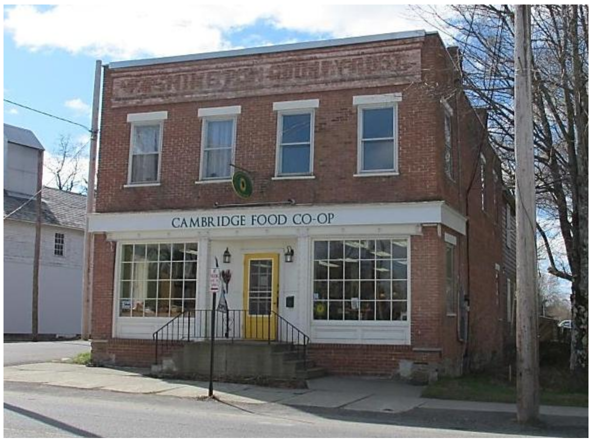

ENERGY CONSERVATION IN HISTORIC BUILDINGS

TASK 1 - INVESTIGATIONS FOR INSULATION STRATEGIES

EYP/

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TABLE OF CONTENTS

INTRODUCTION

This investigative report was commissioned by the Preservation League of New York State (PLNYS) to identify insulation strategies appropriate to historic buildings. Various scenarios and degrees of insulation were evaluated against multiple performance criteria. Proposed assemblies were evaluated for condensation or moisture related problems, for potential energy savings, and for how well the changes would respect the existing historic fabric.

The two structures selected by PLNYS as subjects for study were: the Cambridge Co-op in Cambridge, New York, and the Zadock Pratt Museum in Prattsville, New York. While each is unique, both represent a large number of historic wood-framed and masonry structures throughout New York State. Funding for the study was provided by the New York State Energy Research and Development Authority (NYSERDA), under its Energy Code Training Program, as well as the National Center for Preservation Technology and Training.

The analysis began with a comprehensive field study of the existing buildings. Visual and minimally invasive field observations were conducted to determine the existing conditions of each structure, including the building's structural stability and inherent thermal and moisture related properties. These observations provide the basis for multiple, informative computer simulations. Multiple software applications were utilized to evaluate the building's performance with varying levels of insulation.

Various types and methods of insulation were evaluated for their performance and to understand their potential impact on the historic fabric. Extensive hygrothermal analysis was also performed on each of the scenarios, evaluating the proposed thermal modifications against potential moisture related problems.

In addition, the study reviews how the NYS Building Code (2010) and Energy Conservation Construction Code of New York State (2010) apply to the case study buildings in their existing condition as well as with respect to potential insulation scenarios. An energy consumption analysis was performed for each insulation scenario in an effort to evaluate the financial ramifications with each scenario.

Finally, the study discusses the impact of techniques used to insulate historic buildings related to specific matters of historic character and significance; minimizing impact; and allowing for reversibility as recommended by the Secretary of Interior's Standards and Guidelines for Rehabilitation.

It is important to note that infiltration (and exfiltration) of air through a building's envelope can be a significant contributor to energy usage. While a more complete repertoire of solutions to improve the energy efficiency at the building envelope should ultimately include infiltration and humidity control, the purpose of the study is primarily to quantify the effectiveness of building envelope insulation. In practice however, it is believed that a comprehensive insulation installation would also reduce air infiltration to some degree as most insulation projects will result in a tighter building envelope. The tables in the Energy Simulation Analysis section of the study display the assumed impact of infiltration reduction separately from that associated with insulation alone. A reduction in infiltration of 5% of the existing condition is assumed in most savings analyses herein as it represents the modest improvement in infiltration assumed with any insulation project For comparison, savings are also shown for 15% and 30% reduction in air infiltration (each alone and in conjunction with insulation at 100% code).

As further explained in this report, the potential for condensation within a building assembly increases with additional insulation (particularly when starting with none, a common condition for historic buildings). Condensation can have serious negative consequences, it is therefore important to evaluate potential moisture sources and moisture movement in conjunction with insulation to make an informed decision that will balance energy savings and avoid problems.

DESCRIPTIONS OF CASE STUDY BUILDINGS

Cambridge Food Co-op

The Cambridge Food Co-op in Cambridge, New York, was originally constructed in the 1850s and used as newspaper offices and a printing facility. The first floor of the building is currently used for Co-op functions, while the second floor is used as tenant office space. A small storage area and mechanical equipment exist in the unfinished basement.

The original building is brick masonry bearing-wall construction on a fieldstone foundation; wall thicknesses vary from 8" at the upper floor to 2'-0" at some of the basement walls. The structure is generally in fair condition but has experienced significant structural settlement over time and some masonry deterioration. General moisture issues are already present, primarily due to rising damp in the foundations and lower areas of the masonry walls above grade, and at the areas of the masonry walls over the height of the building that conceal chimney flues.

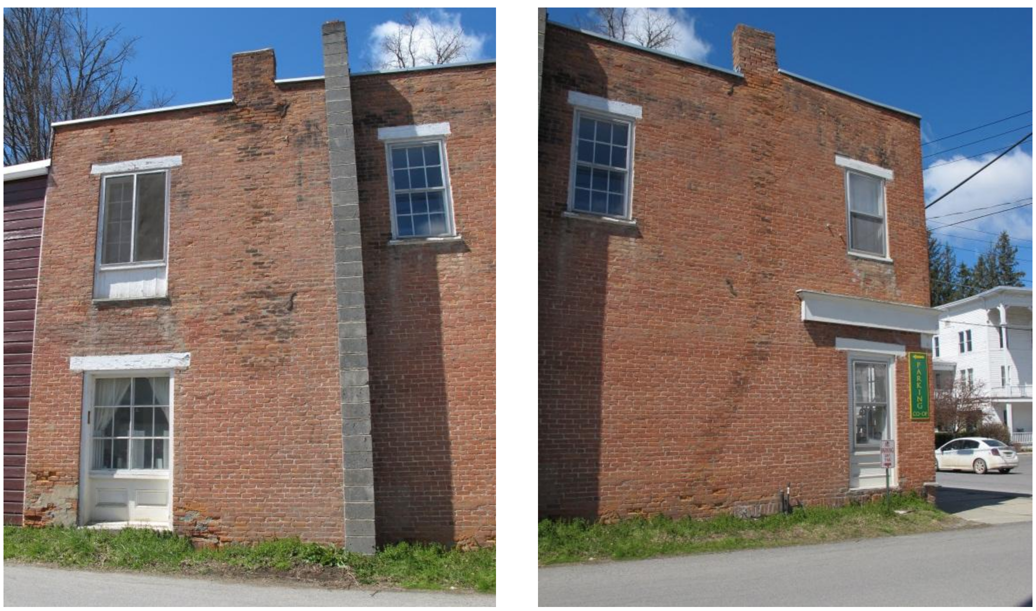

Figure 01. Brick masonry deterioration at the Cambridge Food Co-op primarily occurs in areas affected by moisture, manifesting itself on the surface of the walls in brick spalling or efflorescence, or both. This is caused either by moisture infiltration such as rising damp or condensation emanating from inside chimney flues.

The Co-op has been renovated and adaptively reused over time, leaving very few exposed original finished surfaces in the occupied spaces; for instance, tongue-and-groove wood plank ceilings, in some cases finished with paint, and tin ceilings have been covered by multiple layers of acoustic ceiling tile systems, largely concealing the original fabric. Walls with original plaster applied directly to the brick masonry have been concealed behind more recently furred-out framing and gypsum board; in some cases the newer walls and ceiling cavities have been inconsistently insulated with fiberglass batt.

Figure 02. Two layers of dropped ceilings conceal the original tin ceilings in at least two rooms at the second floor.

Presumably not long after the original masonry construction was completed, a timber-framed addition to the back of the building was constructed. Its second floor, which is in the process of being insulated and finished to become a new tenant space, reveals more about the original construction of the wing. The first floor of the addition has been completely renovated, with furred-out walls of painted gypsum board, and insulation.

It is interesting to note that the use of the first floor as a market creates an unusual energy consumption dynamic. Several large merchandise coolers require compressors whose operations consume a significant amount of electricity but produce a significant amount of residual heat. This residual heat enables the Co-op to keep the space warm in winter without burning much oil. This report's analysis of the Co-op energy loads show this in greater detail.

Figure 03. The Co-op interior includes at least seven coolers in the occupied space of the store.

Zadock Pratt Museum

The Zadock Pratt Museum in Prattsville, New York, was originally built in 1828 as a two-story, five-bay residence in the Federal Style. The house is primarily constructed in a hemlock post-and-beam assembly, lime plaster-on-wood lath supported on hemlock wood-stud wall framing, supported by a fieldstone foundation. It was substantially altered in the 1850s with the addition of more elaborate architectural details, somewhat derivative of the Italianate Style, a practice not uncommon for mid-nineteenth century stylized upgrades. Over time several wings were added to the building, including one which involved lifting, rotating 90°, and moving 20 feet to merge the free-standing bank building immediately next door with the original mass of the house. Today the structure total footprint is expansive, with a full basement below only two-thirds of the original building and crawl spaces beneath the remaining areas of the structure.


Figure 04. Elevations of the original, 5-bay house with significant stylistic modifications made in the 1850s. The image on the left shows the former bank now attached to the main house, while the image on the right shows the shed addition in the rear courtyard of the house.

The house has operated as a museum since 1959. In the 1970s and 80s, the building underwent systems and energy-efficiency upgrades, including the comprehensive replacement of the original plaster-on-lath with gypsum board and installation of insulation. While the walls and attic floor of the house are insulated with six-inch thick foil- or paper-faced fiberglass battens, the bank building's unique construction, particularly at the walls, required a different approach; walls in this wing are constructed of 1 ¾"-thick wood planks, spanning vertically between timber framing at the head and sill of each wall and varying in width between 8" and 1'-7". Wood clapboards are applied directly to the exterior of the planks, originally there was plaster-and-wood lath applied to the interior of the planks. After the removal of the interior plaster and lath, 1"-thick, foil-faced polyisocyanurate insulation boards were applied before the installation of interior gypsum board.

One room in a different wing of the house has foam sprayed into the original stud wall cavities. This appears to be an isolated campaign of insulating, and it is not clear whether this is the only place spray foam was used.


Figure 05. Image on the left shows an example of the unique plank wall sheathing at the former bank building, which was moved and attached to the Pratt Museum. Image on the right shows remnants of foil-faced 1" polyisocyanurate board insulation below ½" gypsum board fitting behind the trim surrounding the window opening.

In most areas of the house, careful attention was paid to maintain the original plane of the walls, especially as they abutted various trimmed window and door openings. Original trim was in most cases left in place or removed and carefully reinstalled to facilitate modification of the wall assembly. Selected walls in added wing spaces have exterior walls that have been either entirely rebuilt or significantly furred out with newer wall framing, simultaneously increasing the possibilities for effective use of insulation and for making interior wall surfaces plumb where the original walls have settled over time.


Figure 06. Images show typical variations on stud wall framing. Image on the left shows an exterior wall with a newer interior stud wall added to provide a new cavity for insulation and to re-plumb the interior wall surface; image on the right shows typical original stud framing, with original door and base trim left in place and used as a guide for edges of the new gypsum board walls.

While the walls and second-floor ceilings appear to be almost entirely insulated, the walls of the original basement, crawl spaces, and flooring of the first floor appear to be uninsulated; the roof rafters are also uninsulated.

As was the case for many of the historic buildings in Prattsville, floods resulting from tropical storm Irene in September 2011 significantly damaged the first floor of the Museum. Subsequently all gypsum board and insulation in wall cavities was removed to approximately mid-height, exposing the original framing and clapboards. This provided significant insight into how the building was originally constructed and how it was modified over time. As will be discussed in the Recommendations section of the study, with issues of preservation of original materials aside, this deconstruction also provides valuable insight into what appears to have been a successful attempt to provide insulation in the building.

METHODOLOGY AND STRATEGIES

In the broadest sense, the concept and practical use of insulation to improve thermal comfort and control has existed for thousands of years. Insulation has been used in myriad dwelling types and has been composed of many materials, with the fundamental purpose of slowing the transmittance of heat from one side of a built assembly to the other.

Addressing insulation levels within any building is a good step towards realizing energy savings in the structure's thermal loads. The Environmental Protection Agency (EPA) estimates a typical homeowner could see a 20% savings in their heating and cooling bill by sealing and insulating their homes[1], but the formula for success is not simply to add as much insulation as possible. Several factors should be taken into account to achieve the best results and avoid potential problems.

The 2010 Building Code of New York State and the referenced 2010 Energy Conservation Construction Code of NYS (ECCCNYS) prescribe quantities of insulation for most cases within the New York State, but care needs to be taken to install the insulation correctly without adverse effects.

The Secretary of the Interiors Standards and Guidelines for Rehabilitation (Department of the Interior regulations 36 CFR 67), recently packaged as a more coordinated volume in the 2011 version entitled "The Secretary of the Interior's Standards for Rehabilitation & Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings" serves as a good resource for any restoration project. The guidelines are organized as practices *Recommended* vs. *Not Recommended*. The guidelines leave significant room for interpretation and application of the best practices for specific problems. One of the clearest messages is that modifications or renovations should to the greatest extent possible be reversible in nature, and should "do no harm" to the most significant features of important historic resources.[2]

When dealing with historic buildings in particular, moisture-related issues are an even greater concern. In some cases, protection of the historic fabric itself may be deemed more important than energy savings, and careful economic and hygrothermal analysis of individual buildings may show that the value provided by insulation is not high enough to make it worth putting materials at significant risk for damage. Analysis provided in this study explains where the advantages and disadvantages lie.

It is important to note that this report intentionally focuses on heating-related benefits and issues regarding insulation and only tangentially addresses air infiltration. Given the climate in New York State, the energy saving impact of insulation in winter heating far outweighs the potential savings for buildings with air conditioning in summer. The rate of heat transfer is directly proportional to the temperature difference between the interior and exterior surfaces of the envelope. That is, the temperature difference between the interior of a conditioned building (68° to 72°F in the winter) and an exterior temperature of 20°, 10° or even 0°F creates a temperature

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[1] http://www.energystar.gov/index.cfm?c=home_sealing.hm_improvement_methodology

[2] *The Secretary of the Interior's Standards for Rehabilitation & Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings,* U.S. Department of the Interior, National Park Service, Technical Preservation Services, Washington, D.C., 2011 Anne E. Grimmer with Jo Ellen Hensley; Liz Petrella, Audrey T. Tepper; http://www.nps.gov/tps/standards/rehabilitation/sustainability-guidelines.pdf.

differential that is usually at least twice what might occur in the summer cooling months. For these reasons, code requirements and economic justification for insulation in New York State are dictated by winter (heating) conditions.

By design, the two subject structures of this study possess a wide spectrum of envelope assemblies and varying amounts of intact historic fabric. Simply adding insulation to provide incremental gains in energy savings may come at a much more significant cost in the short than the long term. Considerations should be made for all the life-cycle costs involved, including hard and soft costs of material and labor for installation. The precise resilience of historic fabric prior to installation of an insulation layer is less tangible and difficult to calculate; fabrics such as old plaster, wood, and masonry that are fragile to begin with may experience new stresses that could accelerate their deterioration.

While it is has not been specifically quantified for this study, with potential risks to the building fabric aside, accumulation of moisture within a building's insulated envelope significantly minimizes the thermal performance of the assembly if it gets wet.[3] Unlike condensation that occurs on a cold surface, insulation with absorptive characteristics can easily wick and transfer moisture via capillary action away from the moisture source, potentially saturating some or all of the insulation itself and also creating a potential bridge to other surfaces.

While deterioration of the physical materials is a concern itself, the increased moisture content of the insulation displaces the trapped air within the material, the very source of the insulation's capacity for thermal resistance – thus reducing its insulation value. Once this matrix of critical mass is contaminated or saturated with moisture, air is displaced by a more conductive material and the effectiveness of the critical insulating mass drops significantly.[4]

CONDENSATION ISSUES

When dealing with historic buildings in particular, moisture related issues are a significant concern, moisture is related to almost all performance and deterioration problems that affect a building envelope. Efforts must be taken to avoid further damage to construction that may have already undergone internal damage or decay over time, leaving an already weakened and delicate system.

Perhaps the most important issue facing all building envelopes with any degree of thermal resistance is the potential for vapor to condense and cause moisture-related deterioration within the assembly, either creating a new cycle of deterioration where none existed previously or accelerating one that already exists. As the thermal profile of an assembly changes with added insulation, the dynamics of moisture within that assembly will also change. This is important because it directly affects the point at which condensation will develop and potentially damage building materials or the entire assembly.

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[3] Owen, Mark, editor, Heat, Air, and Moisture Control in Building Assemblies-Material Properties, pp. 25.15, *ASHRAE Handbook of Fundamentals 2009*, American Society of Heating, Refrigeration and Air Conditioning Engineers; Atlanta, GA .

[4] *Air Filtration with Moisture and Frosting Phase Changes in Fiberglass Insulation – I. Experiment,* D. R. Mitchell, Y. –X. Tao, R. W. Besant; International Journal of Heat and Mass Transfer; Volume 38, Issue 9, June 1995; pp. 1587-1596.

Based on a variety of factors – including economics, availability of materials, and limitations in technology – the majority of older buildings in New York State were rarely originally insulated for thermal purposes. In these under-insulated assemblies there is often no potential for condensation as the heat generated inside the building to keep occupants warm is also keeping the entire envelope assembly warm, enough to assure that vapor will rarely condense. The potential for significant deterioration resulting from condensation or freeze/thaw cycling is dramatically reduced in this case.

When insulation is introduced to a building assembly, the dew point location naturally changes. Since insulation reduces the rate of thermal transmittance, the dew point tends to shift toward the interior (or heated) side of the assembly. This shift is capable of increasing the potential for condensation, infiltration, freeze/thaw cycling and related deterioration. Adding insulation to an assembly could relocate the dew point within the assembly for the first time, potentially causing rapid and dramatic deterioration.

Moisture within the envelope can be accounted for and addressed in two ways[5]. The first is to modify interior environmental conditions by mechanically dehumidifying (or humidifying) the space as necessary to avoid adverse conditions. This can be a costly approach and is not always consistently accomplished in a residential setting. In addition, dehumidification can sometimes produce a reverse-migration of moisture through a wall, into the building. For example, the use of a dehumidifier in a basement can draw moisture through a masonry or even poured-in-place concrete wall from outside to inside, accelerating the process of drying but also drawing salts and other minerals through the wall to the dry surface. This process is exemplified by efflorescence, which manifests as a light gray to white hue on the surface of masonry construction.

The other approach to dealing with envelope moisture is to design and construct the building envelope to properly deal with naturally occurring environmental conditions. This report assumes the humidity level within the case study buildings is not artificially controlled or modified. Evaluations in the report are therefore focused on the exterior building envelope and design considerations to avoid moisture related problems.

[5] TenWolde, Anton, Manual Analysis Tools, Ch.7, in *"Moisture Analysis and Condensation Control in Building Envelopes",* Treschel, Heinz R., editor, ASTM; Philadelphia, PA, 2001

APPLICABLE BUILDING CODES

The Building Code of New York State (BCNYS) and the Existing Building Code of New York State both reference the Energy Conservation Construction Code of NYS (ECCCNYS) for all matters of energy efficiency. The 2010 versions of these codes were current at the time of printing. The 2010 ECCNYS (which became effective December 28, 2010) is based upon the 2009 International Energy Conservation Code; all new construction as well as limited renovation work must comply with these requirements.
In the case of existing buildings the ECCCNYS defines the extent at which energy performance measures need to be performed.

Although the ECCCNYS has specific exceptions in respect to structures with historic significance, this report assumes that these exceptions do not apply to the case study buildings.[6] The ECCCNYS further defines the energy performance requirements for existing structures as determined by the scope of work being performed, typically building additions would be fully compliant with the requirements for a new building. In certain circumstances a building alteration project may not need to be fully compliant with the performance criteria set for new work. For example, in renovation work where the exterior envelope framing cavity is not being altered the code allows the cavity to be filled with an insulation having a nominal value of R-3.0 per inch.

For the purposes of this study, estimated energy savings were evaluated in respect to compliance with the code requirements for a new building as well as for various percentages of these values. (See "Energy Simulation Analysis")

The ECCCNYS gives two options for compliance for new work: calculating and predicting energy efficiency through specialized computer modeling software[7-8]; or following prescriptive guidelines. For the basis of this report, the buildings were evaluated under the code's prescriptive guidelines, wherein the code dictates specific thermal values for each building envelope element.

The ECCCNYS differentiates thermal performance requirements for either residential or commercial buildings; the residential prescriptive requirements are, in most cases, more stringent than the commercial. To be useful to a larger audience, this report uses the *residential* thermal requirements for comparative analysis.

[6] 2010 ECCNYS – Chapter 101.4.2 (excerpt of code section included in appendix).

[7] Online residential energy compliance software may be found at https://energycode.pnl.gov/REheckWeb/.

[8] For online commercial building energy compliance software see https://energycode.pnl.gov/COMcheckWeb/.

There are eight climate zones in the continental United States, three of which – zones 4, 5, and 6 –are distinguished within New York State by the ECCCNYS.

ZONE 4

Bronx	Queens
Kings	Richmond
Nassau	Suffolk
New York	Westchester

ZONE 5

Albany	Greene	Putnam
Cayuga	Livingston	Rensselaer
Chautauqua	Monroe	Rockland
Chemung	Niagara	Saratoga
Columbia	Onondaga	Schenectady
Cortland	Ontario	Seneca
Dutchess	Orange	Tioga
Erie	Orleans	Washington
Geneseo	Oswego	Wayne
		Yates

ZONE 6

Allegany	Hamilton	Schuyler
Broome	Herkimer	St. Lawrence
Cattaraugus	Jefferson	Steuben
Chenango	Lewis	Sullivan
Clinton	Madison	Tompkins
Delaware	Montgomery	Ulster
Essex	Oneida	Warren
Franklin	Otsego	Wyoming
Fulton	Schoharie	

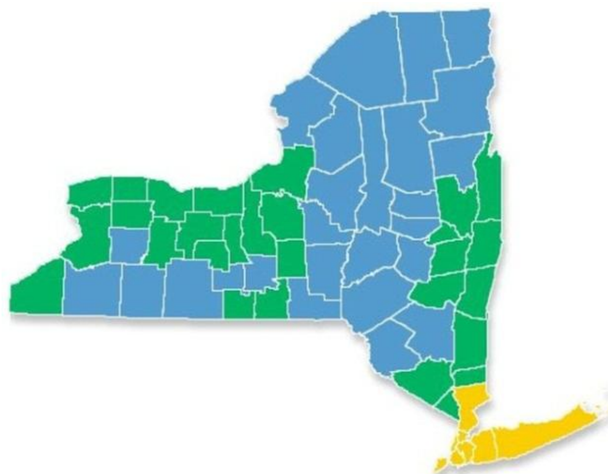

Figure 07: Climate Zones of New York State by county

INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT [a]

TABLE: RCNYS-RN1102.1 & ECCCNYS-E402.1.1

Climate Zone	Fenestration U-Factor [b]	Skylight U-Factor [b]	Ceiling R-Value	Wood Frame Wall R-Value [f]	Mass Wall R-Value [g]	Floor R-Value	Basement Wall R-Value [c]	Slab R-Value & Depth [d]	Crawl Space Wall R-Value [c]
4	0.35	0.6	38	13	5/10 [g]	19	10/13 c	10, 2ft [d]	10/13 c
5	0.35	0.6	38	20 or 13+5 [f]	13/17 [g]	30 [e]	10/13 c	10, 2ft [d]	10/13 c
6	0.35	0.6	49	20 or 13+5 [f]	15/19 [g]	30 [e]	15/19 c	10, 4ft [d]	10/13 c

a. *R*-values are minimums. *U*-factors and SHGC are maximums. R-19 batts compressed into a nominal 2´ 6 framing cavity such that the *R*-value is reduced by R-1 or more shall be marked with the compressed batt *R*-value in addition to the full thickness *R*-value.

b. *The fenestration U-factor column excludes skylights.*

c. The first value shown represents minimum R-value of continuous insulated sheathing on the interior or the exterior of the wall, the second value shown represents minimum R-value of cavity insulation at the interior of the basement wall. "10/13" means R-10 continuous insulated sheathing on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.

d. R-5 shall be added to the required slab edge R-values for heated slabs.

e. Or insulation sufficient to fill the framing cavity, R-19 minimum.

f. "13+5" means R-13 cavity insulation plus R-5 insulated sheathing. When structural sheathing is utilized per requirements of the Residential Code of New York State, §RR602.10 Wall Bracing, insulating sheathing with a minimum value R-2 shall be added over the required structural sheathing. All other areas must be sheathed with insulating sheathing of R-5 as indicated by the Table. If 100 percent continuous structural panel sheathing is used on a 2 by 4 wall, then R-5 continuous insulated sheathing must also be applied over the structural sheathing.

g. The second R-value applies when more than half the insulation is on the interior of the mass wall.

Figure 08. Summary of the Code prescriptive thermal requirements for each component of residential buildings in the three climate zones of NYS. Note: The Residential Building Code of New York State offers the following exception to prescriptive compliance for renovated buildings where the energy use is not increased (2010 RCNYS Chapter RN1101.3.1): "Alterations, renovations or repairs to roof/ceiling, wall or floor cavities which are insulated to a full depth with insulation having a minimum value of R-3.0 per inch."

The Cambridge Food Co-op and Zadock Pratt Museum buildings were selected by the PLNYS as case studies for review as they are representative of many older buildings in New York State. These two structures are also good references for evaluation as they address two significant distinctions within the Building Code and the ECCCNYS, "mass walls" and "wood framed walls".

The Cambridge Co-op is constructed with a load-bearing masonry exterior wall and is considered within the codes to be a "mass wall" with inherent thermal mass and associated qualities such as "thermal lag," or the inherent ability to retain a current thermal state longer than non-masonry construction. In contrast, the Zadock Pratt Museum is constructed with wood-framed exterior walls which, relative to masonry construction, have much less capacity to modulate thermal swings through the envelope. Each of the two wall types has different thermal requirements within the Building and Energy codes.

While both the buildings selected are within climate zone 5, this report's analyses evaluate the structures under hypothetical scenarios located in each of the three climate zones of New York. Analysis also provides predicted energy efficiency at four levels of compliance with the code – 50%, 75%, 100%, and 125% of code minimums for new construction. As previously noted, moisture and air infiltration play undeniable roles in the efficacy of insulation in general and can be a major issue in the decision-making process regarding its use in older buildings. The ECCCNYS requirement for a continuous air barrier as well as a vapor retarder is addressed in the analysis and recommendations sections of this study.

BUILDING INSULATION AND AIR/VAPOR BARRIER PRODUCTS

Building insulation is readily available in many forms and materials that are generally categorized, packaged, and sold according to "R-value," a measure of the material's thermal resistance –its ability to slow or resist the transfer or movement of heat. R-value is important because it provides a standard point of reference for comparing products and solutions, quantifying and better predicting ultimate performance. A large part of a building's overall energy consumption is a result of a building envelope's ability to resist or minimize the transfer of heat. Selecting the appropriate insulation product as well as the proper quantity and installation methods is critical to maximizing energy savings.

A thorough approach to analyzing a building's potential for heating-related energy savings and occupant comfort should evaluate the building envelope as a complete system, considering each piece individually as well as in unison with the complete assembly. Insulation and heat transfer in a building assembly form only one part of the equation; the successful analysis of the complete system relies on an understanding of air and moisture movement as well. Corresponding to the numerous types of insulation available, there are also many types of air barrier and vapor retarder systems. When evaluating an older structure for energy efficiency and increased insulation, it is critical to select the appropriate system to achieve the desired results. Ideally the system can be installed in a manner that does little or no damage to the existing finishes surfaces and, in the case of character-defining historic fabric, is easily reversible. Products and systems should be evaluated together to ensure they will perform as desired and cause no adverse effects.

The Energy Conservation Construction Code of New York State (2010) dictates the minimum required R-value for each component of a building assembly in respect to the applicable climate zone. It may be determined that there is value in installing insulation with R-value above the code minimum. A payback or life-cycle cost analysis could be performed to weigh the cost of installation of different amounts of insulation against the extended energy savings. Although the energy savings may not totally surpass the cost of installation; successfully sealing and insulating a building can dramatically improve occupant comfort.

Insulation

Building insulation products are generically available in 4 major categories: ***battens*** (batt) roll form such as fiberglass battens or semi-rigid batts such as with mineral fiber; ***loose-fill*** (blown) fibrous products such as cellulose, fiberglass, or rockwool; ***spray foam*** (open or closed cell); and ***rigid foam*** boards. Each of these categories has many variations, each with similarities and significant differences.[9] Products should be evaluated not only for thermal resistance (R-value) but also for other factors such as cost, ease of installation, durability, lifecycle, and compatibility with the overall system.

Batten Insulation (Batts)

Batten insulation is typically available in folded or roll form or, as in the case of mineral wool, as a semi-rigid product. Batt insulation in typically installed between framing members and sometimes additionally laid perpendicular across the top of horizontally-oriented framing. The ultimate success of this product relies on installation techniques; care should be taken to fill all areas and avoid cracks or voids. The inclusion of a vapor

[9] NAIMA – North American Insulation Manufacturer's Association, http://www.naima.org.

retarder should be evaluated for potential moisture movement and condensation within the insulated assembly. Batten insulation products range from $1.00 to $2.00 a square foot, dependent on R-value and installation specifics, and can typically be installed by a building owner, significantly reducing costs.

Batten insulation in the form of fiberglass batt is likely the most ubiquitous building insulation product available; pink rolls of insulation are easily the most recognized.[10] These batts are readily available in standard thicknesses and widths with a variety of facings; they are easy to install and fairly cost effective, with a thermal resistance factor of approximately R-3.5 per inch. As fiberglass can deteriorate, compress or hold moisture, they may lose some effective thermal value over time.

Mineral fiber insulation is becoming more prevalent in the U.S. after years of use in Europe and Canada. These products have a thermal resistance factor of approximately R-3.7 per inch and are becoming more available in local home centers. Although typically not sold with as many facings as fiberglass battens, mineral fiber is sold in typical widths and thickness and is perhaps easier to install than typical fiberglass. Mineral fiber insulation offers very high moisture resistance and is extremely flame resistant.[11]

Loose-fill (Blown) Insulation

With all loose-fill (blown) insulations, fibrous material is blown or sprayed with specialized equipment into cavities or areas to a desired density and depth. This application process makes loose-fill products well suited for renovation applications or difficult-to-access areas. In areas of exterior wall framing, multiple holes approximately 2 inches in diameter are drilled through the interior surface. The product is then blown through these holes to the desired content, and the holes patched to match surrounding conditions. If conditions allow, the product could alternately be installed from exterior access points. Although installation equipment can be rented and operated by an untrained building owner, the application process can be difficult and may be best left to a trained professional.

Most readily available loose-fill products have been developed to be non-flammable, resistant to mold, insects, and rodents, and environmentally friendly. The three major loose-fill products available are cellulose, fiberglass, and mineral (rock or slag) wool. Each product has similar characteristics and qualities. When installing any loose-fill product, care should be taken to ensure the proper density is maintained during installation as performance is dependent on the material density as well as proper coverage. Although recent product developments have addressed the issue to some extent, blown products have been known to settle over time, decreasing their overall thermal performance. A lifecycle longevity analysis should be performed during material selection.

As with any insulation product, electrical fixtures, recessed lights, and heating flues or pipes may need adequate clearance unless specifically designed for insulation contact. Care should also be taken in the placement and selection of any vapor retarders while using a blown insulation product as they have a longer drying cycle. The

[10] Owens Corning Fiberglass Batt Insulation (see appendix for data sheet) http://www.owenscorning.com.

[11] Roxul Mineral Fiber Insulation (see appendix for mineral fiber insulation data sheet), http://www.roxul.com/home.

Cellulose Insulation Manufacturers Association recommends against a vapor retarder when using blown cellulose.[12]

Blown products like cellulose (or fiberglass) typically have a thermal resistance factor of approximately R-3.5 per inch and range in price from $3.00 to $4.50 a square foot, dependent on R-value and installation specifics. Blown products can be installed by a building owner but without significant savings and requires some skill to apply correctly; installation may be best left to a professional.

Spray Foam Insulation

Polyurethane spray foam products, which simultaneously seal and insulate, are becoming more prevalent in the insulation industry as people become more aware of potential moisture-related issues and the impacts of air infiltration. Poly spray foams offer a thermal resistance factor of approximately R-6.2 per inch and are available in closed- or open-cell varieties. As with all insulation, it is important to understand the thermal and moisture dynamics of the assembly. The ability of spray foam products to seal *out* moisture can also have the negative effect of sealing moisture within the assembly, thereby prolonging the natural drying cycle. Spray foams are flammable products, therefore it is critical that they not be left exposed to the interior. [13]

Spray foam insulation products range from $1.75 to $4.00 a square foot, dependent on R-value and installation specifics. Spray foam products can be installed by a building owner but without significant savings; proper installation requires significant skill and should be best left to an experienced professional.

Rigid Foam Board Insulation

Rigid foam board insulations are available in multiple formats, most of which offer a thermal resistance factor of approximately R-4 per inch. Foam board prices range from $1.50 to $3.00 a square foot, dependent on the project specifics. Similar to spray foam, foam boards also need to be protected from the interior to avoid flame spread. Joints between boards may cause gaps in the thermal continuity of the product; boards should be installed tightly with their joints taped. As most foam boards are fairly vapor resistant or impermeable, potential vapor drive within the assembly should be evaluated.[14]

Vapor Retarders

Vapor retarders are used in a building assembly to control the movement of moisture, inhibiting vapor from reaching the dew point or point of condensation. Care must be taken during vapor retarder selection and placement to avoid conditions of trapped moisture.

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[12] Nu Wool Cellulose Insulation (see appendix for blown cellulose insulation data sheet), http://www.nuwool.com; Certainteed InsulSafe Blown Fiberglass (see appendix for blown fiberglass insulation data sheet), http://www.certainteed.com/products/insulation/index/317364; CIMA (Cellulose Insulation Manufacturers Association), http://www.cellulose.org/CIMA.

[13] Icynene Spray Foam Insulation (see appendix for closed and open cell spray foam insulation data sheets), http://www.icynene.com/.

