Energy Audit

Ephraim Curtis Middle School

22 Pratts Mill Road
Sudbury, MA 01776

Prepared for:
Massachusetts Department of Energy Resources
Energy Audit Program

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FEC Project No.: F09-015-02

Report Date: June 26, 2009

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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, Ephraim Curtis Middle School, located at 22 Pratts Mill Road, 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 27, 2009.

1.1 General Description of Building

The Ephraim Curtis Middle School in Sudbury, MA reportedly contains 155,000 square feet and was constructed around 1999-2000. The building includes a 3-story classroom section that serves around 1,000 students in grades 5th through 8th.

Since the relatively recent construction, significant energy upgrades include:

- Installation of variable frequency drives (VFD) for the hot water circulating pumps
- Conversion of air handling unit control from face and bypass dampers to hot water valves

Mr. Joe Kupczewski, Supervisor of Facilities, served as the on-site representative for the energy audit.

1.2 ECM Table

FEC has identified 6 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 Upgrades	$12,000	-5.30	13104			6365			48.6%		0	$1,273
2	Vending Machine Controls	$250	-0.14	2,925			878			30.0%		0	$176
3	VFDs on RTUs	$58,000	-28.18	214475			70,455			32.9%		0	$14,091
4	Pilot Light Conversion	$900			6			6			100.0%	0	$93
5	Shut Down Water Heater	$250			16			16			100.0%	0	$255
6	Condensing Boiler(s)	$120,000			6000			540			9.0%	0	$8,370
	Total	$191,400	-33.62	1274700	6486	0	77697	562	0	6.1%	8.7%	0	$24,257

1.3 Financial Summary

If these ECM’s are implemented, Ephraim Curtis Middle School can potentially save approximately $24,257 per year with an investment of $191,400.

1.4 Clean Tech

There currently does not appear to be clean technology opportunities available at Ephraim Curtis Middle 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 Ephraim Curtis Middle School in Sudbury, MA reportedly contains 155,000 square feet and was constructed around 1999-2000. The building includes a 3-story classroom section that serves around 1,000 students in grades 5th through 8th.

The building is typically occupied from 7:00 am to 3:00 pm during the school year with some night functions each week in the auditorium or cafeteria. The gym is used during the summer months.

The building has colored split-face concrete block exterior walls with interior steel framing. The roofs are low-slope single-ply EPDM membrane systems supported by the steel framing. The windows are double-pane insulated units typically with internal sunshades. Celestial skylights are provided in the cafeteria and library. The main entrance includes a vestibule while other exterior doors are typically insulated steel doors with glazing sections.

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	Total Cooling Capacity MBH	Hot Water Heating MBH
RTU-1	Science Prep	1,260	1,260	5	62	95
RTU-2	Interior Classroom	16,260	6,500	15	565	375
RTU-3	Classroom	11,275	11,275	10	NA	852
RTU-4	Classroom	9,150	9,150	15	NA	691
RTU-5	Office	8,645	2,350	10	276	176
RTU-6	Kitchen	6,050	6,050	7.5	NA	541
RTU-7	Library	10,350	2,500	15	330	365
RTU-8	Cafeteria	6,400	4,500	7.5	201	419
RTU-9	Office	4,950	1,755	7.5	173	134
RTU-10	Gym	7,000	5,100	7.5	NA	623
RTU-11	Locker Rooms	1,150	1,150	2	NA	86
RTU-12	Auditorium	12,000	7,500	15	518	693
RTU-13	Electronics	2,650	1,050	3	83	111
RTU-14	Music	2,700	2,700	3	NA	204

- Variable-air-volume (VAV) boxes typically distribute the conditioned air in each zone. The library, gym, and cafeteria RTUs are provided with carbon dioxide detectors. Rooftop units provided with air-conditioning also have air-side economizers.
- Eight (8) heat pump unit ventilators have been added to the science classrooms on the north side of the building.
- Hot water for heating is provided by three Burnham boilers manufactured around 2000; each unit is rated for a gross hot water output capacity of 4,551-BTU/HR.
- The hot water is distributed by two 40-horsepower motors with 94.5% efficiencies and pumps that supply hot water to the rooftop air-handling units. The circulating pumps have been upgraded with variable frequency drive controls.
- The building has Direct Digital Controls (DDC) by Delta with remote capabilities.

