Energy Audit

St. Andrews Episcopal Church
354 Main Street
Hopkinton, NH

April 13, 2021

BUILDING STRATEGIES FOR AN AFFORDABLE FUTURE
S.E.E.D.S.
SUSTAINABLE ENERGY EDUCATION DEMONSTRATION SERVICES
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Introduction

The purpose of an energy audit is to identify energy saving measures (ESM) in a building. Computer simulated energy models are developed to estimate 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/or more efficient mechanical systems. The cost of those measures can then be analyzed in terms of predicted energy saved and savings potential from converting to different sources of energy. The primary objective is to evaluate the level of investment warranted by energy and dollars saved from those specific measures.

In this case, the audit has been partially paid for by a grant from the Episcopal Diocese of New Hampshire. In keeping with the intent of the diocese, a reduction of raw energy consumption and carbon emissions has also been analyzed to address the pursuit ecological sustainability and addressing the climate crisis.

This audit has been prepared with the best of intentions to assist the Building & Grounds Ministry and other parishioners make informed decisions regarding energy saving improvements in keeping with their long term goals for the Church property. 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 disclosed.

Executive Summary

The primary focus of this study has been to explore opportunities to upgrade the thermal envelope—that is the barrier between inside conditioned space and the climate outside. In most buildings in cold climates, the more effective the envelope, the less energy needed to achieve comfort inside. Effective thermal envelopes are tight (limiting air leakage), with effective levels of insulation installed in contact with an air barrier on all sides. Critical to managing heat transfer or flow, is effectively managing moisture. Buildings don't need to breathe, but material assemblies do need to be able to dry out if they get wet!

From a thermodynamic and construction perspective, St. Andrews Church can be thought of as four distinct buildings, served by seven distinct heating systems. All areas can be significantly improved by upgrading insulation levels in the ceiling or the walls, but in this case, instead of addressing each envelope component type as distinct, the building areas have been analyzed as somewhat separate sections.

A financial summary of the recommended ESM is on the next page with a summary of energy savings on page five. The ESM are described as four 'packages', each package addressing a distinct building section or area. It may be more cost effective for an insulation contractor to complete all ESM as one project, but each package has been developed to be able to do phase the improvements over time if necessary. Prioritizing which comes first can be based on predicted savings, available resources, or logistical parameters around occupied spaces or other work in progress. In this case, both the overall impact on savings and the ongoing work on the Sanctuary ceiling makes the Sanctuary the best place to start!

The propane fired furnaces are relatively new and efficient, so replacement options have not been explored, other than referencing the advantage of converting to electric heat pumps at some time in the future. Reducing heating loads through improvements to the envelope benefits both short and long term goals.

Summary of Recommended Energy Saving Measures

The ESM below are presented as packages per area to optimize energy and dollar savings for both heating. Savings for cooling has not been included due to not knowing which windows the units are installed. The ESM are described in greater detail within each "Areas" section of this report.

In short, investing a total of an estimated $44,390, would result in an estimated annual dollar savings of $5,061 at the $1.95 per gallon price for propane. This also translates to a simple payback of 8.8 years. Since envelope measures typically have a service life of (at least) 25 years, the investment gain over that time period would be $82,135 at current energy prices, and yield a 4.3% annual return on investment (RO1).

If the improvements were phased over time, it is recommended to complete the ESM for a building area, instead of, for example, improving all ceilings throughout the complex. That is why line item savings are not included: they are proposed as individual packages.

Area or Zone	Sq Ft SA or Description	Estimated ESM Cost	Estimated Annual Savings	Simple Payback Years	Invest - ment Gain	ROI	Annual ROI
Great Hall							
Air Sealing	2 double doors and spot sealing	$425					
Foundation	300	$2,950					
Ceiling Slopes	492	$3,198					
		$6,573	$699	7.3	$10,902	165.9%	4.0%
2002 Upper Floor							
Ceiling	1982	$9,117					
Thermodome	Purchased or constructed	$350					
Weather stripping	10 windows and one door	$400					
		$9,867	$549	18.0	$3,858	39.1%	1.3%
1990 Connector							
Ceiling	1305	$5,155					
Weather-Strip	2 doors	$125					
		$5,280	$372	14.2	$35,220	667.1%	8.5%
Sanctuary							
Ceiling	2508	$6,643					
Crawl Space Floor	2000	$3,500					
Foundation Walls	328	$1,312					
Walls	3298	$11,215					
		$22,670	$3,441	6.6	$63,355	279.5%	5.5%
All Four Areas	Totals	$44,390	$5,061	8.8	$82,135	185%	4.3%

The Sanctuary Package

#	Sanctuary Envelope ESM	Cost of Measure	Dollars Saved	Simple Payback Years	Life of Measure	Investment Gain	ROI	Annual
1	Ceiling	$6,643	$95	69.9	25	-$4,268	-64.3%	-4.0%
2	Basement	$4,812	$328	14.7	25	$3,388	70.4%	2.2%
3	Walls	$11,215	$2,141	5.2	25	$42,310	377.3%	6.5%
1-3	All three	$22,670	$3,441	6.6	25	$64,067	291.8%	5.6%

Estimated savings from each measure is offered for the Sanctuary, in part because it has its own propane tank, and therefore there is greater confidence from comparing actual to modeled savings. But as with the other 'packages' the whole is indeed greater than the sum of its parts. In other words, the more comprehensive the improvements to the thermal envelope, the better the results so it is recommended to complete all three measures in order to yield the optimal benefits.

Energy Savings

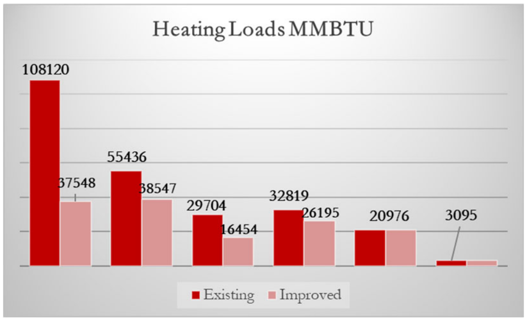
The chart below reflects the estimated reductions in energy and greenhouse gas emissions (CO2 only) from each completed ESM package.

Area	Annual Reduction LP Gallons	Site Energy Saved	Source Energy Saved	GHG Reduction Tons
Great Hall	358	32.7	36.0	2.4
2002 Wing Upper Floor	282	25.7	28.3	1.9
1990 Connector	191	17.4	19.2	1.3
Sanctuary	1765	161.1	177.2	12.0
	2595	237.0	260.7	17.6

Heating Load Reductions

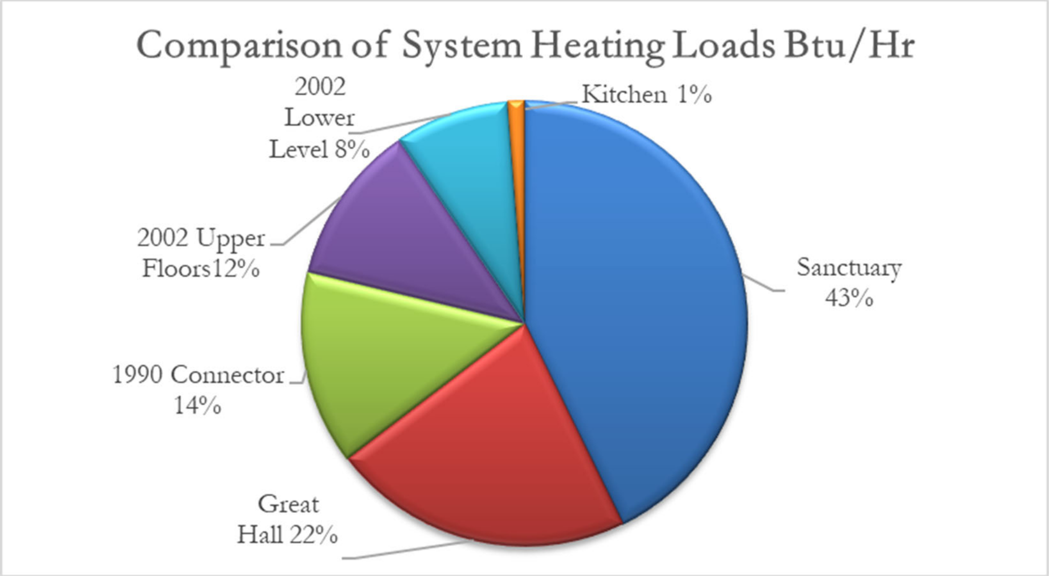
The other consequence of improving the thermal envelope is the overall reduction in 'peak heating load'. In this case, because of the frequency of unoccupied hours, the peak heating load reflects the BTUS needed to maintain 55 degrees indoors when the outdoor temperature is –2 degrees. In other words a delta T of 57 degrees which is lower than what should be used for any calculation for sizing new equipment. The relative reductions would be similar with a 67 degree delta T. Load calculation software reports are included at the end of this document.

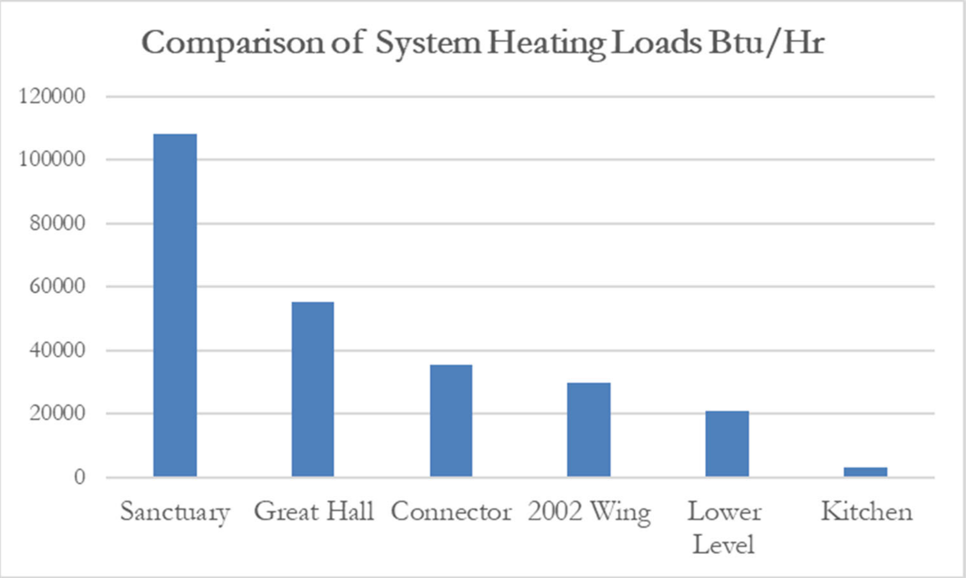
Area	Existing	Improved
Sanctuary	108,120	37,548
Great Hall	55,436	38,547
2002 Upper Floor	29,704	16,454
1990 Connector	32,819	26,195
2002 Lower Floor	20,976	20,976
Kitchen	3,095	3,095
Total Building	250,150	142,815



More Load Charts and Graphs

The information below is offered as a visual way to think about prioritizing improvement packages.





Historic Energy Use Analysis

The energy analysis below is based on the fuel data for 2019, at an average price of $1.97 per gallon and three year average electric data, 2018-2020.

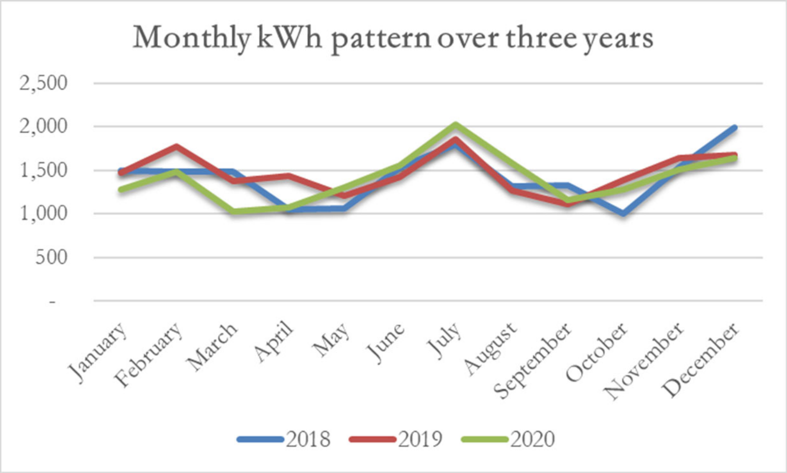
Energy	Units	Site Btus	Source Btus	$Cost	Tons CO2
Electric kWh	17,259	58,887,708	196,079,499	$3,405	24.3
Church Propane	2,862	261,300,600	287,430,660	$5,686	17.7
Parish Propane	3,125	285,312,500	313,843,750	$6,107	19.4
Totals		605,500,808	797,353,909	$15,198	21.2
EUI KBtu/FT2	13257	45.7	60.1	$1.15	82.6

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 electric transmission losses and some allowance for off site generation and other considerations. Since the per unit cost for energy varies greatly over time, converting all forms of energy to Btus can be a more accurate way of looking at a building's energy demands and potential reductions from energy saving measures.

Based on the information provided, the Site EUI for the entire facility is 45.7 thousand Btus per square foot (KBtu/Ft2) and Source EUI is 60.1 KBtu/Ft2. Based on current prices, the cost per square foot is $1.15. Greenhouse Gas emissions (CO2 only) for Source energy input is 82.6 tons per year.

	Floor Area	Site KBtu/FT2	Source KBtu/Ft2
Sanctuary Heating	2508	104.2	114.6

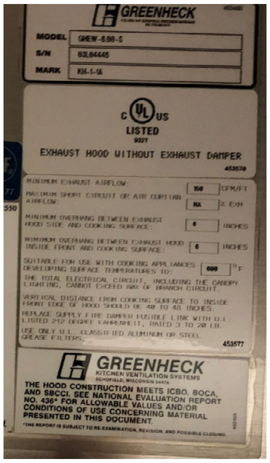
The EUI for the whole facility—estimated at 13,257 Ft2—is not excessively high when compared to other NH buildings of these construction eras. Heating alone for the Sanctuary is 104.2 KBtu, which is considerably higher.



The monthly electric usage shows a remarkably similar pattern over three years, including 2020 when the buildings were mostly unoccupied. The winter peaks could be due to air handlers while the summer peaks are likely due to air conditioning and dehumidification.

Building Electric Loads

A variety of electric devices serve important building functions: exhaust the kitchen hood, dehumidify the basement, heat water for handwashing, and pump water from the sump. Window air conditioning units for space cooling range in efficiency but all found to be less than EER 9.5. Summer peak loads are estimated to cost about $600 (including demand charges). Before replacing older window units, exploring installing ductless air source heat pumps to provide more efficient summer cooling and supplemental winter heating is advised following envelope improvements. An additional analysis can be provided at that time, and when occupancy patterns return to 'normal.'

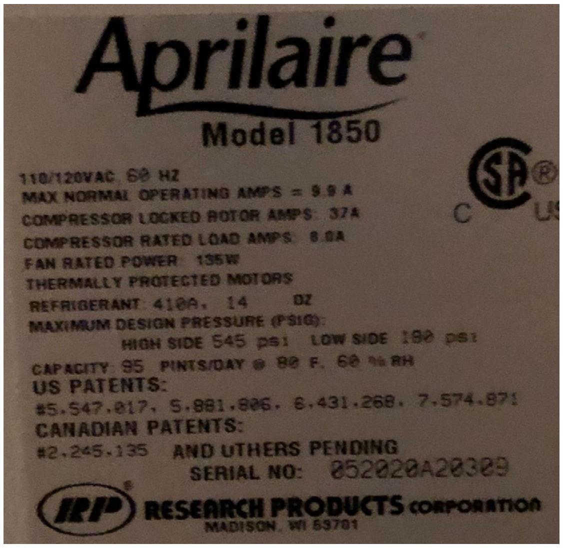

GREENHECK

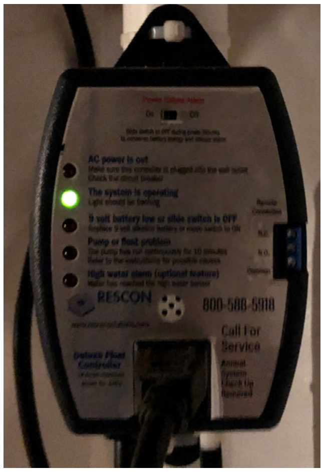
MODEL GHEW-6.50-S
S/N 83L84445
MARK KH-1-1A

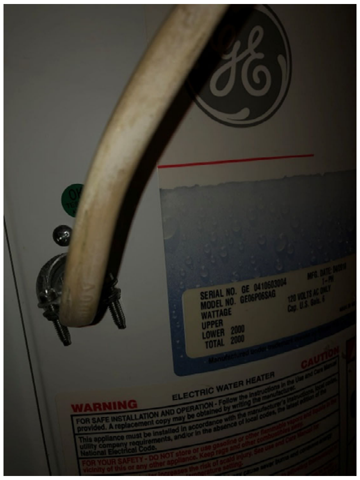
c UL US
LISTED
EXHAUST HOOD WITHOUT EXHAUST DAMPER
453578

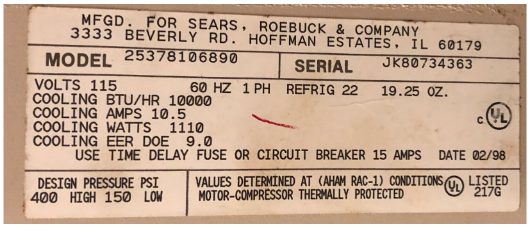
MINIMUM EXHAUST AIRFLOW: 150 CFM/FT
MAXIMUM SHORT CIRCUIT OR AIR CURTIAN AIRFLOW: NA % E/H
MINIMUM OVERHANG BETWEEN EXHAUST HOOD SIDE AND COOKING SURFACE: 0 INCHES
MINIMUM OVERHANG BETWEEN EXHAUST HOOD INSIDE FRONT AND COOKING SURFACE: 6 INCHES
SUITABLE FOR USE WITH COOKING APPLIANCES DEVELOPING SURFACE TEMPERATURES TO: 600 °F
THE TOTAL ELECTRICAL CIRCUIT, INCLUDING THE CANOPY LIGHTING, CANNOT EXCEED 80% OF BRANCH CIRCUIT.
VERTICAL DISTANCE FROM COOKING SURFACE TO INSIDE FRONT EDGE OF HOOD SHOULD BE 40 TO 48 INCHES.
REPLACE SUPPLY FIRE DAMPER FUSIBLE LINK WITH U.L. LISTED 212 DEGREE FAHRENHEIT, RATED 3 TO 20 LB.
USE ONLY U.L. CLASSIFIED ALUMINUM OR STEEL GREASE FILTERS.
453577

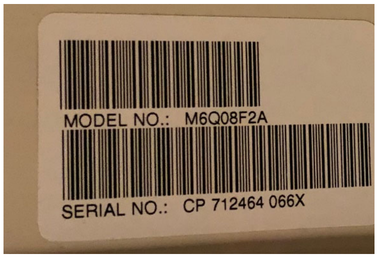
GREENHECK
KITCHEN VENTILATION SYSTEMS
SCHOFIELD, WISCONSIN 54476
THE HOOD CONSTRUCTION MEETS ICBO, BOCA, AND SBCCI. SEE NATIONAL EVALUATION REPORT NO. 436* FOR ALLOWABLE VALUES AND/OR CONDITIONS OF USE CONCERNING MATERIAL PRESENTED IN THIS DOCUMENT.
*THE REPORT IS SUBJECT TO RE-EXAMINATION, REVISION, AND POSSIBLE CLOSING.


