# ENERGY AUDIT
## REPORT

**TOWN OF NEEDHAM**
Department of Public Facilities
1471 Highland Avenue
Needham, Massachusetts 02492
**Kate Fitzpatrick**

# ENERGY AUDIT REPORT

**of**

**ELIOT ELEMENTARY SCHOOL**
135 Wellesley Avenue
Needham, Massachusetts 02492


**PREPARED BY:**

**EMG**
222 Schilling Circle, Suite 275
Hunt Valley, Maryland 21031
800.733.0660
410.785.6220 (fax)
www.emgcorp.com

**EMG CONTACT:**

**Kalyana Vadala**
Program Manager
800.733.0660, ext.6236
kkvadala@emgcorp.com


**EMG Project #:** 98515.11R-002.268
**Date of Report:** February 12, 2012
**On site Date:** September 6-7, 2011

# TABLE OF CONTENTS

# 1. CERTIFICATION

EMG has completed an Energy Audit of Eliot Elementary School located at 135 Wellesley Avenue, Needham, Massachusetts 02492. EMG visited the site on September 6 and 7, 2011.

The assessment was performed at the Client's request using methods and procedures consistent with ASHRAE Level II Energy Audit and using methods and procedures as outlined in EMG's Proposal.

This report is exclusively for the use and benefit of the Client identified on the first page of this report. The purpose for which this report shall be used shall be limited to the use as stated in the contract between the client and EMG.

This report is not for the use or benefit of, nor may it be relied upon by any other person or entity, for any purpose without the advance written consent of EMG.

Estimated installation costs are based on EMG's experience on similar projects and industry standard cost estimating tools including *RS Means*. In developing the installed costs, EMG also considered the area correction factors for labor rates for Needham, MA. Since actual installed costs may vary widely for particular installation based on labor & material rates at time of installation, EMG does not guarantee installed cost estimates and shall in no event be liable should actual installed costs vary from the estimated costs herein. We strongly encourage the owner to confirm these cost estimates independently. EMG does not guarantee the costs savings estimated in this report. EMG shall in no event be liable should the actual energy savings vary from the savings estimated herein.

EMG certifies that EMG has no undisclosed interest in the subject property and that EMG's employment and compensation are not contingent upon the findings or estimated costs to remedy any deficiencies due to deferred maintenance and any noted component or system replacements.

Any questions regarding this report should be directed to Kalyana Vadala at 800.733.0660, ext. 6236.

**Prepared by:** John McLurg, P.E.
Energy Auditor
Project Manager

**Reviewed by:** _____
Kalyana Vadala
Program Manager

# 2. EXECUTIVE SUMMARY

The purpose of this Energy Audit is to provide Town of Needham and John Eliot Elementary School with a baseline of energy usage and the relative energy efficiency of the facility and specific recommendations for Energy Conservation Measures. Information obtained from these analyses may be used to support a future application to an Energy Conservation Program, Federal & Utility grants towards energy conservation, support performance contracting, justify a municipal bond funded improvement program, or as a basis for replacement of equipment or systems.

The school property has one, 2-story building containing approximately 72,504 square feet consisting of offices, classrooms, auditorium, cafeteria, gym, mechanical and storage rooms. The Construction of the property was completed in 2003. The building and its systems have been maintained in good condition and no upgrades or renovations have been made since construction.

The study included a review of the building's construction features, historical energy and water consumption and costs, review of the building envelope, HVAC equipment, heat distribution systems, lighting, and the building's operational and maintenance practices.

Eliot Elementary School was constructed with many energy-conservation features. In particular, the south and west exposures of the building feature large areas of glazing which allow abundant natural light inside the building. Much of the HVAC equipment features motors controlled by Variable-Frequency Drives (VFD) to reduce unnecessary electrical energy consumption during part load conditions. Two Rooftop Air Handlers make use of $CO_2$ sensors to minimize outdoor air volume based on occupancy. Light fixtures are energy-conserving fluorescent fixtures with electronic ballasts or Compact-Fluorescent (CFL) lamps. Most interior light fixtures are controlled by motion sensors. John Eliot Elementary School currently has a central BMS system controlling the HVAC systems at the school. Finally, the building features water-conserving plumbing fixtures.

**Summary of Existing Energy Performance**

| | |
|---|---|
| Building's Annual Energy Consumption | 5,729,902 kBtu |
| Total Annual Energy Costs | $153,150 |

EMG has identified 7 Energy Conservation Measures (ECMs) for this property. The savings for each measure are calculated using standard engineering methods followed in the industry, and detailed calculations for ECM are provided in Appendix for reference. A 10% discount in energy savings was applied to account for the interactive effects amongst the ECMs. In addition to the consideration of the interactive effects, EMG has applied a 15% contingency to the implementation costs to account for potential cost overruns during the implementation of the ECMs.

The following table summarizes the recommended ECMs in terms of description, investment cost, energy consumption reduction, and cost savings.

**Summary of Financial Information for Recommended Energy Conservation Measures**

| Item | Estimate |
|---|---|
| Total Initial ECM Investment *(Current Dollars Only)* | $43,039 |
| Estimated Annual Cost Savings Related to ECMs *(Current Dollars Only)* | $11,005 |
| ECM Effective Payback (years) | 3.91 |
| Estimated Annual Energy Savings | 11% |
| Estimated Annual Energy Cost Savings | 7% |

| List of Recommended Energy Conservation Measures For John Eliot Elementary School | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ECM # | Description of ECM | Projected Initial Investment | Estimated Annual Energy Savings | | Estimated Annual Water Savings | Total Energy Savings | Total Estimated Annual Cost Savings | Simple Payback |
| | | $ | Natural Gas Therms | Electricity kWh | kgal | MMbtu | $ | Years |
| **No/Low Cost Recommendations** | | | | | | | | |
| 1 | Install Energy Savers on Vending, Snack Machines<br>Details: Electric Water Cooler and "Coke" Machine located in Teacher's Dining Room | $390 | 0 | 2,300 | 0 | 8 | $478 | 0.82 |
| 2 | Install Timers On Rooftop Exhaust Fans<br>Details: Restroom Exhaust Fans (EF1-7, EF-18), 2HP total | $516 | 0 | 1,547 | 0 | 5 | $321 | 1.60 |
| 3 | Convert Gas Pilot Stoves To Electronic Ignition Stoves<br>Details: Convert Kitchen Range to Electronic Ignition | $215 | 34 | 0 | 0 | 3 | $37 | 5.87 |
| **Totals for No/Low Cost Items** | | **$1,120** | **34** | **3,847** | **0** | **17** | **$835** | **1.34** |
| **Capital Cost Recommendations** | | | | | | | | |
| 1 | Install Automatic Lighting Controls<br>Details: Exploit natural light in corridors, etc. | $1,632 | 0 | 11,044 | 0 | 38 | $2,293 | 0.71 |
| 2 | Re-Commission The Building & Its Control Systems<br>Details: Rebalance air flow; verify control system operations | $20,711 | 5,864 | 0 | 0 | 586 | $6,314 | 3.28 |
| 3 | Replace High Intensity Discharge Lamp (HID) with Induction Lighting<br>Details: Replace HID Gym lights and lobby flood lights with induction fixtures. | $11,921 | 0 | 11,337 | 0 | 39 | $2,498 | 4.77 |
| 4 | Install On-Demand Ventilation on Air Handlers in Mechanical Room<br>Details: Convert Gym Air Handlers (AH-1,2) to On-Demand Ventilation. | $2,041 | 250 | 22 | 0 | 25 | $288 | 7.09 |
| **Total For Capital Cost** | | **$36,305** | **6,114** | **22,403** | **0** | **688** | **$11,393** | **3.19** |
| | *Interactive Savings Discount @ 10%* | | -615 | -2,625 | | -70 | -$1,223 | |
| | *Total Contingency Expenses @ 15%* | $5,614 | | | | | | |
| **Total for Improvements** | | **$43,039** | **5,533** | **23,625** | **0** | **634** | **$11,005** | **3.91** |

# 3. BENCHMARKING/ENERGY PERFORMANCE SUMMARY

## 3.1. ENERGY STAR PORTFOLIO MANAGER FACILITY SUMMARY

EMG uses the Portfolio Manager tool developed by the Federal Environmental Protection Agency to track relative energy uses of buildings by property type. This tool allows the input of a facility's historic utility data to be compared with normalized data of a large database of its peer facilities.

Below is the EPA Performance rating:

| | |
|---|---|
| John Eliot Elementary School: | 62 |
| National Average k-12 school: | 50 |
| Rating required to apply for Energy Star certification: | 75 |

## 3.2. EPA ENERGY STAR RATING

The national energy performance rating is a type of external benchmark that helps energy managers to assess how efficiently their buildings use energy, relative to similar buildings nationwide. The rating system's 1-100 scale allows everyone to understand quickly how a building is performing. For example, a rating of 50 indicates an average energy performance, while a rating of 75 or better indicates top performance. The higher the rating, the better the building is performing. Organizations can evaluate energy performance among the buildings in their portfolio, while also comparing their performance with other similar buildings nationwide. Additionally, building owners and managers can use the performance ratings to help identify buildings that offer the best opportunity for energy improvement and recognition.

To receive the energy performance rating, facility-related data entered into the Portfolio Manager, must adhere to a series of operating and energy use conditions. If one or more of these conditions are not met, the facility will receive "N/A" (Not Available) as a rating. "NA" means that the Portfolio Manager is unable to calculate a rating for that particular period ending date, given the operating and energy use conditions provided.

A building must obtain a rating of 75 or better to be eligible to apply for the Energy Star Certification. However, a rating of 75 does not necessarily mean that a building will qualify.

## 3.3. SOURCE ENERGY AND SITE ENERGY

Buildings use a variety of forms of energy, including Electricity, natural gas, fuel oil, and district steam. In order to provide an un-biased rating, the methodology must add together all of the energy used in a building. To combine energy in an equitable way, the ratings use source energy. Source energy is the energy that is consumed at the site, in addition to the energy used in generation and transmission.

The purpose of the conversion from site energy to source energy is to provide an equitable assessment of building-level energy efficiency. Because billed site energy use includes a combination of primary and secondary forms of energy, a comparison using site energy does not provide an equivalent thermodynamic assessment for buildings with different fuel mixes. In contrast, source energy incorporates all transmission, delivery, and production losses, which accounts for all primary fuel consumption and enables a complete assessment of energy efficiency in a building. When source energy is used to evaluate energy performance, an individual building's performance does not receive either a credit or a penalty for using any particular fuel type.

**Facility**
Needham: Eliot Elementary School
135 Wellesley Avenue
Needham, MA 02492

**Facility Owner**
N/A

**Primary Contact for this Facility**
Bill Champion
222 Schilling Circle Suite 275
Hunt Valley, MD 21031

## General Information

| Needham: Eliot Elementary School | |
|---|---|
| Gross Floor Area Excluding Parking: (ft²) | 72,504 |
| Year Built | 2003 |
| For 12-month Evaluation Period Ending Date: | June 30, 2011 |

## Facility Space Use Summary

| Elementary School | |
|---|---|
| Space Type | K-12 School |
| Gross Floor Area(ft²) | 72,504 |
| Open Weekends?[d] | No |
| Number of PCs[d] | 127 |
| Number of walk-in refrigeration/freezer units | 2 |
| Presence of cooking facilities[d] | Yes |
| Percent Cooled | 90 |
| Percent Heated[d] | 100 |
| Months[d] | 9 |
| High School?[d] | No |
| School District[e] | Needham |

## Energy Performance Comparison

| | Evaluation Periods | | Comparisons | | |
|---|---|---|---|---|---|
| **Performance Metrics** | **Current (Ending Date 06/30/2011)** | **Baseline (Ending Date 06/30/2011)** | **Rating of 75** | **Target** | **National Median** |
| Energy Performance Rating | 62 | 62 | 75 | N/A | 50 |
| Energy Intensity | | | | | |
| *Site (kBtu/ft²)* | 79 | 79 | 69 | N/A | 89 |
| *Source (kBtu/ft²)* | 140 | 140 | 123 | N/A | 158 |
| Energy Cost | | | | | |
| *$/year* | $ 152,256.63 | $ 152,256.63 | $ 133,977.34 | N/A | $ 171,308.01 |
| *$/ft²/year* | $ 2.10 | $ 2.10 | $ 1.85 | N/A | $ 2.36 |
| Greenhouse Gas Emissions | | | | | |
| MtCO$_2$e/year | 409 | 409 | 360 | N/A | 460 |
| kgCO$_2$e/ft²/year | 6 | 6 | 5 | N/A | 7 |

# 4. INTRODUCTION

The purpose of this Energy Audit is to provide John Eliot Elementary School with a baseline of energy usage, the relative energy efficiency of the facility, and specific recommendations for Energy Conservation Measures. Information obtained from these analyses may be used to support a future application to an Energy Conservation Program, Federal and Utility grants towards energy conservation, as well as support performance contracting, justify a municipal bond-funded improvement program, or as a basis for replacement of equipment or systems.

The energy audit consisted of an on site visual assessment to determine current conditions, itemize the energy consuming equipment (i.e. Boilers, roof-top-cooling units (RTU), DHW equipment); review lighting systems both exterior and interior; and review efficiency of all such equipment. The study also included interviews and consultation with operational and maintenance personnel. The following is a summary of the tasks and reporting that make up the Energy Audit portion of the report.

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### ENERGY AND WATER USING EQUIPMENT

- EMG has surveyed the common areas, office areas, classrooms, maintenance facilities and mechanical rooms to document utility-related equipment, including heating systems, cooling systems, air handling systems and lighting systems.

### BUILDING ENVELOPE

- EMG has reviewed the characteristics and conditions of the building envelope, checking insulation values and conditions. This review also includes an inspection of the condition of walls, windows, doors, roof areas, insulation and special use areas. Where we anticipated significant losses, we utilized infrared thermographs to analyze heat loss across the envelope.

### RECOMMENDATIONS FOR ENERGY SAVINGS OPPORTUNITIES

- Based on the information gathered during the on site assessment, the utility rates, as well as recent consumption data and engineering analysis, EMG has identified opportunities to save energy and provide probable construction costs, projected energy/utility savings and provide a simple payback analysis.

### ANALYSIS OF ENERGY CONSUMPTION

- Based on the information gathered during the on site assessment and a minimum of one year of utility billing history, EMG has conducted an analysis of the energy usage of all equipment, and identified which equipment is using the most energy and what equipment upgrades may be necessary. As a result, equipment upgrades or replacements are identified that may provide a reasonable return on the investment and improve maintenance reliability.

### ENERGY AUDIT PROCESS

- Interviewing staff and review plans and past upgrades
- Performing an energy audit for each use type
- Performing a preliminary evaluation of the utility system
- Analyzing findings, utilizing ECM cost-benefit worksheets
- Making preliminary recommendations for system energy improvements and measures
- Estimating initial cost and changes in operating and maintenance costs based on implementation of energy efficiency measures
- Ranking recommended cost measures, based on the criticality of the project and the largest payback

**REPORTING**

The EMG Energy Audit Report includes:

- A comprehensive study identifying all applicable Energy Conservation Measures (ECMs) and priorities, based on initial cost and payback
- A narrative discussion of building systems/components considered and a discussion of energy improvement options;
- A summary of ECMs including initial costs and simple payback based on current utility rates and expected annual savings.

# 5. FACILITY OVERVIEW AND EXISTING CONDITIONS

## 5.1. BUILDING OCCUPANCY

School is in session 180 days during the year. Teachers and staff work in the school for approximately 185 days during the year. During the school year, the building is accessible to teachers and staff between 6.30am and 10pm. The school building is frequently accessible to the public during evening and weekend hours for various extra-curricular activities such as school plays or night basketball during the school year and also during the summer.

According to the latest available information, 409 students are assigned to Eliot Elementary School. The school has 19 classrooms. Assuming 19 teachers and an equivalent number of staff yields a normal building occupancy of 447 people. After-hours programs might result in an equal occupancy, assuming activities involving the Multi-Purpose room and the Gymnasium.

| | |
|---|---|
| Facility Occupancy (avg. people/day) | 447 |
| Standard Operating Hours/day | 15.5 |
| Maintenance/ Staff Hours/day | 6.30am-10pm |

**Summary of Facility Operating Hours**

| | Hours Open to the Public | Hours Open to Employees |
|---|---|---|
| Monday-Friday | 8am-3pm | 6.30am-10pm |
| Saturday | By Arrangement | By Arrangement |
| Sunday | By Arrangement | By Arrangement |

## 5.2. BUILDING ENVELOPE

The building envelope consists of the exterior shell, made up of the walls, windows, roof, and floor. The envelope provides building integrity and separates the exterior from the interior conditioned space.

According to the structural drawings, the building foundation consists of a conventional, reinforced concrete, slab-on-grade foundation with exterior wall and column footings. The building has structural steel columns supporting the second floor and roof. The second floor has a concrete-topped metal deck supported by open-web joists. The primary roofs are classified as flat. The roofs are finished with stone ballast over a single ply membrane which is laid over acoustic roof panels. The roof is observed to be in good condition.

The exterior walls are finished with brick masonry veneer or metal siding. No cracks or infiltration issues were observed and all exterior walls are in good condition.

| Item | Construction Type |
|---|---|
| Foundation | Slab-on-grade with Column Footings and Wall footings. |
| Structure | Steel-framed with open-web joists and roof trusses. |
| Exterior Walls | Masonry Cavity Walls, CMU with brick veneer or metal siding |
| Roof | Metal Cellular Acoustic Panel Roof Deck with membrane and stone ballast. |

The following table describes the insulation levels of different surfaces at the property based on provided facility drawings:

| Building Element | Estimated Insulation |
|---|---|
| Roof | R – 40 |
| Floors | R – 30 |
| Walls Above Grade | R – 19 |

The windows are part of an aluminum framed storefront system incorporating the entry doors. The windows are glazed with insulated panes set in metal frames. The entrance doors are fully glazed, aluminum framed doors set in the storefront framing system. Caulking and weather stripping are in good condition.

The windows are aluminum-framed, double-pane glazed units. The caulking was in good condition. Air infiltration was not reported near the windows. No window issues such as infiltration or condensation were observed.

The main entrance doors are fully glazed & double paned, aluminum framed entry doors set in metal frames. Weather stripping was observed around the door openings. The weather stripping was observed to be in good condition. Caulking was observed at the perimeter of the door frames. The caulking was observed to be in good condition.

The additional entrance doors were full-glass panel doors. Service doors were insulated steel doors. Caulking and weatherstripping were observed to be in good condition.

## 5.3. BUILDING HEATING, VENTILATION AND AIR-CONDITIONING (HVAC)

Building Automation System (BAS)

The building HVAC system is controlled by a Barber-Coleman 8000 Building Automation System (BAS). The BAS controls all HVAC equipment to maintain a winter indoor temperature setpoint of 68ºF and a summer temperature setpoint of 75ºF. The building temperature is measured by sensors located throughout the building which transmit to the BAS. The BAS control valves, dampers, fans and pumps to maintain setpoint temperatures. During a normal school day, the BAS controls the HVAC system so that Rooftop Units and Exhaust Fans shut off at 4pm. Also, the hydronic boiler reverts to low-fire. In the event that the space temperature measured next to the fin tube units drops below 45ºF, the BAS will restart the Rooftop Units to provide heat to the space. Otherwise, the HVAC equipment reverts to normal operation at 6.30am in the morning of the school day. When requests are received to operate the HVAC equipment outside of regular hours for extra-curricular activities, the BAS is programmed to run the HVAC equipment during those hours.

