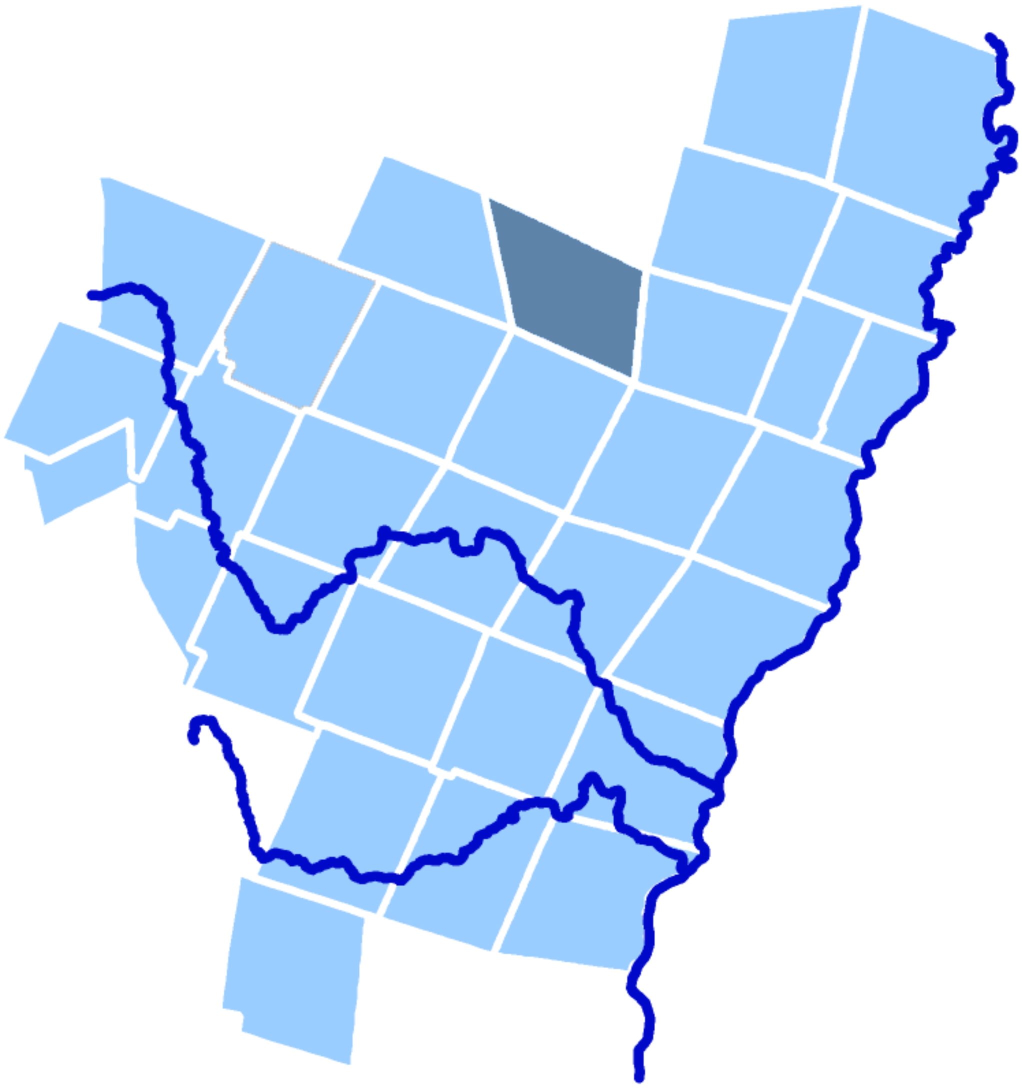
Two Rivers-Ottauquechee Regional Commission



Chelsea Public School

Building Energy Plan

Provided for the Town of Chelsea by the Two Rivers-Ottauquechee Regional Commission's Energy Efficiency and Conservation Program.
Funded through a grant from the US Department of Energy.

This Building Energy Plan was provided for your community at no charge with help from an Energy Efficiency and Conservation Block Grant through the US Department of Energy.

For Questions about the Two Rivers Ottauquechee Energy Efficiency and Conservation Program, please contact:

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Senior Planner
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Jon Haehnel
Zero by Degrees
tel: 802-522-9713
email: zerobydegrees@gmail.com

Zero by Degrees LLC

Energy Independence in Affordable Steps

Building Energy Plan

December 13, 2012

To: Chelsea School board and Mr. Chris Sargent, TRORC
From: Jon Haehnel, Zero by Degrees LLC

RE: Energy Audit Conducted November 21 &29, 2012 on the Chelsea Public School

Thank you for inviting Zero by Degrees LLC to help with your building energy needs. The following report presents our findings and recommendations from our diagnostic visit(s). It is our hope that this report can be the basis for a long term energy plan for the building. Parts of this report are provided by Chris Hebb of Dynamic Integrations LLC, a sub consultant to Zero by Degrees.

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Purpose

To identify potential building retrofits and operational practices to reduce energy use.

Summary of Analyzed Measures

Measure	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
O&M #1 - Operational measures	$165	$290	$0	$290	15	1.8	8.5
ECM #1 - Improve Temperature Controls	$6,203	$19,020	$0	$19,020	15	3.1	4.9
ECM #2 - Air Sealing	$3,194	$10,500	$0	$10,500	15	3.3	4.6
ECM #3 - Kitchen HW from Boiler	$491	$2,000	$0	$2,000	15	4.1	3.7
ECM #4 - Improve Insulation	$3,005	$14,725	$0	$14,725	30	4.9	6.1
ECM #5 - Upgrade Lighting	$1,102	$5,780	$315	$5,465	20	5.0	4.0
ECM #6 - Reduce plug loads	$105	$600	$45	$555	15	5.3	2.8
ECM #7 - Window Improvements	$3,719	$27,995	$0	$27,995	15	7.5	2.0
ECM #8 - LPG Booster Heater	$1,591	$10,000	$0	$10,000	15	6.3	2.4

O&M - Operation & Maintenance Measure- low or no cost measures that involve changes in how the building is used or operated.
ECM - Energy Conservation Measure - measures that involve some expense to make a change to the building.
Simple Payback – The number of years the energy improvement will take to pay back the investment.
SIR - Savings to investment ratio, is the present value of savings divided by the cost. It is considered the most meaningful criteria for ranking measures. The higher the SIR the better the return on investment. Generally, an SIR less than 1 is considered a poor energy investment although there may be other reasons besides savings for going ahead with the measure.

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Notes for Understanding this Report

1. Cost estimates in this report typically include the cost for materials and labor to implement the energy efficiency measure. There can be many hidden costs associated with any building improvement that are beyond the scope of this energy audit report. The following costs may apply to the energy efficiency measures listed but have not been specifically accounted for in this report: design, demolition, temporary staging or masking beyond the normal measures of the installation crew, temporary storage or moving costs, increased maintenance costs, historic preservation review, permitting, state and federal regulations for lead, asbestos, radon, and the like. There may also be salvage value for old equipment or reduced maintenance that could reduce the cost of an energy improvement. Salvage values and reduced maintenance are not accounted for in the cost estimates in this report. Cost predictions in this report are not estimates or fixed quotes. They only indicate the approximate cost for the recommended upgrade assuming that you hire an outside contractor for the upgrade and are meant to aid in making preliminary decisions. Especially for complex and large projects, a detailed review of the costs and maintenance implications is recommended.
2. There are several "wild cards" in predicting energy savings. Among them, the weather from year to year, occupant behavior, changes in levels of occupancy and environmental factors that are difficult to quantify. For these reasons, predicted savings are guidelines and not guarantees.
3. When viewing thermographs, lighter colors indicate higher surface temperatures than darker colors. What is considered "heat loss" is dependent upon the perspective from which it is viewed.
4. Some infrared images are taken under depressurization. Depressurization causes all outdoor air to flow inward and is not the normal operating state of the building. It is done to reveal conditions that would not normally be detected or to enhance thermographic images. Depressurization is also used to mimic the environment a building would be under in conditions of high wind or very cold temperatures. The building was depressurized to about –45 Pascals during the last part of the imaging.
5. Air leaks are detected by the infrared camera when cooler air "washes" across a surface. The pattern of air leakage is typically dark wispy lines emanating from the air leakage site.
6. I used $0.146/kWh, $2.499/gallon of propane and $3.28/gallon of oil and to predict cost savings. These are taken from the energy consumption information provided. Energy prices are volatile and difficult to predict year to year but the long term trend is that energy prices will continue to rise.
7. Rebates, incentives, and tax credits may change or have termination dates. Verify that the suggested rebates/credits in this report are still in effect and look for additional programs that may have come into effect at http://www.dsireusa.org/ and http://www.efficiencyvermont.org/pages/ when you are ready to implement your energy conservation measures. Lighting, motors, heating, cooling, and ventilation system rebates may be applied for directly through Efficiency Vermont's website http://www.efficiencyvermont.com/pages/.

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Health and Safety Recommendations

All building systems interrelate and occasionally improvements to one building system can create problems in another. Measures to improve energy efficiency should be regarded in the context of the health and safety of occupants and in the long term durability of a building. Careful consideration of the following and testing before and after efficiency improvements will help to prevent conditions that could have a negative impact on the building.

