Energy Audit

Gen. John Nixon Elementary School

472 Concord Road
Sudbury, MA 01776

Prepared for:
Massachusetts Department of Energy Resources

Energy Audit Program

Prepared by:

Russell Friend PE

Facility Energy Consultants, LLC

800 Purchase Street, Suite 314
New Bedford, MA 02740

FEC Project No.: F09-015-03

Report Date: June 26, 2009

Table of Contents

Executive Summary

The Massachusetts Department of Energy Resources contracted with Facility Energy Consultants, LLC, (FEC) to conduct an energy audit of the subject property, Gen. John Nixon Elementary School, located at 472 Concord 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 17, 2009.

1.1 General Description of Building

The Gen. John Nixon Elementary School in Sudbury, MA is a single-story school building that reportedly contains around 58,215 square feet. The school was reportedly originally constructed around 1960 and had a significant renovation and expansion around 1995.

Recent significant energy upgrades include:

- Installation of variable frequency drives (VFD) for the hot water circulating pumps
- Installation of a time clock for the domestic hot water heater and circulating pump

The site visit for the energy audit portion was essentially performed unescorted.

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
				Existing			Savings with ECM			% Reduction			
					MMBTU			MMBTU					
#	Description	Installed Cost		KWh	Primary Fuel	Backup Fuel	KWh	Primary Fuel	Backup Fuel	KWh	MMBTU		
1	Vending Machine controls	$250	-0.09	1,950			585			30.0%		0.25	$117
2	Replace Refrigerators	$550	-0.054	859			476			55.4%		0.20	$90
3	DCV and VFDs for Gym AHU	$6,000	-1.838	13,988	121		4,595	19.3		32.9%	15.9%	2.97	$1,199
4	DCV and VFDs for Café AHU	$6,000	-1.225	9,325	92		3,063	16.4		32.9%	17.7%	2.17	$859
5	Convert Pilot Lights	$300			2			2.0			100.0%	0.11	$34
6	Seal and Insulate Ducts	$2,200			150			28.8			19.2%	1.53	$488
7	Replace Windows	$16,000			80			80.1			100.0%	4.24	$1,353
	Total:	**$31,300**	**-3.208**	**345360**	**4705**	**0**	**8,719**	**146.6**	**0**	**2.5%**	**3.1%**	**11.47**	**$4,140**

1.3 Financial Summary

If these ECM's are implemented, Gen. John Nixon Elementary School can potentially save approximately $4,140 per year with an investment of $31,300.

1.4 Clean Tech

There currently does not appear to be clean technology opportunities available at Gen. John Nixon 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 Gen. John Nixon Elementary School in Sudbury, MA is a single-story school building that reportedly contains around 58,215 square feet. The school was reportedly originally constructed around 1960 and had a significant renovation and expansion around 1995. 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 summer use.

The building has face brick exterior walls with concrete block backup. Except for the cafeteria, the roofs are low-slope single-ply EPDM membrane systems supported by the steel framing and concrete block walls. The cafeteria roof is sloped and covered with asphalt shingles. The windows of the addition are double-pane; however, single-pane windows are located at the original sections of the building including the full-height glass walls of the cafeteria. There are windows at the rotunda over the library. We counted approximately ten (10) double-dome acrylic skylights. The main entrance was retrofitted with a glass vestibule while other exterior doors are typically insulated steel doors.

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	Gym	6,000	3,000	7.5	324
RTU-2	Admin/Library	6,190	2,000	7.5	221

- A direct expansion cooling coil was added to the rooftop ductwork of RTU-2 several years after construction to cool the library.
- An overhead-mounted air-handling unit (AHU) provides ventilation and heating (hot water coil) for the cafeteria.
- Besides the RTUs and AHU, heating is provided by the classroom unit ventilators and radiant baseboard heaters.
- Besides the library air-conditioning, cooling is also provided by approximately six (6) thru-window units and three (3) 1½-ton split-systems in select classrooms and offices.
- Hot water for heating is provided by three natural gas-fired Patterson-Kelly boilers manufactured around 1995; each unit is rated for a gross hot water output capacity of 1,380-BTU/HR.
- The hot water is distributed by two 10-horsepower motors with 91.7% efficiencies and pumps that supply hot water to the RTUs, AHU, unit ventilators and baseboard heaters. The circulating pumps have been upgraded with variable frequency drive controls.
- The building control system is a mix between digital Johnson Controls at the front end and pneumatically controlled devices.

