Energy Audit

December 2018

Funded by

EVERSOURCE ENERGY

The Mann House

Mason, NH

Audit Prepared by

BUILDING STRATEGIES FOR AN AFFORDABLE FUTURE
S.E.E.D.S.
SUSTAINABLE ENERGY EDUCATION DEMONSTRATION SERVICES
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16 Darling Hill Road, Mason

Elevation 740'

42°44'N and 71°46 W

Introduction

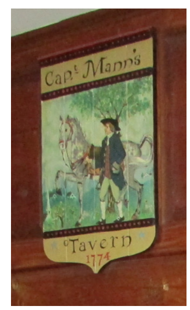
This Envelope Assessment and Energy Audit has been paid for by Eversource. The purpose of an energy audit is to identify energy saving measures (ESM) in a building. A computer simulated energy model was developed for this project using multiple strategies and software, including Manual J compatible load calculating software. The model estimates predicted future energy consumption based on the local climate conditions, physical dimensions and characteristics of a building, mechanical systems, presumed lighting, equipment, and occupancy patterns, in addition to a number of other variables.

With the building modeled in existing conditions, energy savings can be estimated for improvements to the thermal envelope and mechanical systems. The cost of those measures can then be analyzed in terms of predicted energy saved. The primary objective is to evaluate the level of investment warranted by energy and dollars saved from those specific measures.

This audit has been prepared with the best of intentions to assist the Town make informed decisions towards energy saving improvements. We do not make any warranty, expressed or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed.

Executive Summary

The primary focus of this Audit has been to recommend improvements to the thermal envelope for the building which houses the Town Offices and Library.



General description: Presuming the Mann House was once Capt Mann's 1774 Tavern, the original structure may be around 274 years old. Even if rebuilt, it is at least 100+ years old. Except for a mixture of old horse hair and newer fiberglass batts above the ceiling of the 2nd floor, the building is uninsulated with mostly single pane windows and exterior storms. It has a full basement with rubble foundation and concrete slab floor. A far more recent one story addition to the north now serves as the Library. It is slab on grade, has Jeld Wen double pane windows, and fiberglass batts in the wall framing. Above the ceiling is a mixture of fiberglass batts with blown in fiberglass on top. It is a vented attic space without insulation in the two foot slopes. An enclosed glass porch to the west houses the Children's Room. In 2008, the glass was removed and new 2x4 framing was insulated with faced fiberglass. The tongue and groove ceiling boards are original and were not disturbed.

These three distinct, but interconnected, structures are now heated via hot water baseboard and an oil fired Peerless boiler installed in 2011. Five removeable window AC units and one permanent wall unit provide cooling to the entire first floor. The second floor, housing the Historical Society Collection, a room used for Library storage, and a meeting room for the Conservation Commission and Building Inspector, is infrequently occupied.

The overall improvement strategy is to provide general air sealing and upgrade the insulation levels on each of the three ceiling planes. Details are offered on page five and in the notes found in the section with thermographic and digital photos. A financial summary with estimated costs and savings can be found on the next page. Contact Rich Burns of Shakes to Shingles for a proposal at rich@shakestoshingles.com 451-1115.

Converting the T12 and T8 fluorescents to LED lighting throughout the building is recommended and likely to receive 50% rebates from Eversource. Contact Carl Edin at cedin@emcinc-online.com for a turn-key proposal.

Summary of Cost vs Savings Analysis: Dollars and Energy

The chart below summarizes cost and savings of the recommended envelope improvements from the existing conditions, based on the results of the energy model. Each of the five measures has its own associated costs and energy savings, however each subsequent measure builds on previous improvements so it is strongly recommended that all five be completed as a package. The foundation wall, in particular, is listed as item #4 however is key to managing moisture in the building and should be completed prior to all air sealing. Further detail is offered in subsequent pages. Note: the analysis referred to as a 'cost / savings' as they are designed with additional benefits, such as moisture management which helps address air quality and building durability, reducing icicles and ice dams and improving occupant comfort.

#	Energy Saving Measures, Intended as a Whole Package	Annual Heating Cost	Annual Cooling Cost	Total Annual Cost	Dollar Savings	Cost of Measure	Simple Pay Back Years	Energy Savings MMBtu	Life of Measure	Invest-ment Gain	ROI	Annu-alized ROI
	Existing	$3,936	$459	$4,395								
1	North Ceilings & AS	$3,695	$427	$4,122	$273	$3,393	12.4	13.6	25	$3,432	101%	2.8%
2	Mann Ceiling & AS	$3,187	$413	$3,600	$522	$5,099	9.8	27.7	25	$7,959	56%	3.8%
3	Children's Ceiling & AS	$3,146	$406	$3,552	$48	$1,131	23.6	2.4	25	$69	6%	0.24%
4	Foundation Wall	$2,715	$393	$3,108	$444	$3,311	7.5	23.6	25	$7,789	235%	5.0%
5	Mann House Walls	$2,025	$288	$2,313	$795	$4,127	5.2	39.3	25	$15,748	382%	6.5%
	Total Envelope Upgrade				$2,082	$17,060	8.2	106.6	25	$34,990	205%	4.6%
	Convert to ASHP											
6	# 1-4 with ASHP	$1,707	$210	$1,917	$396	$24,000	60.6		18	-$16,872	-70.0%	-6.5%
7	#1-5 with ASHP	$1,386	$154	$1,540	$377	$20,000	53.1		18	-$13,214	-66.1%	-5.8%

The bottom line, highlighted in yellow, is that by investing $17,060 to insulate and seal the basement walls, air sealing and upgrading insulation levels at all three ceiling planes, general weather-stripping and air sealing, and insulating the walls of the original structure, the Town can expect to save an average $2,082 a year at $2.56 per gallon or oil. This suggests a simple pay back of 8.2 years (at stagnant oil prices). Since energy improvements continue to save long after the initial investment has been 'paid back', it shows an investment return of $34,990 based on a service life of 25 years. This calculates to an annualized return on investment (ROI) of 4.6%. If approved for a 50% Eversource rebate (per their Municipal Energy Efficiency Program), the investment is reduced to $8,530 and annualized ROI jumps to 10.6%.

5	with Eversource Funds Rebate	$2,025	$288	$2,313	$2,082	$8,530	4.1	n/a	25	$43,520	510%	10.6%

Converting to electric air source heat pumps was also modeled and summarized as items #'s 6-7, with and without insulating the walls. The savings do not justify the expense at $2.56 per gallon of oil. The chart below shows savings if (when) the cost of heating oil rises to $3.50 per gallon. Installation cost is ball park estimate.

6	# 1-4 with ASHP	$3,712	$393	$4,105	$2,188	$24,000	11.0	n/a	18	$15,382	64.1%	2.8%
7	#1-5 with ASHP	$2,769	$288	$3,057	$1,517	$20,000	13.2	n/a	18	$7,298	36.5%	1.7%

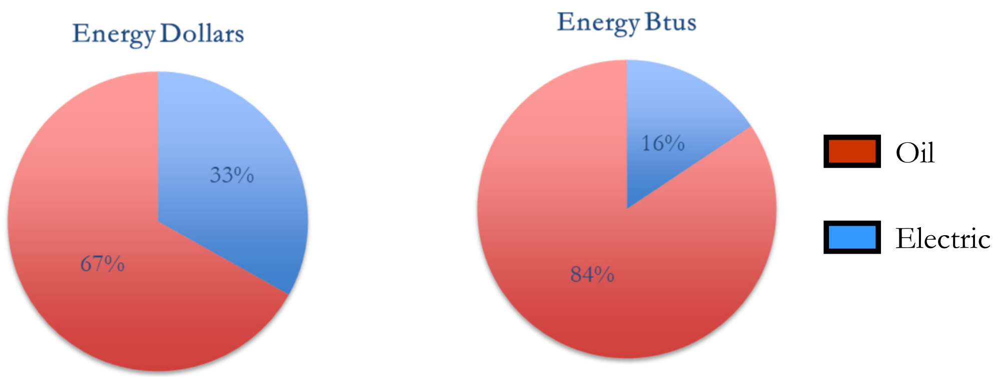
Existing Energy Use Analysis

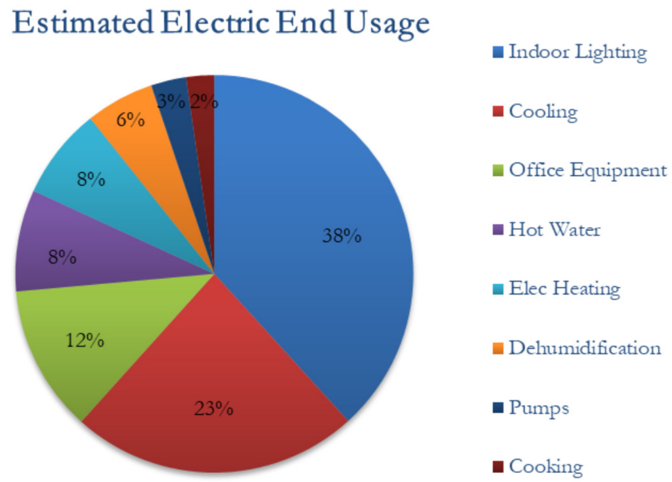
The energy analysis below is based on three year average oil use and 12 months electric usage.