1. There are no CO detectors in the building. At least 1 should be installed in the kitchen and boiler room.

Energy Plan - Energy Efficiency Measure Descriptions

The following measures with predicted savings, predicted costs, and implementation notes can be used as the foundation for a long-term energy plan for this building. The energy plan has the potential to save the most energy at the least cost if consulted at least once a year and before every renovation, addition, and equipment or building upgrade.

1. O&M #1 – Operational Measures

Chelsea school mechanical equipment is very efficiently operated. Major equipment, including the boiler, kitchen booster heater, and dishwasher are manually turned off regularly to reduce standby losses. If not currently done, the kitchen service water circulator should be turned off at night.

Also in the kitchen, the walk-in freezer door seal needs repair and the milk cooler door hinge is not holding the door seal tight.

The control settings on in the boiler room are causing excessive operation of the boiler water supply pump to the water heater. In mild weather the boiler operates between 130° and 140°F while the service water temperature is set at 140° so the pump runs continuously without attaining the water heater setpoint. Lowering the water heater setpoint would alleviate this problem.

Many of the computers in the building were on while the building was unoccupied. Computers, especially those in the media center and computer lab, should be shut down every day and for the weekends. There is software available that will allow computers to shut down on a schedule if they are not being actively used.

The 2 large photo copy machines can be turned off every night and on weekends so they do not remain on standby. Even in standby mode they can consume as much as 50 watts. Similarly, most of the various small printers were left on at night and can be turned off every night.

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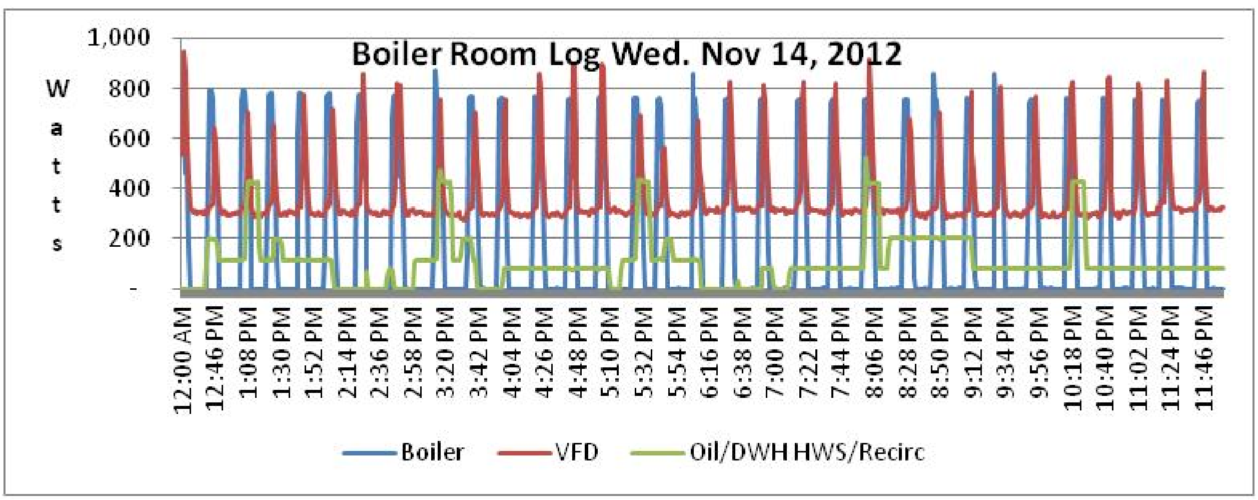
Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
-2	($5)	0	$0	2,718	$170	$165	$290	$0	$290	15	1.8	8.5

2. ECM #1 – Improve Temperature Controls

There are several energy saving control opportunities available that cannot be accomplished manually. They are oriented toward eliminating unnecessary equipment operation during unoccupied times.

1. All heating equipment should be kept off during unoccupied times when outside temperatures are above 30° F. Following is a graph of heating equipment operation from noon to midnight when outside temperatures were in the low 30's.



There is little or no difference between the occupied and unoccupied operation. The boiler fires for 6 minutes every 22 minutes. Half of the firing time is a purge cycle so the burner fires for only 3 minutes.

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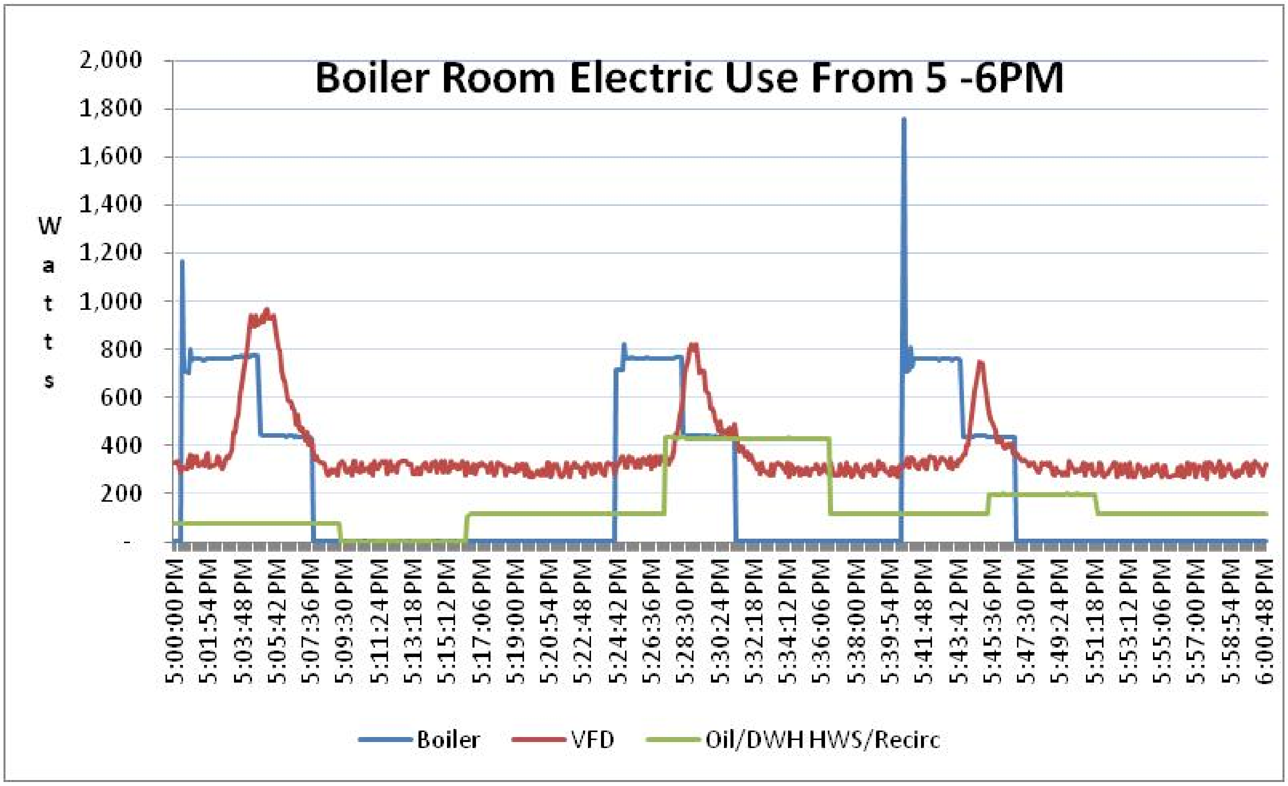

This is very inefficient operation. Though the stack test showed a combustion efficiency of 88% the overall efficiency at this load is probably less than 60%. (The spike is the start up load of the burner.)

When the water heats up the variable frequency drive (VFD) pumps speed up for one minute and then go back to 20% (300W). The oil transfer pump (400W) runs after the boiler has fired 6 times and domestic hot water recirculator and hot water supply pumps run most of the time. Though the chart is of electric use it represents about 5 gallons of fuel use as well. In addition to locking out this equipment the unit ventilators should stay off when there is no need for heat or ventilation.

2. A low night setback should be implemented. Try 40 or 45°, though the building will rarely if ever drop this low. In order to protect coils in the unit ventilators allow the VFD pumps to run below 30°F outside air without the boilers. Fire the boilers only on a call from a room thermostat.

This approach will require a varying warm up time in the morning, a short period on mild nights and a longer period in cold weather or after a weekend. An optimized start begins warm up as late as possible in the morning and there are various methods of accomplishing it. Some residential thermostats measure how fast the house cools down the night before and calculate a longer warm up time based on a quick cool down. Energy managements systems often use an algorithm based on outside air temperature or the

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difference between outside and inside air. Unoccupied times will need to be programmed based on the school calendar.

The best efficiency will be obtained with the lowest setback and the least equipment operation. Optimization of temperature control will require testing, controls adjustment, and monitoring areas for potential freezing. If the school does not have the in-house resources for this extra follow up work hire an energy manager.

3. The boilers are substantially oversized. To alleviate some of the low load short cycling of the burner reduce the firing rate (nozzles) of both boilers to the minimum the burner will accept.

