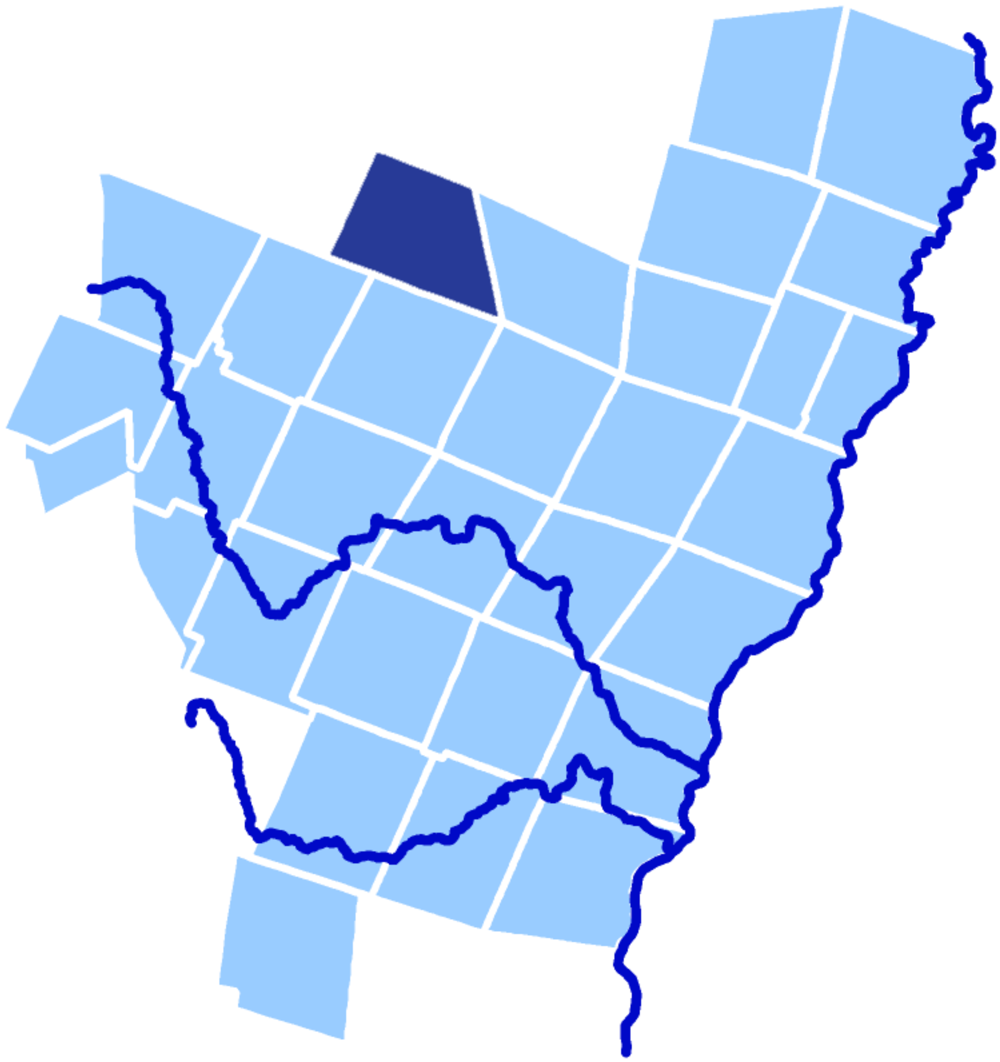
Two Rivers-Ottauquechee Regional Commission



Brookfield Town Office/Library Building Energy Plan

Provided for the Town of Brookfield 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
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Zero by Degrees LLC

Energy Independence in Affordable Steps

Building Energy Plan

June 7, 2011

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

RE: Energy Audit Conducted April 13, 2011 on the Brookfield Town Office and Library.

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 Brookfield Office and Library are in improving the heating distribution and controls so that less heat is lost from ducts into the attic and the library can be turned down to 50 F when it is not in use. Other large opportunities exist in insulating the library walls, air sealing the attic, and in installing insulated bulkhead doors.

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 - Simple Electrical Improvements	$67	$165	$0	$165	15	2.5	6.1
ECM #1 - Heating Distribution and Controls	$794	$6,350	$297	$6,053	25	7.6	3.3
ECM #2 - Occupancy Sensors	$51	$500	$100	$400	15	7.8	1.9
ECM #3 - Insulate Library Walls	$292	$3,300	$883	$2,418	30	8.3	3.6
ECM #4 - Air Seal and Insulate	$429	$8,150	$662	$7,488	30	17.5	1.7

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.