Aprilaire
Model 1850
110/120VAC 60 HZ
MAX NORMAL OPERATING AMPS = 9.9 A
COMPRESSOR LOCKED ROTOR AMPS 37A
COMPRESSOR RATED LOAD AMPS 8.8A
FAN RATED POWER 135W
THERMALLY PROTECTED MOTORS
REFRIGERANT 410A, 14 OZ
MAXIMUM DESIGN PRESSURE (PSIG):
HIGH SIDE 545 psi LOW SIDE 180 psi
CAPACITY 95 PINTS/DAY @ 80 F, 60 % RH
US PATENTS:
#5,547,017, 5,881,806, 6,431,268, 7,574,871
CANADIAN PATENTS:
#2,245,135 AND OTHERS PENDING
SERIAL NO: 052020A20309
RESEARCH PRODUCTS CORPORATION
MADISON, WI 53701





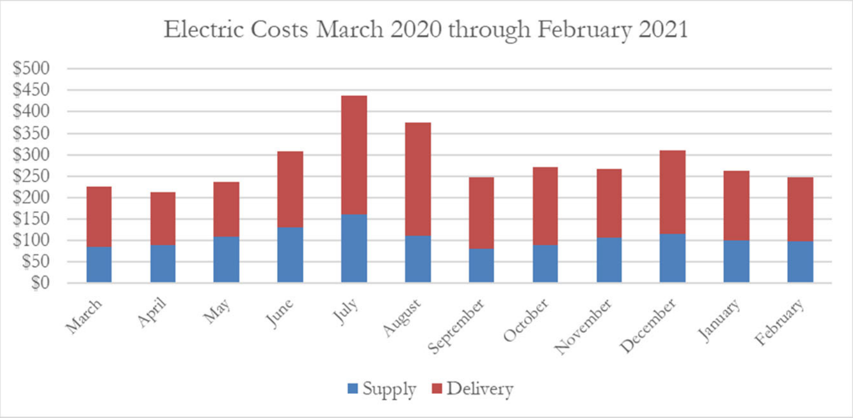

MFGD. FOR SEARS, ROEBUCK & COMPANY
3333 BEVERLY RD. HOFFMAN ESTATES, IL 60179
MODEL 25378106890 SERIAL JK80734363
VOLTS 115 60 HZ 1 PH REFRIG 22 19.25 OZ.
COOLING BTU/HR 10000
COOLING AMPS 10.5
COOLING WATTS 1110
COOLING EER DOE 9.0
USE TIME DELAY FUSE OR CIRCUIT BREAKER 15 AMPS DATE 02/98
DESIGN PRESSURE PSI 400 HIGH 150 LOW
VALUES DETERMINED AT (AHAM RAC-1) CONDITIONS MOTOR-COMPRESSOR THERMALLY PROTECTED
c UL LISTED 217G

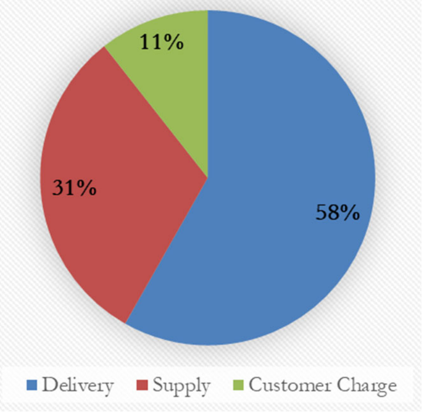

MODEL NO.: M6Q08F2A
SERIAL NO.: CP 712464 066X


DATE COD
ELECTROLUX
MAJOR
APPLIANCES NA
Augusta GA. USA
MODEL:FAA074S7A
ENG: 14
ELECTRICAL:
115 VOLTS, 60HZ, 1PH.
COOLING DATA:
BTU-6,500 EER-9.7
AMPS-6.2
WATTS-670

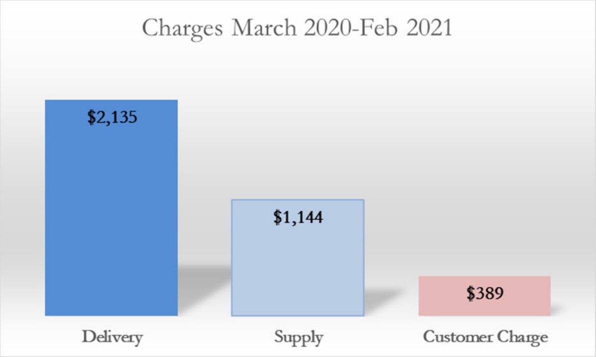
AC units range in age from 6 to 14 years.

Electric Costs

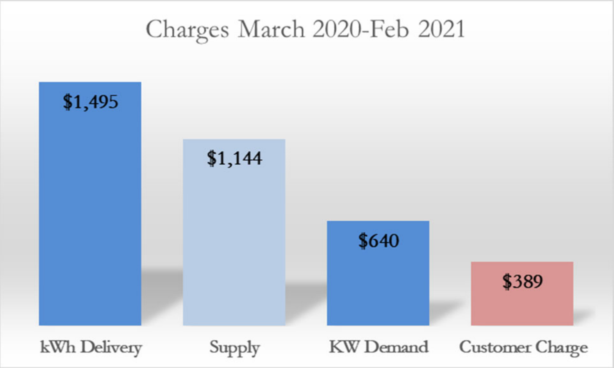




Electric bills can be very confusing to decipher. As we move towards renewable energy and a greater reliance on the electric grid for more of our energy needs, it can be helpful to think in terms of separating the cost to generate electric energy and the costs to deliver it to our buildings. This is especially relevant if the Church considers installing a PV Solar Array for on site electric generation. For example, even if the Church were able to generate 75% of its annual electric usage, the dollar value would be equal to the cost of supply (about 7.5 cents per kWh) and a portion of the delivery cost, because you'd still be relying on administration, transmission lines and all the associated costs.

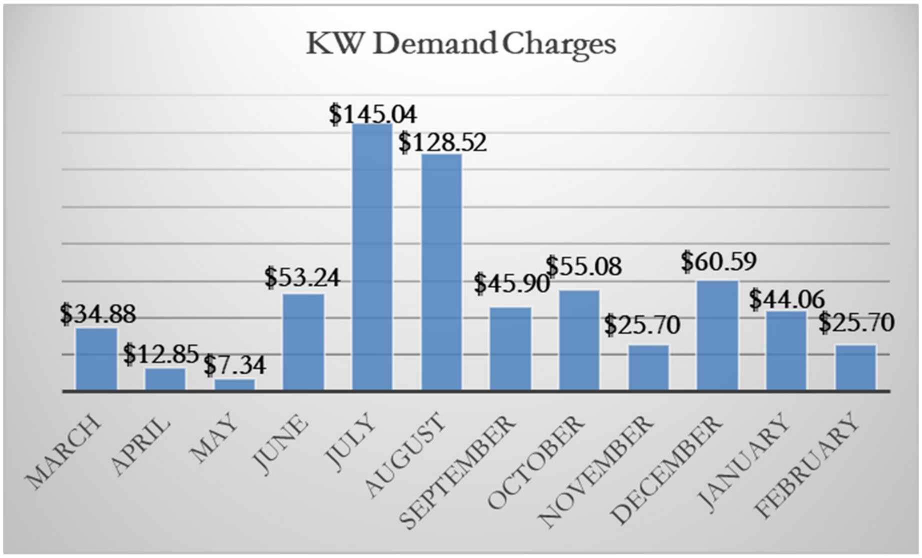


Breaking down delivery charges one more step, KW Demand has less to do with the kWh used and more about the time they were used: ie to compensate for the times when the grid has the highest demand for power; and to encourage customers to manage their demand reward strategies for demand side management.



Demand Charges

Energy efficiency measures can reduce the amount of electricity consumed, but may or may not impact the peak demand in any given month. That is, the hours each month which reflects the peak consumption. Since the electric grid must be able to provide enough supply to satisfy total demand at any given time (in order to prevent brown outs), non residential consumers are charged for their KW Peak Demand for each month.



From March 2020 through February 2021, the total charge for KW Demand was $640; $274 (43%) of which occurred in July and August. If understood correctly, the building was largely unoccupied in July and August 2020, so the spike in both kWh consumption and KW demand - which has happened for at least three years—is as likely due to window air conditioning units and / or dehumidification.

Installing a VB on the crawl space floor under the Great Hall may reduce humidity levels enough to put the dehumidifiers on a timer so they operate at low demand times, such as early morning or at night.

Heating Energy Cost Comparisons per million BTU (MMBTU)

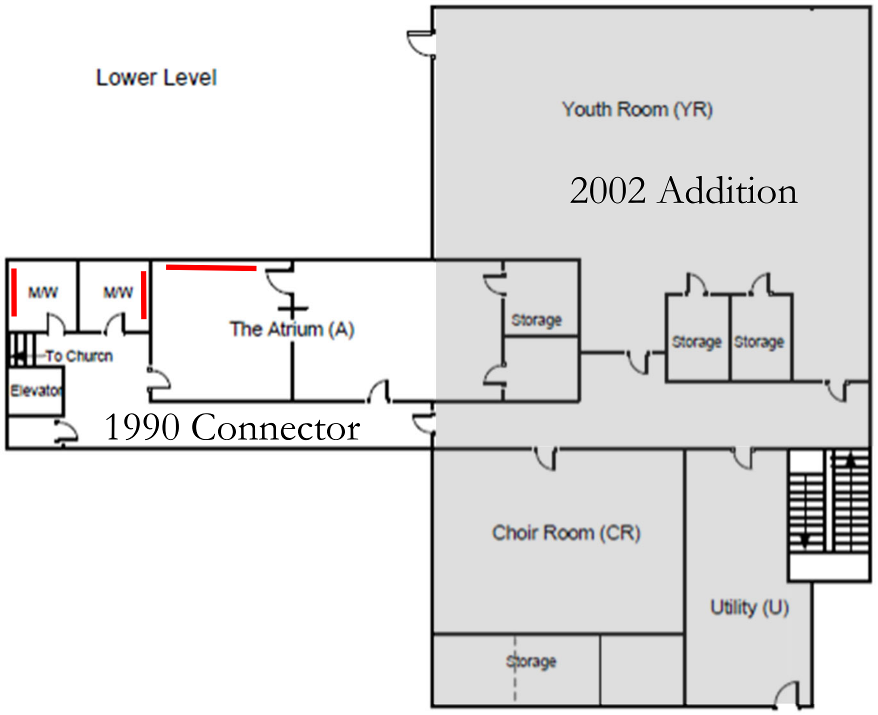
The chart below was pasted from an on-line interactive calculator, where fuel prices and system efficiencies are inputs to determine the 1) Fuel (or energy) Price per millions Btus and the 2) Fuel (or energy) Cost per million Btus based on the system efficiency of the system used.

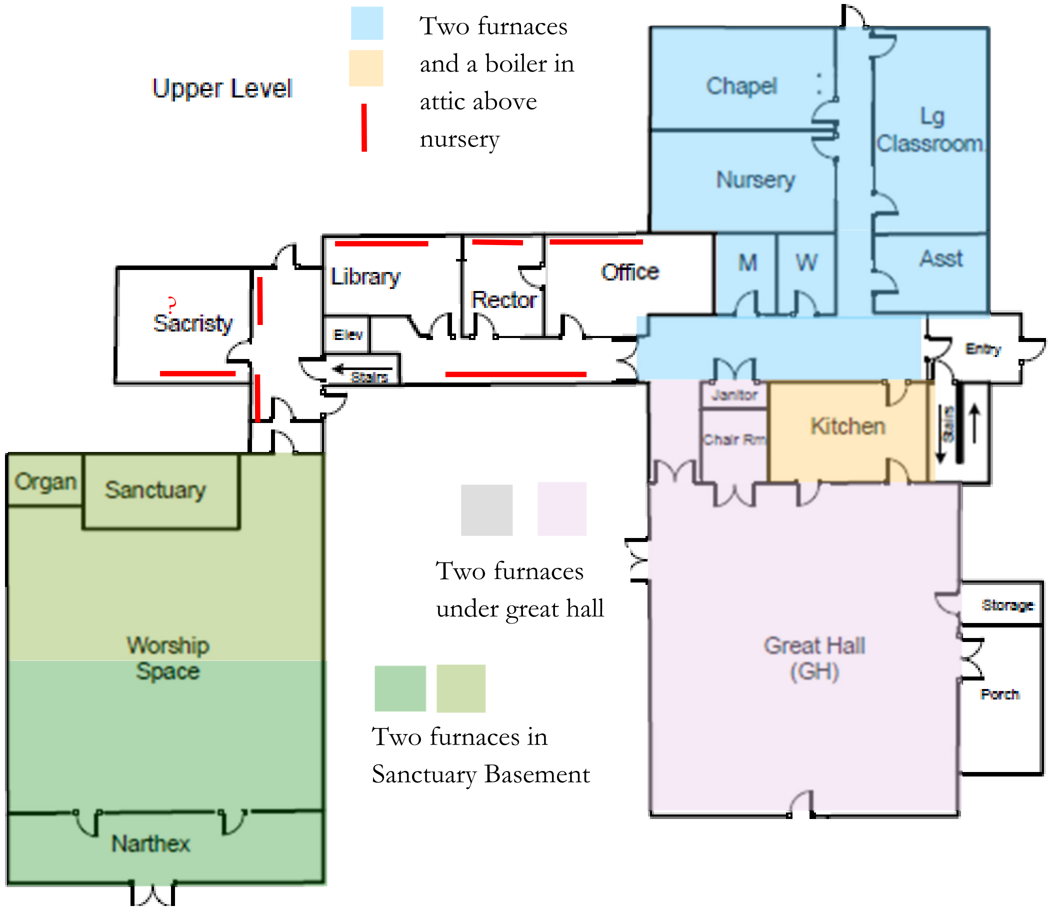
At current prices, note that the cost of heating with propane, via a high efficiency condensing unit, is $22.48 per MMBTU and competitive with electric air source heat pumps (ASHP), though higher than heating with ground source heat pumps (AKA GSHP or Geothermal).

If the price of propane rises to $2.95 per gallon, the cost per MMBTU would then be $34.01. At that time, converting to ASHP would be a cost effective options. The other reason to convert to the highly efficient cold climate heat pumps is to transition off fossil fuels and offset electric usage with on site PV generation. Understanding, of course, that heating is needed mostly from November through April, where as solar PV in this region generates most of the electricity from April through October.

Space heating is currently requiring 546.6 MMBTU. Following all recommended measures, the heating load would be reduced an estimated 237 MMBTU to 310 MMTBU. Reducing demand or load is always a first step before replacing supply equipment.

Fuel Type	Fuel Unit	Fuel Price Per Unit (dollars)	Fuel Heat Content Per Unit (Btu)	Fuel Price Per Million Btu (dollars)	Heating Appliance Type	Type of Efficiency Rating	Approx. Efficiency (%)	Fuel Cost Per Million Btu (dollars)
Propane	gallons	$1.95	91,300	$21.36	HE Condensing Boiler	AFUE	95%	$22.48
Pellets	Ton	$255	16,500,000	$15.45	Space Heater	EPA	78%	$19.81
Electricity	kWh	0.185	3,412	$54.22	Space Heater	COP 1	99.9%	$54.27
				domestic Hot water	Electric Resistance Water Heater	Energy Factor (EF)	0.90	$60.24
				domestic Hot water	Hot Water Heat Pump - in unconditioned space	EF (varies)	2.30	$23.57
				domestic Hot water	Hot Water Heat Pump - in conditioned space	EF (up to)	3.70	$14.65
				Space heating	VRF ASHP	COP 2.3	230%	$23.57
				Space	GSHP (aka geothermal)	COP 3.8	400%	$13.56

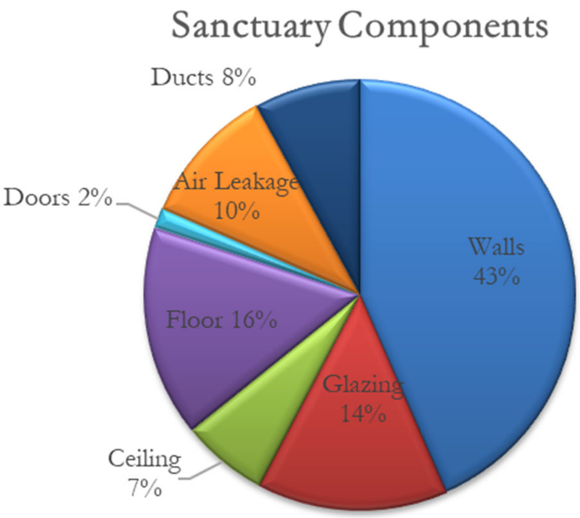

Lower Level
Youth Room (YR)
2002 Addition
M/W
M/W
The Atrium (A)
Storage
Storage
Storage
To Church
Elevator
1990 Connector
Choir Room (CR)
Utility (U)
Storage


Upper Level
Two furnaces and a boiler in attic above nursery
Chapel
Lg Classroom
Nursery
Sacristy
Library
Rector
Office
M
W
Asst
Elev
Stairs
Entry
Janitor
Chair Rm
Kitchen
Stairs
Organ
Sanctuary
Worship Space
Narthex
Two furnaces under great hall
Two furnaces in Sanctuary Basement
Storage
Great Hall (GH)
Porch

The Sanctuary

The thermal envelope of a building can be described in terms of the materials in each component: ie, foundation (or floor), walls, ceilings, windows, doors, and air leakage through all the cracks and gaps in the transitions between materials and components.

Based on this study, the conductive and convective heat loss through each envelope component is presented in the pie chart in terms of 'relative responsibility'. In the case of the Sanctuary, the uninsulated walls are believed to account for 43% of the building's heat loss or load. This analysis helps inform and priorize the four recommended energy saving measures.



There has already been discussion around replacing (and adding) the insulation above the ceiling as part of the plaster repairs. The relatively low percentage of heat loss through the ceiling is due to the uninsulated foundation and large surface area of uninsulated stone walls. The recommendation is to improve all three components, which will also result in reducing air leakage and distribution losses from ducts. The exterior storm windows offer some improved thermal performance while also protecting the lovely stained glass, so no additional measures are recommended.