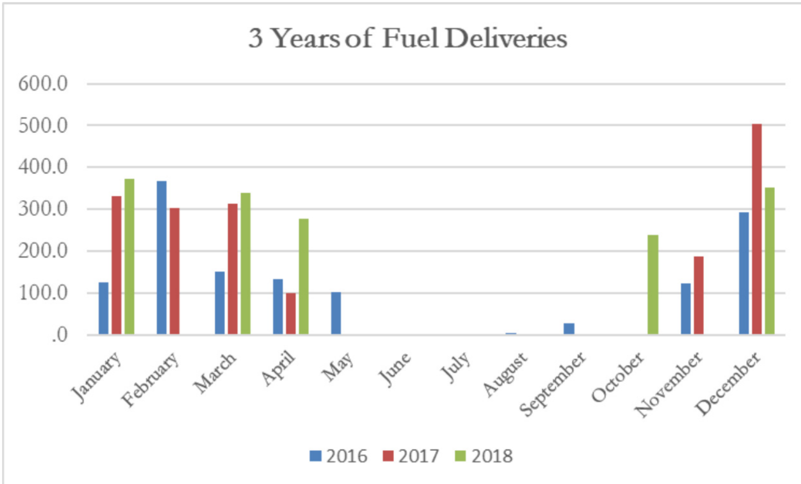
Energy	Units	Site Btus	Source Btus	Cost
Electric - kWh	11622	39,654,264	132,037,542	$1,962
Oil - Gallons	1547	214,259,500	246,398,425	$3,960
Totals		253,913,764	378,435,967	$5,922
EUI as KBtu/FT2	3172	80.0	119.3	$1.87

The Energy Utilization Index (EUI) offers a simple snapshot analysis of a building's energy use by looking at total amount of energy input (converted to Btu's) divided by the floor area of conditioned space. "Site Energy" refers to units of energy delivered to a site. Source energy includes transmission and some allowance for off site generation and other considerations. Source energy is used to equal the playing field when comparing electrical consumption with on site combustion fuel energy and to better reflect GHG emissions when considering off site generation.

Based on the information provided the building's total Site EUI is 80.0 KBtu/ft2 at a cost of $1.87per sq ft. The Source EUI is 119.3 KBtu/ft2.



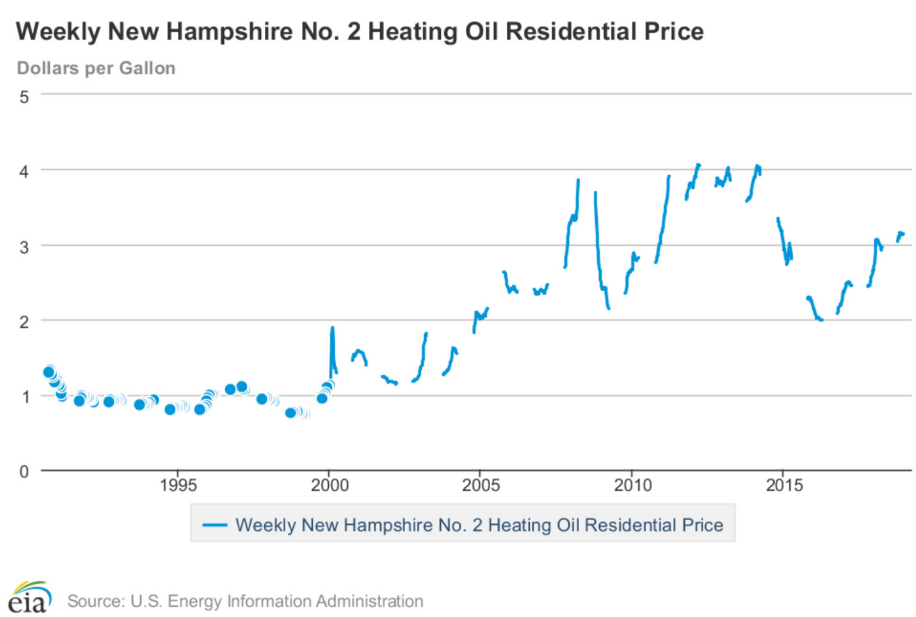




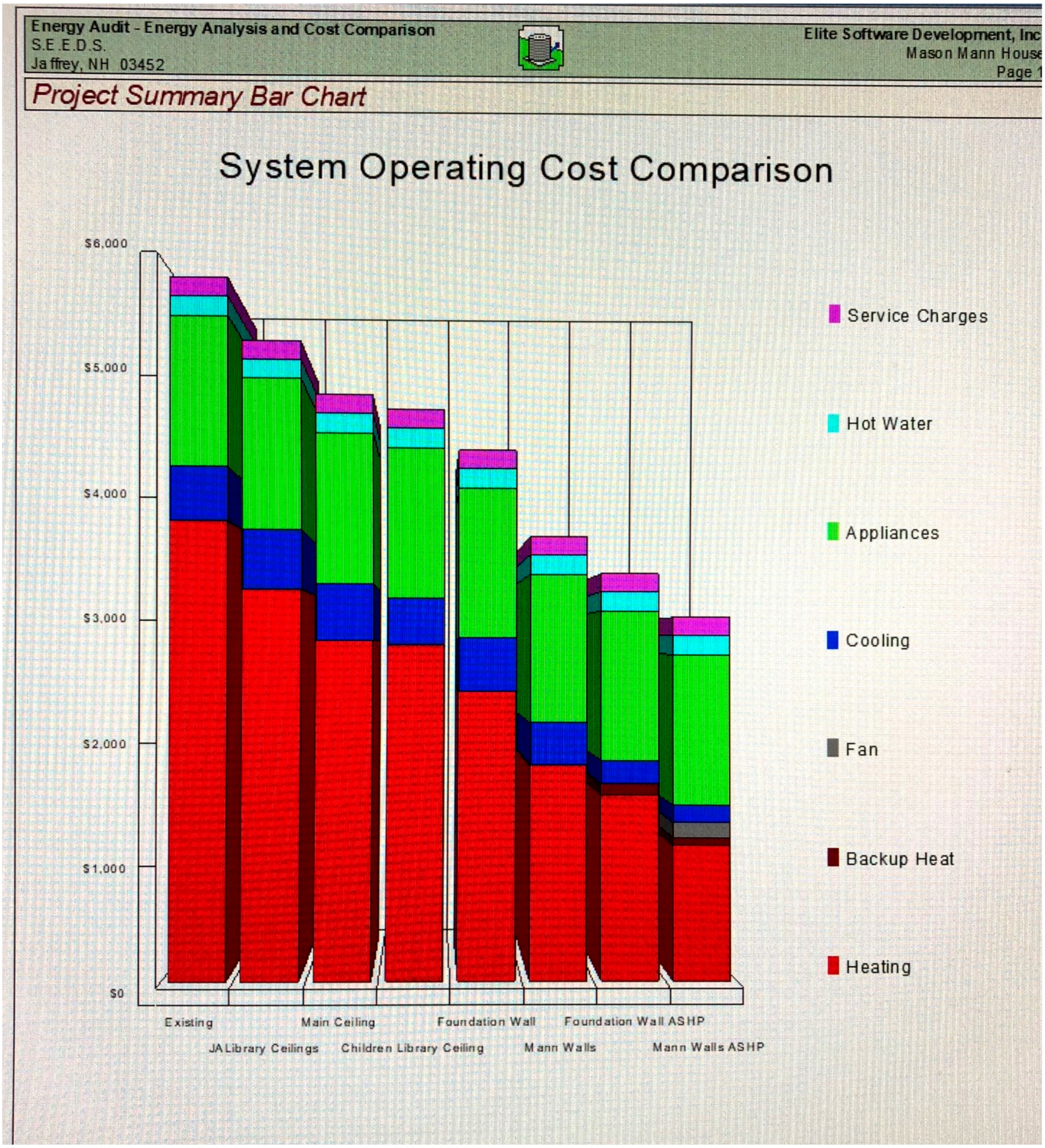
The chart shows a general pattern over three years of monthly deliveries, though the specific time of month varies, as do temperatures throughout a heating season.

A common goal of an energy audit is to estimate energy savings from various efficiency measures. Those savings can be measured in Btus and/or dollars. Estimating dollars saved per year or over time is a particular challenge since the per energy unit costs will vary from month to month and year to year. The chart at the bottom of the page shows that variation for residential heating oil for the last 28 years. Considered a 'volatile' market, the overall trend is one of rising costs. With a future carbon tax, the price of fossil fuels could rise even more—or lower as demand diminishes. Without a crystal ball, energy audits just have to choose a number: typically either the average price from the previous year or the cost of heating oil whenever the report was completed.