Building Heating

The building has two maim types of heating systems. The rooftop units have integral gas-fired furnaces which pre-heat air directly to 65ºF and distribute heated air into ductwork and then into the VAV units and, finally, into the space. The hydronic coils in the VAV boxes in conjunction with the perimeter fin-tube radiator reheat the air to desired space temperature.

The building has 2 gas-fired hot water boilers located in Room 206 that heat the hydronic loop. The boilers operate during heating season, only. Under normal circumstances, only one boiler will operate and the other remains in standby. Each boiler rotates monthly between standby and on-line operation. Normal hot water supply temperature setpoint is 180ºF. During moderate weather (above 60ºF.), the heating water temperature will reset to 140ºF. During extreme cold weather (0ºF or below), both boilers will be on line and heating water temperature setpoint will be 200ºF. Two 7.5 horsepower (150gpm @ 75') pumps circulate heated water through a two-pipe system to the hydronic heating equipment located throughout the building spaces. Normally, only one pump will operate but both pumps will operate when the heating system requires maximum flow. The circulating pump motors feature Variable Frequency Drives (VFD). The BAS controls the speed of the pump motors and heated water flow to match demand, thus reducing unnecessary electric energy consumption. Hydronic heating devices in the building space include fin-tube units, unit heaters, cabinet unit heaters Gym air handlers and VAV reheat units.

The building hydronic fin-tube units are designed to maintain a night-time winter space temperature of 60ºF. During occupied periods, the fin-tube units are designed to maintain a space temperature of 65ºF.

Cabinet Unit Heaters are located in the vestibules at the main building entrances. These units are mounted flush with the interior wall surfaces and are designed to maintain a space temperature of 60ºF.

Unit Heaters are located in the elevator machine room, storage rooms, kitchen and mechanical room 206. These units are similar to the cabinet unit heaters but they are used in areas where aesthetic appearance is not important.

Air handler AH1 and AH-2 are located in the Gymnasium. These air handlers are equipped with heating water coils.

Classrooms and offices have Variable-Air Volume (VAV) units equipped with heating water reheat coils. The VAV units are supplied with conditioned air from the Rooftop Air Handlers. The air entering the VAV unit is heated by the hot-water reheat coils to the desired temperature and then it enters the space and mixes with the air in the space to maintain the desired space set-point temperature.

Rooftop Air Handlers draw outside or "fresh" air from the atmosphere and mix it with air drawn from the interior spaces ("return" air). The mixed air is then drawn through gas-fired heat exchangers in the furnace section of the air handler. This heated air then passes through the supply fan which pumps the air into the building ductwork. The heated air then passes through VAV units where it is reheated, if necessary, to the desired temperature. The air then passes through ceiling diffusers and mixes with the room air to maintain the room temperature at the setpoint as controlled by the BAS. The Rooftop Air Handlers are "Variable Air Volume" (VAV) systems. Each unit supply and return fan is controlled by a Variable Frequency Drive (VFD) which modulates the fan to control the volume of air supplied to the various VAV units in response to space heating demand. The VAV systems are much more energy-efficient when compared with Constant Volume (CV) systems.

Ventilation

Rooftop exhaust fans (EF) provide ventilation to pat of the building spaces including restrooms. This includes the emergency generator room, kitchen, gym and restrooms. The restroom exhaust fans operate continuously between 6.30am and 4pm. General ventilation is provided by the Rooftop units which exhaust a fraction of the return air into the atmosphere. This exhaust air is replaced with outside or "fresh" air which is drawn into the air handler. In the case of the Cafeteria and Multipurpose room units (RTU3 and RTU4); the outside air damper is modulated by the BMS in response to $CO_2$ concentrations in these spaces. This reduces the volume of outside air drawn into the Rooftop Unit to what is actually required for occupants health and comfort. Usually, more energy is required to heat or cool Outside Air when compared with Return Air and minimizing the quantity of Outside Air will reduce energy consumption.

Air-conditioning

Cooling air is supplied to the building spaces by the Rooftop Units. Additional cooling is provided by small split-system units. Each Rooftop Unit is Direct Expansion (DX) equipped with an integral (air-cooled) chiller/condenser unit. The chiller cools a refrigerant (R-22) and the refrigerant circulates through cooling coils which remove heat from the mixed air drawn into the Rooftop Unit. The cooled air is then drawn through the air handler supply fan which pumps the cooled air into the building ductwork. The cooled air then passes through VAV units and then passes through ceiling diffusers and mixes with the room air to maintain the room temperature at the setpoint as controlled by the BAS. As mentioned above, the Rooftop Air Handlers are "Variable Air Volume" (VAV) systems. In response to space cooling load, the VAV unit damper modulates to control the volumetric flow of cooled air into the space. The interaction of the various VAV unit dampers causes changes in duct static pressure. Sensors located in the ductwork transmit the static pressure reading to the BAS and which controls the VFD fans in the Rooftop Unit. The fans will then control the amount of air flowing into the ductwork.

| Item | Measured Values |
|---|---|
| Major Heating system type/capacity | Boilers & RTU Furnaces/7,220 MBH, total |
| Major Cooling System type/capacity | RTU1,2,3,4/ 229 tons, total |
| Heating hot water supply temperature | 180°F |
| Outside Air temperature & Relative Humidity (%) at time of audit | 62°F/47% |
| Interior space temperatures & Relative Humidity (RH%) | 71°F/47% |
| Supply Air Temperature (SAT)/Return Air Temperature (RAT) | 65°/76° |
| Avg. Supply Air rate (CFM/Sq.ft) | 1.39 |
| Avg. Interior space thermostat set-point | 75° |
| Avg. Outside Air rate (% & CFM/Sq.ft or CFM/person) | 0.56cfm/square-foot; 86cfm/person |

The Mechanical Equipment Schedule in Appendix contains a summary of the HVAC Equipment at the property.

## 5.4. BUILDING LIGHTING

Interior lighting in the classrooms, offices, cafeteria, library, bathrooms, hallways, storage, and utility rooms are primarily lit by 2 bulb, 32 watt, T8 fluorescent light fixtures with electronic ballasts. The emergency light fixtures and "exit" fixtures are continuously energized. In the event of a power failure, the building emergency generator will be activated to power these fixtures. The remainder of the building light circuits are activated at 6.30am each school day and deactivated at 10pm. At the time of the energy audit, the exterior light fixtures were programmed to activate at 5am in the morning and deactivate at 6.30am. In the evening, the lights were set to activate at 6pm and deactivate at 10.30pm. These times can be adjusted to accommodate the change of the seasons and extra-curricular activities.

Inside the building, corridor lighting circuits are controlled by key switches. The same applies to the Gym. Some rooms such as the Mechanical Rooms and janitor closets have lights controlled by wall switches. The majority of the rooms, including the classrooms, restrooms, and most offices are controlled by motion detectors. Each motion detector will switch the room lights "off" if it does not detect motion within a 15-minute interval. This conserves energy by turning light fixtures "off" when the room is unoccupied. Classrooms have 4-switch gang switches mounted on the wall. These switches allow the teacher to adjust the room lighting by turning individual lighting circuits "on" or "off" until the desired light level is achieved. As mentioned above, the room motion sensor will turn the lights "off" when the room is unoccupied. Most private offices use a similar method of control.

Offices are furnished with lay-in ceilings so most lighting in these areas is provide by linear-fluorescent fixtures with 2 (32-watt) T-8 lamps, reflectors and electronic ballasts. Classrooms have similar fixtures, except they are pendant-mounted for greater efficiency. Additional lighting is furnished by recessed "can" fixtures using (mostly 26W) CFL lamps and/or cove lighting in the form of T-8 fixtures. Corridor and stair lighting features wall sconce fixtures with 26W CFL lamps. Gym lighting is provided by 400W metal-halide fixtures. Surface-mounted CFL light fixtures on the exterior walls provide the exterior building with site illumination. Recessed CFL light fixtures are located in the exterior soffits. Parking lot lighting is provided by property-owned 175W metal-halide fixtures. The poles are spaced along the drive aisles throughout the parking areas.

Generally speaking, building lighting is adequate. Some light fixtures have burned out but the number is small and illumination levels have not been noticeably degraded. During the energy audit, light levels were taken in the majority of the rooms. The various rooms have been grouped by function such as classrooms, dining, hallways, restrooms and gymnasium. For each functional group, the light readings were averaged and the results obtained appear in the following table along with recommended light levels:

| Space type | Measured Light Levels (foot candles) | ASHRAE/IESNA Recommended Levels (foot candles) |
|---|---|---|
| **Classrooms** | 42 | 50 |
| **Student Dining** | 34 | 20 |
| **Hallways** | 26 | 20 |
| **Restrooms** | 24 | 20 |
| **Gym** | 10 | 30 |
| **Avg. Building Lighting Density, W/Sq.Ft** | 1.19 | |

*Note: 1 foot candle = 10.764 lux*

The table shows that building lighting levels are generally adequate when compared with recommended levels. Some spaces in the building are exposed to natural light and additional energy savings could be realized by reducing artificial lighting at times when natural light is adequate. This is particularly true for some of the corridors and stairways. Other spaces with natural light include the Art Room, Music Room, Kindergarten Classrooms, Cafeteria and Multi-purpose Room.

The Lighting Systems Schedules in Appendix contain a summary of the Existing Lighting Systems at the property, along with proposed Lighting Energy Conservation Measures.

## 5.5. BUILDING ELEVATORS AND CONVEYING SYSTEMS

There is one hydraulic passenger elevator. The elevator machinery is located in a room adjacent to the shaft.

## 5.6. BUILDING DOMESTIC HOT WATER

Domestic water is supplied to the building from the Town of Needham. The building water meter is located in Room 149.

The building central Domestic Hot Water (DHW) system consists of a gas-fired 400-gallon, 600MBH (input) water heater which maintains the tank water temperature at 150°F. The heated water passes from the tank and into a mixing valve which reduces the temperature of the water pumped to the wash basins and showers to a safe temperature of 120°F (maximum). The water pumped to the dishwasher in the kitchen is heated to a higher temperature (170°F-180°F) by a booster unit at the dishwasher. The water is circulated through each piping loop by a 1/8HP circulating pump. DHW piping is well-insulated. The hot water temperature measured at one washbasin was 105°F.

A 400-gallon gas-fired water heater supplies domestic hot water. The water heater is located in Room 206 (Main Mechanical Room). The water heater has a rated input capacity of 600,000 BTUH. The central hot water system consists of the water heater, 2 circulating pumps, and a mixing valve.

The common area restrooms have commercial-grade fixtures and accessories, including water closets and lavatories. The toilets consist of flush valves. The typical flush volume was 1.6 GPF. The lavatories are equipped with aerators rated at 2.2 GPM. The lavatories are operated by manual hand valves.

| | |
|---|---|
| **DHW type** | Gas |
| **Storage Tank Capacity** | 400-gallon |
| **Heating/tank set-point** | 150°F. |
| **DHW temperature at faucet** | 105°F. |
| **Building faucets, GPM** | 2.2 |
| **Water closets/toilets, GPF** | 1.6 |

## 5.7. BUILDING NATURAL GAS AND ELECTRICITY

The building is connected to the natural gas utility (NStar). The gas main on the adjacent public street supplies the natural gas service. The gas meter and regulator is located along the exterior wall of the building. The gas distribution piping within the building is malleable steel (black iron).

The facility is master-metered for natural gas. There is a natural gas meter located near the northeast corner of the building.

The electrical supply lines run underground from a pad-mounted transformer to an interior-mounted electrical meter. The main electrical service size is 2,000amps, 480/277-volt, three-phase, four-wire alternating current (AC). The electrical wiring is copper, installed in metallic conduit. Circuit breaker panels are located throughout the building. The facility is master-metered for Electricity. There is one electric meter at the property, located in Room 208.

A natural gas-engine-driven 750 kVA emergency electrical generator is located in Room 209. The generator provides back-up power for elements of the fire and life safety systems.

| | |
|---|---|
| **Electrical Transformer Type (Wye, Delta)** | Delta |
| **Mounting** | Pad-mounted |
| **Location** | Visitor Parking Area |
| **Main Building Electric service** | Receptacles, Emergency Systems and Lights |
| **Primary Volts** | 13,800 |
| **Secondary Volts** | 480/277 |
| **Phase** | 3 |
| **Wire** | 4 |
| **Amp** | |
| **On site Generator (Y/N)** | yes |
| **Generator Capacity, KVA** | 750 |
| **Generator Fuel Type** | Natural Gas |

| | | | |
|---|---|---|---|
| **Electric Meter type (Master/Sub/Direct)** | Master | **Natural Gas Meter type (Master/Sub/Direct)** | Master |
| **Meter Location** | Room 208 | **Meter Location** | Building Exterior |
| **Main meter number** | 5067844 | **Main meter number** | |

# 6. UTILITY ANALYSIS

Establishing the energy baseline begins with an analysis of the utility cost and consumption of the building. Utilizing the historical energy data and local weather information, we evaluate the existing utility consumption and assign it to the various end-uses throughout the buildings. The Historical Data Analysis breaks down utilities by consumption, cost and annual profile.

This data is analyzed, using standard engineering assumptions and practices. The analysis serves the following functions:

- Allows our engineers to benchmark the energy and water consumption of the facilities against consumption of efficient buildings of similar construction, use and occupancy.
- Generates the historical and current unit costs for energy and water
- Provides an indication of how well changes in energy consumption correlate to changes in weather.
- Reveals potential opportunities for energy consumption and/or cost reduction. For example, the analysis may indicate that there is excessive, simultaneous heating and cooling, which may mean that there is an opportunity to improve the control of the heating and cooling systems.

By performing this analysis and leveraging our experience, our engineers prioritize buildings and pinpoint systems for additional investigation during the site visit, thereby maximizing the benefit of their time spent on site and minimizing time and effort by the customer's personnel.

Based upon the utility information provided about the Eliot Elementary School, the following energy rates are utilized in determining existing and proposed energy costs.

**Utility Rates used for Cost Analysis**

| Electricity (Blended Rate) | Natural Gas |
|---|---|
| $0.21/kWh | $1.08/therm |

The data analyzed provides the following information: 1) breakdown of utilities by consumption, 2) cost and annual profile, 3) baseline consumption in terms of energy/utility at the facility, 4) the Energy Use Index, or Btu/sq ft, and cost/sq ft. For multiple water meters, the utility data is combined to illustrate annual consumption for each utility type.

## 6.1. ELECTRICITY

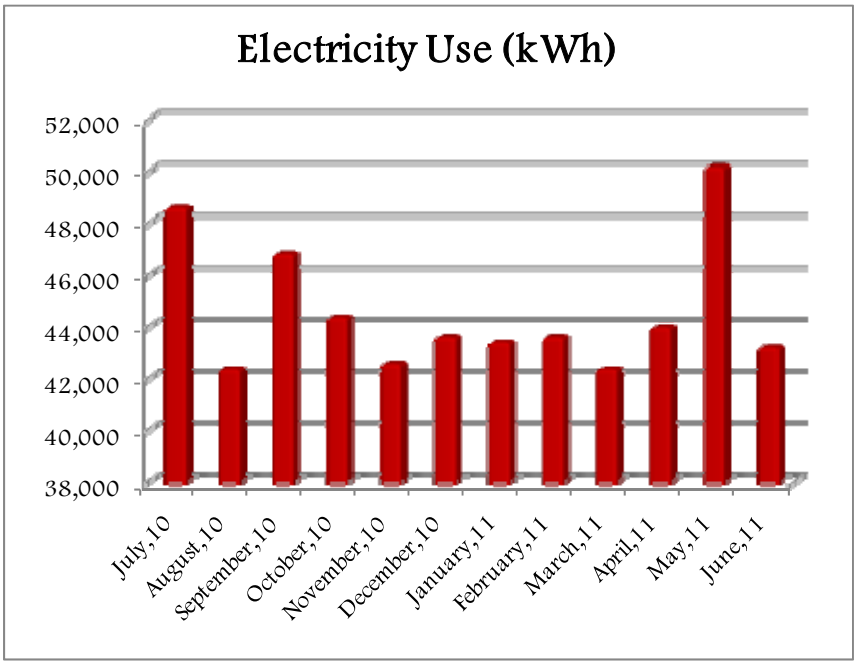
NStar satisfies the Electricity requirements of the facility.

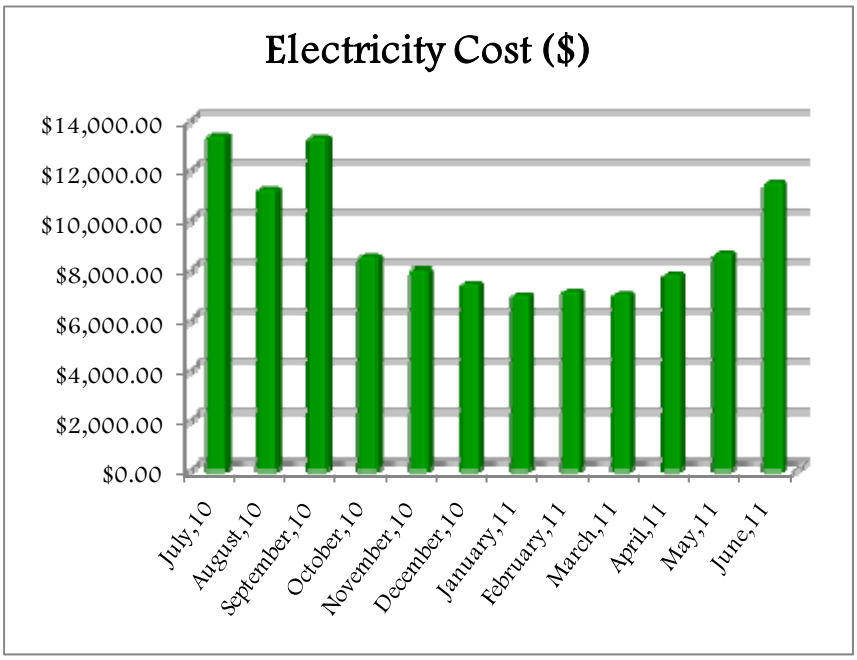
During the school year, lighting comprises the largest component of electrical consumption. The remainder of the consumption is taken up with hard-wired equipment such as fans, pumps, kitchen equipment, freezers, pumps and other equipment. Additional power is consumed by office equipment and appliances connected to receptacles ("plug load") such as computers, copiers, smart boards, etc. All of these loads form the "base load" which remains fairly constant during the school year. The consumption during January, February and March probably approximates the base load. During the warmer months, the air-conditioning chillers operate and this adds significantly to the building electrical power consumption. Examination of the following charts shows that July power consumption was significant even though school was out of session for the summer. This may be indicative of significant extra-curricular activities during the month. Also, unit cost was significantly higher during high-consumption months. This may be a result of peak demand charges during those months.

Based on the 2010/2011 electric usage & costs, the average price paid during the year was $0.21 per kWh. The total annual Electricity consumption for the 12-month period analyzed is 535,200kWhr for a total cost of $111,112.95.

