Energy Audit

Israel Loring Elementary School

80 Woodside Drive
Sudbury, MA 01776

Prepared for:
Massachusetts Department of Energy Resources

Energy Audit Program

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Executive Summary

The Massachusetts Department of Energy Resources contracted with Facility Energy Consultants, LLC, (FEC) to conduct an energy audit of the subject property, Israel Loring Elementary School, located at 80 Woodside Drive, Sudbury, Massachusetts 01776. The audit consisted of a building evaluation aimed at 1) assessing the overall energy usage efficiency of the building and its on-site systems, 2) identifying potential energy areas of improvement in these systems based on a maximum of a 15 year payback period, and 3) where applicable, proposing "clean energy" alternatives to the current systems where future energy savings could be realized. Included as part of the audit was a review of the building's construction features, its historical energy costs, discussions with the local utilities concerning the property's energy usage, and discussions with the prime energy equipment suppliers/manufactures for the purpose of determining more efficient alternatives. The energy audit site visit was performed on June 18, 2009.

1.1 General Description of Building

The Israel Loring Elementary School in Sudbury, MA is a two-story school building that reportedly contains around 74,451 square feet. The school was constructed 1999 and contains approximately 32 classrooms.

Since the relatively recent construction, significant energy upgrades include:

- Installation of variable frequency drives (VFD) for the hot water circulating pumps

Mr. Shawn, Custodian, provided access to the subject property for the energy audit site visit.

1.2 ECM Table

FEC has identified 7 Energy Conservation Measures (ECMs) for this property. The following table summarizes these ECMs in terms of description, the initial investment required to implement these ECMs and their impact on energy and cost savings.

Proposed ECMs			Effect on connected electrical load (kW)	Annual Energy Usage								Annual Reduction in Greenhouse Gas (CO_2) Emissions (Tons)	Annual Savings
#	Description	Installed Cost		Existing			Savings with ECM			% Reduction			
				KWh	MMBTU		KWh	MMBTU					
					Primary Fuel	Backup Fuel		Primary Fuel	Backup Fuel	KWh	MMBTU		
1	Lighting Upgrade	$4,400	2.81	9060	0		4212	0.0		46.5%		1.79	$800
2	Vending Machine Controls	$250	0.09	1,950	0		585	0.0		30.0%		0.25	$111
3	Replace Refrigerator	$550	0.05	800	0		417	0.0		52.1%		0.18	$79
4	DCV in Gym	$1,200		0	155		0	24.7			15.9%	1.31	$414
5	DCV and VFDs on Café RTUs	$6,000	2.45	18,650	1,292		6127	22.9		32.9%	1.8%	3.81	$1,549
6	Convert Pilot Lights	$600		0	4		0	4.0			100.0%	0.21	$67
7	Off-line Water Heater	$150		0	9		0	9.1			100.0%	0.48	$153
	Total:	$13,150	5.40	528,320	3478	0	11341	60.7	0	2.1%	1.7%	8.03	$3,175

1.3 Financial Summary

If these ECM's are implemented, Israel Loring Elementary School can potentially save approximately $3,175 per year with an investment of $13,150.

1.4 Clean Tech

There currently does not appear to be clean technology opportunities available at Israel Loring Elementary School.

2 Introduction

Through the Energy Audit Program (EAP) offered by the Commonwealth of Massachusetts, Department of Energy Resources (DOER), technical assistance is provided to cities, towns, regional school districts and wastewater districts to identify capital improvements to reduce energy costs.

The purpose of this audit report is to provide the program participant with a list of energy conservation projects, their costs and estimated energy savings. This information may be used to support a future application to DOER's Energy Conservation Improvement Program, support performance contracting or justify a municipal bond funded improvement program. EAP is a state funded grant program that provides funds for energy conserving capital improvements.

The approach taken in this audit included a thorough walk-through of the buildings and associated systems and equipment, including both process systems and building systems. The major areas covered in the audit included the building envelope, electrical systems, HVAC systems, lighting systems and operational and maintenance procedures. Another element of the audit is an initial interview and ongoing consultation with operational and maintenance personnel as well as building occupants. This approach is critical to the quality of the audit process, since the input of building personnel is invaluable to the effort to obtain accurate information required for the audit

Facility Energy Consultants, LLC, (FEC) is pleased to submit this Energy Audit for the subject property. Our services have been performed in accordance with the scope of services and terms and conditions in FEC's contract with the Massachusetts Department of Energy Resources dated January 26, 2009.

The conclusions, recommendations, and financial implications presented in this report are based on a brief review of available drawings, interviews with key personnel who have a working knowledge of this property, our site observations, and our experience on similar projects. Observations were made by a trained professional or professionals but there may be energy conservation opportunities at the facility that were not readily accessible, not visible or which were inadvertently overlooked. Additional energy conservation measures may develop with time that were not evident at the time of this audit.

Recommendations presented in this report are conceptual in nature and are not intended to serve as a scope of work for implementation. Additional assessment and preparation of construction drawings may be required in order to develop a formal scope of work and to develop actual implementation budgets.

