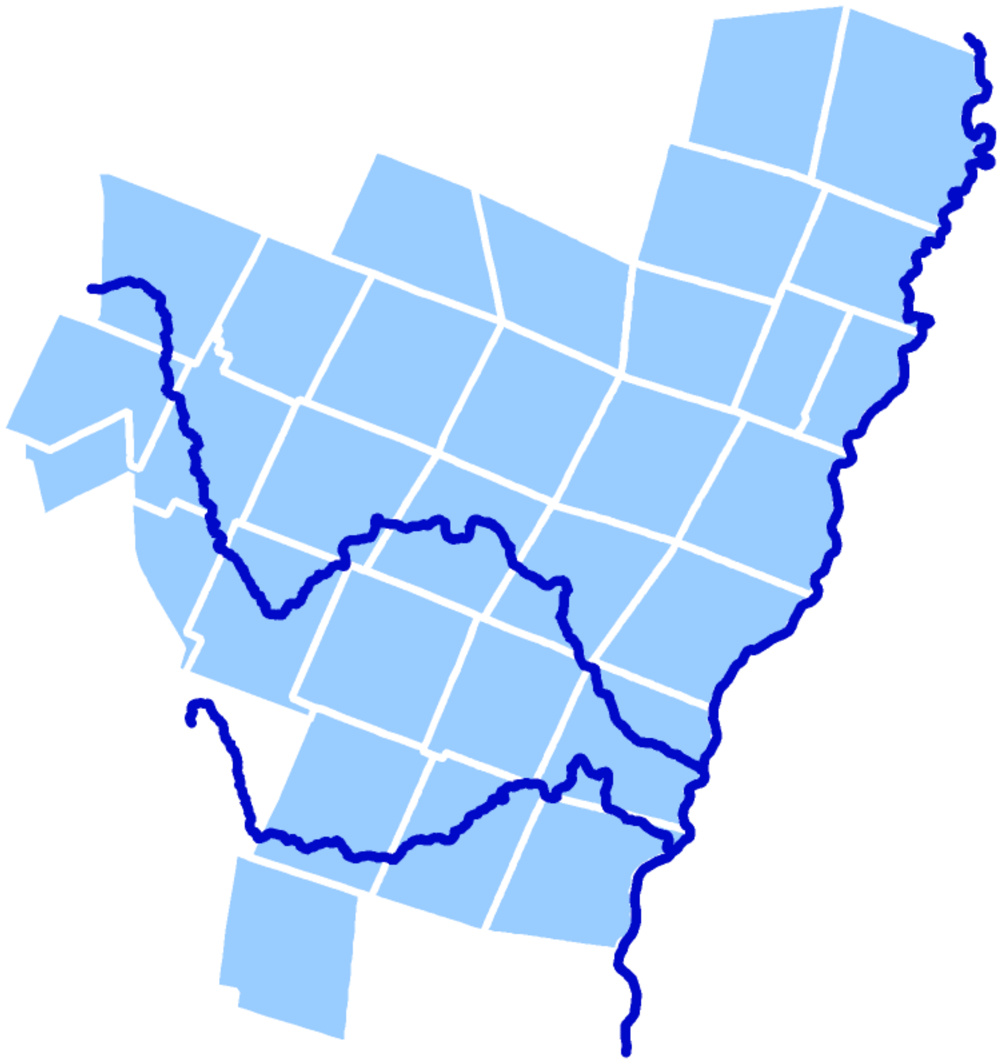
Two Rivers-Ottauquechee Regional Commission



Vershire Town Garage

Building Energy Plan

Provided for the Town of Vershire 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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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

November 16, 2010

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

RE: Energy Audit Conducted September 16, 2010 on the Vershire Town Garage

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 in improving the insulation and airtightness of the walls and the ceiling, replacing the T12 lights with high performance T8 lighting, and correcting the short cycling of the Modine heaters. The short cycling of the Modine heaters is not fully understood and may simply be a byproduct of the rapid cooling of the garage because of the poor insulation and air barrier. In other words, the Modine efficiency may improve once the building shell does. Improvements in the attic air barrier and insulation systems will also have the added benefit of solving a significant condensation problem in the attic: in the winter condensation builds up on the underside of the metal roofing and "rains" down on the ceiling insulation.

