Scoping Energy Audit

prepared for

Pittsfield Schools

Pittsfield, NH

sponsored by

Eversource

energy & resource solutions

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Acknowledgments

Max Twogood of ERS managed this audit with assistance from Daniel Stewart of ERS. John Freeman of the Pittsfield School District initiated the audit process and was involved throughout the project with assistance from Derek Hamilton. Mark Toussaint from Eversource provided utility support.

Executive Summary

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This report details the recommendations and conclusions of a scoping energy audit sponsored by Eversource and Pittsfield School District at Pittsfield Schools in Pittsfield, New Hampshire.

1.1 Introduction

ERS conducted an energy study aimed at identifying energy efficiency measures (EEMs) at the Pittsfield Middle High School (MHS), Elementary School (ES), and the Superintendent Building (SIB). Photo 1-1 shows an aerial view of the school campus.

Photo 1-1. Pittsfield New Hampshire Schools

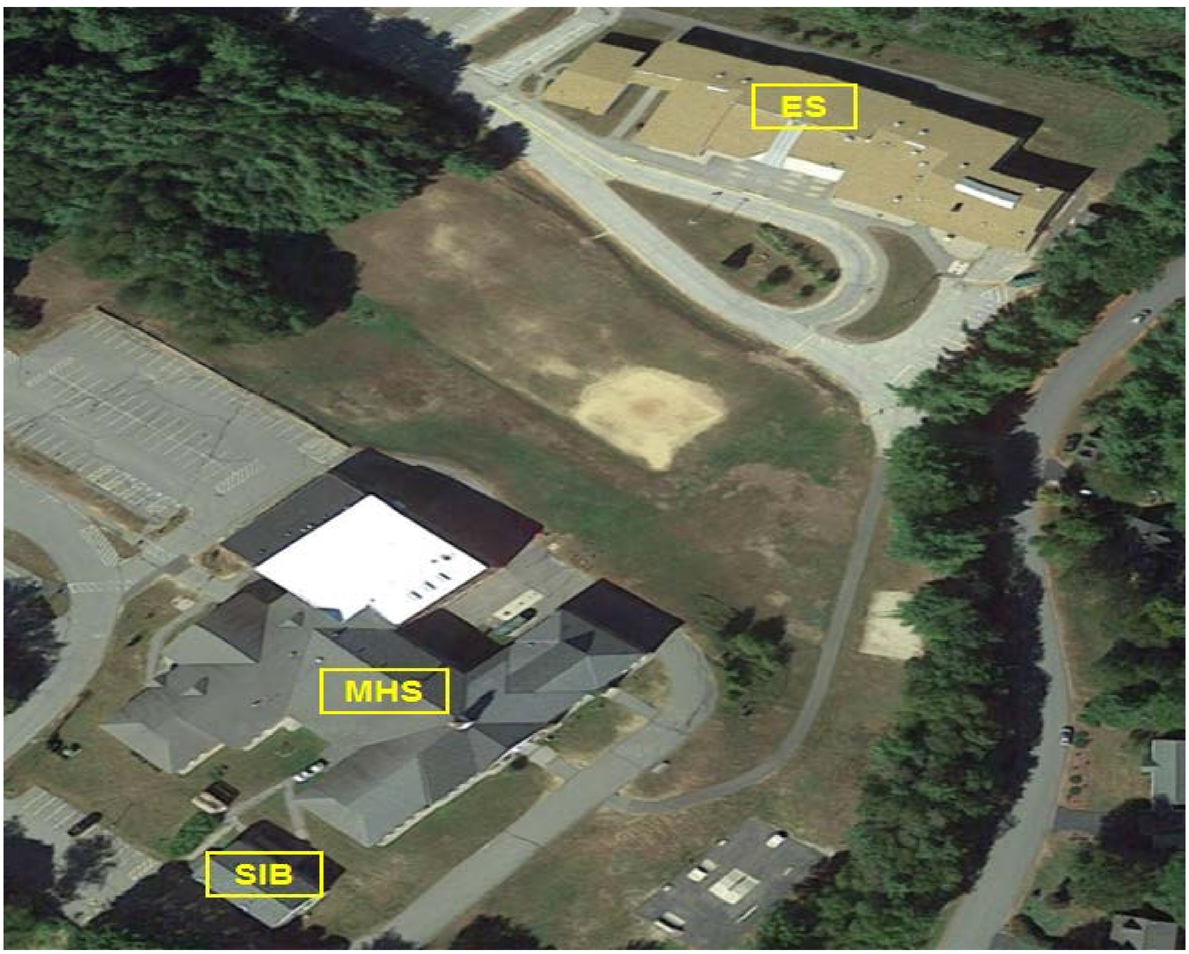


Image source: Google Earth

Daniel Stewart and Max Twogood of ERS met with John Freeman and Derek Hamilton of the Pittsfield School District on January 11, 2016, to tour the three buildings, inspect all major mechanical equipment, and discuss the operation of each facility. Max Twogood and Daniel Stewart returned to the site on February 11, 2016, to install metering equipment on the boilers and a sample of air handling units (AHUs) serving the MHS which we had identified as the equipment likely having the greatest energy savings opportunities. This report includes our conclusions and recommendations based on our analysis of that metered data as well as additional recommendations and energy savings estimates for other opportunities that we identified on-site.

The details of our findings and recommendations are contained in this report as follows:

- A summary of recommended EEMs is presented in Section 1-3.
- Section 2 of this report contains detailed descriptions of the facility and the energy systems reviewed in this study.
- Section 3 includes detailed discussions for each recommended measure.
- Section 4 includes a brief discussion of the informational measures (IMs) identified during the site visits and through conversations with facility staff members.
- Supporting analysis and information can be found in the appendix at the end of this report. This includes the Eversource Green Page, which translates energy savings into reductions in greenhouse gas emissions.

1.2 Energy Use

Eversource maintains one electric meter that serves the MHS and SIB and one that serves the ES. Electrical energy is primarily used in the three buildings for ventilation, lighting, air conditioning, kitchen equipment, domestic hot water (DHW) pumps, and computers and other office equipment. Both schools are heated by hot water (HW) boilers that consume #2 fuel oil and the SIB is heated by propane. The following sections summarize energy use at the facility, and a more detailed discussion is presented in Sections 2.2 and 2.3.

1.2.1 Electrical Usage History

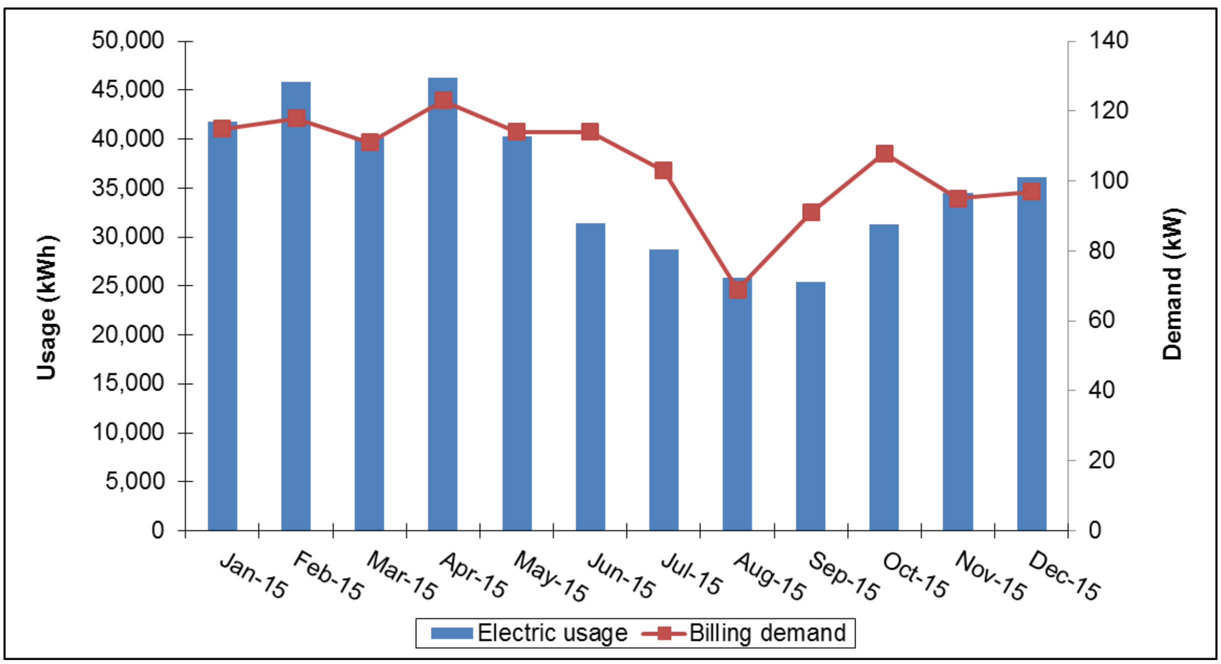
In preparing this report, ERS studied the current electrical energy use at the facility. Based on billing data from 2015, the total annual electrical energy consumption on the meter serving the MHS and SIB was 427,520 kWh at a total cost of approximately $61,732. Peak demand during this period was 123 kW, and it occurred in April 2015. The MHS/SIB energy use history is shown in Table 1-1 and presented graphically in Figure 1-1. Note that the cost figures shown are based on Eversource's January 2016 rate structure and may differ from the actual billed amount. See Section 2.4.1 for details on the rate structure.

Table 1-1. MHS and SIB Electric Billing History

Month	Billed Demand (kW)	Energy Use (kWh)	Energy Cost	Demand Cost	Total Bill[1]	Average Rate ($/kWh)	Load Factor	No. of Days	kWh per Day
Jan-15	115	41,760	$4,523	$1,410	$5,933	$0.1421	49%	31	1,347
Feb-15	118	45,840	$4,965	$1,447	$6,412	$0.1399	52%	31	1,479
Mar-15	111	40,160	$4,350	$1,361	$5,711	$0.1422	54%	28	1,434
Apr-15	123	46,240	$5,009	$1,508	$6,517	$0.1409	51%	31	1,492
May-15	114	40,320	$4,367	$1,398	$5,765	$0.1430	49%	30	1,344
Jun-15	114	31,360	$3,397	$1,398	$4,795	$0.1529	37%	31	1,012
Jul-15	103	28,720	$3,111	$1,263	$4,374	$0.1523	39%	30	957
Aug-15	69	25,840	$2,799	$846	$3,645	$0.1411	50%	31	834
Sep-15	91	25,440	$2,756	$1,116	$3,871	$0.1522	38%	31	821
Oct-15	108	31,280	$3,388	$1,324	$4,712	$0.1506	40%	30	1,043
Nov-15	95	34,480	$3,735	$1,165	$4,900	$0.1421	49%	31	1,112
Dec-15	97	36,080	$3,908	$1,189	$5,097	$0.1413	52%	30	1,203
Peak	**123**	**46,240**	**$5,009**	**$1,508**	**$6,517**	**$0.1529**	**54%**	**N/A**	**1,492**
Average	**105**	**35,627**	**$3,859**	**$1,285**	**$5,144**	**$0.1444**	**47%**	**N/A**	**1,173**
Total	**N/A**	**427,520**	**$46,309**	**$15,423**	**$61,732**	**N/A**	**N/A**	**365**	**N/A**

[1] Estimated costs based on Eversource NH 2016 GV rate structure. Actual billed amount may vary.
N/A= Not applicable

Figure 1-1. MHS and SIB Electric Billing History



Based on billing data from 2015, the ES's total annual electrical energy consumption was 232,057 kWh at a total cost of approximately $35,082. Peak demand during this period was 85 kW, and it occurred in April 2015. Table 1-2 presents the electric billing history for the ES for 2015; again, the costs presented are based on 2016 rates.

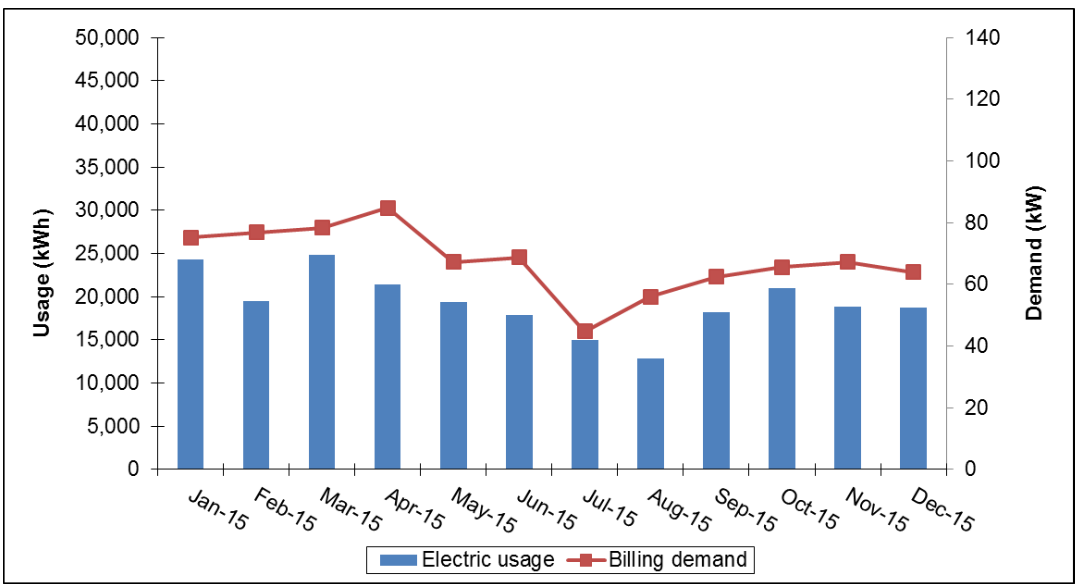
Table 1-2. ES Electric Billing History

Month	Billed Demand (kW)	Energy Use (kWh)	Energy Cost	Demand Cost	Total Bill[1]	Average Rate ($/kWh)	Load Factor	No. of Days	kWh per Day
Jan-15	75	24,320	$2,634	$922	$3,556	$0.1462	42%	32	760
Feb-15	77	19,520	$2,114	$942	$3,056	$0.1566	39%	27	723
Mar-15	78	24,800	$2,686	$961	$3,648	$0.1471	44%	30	827
Apr-15	85	21,440	$2,322	$1,040	$3,362	$0.1568	35%	30	715
May-15	67	19,360	$2,097	$824	$2,921	$0.1509	39%	31	625
Jun-15	69	17,920	$1,941	$843	$2,785	$0.1554	36%	30	597
Jul-15	45	15,040	$1,629	$549	$2,178	$0.1448	42%	33	456
Aug-15	56	12,800	$1,386	$687	$2,073	$0.1620	33%	29	441
Sep-15	62	18,240	$1,976	$765	$2,741	$0.1503	41%	30	608
Oct-15	66	20,960	$2,270	$804	$3,075	$0.1467	42%	32	655
Nov-15	67	18,880	$2,045	$824	$2,869	$0.1520	40%	29	651
Dec-15	64	18,777	$2,034	$785	$2,819	$0.1501	41%	30	626
Peak	**85**	**24,800**	**$2,686**	**$1,040**	**$3,648**	**$0.1620**	**44%**	**N/A**	**827**
Average	**68**	**19,338**	**$2,095**	**$829**	**$2,923**	**$0.1516**	**39%**	**N/A**	**640**
Total	**N/A**	**232,057**	**$25,136**	**$9,945**	**$35,082**	**N/A**	**N/A**	**363**	**N/A**

[1] Estimated costs based on Eversource NH 2016 GV rate structure. Actual billed amount may vary.

Figure 1-2 presents a month-to-month profile of electricity usage on the ES meter over the same billing period.

