Energy Audit

Peter Noyes Elementary School

280 Old Sudbury Road
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, Peter Noyes Elementary School, located at 280 Old Sudbury 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 Peter Noyes Elementary School in Sudbury, MA is a two-story split level school building that reportedly contains around 65,000 square feet. The school was reportedly originally constructed in the 1950s, had an expansion in the 1970s, and a significant renovation around 2000.

Recent significant energy upgrades include:

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

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

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
#	Description	Installed Cost		Existing			Savings with ECM			% Reduction			
				KWh	MMBTU		KWh	MMBTU					
					Primary Fuel	Backup Fuel		Primary Fuel	Backup Fuel	KWh	MMBTU		
1	Vending Machine Controls	$250	- 0.045	975			293			30.0%		0.12	$59
2	DCV and VFDs on Gym AHUs	$10,000	- 3.676	27,975	201.7		9,190	32.1		32.9%	15.9%	5.60	$2,282
3	DCV and VFDs for Café AHU	$5,200	- 1.225	9,325	81.9		3,063	14.5		32.9%	17.7%	2.07	$825
4	Gas Kitchen Appliances	$35,000	- 98.79	71,132	-		71,132	-303.5		100.0%		14.08	$9,016
5	Install Vestibule	$10,000			69.9			69.9			100.0%	3.71	$1,168
6	Condensing Boiler	$110,000			4,250.0			850.0			20.0%	45.05	$14,195
	Total:	**$170,450.00**	**- 103.7**	**422,800**	**4,335**	**0**	**83,678**	**663.1**	**0**	**19.8%**	**15.3%**	**70.62**	**$27,544**

1.3 Financial Summary

If these ECM's are implemented, Peter Noyes Elementary School can potentially save approximately $27,544 per year with an investment of $170,450.

1.4 Clean Tech

The south-facing roof of the Peter Noyes Elementary School may be an optimum location for a solar PV array. It has many positive attributes that would lend themselves to the feasibility of a solar photovoltaic (PV) array. In addition to having a large sloped roof with exposure to the southern sky with no nearby buildings or trees that would cast shadows, the school can benefit from the educational opportunities a solar array can provide.

Typically, schools have low summer electric consumption so they cannot benefit fully from the peak demand reduction cost savings that help to justify the cost. The adjacent town-owned Flynn Building has significant summertime electric demands during peak periods. It may be possible for the school to benefit from the solar array during its peak periods throughout the school year and the Flynn building benefits similarly in the summer. FEC recommends that this location be considered for further study as a potential site for this clean technology.

No other opportunities were identified to take advantage of clean technologies at Peter Noyes 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 Peter Noyes Elementary School in Sudbury, MA is a two-story split level school building that reportedly contains around 65,000 square feet. The school was reportedly originally constructed in the 1950s, had an expansion in the 1970s, and a significant renovation around 2000. 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 4" face brick exterior walls with 6" concrete block backup. The roofs are low-slope single-ply EPDM membrane systems supported by the wood and steel framing. The windows are both double- and single-pane units. The main entrances are typically insulated steel doors with glazing sections without vestibules.

Information from the 1999 renovation drawings about the air-conditioning units such as area served and capacities is included in the table below.

Unit	Area Served	Total CFM	Min. Outside Air	Supply Fan HP	Cooling MBH
RTU-1	Speech	1,200	240	1.5	36
RTU-2	Guidance	1,200	240	1.5	36
AHU-1	Admin/computer	4,555	910	2.9	143
AHU-2	Library/language	6,000	1,200	3.7	189