The average cost that Mason paid for heating oil for 2018 was $2.37. Averaged over the last three years, the average per gallon cost was $2.16. The current cost per gallon (as of December 2018) is $3.14. So for the purposes of this analysis, the per gallon cost will be the average of those three: or $2.56 per gallon. This may well prove too conservative, which means predicted savings will be lower than actual savings.



Breakdown of Existing Energy Costs



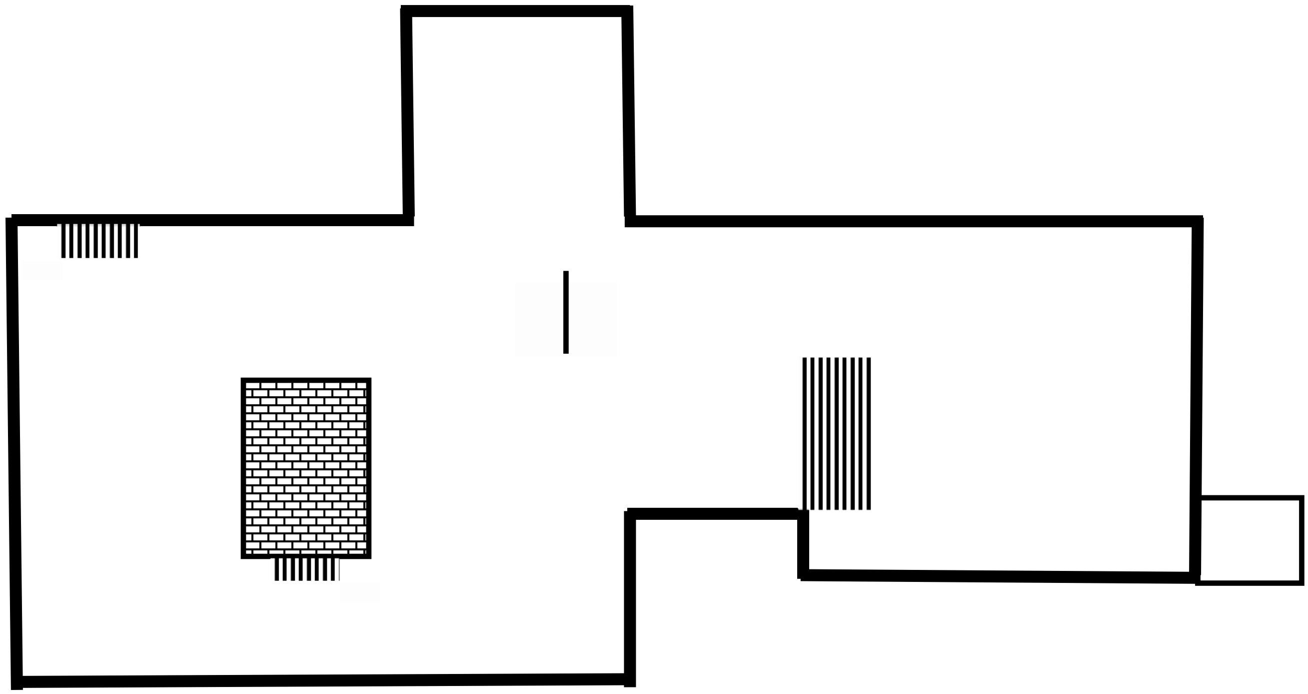
Exterior Photos

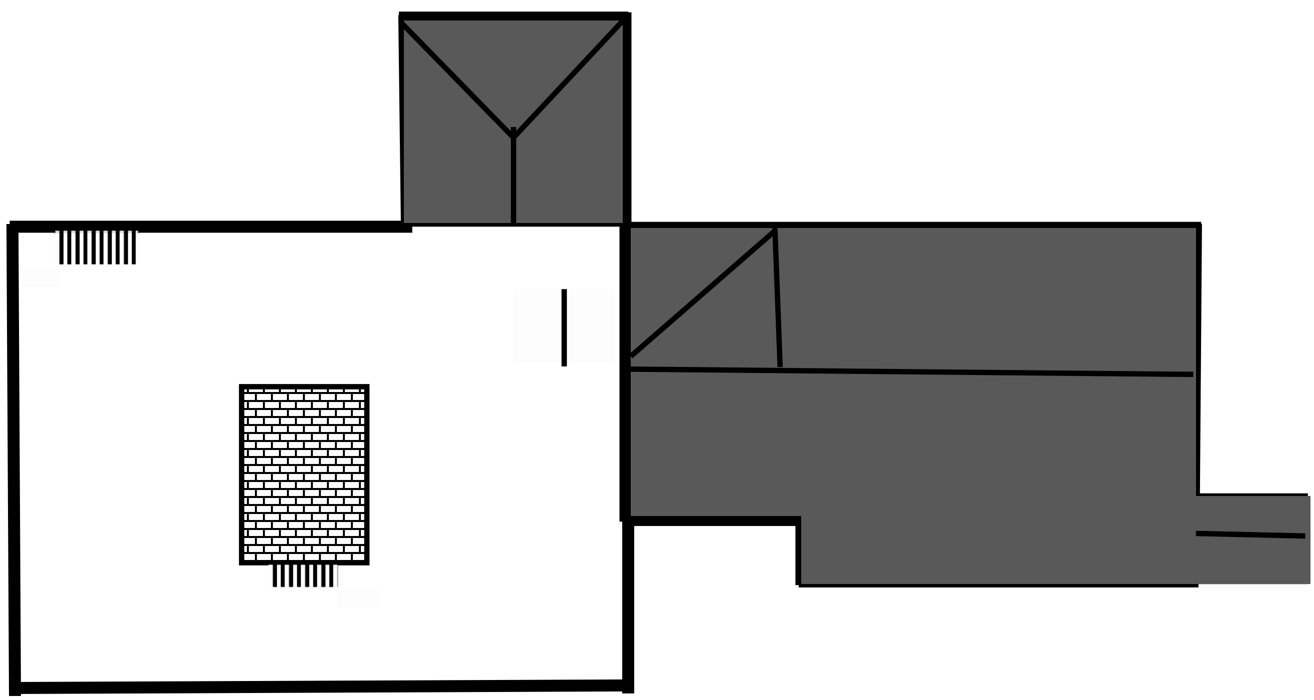
East Facing

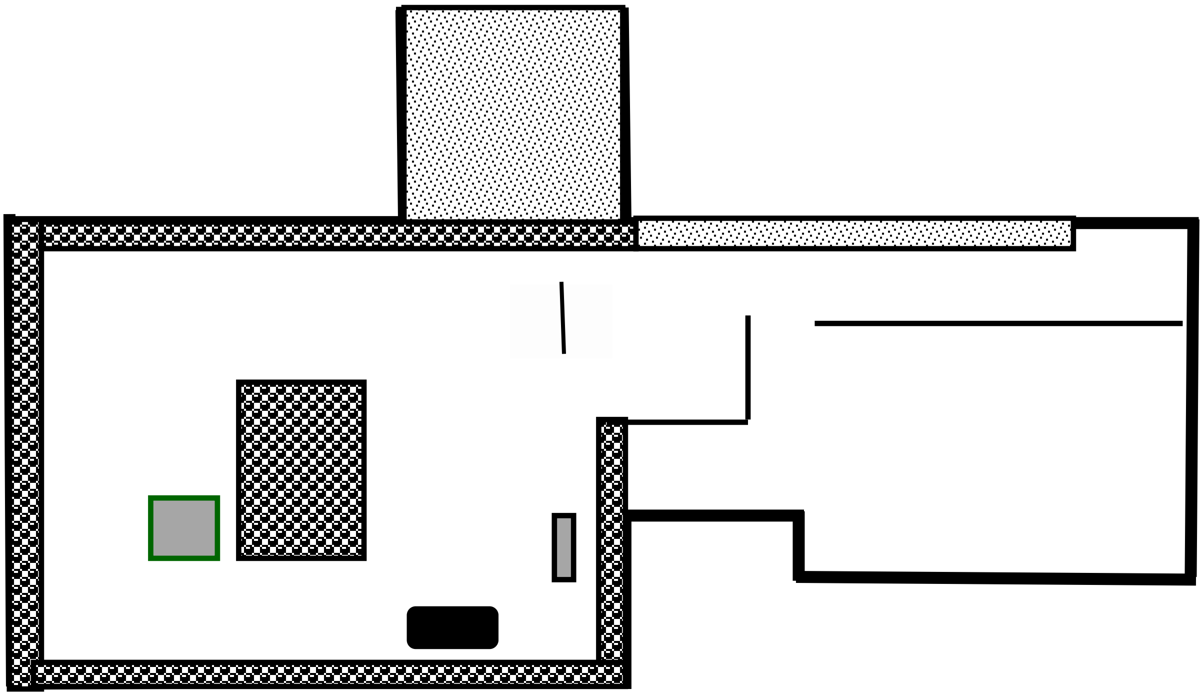
West Facing

South Facing

North Facing







The Thermal Envelope—Introduction

Warm Air Rises, because its lighter

Heat Moves to Cold, in any old direction

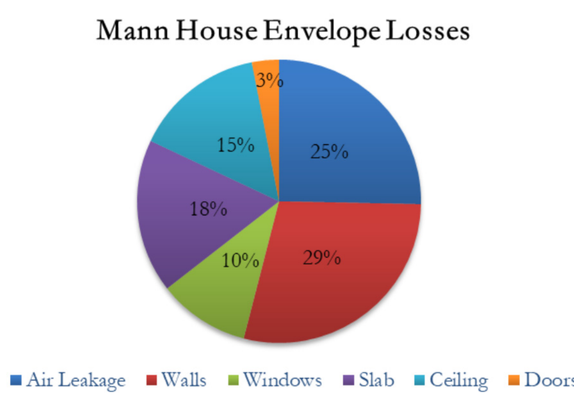
The Envelope (aka Shell) of a building refers to all the collection of materials which, in sum, create the 'thermal boundary' between inside conditioned space and outside weather/climate in all its glory. These materials make up the walls, windows, ceiling or roof, window fames and glass, doors, foundation walls and floor. Based on the their material properties, they function as control layers to manage water, vapor, air, and heat transfer.

There are many different kinds of insulation materials. Like all materials, each has its own material properties in terms of resistance to conductive heat transfer (R-Value), density, resistance to absorbing water, permeability to air and permeability to vapor. The thickness of the installed insulation material also determines its R-value.

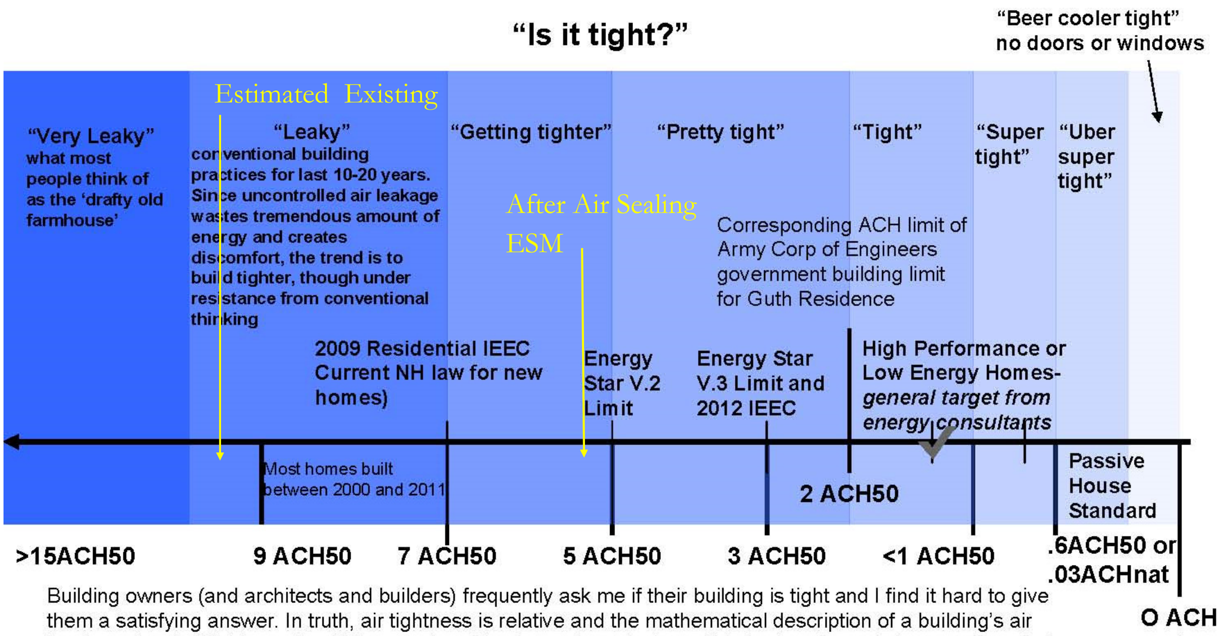
Another factor is the continuity of materials, which is key to slowing (ideally stopping) the movement of air. The graphic to the right shows typical 'air leakage sites' in a stick framed house. and heat. Continuous insulation (referred to in modern energy codes as "ci") eliminates 'thermal bridging'. A 4" wood stud, for example, acts as a bridge in a wall with insulation in the cavities since 4" of wood conducts heat more rapidly than 4" of insulation. In short: establishing a continuous air barrier in direct contact with continuous insulation is the most effective thermal barrier to reducing heat transfer—either from inside to outside in winter, or outside to inside in the summer.