Summary of Analyzed Measures

Measure	Energy Savings ($)	Cost of Measure	Possible Rebate	Cost with Rebate	Lifecycle (Years)	Simple Payback (Years)	SIR
ECM#1.Uprade lighting	$243	$1,672	$640	$1,032	20	4	5
ECM#2. Improve walls	$1,051	$13,855	$2,446	$11,409	40	11	4
ECM#3.Improve attic	$1,479	$10,844	$1,520	$9,324	40	6	6
ECM#4.Weatherize doors	$96	$1,000	$0	$1,000	5	10	0.48
ECM#5.Reduce Modine cycling	$768	$2,500	$100	$2,400	10	3	3
ECM#6. Air seal the walls	$701	$4,000	$500	$3,500	40	5	8

Definitions:
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

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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.

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. A detailed review of the costs and maintenance implications is recommended, especially for complex or large projects.
2. **Predicted energy savings for each measure should be viewed as the savings that would be obtained if only that measure was completed. In other words, energy savings are interactive, and the implementation of one measure can reduce the potential savings of subsequent measures. This is especially true for envelope improvements and heating system improvements.**
3. 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.
4. 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.
5. 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.
6. 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.

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7. I used \$0.198/kWh and \$1.43/gallon of propane to predict cost savings. These values are averages of the values provided with the energy consumption information 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.
8. 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. 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 this building. At least 1 should be installed per floor.
2. The emergency switches for the Propane heaters are located high on the walls, essentially inaccessible in the event of a problem. Switches for the heaters are also located down at the workbench but do not have the red emergency switch plates identifying them. The switch covers at the work bench should be replaced with the red switch plates so the switches can be quickly identified.
3. There is no provision to remove exhaust fumes from the building while a motor vehicle is going. A tube that can be attached to the exhaust pipe and vented outside should be installed. Also, an exhaust fan that can be run only when the bay doors are partially open (to avoid back drafting the furnaces) should be considered.
4. The present natural ventilation is sufficient for the town garage and the occupants (see building ventilation below). Continuous mechanical ventilation equal to 190 CFM **may be** required for proper ventilation of the building when the building air tightness is improved. Mechanical ventilation with heat recovery is advised to reduce heat loss. A certified home performance contractor should provide options for air tightening and mechanical ventilation before any envelope work is performed.

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 facility. 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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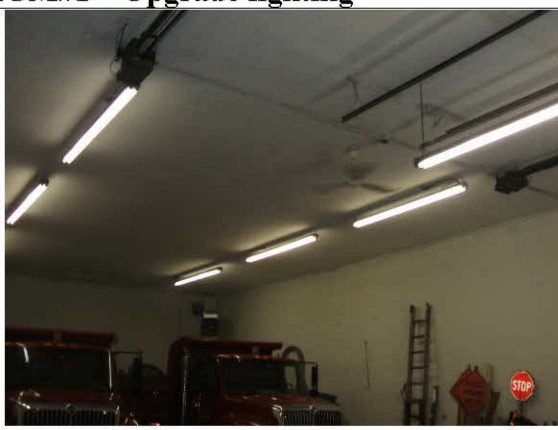
1. ECM#1 – Upgrade lighting



Finding: Most of the existing lights are T12 fluorescent fixtures with magnetic ballasts.
Recommendation: Replace the existing light fixtures with T8 lights with electronic, low ballast factor, ballasts. The main lights on the ceiling can be replaced with tandem 4' units rather than 8' lights. The 4' T8 bulbs are easier to obtain and have a longer life than the 8' T12 bulbs so they will need to be replaced less often. Heating costs will increase slightly with this measure because T8 lights will give off less heat than the T12 lights.
Implementation and timing: This measure can be implemented immediately, the lights are surface mounted and easily replaced. Implementation costs may be higher if the existing wiring is not code compliant. Cramer electric provided budget pricing for the upgrade, contact Reg Cramer at 802-333-3298 for more information on the installation.