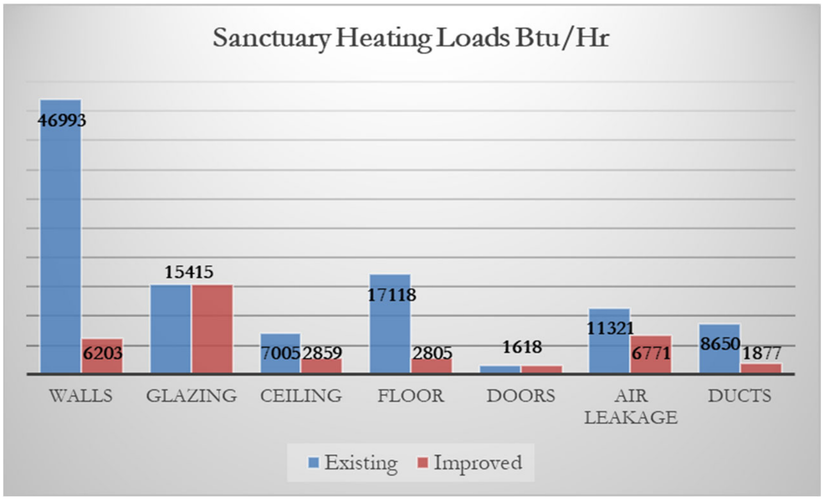
The advantage of spraying a one inch skim coat of closed cell foam over the attic floor is to provide a vapor retarder as well as some structure support for the weight of 18" cellulose or15" blown in mineral wool. The reason to consider mineral wool is that it would be an appropriate insulation to blow into the walls and curved ceiling from the attic above. Install netting over the arched structure at the top of the stairs and fill the cavity with insulation. Lastly, install a constructed or purchased thermodome over the top of the stairs and seal perimeter with weatherstripping.

Photos and a description of insulating the foundation walls are included on pages 19 and 20.

The chart to the right presents the resulting reductions in peak hourly heat loss following the recommended ESM. The totals for each condition:

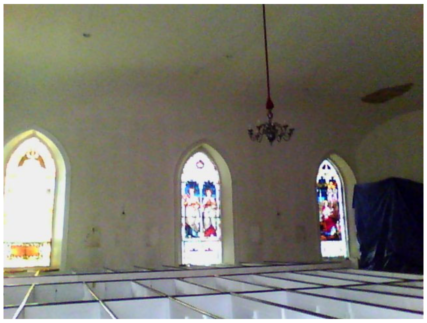
Existing conditions: 108,120 Btu/Hr

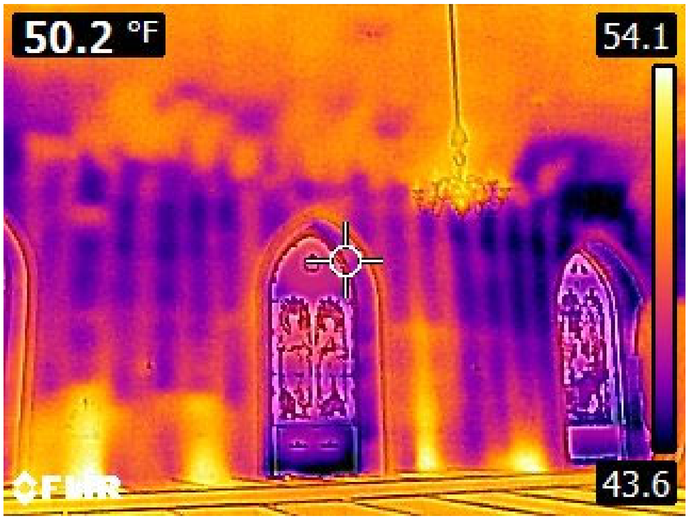
Improved: 37,548 The 66% load reduction is largely due to insulating the walls.



The Sanctuary

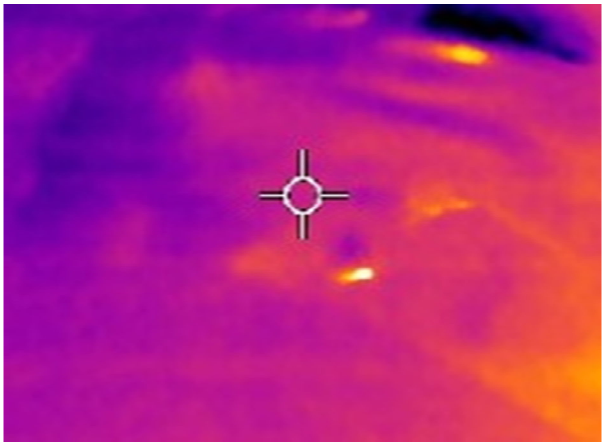
Thermographic (aka Infra Red or IR) images depict differences in surface temperatures. The darker the color, the cooler the surface temperature. So dark colors on inside surfaces, when taken on a cold day, usually indicates more rapid heat loss through the materials which make up that part of the building's shell or envelope. There are caveats: the emissivity of a reflective material, for example, such as glass or metal, may not show accurately.

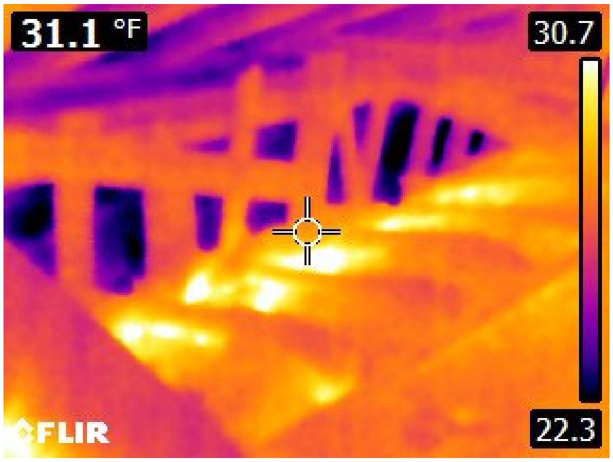


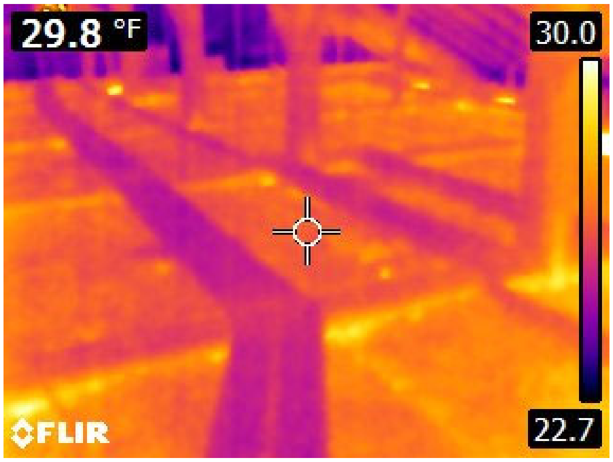


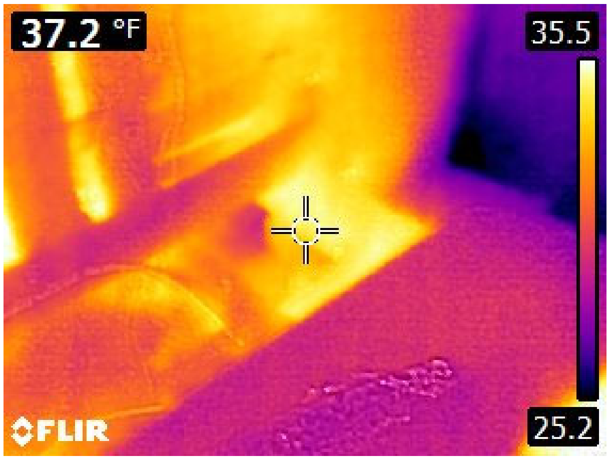
The Sanctuary—Ceiling

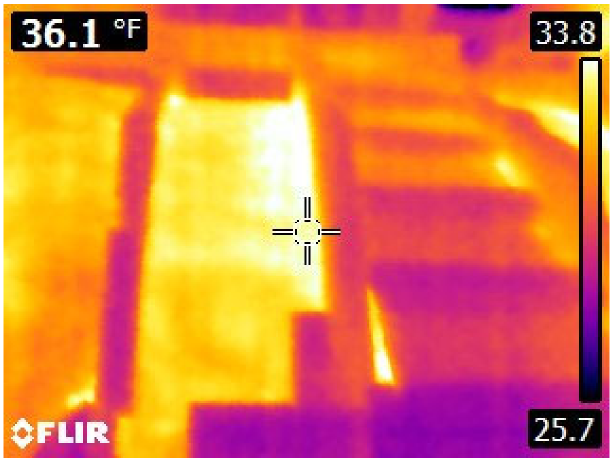
Standing in the attic looking at the floor, these bright colors indicate comparatively warmer surface temperatures as heat from below moves more rapidly along framing or penetrations or uninsulated cavities such as where the framing curves down to the wall. Attic was too dark for digital images, but its still fairly clear what we're looking at just by virtue of heat signatures. Clarke's photos are included on the next page, with gratitude.











Photos courtesy of Clarke

Upgrading the Sanctuary Ceiling Insulation—from an email prior to the site visit

Option A: From an energy cost/savings analysis, the energy savings from
simply blowing in more cellulose on top of what is there - possibly down the curved slopes as well - would be more easily justified from a dollar savings alone.

In other words, there should be energy savings but only enough for a 'reasonable payback' based on the relatively low cost of just blowing in more on top.

How much weight can be supported for additional cellulose is an unknown.

People often use much lighter blown in fiberglass (we in the building science community call it "white fluffy stuff" -
its lighter, so less risk, but its less dense, so poorer performance as it allows air movement. I have yet to ever recommend it

Option B: From a best practices perspective, my suggestion would have been / will be to:

1. remove / vaccum all the existing material (cellulose, foil faced paper and whatever other stuff is lying around)
2. Remove all knob and tube wiring - assuring there are no 'phantom loads' from the old wiring (which can still work, but is only safe when surrounded by air
3. Inspect all framing, wiring, etc - because you can!
4. Spray a 1-1.5" skim coat of closed cell foam onto the back of the lathe
5. Blow in 15" cellulose in an even layer - ideally, you would be covering all framing, though maintaining at least some sort of 'cat walk' is a good idea
6. You could also be sure that the cellulose would only have borates in it for fire/rodent retarding properties - not aluminum sulfates which was/ is cheaper and yet can cause corrosion of wiring. used less widely now, but still worth checking

The cost of that approach would likely not be justifiable from - energy savings alone. It is considered best practices - for the long term - because

a) you have removed all contaminated material, especially from rodents/bats etc
b) starting with a clean and know to be safe substrate - including wiring
c) the closed cell foam establishes an effective air barrier and class 1 vapor retarder, and additional R6 thermal barrier, while also providing some structural strength to support the weight of the cellulose

Option C: A third option would be to use blown in rock or mineral wool instead of cellulose - Rock wool has slightly higher Rvalue but more importantly, better fire retarding properties and is less inviting to rodents. It is also slightly heavier - though 'should' still be okay over the foam substrate. Perhaps the plasterer will - at that time - be able to offer an opinion of the strength/condition of the lathe and new plaster layer.

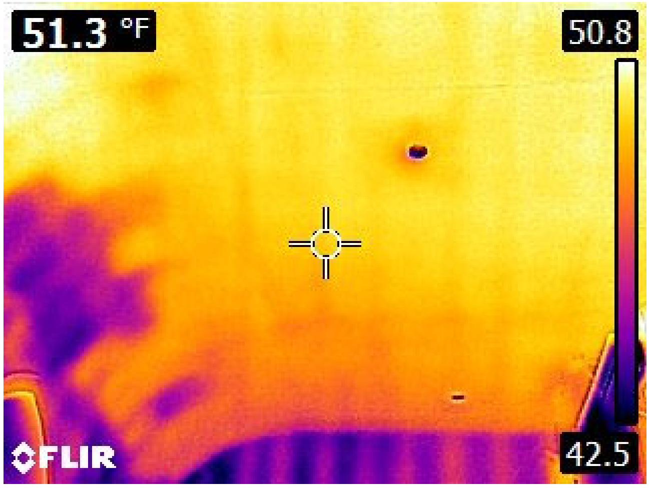
Considerations

1. The energy saving impact from going from R20to R50 is relatively small. An effective R50 with no thermal bridging is minimum for a 21st century ceiling plane - but there is a law of diminishing returns from a dollar cost perspective

2. Closed cell foam has a relatively high GWP (global warming potential) and embodied energy; a two part chemical which off gasses (quickly) toxic materials, and is flammable. Its use is only suggested when its the 'best' product for the situation and in as limited a quantity as possible. Ie - its a very effective option for this type of ceiling skim coat and for below grade rock wall foundations.

In sum, if you can accept the considerations, Option B or C remains 'best practices' but will be more expensive and beyond an impressive financial return on investment.

The Sanctuary—Walls



With all the discussion about improving the insulation above the ceiling—which is recommended as part of the plaster refurbishment—the uninsulated walls are a source of significant losses! People tend to say "heat rises", but in fact, warm air rises due to it being less dense or lighter than cold air and the process of convection. But heat moves to cold, via conduction, in any direction. In other words, an effective air and insulation barrier at the ceiling is important to slow heat loss by both conduction and convection, but insulating the walls effectively can be equally important.

Mineral—or rock—wool is recommended for the walls because it is resistant to moisture which may form as condensation on the cold stone. Like cellulose, the insulation is vapor open which means it would allow drying to the interior through the plaster walls.

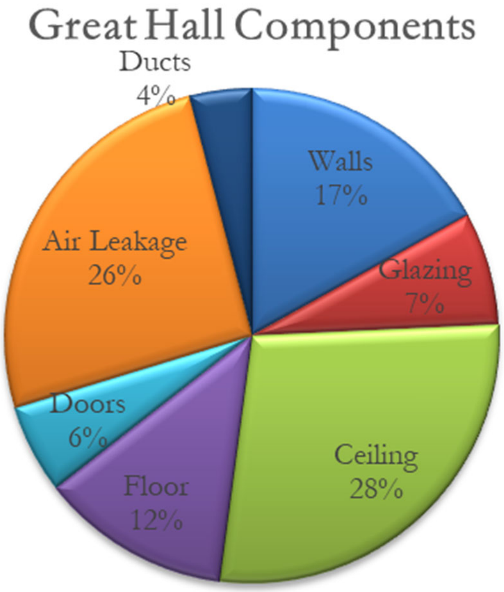
The Sanctuary– Floor / Basement

Most of the Sanctuary is over narrow crawlspace and dirt floor. Served by two high efficiency condensing furnaces, the duct work is neither air sealed nor insulated. This is actually somewhat helpful in that the have helped keep the basement warm and dry. But note that the warmer floor above is also heating the crawlspace and basement.

The Sanctuary– Floor / Basement

The recommendation is to lay (admittedly with some difficulty) a 10 ml vapor barrier (commercial grade Stego Wrap or similar) over the entire dirt floor, tape sealing it to piers, other penetrations, and exterior foundations walls. Then spraying 2" inches closed cell foam on the foundation walls up to the sills. The purpose of this is to effect both an air and vapor barrier at the floor and walls to prevent migration of moisture and other soil gasses. Mastic sealing all rigid duct work is also advised, though insulation is less necessary within what would then be the thermal envelope.

The Great Hall



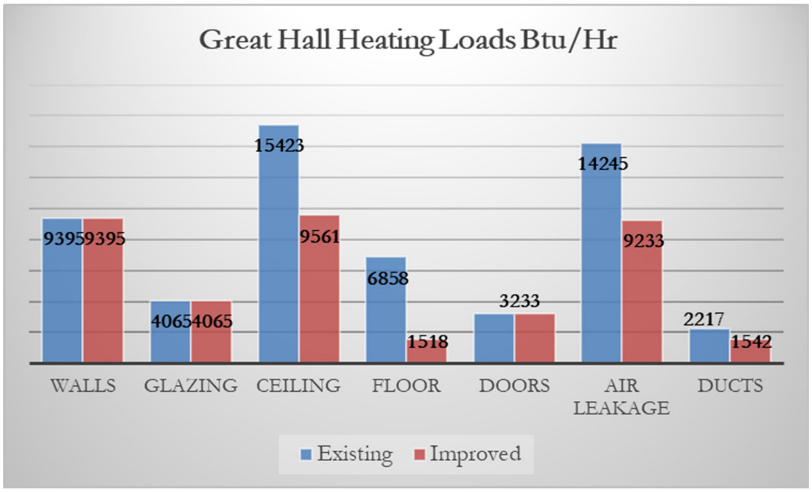
As noted earlier, the type and thickness of the roof or ceiling insulation is not known. But based on my estimates, the total ceiling represents the most significant source of heat loss from the Hall, followed by air leakage, walls, and floor. As is often the case, selecting ESM is a balancing act between energy saving potential and the installed cost of the measure.

In this case, air sealing and re-insulating the slopes of the adjoining attic, insulating the crawlspace below, and targeted air sealing are predicted to be cost effective with annual savings of just under $700 and a 4% yearly return for 25 years at today's energy prices.

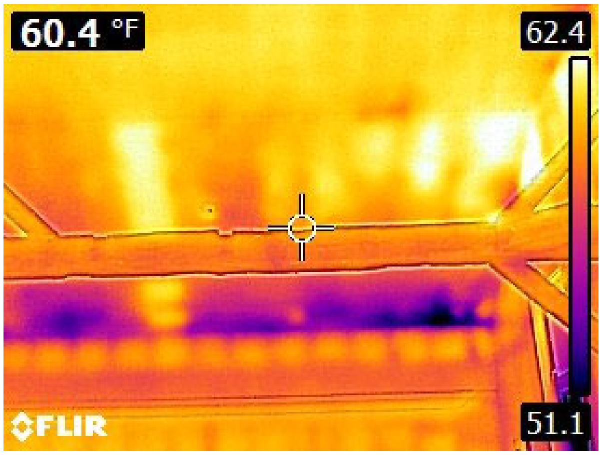
1. Air Sealing: Install commercial grade weatherstripping to the two double doors and original wood door.
2. Foundation: Lay a minimum thickness of 10ml Vapor Barrier on the floor of the crawl space, extending 6-10" up the foundation wall, then spray 3" closed cell foam from the rim joists/beam down over the liner, or to 1' above the floor in the basement area. This combination results in a continuous vapor (including soil gasses), air, and thermal barrier, thereby bringing the basement and crawlspace into the thermal envelope (Photos not available).
3. The slopes on the north end of the Hall are believed to be accessible by the 2009 attic, though not by me. If this presumption is correct, the IR images on the next page suggest that any insulation on the ceiling slope is performing very poorly. Air sealing all framing seams and insulating the rafter bays with a minimum effective R30 is what was modeled for this ESM. Spray foam is an option, but so would be installing netting and dense packing cellulose or mineral wool.

