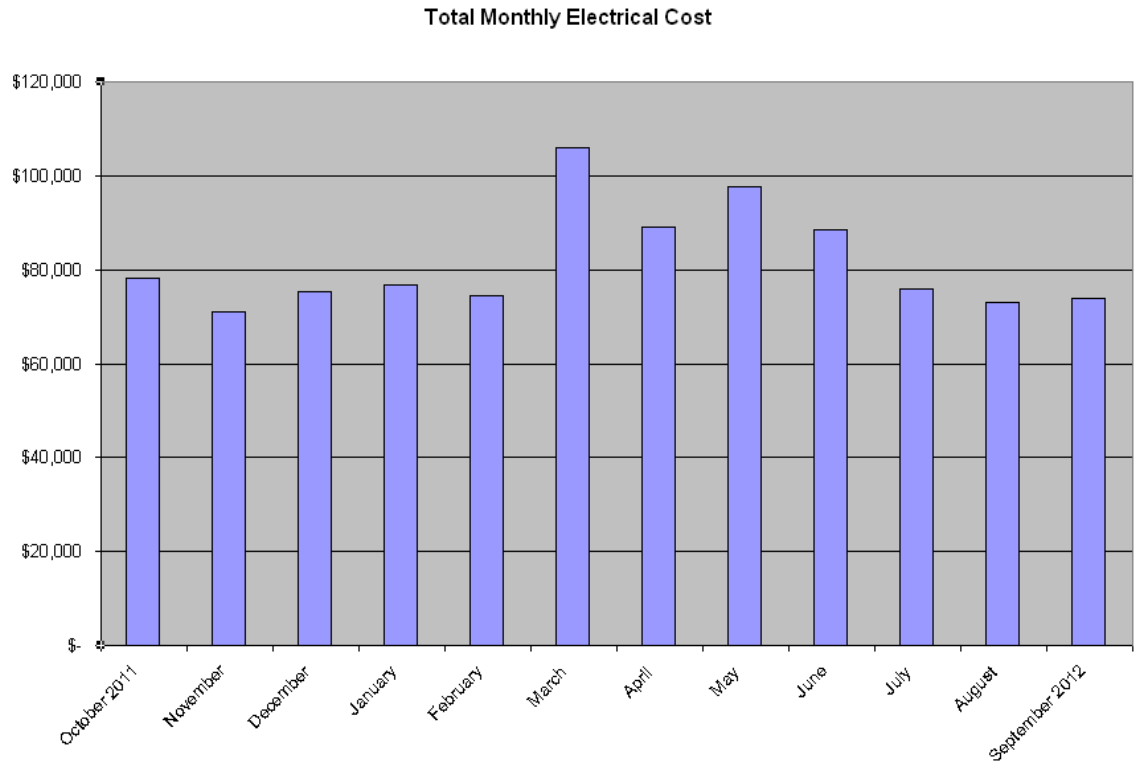


Figure 4.1: Monthly kWh Consumption

4.2 Business Activity Indicators (BAI) and Baseline Energy Use

Key Performance Indicators (KPI) are determined by dividing consumption units by the Business Activity Indicator (BAI). In the case of Educational Institutions the BAI is "Equivalent Full Time Students" (EFTS)

A lower Key Performance Indicator indicates lower consumption per student.

This indicator can be used to compare how different schools rate against each other in terms of energy consumption. MOE may also use this indicator for policy setting by setting a benchmark KPI that all its facilities will abide by.