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
-31	1451	($44)	$287	$243	$1,672	$640	$1,032	20	4	5

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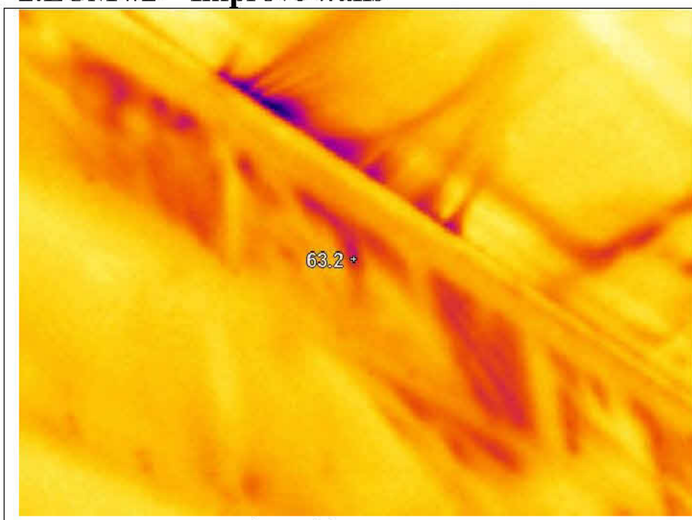
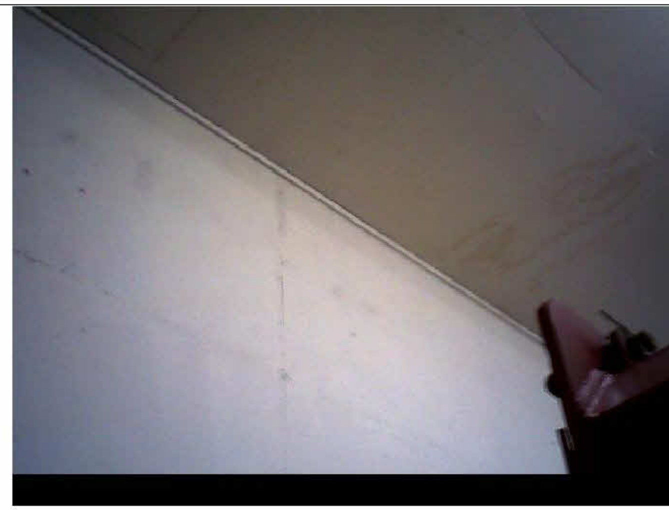
2.ECM #2 – Improve walls

 IR014999.IS2- Infrared image 9/16/2010 6:20:33 AM	 Visible Light Image
 Looking down into the top of the wall from the attic	 4" air space at the bottom of the wall where cold air pours in

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Finding: The wall cavities are about 8" thick comprised of wood posts with horizontal 2x4 strapping on either side. Fiberglass batts about 5" thick run up the middle of these walls but air can move easily around it. The effective R-value of the wall is far less than the R-value rating of the batt, R13 at best. The walls have a 2" to 4" gap at the bottom and are open into the attic at the top. In many places the insulation has sagged and fallen inside the walls. All of these characteristics combine to make it easy for warm air to enter the walls, rise to the top, and exit into the attic where it hits the cold roof and condenses moisture.
Recommendation: Air seal the top and bottom of the walls and add more insulation to the walls. This can be done in several ways but the simplest approach would be to remove the metal siding and existing insulation so closed cell spray foam can be installed from outside (to at least R21 value) against the back of the plywood. The spray foam is costly so this approach increases the payback term. Other methods could be employed at a lower cost but need to meet the same goals of increased R-value and airtight construction in order to be effective. Please note that as air tightness increases there may be a need for mechanical ventilation, see notes under "Health and Safety" above.
Implementation and timing: If an addition or renovation is planned within the next 5 years this upgrade should be coordinated with it. This measure involves the removal and reinstallation of siding which would be a low cost proposition if a construction crew was already on site for other work. However, the air sealing portion of this work should not wait and is explained further in ECM#6 below.

