

# Energy Audit



## **Josiah Haynes Elementary School**

169 Haynes 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, Josiah Haynes Elementary School, located at 169 Haynes 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/manufacturers for the purpose of determining more efficient alternatives. The energy audit site visit was performed on June 18, 2009.

### **1.1 General Description of Building**

The Josiah Haynes Elementary School in Sudbury, MA is a single-story school building that reportedly contains around 62,811 square feet. The school was reportedly originally constructed in the 1950s with a significant renovation and expansion around 1999-2000.

Recent significant energy upgrades include:

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

Mr. Glen, Custodian/Janitor, provided access to the subject property for the energy audit site visit.

## 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 <sub>2</sub> ) 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	\$500	0.09	1,950			585			30.0%		0.25	\$105
2	Replace Refrigerator	\$1,100	0.09	1516			750			49.5%		0.32	\$135
3	DCV and VFDs on Gym AHUs	\$6,000	1.84	13,988			4,595			32.9%		1.95	\$1,363
4	DCV and VFDs for Café AHU	\$10,000	2.45	18,650			6,127			32.9%		2.60	\$1,588
5	Pilot Light Conversion	\$600			4			4			100.0%	0.21	\$67
6	Condensing Boiler	\$65,000			4000			400			10.0%	21.20	\$6,680
<b>Total</b>		<b>\$83,200</b>	<b>4.46</b>	<b>386616</b>	<b>4480</b>	<b>0</b>	<b>12,056</b>	<b>404</b>	<b>0</b>	<b>3.1%</b>	<b>9.0%</b>	<b>26.52</b>	<b>\$9,938</b>

### **1.3 Financial Summary**

If these ECM's are implemented, Josiah Haynes Elementary School can potentially save approximately \$9,938 per year with an investment of \$83,200.

### **1.4 Clean Tech**

There currently does not appear to be clean technology opportunities available at Josiah Haynes 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 Josiah Haynes Elementary School in Sudbury, MA is a single-story school building that reportedly contains around 62,811 square feet. The school was reportedly originally constructed in the 1950s with a significant renovation and expansion around 1999-2000. 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 limited use.

The building includes around 27 classrooms, administration offices, kitchen, library, computer lab, cafeteria which includes the stage and is used as a multi-purpose room, and a gymnasium. The building has face brick exterior walls with concrete block backup. Except for the cafeteria and gymnasium, the roofs are low-slope single-ply EPDM membrane systems supported by the steel framing and concrete block walls. The pitched roof of the cafeteria/auditorium is covered with a single-ply EPDM membrane while the gym sloped roof has asphalt shingles. The windows are double-pane units with interior sunshades. We counted approximately eighteen (18) 2'x4' double-dome acrylic skylights, typically located over the hallways. The main entrance has a vestibule while other exterior doors are typically insulated steel doors.

Hot water for heating is provided by two Hydrotherm natural gas-fired modular cast iron boilers manufactured around 2000. Each section is rated for an input capacity of 300-BTU/HR; each boiler has nine sections so each boiler has an input capacity of around 2,700-BTU/HR. The hot water is distributed by two 7.5-horsepower motors with 91% efficiencies and pumps that supply hot water to the RTUs, classroom unit ventilators, and baseboard heaters. The circulating pumps have been upgraded with variable frequency drive controls. Rooftop air handling units (RTUs) with hot water heating coils provide conditioned air to the cafeteria and gymnasium.

A similar RTU is provided for the library but the unit was provided with a direct expansion cooling coil and associated rooftop condensing unit to cool the library. Additional cooling is provided to the computer lab and admin/lobby by two packaged rooftop units. A couple classrooms are also provided with thru-window air-conditioners. The building control system is Honeywell digital.

The domestic hot water is supplied by a 250-gallon natural gas-fired water heater rated at 600,000-BTUH input capacity; the unit was installed during the renovation. Two (2) ½-horsepower motors circulate the hot water.