[14] Owens Corning Foamular Foam Board Insulation (see appendix for foam board insulation data sheet), http://www.owenscorning.com/.

Vapor retarders are categorized into three classes according to their vapor permeance or "perm" rating.[15]

Class I: 0.1 perm or less
Class II: 1.0 perm and less and greater than 0.1 perm
Class III: 10 perm and less and greater than 1 perm

In most cases, Class I or II vapor retarders are required on the interior side of frame walls in climate zones 5 and 6[16], while certain conditions require Class III.[17]

Typical products by vapor retarder class[18] are:
Class I: Sheet polyethylene
Class II: Kraft-faced insulation or low-perm paint
Class III: Latex paint

A "smart vapor retarder" has recently become available.[19] According to the manufacturer, this product has the capacity to inhibit moisture from entering the assembly while also allowing trapped moisture escape and the assembly to dry. While this technology seems promising, it is fairly new to the industry and could use further testing and field experience.

Air Barriers

Although not specifically addressed in this report, a continuous air barrier system is an important component of most successful building envelope assemblies. Air infiltration can be a significant factor in energy consumption. As moisture laden air is introduced into a building's assembly the thermal properties of the insulation can be greatly reduced. Although a comprehensive building insulation system will inherently reduce air infiltration to some degree, there is very little data available to predict or measure the actual values. The magnitude of air infiltration reduction will be a factor of the particular insulation product as well as the quality of the installation.
Because of the significance of air infiltration, envelope tightness and proper sealing of the building enclosure have become mandatory within the building code. A successful air barrier system will increase effectiveness of insulation and energy efficiency while also reducing the potential of moisture-related issues.[20]

Additional Information

Additional product information is included in the appendix of this report and referenced as footnotes throughout the body of the report. This supplemental information is included to assist further research and deeper, more technical comparison between products.

[15] Owen, Mark, editor, Heat, Air, and Moisture Control in Building Assemblies-Material Properties, pp. 26.14, *ASHRAE Handbook of Fundamentals* 2009, American Society of Heating, Refrigeration and Air Conditioning Engineers; Atlanta, GA .

[16] ECCCNY, Table 402.5.

[17] ECCCNY, Table 402.5.1.

[18] ECCCNY, Section 402.5.2.

[19] http://www.certainteed.com/products/insulation/mold-prevention/317391.

[20] ABAA (Air Barrier Association of America), http://www.airbarrier.org/.

ANALYTIC TOOLS

Hygrothermal Analysis – Software Summary

Modern design methodology necessitates that a building enclosure address the effects of heat, air, and moisture (HAM) across the assembly. A proper hygrothermal analysis should be completed to evaluate temperature and moisture across the assembly over a period of time through specific environmental conditions. This analysis should provide the necessary information to accurately predict performance. This report uses a number of software tools and techniques to perform the necessary hygrothermal analysis over multiple scenarios. The resulting information and findings have been evaluated, cross-referenced and blended to reach the stated conclusions[21].

It is important to note that interior humidity has a significant impact on the potential for condensation within building envelope cavities. The analysis in this study assumes that no forced humidification is employed in winter and swing season months. When humidification is added, the potential for condensation dramatically increases. This could become a very significant issue if the use of the historic structure changes to one with increase humidity. An example of this would be modifying a building to become a museum, since sensitive archives and artifacts require specific levels of humidity to be maintained year round for their protection.

The software programs used for the hygrothermal analysis are ***HAM*** ("The Heat, Air and Moisture Toolbox"), ***THERM***, and ***WUFI Pro***. Each program provided related analysis that was blended and cross-validated. A description of each program and its use in this analysis and report follows.

HAM Toolbox

HAM (version V.1B-E/U), developed and maintained by Rick Quirouette, is a one-dimensional analysis tool that evaluates building assemblies under various criteria.[22] The software package includes tools to quickly evaluate wall assemblies for overall R-value, condensation potential, and dew point location. User-defined wall assemblies are evaluated in respect to two-peak climate conditions in winter and summer.

While the software has strengths in its ability to quickly model and evaluate multiple assemblies and configurations, it is limited by its static analysis and does not account for fluctuations in climate and environmental conditions or the continual wetting-and-drying cycle within a building envelope. This report uses the HAM Toolbox to rapidly evaluate multiple configurations and help focus the analytic process. The findings of this software were also helpful in validating and confirming findings in other programs. Direct output and images from the HAM Toolbox are presented in the Appendix of this report.

THERM

THERM (version 6.3)[23] is a software analysis tool developed at the Lawrence Berkley National Laboratory (LBNL) to model heat transfer through building assemblies. THERM allows the user to model and evaluate complex building assemblies and intersections of various components. The software performs a heat transfer analysis across the

[21] Straube, John, Burnett, John, Overview of Hygrothermal (HAM) Analysis Methods, Ch.5, in *"Moisture Analysis and Condensation Control in Building Envelopes",* Treschel, Heinz R., editor, ASTM; Philadelphia, PA, 2001

[22] Quirouette Building Specialties Ltd. www.qbstoolbox.com.

[23] http://windows.lbl.gov/software/therm/therm.html

user-defined model using specific thermal properties and characteristics of each material in relation to the user-defined environmental conditions. The results of THERM analysis depict the thermal profile of the assembly as well as specific U-values and areas of thermal flux. This analysis of thermal conditions is useful in understanding potential moisture movement and behavior within the assembly.

This report uses multiple THERM models to evaluate complex areas and intersections of the building's envelope. THERM temperature profiles were mapped against vapor pressure and dew-point analysis performed through other cited techniques. This combination and blending of modeling output provides a deeper understanding of the conditions under evaluation. Direct output and images from the THERM analysis are presented in the Appendix of this report.

WUFI Pro

Perhaps the best-known and most highly regarded software tool for analysis of building envelope physics is WUFI Pro.[24] WUFI Pro was originally developed by the Fraunhofer Institute for Building Physics in Germany and later jointly developed with the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee, for use in the U.S. WUFI Pro (version 5.1) performs a one-dimensional calculation and analysis of the heat and moisture transport through a building assembly, resulting in a hygrothermal model with a fairly comprehensive analysis of the user-defined system.

What makes the WUFI model very useful is its ability to be run for a user-defined period of time, evaluating the assembly's performance in relation to fairly accurate weather data, through multiple seasons and conditions. Unlike other analytical tools, whether manual calculation or computer analysis, WUFI Pro evaluates and incorporates the predicted wetting/ drying potential of the assembly by providing a more dynamic view. Because moisture problems within an assembly typically occur because the assembly cannot reach a balance of drying cycle over wetting periods, understanding the wetting/drying cycle within an envelope is critical to better predicting and remedying adverse conditions.[25] If the assembly can experience an associated and sufficient drying cycle, it may be acceptable for the assembly to undergo certain short periods of wetting or internal condensation.

For this purposes of this study, WUFI models were run through a typical one-year cycle for each of the various insulating scenarios. The results were evaluated for potential moisture-related problems, and various samples of output from the WUFI analysis are included in within this report. Actual film (.AVI) files generated to produce the report can be provided on request.

[24] http://www.wufi-pro.com/

[25] *Building Science for Building Enclosures,* Straube, John and Burnett, Eric, Westford, MA: Building Science Press, 2005.

Energy Analysis – Software Summary
eQUEST

eQUEST (version 3.64) is a Department of Energy-based energy simulation software that is recognized as an industry-standard tool for performing building energy analyses. Designed to perform detailed comparative analysis of building designs and technologies, eQUEST applies sophisticated building energy-use simulation techniques. This software is also approved by the U.S. Green Building Council for demonstrating compliance with Energy and Atmosphere (EA) credits on projects attempting LEED certification.

The ability of the software to provide comprehensive detail depends on the breadth, precision, and accuracy of information that can be provided in the first place. Information required to create an energy model typically includes the building's geometry; envelope construction (including insulation values); lighting power densities; HVAC system types and control strategies; internal or process loads; and a building occupancy schedule.

eQUEST is often used to inform the building design process or in this case, the renovation/adaptive reuse process. By creating a relatively accurate model of a building, the building's energy consumption can be projected over the course of the Typical Meteorological Year (TMY) as well as estimated energy savings from implementing various alternatives. Building owners can then compare the energy and cost savings for alternatives against the additional cost of each to determine relative economic benefits. For new construction as well as some existing buildings, eQUEST can actually be used to demonstrate that the building will perform better than an average building constructed to code requirements.

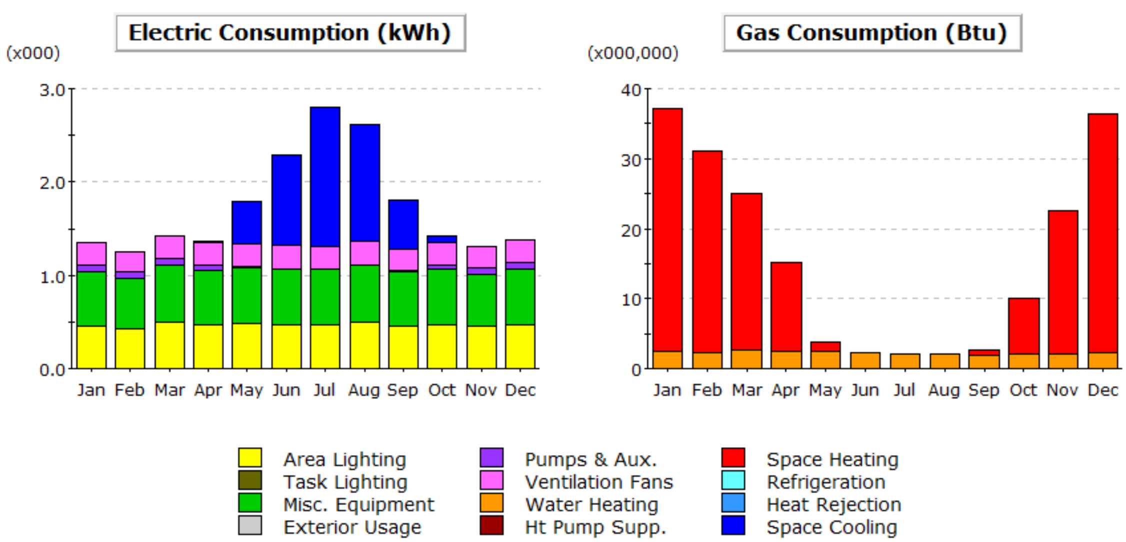


Figure 09: Typical distribution of a building's energy consumption.

The program generates output reports which show projected building energy consumption on an hourly basis over the course of a full year. The graphs above show the monthly electric and fuel consumption for a given building, separated according to end-use. Visual representations of energy consumption can yield insights into how the building systems are operating over the course of the year. The graph on the left shows cooling energy use rising during the summer months, as would be expected, and minimal cooling throughout the rest of the year. The graph on the right shows the inverse for heating energy usage, which peaks during the winter months and falls to zero during the summer. Not all energy use categories shown in the graphics above apply to all building types.

Energy models are not precise at predicting *actual* energy use for buildings, in part because typical vs. actual weather is used, and the method and quality of real construction varies from ideal. Such models, however, are generally considered accurate regarding the relative energy impact of various alternatives including insulation values. Models can therefore help guide conceptual decisions: whether to insulate or not; and what method of insulation will work best considering all factors.

For an existing building, a model can be calibrated by making adjustments to various assumptions, so that the projected energy use for a year reasonably matches the actual energy history. This can increase the confidence level for projecting savings from changes. Unfortunately, actual energy consumption data over a significant period was not readily available for either case study building. Since the both buildings use oil for heating, it is unlikely there is historical use information per month; at best typically only periodic delivery quantities are available. The baseline energy projections for both buildings appear reasonable based on experience, and the savings projections are within acceptable tolerances.

ENERGY SIMULATION ANALYSIS

Cambridge Food Co-op

A baseline energy model for the Cambridge Food Co-op was constructed based on the findings from our site visit and information provided by building occupants. eQUEST inputs for creating the energy model included the building's geometry, roof and wall constructions, HVAC systems, internal loads, and the building occupancy schedule. Internal loads for the Cambridge model accounted for coolers and other equipment used in the first floor store, as well as some small plug loads (computers, printers, etc.) in the second floor offices. Since lighting and domestic hot water loads would have only a negligible effect when comparing the heating energy savings of the various insulation scenarios, those items were removed to simplify the model.

There are two distinct HVAC systems used to condition the Co-op. An oil-fired, forced-air furnace provides heating to the first floor store supplemented by cooling via an electric direct expansion (DX) cooling coil and a condenser located outside the rear of the building. An oil-fired boiler serves the hot water baseboard radiators which heat the second floor units. Second floor spaces are not cooled. Both systems could be considered typical for residential spaces in older buildings.

While it is not a specific focus of this study, air infiltration inevitably is an important factor when addressing heat loss in a building and must be considered when creating a comprehensive energy model. Infiltration rates in buildings are often defined in terms of the number of air changes per hour (ACH) at 50 Pascal (equivalent to roughly 20 MPH wind speeds). Continuous 20 MPH wind speeds are rare in many climates, but it is a frame of reference for quantifying the draftiness of a building. To put it in perspective, a building considered to be tight would have an ACH50 rating of less than 5. A moderately sealed building would have an ACH50 between 5 and 10, and a leaky building would have an ACH50 greater than 10. The infiltration rate for a building can be confirmed by conducting a blower door test, which isolates a portion of the building; applies pressure to the space via a variable speed fan (blower door); and measures the resultant airflow. Note that while a blower door test was performed for the Zadock Pratt Museum (see below), one has not yet been performed for the Cambridge Food Coop. The model utilizes a 7 ACH50 infiltration rate – a conservative estimate based on the apparent condition of the building envelope at the time of the site visit – and adjusts the number of ACH proportionally on an hourly basis, based on the wind speeds at that particular location.

In the absence of actual utility bills, the utility rates used in the energy model for the Cambridge Food Coop are based on average utility prices for this past heating season for this location as listed on the NYSERDA website. The results shown here are based on a fuel oil rate of $3.86 per gallon and an electric rate of $0.17 per kWh.

The Cambridge Food Coop appeared to have little-to-no insulation within the exterior wall cavities and a small amount of insulation over only part of the second floor ceiling. For the sake of comparison and to show the value in addressing the building envelope in an un-insulated building, the baseline building was therefore modeled as having no wall or roof insulation (as is). Even so, the building construction components have an effective R value of 4.1.

The table below shows a number of building envelope improvement scenarios. The baseline energy model was placed in each of the three climate zones of New York State (4, 5, and 6) and modeled with progressively better building envelope improvements, compared with a baseline model of zero wall and roof insulation. The first "R-Value" column in the table estimates the R-value for the existing wall/roof construction with no insulation.

The first scenario for each location addresses building air infiltration only. Air that infiltrates the building through gaps in the exterior walls and window frames must be effectively conditioned to meet the space temperature, which can be costly, especially during peak heating and cooling conditions. Adding some type of wall insulation will inherently reduce some infiltration. The energy savings models assume that a reduction in infiltration of a minimum of 5% occurs when a wall insulation project occurs. This represents the lower end of air infiltration reduction. The tables differentiate the savings from the infiltration reduction alone, then with the addition of varying amounts of insulation. The columns to the far right show savings with 15% and 30% infiltration reduction (and with 100% code insulation). These might better represent actual savings from a proper air sealing and insulation project.

Cambridge

	Wall Only (Wall Area = 2,910 ft^2)				Roof Only (Roof Area = 1,810 ft^2)				Combined Wall & Roof	Combined Wall & Roof w/ 15% Infiltration Reduction	Combined Wall & Roof w/ 30% Infiltration Reduction
Zone-5 (Upstate NY)	R-Values			% Heating Energy Savings	R-Values			% Heating Energy Savings	% Heating Energy Savings	% Heating Energy Savings	% Heating Energy Savings
	Existing Wall	Insulation	Total		Existing Roof	Insulation	Total				
Infiltration Reduction (5%)	4.1	-	4.1	4.7%	4.1	-	4.1	4.7%	4.7%	13.4%	25.6%
50%	"	8.5	12.6	17.1%	"	19	23.1	26.7%	38.3%	-	-
75%	"	12.75	16.85	19.0%	"	28.5	32.6	27.8%	40.6%	-	-
100%	"	17	21.1	20.0%	"	38	42.1	28.2%	41.7%	47.6%	55.6%
125%	"	21.25	25.35	20.9%	"	47.5	51.6	28.5%	42.4%	-	-
Zone-4 (NYC)											
Infiltration Reduction (5%)	4.1	-	4.1	4.5%	4.1	-	4.1	4.5%	4.5%	14.0%	28.8%
50%	"	5	9.1	12.4%	"	19	23.1	26.0%	34.8%	-	-
75%	"	7.5	11.6	14.6%	"	28.5	32.6	26.9%	36.9%	-	-
100%	"	10	14.1	16.0%	"	38	42.1	27.3%	38.4%	44.6%	53.9%
125%	"	12.5	16.6	16.9%	"	47.5	51.6	27.9%	39.3%	-	-
Zone-6 (Western NY)											
Infiltration Reduction (5%)	4.1	-	4.1	4.1%	4.1	-	4.1	4.1%	4.1%	11.9%	24.1%
50%	"	9.5	13.6	16.6%	"	24.5	28.6	28.2%	41.4%	-	-
75%	"	14.25	18.35	18.4%	"	36.75	40.85	29.3%	43.4%	-	-
100%	"	19	23.1	19.5%	"	49	53.1	29.9%	44.5%	50.2%	58.1%
125%	"	23.75	27.85	20.2%	"	61.25	65.35	30.3%	45.1%	-	-

CLIMATE ZONE	COUNTY	WINTER DESIGN DRY-BULB TEMP	SUMMER DESIGN DRY-BULB TEMP	COINCIDENT WET-BULB TEMP	HEATING DEGREE DAYS
4	Queens	13	89	73	4910
5	Albany	-7	86	70	6894
6	Oneida	-5	86	70	7244

Figure 10. Energy Analysis Summary table showing the energy savings from adding various levels of wall and roof insulation in New York's three climate zones for the Cambridge Food Co-op

Throughout the three climate zones in New York State, adding roof insulation appears to be a better value than adding wall insulation. This confirms the conventional wisdom that because heat rises, a significant portion of a building's heat loss is associated with the roof. Furthermore, insulating a building's roof is generally less expensive than insulating existing exterior walls, even though the recommended levels of roof insulation are higher than those for walls. This is because most buildings (with the exception of single-story structures) have more wall area than roof area, and the installation itself is generally less intrusive. Fiberglass batten insulation can often be added above top floor ceilings with minimal disruptions to building occupants and the building itself. Adding wall insulation, on the other hand, can be more complex and may even require removing all or part of the interior or exterior wall.

The findings of the energy portion of the study show that while significant heating energy savings can be achieved by adding some level of insulation to a previously un-insulated roof or wall, the incremental benefit of adding insulation beyond what is required by code appears limited compared to the probable installation cost. Other factors, however, may motivate a building owner to pursue a highly efficient building envelope.

Zadock Pratt Museum

A baseline energy model for the Zadock Pratt Museum was constructed in much the same way as the Cambridge energy model. Measurements taken during the site visits enabled the creation of floor plans for the building, which were then imported into the modeling software. The conditions of the first floor walls provided a unique opportunity to fully examine the exterior wall cavities. While there had been some insulation in the exterior wall prior to the flood, for the purposes of this study, the baseline energy model for the museum assumes no wall insulation. For the sake of comparison, the existing attic insulation has also been eliminated in the baseline model as well as lighting and domestic hot water loads, as they would have a negligible impact in regard to comparing savings between various scenarios.

Internal loads in the Museum models were relatively minimal and included some small plug loads in the first and second floor spaces as well the range, dishwasher, and refrigerator in the first floor apartment.

Two HVAC systems are used to condition the building. The first and second floors of the museum are served by an oil-fired forced air furnace, while heating for the first floor apartment is provided by baseboard radiators served by an oil-fired hot water boiler. Neither portion of the building is cooled during the summer months.

The infiltration rate used in the model (11.7 ACH50) is based on a blower door test performed on a second floor room during our initial site visit. Due to the condition of the first floor walls, this was the only space in the building which was fit to be used for the test. The model adjusts the number of ACH on an hourly basis based on the wind speeds at that particular location.

In the absence of actual utility bills, the utility rates used in the energy model for the Museum are based on average utility prices for this past heating season for this location as listed on the NYSERDA website. The results shown here are based on a fuel oil rate of $3.91 per gallon and an electric rate of $0.17 per kWh.

The table below shows a number of building envelope improvement scenarios similar to the Co-op analysis. The baseline energy model was placed in each of the three climate zones of New York State (4, 5, and 6) and modeled with progressively better building envelope improvements, compared with a baseline model of zero wall and roof insulation. The first "R-Value" column in the table estimates the R-value for the existing wall/roof construction with no insulation. Infiltration reduction is included in a method as previously described for the Cambridge project.

Though there is a measurable difference in heating energy consumption for the models in the three climate zones due to differences in annual weather conditions, there does not appear to be a significant difference in the percentage of savings projected for the various insulation measures. All building features are the same in each zone, so it is not surprising that the percentage difference in heating bill savings for the same measure (i.e. 50% code-required wall insulation) is minimal across the three zones. It should be noted, however, that heating energy bills in Oneida (climate zone 6) will be higher than in New York City (climate zone 4), so a heating energy savings of 25% in Oneida is worth more in dollars than an equivalent percentage savings in New York City and may provide a better simple payback if the cost of insulation is similar.

Prattsville

	Wall Only				Roof Only				Combined Wall & Roof	Combined Wall & Roof w/ 15% Infiltration Reduction	Combined Wall & Roof w/ 30% Infiltration Reduction
	Wall Area = 4,810 ft^2				Roof Area = 3,340 ft^2						
Zone-5 (Upstate NY)	R-Values: Existing Wall	Insulation	Total	% Heating Energy Savings	R-Values: Existing Roof	Insulation	Total	% Heating Energy Savings	% Heating Energy Savings	% Heating Energy Savings	% Heating Energy Savings
Infiltration Reduction (5%)	2.7	-	2.7	4.0%	4.2	-	4.2	4.0%	4.0%	11.9%	23.1%
50%	"	10	12.7	13.8%	"	19	23.2	23.6%	33.8%	-	-
75%	"	15	17.7	14.8%	"	28.5	32.7	24.5%	36.0%	-	-
100%	"	20	22.7	15.4%	"	38	42.2	24.8%	37.0%	44.0%	53.7%
125%	"	25	27.7	15.8%	"	47.5	51.7	25.0%	37.7%	-	-
Zone-4 (NYC)											
Infiltration Reduction (5%)	2.7	-	2.7	4.5%	4.2	-	4.2	4.5%	4.5%	13.6%	26.1%
50%	"	6.5	9.2	12.4%	"	19	23.2	22.6%	30.8%	-	-
75%	"	9.75	12.45	13.6%	"	28.5	32.7	23.5%	32.7%	-	-
100%	"	13	15.7	14.3%	"	38	42.2	23.7%	33.7%	41.6%	52.1%
125%	"	16.25	18.95	14.8%	"	47.5	51.7	23.8%	34.3%	-	-
Zone-6 (Western NY)											
Infiltration Reduction (5%)	2.7	-	2.7	3.6%	4.2	-	4.2	3.6%	3.6%	10.8%	21.7%
50%	"	10	12.7	13.8%	"	24.5	28.7	23.9%	33.9%	-	-
75%	"	15	17.7	14.8%	"	36.75	40.95	24.9%	36.0%	-	-
100%	"	20	22.7	15.4%	"	49	53.2	25.3%	37.2%	43.8%	53.6%
125%	"	25	27.7	15.9%	"	61.25	65.45	25.8%	38.0%	-	-

CLIMATE ZONE	COUNTY	WINTER DESIGN DRY-BULB TEMP	SUMMER DESIGN DRY-BULB TEMP	COINCIDENT WET-BULB TEMP	HEATING DEGREE DAYS
4	Queens	13	89	73	4910
5	Albany	-7	86	70	6894
6	Oneida	-5	86	70	7244

Figure 11. Energy Analysis Summary table showing the energy savings from adding various levels of wall and roof insulation in New York's three climate zones for the Zadock Pratt Museum

Adding insulation to an un-insulated building roof, as opposed to un-insulated exterior walls, appears to provide better heating energy savings. Insulating both walls and roof can provide additional savings, but the benefits of insulating either roof or walls only are not directly additive. This reflects reality: improving the building envelope can reduce heating energy consumption, but a heating load will always exist in some form. This means that first-step savings (i.e. going from no roof insulation to 50% of what is required by code) are relatively easy to achieve, but realizing heating energy savings beyond 30 to 40%, for example, becomes more difficult and ultimately more costly. The point of diminishing returns may vary in terms of how much time and money individuals are willing to invest; it may also vary from building to building based upon what is actually feasible with regard to installation. From an energy perspective, the most cost-effective results are likely achieved by reducing air infiltration wherever possible and having some practical level of insulation in both the roof and exterior walls.

HYGROTHERMAL ANALYSIS & FINAL RECOMMENDATIONS

The included energy analysis was performed to evaluate potential energy savings in relation to the addition of varying degrees of insulation to a building's envelope. Concurrently, significant analysis was performed and has provided a better understanding of the dynamics of the building envelope in current, existing conditions and with respect to any proposed insulation modifications.

The conclusions included here are based on detailed hygrothermal analysis for each of the proposed insulation scenarios. Custom computer models were developed for each of the scenarios using the specific thermal and moisture properties of each of the building materials. Exterior environmental conditions were used for a typical year's duration as well as for worst case conditions. The controlling condition for condensation analysis in New York is the winter or heating season. Based on the available moisture content in the air in relation to expected exterior as well as interior temperatures, it is predicted there will be approximately 25% relative humidity (RH) in the interior spaces of the case study buildings during the winter months. These worst-case conditions were only one factor in the analysis; the dynamic, year-long WUFI analysis provides a better understanding of the predicted conditions and potential for problems in the exterior envelope.

Cambridge Food Co-Op, Cambridge, New York

The Cambridge Food Co-Op building is constructed with an exterior, load-bearing masonry (brick) wall approximately 10" thick with an original lath and plaster interior. The interior wall has subsequently been furred out with wood framing and ½" gypsum wallboard. This furred wall creates a void space with an average depth of 4 inches. Although this cavity is currently not insulated, it could provide an opportunity for added insulation. The existing masonry shows signs of decay and damage from internal moisture: there is evidence of buckling, spalling, and bowing of the masonry over various areas of wall, as well as significant decaying and failing mortar joints. This is important to note while evaluating the wall for potential modifications.

Figure 12. Image on the left shows area of brick spalling and attempted repair using hard portland cement mortar. Cement-based mortars are generally incompatible with historic lime-based mortars and tend to cause more accelerated deterioration of the masonry assemblies they are meant to repair. The image on the right shows significant settlement and bowing of the masonry wall within the last 6'-0"+/- as it approaches the intersection with the timber-framed addition.

The existing envelope conditions at the Co-op were modeled, evaluated, and found to show no signs of potential interior condensation. The analysis and actual field conditions do, however, show moisture accumulation within the exterior masonry, as exhibited by deterioration and actual wet surfaces, primarily due to rising damp. The confirmation of modeled results with actual field conditions is important because it provides yet another parameter to verify risk and potential for infiltration, condensation, and other damaging factors.

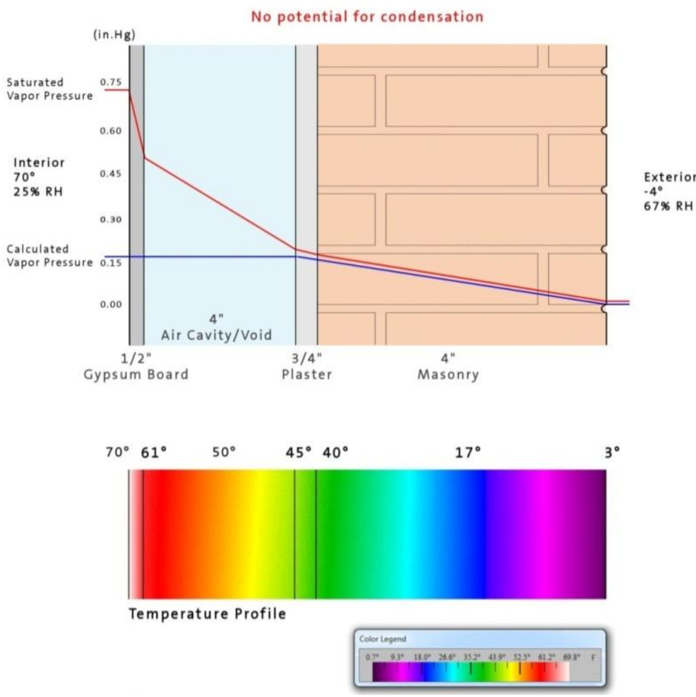


Figure 13: Cambridge Food Co-Op
Existing conditions @ Typical Exterior Wall
Hygrothermal Analysis

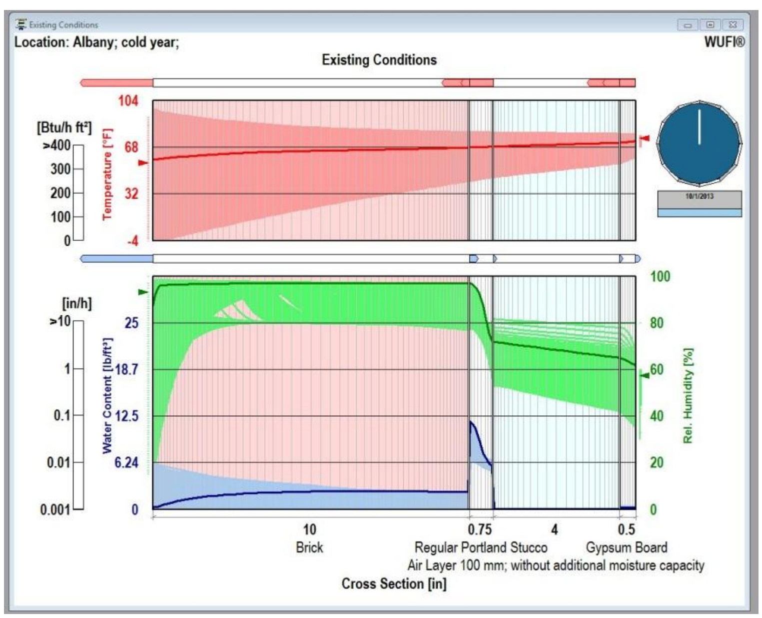


Figure 14: Cambridge Food Co-Op
Existing Conditions at Typical Exterior Masonry Wall - Yearly Cycle – WUFI Hygrothermal Analysis shows that the existing condition of the wall allows for excess moisture accumulation within masonry, but that the masonry is being warmed from the interior. While the presence of moisture itself is not desirable, heating of the masonry assembly reduces the potential for damage from freeze/thaw cycling.

It was noted that currently the existing masonry wall is, in effect, being heated and warmed from the interior space as heat escapes through the un-insulated wall. This is increasing the heating load on the building and perhaps creating undesirable interior conditions on colder days. The same heat loss is most likely also helping the masonry undergo an important drying cycle and avoid even greater damage from freezing internal moisture during the winter months.

The wall assembly was next evaluated with insulation added to the interior framed cavity. The existing framed cavity was assumed to be insulated to full depth with an insulation of approximately R-4 per inch. The analysis of the proposed insulated wall shows potential for condensation within the insulated cavity if moisture is not controlled. If left uncontrolled, vapor drive would occur outward, resulting in moisture condensation on the first coldest surface, in this case the interior face of plaster.

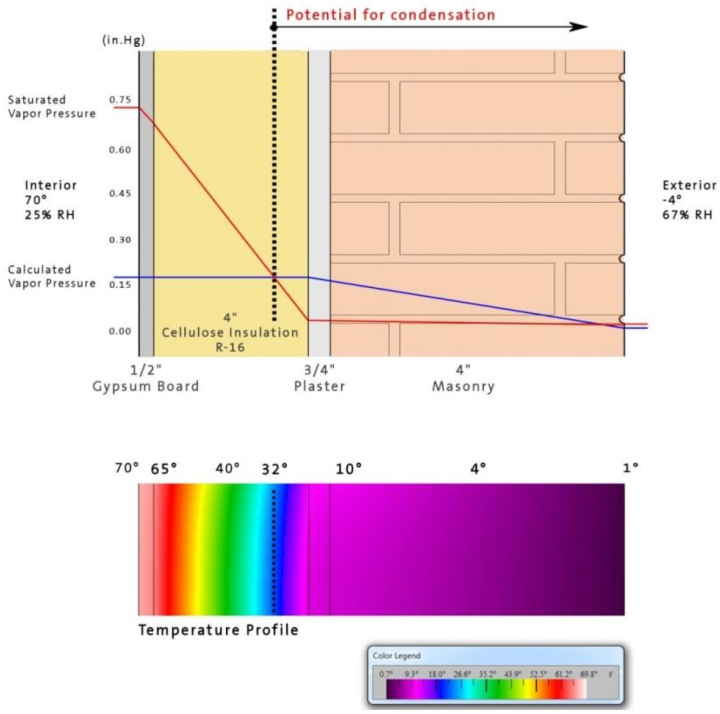


Figure 15: Cambridge Food Co-Op
Insulated Conditions @ Typical Exterior Wall
Hygrothermal Analysis

This moisture drive should be controlled through the installation of a vapor retarder on the "warm side" of the insulation, as will be discussed below. It is important to note that since the exterior wall at the Co-op is insulated, the thermal profile shifts significantly, subsequently keeping the masonry colder for longer periods of time. This resulting condition should be carefully considered, since retaining internal moisture for longer periods of time, potentially during freezing conditions, will dramatically increase the risk of masonry damage in freeze/thaw cycling.

Cambridge Recommendations:
The roof of Co-op is in fair condition at best and will be due for replacement in the next 3–5 years. This would present an excellent opportunity to also insulate the assembly at the upper side, since it is not currently well insulated. A fully-adhered membrane roof over rigid polyisocyanurate (polyiso) foam board insulation at 4" thickness would provide a thermal resistance of R-20 and significant energy savings. In addition, this method would actually provide flexibility for exposing and restoring the original ceilings and lighting.

