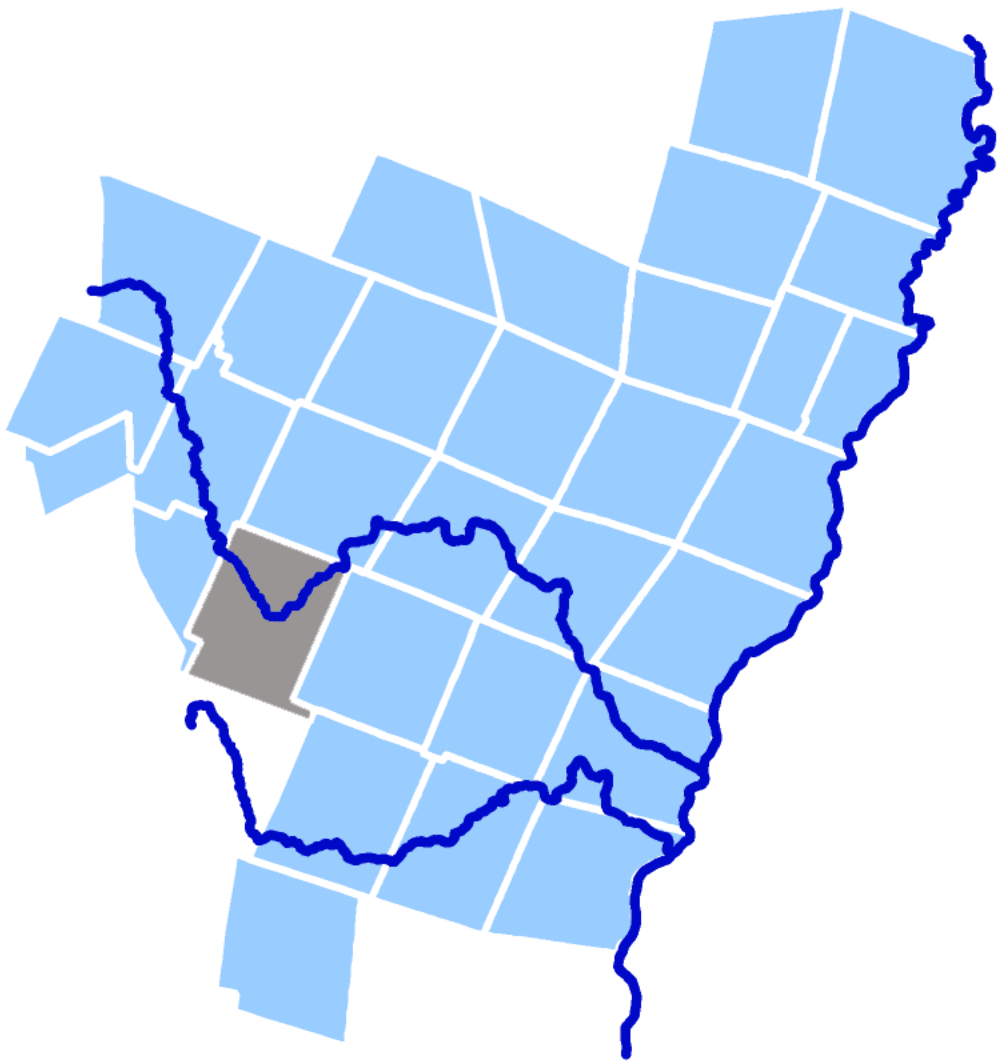
Two Rivers-Ottauquechee Regional Commission



Stockbridge Town Garage

Building Energy Plan

Provided for the Town of Stockbridge 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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Zero by Degrees LLC

Energy Independence in Affordable Steps

Building Energy Plan

December 17, 2010

To: Stockbridge Selectboard and Mr. Chris Sargent, TRORC
From: Jon Haehnel, Zero by Degrees LLC

RE: Energy Audit Conducted October 5, 2010 on the Stockbridge Town Garage and Fire Dept.

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.

Purpose

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

Executive Summary

The most significant energy saving opportunities at the town garage are replacing the boiler, improving the insulation and airtightness of the ceiling, and in replacing the outdoor lighting. Improving the ceiling is not a simple solution but the cost effectiveness of this measure could be greatly improved if the work was timed with replacement of the roof membrane.