The domestic hot water is supplied by two 225-gallon natural gas-fired water heaters rated at 600,000-BTUH input capacities each.

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, the library and cafeteria have some metal halide lights. Exterior site lighting is provided by pole-mounted fixtures controlled by individual photo cells.

The interior areas of the building are primarily finished with drywall or painted concrete blocks, 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	$ 0.196/kWh	$ 249,698
Gas	NGRID	$ 1.67/therm	$ 103,564
#2 Oil			
Water & Sewer		NA	NA
Propane Gas		NA	NA
TOTALS			**$ 353,262**

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)
155,000	$ 353,562	$2.28	72

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. Ephraim Curtis Middle School's energy intensity is 72 KBTU/SF/YR with an energy cost of $2.28 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 47th 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	47	47	75	N/A	50
Energy Intensity					
Site (kBtu/ft2)	72	72	55	N/A	70
Source (kBtu/ft2)	141	141	108	N/A	138
Energy Cost					
$/year	$ 353,348.00	$ 353,348.00	$ 270,285.40	N/A	$ 345,626.97
$/ft2/year	$ 2.28	$ 2.28	$ 1.74	N/A	$ 2.23
Greenhouse Gas Emissions					
$MtCO_2e$/year	908	908	695	N/A	888
$kgCO_2e$/ft2/year	6	6	5	N/A	6

5 Energy Conservation Measures

5.1 ECM Summary

FEC has identified 6 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
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#	Description	Installed Cost		KWh	Primary Fuel	Backup Fuel	KWh	Primary Fuel	Backup Fuel	KWh	MMBTU		
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2	Vending Machine Controls	$250	-0.14	2,925			878			30.0%		0	$176
3	VFDs on RTUs	$58,000	-28.18	214475			70,455			32.9%		0	$14,091
4	Pilot Light Conversion	$900			6			6			100.0%	0	$93
5	Shut Down Water Heater	$250			16			16			100.0%	0	$255
6	Condensing Boiler(s)	$120,000			6000			540			9.0%	0	$8,370
	Total	$191,400	-33.62	1274700	6486	0	77697	562	0	6.1%	8.7%	0	$24,257

If these ECM's are implemented, the Ephraim Curtis Middle can potentially save approximately $24,257 per year with an investment of $191,400.

5.2 ECM Discussion

FEC has identified 6 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

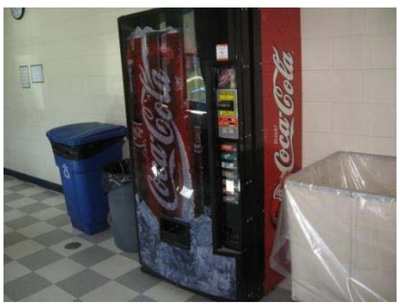
Library Lighting

The cafeteria has fourteen (14) 400-watt metal halide units and the library has ten (10). We estimate that the lights are on around 1,200 hours per year.

Recommendation: Replace the metal halide fixtures with energy efficient T5 fixtures.

Cost to implement	$12,000	Est. annual cost savings	$1,273	Payback period	9.4 years

5.2.2 Install Timers on the Vending Machines



Vending Machine

We observed three (3) 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	$750	Est. annual cost savings	$176	Payback period	4.3 years

5.2.3 Install VFD Fan Speed Control for Rooftop Units

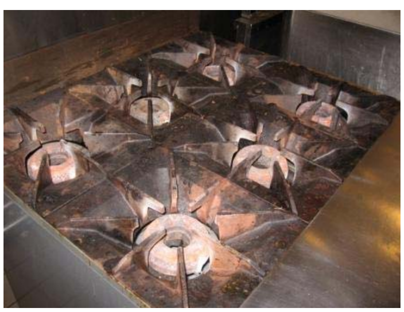
Rooftop Units

Fourteen (14) rooftop units (RTUs) provide heating and cooling for the school. The library, gym, and cafeteria RTUs are provided with carbon dioxide detectors. Rooftop units provided with air-conditioning also have air-side economizers. The supply air capacities, minimum outside air, supply fan horsepower and nominal heating and cooling capacities are indicated in the table at the front of the report.