The domestic hot water is supplied by a 65-gallon natural gas-fired water heater rated at 360,000-BTUH input capacity; the unit was manufactured in 2004.

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 and cafeteria. Exterior site lighting is provided by a few pole-mounted fixtures controlled by a timer.

The interior areas of the building are primarily finished with painted concrete blocks, vinyl tile or carpet flooring, and exposed structure ceilings.

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	$ 0.188/kWh	$64,855.00
Gas	NGRID	$ 1.69/therm	$47,047.00
#2 Oil		NA	NA
Water & Sewer		NA	NA
Propane Gas		NA	NA
TOTALS			**$ 111,902.00**

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)
58,215	$ 111,902	$1.92	68

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 Gen. John Nixon Elementary School's energy intensity is 68 KBTU/SF/YR with an energy cost of $1.92 per square foot. Both of these figures are relatively 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 62nd 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	62	62	75	N/A	50
Energy Intensity					
Site (kBtu/ft2)	68	68	60	N/A	76
Source (kBtu/ft2)	118	118	103	N/A	132
Energy Cost					
$/year	$ 111,677.00	$ 111,677.00	$ 97,692.75	N/A	$ 124,922.64
$/ft2/year	$ 1.92	$ 1.92	$ 1.68	N/A	$ 2.15
Greenhouse Gas Emissions					
$MtCO_2e$/year	294	294	257	N/A	329
$kgCO_2e$/ft2/year	5	5	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
#	Description	Installed Cost		Existing			Savings with ECM			% Reduction			
				KWh	MMBTU		KWh	MMBTU		KWh	MMBTU		
					Primary Fuel	Backup Fuel		Primary Fuel	Backup Fuel				
1	Vending Machine controls	$250	-0.09	1,950			585			30.0%		0.25	$117
2	Replace Refrigerators	$550	-0.054	859			476			55.4%		0.20	$90
3	DCV and VFDs for Gym AHU	$6,000	-1.838	13,988	121		4,595	19.3		32.9%	15.9%	2.97	$1,199
4	DCV and VFDs for Café AHU	$6,000	-1.225	9,325	92		3,063	16.4		32.9%	17.7%	2.17	$859
5	Convert Pilot Lights	$300			2			2.0			100.0%	0.11	$34
6	Seal and Insulate Ducts	$2,200			150			28.8			19.2%	1.53	$488
7	Replace Windows	$16,000			80			80.1			100.0%	4.24	$1,353
	Total:	**$31,300**	**-3.208**	**345360**	**4705**	**0**	**8,719**	**146.6**	**0**	**2.5%**	**3.1%**	**11.47**	**$4,140**

If these ECM's are implemented, the Sudbury Gen. John Nixon Elementary can potentially save approximately $4,140 per year with an investment of $31,300.

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 Install Timers on the Vending Machines

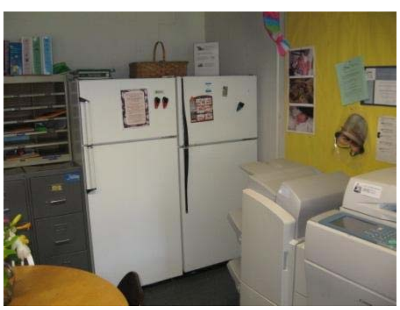
Vending Machine

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	$117	Payback period	4.3 years

5.2.2 Replace Refrigerators



Break room refrigerators

We observed two (2) top freezer refrigerators in the teacher's break room. One unit is 18.2-cubic feet in size, was manufactured in 1992, and based on the information at the Energy Star Refrigerator Retirement Savings Calculator, the unit uses 859-kWh/year. The second unit is 15-cubic feet in size, was manufactured in 1998, and based on the information at the Energy Star Refrigerator Retirement Savings Calculator, the unit uses 650-kWh/year. A new 18.2-cubic foot Energy Star rated unit will use around 383-kWh/year.