Although not specifically analyzed in this report, the next recommendation is to repair and seal the existing windows and openings along the perimeters of where masonry openings meet wooden window frames as well as the proper fit & operation of the windows and triple-track storm windows themselves. Reducing outside air infiltration will greatly reduce the building's energy consumption and contribute to occupant comfort. In the case of the robust masonry wall at Cambridge, the majority of air infiltration will happen at wall openings or related junctures. There is little concern for air infiltration within or through the wall assembly itself, therefore the below recommendation do not include an additional air barrier.

A third action towards energy efficiency could be to insulate the exterior walls, but this should be approached carefully. If there is a desire to maintain the existing gypsum wallboard (gwb), cellulose insulation could be blown into the existing framing cavity through small holes in the gwb. Cellulose added to the existing cavity would provide an added average thermal resistance factor of R-16 to the walls and could control a certain amount of air infiltration from passing through the masonry. There is a risk, however, that over time the cellulose could settle within the wall and need to be topped off to maintain its initial thermal value. Although the Cellulose Insulation Association recommends no vapor retarder be used with its product, it is recommended that a Class II perm paint should be considered for interior wall surfaces to complement the use of the cellulose. A sheet vapor retarder with a lower perm rating should be avoided as the interior wall will need to continue to dry to the interior. A smart vapor retarder could also be tested in this application; ultimately more research on its appropriate fit for this particular building is required.

Ideally, the interior gypsum wallboard would be removed and the wall properly insulated. In that case, it is recommended the wall be insulated with mineral fiber (or fiberglass) battens insulation at approximately R-19 with the new gypsum wallboard then coated with a Class II vapor retarder paint.

As in any wall insulation scenario, it would be advantageous to address the intersection of floor joists to exterior wall. Since it is difficult to complete the vapor retarder system over these areas, an alternative at these locations could be to spray with open-cell foam insulation product. Spray foam in these areas would seal the difficult material transitions as well as provide sufficient insulation, but it is crucial that the material be applied correctly. Even an open-celled foam may have much lower permeability than other products and thus may put the masonry-to-wood interface breathability at some elevated risk. Existing finishes will have to be removed in certain areas to allow application of the foam, and it would be extremely important to make repairs to the masonry and wood framing interface at the same time.
The above recommendations are in the most part reversible in nature, with the exception of the spray foam areas. It is intended that the original interior plaster finish as well as the masonry exterior wall be maintained and protected. The above recommendations take into careful consideration the delicate status of the masonry today as well as the desire to protect the system from further harm. Note that additional calculation and analysis data are available in the Appendix.

The Zadock Pratt Museum, Prattsville, New York

The Zadock Pratt Museum building is predominantly wood-framed construction. There are multiple methods of framing and sheathing present ranging from larger timber post and beam with heavy plank sheathing to unsheathed areas with only clapboard siding. For the purposes of this report, the framing methods used in the front, main house were evaluated.

In August of 2011, Hurricane Irene caused significant flooding in the Prattsville area, including the Zadock Pratt museum. The subsequent cleanup has left the walls partially exposed as the interior of the walls are left to dry. Observations suggest that pre-flood method of wall construction may have provided a very viable solution to insulation and moisture control issues. The following analysis was performed assuming walls had no insulation (as originally constructed) in comparison to level of added insulation (closer to recent modifications).

Figure 16. Image on the left shows an exposed section of the exterior plank wall construction in the bank window. Image on the right shows the intersection of a more common interior stud wall framing condition in the original footprint with a modified version of the plank framing used in the bank wing.

The existing envelope conditions at the Museum were modeled, evaluated, and found to show no signs of potential interior condensation. The walls as originally constructed would have allowed for significant air infiltration and heat loss.

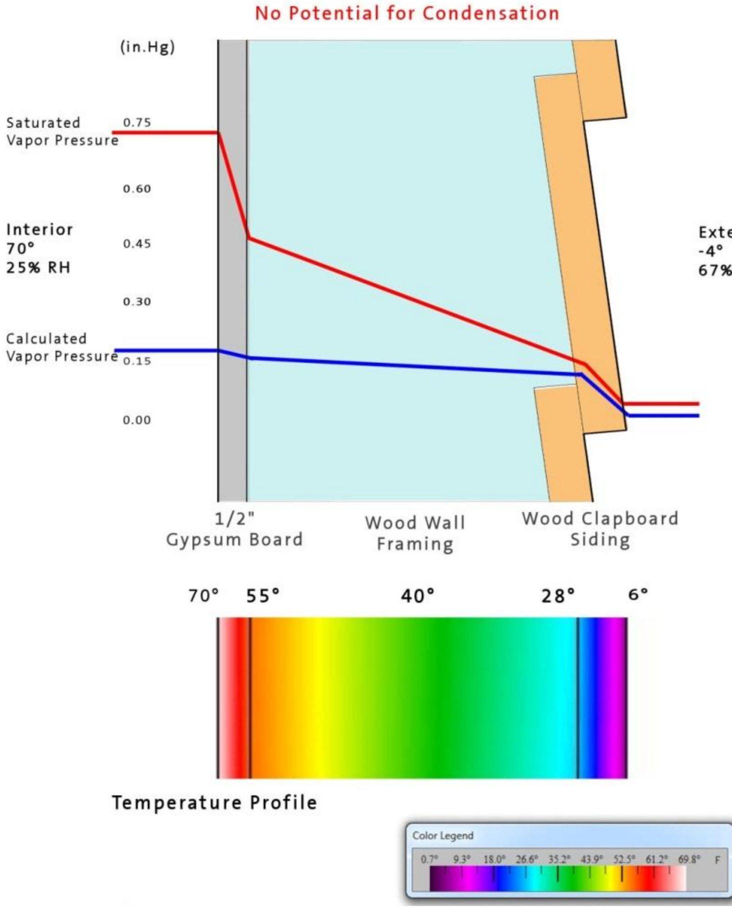


Figure 17: Zadock Pratt Museum
Insulated Conditions @ Typical Exterior Wall
Hygrothermal Analysis

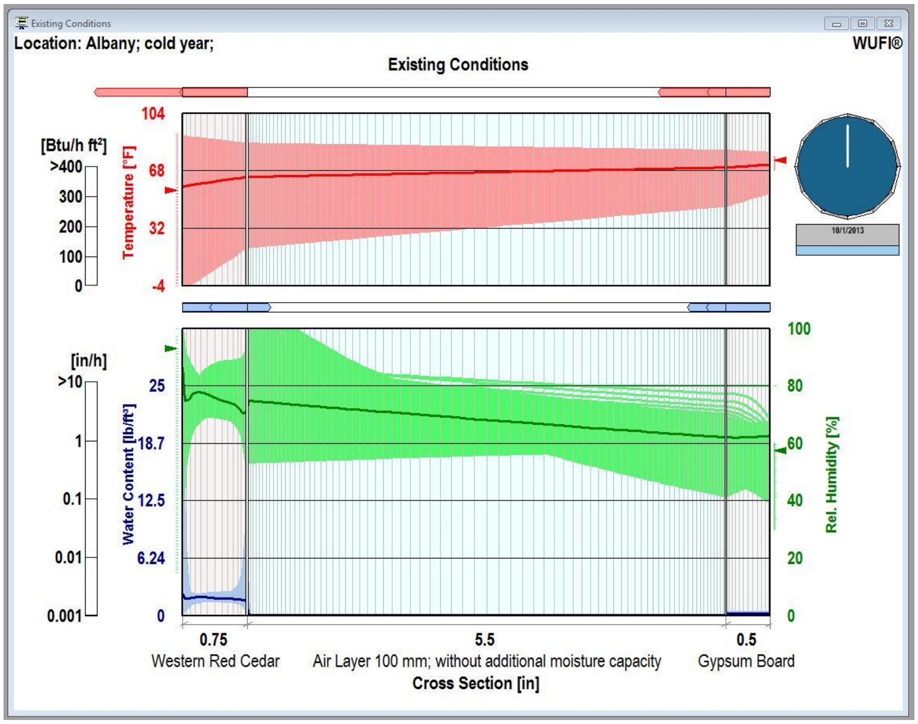


Figure 18: Zadock Pratt Museum
Existing Conditions at Typical Exterior Wall- Yearly Cycle
WUFI Hygrothermal Analysis

Notes/Observations:

- *excess moisture accumulation*
- *constant heat flow through wall*

The original wood construction experienced natural seasons and cycles of wetting and drying over time, allowing the wood to perform and survive rather well. Although perhaps favorable to the integrity of the wood, these conditions are not at all desirable to current habitants. There needs to be some level of insulation, air infiltration control and moisture management introduced to the assembly to meet today's occupant comfort levels.

The wall assembly was next evaluated with insulation added to the interior frame cavity (similar to modifications prior to flooding). The frame cavity was assumed to be insulated to full depth with an insulation of approximately R-4 per inch. The analysis of the proposed insulated wall shows potential for condensation within the insulated cavity if moisture is not controlled. If left uncontrolled, vapor drive would occur outward, resulting in moisture condensation on the first coldest surface, in this case the interior face of clapboard.
This moisture drive should be controlled through the installation of a vapor retarder on the "warm side" of the insulation.

Although not specifically a focus of this report, air infiltration should be addressed at the Museum. The current exterior wall will allow significant exterior air infiltration bringing in moisture-laden air and changing the thermal profile of the wall considerably, adversely affecting the dew point location. These items are addressed in the recommendations below.

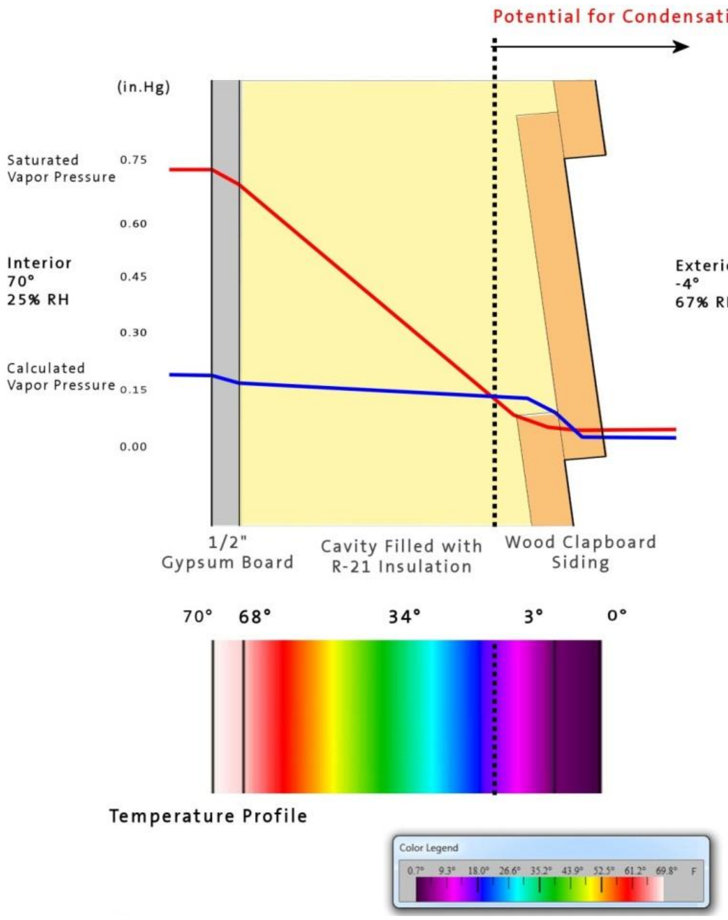


Figure 19: Zadock Pratt Museum
Insulated Conditions @ Typical Exterior Wall
Hygrothermal Analysis

Prattsville Recommendations:

The first recommendation towards decreasing energy consumption at the Zadock Pratt Museum would be to add more insulation to the attic floor and to look carefully at opportunities to insulate at the eaves without hindering air circulation. Currently the attic insulation over the building is somewhat inconsistent. The depth of the insulation appears to vary across the attic surface, including some areas that appear to be without any coverage. The attic should be further evaluated and insulated to a more consistent level. An un-faced layer of fiberglass batts should be rolled perpendicular to the ceiling framing at a minimum total depth of 12" with an approximate value of R-38. The new insulation should be installed to provide consistent coverage. This measure alone could result in an approximately 30% savings in the yearly heating load. Alternatively, rigid board insulation covered by plywood could be used to preserve the storage capacity of the attic. Note that NYS Building Code may ultimately prevent this space from being used as storage without fire suppression.

Additional actions towards energy efficiency for the museum should address the exterior walls. Since the recent flood, the walls have been opened up and left to dry naturally. Assuming this process has had sufficient time and the wood structure and siding have dried adequately, the process of rebuilding the walls should begin. The walls as built do not have much thermal resistance, air infiltration resistance, or weather resistance. The recommendation is to address all of these issues to some degree, focusing first on the latter two characteristics.

If removal and reinstallation of clapboards is not an option – and to greatly reduce air infiltration as well as resist driving water intrusion – the interior face of the exterior clapboards should be wrapped with a continuous layer of air barrier such as Tyvek sheeting or 15# felt building paper, similar to the method already utilized at the first floor walls. This material should be wrapped and stapled between wall framing members and held tight to the backside of the wood siding. This approach will reduce air infiltration and form a weather barrier but should allow breathability for the backside of the clapboards and their interface with wood framing.

The wall cavities should then be insulated with a batt insulation product to the maximum depth possible (4"–5" average). Since the building is obviously prone to flooding, a mineral fiber board or batt is recommended for its excellent water resistance. Finally, a continuous layer of vapor retarder should be applied prior to the finished gypsum board. A 2-mil polyurethane sheet with all joints taped is recommended. If possible, various products could be tested for this application, e.g. the newer smart vapor retarders or even foil-faced batt insulation. The application of a lower perm paint would probably not be sufficient to stop vapor movement through the wall.

Although not specifically analyzed in this report, the next recommendation is to repair and seal the existing windows and openings. Although the windows of the Museum are in rather good condition considering their age, they could still benefit from some attention. Reducing outside air infiltration will greatly reduce the building's energy consumption and contribute to occupant comfort.

Final Conclusions

This report focuses on the impacts of adding insulation to older buildings in an effort to achieve measurable energy savings. While it is important to address energy conservation in most occupied buildings, older structures require careful evaluation of many interrelated factors early in the decision-making process. A primary tenet of the Secretary of Interior's Standards for Rehabilitation is that renovations to historic buildings should "do no harm." At the same time, there is sometimes a desire to perform only renovations or modifications that are easily reversible as well. Comprehensive evaluation of the potential effects of insulating the building envelope is critical to ensuring renovations that do no harm. As stated in this report, adding insulation to a building envelope has the potential to dramatically shift the thermal profile of the assembly. Because there is a direct link between the thermal profile of an assembly and the point at which vapor will condense within that assembly, it is essential that this and other issues, such as rate of vapor migration, interior moisture control in the heating season and air circulation, be addressed.

When evaluating energy conservation measures in an older or historic building, it is critical to understand the dynamics of the envelope. Typically, an older structure is already compromised to some degree and has undergone significant changes over its lifespan so that it has either reached the state of equilibrium that allows its survival, or it is in need of immediate attention. When considering the introduction of thermal insulation, it is important to analyze plans for the overall rehabilitation or restoration process within the context of these issues.

Both the Cambridge Food Co-Op and the Zadock Pratt Museum have exterior wall systems that need to undergo continual drying cycles to avoid prolonged damage. This drying balance is necessary in any building but even more important in an older structure, where the goal is to ensure that the assembly undergoes more drying than wetting periods. Brief, intermittent instances of moisture, whether from condensation or water intrusion, are acceptable in cases where the assembly can dry quickly enough. It is important to acknowledge and assist this drying cycle when considering the addition of insulation to the existing envelopes. In the case of the Co-op, for example, the exterior masonry may already be at a saturation point. As insulation is added to its interior, the exterior masonry could remain colder (and wetter) for longer periods of time, perhaps even increasing the amount and frequency of internal masonry freezing.

As insulation levels are increased, the dew point or saturation point in the building assemblies will move closer to the interior. One way to avoid condensation at this point is to stop vapor from migrating to this temperature point, usually through the use of a vapor retarder. Vapor retarders, however, are not perfect; they can actuality trap moisture within the assembly. Careful analysis is needed to shape a solution that balances the desire to stop moisture migration with the desire to allow natural drying.

The findings of this report show there could be significant energy savings from the addition of insulation to an older building. In relation to the requirements of the New York State Building and Energy Conservation Code, the savings seem to reach a peak benefit around the code-mandated minimums. This report does not evaluate energy savings in relation to cost of installation or payback over time. The analyses of this report show that although insulation can be added to reach a significant energy savings in theory, the process, if not done properly, could at the same time cause harm to the structure.

Task 2 of this process is to implement the recommendations of this report and subsequently perform quantitative observations and testing of the installation. The Task 2 monitoring and measurement stage would most likely be best suited for the Zadock Pratt Museum. The wing off the back of the original house that connects with the rental unit may be well suited for the monitoring exercise. The recommendation is to construct multiple panels of varying construction and perform testing over the course of one heating season. If the Museum would prefer to be operational prior to the testing cycle, then the majority of the building could be insulated as recommended in the body of this report while this one section remained as a “testing center.” Prior to any restoration or insulation project, the Museum building may still need to complete its drying cycle from the flood damage of August 2011. Moisture meter testing should be performed on the building elements that were saturated in the recent flood, and the walls should not be insulated and closed until they have been confirmed to have sufficiently dried.

Assuming this approach is acceptable, a more comprehensive plan including construction documents for the test panels and monitoring could be developed. It is recommended that 3–4 wall panels be constructed with varying degrees of insulation and multiple methods of vapor control in place. The test panels would need to be isolated and sealed from one another to each provide independent results. Each panel would be suited with monitoring sensors to log moisture and temperature at various points within the wall. This monitoring would be cataloged against the interior and exterior climate conditions over the course of one year, preferably starting in September, ahead of the beginning of the fall swing season, when there is a generally a switch from cooling to heating mode.

Recommendations for Future Building Monitoring

After careful consideration of all information gathered for the Prattsville Museum and the Cambridge Coop, and in discussion with the Preservation League of New York State it is recommended that the best use of resources for Part II of the Insulation Study should focus on the Prattsville Museum. It exhibits a variety of archaic construction details similar to a large segment of historic building stock in New York State, and for the purposes of efficiently utilizing funding for this work it will provide the best test/results laboratory setting of the two subject structures.

Given its current use as a museum, the data will also be useful in the larger discussion about controlling heating, cooling and humidity in spaces that contain sensitive archival material. There are hundreds of historic buildings in New York State and thousands across the northeast that would greatly benefit from the results of this kind of investigation.

It is recommended that insulation assembly testing should be focused at the wing added to the original building footprint, and connecting it with the house behind it for reason including but not limited to the following:

1. This space provides a combination of full floor-to-ceiling wall cavities and discontinuous cavities, constructed of at least two wall types and including a manageable number of windows and doors at east- and west-facing exterior walls;
2. it provides relatively accessible crawlspace monitoring opportunities; and
3. there is an opportunity to provide monitoring at the attic level, above the second floor and within the same general footprint.

While the potential solutions for insulating the attic and crawl spaces will likely resemble what is currently in place with minor changes, multiple wall types presents opportunities to test a variety of insulation strategies. The key to success is consistency of testing combined with continuity of the assembly tested in a relatively confined zone; for instance, it would be useful to monitor and compare wall cavities that run floor to ceiling, uninterrupted versus those interrupted by windows or doors to determine how the assembly works in different conditions. By contrast, testing similar cavity configurations with differing insulating assemblies will also provide significant and useful results. In any case, a carefully planned strategy is necessary to achieve a useful result.

It is also recommended that the Preservation League work in concert with NYSERDA to procure remote, U-Series HOBO T/H sensors by Onset (http://www.onsetcomp.com/products/hobo-data-loggers) for use in the next phase of the Study. As many as ten sensors in two or three configurations should provide useful information in a particular assembly as well as monitor ambient conditions within and immediately outside the building. The sensor housings could be attached to convenient surface location for viewing and data retrieval access, and where necessary would be fitted with wire leads to the interiors of wall assemblies.

Ideally, the sensors should be installed and collecting data in a fixed location for a 12-month period. This will allow for the most reliable information over a complete 4-season cycle, and would reduce the variability, margin of error and need for extrapolation that short-term data collection would create. Incomplete or flawed data sets can result from improperly installed equipment and basing conclusions on short durations of data; while the data collection and interpretation process can be started for 6-month, 3-month or even shorter intervals, there is no substitute for a full year of data collection whenever possible, and it would be better coordinated/compared with the WUFI extrapolations.

The results of Part II of the study should provide significant data to determine what the “best” solutions are specific to wood-framed construction variations, but should also provide some broader guidance and applicability for other archaic construction types in historic buildings.

GENERAL ENERGY CONSERVATION MEASURES

Priorities for Energy Conservation

When considering energy savings in existing buildings, it is important to understand the largest source of energy consumption as well as the range of energy-savings options. With this knowledge, efforts can be prioritized and informed decisions made considering the available alternatives.

The typical magnitude of energy use in residence and small office/commercial buildings in NYS are as follows, in order of magnitude:

1. Space heating - thermal losses via conduction (heat movement) & air infiltration/exfiltration (air movement);
2. Electricity for lighting, refrigeration, laundry, cooking & other appliances, electronic devices;
3. Heating hot water (kitchen, laundry & bathroom); and
4. Air conditioning

Specialty needs, such as hot tubs and swimming pools (pump, heating), can also incur substantial additional costs.

Past utility bills should be evaluated for heating and cooling values to determine savings potential. An energy audit by a knowledgeable professional may help prioritize the next steps. Specialized field testing may be appropriate. A blower door test for air infiltration rates or infrared camera imaging could help locate leaks or insulation voids.

Energy Conservation Measures:

No/low-cost options (payback typically less than 1–2 years)

1. Occupant-based controls can be free and have an immediate payback. Lower the system's heating set point in winter (and summer set point if air conditioned).
2. Setting back heating temperature at night or while away can also be done for free. Alternately, a programmable thermostat is a good investment (if properly programmed and used). Heating systems with very slow recovery may cause discomfort, and air to air heat pumps with resistance heat supplements may create unexpected cost increases.
3. Focus on upgrading the efficiency of electrical devices that are in use for long hours. Incandescent lights left on for more than a few hours a day should be replaced with fluorescent lamps (possibly LEDs).
4. Reduce infiltration by weather-stripping door openings; caulking any visible gaps around window and door frames as well as penetrations in the exterior (pipes, wires); and applying foam sealers on electrical outlets and switches located on exterior walls. Much of this can be done by anyone at low cost. As a temporary measure, plastic can be installed over leaky windows or infrequently used doors in winter. All these materials are readily available at hardware stores.

Medium-cost options (payback typically less than 3-8 years)

1. Replacing old refrigerators or freezers may provide real savings; certainly buy an energy-efficient model when an old unit fails.
2. Replacing old, inefficient heating boilers, especially with a condensing furnace, may yield a payback within only a few years. Changing your space heating or domestic hot water energy source from electric (or possibly oil) to natural gas may be worth a close look but could be expensive. When replacing equipment due to age or failure, upgrading is often appropriate.
3. Add insulation in ceiling/attic spaces or other easily accessible spaces where it does not exist or is rated at only a fraction of the currently recommended R value.

High-cost options (payback typically over 10 years and frequently as long as 20 years or more. The payback period may exceed the useful life of some materials)

1. Replace air conditioning equipment that is less than 10 years old.
2. Window replacement generally yields a long-term payback if existing units close properly, are reasonably air tight, and have their perimeters properly sealed.
3. Insulation of exterior walls is expensive unless it is already part of a renovation. Potential for condensation is a concern (as described in the following pages), and prevention within envelope cavity can be expensive as well.

Guiding Questions for Decision Making

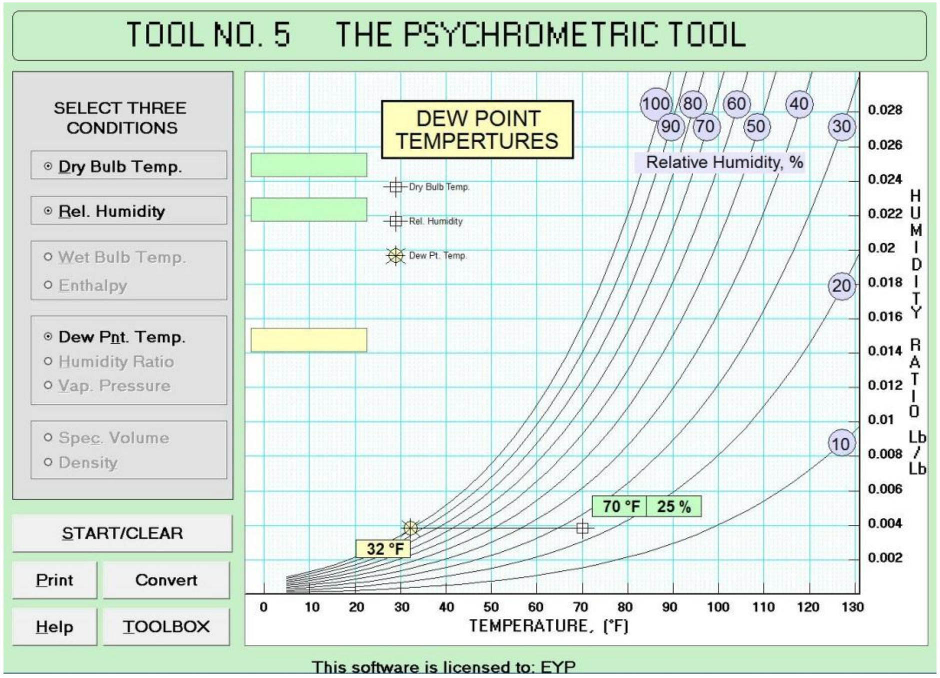
The following questions are organized to offer basic conceptual guidance and potential cautions when attempting any energy savings measures.

1. Has the building infiltration been evaluated and reduced where practical?	YES	Any additional infiltration reduction will produce minimal benefit
	NO	Consider caulking around windows, doors, and other openings. Add weather-stripping to windows, doors, and all exterior penetrations (outlets, switches, pipes, cables). Verify foundation-to-wall and wall-to-roof joints are sealed and insulated). Consider a blower door test to determine infiltration rate.
2. Does the building have a significant amount of forced outdoor air ventilation? (not typical for a residence)	YES	Optimize the amount and timing of outside air being forced in by fans. Consider reducing outside air based on occupancy (fixed or variable). The relative benefit of additional insulation will be reduced under these conditions.
	NO	Concentrate on infiltration reduction, then insulation as recommended in this report
3. Is there insulation now and does it fill the framing cavities?	YES	Not much can be done without removing interior or exterior finishes.
	NO	Consider insulation addition as recommended in this report
4. Is the building typically heated to significantly less than 68-70 degrees in winter?	YES	Less insulation is needed based on economic return in comparison to normally heated buildings. If renovating, insulation thicknesses can be determined by code.
	NO	Consider insulation addition as recommended in this report
5. Do you plan on removing either the interior or exterior wall surfaces?	YES	Consider insulation addition as recommended in this report
	NO	Ability to add insulation is limited to current wall cavity thickness; practical ability to add insulation may be limited to blown-in or foam (non-reversible) type. There is likely no code requirement to add insulation.

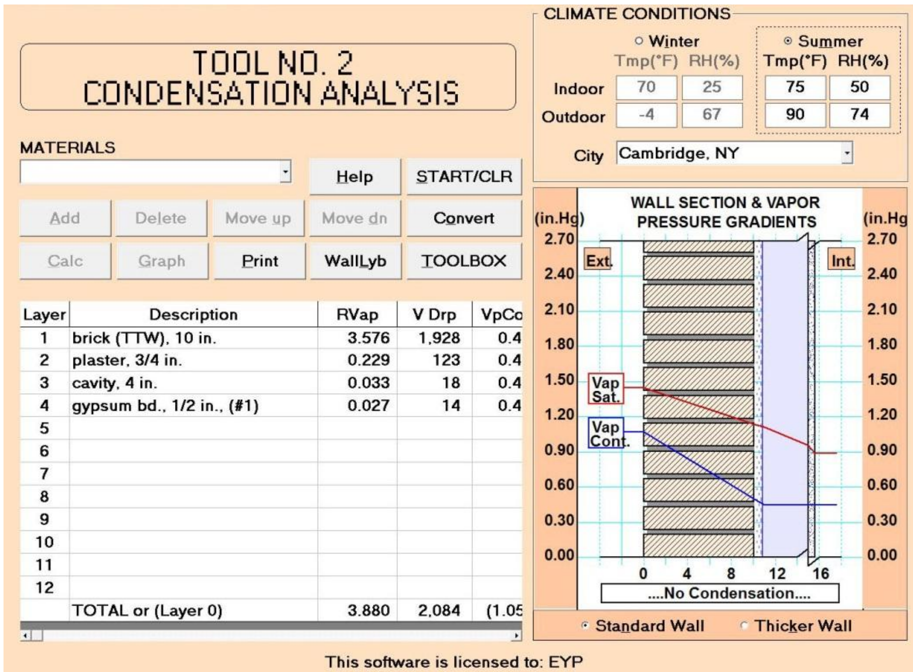
6. Do you plan on removing the exterior wall?	YES	Several options exist to insulate wall cavities and add vapor retarder from the exterior.
	NO	Insulate from inside with recommendations from this report
7. If removing the interior wall surface, do you wish to have more insulation thickness than the current wall cavity?	YES	Evaluate ability to locate new wall in from prior location to allow room for more insulation. Wider returns at windows may be necessary if new insulation does not fit in existing framing bay. Some floor space will be lost. Ceiling-to-wall joint will need to be considered.
	NO	Consider insulation addition as recommended in this report
8. Is the building humidified in the winter or does it have moisture sources that are not reliably exhausted?	YES	Condensation is a real concern and could occur within the wall cavity, causing undesirable consequences. Condensation is more likely to occur in any area where warm, humid air meet a cold surface (as around windows). Relative humidity levels should be rest lower as the exterior temperature drops to reduce the risk of condensation. Consider methods to exhaust moisture in winter to prevent high relative humidity. Much more than normal attention required to prevent reaching the dew point within a wall cavity (vapor barrier, dew point analysis).
	NO	Consider insulation addition and vapor control as recommended in this report
9. Is the building air conditioned?	YES	There is an increased risk of condensation where warm moist outdoor air meets a cool surface (below the dew point of the outside air). Caution advised specifically where the coolest temperatures exist, such as AC discharge and ductwork, before mixing with room air. The heating benefit from insulation is normally several times greater than for AC in northern climates.
	NO	Consider insulation addition as recommended in this report. Condensation in summer is not a concern
10. Is the relative cost for heating energy higher than average in your area?	YES	More insulation than required by code may be advisable.
	NO	Consider insulation addition as recommended in this report

APPENDIX A

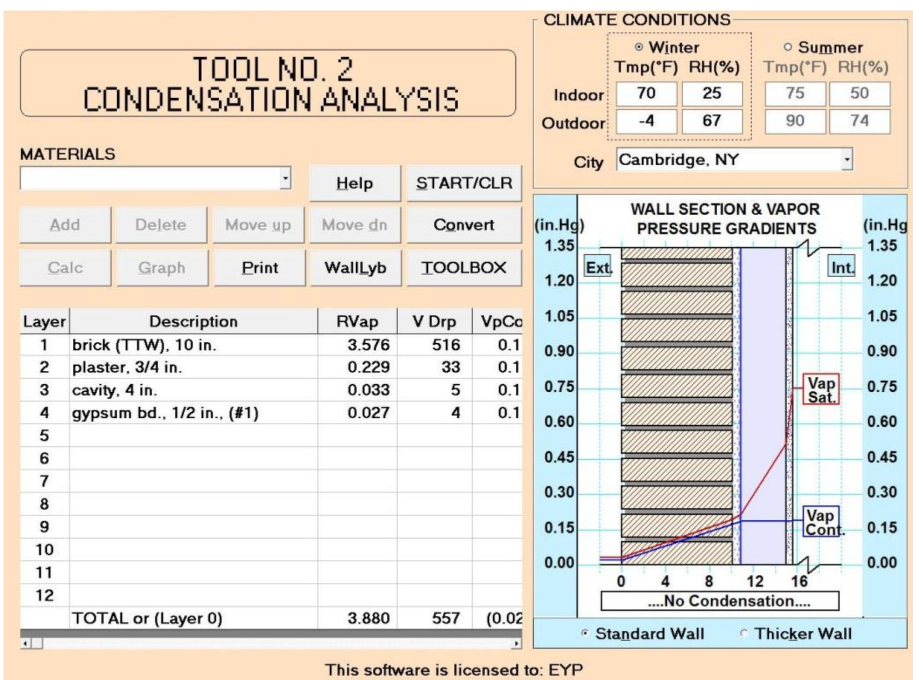
HYGROTHERMAL ANALYSES



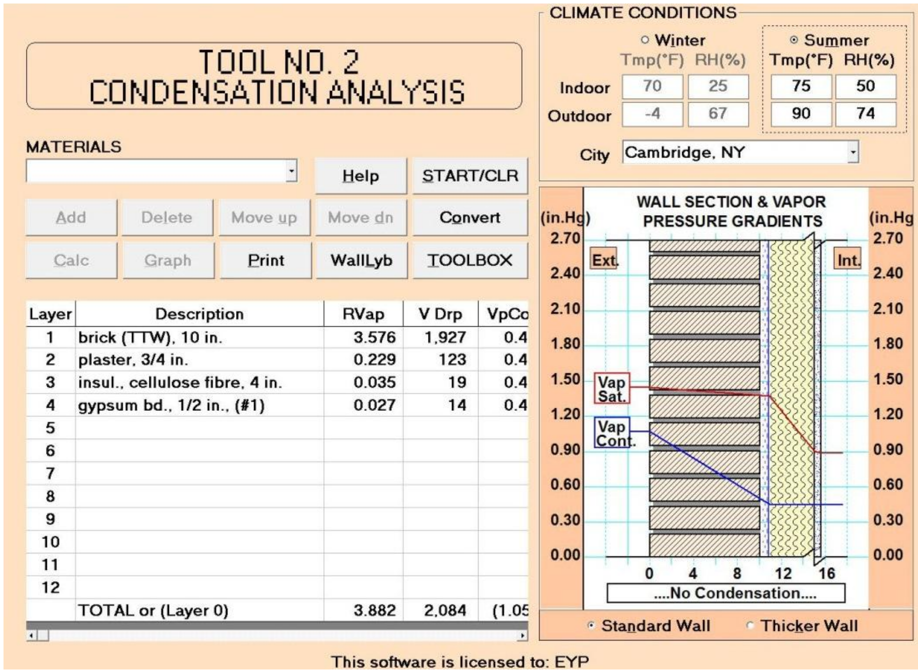
Appendix Figure A-01:..
Psychometric Analysis of Dew Point Temperature