Table 4.2: Baseline Energy Use

Baseline Start Date	October 2011
Baseline End Date	September 2012
Baseline Energy Use per Annum (kWh)	1,960,000
Middle & High Schools Only (kWh)	842,800
Administration Only (kWh)	137,200
Elementary & Kindergarten Only (kWh)	980,000
TOTAL CO_2 Emissions (tonnes)	1,666
Is Baseline representative of normal Energy Use	Yes
Baseline Activity Indicator 1	EFTS
Quantity of Site Business Indicator 1	6221
Baseline Energy use Key Performance Indicator 1	315 kWh/EFTS
Baseline Activity Indicator 2	Middle, & High School Students
Quantity of Site Business Indicator 2	2,434
Baseline Energy use Key Performance Indicator 2	346 kWh/ High School Student

Baseline Activity Indicator 3	Elementary & Kindergarten
Quantity of Site Business Indicator 1	3,787
Baseline Energy use Key Performance Indicator 1	259 kWh /Elem.& Kinder. Student
Baseline Activity Indicator 4	Administration Staff
Quantity of Site Business Indicator 1	57
Baseline Energy use Key Performance Indicator 1	2,407 kWh/ Admin. Staff
Demand (see note 1)	
Baseline high peak Electrical use (kWh)	212,134
Baseline low peak Electrical use (kWh)	141,768
Note 1: Low and high peak electrical use is based on the summation of the monthly peak for the audited buildings.	

4.3 Electricity

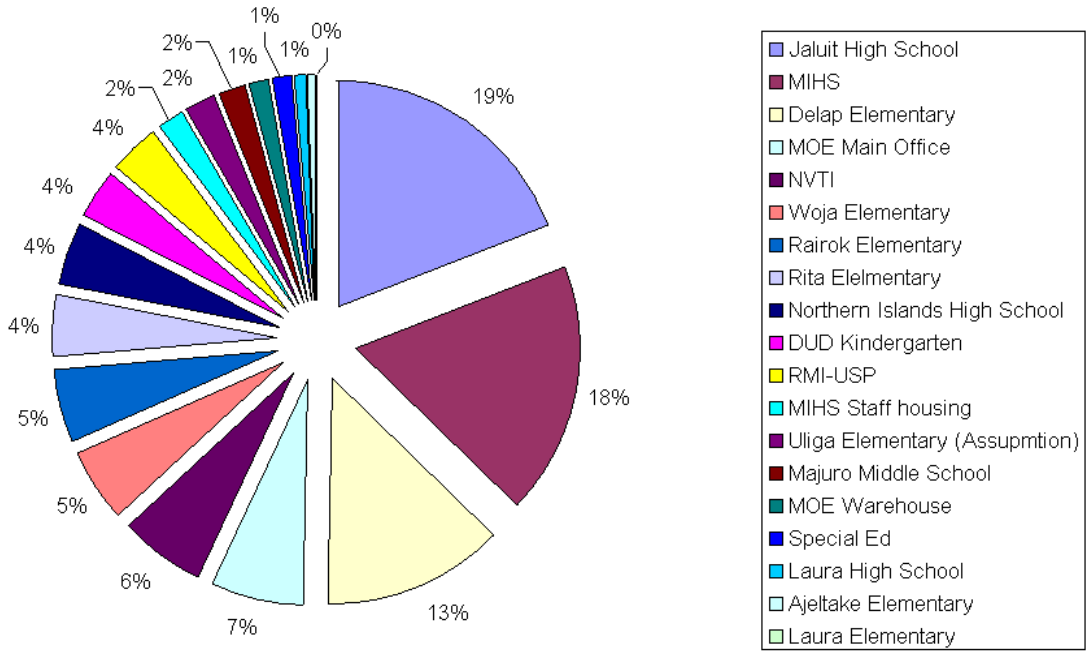
4.3.1 General Description

The MOE Facilities are supplied by separate supplies metered by MEC Energy meters. While most meters have no MEC multipier rate on them, the following meters have a multipication factor on them (shown in brackets)

- MIHS New Building (x60)
- MIHS Kakije Corner (x10)
- NVTI (x60)
- Delap Elementary New building (x10)
- Rairok Elementary New building (x80)
- Rairok Classroom 4 (x10)
- Rairok Classroom Tr (x10)
- Kindergarten Delap (x10)
- Kindergarten Rairok (x10)
- Jaluit High school Cafeteria (x10)
- Jaluit High School Dormitory (x10)

The graph below shows the percentage share of total electrical consumption per audited facility