**Electricity Consumption and Cost Data**

| Billing Month | Electricity Consumption (kWh) | Unit Cost/kWh | Total Cost |
|---|---|---|---|
| **July,10** | 48,600 | $0.28 | $13,405.15 |
| **August,10** | 42,400 | $0.27 | $11,246.03 |
| **September,10** | 46,800 | $0.28 | $13,319.26 |
| **October,10** | 44,400 | $0.19 | $8,511.98 |
| **November,10** | 42,600 | $0.19 | $8,003.38 |
| **December,10** | 43,600 | $0.17 | $7,454.09 |
| **January,11** | 43,400 | $0.16 | $6,983.72 |
| **February,11** | 43,600 | $0.16 | $7,146.94 |
| **March,11** | 42,400 | $0.17 | $7,023.46 |
| **April,11** | 44,000 | $0.18 | $7,847.00 |
| **May,11** | 50,200 | $0.17 | $8,641.69 |
| **June,11** | 43,200 | $0.27 | $11,530.25 |
| **Total** | **535,200** | **$0.21** | **$111,112.95** |


Electricity Use (kWh)
52,000
50,000
48,000
46,000
44,000
42,000
40,000
38,000
July,10
August,10
September,10
October,10
November,10
December,10
January,11
February,11
March,11
April,11
May,11
June,11


Electricity Cost ($)
$14,000.00
$12,000.00
$10,000.00
$8,000.00
$6,000.00
$4,000.00
$2,000.00
$0.00
July,10
August,10
September,10
October,10
November,10
December,10
January,11
February,11
March,11
April,11
May,11
June,11

## 6.2. NATURAL GAS

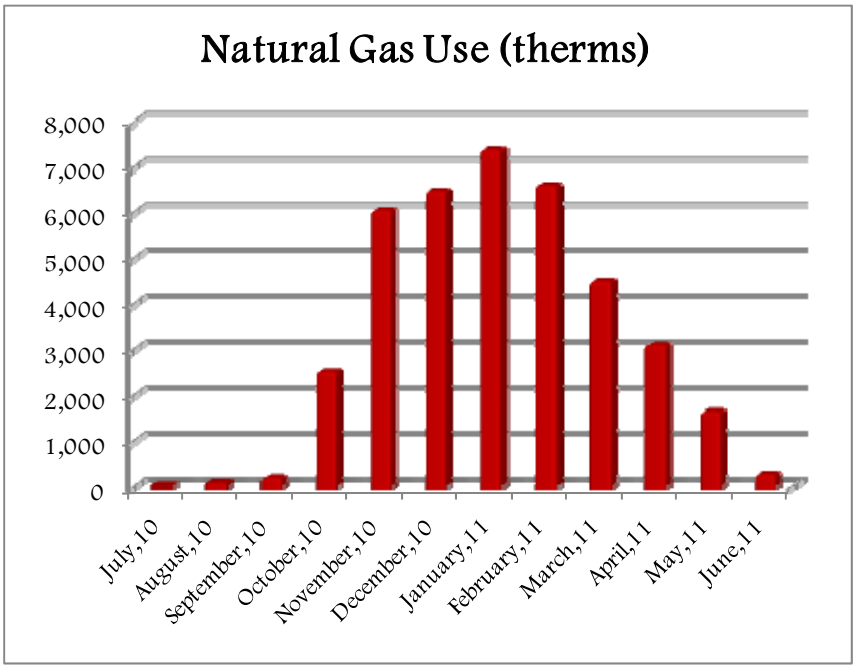
NStar satisfies the natural gas requirements of the facility.

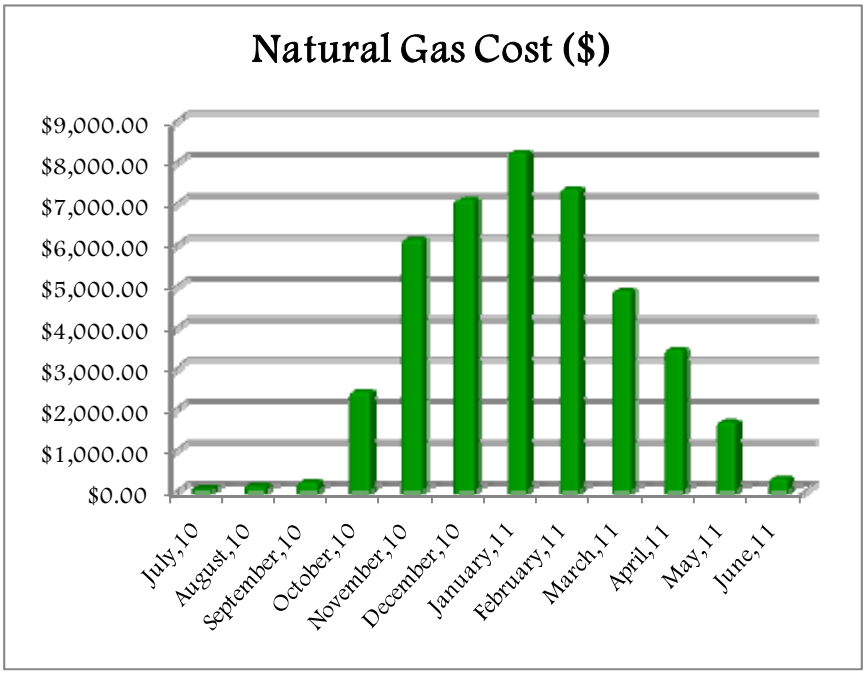
During the school year, the main component of gas consumption is heating. The other main component of gas consumption is for cooking and domestic hot water heating. The cooking and water heating load represents the "base load" which remains relatively constant during the school year. During the winter months, gas consumption increases markedly and this is, of course, caused by the heating requirements of the boilers and rooftop unit furnaces. During the summer months, total gas consumption is negligible which indicates that gas-fired equipment is not operating during those months.

Based on the 2010/2011 natural gas usage & costs, the average price paid during the year was $1.08 per therm. The total annual natural gas consumption for the 12-month period analyzed is 39,038 for a total cost of $42,037.35.

**Natural Gas Consumption and Cost Data**

| Billing Month | Consumption (therms) | Unit Cost/therm | Total Cost |
|---|---|---|---|
| July, 2010 | 26 | $2.19 | $56.83 |
| August, 2010 | 102 | $1.31 | $133.64 |
| September,2010 | 219 | $1.05 | $230.81 |
| October, 2010 | 2,550 | $.95 | $2,424.29 |
| November,2010 202010 | 6,053 | $1.01 | $6,131.31 |
| December, 2010 | 6,487 | $1.09 | $7,100.86 |
| January, 2011 | 7,396 | $1.11 | $8,242.81 |
| February, 2011 | 6,613 | $1.11 | $7,361.22 |
| March, 2011 | 4,523 | $1.08 | $4,844.69 |
| April, 2011 | 3,115 | $1.11 | $3,442.29 |
| May, 2011 | 1,664 | $1.03 | $1,706.40 |
| June, 2011 | 290 | $1.11 | $321.50 |
| Total/Average | **39,038** | **$1.08** | **$42,037.35** |


Natural Gas Use (therms)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
July,10
August,10
September,10
October,10
November,10
December,10
January,11
February,11
March,11
April,11
May,11
June,11

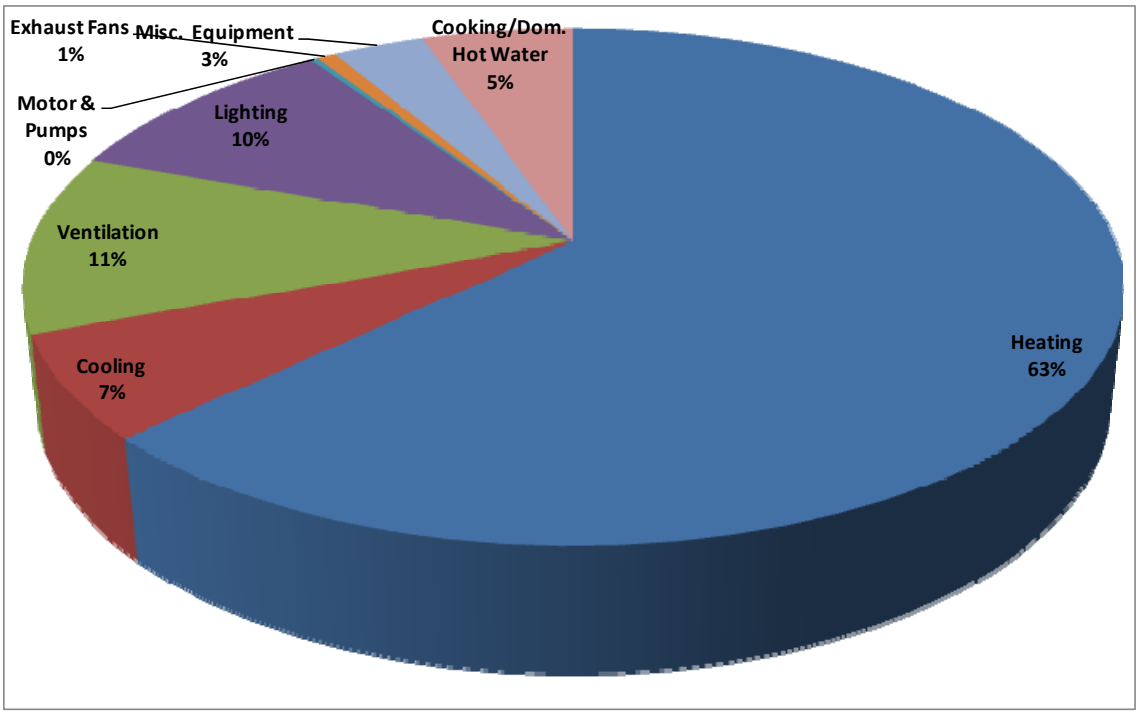

Natural Gas Cost ($)
$9,000.00
$8,000.00
$7,000.00
$6,000.00
$5,000.00
$4,000.00
$3,000.00
$2,000.00
$1,000.00
$0.00
July,10
August,10
September,10
October,10
November,10
December,10
January,11
February,11
March,11
April,11
May,11
June,11

# 7. END USE ENERGY DISTRIBUTION

Following table shows the annual end-use energy distribution by component for FY 2011 (base year) for John Eliot School.

| System Type | kWh | therms | kBtu | % of Total |
|---|---|---|---|---|
| **Heating** | | 36,026 | 3,602,600 | 63% |
| **Cooling** | 108,189 | | 369,140 | 6% |
| **Ventilation** | 188,297 | | 642,469 | 11% |
| **Lighting** | 169,576 | | 578,595 | 10% |
| **Motor & Pumps** | 4,035 | | 13,768 | 0.2% |
| **Exhaust Fans** | 11,191 | | 38,184 | 1% |
| **Misc. Equipment** | 53,912 | | 183,946 | 3% |
| **Cooking/Dom. Hot Water** | | 3,012 | 301,200 | 5% |
| | | | | |
| **Total** | **535,200** | **39,038** | **5,729,902** | **100%** |

*note: FY 2011 (July 2010 – June 2011) is used as baseline year for analysis*



# 8. ENERGY CONSERVATION MEASURES (ECM)

EMG has identified a total of 8 Energy Conservation Measures (ECMs) for this property. All the ECMs are broken into two major categories:

1. **No/Low Cost Recommendations**: No/Low cost is defined as any project with initial investment of less than $1,000
2. **Capital Cost Recommendations**: Capital cost defined as any project with initial investment greater than $1,000

EMG screens ECMs using two financial methodologies. ECMs which are considered financially viable must meet both criteria.

1. Simple Payback Period –The number of years required for the cumulative value of energy or water cost savings less future non-fuel or non-water costs to equal the investment costs of the building energy or water system, without consideration of discount rates. ECMs with a payback period greater than the Expected Useful Life (EUL) of the project are not typically recommended, as the cost of the project will not be recovered during the lifespan of the equipment. These ECMs are recommended for implementation during future system replacement. At that time, replacement may be evaluated based on the premium cost of installing energy efficient equipment.

$$Simple\ Payback = \frac{Initial\ Cost}{Annual\ Savings}$$

2. Savings-to-Investment Ratio (SIR) – The savings-to-investment ratio is the ratio of the present value savings to the present value costs of an energy or water conservation measure. The numerator of the ratio is the present value over the estimated useful life (EUL) of net savings in energy or water and non-fuel or non-water operation and maintenance costs attributable to the proposed energy or water conservation measure. The denominator of the ratio is the present value of the net increase in investment and replacement costs less salvage value attributable to the proposed energy or water conservation measure. It is recommended that energy efficiency recommendations should be based on a calculated SIR, with larger SIRs receiving a higher priority. A project is typically only recommended if SIR is greater than or equal to 1.0, unless other factors outweigh the financial benefit.

$$SIR = \frac{Present\ Value\ (Annual\ Savings, i\%, EUL)}{Initial\ Cost}$$

**Key Metrics to Benchmark the Subject Property's Energy Usage Profile**

- Building Site Energy Use Intensity - The sum of the total site energy use in thousand of Btu per unit of gross building area. Site energy accounts for all energy consumed at the building location only not the energy consumed during generation and transmission of the energy to the site.
- Building Source Energy Use Intensity – The sum of the total source energy use in thousand of Btu per unit of gross building area. Source energy is the energy consumed during generation and transmission in supplying the energy to your site.
- Building Cost Intensity - This metric is the sum of all energy use costs in dollars per unit of gross building area.
- Greenhouse Gas Emissions - Although there are numerous gases that are classified as contributors to the total for Greenhouse Emissions, the scope of this energy audit focuses on carbon dioxide ($CO_2$). Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement).

| Site Energy Use Intensity (EUI) | Rating | |
|---|---|---|
| Current Site Energy Use Intensity (EUI) | 79 | kBtu/ft2 |
| Post ECM Site Energy Use Intensity (EUI) | 70 | kBtu/ft2 |
| **Source Energy Use Intensity (EUI)** | Rating | |
| Current Source Energy Use Intensity (EUI) | 140 | kBtu/ft2 |
| Post ECM Source Energy Use Intensity (EUI) | 129 | kBtu/ft2 |
| **Building Cost Intensity (BCI)** | Rating | |
| Current Building Cost Intensity | $2.11 | /ft2 |
| Post ECM Building Cost Intensity | $1.96 | /ft2 |

**Summary of the Greenhouse Gas Reductions from Recommended Energy Conservation Measures**

The following table provides a summary of the projected Greenhouse Gas Emissions reductions as a result of the recommended Energy Conservation Measures:

| Greenhouse Gas Emissions Reduction | Rating | |
|---|---|---|
| Estimated kWh Reduction | 23,625 | kWh |
| Estimated Annual Thermal Energy Reduction | 5,533 | Therms |
| Total $CO_2$ Emissions Reduced | 8 | $MtCO_2/yr$ |
| Total Cars Off The Road (Equivalent)* | 1 | |
| Total Acres of Pine Trees Planted (Equivalent)* | 2 | |

*Equivalent reductions per DOE emissions calculation algorithms.

The following table describes each recommended ECM in terms of initial investment, Electricity and natural gas savings, water savings, annual energy cost and maintenance savings, payback and SIR.

## List of Recommended Energy Conservation Measures For John Eliot Elementary School

| ECM # | Description of ECM | Projected Initial Investment | Estimated Annual Energy Savings | | Estimated Annual Water Savings | Total Energy Savings | Estimated Cost Savings | Estimated Annual O&M Savings | Total Estimated Annual Cost Savings | Simple Payback | S.I.R. | Life Cycle Savings | Expected Useful Life (EUL) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $ | Natural Gas | Electricity | kgal | MMbtu | $ | $ | $ | Years | | $ | Years |
| | | | Therms | kWh | | | | | | | | | |
| **No/Low Cost Recommendations** | | | | | | | | | | | | | |
| 1 | Install Energy Savers on Vending, Snack Machines<br>Details: Electric Water Cooler and "Coke" Machine located in Teacher's Dining Room | $390 | 0 | 2,300 | 0 | 8 | $478 | $0 | $478 | 0.82 | 14.62 | $5,310 | 15.00 |
| 2 | Install Timers On Rooftop Exhaust Fans<br>Details: Restroom Exhaust Fans (EF1-7, EF-18), 2HP total | $516 | 0 | 1,547 | 0 | 5 | $321 | $0 | $321 | 1.60 | 7.44 | $3,320 | 15.00 |
| 3 | Convert Gas Pilot Stoves To Electronic Ignition Stoves<br>Details: Convert Kitchen Range to Electronic Ignition | $215 | 34 | 0 | 0 | 3 | $37 | $0 | $37 | 5.87 | 2.03 | $222 | 15.00 |
| **Totals for No/Low Cost Items** | | **$1,120** | **34** | **3,847** | **0** | **17** | **$835** | **$0** | **$835** | **1.34** | | | |
| **Capital Cost Recommendations** | | | | | | | | | | | | | |
| 1 | Install Automatic Lighting Controls<br>Details: Exploit natural light in corridors, etc. | $1,632 | 0 | 11,044 | 0 | 38 | $2,293 | $0 | $2,293 | 0.71 | 16.77 | $25,739 | 15.00 |
| 2 | Re-Commission The Building & Its Control Systems<br>Details: Rebalance air flow; verify control system operations | $20,711 | 5,864 | 0 | 0 | 586 | $6,314 | $0 | $6,314 | 3.28 | 2.60 | $33,152 | 10.00 |
| 3 | Replace High Intensity Discharge Lamp (HID) with Induction Lighting<br>Details: Replace HID Gym lights and lobby flood lights with induction fixtures. | $11,921 | 0 | 11,337 | 0 | 39 | $2,354 | $144 | $2,498 | 4.77 | 2.23 | $14,666 | 14.00 |
| 4 | Install On-Demand Ventilation on Air Handlers in Mechanical Room<br>Details: Convert Gym Air Handlers (AH-1,2) to On-Demand Ventilation. | $2,041 | 250 | 22 | 0 | 25 | $274 | $14 | $288 | 7.09 | 1.60 | $1,231 | 15.00 |
| **Total For Capital Cost** | | **$36,305** | **6,114** | **22,403** | **0** | **688** | **$11,235** | **$158** | **$11,393** | **3.19** | | | |
| | *Interactive Savings Discount @ 10%* | | -615 | -2,625 | | -70 | -$1,207 | -$16 | -$1,223 | | | | |
| | *Total Contingency Expenses @ 15%* | $5,614 | | | | | | | | | | | |
| **Total for Improvements** | | **$43,039** | **5,533** | **23,625** | **0** | **634** | **$10,863** | **$142** | **$11,005** | **3.91** | | | |

If all of the above mentioned ECM's are implemented, John Eliot Elementary School could potentially save approximately $11,005 per year with an investment of $43,039, yielding a net effective payback of 3.91 years.

## 8.1. ECM CALCULATION ASSUMPTIONS

EMG has made the following assumptions in calculation of the Energy Conservation Measures.

- Building operating hours, as detailed in section 5.1 are assumed to be 78 hours per week (during the school year, assumed to be 37 weeks long).
- The facility occupancy is assumed to be 447 people.
- Annual Heating Equipment Operating Hours are derived from actual consumption and equipment input rates to be 3,144 hours/year
- Typical lighting operating hours are assumed to be 15.5 per day or 2,868 hours per (school) year.