Figure 1-2. ES Electric Billing History



1.2.2 Fuel Oil Usage History

Both school buildings use #2 fuel oil for space heating and DHW. Table 1-3 summarizes the fuel delivery and billing history for the school buildings from 2013 through 2015.

Table 1-3. Fuel Consumption History

Year	Middle High School	Elementary School	Total #2 Oil
2013	24,454	12,798	37,252
2014	24,091	13,650	37,741
2015	31,606	14,781	46,387
Average	**26,717**	**13,743**	**40,460**
Average $/gallon	$3.0494	$3.0505	$3.0498
Average cost	**$81,472**	**$41,923**	**$123,395**

1.2.3 Propane Usage History

The SIB uses propane for space heating and DHW. We did not examine propane consumption in the SIB in detail during this study.

1.3 Summary of Recommended Energy Efficiency Measures

ERS recommends a total of eight EEMs for implementation. These EEMs should be reviewed to determine if they are consistent with the facility's operational requirements and the desires of the Pittsfield School District and the school board. Details for each measure are listed in Table 1-4. This table shows estimated energy savings, cost savings, implementation costs, and simple payback period for each measure considered. Brief descriptions of each measure are contained in the sections that follow. Detailed descriptions for each measure can be found in Section 3.

Table 1-4. Recommended EEMs

Measure Name	Energy Savings Estimated (kWh)	Demand Savings Estimated (kW)	Fuel Oil Savings Estimated (Gallons)	Annual Energy Cost Savings Estimated	Estimated Implementation Cost	Simple Payback
MHS EEM-1: Install programmable thermostats in classrooms	0	0	1,498	$3,308	$9,360	2.8
MHS EEM-2: Recommission energy recovery ventilator (ERV) #2	0	0	215	$490	$1,500	3.1
MHS EEM-3: Replace door weather stripping[1]	0	0	4	$8.08	$55	6.8
MHS EEM-4: Improve attic insulation	0	0	2,466	$5,445	$43,000	7.9
MHS EEM-5a: Install condensing boilers	0	0	1,868	$4,260	$100,000[a]	23.5
MHS EEM-5b: Install a boiler stack economizer	0	0	1,282	$2,924	$30,000	10.3
MHS total	**0**	**0**	**7,333**	**$16,435**	**$183,915**	**11.2**
ES EEM-1: Upgrade interior lighting controls	8,156	0	0	$883	$3,000	3.4
ES total	**8,156**	**0**	**0**	**$883**	**$3,000**	**3.4**
SIB EEM-1: Implement setback controls in the office	2,277	0	192[b]	$822	$360	0.4
SIB total	**2,277**	**0**	**201**	**$691**	**$360**	**0.5**
Pittsfield Schools total	**10,433**	**0**	**7,534**	**$18,009**	**$187,275**	**10.4**

[a]ERS recommends this measure upon existing equipment failure, at which point the incremental cost payback is an estimated 3.9 years.
[b]Fuel savings are in gallons of propane instead of #2 oil.
[1]Savings for MHS EEM-3 are represented per door

1.3.1 MHS EEM-1: Install Programmable Thermostats in Classrooms

During our site visit, the staff indicated that the four classrooms included in a recent addition to the school have programmable thermostats and are set back during unoccupied hours. Implementing unoccupied temperature setback controls would reduce the run-time hours for the AHUs, ERVs, and boilers by increasing the cooling setpoints and reducing the heating setpoints when the spaces are unoccupied. ERS recommends installing programmable thermostats in all classrooms or all zones including classrooms and setting the space temperatures back to 86°F during unoccupied cooling hours and 60°F during unoccupied heating hours.

1.3.2 MHS EEM-2: Recommission Energy Recovery Ventilator #2

The MHS has nine AHUs equipped with energy recovery wheels that are designed to transfer latent and sensible heat from the return air (RA) to the mixed air (MA). ERS used metered data to determine the operating profiles and heat recovery effectiveness of three of the units. The data indicates that ERV-2 is not nearly as effective at heat recovery compared to ERV-8. We estimate that refurbishing or replacing the energy recovery wheel in that unit will save approximately 215 gallons of #2 fuel oil. With an estimated implementation cost of $1,500 and estimated energy cost savings of $490, the measure has a simple payback of 3.1 years.

1.3.3 MHS EEM-3: Replace Door Weather Stripping

Air sealing helps reduce infiltration through doors, windows, and other leaky penetration points in the building shell. We observed several double doors with infiltration points between and below the doors. Replacing or installing weather stripping on these doors will help reduce the infiltration through these points and subsequently reduce the facility's space heating load. We estimate that it will cost approximately $55, including external labor, to replace weather stripping on each door, and save an average of 3.7 gallons of fuel oil ($11.60), annually per door.

1.3.4 MHS EEM-4: Improve Attic Insulation

While on-site ERS observed the current conditions of the attic space over the older sections of the MHS. The school uses loose blown cellulose in between ceiling joists; much of it looked degraded and was not equally dispersed across the attic floor. Some areas had piles approximately 6 inches high, while other areas had as low as an inch. During the site visit the outside air temperature (OAT) was approximately 8°F and the attic was approximately 50°F. Theoretically, the temperature of a ventilated attic space should be close to the OAT if it's not sealed, has no thermal loads, and is uninsulated in the eaves; therefore, there is likely a large amount of heat loss to this attic from the heated spaces below. There was some HW piping without insulation, but there was only a small amount of exposed surface area. There were also long runs of insulated duct work; the insulation was in good condition so its heat losses are likely small.

Improving the insulation on the attic floor will help mitigate the thermal losses observed by the conditioned spaces. For Pittsfield's climate zone (6), the Department of Energy (DOE) recommends R-49 – R-60 attic insulation, which would require 14 inches of loose blown cellulose. The joists also serve as a thermal break and it would be beneficial to cover them with a continuous layer of insulation. We estimate the potential annual fuel cost savings for this measure to be $4,759; with an estimated installation cost of $43,000 the payback for the measure is approximately 9.0 years.

1.3.5 MHS EEM-5: Upgrade Boilers

The existing MHS boilers operate with an estimated efficiency of 80%, which means that energy equivalent to approximately 5,000 gallons of fuel oil leaves the facility in the boilers' flue gasses. We recommend attempting to reduce the magnitude of this waste by either replacing the existing atmospheric boilers with condensing units or installing stack economizers on the existing boilers.

MHS EEM-5a: Replace Existing Boilers with Condensing Boilers

Condensing boilers can achieve peak efficiencies as high as 97% and typically achieve an annual fuel utilization efficiency (AFUE) of 88%–91% by recovering additional heat, including latent heat, from flue gasses. The recovered heat is used to preheat boiler feed water or intake combustion air. ERS estimates that a condensing boiler operating with a HW temperature reset control strategy could reduce the MHS heating fuel use by approximately 9%, translating to 1,868 gallons of #2 fuel oil and $4,260 of savings annually. The capital cost of new boilers limits the applicability of this measure to an end-of-life replacement, at which point the incremental cost of purchasing the condensing boiler instead of a standard unit has an estimated 3.9-year payback on the basis of energy cost savings alone.

MHS EEM-5b: Install a Non-Condensing Stack Economizer on Existing Boiler System

The existing MHS boilers are approximately 16 years old and in good condition. Retrofitting the stack economizer to recover waste heat from the flue gas of the existing boilers achieves similar heat recovery from flue gasses to a condensing boiler. A condensing stack economizer can raise the efficiency of a standard atmospheric boiler toward condensing boiler levels. Non-condensing economizers only recover sensible heat from the flue gas, but require less expensive materials, which results in a much lower unit cost. We estimate that installing a non-condensing economizer can save approximately 6% of the total fuel that the MHS uses for space heating; this translates to #2 fuel oil savings of 1,282 gallons and $2,924 annually and an estimated simple payback of 10 years.

1.3.6 ES EEM-1: Upgrade Interior Lighting Controls

Facility maintenance personnel indicated that the ES's main atrium lights are often manually turned off during the day when natural light permits. We recommend installing daylight harvesting controls capable of automating this process to minimize the operating hours of this lighting system. We estimate that daylight harvesting controls can reduce the annual full load equivalent operating hours of the ES atrium lighting system by 30%.

ES occupants report that some areas appear overly lit following the school's LED upgrades, which is relatively common for one-to-one LED replacement projects due to the higher efficiency and improved color rendering of LED fixtures or the directionality of their light. We recommend installing dimming switches on circuits serving overly lit spaces where the LED fixtures are dimmable and installing reduced-wattage fixtures in overly lit spaces for which the LED fixtures are not dimmable. We estimate that dimming controls and reduced-wattage LEDs can reduce the ES interior lighting usage by approximately 7%. The total estimates savings for this measure are 8,156 kWh and $883. With an estimated implementation cost of $3,000, the payback is 3.4 years.

1.3.7 SIB EEM-1: Implement Setback Controls in the Superintendent Building

The superintendent's office does not have programmable thermostats and therefore lacks the ability to set back temperatures after hours. Implementing unoccupied temperature setback controls would reduce the run-time hours for the AHUs by increasing the cooling setpoints and reducing the heating setpoints when the spaces are unoccupied. ERS recommends installing programmable thermostats in the superintendent's office and setting the space temperatures back to 86°F during unoccupied cooling hours and 60°F during unoccupied heating hours. Setback controls will help reduce annual oil consumption by reducing AHU operation during the heating season, as well as yielding electric savings resulting from reduced cooling loads during the cooling season. We estimate that this measure will save approximately 2,277 kWh and 192 gallons of propane annually with a total energy cost savings of $831. With an estimated implementation cost of $360, the measure has a payback of 6 months.

1.4 Summary of Informational Measures

ERS identified seven additional measures at the three buildings that were outside the scope of this study and are presented as informational measures (IMs) in this section. Savings estimates for the IMs, where provided, are included for informational purposes only; more detailed analyses are required to refine these estimates.

1.4.1 MHS IM-1: Implement HW Temperature Reset

The MHS boilers are set to provide HW at 180°F throughout the heating season. We recommend reducing the HW supply temperature (HWST) during periods of mild OAT. This can be achieved manually; however, to ensure the persistence of the measure and its associated savings we recommend installing a retrofit control system to automatically reset the HWST according to the OAT. We estimate that implementing this operating procedure could save up to 1.5% of heating fuel use annually, translating to fuel oil savings of approximately 400 gallons and $1,250.

1.4.2 MHS IM-2: Repair Hot Water Pipe Insulation

The HW piping in the MHS attic is generally well insulated along straight lengths of pipe; however, we noticed many exposed fittings, valves, and angle joints throughout the system while on-site. We recommend insulating all bare elements with a minimum of 1 inch of mineral fiber or other appropriate insulating material. As a best practice, all HW piping should be insulated and this measure could potentially alleviate some of the ice dam issues that the MHS has reported by reducing the attic space temperature during the heating season.

1.4.3 MHS IM-3: Duct Boiler Intake Combustion Air through the Flue Chase

Pittsfield may be able to synthesize a stack economizing effect by drawing intake air for the boilers through the exhaust stack chase. This would preheat the combustion air before it arrives at the boilers. It would also directly reduce the temperature of the air within the chase, thereby alleviating the overheating issues in the back room of the library. Besides creating a more comfortable space, reducing the internal loads in the library back room could eliminate the winter air-conditioning operation that has been reported by facility staff.

We estimate that this approach towards stack economizing could achieve 25% of the heat recovery potential that we calculated for EEM-1b regarding the installation of a non-condensing stack economizer. Note that this would be a more customized approach to achieve a similar effect, and precautions should be taken to reduce the chances of condensation in the boiler stack. We estimate that preheating the intake air could result in annual fuel oil savings of 320 gallons and $730 annually.

1.4.4 MHS IM-4: Install Rooftop Solar

The MHS has roof has space available to install a 65 kW solar PV system. ERS used the National Renewable Energy Laboratory's PVWatts® tool to calculate the potential savings for the proposed PV system, resulting in average annual energy production of 81,289 kWh. The tool also estimates an installation cost of $168,220, which is based on $2.6/watt of installed capacity. There are some solar rebates and government bonds available for public schools to defray some of the upfront cost. We believe the MHS to be a good potential installation site because its elevation reduces the shading impacts from surrounding trees and buildings; however, the ES may also serve as a suitable installation site for a PV system. We recommend that Pittsfield Schools solicit vendor quotes and third-party savings estimates to determine the value of installing a PV system at one or both of the facilities. In addition to energy savings, a PV system could serve as a valuable education tool for students attending Pittsfield Schools.

1.4.5 ES IM-1: Repair Hot Water Pipe Insulation

While on-site we identified a HW pipe that was approximately 4 feet long and 8 inches in diameter and not insulated. This piping was exposed to conditioned spaces in a room adjacent to the central atrium. We recommend insulating this pipe with at least 1 inch of mineral fiber or other appropriate insulating material. The savings associated with insulating this pipe were estimated using the 3EPlus software created by the North American Insulation Manufacturers Association. We estimate annual fuel cost savings of approximately $270 and a payback of under 6 months for this measure.

1.4.6 ES IM-2: Replace Pneumatic Controls

The ES's HVAC system is pneumatically controlled, which limits the number of control strategies that the system can adopt and demands usage of energy-intensive compressed air. We estimate that the tighter control parameters that a digital system can maintain will reduce energy spending by approximately 2%, or $1,500 per year. At this level of savings, converting the system to digital control will not have an acceptable payback on the merits of energy savings alone; however, digital controls may reduce maintenance costs, improving the economic value of this measure, while also enhancing the environmental control and comfort in the ES.

1.4.7 SIB IM-1: Seal Penetration Point for Old Dust Collector System

Adjacent to the administrative offices on the first floor of the SIB, there is an old woodshop. This space is primarily used for storage and is conditioned. This space has an old dust collector system that is no longer in use, but its uninsulated ductwork still penetrates the building shell. We recommend capping and sealing this penetration point to mitigate air leakage and reduce the overall infiltration loads on the HVAC system serving this space. This measure would likely result in small savings but would have a low implementation cost. Additional information regarding the operation of this space and its HVAC equipment is necessary to quantify the energy impacts of this measure.

Facility Description

2

This section discusses the facility and the major energy-consuming systems that were reviewed during this study. The details and assumptions behind the annual energy consumption and end-use breakdowns of major electrical systems in the building are also presented.

2.1 Facility Description

Pittsfield, NH operates two public schools, including the Elementary School (ES) for students in kindergarten through sixth grade and the Middle High School (MHS) for grades seven through twelve. Four new classrooms were added on to the MHS in 2000. The school's boiler plant and a significant portion of its hot water (HW) piping were replaced and a new heating control system was added with the addition. The new system incorporated direct digital control (DDC) actuators for new HW reheat coils and two-way valves. Photo 2-1 shows an aerial view of the school campus.