Summary of Analyzed Measures

Measure	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
ECM#1 Upgrade interior lighting	$170	$4,000	$1,160	$2,840	20	17	1.2
ECM#2 Upgrade outside lighting	$153	$2,400	$300	$2,100	20	14	1.5
ECM#3 Upgrade heating system	$1,914	$12,600	$380	$12,220	20	6	3.1
ECM#4 Improve the Envelope	$1,812	$32,108	$4,371	$27,737	40	15	2.6
ECM and O&M #5 Reduce electrical loads	$42	$800	$0	$800	10	19	0.5

O&M - Operation & Maintenance measure
ECM - Energy Conservation Measure
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 –30 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 $0.126/kWh peak and $2.49/gallon of oil to predict cost savings. These are taken from the energy consumption information provided but do not include demand rates or administrative charges. 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,

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cooling, and ventilation system rebates may be applied for directly through Efficiency Vermont's website http://www.efficiencyvermont.com/pages/. Insulation and air sealing rebates through Efficiency Vermont may require that the work be done through a certified home performance contractor and that all health and safety recommendations be completed in order to qualify for the rebate.

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 per floor.
2. The boiler in the garage failed to properly draft under worst case conditions when the large exhaust fan was turned on. This fan is only used for welding. When it is used the bay doors MUST be open in order to provide make up air for the fan and avoid dangerous back drafting of the furnace. In addition the burner could be damaged if the flames "roll back" onto the burner because of back drafting.
3. The present natural ventilation is sufficient for the town office and the occupants (see building ventilation below). Continuous mechanical ventilation equal to 107 CFM may be required for proper ventilation of the building if the building air tightness is improved. A certified home performance contractor should provide options for air tightening and mechanical ventilation before any envelope work is performed.
4. The boiler flue is corroded and has holes in it where it enters the chimney. This piping should be replaced.
5. Currently, there is no way to remove exhaust fumes from the building while a motor vehicle is running. A tube that can be attached to the exhaust pipe and vented outside should be installed.

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 these buildings. 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.

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1. ECM#1 – Upgrade Interior Lighting

Finding: Most of the lighting in the town garage is T12 fluorescent lighting. There are some incandescent bulbs still in use but Dave Brown has been replacing them with CFL lights as they burn out. There are also a total of five 175W mercury vapor lights in the building.

Recommendation: Replace all the T12 fluorescent lighting with high performance T8 lighting. Replace all incandescent bulbs with comparable light quality CFLs or LED bulbs when the bulbs are blown. Switch the mercury vapor lights to 4 lamp high performance T8 lighting.

Implementation and timing: Implement within the next year. The extra incentives for switching to T8 lighting are good through 2011 and T12 lighting is being phased out of production. T8 bulbs are readily available and have a longer life than most T12 bulbs. High performance T8 lighting with low ballast factor should be used for maximum energy savings.
Replace the incandescent bulbs with CFL or LED replacements as old bulbs burn out. They are not used often enough to warrant immediate replacement.

Gallons saved	kWh saved	Savings Heating	Savings Electricity	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
-11	1487	($28)	$198	$170	$4,000	$1,160	$2,840	20	17	1.2

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2. ECM #2 – Upgrade Outside Lighting

Finding: There are 2 outside lights on the garage and 1 on the salt shed on photo sensor controls. At least one is on all night, every night. In the winter, 2 and occasionally 3 may be on all night. The salt shed light is supposed to be off most of the time but occasionally it is left on. I was not able to confirm the wattage but I believe that they each have a 250 watt high pressure sodium (HPS) bulb.

Recommendation: Switch the outdoor HPS lights to an LED light with comparable light quality. Check the rated lumin output of the existing HPS light to find the best match in a LED replacement. Alternatively, you may consider using an incandescent flood light on a motion sensor for security so the lights do not have to remain on all night.

Implementation and timing: The LED incentives through Efficiency VT are quite good right now but anticipated to be reduced in 2011. Unfortunately, the payback term is still long for LED lights because they are expensive. It will be more cost effective to switch to incandescent flood lights on a motion sensor or reduce to only one HPS light on all night for security until they reach the end of life and then replace them one at a time with LED lights.

Gallons saved	kWh saved	Savings Heating	Savings Electricity	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
0	1144	$0	$153	$153	$2,400	$300	$2,100	20	14	1.5

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3. ECM#3 – Upgrade Town Garage Heating

Finding: The existing boiler looks at least 30 years old and has a steady state efficiency of 74% and the heating distribution pipes are uninsulated. Those that work in the building comment that the boiler seems to always be on in the winter. This is in part because the boiler is inefficient and in part because the building cools too rapidly even when the massive doors are closed.