- According to the drawings reviewed, the terminal devices for the RTUs are constant volume fan powered mixing boxes while the terminal devices for the AHUs are variable-air-volume (VAV) boxes. These systems reportedly have digital controls. The terminal devices have hot water reheat coils.
- Overhead-mounted air-handling units (AHUs) provide ventilation and heating (hot water coil) for the cafeteria and gym.
- Heating is provided by the classroom unit ventilators.
- We noted that two classrooms have thru-window air-conditioners.
- Hot water for heating is provided by two natural gas-fired Cleaver-Brooks fire tube boilers manufactured around 1970; each unit is rated for a gross hot water output capacity of 2,511-BTU/HR.
- Because of the phased construction, there are two separate heating hot water circulating systems. The hot water is distributed by four 5-horsepower motors with 89.5% efficiencies and pumps that supply hot water to the AHUs and classroom unit ventilators. The circulating pumps have been upgraded with variable frequency drive controls.
- The building control system is a mix between digital Honeywell controls and pneumatically controlled devices such as the unit ventilators.

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. Limited exterior site lighting is provided by a couple building- and pole-mounted fixtures reportedly controlled by a timer.

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	$ 0.198/kWh	$72,386.00
Gas	NGRID	$ 1.67/therm	$83,619.00
#2 Oil			
Water & Sewer		Not Available	Not Available
Propane Gas		NA	NA
TOTALS			**$ 156,005**

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)
65,000	$ 156,005	$2.40	89

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 Peter Noyes Elementary School's energy intensity is 89 KBTU/SF/YR with an energy cost of $2.40 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 38th 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	38	38	75	N/A	50
Energy Intensity					
Site (kBtu/ft2)	89	89	63	N/A	81
Source (kBtu/ft2)	144	144	102	N/A	131
Energy Cost					
$/year	$ 156,005.00	$ 156,005.00	$ 110,584.71	N/A	$ 141,420.66
$/ft2/year	$ 2.40	$ 2.40	$ 1.70	N/A	$ 2.18
Greenhouse Gas Emissions					
$MtCO_2e$/year	410	410	291	N/A	372
$kgCO_2e$/ft2/year	6	6	4	N/A	5

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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				KWh	MMBTU		KWh	MMBTU					
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If these ECM's are implemented, the Sudbury' Peter Noyes Elementary can potentially save approximately $27,544 per year with an investment of $170,450

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 Install Timer on the Vending Machine

Vending Machine

We observed a vending machine in the teachers' lounge. 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 a vending machine timer be installed on the vending machine.

Cost to implement	$250	Est. annual cost savings	$59	Payback period	4.3 years

5.2.2 Install DCV and VFD Fan Speed Control for Gym Air-Handling Units

Two (2) ceiling suspended air-handling units (AHUs) are used in the gymnasium to provide heat and the required outside fresh air. Currently, the AHUs are 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 units and the specifications were not shown on the construction drawings; therefore we have assumed 7.5-horsepower supply fan motors.

Gym Air-handling Unit

Recommendation:
It is recommended to retrofit the gym AHUs with common CO2 sensors and related controls to adjust the occupied mode ventilation in response to actual occupancy. The sensors 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	$10,000	Est. annual cost savings	$2,282	Payback period	4.4 years

5.2.3 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 7.5-horsepower supply fan motor.

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	$5,200	Est. annual cost savings	$825	Payback period	6.3 years

5.2.4 Convert Electric Kitchen Equipment to Natural Gas

Electric Kitchen Range

The kitchen range, three convection ovens and a steamer are electric. The heating capacity per dollar unit of electricity is relatively expensive compared to natural gas.

Recommendation: Replace the electric kitchen equipment with natural gas equipment. Cost includes gas range, two convection ovens, and steamer plus installation of natural gas service.

Cost to implement	$35,000	Est. annual cost savings	$9,016	Payback period	3.9 years

5.2.5 Create Vestibule for School Bus Doors

Entrance doors used for the school bus loading and unloading

The main entrance doors used daily for the buses do not have a vestibule which allows for a large volume of conditioned air to escape. The existing configuration wastes energy as the cold outdoor air will need to be heated during the winter months; a vestibule will reduce the amount of uncontrolled ventilation increasing the building's energy performance.