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 this 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 $0.14/kWh peak and $2.70/gallon of oil to predict cost savings. These costs 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, 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 with Energy Star contractor and that all health and safety recommendations be completed in order to qualify for the rebate.

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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. Have the boiler tuned to reduce CO levels (See "Combustion Testing" below).
2. The present natural ventilation is sufficient for the building and the occupants (see "Building Ventilation" below). Continuous mechanical ventilation may be required for proper ventilation of the building if the building air tightness is significantly improved. Consult with a certified home performance contractor to determine the proper ventilation rate for the building as part of developing the work scope for major envelope improvements.

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 – Simple Electrical Improvements

The outside flood lights were on during the day when I was there and I was told they stay on all the time because the sensors are broken. Repair the sensors as soon as possible so the lights will turn on only at night when there is motion nearby.

Most of the incandescent bulbs have been replaced with CFL bulbs except for a few in the library ceiling, outside lights, and in the bathroom. Replace all incandescent bulbs that are on for several hours a day with comparable light quality CFLs or LED bulbs. CFL bulbs come in many sizes now to fit nearly any application. LED bulbs are available to replace incandescent lights up to 60 watts, respond instantaneously, and have excellent light quality. Unfortunately, LED bulbs are still quite expensive so I would check specific rebates on LED bulbs before purchasing. Both CFL and LED bulbs promise longer life than incandescent bulbs although quality seems to matter a great deal on this issue; I have had many CFL bulbs expire long before they were supposed to. Replace the incandescent bulbs that are rarely used when the old bulbs burn out since they not used often enough to warrant immediate replacement. Although there are no additional incentives for switching to CFL bulbs Efficiency VT has been working with retailers to provide rebates at the point of sale so the cost of the CFL bulbs is very reasonable.

The large photocopier is turned off at night; the same should be done for the laser printer. Likewise, all the computers except the server should be turned off completely at night. Install "intelligent" plug strips (called "Smart Strips") for all computers except the server so that when the computer goes off any peripheral devices connected to the plug strip are turned off automatically.

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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
-4	415	($10)	$77	$67	$165	$0	$165	15	2.5	6.1

2. ECM #1 – Heating Distribution and Controls

The existing ducts are poorly sealed and insulated.

Heat from the ducts is being lost into the cold attics.

Visual reference for the IR picture

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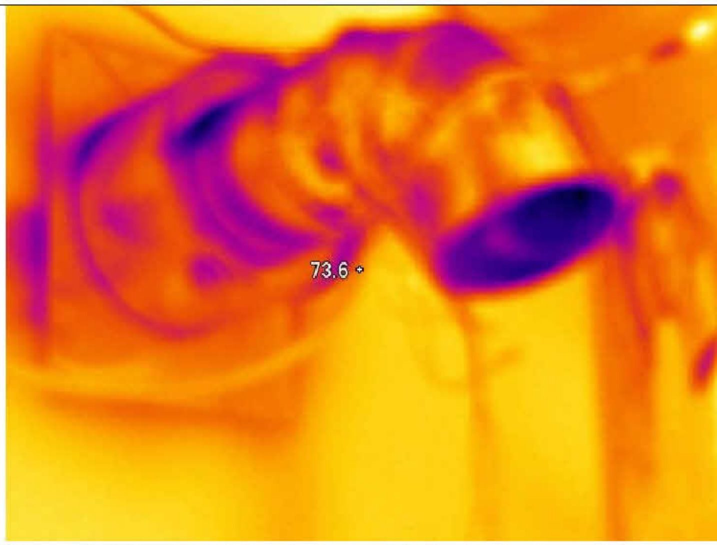

The outside air intake is large air leak that can be eliminated by ducting combustion air directly to the burner.

Visual reference for the IR picture

The office and library furnaces had steady state efficiencies of 77.7% and 75.9% respectively. Judging by their age I expect their annual fuel utilization efficiencies (AFUE) to be in the 65% range. Plan to replace the office furnace with a new high efficiency furnace (92% AFUE or better) with an ECM fan motor as soon as possible. When the new furnace is installed, bring the combustion intake air directly to burner and remove the existing air intake to the boiler room and insulate and seal shut the opening. At that time, it would be appropriate to install a mechanical damper on the branch of the ducts that go to the library that is controlled by a programmable thermostat in the library so the library can be heated independently of the office space. Have an experienced HVAC technician or engineer review the present duct system to determine if it can be zoned properly or if a dump zone is needed for proper operation of the furnace. Remove the insulation on all the ducts in the attic so all seams on the ducts can be heavily coated with mastic and reinsulated and add balancing dampers at each supply so the air flow can be adjusted and balanced. Go heavy on the mastic to be assured the ducts are well sealed, the typical application is not sufficient. At the same time, have the HVAC technician review the return air on the office ducts to see if it is adequate. Two returns are covered in furnace room presently and the cabinet cover is sucked in indicating that the air handler is starved for return air.