Photo 2-1. Pittsfield, NH Schools

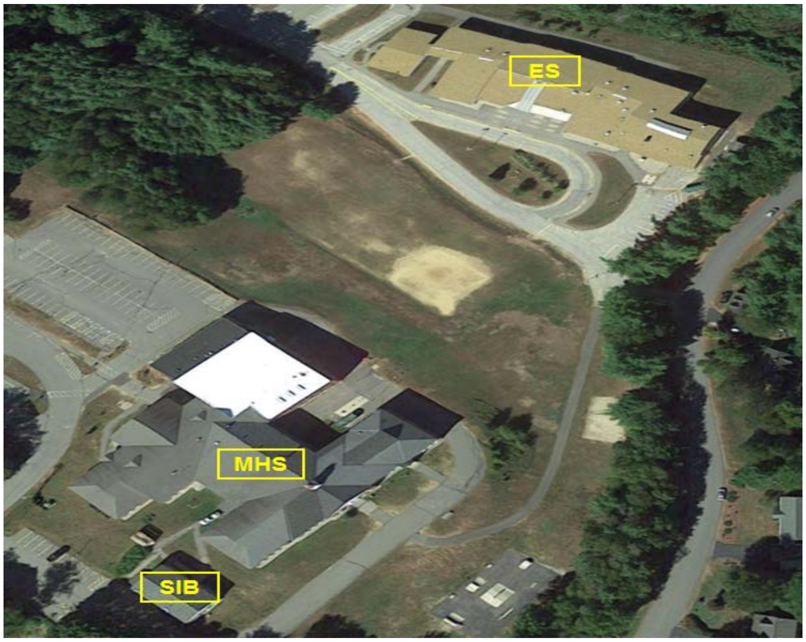


Image source: Google Earth

The Superintendent Building (SIB) is a two-story building that houses administrative offices on the first floor and a wood shop for MHS students on the second floor. There is also an old woodshop on the first floor, adjacent to the administrative offices, which is no longer in use.

2.2 Major Energy End Uses

The following sections discuss the major energy-consuming systems and equipment that ERS studied during the course of this energy audit.

2.2.1 Air Handling Equipment

The MHS has four air handling units (AHUs) that have direct expansion (DX) cooling and eight energy recovery ventilators (ERVs) that are equipped with energy recovery wheels. There are HW reheat coils equipped with modulating two-way valves located in the duct work downstream of all AHUs. See Section 2.2.2 for a discussion of the HW coil operation. Most of the air handling equipment in the MHS operates year-round; however, maintenance personnel occasionally shut down units manually during warmer periods when they notice many open windows in the zone. Table 2-1 lists the key details of the MHS air handling equipment inventory.

Table 2-1. Air Handling Equipment Inventory

Unit ID	Make	Model	Design CFM	Rated Cooling (Tons)	Space Type Served	Outdoor Air Damper Operation	Unit Operation[1]
AH-1	Magic Aire	48 BHX	1600	4	Classroom	Fixed	24/7
AH-2	Magic Aire	48 BHX	1600	4	Classroom	Fixed	24/7
AH-3	Magic Aire	48 BHX	1600	4	Administration	Fixed	24/7
AH-4	Magic Aire	120 BHX	4000	10	Library	Manual	24/7
ERV-2	Venmar	ERV3000IDD	3450	0	Gym/lockers	Fixed	Manual
ERV-3	Venmar	ERV3000IDD	3450	0	Gym/lockers	Fixed	Manual
ERV-4	Venmar	ERV3000I	3000	0	Kitchen/cafeteria	Fixed	24/7
ERV-5	Venmar	ERV3000I	3600	0	Hallway	Fixed	24/7
ERV-6	Venmar	ERV3000I	3450	0	Hallway	Fixed	24/7
ERV-7	Venmar	ERV3000I	2450	0	Classroom	Fixed	24/7
ERV-8	Venmar	ERV3000D	3500	0	Classroom	Fixed	24/7
ERV-9	Venmar	ERV3000I	3900	0	Classroom	Fixed	24/7

[1] Facility maintenance staff members report shutting many units down for all or part of the summer.

While on site, we examined three AHUs that serve the ES. Two units serve the two wings of the school while the third serves the gym. The AHUs are equipped with HW heating coils. All of the AHUs operate 24/7 except during warmer periods when facility staff shut them down and operable windows are used. The AHUs in the ES were not studied in detail during this audit and no inventory is provided.

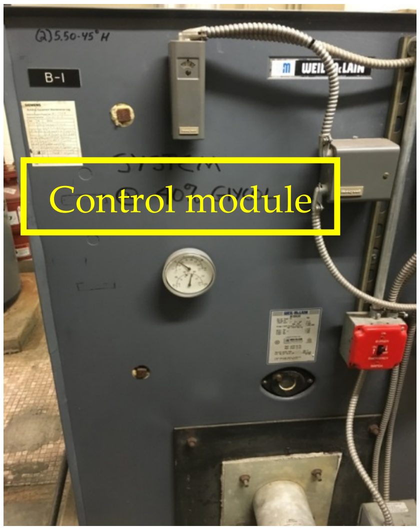
2.2.2 Boilers and Space Heating

The MHS features a pair of Weil-McLain model 788 boilers that produce HW for space heating using #2 fuel oil and have a rated fuel input capacity of 14.2 gallons per hour (gph), or approximately 2,000 MBH. Photo 2-2 shows the space-heating boilers in the MHS boiler room.

Photo 2-2. MHS Boiler Plant

The units, which were installed during the expansion of the MHS in 2000, operate in tandem to maintain the system's HW supply temperature setpoint. The setpoint is set manually on a control module mounted to each boiler, as shown in Photo 2-3. Also located on the front of each unit, though not shown in the photo, is a switch to toggle between high and low firing rate.

Photo 2-3. MHS Boiler Controls



The MHS heating system has a central control panel that links each HW reheat valve with the corresponding thermostat located in the zone it serves. When the thermostat calls for heating, the control system modulates the HW valve to maintain an active heating discharge air temperature (DAT). The DAT is manually set by turning the knob on the left control module shown in Photo 2-4. All of the units that ERS inspected were set to maintain a DAT of approximately 70°F. Pittsfield staff members identified several valves that are adjusted manually based on occupant feedback because the valves were no longer modulating automatically.

Photo 2-4. Typical HW Coil Control Module-Sensor Setup

The ES is heated by a pair of oil-fired H.B. Smith HW boilers installed in 1989. Each boiler has a capacity of 2,000 MBH. As with the MHS boilers, the ES units operate in tandem with each other, cycling on either high or low fire to maintain a HW temperature that is manually set on each unit. Photo 2-5 shows the space heating boilers installed at the ES along with the school's domestic hot water (DHW) boiler in the foreground.

Photo 2-5. ES Boiler Room

2.2.3 Lighting

Both facilities are replacing their interior fluorescent fixtures with light emitting diode (LED) fixtures. The MHS now predominantly features 2′x4′ recessed LED fixtures throughout the school.

The ES has replaced all preexisting interior 4-foot T-8s with LED fixtures and installed several overhead LED fixtures in the school's open atrium. The facility staff occasionally turns off the overhead atrium lights when ambient daylight is sufficient for the space. The ES still has several

8-foot fluorescent T-8 fixtures that remain in classrooms because there were no cost-effective or approved LED solutions at the time that the rest of the fixtures were upgraded. Facility staff members report that some spaces that received LED lighting upgrades are overly lit with the new fixtures. Photo 2-6 shows LED fixtures with dimming shades.

Photo 2-6. Example – Overly Lit Space with LED Fixtures

2.2.4 Kitchen Equipment

The MHS kitchen had a walk-in cooler and freezer in a singular unit. The walk-in cooler was set to 39°F and the freezer was set to -8°F. The cooler and the freezer both had two evaporator fans, shown in Photo 2-7 below, with standard efficiency shaded-pole motors. The kitchen staff also used a large commercial refrigerator set at 41°F. Amongst other miscellaneous commercial kitchen equipment, the MHS had a twelve-burner stove and a large range exhaust hood. The kitchen staff at the MHS is consistent about turning off the fume hood when there is no food preparation happening, although they report that the hood occasionally operates longer hours during warmer weather to exhaust warm kitchen air.

Photo 2-7. Walk-in Freezer Evaporator Fans

The ES did not have a walk-in cooler or freezer, but it did have a large commercial refrigerator. Similar to the MHS, the ES had a large range exhausted by an overhead range hood. In the ES, however, kitchen staff operates the range hood all day to ventilate the kitchen when occupied, because otherwise the kitchen gets too hot from internal loads.

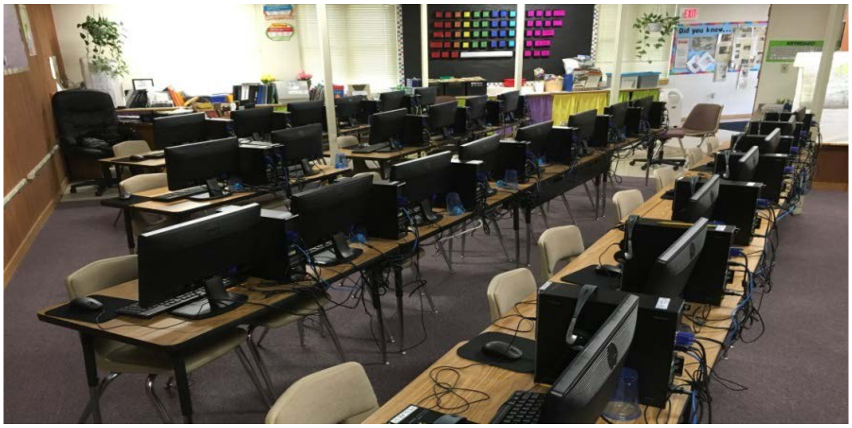
2.2.5 Plug Loads

The MHS uses approximately 500 desktop computers, like the ones shown in Photo 2-8. The computers are used intermittently to support classroom lessons and student research. When not in use, the computers are left on, in idle, or turned off. The MHS also has approximately 500 tablets that are used to support classroom lessons. Other miscellaneous plug loads include lamps, printers, phones, and security cameras.

Photo 2-8. Desktop Computers in the MHS Library

The elementary school also had desktop computer in their computer lab, shown in Photo 2-9. Similar to the HS, many computers are left on or in idle, although according to our observations the ES seemed more consistent about turning computers off. There were approximately thirty computers in this space and ES staff and teachers also use personal desktop computers. Other plug loads at the ES include lamps, printers, phones, and other office equipment.

Photo 2-9. Elementary School Computer Lab



2.3 Energy Use

Both facilities use electricity for lighting, ventilation, kitchen equipment, space cooling, computers, and other plug loads. The MHS and ES use #2 fuel oil for space heating, DHW, and cooking. The following sections detail the facilities' energy use histories, end-use breakdowns, and current billing cost structures.

2.3.1 Eversource GV Rate Cost Structure

Eversource maintains one meter for the ES and a second that serves the MHS and SIB. The two meters are billed under Eversource's GV rate structure, which applies to commercial and industrial customers with an annual peak demand not exceeding 1,000 kW. Table 2-2 presents details about the rate structure. ERS used the energy and demand costs listed in the table to calculate the electric cost savings for each measure.

Table 2-2. Eversource GV Rates as of January 1, 2016

Eversource – GV Rate (January 2016)	
Electrical Demand ($/kW)	
$5.61	First 100 kW (distribution demand charges)
$5.37	All additional 100 kW (distribution demand charges)
$6.76	All kW (transmission demand charge)
$0.13	All kW (stranded cost recovery demand charge)
Demand billed as the greatest measured demand of:	
	Maximum on-peak demand
	80% of preceding 11 months
	50% of off-peak demand
Electrical Energy ($ /kWh)	
$0.09990	All kWh (energy charge)
$0.00609	First 200,000 kWh (distribution cost)
$0.00511	All additional kWh (distribution cost)
-$0.00054	All kWh (stranded cost recovery charge)
$0.00330	All kWh (systems benefit charge)
$0.00055	All kWh (electricity consumption tax)
$0.00000	All kWh (third-party energy charge)
Service Charge	
$194.96	Monthly customer charge
On-Peak Periods	
M–F, 7 a.m.–8 p.m., non-holidays	

The demand and energy cost figures used in our savings calculations are summarized in Table 2-3.

Table 2-3. Marginal Costs of Electricity

Utility: Eversource – New Hampshire **Rate:** GV (January 2016)	
Demand charge ($/kW)	$12.2600
Energy charge ($/kWh)	$0.1083

2.3.2 Electric Usage History

Table 2-4 presents the electric billing history for the MHS and SIB from 2015. Note that the energy and demand costs presented are based on the January 2016 rate structure shown above, and may differ from the actual amount billed.

Table 2-4. MHS and SIB Electric Billing History

Month	Billed Demand (kW)	Energy Use (kWh)	Energy Cost	Demand Cost	Total Bill[1]	Average Rate ($/kWh)	Load Factor	No. of Days	kWh per Day
Jan-15	115	41,760	$4,523	$1,410	$5,933	$0.1421	49%	31	1,347
Feb-15	118	45,840	$4,965	$1,447	$6,412	$0.1399	52%	31	1,479
Mar-15	111	40,160	$4,350	$1,361	$5,711	$0.1422	54%	28	1,434
Apr-15	123	46,240	$5,009	$1,508	$6,517	$0.1409	51%	31	1,492
May-15	114	40,320	$4,367	$1,398	$5,765	$0.1430	49%	30	1,344
Jun-15	114	31,360	$3,397	$1,398	$4,795	$0.1529	37%	31	1,012
Jul-15	103	28,720	$3,111	$1,263	$4,374	$0.1523	39%	30	957
Aug-15	69	25,840	$2,799	$846	$3,645	$0.1411	50%	31	834
Sep-15	91	25,440	$2,756	$1,116	$3,871	$0.1522	38%	31	821
Oct-15	108	31,280	$3,388	$1,324	$4,712	$0.1506	40%	30	1,043
Nov-15	95	34,480	$3,735	$1,165	$4,900	$0.1421	49%	31	1,112
Dec-15	97	36,080	$3,908	$1,189	$5,097	$0.1413	52%	30	1,203
Peak	**123**	**46,240**	**$5,009**	**$1,508**	**$6,517**	**$0.1529**	**54%**	**N/A**	**1,492**
Average	**105**	**35,627**	**$3,859**	**$1,285**	**$5,144**	**$0.1444**	**47%**	**N/A**	**1,173**
Total	**N/A**	**427,520**	**$46,309**	**$15,423**	**$61,732**	**N/A**	**N/A**	**365**	**N/A**

[1] Estimated costs based on Eversource NH 2016 GV rate structure. Actual billed amount may vary.
N/A= Not applicable

Figure 2-1 presents a month-to-month profile of electricity usage on the MHS meter over the same billing period.

Figure 2-1. MHS and SIB Electric Billing History

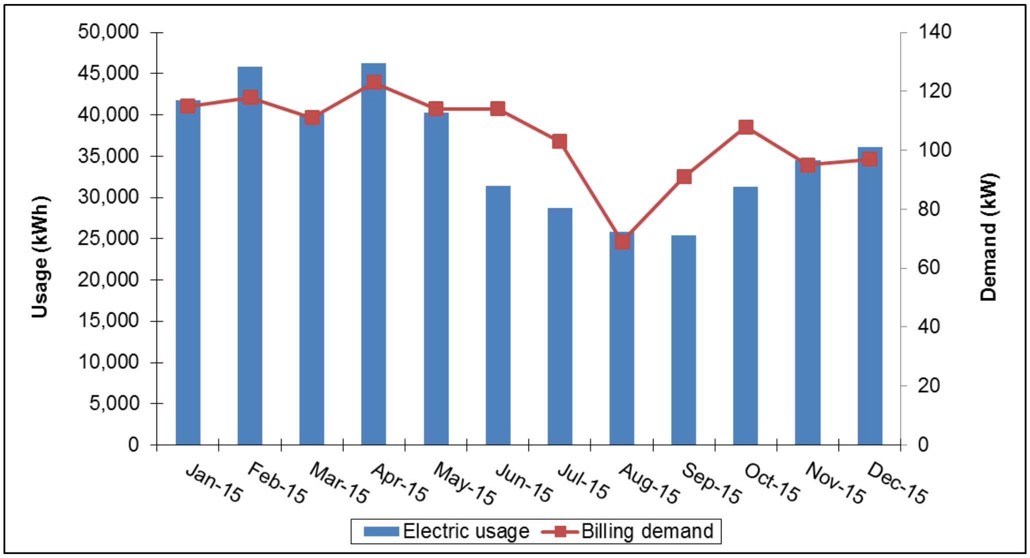


Table 2-5 presents the electric billing history for the ES for 2015; again, the costs presented are based on 2016 rates.