Recommendation: Install a programmable thermostat and program in a night setback of 55F. Replace the boiler with a unit that has an annual fuel utilization efficiency (AFUE) of 85% or better. The new boiler should also have an outdoor air reset control to increase efficiency even further. Install an intake air duct direct to the burner so no indoor air is required for combustion. This eliminates the potential for back drafting even if the big exhaust fan is on and is safer for improving the air tightness of the building shell. Insulate the distribution pipes so the modines and radiators receive higher temperature water. Finally, I recommend installing programmable thermostats with "2 hour occupied" overrides in each of the 3 zones of the building. Dave keeps the building set at 60 F all the time now so the energy savings from programmable thermostats will be slight. However, 2 hour occupied setting allows anyone to come in and increase the temperature just while they are there and then the thermostat reverts back to the preset limits after 2 hours. These thermostats will reduce the number of times that the thermostat is accidentally left too high.

Implementation and timing: Make the recommended improvements as soon as possible.

Gallons saved	kWh saved	Savings Heating	Savings Electricity	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
752	307	$1,873	$41	$1,914	$12,600	$380	$12,220	20	6	3.1

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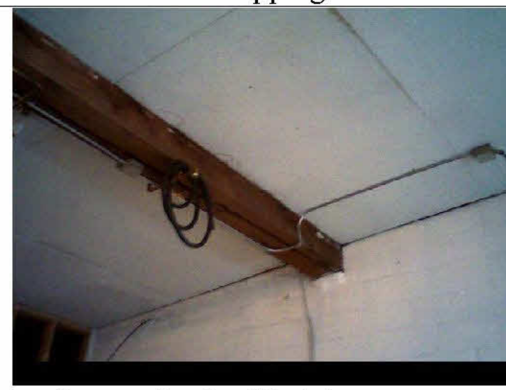
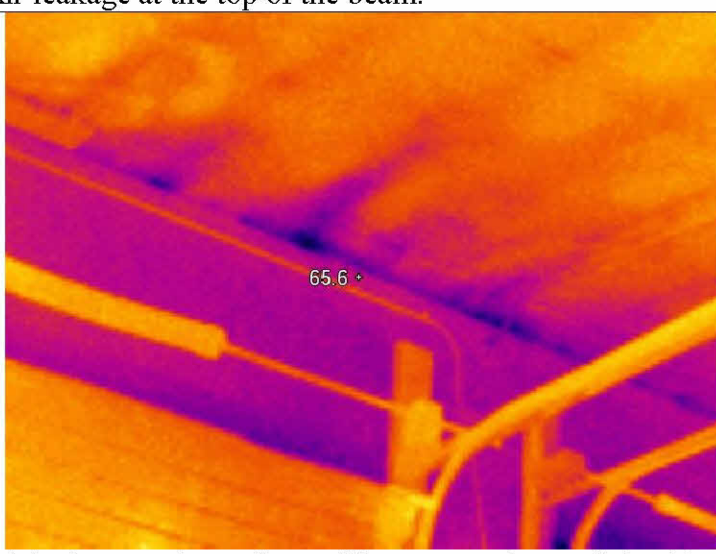
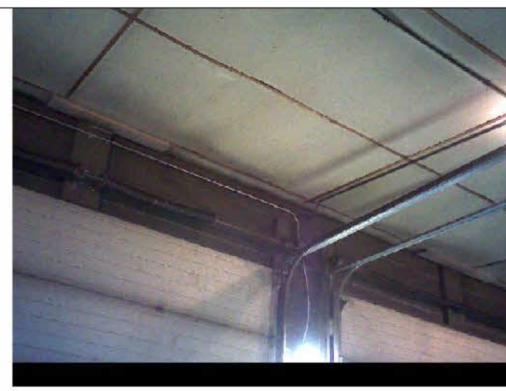
4. ECM#4 – Improve the Envelope

Broken attic hatch	Attic insulation with strapping below
 Air leakage at the top of the beam.	 Visual reference for the IR picture
 Air leakage at the wall to ceiling connection. Air is able to get around the fiberglass into the vent space above it.	 Visual reference for the IR picture