## 8.2. NO/LOW COST ECM DESCRIPTIONS

EMG has identified 3 No/Low Cost Energy Conservation Measures (ECMs) for this property. This includes all measures which can be implemented below the cost threshold of $1,000. The following paragraphs describe each of these ECMs along with the initial installed costs, annual energy savings, and payback periods.

### 8.2.1. Install Energy Controllers On Electric Water Cooler and Vending Machine

Electric Water Coolers and soft drink vending machines are usually designed to operate all day round irrespective of the occupancy level in the office. This means that the vending machines operate for more than 12 hours a day when not required in case of commercial establishments.

In the teacher dining room, there is a "Coke" machine and there is an Electric Water Cooler near the main entrance lobby. EMG recommends installing vend misers on these units, which will automatically reduce the running time of the units during weekends and unoccupied hours. There are two types of vend misers; one has a timer in it, which is programmed to turn off or tune down the vending machines after the office hours and bring it back up an hour before the office opens. The other is a motion sensor based system that tunes down the machines upon detecting no-occupancy for a pre-programmed duration of time. In the case of vending machines storing chilled products, the vend miser does not turn off the machine entirely, but reduces the operating time of the compressor, such that the machine maintains the products at a minimum tolerable temperature.

Since the "Coke" machine is probably owned by a local distributor, they should be contacted to determine if they are willing to retrofit the unit with a vending miser or substitute another unit equipped with a vending miser.

EMG estimates the total installation cost of two vending misers at $390. EMG projects annual savings of $478 which yields a payback of.82 years.

### 8.2.2. Install Timers on Rooftop Exhaust Fans

Ventilation systems bring fresh outdoor air into the building to provide the occupants with oxygen and to dilute internally-generated air pollutants. Reducing the operating times for discrete ventilation exhaust systems saves fan energy. Curtailing ventilation air reduces heating or cooling loads, except under economizer operation. When a building zone is unoccupied, the ventilation system should be turned off, unless it is "flushing" the building in an economizer mode. Coordinate changes to ventilation air supply with changes to exhaust systems to maintain air balance in the space. Exhaust fans are generally used in areas with high concentrations of pollutants generated from occupants' activities. These exhaust requirements are rarely continuous, and the fans should operate only as needed. Kitchen exhaust fans and make-up air units should only operate while cooking is in progress. This can be accomplished with timers and manual overhead switches. Manual timers are applicable to bathroom exhaust fans. Sensors may be used to shut down fans in intermittently occupied rooms. Care should be exercised in controlling the exhaust from fume hoods used to vent toxic gases in laboratories.

The building has 8 rooftop exhaust fans that are estimated to be continuously running for 9.5 hours a day. The normal hours at the school are from 6:00 AM till 4:30 pm (Monday-Friday). EMG recommends installing a mechanical timer on each rooftop restroom exhaust fan such that it is turned off a few minutes after the restroom lights are turned "off" by the motion sensor. Assuming that the exhaust fan run time is reduced to 4 hours a day, annual run time will be reduced to 1,018 hours each year.

EMG estimates the total installation cost of 8 exhaust fan timers at $516. EMG projects annual savings of $321 which yields a payback of 1.6 years.

### 8.2.3. Convert From Gas Pilot to Electronic Ignition for Kitchen Range

Standing pilot ignition systems are common on older boilers, furnaces, water heaters and ranges. Standing pilot systems utilize a constantly burning pilot light to ignite the combustion equipment when it is activated. When the pilot light for gas-fired equipment burns constantly, energy is wasted. This type of pilot light can be replaced with an automatic electronic ignition system that ignites the pilot only when the equipment is activated for use. Many companies make pilot ignition retrofit systems that can be installed on the existing equipment by skilled technicians. Installing electronic ignition kits will reduce the natural gas consumption by eliminating wasted fuel as the gas flow is only activated when the equipment is in operation.

This ECM recommends replacing the standing pilot ignition system with an electronic ignition system on the kitchen range. It is recommended that the equipment manufacturer be consulted to ensure compatibility of the equipment with an electronic ignition kit.

EMG estimates the total installation cost of an electronic ignition system at $215. EMG projects annual savings of $37 which yields a payback of 5.87 years.

## 8.3. CAPITAL COST ECM DESCRIPTIONS

EMG has identified 5 Capital Cost Energy Conservation Measures (ECMs) for this property. This list includes recommended measures which have an estimated implementation cost of greater than $1,000. The following paragraphs describe each of these ECMs, in addition to their initial installed costs, annual energy savings, and payback periods.

### 8.3.1. Install Automatic Lighting Controls

One of the best ways to save energy is to turn off lights that are not needed. This saves energy, as well as extends the replacement time on lamps. (While frequent switching may in some cases shorten lamp life, the savings in electrical power will more than compensate).

The operating time of lighting systems can be reduced either automatically or manually. Automated controls are more reliable for ensuring that energy savings are achieved. Local switches can be labeled to encourage occupants to turn off lights when leaving an area. Individual switches in perimeter offices permit occupants to reduce lighting levels on sunny days. Sophisticated lighting control systems are available, but they are costly to retrofit. They should be considered when the lighting system is being replaced. With the exception of security lights, storeroom lighting can be placed on timed switches that shut off after the selected interval. All exterior lighting, as well as interior lighting in glass-enclosed vestibules, should be placed on photocell and/or timer control.

Several building interior spaces are exposed to natural light through south or west-facing windows. Many of these spaces are corridors or stairways which do not require high illumination levels. Also, the Cafeteria, Multi-purpose Room, Music Classroom and Art Classroom have large windows with a south-facing exposure.

In spaces exposed to natural light, EMG recommends installing a photo control sensor that shall control the ON/OFF function of the overhead lights. The photo controls can be pre-programmed to turn on the overhead lamps when the ambient lighting levels falls below a pre-determined level. This ensures that each space is sufficiently lit, even on cloudy days.

EMG estimates the total installation cost of 19 photosensors at $1,632. EMG projects annual savings at $2,293 which yields a payback of.71 years.

### 8.3.2. Recommission the Building

As part of the energy audit, EMG interviewed building occupants to determine their satisfaction with the building environment. Many teachers expressed satisfaction with the existing building temperature control but other teachers had reservations. In particular, some teachers indicated that Room 165 had "inconsistent" temperature control while Room 153 is an "icebox" during the winter. These are subjective opinions but they may indicate problems with the building temperature control system. The building was probably commissioned around 2003. However, it is possible that some components of the building temperature control system have failed or are no longer operating properly.

EMG recommends that the building HVAC system should be "recommissioned." The recommissioning process should verify if the building HVAC system was installed as the designer intended and is operating as designed. The recommissioning process should provide insight into possible problems with the HVAC system operation.

EMG estimates the total cost of recommisssioning the existing HVAC system at $20,711. EMG projects annual savings of $6,314 which yields a payback of 3.28 years.

### 8.3.3. Replace High Intensity Discharge (HID) Lamp with Induction Lighting

An induction light is similar to a fluorescent light in that mercury in a gas fill inside the bulb is excited; emitting UV radiation that in turn is converted into visible white light by the phosphor coating on the bulb. Like fluorescent, the phosphor coating determines the color qualities of the light. Fluorescent lamps use electrodes to strike the arc and initiate the flow of current through the lamp, which excites the gas fill. Each time voltage is supplied by the ballast and the arc is struck, the electrodes degrade a little, eventually causing the lamp to fail. Induction lamps do not use electrodes. Instead of ballast, the system uses a high-frequency generator with a power coupler.

The generator produces a radio frequency magnetic field to excite gas fill. With no electrodes, the lamp lasts longer. Induction lamps, in fact, last up to 100,000 hours, with the lamp producing 70% of its light output at 60,000 hours. In other words, their rated life is 5-13 times longer than metal halide (7,500 to 20,000 hours at 10 hours/start).

Induction lamps are ideally suited for high-ceiling applications where the lamps are difficult, costly or hazardous to access. They are also ideally suited for such applications where the advantages of fluorescent lighting are sought but a light source is needed that can start and operate efficiently in extremely cold temperatures. As a result, induction lighting is a suitable for a wide range of applications, including not only warehouses, industrial buildings, cafeterias, gymnasiums, etc., but also signage, tunnels, bridges, roadways, outdoor area and security fixtures, parking garages, public spaces, and freezer and cold storage lighting.

The increased costs occurs in the induction systems themselves – which could be 5 to 6 times more than metal halide systems, and also in new fixtures, which can inflate payback periods and reduce return on investment. But you also generally get a 30% reduction in capital and operating costs immediately from the reduced number of fixtures made possible by the higher light output. You also get 15% more efficiency just because the induction system (lamp and electronic ballast) is more efficient. Apply that over ten years plus reduced replacement and maintenance costs compared to metal halide and other HID lamps and suddenly it makes a lot of sense to go into induction lighting systems.

- Long Service Life: up to 100,000hrs ( 5 times the lamp life of Metal Halides)
- Energy Saving: save up to 40% compared to metal halides, 13 times more efficient than incandescent light bulbs, and up to twice as efficient as compact fluorescent lights
- Instant On/Off: no waiting time between re-strike
- High Efficiency: lighting efficiency $>$80lm/w
- High Lumens Maintenance: $>$70% after 60,000 hrs
- Wide Selection of Color Temperature:2720K- 6500K
- High Power Factor Ballast: $\lambda > 0.95$
- Flicker-free : high frequency (250KHz) creates a better and more comfortable light for users and prevents eye injury when viewed directly
- Optional Dimmable Ballast for Integrated Control: linearly dimmable to 30%

This ECM involves replacing the existing 400W HID gym lights and the existing 150W lobby HID fixtures.

EMG estimates the replacement cost of 16 existing 400W HID gym light fixtures with 250W Induction fixtures and the replacement cost of 6 existing 150W lobby fixtures will total $11,921. EMG projects annual savings of 11,337 kW-hr or $2,498 which yields a payback of 4.77 years.

### 8.3.4. Install On-Demand Ventilation on Air Handlers

Some buildings are ventilated at a rate in excess of the recommended values. To reduce the energy consumed by the ventilation system, the ventilation rates should be lowered, unless typically high levels of pollutants are being generated. (If human carcinogens or other harmful contaminants are suspected to be present in the occupied space, other relevant standards or guidelines, such as OSHA or NIH, must supersede the listed values.) For spaces with transient or variable occupancy, the quantity of outdoor air should be adjusted by use of dampers, multi-speed ventilation fans, or by duty cycling the system. When contaminants independent of the occupants are generated in the space, the supply of outdoor air should lead occupancy so that acceptable conditions are attained before occupants return. On the other hand, if contaminants are generated solely by the occupants, the supply of outdoor air may lag occupancy. Such control over the ventilation rate can be achieved by installing on demand ventilation system on air-handling units that senses the amount of carbon di-oxide in the return air and modulates the external air flow based on it. In case the $CO_2$ levels are low, which means the occupancy level in the facility is below normal, hence there doesn't exist, a need to bring in fresh air. This indirectly reduces the load on the air handling unit as it decreases the amount of energy required to condition the outside air. Conversely on detecting a high level of pollutants and carbon di-oxide residue in the return air, the sensor shall modulate to increase the intake of outside air, for compensating the impure air.

The school Gymnasium has 2 exhaust fans, located in the Gym. Based on the above explanation, EMG recommends installing On-Demand Ventilation sensors on these exhaust fans. It is estimated that the use of On-Demand Ventilation shall result in energy savings of at least 15% annually, which comes to about 21.57Kwh and 250.31 therm, annually.

EMG estimates the total cost of converting both gym air handlers to On-Demand Ventilation at $2,041. EMG projects annual savings of $288 which yields a payback of 7.09 years.

# 9. IMPLEMENTION OF AN OPERATIONS AND MAINTENANCE PLAN

The quality of the maintenance and the operation of the facility's energy systems have a direct effect on its overall energy efficiency. Energy-efficiency needs to be a consideration when implementing facility modifications, equipment replacements, and general corrective actions. The following is a list of activities that should be performed as part of the routine maintenance program for the property. These actions, which have been divided into specific and general recommendations, will insure that the energy conservation measures identified in this report will remain effective. The following general recommendations should be continued or implemented.

Building Envelope

1. Check Caulking and weather stripping throughout the envelope
   - Currently in good condition. No immediate need noted.
2. Windows inspected periodically for damaged panes and failed thermal seals
   - Currently all windows, doors and seals in good condition.
3. Automatic door closing mechanisms repaired and adjusted as needed
   - Currently all doors closing properly.
4. Roof and insulation checked at least annually
   - Currently in good condition. New insulation improvements recommended for cafeteria and gym.

Heating and Cooling

1. The burners cleaned and fuel/air ratios optimized during routine maintenance checks
   - Boiler not running at time of audit. But per maintenance burners are cleaned and A/F adjusted annually.
2. Boiler and RTUs inspected and cleaned annually
   - Currently in practice.
3. Temperature settings reduced in unoccupied areas and set points seasonally adjusted.
   - Currently occupied/unoccupied set points maintained by BMS. EMG verified and the system appeared to be monitoring properly. But Retro-commissioning is recommended as an ECM will replace mal functioning sensors.
4. Control valves and dampers checked for functionality semi-annually and repaired, when needed
   - Is recommended as part of retro-commissioning
5. Equipment inspected for worn or damaged parts as part of a monthly maintenance check
   - Currently in practice
6. Ductwork visually inspected and checked for leaks or damaged insulation as part of a semi-annual maintenance check
7. Hot air registers and return air ductwork clean and unobstructed once every 3-5 years
   - Duct work recently cleaned.
8. Air dampers operating correctly
   - Is recommended as part of retro-commissioning. Currently controlled by BMS.
9. Test and balance completed annually to ensure heating uniform throughout the spaces
   - Is recommended as part of retro-commissioning.

10. Evaporator coils and condenser coils regularly checked and cleaned
    - Once every 3-5 years.
11. Air filters inspected monthly and replaced prior to excessive visual buildup (May increase filter costs, but will reduce fan energy costs)
    - Currently in practice.

Domestic Hot Water

1. Domestic hot water heater temperature set to the minimum temperature required
   - Recommended as an ECM
2. Hot water piping checked routinely for damaged insulated and leaks
   - Currently in good condition.

Lighting

1. Over-lit areas managed by bi-level switching or photocell controls or de-lamping
   - Currently recommended
2. Only energy-efficient replacement lamps used and in-stock for replacement
3. Lighting fixture reflective surfaces and translucent covers clean
   - Currently in good condition
4. Walls clean and bright to maximize lighting effectiveness
5. Rooms controlled by motion or occupancy sensors
   - Currently recommended as ECM
6. Timers and/or photocells operating correctly on exterior lighting
   - Operating properly. Currently on timer and EMG recommends combination of photocell and timer to reduce unnecessary operating hours.

Existing Equipment and Replacements

1. Refrigerator and freezer doors closed and sealed correctly
   - Currently kitchen freezers are properly weather stripped and in good condition
2. Kitchen exhaust fans only used when needed or sensors installed to limit operation
   - Currently there are no sensors. School was not functioning at time of audit. But EMG recommends kitchen exhaust hood sensor to shut fan off during day when not needed.
3. Office/ computer equipment either in the "sleep" or "off" mode when not used
   - Smart strips are good application.
4. All other recommended equipment specific preventive maintenance actions conducted

In addition, equipment replacement performed assuring that:

1. All equipment replacements not over/undersized for the particular application
2. All equipment replacements with energy conserving and/or high efficiency devices

# 10. APPENDICES

APPENDIX A: Photographic Record
APPENDIX B: Site Plan
APPENDIX C: Records of Communication
APPENDIX D: Glossary of Terms
APPENDIX E: Mechanical Equipment Inventory
APPENDIX F: Lighting Systems Schedules
APPENDIX G: ECM Calculations
APPENDIX H: Supporting Documents

# APPENDIX A:
# PHOTOGRAPHIC RECORD

DUE DILIGENCE FOR THE LIFE CYCLE OF REAL ESTATE

## EMG PHOTOGRAPHIC RECORD

**Project No.: 98515.11R-002.268** **Project Name: Eliot Elementary School**

| Photo #1: | East elevation of building |
|---|---|

| Photo #2: | North elevation of building showing main building entrance |
|---|---|

| Photo #3: | View of building (looking west) |
|---|---|

| Photo #4: | View of building (looking north) |
|---|---|

| Photo #5: | View of roof |
|---|---|

| Photo #6: | Insulated window |
|---|---|

DUE DILIGENCE FOR THE LIFE CYCLE OF REAL ESTATE

## EMG PHOTOGRAPHIC RECORD

**Project No.: 98515.11R-002.268** **Project Name: Eliot Elementary School**


| | |
|---|---|
| Photo #7: | Building water meter in Room 149 |

| | |
|---|---|
| Photo #8: | Building gas meter |

| | |
|---|---|
| Photo #9: | Building main transformer |


| | |
|---|---|
| Photo #10: | Building electric meter in Room 208 |


| | |
|---|---|
| Photo #11: | Building emergency generator |


| | |
|---|---|
| Photo #12: | Hot water boiler |

## EMG PHOTOGRAPHIC RECORD

**Project No.: 98515.11R-002.268** **Project Name: Eliot Elementary School**

| Photo #13: | Typical fin-tube unit |
|---|---|

| Photo #14: | Typical unit heater |
|---|---|

| Photo #15: | Space VAV reheat unit |
|---|---|

| Photo #16: | Rooftop air handler unit |
|---|---|

| Photo #17: | Rooftop unit filter section |
|---|---|

| Photo #18: | Building central DHW system |
|---|---|

## EMG PHOTOGRAPHIC RECORD

**Project No.: 98515.11R-002.268** **Project Name: Eliot Elementary School**

| Photo #19: | Rooftop exhaust fan |
|---|---|


| Photo #20: | BAS interface |
|---|---|

| Photo #21: | Light fixtures in typical classroom |
|---|---|

| Photo #22: | Electric water cooler |
|---|---|

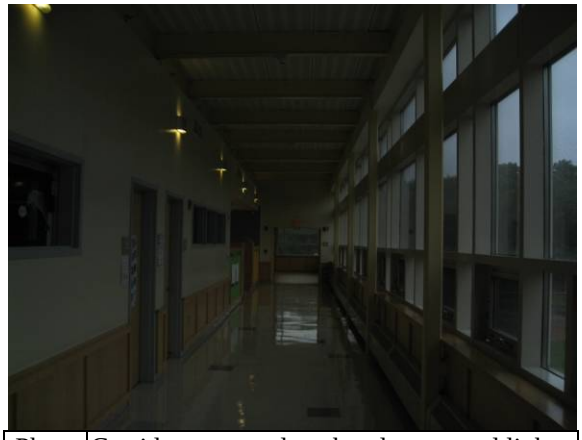
| Photo #23: | Rooftop exhaust fans |
|---|---|