Recommendation: It is recommended that the older refrigerator be replaced with Energy Star rated refrigerators.

Cost to implement	$550	Est. annual cost savings	$90	Payback period	6.1 years

5.2.3 Install DCV and VFD Fan Speed Control for Gym Rooftop Unit

Gym Rooftop Unit

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 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.

Cost to implement	$6,000	Est. annual cost savings	$1,199	Payback period	5.0 years

5.2.4 Install DCV and VFD Fan Speed Control for Cafeteria Air-Handling Unit

A ceiling suspended air-handling unit (AHU) is used in the cafeteria to provide heat and the required outside fresh air. Currently, the AHU 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. Please note that access was not provided to the unit and the specifications were not shown on the construction drawings; therefore we have assumed a 5-horsepower supply fan motor.

Cafeteria Air-Handling Unit

Recommendation:
It is recommended to retrofit the cafeteria AHU 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.

Cost to implement	$6,000	Est. annual cost savings	$859	Payback period	6.4 years

5.2.5 Convert Range Pilot Light to Electronic Ignition

Kitchen Range

The kitchen range is natural gas and has two 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	$300	Est. annual cost savings	$34	Payback period	8.9 years

5.2.6 RTU for Library/Admin

Top: RTU for library/admin

Bottom: Damaged ductwork insulation

The addition of 1995 included a rooftop air-handling unit (RTU-2) with a hot water heating coil for the library and administration area. A direct expansion cooling coil was added to the rooftop ductwork after construction in 1999 to cool the library. The supply ductwork of the RTU splits on the roof to serve the library and admin area. The branch serving the library was provided with the DX coil. The rooftop ductwork has insulation; however, the insulation is damaged in areas creating energy leaks. Furthermore, we observed penetrations through the ductwork and conditioned air was being discharged into the ambient air. Duct leakage and inappropriate insulation can be a large source of energy waste.

Recommendation: It is recommended that the ductwork be repaired and reinsulated or the replaced and reinsulated. The cost included is for ductwork repair and replacement of the insulation.

Cost to implement	$2,200	Est. annual cost savings	$488	Payback period	4.5 years

5.2.7 Replace Single-Pane Windows

Single-pane windows

The windows of the addition are double-pane; however, single-pane windows are located at the original sections of the building.

Windows are a major factor in energy use and comfort of a building. The non-thermally broke metal frames and single-pane glazing allow for significant air infiltration and the cold drafts (and conduction) can make the room feel uncomfortable. Appropriately selected windows and sun shades can take advantage of the natural solar heating in the winter and eliminate the large heat gain in the summer months.

Recommendation: It is recommended that old single-pane windows be replaced with new energy efficient double-pane insulated windows. Please note that indications were made that the material on the exterior side of the building under the windows might contain asbestos. The indicated cost below does not consider additional costs for any asbestos remediation that might be required. If required, the payback period would be lengthened.

Cost to implement	$16,000	Est. annual cost savings	$1,353	Payback period	11.8 years

5.3 Other ECMs Considered

- While in the mechanical room, we noted an air leak from near one the compressors. We recommend thoroughly inspecting the pneumatic air system to identify and repair any leaks as part of routine maintenance.