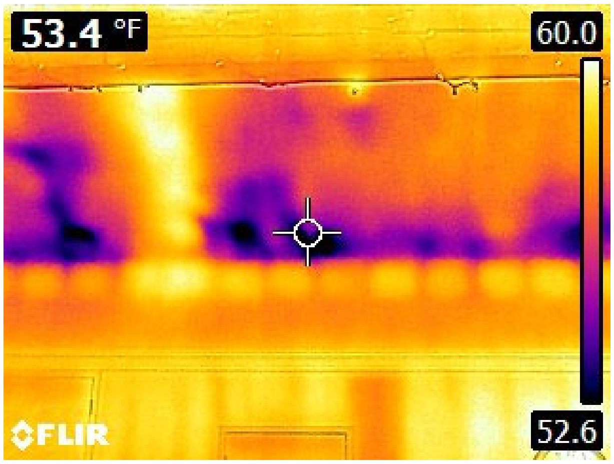
The existing heating load is calculated at 55,436 Btu/Hr. Following recommended improvements, the resulting load would be calculated at 38,547 Btu/Hr.

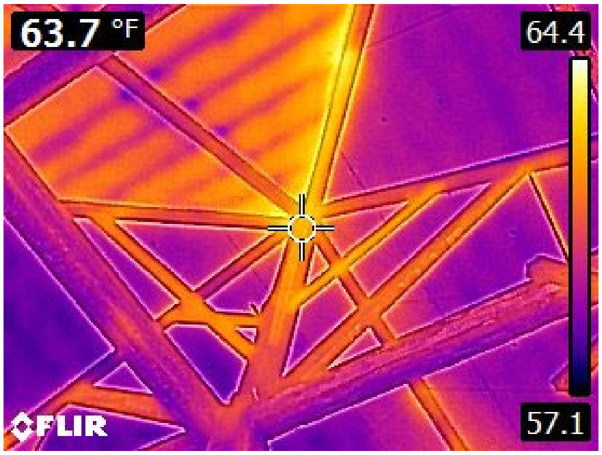
If the Church decided to convert to electric heat pumps at some point in the future, the existing conditions would likely require a 5-ton condensing unit while a 3-ton unit would likely suffice for the improved conditions.



The Great Hall—Ceilings

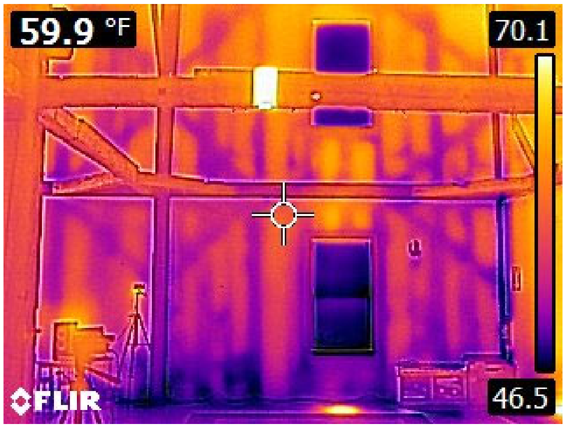






Its difficult to interpret the ceiling (s) of the Great Hall from the IR image above, but it appears that there are rigid foam panels above most of the framing. The slopes adjoining the attic of above the kitchen appear to have fiberglass batt insulation but without effective air sealing. I was not able to access this area in the attic but presume it is accessible (with difficulty) and that removing batts to air seal then replace batts with an air barrier membrane will effect a considerable improvement.

The Great Hall—Walls



The walls of the Great Hall have insulation in the cavity bays—which is a good thing! But note the impact of framing on what's called "thermal bridging". Wood framing accounts for 18-20% of the wall surface area—so what might be optimistically thought of as an "R19" wall, has an effective performance of R12. Improving wall performance by removing siding and wrapping the exterior with rigid insulation is part of what is considered a "Deep Energy Retrofit". In this case, the predicted savings would be less than $400 per year at today's propane prices; very hard to justify the $45-65K cost on dollar savings alone. Other benefits include reducing the total load if converting to heat pumps; replacing siding allows for improving window flashing and adding a drainage plane and back venting for greater durability, and reducing another ton of green house gas emissions.

The Great Hall—Walls

Framing Member Depth (inches)	5.5
Framing Member Thermal Resistance (R/inch)	1.10
Framing Member % of assembly surface area	20%
Cavity Insulation Depth (inches)	5.5
Cavity Insulation Thermal Resistance (R/inch)	2.25
Continuous Insulation Thickness (inches)	0.00
Continuous Thermal Resistance (R/inch)	0.00
Drywall, sheathing and air films	2.00
Nominal R Value, framing + insulation	12.4
System R Value, framing + insulation	10.2
Overall R value	*12.2*

Based on voids and air leakage sites

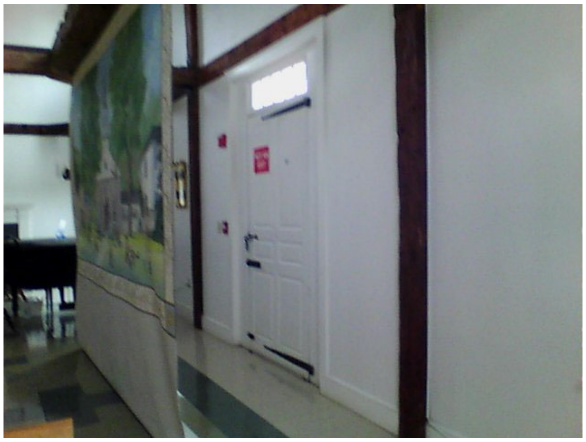
Framing Member Depth (inches)	5.5
Framing Member Thermal Resistance (R/inch)	1.10
Framing Member % of assembly surface area	20%
Cavity Insulation Depth (inches)	5.5
Cavity Insulation Thermal Resistance (R/inch)	2.75
Continuous Insulation Thickness (inches)	3.00
Continuous Thermal Resistance (R/inch)	4.00
Drywall, sheathing and air films	2.00
Nominal R Value, framing + insulation	27.1
System R Value, framing + insulation	24.6
Overall R value	*26.6*

Based on voids but air leakage sites sealed on the exterior

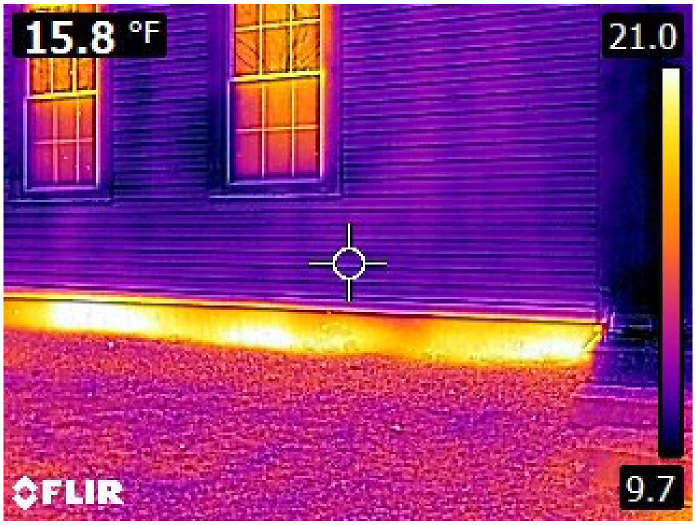
Adding three inches of vapor open Roxul Comfortboard on the exterior (R4 per inch) more than doubles the thermal performance of the walls. It also allows for improved window flashing, a continuous air barrier, and installing a drainage plane and vented siding to prolonged paint life and overall durability. It usually makes sense to also upgrade windows at the same time. It is not a cost effective energy saving measure at this time, but included here as it would be a 'next step' toward achieving a net zero building.

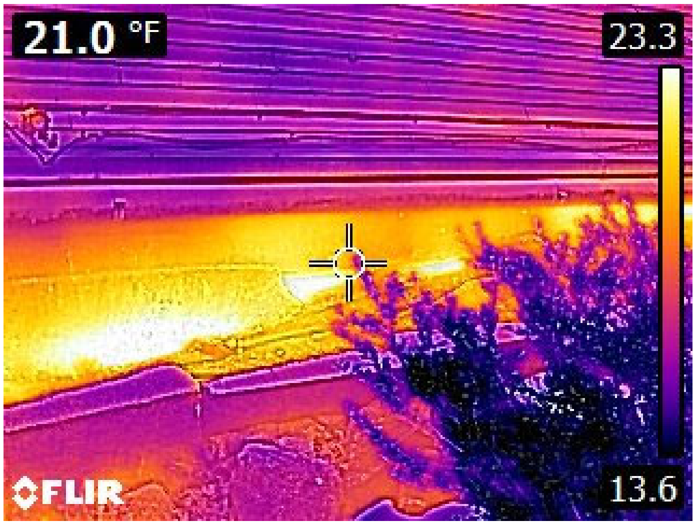
ROCKWOOL COMFORTBOARD™ 110 is a rigid, high density, non-combustible, stone wool insulation board designed for use as an exterior continuous insulation in commercial applications. This thermally efficient, moisture resistant, vapor permeable board is effective against fire, moisture, thermal bridging and allows for superior drying potential.

The Great Hall—Floor (Basement)



The Great Hall—Floor (Basement)





Unfortunately, photos of the basement were not saved. However these exterior IR images suggest the significance of uninsulated foundation walls and the relative heat loss—heat which is lost from the floor, down into the crawlspace and basement, then out the foundation walls. Insulating the walls—and not the floor—is strongly recommended in order to prevent an even colder—and damper - crawlspace.

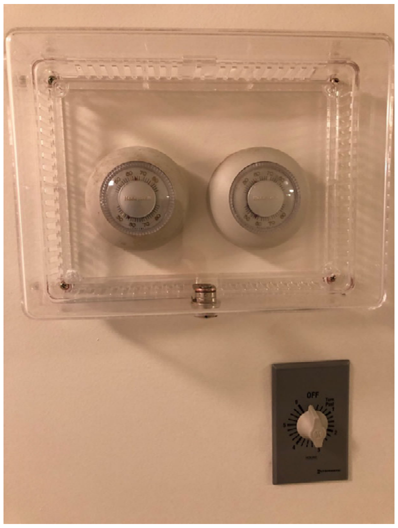
While not a perfect analogy, one can think of a warm and dry basement the same way one might think of warm and dry feet. A good pair of socks can make the difference for one's comfort and health: so it is with a warm and dry basement's impact on the durability and comfort of a building.

Heading Systems—Great Hall Basement

Great Hall

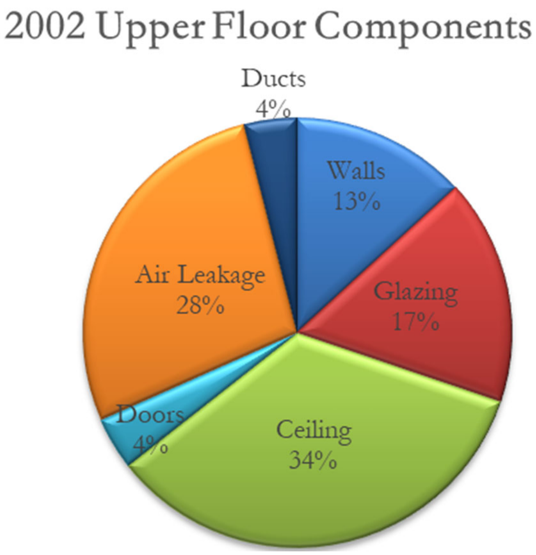
It appears that a dehumidifier may be set up to drain into a humidifier in the furnace air handler. Current thinking in building science is to resist adding moisture to ducted air systems. Dry air is a condition of outside air leakage so air sealing can raise indoor humidity enough to improve comfort, without blowing or 'forcing' moisture into the envelope layers.

2002 Downstairs



There are more modern programmable thermostats, but it appears that the dial type thermostats set up for 'occupied' and 'unoccupied' may be working adequately. One advantage to installing 7-day digital programmable would be the 'auto reset' function. If someone overrides the program, it will automatically revert to the pre-set temperature in 2 hours.

2002 Addition



In this part of the building, the ceiling and air leakage account for over 62% of heat loss. Window glass accounts for 17% of conductive losses, but both windows and doors are partly responsible for the air leakage—which is not included in the 4% and 17% which is only about conductive heat transfer.

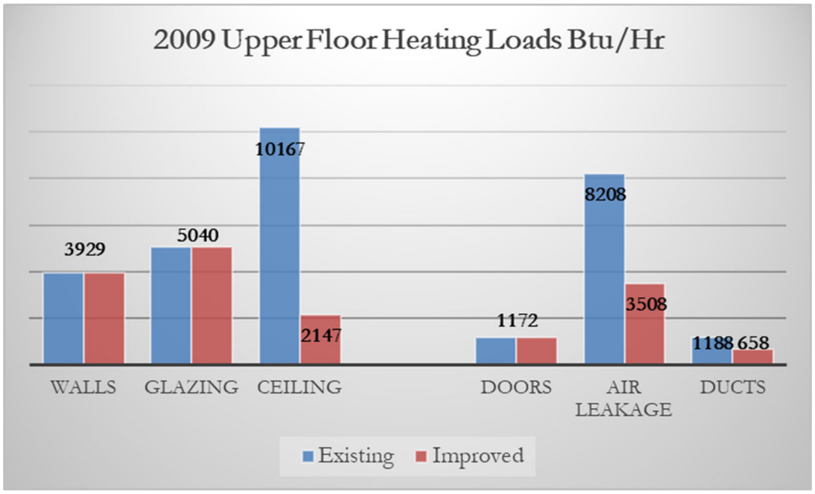
These percentages are not at all uncommon for buildings constructed in NH from the 1980's to 2010 or even more recently. The reliance on fiberglass batts for ceiling insulation, without being in contact with a continuous air barrier on all six sides, allows for outside air to bypass the insulation and cool the outer surface of the ceiling, especially around the framing. (See photos on next two pages).

Adding weather-stripping to the exterior doors and around the windows is recommended. However, the most effective way to reduce uncontrolled air leakage is to effect a continuous air barrier at the ceiling plane.

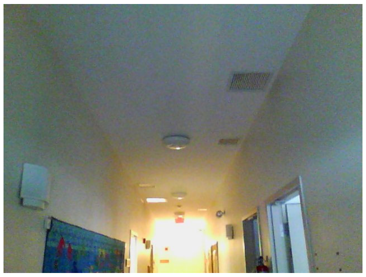
A good place to start is to construct or purchase a thermodome for above the drop down ladder. It should be weighted or heavy enough to form a good seal against weatherstripping when in place. Air sealing all ceiling penetrations, the perimeter of the attic, and all interior wall top plates—with silicone sealant or a two part foam—will require moving the existing fiberglass aside. In this case, it is suggested to move the insulation aside on half the attic, air seal, then blow in 6 inches of cellulose on top of the existing vapor retarder, before spreading the batts back on top of the cellulose—perpendicular to the joists—followed by an other 8" layer of cellulose—making sure to keep the fiberglass at least two feet from the perimeter of the attic and completely incased in cellulose. Mound insulation over the ducts at least one foot thick.

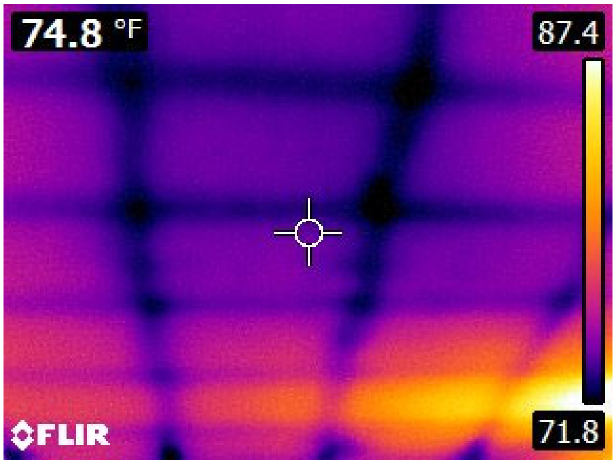
While not an ideal strategy, it is less expensive than removing all the insulation entirely and puts to the best use possible of all that fiberglass. The goal is to limit its exposure to air to prevent wind washing and thermal bypass areas.

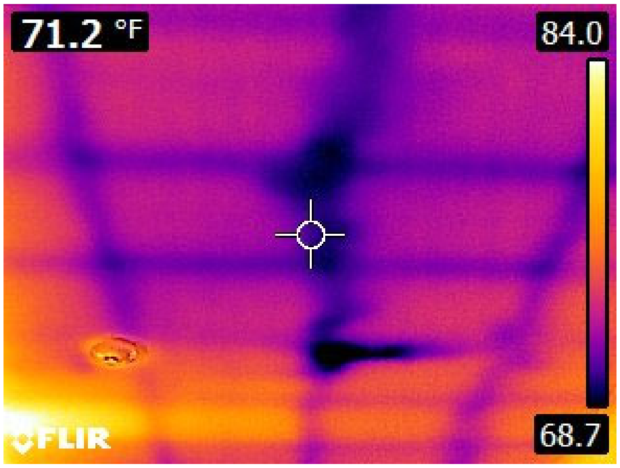
These measures are predicted to result in a 45% reduction in heat loss through envelope components and duct work.



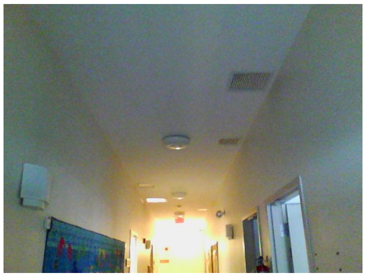
2009 Addition—Ceiling

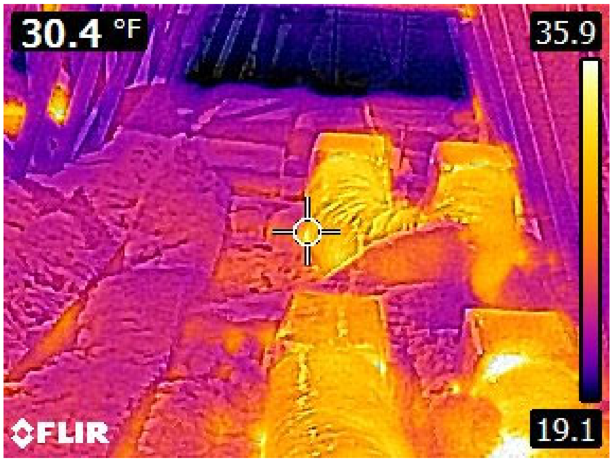






2002 Addition—Ceiling

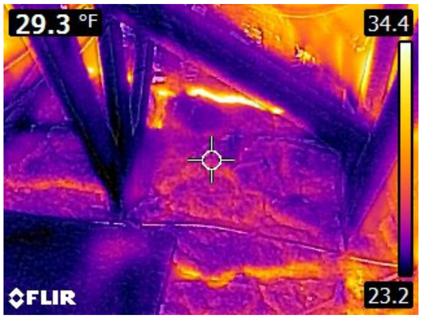


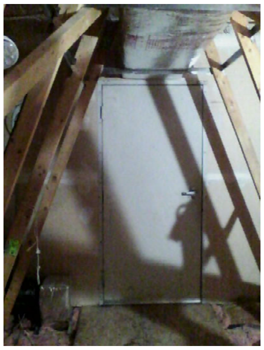


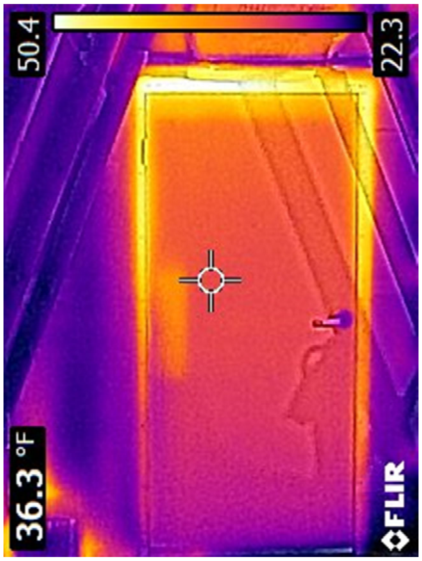
Brighter colors indicate warmer surfaces—and in this case, when standing in a cold attic, heat loss from conditioned space below.