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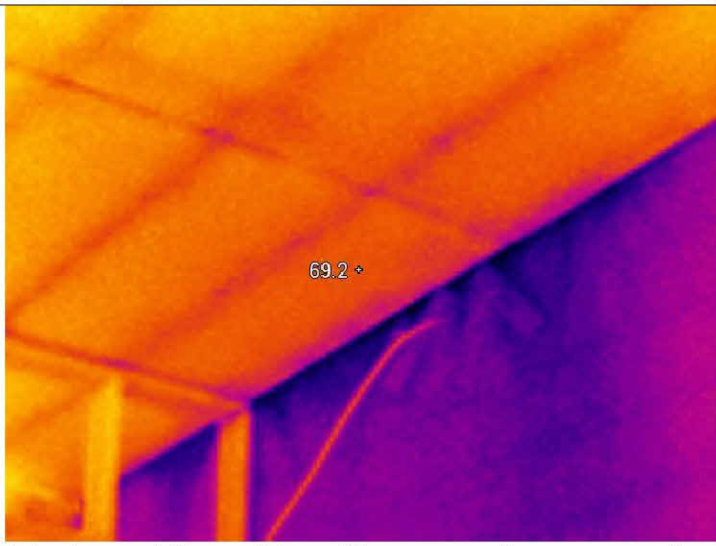
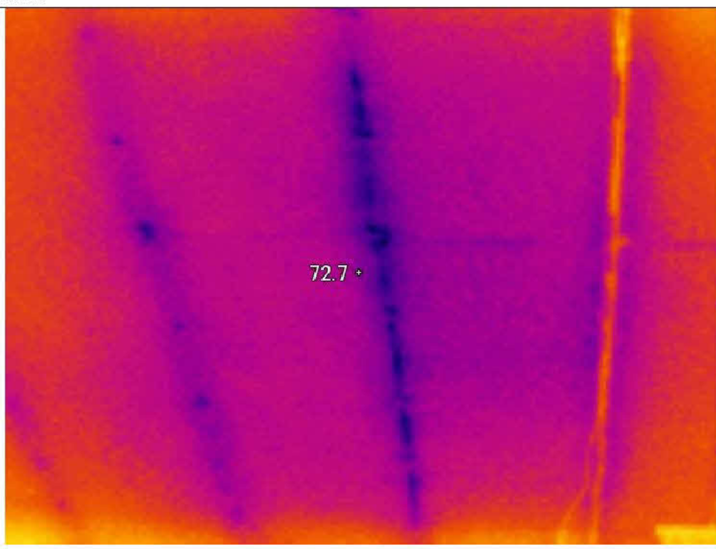
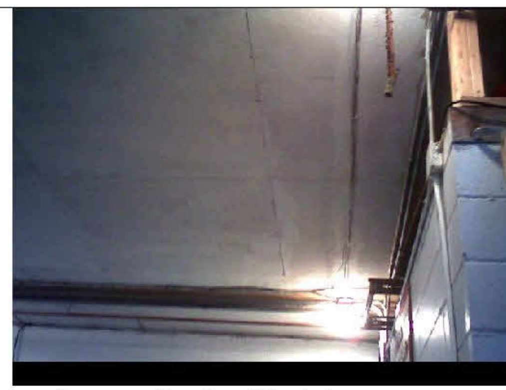
 Air leakage at the wall to ceiling connection on an end wall.	 Visual reference for the IR picture
 Air leakage through the panel joints on the ceiling.	 Visual reference for the IR picture

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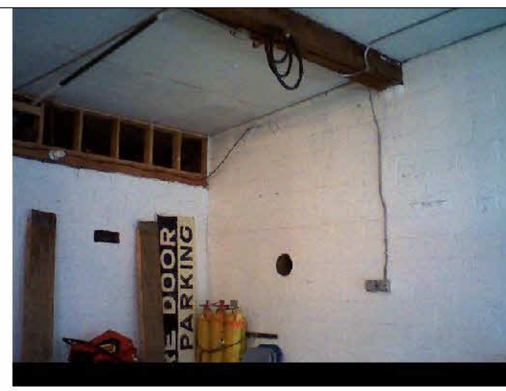
The exposed slab edge radiates heat to the outside and should be insulated like the rest of the wall.

The open hole to the old chimney.