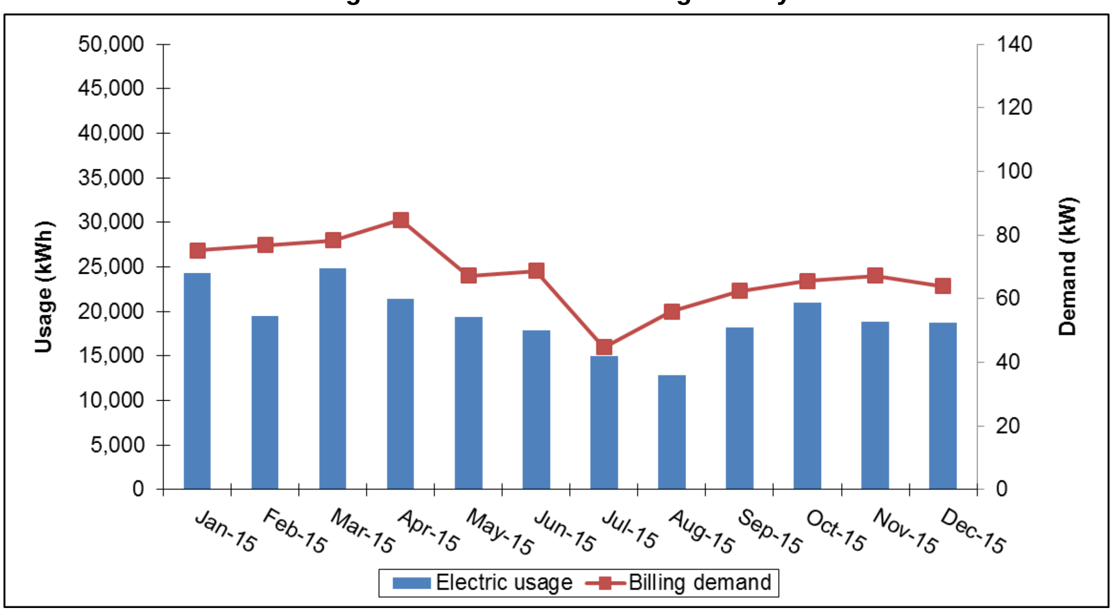
Table 2-5. ES Electric Billing History

Month	Billed Demand (kW)	Energy Use (kWh)	Energy Cost	Demand Cost	Total Bill[1]	Average Rate ($/kWh)	Load Factor	No. of Days	kWh per Day
Jan-15	75	24,320	$2,634	$922	$3,556	$0.1462	42%	32	760
Feb-15	77	19,520	$2,114	$942	$3,056	$0.1566	39%	27	723
Mar-15	78	24,800	$2,686	$961	$3,648	$0.1471	44%	30	827
Apr-15	85	21,440	$2,322	$1,040	$3,362	$0.1568	35%	30	715
May-15	67	19,360	$2,097	$824	$2,921	$0.1509	39%	31	625
Jun-15	69	17,920	$1,941	$843	$2,785	$0.1554	36%	30	597
Jul-15	45	15,040	$1,629	$549	$2,178	$0.1448	42%	33	456
Aug-15	56	12,800	$1,386	$687	$2,073	$0.1620	33%	29	441
Sep-15	62	18,240	$1,976	$765	$2,741	$0.1503	41%	30	608
Oct-15	66	20,960	$2,270	$804	$3,075	$0.1467	42%	32	655
Nov-15	67	18,880	$2,045	$824	$2,869	$0.1520	40%	29	651
Dec-15	64	18,777	$2,034	$785	$2,819	$0.1501	41%	30	626
Peak	**85**	**24,800**	**$2,686**	**$1,040**	**$3,648**	**$0.1620**	**44%**	**N/A**	**827**
Average	**68**	**19,338**	**$2,095**	**$829**	**$2,923**	**$0.1516**	**39%**	**N/A**	**640**
Total	**N/A**	**232,057**	**$25,136**	**$9,945**	**$35,082**	**N/A**	**N/A**	**363**	**N/A**

[1]Estimated costs based on Eversource NH 2016 GV rate structure. Actual billed amount may vary.
N/A = Not applicable

Figure 2-2 presents a month-to-month profile of electricity usage on the ES meter over the same billing period.

Figure 2-2. ES Electric Billing History



ERS made the following observations on the utility data provided:

- The higher load factor for the MHS indicates that its base load electric end uses account for a greater portion of its total usage than with the ES.
- The electric consumption for both facilities is most directly influenced by the schools' operation schedules. Both facilities have peak electric demand in the spring when school is still in session, but possibly more air-conditioning systems are coming on.
- Both schools experience their lowest demand in August when facility staff members report that school is out of session and there are no summer camps. However, we could not reconcile why energy consumption stays relatively constant in August even though peak demand drops off considerably.
- Both facilities have low cooling loads that do not show up clearly in the bills.

2.3.3 Electric Energy Use Breakdown

ERS created energy use breakdowns for both electric meters based on equipment inventories and our understanding of each facility's operation. Figure 2-3 shows the MHS breakdown while Figure 2-4 shows the breakdown for the ES. We estimate that lighting is the largest end use for both facilities, followed by air handling equipment.

Figure 2-3. MHS Energy Use Breakdown

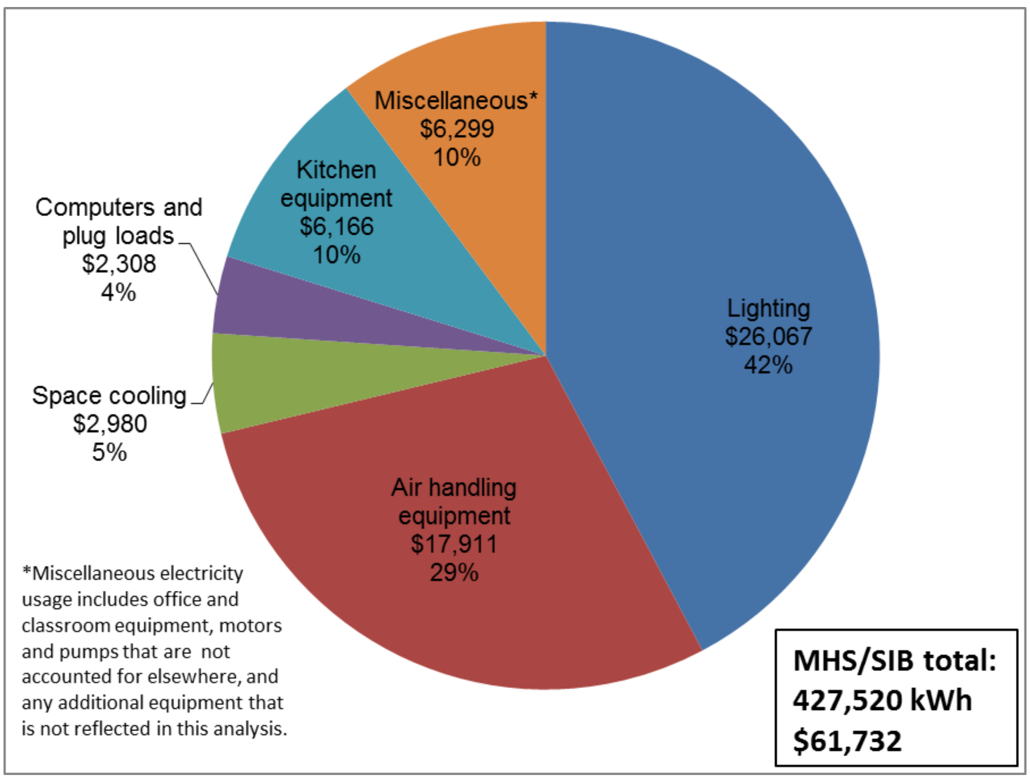
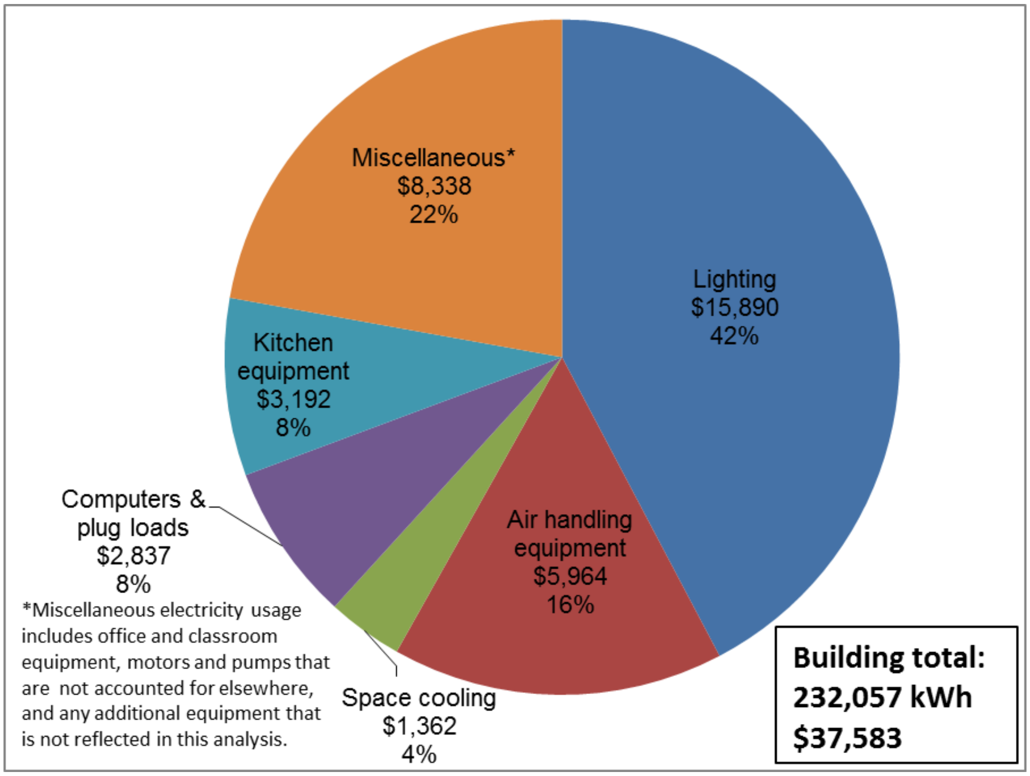


Figure 2-4. ES Energy Use Breakdown



2.3.4 Fuel Oil Costs

The Pittsfield School District has historically signed on to purchasing agreements with a local fuel supplier to lock in a fixed rate price, typically for a 1-year period. Table 2-6 shows the prices that the Pittsfield School District has paid for #2 fuel oil in recent years. ERS used the 2016 price shown in the table to estimate the annual fuel cost savings for each measure. We believe that this will result in the most accurate first-year savings estimates; however, oil prices hit a 10-year low in 2016 and we anticipate greater average annual savings over the lifetime of each measure.

Table 2-6. #2 Fuel Oil Cost History

Year	Middle High School	Elementary School
2013	$3.2750	$3.2750
2014	$3.1950	$3.1950
2015	$3.1714	$3.1714
2016	$2.2081	$2.2081

2.3.5 Fuel Oil Usage History

Based on recent billing data, the MHS and ES consume approximately 26,717 and 13,743 gallons of #2 fuel oil per year, respectively. Using the average price each facility paid for fuel oil over the supplied billing period, this translates to annual fuel oil charges of approximately $81,472 for the MHS and $41,923 for the ES. Table 2-7 summarizes the fuel oil delivery history for each school from 2013 through 2015.

Table 2-7. Fuel Oil Consumption History

Year	Middle High School #2 Oil (Gallons)	Elementary School #2 Oil (Gallons)	Total #2 Oil (Gallons)
2013	24,454	12,798	**37,252**
2014	24,091	13,650	**37,741**
2015	31,606	14,781	**46,387**
Average	**26,717**	**13,743**	**40,460**

2.3.6 Fuel Oil Use Breakdown

ERS did not conduct a detailed heating fuel breakdown during this study; however, based on our experience with similar facilities we estimate that approximately 80% of the total fuel oil consumption for each facility is attributable to space heating, approximately 15% is used for DHW, and the remainder represents cooking and other miscellaneous uses.

2.3.7 Propane Use

The SIB uses propane for space heating and DHW. We did not examine propane consumption in the SIB in detail during this study.

2.4 Alternative Heating Fuels

Pittsfield Schools rely primarily on #2 fuel oil for space heating and DHW, but there are other viable heating fuels available. Table 2-8 shows current prices (June 8, 2016) published by the New Hampshire Office of Energy and Planning[1] for different heating fuels throughout the state.

Table 2-8. Heating Fuel Cost Comparison

Fuel Type	Unit Cost	Energy Content	Energy Cost ($/MMBtu)
#2 fuel oil	$1.95/gallon	138,690 btu/gallon	$14.04
Propane	$2.58/gallon	91,333 btu/gallon	$28.26
Kerosene	$2.72/gallon	135,000 btu/gallon	$20.12
Natural gas	$0.83/therm	100,000 btu/therm	$8.30
Wood pellets	$258.18/ton	16,500,000 btu/ton	$15.65
Electricity[1]	$0.1083	3,412 btu/kWh	$31.73

[1]Electricity cost data based on current marginal costs for Eversource's GV rate.

Table 2-9 shows a comparison between the estimated annual costs associated with each heating fuel type using the current pricing shown in Table 2-8 above and estimated system efficiencies.

[1] https://www.nh.gov/oep/energy/energy-nh/fuel-prices/

Natural gas service is not available at Pittsfield Schools and therefore fuel oil is currently the least expensive heating fuel available to in to NH customers.

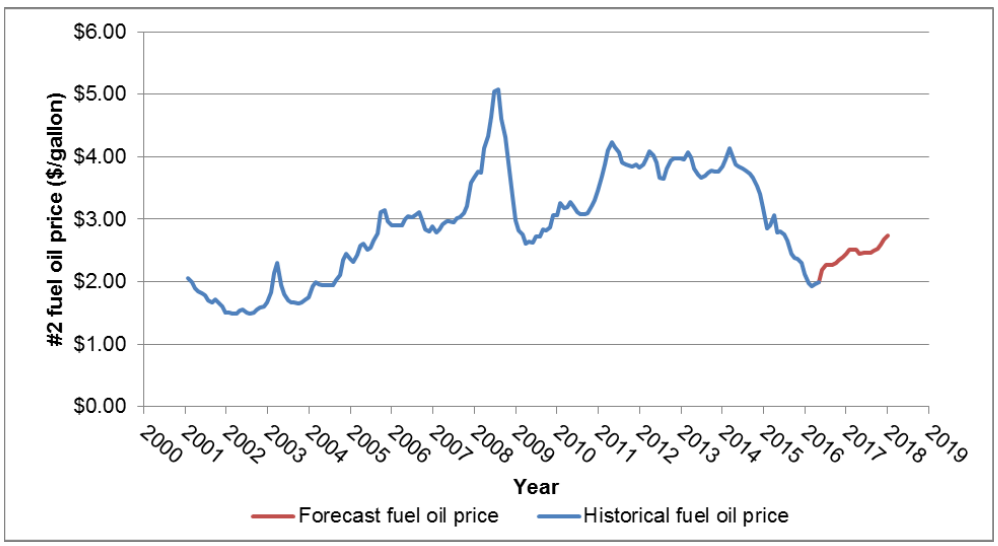
Table 2-9. Heating Fuel Cost Comparison

Fuel Type	Energy Cost ($/MMBtu)	Estimated Utilization Efficiency	Estimated MHS Fuel Usage (MMBtu/yr)	Estimated ES Fuel Usage (MMBtu/yr)	Estimated Total Annual Energy Cost	Estimated Annual Cost Savings	Estimated Annual Cost Savings
#2 fuel oil	$14.04	80%	4,632	2,383	$98,480	$0	0%
Propane	$28.26	80%	4,632	2,383	$198,223	-$99,743	-101%
Kerosene	$20.12	80%	4,632	2,383	$141,127	-$42,647	-43%
Natural gas[1]	$8.30	80%	4,632	2,383	$58,218	$40,262	41%
Wood pellets	$15.65	78%	4,751	2,444	$112,588	-$14,108	-14%
Electricity	$31.73	100%	3,705	1,906	$178,050	-$79,570	-81%

[1]Natural gas is not currently available to Pittsfield Schools

According to the US Energy Information Administration (EIA), national average fuel oil prices are currently at a 10-year low. The EIA also predicts a 21% price increase from 2016 to 2017. Assuming this prediction holds for NH oil prices and pellet fuel prices remain constant, pellets will surpass #2 oil as the least-expensive fuel available and could save Pittsfield Schools an estimated $6,409 annually. Figure 2-5 shows the EIA historical and forecast prices of oil.