Recommendation: It is recommended that a vestibule be created at the doors used for bus loading.

Cost to implement	$10,000	Est. annual cost savings	$1,168	Payback period	8.6 years

5.2.6 Replace Existing Boilers with a Condensing Boiler

Existing Cleaver-Brooks Boilers

Hot water for heating is provided by two natural gas-fired Cleaver-Brooks fire tube boilers manufactured around 1970; each unit is rated for a gross input capacity of 2,511-BTU/HR. These boilers provide hot water to the AHUs and unit ventilators. Based on the observed testing data tags from 2008, the boilers had an efficiency of around 83-84%. 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.

Recommendation: It is recommended that the existing boilers be replaced with an equivalently-sized standard boiler and condensing boiler. Controls would need to be included 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. Mixing condensing and conventional boilers on the same system requires engineering design.

Cost to implement	$110,000	Est. annual cost savings	$14,195	Payback period	7.7 years

5.3 Other ECMs Considered

During our site visit we noted that single-pane windows are located around the building. We counted approximately 123 single-pane windows that ranged in size from 3'x4' to 6'x6.

- Windows are a major factor in energy use and comfort of a building. The non-thermally broke metal frames and single-pane glazing can 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. Energy savings from the replacement of the single-paned windows with double-paned windows calculated as a potential ECM. Based on a $30/sf window replacement cost, the annual energy savings attributed to the potential ECM was around $3,500/yr with a project cost of around $84,000. This putt the simple payback period of the ECM around 25 years. This was not included as an ECM. The calculation is included in the appendix and if a significantly less expensive window alternative can be found, window replacement may be justified.

- A 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.

- While at the Nixon Elementary school we noticed a time clock was installed on the domestic hot water heater that controls the circulating pump and operating times. The addition of a time clock at the Noyes domestic water heater is considered an energy conservation measure considering that Mr. Kupczewski should easily be able to install a timer as part of routine maintenance.

- Consideration should be given to incorporating the pneumatic compressor with the energy management system so that the compressor does not needlessly maintain system pressure when pneumatic controls are not necessary.

- There are two refrigerators and an upright freezer in the teacher's lounge. The units were manufactured around 2001 and are relatively energy efficient and replacement is not considered a prudent ECM due to the estimated 15+ year payback period.

- During our site visit we noted two (2) 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 compared 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 relatively quick payback period compared to a non-Energy Star rated unit.

- During our site visit we noted twenty-five (25) computer monitors on in the computer lab when the classroom was unoccupied. Computer settings can be adjusted to turn off the monitors and place the machines 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 roof appears to have exceeded its expected useful life as we noted the membrane seams are typically failed and open to water infiltration. Replacement of the roof is anticipated to be required in the near term based on the observed seam conditions. We utilized a US Department of Energy Low-Slope Roof calculator to investigate if a white cool roof would be considered and ECM versus the typical black rubber membrane roof. Since the majority of the building is not air-conditioned, any additional heat gain by a black roof would not be offset by electricity consumption for air conditioning. Based on the DOE calculator, the heating fuel consumption in the winter would most likely increase by around $500 if a cool white roof was chosen due to the decreased heat gain during the winter months. Therefore, since the building is not air-conditioned during the summer months, we suggest a black colored roof versus a white cool roof.

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 Peter Noyes Elementary School
The south-facing roof of the Peter Noyes Elementary School may be an optimum location for a solar PV array. It has many positive attributes that would lend themselves to the feasibility of a solar photovoltaic (PV) array. In addition to having a large sloped roof with exposure to the southern sky with no nearby buildings or trees that would cast shadows, the school can benefit from the educational opportunities a solar array can provide. Typically, schools have low summer electric consumption so they cannot benefit fully from the peak demand reduction cost savings that help to justify the cost. The adjacent town-owned Flynn Building has significant summertime electric demands during peak periods. It may be possible for the school to benefit from the solar array during its peak periods throughout the school year and the Flynn building benefits similarly in the summer. FEC recommends that this location be considered for further study as a potential site for this clean technology.