Opinions of probable capital costs are intended only to provide an order of magnitude or scale of the recommendations and were prepared, without developing a formal scope of work. The Opinions of Probable Costs were based on a combination of sources including published sources of cost data such as R.S. Means, discussions with the site contact(s) and others identified in this report and our experience with other projects. Actual costs will be dependant upon many factors that are beyond FEC's control including but not limited to the quality of the type and design of the remedy/replacement, quality of the materials and installation, manufacturer and type of equipment or system selected, field conditions, the extent of work performed at any one time, whether items are purchased individually or under a master purchase contract, and other factors. Additionally, bids for work can vary widely (e.g., 50-percent to 200-percent of the mean bid). If any of the opinions of probable capital costs presented herein are considered critical in making decisions about the Subject Property, FEC recommends that formal scopes of work be developed and quotations be obtained from contractors or suppliers, prior to making a final decision on the property.

3 Facility Description

The Israel Loring Elementary School in Sudbury, MA is a two-story school building that reportedly contains around 74,451 square feet. The school was constructed 1999 and contains approximately 32 classrooms. The building is typically occupied from 7:00 am to 3:00 pm during the school year. The gym has some additional after school and summertime limited use.

The building includes administration offices, kitchen, library, computer lab, cafeteria which includes the stage and is used as a multi-purpose room, and a gymnasium. The building exterior walls are face brick and colored split-face concrete blocks. The roofs are low-slope single-ply EPDM membrane systems supported by the steel framing and concrete block walls. There are pitched roofs with standing seam metal systems along the front sides of the building, cafeteria and at the rotunda. The windows are aluminum framed double-pane insulated units with interior sunshades. The main entrance has a vestibule while other exterior doors are typically aluminum framed storefront-type units with glazing.

Information about the rooftop units such as area served and capacities is included in the table below.

Unit	Area Served	Total CFM	Min. Outside Air	Supply Fan HP	Hot Water Heating MBH
RTU-1	Library/Admin	9,000	2,250	15	197
RTU-2	Gym	3,000	1,500	2	227
RTU-3	Gym	3,000	1,500	2	227
RTU-4	Classrooms	5,600	5,600	7.5	496
RTU-5	Kitchen	4,700	4,700	5	416
RTU-6	Cafeteria	7,900	3,160	10	443
RTU-7	Classrooms	4,275	4,275	5	378
RTU-8	Classrooms	5,955	5,955	7.5	527

- Excluding the classroom RTUs, the RTUs include exhaust/return fans from the ceiling plenum space. The RTUs are constant volume and excluding units that serve large spaces, only tempered air is distributed.
- The only RTU provided with air-conditioning is RTU-1 which serves the library and some administration spaces. An approximately 25-ton condensing unit with a direct expansion coil in the RTU provides air-conditioning.
- Approximately six classrooms are provided with thru-window air-conditioners.
- Heating of the building is provided by perimeter hot water baseboard heaters located in the classrooms and along exterior walls.
- Hot water for heating is provided by two Burnham boilers manufactured in 1999; each unit is rated for a gross output capacity of 3,353-BTU/HR.
- The hot water is distributed by two 15-horsepower motors with 92.4% efficiencies and pumps that can supply 480-gallons per minute of hot water to the rooftop air-handling units and radiant heaters. The circulating pumps have been upgraded with variable frequency drive controls.
- The building digital control system is Metasys from Johnson Controls.

The domestic hot water is supplied by two 125-gallon natural gas-fired water heaters rated at 399,000-BTUH input capacities each. A hot water circulating pump was not observed; however, the pipes were insulated and marked as having electric heat trace on the hot water supply piping.

The school's lighting is primarily supplied by energy efficient T8 florescent bulbs with electronic ballasts. Energy efficient T5 fixtures are provided in the gym. However, metal halide units were observed in the cafeteria and in a 1st floor hallway. Exterior site lighting is provided by building- and pole-mounted fixtures. Each pole fixture includes a photo cell and reportedly contain metal halide bulbs.

The interior areas of the building are primarily finished with painted concrete block and drywall, vinyl tile or carpet flooring, and suspended acoustic ceiling tiles.

4 Energy Usage Analysis and Benchmarking

4.1 Usage Analysis

The following table summarizes the basic energy rates and FY08 energy cost expenditure data that formed the basis for many of the calculations in this report.

Utility	Provider	Rates	FY08 Expenditures
Electric	NSTAR	$ 0.190/kWh	$100,541.00
Gas	NGRID	$ 1.68/therm	$ 58,405.00
#2 Oil			
Water & Sewer		NA	NA
Propane Gas		NA	NA
TOTALS			**$158,946.00**

The following table lists the building's area and its total energy and cost indices. The total energy index is a measure of energy intensity, or annual energy usage per square foot of building area. Similarly, the energy cost index is a measure of annual energy costs per square foot of building area.

Heated Area (SF)	Total Annual Cost Of Energy ($)	Energy Cost Index $/SF-Year	Total Energy Index (KBTU/SF-YR)
74,451	$ 158,946	$2.22	74

4.2 Benchmarking in Energy Star

Benchmarking has been employed in order to make determinations of the relative energy efficiency of this facility. FEC, in cooperation with the Massachusetts Department of Energy Resources, is using the Portfolio Manager tool developed by the Federal EPA. The Portfolio Manager tool allows the input of historic utility data of a facility to be compared to normalized data of a large database of buildings of its peers.