Figure 4.3.1: Percentage share of Energy Consumption



4.3.2 Electricity Consumption, Cost and Performance

The graph below provides a comparison of energy consumption from the audited MOE facilities

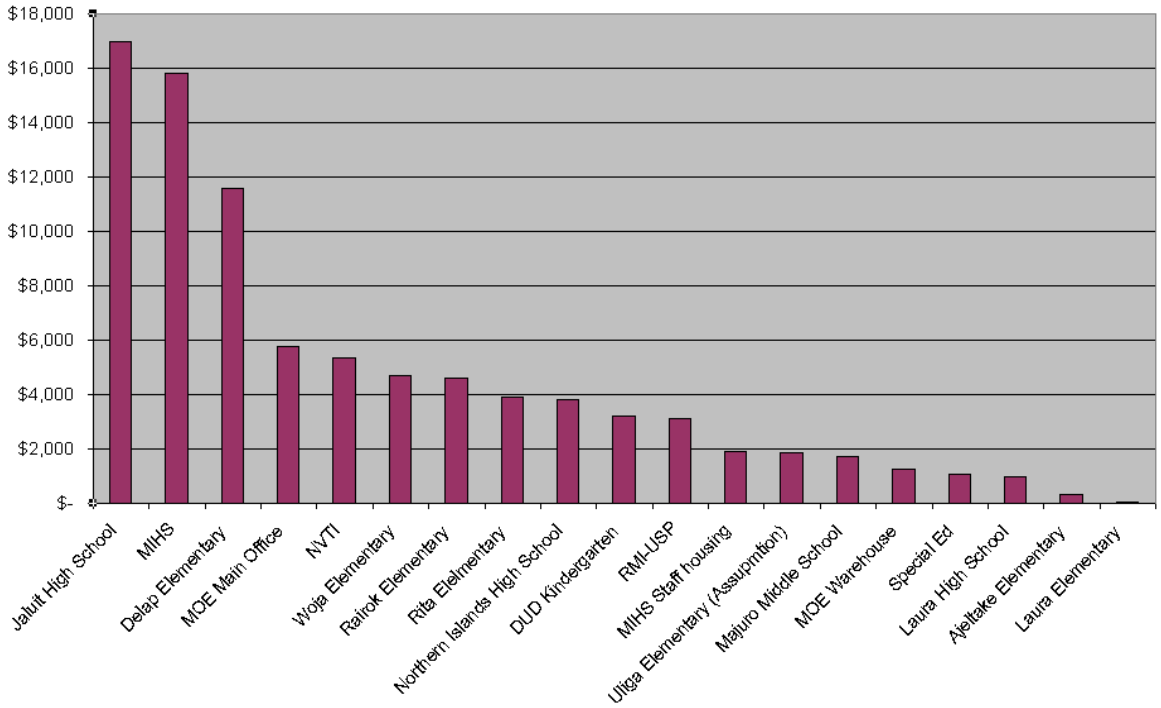


Figure 4.3.2 Typical Monthly Energy Costs

Seasonal Patterns of Electricity Use

Figure 4.3.2b shows MOE's monthly electricity consumption and cost for the 2012 Fiscal Year spanning October 2011 – September 2012.