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
729	60	$1,039	$12	$1,051	$13,855	$2,446	$11,409	40	11	4

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3.ECM#3 - Improve Attic

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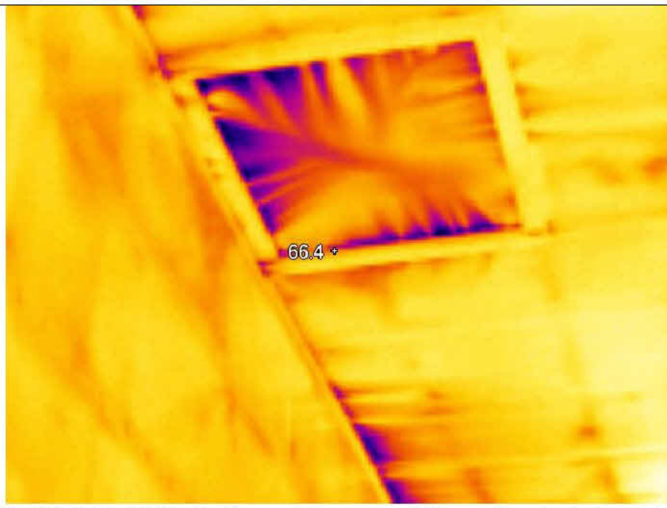

IR014987.IS2- Infrared image of the attic hatch and leaky wall to ceiling connection.
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Visible Light Image

The lines are water lines below the roof purlins.

Finding: The attic was once insulated with about 6" of fiberglass batt insulation, even then that wasn't enough insulation. Now, that batt is only about 3" thick because it has been "rained on" by condensation from the metal roof for many years. The effective R-value of the ceiling system is probably less than 7. Too much warm air is getting into the attic and condensing moisture on the metal roof panels.

Recommendation: Because of the condensation the solution cannot simply be to pile more insulation on top of the existing insulation, it will be damaged after the first winter. The solution must also address the air leakage into the attic. The existing fiberglass needs to be removed and I recommend a 2" layer of closed cell spray foam across the entire attic to air seal it. Then, cover the foam with about 11" of cellulose for a total R value of R50. The attic hatch needs to have rigid foam glued to the top of it to the same R-value as the attic and then it needs weather stripping that t perimeter so it seals tightly when

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closed. Please note that as air tightness increases there may be a need for mechanical ventilation, see notes under "Health and Safety" above.

Implementation and timing: This measure should be implemented as soon as possible. Access is good in the attic and the condensation needs to be stopped.

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
1010	203	$1,439	$40	$1,479	$10,844	$1,520	$9,324	40	6	6

4. ECM#4 - Weatherize Doors

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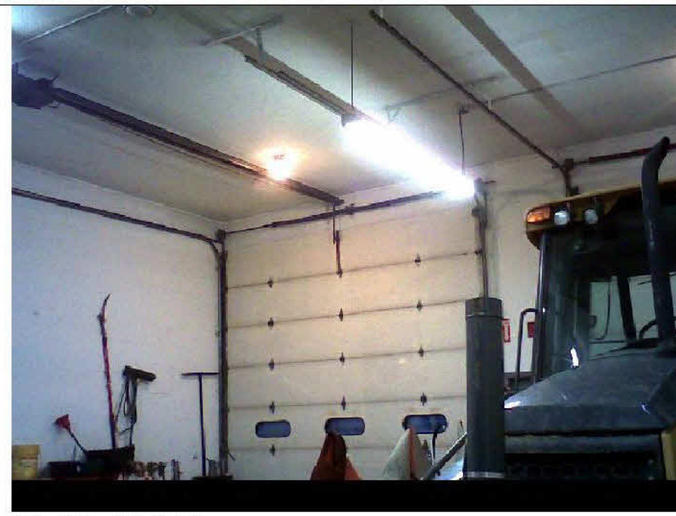