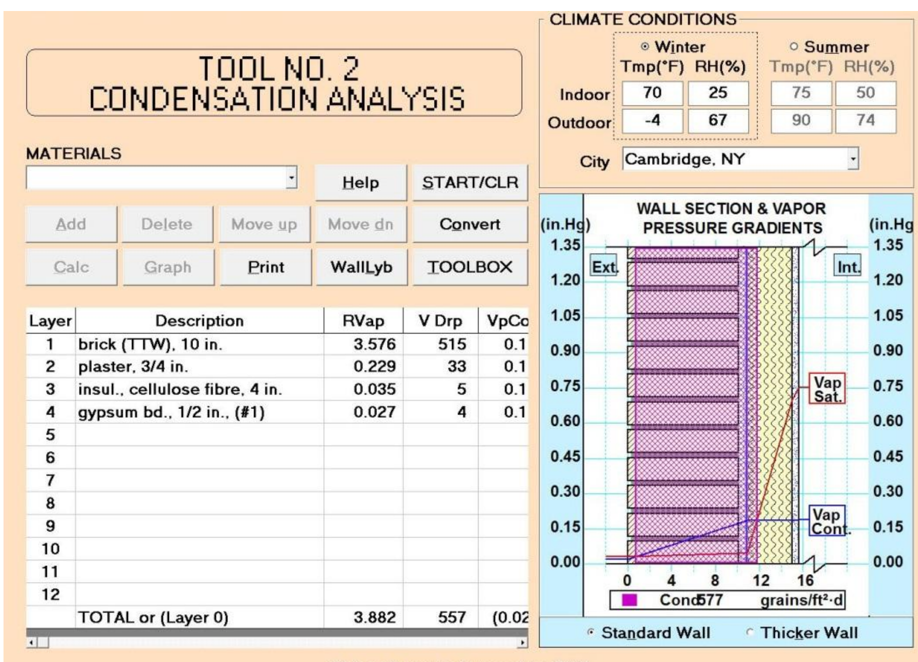
Appendix Figure A-02:
Cambridge Food Co-Op
Existing Conditions – Summer condensation analysis



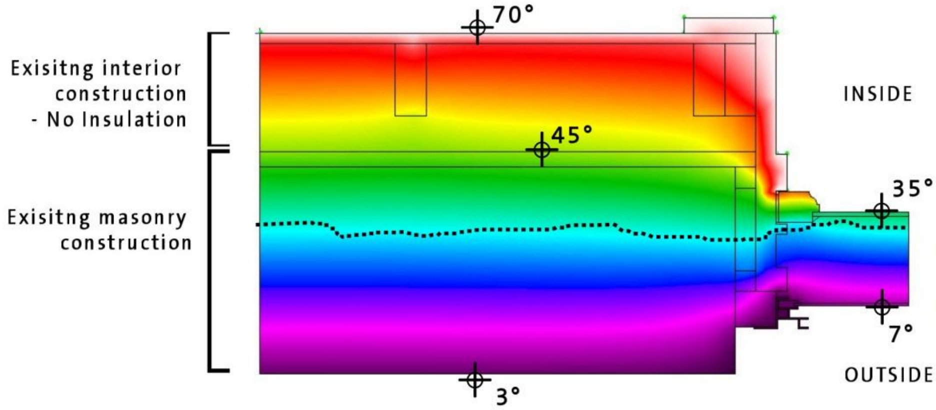
Appendix Figure A-03:
Cambridge Food Co-Op
Existing Conditions – Winter condensation analysis

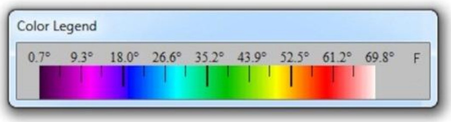


Appendix Figure A-04:
Cambridge Food Co-Op
Insulated Wall – Summer condensation analysis



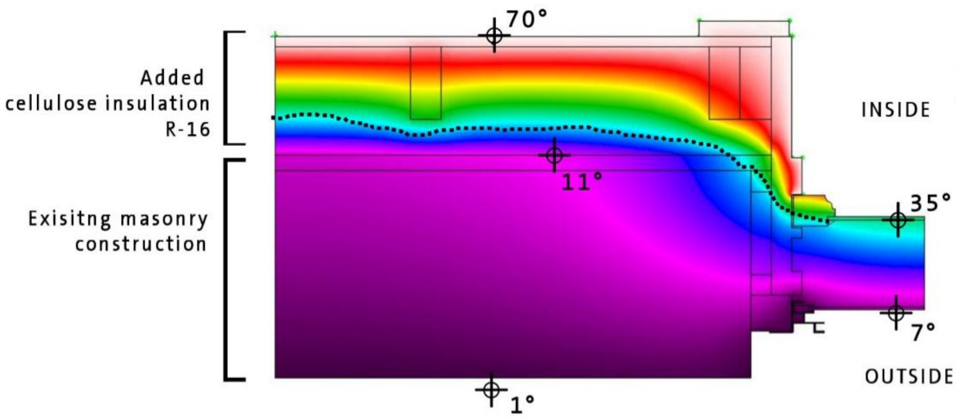
Appendix Figure A-05:
Cambridge Food Co-Op
Insulated Wall – Winter condensation analysis

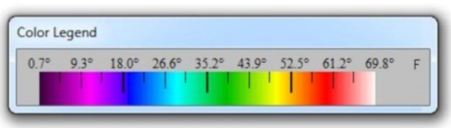




Color Temperature Legend

Appendix Figure A-06:
Cambridge Food Co-Op
Existing Conditions @ Typical Window Jamb – Thermal Profile Analysis





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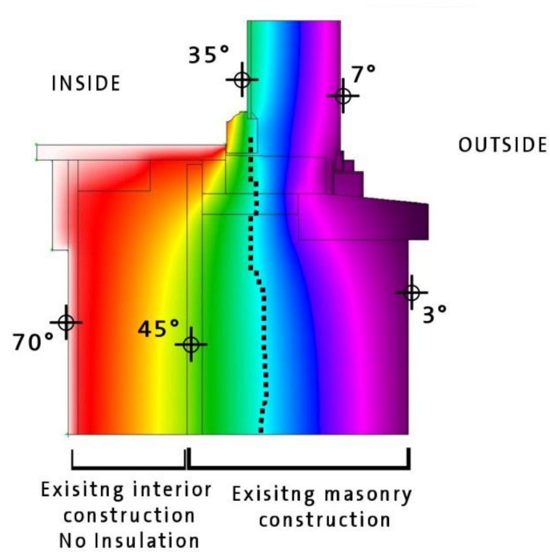
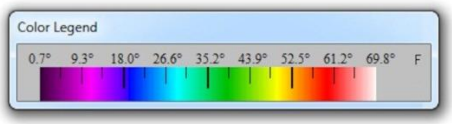
Appendix Figure A-07:
Cambridge Food Co-Op
Insulated Wall @ Typical Window Jamb – Thermal Profile Analysis





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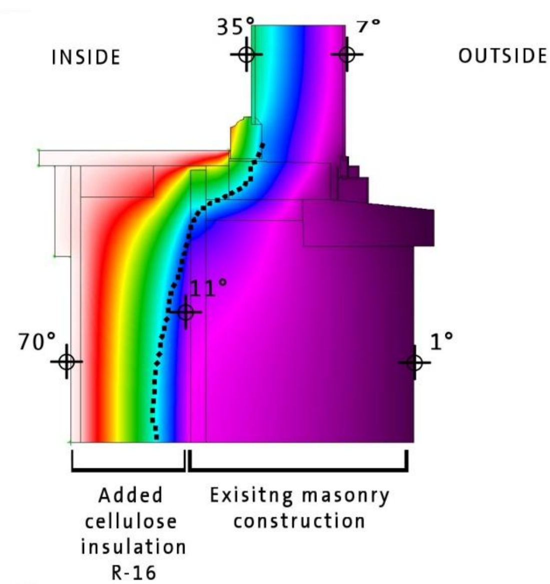
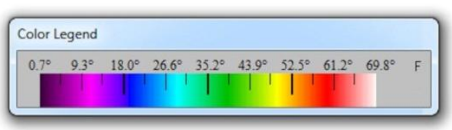
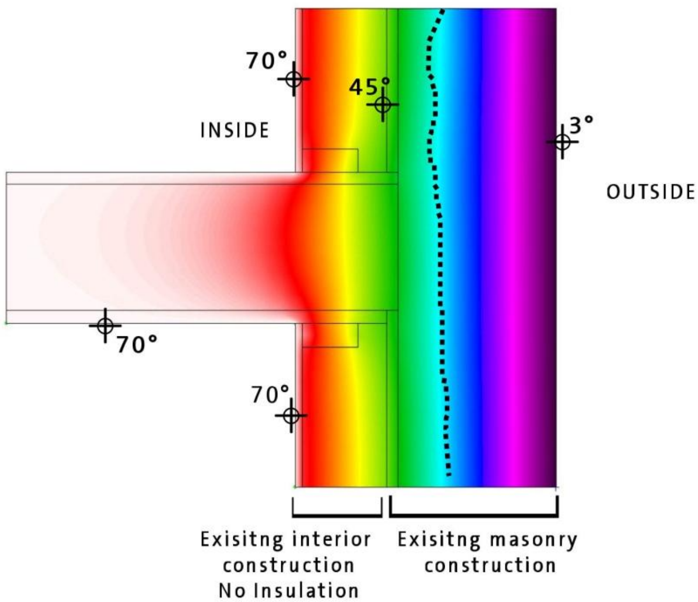
Appendix Figure A-08:
Cambridge Food Co-Op
Existing Conditions @ Typical Window Sill – Thermal Profile Analysis

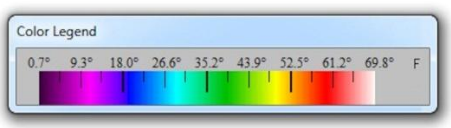




Color Temperature Legend

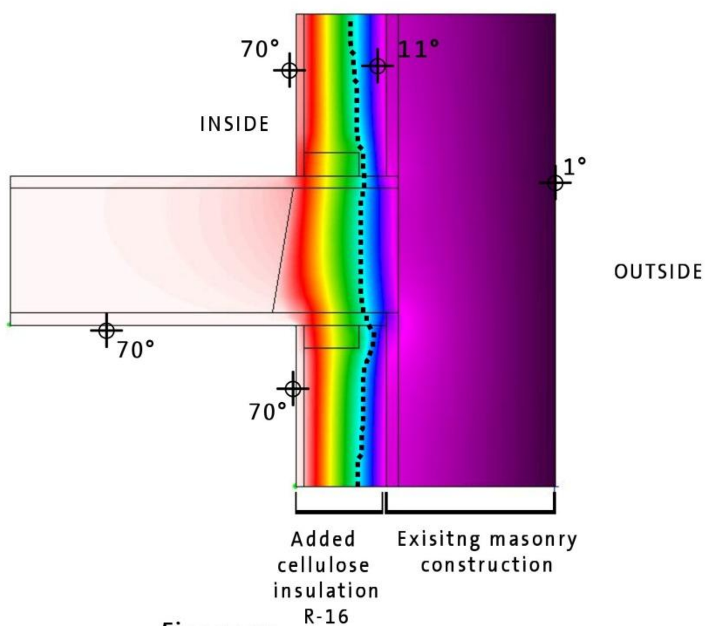
Appendix Figure A-09:
Cambridge Food Co-Op
Insulated Wall @ Typical Window Sill – Thermal Profile Analysis



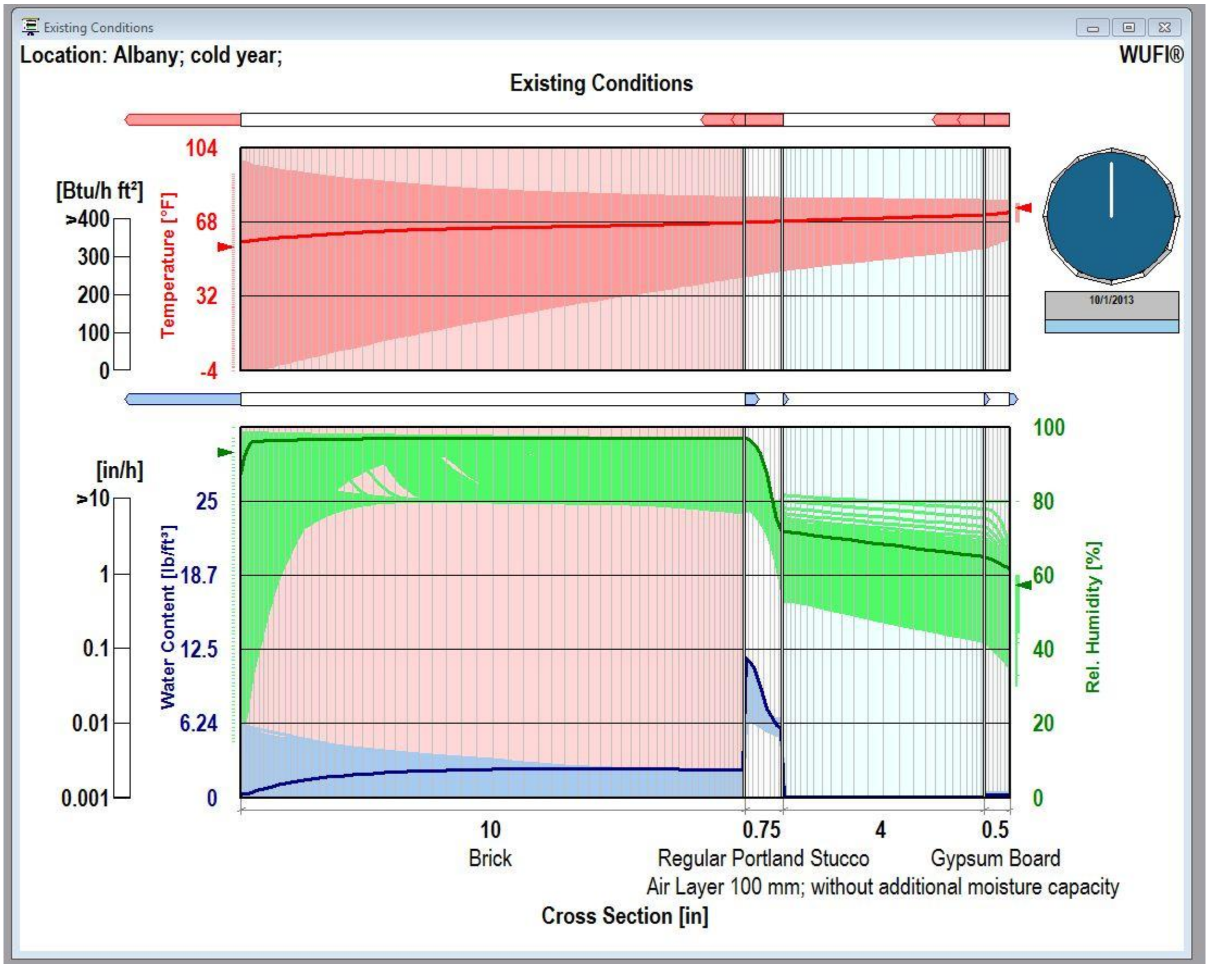


Color Temperature Legend

Appendix Figure A-10:
Cambridge Food Co-Op
Existing Conditions @ Typical Floor Edge – Thermal Profile Analysis

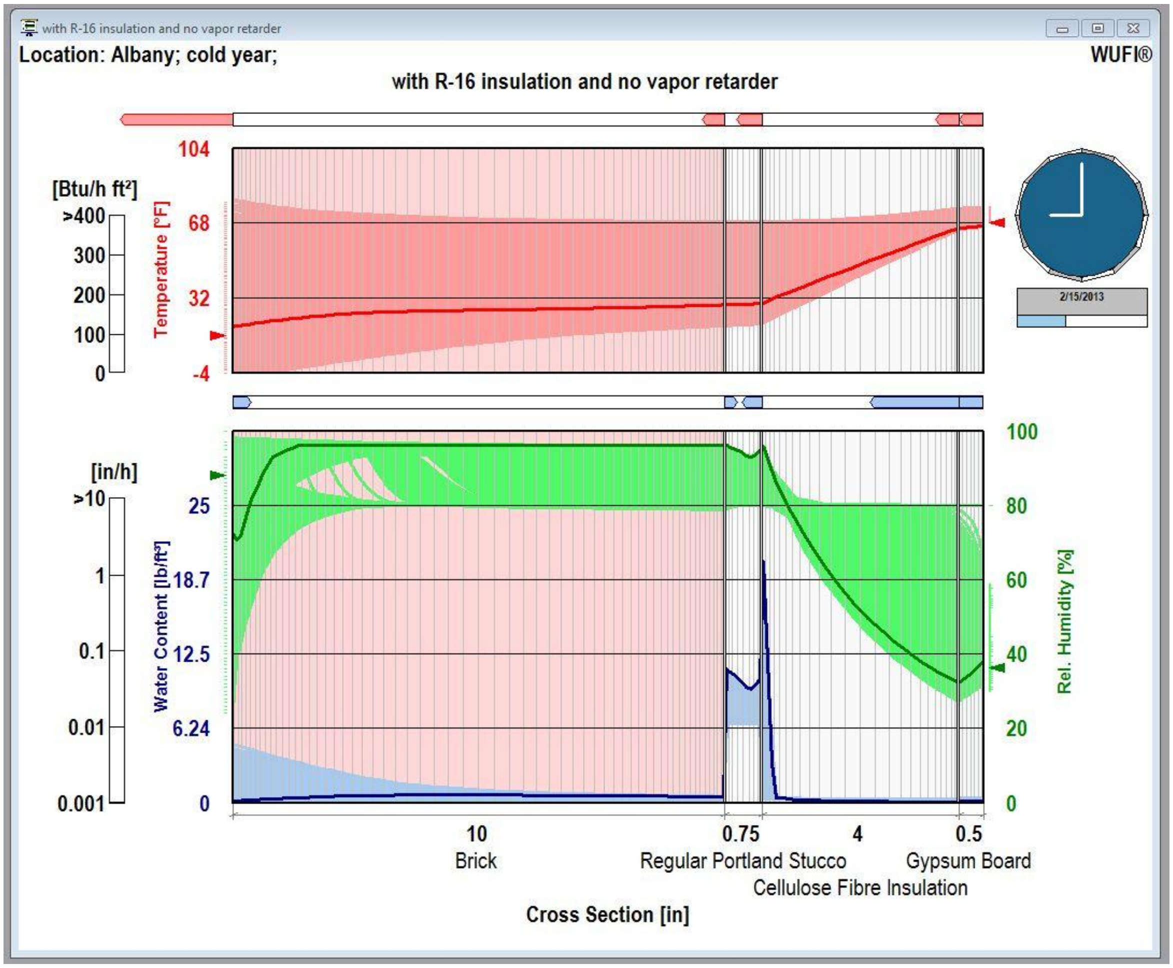


Appendix Figure A-11:
Cambridge Food Co-Op
Insulated Wall @ Typical Floor Edge – Thermal Profile Analysis

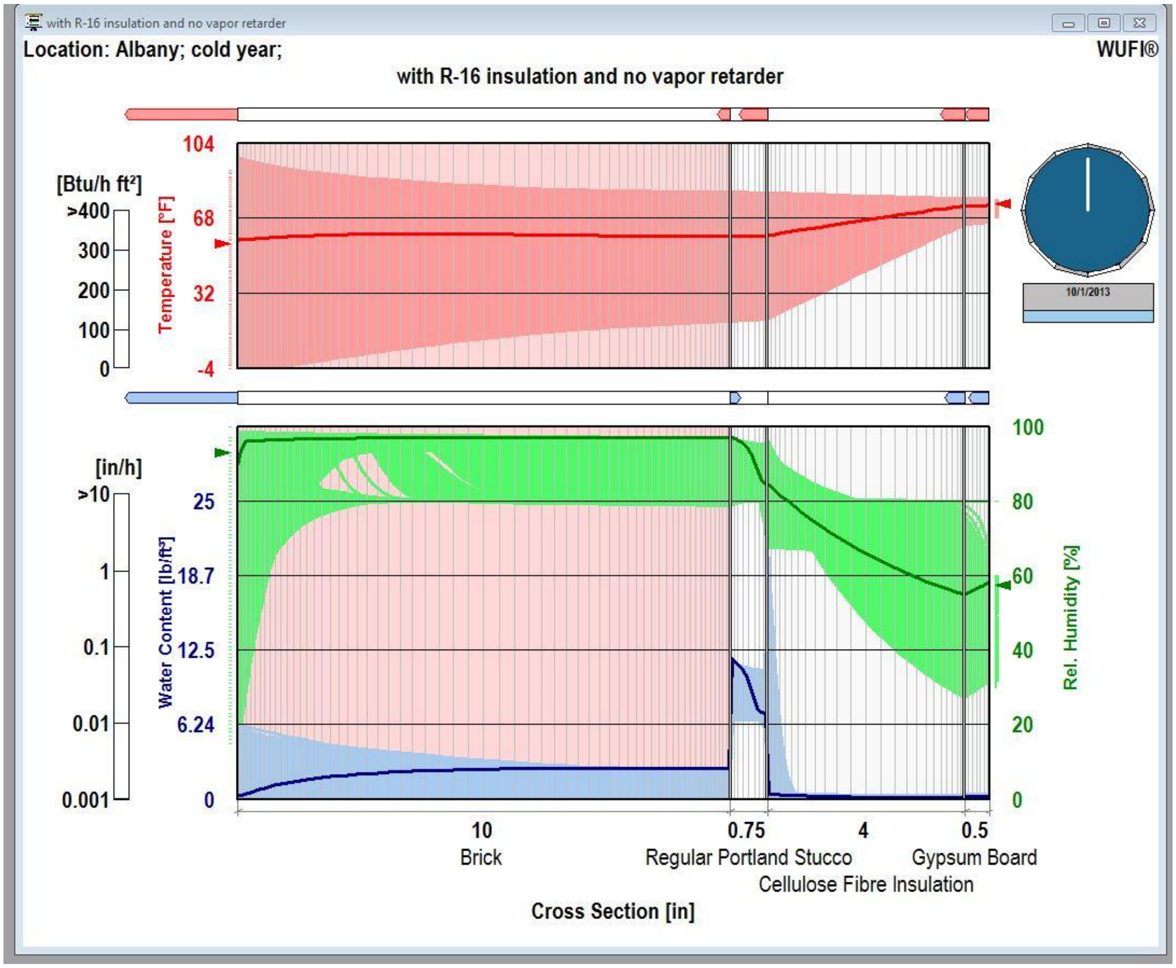


Appendix Figure A-12:
Cambridge Food Co-Op
Existing Conditions at Typical Exterior Masonry Wall - Yearly Cycle

WUFI Hygrothermal Analysis shows that the existing condition of the wall allows for excess moisture accumulation within masonry, but that the masonry is being warmed from the interior. While the presence of moisture itself is not desirable, heating of the masonry assembly reduces the potential for damage from freeze/thaw cycling.



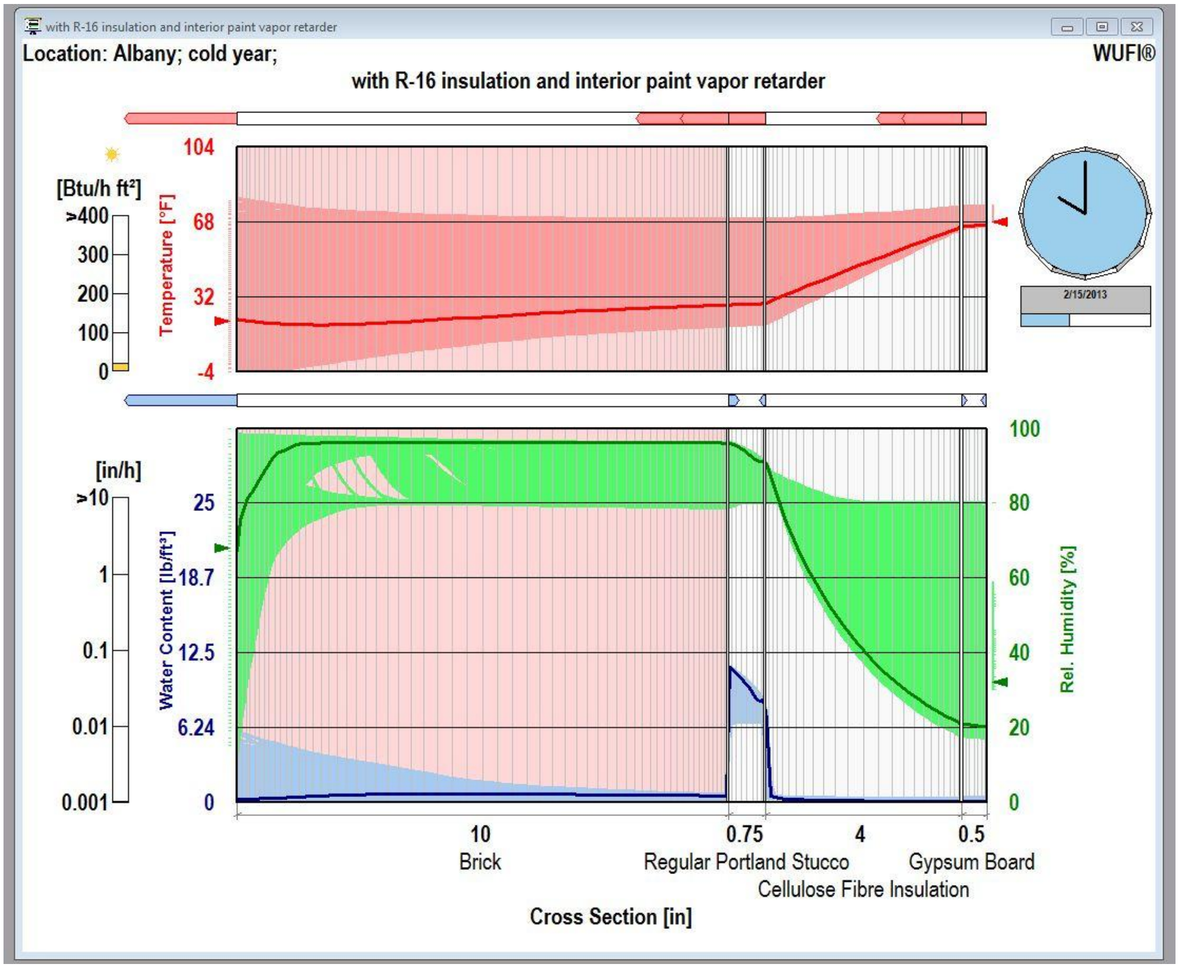
Appendix Figure A-13:
Cambridge Food Co-Op
Insulated Wall - No Vapor Retarder - Mid-Winter Condition
WUFI Hygrothermal Analysis shows that when insulation is added (for instance, blown-in cellulose fiber), it affects the temperature gradient of the wall; the excess moisture accumulation within masonry has not decreased, and the masonry has become moderately colder than it was in the existing condition. In addition, it shows the moisture accumulation spikes at the surface of the plaster.



Appendix Figure A-14:
Cambridge Food Co-Op
Insulated Wall – No Vapor Retarder - Yearly Cycle
WUFI Hygrothermal Analysis

Notes:

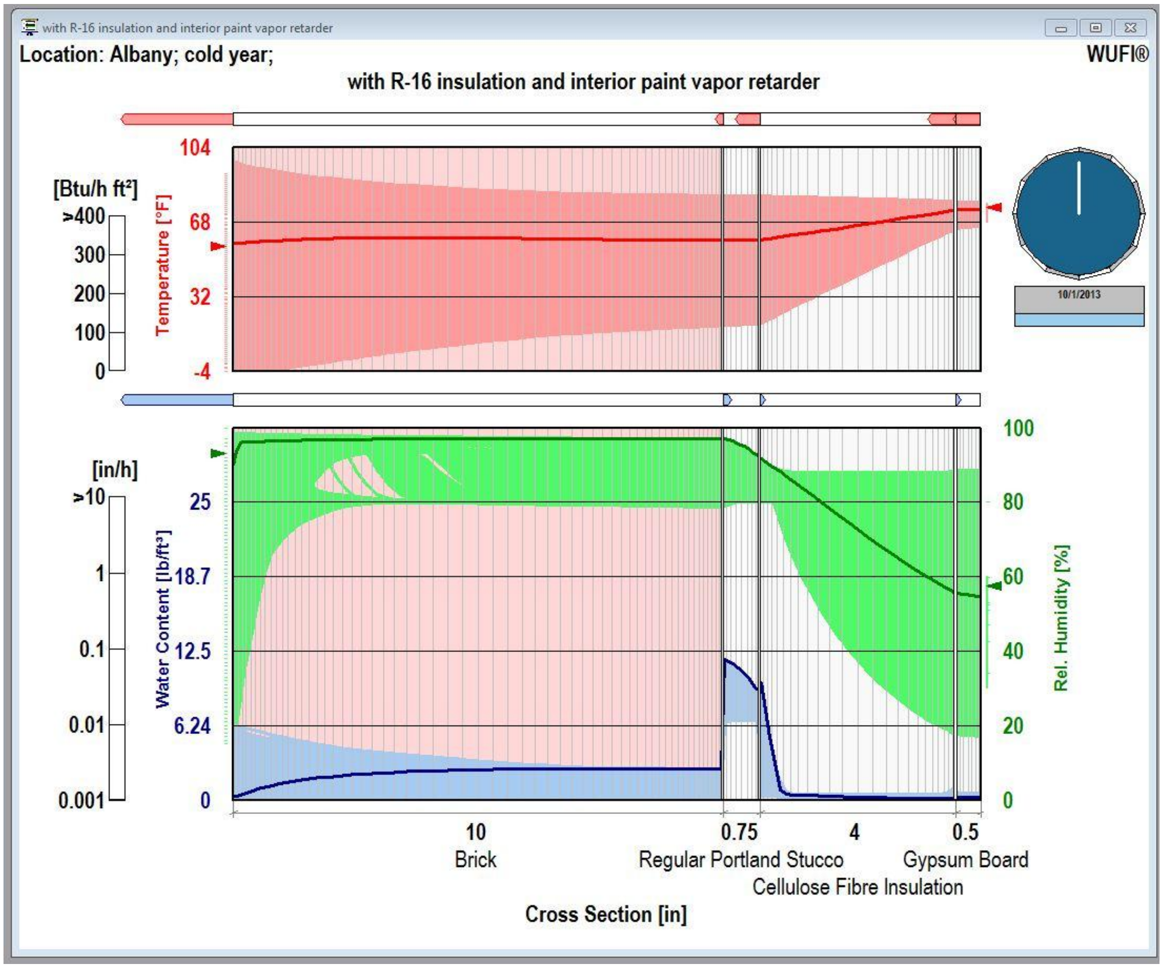
- excess moisture accumulation within masonry
- masonry is moderately "colder" than existing
- moisture accumulation on interior face of plaster and within plaster



Appendix Figure A-15:
Cambridge Food Co-Op
Insulated Wall – Vapor Retarder Paint on Interior – Mid-Winter Condition
WUFI Hygrothermal Analysis

Notes:

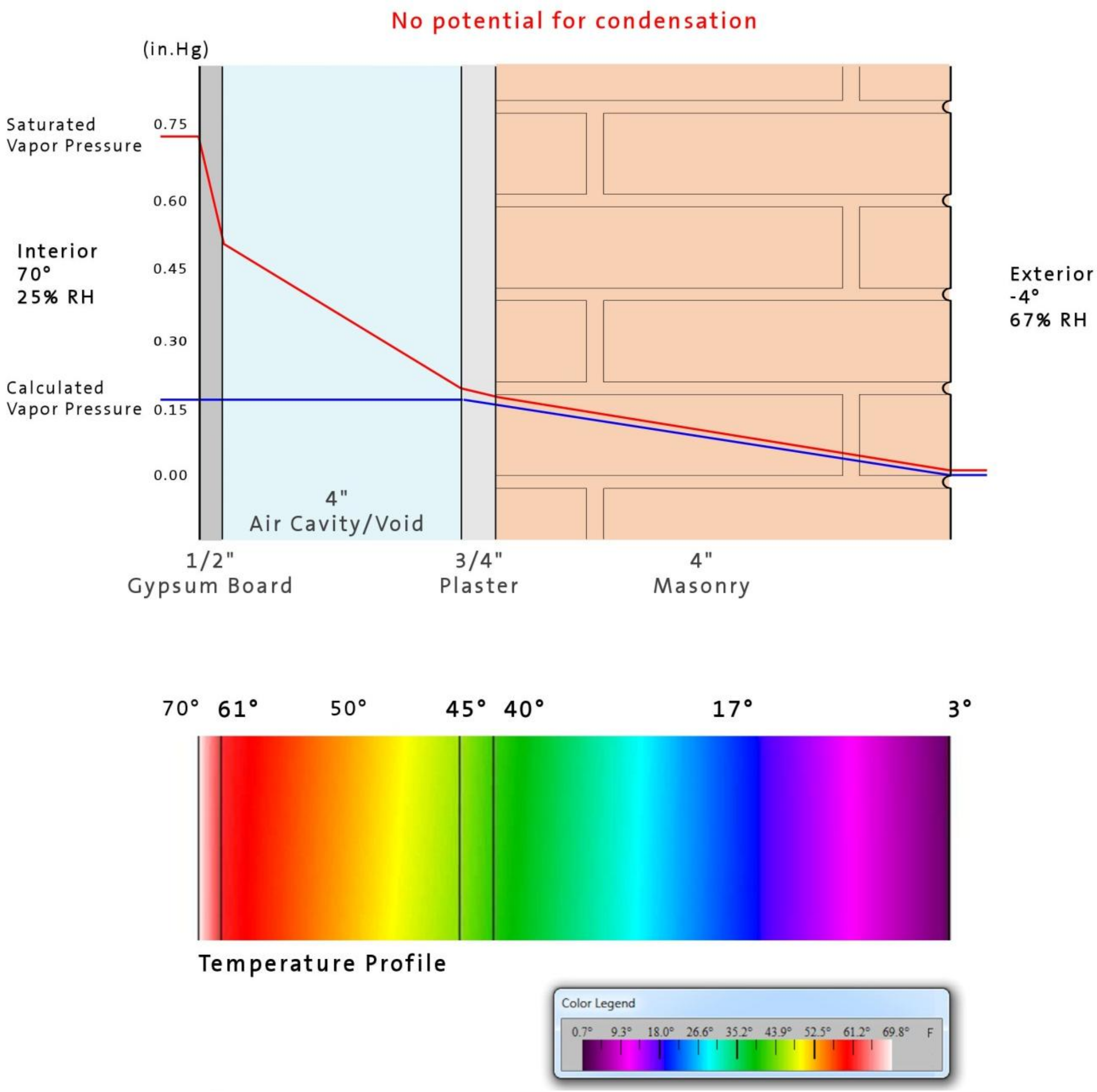
- *excess moisture accumulation within masonry*
- *masonry is moderately "colder" than existing*
- *moisture accumulation is reduced from w/o vapor retarder*
- *RH is not reaching saturation point of 100%*