The library is open for only a few hours a week and since it has no water supply lines the thermostat could be turned down to at least 50 F when it is not in use. Create a separate zone for the library by closing the interior door when it is not in use and set the programmable thermostat to turn up the temperature about 1 hour before the normal library hours and turn down the temperature when the library is closed.

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Alternatively, the library could be made a separate zone for less cost by using the existing furnace in the basement of the library on a programmable thermostat, blocking all the heating ducts coming from the office furnace, and sealing and insulating all the ducts in the basement. The downside of this approach is the additional savings from having a higher efficiency furnace will not be realized. In any case, setting the thermostat very low when the library is not in use is an important energy saving strategy.

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
269	298	$725	$68	$794	$6,350	$297	$6,053	25	7.6	3.3

3. ECM #2 – Occupancy Sensors

The hallway and vault lights are on all day when the office is open. Install occupancy sensors so they turn on automatically only when the vault or hallway is needed and turn off when no one is present. The bathroom could also have a low cost occupancy sensor installed at the socket but it may not save much because the light is not typically left on.

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
-2	255	($5)	$56	$51	$500	$100	$400	15	7.8	1.9

4. ECM #3 – Insulate Library Walls

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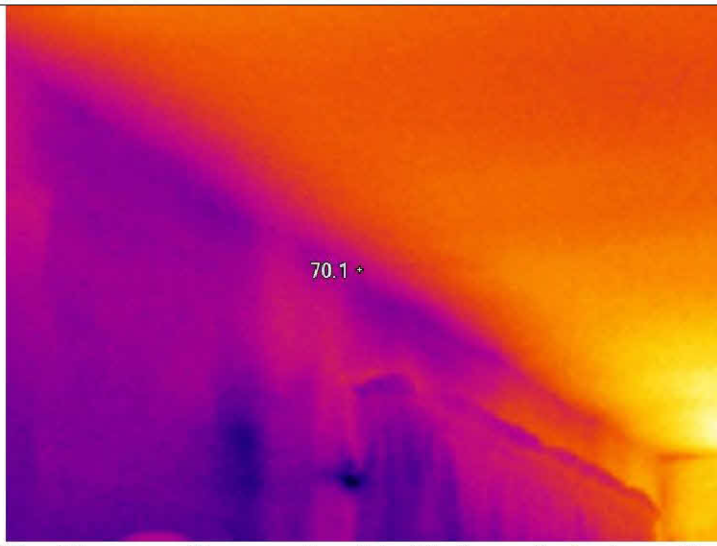
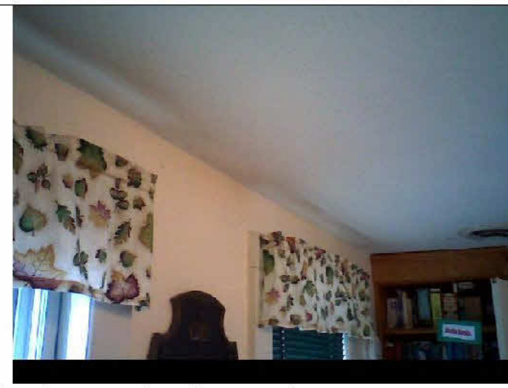


The library walls are uninsulated lathe and plaster walls.



Visual reference for the IR picture

The clapboards are in need of repair and paint.

The library walls are empty and have 4" of cavity space so they could be insulated with dense packed cellulose or open cell foam. I recommend insulating them from outside just before the clapboards are to be repainted (within the next 5 years) so holes drilled through the siding for the insulation can be patched easily.

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
99	110	$267	$25	$292	$3,300	$883	$2,418	30	8.3	3.6