Mason's Mann House and Library Envelope Assessment

The pie chart shows the estimated break down of where heat loss occurs. The numbers reflect the percentage associated with each envelope component based on their assessed thermal performance.



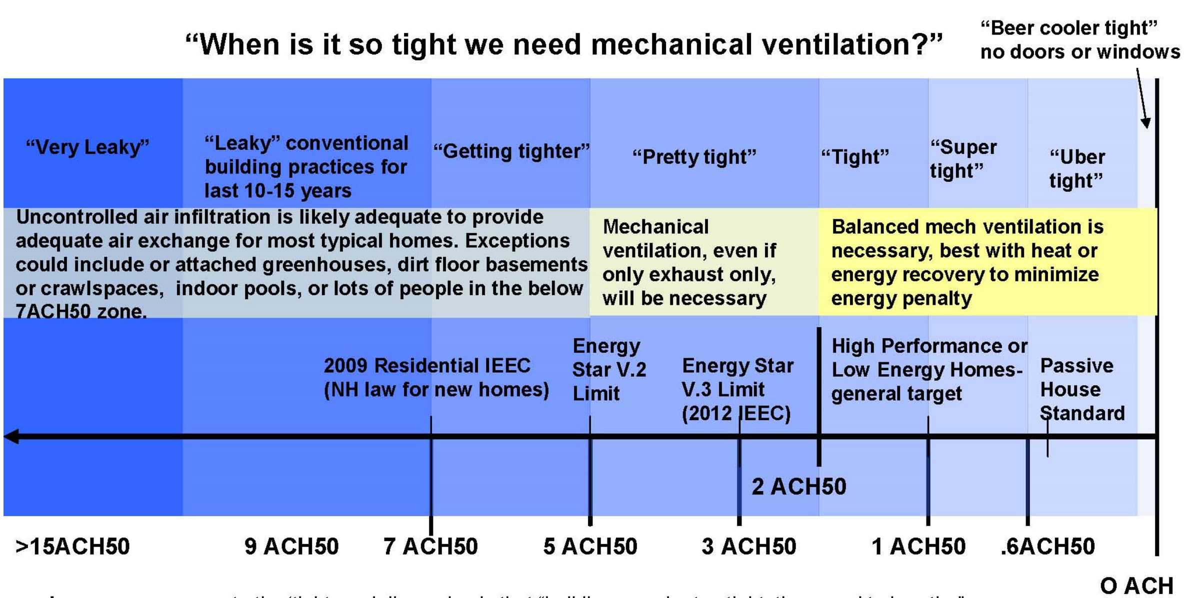
It's a tad more complicated in that physical materials are associated with **conductive** heat transfer, where as air leakage (ie the lack of a physical barrier) is associated with **convective** heat transfer. For example: it is estimated that 15% of the annual heat loss occurs through the insulation in the three ceiling planes. However, the ceiling plane is in large part responsible for convective heat loss which is represented in the 25% attributed to 'air leakage'. In fact, windows, doors, and the foundation all contribute to convective losses. But air sealing the ceiling (highest) plane reduces the 'stack' or 'chimney effect' where cooler, outside is drawn in through gaps in the framing and window sashes, rises as it is heated, then exfiltrates through the ceiling and roof. This is also the primary cause of icicles and ice dams as the heated air warms the underside of the roof sheathing, melts snow, which then drains down to the eave and freezes when exposed to air. from below. This is why the recommended energy saving measures focus on air sealing at the ceiling planes and targeted 'gaps and cracks throughout the building. Improving insulation layers is also cost effective as well as a complimentary measure to establishing an air barrier at the ceiling plane.



Building owners (and architects and builders) frequently ask me if their building is tight and I find it hard to give them a satisfying answer. In truth, air tightness is relative and the mathematical description of a building's air barrier or level of tightness has little meaning at best – and can be incredibly boring at worst. I once attempted humor with "well, if it were a submarine, everyone would drown" but, while accurate, proved less than helpful. So this graphic has been developed in an attempt to explain the spectrum of tightness in terms of existing buildings and the direction we're headed in terms of codes and standards. The tighter the building, the less air infiltration, and therefore heat loss, in the winter – which means less energy needed to run your equipment.