Figure 2-5. Historical and Forecast Fuel Oil Price



Source: https://www.nh.gov/oep/energy/energy-nh/fuel-prices/documents/fuel-price-chart-long.pdf

ERS recommends that Pittsfield Schools consider all potential fuel types if faced with an end-of-life replacement of the boiler plants in each school, keeping in mind that switching to another bulk-delivered fuel will require the installation of a new fuel storage system.

Energy Efficiency Measures

3

ENERGY EFFICIENCY MEASURES

This section provides details of the recommended energy efficiency measures (EEMs) for the Pittsfield Schools.

Four EEMs have been studied and are recommended for implementation at the Middle High School (MHS). They are:

- ❑ MHS EEM-1: Install programmable thermostats in classrooms
- ❑ MHS EEM-2: Recommission energy recovery ventilator #2
- ❑ MHS EEM-3: Replace door weather stripping
- ❑ MHS EEM-4: Improve attic insulation
- ❑ MHS EEM-5: Upgrade boilers

The following EEM has been studied and is recommended at the Elementary School (ES)

- ❑ ES EEM-1: Upgrade interior lighting controls

The following EEM has been studied and is recommended for implementation at the SIB:

- ❑ SIB EEM-1: Install programmable thermostats in office spaces

These EEMs should be reviewed to determine whether they are consistent with the facility's operational requirements and the desires of Pittsfield Schools and the school board. The following subsections indicate estimated implementation costs as well as energy, demand, and cost savings for each measure.

3.1 MHS EEM-1: Install Programmable Thermostats in Classrooms

Energy Impacts				
Electric Energy Savings (kWh/yr)	**#2 Oil Savings (Gallons/yr)**	**Annual Savings ($/yr)**	**Estimated Total Cost ($)**	**Simple Payback (Years)**
0	**1,498**	**$3,308**	**$9,360**	**2.8**

3.1.1 Discussion

During our site visit the staff indicated that four classrooms have programmable thermostats and are set back during unoccupied hours. Implementing unoccupied temperature setback controls would reduce the run-time hours for the AHUs and ERVs by increasing the cooling setpoints and reducing the heating setpoints when the spaces are unoccupied. ERS recommends installing programmable thermostats in all classrooms or zones including classrooms and setting the space temperatures back to 86°F during unoccupied cooling hours and 60°F during unoccupied heating hours. Figure 3-1 shows an example of a programmable thermostat.

Figure 3-1. Programmable Thermostat

3.1.2 Measure Implementation and Savings Summary

To enable setback controls, it is necessary to install programmable thermostats that are able to record different temperature setpoints depending on the day of the week and the time of day. The functionality and the interface for programmable thermostats can vary among manufacturers. ERS recommends that Pittsfield compare different thermostats to determine which one meets the requirements of their space.

Table 3-1 shows an inventory of the existing AHUs and ERVs that serve classrooms currently operating 24/7, all of which would benefit from setback controls. The table shows each unit's make, model, and capacity (tons).

Table 3-1. RTU Inventory

Unit ID	Make	Model	Rated Cooling (Tons)
AH-1	Magic Aire	48 BHX	4
AH-2	Magic Aire	48 BHX	4
ERV-7	Venmar	ERV3000I	0
ERV-8	Venmar	ERV3000D	0
ERV-9	Venmar	ERV3000I	0

Temperature setbacks can contribute to 2%–3% savings per degree setback over a 24-hour period. To be conservative, we assumed 1% per degree setback given that the setback would occur over 12 hours. The savings were calculated assuming that all affected units currently maintain a 72°F setpoint in their designated spaces. Table 3-2 shows the baseline and proposed temperature setpoints.

Table 3-2. Current and Proposed Temperature Setpoints

Temp Setpoints	Baseline (°F)	Proposed (°F)
Cooling occupied temperature setpoint	72	72
Cooling unoccupied temperature setpoint	72	86
Heating occupied temperature setpoint	72	72
Heating unoccupied temperature setpoint	72	65

Only the oil savings were determined for this measure. Due to the small number of AHUs with cooling, the relatively short cooling season in Pittsfield, and the reduced operation during the summer, the cooling savings would be comparatively low. However, if the AHUs are cooling during unoccupied hours in the summer, there would be additional electric energy savings realized by this measure. We recommend keeping the current occupied setpoint at 72°F, increasing the unoccupied cooling setpoint to 86°F, and reducing the unoccupied heating setpoint to 65°F. The oil savings for implementing this measure are reported in Table 3-3.

Table 3-3. Heating Savings Summary

Oil savings (MMBtu / year)	208
Oil savings (gallons / year)	1,498
Total cost savings ($ / yr)	$3,308
Implementation cost ($)	$9,360
Simple payback, years	**2.8**

The implementation cost was determined assuming that Pittsfield would install a thermostat in each classroom. We assumed that there were approximately twenty-six classrooms without programmable thermostats. The estimated cost including labor is $300 per thermostat, making the total cost for this project $9,360 for twenty-six thermostats, yielding a 2.8-year simple payback.

3.2 MHS EEM-2: Recommission Energy Recovery Ventilator #2

Energy Impacts				
Electric Energy Savings (kWh/yr)	**#2 Oil Savings (Gallons/yr)**	**Annual Savings ($/yr)**	**Estimated Total Cost ($)**	**Simple Payback (Years)**
0	**215**	**$490**	**$1,500**	**3.2**

3.2.1 Discussion

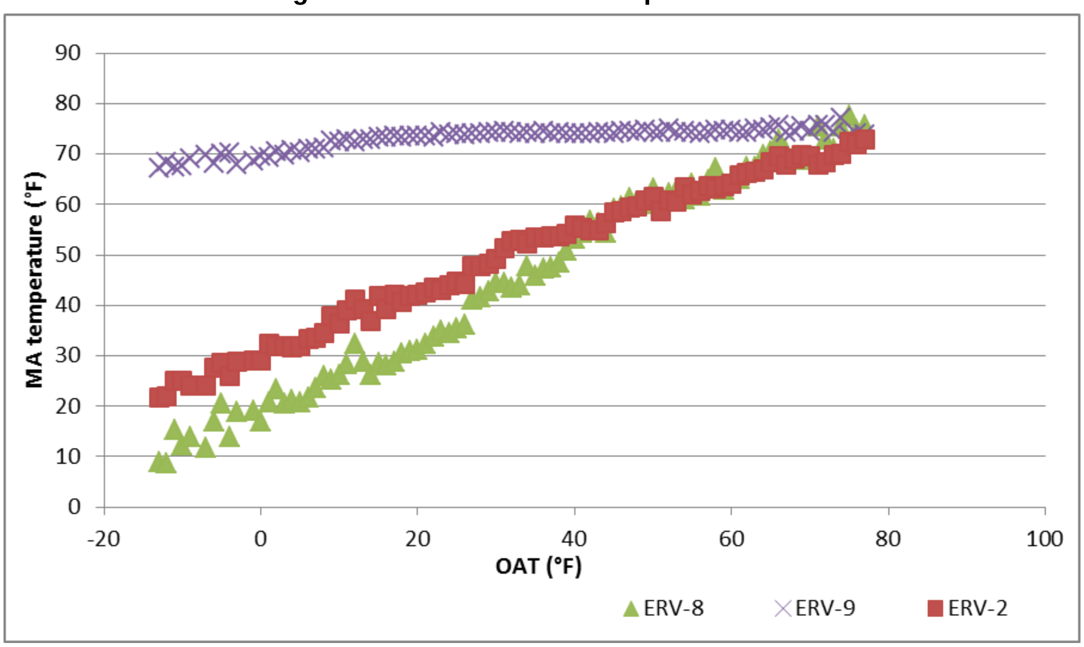
The MHS has nine ERVs that contain energy recovery wheels and operate 24/7. ERS metered the mixed air (MA) and primary supply air (PSA) temperatures and relative humidity in three units to determine the effectiveness of the heat recovery for each unit. Table 3-4 lists the metered units.

Table 3-4. Metered ERVs

Unit ID	Make	Model	Design CFM	Rated Cooling (tons)	Space Type Served	Outdoor Air Damper Operation	Unit Operation
ERV-2	Venmar	ERV3000IDD	3450	0	Gym/lockers	Fixed	Manual
ERV-8	Venmar	ERV3000D	3500	0	Classroom	Fixed	24/7
ERV-9	Venmar	ERV3000I	3900	0	Classroom	Fixed	24/7

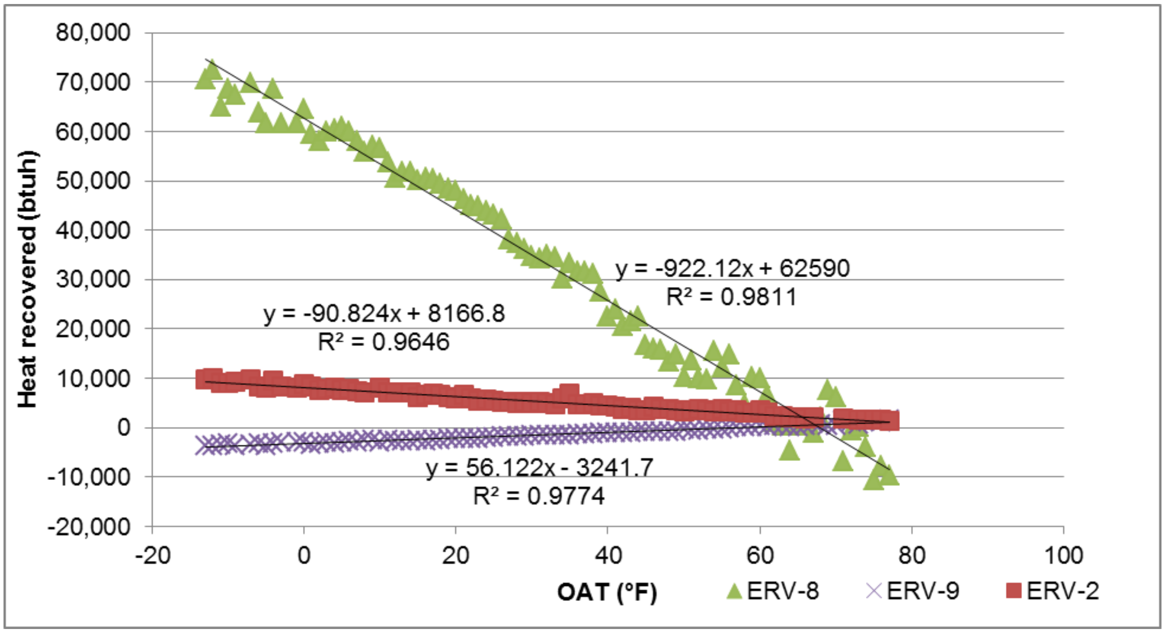
Figure 3-2 shows the MA temperatures for the three metered units. The metered data shows that each unit brings in a fixed percentage of outdoor air (OA). Note that ERV-8 and ERV-2 both appear to be taking in a large, fixed portion of OA while ERV-9 appears to recirculate air, which is apparent by the 70°F MA temperature during periods of 0°F OA temperatures

Figure 3-2. MHS ERV MA Temperature Data



In our analysis we used metered MA and PSA temperatures to calculate the heat recovered by the three units, as shown in Figure 3-3. The data confirmed that while ERV-8 and ERV-9 operate 24/7, ERV-2 is manually shut down at times and operates for an estimated 1,898 hours per year.

Figure 3-3. MHS ERV Heat Recovery Profiles



ERV-8 is operating as expected, transferring the most heat at low OATs; no heat is transferred as the OAT approaches the interior setpoint. ERV-2 operates with a MA temperature similar to ERV-8's but does not recover nearly as much energy. We believe that recommissioning ERV-2 will enable it to recover heat as effectively as ERV-8.

The metered data for ERV-9 shows that the unit extracts heat from the MA stream as it passes through the enthalpy wheel. This is likely due to the placement of the return air (RA) grille at the top of the gym where the air is warmer than the setpoint. This unit is also operating in recirculation mode and is bringing in little to no OA. Operating the unit in recirculation mode means that it does not have any OA loads, and therefore there is nothing to gain from refurbishing the heat recovery capabilities of this unit.

3.2.2 Measure Implementation and Savings Summary

The potential energy recovery of an ERV depends upon the relative enthalpies of the MA and RA flows. We normalized the heat recovery for each unit by the temperature difference between these two air streams and design cfm and calculated the potential savings for refurbishing ERV-2 by applying the normalized ERV-8 heat recovery to the ERV-2 operating profile. Table 3-5 summarized the savings analysis for refurbishing ERV-2.

Table 3-5. ERV-2 Refurbishment Savings Analysis Summary

OAT (°F)	ERV-2 Hours	Baseline ERV-2 Heat Recovery (Btu/h)	Estimated Space Temp (°F)	ERV-2 MAT	ERV-8 MAT	Refurbished ERV-2 Heat Recovery (Btu/h)	Refurbished ERV-2 Heat Load Reduction (MBH)	Refurbished ERV-2 Heating Savings (MBtu)	Refurbished ERV-2 #2 Fuel Oil Savings (Gal)	Fuel Cost Savings
90	12	-244	77	82	89	-8,218	0	0	0.0	$0
85	43	256	75	79	85	-5,742	0	0	0.0	$0
80	63	757	74	76	81	-3,312	0	0	0.0	$0
75	84	1,257	73	74	77	-1,007	0	0	0.0	$0
70	123	1,758	72	71	74	699	0	0	0.0	$0
65	159	2,258	71	68	70	5,714	3	549	5.0	$11
60	170	2,759	71	65	66	7,600	5	831	7.5	$17
55	151	3,259	71	62	62	10,501	7	1,110	10.0	$23
50	127	3,760	71	59	58	13,507	10	1,256	11.3	$26
45	116	4,260	71	57	54	16,544	12	1,445	13.0	$30
40	115	4,761	71	54	50	19,595	15	1,733	15.6	$36
35	165	5,261	71	51	46	22,654	17	2,920	26.3	$60
30	186	5,762	71	48	43	25,718	20	3,773	34.0	$78
25	144	6,262	71	45	39	28,784	23	3,307	29.8	$68
20	95	6,763	71	42	35	31,852	25	2,414	21.8	$50
15	57	7,263	71	39	31	34,921	28	1,596	14.4	$33
10	38	7,764	71	37	27	37,991	30	1,172	10.6	$24
5	22	8,264	71	34	23	41,063	33	730	6.6	$15
0	18	8,765	71	31	19	44,134	35	631	5.7	$13
-5	6	9,265	71	28	15	47,206	38	251	2.3	$5
-10	3	9,766	71	25	12	50,279	41	107	1.0	$2
Total	**1,898**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**23,825**	**215**	**$490**

Table 3-6 shows a summary of the energy savings associated with recommissioning ERV-2 so that it is operating as intended.