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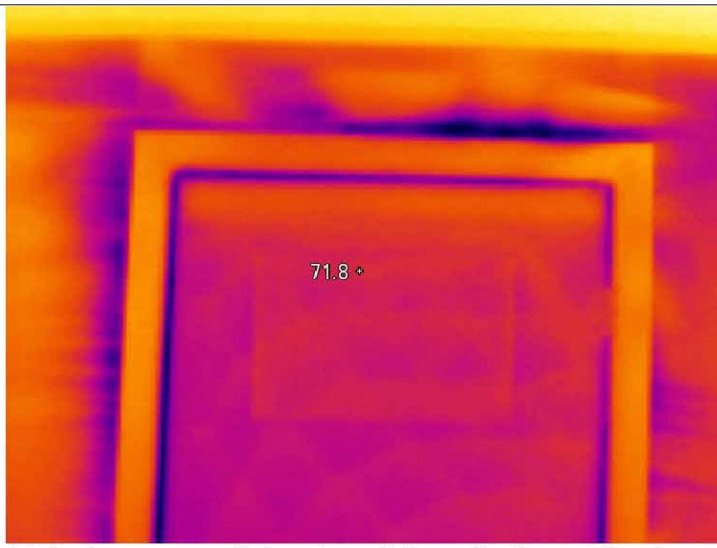
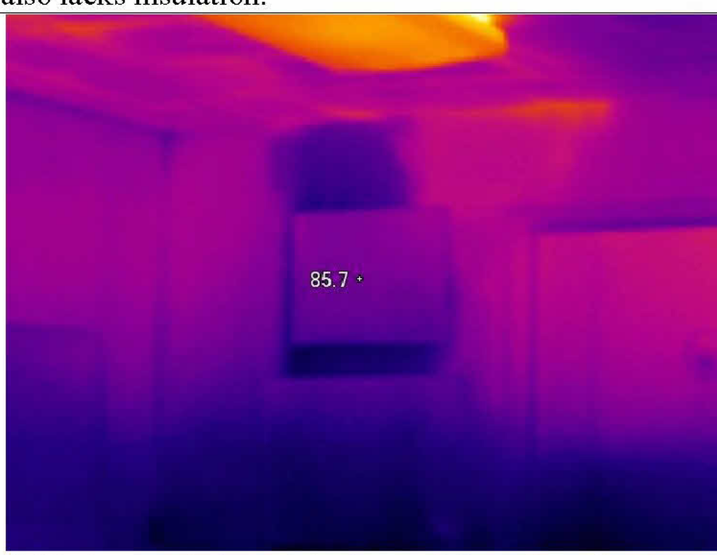
5. ECM#4 – Air Seal and Insulate

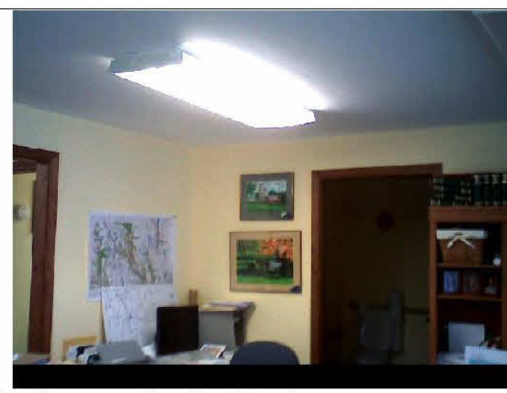


Air leakage around the trim of the attic door. The door also lacks insulation.

Visual reference for the IR picture



Cold air down into an interior wall from the attic above.



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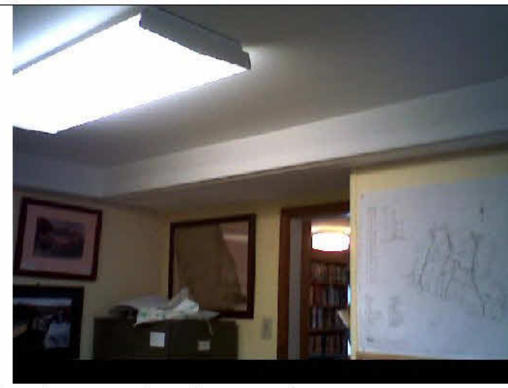
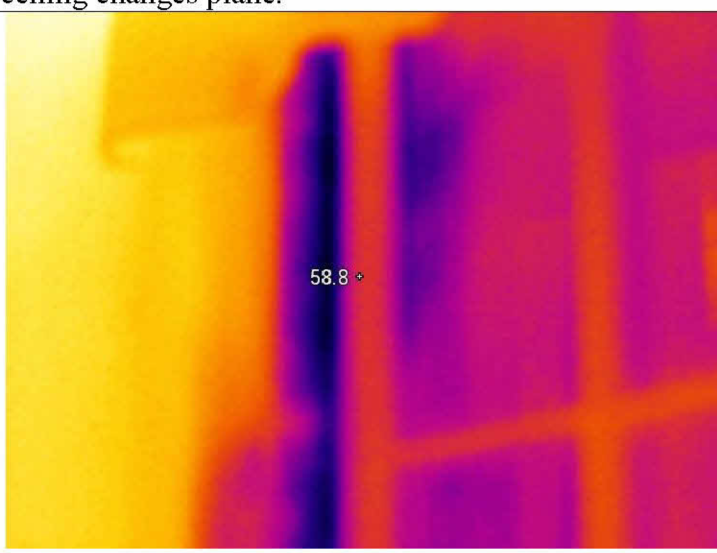
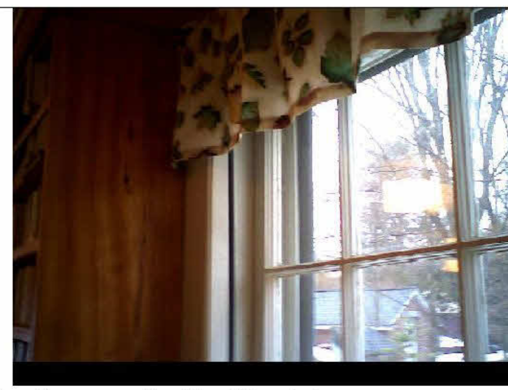
Cold ceiling bays and interior wall bays where the ceiling changes plane.	Visual reference for the IR picture
Air leakage at the jamb of a library window upper sash.	Visual reference for the IR picture