"ACH50" or Air Changes per Hour at -50 pascals, means the number of times the indoor conditioned air will exchange with outdoor air within one hour when the building is under -50 pascals of pressure. This is a standardized testing condition, using a blower door fan assembly. One can ***estimate*** the air exchange rate under natural conditions by dividing by 15. Colored boxes above are generalized zones for this discussion only.

1



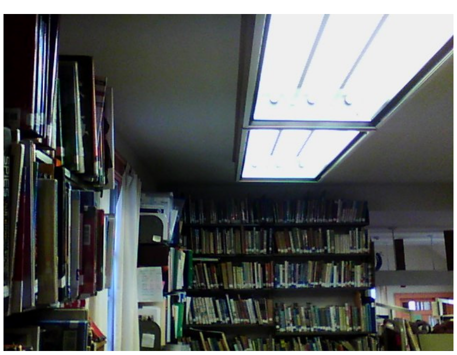
A common response to the 'tightness' discussion is that "buildings can be too tight: they need to breathe". The truth is that people need to breathe – buildings just need to be able to dry. Very high air leakage allowed buildings (wall and roof assemblies, etc.) to dry out if they got wet. But it takes tremendous amounts of energy to maintain comfortable indoor temperatures with so much air leakage. So the answer is: buildings *cannot be too tight*, and in fact must become as tight as we can make them, as long as they are designed to be able to dry out and as long as we provide mechanical ventilation when necessary so that people have enough fresh (or filtered) air to breathe. The various yellow shaded boxes above categorizes, in very general terms, when mechanical ventilation might be needed. There are a number of factors to consider when determining specific ventilation requirements – either by code or specific occupancy realties.

2

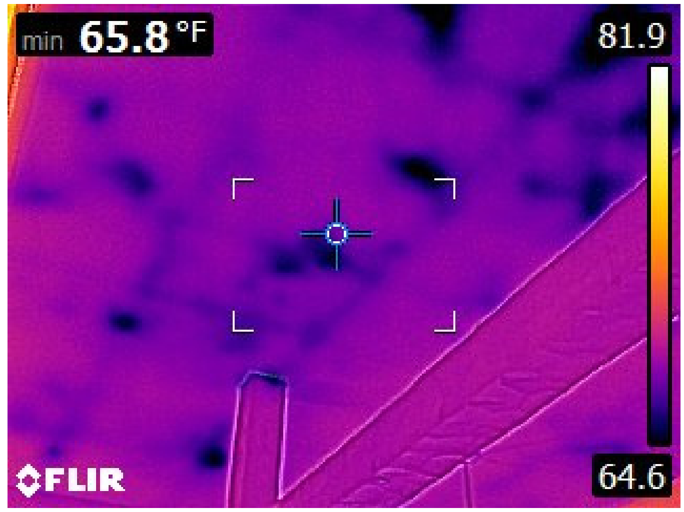
ESM #1: Junior and Adult Library

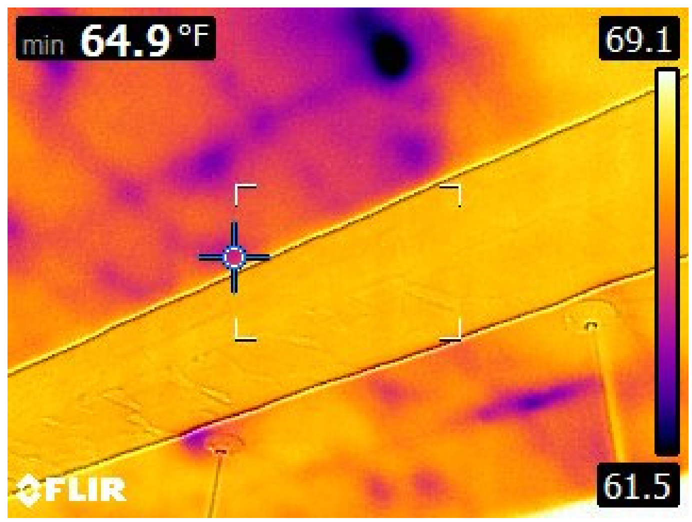
There is a lot of insulating material above the ceiling, however there are signs of rodent activity and pockets or voids suggesting diminished performance. Moe significantly, slopes are largely uninsulated and the perimeter lacks a continuous air barrier. Recommended package: Remove all material, air seal all penetrations and install and foam seal Accuvents in the slopes, then blow in 16" cellulose. Insulate and seal hatch. Air seal the gaps between drywall and beams on the interior side. Weather-strip doors and windows. Additional benefits: the desk area will be warmer without needing space heater.

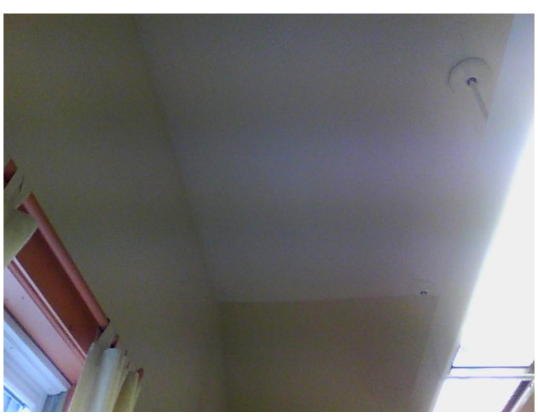
Thermographic images depict differences in surface temperatures. Dark areas are cooler surfaces indicating, in this case, areas of greater heat loss.

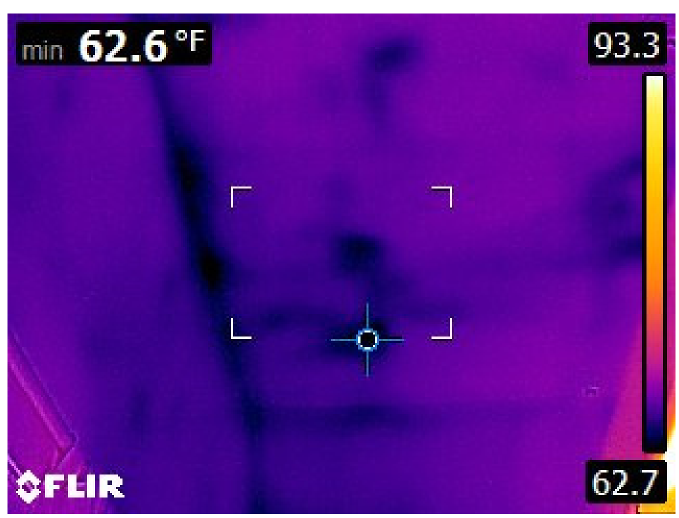


ESM #1: Junior and Adult Library









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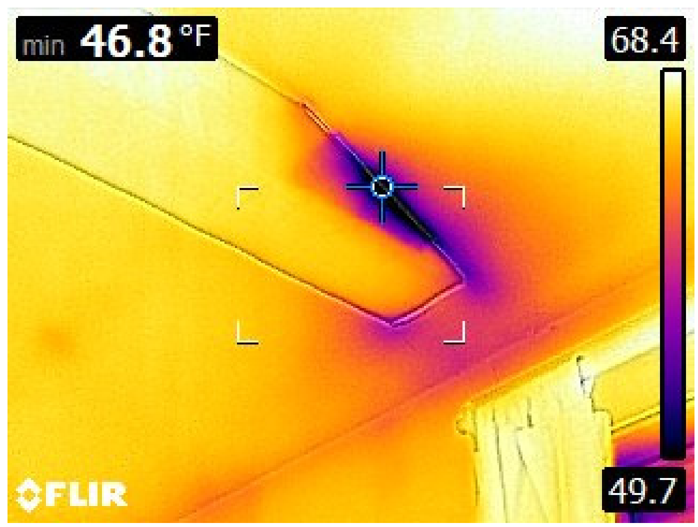
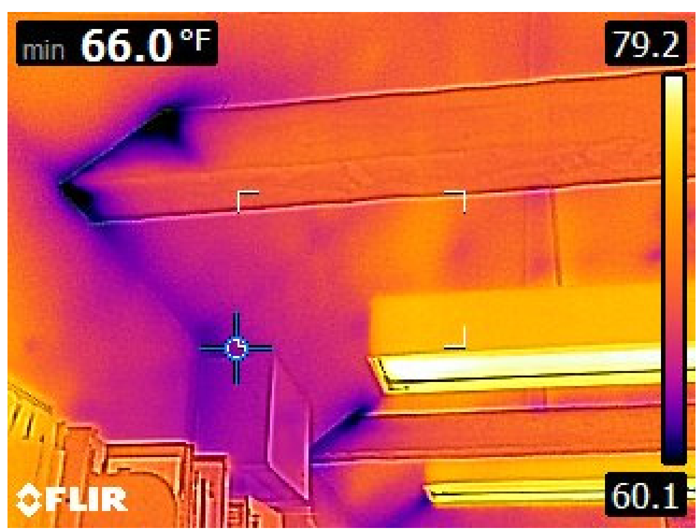
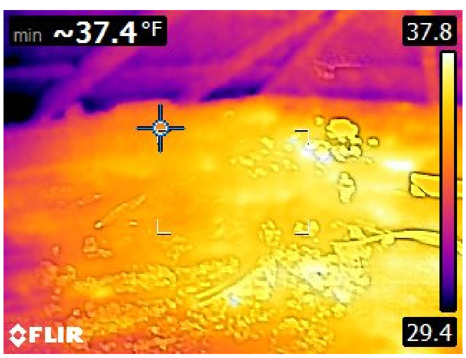