Energy Star has compiled a database of some facility types sufficient to allow energy use comparisons.

The energy use metric (energy intensity) of KBTU/SF/yr was used as a general guide to determine the efficiency of this facility. The Israel Loring Elementary School's energy intensity is 74 KBTU/SF/YR with an energy cost of $2.22 per square foot. Both of these figures are high. Based on this, it was determined that this facility should be audited for potential energy savings measures.

After adjustment of some building assumptions, this building rated in the 42nd percentile for energy efficiency against Energy Star's School database.

The results generated by Portfolio Manager related to this facility are displayed below in section 4.3.

4.3 Statement of Energy Performance

Energy Performance Comparison

	Evaluation Periods		Comparisons		
Performance Metrics	**Current** (Ending Date 06/30/2008)	**Baseline** (Ending Date 06/30/2008)	**Rating of 75**	**Target**	**National Average**
Energy Performance Rating	42	42	75	N/A	50
Energy Intensity					
Site (kBtu/ft2)	74	74	54	N/A	69
Source (kBtu/ft2)	135	135	99	N/A	127
Energy Cost					
$/year	$ 158,947.00	$ 158,947.00	$ 116,796.26	N/A	$ 149,334.05
$/ft2/year	$ 2.22	$ 2.22	$ 1.63	N/A	$ 2.09
Greenhouse Gas Emissions					
$MtCO_2e$/year	409	409	301	N/A	384
$kgCO_2e/ft^2$/year	6	6	4	N/A	6

5 Energy Conservation Measures

5.1 ECM Summary

FEC has identified 7 Energy Conservation Measures (ECMs) for this property. The following table summarizes these ECMs in terms of description, the initial investment required to implement these ECMs and their impact on energy and cost savings.

Proposed ECMs			Effect on connected electrical load (kW)	Annual Energy Usage								Annual Reduction in Greenhouse Gas (CO_2) Emissions (Tons)	Annual Savings
				Existing			Savings with ECM			% Reduction			
					MMBTU			MMBTU					
#	Description	Installed Cost		KWh	Primary Fuel	Backup Fuel	KWh	Primary Fuel	Backup Fuel	KWh	MMBTU		
1	Lighting Upgrade	$4,400	2.81	9060	0		4212	0.0		46.5%		1.79	$800
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3	Replace Refrigerator	$550	0.05	800	0		417	0.0		52.1%		0.18	$79
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	Total:	$13,150	5.40	528,320	3478	0	11341	60.7	0	2.1%	1.7%	8.03	$3,175

If these ECM's are implemented, Israel Loring Elementary can potentially save approximately $3,175 per year with an investment of $13,150.

5.2 ECM Discussion

FEC has identified 7 Recommended Energy Conservation Measures (ECMs) for this property. The following paragraphs describe each of these ECMs along with the initial annual energy savings and payback period for each ECM.

5.2.1 Lighting Upgrades: Metal Halide to T5 fluorescent fixtures

Cafeteria Lighting

The cafeteria has eight (8) 400-watt metal halide units. In the 1st floor hallway near the main entrance lobby, we noted eight (8) can fixtures with 250-watt metal halide units. We estimate that the lights are on around 1,500 hours per year.

Recommendation: It is recommended to replace each 400w metal halide with a 4 lamp T5 florescent 4' long and each 250w metal halide with a 3 lamp T5 florescent 4' long fixture.

Cost to implement	$4,400	Est. annual cost savings	$800	Payback period	5.5 years

5.2.2 Install Timers on the Vending Machines

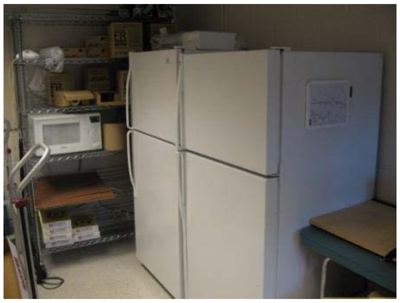
Vending Machine

We observed two (2) vending machines. Vending machines that refrigerate non-perishable items can be turned off when the building is not occupied by using timers. The timer would turn off the unit and its compressor during unoccupied times and would turn on in the early morning with ample cooling time to chill the contents in time for dispensing during the work day.

Recommendation: It is recommended that vending machine timers be installed on the vending machines.

Cost to implement	$500	Est. annual cost savings	$111	Payback period	4.5 years

5.2.3 Replace Refrigerator



Refrigerators

We observed the four (4) following refrigerators. One unit is 18.2-cubic feet in size, was manufactured in 2001, and based on the information at the Energy Star Refrigerator Retirement Savings Calculator, the unit uses 533-kWh/year. The second unit is 22.4-cubic feet in size, was manufactured in 2006, and uses 502-kWh/year. The third unit is 21-cubic feet in size, was manufactured in 2005, and uses 543-kWh/year. The fourth unit is 19-cubic feet in size, was manufactured in 2000, and uses 800-kWh/year. A new 18.2-cubic foot Energy Star rated unit can use around 383-kWh/year.