Visual reference for the IR picture

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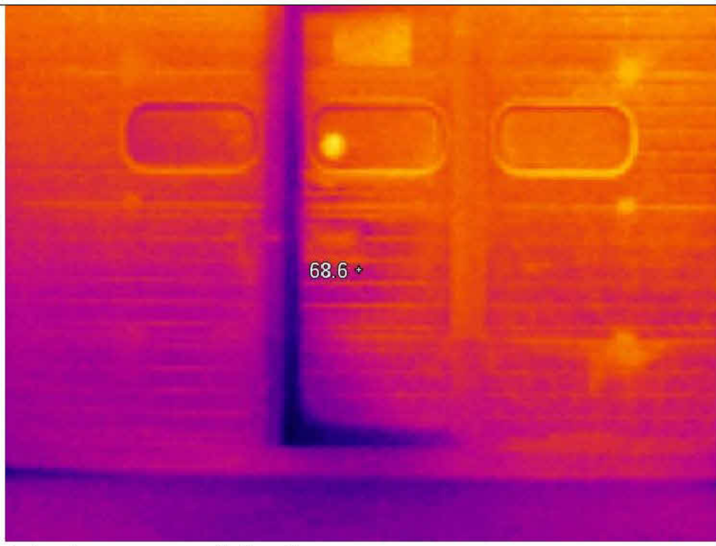

Air leakage around the door.

Visual reference for the IR picture

Finding: The roof insulation is R19 fiberglass batt with an air space above. There appears to be no additional insulation under the roof membrane. The walls have 2" of closed cell spray foam on the outside of the concrete block walls for a total R-value of about 13. The slab edge at the base of the walls is uninsulated.
Air leakage in this building is higher than average and is found mostly around the bay doors, through the ceiling, and at the wall to ceiling connection. I believe that warm air can get through the seams in the ceiling and into the vent space above the fiberglass. There is also significant air leakage through the ventilation fan dampers, around the man door that is in the bay door, and through the wall opening to the old chimney.

Recommendation: First, fix the easy stuff. Block and foam seal the opening to the old chimney, install an insulated and weather-stripped door on hinges to cover the vent fan when not in use, and weather strip the man door and the bay doors. Most of the bay doors leak at the top and sides but the first bay door leaks at the bottom also. Adjust the door closers so the top of the door meets the weather-stripping when closed. Check the weather-stripping at the sides to make sure it is in good repair and in close contact with the door and check the rubber gasket at the bottom of the door for damage. When the door is closed and with the lights off, look at the door from all sides for daylight. If you see daylight the weather stripping is not tight to the door. At the same time pull the fiberglass chinking around the wooden man door on the south side with one-part foam (Good Stuff by Dow or Purfil), it makes a much tighter seal between the door frame and the wall. Finally, insulate the slab edge with as much thickness in rigid foam board as can be tucked under the existing siding. Dig down beside the slab and frost wall for 8-10" so the foam can be glued tight to the frost wall, then backfill against the rigid and cover the foam that is above grade with stucco for protection against sunlight. The rigid foam thickness should be narrower than the existing siding so water cannot get behind the foam. Do not bother to install rigid where there is finished driveway tight to the building.

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Next, address the air leakage through the ceiling. This is not an easy task but the goal is to make the ceiling an airtight barrier that keeps warm air trapped inside. One idea is to inject the ceiling bays with densely packed cellulose through holes in the ceiling. This would work to address air leakage and add needed R-value to the roof system. The downside is that it is not without risk. Cellulose is a good product that I often recommend for walls but it isn't a good product for unvented roofs. It has the slight potential to accelerate moisture damage in this application.

I think the best options are: 1- Pull the ceiling down and install closed cell spray foam (to at least R50) against the roof deck, making sure the foam seals to the top of the walls on all sides. Then reinstall the ceiling. 2- install 5" of rigid polyisocyanurate foam board (R7 per inch) from inside onto the ceiling taking care to foam seal the rigid to the walls and every beam or penetration in the ceiling. Cover the rigid with sheetrock and then mud and tape the seams with at least 2 layers of mud. The mud doesn't have to be pretty, it serves to make a continuous air barrier that spans all the joints in the rigid foam. Foam seal the sheetrock to the perimeter and at all penetrations through the ceiling. This system allows the roof to remain vented but now blocks all the pathways warm air has to the vent space above the fiberglass. 3-Wait until the roof membrane needs to be replaced and add rigid insulation to the roof from above. This strategy takes advantage of the opportunity to improve insulation while the crew is there for other work so the work is more cost effective. This is not without complication because to do it right the roof venting has to be eliminated and the rigid insulation has to be air sealed to the walls below but it can be done when the roof membrane is up. Unfortunately, over half the membrane was replaced just a couple years ago so a new roof may be several years away.