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 Peter Noyes 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 Peter Noyes 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

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

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 Peter Noyes Elementary School

Based on this audit, and due to its location, a solar photovoltaic system may be a justified clean technology for Peter Noyes Elementary School. It is recommended that this site be considered for a solar PV system.

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. Furthermore, complete realization of the capabilities of the VFDs on the circulating pumps might not be recognized as it was indicated that the frequency is manually adjusted. 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.

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		1							$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:									1		
	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	1	x	150	/	1,000	=		975	kWh/yr	
Step 4	Calculate energy consumption with timers:												
				2b		2c		3					
		4,550	x	1	x	150	/	1,000	=		683	kWh/yr	
Step 5	Calculate annual energy savings:												
						3		4					
						975	-	683	=		293	kWh/yr	
Step 6	Calculate annual cost savings:												
						5		2d					
						293	x	0.2000	=		$59	$/yr	
Step 7	Calculate payback period:												
						1		6					
						250	/	59	=		4.3	yrs	

DCV and VFDs on Gym AHUs

Demand Control Ventilation

Cost to install CO2 sensors in each ventilation unit =	$	1,000
Total number of ventilation units =		2
Total cost to install DCV in the Gymnsium =	**$**	**2,000**
Cost of energy modeled without DCV (from hourly analysis) =	$	3,368
Cost of energy modeled with DCV (from hourly analysis) =	$	2,831
Annual Cost of energy saved	**$**	**536**
Cost of energy	$/therm	1.67
Energy Saved	therms	321
Simple Payback (yrs)		**3.7**

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	$	10,000
Annual Savings	$	2,282
Simple Payback	$	4.4

Install VFDs

Step 1 Obtain total cost of installing VFDs on motors

Number of motors 2 — $8,000 $

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:	15	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	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 0.190 = $1,746 $/yr

Step 7 Calculate payback period:

1		6			
10,000	/	1746	=	5.7	yrs

entered

calculated

DCV and VFDs for Café AHU

Demand Control Ventilation

Cost to install CO2 sensors in each ventilation unit =	$	1,200
Total number of ventilation units =		1
Total cost to install DCV in the Cafeteria =	**$**	**1,200**
Cost of energy modeled without DCV (from hourly analysis) =	$	1,367
Cost of energy modeled with DCV (from hourly analysis) =	$	1,125
Annual Cost of energy saved	**$**	**243**
Cost of energy	$/therm	1.67
Energy Saved	therms	145
Simple Payback (yrs)		**4.9**

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	$ 5,200
Annual Savings	$825
Simple Payback (years)	6.3

Install VFDs

Step 1 Obtain total cost of installing VFDs on motors

Number of motors 1 — $4,000 $

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			
4,000	/	582	=	6.9	yrs

entered
calculated

Gas Kitchen Appliances

Assumptions:
Total annual gas consumption = 43352 therms
Typical gas consumption for cooking ~ 7% of total annual fuel consumption
Cost of gas appliances = **$ 35,000**
Gas appliance efficiency / electric appliance efficiency = 0.8
kwh/therm = 29.3
$/kWh = $ 0.198
$/therm = $ 1.67

Gas

therms/yr for cooking	7%	x	43352	=	3034.64	therms			

Electric

therms/yr for cooking	3034.64	x	0.8	=	2428	therms			
kwh/yr for cooking =	2428	x	29.3	=	71131.96	kWh			
Gas consumption cost	=		3034.64	x	$ 1.67	=	$ 5,068		
Electric consumption cost =			71131.96	x	$ 0.198	=	$ 14,084		
Annual savings with gas =			$ 14,084	-	$ 5,068	=	**$ 9,016**		
Simple Payback (years) =			$ 35,000	/	$ 9,016	=	**3.9**		