Recommendation: Based on our analysis, replacing the three newest units would result in payback periods ranging from 18-24-years; therefore they are not considered an ECM. However, it is recommended that the 2000-vintage refrigerator be replaced with Energy Star rated refrigerator.

Cost to implement	$550	Est. annual cost savings	$79	Payback period	6.9 years

5.2.4 Install DCV and VFD Fan Speed Control for Gym Rooftop Units

Gym rooftop air-handling units

A rooftop air-handling unit (RTU) is used in the gym to provide heat and the required outside fresh air. Currently, the RTU is designed to provide outside air sufficient to meet fresh air demand at maximum space design occupancy. Most often, the maximum design occupancy is not occurring in this space.

Recommendation:
It is recommended to retrofit the gym RTUs with common CO_2 sensors and related controls to adjust the occupied mode ventilation in response to actual occupancy. The sensors shall monitor CO_2 gas concentration to reflect room occupancy. The outside air dampers shall sequence in response to changes in occupancy. Work will require integrating electronic controls with the existing pneumatic controls. This ECM will reduce heating energy required to condition unnecessary ventilation.

Cost to implement	$10,000	Est. annual cost savings	$880	Payback period	11.4 years

5.2.5 Install DCV and VFD Fan Speed Control for Cafeteria Rooftop Unit

Cafeteria Rooftop Unit

A rooftop air-handling unit (RTU) is used in the cafeteria to provide heat and the required outside fresh air. The drawings reviewed indicated a 10-horsepower supply fan motor for the cafe RTU. Currently, the RTU is designed to provide outside air sufficient to meet fresh air demand at maximum space design occupancy. Most often, the maximum design occupancy is not occurring in these spaces.

Recommendation:
It is recommended to retrofit the cafeteria RTU with a common CO2 sensor and related controls to adjust the occupied mode ventilation in response to actual occupancy. The sensor shall monitor CO2 gas concentration to reflect room occupancy. The outside air dampers shall sequence in response to changes in occupancy. Work will require integrating electronic controls with the existing pneumatic controls. This ECM will reduce heating energy required to condition unnecessary ventilation.

It is also recommended to install Variable Frequency Drives (VFD) to control fan speed in response to demand by ventilation and/or temperature controls. In periods of low demand for air flow, the supply fans shall slow to match demand. The DCV cycle shall sequence as described above. Work will require electrical, mechanical and automatic controls contractors to implement. This ECM will reduce heating energy required to condition unnecessary ventilation and will reduce electric energy for fan operation. The site contact reported that sometimes the RTU is turned off because it is too noisy, installation of VFD should help reduce the amount of noise.

Cost to implement	$6,000	Est. annual cost savings	$1,549	Payback period	3.9 years

5.2.6 Convert Range Pilot Light to Electronic Ignition

Kitchen Range

The kitchen range is natural gas and has four continuously burning pilots to ignite the burners. Although the rate of consumption can vary for pilot lights, a continuously burning pilot can consume between 10- to 15-therms of natural gas per year.

Recommendation: Convert the gas range to an electronic ignition to eliminate the pilot lights.

Cost to implement	$600	Est. annual cost savings	$67	Payback period	8.9 years

5.2.7 Take offline one of the two Hot Water Heaters

Domestic Water Heaters

The domestic hot water is supplied by two 125-gallon natural gas-fired water heaters rated at 399,000-BTUH input capacities each. It is assumed that the water heaters change lead positions however; both tanks maintain hot water throughout the year. The combined 250-gallon size capacity appears too large given the elementary school setting. Replacing the existing water heaters with electric on-demand point-of-use water heaters is not considered a prudent ECM given the number of toilet rooms and kitchen hot water demand.

Water heaters typically have a standby loss of temperature in the range of 0.5-1-degree per hour per gallon. Based on our calculations, even if one of the water heaters is not used but allowed to maintain the hot water storage temperature, the water heater costs around $150 per year to operate.

Recommendation: It is recommended that one of the water heaters be taken off line alternating yearly. The indicated cost assumes that in-house labor will be able to take offline one of the water heaters without significant capital expense required.

We noted that the tempered water temperature was around 130 degrees; we suggest considering lowering the tempered water temperature.

Cost to implement	$150	Est. annual cost savings	$153	Payback period	1.0 years

5.3 Other ECMs Considered

- A 24-kW hot water heater booster is provided for the kitchen dishwasher. Costs to operate the booster are significantly more when used during peak periods as compared to off-peak times. If possible, we suggest only using the dishwasher and associated heating booster during off-peak periods to reduce energy costs.

- Domestic Hot Water:

  While in the boiler room we noted that the tempered water mixing valves were turned to “hot” however, the thermometers displayed only 60-90 degree supply hot water temperate (the hot water feed was warm to the touch but not hot as would be expected). The water heater was reading around 130 degree water. Something is obviously not performing as intended; however, the situation is actually saving energy by reducing the quantity of hot water consumed. If not having warm/hot water (safe temperature is less than 120 degrees) to the toilet rooms is acceptable by local code officials and school administration, then the current situation actually is energy efficient.