2002 Addition—Ceiling

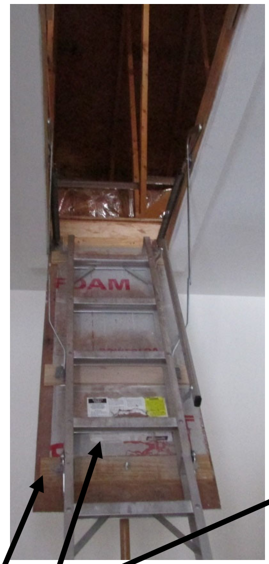
There is a lot of fiberglass material on the floor of this attic, but it is installed in such a way which still allows considerable heat loss through thermal bridging and thermal ‘bypass’; that is, wherever fiberglass isn’t in contact with an air barrier on the ceiling side, cold air can move into contact with the ceiling, thereby bypassing the insulation.

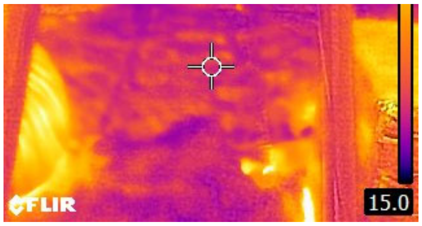


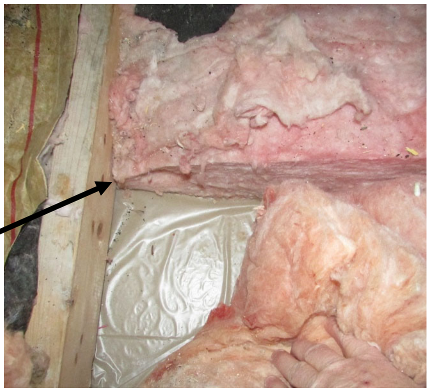




A “thermodome” over the ladder is recommended.







Insulation thickness ranges from 0 to 12 inches. But average depth isn’t as important as continuity and an air barrier.

2002 Addition—Pressure Plane

Warm air rises because its lighter—and less dense—than colder air. When heating ducts are in the ceiling, warm air can tend to stay closer to the ceiling, also in part due to a ‘pressure plane’ - that is a line of pressure caused by cold air filtration coming from lower in the building then rising as it is heated. This can cause a stratification of temperature layers such as in the photos above. The top of the exterior walls are over 20 degrees warmer than the floor. As the ceiling plane gets ‘tighter’ and air infiltration from the floor and windows is reduced, the temperature difference between the floor and the ceiling is reduced.

Heating Systems—2002 Addition Attic

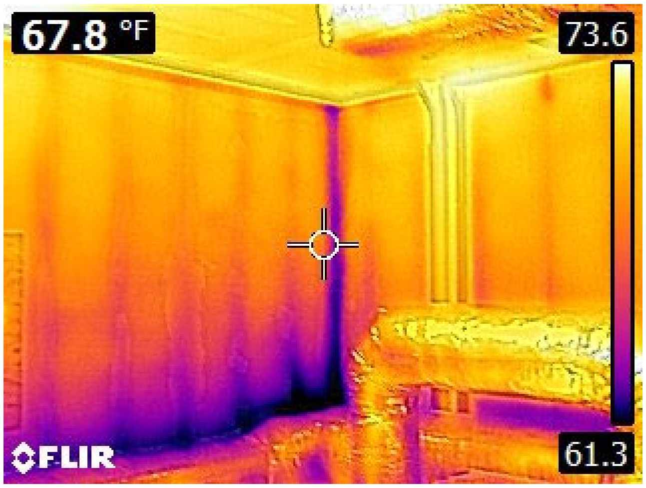
WEIL-McLAIN
GV

Boiler Model (Modele de Chaudiere)............... GV-4
Series No. (Nom bre de Serie)............... 4
Type of Gas (Type de Gaz)............... Natural (Naturel)
Input (Entree)............... 105,000 Btu/hr (30,8 kW)
Inlet Gas Pressure (Pression de gaz d-entre)
Maximum............... 13.0 "wc (3,2 kPa)
Minimum............... 4.0 "wc (1,0 kPa)
Manifold Gas Pressure (Pression de gaz au collector)........ -0.2 "wc (-0,05 kPa)
D.O.E. Heating Capacity (D.O.E. Capacite de chauffage)........ 92,000 Btu/hr (27,0 kW)
Net I=B=R Output (Sortie Nette d'I=B=R) Water (Eau)............... 80 MBH (23,4 kW)
Electrical Input less than 12 amperes, 120 volts, 60 hertz
(Entree electrique moins de 12 amperes, 120 volts, 60

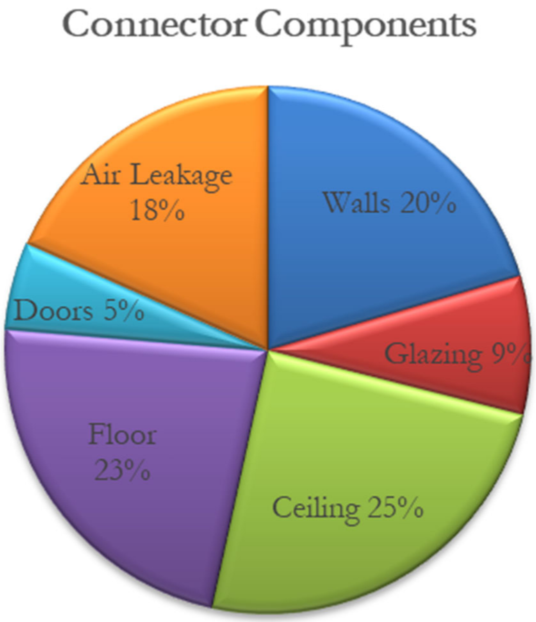
Weil McLean oil boiler converted to propane. Input 105,000 Btu/hr

D.O.E. Output Capacity 92MBH and Net IBR 80MBH

Reznor serves kitchen heating and range hood air handling



1990 Connector Addition



The Connector Addition is defined, for this study, as the two story structure and Sacristy, all heated by the propane boiler in the 2002 attic and hydronic (hot water) baseboard.

The pie char shows a fairly equal distribution of 'heat loss responsibility'. In this case, the ESM are based on what's more easily accessible: weather-stripping exterior doors and air sealing and adding insulation above the ceiling.

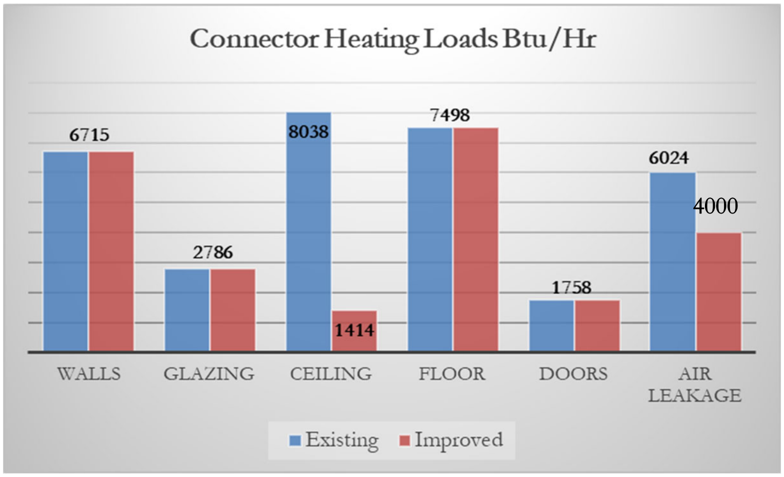
The 'floor's losses include the crawl space under the Sacristy, but no access was located. The rim and band joists of the ceiling, and walls, of the Youth Room all show signs of air leakage, but the cost to remove and replace drywall makes the cost to high for the potential savings and CO2 reductions. These areas are mentioned here in the event that renovations or other changes are planned.

Generally speaking, whenever finished surfaces are removed, it is always worth diligently air sealing and exploring opportunities to improve the insulation layer. That can often mean replacing fiberglass with dense pack cellulose, or other high density strategy.

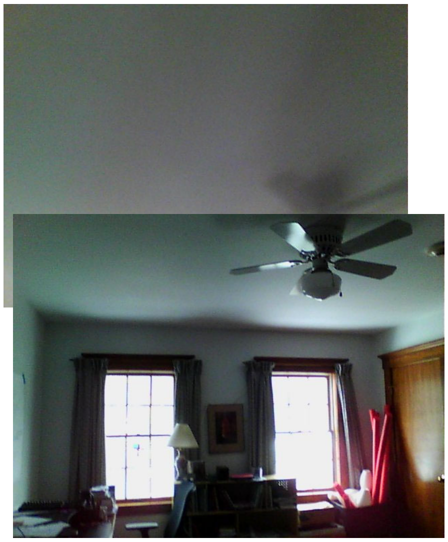
The recommended ESM in this study are:

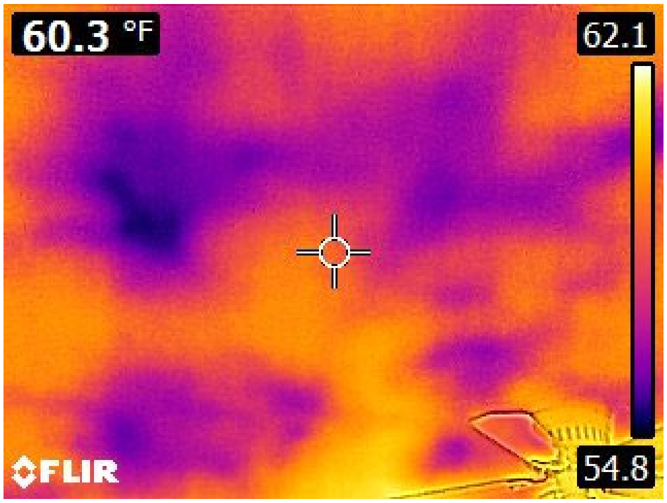
1. Install commercial grade weatherstripping to the two exterior doors in the hall between the Sacristy and the Sanctuary.
2. There appears to be an access to the space above the ceiling in the Office of the upper level. This was not accessed during the site visit but the IR images as shown on the next page clearly indicate severe deficiencies in the insulation. Access above the Sacristy was not located. The estimated cost is based on 1305 ft2 of ceiling at $3.95 per ft2. This should allow for any necessary air sealing and blowing in an additional 16-18" cellulose. If the existing material has gotten wet, or is contaminated by rodents, it should be removed which may increase the cost.

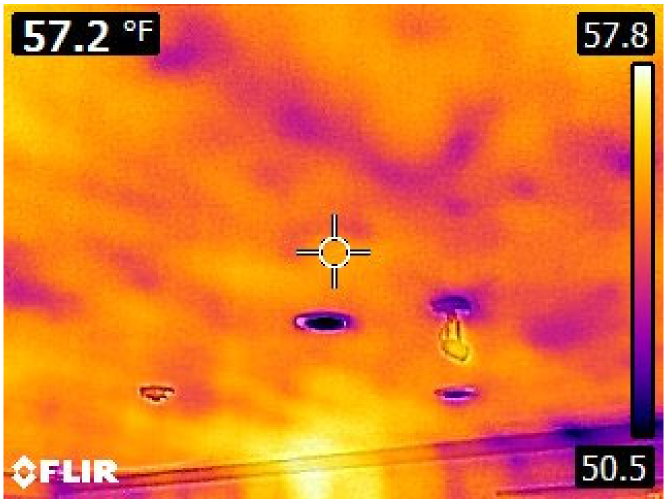
The two measures are predicted to result in a load reduction of 28% - from 29,704Btu/Hr (2.5 tons of heat pump) to 16,454 (1.5 tons of heat pump) is substantial.



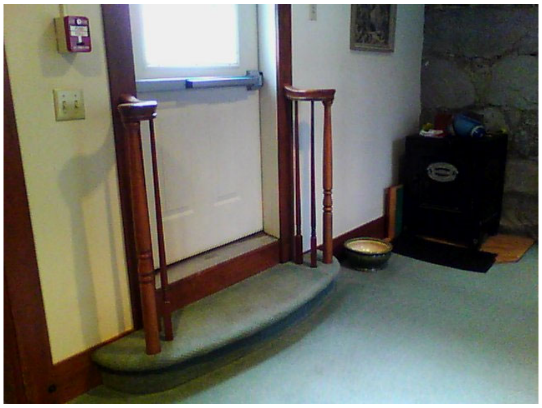
2002 Addition Ceiling

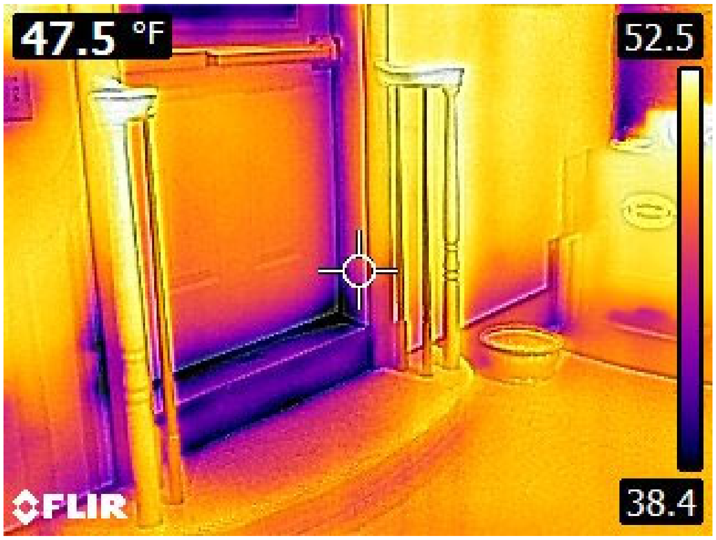


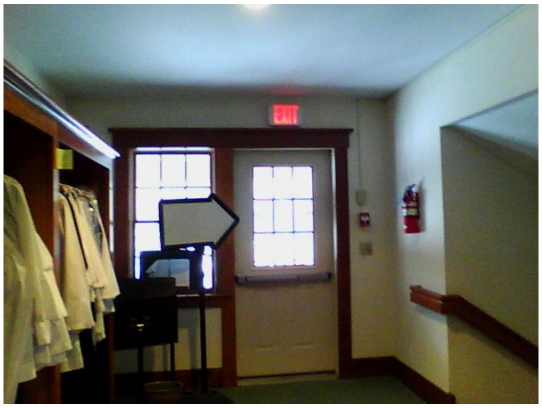




Sacristy and Hall



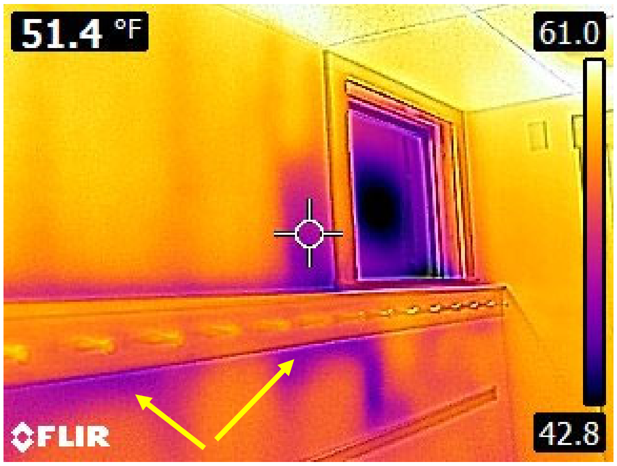




1990 Addition; Lower Floor

There are deficiencies in the thermal envelope of the lower levels of both the 1990 and 2002 additions, however the costs would involve removing and replacing finished surface, which would substantially outweigh the potential energy savings.

Air sealing the gaps and cracks between wood framing members and transitions from one structural element to another is the most glaring issue as seen below: where foundation wall meets stick framing and the rim/band joists between floors.



St. Andrews EXISTING CONDITIONS
HVAC Load Calculations

for

St Andrews Episcopal Church
Main Street
Hopkinton, NH

Prepared By:

Margaret Dillon
S.E.E.D.S.

603-532-8979
Tuesday, April 13, 2021

Rhvac is an ACCA approved Manual J, D and S computer program.
Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.

Project Report

General Project Information

Project Title:	St. Andrews EXISTING CONDITIONS
Project Date:	Saturday, April 3, 2021
Client Name:	St Andrews Episcopal Church
Client Address:	Main Street
Client City:	Hopkinton, NH
Company Name:	S.E.E.D.S.
Company Representative:	Margaret Dillon
Company Phone:	603-532-8979
Company E-Mail Address:	mdillon@myfairpoint.net

Design Data

Reference City:		Concord AP, New Hampshire
Building Orientation:		Front door faces East
Daily Temperature Range:		High
Latitude:	43	Degrees
Elevation:	510	ft.
Altitude Factor:	0.982	

	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	n/a	n/a	55	n/a
Summer:	87	70	43%	50%	75	19

Check Figures

Total Building Supply CFM:	1,862	CFM Per Square ft.:	0.173	*
Square ft. of Room Area:	10,779	Square ft. Per Ton:	0	**
Volume (ft³):	117,912***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

Building Loads

Total Heating Required Including Ventilation Air:	142,030	Btuh	142.030	MBH

Notes

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Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.
All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

Miscellaneous Report

System 1 Great Hall Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

System 2 Choir And Youth Room Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

System 3 Kitchen Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

System 4 Classroom Wing & Hall Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

System 5 Boiler.Connector Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

Duct Sizing Inputs

	Main Trunk		Runouts	
Calculate:	Yes		Yes	
Use Schedule:	Yes		Yes	
Roughness Factor:	0.00300		0.01000	
Pressure Drop:	0.1000	in.wg./100 ft.	0.1000	in.wg./100 ft.
Minimum Velocity:	0	ft./min	0	ft./min
Maximum Velocity:	900	ft./min	750	ft./min
Minimum Height:	0	in.	0	in.
Maximum Height:	0	in.	0	in.