Recommendation:
It is recommended to install Variable Frequency Drives (VFD) to control the fan speed at RTUs with more than 5-horsepower motors. In periods of low demand for air flow, the supply fans shall slow to match demand. Work will require electrical, mechanical and automatic controls contractors to implement. This ECM will reduce heating and cooling energy required to condition unnecessary air and will reduce electric energy for fan operation.

Cost to implement	$58,000	Est. annual cost savings	$14,091	Payback period	4.1 years

5.2.4 Convert Range Pilot Light to Electronic Ignition



Kitchen Range

The kitchen range is natural gas and has six 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	$900	Est. annual cost savings	$93	Payback period	9.7 years

5.2.5 Take offline one of the two Hot Water Heaters

Domestic Water Heaters

The domestic hot water is supplied by two 225-gallon natural gas-fired water heaters rated at 600,000-BTUH input capacities each. The site contact reported the water heaters change lead positions however; both tanks maintain hot water throughout the year. The combined 450-gallon size capacity appears too large given the middle school (5th thru 8th grade). Replacing the existing water heaters with electric on-demand point-of-use water heaters is not considered a prudent ECM given the 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 $250 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	$250	Est. annual cost savings	$255	Payback period	1.0 years

5.2.6 Replace Existing Boiler with a Condensing Boiler

Existing Burnham Boilers

Hot water for heating is provided by three Burnham cast iron sectional boilers manufactured around 2000; each unit is rated for a gross hot water capacity of 4,551-BTU/HR. These boilers provide hot water to the rooftop air-handling units. Based on the observed testing data tags from 2008, the boilers had an efficiency of around 82%. 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 measured combustion efficiency at full fire.

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.

Recommendation: It is recommended that one existing boiler be replaced with an equivalently-sized condensing boiler or boilers. Controls would need to be updated that would allow the condensing boiler to always be the boiler at partial load. This strategy has the effect of maximizing the advantages of the condensing boiler without incurring the cost of replacing all of the boiler capacity with more expensive condensing boilers. Please note that mixing condensing and conventional boilers on the same system requires engineering design. It is likely that two condensing boiler may be required to match the capacity of one of the existing boilers. The cost for two condensing boiler is included in the calculation.

Cost to implement	$120,000	Est. annual cost savings	$8,370	Payback period	14.3 years

5.3 Other ECMs Considered

No other ECMs were considered.

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. Automatic door closing mechanisms are functional.
5. Interior vestibule doors are closed.
6. Doors that receive higher use should be frequently checked for appropriate weather stripping.

Heating and Cooling

7. Temperature settings are reduced in unoccupied areas and set points are seasonally adjusted.
8. Control valves and dampers are fully functional.
9. Equipment is inspected for worn or damaged parts.
10. Hot air registers and return air ductwork are clean and unobstructed.
11. Air dampers are operating correctly.
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.

Domestic Hot Water

15. Domestic hot water heater temperature is set to the minimum temperature required.
16. All hot water piping is insulated and not leaking.
17. Tank-type water heaters are flushed as required.
18. Please refer to our previous discussion related to only using one water heater throughout the year

Lighting

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

Miscellaneous

23. Refrigerator and freezer doors close and seal correctly.
24. Office/computer equipment is either in the "sleep" or off mode when not used.
25. All other recommended equipment specific preventive maintenance actions are conducted,
26. Usage demands on the building/equipment have not changed significantly since the original building commissioning or the most recent retro-commissioning.
27. All equipment replacements are not over/undersized for the particular application, and
28. All equipment replacements should be with energy conserving and/or high efficiency devices.
29. 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
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.

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 Ephraim Curtis Middle School
Solar PV at Ephraim Curtis Middle 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:

- Commercial scale projects that primarily serve wholesale markets
- Community-scale 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
- Small-scale projects under 100 kW serving residential, small commercial or institutional buildings.

Wind at Ephraim Curtis Middle 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 Ephraim Curtis Middle 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 Ephraim Curtis Middle School

Based on this audit, and due to its location, Ephraim Curtis Middle 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 programming in as much as possible the control system sequences in order to eliminate the need for manual override operations.