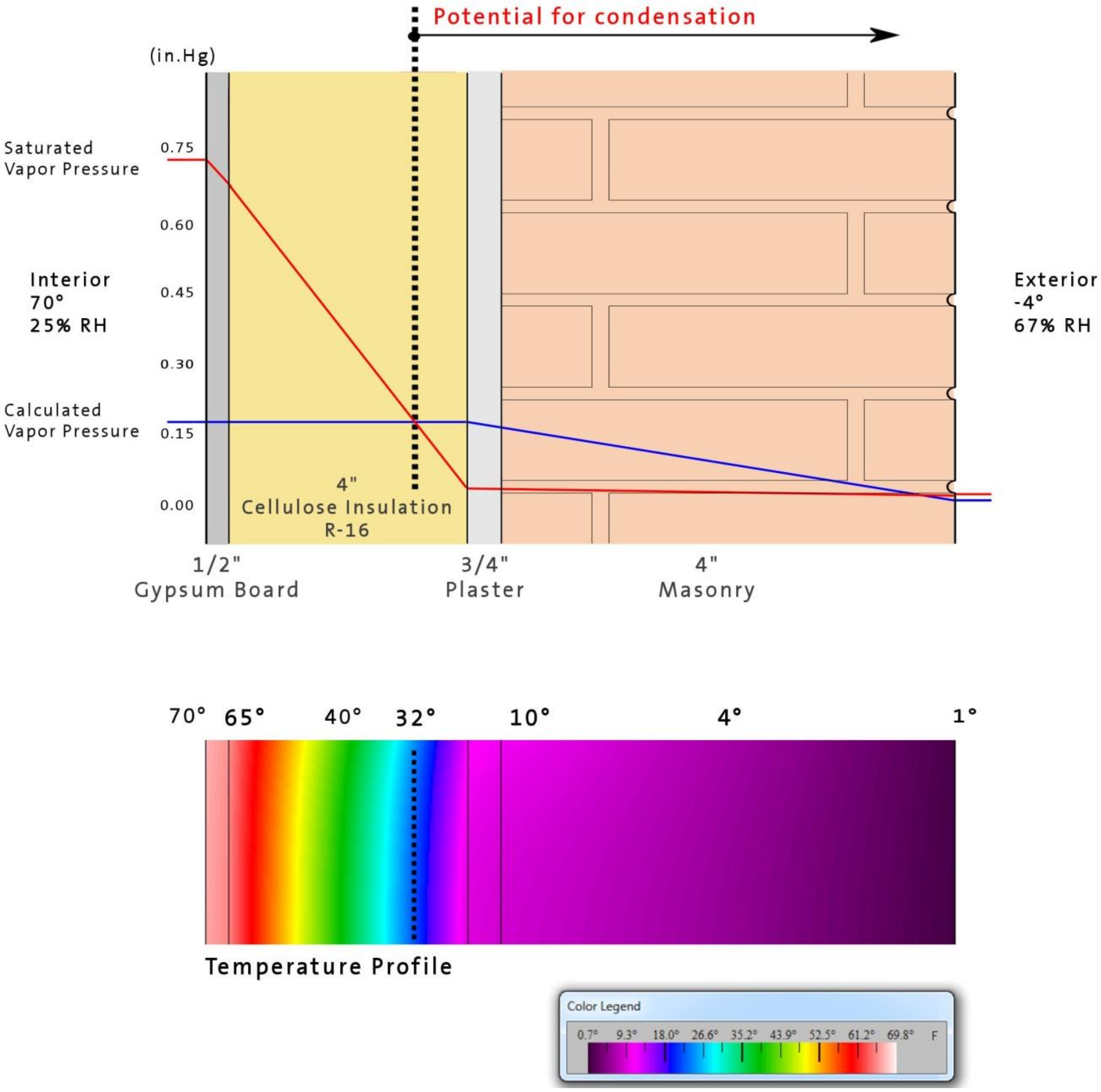
Appendix Figure A-16:
Cambridge Food Co-Op
Insulated Wall – Vapor Retarder Paint on Interior – yearly Cycle
WUFI Hygrothermal Analysis

Notes:

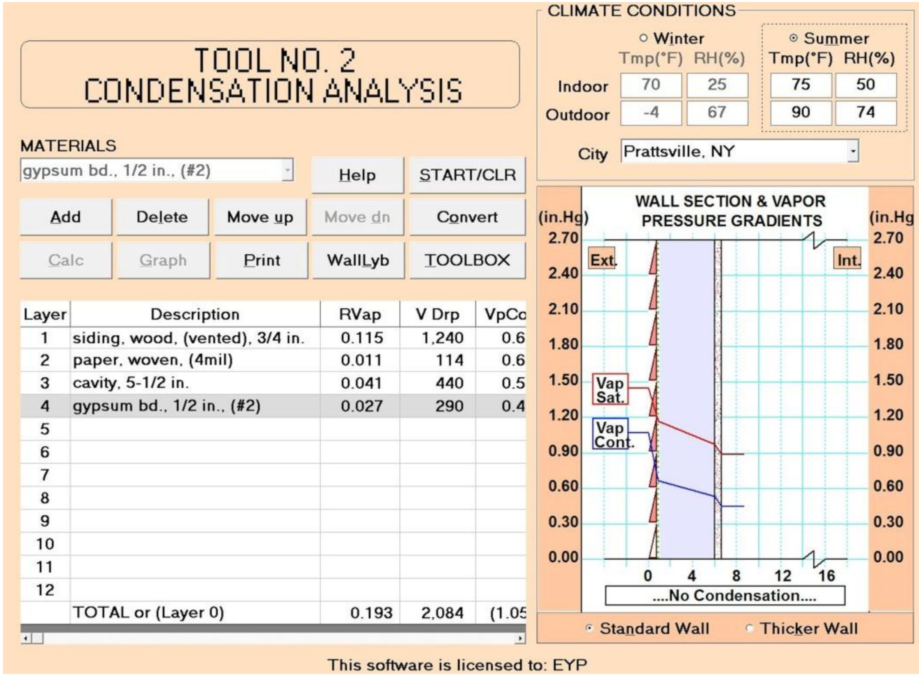
- *excess moisture accumulation within masonry*
- *masonry is moderately "colder" than existing*
- *moisture accumulation is reduced from w/o vapor retarder*
- *RH is not reaching saturation point of 100%*



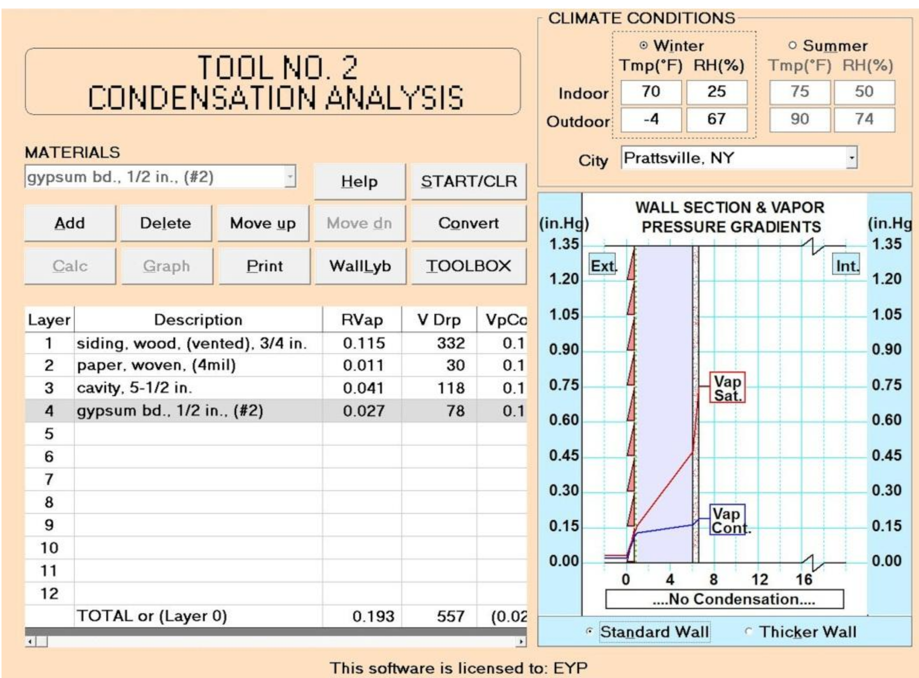
Appendix Figure A-17:
Cambridge Food Co-Op
Existing conditions @ Typical Exterior Wall
Hygrothermal Analysis



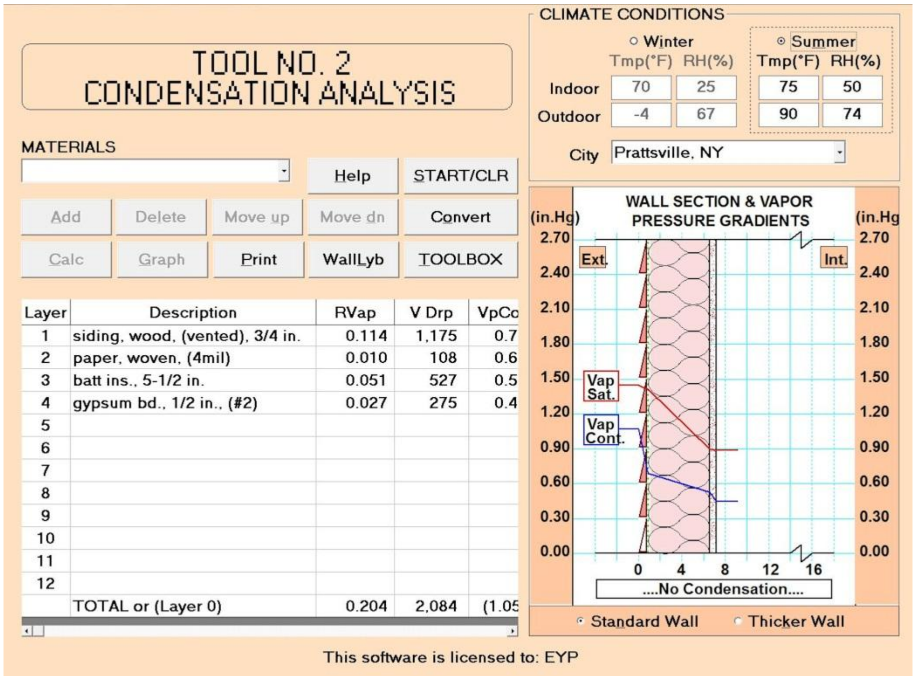
Appendix Figure A-18:
Cambridge Food Co-Op
Insulated Conditions @ Typical Exterior Wall
Hygrothermal Analysis



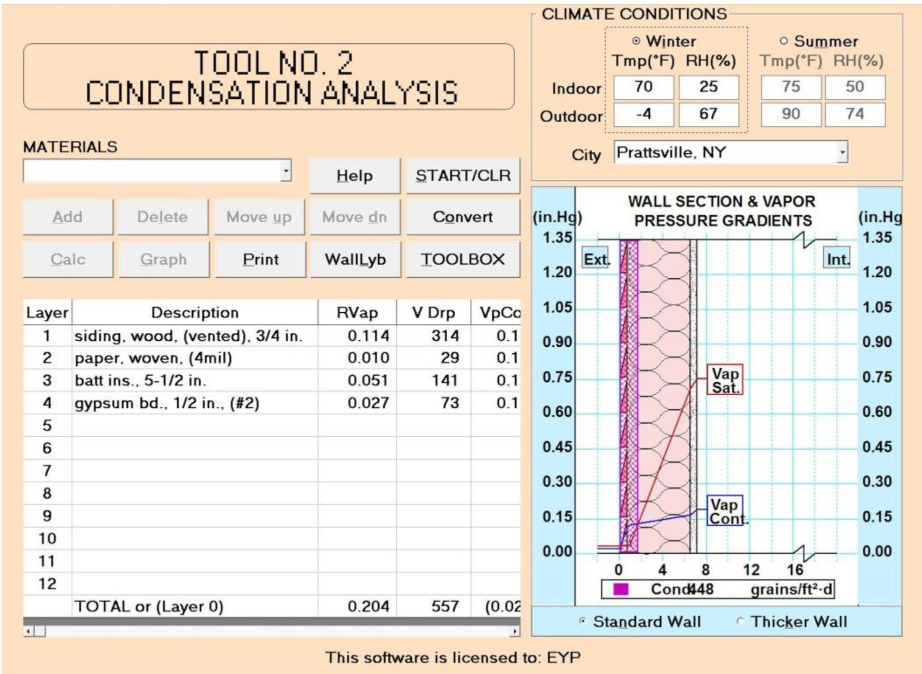
Appendix Figure A-19:
Zadock Pratt Museum
Existing Conditions – Summer condensation analysis



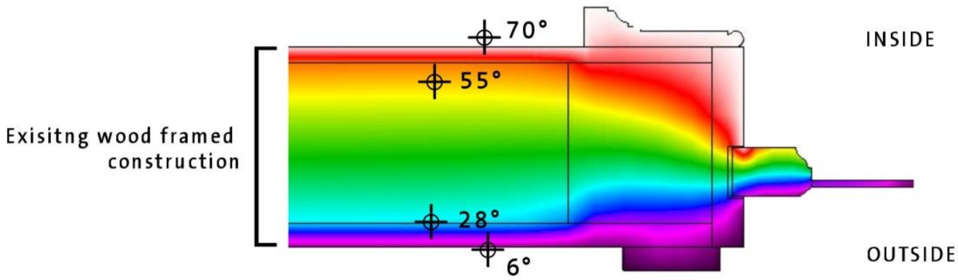
Appendix Figure A-20:
Zadock Pratt Museum
Existing Conditions – Winter condensation analysis

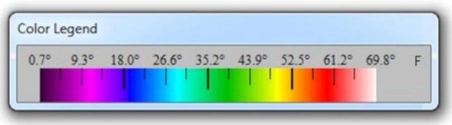


Appendix Figure A-21:
Zadock Pratt Museum
Insulated Wall – Summer condensation analysis



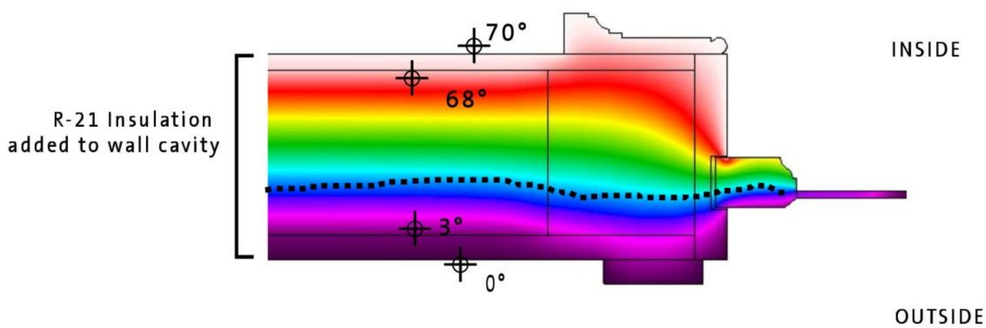
Appendix Figure A-22:
Zadock Pratt Museum
Insulated Wall – Winter condensation analysis

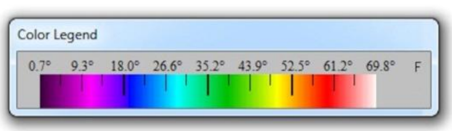




Color Temperature Legend

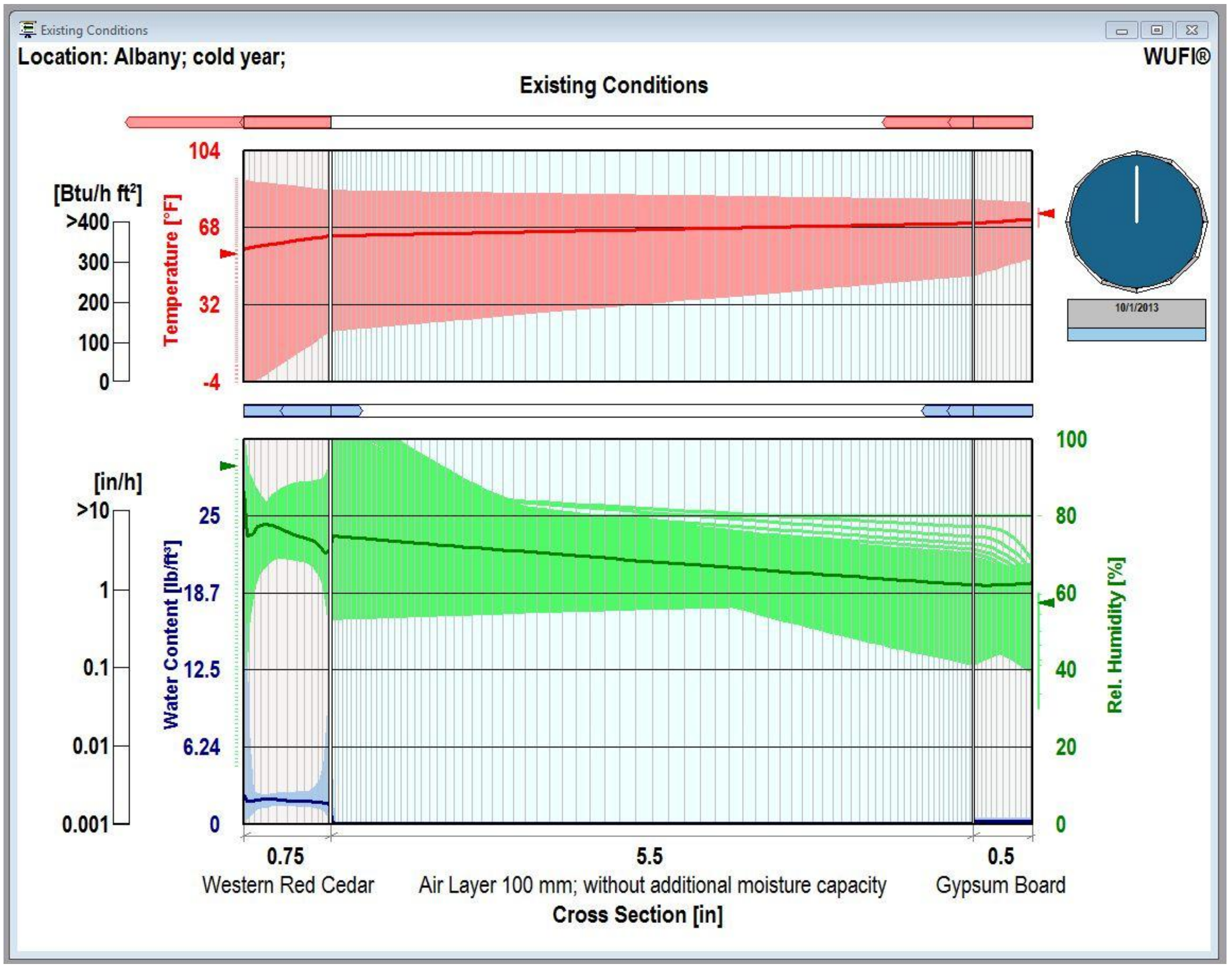
Appendix Figure A-23:
Zadock Pratt Museum
Existing Conditions @ Typical Window Jamb – Thermal Profile Analysis





Color Temperature Legend

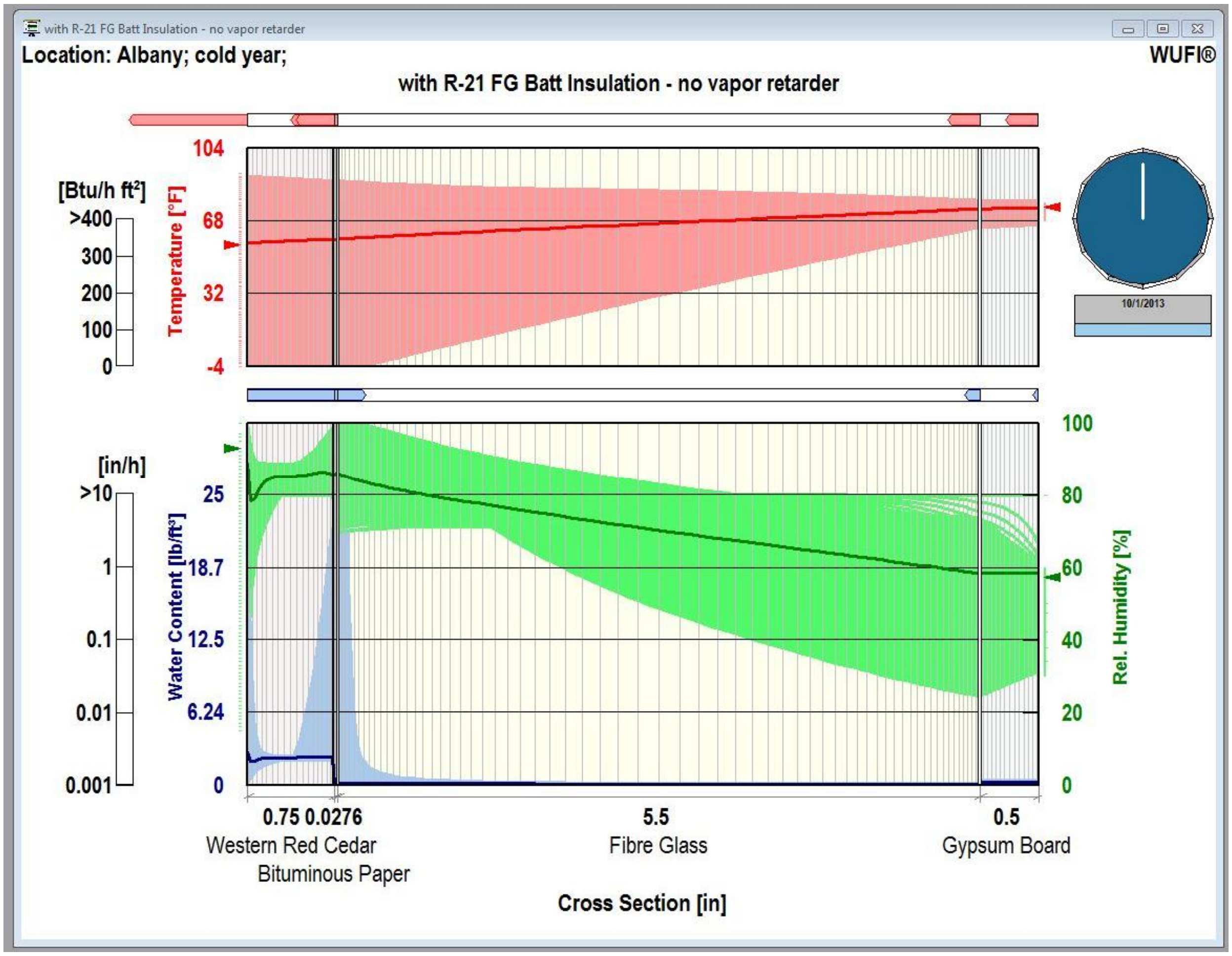
Appendix Figure A-24:
Zadock Pratt Museum
Insulated Wall @ Typical Window Jamb – Thermal Profile Analysis



Appendix Figure A-25:
Zadock Pratt Museum
Existing conditions @ Typical Exterior Wall- Yearly Cycle
WUFI Hygrothermal Analysis

Notes:

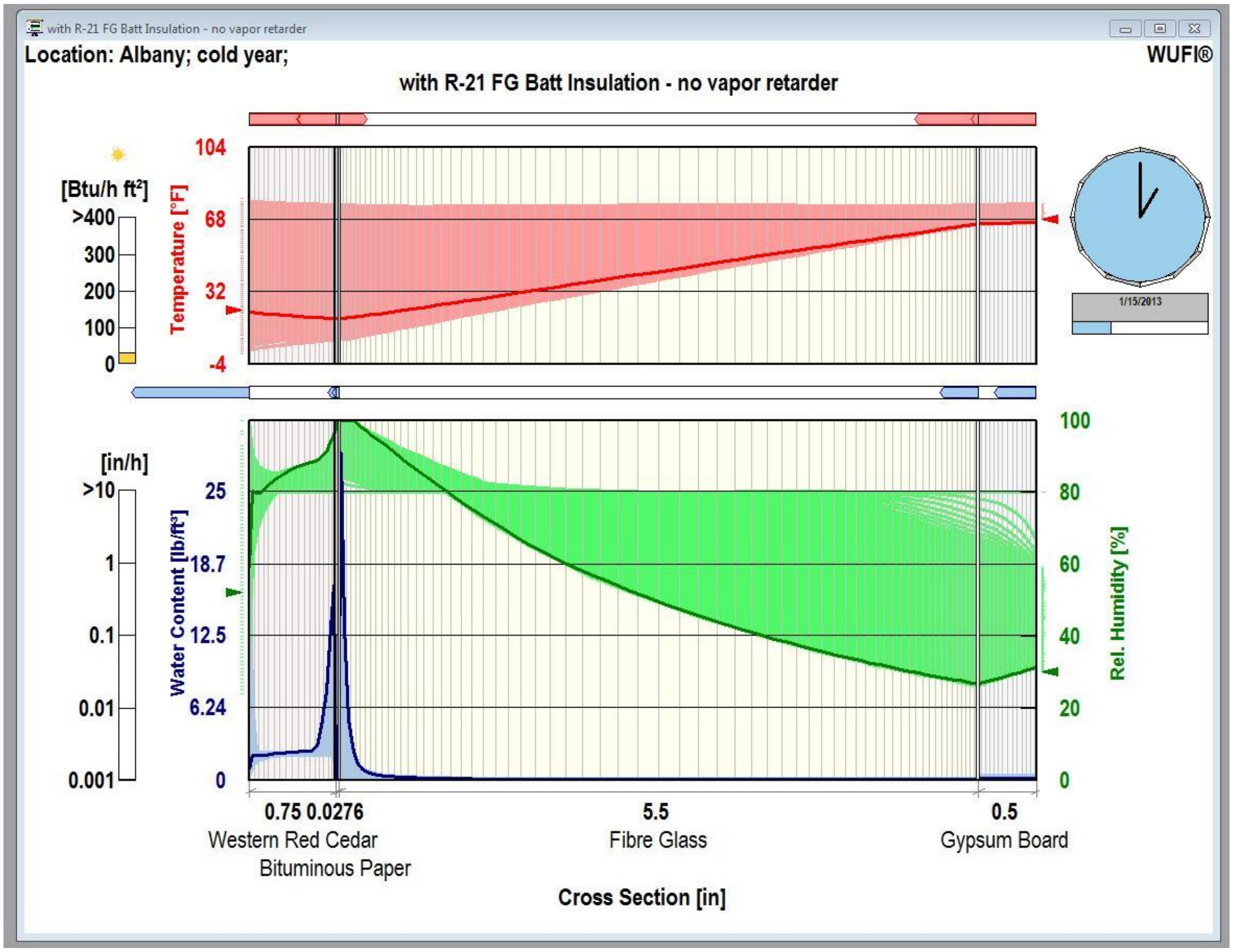
- *excess moisture accumulation*
- *constant heat flow through wall*



Appendix Figure A-26:
Zadock Pratt Museum
Insulated Wall - No Vapor Retarder – Yearly Cycle
WUFI Hygrothermal Analysis

Notes:

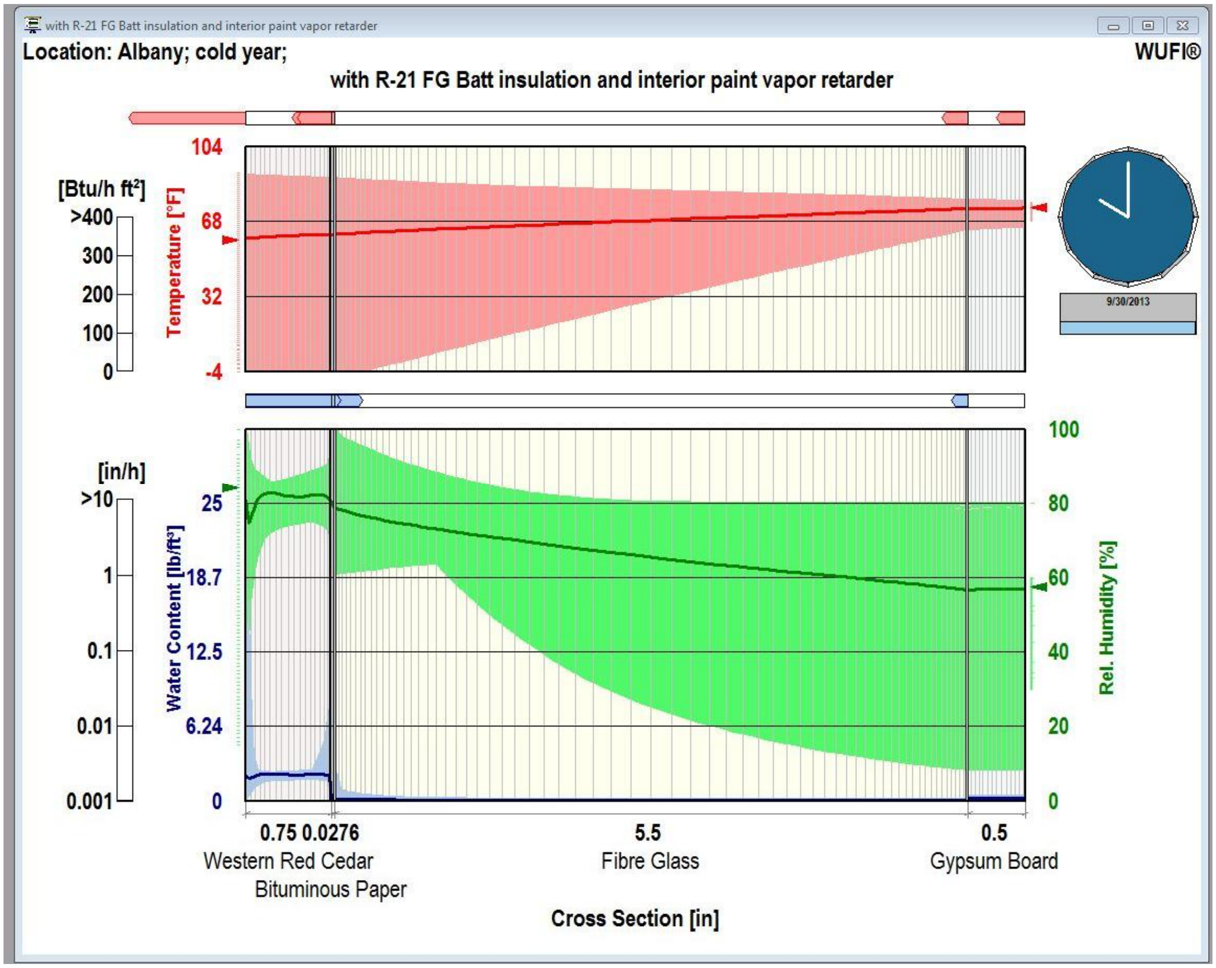
- *excess moisture accumulation on interior face of siding*



Appendix Figure A-27:
Zadock Pratt Museum
Insulated Wall - No Vapor Retarder – Mid-Winter Condition
WUFI Hygrothermal Analysis

Notes:

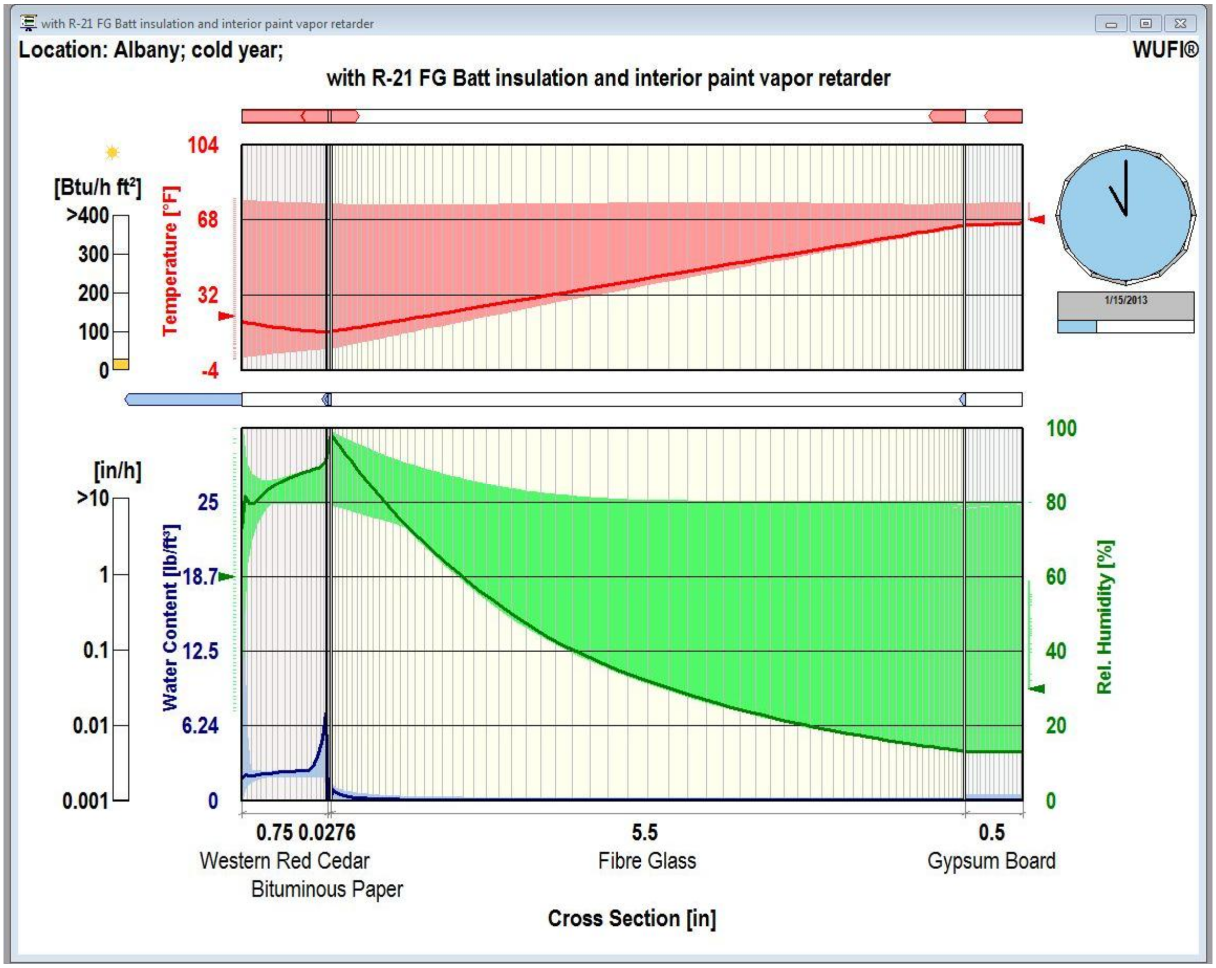
- *excess moisture accumulation on interior face of siding*
- *Relative Humidity (RH) reaches saturation point (100%)*



Appendix Figure A-28:
Zadock Pratt Museum
Insulated Wall – Vapor Retarder Paint on Interior – Yearly Cycle
WUFI Hygrothermal Analysis

Notes:

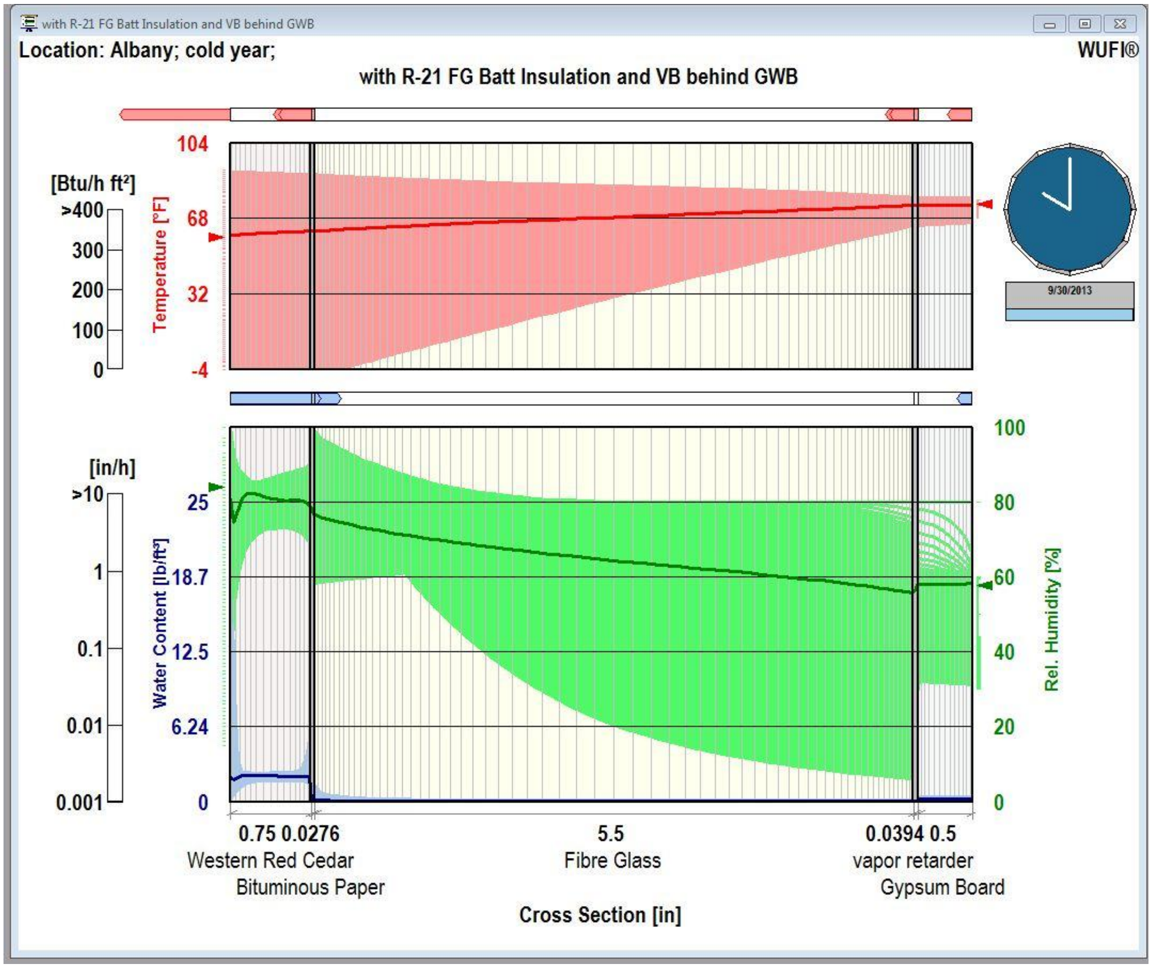
- *Moisture is not accumulating within wall*
- *drying cycle is surpassing wetting periods*



Appendix Figure A-29:
Zadock Pratt Museum
Insulated Wall – Vapor Retarder Paint on Interior – Mid-Winter Condition
WUFI Hygrothermal Analysis

Notes:

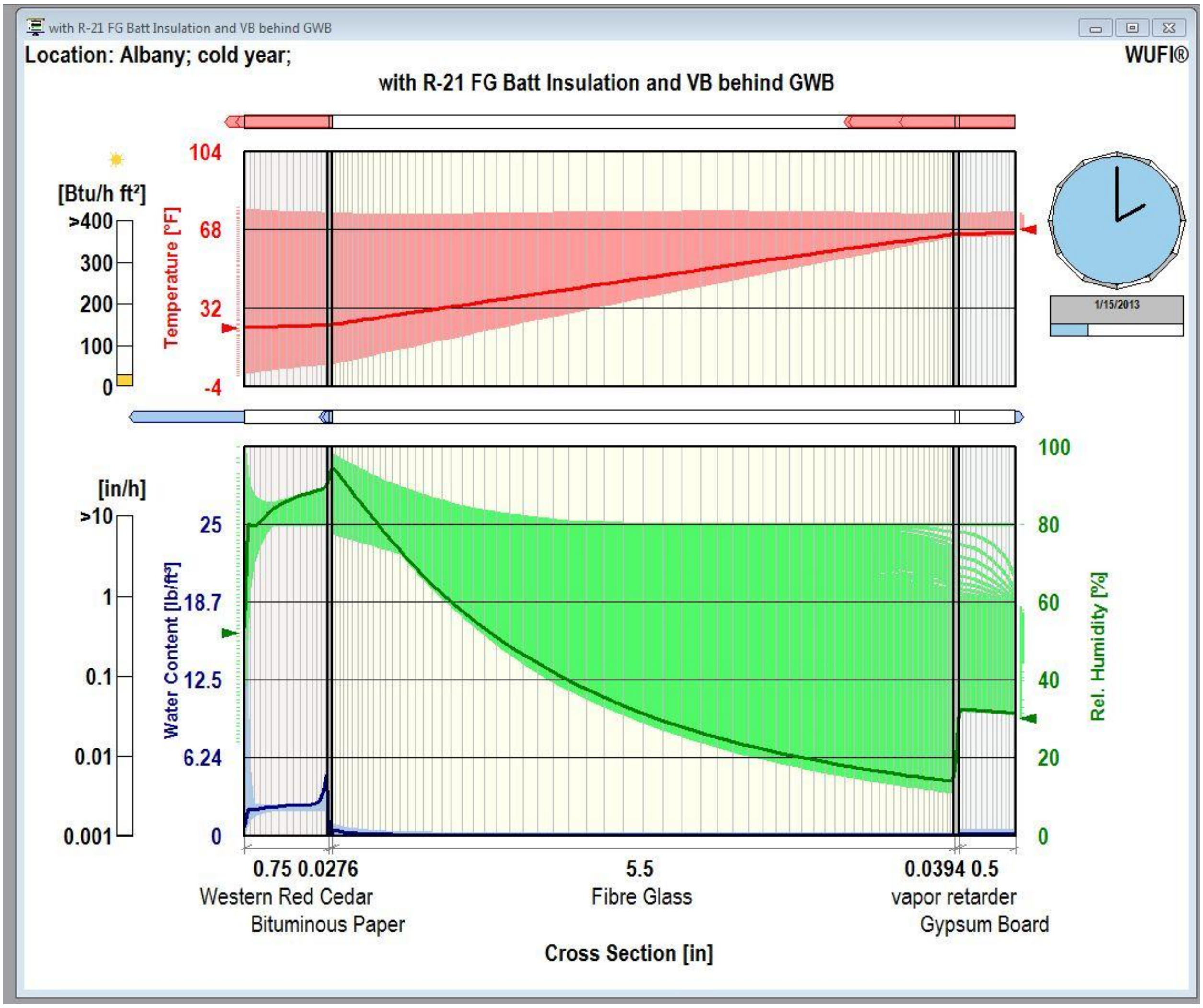
- *relative humidity (RH) reaches saturation point for short periods of time*
- *Moisture is not accumulating within wall*
- *drying cycle is surpassing wetting periods*



Appendix Figure A-30:
Zadock Pratt Museum
Insulated Wall – Vapor Retarder Sheet on Interior – Yearly Cycle
WUFI Hygrothermal Analysis

Notes:

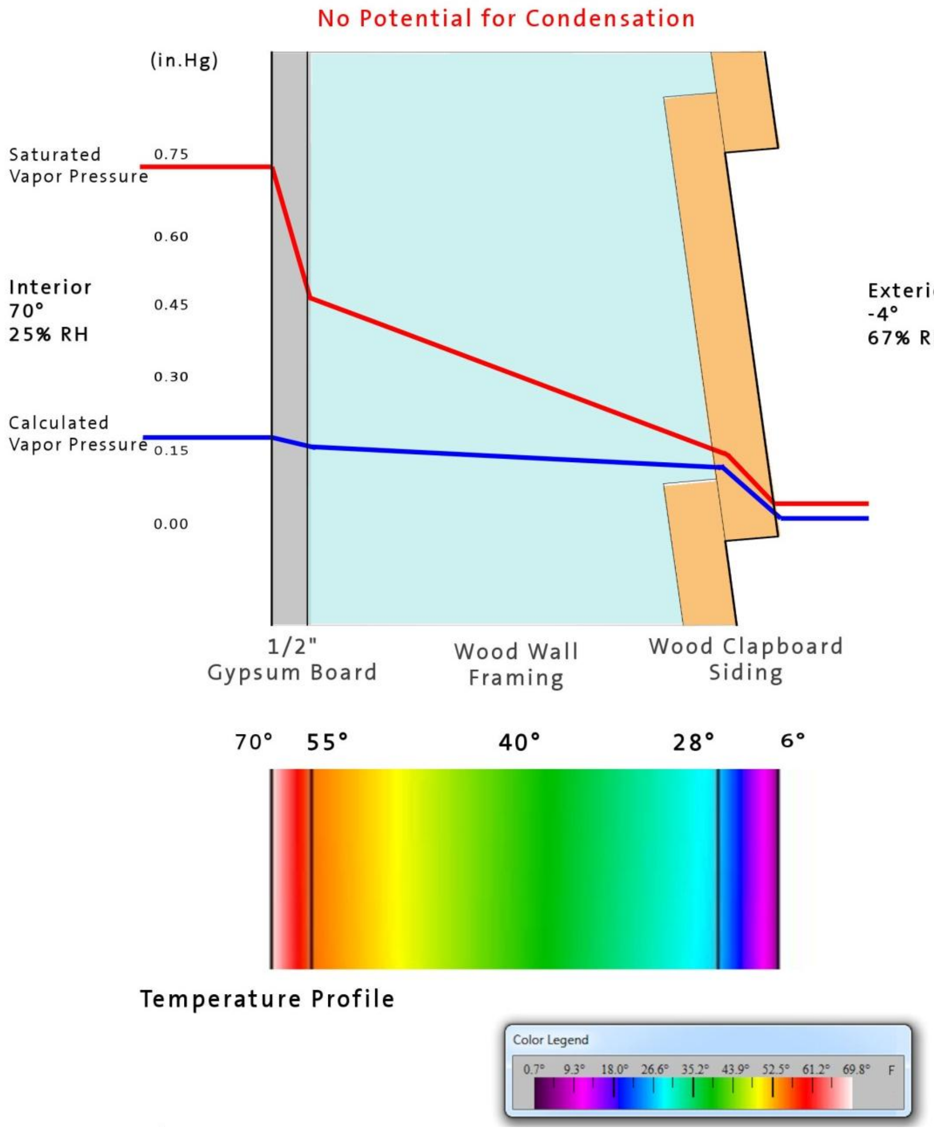
- *Moisture is not accumulating within wall*
- *drying cycle is surpassing wetting periods*



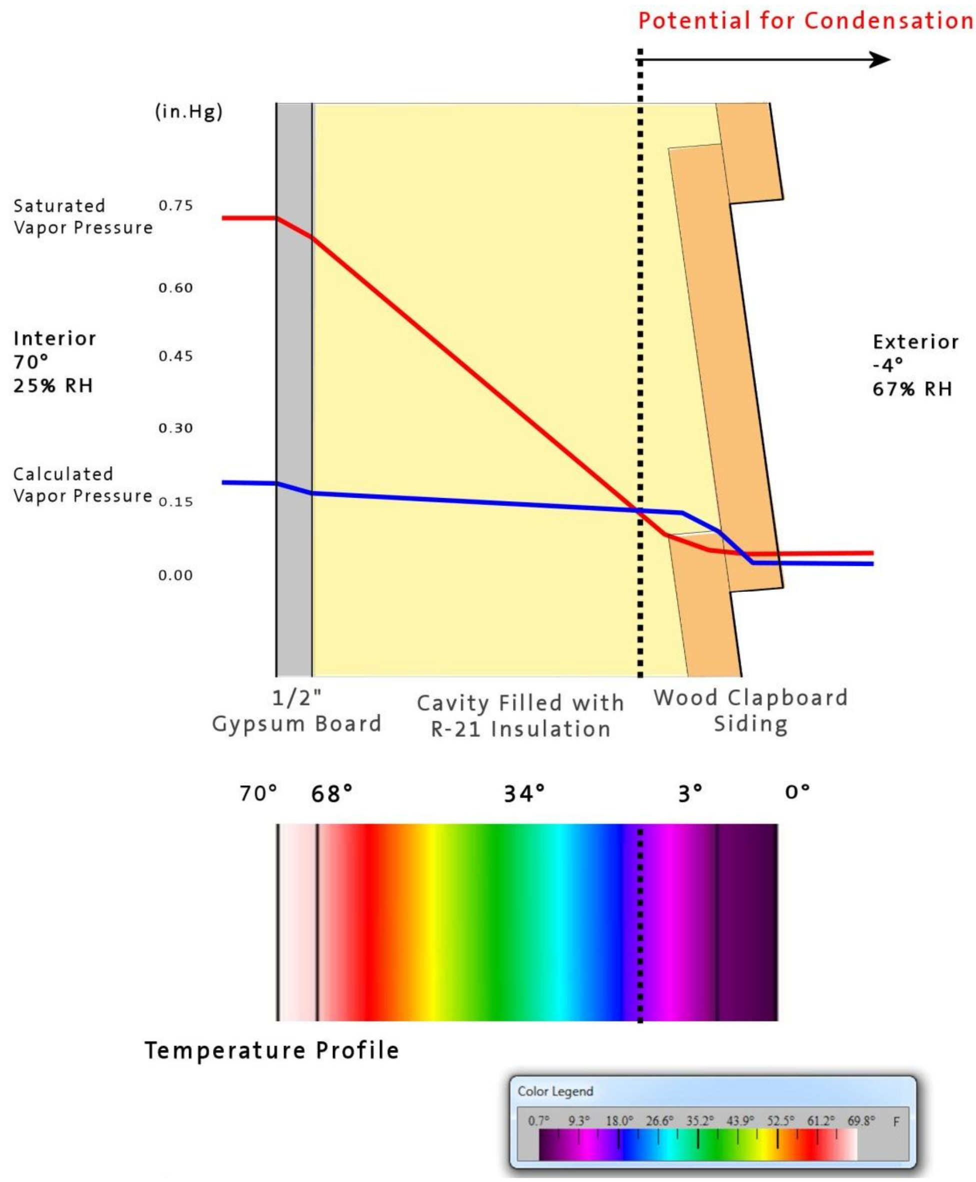
Appendix Figure A-31:
Zadock Pratt Museum
Insulated Wall – Vapor Retarder Sheet on Interior – Mid-Winter Condition
WUFI Hygrothermal Analysis

Notes:

- *relative humidity (RH) reaches saturation point for short periods of time*
- *Moisture is not accumulating within wall*
- *drying cycle is surpassing wetting periods*



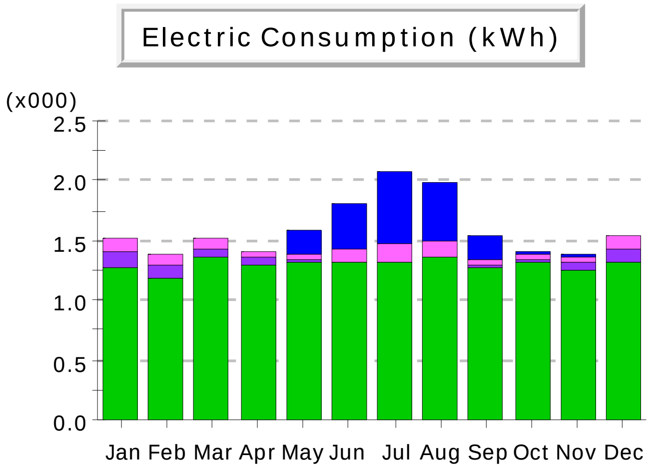
Appendix Figure A-32:
Zadock Pratt Museum
Insulated Conditions @ Typical Exterior Wall
Hygrothermal Analysis

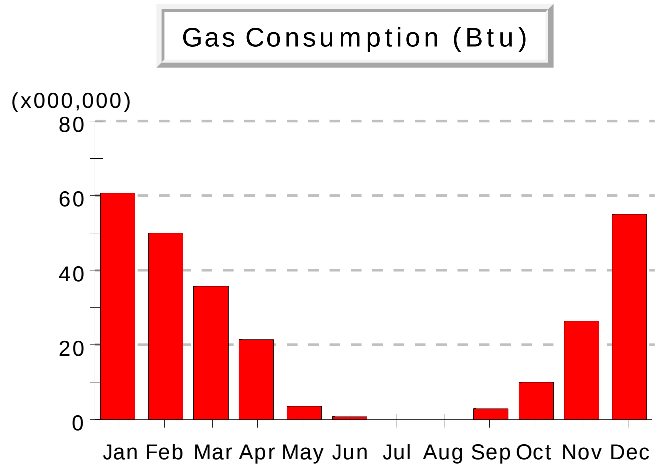


Appendix Figure A-33:
Zadock Pratt Museum
Insulated Conditions @ Typical Exterior Wall
Hygrothermal Analysis

APPENDIX B

eQUEST – CAMBRIDGE OUTPUT



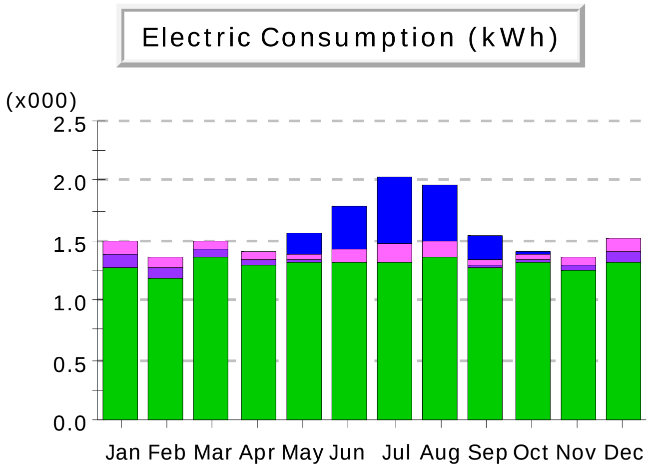


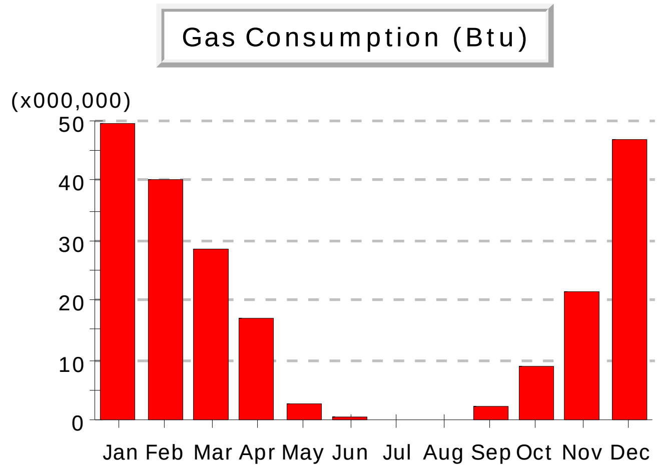
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.19	0.39	0.59	0.49	0.20	0.03	0.00	-	1.89
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.11	0.10	0.08	0.05	0.06	0.11	0.16	0.14	0.06	0.03	0.06	0.11	1.09
Pumps & Aux.	0.12	0.10	0.08	0.05	0.01	0.00	-	0.00	0.01	0.03	0.06	0.11	0.56
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.51	1.39	1.52	1.41	1.58	1.82	2.07	1.99	1.55	1.40	1.37	1.53	19.14

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	60.39	49.72	35.74	21.24	3.46	0.61	-	0.16	2.73	10.28	26.47	54.73	265.53
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	60.39	49.72	35.74	21.24	3.46	0.61	-	0.16	2.73	10.28	26.47	54.73	265.53



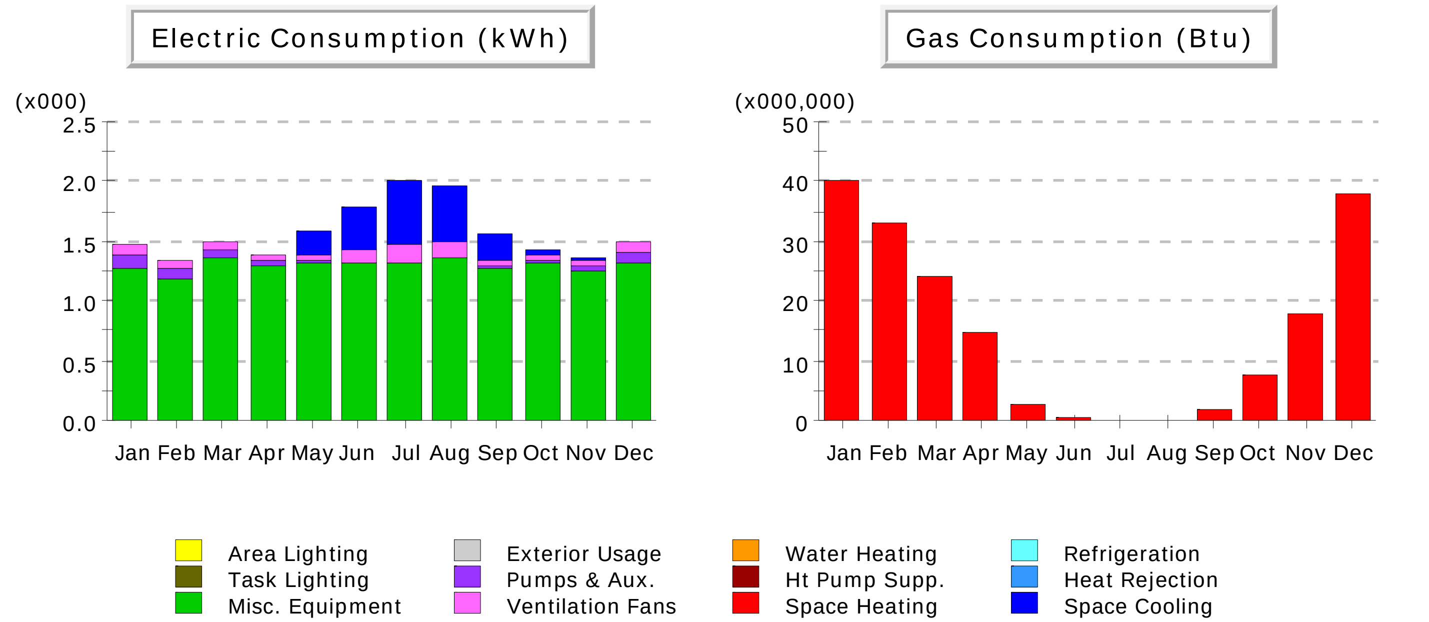


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.18	0.38	0.56	0.47	0.20	0.03	0.00	-	1.82
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.10	0.09	0.07	0.05	0.05	0.11	0.16	0.13	0.06	0.03	0.06	0.10	1.02
Pumps & Aux.	0.10	0.08	0.07	0.04	0.01	0.00	-	0.00	0.01	0.03	0.06	0.10	0.51
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.49	1.36	1.50	1.40	1.57	1.80	2.03	1.97	1.54	1.40	1.36	1.51	18.93

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	49.76	40.32	28.67	17.00	2.89	0.45	-	0.12	2.31	9.04	21.47	46.96	219.01
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	49.76	40.32	28.67	17.00	2.89	0.45	-	0.12	2.31	9.04	21.47	46.96	219.01

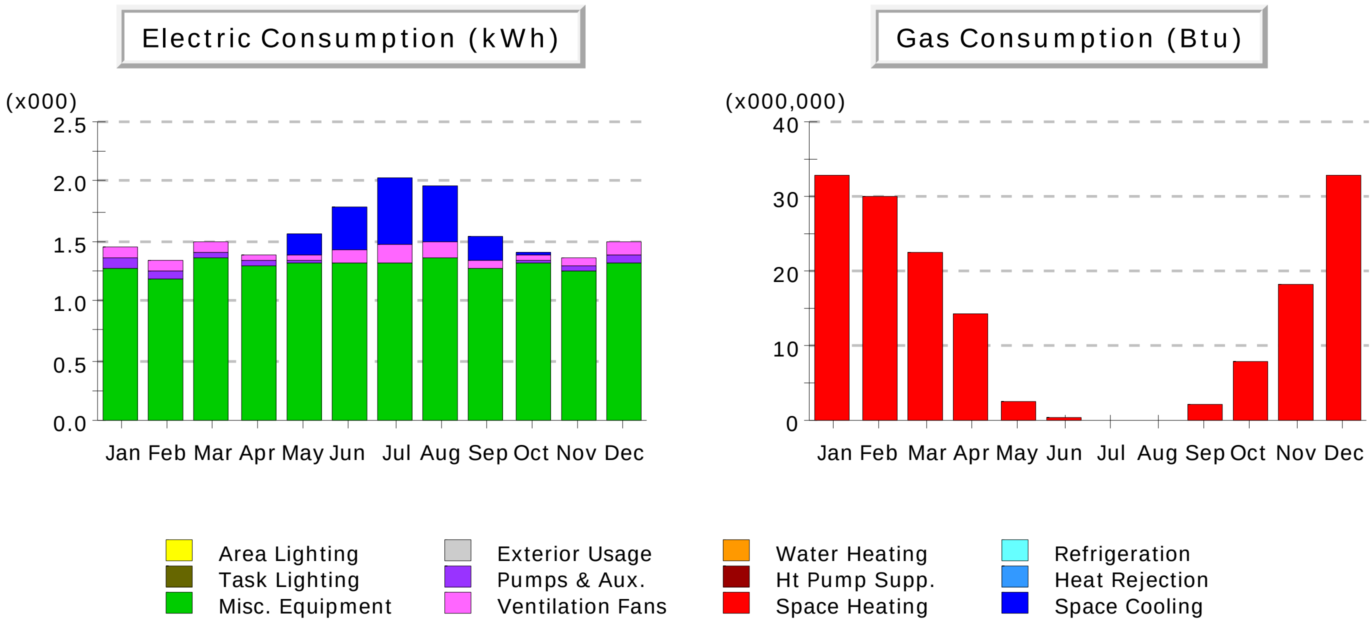


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.20	0.37	0.54	0.47	0.21	0.05	0.00	-	1.85
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.09	0.08	0.06	0.04	0.06	0.10	0.15	0.13	0.06	0.03	0.05	0.08	0.94
Pumps & Aux.	0.09	0.08	0.07	0.04	0.01	0.00	-	0.00	0.01	0.03	0.06	0.09	0.48
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.46	1.34	1.49	1.39	1.59	1.79	2.00	1.96	1.56	1.42	1.35	1.49	18.86

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	40.30	33.16	24.08	14.58	2.57	0.42	-	0.14	1.95	7.60	18.08	38.02	180.89
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	40.30	33.16	24.08	14.58	2.57	0.42	-	0.14	1.95	7.60	18.08	38.02	180.89

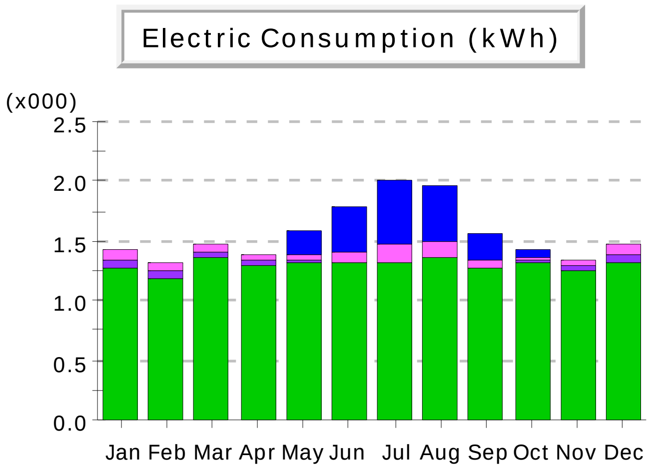


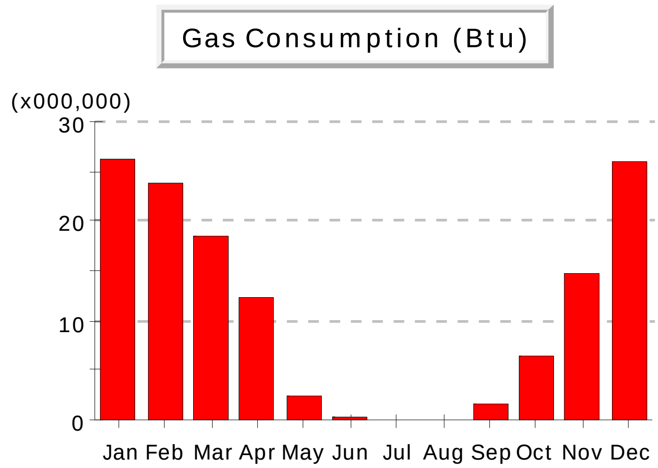
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.18	0.38	0.56	0.47	0.20	0.03	0.00	-	1.82
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.10	0.09	0.07	0.05	0.05	0.11	0.16	0.13	0.06	0.03	0.06	0.10	1.02
Pumps & Aux.	0.07	0.07	0.06	0.04	0.01	0.00	-	0.00	0.01	0.03	0.05	0.07	0.40
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.45	1.35	1.49	1.39	1.57	1.80	2.03	1.96	1.54	1.40	1.35	1.49	18.83

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	32.90	30.00	22.43	14.44	2.66	0.35	-	-	2.02	7.90	18.15	32.73	163.58
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	32.90	30.00	22.43	14.44	2.66	0.35	-	-	2.02	7.90	18.15	32.73	163.58



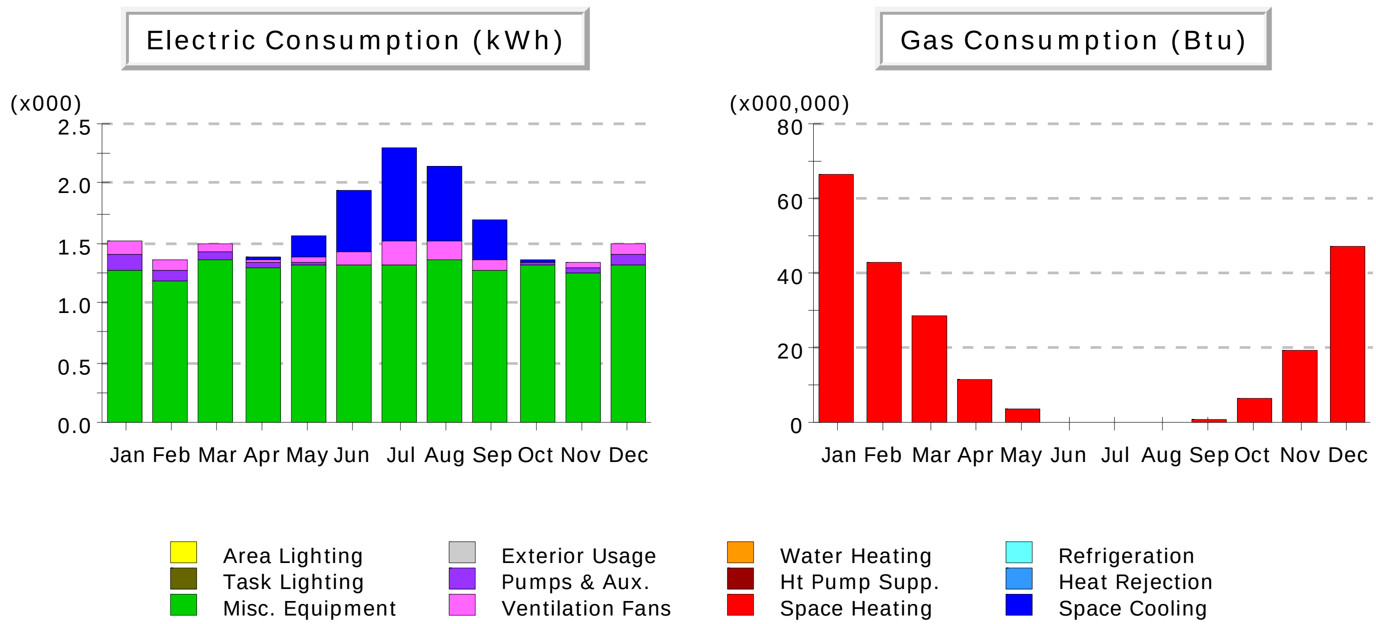


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.20	0.37	0.54	0.47	0.21	0.05	0.00	-	1.85
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.09	0.08	0.06	0.04	0.06	0.10	0.15	0.13	0.06	0.03	0.05	0.08	0.94
Pumps & Aux.	0.06	0.06	0.06	0.04	0.01	0.00	-	-	0.00	0.02	0.05	0.07	0.38
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.43	1.33	1.48	1.39	1.59	1.79	2.00	1.96	1.56	1.42	1.35	1.47	18.76