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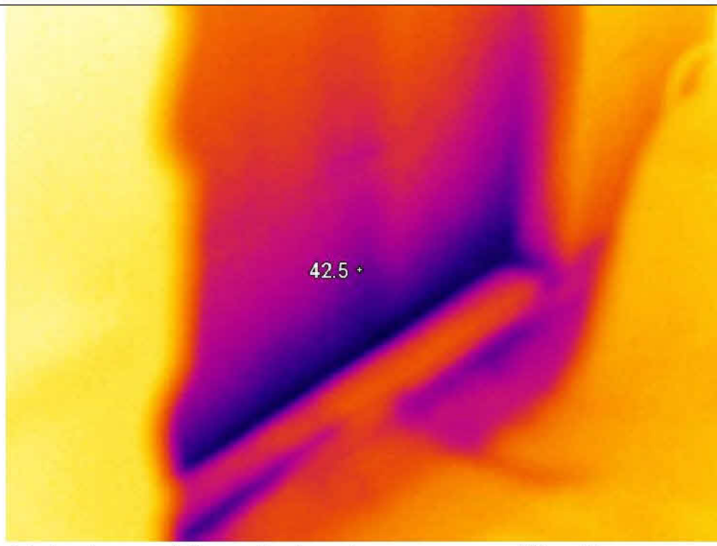
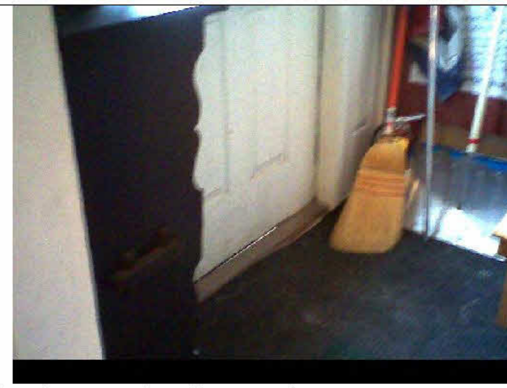
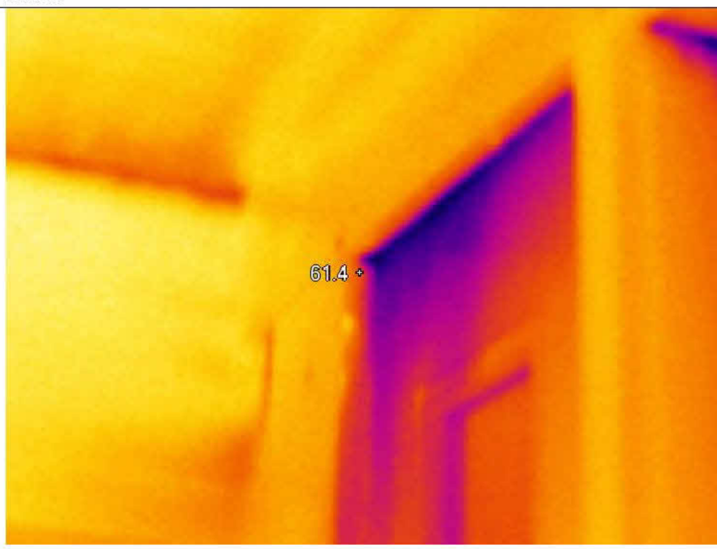
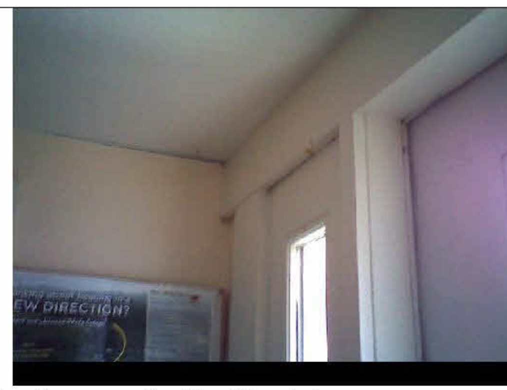
 Air leakage at the missing door sweep of the library door.	 Visual reference for the IR picture
 Air leakage around the door side light.	 Visual reference for the IR picture