Table 3-6. Savings Summary

Electric energy savings (kWh/yr)	0
Electric cost savings ($/yr)	$0
Fuel savings (#2 oil gallons/yr)	215
Fuel cost savings ($/yr)	$490
Total cost savings	$490
Estimated implementation cost	$1,500
Payback (years)	**3.1**

Based on our understanding of the maintenance history and current operation of the remaining six ERVs, we predict that additional refurbishment opportunities exist with other units. We recommend assessing the remaining units and refurbishing those achieving the worst heat recovery performance.

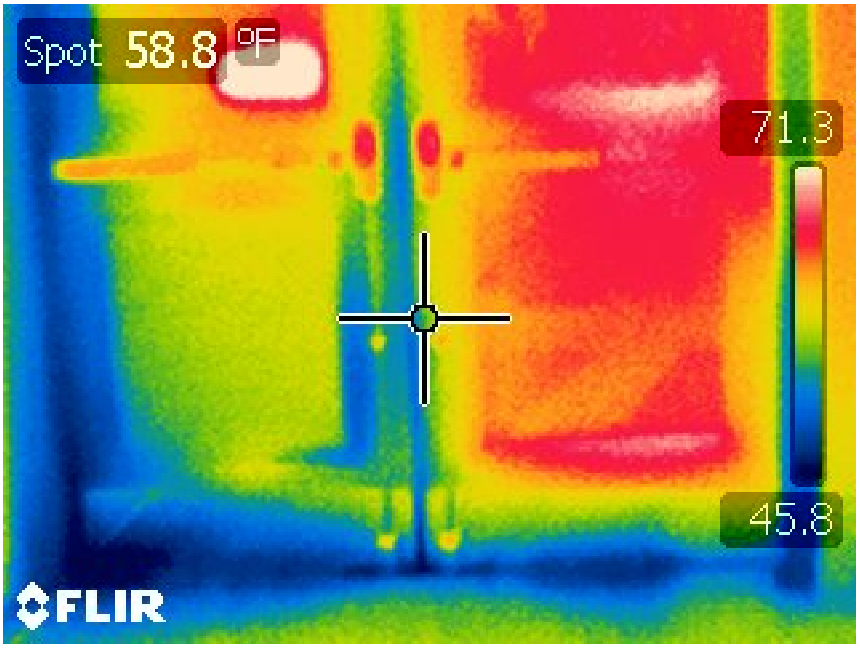
3.3 MHS EEM-3: Replace Door Weather Stripping

Energy Impacts Per Door				
Electric Energy Savings (kWh/yr)	#2 Oil Savings (Gallons/yr)	Annual Savings ($/yr)	Estimated Total Cost ($)	Simple Payback (Years)
0	3.7/door	$8.08/door	$55.00/door	6.8

3.3.1 Discussion

Air sealing helps reduces infiltration through doors, windows, and other leaky penetration points in the building shell. We observed several double doors with infiltration points between and below the doors. Repairing or installing weather stripping on these doors will help reduce the infiltration through these points. The windows seals were in decent condition. Photo 3-1 below shows an infrared image of an exterior door showing significantly colder sections at the base and between the doors.

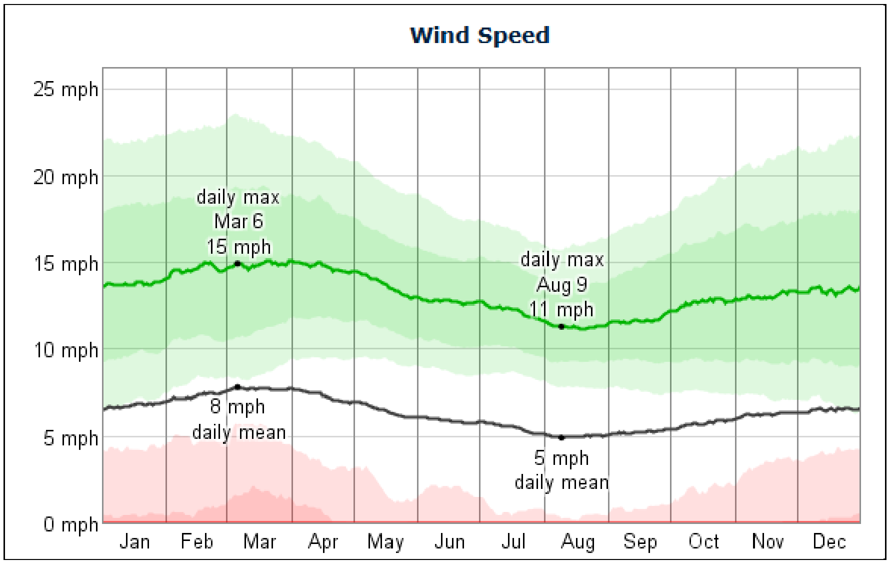
Photo 3-1. Infrared Image of Door Infiltration



3.3.2 Measure Implementation and Savings Summary

Weather stripping helps to better seal the building, reducing the air changes per hour observed by cooling and heating equipment. Given the length of the heating season in Pittsfield, NH, this measure will have a greater impact on heating equipment. The savings for this measure were determined using the crack method published by ASHRAE, which examines the local exterior wind speeds and door crack characteristics to determine the flow (cfm) through door cracks. Figure 3-4 shows the average wind speed for the area, which was approximately 15 mph in the winter.

Figure 3-4. Pittsfield Wind Speeds



An annual OAT profile was set up using TMY3 data. For the heating season the heat losses through door cracks were calculated using the following equation:

$$Q = 1.08 \times CFM \times \Delta T$$

Table 3-7 summarizes the annual savings potential per door, including energy savings, cost savings, and simple payback. While weather stripping does impact cooling loads as well, electric savings were not quantified due to the relatively small number of occupied cooling degree days and a lack of information regarding the zones that had both cooling and exterior doors. Since some electric savings will be realized, we believe these estimated savings and payback to be conservative. Note that the installation cost includes an estimated cost for external labor that could be reduced using internal labor.

Table 3-7. Energy Savings Summary

Energy savings per door	0.5 MMBtu/year
Oil savings per door	3.7 gallons/year
Cost savings per door	$8.08/year
Installation cost	$55.00/door
Payback	**6.8 years**

The MHS may also benefit from additional air sealing measures, including checking for duct leakage. Sealing other envelope penetration points, including windows, and reducing duct leakage will reduce the total air changes per hour handled by the heating and cooling equipment.

3.4 MHS EEM-4: Improve Attic Insulation

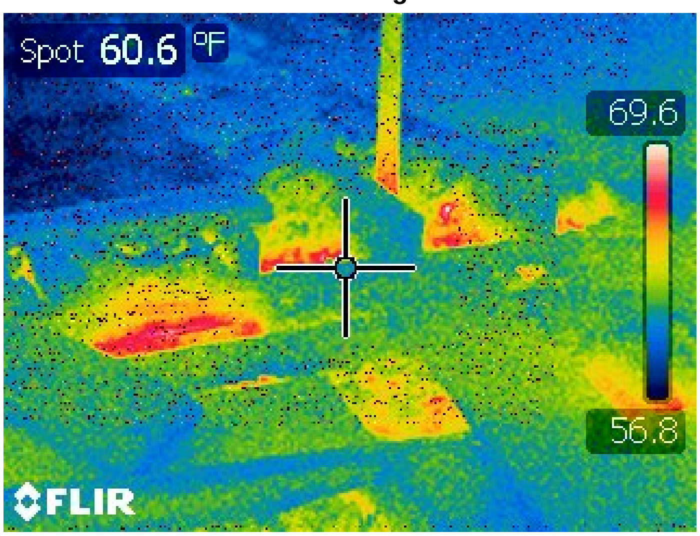
Energy Impacts				
Electric Energy Savings (kWh/yr)	#2 Oil Savings (Gallons/yr)	Annual Savings ($/yr)	Estimated Total Cost ($)	Simple Payback (Years)
0	2,466	$5,445	$43,000	7.9

3.4.1 Discussion

While on-site ERS observed the current conditions of the attic space over the older sections of the MHS. The school uses loose blown cellulose in between ceiling joists; much of it looked degraded and it was not equally dispersed across the attic floor. Some areas had piles approximately 6 inches high, while other areas had as low as an inch. During the site visit the OAT was approximately 8°F and the attic was as high as 50˚F. Theoretically, the attic space should be close to the OAT if it's not sealed and insulated in the attic eaves; therefore, there is likely a large amount of heat loss to the attic from the heated spaces below. While there was some piping without insulation, it was only a small amount of exposed surface area and the duct insulation was in good condition.

Photo 3-2 shows an infrared image taken of the attic floor. The red area is an example of where heat is escaping from the building into the unconditioned attic space. Improving the insulation in the attic will help mitigate the thermal losses observed in the conditioned spaces. For Pittsfield's climate zone[2] (6), the Department of Energy (DOE) recommends R-49 – R-60 attic insulation, which would require 14 inches of loose blown cellulose. The joists also serve as a thermal break and it would be beneficial to cover them with a continuous layer of insulation.

Photo 3-2. Infrared Image of Attic Floor

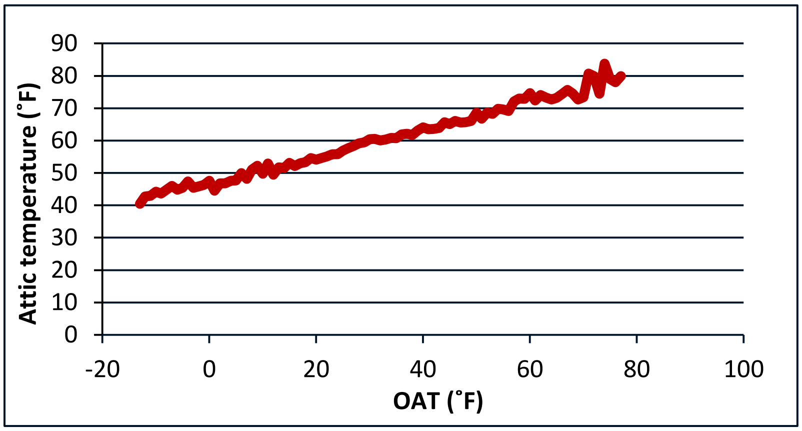


[2] Based on US from the International Energy Conservation Code (IECC)

3.4.2 Measure Implementation and Savings Summary

During our site visit, we metered the attic space temperature. As shown in Figure 3-5, the attic space temperature is consistently about 40°F warmer than the OAT. A limiting constraint to installing 8 inches of insulation may be the available vertical height. An alternative that may have a greater cost is to change out the insulating material. Other materials are available and commonly used for attic floors that have greater insulating properties, allowing them to achieve R-value with less thickness, including stone wool and extruded polystyrene.

Figure 3-5. Attic Temperature Relative to Outside Air Temperature



The energy savings were estimated by comparing the heat losses with 4 inches (on average) of loose blown cellulose insulation, and that of 8 inches. Given Pittsfield's thermal loads in the attic, including hot water piping and ductwork, we conservatively estimated that a properly insulated attic would only be about 20°F warmer than outside air. The heat losses were calculated annually using typical meteorological year (TMY3) weather data from a nearby weather station. Using the temperature difference between the conditioned space and the attic (ΔT), the area (A) of the attic, and the U-value (1/R-value) of the insulation, the heat losses (Q) were calculated using the following equation:

$$Q = U \times A \times \Delta T$$

Table 3-8 shows a summary of the energy savings associated with improving the existing insulation from what was observed to be approximately R-15 to R-49. This table also shows and approximate installation cost for loose blown cellulose referenced from RSMeans cost data and the associated simple payback using the currently billed electric rate.

Table 3-8. Savings Summary

Energy savings (MMBtu/yr)	274
Oil savings (gallons/year)	2,466
Cost savings ($/year)	$5,445
Implementation cost ($)	$43,000
Simple payback, years	**7.9**

3.5 MHS EEM-5: Upgrade Boilers

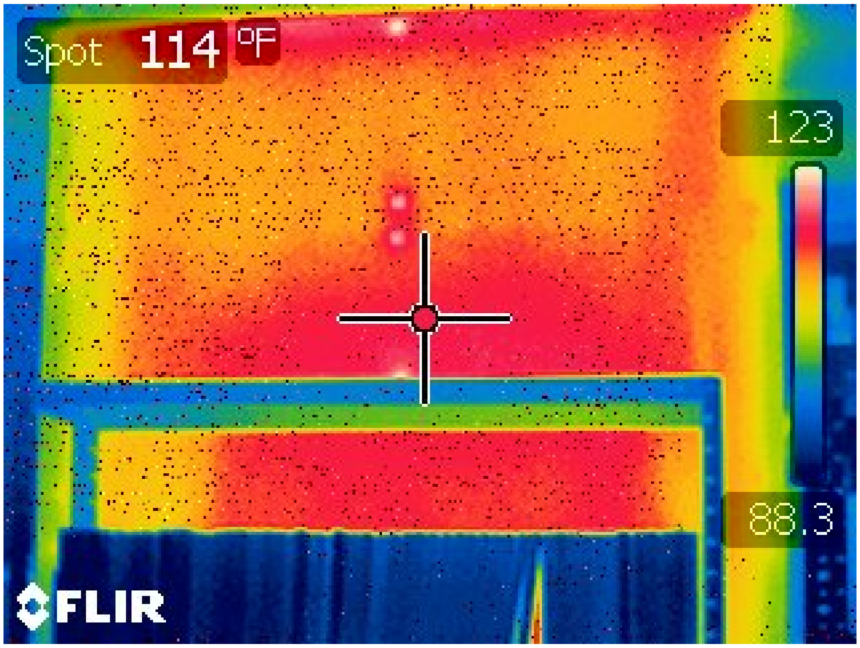
Energy Impacts	Option A: Install Condensing Boilers			
Electric Energy Savings (kWh/yr)	#2 Oil Savings (Gallons/yr)	Annual Savings ($/yr)	Estimated Total Cost ($)	Simple Payback (Years)
0	1,868	**$4,260**	$100,000	**23.5**

Energy Impacts	Option B: Install a Boiler Stack Economizer			
Electric Energy Savings (kWh/yr)	#2 Oil Savings (Gallons/yr)	Annual Savings ($/yr)	Estimated Total Cost ($)	Simple Payback (Years)
0	**1,282**	**$2,924**	**$30,000**	**10.3**

3.5.1 Discussion

The boilers serving the MHS operate with an estimated thermal efficiency of 80%; the remaining input fuel energy leaves the boilers through the flue as waste heat expelled to the atmosphere. This heat loss has an energy content equivalent to approximately 5,000 gallons of #2 fuel oil per year. In addition to being unutilized energy, the hot flue gas exits the building via a double-walled exhaust stack positioned inside an uninsulated chase that runs through the back room in the library, overheating that space and causing simultaneous cooling and heating in the library. Photo 3-2 is a thermal image of the stack chase that shows the surface temperature of the chase as it reaches temperatures of up to 123°F.

Photo 3-2. Uninsulated Stack Chase in Library Back Room



ERS recommends that Pittsfield Schools install equipment that is capable of reclaiming the flue gas heat, thereby increasing the overall thermal efficiency of the boiler plant. The next sections discuss two potential avenues by which this heat recovery can be achieved.