Implementation and timing: The simple air sealing, slab insulation, and weather stripping work should be implemented immediately and the payback will be fast. The ceiling work can also be implemented immediately but you will have to work with a certified home performance contractor to take advantage of the rebates and to discuss the air sealing in the context of proper building ventilation (see health and safety notes above). The payback for the ceiling work is longer because the costs are substantial. The approximate cost for the upgrade I used was calculated for either of the ceiling options 1 or 2, they will cost about the same. Costs will be lower if the insulation and air sealing can be done from above at the same time as replacing the roof membrane.

Gallons saved	kWh saved	Savings Heating	Savings Electricity	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
712	292	$1,773	$39	$1,812	$32,108	$4,371	$27,737	40	15	2.6

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5. ECM and O&M #5 – Reduce Electrical Loads

Finding: The 43 gallon water heater is on standby year round even when consumption is low, primarily for hand washing. There is a second refrigerator that is nearly empty but running.

Recommendation: Replace the water heater with an electric on-demand hot water heater to supply hot water for hand washing and other limited uses. Consolidate food items so they can all be stored in one refrigerator and disconnect the other.

Implementation and timing: Shut off the second refrigerator immediately, this is low cost energy savings measure. However, it doesn't really make sense to change the hot water heater even though the present water heater is too large for just hand washing. The payback is still long even with the low cost of implementation.

Gallons saved	kWh saved	Savings Heating	Savings Electricity	Total Savings	Approx. Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
0	319	$0	$42	$42	$800	$0	$800	10	19	0.5

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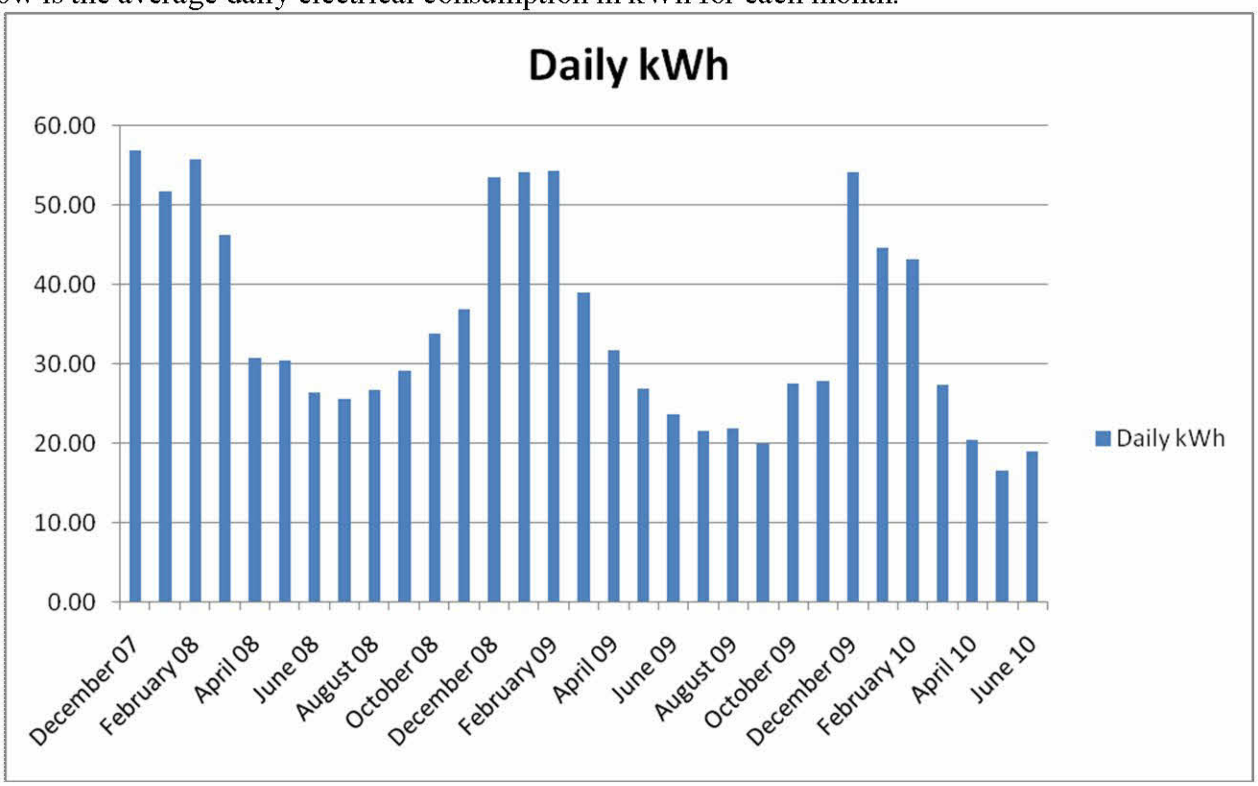
Existing Energy Use