| Photo #24: | Gas kitchen range with continuous pilot |
|---|---|

## EMG PHOTOGRAPHIC RECORD

**Project No.: 98515.11R-002.268** **Project Name: Eliot Elementary School**

| Photo #25: | Kindergarten classrooms with south-facing windows |
|---|---|



| Photo #26: | Corridors exposed to abundant natural light |
|---|---|

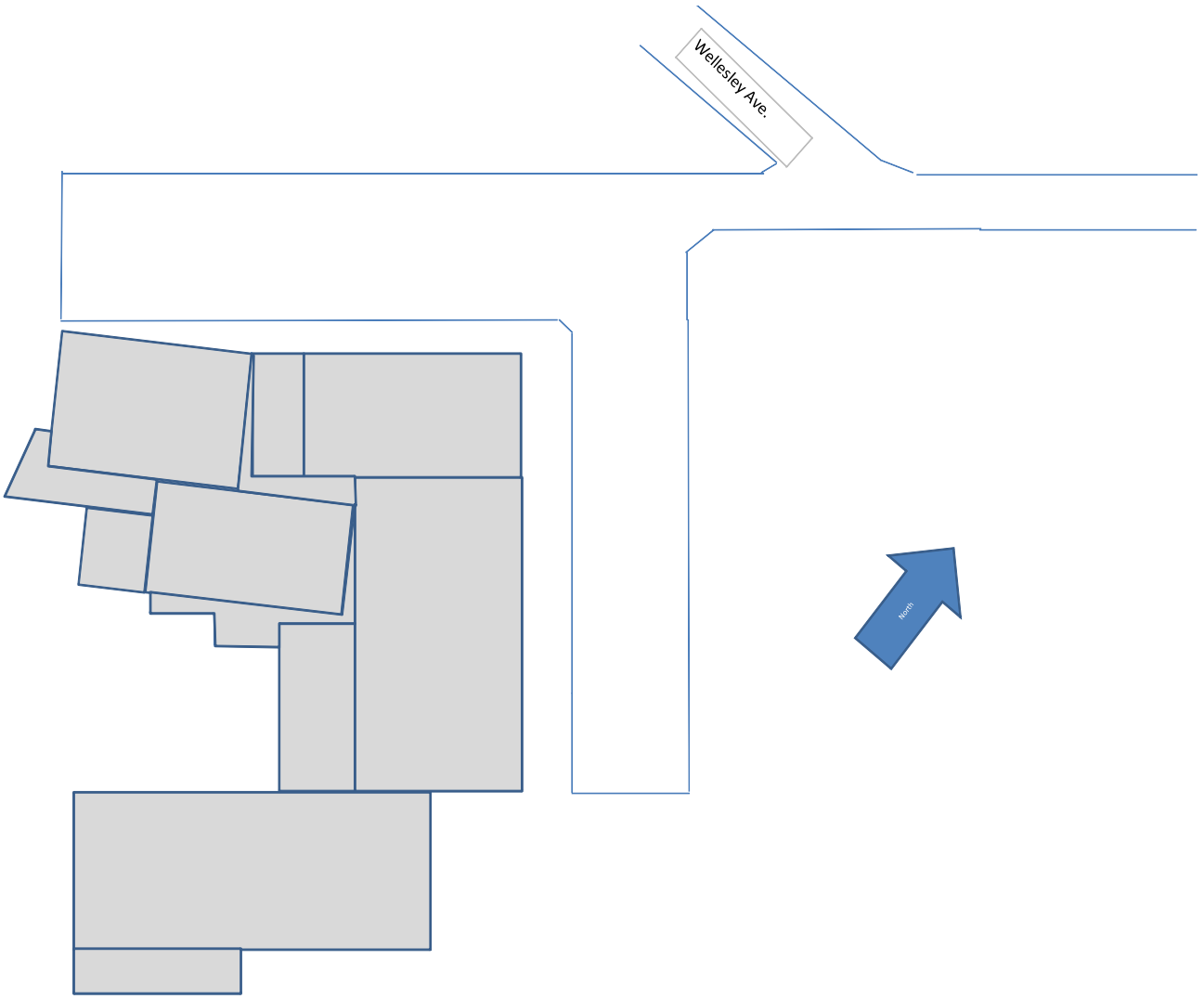
| Photo #27: | Building glazing on south and west elevations |
|---|---|

| Photo #28: | Existing gym light fixtures and air handler |
|---|---|

| Photo #29: | Existing gym roof deck-possible skylight location |
|---|---|

| Photo #30: | Typical motion sensor |
|---|---|

# APPENDIX B:
## SITE PLAN




# John Eliot Elementary School

135 Wellesley Ave.
Needham, Ma. 02492
Approx. 69,035 sq.-ft.

# APPENDIX C:
# RECORDS OF COMMUNICATION

## RECORD OF COMMUNICATION

| | | | |
|---|---|---|---|
| **Date:** | **August 31, 2011** | **Time:** | **10:00 AM** |
| **Project Number:** | **98515.11R-002.268** | **Recorded by:** | **J. McLurg Field Observer/Project Manager** |
| **Project Name:** | **Eliot Elementary School** | | |

**Communication with:** **Wayne Whisler**
**of:** **Town of Needham**
**Phone:** **781-898-7257**

**Communication via:**

X **Telephone Conversation**
**Discussions During Site Assessment**
**Office Visitation/Meeting at:**
**Other:**

**RE: Eliot Elementary School Energy Audit**

**Summary of Communication**:

Made arrangements for site visit on September 6.

# RECORD OF COMMUNICATION

| | | | |
|---|---|---|---|
| **Date:** | **September 6-7, 2011** | **Time:** | **9:00am-5:00pm (Sept 6), 7:30am-12noon (Sept 7).** |
| **Project Number:** | **98515.11R-002.268** | **Recorded by:** | **J. McLurg Field Observer/Project Manager** |
| **Project Name:** | **Eliot Elementary School** | | |

**Communication with:** Wayne Whisler and Yustil
**of:** Town of Needham
**Phone:**

**Communication via:**

- Telephone Conversation
- X Discussions During Site Assessment
- Office Visitation/Meeting at:
- Other:

**RE: Eliot Elementary School Energy Audit**

**Summary of Communication**:

Wayne and Yustil accompanied me during September 6 Site Visit. Yustil accompanied me during the September 7 site visit.

# APPENDIX D:
# GLOSSARY OF TERMS

## Glossary of Terms and Acronyms

ECM – Energy Conservation Measures are projects recommended to reduce energy consumption. These can be No/Low cost items implemented as part of routine maintenance or Capital Cost items to be implemented as a capital improvement project.

Initial Investment – The estimated cost of implementing an ECM project. Estimates typically are based on R.S. Means Construction cost data and Industry Standards.

Annual Energy Savings – The reduction in energy consumption attributable to the implementation of a particular ECM. These savings values do not include the interactive effects of other ECMs.

Cost Savings – The expected reduction in utility or energy costs achieved through the corresponding reduction in energy consumption by implementation of an ECM.

Simple Payback Period –The number of years required for the cumulative value of energy or water cost savings less future non-fuel or non-water costs to equal the investment costs of the building energy or water system, without consideration of discount rates.

EUL – Expected Useful Life is the estimated lifespan of a typical piece of equipment based on industry accepted standards.

RUL – Remaining Useful Life is the EUL minus the effective age of the equipment and reflects the estimated number of operating years remaining for the item.

SIR - The savings-to-investment ratio is the ratio of the present value savings to the present value costs of an energy or water conservation measure. The numerator of the ratio is the present value of net savings in energy or water and non-fuel or non-water operation and maintenance costs attributable to the proposed energy or water conservation measure. The denominator of the ratio is the present value of the net increase in investment and replacement costs less salvage value attributable to the proposed energy or water conservation measure. It is recommended that energy-efficiency recommendations be based on a calculated SIR, with larger SIRs receiving a higher priority. A project typically is recommended only if the SIR is greater than or equal to 1.0, unless other factors outweigh the financial benefit.

Life Cycle Cost - The sum of the present values of (a) **I**nvestment costs, less salvage values at the end of the study period; (b) Non-fuel operation and maintenance costs: (c) Replacement costs less salvage costs of replaced building systems; and (d) Energy and/or water costs.

Life Cycle Savings – The sum of the estimated annual cost savings over the EUL of the recommended ECM, expressed in present value dollars.

Building Site Energy Use Intensity - The sum of the total site energy use in thousand of Btu per unit of gross building area. Site energy accounts for all energy consumed at the building location only not the energy consumed during generation and transmission of the energy to the site.

Building Source Energy Use Intensity – The sum of the total source energy use in thousand of Btu per unit of gross building area. Source energy is the energy consumed during generation and transmission in supplying the energy to your site.

Building Cost Intensity - This metric is the sum of all energy use costs in dollars per unit of gross building area.

Greenhouse Gas Emissions - Although there are numerous gases that are classified as contributors to the total for Greenhouse Emissions, the scope of this energy audit focuses on carbon dioxide ($CO_2$). Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement).

# APPENDIX E:
# MECHANICAL EQUIPMENT INVENTORY

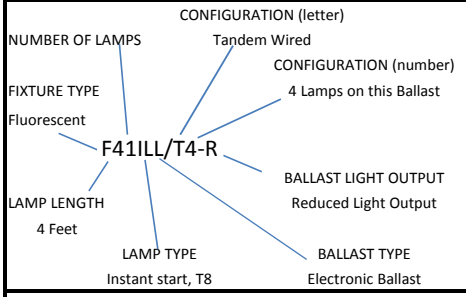
| Mechanical Equipment Inventory | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Equipment | Manufacturer | Age | Location | Model/ Type | Capacity | Serves | Operating Hours/Year | Remarks |
| RTU-1 | McQuay | 2003 | Roof | | 19,500 cfm | Building-North | 3,000 (estimate) | Rooftop Air Handler |
| RTU-2 | McQuay | 2003 | Roof | | 32,500 cfm | Building-South | 3,000 (estimate | Rooftop Air Handler |
| RTU-3 | McQuay | 2003 | Roof | | 19,500 cfm | Multipurpose Room | 3,000 (estimate) | Rooftop Air Handler |
| RTU-4 | McQuay | 2003 | Roof | | 10,000 cfm | Cafeteria | 3,000 (estimate) | Rooftop Air Handler |
| AH-1 | McQuay | 2003 | Gym | | 5,000 cfm | Gym | 1,500 (estimate) | Gym Air Handler |
| AH-2 | McQuay | 2003 | Gym | | 5,000 cfm | Gym | 1,500 (estimate) | Gym Air Handler |
| AH-3 | McQuay | 2003 | Rm 206 | | 4,690 cfm | Boilers | 3,144 | Combustion Air Unit |
| B1, 2 | AO Smith | 2003 | Rm 206 | | 2,840 MBH | Hydronic System | 3,144 | Boiler |
| EF-1 | Cook | 2003 | Roof | | 175 cfm | Toilets | 1,758 | Exhaust Fan |
| EF-2 | Cook | 2003 | Roof | | 200 cfm | Toilets | 1,758 | Exhaust Fan |
| EF-3 | Cook | 2003 | Roof | | 200 cfm | Toilets | 1,758 | Exhaust Fan |
| EF-4 | Cook | 2003 | Roof | | 300 cfm | Toilets | 1,758 | Exhaust Fan |
| EF-5 | Cook | 2003 | Roof | | 375 cfm | Toilets | 1,758 | Exhaust Fan |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| EF-6 | Cook | 2003 | Roof | | 460 cfm | Toilets | 1,758 | Exhaust Fan |
| EF-7 | Cook | 2003 | Roof | | 750 cfm | Toilets | 1,758 | Exhaust Fan |
| EF-8 | Cook | 2003 | Roof | | 1,100 cfm | Kiln | 1,758 | Exhaust Fan |
| EF-9 | Cook | 2003 | Roof | | 4,400 cfm | Kitchen Hood | 1,758 | Exhaust Fan |
| EF-10 | Cook | 2003 | Roof | | 5,000 cfm | Gym | 1,758 | Exhaust Fan |
| EF-11 | Cook | 2003 | Roof | | 5,000 cfm | Gym | 1,758 | Exhaust Fan |
| EF-12 | Cook | 2003 | Roof | | 250 cfm | Kitchen Toilet/storage | 1,758 | Exhaust Fan |
| EF-13 | Cook | 2003 | Roof | | 2,770 cfm | Room 208 | 1,758 | Exhaust Fan |
| EF-14 | Cook | 2003 | Roof | | 600 cfm | Room 209 | 1,758 | Exhaust Fan |
| EF-15 | Cook | 2003 | Roof | | | Room 120 | 1,758 | Exhaust Fan |
| EF-16 | Cook | 2003 | Roof | | 700 cfm | Dishwasher | 1,758 | Exhaust Fan |
| EF-17 | Cook | 2003 | Roof | | 700 cfm | Outside Storage | 1,758 | Exhaust Fan |
| EF-18 | Cook | 2003 | | | 750 cfm | Toilets | 1,758 | Exhaust Fan |
| EF-19 | Cook | 2003 | | | 100 cfm | Room 207 | 1,758 | Exhaust Fan |
| HP 1,2 | Armstrong | 2003 | | | 150 gpm | Hydronic System | 3,144 | HW Pump |

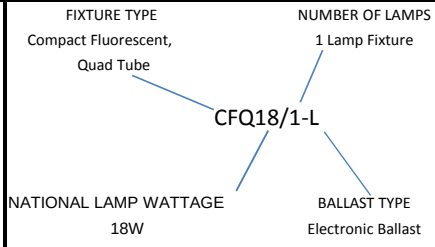
# APPENDIX F:
# LIGHTING SYSTEMS SCHEDULES

# Fixture Code Legend and Notes

*Sample Linear Fluorescent Fixture Code*




*Sample of Other Fixture Code:*




**Code Explanations**

*Fixture Type*

| | |
|---|---|
| CF | Compact Fluorescent |
| CFD | Compact Fluorescent, double-D shape |
| CFS | Compact Fluorescent, Spiral |
| CFT | Compact Fluorescent, Twin tube (including "Biaxial" fixtures) |
| CFQ | Compact Fluorescent, Quad tube |
| ECF | Exit sign, Compact Fluorescent |
| EI | Exit sign, Incandescent |
| ELED | Exit sign, LED |
| F | Fluorescent, linear |
| FC | Fluorescent, Circline |
| FU | Fluorescent, U-tube |
| H | Halogen |
| HLV | Halogen, Low Voltage |
| HPS | High Pressure Sodium |
| I | Incandescent |
| LED | Light Emitting Diode (LED) traffic signal |
| MH | Metal Halide |
| MHPS | Metal Halide, Pulse Start |
| MV | Mercury Vapor |
| QL | Induction |

*Lamp Type*

*for fluorescent fixtures*

| | |
|---|---|
| A | "F25T12" - 25 watt, 4ft, T12 lamp |
| IL | T8, Instant start |
| SIL | T8, Instant start, Super 30 watt |
| SSIL | T8, Instant start, Super 28 watt |
| L | T8, rapid start |
| G | T5, standard |
| GH | T5, standard, High output lamp |
| E | T12, Energy efficient |
| EH | T12, Energy efficient, High output lamp |
| EI | T12, Energy efficient, Instant start |
| EV | T12, Energy efficient, Very high output |
| S | T12, Standard |
| SIL | T12, Standard, Instant start |
| SH | T12, Standard, High output lamp |
| SV | T12, Standard, Very high output lamp |
| T | T10, Standard |

*for LED traffic signals*

| | |
|---|---|
| 12GA | 12" Green Arrow |
| 12GB | 12" Green Ball |
| 12RA | 12" Red Arrow |
| 12RB | 12" Red Ball |
| 8GB | 8" Green Ball |
| 8RB | 8" Red Ball |
| PH | Pedestrian Hand signal |

Ballast Type

*for fluorescent fixtures*

| | |
|---|---|
| L | Electronic |
| S | Standard magnetic |
| E | Emergy efficient magnetic |

*Configuration (letter)*

| | |
|---|---|
| T | Tandem wired fixture |
| D | Delamped fixture, i.e. some lamps permanently removed but ballasts remain |

*Configuration (number)*

*for delamped fixtures*

Number signifies the total number of ballasts in the fixture: e.g. An "F42EEID2" is an "F44EE" with two lamps removed so that there is one extaneous ballast

*for tandem wired ballasts*

Number signifies the total number of lamps being run by the ballast: e.g. An "F42LLIT4" would indicate that a four-lamp ballast is wired to run two-lamp fixtures.

*with no preceding letter*

Number indicates the number of ballasts in an ambiguous multiple ballast fixture: e.g. An "F43ILU2" indicates a three-lamp fixture with two ballasts (as is often the case if there is A/B switching).

*Ballast Light Output*

| | |
|---|---|
| R | Reduced light output |
| H | High light output |
| V | Very high light output |

Notes:

1) The column labeled Watts/Fixtures in the data table includes ballast loads.

2) The fixture wattage values represent an average value, rounded to the nearest whole watt.