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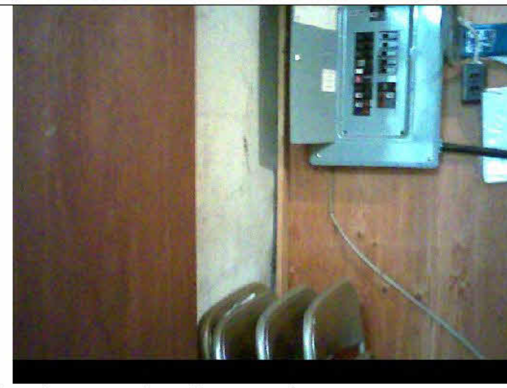
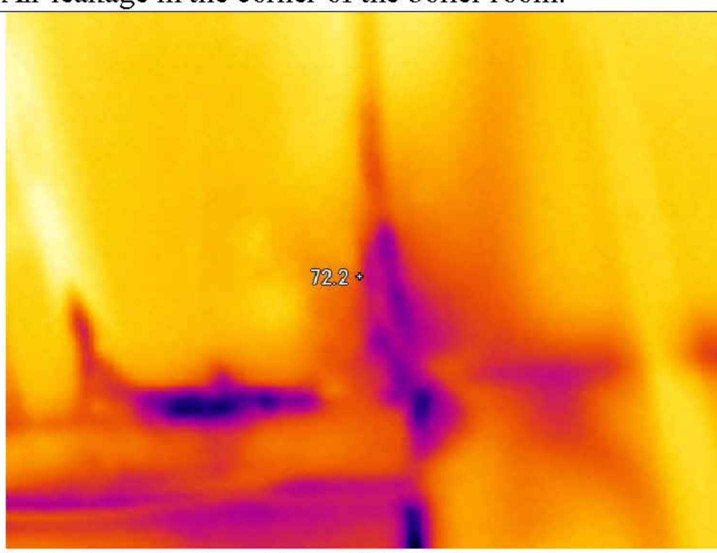
Air leakage in the corner of the boiler room.	Visual reference for the IR picture
Air leakage in the ceiling of the boiler room.	Visual reference for the IR picture

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The basement bulkhead allows outside air into the basement.

The top of a defunct chimney in the attic. It has a plug in it but I am not sure that it is air sealed.

Air seal the office attic at the same time as the duct improvements described above. Move the existing fiberglass and cellulose to expose all the tops of the interior walls, dropped ceilings, and mechanical and electrical penetrations in the ceiling so they can be sealed with foam. Seal a rigid foam plug in place in the defunct chimney in the library attic. I recommend using a blower door during the air sealing work to check the progress of air sealing efforts. Home performance contractors should have their own blower door to check progress. After air sealing is complete reinstall the existing insulation and then cover the whole attic in about 8 more inches of cellulose.

If the library furnace is no longer used close the duct openings in the floor and insulate the basement ceiling with 2 layers of 2" rigid foam board staggered and foam sealed in place between the floor joists. Install an insulated and airtight doorway at the base of the bulkhead stairs. This is a major location for air infiltration and the whole building will benefit in reduced stack effect by sealing this entrance.

Insulate and weather strip the interior doors to the attic and basement by adding 2-3" rigid insulation to the back of the door and weather stripping the door and adding a door sweep at the threshold (see further on in this section for details on exterior doors). The attic door should also have the trim removed so the door frame can be foam sealed to the rough opening of the wall.

Foam seal all the visible gaps and transitions in the sheetrock on the walls and ceiling of the boiler room.

Most of the single pane windows with storm windows in the library are air leaky at all sides of each sash. Make the upper sash a fixed pane and caulk it in place. Weather strip the lower sash and the storm windows based on the recommendations below*:

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1. Window sashes can be sealed at top, bottom and edges by installing v-shaped weather-strip. Top and bottom weather-strip can be installed on the window casing where the top and bottom sash close, with sash in place. To install side weather-strip, remove the window stops from one side of the sash, remove the sash, install v-shaped weather-strip on the window jamb with point of weather-strip pointing in and replace the sash. If sash is too tight to fit with new weather-strip, you will need to trim off a very small amount from one of the sash edges, leaving sash wide enough that they press out against and compress the weather-strip. Vinyl v-weather-strip is available from most building supply warehouses. Much longer lasting bronze v-strip is available from Architectural Resource Center: http://www.aresource.com/cushion.html#start
2. If you can shake the sash and they rattle, you can tighten the window latches that pull the sash together by removing the inner portion of the closing mechanism, filling old screw holes with wooden match sticks or slivers of wood, replace the latch, drilling new holes further away from the outer part of the latch so it pulls the two sash tightly together.
3. If you have old sash with ropes, pulleys and counterweights, remove the inside trim piece covering the counterweight cavity on each side of window. Cut the counterweight cord and remove the counterweights (make sure each sash is latched so they do not drop when removing counterweights). Remove window stops from one side and remove sash. (This is a good time to install v-shaped weather-strip at sides – see above.) Remove cording attached to sash and remove pulleys from window jambs. If you do not need to retain opening capability of outer/upper sash, reinstall it, temporarily screwing sash in place and caulk at edges. If you want to keep the sash operable, replace old counterweigh pulleys with "Pullman Window Counterbalance" (available at: 585-334-1350, http://pullmanbalances.com/) and attach counterweight spring to sash and replace. Then fill the counterweight cavity with polyisocyanurate foam insulation board, slightly undercut around the outside and air seal edges of foam board with minimal-expanding spray foam.
4. Caulk the edges of exterior storm windows to the trim with high quality exterior grade acrylic latex caulk with silicone – make sure not to caulk over the round weep holes at the bottom of the storm panel that drain out condensation.
5. If any of the storm windows do not close tightly, leaving a gap in opposing corners when closed, you will need to loosen three sides of the storm window frame from the trim outside, square it up so it closes properly and reattach with caulk and screws.

* Source: Green Energy Times - Fall 2010

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). 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. Remove the wood trim and foam seal the perimeter of the side lights on the library door.

Implementation notes: It may not make sense to all these insulation and air sealing projects at once because the payback is long. Do the simplest measures first such as an airtight bulkhead door, weather-stripping doors and windows, and sealing the boiler room sheetrock gaps. Also, do those measures that

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can be coordinated with other work such as air sealing the attic when the ducts are being moved and changed.

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
145	161	$392	$37	$429	$8,150	$662	$7,488	30	17.5	1.7

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 Brookfield Town Office and Library							
Energy type	Unit	Total 2010	Total 2009	Total 2008	Average	Annual Base load	Annual Seasonal load
Electricity	kWh	6032	5978	5202	5737	4592	1145
Heating Oil	Gallons	759	683	907	783	0	783

Below is the monthly electrical consumption in kWh for each month.

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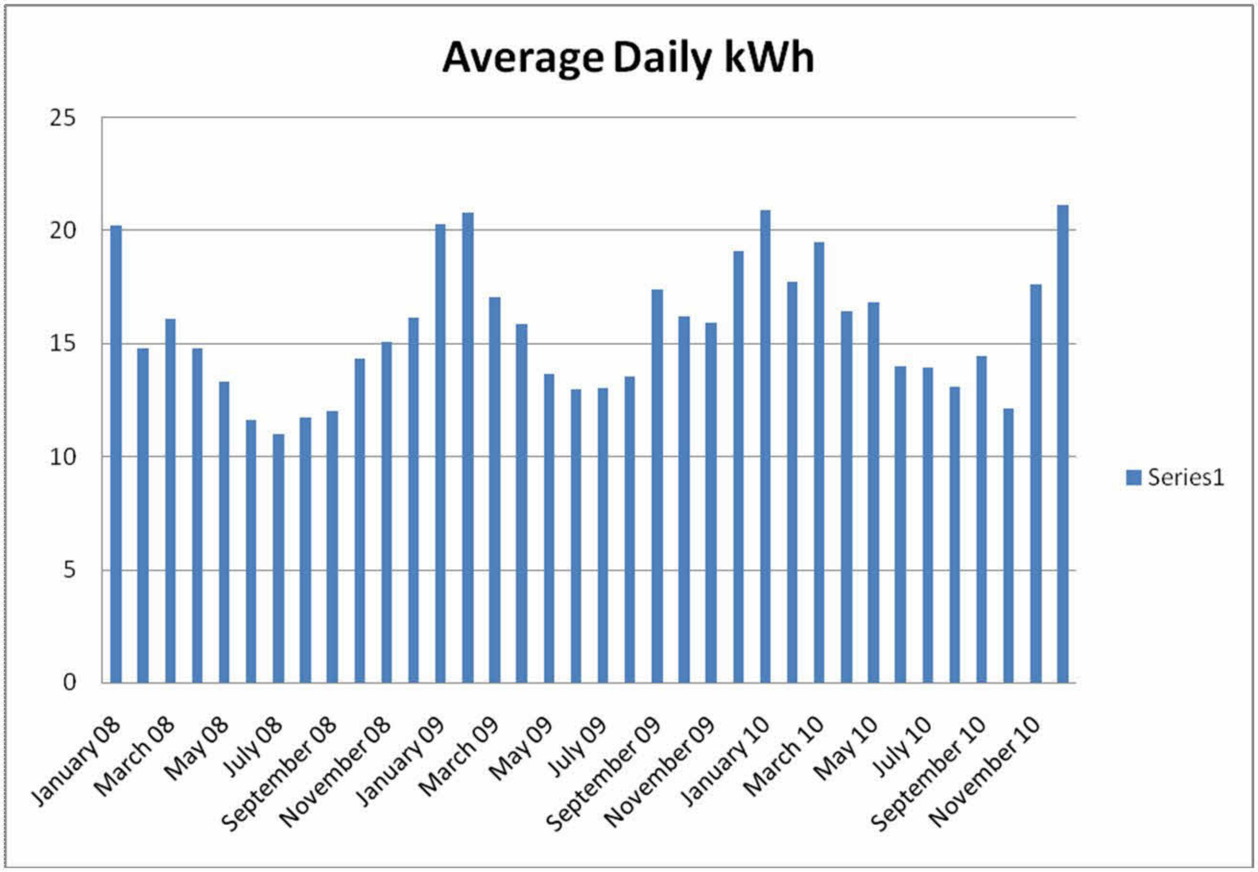