Visible Light Image

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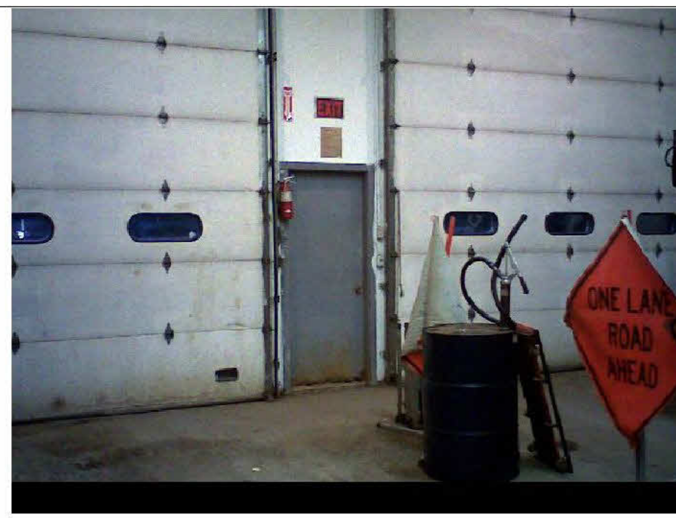

Visible Light Image

Finding: The front man door leaks at the perimeter and the top and sides of the bay doors leak.
Recommendation: Replacing doors is generally not a cost effective energy saving measure and should only be done when the door is at the end of its structural life as the front man door is. The most energy efficient door is fiberglass with a solid insulated core and bulb weather-stripping on top, bottom, and jambs. Ideally the latch should engage the door frame at more than one location. If a metal door is required, choose a door with an insulated core and the inside metal is thermally broken from the outside metal. If the door requires a window, choose a window with the smallest necessary area that is double

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pane, fiberglass framed, low-conductivity edge spacers, and is gas filled. The new door frame should be foam sealed to the rough opening.

The bay doors leak at the top because the top panel of the door doesn't come in full contact with the weather stripping when the door is closed. With some adjustment it should close better. The weather-stripping needs to be refit around the door so it is in maximal contact when the door is closed.

Implementation and timing: Economically this measure doesn't make sense unless it can be done very inexpensively and timed with other work. Replacing the man door has to be done anyway so it makes sense to put in a well insulated door. The weather stripping on the bay doors needs to be checked every year and replaced every 5 years. The sad part is, even with perfect weather stripping, one of those bay doors open for 5 minutes exhausts all the heat in the building.

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
67	5	$95	$1	$96	$1,000	$0	$1,000	5	10	0.48

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5. ECM #5 - Reduce Modine Cycling

The thermostat in relation to the Modine heater.

Finding: Both of the modine heaters came on every 3-4 minutes, ran for about 1.5 minutes and then shut off. This was on a day when it was 44 F outside. What do these heaters do on a really cold day? Alan Lyford said the heater over the bathroom was more prone to short cycling than the other one. Both heaters are less than 10 years old.

The thermostats are located at about 5' high on either side of the garage on walls that are not very airtight. It is possible that with ceiling air leakage, heat stratification, and drafty walls the thermostats are only momentarily satisfied and call often. Other possible reasons for the short cycling are that the units are oversized for the garage or they are way out of tune. With the building so air leaky and poorly insulated it is hard to know exactly why the Modines are short cycling but it is important that they stop because they never reach their rated efficiency that way.