  A hot water circulating pump was not observed; however, the pipes were insulated and marked as having electric heat trace tape on the hot water supply piping. The energy management system is located in the boiler room and has available inputs. A time clock could be installed on the domestic hot water heater to control the heat tape and water heater operating times. It's our understanding that facility maintenance could install the time clock and integrating with the EMS should also be rather easy; therefore, this is considered a no cost/low cost energy conservation measure.

- Due to the construction of the existing RTUs with face and bypass dampers and the return air and supply air configuration, installation of heat recovery wheels on the units is not considered a prudent ECM. However, these units are around 10-years old and have a typical expected useful life of around 20-years before significant repairs/rebuilding or replacement is warranted. When significant repairs/rebuilding or replacement is warranted, further consideration should be given to installing heat recovery wheels to recapture the heat in the exhaust air. Considering the required capital expense anyway, providing heat recovery wheels might be an ECM in the future.
- During our site visit we noted approximately six (6) thru-window units. Assuming that a unit at most gets used for cooling 5 times in August, 10 in September, and 20 in June at 6 hours each time, the annual cooling hours might be only around 210 hours. Based on our estimations, replacing the existing units with new energy star units is not considered a prudent ECM due to the relatively limited use and resulting high payback periods of over 15-years. However, even with the limited use, when replacement is required, we suggest purchasing the Energy Star units which can have a relatively quick payback period compared to a non-Energy Star rated unit.

- During our site visit we noted items covering the vent grates of the classroom radiant heaters. Ensuring that these grates are not covered or blocked would slightly increase the building's energy efficiency.
- Hot water for heating is provided by two Burnham natural gas-fired cast iron sectional boilers manufactured around 1999; each unit is rated for a gross hot water capacity of 3,353-BTU/HR. These boilers provide hot water to the RTUs and radiant baseboard heaters. Based on the observed testing data tags from 2008, the boilers had an efficiency of around 85%. Conventional boilers are typically approximately 80-85% efficient at full fire. When the boilers are less than full fire or cycling on and off the efficiencies are typically much lower. During periods of low demand, boiler efficiency can be much lower than the units overall efficiency. Although more expensive than their traditional counterparts, condensing boilers are more efficient than traditional water tube boilers and maintain high efficiency over a wide range of return water temperature and demand. Similar applications in Massachusetts have shown significant boiler efficiency improvement. We considered replacing one of the existing boilers with a condensing boiler; however, due to the large size boiler and resulting relatively large capital investment along with the relatively low amount of natural gas typically consumed for heating (around 30,500-therms per year) we estimated a simple payback period of around 19.5-years. Therefore replacing a boiler is not considered a prudent ECM.

6 Operational and Maintenance Analysis

The quality of the maintenance and operation of the facility's energy systems has 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. Caulking and weather stripping is functional and effective.
2. Holes are patched in the building envelope.
3. Cracked or fogged windowpanes are repaired.
4. Cracked or fogged skylights are replaced
5. Automatic door closing mechanisms are functional.
6. Interior vestibule doors are closed.
7. Doors that receive higher use should be frequently checked for appropriate weather stripping.

Heating and Cooling

8. Temperature settings are reduced in unoccupied areas and set points are seasonally adjusted.
9. Control valves and dampers are fully functional. Air dampers are operating correctly.
10. Equipment is inspected for worn or damaged parts.
11. Hot air registers and return air ductwork are clean and unobstructed.
12. Heating is uniform throughout the designated areas.
13. Evaporator and condenser coils in AC equipment are clean.
14. Air filters are clean and replaced as needed.
15. Ensure items are not stored on the grates of the classroom ventilators
16. Thru-window units should be removed during the winter season

Domestic Hot Water

17. Domestic hot water heater temperature is set to the minimum temperature required.
18. All hot water piping is insulated and not leaking.
19. Tank-type water heaters are flushed as required.

Lighting

20. Only energy efficient replacement lamps are used and in-stock.
21. Lighting fixture reflective surfaces and translucent covers are clean.
22. Walls are clean and bright.
23. Timers and/or photocells are operating correctly on exterior lighting.

Miscellaneous

24. Refrigerator and freezer doors close and seal correctly.
25. Office/computer equipment is either in the "sleep" or off mode when not used.
26. All other recommended equipment specific preventive maintenance actions are conducted,
27. Usage demands on the building/equipment have not changed significantly since the original building commissioning or the most recent retro-commissioning.
28. All equipment replacements are not over/undersized for the particular application, and
29. All equipment replacements should be with energy conserving and/or high efficiency devices.
30. Having a nighttime janitorial/cleaning staff can lead to energy waste when the same work can be shifted to the daytime when the building is typically occupied anyway. A nighttime crew requires the building to be conditioned and illuminated.
31. It is recommended that all computers be configured to go into sleep mode after a predetermined time. Instructions for installing this feature on any computer are available from the following Energy Star website: http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_implementation_res#tech_assistance

7 Clean Technology Opportunities

The Commonwealth of Massachusetts is dedicated to promoting clean energy as an alternative to traditional sources of energy. As such, the DOER and other agencies have developed a number of programs to promote the use of clean energy sources by potentially providing technical assistance and/or financial incentives based on project feasibility. A brief discussion of the various programs is provided below, along with specific projects that may be appropriate for the respective technologies.