4. The domestic hot water recirculator pumps run during unoccupied hours. Add these to a programmable controller.

There are a few ways of accomplishing the above functions. The school is now controlled by two incompatible systems, the unit vents have a high end residential/light commercial system of standalone iWorx controllers made by Taco. They are not programmable by the building operator without wiring the unit vents together and installing a central controller. An effective night setback cannot be implemented with the current system. This system is not BACNET compatible so a central controller cannot practically be installed that would also control the boiler room equipment which is on a BACNET compatible Atherton controller. Both areas (unit vents and boiler room) need an upgrade to accomplish the desired control. Two approaches are to upgrade the systems individually or replace the boiler room controller with an iWorx controller. Either approach will cost between $15,000 and $20,000. The school may save 3-$4,000 by pulling the communication wire in-house for the unit vents.

Rough budget costs were obtained from Vermont Mechanical and Control Technologies. Vermont Mechanical said the central control would cost $11,000 and that replacing the Atherton control would increase the cost to 15 - $20,000. Control Technologies can provide the night setback and service water control in the boiler room for $5,500 using the Atherton board.

Because the school's unit vent control RFP requested BACNET controls and the system was installed less than a year ago it is possible the school could obtain some remedy from Vermont Mechanical for the installation of the incompatible iWorx system.

In the long run a unified system will be the most efficient and the most manageable so the iWorx upgrade is the recommended course.

A minor control change that can be made immediately is to turn the unit heater in the back vestibule way down or off. It is very warm in that small space and the metal and glass door with sidelights has very little R-value. See images below.

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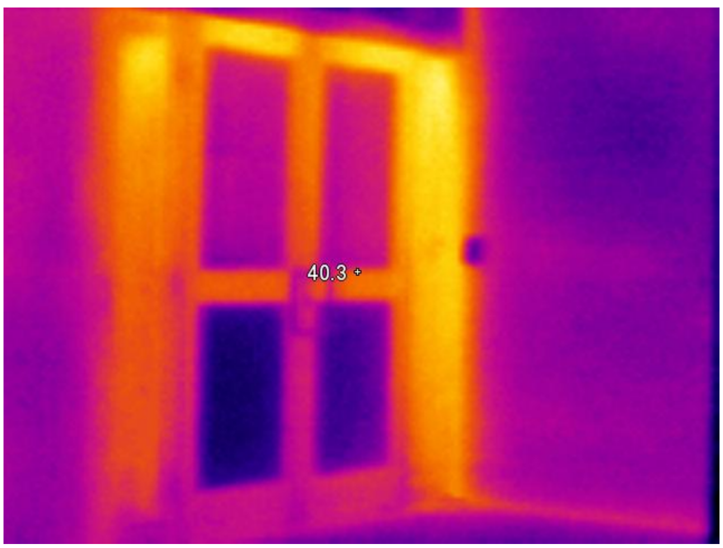
a. IR014284.IS2
11/29/2012 7:41:00 PM

Visible Light Image



b. IR014287.IS2
11/29/2012 7:41:32 PM

Visible Light Image

Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
1638	$5,371	0	$0	13,632	$831	$6,203	$19,020	$0	$19,020	15	3.1	4.9

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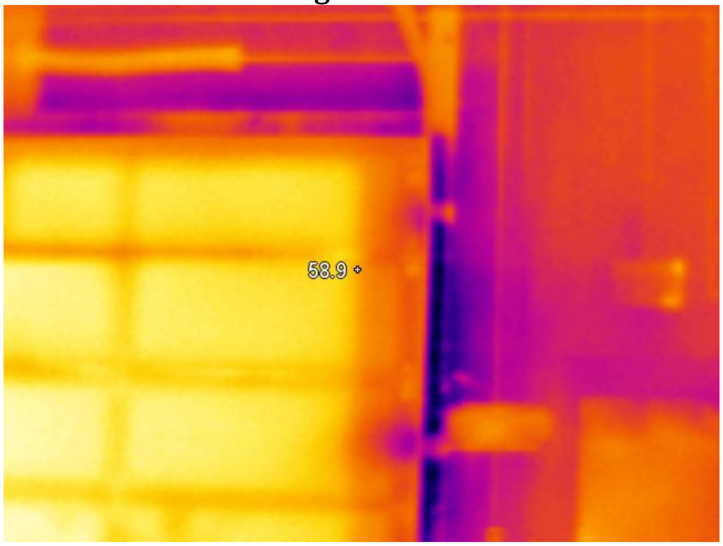
3. ECM #2 - Air Sealing



a. IR013891.IS2
11/21/2012 9:21:30 AM
It is not a surprise that this overhead door leaks at the perimeter. It is hard to make these type of doors tight. What is surprising is…

Visible Light Image

b.
…that there are NO weather seals on the bay door. The shop man door is also missing weather seals.

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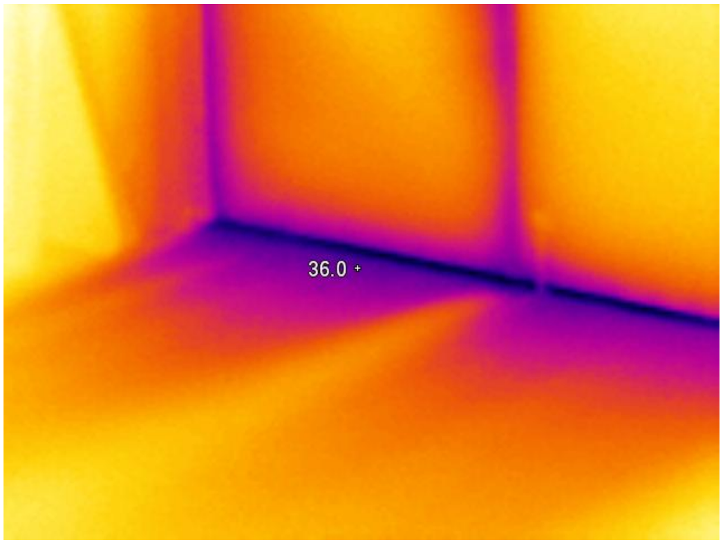
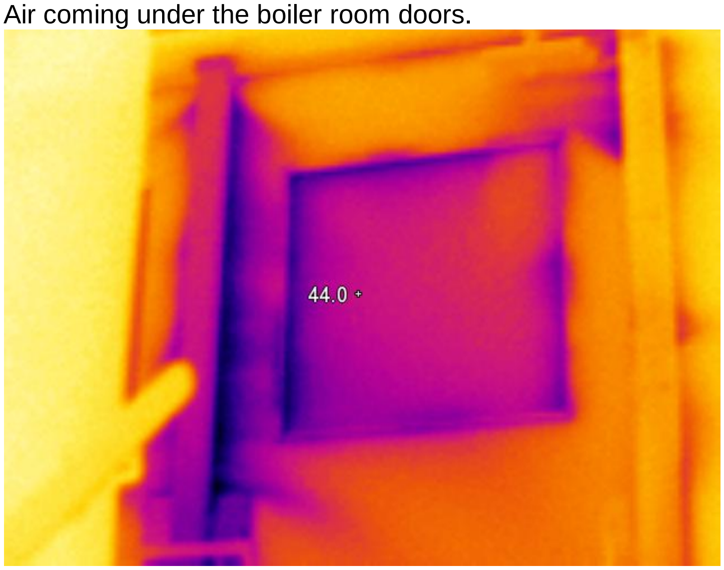
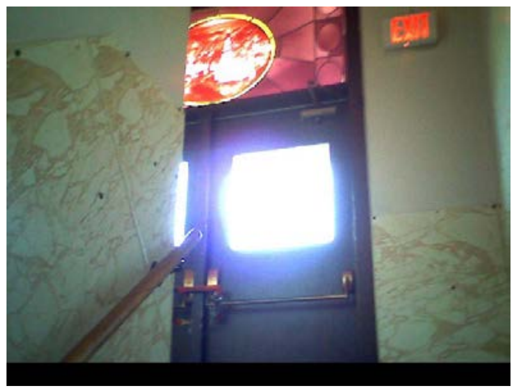


Visible Light Image

c. IR013904.IS2
11/21/2012 9:25:42 AM
Air coming under the boiler room doors.





Visible Light Image

d. IR014036.IS2
11/21/2012 10:13:56 AM
Air coming through the front doors and at the door trim.