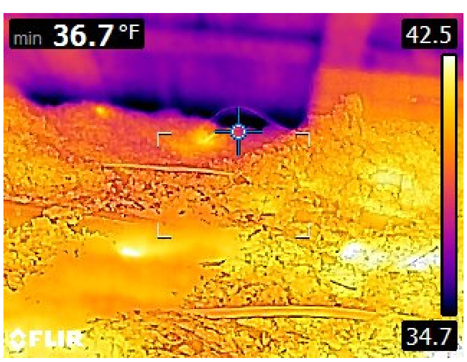


ESM #2: Mann House Ceiling and Weather-stripping

The conditions and recommendations for the Main Attic are identical to the Library wing. Once the material has been removed, inspect all wiring and wood for damage or weaknesses. Also check chimney flashing and use rock wool and fire stop caulk or flashing where the chimney penetrates through the attic floor.

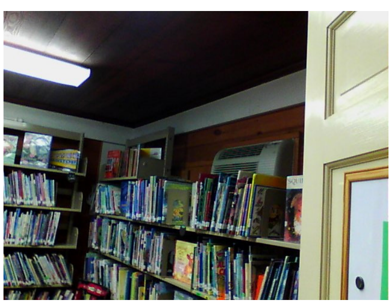
In this case, taken from inside the cold attic, bright colors indicate heat loss from (semi) conditioned spaces below. Brightest spots may be a sign or wiring or where ceiling lights exist. (IR camera also takes digital images, but without a flash in the dark, they didn't come out)

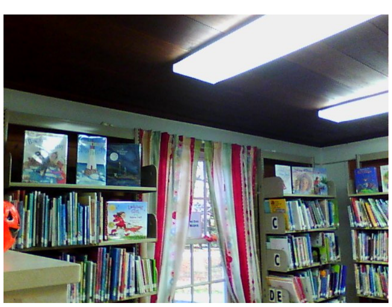


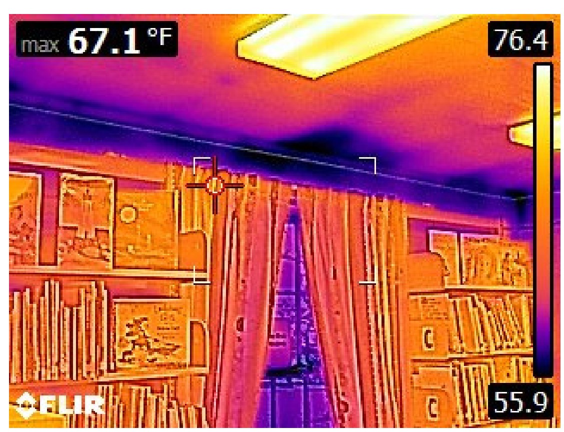


ESM #3: Children's Room Ceiling and Weather-stripping

Insulation was not added above the ceiling in the 2008 renovation so it is not clear what exists above this ceiling plane and there is currently no access. There is no room to access under the roof from the outside so it is recommended that an access hatch be (carefully) cut into the ceiling and replaced and patched afterwards. Depending on what is discovered and ability to reach the perimeter, either air seal and blow cellulose as the other attics, or spray closed foam 6" on the underside of the roof sheathing. Note that if sheathing needs to be repaired or replaced, it should be done prior to spraying foam!

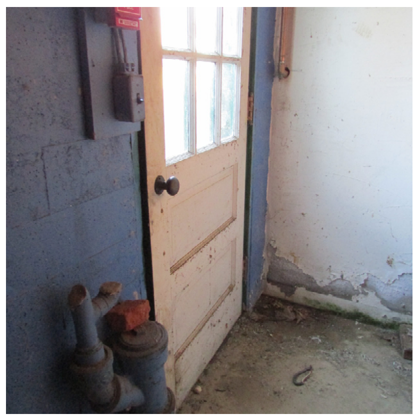






ESM #4: Foundation Wall Insulation

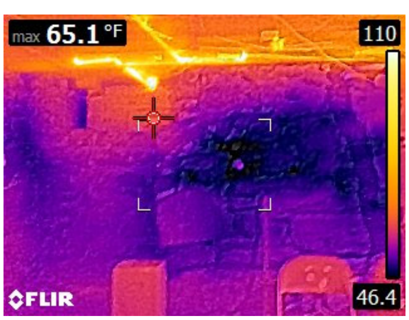
Though listed as item #4, this ESM is key to both saving energy and managing moisture throughout the building. Closed cell spray foam is an appropriate option from a thermodynamic perspective, but if there is resistance from historical preservation goals, then applying a plastic liner and rock (mineral) wool batts may be an acceptable option. The goal is to create a continuous air and vapor barrier with a minimum of R10 insulating material on the below grade foundation walls. Above grade walls should receive and effective R20 and exterior dor should be weather-stripped and a rigid foam panel installed for winter. The sill beams, however, should be air sealed but not insulated as water can move up through the mortar via capillarity and the beams should not be deprived of heat or the ability to dry back to the interior. If there is new evidence of water intrusion, re-evaluate to determine if it can be stopped from the outside, or escorted more effectively to a sump hole with pump.

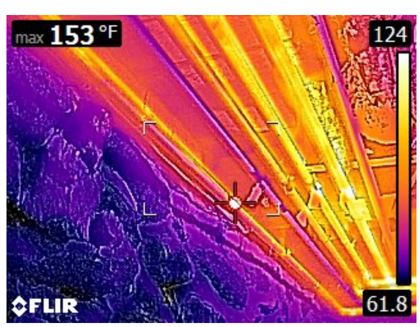


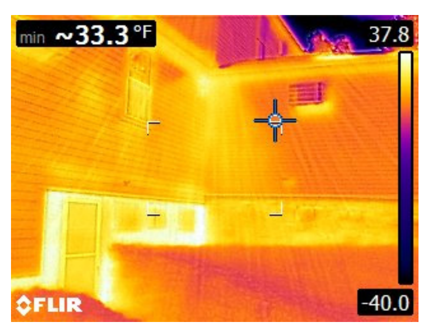
Once insulated, the heat loss from pipes and boiler jacket losses will maintain a warm and dry basement while reducing heating from the intentionally conditioned spaces above.

Water pipes should not be insulated now, as the heat loss into the basement serves an important purpose—and don't need to be insulated afterward walls, since the losses to the outside will be minimal.

The crawl space under the Library was not accessed, though it too may present a similar opportunity!







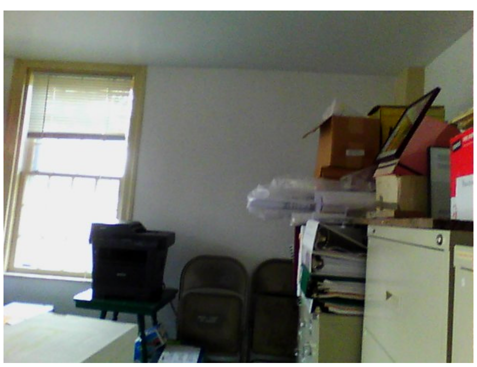
ESM #5: Insulate Mann House Walls

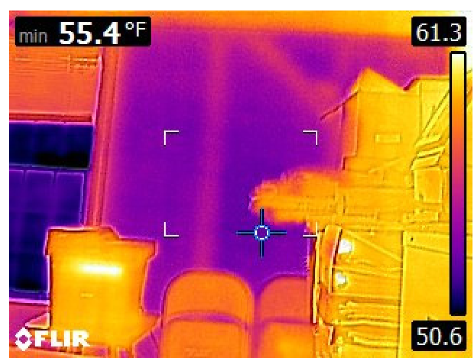
The exterior walls of the original structure appear to have no insulation material, except possibly in the north wall of the 2nd floor—which would be unusual but anything's possible.

Cellulose can be blown in from the outside by removing a clapboard and drilling a two inch hole into each cavity between stud bays. Corners will need more than one hole to access below cross framing.