Outside Air Data

	Winter		Summer	
Infiltration Specified:	0.267	AC/hr	0.142	AC/hr
	525	CFM	280	CFM
Infiltration Actual:	0.267	AC/hr	0.142	AC/hr
Building Volume:	X 117,912*	Cu.ft.	X 117,912*	Cu.ft.
	31,488	Cu.ft./hr	16,776	Cu.ft./hr
	X 0.0167		X 0.0167	
Total Building Infiltration:	525	CFM	280	CFM
Total Building Ventilation:	0	CFM	0	CFM

*Indicated volume is based on custom building volume.

---System 1---

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.280 AC/hr (231 CFM), Construction: Average
Summer Infiltration Specified: 0.150 AC/hr (124 CFM), Construction: Average

---System 2---

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.100 AC/hr (40 CFM), Construction: Tight
Summer Infiltration Specified: 0.050 AC/hr (20 CFM), Construction: Tight

---System 3---

Miscellaneous Report (cont'd)

Outside Air Data

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.280 AC/hr (22 CFM), Construction: Average
Summer Infiltration Specified: 0.150 AC/hr (12 CFM), Construction: Average

---System 4---

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.430 AC/hr (133 CFM), Construction: Semi-Loose
Summer Infiltration Specified: 0.230 AC/hr (71 CFM), Construction: Semi-Loose

---System 5---

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.280 AC/hr (98 CFM), Construction: Average
Summer Infiltration Specified: 0.150 AC/hr (52 CFM), Construction: Average

Duct Load Factor Scenarios for System 1

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	6	677	No
1	Return		Closed Crawl A	-	0.12	6	251	No

Duct Load Factor Scenarios for System 2

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	6	677	No
1	Return		Closed Crawl A	-	0.12	6	251	No

Duct Load Factor Scenarios for System 3

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	6	677	No
1	Return		Closed Crawl A	-	0.12	6	251	No

Duct Load Factor Scenarios for System 4

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	6	677	No
1	Return		Closed Crawl A	-	0.12	6	251	No

Load Preview Report

Scope	Net Ton	ft.²/Ton	Area	Sen Gain	Lat Gain	Net Gain	Sen Loss	Sys Htg CFM	Sys Clg CFM	Sys Act CFM	Duct Size
Building	0.00	0	10,779	0	0	0	142,030	1,862	0	1,862	
System 1	0.00	0	2,173	0	0	0	55,436	725	0	725	10x14
Return Duct				0	0	0	600				
Zone 1			2,173	0	0	0	54,837	725	0	725	10x14
1-Great Hall			2,173	0	0	0	54,837	725	0	725	7--7
System 2	0.00	0	3,285	0	0	0	20,976	273	0	273	7x9
Return Duct				0	0	0	340				
Zone 1			3,285	0	0	0	20,635	273	0	273	7x9
2-Utility Room			644	0	0	0	488	6	0	6	1--4
3-Choir Room			504	0	0	0	1,815	24	0	24	1--4
4-Hall			343	0	0	0	428	6	0	6	1--4
5-Youth Room			1,794	0	0	0	17,905	237	0	237	3--6
System 3	0.00	0	371	0	0	0	3,095	40	0	40	4x4
Return Duct				0	0	0	33				
Zone 1			371	0	0	0	3,061	40	0	40	4x4
15-Kitchen			371	0	0	0	3,061	40	0	40	1--5
System 4	0.00	0	2,110	0	0	0	29,704	389	0	389	8x11
Return Duct				0	0	0	321				
Zone 1			2,110	0	0	0	29,383	389	0	389	8x11
16-Entry & Hall			660	0	0	0	7,056	93	0	93	1--6
17-Assistant			192	0	0	0	2,495	33	0	33	1--4
18-Lg Classroom			442	0	0	0	8,668	115	0	115	2--5
19-Chapel			344	0	0	0	7,254	96	0	96	1--6
20-Nursery			344	0	0	0	3,910	52	0	52	1--5
21-2009 Restrooms			128	0	0	0	0	0	0	0	0--0
System 5	0.00	0	2,840	0	0	0	32,819	434	0	434	8x12
Zone 1			2,840	0	0	0	32,819	434	0	434	8x12
6-Atrium			1,260	0	0	0	8,846	117	0	117	2--5
7-Restroom			104	0	0	0	1,041	14	0	14	1--4
8-Hall			170	0	0	0	2,095	28	0	28	1--4
9-2nd Floor Connector Hall			154	0	0	0	3,428	45	0	45	1--5
10-Office			288	0	0	0	3,025	40	0	40	1--5
11-Rector			144	0	0	0	1,905	25	0	25	1--4
12-Library			240	0	0	0	2,729	36	0	36	1--4
13-Hall Landing			216	0	0	0	3,853	51	0	51	1--5
14-Sacristy			264	0	0	0	5,897	78	0	78	1--6

Total Building Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Replacement: Glazing-Wood double hung, DP, clear, U-value 0.36, SHGC 0.57	192.2	3,939	0	0	0
1E-cm: Glazing-Double pane window, fixed sash, clear, metal frame no break, U-value 0.69, SHGC 0.69	6.2	244	0	0	0
double pane: Glazing-wood thermal pane window 90s, U-value 0.47, SHGC 0.56	253.4	6,788	0	0	0
double pane: Glazing-wood thermal pane window 90s, U-value 0.37, SHGC 0.56	120.5	2,542	0	0	0
11G: Door-Wood - Panel, U-value 0.54	175.4	5,400	0	0	0
11J: Door-Metal - Fiberglass Core, U-value 0.6	39.4	1,349	0	0	0
Great Hall Walls: Wall-Frame, Custom, Insulated 2x6 with 20% framing factor, U-value 0.08	1964.9	8,961	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	2952	11,444	0	0	0
15A11-0ocw-2: Wall-Basement, , framing with R-11 sill to floor in 2 x 4 cavity, open core, no board insulation, plus interior finish, wood studs, 2' floor depth, U-value 0.074	1077	5,856	0	0	0
18A-13: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Dark or Bold-Color Asphalt Shingle, Dark Metal, Dark Membrane, Dark Tar and Gravel, R-13 blanket or loose fill, U-value 0.076	2371.2	10,272	0	0	0
Slopes to Attic: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Custom, Slopes Enclosed by new attic, U-value 0.241	492	6,759	0	0	0
Fiberglass: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Batts on VB with penetrations, U-value 0.09	851.5	4,368	0	0	0
Fiberglass-ml: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Batts on VB with penetrations, light metal, U-value 0.09	1130.5	5,799	0	0	0
Blown In: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, R10 Estimated.Large Voids, U-value 0.108	1305.8	8,038	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.168	4712.1	23,182	0	0	0
Subtotals for structure:		104,941	0	0	0
People:	20		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		4,788	0	0	0
Infiltration: Winter CFM: 525, Summer CFM: 280		32,301	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
Total Building Load Totals:		142,030	0	0	0

Check Figures

Total Building Supply CFM:	1,862	CFM Per Square ft.:	0.173 *
Square ft. of Room Area:	10,779	Square ft. Per Ton:	0 **
Volume (ft³):	117,912***		

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.

Total Building Summary Loads (cont'd)

Check Figures

** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

Building Loads

Total Heating Required Including Ventilation Air:	142,030	Btuh	142.030	MBH

Notes

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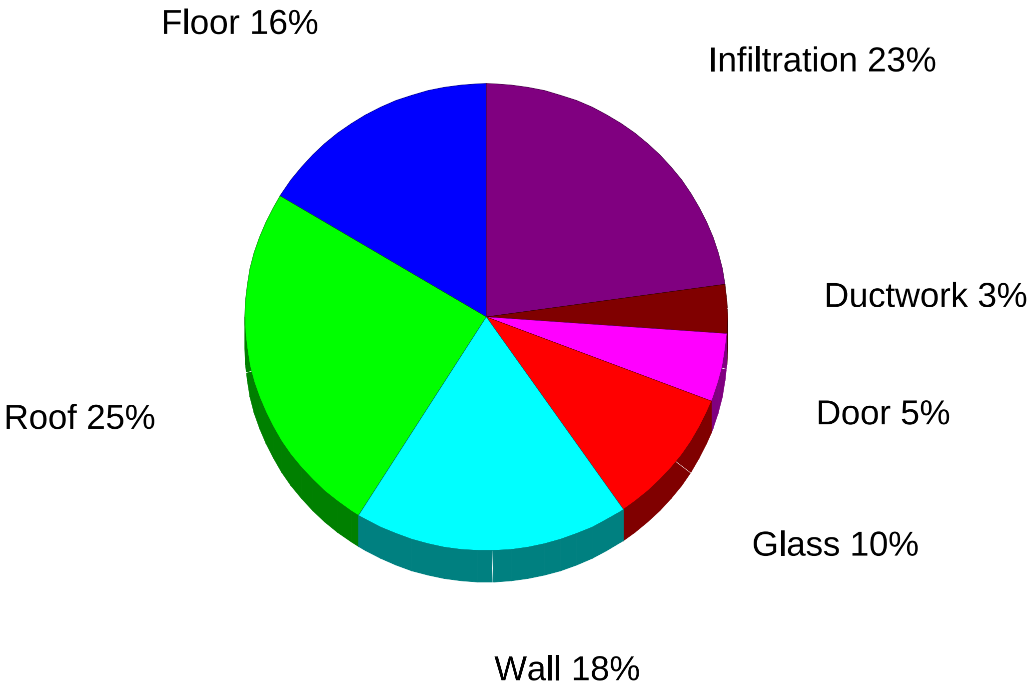
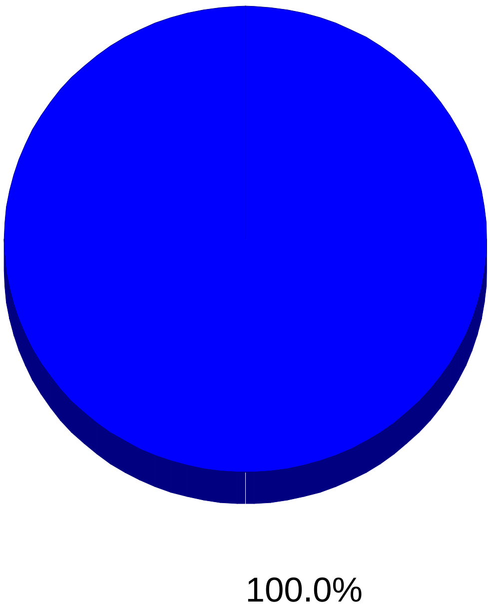
Building Pie Chart





System 1 Great Hall Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Replacement: Glazing-Wood double hung, DP, clear, U-value 0.36, SHGC 0.57	192.2	3,939	0	0	0
1E-cm: Glazing-Double pane window, fixed sash, clear, metal frame no break, U-value 0.69, SHGC 0.69	3.2	126	0	0	0
11G: Door-Wood - Panel, U-value 0.54	61.2	1,884	0	0	0
11J: Door-Metal - Fiberglass Core, U-value 0.6	39.4	1,349	0	0	0
Great Hall Walls: Wall-Frame, Custom, Insulated 2x6 with 20% framing factor, U-value 0.08	1964.9	8,961	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	112	434	0	0	0
18A-13: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Dark or Bold-Color Asphalt Shingle, Dark Metal, Dark Membrane, Dark Tar and Gravel, R-13 blanket or loose fill, U-value 0.076	2000	8,664	0	0	0
Slopes to Attic: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Custom, Slopes Enclosed by new attic, U-value 0.241	492	6,759	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.168	1394	6,858	0	0	0
Subtotals for structure:		38,974	0	0	0
People:	20		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		2,217	0	0	0
Infiltration: Winter CFM: 231, Summer CFM: 124		14,245	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 1 Great Hall Load Totals:		55,436	0	0	0

Check Figures

Supply CFM:	725	CFM Per Square ft.:	0.334	*
Square ft. of Room Area:	2,173	Square ft. Per Ton:	0	**
Volume (ft³):	49,592***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 55,436 Btuh 55.436 MBH

Notes

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Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

System 2 Choir And Youth Room Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
1E-cm: Glazing-Double pane window, fixed sash, clear, metal frame no break, U-value 0.69, SHGC 0.69	3	118	0	0	0
double pane: Glazing-wood thermal pane window 90s, U-value 0.47, SHGC 0.56	56.2	1,504	0	0	0
11G: Door-Wood - Panel, U-value 0.54	19	586	0	0	0
15A11-0ocw-2: Wall-Basement, , framing with R-11 sill to floor in 2 x 4 cavity, open core, no board insulation, plus interior finish, wood studs, 2' floor depth, U-value 0.074	1029	5,614	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	156.8	608	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.168	1794	8,826	0	0	0
Subtotals for structure:		17,256	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		1,259	0	0	0
Infiltration: Winter CFM: 40, Summer CFM: 20		2,461	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 2 Choir And Youth Room Load Totals:		20,976	0	0	0

Check Figures

Supply CFM:	273	CFM Per Square ft.:	0.083 *
Square ft. of Room Area:	3,285	Square ft. Per Ton:	0 **
Volume (ft³):	23,991***		

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 20,976 Btuh 20.976 MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

System 3 Kitchen Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
18A-13: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Dark or Bold-Color Asphalt Shingle, Dark Metal, Dark Membrane, Dark Tar and Gravel, R-13 blanket or loose fill, U-value 0.076	371.2	1,608	0	0	0
Subtotals for structure:		1,608	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		124	0	0	0
Infiltration: Winter CFM: 22, Summer CFM: 12		1,363	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 3 Kitchen Load Totals:		3,095	0	0	0

Check Figures

Supply CFM:	40	CFM Per Square ft.:	0.109	*
Square ft. of Room Area:	371	Square ft. Per Ton:	0	**
Volume (ft³):	4,745***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air:	3,095	Btuh	3.095	MBH

Notes

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Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

System 4 Classroom Wing & Hall Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
double pane: Glazing-wood thermal pane window 90s, U-value 0.47, SHGC 0.56	188.2	5,040	0	0	0
11G: Door-Wood - Panel, U-value 0.54	38.1	1,172	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	1013.3	3,929	0	0	0
Fiberglass: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Batts on VB with penetrations, U-value 0.09	851.5	4,368	0	0	0
Fiberglass-ml: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Batts on VB with penetrations, light metal, U-value 0.09	1130.5	5,799	0	0	0
Subtotals for structure:		20,308	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		1,188	0	0	0
Infiltration: Winter CFM: 133, Summer CFM: 71		8,208	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 4 Classroom Wing & Hall Load Totals:		29,704	0	0	0

Check Figures

Supply CFM:	389	CFM Per Square ft.:	0.184	*
Square ft. of Room Area:	2,110	Square ft. Per Ton:	0	**
Volume (ft³):	18,606***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 29,704 Btuh 29.704 MBH

Notes

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Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.
All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

System 5 Boiler.Connector Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
double pane: Glazing-wood thermal pane window 90s, U-value 0.37, SHGC 0.56	120.5	2,542	0	0	0
double pane: Glazing-wood thermal pane window 90s, U-value 0.47, SHGC 0.56	9.1	244	0	0	0
11G: Door-Wood - Panel, U-value 0.54	57.1	1,758	0	0	0
15A11-0ocw-2: Wall-Basement, , framing with R-11 sill to floor in 2 x 4 cavity, open core, no board insulation, plus interior finish, wood studs, 2' floor depth, U-value 0.074	48	242	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	1669.9	6,473	0	0	0
Blown In: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, R10 Estimated.Large Voids, U-value 0.108	1305.8	8,038	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.168	1524.1	7,498	0	0	0
Subtotals for structure:		26,795	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		0	0	0	0
Infiltration: Winter CFM: 98, Summer CFM: 52		6,024	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 5 Boiler.Connector Load Totals:		32,819	0	0	0

Check Figures

Supply CFM:	434	CFM Per Square ft.:	0.153	*
Square ft. of Room Area:	2,840	Square ft. Per Ton:	0	**
Volume (ft³):	20,978***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 32,819 Btuh 32.819 MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

St. Andrews IMPROVED
HVAC Load Calculations

for

St Andrews Episcopal Church
Main Street
Hopkinton, NH

Elite Software

RHVAC
Residential
HVAC Loads

Prepared By:

Margaret Dillon
S.E.E.D.S.

603-532-8979
Tuesday, April 13, 2021

Rhvac is an ACCA approved Manual J, D and S computer program.
Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.

Project Report

General Project Information

Project Title:	St. Andrews IMPROVED
Project Date:	Saturday, April 3, 2021
Client Name:	St Andrews Episcopal Church
Client Address:	Main Street
Client City:	Hopkinton, NH
Company Name:	S.E.E.D.S.
Company Representative:	Margaret Dillon
Company Phone:	603-532-8979
Company E-Mail Address:	mdillon@myfairpoint.net

Design Data

Reference City:		Concord AP, New Hampshire
Building Orientation:		Front door faces East
Daily Temperature Range:		High
Latitude:	43	Degrees
Elevation:	510	ft.
Altitude Factor:	0.982	

	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	n/a	n/a	55	n/a
Summer:	87	70	43%	50%	75	19

Check Figures

Total Building Supply CFM:	1,353	CFM Per Square ft.:	0.126	*
Square ft. of Room Area:	10,779	Square ft. Per Ton:	0	**
Volume (ft³):	117,912***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

Building Loads

Total Heating Required Including Ventilation Air:	103,242	Btuh	103.242	MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

Miscellaneous Report

System 1 Great Hall Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

System 2 Choir And Youth Room Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

System 3 Kitchen Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

System 4 Classroom Wing & Hall Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

System 5 Boiler.Connector Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

Duct Sizing Inputs

	Main Trunk		Runouts	
Calculate:	Yes		Yes	
Use Schedule:	Yes		Yes	
Roughness Factor:	0.00300		0.01000	
Pressure Drop:	0.1000	in.wg./100 ft.	0.1000	in.wg./100 ft.
Minimum Velocity:	0	ft./min	0	ft./min
Maximum Velocity:	900	ft./min	750	ft./min
Minimum Height:	0	in.	0	in.
Maximum Height:	0	in.	0	in.

Outside Air Data

	Winter		Summer	
Infiltration Specified:	0.170	AC/hr	0.155	AC/hr
	334	CFM	304	CFM
Infiltration Actual:	0.170	AC/hr	0.155	AC/hr
Building Volume:	X 117,912*	Cu.ft.	X 117,912*	Cu.ft.
	20,048	Cu.ft./hr	18,231	Cu.ft./hr
	X 0.0167		X 0.0167	
Total Building Infiltration:	334	CFM	304	CFM
Total Building Ventilation:	0	CFM	0	CFM

*Indicated volume is based on custom building volume.