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. Pendant fixtures with six (6) 42-watt T4 bulbs are provided in the cafeteria and library. Exterior site lighting is provided by building- and 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 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	\$ 0.172/kWh	\$66,588.00
Gas	NGRID	\$ 1.67/therm	\$74,754.00
#2 Oil			
Water & Sewer		NA	NA
Propane Gas		NA	NA
<b>TOTALS</b>			<b>\$141,342.00</b>

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)
62,811	\$ 141,342	\$2.23	92

### 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. Josiah Haynes Elementary School's energy intensity is 92 KBTU/SF/YR with an energy cost of \$2.23 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 58th 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

Performance Metrics	Evaluation Periods		Comparisons		
	Current (Ending Date 06/30/2008)	Baseline (Ending Date 06/30/2008)	Rating of 75	Target	National Average
Energy Performance Rating	58	58	75	N/A	50
Energy Intensity					
Site (kBtu/ft <sup>2</sup> )	92	92	78	N/A	100
Source (kBtu/ft <sup>2</sup> )	144	144	122	N/A	157
Energy Cost					
\$/year	\$ 139,841.00	\$ 139,841.00	\$ 118,429.65	N/A	\$ 151,456.51
\$/ft <sup>2</sup> /year	\$ 2.23	\$ 2.23	\$ 1.89	N/A	\$ 2.42
Greenhouse Gas Emissions					
MtCO <sub>2</sub> e/year	N/A	N/A	N/A	N/A	N/A
kgCO <sub>2</sub> e/ft <sup>2</sup> /year	N/A	N/A	N/A	N/A	N/A

## 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 <sub>2</sub> ) 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	\$500	0.09	1,950			585			30.0%		0.25	\$105
2	Replace Refrigerator	\$1,100	0.09	1516			750			49.5%		0.32	\$135
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If these ECM's are implemented, the Josiah Haynes Elementary can potentially save approximately \$9,938 per year with an investment of \$83,200.

## 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 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	\$105	Payback period	4.7 years
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### 5.2.2 Replace Refrigerators



Break room refrigerators

We observed the three (3) following top freezer refrigerators. One unit is 18.2-cubic feet in size, was manufactured in 2002, and based on the information at the Energy Star Refrigerator Retirement Savings Calculator, the unit uses 533-kWh/year. The second unit is 15.5-cubic feet in size, was manufactured in 2000, and uses 643-kWh/year. The third unit is 19.7-cubic feet in size, was manufactured in 2000, and uses 873-kWh/year. A new 18.2-cubic foot Energy Star rated unit can use around 383-kWh/year.

**Recommendation:** Based on our analysis, replacing the 2002 unit would result in a 20-year payback and therefore is not considered an ECM. However, it is recommended that the two 2000-vintage refrigerators be replaced with Energy Star rated refrigerators.

Cost to implement	\$1,100	Est. annual cost savings	\$135	Payback period	8.1 years
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### 5.2.3 Install DCV and VFD Fan Speed Control for 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. 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 similar to the observed cafeteria RTUs.

**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	\$1,363	Payback period	4.4 years
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### 5.2.4 Install DCV and VFD Fan Speed Control for Cafeteria Air-Handling Units



Two (2) rooftop air-handling units (RTUs) are used in the cafeteria and auditorium to provide heat and the required outside fresh air; we observed 5-hp motors within the units. Currently, the RTUs 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 these spaces.

**Recommendation:**

It is recommended to retrofit the cafeteria and auditorium RTUs with a

### Cafeteria Air-Handling Unit

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

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

Cost to implement	\$10,000	Est. annual cost savings	\$1,588	Payback period	6.3 years
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### 5.2.5 Convert Range Pilot Light to Electronic Ignition



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

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

*Kitchen Range*

Cost to implement	\$600	Est. annual cost savings	\$67	Payback period	9.0 years
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## 5.2.6 Replace Existing Boiler with a Condensing Boiler



Existing Hydrotherm Boilers

Hot water for heating is provided by two Hydrotherm natural gas-fired modular cast iron boilers manufactured around 2000. Each section is rated for an input capacity of 300-BTU/HR; each boiler has nine sections so each boiler has an input capacity of around 2,700-BTU/HR. These boilers provide hot water to the RTUs, classroom unit ventilators, and baseboard heaters. Based on the observed testing data tags from 2008, the boilers had an efficiency of around 82-85%. Conventional boilers are typically approximately 80-85% efficient at full fire. When the boilers are less than full fire or cycling on and off the efficiencies are typically much lower. This system is designed to limit the size of the boiler capacity firing at less than optimum efficiency conditions. Although these “gang” systems can be more efficient than larger staged boilers, maintenance costs can be high due to the number of boiler units.