Based on the observed construction drawings, the rooftop units (RTUs) were designed and installed with face and bypass dampers. According to the facilities director, air handling units operating in cooling mode pick up some heat off of their internal hot water coil even when in bypass mode if hot water is being called for elsewhere in the building. This scenario is particularly costly because both heating and cooling energy is being paid for and canceling each other out. The facility director has been attacking this problem using two solutions. First, he has replaced unit ventilators with stand-alone heat pumps for north-facing spaces that tend to continue to call for heat even when the rest of the building is in cooling mode. This eliminates many hours of both heating and cooling demand in the building. The other solution is to retrofit those air handling units which are most likely to be in cooling mode when the rest of the building still requires heat with hot water flow valves to turn off the hot water to those units which are first to call for heat. Several units have reportedly been retro-fitted and the new valves and static pressure sensors have been purchased for several additional units; the new units will be installed during the summer break. FEC opines that installing the water valves should save energy by limiting the heat transferred unintentionally by units in cooling mode; therefore, we suggest continuing to identify and upgrade the RTUs that tend to operate in cooling mode when the rest of the facility requires heat with water valves.

9 Appendices

ECM Calculations

Lighting Upgrades

400w Metal Halide to T5 4 Lamp 54w 4' Electronic Ballast

Location: Cafeteria and Library

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											
400w Metal Halide		24	455	1200	13104	$0.20	$2,621				
Recommended											
T5 4 Lamp 54w 4' Electronic Ballast	$500	24	234	1200	6739	$0.200	$1,348	6365	**$12,000**	**$1,273**	**9.4**

Vending Machine Controls

Step 1 Obtain total cost of installing timers on all vending machines

Number of machines	3		$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:	3	
c	Watts per machine:	150	Watts
d	Cost of electricity:	0.2000	$/kWh
	Run time with timers	70%	

Step 3 Calculate existing energy consumption :

2a		2b		2c					
6,500	x	3	x	150	/	1,000	=	2,925	kWh/yr

Step 4 Calculate energy consumption with timers:

		2b		2c		3			
4,550	x	3	x	150	/	1,000	=	2,048	kWh/yr

Step 5 Calculate annual energy savings:

3		4			
2,925	-	2,048	=	878	kWh/yr

Step 6 Calculate annual cost savings:

5		2d			
878	x	0.2000	=	$176	$/yr

Step 7 Calculate payback period:

1		6			
750	/	176	=	4.3	yrs

entered
calculated

Install VFDs	**VFDs on RTUs**		
Step 1	Obtain total cost of installing VFDs on fan motors		
	Number of motors	4	$6,000 $
Step 2	Transfer the following information from the Survey:		
4-84	**a**	Annual hours of operation:	2,500
4-80	**b**	Percent of rated Speed:	70%
4-81	**c**	Total running HP:	15 HP
5-9	**d**	Cost of electricity:	0.2 $/kWh
		Run time with at reduced speed	50%
Step 3	Calculate existing energy consumption :	2a × 2c	
		2,500 x 1.00 x 15.0 x 0.746 =	27,975 kWh/yr
Step 4	Calculate energy savings with VFDs:	2b × 2c × 3	
		1,250 x 0.66 x 15.0 x 0.746 =	9,190 kWh/yr
Step 6	Calculate annual cost savings:		
		9190 x 0.200 =	$1,838 $/yr
Step 7	Calculate payback period:	1 / 6	
	entered / calculated	6,000 / 1838 =	3.3 yrs

Install VFDs	**Install Variable Frequency Drives on rooftop units**		
Step 1	Obtain total cost of installing VFDs on fan motors		
	Number of motors	1	$5,000 $
Step 2	Transfer the following information from the Survey:		
4-84	**a**	Annual hours of operation:	2,500
4-80	**b**	Percent of rated Speed:	70%
4-81	**c**	Total running HP:	7.5 HP
5-9	**d**	Cost of electricity:	0.2 $/kWh
		Run time with at reduced speed	50%
Step 3	Calculate existing energy consumption :	2a × 2c	
		2,500 x 1.00 x 7.5 x 0.746 =	13,988 kWh/yr
Step 4	Calculate energy savings with VFDs:	2b × 2c × 3	
		1,250 x 0.66 x 7.5 x 0.746 =	4,595 kWh/yr
Step 6	Calculate annual cost savings:		
		4595 x 0.200 =	$919 $/yr
Step 7	Calculate payback period:	1 / 6	
	entered / calculated	5,000 / 919 =	5.4 yrs