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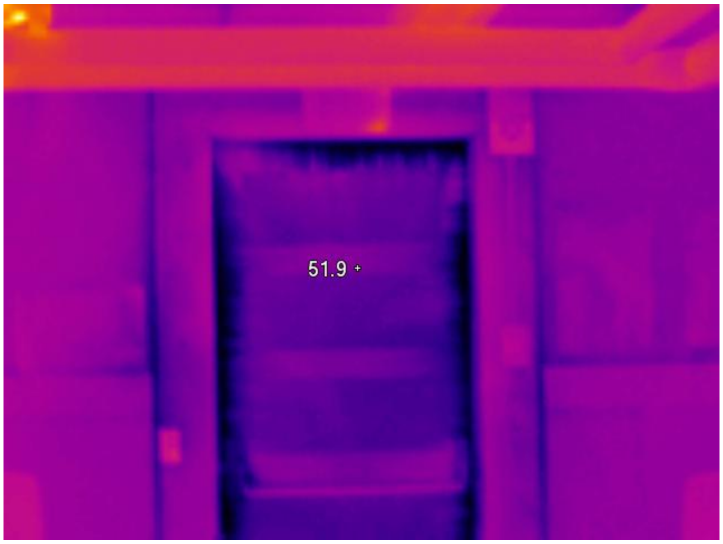
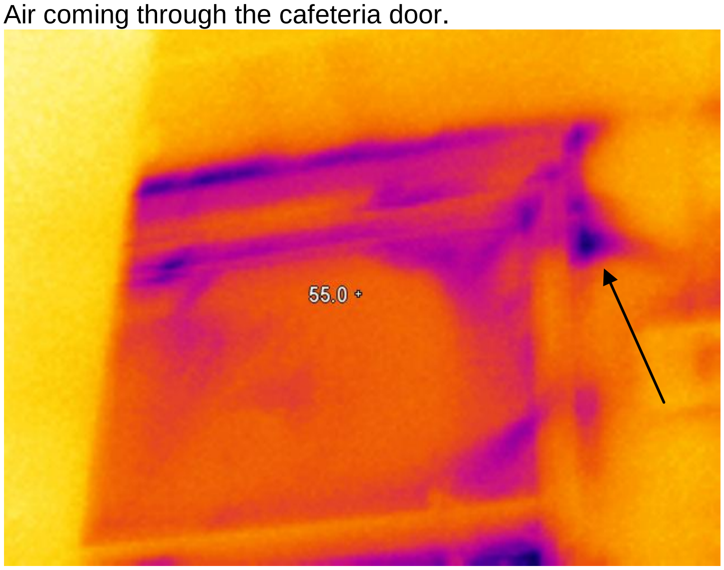
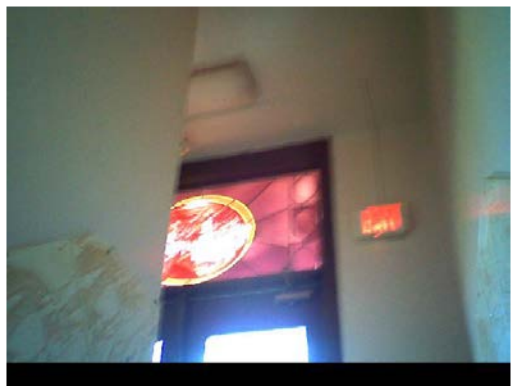


Visible Light Image

e. IR014048.IS2
11/21/2012 10:15:26 AM
Air coming through the cafeteria door.





Visible Light Image

f. IR014035.IS2
11/21/2012 10:13:52 AM
The trim surrounding the decorative window above the front door is leaky.

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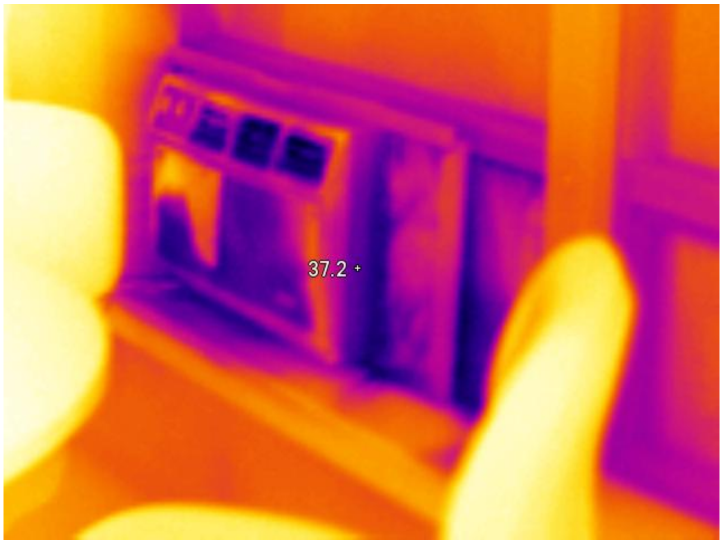
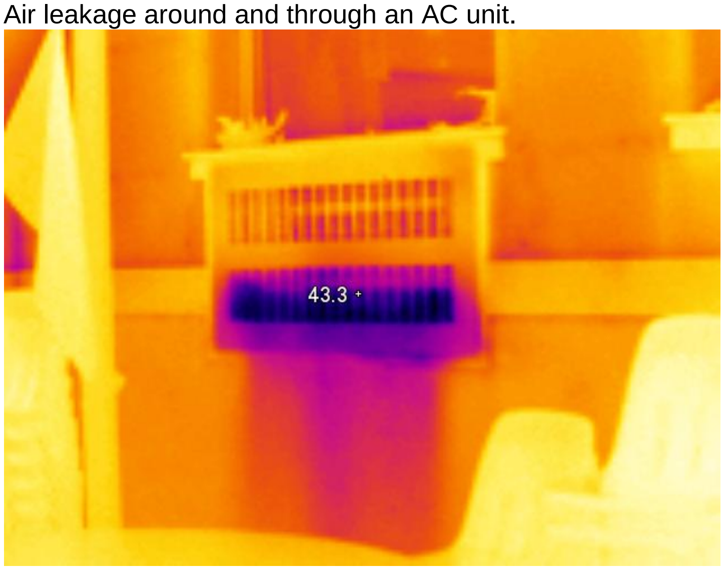


Visible Light Image

g. IR013977.IS2
11/21/2012 9:57:44 AM
Air leakage around and through an AC unit.



Visible Light Image

h. IR014225.IS2
11/29/2012 5:46:03 PM
Cold air pouring in through a typical relief damper (this image was taken under normal pressure). These are designed to only open with excessive indoor air pressure but it is clear that they cannot stop dense outside air.

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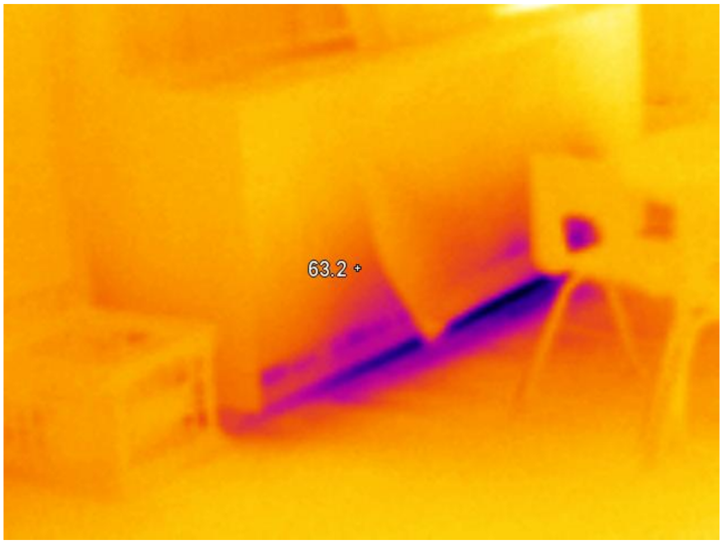
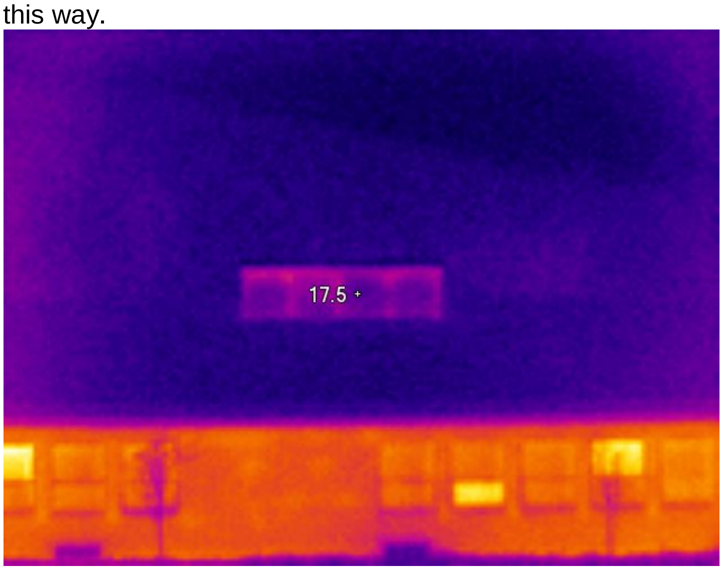


Visible Light Image

i. IR014234.IS2
11/29/2012 6:37:25 PM
Air leakage under a typical unit ventilator. They all looked this way.



Visible Light Image

j. IR014291.IS2
11/29/2012 7:42:11 PM
In 2007 the roof of the 1978 building was insulated and all these vents should have been sealed closed. Some were, like this one.