In addition, clapboards at the band joists—between floors—can be removed and air sealed from the outside.

It should be noted that the building has survived these centuries (?) because a) it never caught on fire and b) it was able to dry if it got wet. Adding insulation to the walls changes the dynamics and will make the exterior sheathing colder, therefore increasingly the risk of condensation. However, with four inch cavities, there will still be heat transfer and cellulose maintains excellent drying capacity. But it would also increase the importance of air sealing (reducing air transported vapor) and managing sources of vapor. Additional benefits include making interior wall surfaces warmer and therefore more comfortable for occupants!





Windows

General weathers-tripping of doors and windows is advised, though with an effective air barrier at ceiling planes, air leakage through windows will be reduced. Adding interior glazing panels has gained increasing favor for historic windows as long as they form a very tight air seal. Also, if windows are opened in mild seasons, there needs to be a good place to store the panels. While they would save energy and improve comfort for occupants, the energy model suggested it would not be a cost effective measure for the Mann House so are not recommended at this time. Article below offered for information only.

window treatments

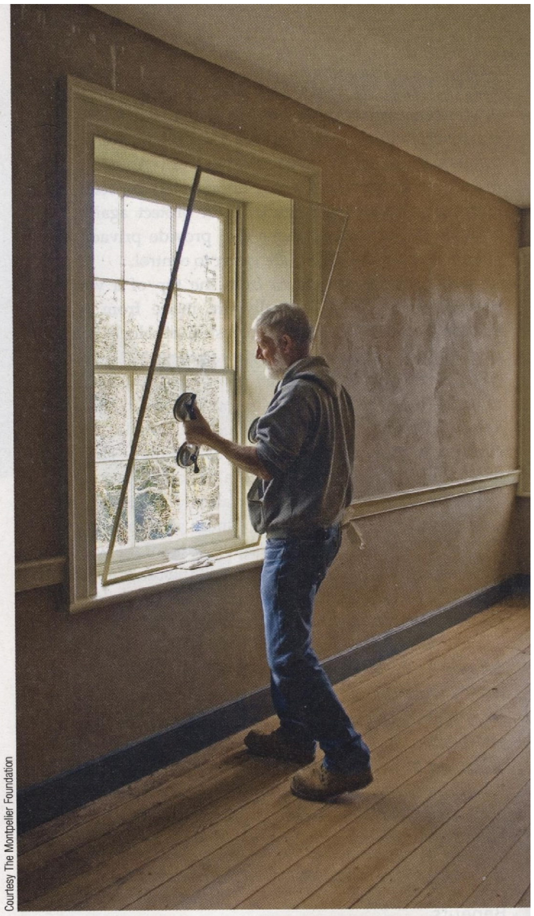
Interior Glazing Panels

Often referred to as "interior storm windows," interior glazing panels are an inexpensive way to add a layer of glazing to a window to boost energy performance. They function much like exterior storm windows, except that they don't provide additional protection against the elements. Most are designed to be removed in the summer, though some include operable panels on tracks.

Most interior glazing panels are lightweight with plastic glazing or clear plastic film. The most common glazings are acrylic (such as Plexiglas) or polycarbonate (such as Lexan). Polycarbonate is stronger than acrylic, but softer, so more scratch-prone. Acrylic now contains ultraviolet light inhibitors that slow yellowing. Glass is sometimes used and is the most durable, as long as it doesn't get broken, but is also heavier. With glass, including a low-e coating may be possible, which will boost energy performance significantly (unfortunately, low-e often isn't an option).

The frames are most commonly aluminum, but can be vinyl, wood, or steel. Steel frames may come with rubber-encased magnetic weatherstripping, for a tight seal to window frames or metallic strips added to the window casings. At least one manufacturer of interior glazing panels produces a double-glazed panel with thin plastic film stretched taught around a tubular aluminum frame. Do-it-yourself kits are available with frames and heat-shrink plastic film that is stretched taut over frames using a hair dryer.

For moisture management, it is preferable to have the inner layer of glazing be the most airtight, since this allows trapped moisture in the window system to escape. This is a benefit of tightly fitting interior glazing panels when the prime windows are old and leaky.



Courtesy The Montpelier Foundation

Interior glazing panels are an inexpensive way to boost a home's energy performance without compromising its architectural integrity.

Benefits
- Reduces heat loss and air flow through windows to improve comfort
- Reduces risk of condensation if panels are tight-fitting
- Helps dampen outdoor sound transmission
- Usually relatively low-cost

Drawbacks
- May hamper egress
- Usually requires seasonal installation and storage when not in use
- May affect visibility (plastic panels may not be optically clear)

Aesthetics
- Most, but not all, panels are relatively unobtrusive

Tips & Cautions
- Clean windows and interior panels before installing
- Use only cleaning agents appropriate for the type of glazing—check with manufacturer; be careful not to scratch plastic panels
- Label panels for reinstallation to the correct windows and allow space for seasonal storage

When To Consider
- If historic codes, covenants, or condominium association rules preclude installation of exterior storm windows
- If you need additional window insulation on an upper floor where installing exterior storm windows would be difficult
- If you are renting and don't want to invest in more-permanent window treatments, such as exterior low-e storm windows
- If existing windows are leaky
- If climate is moderate or cold, and additional window insulation during the heating season is desirable
- If window egress is not an issue

Cost
- \$60 per window (plastic); \$120 per window (low-e glass)

Boiler

Peerless Boiler Model #WBV-04-WPCL

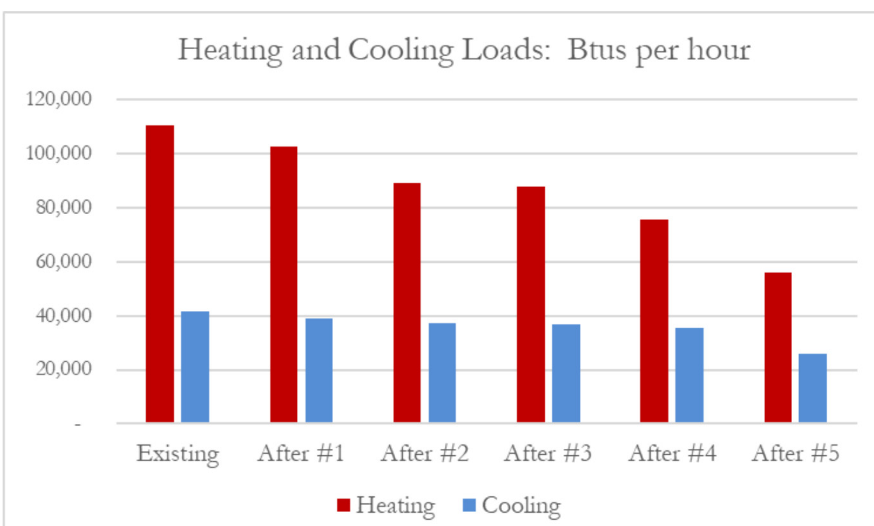
DOE Input 180KBtu/Hr

Output Capacity: 151KBtu/Hr

NET IBR

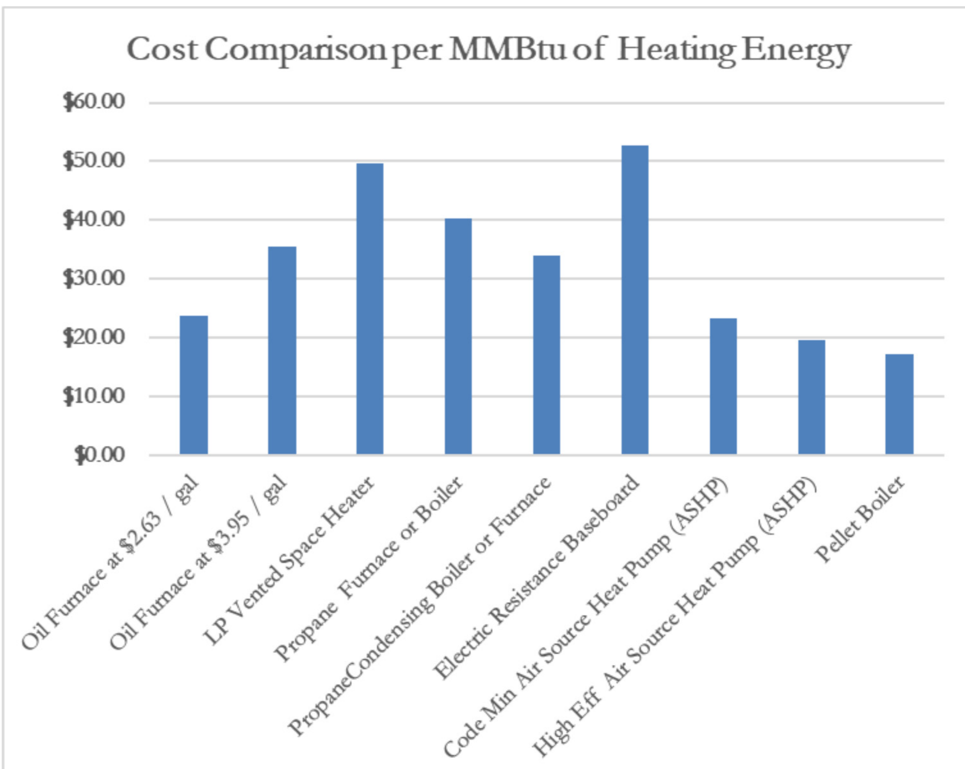
Based on the serial #659314-**201105,** the boiler was manufactured in May, 2011, however the presence of rust and flue gas leakage at the door make it look much older than its young 7 years!