Recommendation: Complete the attic repairs and air sealing as soon as possible to see if the short cycling stops because the building heat is not lost so quickly. the problem may go away after the building is improved. Have the units checked by a technician to make sure they are operating properly and install a second ceiling fan to help reduce heat stratification. Remove the thermostats from walls and mount new programmable ones on a piece of rigid insulation to separate them from the drafty walls (if the walls are not getting reinsulated soon). If none of these measures has an impact on the short cycling then have their sizing verified with a heat load calculation done by an HVAC engineer.

Implementation and timing: Some of the smaller tasks such as a tune up and new thermostats should be done immediately but I don't recommend doing the full scope of work on the Modines until we know the building shell is much more efficient.

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
543	-30	$774	($6)	$768	$2,500	$100	$2,400	10	3	3

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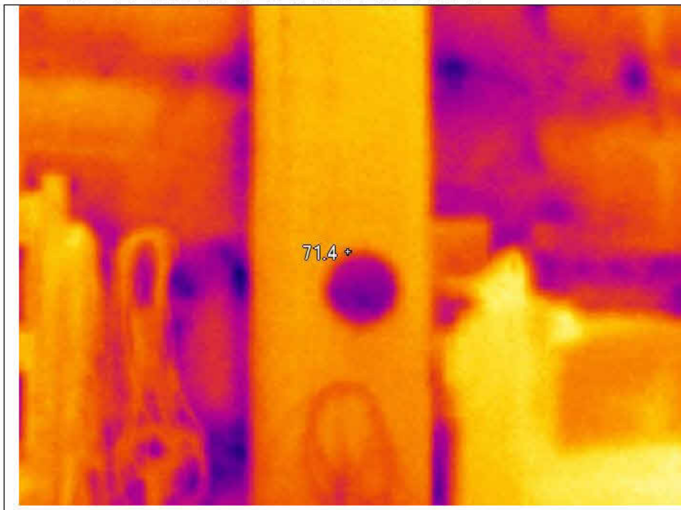
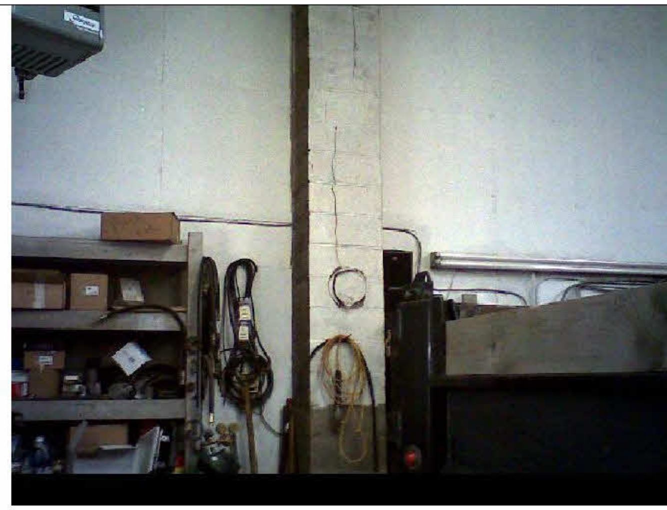
6. ECM #6 Air Seal the Walls

 IR014984.IS2 9/16/2010 6:17:40 AM	 Visible Light Image
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 The hose pipe in the wall	

Finding: As mentioned previously the walls leak at the top and the bottom and are a direct path to the attic. Not mentioned previously are the old chimney openings that need to be sealed shut and the hose penetration through the wall that needs to be blocked in the winter. The air leakage in these walls is excessive and it contributes to the condensation problem in the attic.