Install VFDs	**Install Variable Frequency Drives on rooftop units**		
Step 1	Obtain total cost of installing VFDs on fan motors		
	Number of motors	1	$5,000 $
Step 2	Transfer the following information from the Survey:		
4-84	**a**	Annual hours of operation:	2,500
4-80	**b**	Percent of rated Speed:	70%
4-81	**c**	Total running HP:	10 HP
5-9	**d**	Cost of electricity:	0.2 $/kWh
		Run time with at reduced speed	50%
Step 3	Calculate existing energy consumption :	2a × 2c	
		2,500 x 1.00 x 10.0 x 0.746 =	18,650 kWh/yr
Step 4	Calculate energy savings with VFDs:	2b × 2c × 3	
		1,250 x 0.66 x 10.0 x 0.746 =	6,127 kWh/yr
Step 6	Calculate annual cost savings:		
		6127 x 0.200 =	$1,225 $/yr
Step 7	Calculate payback period:	1 / 6	
	entered / calculated	5,000 / 1225 =	4.1 yrs

Install VFDs	**Install Variable Frequency Drives on rooftop units**		
Step 1	Obtain total cost of installing VFDs on fan motors		
	Number of motors	1	$4,000 $
Step 2	Transfer the following information from the Survey:		
4-84	**a**	Annual hours of operation:	2,500
4-80	**b**	Percent of rated Speed:	70%
4-81	**c**	Total running HP:	5 HP
5-9	**d**	Cost of electricity:	0.2 $/kWh
		Run time with at reduced speed	50%
Step 3	Calculate existing energy consumption :	2a × 2c	
		2,500 x 1.00 x 5.0 x 0.746 =	9,325 kWh/yr
Step 4	Calculate energy savings with VFDs:	2b × 2c × 3	
		1,250 x 0.66 x 5.0 x 0.746 =	3,063 kWh/yr
Step 6	Calculate annual cost savings:		
		3063 x 0.200 =	$613 $/yr
Step 7	Calculate payback period:	1 / 6	
	entered / calculated	4,000 / 613 =	6.5 yrs

Pilot Light Conversion

Typical Annual Pilot Light Consumption =	10	therms/year
Number of Pilot Lights =	6	
Cost of Natural Gas =	$1.55	therm
Cost to retorfit to electrcnic ignition/pilot light	$150	

Annual Energy Savings	60	therms
Cost:	$900	
Annual Savings	$ 93.00	
Simple Payback	9.7	

Shut Down Water Heater

Current Usage:	Stand-by Loss	
Stand-by heat loss	1	degree per hour
Volume	225	gallons
Fuel Rate ($/therm)	1.55	
Consumption		
Therms per Year	164	
Capital Cost	$250	
Consumption Cost	$255	
Simple Payback	**1.0**	**year**

Condensing Boiler(s)

Step 1	Obtain total cost of replacing the heating plant, including equipment, labor, structural alterations, etc.							
							120,000	$
Step 2	Transfer the following information from the Survey:							
5-14	**a**	Annual heating fuel consumption:				Gas:	60,000	therm/yr
						Oil:		gal/yr
						Prop		gal/yr
	b	Efficiency of existing plant:					0.78	
5-9	**c**	Cost of heating fuel:				Gas:	1.55	$/therm
						Oil:		$/gal
						Prop		$/gal
Step 3	Estimate efficiency improvement (as a decimal fraction):							
					2b			
			.87	-	0.78	=	0.09	
Step 4	Estimate annual energy savings:							
			3		2a			
		Gas:	0.09	x	60,000	=	5400	
		Oil:	0.09	x	0.00	=	0	
		Propane:	0.09	x	0.00	=	0	$/yr
Step 5	Calculate annual cost savings:							
			4		2c			
		Gas:	5,400	x	1.55	=	8,370	
		Oil:	0.00	x	0.00	=	#REF!	
		Propane:	0.00	x	0.00	=	0	$/yr
Step 6	Calculate payback period:							
			1		5			
		Gas:	120,000	/	8370.00	=	14.3	yrs
		Oil:	120,000	/	#REF!	=	#REF!	yrs
		Propane:	120,000	/	0.00	=	0	yrs