Solar Energy

Through the Commonwealth Solar Program[1], rebates are offered to encourage the installation of solar photovoltaic (PV) power by homeowners, businesses and municipalities. The rebate program is designed to help defray the costs that are associated with the installation of eligible systems from 20% - 60%. Rebate applications have been available since January 23, 2008. Incentives are greater for projects on public buildings and those that incorporate products manufactured in Massachusetts. The rebates are available for systems that will be directly owned by the applicant, as well as those financed through a third-party ownership model that takes advantage of federal and state tax credits. A total of $68 million is available over the next four years. The following table provides the initial rebate levels:

Non-Residential Rebates for Incremental Capacity ($/Watt)				
Incremental Capacity	**First:** **1 to 25 kW**	**Next:** **> 25 to 100 kW**	**Next:** **> 100 kW to 200 kW**	**Next:** **> 200 kW to 500 kW**
Base Incentive	$3.15	$3.00	$2.00	$1.40
PLUS: Additions to Base Incentives				
Massachusetts Manufactured System	$0.15	$0.15	$0.15	$0.15
Public Building	$1.00	$1.00	$1.00	$1.00

Third-Party PV Financing Resources

MTC and DOER encourage applicants to explore various options for financing their PV project. One such option is known as Third-Party Financing. With Third-Party Financing, the PV system is owned and operated by an entity that is separate from the building owner or the PV installer. The Third-Party Financing entity has sufficient financial capital to pay for the entire installation and to maintain and operate the system over its lifetime. In return, the building owner, or “host” site, signs a long term contract agreeing to purchase all the power produced by the PV system.

Third-Party Financing is a way to install a large PV array with little or no up-front capital expense from the building owner or “host” site. This type of financing may be most applicable to entities such as non-profits or public buildings. The Third-Party PV Owner can utilize the substantial tax incentives available for PV projects, along with rebates and other incentives, plus the sale of the electricity from the PV array to finance the PV project.

Solar Hot Water

The State supports the use of solar hot water systems and the payback periods are generally attractive for buildings with high water usage. Systems are generally composed of solar thermal collectors, a fluid system to move the heat from the collector to its point of usage, and a reservoir or tank for heat storage and subsequent use. The systems may be used to heat water for home or business use, for swimming pools, underfloor heating or as an energy input for space heating and cooling and industrial applications. Attractive applications for town buildings and facilities may include municipal pools, schools especially with summer locker room or kitchen usage, fire stations, and public housing facilities. On a periodic basis, the DOER accepts grant applications for solar hot water systems.

[1] Web site: www.commonwealthsolar.org

Solar at Israel Loring Elementary School

Solar PV at Israel Loring Elementary School is not recommended. Even given available incentive programs, a solar photovoltaic will not achieve a justified simple payback.

The current domestic hot water demand is relatively low and not continuous in the summer months. For this reason, a solar hot water feasibility study is not recommended for this facility.

Wind

The Massachusetts Renewable Energy Trust's (MRET) Commonwealth Wind initiative will provide an overarching framework to expand investments for wind energy installations in Massachusetts and help the Commonwealth meet Governor Deval Patrick's 2000 MW by 2020 wind goals as well as the Renewable Portfolio Standard (RPS). MRET will formally launch Commonwealth Wind during the summer of 2009 and additional details on the program will be available then. The three types of projects listed below would qualify for technical and/or financial assistance:

- <u>Commercial scale</u> projects that primarily serve wholesale markets
- <u>Community-scale</u> projects in the 100 kW to approximately2 MW range where the project sponsor and primary beneficiary is a private company or organization, a municipality, or a government agency, and
- <u>Small-scale</u> projects under 100 kW serving residential, small commercial or institutional buildings.

Wind at Israel Loring Elementary School

Based on the wind map of Massachusetts provided by the U.S. Department of Energy, Sudbury is located in a Class 1 or 2 wind region. A Class 1 wind is defined as wind power rated at 0-200 watts/square meter at a height of 50 feet. Class 2 wind is defined as wind power rated at 200 to 300 watts/square meter. These are the lowest wind power designation and regions with a Class 1 and 2 designations are typically not recommended for wind energy projects. A Massachusetts wind resource map can be found at the following web site: http://www.windpoweringamerica.gov/maps_template.asp?stateab=ma

Wood Pellet Fueled Heating

On a periodic basis, the DOER accepts grant applications for wood pellet fueled heating systems[2], which burn pellets made from renewable sources of energy such as compacted sawdust, wood chips, bark and agricultural crop waste. Funding is available to cities, towns, regional school districts, as well as water and wastewater districts. A maximum of $50,000 per project is available for installation; however, applicants may propose greater grant requests, which will be considered based on the merits of the project and available funding. A total of $525,000 is available for this program. The grantee is responsible for repaying 30% of the funds granted within one year of the completed installation.