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 Stockbridge Town Garage							
Energy type	**Unit**	**Total 2009**	**Total 2008**	**Total 2007**	**Average**	**Annual Base load**	**Annual Seasonal load**
Electricity	kWh	12334	13741	NA	13037.5	7396	5641.5
Heating Oil	Gallons	2385.2	2673.3	NA	2529.25	0	2529.25

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



As can be seen in the chart above, the daily electrical load nearly doubles in the winter season. There are many contributors that increase electrical use in the winter: furnace/boiler run time, pump and modine running time, and longer lighting run time in the winter. All of these loads combined are enough to explain the jump in daily kWh.

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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 cannot be precise.

Energy Intensity Benchmarks					
Building Name	Floor Area sq. ft.	Electricity kWh/sf	Heating Oil gallons/sf	Heat Energy kBTU/sf	Total Energy kBTU/sf
Stockbridge Town Garage	5052	2.6	0.50	69.5	78.3
Similar TYPE Buildings in NE		5.9	0.24	33.3	41.6
Similar SIZE buildings in NE		9	0.50	69.4	90.7

This table is showing that electrical consumption is well below average and heating consumption is about average to higher than average for buildings of similar size and type in the North East (NE).

Combustion Testing

The table below summarizes the testing on the boiler. Cells in red indicate failure to draft or carbon monoxide (CO) levels above 25ppm which is an indicator of incomplete combustion and a possible health risk if the chimney was not properly drafting. The tests show that the flue is properly drafting under normal scenarios but the flue is not drafting under worst case scenario (when the large ventilation fan is going). The draft test result was obtained under normal pressure conditions because I did not want to run the boiler any longer than necessary in case the back drafting caused by the ventilation fan would damage the burner.

CAZ- combustion appliance zone, the area where a combustion appliance is and where pressure readings are taken to determine if conditions for back drafting may occur.

Worst case – turning on all fans and appliances that can make the building negatively pressurized to see if the potential for back drafting exists.

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Combustion Testing- Furnace #1, Fuel		
Baseline CAZ pressure	-1	Pascals
Worst case CAZ pressure	-18.8	Pascals
Worst Case Spillage	failed under worst case	
Steady State Stack Temperature	476	˚ F
Steady State Efficiency	74	%
Flue CO	15	ppm
Outside temp	63	˚ F
Minimum Acceptable draft	-1.175	Pascals
Draft	-12	Pascals
Ambiant CO	0	ppm

Building Ventilation

The table below is a summary of the calculations to determine the minimum ventilation required for the building compared to the ventilation rate determined by blower door testing. Based on our testing the town garage is sufficiently ventilated at present but may need mechanical ventilation or review by a HVAC engineer to determine the proper ventilation rate if air tightening measures are employed for the building.

Minimum Building Airflow Standard (ASHRAE 62-89)		
Conditioned space floor area	5052	square feet
Excluded areas	none	
Total conditioned volume	63371	cubic feet
# of regular occupants	2	people
# of stories above grade	1	stories
Zone and Location	2	Stockbridge, VT
N- factor and Adj. N- factor	19	19.0
Required Building ventilation	370	CFM
Required Occupant ventilation	30	CFM
Minimum airflow standard	7024	CFM50
Blower door test result	7930	CFM50
Minimum airflow standard met?		Yes

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Blower Door Test Results

Ambient conditions 10-5-10:
Outside temperature: 63 °F
Inside temperature: 63 °F
Wind conditions: calm
Time of day: 10:00 am

Notes:
1. All interior doors were open.
2. All exterior doors and windows were closed and latched.
3. Heaters were turned off.

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
7930	63,371	7.51	9,114	0.87

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 modern construction	0.60 to 0.90
Stockbridge Town Garage	**0.87**
Another Local Town Garage	0.38
Another Local Town Garage	1.00
Leaky construction	> 0.60

Acknowledgment: *"This material is based upon work supported by the Department of Energy under award number(s) DE-SC0003428"*
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