- While on the roof we counted approximately ten (10) 2'x2' double-dome acrylic skylights and one (1) 6'x6' skylight. We noted that one of the small skylights was broken as made evident by condensation between the domes. The broken skylight should be replaced as part of routine maintenance.
- During our site visit we noted approximately six (6) thru-window units as follows:

Area Served	EER	Cooling BTUs
LLD	10.2	15,000
Teachers lounge	8.5	28,500
Nurse	10.1	13,800
Admin	8.5	12,000
Principal	10.2	11,800
Classroom 5	9.5	12,000

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 by comparing some of the existing units to new energy star units, 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 rapid payback from energy savings compared to a non-Energy Star rated unit.

- During our site visit we noted thirteen (13) computer monitors on in the computer lab when the classroom was unoccupied. Computer settings can be adjusted to turn off the monitor and place the machine in sleep mode. 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
- The windows of the addition are double-pane; however, single-pane windows are located at the original sections of the building including the full-height glass walls of the cafeteria. We considered replacing the cafeteria windows, however, the area is not cooled so there would be no energy savings from reducing the heat gain in the summer months. Floor-to-ceiling fabric curtains are provided for the cafeteria windows. In the winter months, we imagine that the potential solar heat gain through the windows might help reduce energy costs to heat the cafeteria. Therefore, replacing the cafeteria windows 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. Thoroughly inspect the pneumatic air system to identify and repair any leaks
16. Ensure items are not stored on the grates of the classroom ventilators
17. Thru-window units should be removed during the winter season

Domestic Hot Water

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

Lighting

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

Miscellaneous

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

Solar PV at Gen. John Nixon 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:

- 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 Gen. John Nixon 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 Gen. John Nixon 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 Gen. John Nixon Elementary School

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

A time clock was installed on the domestic hot water heater that controls the circulating pump and operating times. The addition of this time clock is considered a good energy conservation measure.

During our site visit, we noted items stored on the grates of the classroom ventilators. Items stored on the ventilators will make the units work harder and consume more energy. We suggest that the teachers be reminded to not store items on the ventilators and the janitors or cleaning crew should diligently remove items stored on the ventilators.

9 Appendices

ECM Calculations

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:	0.2000	$/kWh
	Run time with timers	70%	

Step 3 Calculate existing energy consumption :

2a		2b		2c					
6,500	x	2	x	150	/	1,000	=	1,950	kWh/yr

Step 4 Calculate energy consumption with timers:

		2b		2c		3			
4,550	x	2	x	150	/	1,000	=	1,365	kWh/yr

Step 5 Calculate annual energy savings:

3		4			
1,950	-	1,365	=	585	kWh/yr

Step 6 Calculate annual cost savings:

5		2d			
585	x	0.2000	=	$117	$/yr

Step 7 Calculate payback period:

1		6			
500	/	117	=	4.3	yrs

Replace Refrigerators

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:						859	kWh/yr
Step 4	Calculate annual energy savings per refrigerator:							
			3					
			859	-	383	=	476	kWh/yr
Step 5	Estimate annual energy savings:							
			2a		4			
			1	x	476.00	=	476	kWh/yr
Step 6	Calculate annual cost savings:							
			5		2c			
			476	x	0.19	=	$90	$/yr
Step 7	Calculate payback period:							
			1		6			
			550	/	90	=	6.1	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 and VFDs for Gym AHU

Demand Control Ventilation

Cost to install CO2 sensors in each ventilation unit =			$	1,000
Total number of ventilation units =				1
Total cost to install DCV in the Gymnsium =			**$**	**1,000**
Cost of energy modeled without DCV (from hourly analysis) =			$	2,047
Cost of energy modeled with DCV (from hourly analysis) =			$	1,721
	Annual Cost of energy saved		**$**	**326**
	Cost of energy	$/therm		1.69
	Energy Saved	therms		193
	Simple Payback (yrs)			**5.2**

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	$ 1,199
Simple Payback	$ 5.00

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:	7.5	HP
5-9	**d**	Cost of electricity:	0.19	$/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	0.190	=	$873	$/yr

Step 7 Calculate payback period:

1		6			
5,000	/	873	=	5.7	yrs

entered
calculated

DCV and VFDs for Café AHU

Demand Control Ventilation				
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) =			$	1,562
Cost of energy modeled with DCV (from hourly analysis) =			$	1,285
Annual Cost of energy saved			**$**	**277**
Cost of energy		$/therm		1.69
	Energy Saved	therms		164
	Simple Payback (yrs)			**6.1**

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	$	859
Simple Payback	$	6.98

Install Variable Frequency Drives on café AHU

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:									5	HP
5-9	**d**	Cost of electricity:									0.19	$/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	0.190	=		$582	$/yr
Step 7	Calculate payback period:											
						1		6				
	entered					5,000	/	582	=		8.6	yrs
	calculated											

Convert Pilot Lights			
Typical Annual Pilot Light Consumption =		10	therms/year
Number of Pilot Lights =		2	
Cost of Natural Gas =		$1.69	therm
Cost to retrofit to electronic ignition/pilot light		$150	
Annual Energy Savings	20 therms		
Cost:	$300		
Annual Savings	$ 33.80		
Simple Payback	8.9		

Seal and Insulate Ducts

Assumptions:

Typical annual school energy intensity for HVAC in the North East =					25	kbtu/sqft
Loss though uniinsuated and unsealed ductwork =					15%	
Volume served by this RTU =					6000	sf
Boiler efficiency =					78%	
Cost per therm =					$1.69	per therm
Annual space consumption (therms) =	25	x	6000	=	150000	kbtu
Fuel energy demanded (therm)	150000	/	78%	=	192307.7	kbtu
Energy lost from poor ductwork =	192308	x	15%	=	28846	kbtu
				=	288.5	therms
Cost to correct ductwork and replace insulation		=			**$2,200**	
Annual cost savings =	288.5	*	$1.69	=	**$487.50**	
Simple payback =	$2,200	/	$487.50	=	**4.5**	

Replace Windows

This analysis is for replacement of single-pane aluminum frame windows with double-pane low-e coated windows with aluminum frames having thermal breaks, and 1/2" spacing between glazings

Step 1	Obtain total cost of replacing windows:							
	$/window	$1,000	# of windows/u	16	# of units	1	$16,000	
Step 2	Transfer the following information from the Survey:							
4-8	**a**	Heating degree-day zone:					3.43	DDZ
4-18	**b**	Area of windows to be replaced			Each-SF	28	448	sq. ft.
4-17	**c**	Total volume of buildings in development:					169,740	cu. ft.
4-23	**d**	Are existing windows adequately weatherstripped:					Yes	
5-9	**e**	Cost of heating fuel:				Gas:	1.69	$/therm
						Oil:	NA	$/gal
						Electric:	0.1900	$/kWh
						Propane:	NA	$/gal
Step 3	Obtain the following savings factors from Tables 1 and 2:							
Table 1	**a**	Conductance savings factor:					0.180	
Table 2	**b**	Infiltration savings factor:					0.0009	

Step 4 Estimate annual energy savings due to conduction losses:

2a		2b		3a			
3.43	x	448	x	0.180	=	277	/yr

Step 5 Estimate annual energy savings due to infiltration losses:

2a		2c		3b			
3.43	x	169,740	x	0.0009	=	524	/yr

Step 6 Estimate total energy savings:

4		5			
277	+	524	=	801	/yr

Step 7 Calculate annual cost savings:

	6		2e		
Energy	801	x	1.690	=	$1,353

Step 8 Calculate your payback period:

1		7			
$16,000	/	$1,353	=	11.8	yrs

Table 1: Conductance Savings Factor

Fuel	**Savings Factor**
Gas	0.180
Oil	0.129
Electric	3.692
Propane	0.197

Table 2: Infiltration Savings Factors

Adequate Weather-stripping	**Fuel Type** Gas	**Oil**	**Electric**	**Propane**
No	0.0026	0.0019	0.0533	0.0028
Yes	0.0009	0.0006	0.0178	0.0010