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. 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. Note that mixing condensing and conventional boilers on the same system requires engineering design.

A condensing boiler would also offer maintenance advantages that are not included as part of the economic justification.

Cost to implement	\$65,000	Est. annual cost savings	\$6,680	Payback period	12.7 years
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### 5.3 Other ECMs Considered

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

- Domestic Hot Water:

The domestic hot water is supplied by a 250-gallon natural gas-fired water heater rated at 600,000-BTUH input capacity. The unit appears too large given the elementary school setting. We considered providing point-of-use electric instantaneous water heaters at the five toilet rooms and installing a small commercial water heater for the kitchen; however, the payback period was estimated at over 20-years. However, when replacement of the water heater is warranted, considering the required capital cost for the new water heater, retrofitting the domestic hot water system with instantaneous heaters in the toilet rooms and a natural gas water heater for the kitchen maybe an attractive ECM. Either way, the retrofitted system or the replacement water heater should be appropriately sized and designed considering the actual hot water demand.

While in the boiler room we noted that the tempered water mixing valves were turned to “hot” however, the thermometer displayed only 90 degree supply hot water temperate (the hot water feed was warm to the touch but not hot as would be expected). The water heater was reading around 130 degree water. The site visit stated that the remote bathrooms never have hot water. Something is obviously not performing as intended; however, the situation is actually saving energy by reducing the quantity of hot water consumed. If not having warm/hot water (safe temperature is less than 120 degrees) to the toilet rooms is acceptable by local code officials and school administration, then the current situation actually is energy efficient.

Two (2) ½-horsepower motors circulate the domestic hot water. The energy management system is located in the boiler room and has available inputs. A time clock could be installed on the domestic hot water heater to control the circulating pumps and water heater operating times. It’s our understanding that facility maintenance could install the time clock and integrating with the EMS should also be rather easy; therefore, this is considered a no cost/low cost energy conservation measure.

- During our site visit we noted approximately 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, 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-six (26) computers in the computer lab and ten (10) more in the library. We noted that five (5) monitors were on even though the computers were not being used. 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](http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_implementation_res#tech_assistance)
- We noted three (3) incandescent bulbs in the showcase in the entrance lobby. We recommend replacing these incandescent bulbs with compact fluorescent bulbs as a no cost/low cost 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<sup>1</sup>, 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:

<b>Non-Residential Rebates for Incremental Capacity (\$/Watt)</b>				
<b>Incremental Capacity</b>	<b>First: 1 to 25 kW</b>	<b>Next: &gt; 25 to 100 kW</b>	<b>Next: &gt; 100 kW to 200 kW</b>	<b>Next: &gt; 200 kW to 500 kW</b>
<b>Base Incentive</b>	\$3.15	\$3.00	\$2.00	\$1.40
<b><i>PLUS: Additions to Base Incentives</i></b>				
<b>Massachusetts Manufactured System</b>	\$0.15	\$0.15	\$0.15	\$0.15
<b>Public Building</b>	\$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.

<sup>1</sup> Web site: [www.commonwealthsolar.org](http://www.commonwealthsolar.org)

### ***Solar at Josiah Haynes Elementary School***

Solar PV at Josiah Haynes 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 approximately 2 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 Josiah Haynes 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](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<sup>2</sup>, 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 Josiah Haynes 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 Josiah Haynes Elementary School**

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

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<sup>2</sup> [http://www.mass.gov/Eoca/docs/doer/pub\\_info/doer\\_pellet\\_guidebook.pdf](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.