- ❑ MHS EEM-5a: Install condensing boilers
- ❑ MHS EEM-5b: Install a non-condensing stack economizer

3.5.2 MHS EEM-5a: Install Condensing Boilers

Condensing boilers use flue gas heat to preheat the feedwater or combustion air. Condensing boilers are so called because under certain conditions they recover enough latent heat to condense the flue gasses. Figure 3-6 shows a typical efficiency curve for a condensing boiler that recovers flue gas heat and transfers it to the boiler's feedwater. Note the sharp increase in efficiency below 130°F; this represents the point at which the unit's flue gas begins condensing.

Figure 3-6. Typical Condensing Boiler Efficiency Curve

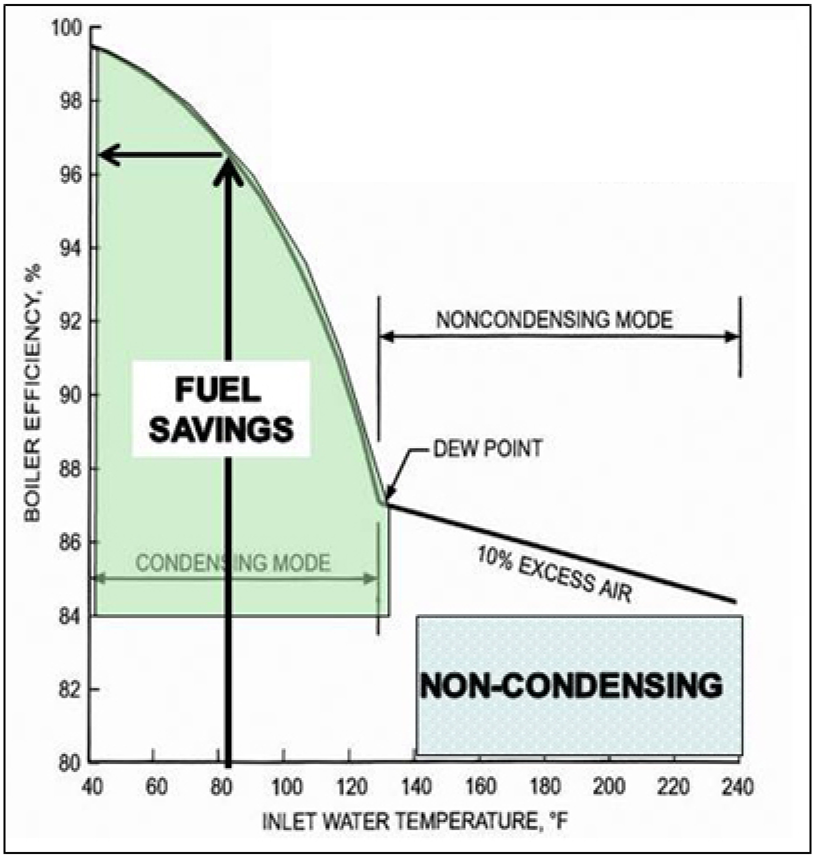
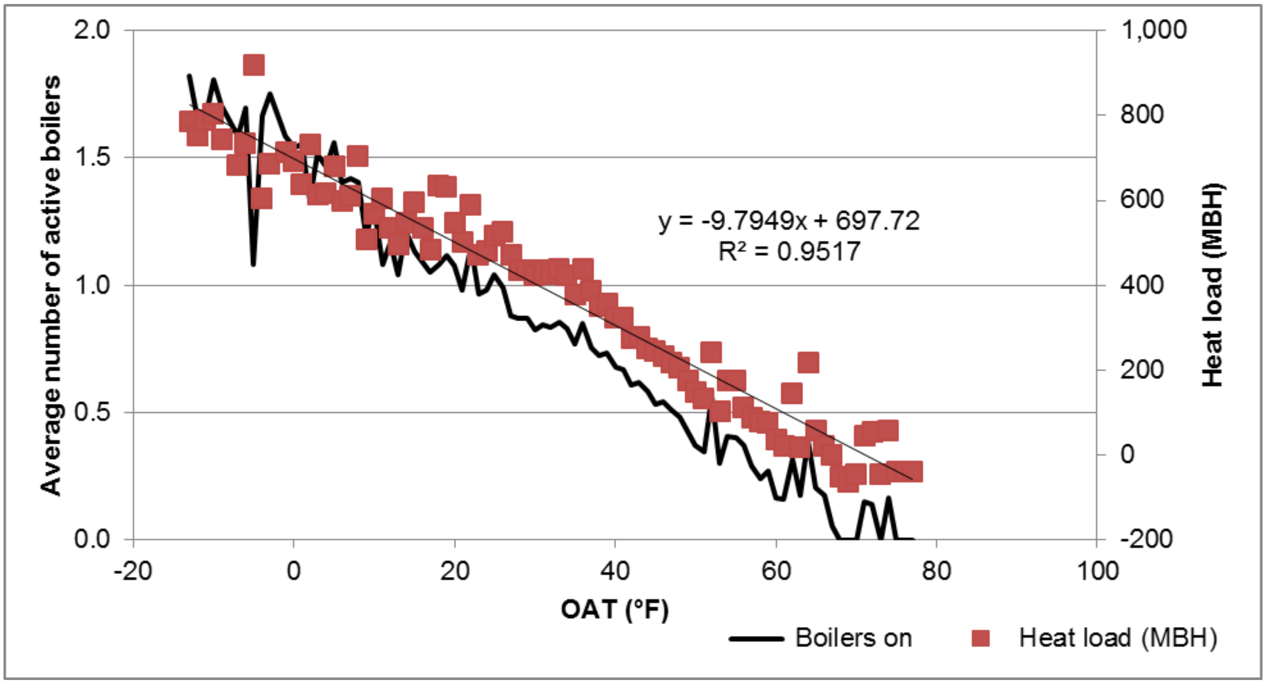


Image credit: Cleaver Brooks

Condensing boilers exist for all major heating fuel types and are capable of turndown ratios as low as 5%–10%, which allows them to match variable system loads.

ERS calculated the potential savings for installing condensing boilers in the MHS using a spreadsheet-based temperature bin analysis. We used metered data collected from the existing boiler plant between February 11, 2016 and April 27, 2016, to model the plant's heating load. Figure 3-7 shows the facility's heating load that was generated using the metered data.

Figure 3-7. MHS Heating Load Profile



ERS modeled the existing boiler system using the heat load profile shown above and calculated the estimated baseline fuel oil use assuming 80% thermal efficiency for the existing boilers. We created an estimated efficiency curve for the proposed condensing boilers and applied it to the same bin analysis to calculate the proposed system usage. Table 3-9 summarizes the savings analysis, showing that the proposed condensing boilers will operate with an estimated annual average efficiency of 88.4%.

Table 3-9. Condensing Boiler Savings Analysis Summary

OAT (°F)	Hours	HW Load (MBH)	Baseline Boiler Efficiency	Baseline Fuel Oil Consumption (Gallons)	Average HW Supply Temperature (°F)	Average HW Return Temperature (°F)	Proposed Boiler Efficiency	Proposed Fuel Oil Consumption (Gallons)	Fuel Oil Savings (Gallons)	Estimated Cost Savings
90	54	0	N/A	0	N/A	N/A	N/A	0	0	$0
85	200	0	N/A	0	N/A	N/A	N/A	0	0	$0
80	292	0	N/A	0	N/A	N/A	N/A	0	0	$0
75	386	0	N/A	0	N/A	N/A	N/A	0	0	$0
70	567	12	80.0%	62	90	85.0	96.0%	51	10	$23

OAT (°F)	Hours	HW Load (MBH)	Baseline Boiler Efficiency	Baseline Fuel Oil Consumption (Gallons)	Average HW Supply Temperature (°F)	Average HW Return Temperature (°F)	Proposed Boiler Efficiency	Proposed Fuel Oil Consumption (Gallons)	Fuel Oil Savings (Gallons)	Estimated Cost Savings
65	735	61	80.0%	404	90	85.0	96.0%	337	67	$154
60	786	110	80.0%	779	92	85.0	96.0%	650	130	$296
55	699	159	80.0%	1,002	101	93.5	94.3%	850	152	$346
50	587	208	80.0%	1,100	110	102.0	92.6%	951	150	$341
45	535	257	80.0%	1,239	119	110.5	90.9%	1,090	149	$339
40	531	306	80.0%	1,464	128	119.0	89.2%	1,313	151	$344
35	763	355	80.0%	2,441	137	127.5	87.5%	2,232	209	$477
30	859	404	80.0%	3,127	146	135.3	86.8%	2,880	246	$562
25	667	453	80.0%	2,722	156	142.8	86.6%	2,514	208	$474
20	437	502	80.0%	1,976	165	150.2	86.4%	1,830	146	$334
15	262	551	80.0%	1,301	174	157.7	86.2%	1,207	93	$212
10	176	600	80.0%	951	183	165.1	85.9%	886	66	$150
5	101	649	80.0%	591	192	172.6	85.7%	551	39	$90
0	81	698	80.0%	509	200	180.0	85.5%	477	33	$75
-5	30	747	80.0%	202	200	180.0	85.5%	189	13	$30
-10	12	796	80.0%	86	200	180.0	85.5%	81	6	$13
Total	**8,760**	**N/A**	**80.0%**	**19,957**	**N/A**	**N/A**	**88.4%**	**18,089**	**1,868**	**$4,260**

We estimate that a condensing boiler plant will save approximately 259 MMBtu per year, which is equivalent to approximately 1,868 gallons of #2 fuel oil or 9% of the total MHS fuel consumption. Assuming that there is no fuel switch involved, this measure is expected to save Pittsfield Schools approximately $4,124 per year at the current price they pay for #2 oil ($2.2081/gallon).

Fuel-fired condensing boilers have one major limitation compared to propane- and natural gas-fired units; they require fuel with ultra-low sulfur content (not exceeding 15 ppm). At higher sulfur concentrations, the condensate produced by the boiler contains levels of sulfuric acid that are high enough to dissolve certain components within the system. With that exception, oil-fired condensing boilers operate similarly to condensing boilers using other fuel types. In addition, many manufacturers offer dual-fuel burners that are capable of using fuel oil and propane (or natural gas).

Based on our experience with similar boiler replacement projects, we estimate the up-front cost of installing a pair of 2,000 MBH condensing boilers and integrating them with the existing HW system to be approximately $100,000. The energy cost savings result in a payback of approximately

23 years and therefore do not warrant this level of investment at this time. ERS recommends installing condensing boilers upon failure of the existing units, at which point the incremental cost over standard equipment should be considered. We estimate that condensing boiler systems have an associated cost premium of approximately 20% over a standard system; this translates to an incremental cost of approximately $16,667 and a simple payback on the incremental investment of approximately 4 years. A summary of the savings for this measure is given in Table 3-10.

Table 3-10. Savings Summary for MHS EEM-5a

Electric energy savings (kWh/yr)	0
Electric cost savings ($/yr)	$0
Fuel savings (#2 oil gallons/yr)	1,868
Fuel cost savings ($/yr)	$4,260
Total cost savings	$4,260
Estimated implementation cost	$100,000
Incremental implementation cost	$16,667
Payback (years)	**23.5**
Incremental Payback (years)	**3.9**

3.5.3 MHS EEM-5b: Install a Non-Condensing Stack Economizer

The existing boilers in the MHS are approximately 16 years old and in operable condition with typical annual maintenance. Well-maintained boilers can last 25 years or longer, and replacing the units before the end of their useful life with high efficiency boilers is not cost-effective on the basis of energy cost savings along. Boiler manufactures sell stack economizers that reclaim heat from the boiler's exhaust header.

Condensing economizers are capable of recovering latent heat from the air stream and safely disposing of the resulting condensate; they can improve a standard boiler's performance such that it approaches that of a condensing boiler. Non-condensing stack economizers reclaim flue gas heat without reducing the gas temperature to its dew point (condensing the flue gasses). They are not capable of recovering latent heat from the air stream and therefore have a lower peak performance. However, because they do not produce condensate, non-condensing economizers do not require some of the more costly materials and installation methods required by condensing units.

We used a bin analysis to calculate the potential savings for retrofitting a non-condensing stack economizer on the existing system by calculating the initial flue gas temperature based on available waste heat from the boilers operating at 80% thermal efficiency. Table 3-11 summarizes our analysis. Note that we assume that the system will extract heat from the flue gas down to 200°F as a precaution against condensing; however, it is possible to reduce the flue gas temperature as low as 160°F in a properly installed and commissioned non-condensing economizer. Non-condensing economizers that preheat boiler feed water normally do not condense until the feed water temperatures drop below 140°F, which is below the typical return water temperature for the MHS. Furthermore, we assumed that only

80% of unutilized input energy (16% of total input energy) will be converted to sensible flue gas heat. The remaining waste heat is attributed to uncaptured latent heat in the combustion air and other system inefficiencies.

Table 3-11. Non-Condensing Economizer Savings Analysis Summary

OAT (°F)	Hours	Number of Active Boilers	Combustion Air Flow (CFM)	Waste Heat Transferred to Flue Gas (MBH)	Initial Flue Gas Temperature (°F)	Reduced Temperature Flue Gas (°F)	Recovered Heat (MBH)	Fuel Savings (MMBtu)	#2 Fuel Oil Savings (Gal)	Estimated #2 Fuel Oil Cost Savings
90	54	0.00	0	0	N/A	N/A	0	0	0	$0
85	200	0.00	0	0	N/A	N/A	0	0	0	$0
80	292	0.00	0	0	N/A	N/A	0	0	0	$0
75	386	0.00	0	0	N/A	N/A	0	0	0	$0
70	567	0.07	41	3	138	138	0	0	0	$0
65	735	0.17	102	15	209	200	1	1	7	$15
60	786	0.27	162	28	227	200	5	5	34	$77
55	699	0.37	223	40	235	200	8	7	53	$122
50	587	0.47	283	52	240	200	12	9	65	$148
45	535	0.57	344	64	243	200	16	11	77	$176
40	531	0.67	404	76	245	200	20	13	94	$215
35	763	0.77	465	89	247	200	23	22	162	$368
30	859	0.88	525	101	248	200	27	29	211	$481
25	667	0.98	586	113	249	200	31	26	186	$425
20	437	1.08	646	125	250	200	35	19	137	$312
15	262	1.18	707	138	250	200	38	13	91	$207
10	176	1.28	767	150	251	200	42	9	67	$153
5	101	1.38	828	162	251	200	46	6	42	$95
0	81	1.48	888	174	252	200	50	5	36	$83
-5	30	1.58	949	187	252	200	53	2	14	$33
-10	12	1.68	1,009	199	253	200	57	1	6	$14
Total	**8,760**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**178**	**1,282**	**$2,924**

N/A= Not applicable

We estimate that a non-condensing stack economizer will be capable of recovering 178 MMBtu of heat throughout a typical year, or approximately 6% of the MHS baseline usage; this equates to 1,282 gallons of #2 fuel oil, or $2,924 per year. We estimate the cost of installing a non-condensing stack economizer at the main header to be $30,000, yielding a simple payback of 10.6 years. A summary of the savings for this measure is given in Table 3-12.

Table 3-12. Savings Summary for MHS EEM-5b

Electric energy savings (kWh/yr)	0
Fuel savings (#2 oil gallons/yr)	1,282
Total cost savings	$2,924
Estimated implementation cost	$30,000
Payback (years)	**10.3**

3.6 ES EEM-1: Upgrade Interior Lighting Controls

Energy Impacts				
Electric Energy Savings (kWh/yr)	#2 Oil Savings (Gallons/yr)	Annual Savings ($/yr)	Estimated Total Cost ($)	Simple Payback (Years)
8,156	0	$883	$3,000	3.4

3.6.1 Discussion

Facility maintenance personnel indicated that the ES's main atrium lights are often manually turned off during days when natural light permits. We recommend installing daylight harvesting controls capable of automating this process to minimize the operating hours of that system.