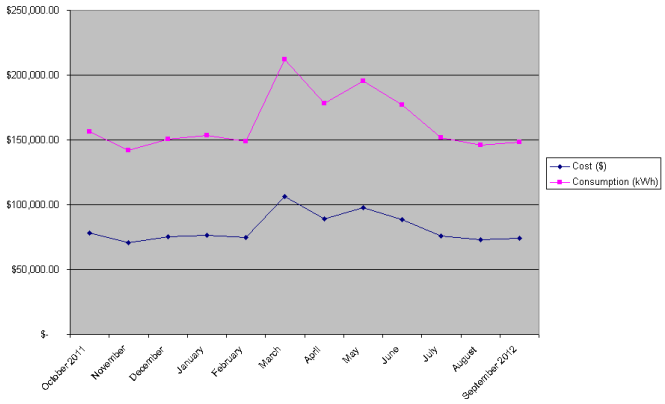


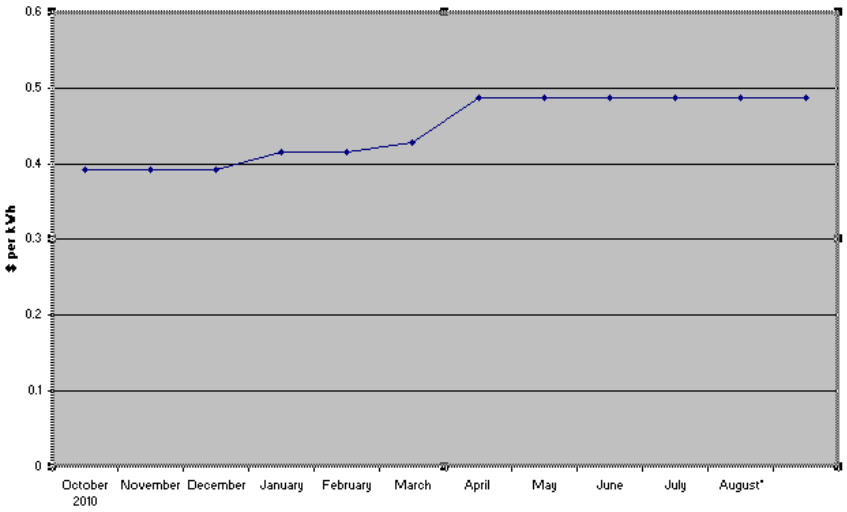
Figure 4.3.2b Energy Consumption and Cost for FY2012

4.3.3 Electricity Tariffs and Trend

The MOE audited buildings are billed at Marshalls Energy Company's (MEC) government rate which is currently 50 cents per kWh at the time of this report. In December 2010, this tariff had been below 40 cents. It rose up incrementally 3 times in the year 2011 to 48.8 cents and again in April 2012 to it's current rate.

The graph below shows the rising trend in electricy prices by MEC in 2011.

Figure 4.3.3: Monthly Tariff – Commercial Rate charged by MEC



Note that with the emerging economies of the World (notably China and India) and the fact that we have passed "peak oil", diesel fuel prices (and hence electrical energy costs) are expected to continue to rise in the future.

4.4 Breakdown of Energy Use and Application

4.4.1 Energy Use by Application

The breakdown of energy consumption by application is shown in Table 4. and Figure 4. These show the most significant applications of energy across the MOE facilities to be Air-conditioning, followed by Lighting. Computers which are ranked third in terms of highest energy consuming equipment at MOE, only consume 5% of total energy. The section labeled "others" comprises radios, water pumps and other small electrical items.