---System 1---

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.181 AC/hr (150 CFM)
Summer Infiltration Specified: 0.181 AC/hr (150 CFM)

---System 2---

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.100 AC/hr (40 CFM), Construction: Tight
Summer Infiltration Specified: 0.050 AC/hr (20 CFM), Construction: Tight

---System 3---

Miscellaneous Report (cont'd)

Outside Air Data

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.280 AC/hr (22 CFM), Construction: Average
Summer Infiltration Specified: 0.150 AC/hr (12 CFM), Construction: Average

---System 4---
Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.184 AC/hr (57 CFM)
Summer Infiltration Specified: 0.184 AC/hr (57 CFM)

---System 5---
Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.186 AC/hr (65 CFM)
Summer Infiltration Specified: 0.186 AC/hr (65 CFM)

Duct Load Factor Scenarios for System 1

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	6	677	No
1	Return		Closed Crawl A	-	0.12	6	251	No

Duct Load Factor Scenarios for System 2

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	6	677	No
1	Return		Closed Crawl A	-	0.12	6	251	No

Duct Load Factor Scenarios for System 3

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	6	677	No
1	Return		Closed Crawl A	-	0.12	6	251	No

Duct Load Factor Scenarios for System 4

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	6	677	No
1	Return		Closed Crawl A	-	0.12	6	251	No

Load Preview Report

Scope	Net Ton	ft.²/Ton	Area	Sen Gain	Lat Gain	Net Gain	Sen Loss	Sys Htg CFM	Sys Clg CFM	Sys Act CFM	Duct Size
Building	0.00	0	10,779	0	0	0	103,242	1,353	0	1,353	
System 1	0.00	0	2,173	0	0	0	38,547	504	0	504	9x11
Return Duct				0	0	0	417				
Zone 1			2,173	0	0	0	38,130	504	0	504	9x11
1-Great Hall			2,173	0	0	0	38,130	504	0	504	5--6
System 2	0.00	0	3,285	0	0	0	20,976	273	0	273	7x9
Return Duct				0	0	0	340				
Zone 1			3,285	0	0	0	20,635	273	0	273	7x9
2-Utility Room			644	0	0	0	488	6	0	6	1--4
3-Choir Room			504	0	0	0	1,815	24	0	24	1--4
4-Hall			343	0	0	0	428	6	0	6	1--4
5-Youth Room			1,794	0	0	0	17,905	237	0	237	3--6
System 3	0.00	0	371	0	0	0	3,095	40	0	40	4x4
Return Duct				0	0	0	33				
Zone 1			371	0	0	0	3,061	40	0	40	4x4
15-Kitchen			371	0	0	0	3,061	40	0	40	1--5
System 4	0.00	0	2,110	0	0	0	16,454	215	0	215	6x9
Return Duct				0	0	0	178				
Zone 1			2,110	0	0	0	16,276	215	0	215	6x9
16-Entry & Hall			660	0	0	0	3,512	46	0	46	1--5
17-Assistant			192	0	0	0	1,390	18	0	18	1--4
18-Lg Classroom			442	0	0	0	5,110	68	0	68	1--6
19-Chapel			344	0	0	0	4,315	57	0	57	1--5
20-Nursery			344	0	0	0	1,950	26	0	26	1--4
21-2009 Restrooms			128	0	0	0	0	0	0	0	0--0
System 5	0.00	0	2,840	0	0	0	24,171	320	0	320	7x10
Zone 1			2,840	0	0	0	24,171	320	0	320	7x10
6-Atrium			1,260	0	0	0	8,579	113	0	113	2--5
7-Restroom			104	0	0	0	883	12	0	12	1--4
8-Hall			170	0	0	0	1,824	24	0	24	1--4
9-2nd Floor Connector Hall			154	0	0	0	2,377	31	0	31	1--4
10-Office			288	0	0	0	1,409	19	0	19	1--4
11-Rector			144	0	0	0	1,020	13	0	13	1--4
12-Library			240	0	0	0	1,357	18	0	18	1--4
13-Hall Landing			216	0	0	0	2,584	34	0	34	1--4
14-Sacristy			264	0	0	0	4,138	55	0	55	1--5

Total Building Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Replacement: Glazing-Wood double hung, DP, clear, U-value 0.36, SHGC 0.57	192.2	3,939	0	0	0
1E-cm: Glazing-Double pane window, fixed sash, clear, metal frame no break, U-value 0.69, SHGC 0.69	6.2	244	0	0	0
double pane: Glazing-wood thermal pane window 90s, U-value 0.47, SHGC 0.56	253.4	6,788	0	0	0
double pane: Glazing-wood thermal pane window 90s, U-value 0.37, SHGC 0.56	120.5	2,542	0	0	0
11G: Door-Wood - Panel, U-value 0.54	175.4	5,400	0	0	0
11J: Door-Metal - Fiberglass Core, U-value 0.6	39.4	1,349	0	0	0
Great Hall Walls: Wall-Frame, Custom, Insulated 2x6 with 20% framing factor, U-value 0.08	1964.9	8,961	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	2952	11,444	0	0	0
15A11-0ocw-2: Wall-Basement, , framing with R-11 sill to floor in 2 x 4 cavity, open core, no board insulation, plus interior finish, wood studs, 2' floor depth, U-value 0.074	1077	5,856	0	0	0
18A-13: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Dark or Bold-Color Asphalt Shingle, Dark Metal, Dark Membrane, Dark Tar and Gravel, R-13 blanket or loose fill, U-value 0.076	2371.2	10,272	0	0	0
16B-30: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Vented Attic, No Radiant Barrier, Dark Asphalt Shingles or Dark Metal, Tar and Gravel or Membrane, R-30 insulation, U-value 0.032	492	897	0	0	0
N16A-50: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Open Blow 18" Cellulose, U-value 0.019	2157.3	2,336	0	0	0
N16A-50-ml: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Open Blow 18" Cellulose, light metal, U-value 0.019	1130.5	1,225	0	0	0
19C1-11osp: Floor-Over enclosed crawl space, R-11 insulation on exposed walls, spray foam insulation, sealed crawl space, passive, R-11 open cell 1/2 lb. spray foam, 3 inches in 2 x 10 joist cavity, U-value 0.072	1394	1,518	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.168	3318.1	16,324	0	0	0
Subtotals for structure:		79,095	0	0	0
People:	20		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		3,582	0	0	0
Infiltration: Winter CFM: 334, Summer CFM: 304		20,565	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
Total Building Load Totals:		103,242	0	0	0

Check Figures

Total Building Supply CFM:	1,353	CFM Per Square ft.:	0.126 *

Total Building Summary Loads (cont'd)

Check Figures

Square ft. of Room Area:	10,779	Square ft. Per Ton:	0 **
Volume (ft³):	117,912***		

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

Building Loads

Total Heating Required Including Ventilation Air:	103,242	Btuh	103.242	MBH

Notes

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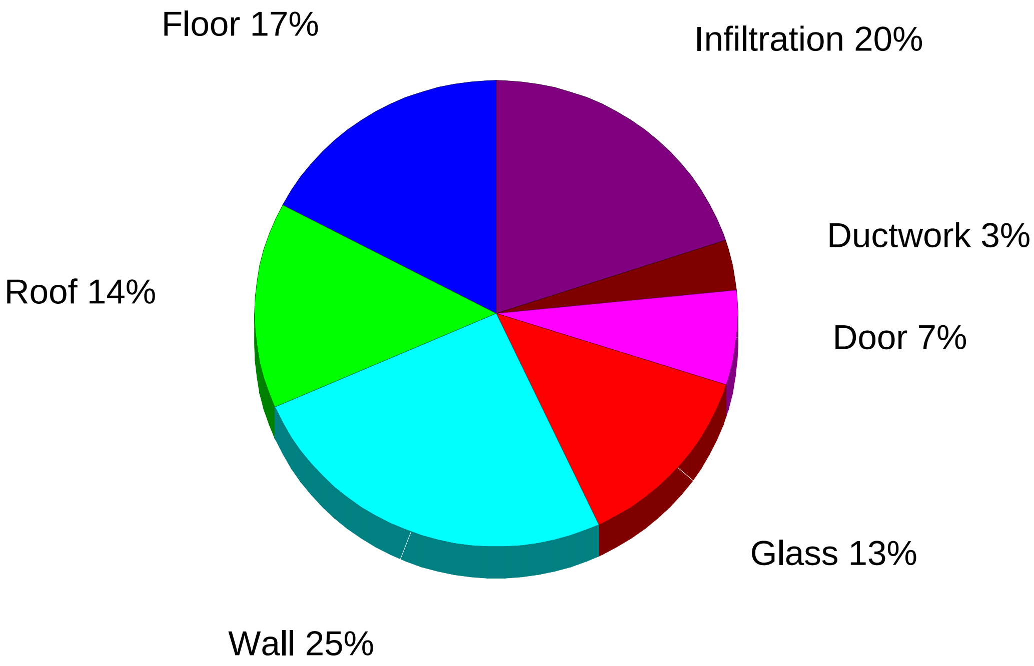
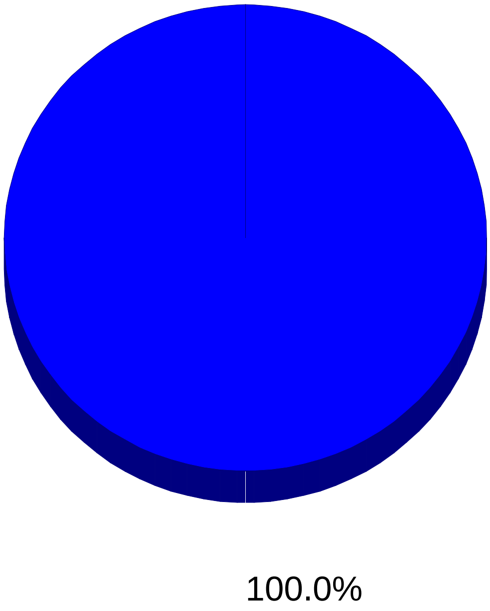
Building Pie Chart





System 1 Great Hall Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Replacement: Glazing-Wood double hung, DP, clear, U-value 0.36, SHGC 0.57	192.2	3,939	0	0	0
1E-cm: Glazing-Double pane window, fixed sash, clear, metal frame no break, U-value 0.69, SHGC 0.69	3.2	126	0	0	0
11G: Door-Wood - Panel, U-value 0.54	61.2	1,884	0	0	0
11J: Door-Metal - Fiberglass Core, U-value 0.6	39.4	1,349	0	0	0
Great Hall Walls: Wall-Frame, Custom, Insulated 2x6 with 20% framing factor, U-value 0.08	1964.9	8,961	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	112	434	0	0	0
18A-13: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Dark or Bold-Color Asphalt Shingle, Dark Metal, Dark Membrane, Dark Tar and Gravel, R-13 blanket or loose fill, U-value 0.076	2000	8,664	0	0	0
16B-30: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Vented Attic, No Radiant Barrier, Dark Asphalt Shingles or Dark Metal, Tar and Gravel or Membrane, R-30 insulation, U-value 0.032	492	897	0	0	0
19C1-11osp: Floor-Over enclosed crawl space, R-11 insulation on exposed walls, spray foam insulation, sealed crawl space, passive, R-11 open cell 1/2 lb. spray foam, 3 inches in 2 x 10 joist cavity, U-value 0.072	1394	1,518	0	0	0
Subtotals for structure:		27,772	0	0	0
People:	20		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		1,542	0	0	0
Infiltration: Winter CFM: 150, Summer CFM: 150		9,233	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 1 Great Hall Load Totals:		38,547	0	0	0

Check Figures

Supply CFM:	504	CFM Per Square ft.:	0.232	*
Square ft. of Room Area:	2,173	Square ft. Per Ton:	0	**
Volume (ft³):	49,592***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 38,547 Btuh 38.547 MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

System 2 Choir And Youth Room Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
1E-cm: Glazing-Double pane window, fixed sash, clear, metal frame no break, U-value 0.69, SHGC 0.69	3	118	0	0	0
double pane: Glazing-wood thermal pane window 90s, U-value 0.47, SHGC 0.56	56.2	1,504	0	0	0
11G: Door-Wood - Panel, U-value 0.54	19	586	0	0	0
15A11-0ocw-2: Wall-Basement, , framing with R-11 sill to floor in 2 x 4 cavity, open core, no board insulation, plus interior finish, wood studs, 2' floor depth, U-value 0.074	1029	5,614	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	156.8	608	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.168	1794	8,826	0	0	0
Subtotals for structure:		17,256	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		1,259	0	0	0
Infiltration: Winter CFM: 40, Summer CFM: 20		2,461	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 2 Choir And Youth Room Load Totals:		20,976	0	0	0

Check Figures

Supply CFM:	273	CFM Per Square ft.:	0.083	*
Square ft. of Room Area:	3,285	Square ft. Per Ton:	0	**
Volume (ft³):	23,991***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air:	20,976	Btuh	20.976	MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

System 3 Kitchen Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
18A-13: Roof/Ceiling-Roof Joists Between Roof Deck and Ceiling or Foam Encapsulated Roof Joists, Dark or Bold-Color Asphalt Shingle, Dark Metal, Dark Membrane, Dark Tar and Gravel, R-13 blanket or loose fill, U-value 0.076	371.2	1,608	0	0	0
Subtotals for structure:		1,608	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		124	0	0	0
Infiltration: Winter CFM: 22, Summer CFM: 12		1,363	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 3 Kitchen Load Totals:		3,095	0	0	0

Check Figures

Supply CFM:	40	CFM Per Square ft.:	0.109 *
Square ft. of Room Area:	371	Square ft. Per Ton:	0 **
Volume (ft³):	4,745***		

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 3,095 Btuh 3.095 MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

System 4 Classroom Wing & Hall Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
double pane: Glazing-wood thermal pane window 90s, U-value 0.47, SHGC 0.56	188.2	5,040	0	0	0
11G: Door-Wood - Panel, U-value 0.54	38.1	1,172	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	1013.3	3,929	0	0	0
N16A-50: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Open Blow 18" Cellulose, U-value 0.019	851.5	922	0	0	0
N16A-50-ml: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Open Blow 18" Cellulose, light metal, U-value 0.019	1130.5	1,225	0	0	0
Subtotals for structure:		12,288	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		658	0	0	0
Infiltration: Winter CFM: 57, Summer CFM: 57		3,508	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 4 Classroom Wing & Hall Load Totals:		16,454	0	0	0

Check Figures

Supply CFM:	215	CFM Per Square ft.:	0.102 *
Square ft. of Room Area:	2,110	Square ft. Per Ton:	0 **
Volume (ft³):	18,606***		

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 16,454 Btuh 16.454 MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

System 5 Boiler.Connector Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
double pane: Glazing-wood thermal pane window 90s, U-value 0.37, SHGC 0.56	120.5	2,542	0	0	0
double pane: Glazing-wood thermal pane window 90s, U-value 0.47, SHGC 0.56	9.1	244	0	0	0
11G: Door-Wood - Panel, U-value 0.54	57.1	1,758	0	0	0
15A11-0ocw-2: Wall-Basement, , framing with R-11 sill to floor in 2 x 4 cavity, open core, no board insulation, plus interior finish, wood studs, 2' floor depth, U-value 0.074	48	242	0	0	0
12E-0sw: Wall-Frame, R-19 insulation in 2 x 6 stud cavity, no board insulation, siding finish, wood studs, U-value 0.068	1669.9	6,473	0	0	0
N16A-50: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, Open Blow 18" Cellulose, U-value 0.019	1305.8	1,414	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.168	1524.1	7,498	0	0	0
Subtotals for structure:		20,171	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		0	0	0	0
Infiltration: Winter CFM: 65, Summer CFM: 65		4,000	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 5 Boiler.Connector Load Totals:		24,171	0	0	0

Check Figures

Supply CFM:	320	CFM Per Square ft.:	0.113	*
Square ft. of Room Area:	2,840	Square ft. Per Ton:	0	**
Volume (ft³):	20,978***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 24,171 Btuh 24.171 MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

St. Andrews Sanctuary Existing HVAC Load Calculations

for

St Andrews Episcopal Church
Main Street
Hopkinton, NH

Elite Software

RHVAC Residential HVAC Loads

Prepared By:

Margaret Dillon
S.E.E.D.S.

603-532-8979
Tuesday, April 13, 2021

Rhvac is an ACCA approved Manual J, D and S computer program.
Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.

Project Report

General Project Information

Project Title: St. Andrews Sanctuary Existing
Project Date: Saturday, April 3, 2021
Client Name: St Andrews Episcopal Church
Client Address: Main Street
Client City: Hopkinton, NH
Company Name: S.E.E.D.S.
Company Representative: Margaret Dillon
Company Phone: 603-532-8979
Company E-Mail Address: mdillon@myfairpoint.net

Design Data

Reference City: Concord AP, New Hampshire
Building Orientation: Front door faces South
Daily Temperature Range: High
Latitude: 43 Degrees
Elevation: 510 ft.
Altitude Factor: 0.982

	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	n/a	n/a	55	n/a
Summer:	87	70	43%	50%	75	19

Check Figures

Total Building Supply CFM:	1,399	CFM Per Square ft.:	0.558	*
Square ft. of Room Area:	2,508	Square ft. Per Ton:	0	**
Volume (ft^3):	50,160***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

Building Loads

Total Heating Required Including Ventilation Air: 108,120 Btuh 108.120 MBH

Notes

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All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

Miscellaneous Report

System 1 Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

Duct Sizing Inputs

	Main Trunk		Runouts	
Calculate:	Yes		Yes	
Use Schedule:	Yes		Yes	
Roughness Factor:	0.00300		0.01000	
Pressure Drop:	0.1000	in.wg./100 ft.	0.1000	in.wg./100 ft.
Minimum Velocity:	0	ft./min	0	ft./min
Maximum Velocity:	900	ft./min	750	ft./min
Minimum Height:	0	in.	0	in.
Maximum Height:	0	in.	0	in.

Outside Air Data

	Winter		Summer	
Infiltration Specified:	0.220	AC/hr	0.110	AC/hr
	184	CFM	92	CFM
Infiltration Actual:	0.220	AC/hr	0.110	AC/hr
Building Volume:	X 50,160*	Cu.ft.	X 50,160*	Cu.ft.
	11,035	Cu.ft./hr	5,518	Cu.ft./hr
	X 0.0167		X 0.0167	
Total Building Infiltration:	184	CFM	92	CFM
Total Building Ventilation:	0	CFM	0	CFM

*Indicated volume is based on custom building volume.