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	26.15	23.84	18.53	12.22	2.35	0.29	-	0.01	1.62	6.40	14.81	25.87	132.08
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	26.15	23.84	18.53	12.22	2.35	0.29	-	0.01	1.62	6.40	14.81	25.87	132.08

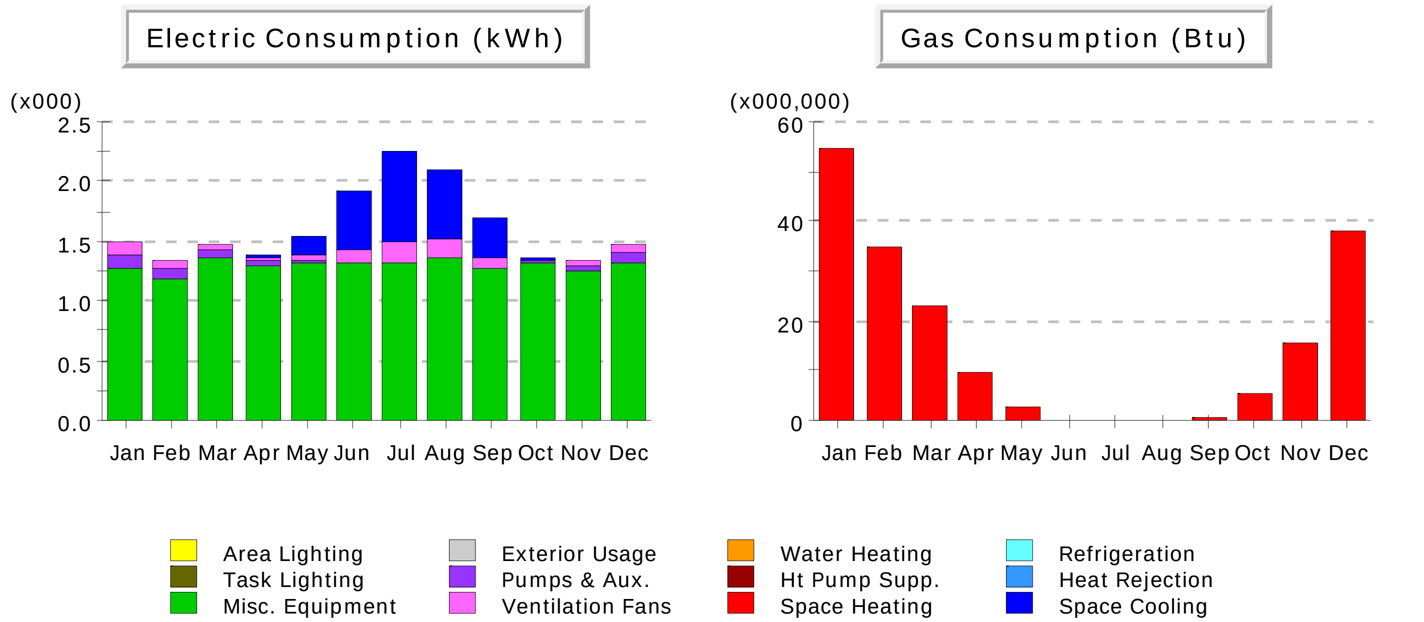


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0.00	0.01	0.17	0.51	0.79	0.62	0.34	0.02	0.00	-	2.47
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.12	0.09	0.07	0.03	0.05	0.13	0.20	0.16	0.08	0.02	0.05	0.09	1.08
Pumps & Aux.	0.12	0.09	0.07	0.03	0.01	0.00	-	0.00	0.00	0.01	0.05	0.09	0.48
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.52	1.36	1.50	1.38	1.55	1.95	2.30	2.14	1.70	1.37	1.34	1.50	19.61

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	66.70	42.83	28.81	11.30	3.33	0.07	-	0.02	0.65	6.65	19.19	47.03	226.60
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	66.70	42.83	28.81	11.30	3.33	0.07	-	0.02	0.65	6.65	19.19	47.03	226.60



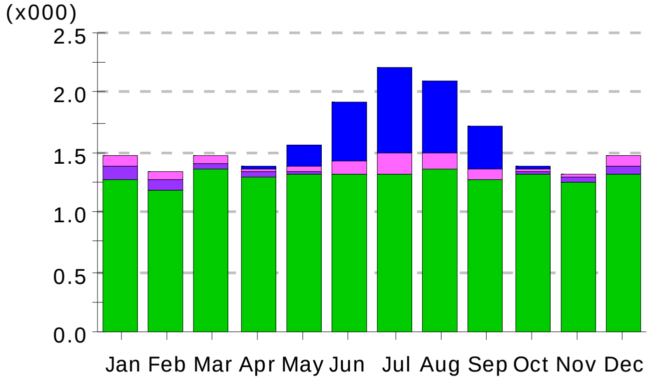
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0.00	0.01	0.17	0.49	0.75	0.60	0.33	0.02	0.00	-	2.37
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.10	0.08	0.06	0.03	0.05	0.12	0.19	0.15	0.09	0.02	0.04	0.08	1.01
Pumps & Aux.	0.11	0.08	0.06	0.03	0.01	0.00	-	0.00	0.00	0.01	0.04	0.08	0.43
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.49	1.34	1.48	1.38	1.55	1.93	2.25	2.11	1.70	1.37	1.33	1.48	19.40

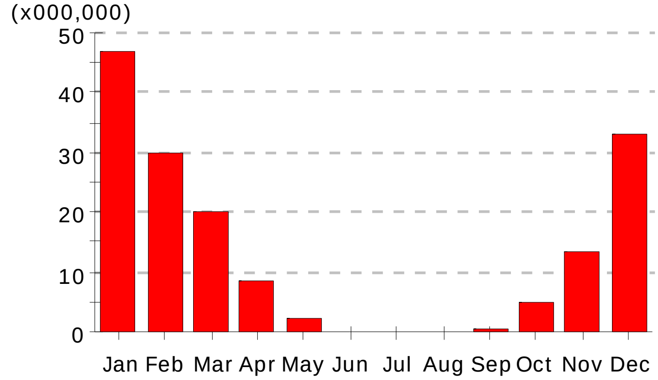
Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	54.63	35.08	22.98	9.69	2.66	0.05	-	-	0.52	5.57	15.59	37.92	184.69
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	54.63	35.08	22.98	9.69	2.66	0.05	-	-	0.52	5.57	15.59	37.92	184.69

Electric Consumption (kWh)



Gas Consumption (Btu)



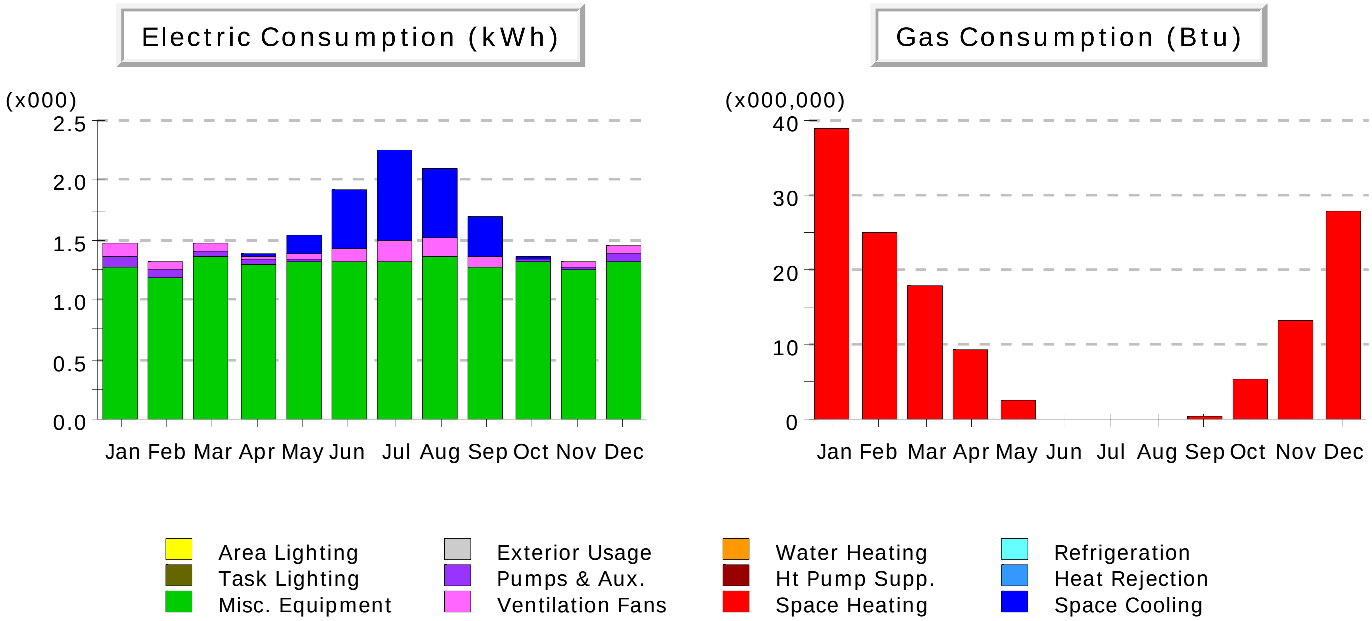
Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0.01	0.02	0.18	0.49	0.72	0.59	0.34	0.04	0.00	0.00	2.39
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.09	0.07	0.05	0.03	0.05	0.12	0.18	0.15	0.09	0.02	0.04	0.07	0.95
Pumps & Aux.	0.10	0.07	0.06	0.03	0.01	0.00	-	0.00	0.00	0.01	0.04	0.08	0.42
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.47	1.33	1.48	1.38	1.56	1.92	2.21	2.09	1.71	1.39	1.33	1.46	19.34

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	46.75	30.10	20.16	8.32	2.37	0.05	-	-	0.50	4.82	13.51	32.92	159.49
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	46.75	30.10	20.16	8.32	2.37	0.05	-	-	0.50	4.82	13.51	32.92	159.49

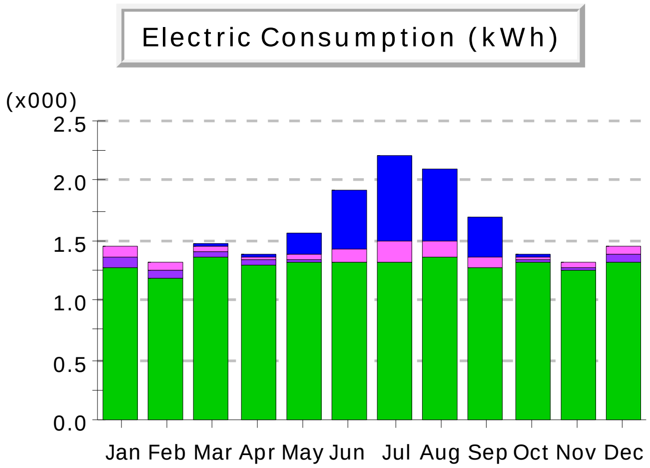


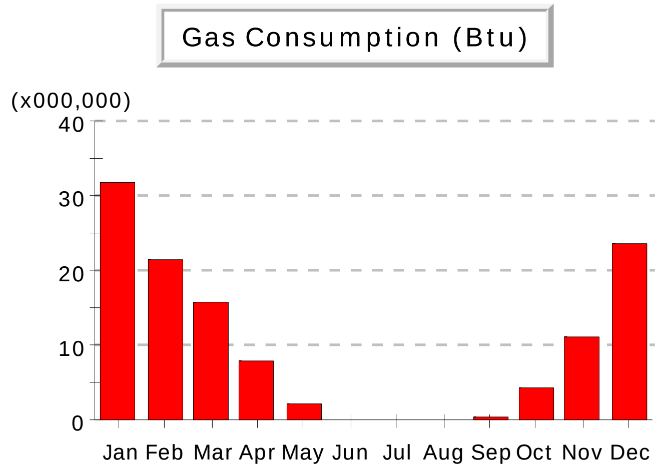
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0.00	0.01	0.17	0.49	0.75	0.60	0.33	0.02	0.00	-	2.37
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.10	0.08	0.06	0.03	0.05	0.12	0.19	0.15	0.09	0.02	0.04	0.08	1.01
Pumps & Aux.	0.08	0.06	0.05	0.03	0.01	0.00	-	-	0.00	0.01	0.04	0.06	0.35
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.46	1.32	1.47	1.38	1.55	1.93	2.25	2.11	1.70	1.37	1.33	1.46	19.32

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	38.97	25.13	17.75	9.26	2.47	0.04	-	-	0.39	5.22	13.06	27.72	140.02
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	38.97	25.13	17.75	9.26	2.47	0.04	-	-	0.39	5.22	13.06	27.72	140.02



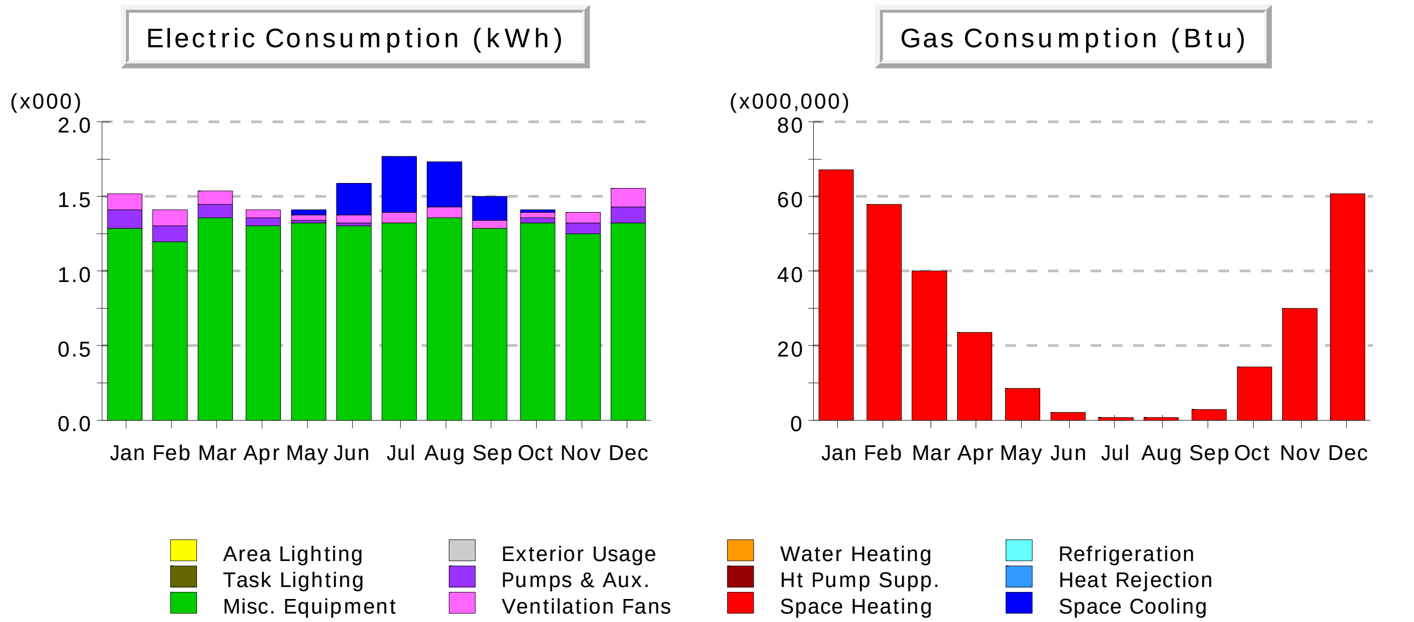


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0.01	0.02	0.18	0.49	0.72	0.59	0.34	0.04	0.00	0.00	2.39
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.09	0.07	0.05	0.03	0.05	0.12	0.18	0.15	0.09	0.02	0.04	0.07	0.95
Pumps & Aux.	0.07	0.06	0.05	0.03	0.01	0.00	-	-	0.00	0.01	0.04	0.06	0.33
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.44	1.31	1.47	1.38	1.56	1.92	2.21	2.09	1.71	1.39	1.32	1.45	19.26

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	31.76	21.37	15.55	7.88	2.14	0.03	-	-	0.37	4.46	11.22	23.42	118.20
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	31.76	21.37	15.55	7.88	2.14	0.03	-	-	0.37	4.46	11.22	23.42	118.20

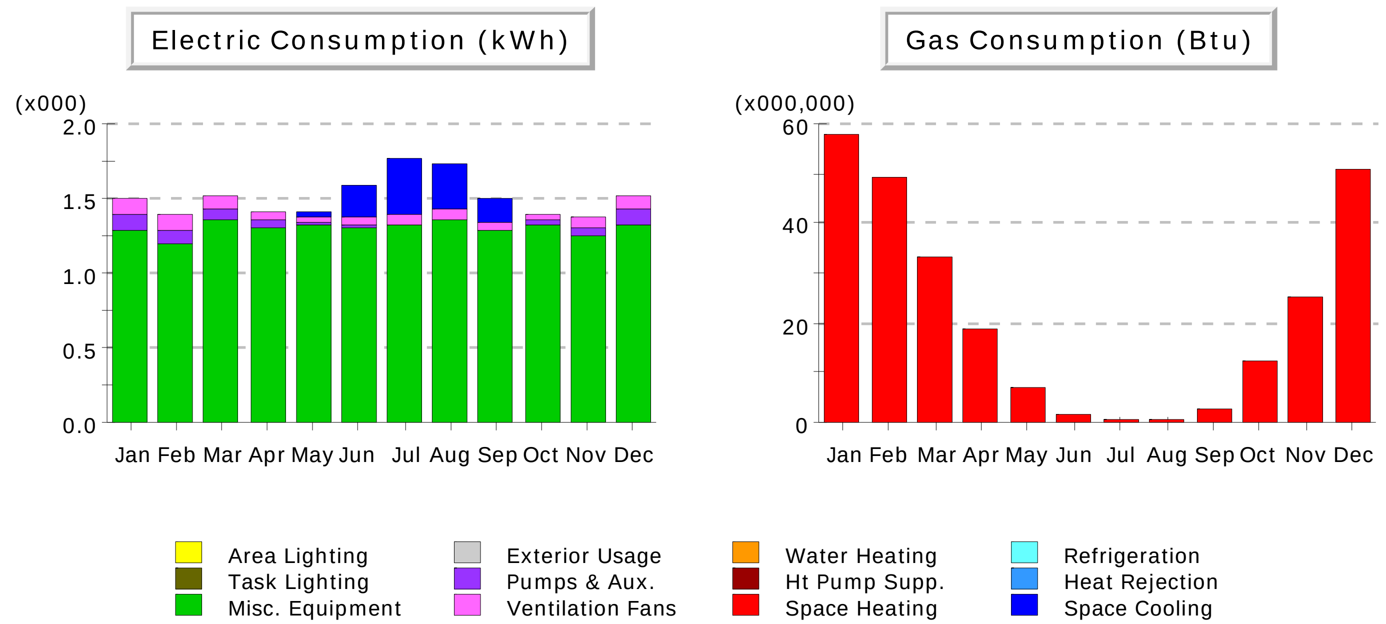


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.04	0.23	0.37	0.30	0.17	0.01	-	-	1.13
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.12	0.11	0.09	0.06	0.03	0.05	0.08	0.06	0.04	0.04	0.07	0.11	0.87
Pumps & Aux.	0.12	0.11	0.09	0.06	0.02	0.01	0.00	0.00	0.01	0.04	0.07	0.12	0.65
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.52	1.41	1.53	1.42	1.41	1.60	1.77	1.73	1.50	1.40	1.39	1.55	18.23

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	67.04	58.04	39.92	23.80	8.48	2.16	0.45	0.83	3.02	14.50	30.25	60.69	309.20
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	67.04	58.04	39.92	23.80	8.48	2.16	0.45	0.83	3.02	14.50	30.25	60.69	309.20

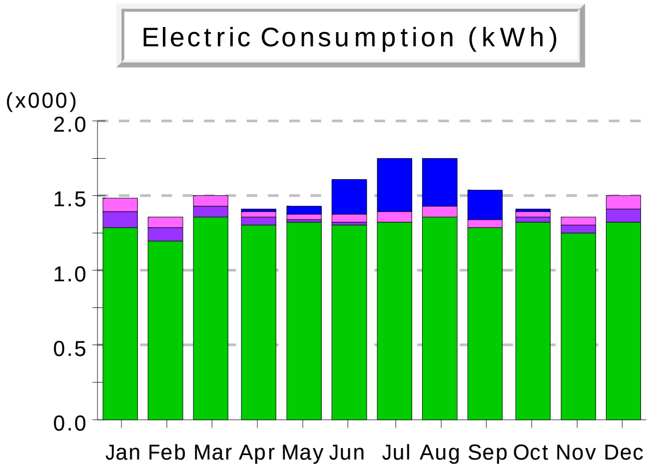


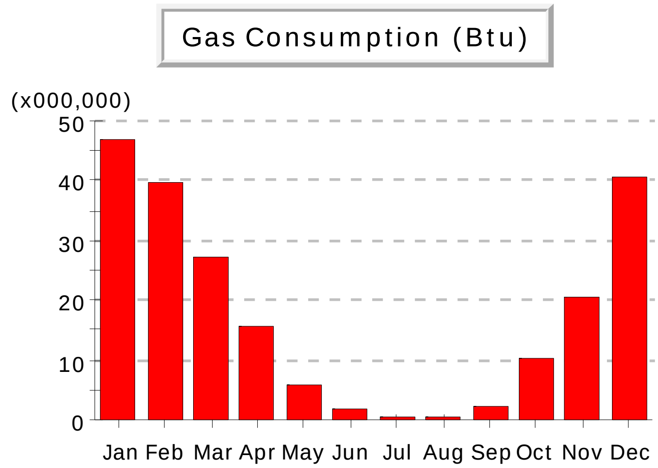
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.04	0.22	0.36	0.30	0.17	0.01	-	-	1.11
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.10	0.10	0.08	0.05	0.03	0.05	0.08	0.06	0.04	0.04	0.06	0.10	0.80
Pumps & Aux.	0.12	0.10	0.08	0.05	0.02	0.01	0.00	0.00	0.01	0.04	0.07	0.11	0.60
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.50	1.39	1.51	1.41	1.41	1.59	1.76	1.72	1.50	1.40	1.37	1.52	18.10

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	57.91	49.34	33.32	18.64	6.90	1.73	0.34	0.64	2.58	12.18	25.41	50.94	259.93
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	57.91	49.34	33.32	18.64	6.90	1.73	0.34	0.64	2.58	12.18	25.41	50.94	259.93



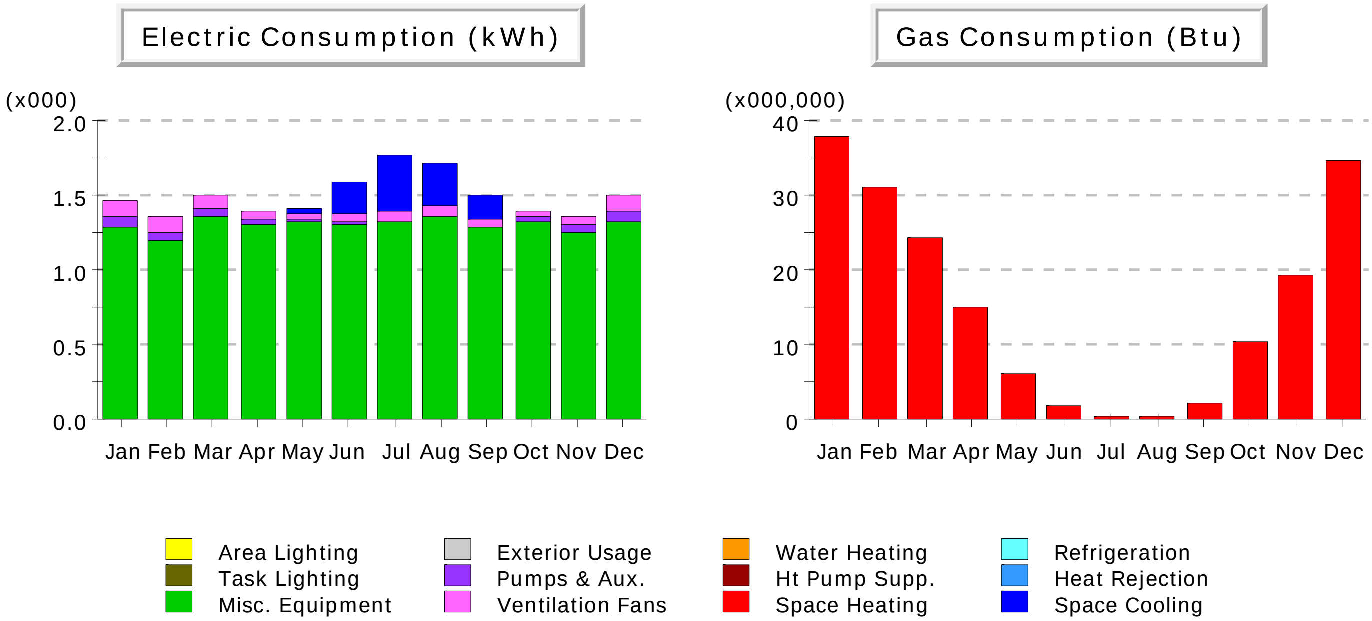


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.01	0.06	0.24	0.36	0.32	0.19	0.03	-	-	1.20
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.09	0.08	0.07	0.05	0.03	0.05	0.08	0.07	0.05	0.03	0.05	0.09	0.73
Pumps & Aux.	0.11	0.09	0.07	0.05	0.02	0.01	0.00	0.00	0.01	0.04	0.06	0.10	0.56
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.48	1.36	1.50	1.41	1.43	1.60	1.76	1.74	1.53	1.41	1.36	1.50	18.08

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	46.75	39.83	27.16	15.81	6.01	1.57	0.33	0.63	2.34	10.17	20.59	40.71	211.89
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	46.75	39.83	27.16	15.81	6.01	1.57	0.33	0.63	2.34	10.17	20.59	40.71	211.89

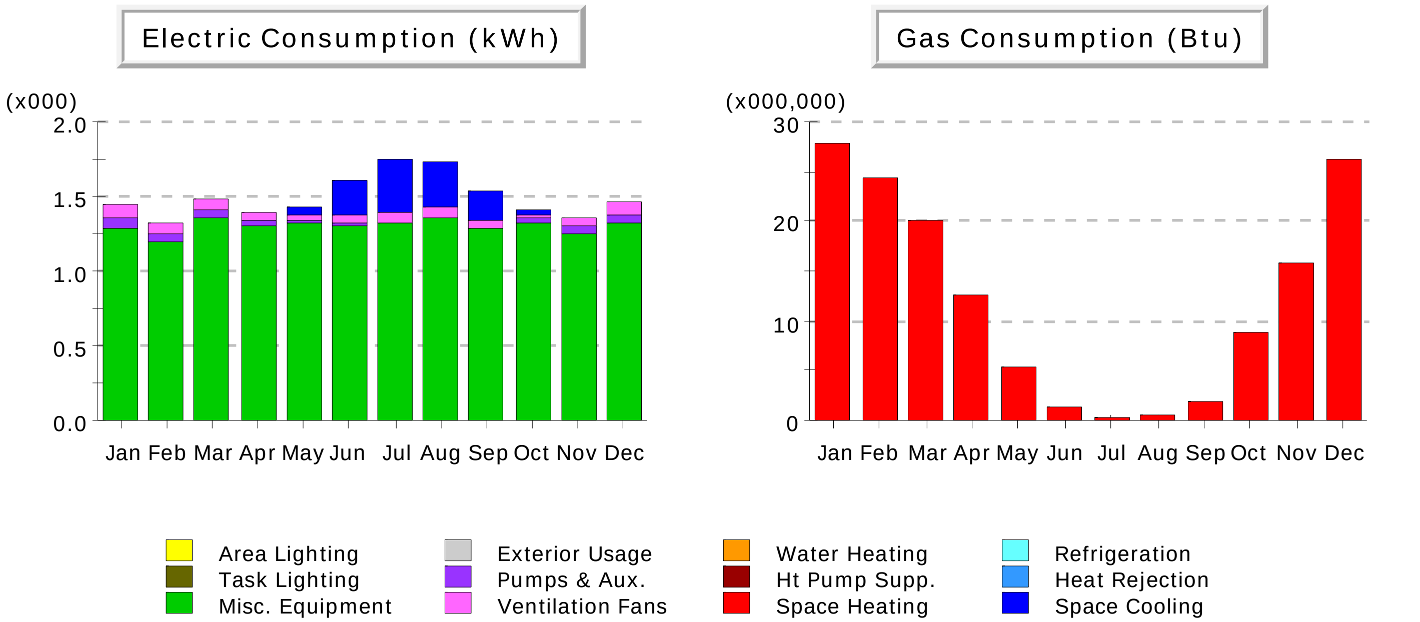


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.00	0.04	0.22	0.36	0.30	0.17	0.01	-	-	1.11
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.10	0.10	0.08	0.05	0.03	0.05	0.08	0.06	0.04	0.04	0.06	0.10	0.80
Pumps & Aux.	0.08	0.06	0.06	0.04	0.02	0.01	0.00	0.00	0.01	0.03	0.05	0.08	0.45
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.47	1.35	1.50	1.40	1.41	1.59	1.76	1.72	1.50	1.40	1.36	1.49	17.95

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	38.02	30.97	24.27	14.93	6.11	1.61	0.30	0.51	2.25	10.52	19.27	34.76	183.52
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	38.02	30.97	24.27	14.93	6.11	1.61	0.30	0.51	2.25	10.52	19.27	34.76	183.52



Electric Consumption (kWh x000)

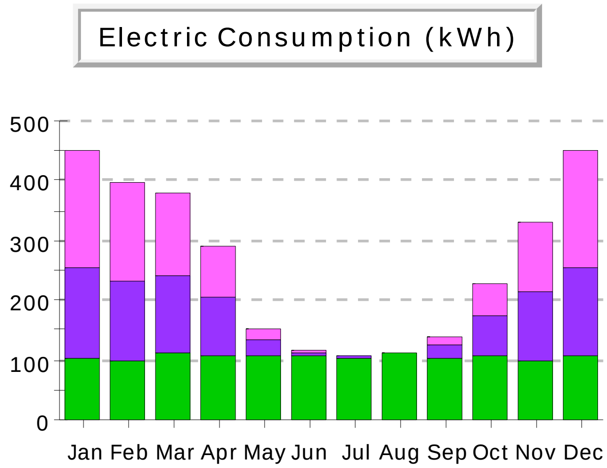
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.01	0.06	0.24	0.36	0.32	0.19	0.03	-	-	1.20
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.09	0.08	0.07	0.05	0.03	0.05	0.08	0.07	0.05	0.03	0.05	0.09	0.73
Pumps & Aux.	0.07	0.06	0.06	0.04	0.02	0.01	0.00	0.00	0.01	0.03	0.05	0.07	0.41
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	1.28	1.19	1.36	1.30	1.32	1.31	1.32	1.36	1.28	1.32	1.24	1.32	15.59
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.44	1.33	1.48	1.40	1.43	1.60	1.75	1.74	1.53	1.41	1.35	1.47	17.94

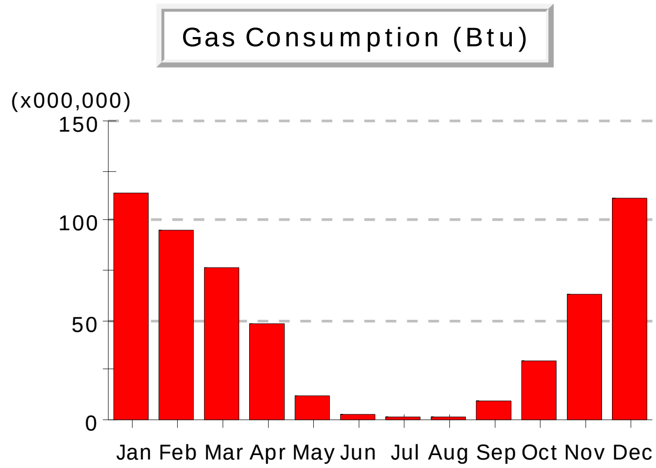
Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	27.94	24.41	20.00	12.67	5.27	1.41	0.25	0.45	1.98	8.75	15.90	26.23	145.26
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	27.94	24.41	20.00	12.67	5.27	1.41	0.25	0.45	1.98	8.75	15.90	26.23	145.26