The circulating pumps have been upgraded with variable frequency drive controls. However, the complete capabilities of the VFDs cannot be realized as they are limited because the unit ventilators are not equipped to handle true variable volume water flow. Instead, it was indicated that the frequency drives are manually adjusted essentially reducing the motor horsepower which would reduce energy consumption. However, the circulating pumps are not operated as variable flow even though they are equipped with variable frequency drive controls.

Each unit ventilator currently has an individual digital time clock to control operation. Indications were made that relays were going to be added to incorporate the unit ventilators into the EMS. In addition, relays were going to be added to the exhaust fans so they too could be controlled by the EMS. Incorporating the unit ventilators and exhaust fans into the EMS should slightly reduce energy consumption and is considered work in progress.

**9 Appendices**  
**ECM Calculations**

## Vending Machine Controls

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

Number of machines   \$

**Step 2** Transfer the following information from the Survey:

<b>a</b>	Annual hours machines are required to be on:	<input type="text" value="6,500"/>	
<b>b</b>	Number of machines:	<input type="text" value="2"/>	
<b>c</b>	Watts per machine:	<input type="text" value="150"/>	Watts
<b>d</b>	Cost of electricity:	<input type="text" value="0.1800"/>	\$/kWh
	Run time with timers	<input type="text" value="70%"/>	

**Step 3** Calculate existing energy consumption :

$\frac{2a}{6,500} \times \frac{2b}{2} \times \frac{2c}{150} / 1,000 = \frac{1,950}{1,950}$  kWh/yr

**Step 4** Calculate energy consumption with timers:

$\frac{4,550}{4,550} \times \frac{2b}{2} \times \frac{2c}{150} / 1,000 = \frac{1,365}{1,365}$  kWh/yr

**Step 5** Calculate annual energy savings:

$\frac{3}{1,950} - \frac{4}{1,365} = \frac{585}{585}$  kWh/yr

**Step 6** Calculate annual cost savings:

$\frac{5}{585} \times \frac{2d}{0.1800} = \frac{\$105}{\$105}$  \$/yr

**Step 7** Calculate payback period:

$\frac{1}{500} / \frac{6}{105} = \frac{4.7}{4.7}$  yrs

## Replace Refrigerator

**Step 1** Obtain total cost of replacing older refrigerators with high-efficiency units:  
 cost per unit:   \$

**Step 2** Transfer the following information from the Survey:  
 4-13 **a** Total number of units   
 5-9 **c** Cost of electricity:  \$/kWh

**Step 3** Obtain the following value from Table 1:  
 Table 1 Approximate annual energy use of each old refrigerator:  kWh/yr

**Step 4** Calculate annual energy savings per refrigerator:  

$$\overset{3}{\boxed{758}} - \boxed{383} = \boxed{375} \text{ kWh/yr}$$

**Step 5** Estimate annual energy savings:  

$$\overset{2a}{\boxed{2}} \times \overset{4}{\boxed{375.00}} = \boxed{750} \text{ kWh/yr}$$

**Step 6** Calculate annual cost savings:  

$$\overset{5}{\boxed{750}} \times \overset{2c}{\boxed{0.18}} = \boxed{\$135} \text{ \$/yr}$$

**Step 7** Calculate payback period:  

$$\overset{1}{\boxed{1,100}} / \overset{6}{\boxed{135}} = \boxed{8.1} \text{ yrs}$$

Size	Unit Cost	Make	Model	Energy Savings
15.0 CF		716	Whirlpool ET5WSEX	442
18.0 CF		776	Whirlpool ET8FTEX	486

**Table 1: Energy Use of Existing Refrigerators**

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

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 =			1
Total cost to install DCV in the Gymnasium =	\$	1,000	
Cost of energy modeled without DCV (from hourly analysis) =	\$	3,363	
Cost of energy modeled with DCV (from hourly analysis) =	\$	2,827	
Annual Cost of energy saved	\$	536	
Cost of energy	\$/therm	1.67	
Energy Saved	therms	321	
Simple Payback (yrs)			3.1