Recommendation: Foam seal the tops of the walls from the attic and the bottoms of the walls at the floor around the entire perimeter of the building. I recommend the foam sealing be done by a professional but it can be done with kit foam by anyone. Block and foam seal the old chimney and the old flue through the wall. Remove the hose and create a winter cap for the hose opening in the wall. Please note that as air tightness increases there may be a need for mechanical ventilation, see notes under "Health and Safety" above.

Implementation and timing: Air sealing should be done immediately IF the walls are not going to be reinsulated in the near term. It is not difficult to access the areas that need to be fixed and it will have a significant impact on heating. If ECM #2 is going to be completed in the near term most of the work will be accomplished and only the old flues and the hose opening will need to be addressed.

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
487	34	$694	$7	$701	$4,000	$500	$3,500	40	5	8

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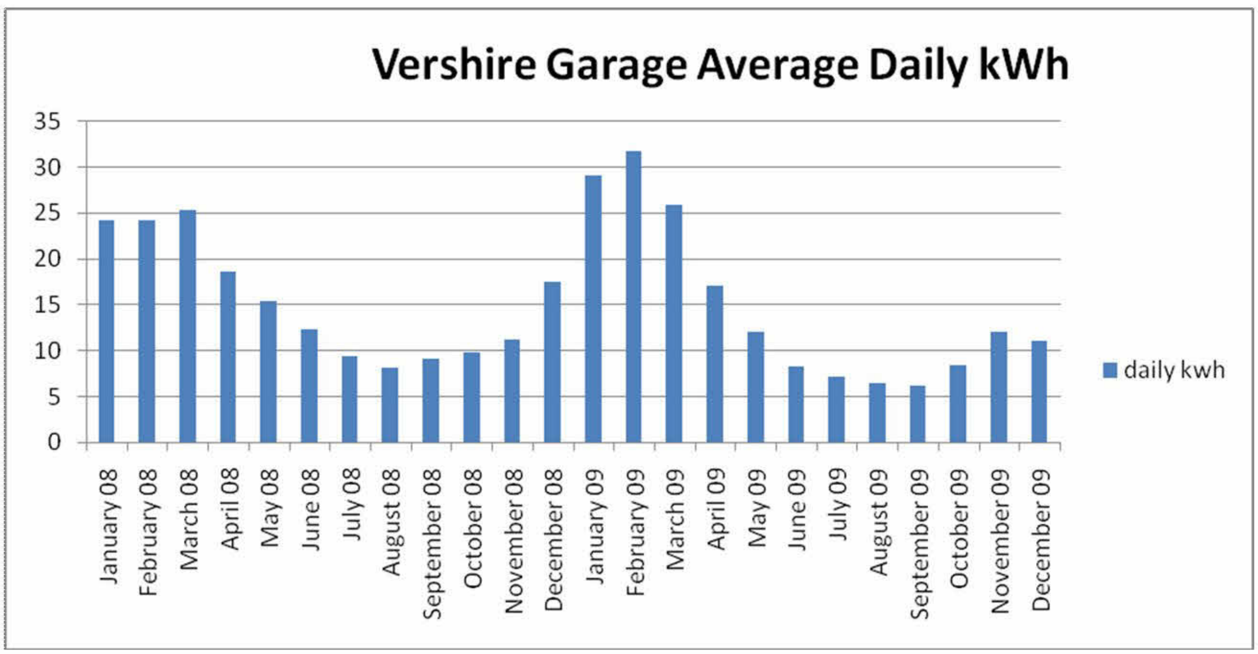
Existing Energy Use
Below is a summary of the energy use for the building in recent years. When possible, the total loads are divided into base load (energy consumption that is consistent month to month such as hot water heating lighting and ventilation) and seasonal load (energy consumption that varies seasonally such as air conditioning or space heating). The designation "NA" indicates data that was not made available for this study.