**Existing Facilities Program Lighting Form:**

*Performance Based*

| | |
|---|---|
| Applicant Name: | |
| Facility Name: | Eliot Elementary School |
| Building Address | 135 Wellesley Avenue Needham Ma. 02492 |
| Date: | 9/13/2011 |

| Existing Control Legend | |
|---|---|
| LS | Light Switch |
| PS | Photosensor |
| TM | Timer |
| MS | Motion Sensor |
| NC | Little or No Control (on all day) |

| INSTRUCTIONS Coding Legend | | | |
|---|---|---|---|
| CF | Compact Fluorescent | I | Incandescent |
| F | Fluorescent, linear | LED | Light Emitting Diode |
| H | Halogen | MH | Metal Halide |
| HPS | High Pressure Sodium | MV | Mercury Vapor |
| I | Incandescent | QL | Induction |

**PRE-INSTALLATION**

| Line Item | ECM | Type of ECM Code (Refer to ECM Code Worksheet) | Floor | Area Description | Light Reading (Record if ECM) | Usage | Usage | Existing Control | Pre Fixt. No. | Pre Fixt Code (Refer to Wattable Table Worksheet) | Pre Watts / Fixt | Pre kW / Space | Baseline Annual Hours | Annual kWh Consumed | Notes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Integer line number | (Type 'ECM" if used) | ECM CODE Worksheet Link | Floor fixture is on | Description of location that matches site map | Lux (link to light standards) | hrs/ week | Weeks/Year | control device (refer to legend above) | # of existing fixtures | Wattage Table Link | Watts/Fixt from Wattage Table | (Pre Watts/Fixt) * (Pre Fixt No.) | Existing annual hours for the usage group | (PreFixt #*PreWatts/Fixt * Baseline Hrs) | | | |
| *Ex.* | | | *10* | *Men's Room* | | *5* | *52* | *LS* | *3* | *F44ILL* | *112* | *0.34* | *3,000* | *1,008* | | | |
| 1 | ECM | PS | 1 | 188,191,194-Kindergarten | 600 | 65 | 37 | MS | 10 | CFQ26/2-L | 50 | 0.50 | 2,405 | 1,203 | | | |
| 2 | | | 1 | 188,191,194-Kindergarten | 600 | 65 | 37 | MS | 30 | F42SE | 86 | 2.58 | 2,405 | 6,205 | | | |
| 3 | | | 1 | 188,191,194-Kindergarten | 600 | 65 | 37 | MS | 25 | F41SE | 50 | 1.25 | 2,405 | 3,006 | | | |
| 4 | | | 1 | Admin Offices | 170 | 65 | 37 | MS | 18 | CFT40/1-L | 43 | 0.77 | 2,405 | 1,861 | | | |
| 5 | | | 1 | Admin Offices | 170 | 65 | 37 | MS | 4 | F44SE | 173 | 0.69 | 2,405 | 1,664 | | | |
| 6 | | | 1 | Admin Offices | 170 | 65 | 37 | MS | 16 | CFQ26/2-L | 50 | 0.80 | 2,405 | 1,924 | | | |
| 7 | | | 1 | Admin Offices | 170 | 65 | 37 | MS | 1 | F42SE | 86 | 0.09 | 2,405 | 207 | | | |
| 8 | | | 1,2 | Classrooms | 589 | 65 | 37 | MS | 114 | F41SE | 50 | 5.70 | 2,405 | 13,709 | | | |
| 9 | | | 1 | Classrooms | 589 | 65 | 37 | MS | 205 | F42SE | 86 | 17.63 | 2,405 | 42,400 | | | |
| 10 | | | 1 | Classrooms | 589 | 65 | 37 | MS | 9 | FU2ILL | 59 | 0.53 | 2,405 | 1,277 | | | |
| 11 | | | 1 | Classrooms | 589 | 65 | 37 | MS | 2 | CFT40/1-L | 43 | 0.09 | 2,405 | 207 | | | |
| 12 | ECM | PS | 1 | 187-Project Area | 560 | 78 | 37 | MS | 12 | CFT40/1-L | 43 | 0.52 | 2,886 | 1,489 | | | |
| 13 | ECM | PS | 1 | 187-Project Area | 560 | 78 | 37 | MS | 5 | CFQ26/2-L | 50 | 0.25 | 2,886 | 722 | | | |
| 14 | | | 1 | Project Area | 560 | 78 | 37 | MS | 24 | CFT40/1-L | 43 | 1.03 | 2,886 | 2,978 | | | |
| 15 | | | 1 | Project Area | 560 | 78 | 37 | MS | 10 | CFQ26/2-L | 50 | 0.50 | 2,886 | 1,443 | | | |
| 16 | ECM | PS | 1 | Art & Music Class | 418 | 65 | 37 | MS | 48 | F42SE | 86 | 4.13 | 2,405 | 9,928 | | | |
| 17 | | | 1 | Conference Room | 304 | 65 | 37 | MS | 6 | CFT40/1-L | 43 | 0.26 | 2,405 | 620 | | | |
| 18 | | | 1 | Work Room | 545 | 65 | 37 | MS | 6 | F44SE | 173 | 1.04 | 2,405 | 2,496 | | | |
| 19 | | | 1 | Work Room | 545 | 65 | 37 | MS | 1 | F41SE | 50 | 0.05 | 2,405 | 120 | | | |
| 20 | ECM | PS | 1 | 171-Corridor | | 78 | 37 | LS | 5 | CFQ26/2-L | 50 | 0.25 | 2,886 | 722 | | | |
| 21 | | | 1 | Corridors | | 78 | 37 | MS | 27 | CFQ26/2-L | 50 | 1.35 | 2,886 | 3,896 | | | |
| 22 | | | 1 | Corridors | | 78 | 37 | LS | 12 | F41SE | 50 | 0.60 | 2,886 | 1,732 | | | |
| 23 | ECM | PS | 1 | 146-Stairs | 118 | 78 | 37 | LS | 7 | CFQ26/2-L | 50 | 0.35 | 2,886 | 1,010 | | | |
| 24 | ECM | PS | 1 | 173-Stairs | 137 | 78 | 37 | LS | 4 | CFQ26/2-L | 50 | 0.20 | 2,886 | 577 | | | |
| 25 | ECM | PS | 1 | 196-Stairs | 195 | 78 | 37 | LS | 3 | CFQ26/2-L | 50 | 0.15 | 2,886 | 433 | | | |
| 26 | ECM | RB | 1 | Gymnasium | 160 | 78 | 37 | LS | 16 | MH400/1 | 458 | 7.33 | 2,886 | 21,149 | | | |
| 27 | ECM | PS | 1 | Gymnasium | 160 | 78 | 37 | LS | 16 | QL165/1 | 165 | 2.64 | 2,886 | 7,619 | | | |
| 28 | ECM | PS | 1 | 107-Cafetorium | 380 | 65 | 37 | MS | 4 | MHPS/LR/100/1 | 118 | 0.47 | 2,405 | 1,135 | | | |
| 29 | ECM | PS | 1 | 108-Multipurpose | 260 | 65 | 37 | MS | 4 | MHPS/LR/100/1 | 118 | 0.47 | 2,405 | 1,135 | | | |
| 30 | | | 1 | 108 Multipurpose-Stage | | 1 | 37 | LS | 27 | H250/1 | 250 | 6.75 | 37 | 250 | | | |
| 31 | | | 1 | Kitchen | 320 | 65 | 37 | MS | 13 | F42SE | 86 | 1.12 | 2,405 | 2,689 | | | |
| 32 | | | 1,2 | Restrooms | 292 | 65 | 37 | MS | 29 | F42SE | 86 | 2.49 | 2,405 | 5,998 | | | |
| 33 | | | 1,2 | Restrooms | 292 | 65 | 37 | MS | 4 | CFQ26/2-L | 50 | 0.20 | 2,405 | 481 | | | |
| 34 | | | 1 | 140-Health | 270 | 65 | 37 | MS | 8 | CFT40/1-L | 43 | 0.34 | 2,405 | 827 | | | |
| 35 | | | 1 | Teacher Dining | 688 | 65 | 37 | MS | 6 | F42SE | 86 | 0.52 | 2,405 | 1,241 | | | |
| 36 | | | 1 | Teacher Dining | 688 | 65 | 37 | MS | 3 | F41SE | 50 | 0.15 | 2,405 | 361 | | | |
| 37 | | | 1 | 101-Lobby | | 78 | 37 | LS | 12 | CFT40/1-L | 43 | 0.52 | 2,886 | 1,489 | | | |
| 38 | | | 1 | 101-Lobby | | 78 | 37 | LS | 3 | F41SE | 50 | 0.15 | 2,886 | 433 | | | |
| 39 | | | 1 | 101-Lobby | | 78 | 37 | LS | 4 | H75/1 | 75 | 0.30 | 2,886 | 866 | | | |
| 40 | | | 1 | 148-Lobby | | 78 | 37 | LS | 10 | CFQ26/2-L | 50 | 0.50 | 2,886 | 1,443 | | | |
| 41 | | | 1 | 100, 103, 106-Vestibule | | 78 | 37 | LS | 8 | CFQ26/1-L | 27 | 0.22 | 2,886 | 623 | | | |
| 42 | ECM | PS | 2 | 216-Corridor | | 78 | 37 | LS | 12 | CFQ26/2-L | 50 | 0.60 | 2,886 | 1,732 | | | |
| 43 | ECM | PS | 2 | 235-Corridor | | 78 | 37 | LS | 8 | CFQ26/2-L | 50 | 0.40 | 2,886 | 1,154 | | | |
| 44 | | | 2 | Balcony & Corridors | | 78 | 37 | LS | 14 | CFQ26/2-L | 50 | 0.70 | 2,886 | 2,020 | | | |
| 45 | ECM | RB | 2 | Balcony & Corridors | | 78 | 37 | LS | 6 | MHPS/LR/150/1 | 170 | 1.02 | 2,886 | 2,944 | | | |
| 46 | ECM | PS | 2 | Stairs | | 78 | 37 | LS | 11 | CFQ26/2-L | 50 | 0.55 | 2,886 | 1,587 | | | |
| 47 | ECM | PS | 1 | 217,230,241 Project Area | 297 | 78 | 37 | MS | 36 | CFT40/1-L | 43 | 1.55 | 2,886 | 4,468 | | | |
| 48 | ECM | PS | 1 | 217,230,241 Project Area | 297 | 78 | 37 | MS | 15 | CFQ26/2-L | 50 | 0.75 | 2,886 | 2,165 | | | |
| 49 | | | 1,2 | Mechanical Rooms | 172 | 78 | 37 | LS | 20 | F42SE | 86 | 1.72 | 2,886 | 4,964 | | | |
| 50 | | | 1 | Tech Center | 545 | 65 | 37 | MS | 12 | F42SE | 86 | 1.03 | 2,405 | 2,482 | | | |
| 51 | | | 1 | Media Center | | 65 | 37 | MS | 1 | F42SE | 86 | 0.09 | 2,405 | 207 | | | |
| 52 | | | 1 | Media Center | | 65 | 37 | MS | 9 | CFT40/1-L | 43 | 0.39 | 2,405 | 931 | | | |
| 53 | | | 1 | Media Center | | 65 | 37 | MS | 12 | F42SE | 86 | 1.03 | 2,405 | 2,482 | | | |
| 54 | | | 1 | Media Center | | 65 | 37 | MS | 8 | CFQ26/2-L | 50 | 0.40 | 2,405 | 962 | | | |
| 55 | | | 1 | Media Center | | 65 | 37 | MS | 4 | MHPS/LR/150/1 | 170 | 0.68 | 2,405 | 1,635 | | | |
| 56 | | | 1 | Building Mounted Fixtures | | 30 | 37 | TM | 16 | CFT13/1 | 17 | 0.27 | 1,110 | 302 | | | |
| 57 | | | 1 | Pole Light Fixtures | | 30 | 37 | TM | 27 | MHPS/LR/175/1 | 194 | 5.24 | 1,110 | 5,814 | | | |
| 58 | | | | | | | | | | | | | | | | | |
| | | | | | | | | **Total Pre Fixt.** | **982** | | **Total Pre kW** | **82** | **Total Annual kWh Consumed** | **185,416** | | | |

| PRE-INSTALLATION | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Line Item** | **ECM** | **Type of ECM Code** (Refer to ECM Code Worksheet) | **Floor** | **Area Description** | **Light Reading** (Record if ECM) | **Usage** | **Usage** | **Existing Control** | **Pre Fixt. No.** | **Pre Fixt Code** (Refer to Wattable Table Worksheet) | **Pre Watts / Fixt** | **Pre kW / Space** | **Baseline Annual Hours** | **Annual kWh Consumed** | |
| Integer line number | (Type 'ECM" if used) | ECM CODE Worksheet Link | Floor fixture is on | Description of location that matches site map | Lux (link to light standards) | hrs/ week | Weeks/Year | control device (refer to legend above) | # of existing fixtures | Wattage Table Link | Watts/Fixt from Wattage Table | (Pre Watts/Fixt) * (Pre Fixt No.) | Existing annual hours for the usage group | (PreFixt #*PreWatts/Fixt * Baseline Hrs) | Notes |

**Existing Facilities Program Lighting Form:**

*Performance Based*

Applicant Name: Eliot Elementary School

Facility Name: Eliot Elementary School

Date: 9/13/2011 Building Address 135 Wellesley Ave., Needham, Ma. 02492

| Existing Control Legend | |
|---|---|
| LS | Light Switch |
| PS | Photosensor |
| T | Timer |
| MS | Motion Sensor |
| EC | Emergency Control |

| INSTRUCTIONS Coding Legend | | | |
|---|---|---|---|
| CF | Compact Fluorescent | I | Incandescent |
| F | Fluorescent, linear | LED | Light Emitting Diode |
| H | Halogen | MH | Metal Halide |
| HPS | High Pressure Sodium | MV | Mercury Vapor |
| I | Incandescent | QL | Induction |

**PRE-INSTALLATION** | **POST-INSTALLATION**

| Line Item | ECM | Type of ECM Code (Refer to ECM Code Worksheet) | Floor | Area Description | Light Reading (Record if ECM) | Usage | Baseline Annual Hours | Existing Control | Pre Fixt. No. | Pre Fixt Code | Pre Watts / Fixt | Pre kW / Space | Post Fixt No. | Pre Fixt Code (Refer to Wattable Table Worksheet) | Post Watts/ Fixt | Post kW / Space | Proposed Weekly Hours | Proposed Operational Weeks | Proposed Annual Hours | Proposed Control | kW Saved | Annual kWh Saved |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Integer line number | (Type "ECM" if applied) | ECM CODE Worksheet Link | Floor fixture is on | Description of location that matches site map | Lux (link to light standards) | hrs/ week | Existing annual hours for the usage group | Pre-installation control device | # of existing fixtures | Wattage Table Link | Watts/Fixt from Wattage Table | (Pre Watts/Fixt) * (Pre Fixt No.) | # of existing fixtures | Wattage Table Link | Watts/Fixt from Wattage Table | (Post Watts/Fixt) * (Post Fixt No.) | hrs / wk | Wks/Yr | Proposed annual hours for the usage group | Post-installation control device | Pre kW/Space - Post kW/Space | (PreFixt #*PreWatts/Fixt * Baseline Hrs) - (PostFixt#*PostWatts/Fixt * Proposed Hours) |
| *Ex.* | | *RB* | *10* | *Men's Room* | | *5* | *3,000* | *Light Switch* | *3* | *F44ILL* | *112* | *0.34* | *3* | *F42ILL* | *59* | *0.18* | | | *2,000* | *Motion Sensor* | *0.16* | *477* |
| 1 | ECM | PS - Installing Photo Sensor | 1 | 188,191,194-Kindergarten | 600 | 65 | 2,405 | MS | 10 | CFQ26/2-L | 50 | 1 | 10 | CFQ26/2-L | 89 | 0.89 | 35.00 | *37* | 1,295 | LS | -0.39 | 50 |
| 2 | | | - | - | | | | | | | - | - | 30 | F42SE | 86 | 2.58 | 30.00 | *0* | 0 | MS | | |
| 3 | | | - | | | | | | | | - | - | 25 | F41SE | 50 | 1.25 | 30.00 | *0* | 0 | MS | | |
| 5 | - | #N/A | - | - | - | - | - | - | - | - | - | - | 7 | F43ILL | 89 | 0.623 | 30.00 | | 0 | MS | -0.62 | 0 |
| 6 | - | #N/A | - | - | - | - | - | - | - | - | - | - | 2 | F42ILL | 59 | 0.118 | 69.00 | | 0 | LS | -0.12 | 0 |
| 7 | - | #N/A | - | - | - | - | - | - | - | - | - | - | 17 | F43ILL | 89 | 1.513 | 15.00 | | 0 | PS | -1.51 | 0 |
| 8 | - | #N/A | - | - | - | - | - | - | - | - | - | - | 16 | F42ILL | 59 | 0.944 | 30.00 | | 0 | MS | -0.94 | 0 |
| 9 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | F44ILL | 112 | 0 | 30.00 | | 0 | MS | 0.00 | 0 |
| 10 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | F44ILL | 112 | 0 | 5.00 | | 0 | MS | 0.00 | 0 |
| 11 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | F42ILL | 59 | 0 | 5.00 | | 0 | MS | 0.00 | 0 |
| 12 | ECM | PS - Installing Photo Sensor | 1 | 187-Project Area | 560 | 78 | 2,886 | MS | 12 | CFT40/1-L | 43 | 1 | 12 | CFT40/1-L | 43 | 0.516 | 58.00 | *37* | 2,146 | MS | 0.00 | 382 |
| 13 | ECM | PS - Installing Photo Sensor | 1 | 187-Project Area | 560 | 78 | 2,886 | MS | 5 | CFQ26/2-L | 50 | 0 | 5 | CFQ26/2-L | 50 | 0.25 | 58.00 | *37* | 2,146 | MS | 0.00 | 185 |
| 14 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | FU2ILL | 59 | 0 | 69.00 | | 0 | LS | 0.00 | 0 |
| 15 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 16 | ECM | PS - Installing Photo Sensor | 1 | Art & Music Class | 418 | 65 | 2,405 | MS | 48 | F42SE | 86 | 4 | 48 | F42SE | 86 | 4.128 | 45.00 | *37* | 1,665 | MS | 0.00 | 3,055 |
| 17 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 18 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 19 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 20 | ECM | PS - Installing Photo Sensor | 1 | 171-Corridor | - | 78 | 2,886 | LS | 5 | CFQ26/2-L | 50 | 0 | | | | | | | | | | |
| 21 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 22 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 23 | ECM | PS - Installing Photo Sensor | 1 | 146-Stairs | 118 | 78 | 2,886 | LS | 7 | CFQ26/2-L | 50 | 0 | 7 | CFQ26/2-L | 50 | 0.35 | 58.00 | 37 | 2,146 | LS | 0.00 | 259 |
| 24 | ECM | PS - Installing Photo Sensor | 1 | 173-Stairs | 137 | 78 | 2,886 | LS | 4 | CFQ26/2-L | 50 | 0 | 4 | CFQ26/2-L | 50 | 0.2 | 58.00 | 37 | 2,146 | LS | 0.00 | 148 |
| 25 | ECM | PS - Installing Photo Sensor | 1 | 196-Stairs | 195 | 78 | 2,886 | LS | 3 | CFQ26/2-L | 50 | 0 | 3 | CFQ26/2-L | 50 | 0.15 | 58.00 | 37 | 2,146 | LS | 0.00 | 111 |
| 26 | ECM | RB - Replace Bulb | 1 | Gymnasium | 160 | 78 | 2,886 | LS | 16 | MH400/1 | 458 | 7 | 16 | QL250/1 | 250 | 4 | 78.00 | 37 | 2,886 | LS | 3.33 | 9,605 |
| 27 | ECM | PS - Installing Photo Sensor | 1 | Gymnasium | 160 | 78 | 2,886 | LS | 16 | QL250/1 | 250 | 3 | 16 | QL250/1 | 250 | 4 | 58.00 | 37 | 2,146 | LS | -1.36 | 2,960 |
| 28 | ECM | PS - Installing Photo Sensor | 1 | 107-Cafetorium | 380 | 65 | 2,405 | MS | 4 | MHPS/LR/100/1 | 118 | 0 | 4 | MHPS/LR/100/1 | 118 | 0.472 | 35.00 | 37 | 1,295 | MS | 0.00 | 524 |
| 29 | ECM | PS - Installing Photo Sensor | 1 | 108-Multipurpose | 260 | 65 | 2,405 | MS | 4 | MHPS/LR/100/1 | 118 | 0 | 4 | MHPS/LR/100/1 | 118 | 0.472 | 35.00 | 37 | 1,295 | | 0.00 | 524 |
| 30 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 31 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 32 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 33 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 34 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 35 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 36 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 37 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 38 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 39 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 40 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 41 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 42 | ECM | PS - Installing Photo Sensor | 2 | 216-Corridor | - | 78 | 2,886 | LS | 12 | CFQ26/2-L | 50 | 1 | 12 | CFQ26/2-L | 50 | 0.6 | 58.00 | 37 | 2,146 | LS | 0.00 | 444 |
| 43 | ECM | PS - Installing Photo Sensor | 2 | 235-Corridor | - | 78 | 2,886 | LS | 8 | CFQ26/2-L | 50 | 0 | 8 | CFQ26/2-L | 50 | 0.4 | 58.00 | 37 | 2,146 | LS | 0.00 | 296 |
| 44 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 45 | ECM | RB - Replace Bulb | 2 | Balcony & Corridors | - | 78 | 2,886 | LS | 6 | MHPS/LR/150/1 | 170 | 1 | 6 | QL70/1 | 70 | 0.42 | 78.00 | 37 | 2,886 | LS | 0.60 | 1,732 |
| 46 | ECM | PS - Installing Photo Sensor | 2 | Stairs | - | 78 | 2,886 | LS | 11 | CFQ26/2-L | 50 | 1 | 11 | CFQ26/2-L | 50 | 0.55 | 58.00 | 37 | 2,146 | PS | 0.00 | 407 |
| 47 | ECM | PS - Installing Photo Sensor | 1 | 217,230,241 Project Area | 297 | 78 | 2,886 | MS | 36 | CFT40/1-L | 43 | 2 | 36 | CFT40/1-L | 43 | 1.548 | 58.00 | 37 | 2,146 | PS | 0.00 | 1,146 |
| 48 | ECM | PS - Installing Photo Sensor | 1 | 217,230,241 Project Area | 297 | 78 | 2,886 | MS | 15 | CFQ26/2-L | 50 | 1 | 15 | CFQ26/2-L | 50 | 0.75 | 58.00 | 37 | 2,146 | PS | 0.00 | 555 |
| 49 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 50 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 51 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 52 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |

| | PRE-INSTALLATION | | | | | | | | | | | | POST-INSTALLATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Line Item** | **ECM** | **Type of ECM Code** (Refer to ECM Code Worksheet) | **Floor** | **Area Description** | **Light Reading** (Record if ECM) | **Usage** | **Baseline Annual Hours** | **Existing Control** | **Pre Fixt. No.** | **Pre Fixt Code** | **Pre Watts / Fixt** | **Pre kW / Space** | **Post Fixt No.** | **Pre Fixt Code** (Refer to Wattable Table Worksheet) | **Post Watts/ Fixt** | **Post kW / Space** | **Proposed Weekly Hours** | **Proposed Operational Weeks** | **Proposed Annual Hours** | **Proposed Control** | **kW Saved** | **Annual kWh Saved** |
| Integer line number | (Type "ECM" if applied) | ECM CODE Worksheet Link | Floor fixture is on | Description of location that matches site map | Lux (link to light standards) | hrs/ week | Existing annual hours for the usage group | Pre-installation control device | # of existing fixtures | Wattage Table Link | Watts/Fixt from Wattage Table | (Pre Watts/Fixt) * (Pre Fixt No.) | # of existing fixtures | Wattage Table Link | Watts/Fixt from Wattage Table | (Post Watts/Fixt) * (Post Fixt No.) | hrs / wk | Wks/Yr | Proposed annual hours for the usage group | Post-installation control device | Pre kW/Space - Post kW/Space | (PreFixt #*PreWatts/Fixt * Baseline Hrs) - (PostFixt#*PostWatts/Fixt * Proposed Hours) |
| 53 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 54 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 55 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 56 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 57 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| 58 | - | #N/A | - | - | - | - | - | - | - | - | - | - | | | | | | | | | | |
| | | | | | | | | **Total Pre Fixt.** | **222** | | **Total Pre kW** | **22.12** | **314** | **Total Post kW** | **2,241.00** | **26.72** | | | | **Total kW Saved** | **-1.02** | **22,381.08** |

**Existing Facilities Program Lighting Form:**

*Performance Based*

Applicant Name: Housing Authority for County of Lebanon

Facility Name: Steven Towers

Date: 8/6/2009

**At the bottom of sheet is IS the INVENTORY ORGANIZED so ECMs that are bi level or tandem can be Tocopied to Bi-level table below**

| Existing Control Legend | |
|---|---|
| LS | Light Switch |
| PS | Photosensor |
| T | Timer |
| MS | Motion Sensor |
| EC | Emergency Control |

| INSTRUCTIONS Coding Legend | | | |
|---|---|---|---|
| CF | Compact Fluorescent | I | Incandescent |
| F | Fluorescent, linear | LED | Light Emitting Diode |
| H | Halogen | MH | Metal Halide |
| HPS | High Pressure Sodium | MV | Mercury Vapor |
| I | Incandescent | QL | Induction |

## Bi-Level / Tandem ECM

| | | | | | | | PRE-INSTALLATION | | | | | POST-INSTALLATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Line Item** | **Building** | **Floor** | **Area Description** | **Light Reading** (Record if ECM) | **Usage** | **Baseline Annual Hours** | **Existing Control** | **Pre Fixt. No.** | **Pre Fixt Code** | **Pre Watts / Fixt** | **Pre kW / Space** | **Scenerio** | **Post Fixt No.** | **Post Fixt Code** | **Post Watts/ Fixt** | **Post kW / Space** | **Proposed Weekly Hours** | **Proposed Annual Hours** | **Proposed Control** | **kW Saved** | **Annual kWh Saved** |
| Integer line number | Building Address / ECM Description | Floor fixture is on | Description of location that matches site map | Lux (link to light standards) | hrs/ week | Existing annual hours for the usage group | Pre-installation control device | # of existing fixtures | Code from Wattage Table | Watts/Fixt from Wattage Table | (Pre Watts/Fixt) * (Pre Fixt No.) | Sensored Lamps / Baseload Lamps | Number of fixtures after retrofit | Code from Wattage Table | Watts/Fixt from Wattage Table | (Post Watts/Fixt) * (Post Fixt No.) | hrs / wk | Proposed annual hours for the usage group | Post-installation control device | Pre kW/Space - Post kW/Space | (PreFixt #*PreWatts/Fixt * Baseline Hrs) - (PostFixt#*PostWatts/Fixt * Proposed Hours) |
| | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | |
| aste HER | Paste 1st BL ECM HERe | 1st BL ECM | Paste 1st BL ECM HERe | aste 1st BL ECM HERe | 1st BL ECM He | 1st BL ECM Ha | ste 1st BL ECM HER | 1st BL ECM | Paste 1st BL ECM HERe | ste 1st BL ECM HEe | 1st BL ECM H | Baseload Lamps | 10 | F41LL | 32 | 0.32 | 168.00 | 8,736 | Motion Sensor | #VALUE! | #VALUE! |
| | | | | | | | | | | | | Sensored Lamps | 10 | F42ILL | 59 | 0.59 | 68.00 | 3,536 | Motion Sensor | | #VALUE! |
| | | | | | | | | | | | | | | | | | | **ECM Bi - level Sub Total** | | **#VALUE!** | **#VALUE!** |
| aste HER | Paste 2nd ECM HERe | e 2nd ECM H | Paste 2nd ECM HERe | Paste 2nd ECM HERe | ste 2nd ECM HEe | te 2nd ECM H | Paste 2nd ECM HERe | e 2nd ECM H | Paste 2nd ECM HERe | aste 2nd ECM HERe | ste 2nd ECM HE | Baseload Lamps | 7 | CFT40/1 | 46 | 0.32 | 168.00 | 8,736 | MS | #VALUE! | #VALUE! |
| | | | | | | | | | | | | Sensored Lamps | 7 | CFT40/2 | 85 | 0.60 | 45.00 | 2,340 | MS | | #VALUE! |
| | | | | | | | | | | | | | | | | | | **ECM Bi - level Sub Total** | | **#VALUE!** | **#VALUE!** |
| aste HER | Paste Thlird ECM HERe | Thlird ECM H | Paste Thlird ECM HERe | aste Thlird ECM HERe | Thlird ECM He | e Thlird ECM H | aste Thlird ECM HER | Thlird ECM | Paste Thlird ECM HERe | ste Thlird ECM HEe | e Thlird ECM H | Baseload Lamps | | | | | | | | | #VALUE! |
| | | | | | | | | | | | | Sensored Lamps | | | | | | | | | #VALUE! |
| | | | | | | | | | | | | | | | | | | **ECM Bi - level Sub Total** | | **#N/A** | **#VALUE!** |
| aste HER | PASTE 4th BL ECM HERE | 4th BL ECM | PASTE 4th BL ECM HERE | STE 4th BL ECM HERE | 4th BL ECM HE | 4th BL ECM IS | STE 4th BL ECM HE | 4th BL ECM | PASTE 4th BL ECM HERE | STE 4th BL ECM HE | 4th BL ECM I | Baseload Lamps | | | | | | | | | #VALUE! |
| | | | | | | | | | | | | Sensored Lamps | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | **ECM Bi - level Sub Total** | | **0.00** | **#VALUE!** |
| aste HER | PASTE 5th BL ECM | STE 5th BL E | PASTE 5th BL ECM | PASTE 5th BL ECM | ASTE 5th BL EC | STE 5th BL EC | PASTE 5th BL ECM | STE 5th BL E | PASTE 5th BL ECM | PASTE 5th BL ECM | STE 5th BL EC | Baseload Lamps | | | | | | | | | #VALUE! |
| | | | | | | | | | | | | Sensored Lamps | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | **ECM Bi - level Sub Total** | | **0.00** | **#VALUE!** |
| aste HER | PASTE 6th BL ECM HERE | 6th BL ECM | PASTE 6th BL ECM HERE | STE 6th BL ECM HERE | 6th BL ECM HE | 6th BL ECM IS | STE 6th BL ECM HE | 6th BL ECM | PASTE 6th BL ECM HERE | STE 6th BL ECM HE | 6th BL ECM I | Baseload Lamps | | | | | | | | | #VALUE! |
| | | | | | | | | | | | | Sensored Lamps | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | **ECM Bi - level Sub Total** | | **0.00** | **#VALUE!** |
| | | | | | | | | | | | | | | | | | | | **Grand Total** | **#VALUE!** | **#VALUE!** |

**BELOW IS FROM INVENTORY WORKSHEET ORGANIZED TO COPY AND PASTE ABOVE**

## Bi-Level / Tandem ECM

| | | | | | | | PRE-INSTALLATION | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Line Item** | **Building** | **Floor** | **Area Description** | **Light Reading** (Record if ECM) | **Usage** | **Baseline Annual Hours** | **Existing Control** | **Pre Fixt. No.** | **Pre Fixt Code** | **Pre Watts / Fixt** | **Pre kW / Space** |
| Integer line number | Building Address / ECM Description | Floor fixture is on | Description of location that matches site map | Lux (link to light standards) | hrs/ week | Existing annual hours for the usage group | Pre-installation control device | # of existing fixtures | Code from Wattage Table | Watts/Fixt from Wattage Table | (Pre Watts/Fixt) * (Pre Fixt No.) |
| 1 | PS | 1 | 188,191,194-Kindergarten | 600 | 65 | 2,405 | MS | 10 | CFQ26/2-L | 50 | 0.50 |
| 2 | 0 | 1 | 188,191,194-Kindergarten | 600 | 65 | 2,405 | MS | 30 | F42SE | 86 | 2.58 |
| 3 | 0 | 1 | 188,191,194-Kindergarten | 600 | 65 | 2,405 | MS | 25 | F41SE | 50 | 1.25 |
| 4 | 0 | 1 | Admin Offices | 170 | 65 | 2,405 | MS | 18 | CFT40/1-L | 43 | 0.77 |
| 5 | 0 | 1 | Admin Offices | 170 | 65 | 2,405 | MS | 4 | F44SE | 173 | 0.69 |
| 6 | 0 | 1 | Admin Offices | 170 | 65 | 2,405 | MS | 16 | CFQ26/2-L | 50 | 0.80 |
| 7 | 0 | 1 | Admin Offices | 170 | 65 | 2,405 | MS | 1 | F42SE | 86 | 0.09 |
| 8 | 0 | 1,2 | Classrooms | 589 | 65 | 2,405 | MS | 114 | F41SE | 50 | 5.70 |
| 9 | 0 | 1 | Classrooms | 589 | 65 | 2,405 | MS | 205 | F42SE | 86 | 17.63 |
| 10 | 0 | 1 | Classrooms | 589 | 65 | 2,405 | MS | 9 | FU2ILL | 59 | 0.53 |
| 11 | 0 | 1 | Classrooms | 589 | 65 | 2,405 | MS | 2 | CFT40/1-L | 43 | 0.09 |
| 12 | PS | 1 | 187-Project Area | 560 | 78 | 2,886 | MS | 12 | CFT40/1-L | 43 | 0.52 |
| 13 | PS | 1 | 187-Project Area | 560 | 78 | 2,886 | MS | 5 | CFQ26/2-L | 50 | 0.25 |
| 14 | 0 | 1 | Project Area | 560 | 78 | 2,886 | MS | 24 | CFT40/1-L | 43 | 1.03 |
| 15 | 0 | 1 | Project Area | 560 | 78 | 2,886 | MS | 10 | CFQ26/2-L | 50 | 0.50 |
| 16 | PS | 1 | Art & Music Class | 418 | 65 | 2,405 | MS | 48 | F42SE | 86 | 4.13 |
| 17 | 0 | 1 | Conference Room | 304 | 65 | 2,405 | MS | 6 | CFT40/1-L | 43 | 0.26 |
| 18 | 0 | 1 | Work Room | 545 | 65 | 2,405 | MS | 6 | F44SE | 173 | 1.04 |
| 19 | 0 | 1 | Work Room | 545 | 65 | 2,405 | MS | 1 | F41SE | 50 | 0.05 |
| 20 | PS | 1 | 171-Corridor | 0 | 78 | 2,886 | LS | 5 | CFQ26/2-L | 50 | 0.25 |
| 21 | 0 | 1 | Corridors | 0 | 78 | 2,886 | MS | 27 | CFQ26/2-L | 50 | 1.35 |
| 22 | 0 | 1 | Corridors | 0 | 78 | 2,886 | LS | 12 | F41SE | 50 | 0.60 |
| 23 | PS | 1 | 146-Stairs | 118 | 78 | 2,886 | LS | 7 | CFQ26/2-L | 50 | 0.35 |
| 24 | PS | 1 | 173-Stairs | 137 | 78 | 2,886 | LS | 4 | CFQ26/2-L | 50 | 0.20 |
| 25 | PS | 1 | 196-Stairs | 195 | 78 | 2,886 | LS | 3 | CFQ26/2-L | 50 | 0.15 |

| | | | | | | | PRE-INSTALLATION | | | | | POST-INSTALLATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Line Item** | **Building** | **Floor** | **Area Description** | **Light Reading** (Record if ECM) | **Usage** | **Baseline Annual Hours** | **Existing Control** | **Pre Fixt. No.** | **Pre Fixt Code** | **Pre Watts / Fixt** | **Pre kW / Space** | **Scenerio** | **Post Fixt No.** | **Post Fixt Code** | **Post Watts/ Fixt** | **Post kW / Space** | **Proposed Weekly Hours** | **Proposed Annual Hours** | **Proposed Control** | **kW Saved** | **Annual kWh Saved** |
| Integer line number | Building Address / ECM Description | Floor fixture is on | Description of location that matches site map | Lux (link to light standards) | hrs/ week | Existing annual hours for the usage group | Pre-installation control device | # of existing fixtures | Code from Wattage Table | Watts/Fixt from Wattage Table | (Pre Watts/Fixt) * (Pre Fixt No.) | Sensored Lamps / Baseload Lamps | Number of fixtures after retrofit | Code from Wattage Table | Watts/Fixt from Wattage Table | (Post Watts/Fixt) * (Post Fixt No.) | hrs / wk | Proposed annual hours for the usage group | Post-installation control device | Pre kW/Space - Post kW/Space | (PreFixt #*PreWatts/Fixt * Baseline Hrs) - (PostFixt#*PostWatts/Fixt * Proposed Hours) |
| 26 | RB | 1 | Gymnasium | 160 | 78 | 2,886 | LS | 16 | MH400/1 | 458 | 7.33 | | | | | | | | | | |
| 27 | PS | 1 | Gymnasium | 160 | 78 | 2,886 | LS | 16 | QL165/1 | 165 | 2.64 | | | | | | | | | | |
| | PS | 1 | 107-Cafetorium | 380 | 65 | 2,405 | MS | 4 | MHPS/LR/100/1 | 118 | 0.47 | | | | | | | | | | |
| | PS | 1 | 108-Multipurpose | 260 | 65 | 2,405 | MS | 4 | MHPS/LR/100/1 | 118 | 0.47 | | | | | | | | | | |
| | 0 | 1 | 108 Multipurpose-Stage | 0 | 1 | 37 | LS | 27 | H250/1 | 250 | 6.75 | | | | | | | | | | |
| | 0 | 1 | Kitchen | 320 | 65 | 2,405 | MS | 13 | F42SE | 86 | 1.12 | | | | | | | | | | |
| | 0 | 1,2 | Restrooms | 292 | 65 | 2,405 | MS | 29 | F42SE | 86 | 2.49 | | | | | | | | | | |
| | 0 | 1,2 | Restrooms | 292 | 65 | 2,405 | MS | 4 | CFQ26/2-L | 50 | 0.20 | | | | | | | | | | |
| | 0 | 1 | 140-Health | 270 | 65 | 2,405 | MS | 8 | CFT40/1-L | 43 | 0.34 | | | | | | | | | | |
| | 0 | 1 | Teacher Dining | 688 | 65 | 2,405 | MS | 6 | F42SE | 86 | 0.52 | | | | | | | | | | |
| | 0 | 1 | Teacher Dining | 688 | 65 | 2,405 | MS | 3 | F41SE | 50 | 0.15 | | | | | | | | | | |
| | 0 | 1 | 101-Lobby | 0 | 78 | 2,886 | LS | 12 | CFT40/1-L | 43 | 0.52 | | | | | | | | | | |
| | 0 | 1 | 101-Lobby | 0 | 78 | 2,886 | LS | 3 | F41SE | 50 | 0.15 | | | | | | | | | | |
| | 0 | 1 | 101-Lobby | 0 | 78 | 2,886 | LS | 4 | H75/1 | 75 | 0.30 | | | | | | | | | | |
| | 0 | 1 | 148-Lobby | 0 | 78 | 2,886 | LS | 10 | CFQ26/2-L | 50 | 0.50 | | | | | | | | | | |
| | 0 | 1 | 100, 103, 106-Vestibule | 0 | 78 | 2,886 | LS | 8 | CFQ26/1-L | 27 | 0.22 | | | | | | | | | | |
| | PS | 2 | 216-Corridor | 0 | 78 | 2,886 | LS | 12 | CFQ26/2-L | 50 | 0.60 | | | | | | | | | | |
| | PS | 2 | 235-Corridor | 0 | 78 | 2,886 | LS | 8 | CFQ26/2-L | 50 | 0.40 | | | | | | | | | | |
| | 0 | 2 | Balcony & Corridors | 0 | 78 | 2,886 | LS | 14 | CFQ26/2-L | 50 | 0.70 | | | | | | | | | | |
| | RB | 2 | Balcony & Corridors | 0 | 78 | 2,886 | LS | 6 | MHPS/LR/150/1 | 170 | 1.02 | | | | | | | | | | |
| | PS | 2 | Stairs | 0 | 78 | 2,886 | LS | 11 | CFQ26/2-L | 50 | 0.55 | | | | | | | | | | |
| | PS | 1 | 217,230,241 Project Area | 297 | 78 | 2,886 | MS | 36 | CFT40/1-L | 43 | 1.55 | | | | | | | | | | |
| | PS | 1 | 217,230,241 Project Area | 297 | 78 | 2,886 | MS | 15 | CFQ26/2-L | 50 | 0.75 | | | | | | | | | | |
| | 0 | 1,2 | Mechanical Rooms | 172 | 78 | 2,886 | LS | 20 | F42SE | 86 | 1.72 | | | | | | | | | | |
| | 0 | 1 | Tech Center | 545 | 65 | 2,405 | MS | 12 | F42SE | 86 | 1.03 | | | | | | | | | | |
| | 0 | 1 | Media Center | 0 | 65 | 2,405 | MS | 1 | F42SE | 86 | 0.09 | | | | | | | | | | |
| | 0 | 1 | Media Center | 0 | 65 | 2,405 | MS | 9 | CFT40/1-L | 43 | 0.39 | | | | | | | | | | |
| | 0 | 1 | Media Center | 0 | 65 | 2,405 | MS | 12 | F42SE | 86 | 1.03 | | | | | | | | | | |
| | 0 | 1 | Media Center | 0 | 65 | 2,405 | MS | 8 | CFQ26/2-L | 50 | 0.40 | | | | | | | | | | |
| | 0 | 1 | Media Center | 0 | 65 | 2,405 | MS | 4 | MHPS/LR/150/1 | 170 | 0.68 | | | | | | | | | | |
| | 0 | 1 | Building Mounted Fixtures | 0 | 30 | 1,110 | TM | 16 | CFT13/1 | 17 | 0.27 | | | | | | | | | | |
| | 0 | 1 | Pole Light Fixtures | 0 | 30 | 1,110 | TM | 27 | MHPS/LR/175/1 | 194 | 5.24 | | | | | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | | | | | | | | | | | | |
| | | | | | | | **Total Pre Fixt.** | **#VALUE!** | | **Total Pre kW** | **#VALUE!** | | **34** | **Total Post kW** | **#REF!** | **1** | | | **Total kW Saved** | **#VALUE!** | **#VALUE!** |