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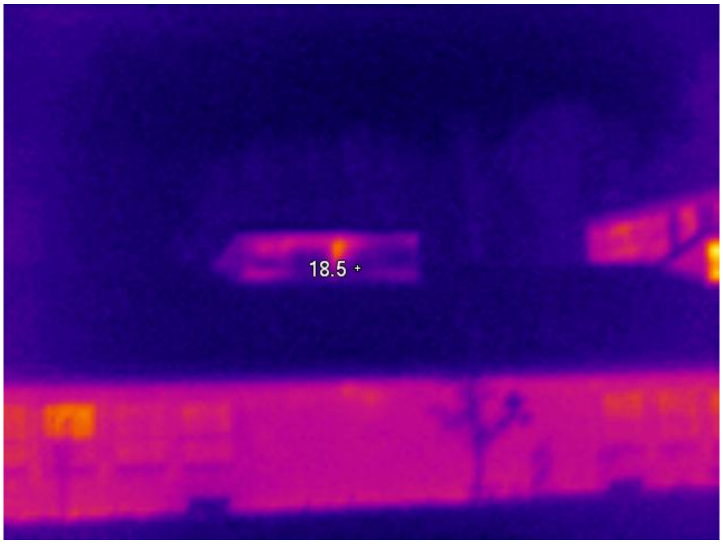

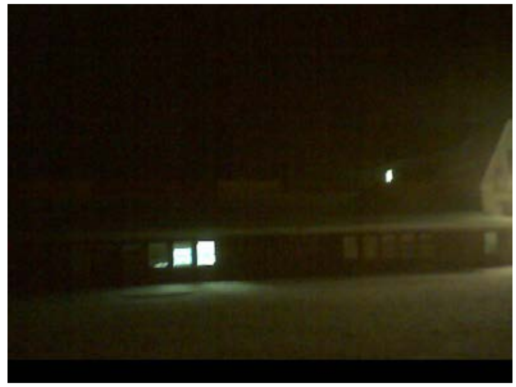

Visible Light Image

k. IR014292.IS2
11/29/2012 7:42:14 PM
This one was not completely sealed.

Visible Light Image

l. IR014298.IS2
11/29/2012 7:42:48 PM
And this one seems to have been missed. Infrared images inside showed that air leakage through the dropped ceiling got progressively worse as I got closer to the connection between the 1978 and 1912 buildings. This is the reason.

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Visible Light Image

m. IR014307.IS2
11/29/2012 7:44:30 PM
Another view of the same vent.

The preceding images show the major air sealing opportunities with the exception of windows which are discussed in a separate measure. The top priority in air sealing is to get the old roof vents closed and sealed. This can be done easily from inside. I could not see how the vents were covered but I did see what looks like rigid foam board near one of the openings. Rigid foam at least 2” thick can be installed to block the openings and then they should be spray foamed in place. The foam work can be done by a professional or by purchasing kit foam. Kit foam is not intuitive to use and I recommend visiting the link http://www.insulation-guide.com/DIY-Spray-Foam-Insulation.html to familiarize yourself with the product first. At the same time, any uninsulated gable ends in the attic should be insulated.

All of the unit ventilators had leaky dampers. As these were recently renovated the contractor should be notified to readjust the linkage arms or replace seals with more flexible ones as needed to obtain a tight fit. At the same time remove the inside grills and foam seal the relief damper housings (not the damper itself) to the walls with gun foam. Ask the mechanical contractor if heavier or better flap dampers can be installed to keep cold air out.

The window AC units should either be removed or covered in the fall and winter seasons. The covers can be made out of wood and rigid foam insulation and should seal to the wall with gasketing and cam latches.

The images above show the worst doors and those should be made a priority. Some of the old classroom exterior doors are well weather-stripped and will only need to be checked. Weather-strip the exterior doors at the head, jambs, and especially at the threshold with commercial grade weather-stripping (www.draftseal.com or Q-lon available through The Energy Federation www.efi.org) or replacement

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parts from the original manufacturer if available. When the door is closed you should not be able to see daylight light at the perimeter. Door thresholds also need to be added/replaced if they can be, if not, door sweeps should be added. *Focus* weather stripping efforts on doors that are used rarely and emergency exits since they have to perform more like walls most of the time. Don’t forget to weather strip “interior” doors that open into cold spaces such as the attic. The attic hatch will be discussed in more detail later.

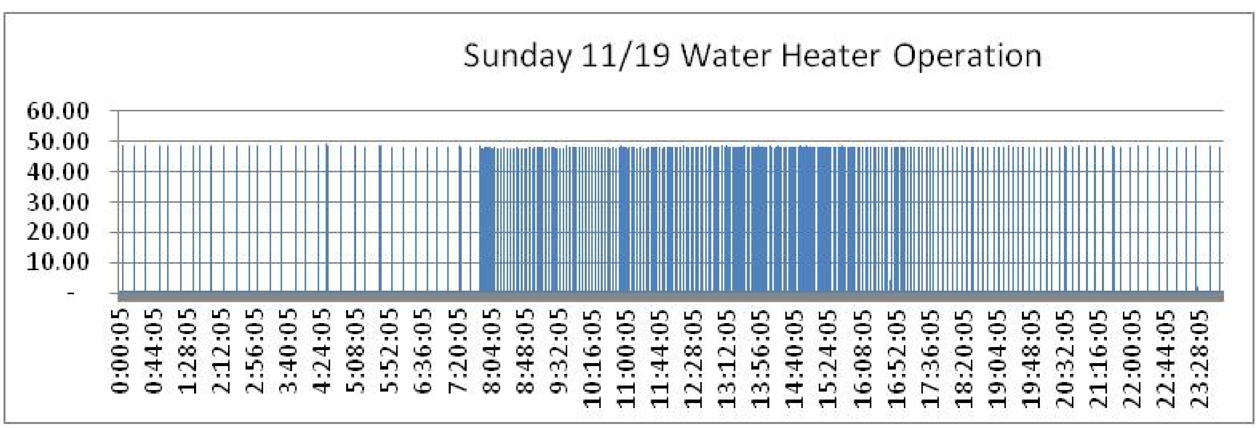
The front door is unique in that it leaks not only through the doors but also where the door trim meets the wall. Carefully caulk all the seams between the door trim and the wall including around the fixed pane window over the door. It would also be good to install a permanent interior storm window over this window to increase the R-value.

Replace the seals and weather strip on the exhaust fan damper in the shop classroom. If this damper is no longer used block the opening permanently with rigid foam sealed in place by gun foam.

Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
969	$3,178	0	$0	69	$16	$3,194	$10,500	$0	$10,500	15	3.3	4.6

4. ECM#3- Kitchen hot water from the Boiler

There are two large electric water heaters serving the kitchen. One of them does not operate because it has a failed breaker and the other cycles on for 40 seconds every three minutes at 12kW during occupied hour. At night and weekends it cycles at 10 minute intervals maintaining 120°F water.



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Above is the kitchen water heater operation on Sunday, November 19th. There was no dishwasher use at on that day.

We recommend extending the boiler indirect heater loop to the kitchen to handle this load. There will be some inefficiency in operating the boiler in warm weather but probably not enough to warrant keeping the electric heaters. They add about 4kW to the peak demand.

Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
-374	($1,225)	0	$0	11,665	$1,716	$491	$2,000	$0	$2,000	15	4.1	3.7

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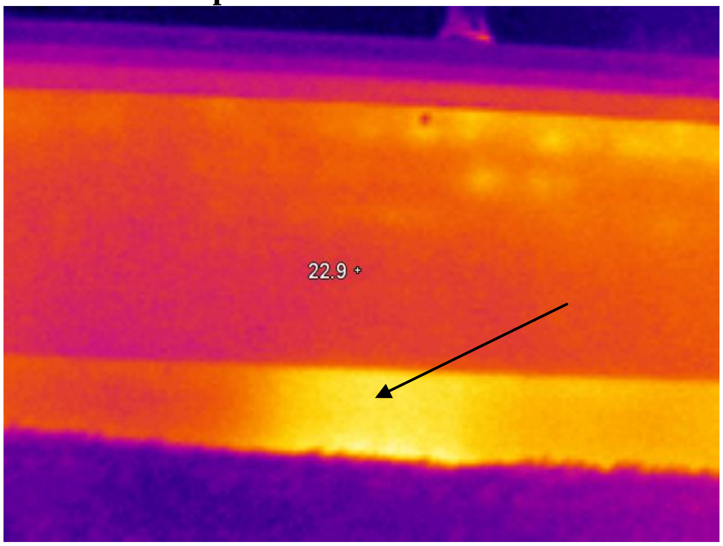
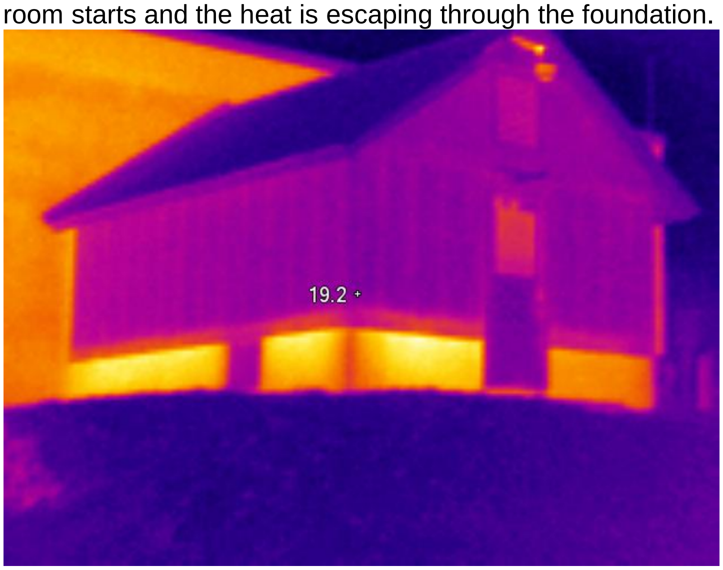
5. ECM#4 – Improve Insulation



Visible Light Image

a. IR014259.IS2
11/29/2012 7:36:56 PM
The change in temperature is where the inside of the boiler room starts and the heat is escaping through the foundation.