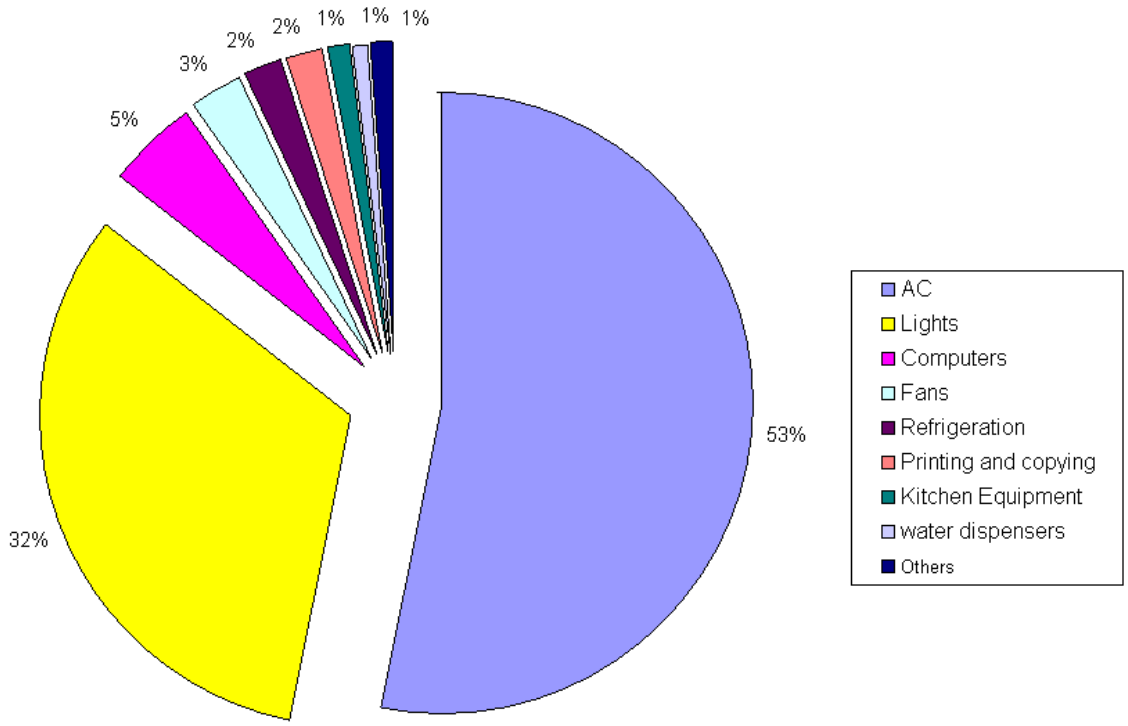
Also note that these measurements were a result of the audit findings gathered by MOE Maintenance staff and results which may differ slightly from the baseline data which was sourced from historical MEC data.

Table 4.4.1a Energy Consumption, Performance and Cost by Application (kWh/ Indicator)

			Performance per BAI	Cost per BAI
Application	Consumption kWh pa	Cost ($) pa	kWh /EFTS	
Air Conditioning	663,722	$ 331,861	107	$ 53.35
Lights	403,452	$ 201,726	65	$ 32.43
Computers	57,774	$ 28,887	9	$ 4.64
Fans	36,300	$ 18,150	6	$ 2.92
Refrigeration	25,941	$ 12,970	4	$ 2.08
Printing & Copying	23,184	$ 11,592	4	$ 1.86
Kitchen Equipment	14,457	$ 7,228	2	$ 1.16
Water Dispensers	7,783	$ 3,891	1	$ 0.63
Others	15,302	$ 7,651	2	$ 1.23
TOTAL	1,247,915	$ 623,958	201	$ 100.30

The Figure below shows a breakdown of the total energy use by application which was a direct result of the energy data collection and amalgamation from all the MOE audit sites identified in section 2.1 of this report.

Figure 4.4 Breakdown of Total Energy Use by Application



5. Analysis of Energy Systems and Estimated Savings Potential[1]

5.1 Overview of Annual Energy Savings Identified

The audit of MOE identified energy efficiency cost savings worth approximately $275,000 per annum including some minor maintenance savings due to reduced operation of systems. These savings represent approximately 45% of the energy used by the audited buildings.

5.2 Air Conditioning Systems (Savings of $182,600)

The split type Air conditioning systems at MOE are not energy efficient with E.E.R less than 2. In comparison, recommended systems are highly efficient inverter split systems manufactured by Daikin with E.E.R around 4. These units will also have factory coated fin protection, meaning that they will last longer in our salty environment as compared to local units which stop operating due to overheating which results from corroded cooling fins. Most locally available units fail within a year or so after installation due to this problem with non-coated cooling fins.

The table below shows the current Air conditioning systems and the proposed replacement systems (Cooling Only) with their high E.E.R.