Energy Use Summary for Vershire Town Garage

Energy type	Unit	Total 2009	Total 2008	Total 2007	Average	Annual Base load	Annual Seasonal load
Electricity	kWh	5342	5598	NA	5470	2403.96	3066.04
Propane	Gallons	2852	3787	3052.8	3230.6	0	3230.6

The average daily electrical consumption in kWh for each month.



The table and chart above show that the electrical base load for this building is not very high, about 44% of the total electrical load. This is indication that there are few opportunities to improve the electrical efficiency of the appliances that are used year round. As can be seen above, the electrical load increases significantly for the winter season. This is caused, in part, by the lights that have to be on for longer hours in the winter but I also believe this is a reflection of the constant cycling of the 2 Modine type heaters.

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Energy Intensity Benchmarks					
Building Name	Floor area sq. ft.	Electricity kWh/sf		Heat Energy kBTU/sf	Total energy kBTU/sf
Vershire Town Garage	2040	2.7		145.2	154.4
Similar TYPE Buildings in NE		5.9		33.3	41.6
Similar SIZE buildings in NE		13.4		69.4	115.1

Energy intensity is energy consumption per square foot of floor area. This table 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 but they are useful comparisons nonetheless.
This chart is showing that electrical consumption is well below average but heating consumption is way above average. Poor insulation, significant air leakage, and short cycling of the Modine heaters corroborate this finding.

Combustion Testing:

The tables below summarize the testing on each combustion appliance. Cells in red indicate 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 both chimneys are properly drafting under normal and worst-case scenarios at present. The N/A designation indicates that the test was not applicable to this combustion appliance either because the test data could not be obtained in a safe manner or testing could not be done in accordance with Building Performance Institute (BPI) protocols.

Combustion Testing- Furnace #1, Fuel- Propane		
Baseline CAZ pressure	-1.4	Pascals
Worst case CAZ pressure	0	Pascals
Worst Case Spillage	passed-	power vented
Steady State Stack Temperature	N/A	° F
Steady State Efficiency	N/A	%
Flue CO	N/A	ppm
Outside temp	44	° F
Minimum Acceptable draft	-1.65	Pascals
Draft	N/A	Pascals
Ambiant CO	0	ppm

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Combustion Testing- Furnace #2 , Fuel- Propane		
Baseline CAZ pressure	-1.4	Pascals
Worst case CAZ pressure	0	Pascals
Worst Case Spillage	passed- power vented	
Steady State Stack Temperature	N/A	˚F
Steady State Efficiency	N/A	%
Flue CO	N/A	ppm
Outside temp	44	˚F
Acceptable draft	-1.65	Pascals
Draft	N/A	Pascals
Ambiant CO	1	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 building is sufficiently ventilated at present and the building will allow significant air tightening measures without the need for mechanical ventilation for its present use. It should be noted that this building has unique ventilation requirements because it houses motor vehicles. The exhaust should be vented directly outside and additional balanced ventilation may be required to keep the CO limits within safe levels when a vehicle is running in the shop.

Minimum Building Airflow Standard (ASHRAE 62-89)		
Conditioned space floor area	2040	square feet
Excluded areas	none	
Total conditioned volume	32640	cubic feet
# of regular occupants	2	people
# of stories above grade	= to 2	stories
Zone and Location	2	Vershire, VT
N- factor and Adj. N- factor	17	13.8
Required Building ventilation	190	CFM
Required Occupant ventailtion	30	CFM
Minimum airflow standard	2622	CFM50
Blower door test result	5056	CFM50
Minimum airflow standard met?		Yes

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Blower Door Test Results:

Ambient conditions 9-16-10:
Outside temperature: 44 °F
Inside temperature: 67 °F
Wind conditions: calm
Time of day: 5:30 am

Notes:
1. All interior doors were open.
2. All exterior doors and windows were closed and latched.
3. Heaters were tuned 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
5,056	32,640	9.29	5,048	1.00

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
Vershire Town Garage	**1.00**
Another Local Town Garage	0.63
Leaky construction	> 0.60

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