Visible Light Image

b. IR014267.IS2
11/29/2012 7:38:05 PM
Heat loss through the foundation. One side appears warmer than the other because that is the side with the radiant heaters. Note also the glowing shop walls beyond.

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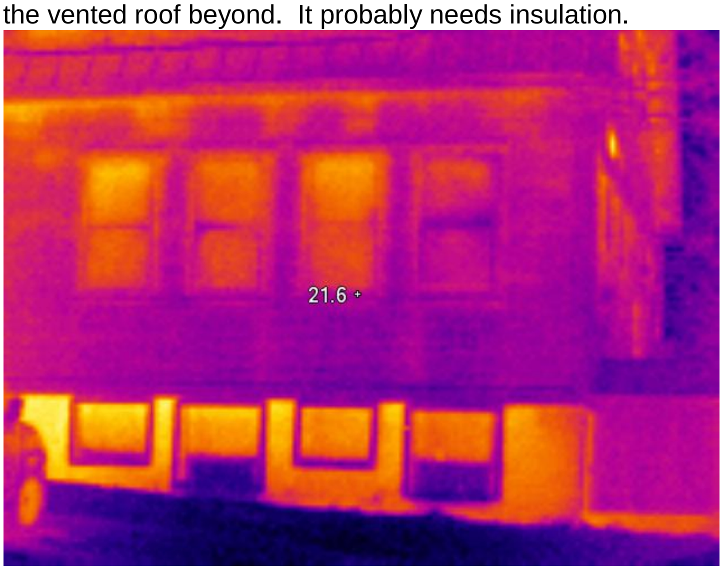
Visible Light Image

c. IR014278.IS2

11/29/2012 7:40:14 PM

The shop walls are in sharp contrast to the framed wall that infills the overhead door opening. Note also the gable end of the vented roof beyond. It probably needs insulation.



Visible Light Image

d. IR014328.IS2

11/29/2012 7:49:53 PM

The foundation walls of the 1912 building.

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e.
Looking under the floor boards of the attic.

f.
The attic where there are no floor boards.

The uninsulated attic hatch

As can be seen above there are 3 wall areas have little insulation: the above grade foundation in the 1912 building, the concrete block walls of the shop and the above grade foundation walls of the maintenance office and boiler room. The best way to insulate all 3 areas is from outside, this brings the thermal mass of the concrete inside the envelope. This will work well for the foundation walls but the roof would have to be modified in order to cover the new wall thickness in the case of the shop walls and that expense will increase the overall cost of the project. Both interior and exterior methods are described below, for budgeting purposes I assumed an interior installation with a covering of sheetrock in all cases.

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Insulate shop walls from outside:

1. From outside dig down into the soil around the foundation and expose 12” to 18” of the foundation wall. Wash off the soil and allow the walls to dry completely.
2. Glue at least 2” thickness of rigid expanded polystyrene (XPS) foam board (blue or pink board) to the wall by setting it in the bottom of the trench and going above grade 1’. Be cautious about the glue you select, get a construction adhesive that is formulated for XPS insulation, the other types will eat the foam.
3. Insulate the rest of the wall with at least 2” of polyisocyanurate board (Tuff- R or equivalent). Thicker insulation is recommended but the majority of the payback comes from the first 2” of insulation. Tape the seams of the rigid insulation.
4. Frame in window box extensions that will connect to the existing windows and flash them to expel moisture to the surface of the rigid insulation. Install air tight storm windows over the window boxes. Be sure to size the storm windows so the existing awning windows can still open in the summer.
5. Modify the roof to extend over the top of the new wall system.
6. Cover the above grade insulation with vertical strapping and then a siding of your choice. The vertical strapping will leave a drainage plane behind the siding to help keep things dry.
7. Backfill the trenches in the soil to cover the below grade insulation.

This method is durable and it brings the mass of concrete block inside the insulation which makes the energy performance of the wall a little better than if the concrete is trapped on the outside of the insulation. It is also easier to access the whole wall from outside and allows the slab edge to be covered. Alternatively, the walls could be insulated from outside in a similar fashion to the method described above with spray foam.

The walls could also be insulated from inside using rigid foam as the primary insulation system and then covered with mudded and taped sheetrock. This method will not insulate the slab edge but should capture 80-90% of the savings as the method above.

Insulate the foundation wall from outside:

1. From outside dig down into the soil around the foundation and expose 12 to 18” of the foundation wall. Wash off the soil and allow the walls to dry completely.
2. Glue at least 2” thickness of rigid expanded polystyrene (XPS) foam board (blue or pink board) to the wall by setting it in the bottom of the trench and going up to the top of the foundation. 3 or 4 inch thickness will save more but the largest payback will come from the first 2” of foam. Be cautious about the glue you select, get a construction adhesive that is formulated for XPS insulation, the other types will eat the foam.
3. Cover the above grade XPS insulation with metal sheeting (break metal), vinyl coil stock, or stucco. You can also get protective coated XPS that can be attached with masonry anchors for a higher price but a faster install.
4. Backfill the trenches in the soil.

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5. Pull the bottom row of siding so flashing can be slid under the siding that will lap over the top of the new XPS insulation. In the case of brick veneer a groove must be cut in the brick so a flashing cap can be installed over the insulation.

Insulate the foundation wall from inside

1. Clear the walls and move shelving as much as possible.
2. Glue at least 2” thickness of rigid expanded polystyrene (XPS) foam board (blue or pink board) to the wall by setting it on the floor. 3 or 4 inch thickness will save more but the largest payback will come from the first 2” of foam. Be cautious about the glue you select, get a construction adhesive that is formulated for XPS insulation, the other types will eat the foam.
3. Cover the XPS with mudded and taped sheetrock.

The financial projections below apply only to foundation and block wall improvements.

The attic insulation is too low under the floorboards, there is only 3” of rock wool for an total R value of about 14. Unfortunately the access to improve the attic floor is difficult. The stored items would have to be moved so the floor could be drilled and filled with dense pack cellulose to a total thickness of 6”. This combination of poor access and only 6” of space makes the measure less cost effective with about a 15 year payback.

The attic insulation that is not covered by floorboards is between 6 and 9” thick for a total R-value of about 30. More could be added easily but there are diminishing returns on the energy savings where there is already adequate R-value. The payback for this measure is also about 15 years. If the whole attic gets improved that saves about 300 gallons or $984 annually at present fuel prices.

Regardless of the long or short term plans for the attic the attic hatch needs to be addressed. Weather-strip the hatch so it seals tightly to the trim when closed. Attach 4” of rigid polyisocyanurate foam board insulation to it. Use wide foil tape to cover and protect the edges of the insulation.

The walls and slopes of the 1912 building are insulated with blown cellulose. As is common for blown cellulose some wall bays got missed and the cellulose has settled in other areas. Again, access and diminishing returns makes improving these areas a difficult financial case. I did not run this scenario through the energy model because the payback is likely greater than 30 years.

Although the financial case for the foundation and concrete block wall insulation is better there is no reason not to consider the attic of the 1912 building as long as low interest funding can be obtained. If the project can be cash positive over the term of the loan then it is worth serious consideration.

Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
911	$2,990	0	$0	65	$15	$3,005	$14,725	$0	$14,725	30	4.9	6.1

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6. ECM#5 – Upgrade Lighting

A metal halide light with a HP sodium light above it.

The bus light on in the middle of the day. In addition to fixing the photo cell this bulb could be replaced with a CFL as has been done on other similar lights.

The lighting in the bathrooms, shop and boiler room could be controlled by occupancy sensors so lights would be off when the rooms are not occupied. Classroom occupancy sensors were also considered but I noticed that many teachers turned off one or 2 banks of lights when day lighting was sufficient or when they were using the projector so the payback for occupancy sensors may not be as fast as if all teachers are encouraged to manually control the lights based on conservation and their needs. Type and placement of occupancy sensors is critical for flawless operation especially in bathrooms. A lighting designer should be consulted for proper placement of occupancy sensors.

I ran a scenario to replace all of the building T8 lights with high performance T8 lights (Super T8) and ballasts and the cost for installing new ballasts made the payback over 30 years. However, just replacing the 32 watt T8 bulbs with high performance 25 watt T8 bulbs has a short payback even though the total energy savings is lower. The high performance T8 bulbs have 10% higher light output so a 25 watt HP bulb will have the roughly the same output as a standard 32 watt T8 bulb. In addition, HP T8 bulbs are purported to have 20% longer life. I measured light levels in several classrooms and in the corridors at night and found all locations to have acceptable light levels even without sunlight. Still, I suggest testing a change in bulbs in 1 or 2 rooms to see if it is noticeable before changing all the lights to 25 watt HP T8 bulbs. Also, you will want to verify that all the existing ballasts are rated for lower wattage bulbs. The ones I inspected were and it is likely that they all are but there may be a few old ballasts that are not.