Heating and Cooling Loads have been calculated using Manual J Compliant software. Note that following envelope improvements, the heating load or demand will be getting smaller and smaller—making the existing boiler increasingly oversized. Because of that—and the possibility that the boiler will need to be replaced sooner than later, converting to electric air source heat pumps has been briefly explored for this audit. A fuel cost comparison chart, based on Btu's per energy source and system efficiencies, has also been included for your information.



Comparisons of Types of Heating Energy and System Types

Unit of Energy	Energy and System Type	$ Cost per Unit	$ per million Btu	System Efficiency
Gallon	Oil Boiler	$2.56	$23.07	80%
Gallon	LP Vented Space Heater	$2.95	$49.69	65%
Gallon	Propane Furnace or Boiler	$2.95	$40.37	80%
Gallon	Propane Condensing Boiler or Furnace	$2.95	$34.00	95%
kWh	Electric Resistance Baseboard	$0.18	$52.75	100%
kWh	Code Min Air Source Heat Pump (ASHP)	$0.18	$23.34	226%
kWh	High Eff Air Source Heat Pump (ASHP)	$0.18	$19.54	270%
Ton	Pellet Boiler	$226	$17.12	80%



Energy prices vary over time though some are more volatile than others. The heat content of energy sources does not vary but delivered heat varies based on the delivery system's efficiency. The chart above compares the cost of per million Btus of delivered heat—based on standard efficiencies. The system efficiency of the existing oil furnace is estimated between 75-80%, resulting in a cost closer to $24.5 per million Btus at last year's cost of oil. While no one has a crystal ball, it is reasonable to assume the costs of energy will continue to rise. It also reasonable to presume that electricity will replace direct burning of fossil fuels as it has a clearer path towards clean and renewable generation.

Temperature Bin Hours for Concord, NH

Temperatures reflect dry bulb averages over a 30 year period—from 1966 through 1996. We can expect increasing humidity and more 90+ days in the future.

BIN	May				June				July				August				September				Total	Total BH
	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T	Bin Hours	9-5
100/104																						
95/99					0	1	0	1	0	2	0	2	0	1	0	1	0	1	0	1	5	5
90/94	0	4	1	5	0	6	1	7	0	14	4	18	0	8	1	9	0	6	1	7	41	34
85/89	0	7	2	9	0	17	5	22	0	36	11	47	0	29	7	36	0	15	3	18	123	97
80/84	0	14	5	19	1	37	13	51	2	60	26	88	1	50	17	68	1	25	9	35	242	172
75/79	0	20	8	28	4	48	23	75	8	58	38	#	5	59	33	97	6	40	20	66	342	205
70/74	2	34	15	51	13	47	37	97	34	44	55	#	25	50	52	#	16	47	33	96	453	188
65/69	7	40	24	71	32	37	46	#	59	20	51	#	56	27	57	#	31	50	43	#	509	134
60/64	20	44	37	#	53	25	45	#	65	11	40	#	60	15	42	#	45	34	51	#	486	

The energy a building uses for heating (supplying heat during the winter) and cooling (rejecting heat during the summer) is based, in part, on the temperature difference between outside and inside; referred to as the Delta T or ΔT.

There are two common methods for determining outside temperatures in order to calculate annual heating and cooling loads for a building: Degree Day Method and Bin Data.

A "degree day" is a unit of measure for recording how hot or how cold it has been over a 24-hour period. The number of degree days applied to any particular day of the week is determined by calculating the mean temperature for the day and then comparing the mean temperature to a base value of 65 degrees F. (National Weather Service)

Weather data is available for Concord, NH and has been used for Mason. Historical data has shows an average of 7686 heating degree days (HDD) and 800 cooling degree days (CDD), which may be high for Harrisville. Degree Days reflect averages and not the high and lows, nor how many hours for each temperature.

Since we measure loads in terms of Btus per hour—and since we do experience extreme temperatures– a more accurate way to calculate loads is by using Bin Data, such as in the chart above.

Temperature "Bins" reference the number of hours in year that the outside temperature falls in to a narrow range of 3 to 5 degrees. The chart above reflects summer temperature ranges, from May through September, which may require cooling for comfort. For example, based on a 30 year record—from 1966 through 1996– there was an average of 36 hours in July when the outside temperature was between 85 and 89 degrees. (circled). The total average of hours in that "bin" is 123. The three columns under each month reflect three 8-hour time blocks and have been shaded here since the building is occupied primarily between the hours of 9-5 and when air conditioning might be desired. Temperature bins for the heating season are shown on the next page.

These charts and explanations are included in this report because Air Source Heat Pumps (ASHP) do not generate heat, but move heat (pump heat) from air between inside and outside through refrigerants and compressors. Their capacity and efficiency is based on air temperatures. Modern, cold climate, heat pumps can operate—ie extract heat– at remarkably low outdoor temperatures, but at lower capacities and efficiencies than higher temperatures.

Bin data for the Heating Season.

While the Monadnock Region does see temperatures drop to as low as –25 every few years, based on 30 years historical data for Concord, the lowest temperature for over 99% of the time is –3 degrees F. Note that the lowest temperatures typically (not always) occur at night when the thermostat is usually turned down.

A lower thermostat setting reduces the Delta T, therefore reducing the amount of heating energy needed.

However, air source heat pump capacity and efficiency depend on outside air temperatures so they are more significant than just the difference between inside and outside.

As noted elsewhere, air source heat pumps also differ from fossil fuel equipment in that they will take longer to heat a space following large thermostat setbacks. This chart is included in the event the Town considering installing very efficient electric air source heat pumps for the Mann House and Library.

BIN	January				February				March				April				May				October				November				December				Total Bin Hours	Total BH
	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T	1-8	9-16	17-00	T		9-5
55/59	1	1	1	3	0	2	1	3	1	9	5	15	7	31	19	57	34	37	41	112	15	41	29	85	6	14	7	27	1	2	1	4	306	137
50/54	1	3	2	6	1	4	2	7	3	17	9	29	15	41	28	84	50	27	48	125	30	53	42	125	9	27	16	52	1	5	3	9	437	177
45/49	1	5	2	8	2	8	4	14	5	28	18	51	28	47	42	117	55	16	39	110	36	43	49	128	16	40	25	81	3	11	6	20	529	198
40/44	3	15	7	25	6	20	10	36	16	45	33	94	44	37	48	129	40	3	20	63	46	20	42	108	30	52	40	122	8	21	12	41	618	213
35/39	15	25	22	62	13	29	26	68	35	50	51	136	53	19	41	113	23	0	5	28	38	8	29	75	38	43	46	127	21	43	28	92	701	217
30/34	29	40	34	103	26	39	27	92	56	43	56	155	44	7	24	75	13	0	2	15	35	2	18	55	46	31	47	124	43	54	53	150	769	216
25/29	27	37	36	100	28	35	37	100	44	22	33	99	29	11	2	42	4	0	0	4	26	0	10	36	42	12	33	87	40	43	48	131	599	160
20/24	29	37	36	102	26	32	31	89	30	14	21	65	11	1	2	14					10	0	1	11	26	4	13	43	32	27	33	92	416	115
15/19	33	30	35	98	29	24	29	82	24	7	13	44	4	0	0	4					2	0	1	3	14	2	6	22	30	20	24	74	327	83
10/14	29	23	29	81	28	16	21	65	15	2	6	23									1	0	0	1	7	0	2	9	21	13	19	53	232	54
5/9	28	16	19	63	25	8	13	46	10	1	1	12													2	0	0	2	15	7	11	33	156	32
0/4	19	9	11	39	17	4	7	28	4	0	0	4																	14	3	7	24	95	16
-5/-1	13	4	7	24	9	2	3	14	2	0	0	2																	9	1	2	12	52	7
-10/-6	11	2	4	17	9	1	2	12	1	0	0	1																	3	0	1	4	34	3
-15/-11	5	1	2	8	4	0	0	4																					2	0	0	2	14	1
-20/-16	3	0	0	3	1	0	0	1																					1	0	0	1	5	0
-25/-21	1	0	0	1																													1	
-30/-31	1			1																													1	