---System 1---

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.220 AC/hr (184 CFM), Construction: Semi-Tight
Summer Infiltration Specified: 0.110 AC/hr (92 CFM), Construction: Semi-Tight

Duct Load Factor Scenarios for System 1

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	0	677	No
1	Return		Closed Crawl A	-	0.12	0	251	No

Load Preview Report

Scope	Net Ton	ft.² /Ton	Area	Sen Gain	Lat Gain	Net Gain	Sen Loss	Sys Htg CFM	Sys Clg CFM	Sys Act CFM	Duct Size
Building	0.00	0	2,508	0	0	0	108,120	1,399	0	1,399	
System 1	0.00	0	2,508	0	0	0	108,120	1,399	0	1,399	16x16
Return Duct				0	0	0	2,339				
Zone 1			2,508	0	0	0	105,780	1,399	0	1,399	16x16
1-Sanctuary			2,508	0	0	0	105,780	1,399	0	1,399	13--7

Total Building Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Stained Glass: Glazing-Historic stained glass with exterior storms, U-value 0.57, SHGC 0.6	460	14,944	0	0	0
1C-cm: Glazing-Single pane window with storm, clear, metal frame no break, U-value 0.87, SHGC 0.67	9.5	471	0	0	0
11D: Door-Wood - Solid Core, U-value 0.39	72.8	1,618	0	0	0
Stone Church: Wall-Block, Custom, 14 inch stone with interior framing plaster finish, U-value 0.25	3297.7	46,993	0	0	0
16BR-19-ml: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), unvented attic with radiant barrier, R-19 insulation, light metal, U-value 0.049	2508	7,005	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.368	2508	17,118	0	0	0
Subtotals for structure:		88,149	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		8,650	0	0	0
Infiltration: Winter CFM: 184, Summer CFM: 92		11,321	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
Total Building Load Totals:		108,120	0	0	0

Check Figures

Total Building Supply CFM:	1,399	CFM Per Square ft.:	0.558 *
Square ft. of Room Area:	2,508	Square ft. Per Ton:	0 **
Volume (ft³):	50,160***		

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

Building Loads

Total Heating Required Including Ventilation Air: 108,120 Btuh 108.120 MBH

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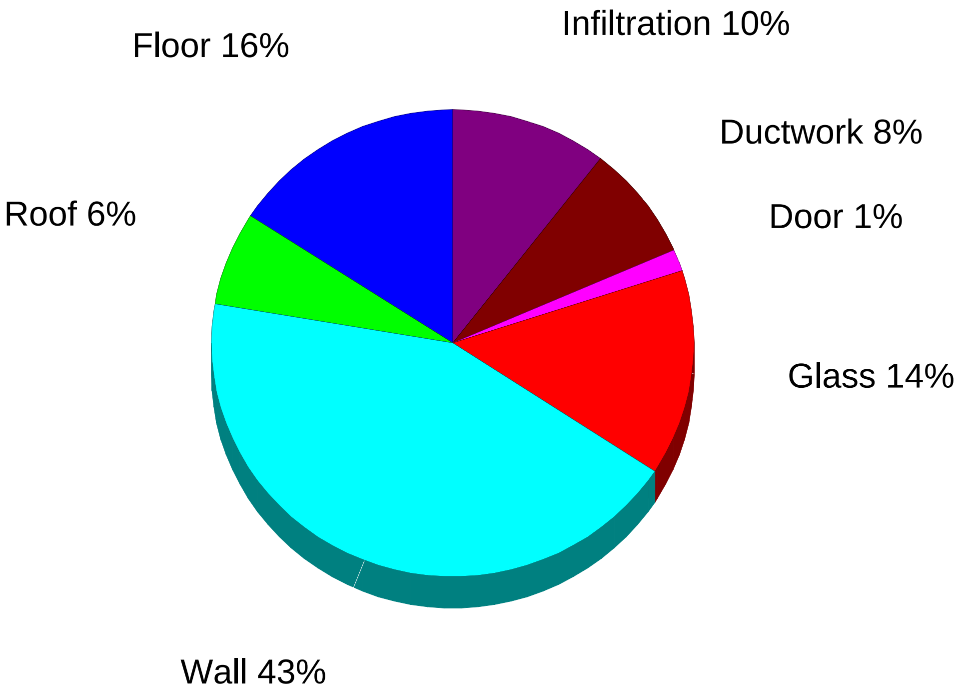
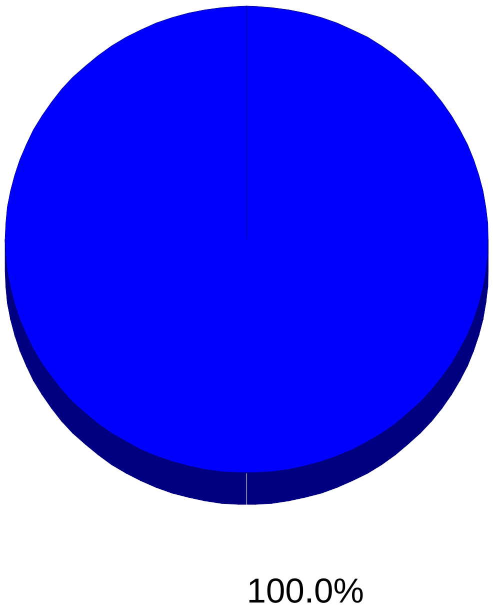
Building Pie Chart





System 1 Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Stained Glass: Glazing-Historic stained glass with exterior storms, U-value 0.57, SHGC 0.6	460	14,944	0	0	0
1C-cm: Glazing-Single pane window with storm, clear, metal frame no break, U-value 0.87, SHGC 0.67	9.5	471	0	0	0
11D: Door-Wood - Solid Core, U-value 0.39	72.8	1,618	0	0	0
Stone Church: Wall-Block, Custom, 14 inch stone with interior framing plaster finish, U-value 0.25	3297.7	46,993	0	0	0
16BR-19-ml: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), unvented attic with radiant barrier, R-19 insulation, light metal, U-value 0.049	2508	7,005	0	0	0
19A-0tp: Floor-Over enclosed crawl space, No insulation on exposed walls, sealed or vented space, passive, no floor insulation, tile or vinyl, U-value 0.368	2508	17,118	0	0	0
Subtotals for structure:		88,149	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		8,650	0	0	0
Infiltration: Winter CFM: 184, Summer CFM: 92		11,321	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 1 Load Totals:		108,120	0	0	0

Check Figures

Supply CFM:	1,399	CFM Per Square ft.:	0.558 *
Square ft. of Room Area:	2,508	Square ft. Per Ton:	0 **
Volume (ft³):	50,160***		

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 108,120 Btuh 108.120 MBH

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St. Andrews ESM 1-3
HVAC Load Calculations

for

St Andrews Episcopal Church
Main Street
Hopkinton, NH

Elite Software

RHVAC RESIDENTIAL HVAC LOADS

Prepared By:

Margaret Dillon
S.E.E.D.S.

603-532-8979
Tuesday, April 13, 2021

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Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.

Project Report

General Project Information

Project Title: St. Andrews ESM 1-3
Project Date: Saturday, April 3, 2021
Client Name: St Andrews Episcopal Church
Client Address: Main Street
Client City: Hopkinton, NH
Company Name: S.E.E.D.S.
Company Representative: Margaret Dillon
Company Phone: 603-532-8979
Company E-Mail Address: mdillon@myfairpoint.net

Design Data

Reference City: Concord AP, New Hampshire
Building Orientation: Front door faces South
Daily Temperature Range: High
Latitude: 43 Degrees
Elevation: 510 ft.
Altitude Factor: 0.982

	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	n/a	n/a	55	n/a
Summer:	87	70	43%	50%	75	19

Check Figures

Total Building Supply CFM: 490
CFM Per Square ft.: 0.195 *
Square ft. of Room Area: 2,508
Square ft. Per Ton: 0 **
Volume (ft³): 50,160***

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

Building Loads

Total Heating Required Including Ventilation Air: 37,548 Btuh 37.548 MBH

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Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

Miscellaneous Report

System 1 Input Data	Outdoor Dry Bulb	Outdoor Wet Bulb	Outdoor Rel.Hum	Indoor Rel.Hum	Indoor Dry Bulb	Grains Difference
Winter:	-2	-2.6	80%	n/a	55	n/a
Summer:	87	70	43%	50%	75	18.94

Duct Sizing Inputs

	Main Trunk		Runouts	
Calculate:	Yes		Yes	
Use Schedule:	Yes		Yes	
Roughness Factor:	0.00300		0.01000	
Pressure Drop:	0.1000	in.wg./100 ft.	0.1000	in.wg./100 ft.
Minimum Velocity:	0	ft./min	0	ft./min
Maximum Velocity:	900	ft./min	750	ft./min
Minimum Height:	0	in.	0	in.
Maximum Height:	0	in.	0	in.

Outside Air Data

	Winter		Summer	
Infiltration Specified:	0.132	AC/hr	0.132	AC/hr
	110	CFM	110	CFM
Infiltration Actual:	0.132	AC/hr	0.132	AC/hr
Building Volume:	X 50,160*	Cu.ft.	X 50,160*	Cu.ft.
	6,600	Cu.ft./hr	6,600	Cu.ft./hr
	X 0.0167		X 0.0167	
Total Building Infiltration:	110	CFM	110	CFM
Total Building Ventilation:	0	CFM	0	CFM

*Indicated volume is based on custom building volume.

---System 1---

Infiltration & Ventilation Sensible Gain Multiplier: 12.96 = (1.10 X 0.982 X 12.00 Summer Temp. Difference)
Infiltration & Ventilation Latent Gain Multiplier: 12.64 = (0.68 X 0.982 X 18.94 Grains Difference)
Infiltration & Ventilation Sensible Loss Multiplier: 61.55 = (1.10 X 0.982 X 57.00 Winter Temp. Difference)
Winter Infiltration Specified: 0.132 AC/hr (110 CFM)
Summer Infiltration Specified: 0.132 AC/hr (110 CFM)

Duct Load Factor Scenarios for System 1

No.	Type	Description	Location	Attic Ceiling	Duct Leakage	Duct Insulation	Surface Area	From [T]MDD
1	Supply		Closed Crawl B	-	0.12	0	677	No
1	Return		Closed Crawl A	-	0.12	0	251	No

Load Preview Report

Scope	Net Ton	ft.² /Ton	Area	Sen Gain	Lat Gain	Net Gain	Sen Loss	Sys Htg CFM	Sys Clg CFM	Sys Act CFM	Duct Size
Building	0.00	0	2,508	0	0	0	37,548	490	0	490	
System 1	0.00	0	2,508	0	0	0	37,548	490	0	490	9x11
Return Duct				0	0	0	508				
Zone 1			2,508	0	0	0	37,041	490	0	490	9x11
1-Sanctuary			2,508	0	0	0	37,041	490	0	490	5--6

Total Building Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Stained Glass: Glazing-Historic stained glass with exterior storms, U-value 0.57, SHGC 0.6	460	14,944	0	0	0
1C-cm: Glazing-Single pane window with storm, clear, metal frame no break, U-value 0.87, SHGC 0.67	9.5	471	0	0	0
11D: Door-Wood - Solid Core, U-value 0.39	72.8	1,618	0	0	0
R30 Roxul: Wall-Block, Custom, R30 Blown in Roxul, U-value 0.033	3297.7	6,203	0	0	0
R50 Roxul: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, R50 Blown in Roxul (or cellulose), U-value 0.02	2508	2,859	0	0	0
R12 Foundation: Floor-Over enclosed crawl space, Custom, two inches SPF on walls, U-value 0.08	2508	2,805	0	0	0
Subtotals for structure:		28,900	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		1,877	0	0	0
Infiltration: Winter CFM: 110, Summer CFM: 110		6,771	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
Total Building Load Totals:		37,548	0	0	0

Check Figures

Total Building Supply CFM:	490	CFM Per Square ft.:	0.195	*
Square ft. of Room Area:	2,508	Square ft. Per Ton:	0	**
Volume (ft³):	50,160***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

Building Loads

Total Heating Required Including Ventilation Air: 37,548 Btuh 37.548 MBH

Notes

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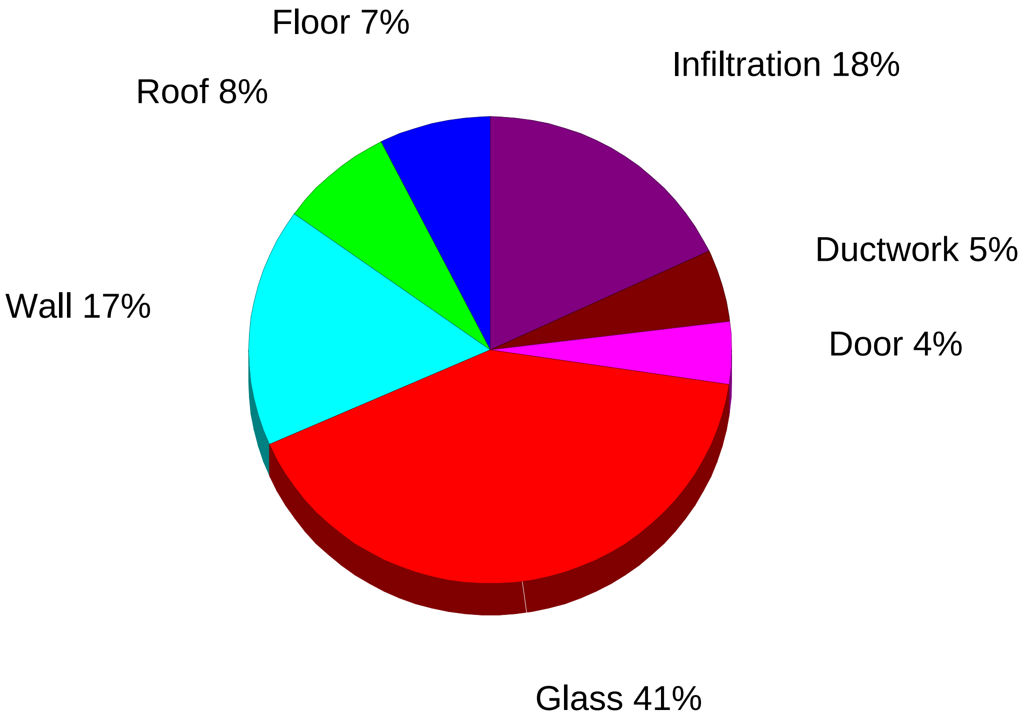
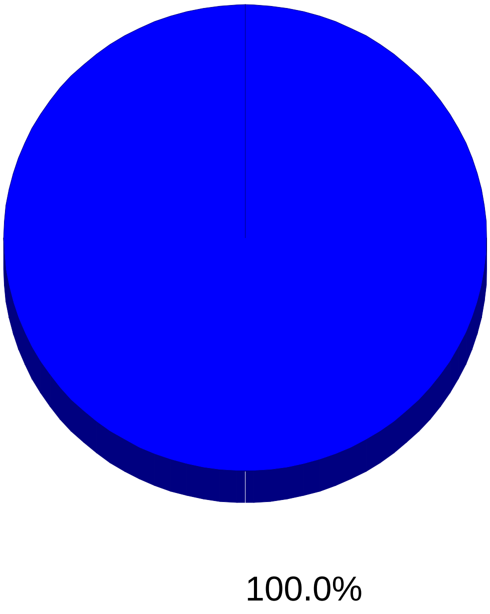
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

Building Pie Chart





System 1 Summary Loads

Component Description	Area Quan	Sen Loss	Lat Gain	Sen Gain	Total Gain
Stained Glass: Glazing-Historic stained glass with exterior storms, U-value 0.57, SHGC 0.6	460	14,944	0	0	0
1C-cm: Glazing-Single pane window with storm, clear, metal frame no break, U-value 0.87, SHGC 0.67	9.5	471	0	0	0
11D: Door-Wood - Solid Core, U-value 0.39	72.8	1,618	0	0	0
R30 Roxul: Wall-Block, Custom, R30 Blown in Roxul, U-value 0.033	3297.7	6,203	0	0	0
R50 Roxul: Roof/Ceiling-Under Attic with Insulation on Attic Floor (also use for Knee Walls and Partition Ceilings), Custom, R50 Blown in Roxul (or cellulose), U-value 0.02	2508	2,859	0	0	0
R12 Foundation: Floor-Over enclosed crawl space, Custom, two inches SPF on walls, U-value 0.08	2508	2,805	0	0	0
Subtotals for structure:		28,900	0	0	0
People:	0		0	0	0
Equipment:			0	0	0
Lighting:	0			0	0
Ductwork:		1,877	0	0	0
Infiltration: Winter CFM: 110, Summer CFM: 110		6,771	0	0	0
Ventilation: Winter CFM: 0, Summer CFM: 0		0	0	0	0
System 1 Load Totals:		37,548	0	0	0

Check Figures

Supply CFM:	490	CFM Per Square ft.:	0.195	*
Square ft. of Room Area:	2,508	Square ft. Per Ton:	0	**
Volume (ft³):	50,160***			

* Based on area of rooms being heated or cooled (whichever governs system) rather than entire floor area.
** Based on area of rooms being cooled.
***Indicated volume is based on custom building volume.

System Loads

Total Heating Required Including Ventilation Air: 37,548 Btuh 37.548 MBH

Notes

Rhvac is an ACCA approved Manual J, D and S computer program.
Calculations are performed per ACCA Manual J 8th Edition, Version 2, and ACCA Manual D.
All computed results are estimates as building use and weather may vary.
Be sure to select a unit that meets both sensible and latent loads according to the manufacturer's performance data at your design conditions.

St Andrews Sanctuary
Energy Cost Analysis

for

St Andrews Episcopal Church
Main Street
Hopkinton, NH

Elite Software

ENERGY
AUDIT

Residential and Light Commercial
Energy Analysis

Prepared By:

Margaret Dillon
S.E.E.D.S.

603-532-8979
Tuesday, April 13, 2021

Project Summary

General Project Information

Project Title:	St Andrews Sanctuary	Company Name:	S.E.E.D.S.
Project Date:	Saturday, April 3, 2021	Company Rep:	Margaret Dillon
Client Name:	St Andrews Episcopal Church	Company Phone:	603-532-8979
Client Address:	Main Street	Company E-Mail Address:	mdillon@myfairpoint.net
Client City:	Hopkinton, NH		

Design Data

Building Area:	2,508 sq.ft.		
People:	0	Heating Load:	99,470 Btuh
Occupancy:	0	Loads Adj. Factor:	0.73
		AC On Temp.:	0 °F
Actual City:	Hopkinton, NH		
Weather Ref. City:	Concord AP, New Hampshire		
Summer Outdoor:	87 °F	Winter Outdoor:	-2 °F
Summer Indoor:	75 °F	Winter Indoor:	55 °F
Cooling Hours:	0	Degree Days:	6,005

Annual Operating Cost Estimate

System Description	Fuel Rates Set	Total Heating Cost	Total Cooling Cost	Annual Service Charges	Total Oper. Cost	Average Monthly Cost
Great Hall Existing	1	$2,295	$0	$0	$2,295	$191
Connector Existing	1	$1,519	$0	$0	$1,519	$127
2009 Wing Existing	1	$1,230	$0	$0	$1,230	$102
2009 Lower Level Existing	1	$869	$0	$0	$869	$72
Kitchen Existing	1	$173	$0	$0	$173	$14
Great Hall Improved	1	$1,596	$0	$0	$1,596	$133
Connector Improved	1	$1,090	$0	$0	$1,090	$91
2009 Wing Improved	1	$681	$0	$0	$681	$57
Great Hall Improved Walls	1	$1,247	$0	$0	$1,247	$104

Project Summary Bar Chart