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I counted 13 outside building lights on at night and I understand all are needed for building security. They are controlled by a timer switch which is set to turn on from 5:00 pm to 7:15 am. The timer could be replaced with a photo sensor that would adjust seasonally for a small savings. Most of the lights are efficient and do not warrant immediate replacement however, the large metal halide light should probably be replaced with a comparable light level LED fixture. Because LED lights are “instant on” this light could be on a motion sensor to further increase energy savings. Also replace the HP sodium bulbs with CFLs in the remaining streetlamp style lights that have not already been changed. Finally, the photo sensor cell needs to be replaced on the pole light by the busses. It was on all day both times I was there.

Most of the exit signs are LED signs except one in the kitchen is fluorescent. Replace it with an LED exit sign.

Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
-30	($100)	0	$0	6,149	$1,202	$1,102	$5,780	$315	$5,465	20	5.0	4.0

7. ECM#6 – Reduce Plug Loads

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The fridge in the staff lounge has a glass door.

This vending machine does not need to be on at night.

The fridge in the staff lounge should be replaced with a similar sized energy star fridge. The glass door has very little R-value so the fridge runs longer than it needs to. At the minimum, turn off the light that is always on inside the fridge, it is generating heat the fridge has to remove as well as wasting electricity.

Buy an occupancy sensor for the vending machine near the cafeteria. This will shut the machine down during unoccupied hours. A sophisticated timer switch can do the same.

All of the classrooms have projectors which sit on standby when they are not used. Standby mode still consumes 6.4 watts. I ran a scenario to put all of these devices on remote controlled plug strips so the teachers can easily shut the projectors off at the end of the day. I thought the reduced phantom load would easily offset the cost of the $30 remote plug strip but the payback is over 20 years. I still recommend it for teachers that would use it.

Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
-3	($10)	0	$0	1,582	$115	$105	$600	$45	$555	15	5.3	2.8

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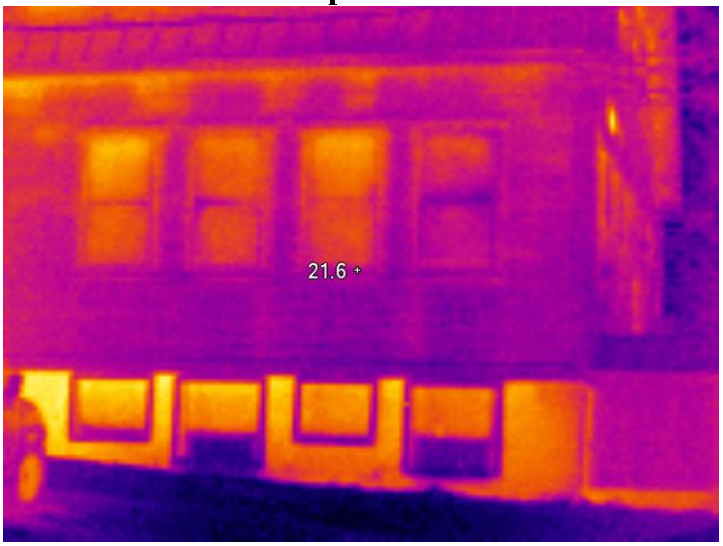
8.ECM#7 – Window Improvements

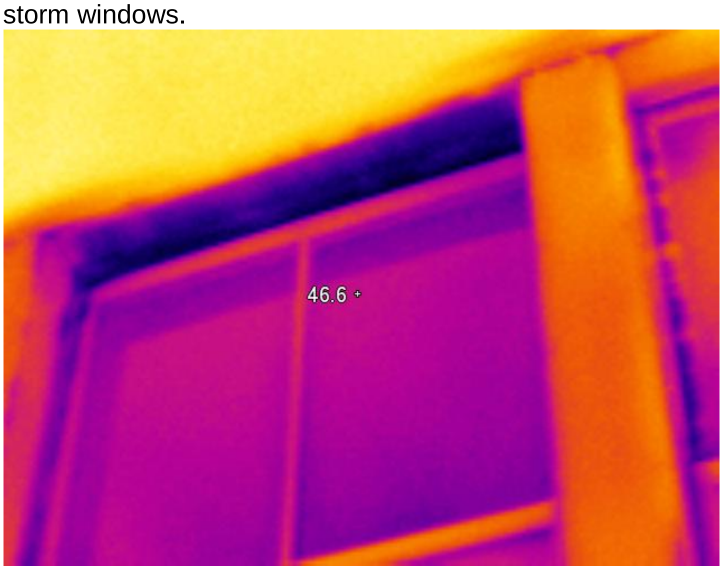


Visible Light Image

a. IR014328.IS2

11/29/2012 7:49:53 PM

The single pane windows on the basement level have no storm windows.



Visible Light Image

b. IR014092.IS2

11/21/2012 10:36:43 AM

This top sash is not fully closed and cold air is pouring in.

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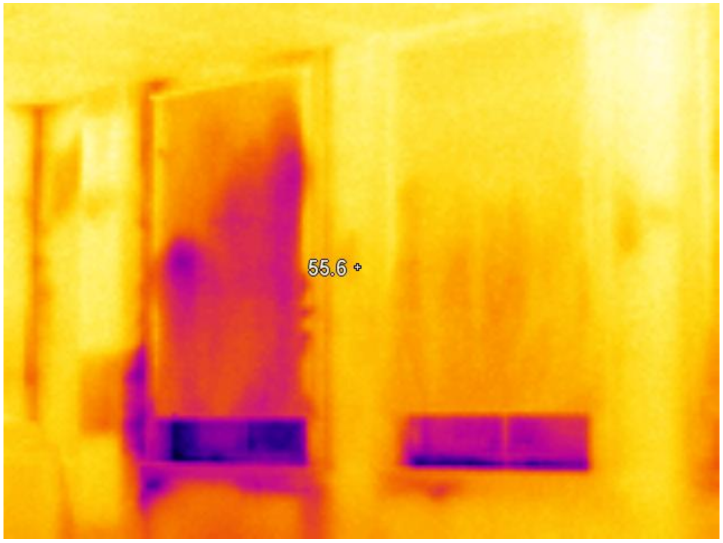

c. IR014062.IS2
11/21/2012 10:25:37 AM
This image shows that not all windows are equally leaky, some are much worse.

Visible Light Image

Most of the windows are single pane wood framed windows with shades. The above grade windows of the 1912 building have an exterior storm window. The shades are primarily to block solar gain but do provide some R-value when drawn.

I recommend interior storm windows similar the one shown below for all windows to increase R-value and decrease air leakage especially on the rattly 1912 windows. On the 1912 windows I further recommend making the upper sash a fixed pane window and caulking it in place.

These interior storms have 2 panes of vinyl film so they are not too expensive and they are gasketed for a tight fit.

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The number and size of the windows in the 1912 building date back to an era when daylight was necessary for schooling. Today, we do not need so much daylight and as the reflective shades will attest, the heat gain from such large windows is undesirable. These windows could easily function at half their size but historical preservation will not allow such a change. However, if it is allowed, I propose installing 1" thick rigid panels of Thermax insulation directly on the glass of the upper sash. The panels could be held in place with dog clamps so the change is not permanent and Thermax comes with a white finish that is durable and reasonably attractive. This low cost solution would provide both R-value and solar shading.

The financial projections only account for interior storms on all windows and air sealing the top sash of the 1912 windows.

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Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
1128	$3,700	0	$0	81	$19	$3,719	$27,995	$0	$27,995	15	7.5	2.0

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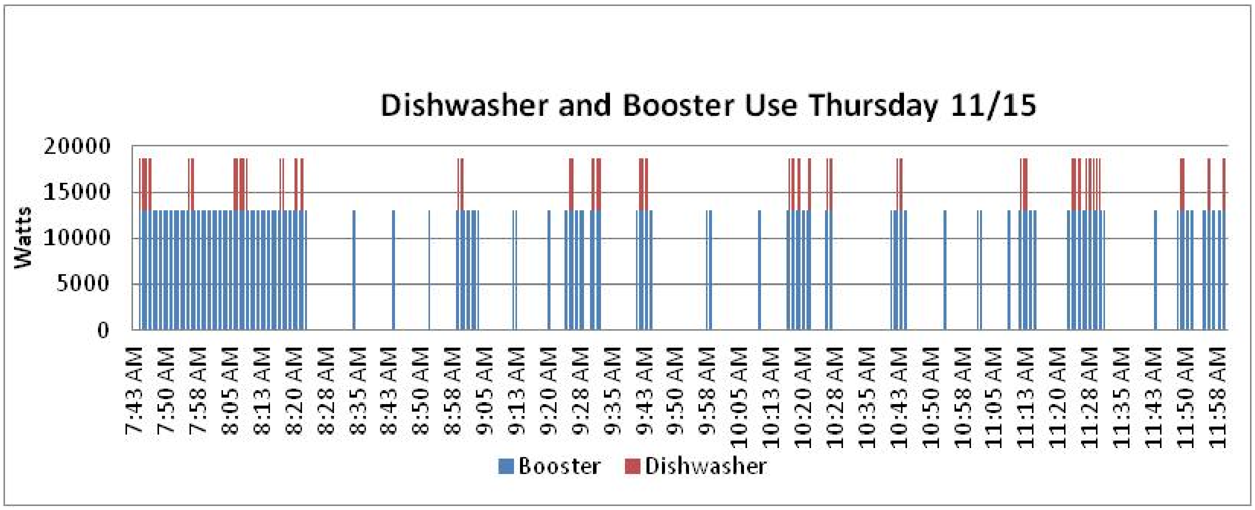
9. ECM#8 – LPG Booster Heater

The 13 kW booster heater for the dishwasher cycles with the dishwasher and sometimes just heat its small storage tank. As noted in Norm Etkind's SEMP site assessment, the energy it uses is five times more expensive than that used by lighting and other appliances because it adds between 4 and 5 kW to the monthly 15 minute peak electrical demand. This cost, around $1 per kWh, makes conversion to LP gas an attractive opportunity.