As discussed in Section 2.2.3, facility staff members report that some newly installed LED fixtures cause some spaces to be overly lit at all times and that some spaces could have reduced light levels periodically. We recommend installing dimming controls where applicable or replacing non-dimmable LEDs in overly lit areas with lower-wattage units.

3.6.2 Measure Implementation and Savings Summary

If the existing LED high-bay fixtures in the ES atrium are dimmable, then the control system should include a photocell in the occupied space that controls the LED output to achieve minimum acceptable light levels. The control logic will be similar if the fixtures are not dimmable; however, the savings will not be as deep. We estimate that the existing atrium lighting system operates for approximately 3,066 hours per year and that daylight harvesting controls can reduce the system's annual usage by 30%. Table 3-13 summarizes our estimates and analysis results.

Table 3-13. Atrium Lighting Daylight Harvest Controls Savings Summary

Lighting System	Connected kW	Annual Hours	Controls Savings	Baseline Energy (kWh)	Proposed Energy (kWh)	Energy Savings (kWh)
ES atrium	1.4	3,066	0.30	4,292	3,005	1,288

We estimate that 10% of the connected lighting in the ES could reduce its usage by 30%, representing potential electric savings of approximately $500 annually. We do not predict any impacts on the facility's billing demand because the lighting system is still expected to operate at 100% for at least a portion of every day.

The implementation cost for this measure will largely depend on the dimmability of the existing fixtures. ERS was unable to verify that the existing fixtures are dimmable; however, our cost estimates assume that they are. We estimate the cost of installing daylight harvesting controls to be $1,100, which includes $100 in materials and $1,000 in labor costs to account for potential wiring and/or high-bay installation of equipment. We estimate that ten areas in the school could benefit from dimming controls and it will cost $150 per area to install them. The total estimated cost for this measure is $3,000. There may be some billing demand savings in the case where a lower-wattage LED is installed; however, for the purpose of this study we assumed that dimmer switches would be used, and therefore no demand savings are proposed.

Table 3-14 summarizes the savings for this measure.

Table 3-14. Savings Summary

Electrical energy savings (kWh/yr)	8,156
Electrical cost savings ($/yr)	$883
Oil savings (MMBtu/year)	0
Oil savings (gallons / year)	0
Oil cost savings ($/year)	$0
Total cost savings ($/yr)	$883
Implementation cost ($)	$3,000
Simple payback, years	**3.4**

3.7 SIB EEM-1: Implement Setback Controls in the Office

Energy Impacts				
Electric Energy Savings (kWh/yr)	Propane Savings (Gallons/yr)	Annual Savings ($/yr)	Estimated Total Cost ($)	Simple Payback (Years)
2,277	192	$822	$360	0.4

During our site visit, the staff indicated that the superintendent's office does not have programmable thermostats and therefore they cannot set back temperatures after hours. Implementing unoccupied temperature setback controls would reduce the run-time hours for the AHUs by increasing the cooling setpoints and reducing the heating setpoints when the spaces are unoccupied. ERS recommends installing programmable thermostats in the superintendent's office and setting the space temperatures back to 86°F during unoccupied cooling hours and 60°F during unoccupied heating hours.

3.7.1 Measure Implementation and Savings Summary

To enable setback controls, it is necessary to install programmable thermostats that are able to record different temperature setpoints depending on the day of the week and the time of day. One AHU serves the superintendent's office 24/7 and would benefit from setback controls. The functionality and the interface for programmable thermostats can vary among manufacturers. ERS recommends that Pittsfield compare different thermostats to determine which one meets the requirements of their space.

The savings were calculated assuming that all affected units currently maintain a 72°F setpoint in their designated spaces. Table 3-15 shows the baseline and proposed temperature setpoints. ERS recommends keeping the current occupied setpoint at 72°F and increasing the unoccupied setpoint from 72°F to 80°F during the cooling season, and from 72°F to 65°F during the heating season.

Table 3-15. Current and Proposed Temperature Setpoints

Temperature Setpoints	Baseline (°F)	Proposed (°F)
Cooling occupied temperature setpoint	72	72
Cooling unoccupied temperature setpoint	72	80
Heating occupied temperature setpoint	72	72
Heating unoccupied temperature setpoint	72	65

Setback controls will help reduce annual oil consumption by reducing AHU operation during the heating season and can contribute to 2%–3% savings per degree setback over a 24-hour period. To be conservative, we assumed 1% per degree setback given that the setback would occur over 12 hours. ERS assumed that the SIB operates during the summer as well, yielding electric savings resulting from reduced cooling loads during unoccupied hours. Both natural gas and electric savings for implementing these temperature shifts are reported in Table 3-16.

Table 3-16 Savings Summary

Electrical energy savings (kWh/yr)	2,277
Electrical cost savings ($/yr)	$247
Propane savings (MMBtu/year)	17.5
Propane savings (gallons / year)	192
Propane cost savings ($/year)	$575
Total cost savings ($/yr)	$822
Implementation cost ($)	$360
Simple payback, years	**0.4**

Informational Measures

4

INFORMATIONAL MEASURES

Informational measures (IMs) are measures that either require more detailed investigation beyond the scope of this assessment, have relatively small savings, or have significantly long paybacks. This section provides details of the IMs for the Pittsfield Schools.

The following IMs were identified at the MHS:

- MHS IM-1: Implement HW temperature reset
- MHS IM-2: Repair hot water pipe insulation
- MHS IM-3: Duct boiler intake combustion air through the flue chase
- MHS IM-4: Install rooftop solar photovoltaic (PV) system

The following IMs were identified at the ES:

- ES IM-1: Repair hot water pipe insulation
- ES IM-2: Replace pneumatic controls with digital system

The following IM was identified at the SIB:

- SIB IM -1: Seal penetration point for old dust collector system

These IMs should be reviewed to determine whether they are consistent with the facility's operational requirements and the desires of Pittsfield Schools and the school board. The following subsections provide details on these IMs.

4.1 MHS IM-1: Implement Hot Water Temperature Reset

The MHS boiler plant is set to supply hot water (HW) at 180°F throughout the heating season. We recommend implementing a HW temperature setback routine that will allow the system to operate using lower-temperature HW during periods with mild heating loads. For example, when the OAT is 50°F, the heating system may be able to maintain space temperatures using HW at 100°F, whereas it might require 180°F HW by the time the OAT drops to 10°F. It may be possible to retrofit a control system consisting of an outside temperature sensor that controls two new HW supply temperature control modules to replace the existing mechanical control modules that are currently installed on each boiler (as shown in Photo 2-3 in Section 2). Alternatively, Pittsfield Schools could implement a new standard operating procedure for the MHS boilers that involves manually reducing the HW supply temperature setpoint during prolonged periods with mild heating load. We estimate that this measure would reduce heating fuel consumption by 1.5% annually, saving 1,250 gallons of fuel oil and $400 per year.

4.2 MHS IM-2: Repair Hot Water Pipe Insulation

The HW piping in the MHS attic is generally well insulated along straight lengths of pipe; however, we noticed many exposed fittings, valves, and angle joints throughout the system while on-site. Exposed copper pipe elements transfer heat from the HW loop to the unconditioned attic space and increase the load on the boilers. We recommend insulating all bare elements with a minimum of 1 inch of mineral fiber or other appropriate insulating material. As a best practice, all HW piping should be insulated, and this measure could potentially alleviate some of the ice dam issues that have been reported by the MHS by reducing the temperature of the attic space during the heating season.

4.3 MHS IM-3: Duct Boiler Intake Combustion Air through the Flue Chase

Pittsfield may be able to synthesize a stack economizing effect by drawing intake air for the boilers through the exhaust stack chase. This would preheat the combustion air using the skin losses from the boiler stack. It would also directly reduce the temperature of the air within the chase, thereby alleviating the overheating issues in the back room of the library. Besides creating a more comfortable space, reducing the overheating in the library could eliminate the simultaneous heating and cooling that has been observed during winter.

We estimate that this approach towards stack economizing could achieve 25% of the heat recovery potential that we calculated for EEM-1b regarding the installation of a non-condensing stack economizer. This estimate translates to annual fuel oil savings of 320 gallons and $730 annually.

4.4 MHS IM-4: Install Rooftop Solar Photovoltaic System

The MHS has roof space upon which a solar PV system could be installed. We used the National Renewable Energy Laboratory’s PVWatts® calculator tool to estimate that the roof has available space for a 64.7 kW PV system, which will generate an estimated 81,289 kWh annually. The tool also estimates an installation cost of $168,220, which is based on $2.6/watt of installed capacity.

The MHS roof does not get shading from nearby trees, but the ridgeline also runs from southwest to northeast, which positions panels at a sub-optimal angle. The ES has some shade potential from surrounding trees and the MHS located on the hill above, but it features a flat roof upon which racks can be installed to appropriately angle panels. We recommend that Pittsfield Schools solicit vendor quotes and third-party savings estimates to determine the value of installing a PV system at one or both of the facilities. In addition to energy savings, a PV system could serve as a valuable education tool for students attending Pittsfield Schools. Figure 4-1 shows the results output from PV Watts.

Figure 4-1. PV Watts Results

RESULTS **81,289 kWh per Year ***

System output may range from 77,509 to 84,882kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Energy Value ($)
January	2.97	5,162	593
February	3.81	6,004	689
March	4.40	7,512	862
April	5.05	7,936	911
May	5.61	8,751	1,005
June	5.77	8,510	977
July	5.72	8,618	989
August	5.36	8,088	929
September	4.57	6,811	782
October	3.51	5,675	651
November	2.58	4,191	481
December	2.31	4,031	463
Annual	4.31	81,289	$ 9,332

Location and Station Identification

Requested Location	pittsfield high school new hampshire
Weather Data Source	(TMY2) CONCORD, NH 3.7 mi
Latitude	43.2° N
Longitude	71.5° W

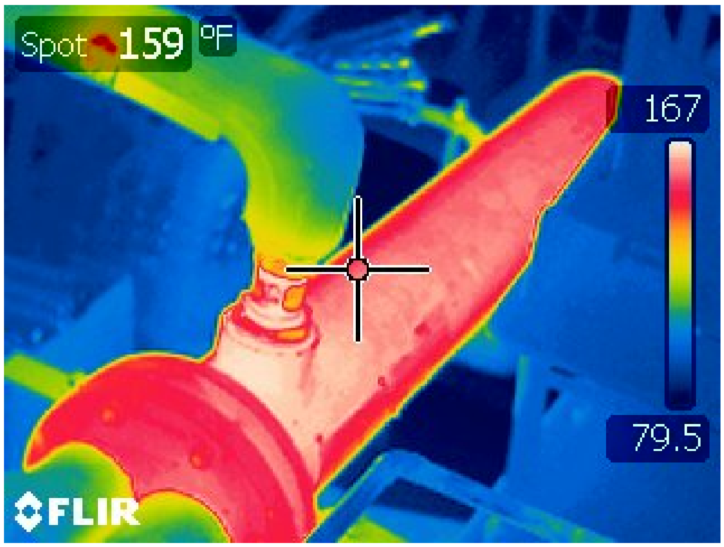
PV System Specifications *(Commercial)*

DC System Size	64.7 kW
Module Type	Standard
Array Type	Fixed (roof mount)
Array Tilt	35°
Array Azimuth	135°
System Losses	14%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

4.5 ES IM-1: Repair Hot Water Pipe Insulation

While on-site we identified a small length of HW piping that was not insulated. This piping was exposed to conditioned spaces in a room adjacent to the central atrium. The site contact indicated that this pipe should have been covered and was planning on looking into it. This pipe, shown in Photo 4-1, was approximately 4 feet long and 8 inches in diameter. Insulating this pipe will increase the temperature of the return HW, decreasing the load on the boiler.

Photo 4-1. Infrared Image of Exposed Hot Water Pipe at the ES



We recommend insulating this pipe with at least 1 inch of mineral fiber or other appropriate insulating material. The savings associated with insulating this pipe were estimated using the 3EPlus software created by the North American Insulation Manufacturers Association. We estimate that repairing this insulation will save approximately 61 gallons per year, contributing to $135 per year in oil savings. With an estimated cost of $60, implementing this measure would yield a 0.4 year payback.

4.6 ES IM-2: Replace Pneumatic Controls with Digital System

The ES's HVAC system is pneumatically controlled, which limits the control strategies that the system can adopt and results in additional air compressor energy being used. We estimate that the tighter control parameters that a digital system can maintain will reduce total energy spending by approximately 2%, or $1,500 per year. At this level of savings, converting the system to digital control will not have an acceptable payback on the merits of energy savings alone. However, reduced maintenance costs will likely result in even greater economic savings, and digital controls will enable the system to adopt modern control strategies that will enhance the quality of the environmental conditions in the ES.

4.7 SIB IM-1: Seal Penetration Point for Old Dust Collector System

Adjacent to the administrative offices on the first floor of the SIB, there is an old woodshop. This space is primarily used for storage. The space is conditioned, and it is manually set back. This space has an old dust collector system that is no longer in use. The duct header for the dust collection system penetrates the front wall of the SIB. This penetration point presents an opportunity for air leakage, increasing the infiltration loads on the HVAC equipment serving that space. We recommend capping and sealing this penetration point to mitigate air leakage and better retain the building's space temperature. This measure would likely result in small savings and have a low implementation cost, but additional information regarding the operation of this space and its HVAC equipment is necessary to accurately estimate the savings for this measure.

Next Steps

5

NEXT STEPS

This section outlines the next steps towards implementation of the recommended measures discussed in this report.

5.1 Project Budgeting

- Solicit quotes from vendors to determine the appropriate cost for each measure.
- Contact Eversource and discuss the available incentives available.
- Determine if the net project costs and energy cost savings justify implementation.

5.2 Request for Proposal

Large projects should be competitively put out to bid. Typically, a bid specification package is developed to clearly provide the scope of work that will be performed and the specific performance characteristics of the equipment required for the project. The RFP should clearly specify the work you expect the vendor to complete, including disposal and cleanup. The RFP should also identify all work that will be done by the customer.

The RFP should state any special conditions, such as the following:

- Certain days or hours that the work can be performed
- Specific safety rules
- Minimum insurance coverage
- Start and completion dates
- High efficiency equipment specifications and criteria
- Required equipment submittals
- References who may be contacted
- Any exceptions the bidder is taking to anything in the RFP

5.3 Review of Proposals

The proposals received in response to the RFP process discussed above can then be compared to one another for price, proposed technologies, and scope of work that the vendors will perform. Answers to clarifying questions or further information may be requested.

Eversource should be contacted to discuss the incentive opportunities associated with the proposed installation and to determine whether technical support in reviewing the equipment selections is needed. All incentives must be preapproved by Eversource.

5.4 Project Installation

- ❑ Verify that all pre-installation work is complete prior to the vendor's arrival.
- ❑ Schedule the installation so that tenants are minimally affected.
- ❑ Oversee vendor installation throughout the process.
- ❑ If possible, keep your Eversource representative updated on the project status.

5.5 Incentives/Rebates

Once the project is installed, Eversource will perform post-installation inspections to verify that the project is installed as intended and that the customer is satisfied with the installation. Invoices for the completed project should be provided to Eversource. At the time of measure installation, the projected energy savings for each measure will be reviewed by the utility and may be revised to account for any deviations between the building operation projected in this report and the actual operation at the time of the measure installation.