# APPENDIX G:
# ECM CALCULATIONS

| UIC | Install On-Demand Ventilation on Air Handlers in Mechanical Room |
|---|---|
| EAC1 | Details: Convert Gym Air Handlers (AH-1,2) to On-Demand Ventilation. |

**ENTER EXISTING CONDITION**

| | | | | | |
|---|---|---|---|---|---|
| Estimated Facility Sq.Ft Under Consideration: | 5,400.00 | Sq.ft | No. of Sensors To Be Installed (One/AHU) | 2.00 | Qty |
| Outside Air Intake CFM (Cubic Feet/Min): | 972.00 | CFM | Estimated Savings From On-Demand Ventilation | 15% | CFM |

| WINTER | | | SUMMER | | |
|---|---|---|---|---|---|
| Select Type of Heating Fuel | Natural Gas | (Select) | Is The Building Cooled? | Yes | (Select) |
| Estimated Annual Heating Plant Efficiency % *(COP in Case of Heat Pumps Only Max 4.5)* | 85.00 | % | Estimated Annual Cooling Plant Efficiency (EER) | 10.90 | EER |
| Annual Heating Degree Days(HDD): | 5630 | | Annual Cooling Degree Days(CDD): | 678 | |
| Estimated Annual Energy Consumed For Heating Outside Air During Winter | 141843.57 | kbtu/Yr | Estimated Annual Energy Consumed For Cooling Outside Air During Summer | 17081.69 | kbtu/Yr |
| Estimated Annual Input Heating Energy Savings By Use of On-Demand Ventillation System | 25031.22 | kbtu/Yr | Estimated Annual Input Cooling Energy Savings By Use of On-Demand Ventillation System | 235.07 | kbtu/Yr |
| Estimated Intake Annual Heating Fuel Savings: | 250.31 | Therm | Estimated Annual Intake Cooling Fuel Savings: | 21.57 | kWh |
| Cost/Unit of Heating Fuel: Therm | $1.08 | $$ | Cost/Unit For Electricity | $0.21 | $$ |
| Estimated Annual Heating Cost Savings | 269.54 | $$ | Estimated Annual Cooling Cost Savings | 4.48 | $$ |

**COST ANALYSIS**

| | | | | | |
|---|---|---|---|---|---|
| Estimated Annual O&M Savings | $13.70 | $$ | Estimated Installation Cost (Including Labor) | $1,900 | $$ |
| Total Estimated Annual Cost Savings | $288 | $$ | Total Estimated Installation Cost | $2,041 | $$ |
| Simple Pay Back Period | 7.09 | Yrs | *Type of Recommendation* | Capital Cost ECM Recommendation | |

| UIC | Install Timers On Rooftop Exhaust Fans |
|---|---|
| EAC7A | Details: Restroom Exhaust Fans (EF1-7, EF-18), 2HP total |

| EXISTING CONDITION | | |
|---|---|---|
| No. of Fan Motors: | 8.00 | Qty |
| Total HP of Fans | 2.00 | HP |
| Total kW: | 1.492 | kW |
| Existing Annual hours of operation: | 1758.00 | Hr |
| Annual kWh: | 2622.94 | kWh |

| PROPOSED CONDITION | | |
|---|---|---|
| New Annual Hours With Timers: | 740.00 | Hr |
| New Annual kWh: | 1104.08 | kWh |
| Annual kWh Savings: | 1547.37 | kWh |

| COST ANALYSIS | | |
|---|---|---|
| Cost/kWh: | **$0.21** | $$ |
| Annual Cost savings: | $321 | $$ |
| Installed cost/timer: | $60.00 | $$ |
| Total Cost of Installment of Timers | $516 | $$ |
| Simple Payback: | 1.60 | Yrs |

*Type of Recommendation* — No/Low Cost ECM Recommendation

| UIC | Install Energy Savers on Vending, Snack Machines |
|---|---|
| EAC8 | Details: Electric Water Cooler and "Coke" Machine located in Teacher's Dining Room |

No. of Vending Machines: 1.00 Qty

No. of Beverage Cooling Machines: 1.00 Qty

No. of Snack Machines 0.00 Qty

## Vending Machines (Cold Beverage Vending Machines)

| | | |
|---|---|---|
| Estimated Annual kWh Consumption of Vending Machine: | 3500.00 | kWh |
| Estimated Annual kWh of Vending Machine With VendMiser: | 1890.00 | kWh |
| Total annual kWh savings: | 1610.00 | kWh |
| Total Annual kWh Savings for All Vending Machines: | 1610.00 | kWh |

## Beverage Cooling Machines

| | | |
|---|---|---|
| Estimated Annual kWh Consumption of Beverage Cooling Machine: | 2300.00 | kWh |
| Estimated Annual kWh of Cooling Machine With CoolerMiser: | 1610.00 | kWh |
| Total Annual kWh savings: | 690.00 | kWh |
| Total Annual kWh Savings For All Cooling Machines: | 690.00 | kWh |

## Snack Vending Machines

| | | |
|---|---|---|
| Estimated Annual kWh Consumption of Individual Snack Machine: | 873.60 | kWh |
| Estimated Annual kWh of Individual Snack Machines With VendMiser: | 366.91 | kWh |
| Total Annual kWh savings: | 506.69 | kWh |
| Total Annual kWh Savings For All Water Fountain Coolers: | 0.00 | kWh |

## Cost Analysis

| | | |
|---|---|---|
| **Total estimated annual kWh savings withEnergy Misers:** | **2300.00** | kWh |
| Cost/kWh: | **$0.21** | |
| Estimated Cost of Vendmiser/ Vending Machine: | $200 | |
| Estimated Cost of Coolermiser/ Water cooler: | $190 | |
| Estimated Cost of Vendmiser/ Snack Machine: | $70 | |
| **Estimated total installed cost of all VendMisers:** | **$390** | |
| **Estimated Total Annual Electricity Savings Using VendingMisers and CoolerMisers:** | **$478** | |
| Simple Payback: | 0.82 | years |

*Type of Recommendation* No/Low Cost ECM Recommendation

| UIC | Re-Commission The Building & Its Control Systems |
|---|---|
| EAC10 | Details: Rebalance air flow; verify control system operations |

| | | |
|---|---|---|
| Enter the Total Area of The Facility | 69,035 | SqFt |
| Select the Type of Heating Fuel: | Natural Gas | *(Select)* |
| Estimated Annual Heating Fuel Consumption: | 36,649 | Therms |
| Is the Property Cooled? | No | *(Select)* |
| Estimated Annual Electrical Energy Consumed For Cooling: | 21,000 | kWh |
| Estimated Energy Savings From Re-Commissining on Building Systems: *(LBNL 2009 Report on Building Commissioning)* | 16% | |
| Estimated Heating Energy Saving Post Re-Commissioning: | 5,864 | Therms |
| Estimated Cooling Energy Saving Post Re-Commissioning: | 0 | kWh |
| Average Heating Fuel Rate Paid By The Property: | $1.08 | $/Therm |
| Average Electrical Rate Paid By The Property: | $0.21 | $/kWh |
| Annual Energy Cost Savings: | $6,314 | $ |
| Estimated Cost For Re-Commissioning The Facility: *(LBNL 2009 Report on Building Commissioning)* | $20,711 | $ |
| Simple Payback Period: | 3.28 | Yrs |

*Type of Recommendation* Capital Cost ECM Recommendation

| *UIC* | **Install Automatic Lighting Controls** |
|---|---|
| **EAL5** | **Details: Exploit natural light in corridors, etc.** |

| | | | |
|---|---|---|---|
| | Type of Sensor | Internal Photosensors | |
| Step: 1 | Total Number of Sensors | 19 | |
| Step: 2 | Purchase Cost/Lighting Control Sensors | $15 | |
| Step: 3 | Installation Cost /Sensor | $65 | |
| Step:4 | Total Installation Costs | $1,632.48 | |
| Step:5 | Total Energy Savings | 11044.00 | kWh |
| Step:6 | Electric Tariff Rate | **$0.21** | $ |
| Step:7 | Total Cost Savings | $2,292.85 | |
| Step:8 | Simple Pay Back Period | 0.71 | Years |
| *Type of Recommendation* | | Capital Cost ECM Recommendation | |

| UIC | Replace High Intensity Discharge Lamp (HID) with Induction Lighting |
|---|---|
| EAL9 | **Details: Replace HID Gym lights and lobby flood lights with induction fixtures.** |

| | | | |
|---|---|---|---|
| Step:1 | Number of 60-100W HID Lamps Replaced by 40W Induction | 0 | |
| | Number of 100-150W HID Lamps Replaced by 70W Induction | 6 | |
| | Number of 150-200W HID Lamps Replaced by 85W Induction | **0** | |
| | Number of 200-250W HID Lamps Replaced by 120W Induction | **0** | |
| | Number of 250-300W HID Lamps Replaced by 165W Induction | **0** | |
| | Number of 300-400W HID Lamps Replaced by 250W Induction | **16** | |
| | Number of 1000W HID Lamps Replaced by (2)300W Induction Lamps | **0** | |
| | **Installation Cost Analysis** | | |
| Step:2 | Subtotal Cost of 40 Watt Induction Self Ballast Retrofit | $0 | |
| Step:3 | Subtotal Cost of 70 Watt Induction Retrofit | $2,220 | |
| Step:4 | Subtotal Cost of 85 Watt Induction Retrofit | $0 | |
| Step:5 | Subtotal Cost of 120 Watt Induction Retrofit | $0 | |
| Step:6 | Subtotal Cost of 165 Watt Induction Retrofit | $0 | |
| Step:7 | Subtotal Cost of 250 Watt Induction Retrofit | $8,880 | |
| Step:8 | Subtotal Cost of 300 Watt Induction Retrofit | $0 | |
| Step:9 | **Total Cost For Retrofit** | $11,921 | |
| | Energy & Cost Saving Analysis | | |
| Step:10 | Estimated Annual Energy Savings | 11337.00 | kwh |
| Step:11 | Current Electric Price Per kWh | $0.21 | $ |
| Step:12 | Estimated Annual Cost Savings | $2,354 | |
| Step:13 | Existing Annual Usage *(For O&M Savings)* | 0 | hrs |
| | Proposed Annual Usage Post Retrofit *(For O&M Savings)* | 0 | hrs |
| | Estimated Annual O&M Savings | $144 | $$ |
| Step:14 | Total Estimated Annual Cost Savings *(Energy & O&M Savings)* | $2,498 | $$ |
| Step:15 | Simple Pay back Period | 4.77 | Yrs |

*Type of Recommendation* Capital Cost ECM Recommendation

*NOTE: Induction Lamps contain 3 to 4 times the life of HID lamps where significant Operation and Maintanence Savings are attained through minimizing frequency of bulb and ballast replacements*

| *UIC* | **Convert Gas Pilot Stoves To Electronic Ignition Stoves** |
|---|---|
| **EAA5** | **Details: Convert Kitchen Range to Electronic Ignition** |

Cost of conversion from standing gas pilot to electronic ignition for one stove: $214.80

Enter total number of gas stoves in the project: 1

Total cost of conversion for all stoves: $214.80

Transfer the following information from the Survey:

| | | | |
|---|---|---|---|
| **a** | Estimated total annual natural gas savings/Range: | 34.00 | therms/yr |
| **b** | Estimated Savings From All Ranges | 34.00 | therms/yr |
| **c** | Cost/therm of natural gas: | **$1.08** | $/therm |

Estimated annual cost savings through conversion:

| therms | | cost/therm | | savings | |
|---|---|---|---|---|---|
| 34.00 | x | 1.08 | = | $36.61 | $/yr |

Calculate payback period:

| | | | | | |
|---|---|---|---|---|---|
| $214.80 | / | $36.61 | = | 5.87 | yrs |

*Type of Recommendation* No/Low Cost ECM Recommendation

# APPENDIX H:
# SUPPORTING DOCUMENTS


PAR38


E17

# METALARC METAL HALIDE

## METALARC CERAMIC

High CRI, Pulse Start, UV Stop, PAR Type - Open or Enclosed Fixtures

| Watts | Bulb | Base | Product Number | Ordering Abbreviation | ANSI Ballast No | Pkg Qty | Beam Type | Beam Angle | Operating Position | Fix Req | Avg Rated Life (hrs) | MBCP | Approx Lumens (initial) | CRI | CCT (K) | Symbols & Footnotes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | PAR38 | E26 Med Skt | 64754☼ | MCP100PAR38/U/830/VWFL | M90/O | 6 | VWFL | 65 | Universal | 0 | 12000 | 5500 | 6500 | 85 | 3000 | 1,4,7, 8,9 |

## METALARC PULSE START

High Output, Reduced Color Shift, Low Wattage, Quartz - Open or Enclosed Fixtures

| Watts | Bulb | Base | Product Number | Ordering Abbreviation | ANSI Ballast No | Pkg Qty | Lamp Finish | Operating Position | Fix Req | Avg Rated Life (hrs) | Approx Lumens (initial) | Approx Lumens (mean) | CRI | CCT (K) | Symbols & Footnotes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | E17 | E26 Med | 64587 | MP50/U/MED | M110/O | 20 | Clear | Universal | 0 | 15000V 10000H | 3450 | 2000 | 70 | 3000 | 7,8 |
| | | | 64588 | MP50/C/U/MED | M110/O | 20 | Coated | Universal | 0 | 15000V 10000H | 3200 | 1750 | 70 | 2900 | 7,8 |
| 70 | E17 | E26 Med | 64547 | MP70/U/MED | M98/O | 20 | Clear | Universal | 0 | 15000V 10000H | 5200 | 3400 | 75 | 3000 | 7,8 |
| | | | 64546 | MP70/C/U/MED | M98/O | 20 | Coated | Universal | 0 | 15000V 10000H | 4700 | 3100 | 75 | 2900 | 7,8 |
| | | | 64625 | MPD70/U/MED/840 | M98/O | 20 | Clear | Universal | 0 | 7500V 6000H | 5500 | 4000 | 80 | 4200 | 7,8 |
| | | | 64621 | MPD70/C/U/MED/840 | M98/O | 20 | Coated | Universal | 0 | 7500V 6000H | 5100 | 3800 | 82 | 4000 | 7,8 |
| 100 | E17 | E26 Med | 64417 | MP100/U/MED | M90/O | 20 | Clear | Universal | 0 | 15000V 10000H | 8500 | 5525 | 75 | 3000 | 7,8 |
| | | | 64418 | MP100/C/U/MED | M90/O | 20 | Coated | Universal | 0 | 15000V 10000H | 7900 | 5800 | 75 | 2900 | 7,8 |
| | | | 64426 | MPD100/U/MED/840 | M90/O | 20 | Clear | Universal | 0 | 7500V 6000H | 8400 | 7500 | 82 | 4200 | 7,8 |
| | | | 64433 | MPD100/C/U/MED/840 | M90/O | 20 | Coated | Universal | 0 | 7500V 6000H | 7700 | 5500 | 82 | 4000 | 7,8 |
| 150 | E17 | E26 Med | 64402 | MP150/U/MED | M102/O | 20 | Clear | Universal | 0 | 15000V 10000H | 12900 | 10000 | 75 | 3000 | 7,8 |
| | | | 64406 | MP150/C/U/MED | M102/O | 20 | Coated | Universal | 0 | 15000V 10000H | 11600 | 9000 | 75 | 2900 | 7,8 |
| | | | 64403 | MPD150/U/MED/840 | M102/O | 20 | Clear | Universal | 0 | 7500V 6000H | 12500 | 11000 | 88 | 4200 | 7,8 |
| | | | 64425 | MPD150/C/U/MED/840 | M102/O | 20 | Coated | Universal | 0 | 7500V 6000H | 11500 | 9500 | 88 | 4000 | 7,8 |

## METALARC PULSE START

High Output, Reduced Color Shift, Low Wattage, Quartz, PAR Type - Open or Enclosed Fixtures

| Watts | Bulb | Base | Product Number | Ordering Abbreviation | ANSI Ballast No | Pkg Qty | Beam Type | Beam Angle | Operating Position | Fix Req | Avg Rated Life (hrs) | MBCP | Approx Lumens (initial) | CRI | CCT (K) | Symbols & Footnotes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 70 | PAR38 | E26 Med Skt | 64590 | MP70PAR38/U/SP20/ECO | M98/O | 6 | SP | 20 | Universal | 0 | 8500 | 3400 | 3400 | 75 | 3200 | 7,8,11 |
| | | | 64592 | MP70PAR38/U/FL35/ECO | M98/O | 6 | FL | 35 | Universal | 0 | 8500 | 10000 | 3400 | 75 | 3200 | 7,8,11 |
| | | | 64594 | MP70PAR38/U/VWFL65/ECO | M98/O | 6 | VWF | 65 | Universal | 0 | 8500 | 3000 | 3400 | 75 | 3200 | 7,8,11 |
| 100 | PAR38 | E26 Med Skt | 64580 | MP100PAR38/U/SP20/ECO | M90/O | 6 | SP | 20 | Universal | 0 | 8500 | 26000 | 5800 | 75 | 3000 | 7,8,11 |
| | | | 64582 | MP100PAR38/U/FL35/ECO | M90/O | 6 | FL | 35 | Universal | 0 | 8500 | 12000 | 5800 | 75 | 3000 | 7,8,11 |
| | | | 64584 | MP100PAR38/U/VWFL65/ECO | M90/O | 6 | VWF | 65 | Universal | 0 | 8500 | 4500 | 5800 | 75 | 3000 | 7,8,11 |
| 150 | PAR38 | E26 Med Skt | 64593 | MP150PAR38/U/SP20/ECO | M102/O | 6 | SP | 20 | Universal | 0 | 8500 | 34000 | 8800 | 75 | 3200 | 7,8,11 |