The cycling seen between dishwasher uses would continue through unoccupied times if the kitchen crew did not throw the disconnect every day.

The capacity of the booster is about 44 MBH (thousand Btu per hour) and can be met by a heater such as the Hatco PMG-60 3 Gal Booster Water Heater which costs $4,500, can be installed by ARC, and should fit under the counter.

Oil Saved (Gal)	Oil Saved ($)	Lpg Saved (Gal)	Lpg Saved ($)	Elec. Saved (kWh)	Elec. Saved ($)	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
0	$0	-75	($186)	1,628	$1,778	$1,591	$10,000	$0	$10,000	15	6.3	2.4

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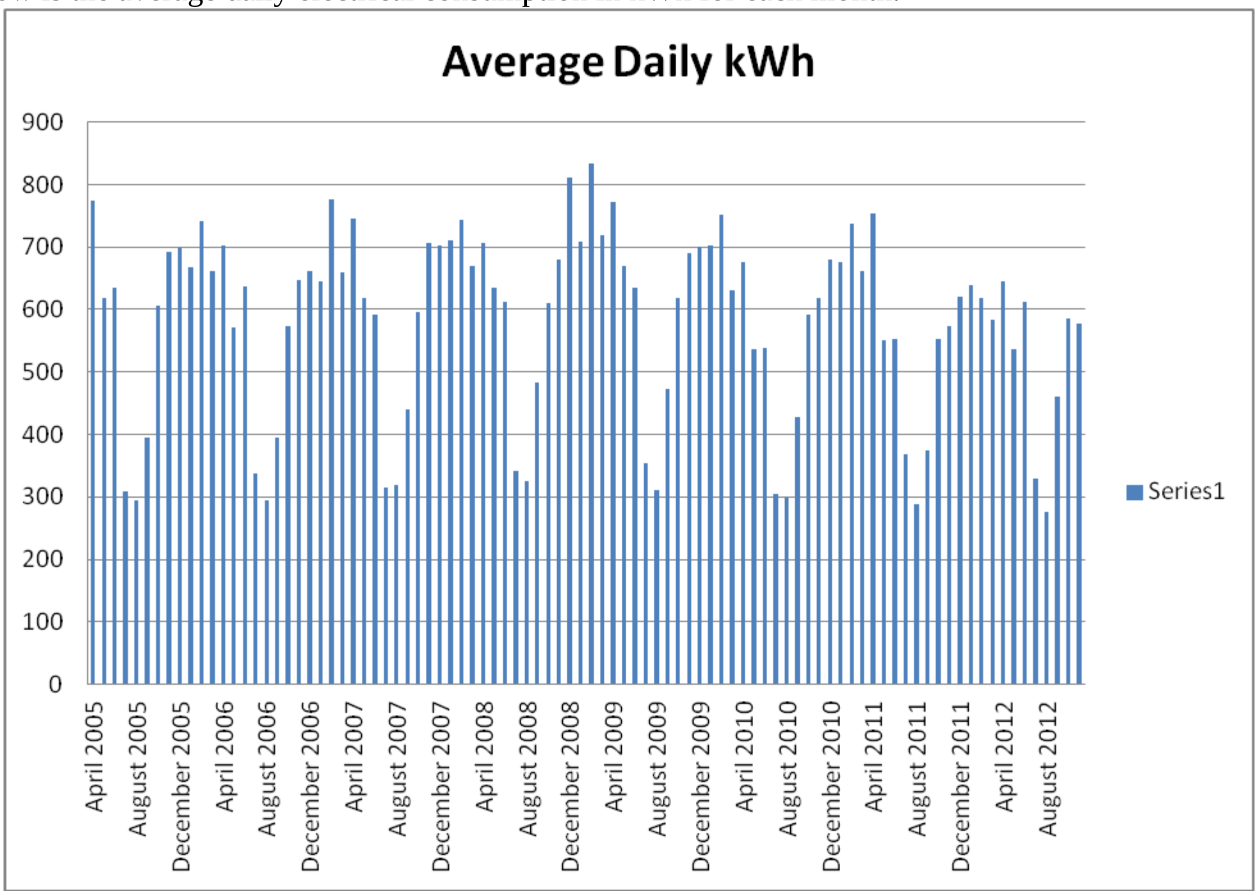
Existing Energy Use

Below is a summary of the energy use for the building in recent years. When possible, the total loads are divided into base load (energy loads that are consistent month to month) and seasonal load (energy loads that spike seasonally). The designation "NA" indicates data that was not made available for this study.

Energy Use Summary for Chelsea Public School

Energy type	Unit	Total 2009	Total 2010	Total 2011	Average	Annual Base load	Annual Seasonal load
Electricity	kWh	220692	207202	195237	207710	108360	99350
Heating Oil	Gallons	10033	14627	15000	13220	NA	13220

Below is the average daily electrical consumption in kWh for each month.



Electric power consumption spikes every February and April which was a mystery. I asked around to try to find possible reasons, heavy cleaning equipment during vacation, use of the kiln? Andrew Doyle came up with the best suggestion, when the students are gone for a week the boilers have to work harder to heat

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the building. All the more reason for central temperature controls so the school can be setback on vacation weeks.

Energy intensity is energy consumption per square foot of floor area. The table below compares the energy intensity of this building with buildings of similar size and type in the North East (NE). Energy intensity per square foot of floor area does not account for differences in building volume or shell surface area so comparisons between buildings are not precise but are still useful.

Energy Intensity Benchmarks					
Building Name	**Floor Area sq. ft.**	**Electricity kWh/sf**	**Heating Oil gallons/sf**	**Heat Energy kBTU/sf**	**Total Energy kBTU/sf**
Chelsea Public School	31994	6.5	0.4	57.4	79.5
Similar TYPE Buildings in NE		7.8	0.3	41.6	68.3
Similar SIZE buildings in NE		9.0	0.2	30.5	61.2

This table is showing that electrical consumption for this building is below average and fuel consumption is higher than average. Data from testing indicates that air leakage and low R-value is one of the main reasons for the higher than average fuel consumption.

Building Ventilation

The table below is a summary of the calculations used to determine the minimum ventilation required for the building compared to the ventilation rate determined by blower door testing. The Building Performance Institute (BPI) protocols that define the ventilation requirement are specifically designed for residential type structures and may not apply here. Based on our testing the building is not sufficiently ventilated by *natural* ventilation but may be sufficiently ventilated with the existing mechanical ventilation. Consult with a HVAC engineer to review the mechanical ventilation when planning improvements that will increase the air tightness of the building.

Minimum Building Airflow Standard (ASHRAE 62-89)		
Conditioned space floor area	31994	square feet
Excluded areas	none	
Total conditioned volume	438580	cubic feet
# of regular occupants	235	people
# of stories above grade	2	stories
Zone and Location	2	Chelsea, VT
N- factor and Adj. N- factor	19	15.4
Required Building ventilation	2558	CFM
Required Occupant ventilation	3525	CFM

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Minimum airflow standard	54250	CFM50
Blower door test result	34820	CFM50
Minimum airflow standard met?		No

Blower Door Test Results

Ambient conditions 11-21-12:
Outside temperature: 30 °F
Inside temperature: 65 °F
Wind conditions: calm
Time of day: 9:00 am

Notes:
1. All interior doors were open except the door to the attic and the door to the nurses office.
2. All exterior doors and windows were closed and latched.
3. Heaters and fans were turned off.
4. Window AC units were still in at the time of the test.

Results:
Most buildings in the United States are tested at 50 Pascals (0.2" w.c. or 1.04 lbs./sq. ft) as a means of comparison. 50 Pascals is about 5 times the pressure a building might experience on a cold winter day. Temperature adjusted CFM50 accounts for the change in air density as it is drawn in through gaps and cracks from outside and is a more accurate measure of air flow under test conditions.

Temperature adjusted CFM @ 50Pa.	Cubic feet of Building Volume	Air changes per hour @ 50Pa.	Square Feet of Building Shell	CFM50/sf of shell
34,820	438,580	4.76	37,404	0.93

Air Leakage Comparison to Other Buildings:

Building	**Air Leakage Rate (CFM50/sf of exposed shell)**
Ultra tight construction	<0.10
High performance construction	<0.25
Typical existing construction	0.60 to 0.90
Typical new construction	0.40 to 0.80
Chelsea Public School	**0.93**
Leaky construction	> 0.60

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