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

Cost	\$ 6,000
Annual Savings	\$ 1,363
Simple Payback	\$ 4.40

Install Variable Frequency Drives on gym rooftop unit			
<b>Step 1</b>	Obtain total cost of installing VFDs on motors		
	Number of motors	1	\$5,000 \$
<b>Step 2</b>	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:	0.18 \$/kWh
		Run time with at reduced speed	50%
<b>Step 3</b>	Calculate existing energy consumption :		
	2a	2c	
	2,500	1.00 x 7.5	x 0.746 = 13,988 kWh/yr
<b>Step 4</b>	Calculate energy savings with VFDs:		
	2b	2c	3
	1,250	x 0.66 x 7.5	x 0.746 = 4,595 kWh/yr
<b>Step 6</b>	Calculate annual cost savings:		
	4595	x 0.180	= \$827 \$/yr
<b>Step 7</b>	Calculate payback period:		
	entered	1	6
	calculated	5,000 / 827	= 6.0 yrs

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 =		2	
<b>Total cost to install DCV in the Cafeteria =</b>	<b>\$</b>	<b>2,000</b>	
Cost of energy modeled without DCV (from hourly analysis) =	\$	2,734	
Cost of energy modeled with DCV (from hourly analysis) =	\$	2,249	
Annual Cost of energy saved	\$	485	
Cost of energy	\$/therm	1.67	
Energy Saved	therms	290	
Simple Payback (yrs)		6.9	

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	\$ 10,000
Total Annual Savings	\$ 1,588
Simple Payback	6.3

Install Variable Frequency Drives on café AHU

<b>Step 1</b>	Obtain total cost of installing VFDs on motors	
	Number of motors	2
		\$8,000 \$
<b>Step 2</b>	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:	0.18 \$/kWh
	Run time with at reduced speed	50%
<b>Step 3</b>	Calculate existing energy consumption :	
	$\frac{2a}{2,500} \times 1.00 \times \frac{2c}{10.0} \times 0.746 = 18,650$ kWh/yr	
<b>Step 4</b>	Calculate energy savings with VFDs:	
	$1,250 \times 0.66 \times \frac{2c}{10.0} \times 0.746 = 6,127$ kWh/yr	
<b>Step 6</b>	Calculate annual cost savings:	
	$6127 \times 0.180 = \$1,103$ \$/yr	
<b>Step 7</b>	Calculate payback period:	
	$\frac{1}{16,000} / \frac{6}{1103} = 14.5$ yrs	
	entered calculated	



### Pilot Light Conversion

Typical Annual Pilot Light Consumption =	10 therms/year
Number of Pilot Lights =	4
Cost of Natural Gas =	\$1.67 therm
Cost to retrofit to electronic ignition/pilot light	\$150

Annual Energy Savings	40 therms
Cost:	\$600
Annual Savings	\$ 67
Simple Payback	9.0

**Condensing Boiler**

**Step 1** Obtain total cost of replacing the heating plant, including equipment, labor, structural alterations, etc.

65,000 \$

**Step 2** Transfer the following information from the Survey:

5-14	<b>a</b>	Annual heating fuel consumption:	Gas:	40,000	therm/yr
			Oil:		gal/yr
			Prop		gal/yr
	<b>b</b>	Efficiency of existing plant:		0.75	
5-9	<b>c</b>	Cost of heating fuel:	Gas:	1.67	\$/therm
			Oil:		\$/gal
			Prop		\$/gal

**Step 3** Estimate efficiency improvement (as a decimal fraction):

$$.85 - \frac{2b}{0.75} = 0.1$$

**Step 4** Estimate annual energy savings:

	3		2a			
Gas:	0.10	x	40,000	=	4000	
Oil:	0.10	x	0.00	=	0	
Propane:	0.10	x	0.00	=	0	\$/yr

**Step 5** Calculate annual cost savings:

	4		2c			
Gas:	4,000	x	1.67	=	6,680	
Oil:	0.00	x	0.00	=	#REF!	
Propane:	0.00	x	0.00	=	0	\$/yr

**Step 6** Calculate payback period:

	1		5			
Gas:	65,000	/	6680.00	=	9.7	yrs
Oil:	65,000	/	#REF!	=	#REF!	yrs
Propane:	65,000	/	0.00	=	0	yrs