Install Vestibule

Step 1 Cost for installing vestibule

			10,000	$

Step 2 Transfer the following information from the Survey:

4-8	**a**	Heating degree-day zone:		3.43	DDZ
4-15	**b**	Average # of occupants:		300	
4-28	**c**	Total number of doors:		4	
4-29	**d**	Average fit of existing doors:		average	
4-30	**e**	Are existing doors weatherstripped:		Yes	
4-32					
4-32	**g**	Thickness of doors (if wood):			Inches
5-9	**h**	Cost of heating fuel:	Gas:	1.67	$/therm
			Oil:	NA	$/gal
			Electric:	NA	$/kWh
			Propane:	NA	$/gal

Step 3 Obtain the following savings factors from Tables 1 and 2:

Table 1	**a**	Conductance savings factor:	0.96
Table 2	**b**	Infiltration savings factor: Based on frequency of operation	50

Step 4 Estimate annual energy savings due to conduction losses:

2a		2c		3a			
3.43	x	4	x	0.96	=	13	/yr

Step 5 Estimate annual energy savings due to infiltration losses:

2a		2c		3b			
3.43	x	4	x	50	=	686	/yr

Step 6 Estimate total energy savings:

4		5			
13.17	+	686.00	=	699	/yr

Step 7 Calculate annual cost savings:

6		2h			
699.17	x	1.67	=	1168	$/yr

Step 8 Calculate your payback period:

1		7			
10000	/	1168	=	8.6	yrs

Table 1: Conductance Savings Factor

Existing Door Type	Gas	Oil	Electric	Propane
Solid Wood 1-3/8"	0.53	0.38	10.9	0.58
Solid Wood 1-3/4"	0.38	0.81	7.8	0.41
Hollow steel	1.06	0.76	21.7	1.16
Insulated Steel	0.96	0.69	19.7	1.05

Table 2: Infiltration Savings Factors

		Existing Door Conditions			
		Non-Weatherstripped			Weather-stripped
Fuel Type	**Occupants**	**Loose**	**Average**	**Tight**	**All Fits**
Gas	2	19.5	12.9	6	1.2
	60	21.3	14.7	7.8	1.8
Oil	2	13.8	9	4.2	0.30
	5	14.7	9.9	5.1	1.5
	>10	22.2	17.5	12.0	3.5
Electric	2	399	261	120	21
	5	423	282	144	45
	>10	460	325	180	60
Propane	2	21.3	14.1	6.6	1.32
	5	22.5	15	7.5	2.28
	>10	29.5	21	14.4	3.25

Condensing Boiler

Step 1	Obtain total cost of replacing the heating plant, including equipment, labor, structural alterations, etc.							
							110,000	$
Step 2	Transfer the following information from the Survey:							
5-14	**a** Annual heating fuel consumption:					Gas:	42,500	therm/yr
						Oil:		gal/yr
						Prop		gal/yr
	b Efficiency of existing plant:						0.71	
5-9	**c** Cost of heating fuel:					Gas:	1.67	$/therm
						Oil:		$/gal
						Prop		$/gal
Step 3	Estimate efficiency improvement (as a decimal fraction):							
					2b			
			.91	-	0.71	=	0.2	
Step 4	Estimate annual energy savings:							
			3		2a			
		Gas:	0.20	x	42,500	=	8500	
		Oil:	0.20	x	0.00	=	0	
		Propane:	0.20	x	0.00	=	0	$/yr
Step 5	Calculate annual cost savings:							
			4		2c			
		Gas:	8,500	x	1.67	=	14,195	
		Oil:	0.00	x	0.00	=	#REF!	
		Propane:	0.00	x	0.00	=	0	$/yr
Step 6	Calculate payback period:							
			1		5			
		Gas:	110,000	/	14195.00	=	7.7	yrs
		Oil:	110,000	/	#REF!	=	#REF!	yrs
		Propane:	110,000	/	0.00	=	0	yrs