Current A/Cs	# of units	Proposed Replacement A/Cs	New E.E.R
18,000- 24,000 BTU	103	Daikin FTXS24LVJU	3.66
9,000 - 12,000 BTU	27	Daikin FTXS09LVJU	4.48

[1] Implementation costs shown are budgetary estimates only. They include cost of equipment, transportation and installation, however this cost will depend on the complexity of the specific installation and will therefore vary with each case

5.3 Lighting (Savings of $92,500)
Lighting at MOE consume approximately 403,450 kWh of electricity a year at a cost of $201,730 (32% of overall electricity cost). The lighting systems at the MOE comprise mostly 40W fluorescent tubes, which account for around 90% of energy consumed by MOE lighting fixtures

A comprehensive upgrade of the lighting systems from 40W fluorescent to 16W LED tubes will subsequently cut lighting costs by 55%. De-lamping fittings will further reduce energy consumption without sacrificing comfortable lighting levels. The following initiatives are recommended:

- Switching from 40W Fluorescent to 16W LED tubes
- Switching from 20W Fluorescent to 9W LED tubes
- Lamp Removals in certain areas where not much lighting is needed
- Motion Detectors especially in corridors

By incorporating motion detectors in corridors and outdoor areas, a substantial amount of electricity may be saved.

6. Utilities Metering and Monitoring

This energy audit has identified baseline consumption and performance levels for MOE based on revenue meter data. It is recommended that a user-friendly electricity usage monitoring system ("efergy") be installed at each meter. This monitoring system installation is to address the following issues:

- Generate monthly and annual reports on MOE energy consumption and performance as part of the new MOE energy management program and for annual reporting to stakeholders.
- Generate monthly and annual reports on individual building energy sources for consumption and performance as part of the MOE energy management program incorporating monitoring and verification of the implementation of energy efficiency opportunities.

These efergy units are available at Do It best for about $100 each. For a very basic monitoring of electrical usage at MOE, all facilities of MOE audited under this report should be installed with these meters. This will document before and after electrical usage (once the energy efficient equipment have been installed) to verify the savings identified in this report.

The image below shows an example of the efergy "elink" software system for monitoring energy consumption.

7. Energy Management

7.1 Incorporating Energy Management

For effective energy management at the MOE, the following recommendations will be carried out as part of the delivery of this report:

1. **Understanding of performance and opportunities**

   Conduct a baseline study (energy audit) to establish energy consumption by major users and opportunities for savings.

   This Technical Review has established baselines and targets and identified energy consumption and opportunities for savings.

2. **Awareness and Training**

   Conduct basic energy-awareness within the organization, focusing on cost savings and environmental issues associated with energy use.

   Following submission of this report, an awareness training session and report summary will be presented to administration and maintenance staff at MOE.

3. **Metering and Monitoring**

   Regularly monitor the energy use by using the "efergy" meters which are to be installed at all energy source for MOE (as identified in this report).

   MOE has to designate an "energy officer" who will be in charge of monitoring the energy usage data as collected by the individual meters. This officer will be able to produce monthly and annual electricity consumption and performance reports by collating information using the efergy software. Reports will have the following outputs:

   a. Changes in business activity indicators
   b. Performance against baseline and target
   c. Identification of areas of poor performance
   d. Highlight savings achieved
   e. Preventative Maintenance
   f. Ensuring systems run efficiently (eg. A/Cs not below 77°F, equipment not used are turned off)

7.2 Energy Initiatives to Date

MOE has purchased several LED bulbs to replace the fluorescent fixtures at the MOE Warehouse in downtown Uliga. These appear to be a trial, however it is recommended that this practice be carried out at all of MOE's facilities, especially targeting the major energy consuming school buildings

7.3 Energy Performance Indicators

Baseline Energy consumption and performance has been established as part of this Technical Review for MOE for the October 2011 – September 2012 period and benchmarks and targets have been established for each of the buildings. Maximum and Minimum electrical demands have also been documented.

The inputs required to compare actual consumption and performance against baseline consumption and performance are as follows:

1. Equivalent Full Time Students (EFTS)
2.

7.4 Monitoring and Verification of energy efficiency Measures

Energy efficiency projects need to be monitored before the project commences and after the project is completed to verify that expected improvements have been achieved. There also needs to be ongoing monitoring to ensure that the expected improvements are maintained.