Electric consumption follows typical seasonal patterns.

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**
Brookfield Town Office and Library	1392	4.1	0.56	78.1	92.2
Similar TYPE Buildings in NE		6.9	0.24	33.3	79.8
Similar SIZE buildings in NE		13.4	0.50	69.4	115.1

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This table is showing that electrical consumption for this building is below average and fuel consumption is significantly above average compared to buildings of similar type and similar size in the NE.

Combustion Testing

The table below summarizes the testing on the boiler and furnaces. Cells in red indicate failure to draft, flue carbon monoxide (CO) levels above 25ppm, or ambient CO levels above normal levels. High CO levels are an indicator of incomplete combustion and a health risk. The N/A designation indicates that the test was not applicable to this combustion appliance because the test data could not be obtained in a safe manner, the appliance configuration does not require testing, or testing could not be done in accordance with Building Performance Institute (BPI) protocols. The tests show that both furnaces should be serviced to insure they are burning safely.

Combustion Testing- Furnace #1 office, #2 Oil		
Baseline CAZ pressure	-1.5	Pascals
Worst case CAZ pressure	0	Pascals
Worst Case Spillage	Passed, draft within 1 minute	
Steady State Stack Temperature	603	˚ F
Steady State Efficiency	77.7	%
Flue CO	40	ppm
Outside temp	40	˚ F
Minimum Acceptable draft	-1.75	Pascals
Draft	-14	Pascals
Ambiant CO	0	ppm

Combustion Testing- Furnace #2 library , #2 Oil		
Baseline CAZ pressure	-0.8	Pascals
Worst case CAZ pressure	-1	Pascals
Worst Case Spillage	NA - direct vent	
Steady State Stack Temperature	634	˚ F
Steady State Efficiency	75.9	%
Flue CO	30	ppm
Outside temp	40	˚ F
Acceptable draft	-1.75	Pascals
Draft	NA - direct vent	Pascals
Ambiant CO	0	ppm

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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.
Ppm- parts per million, the unit of measurement for gases like carbon monoxide.
Pascals- the SI unit for pressure.

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 by natural ventilation at present.

Minimum Building Airflow Standard (ASHRAE 62-89)		
Conditioned space floor area	1392	square feet
Excluded areas	basement	
Total conditioned volume	10364	cubic feet
# of regular occupants	3	people
# of stories above grade	1	stories
Zone and Location	2	Brookfield, VT
N- factor and Adj. N- factor	19	19.0
Required Building ventilation	60	CFM
Required Occupant ventilation	45	CFM
Minimum airflow standard	1149	CFM50
Blower door test result	3488	CFM50
Minimum airflow standard met?		Yes

Blower Door Test Results

Ambient conditions 4-13-11:
Outside temperature: 44 °F
Inside temperature: 73 °F
Wind conditions: calm
Time of day: 12:00 pm

Notes:

1. All interior doors were open except the doors going to the attic and the door to the basement.

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2. All exterior doors and windows were closed and latched.
3. All furnaces were off for 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
3,488	10,364	20.19	3,216	1.08

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
Brookfield Town Office and Library	**1.08**
Leaky construction	> 0.60

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