Wood Pellet Heating for Israel Loring Elementary School

Biofuels are typically attractive alternatives as a heating fuel in locations where wood pellets are available in bulk, the heating demand is sufficient to justify the investment, and when heating fuels with a greater cost than natural gas are the only alternatives. Sudbury does not meet this profile and biofuel heating is not recommended as a cost effective alternative.

7.1 Recommended Clean Energy Projects for Israel Loring Elementary School

Based on this audit, and due to its location, Israel Loring Elementary School does not currently exhibit a building profile that would lend itself to implementation of these clean technologies.

[2] http://www.mass.gov/Eoca/docs/doer/pub_info/doer_pellet_guidebook.pdf

8 Other Considerations

In addition to the actions recommended in Section 6 of this report, the following recommendations should also be considered.

In general, the diligent operation and manual control of the building systems by the facilities director contributes to the energy efficiency of the building. However, ASHRAE and model building codes require minimum indoor air quality (IAQ) standards for school buildings. Some of the indicated manual operations and equipment set-points within the energy management system might not conform to standards and ensure minimum air quality standards are being met in all spaces at all times. Although the diligent operation and control of the building systems by the facilities director contributes to the energy efficiency of the building, we suggest fine tuning the control system and sequences in order to eliminate the need for manual override operations.

The circulating pumps have been upgraded with variable frequency drive controls. However, the complete capabilities of the VFDs are not being realized as it was indicated that the frequency drives are manually adjusted essentially reducing the motor horsepower which would reduce energy consumption. However, the circulating pumps are not operated as variable flow even though they are equipped with variable frequency drive controls.

During our site visit, a teacher of the language disability classroom complained that the interior of the classroom does not get heated during the winter months. The classroom is provided with the typical perimeter radiant heaters; however, the language disability classrooms have the pitched metal roofs for about 10-feet of the classroom along the exterior wall. The pitched area is higher than the typical dropped tile ceiling. We anticipate that the radiant heat form the baseboards are being trapped by the high pitched ceiling and the heat does not flow into the central portion of the classrooms. One possible alternative would be to install a drop tile ceiling at the pitched roof areas that would be at the same height as the rest of classroom thus eliminating the anticipated heat trap. Please note that the language disability classrooms are also unique in the fact that they used to be one large classroom that was subdivided into two areas.

9 Appendices

ECM Calculations

Lighting Upgrade **250w Metal Halide** **to** **T5 3 Lamp 54w 4' Electronic Ballast**
400w Metal Halide **to** **T5 4 Lamp 54w 4' Electronic Ballast**

Location: Cafeteria and Hallway

	Fixture	Cost / Fixture Installed	Number of Fixtures	Watts / Fixture	Hours / Year of Illumination	KWH / Year	Cost / KWH	Total Energy Cost / Year	Annual KWH Saved	**Total Cost to Implement**	**Annual Cost Saving**	**Years to Payback**
Existing												
a.	250w Metal Halide		8	300	1500	3600	$0.19	$684				
b.	400w Metal Halide		8	455	1500	5460	$0.19	$1,037				
Recommended												
a.	T5 3 Lamp 54w 4' Electronic Ballast	$250	8	170	1500	2040	$0.19	$388	1560	**$2,000**	**$296**	**6.7**
b.	T5 4 Lamp 54w 4' Electronic Ballast	$300	8	234	1500	2808	$0.19	$534	2652	**$2,400**	**$504**	**4.8**
						exist	recome					
				Total:	1500	9060	4,848		4212	**$4,400**	**$800**	**5.5**

Vending Machine Controls

Step 1	Obtain total cost of installing timers on all vending machines			
	Number of machines	2	$250	$
Step 2	Transfer the following information from the Survey:			
a	Annual hours machines are required to be on:		6,500	
b	Number of machines:		2	
c	Watts per machine:		150	Watts
d	Cost of electricity:		0.1900	$/kWh
	Run time with timers		70%	
Step 3	Calculate existing energy consumption :			
	2a: 6,500 x 2b: 2 x 2c: 150 / 1,000	=	1,950	kWh/yr
Step 4	Calculate energy consumption with timers:			
	4,550 x 2b: 2 x 2c: 150 / 3: 1,000	=	1,365	kWh/yr
Step 5	Calculate annual energy savings:			
	3: 1,950 - 4: 1,365	=	585	kWh/yr
Step 6	Calculate annual cost savings:			
	5: 585 x 2d: 0.1900	=	$111	$/yr
Step 7	Calculate payback period:			
	1: 500 / 6: 111	=	4.5	yrs

Replace Refrigerator

Step 1	Obtain total cost of replacing older refrigerators with high-efficiency units:						
	cost per unit:	$550				$550	$
Step 2	Transfer the following information from the Survey:						
4-13	**a** Total number of units					1	
5-9	**c** Cost of electricity:					0.19	$/kWh
Step 3	Obtain the following value from Table 1:						
Table 1	Approximate annual energy use of each old refrigerator:					800	kWh/yr
Step 4	Calculate annual energy savings per refrigerator:						
		3					
		800	-	383	=	417	kWh/yr
Step 5	Estimate annual energy savings:						
		2a		4			
		1	x	417.00	=	417	kWh/yr
Step 6	Calculate annual cost savings:						
		5		2c			
		417	x	0.19	=	$79	$/yr
Step 7	Calculate payback period:						
		1		6			
		550	/	79	=	6.9	yrs