Documentation for new buildings and building refurbishments should include estimates of energy consumption and performance at the stage which should be monitored and verified after the building commissioning is complete.

8. Implementation of Projects and Overall Cost Savings

The table below documents the savings potentials that can be achieved by targeting the two main energy consuming systems at the Center – Air Conditioning (accounting for 53% of total energy use) and lighting (32%)

Table 8.1 Energy Efficiency and Cost Savings Potential Projects

	Project	Cost to Implement	Savings (kWh)	Cost Savings	Internal Rate of Return	Payback period	CO2- e avoided (lbs)
1	New 24,000 BTU A/Cs	$206,000	327,200	$163,600	80%	15 months	611,860
2	New 9,000 BTU A/Cs	$46,800	38,000	$19,000	41%	2.5 years	70,980
3	LED Light project	$142,500	185,000	$92,500	65%	1.5 years	345,950
	TOTAL	$395,300	550,200	$275,100	70%	17 months	1,028,800

It is estimated that upon acceptance of these recommendations, a period of 4 months is required for documenting, purchasing and installing the LEDs, and an 8 month period for before the complete installation of the Energy Efficient Air Conditioning Units.

9. Recommendations

It is recommended MOE implement the THREE Energy Efficiency Projects identified in Section 8 of this report. This following set of recommendations should be also followed for maximum savings realization and longevity of energy efficiency equipment:

Air Conditioning

1. All air conditioning units must have factory coated fin protection.
2. All outdoor units for split systems must have roofing/housing in order to minimize heat gain from direct sunlight as well as protect the unit form salt spray
3. All piping between indoor and outdoor units of split systems must be properly insulated with sealed thermal insulation to prevent any loss of coolth to the outside atmosphere
4. All ACs thermostat controls must never be set lower than 25°C or 76°F
5. All AC Outdoor units must be serviced every 3 months or less. This servicing should include cleaning off of the coils and cooling fins of any salt/dust buildup according to the manufacturer's cleaning instructions, as well as spot maintenance for example removing rust spots on the outdoor unit body, and repainting with corrosion resistant paint. Outdoor unit fans should also be checked for ease of movement and axles greased/lubricated if necessary.
6. Indoor units must be serviced and maintained every 6 months or as recommended by manufacturer. Air filters must be cleaned to remove dust, and fans checked for ease of movement.
7. All outdoor units must have a solid base to elevate the unit at least 6 inches from ground level to avoid splashing from rain and also to allow for better ventilation of the unit.
8. Where no cooling is needed after hours and on weekends, split type air conditioning units should be turned off.
9. The "Recommended replacement of AC units" (Appendix 11.2) must be followed. This shows which current AC units should be changed to the recommended units. This recommendation is tied in with the energy saving projects listed in Section 8 of this report.

Computing

1. Only Energy Star rated computers and computing equipment should be utilized at MOE
2. Where possible switch from desktop to Laptops. This will save on the cost of units as well as save on the operational and initial costs of Uninterrupted Power supply (UPS). Laptops also draw less power than traditional desktop units.

10. Conclusion

With a 25% tariff increase within the first four months of 2011 and a further 2.5% increase in 2012, the forecasted trend is for further increase, to follow the rise in world oil prices. Ignoring energy use and energy management needs will become even more costly in the future.

With the saying that a dollar saved is easier than a dollar earned, MOE must seriously consider the significant savings documented herein, as these savings do not just benefit the Ministry, but also benefit the environment by reducing greenhouse gas emissions through reduced energy consumption. The recommended projects also have short payback periods which make them very viable projects because cost recovery averages less than two (2) years. In the business world such short payback projects are very attractive to investors.

The recommendations herein should be implemented at MOE, and the Energy savings achieved documented and monitored against the savings data documented in this report.

11. Appendicies

APPENDIX 11.1

SITE PLANS OF AUDITED BUILDINGS

APPENDIX 11.2

RECOMMENDED INVERTER TYPE SPLIT UNIT AIR-CONDITIONING UNITS

APPENDIX 11.3

RECOMMENDED LED LIGHTING