Size	Unit Cost	Make	Model	Energy Savings
15.0 CF	716	Whirlpool	ET5WSEXS	442
18.0 CF	776	Whirlpool	ET8FTEXS	486

Table 1: Energy Use of Existing Refrigerators

Entered
Calculated

Age	**Energy Use**
1970s	1400 kWh/yr
Early 1980s	1100 kWh/yr
Late 1980s	800 kWh/yr

Cost/Benefit Worksheet

ECM No. 33: Replace Older Refrigerators with High Efficiency Units

Step 1	Obtain total cost of replacing older refrigerators with high-efficiency units:						
	cost per unit:	$550				$550	$
Step 2	Transfer the following information from the Survey:						
4-13	**a** Total number of units					1	
5-9	**c** Cost of electricity:					0.19	$/kWh
Step 3	Obtain the following value from Table 1:						
Table 1	Approximate annual energy use of each old refrigerator:					543	kWh/yr
Step 4	Calculate annual energy savings per refrigerator:						
		3					
		543	-	383	=	160	kWh/yr
Step 5	Estimate annual energy savings:						
		2a		4			
		1	x	160.00	=	160	kWh/yr
Step 6	Calculate annual cost savings:						
		5		2c			
		160	x	0.19	=	$30	$/yr
Step 7	Calculate payback period:						
		1		6			
		550	/	30	=	18.1	yrs

Size	Unit Cost	Make	Model	Energy Savings
15.0 CF	716	Whirlpool	ET5WSEXS	442
18.0 CF	776	Whirlpool	ET8FTEXS	486

Table 1: Energy Use of Existing Refrigerators

Entered
Calculated

Age	**Energy Use**
1970s	1400 kWh/yr
Early 1980s	1100 kWh/yr
Late 1980s	800 kWh/yr

DCV in Gym

Cost to install CO2 sensors for each ventilation unit =		$	1,000
Total number of ventilation units =			2
Total cost to install DCV in the Gymnsium =		**$**	**1,200**
Cost of energy modeled without DCV (from hourly analysis) =		$	2,602
Cost of energy modeled with DCV (from hourly analysis) =		$	2,188
Annual Cost of energy saved		**$**	**414**
Cost of energy	$/therm		1.68
Energy Saved	therms		247
Simple Payback (yrs)			**4.9**

DCV and VFDs on Café RTUs			
Cost to install CO2 sensors in each ventilation unit =		$	1,000
Total number of ventilation units =			1
Total cost to install DCV in the Cafeteria =		**$**	**1,000**
Cost of energy modeled without DCV (from hourly analysis) =		$	2,170
Cost of energy modeled with DCV (from hourly analysis) =		$	1,785
Annual Cost of energy saved		**$**	**385**
Cost of energy	$/therm		1.68
Energy Saved	therms		229
Simple Payback (yrs)			**4.4**

Multiply the square feet of the space by the following factors to get the cost:

	w/o DCV	w/DCV
Gym	0.471	0.396
Cafeteria	0.434	0.357
Auditorium	0.565	0.484
Library	0.756	0.67

Total Cost	$	6,000
Annual Savings	$	1,549
Simple Payback		3.9

Install VFDs

Step 1		Obtain total cost of installing VFDs on motors	
		Number of motors 1	$5,000 $
Step 2		Transfer the following information from the Survey:	
4-84	**a**	Annual hours of operatation:	2,500
4-80	**b**	Percent of rated Speed:	70%
4-81	**c**	Total running HP:	10 HP
5-9	**d**	Cost of electricity:	0.19 $/kWh
		Run time with at reduced speed	50%
Step 3		Calculate existing energy consumption :	
		2a: 2,500 x 1.00 x 2c: 10.0 x 0.746 =	18,650 kWh/yr
Step 4		Calculate energy savings with VFDs:	
		1,250 x 2b: 0.66 x 2c: 10.0 x 3: 0.746 =	6,127 kWh/yr
Step 6		Calculate annual cost savings:	
		6127 x 0.190 =	$1,164 $/yr
Step 7		Calculate payback period:	
		1: 5,000 / 6: 1164 =	4.3 yrs

entered
calculated

Convert Pilot Lights

Typical Annual Pilot Light Consumption =	10	therms/year
Number of Pilot Lights =	4	
Cost of Natural Gas =	$1.68	therm
Cost to retorfit to electrcnic ignition/pilot light	$150	

Annual Energy Savings	40	therms
Cost:	$600	
Annual Savings	$ 67	
Simple Payback	8.9	

Off-line Water Heater

Current Usage:	Stand-by Loss	
Stand-by heat loss	1	degree per hour
Volume	125	gallons
Fuel Rate ($/therm)	1.68	
Consumption		
Therms per Year	91	
Capital Cost	$150	
Consumption Cost	$153	
Simple Payback	**1.0**	**year**