APPENDIX C

eQUEST – PRATTSVILLE OUTPUT



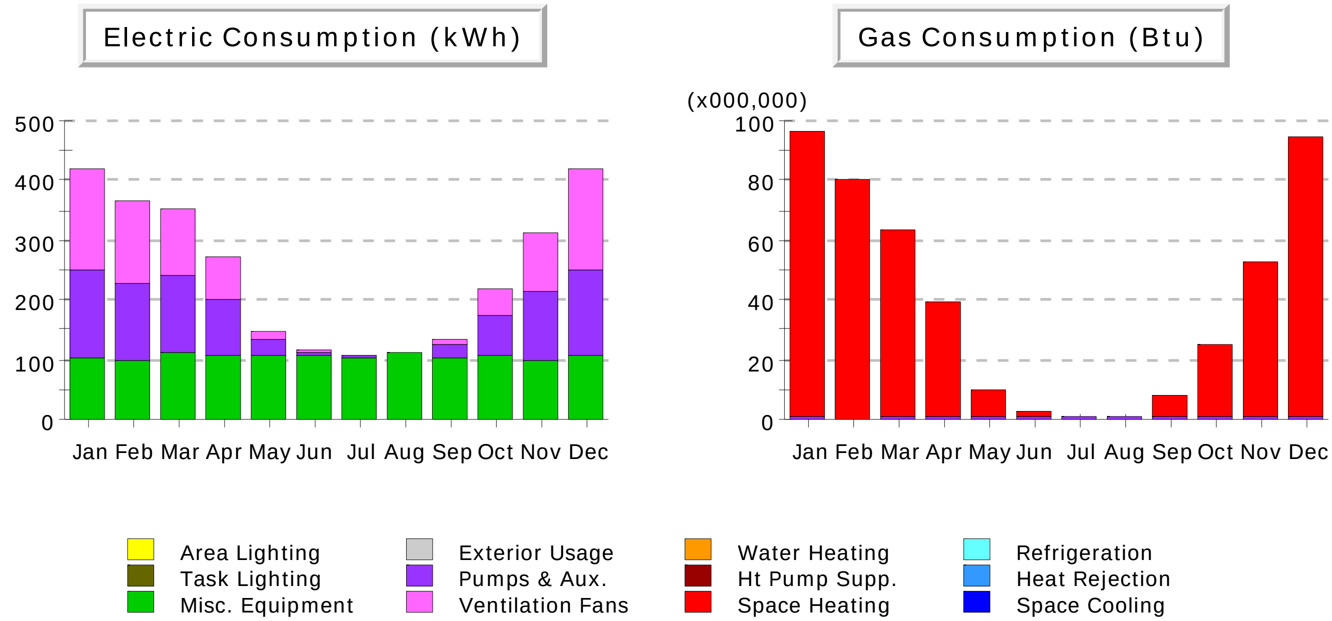


Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	194.8	166.0	136.3	87.0	19.6	3.7	-	0.9	14.9	52.4	115.6	197.1	988.2
Pumps & Aux.	151.7	133.3	132.9	98.3	26.3	7.0	0.8	2.8	18.6	68.8	115.1	147.1	902.6
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	450.6	395.9	379.0	290.5	152.7	116.7	105.6	113.5	138.0	226.9	330.7	451.5	3,151.6

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	113.18	94.85	76.38	48.37	11.16	2.55	0.15	0.87	8.84	29.05	61.92	110.49	557.82
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.45	0.42	0.50	0.51	0.58	0.57	0.60	0.59	0.57	0.56	0.49	0.45	6.28
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	113.64	95.26	76.88	48.88	11.75	3.12	0.75	1.47	9.40	29.61	62.41	110.94	564.10

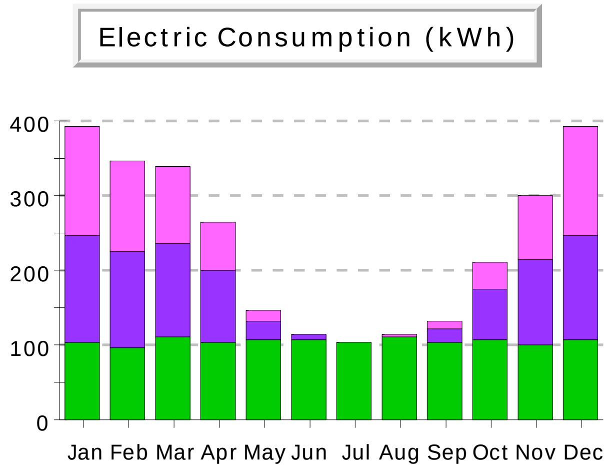


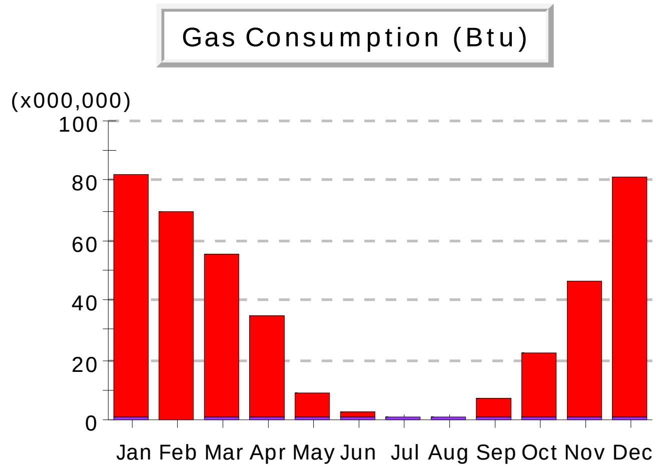
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	166.9	140.7	114.3	71.5	15.8	2.9	-	0.7	12.0	44.1	97.7	168.7	835.3
Pumps & Aux.	146.6	129.7	129.2	95.8	26.3	7.0	0.7	2.7	18.4	68.3	113.8	144.2	882.7
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	417.5	367.0	353.3	272.5	148.9	115.9	105.5	113.1	134.9	218.2	311.6	420.2	2,978.8

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	95.93	79.93	63.13	39.07	9.26	2.06	0.13	0.70	7.29	24.59	52.42	94.55	469.07
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.46	0.43	0.50	0.52	0.58	0.57	0.60	0.59	0.57	0.56	0.50	0.46	6.34
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	96.39	80.36	63.64	39.59	9.84	2.64	0.73	1.29	7.86	25.15	52.92	95.01	475.42



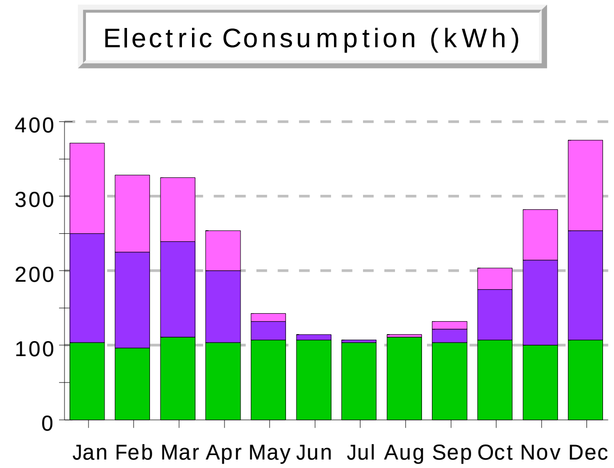


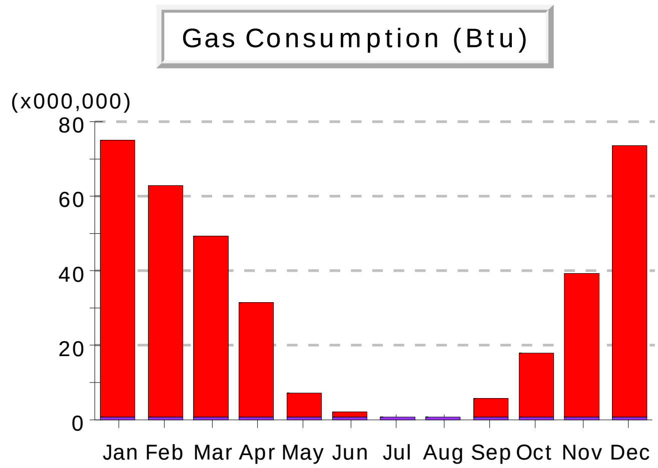
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	146.2	123.7	100.7	64.1	14.1	2.5	-	0.6	10.4	38.0	85.5	147.3	732.9
Pumps & Aux.	141.7	127.2	127.0	94.5	26.3	6.9	0.4	2.7	18.2	68.2	113.3	139.6	865.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	391.9	347.5	337.6	263.7	147.2	115.4	105.3	113.0	133.1	212.0	298.8	394.1	2,859.6

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	82.09	69.56	54.97	34.58	8.45	1.88	0.08	0.64	6.51	21.57	46.10	80.88	407.31
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.48	0.44	0.51	0.52	0.58	0.57	0.60	0.59	0.57	0.56	0.51	0.47	6.41
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	82.56	69.99	55.49	35.10	9.04	2.45	0.68	1.23	7.08	22.13	46.61	81.35	413.72





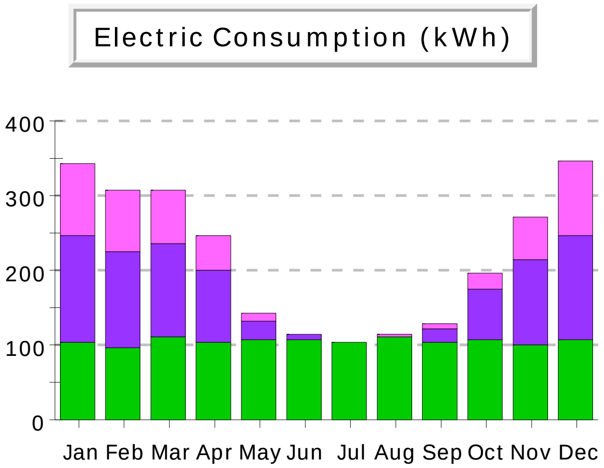
- Area Lighting
- Task Lighting
- Misc. Equipment
- Exterior Usage
- Pumps & Aux.
- Ventilation Fans
- Water Heating
- Ht Pump Supp.
- Space Heating
- Refrigeration
- Heat Rejection
- Space Cooling

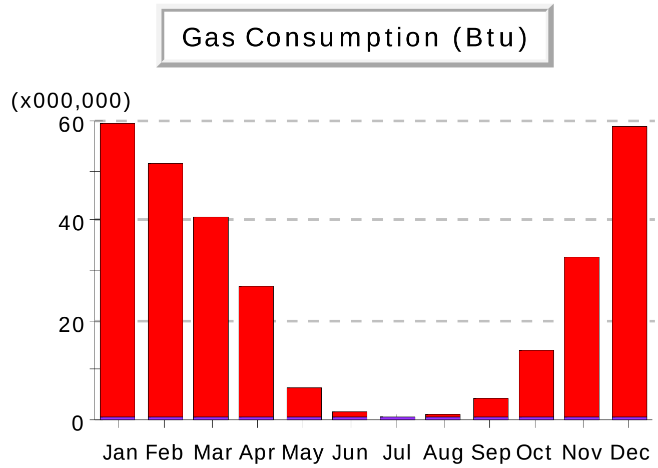
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	120.3	103.0	84.3	53.9	10.8	1.6	-	0.2	7.6	28.7	69.4	122.6	602.5
Pumps & Aux.	147.3	130.1	129.4	95.9	26.3	7.0	0.7	2.7	18.4	68.3	114.1	144.9	884.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	371.7	329.7	323.4	255.0	143.9	114.6	105.5	112.7	130.5	202.8	283.5	374.7	2,748.2

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	74.19	62.17	48.93	30.81	6.79	1.40	0.11	0.43	5.01	17.06	39.08	73.11	359.08
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.48	0.44	0.52	0.53	0.59	0.57	0.60	0.59	0.57	0.57	0.51	0.48	6.45
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	74.67	62.61	49.44	31.33	7.38	1.97	0.71	1.02	5.58	17.63	39.60	73.59	365.54





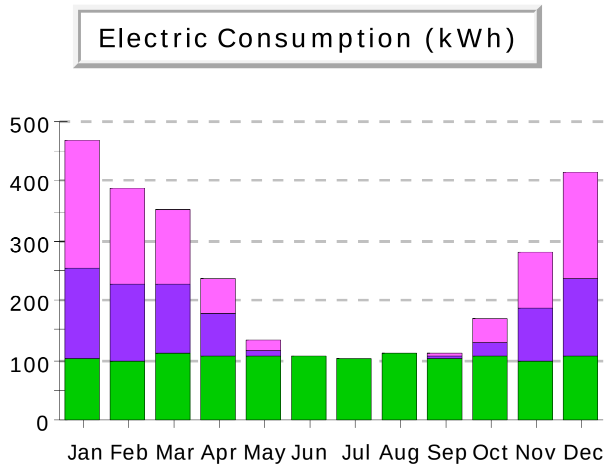
Area Lighting	Exterior Usage	Water Heating	Refrigeration
Task Lighting	Pumps & Aux.	Ht Pump Supp.	Heat Rejection
Misc. Equipment	Ventilation Fans	Space Heating	Space Cooling

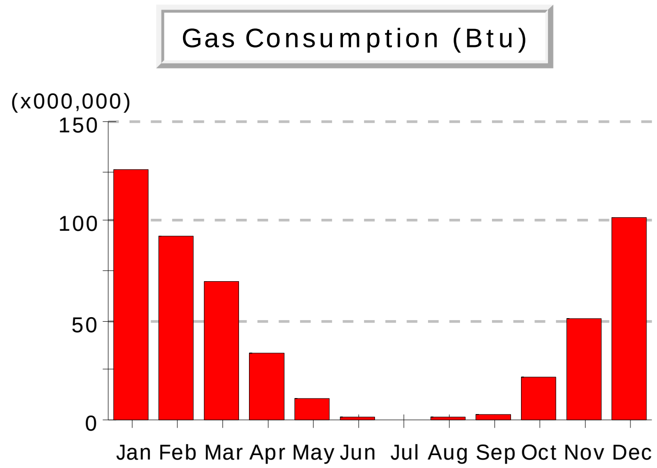
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	97.4	84.4	69.0	45.9	8.7	1.0	-	0.1	5.6	21.2	56.2	99.5	489.3
Pumps & Aux.	142.0	127.4	127.1	94.6	26.3	6.9	0.4	2.7	18.2	68.2	113.4	140.3	867.4
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	343.4	308.4	306.0	245.7	141.8	113.9	105.3	112.6	128.3	195.2	269.7	347.1	2,617.5

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	58.98	50.89	39.94	26.06	5.81	1.09	0.06	0.35	3.97	13.23	32.22	58.61	291.22
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.50	0.46	0.53	0.53	0.59	0.58	0.60	0.60	0.57	0.57	0.52	0.50	6.54
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	59.48	51.35	40.47	26.60	6.40	1.66	0.65	0.95	4.55	13.81	32.74	59.11	297.76



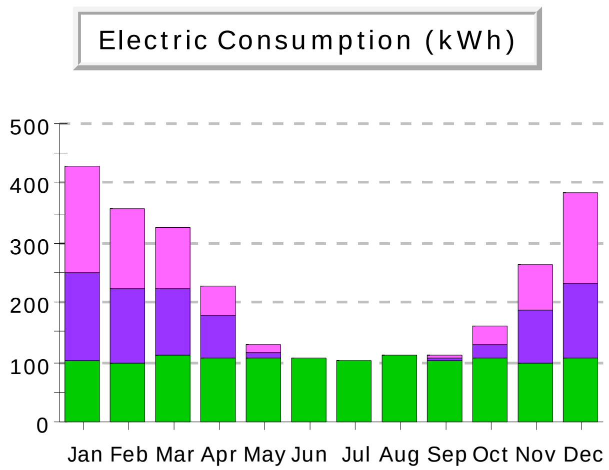


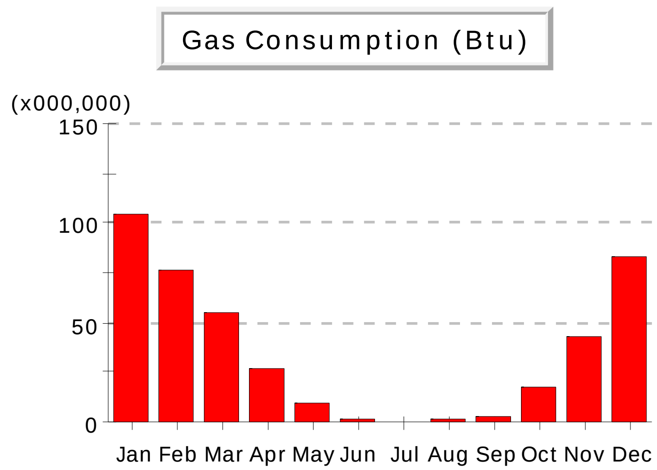
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	214.2	160.3	125.9	61.4	18.2	0.7	-	0.4	4.0	37.3	94.0	180.2	896.7
Pumps & Aux.	151.8	129.7	117.3	71.4	7.6	1.0	0.1	0.5	2.6	24.4	87.1	129.5	723.0
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	470.0	386.7	353.0	238.0	132.6	107.7	104.9	110.7	111.1	167.5	281.2	417.0	2,880.4

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	125.68	92.01	68.96	32.73	10.61	0.70	0.02	0.39	2.72	20.83	50.91	101.03	506.58
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.45	0.43	0.51	0.53	0.58	0.58	0.60	0.59	0.57	0.57	0.51	0.47	6.41
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	126.13	92.44	69.47	33.26	11.19	1.27	0.61	0.98	3.29	21.40	51.42	101.50	512.99





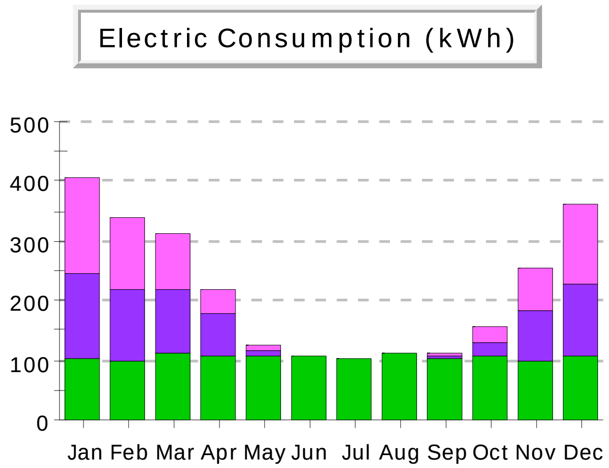
Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

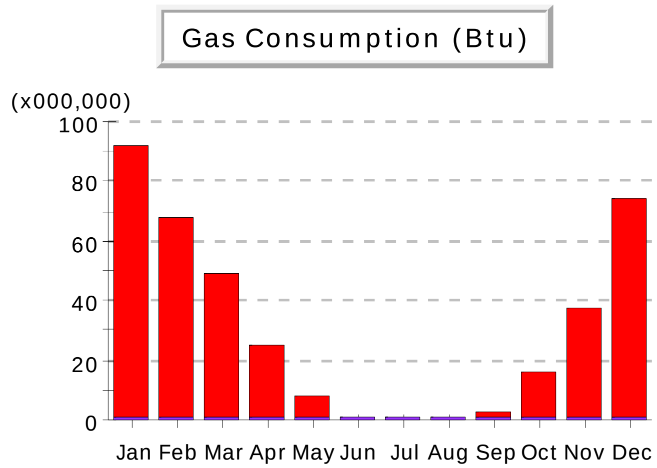
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	180.4	134.3	103.6	49.3	13.9	0.5	-	0.2	3.1	30.1	77.7	151.0	744.1
Pumps & Aux.	144.2	125.8	112.1	71.4	7.6	0.9	0.1	0.5	2.6	24.4	85.4	123.9	698.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	428.6	356.8	325.5	226.0	128.3	107.4	104.9	110.6	110.2	160.2	263.1	382.2	2,703.8

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	103.86	76.43	54.89	26.72	8.38	0.52	0.02	0.29	2.19	17.08	41.80	83.00	415.19
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.46	0.44	0.52	0.54	0.59	0.58	0.60	0.60	0.57	0.57	0.52	0.49	6.47
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	104.33	76.87	55.41	27.26	8.97	1.09	0.61	0.89	2.76	17.66	42.32	83.49	421.66



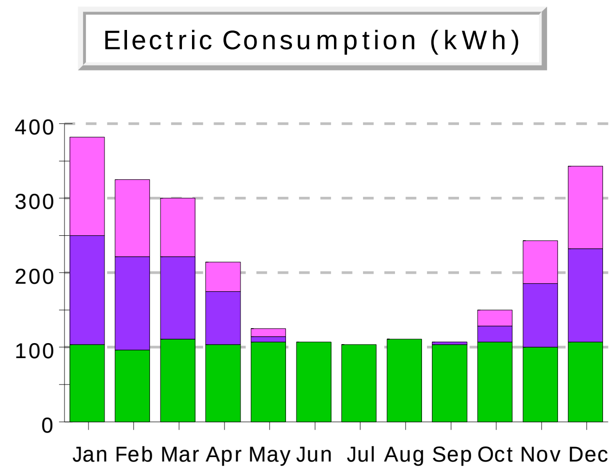


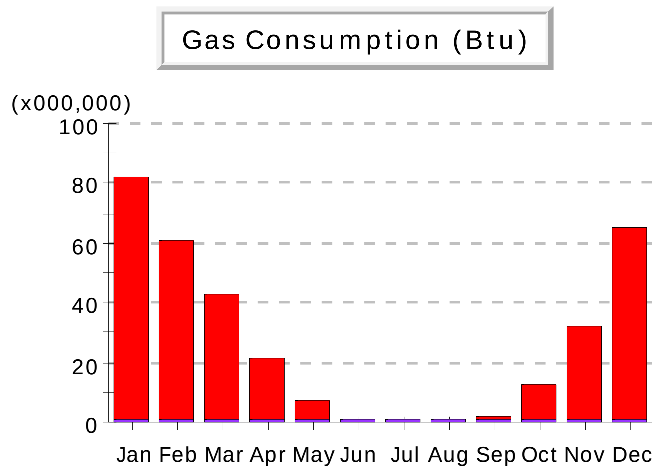
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	161.6	120.5	92.6	43.8	12.8	0.5	-	0.2	3.0	27.7	69.1	134.3	665.9
Pumps & Aux.	140.6	122.0	110.3	71.4	7.6	0.9	0.1	0.5	2.5	24.3	84.0	121.3	685.4
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	406.1	339.1	312.6	220.4	127.2	107.4	104.9	110.5	110.0	157.7	253.1	362.9	2,612.1

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	91.90	66.99	48.42	24.06	7.85	0.50	0.02	0.26	2.14	15.90	36.76	73.17	367.98
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.47	0.45	0.53	0.54	0.59	0.58	0.60	0.60	0.57	0.57	0.52	0.49	6.51
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	92.38	67.44	48.94	24.60	8.44	1.08	0.61	0.85	2.72	16.48	37.29	73.67	374.49





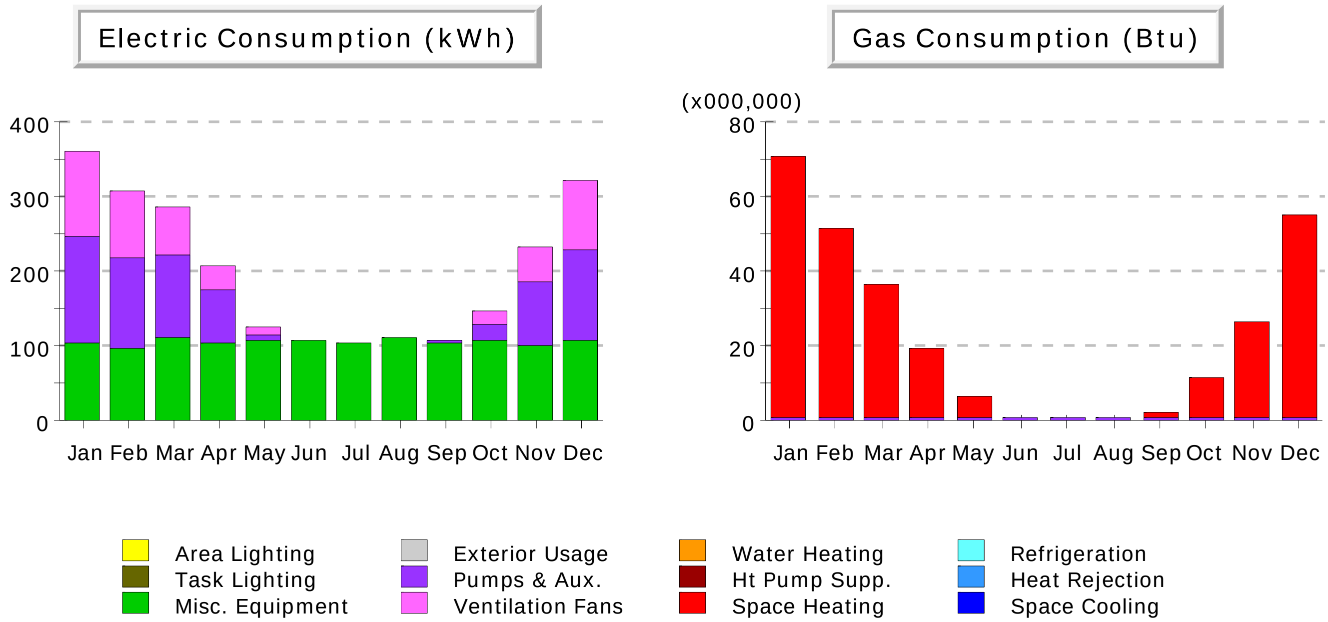
Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	134.5	100.8	77.6	37.7	10.5	0.3	-	0.1	1.8	20.5	55.7	110.8	550.4
Pumps & Aux.	144.2	126.0	112.0	71.4	7.6	0.9	0.1	0.5	2.6	24.4	85.4	124.4	699.6
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	382.8	323.4	299.5	214.3	124.9	107.2	104.9	110.4	108.9	150.7	241.2	342.5	2,510.7

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	82.11	60.45	42.52	21.18	6.73	0.42	0.02	0.19	1.46	12.35	31.22	64.28	322.93
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.48	0.45	0.53	0.54	0.59	0.58	0.60	0.60	0.57	0.58	0.53	0.50	6.55
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	82.59	60.91	43.05	21.72	7.32	1.00	0.61	0.79	2.03	12.93	31.75	64.78	329.48

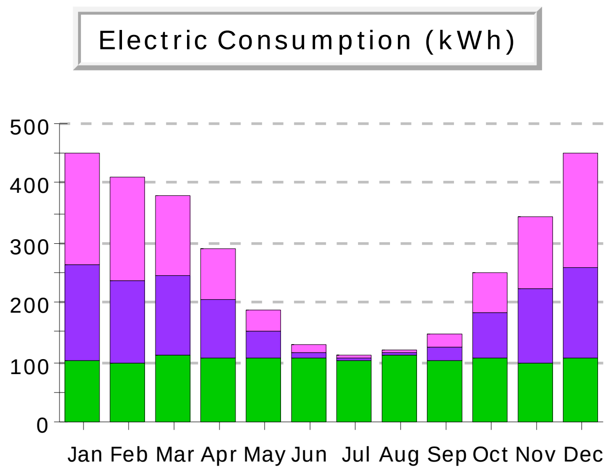


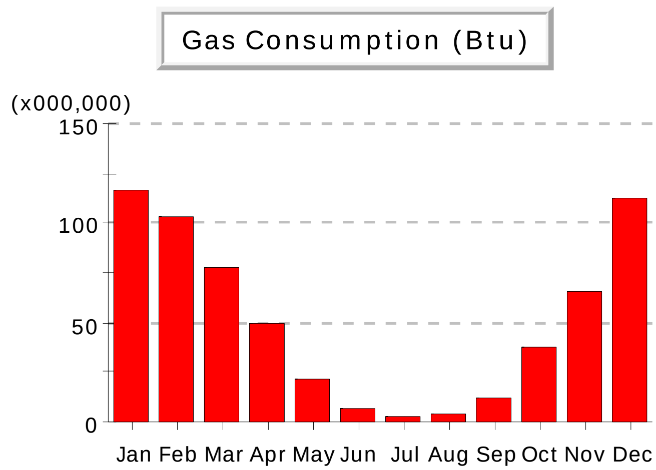
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	115.5	86.6	66.3	32.2	9.3	0.3	-	0.0	1.6	17.6	46.8	94.3	470.4
Pumps & Aux.	140.8	122.4	110.3	71.4	7.6	0.9	0.1	0.5	2.5	24.3	84.0	121.5	686.3
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	360.3	305.6	286.4	208.8	123.7	107.2	104.9	110.4	108.6	147.6	230.9	323.1	2,417.5

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	70.06	51.03	35.97	18.51	6.15	0.39	0.02	0.15	1.37	10.86	26.01	54.28	274.81
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.49	0.46	0.54	0.55	0.59	0.58	0.60	0.60	0.57	0.58	0.54	0.51	6.60
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	70.56	51.49	36.51	19.06	6.74	0.96	0.61	0.75	1.95	11.44	26.55	54.79	281.41





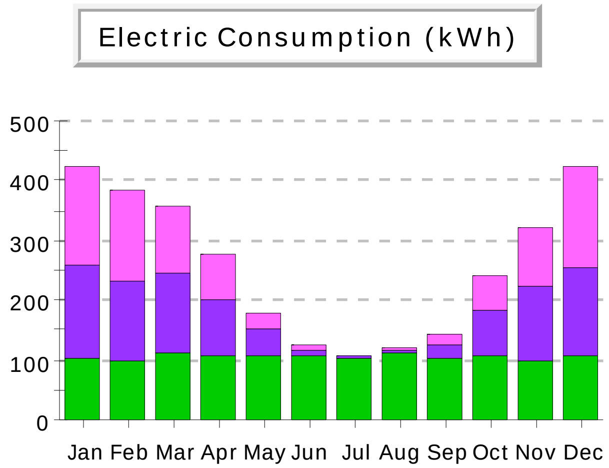
Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

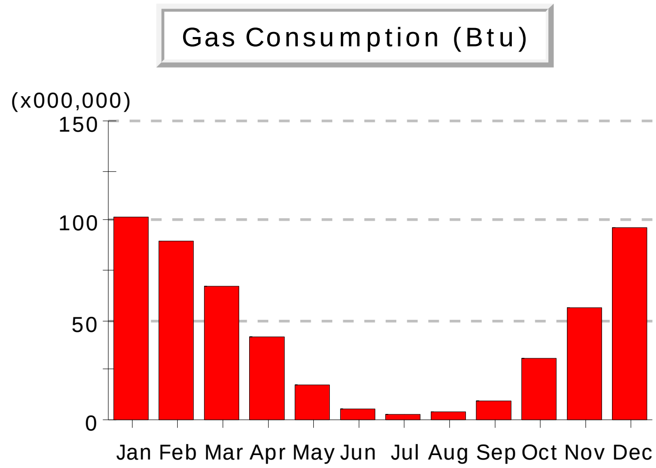
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	185.6	172.2	134.2	87.1	36.1	10.8	3.3	4.9	19.3	66.7	117.4	192.5	1,030.2
Pumps & Aux.	160.5	140.0	137.1	99.5	44.8	11.3	1.8	6.4	22.6	78.6	124.1	152.2	978.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	450.1	408.8	381.2	291.8	187.8	128.1	110.0	121.1	146.5	251.1	341.5	452.0	3,269.9

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	116.26	103.19	77.75	49.33	20.88	6.58	2.29	3.41	11.02	36.54	65.56	111.69	604.49
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.45	0.40	0.49	0.51	0.57	0.57	0.59	0.59	0.56	0.54	0.48	0.45	6.21
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	116.71	103.59	78.24	49.84	21.45	7.15	2.88	4.00	11.58	37.08	66.04	112.14	610.70



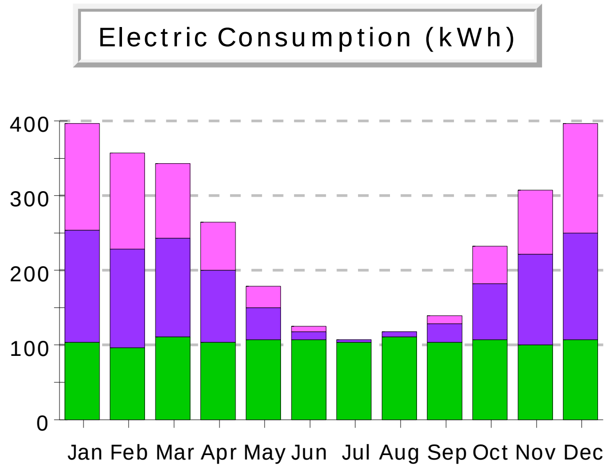


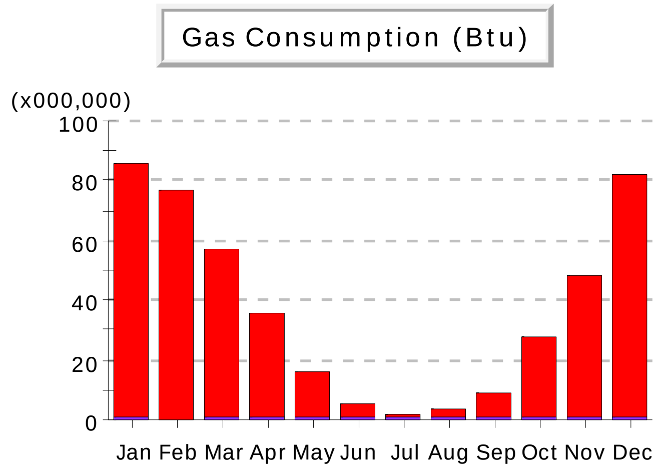
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	162.0	149.4	114.3	73.1	29.8	8.5	2.6	3.8	16.0	56.0	100.9	167.1	883.5
Pumps & Aux.	156.4	136.8	134.8	96.4	44.0	11.3	1.7	6.4	22.6	78.0	121.9	148.0	958.3
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	422.3	382.9	358.9	274.6	180.6	125.8	109.2	120.0	143.1	239.8	322.9	422.4	3,102.6

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	100.73	89.40	66.16	40.39	17.15	5.38	1.89	2.78	9.31	30.89	56.00	96.04	516.12
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.46	0.41	0.50	0.52	0.57	0.57	0.59	0.59	0.56	0.55	0.49	0.46	6.28
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	101.19	89.81	66.66	40.90	17.72	5.95	2.49	3.38	9.88	31.44	56.49	96.49	522.40



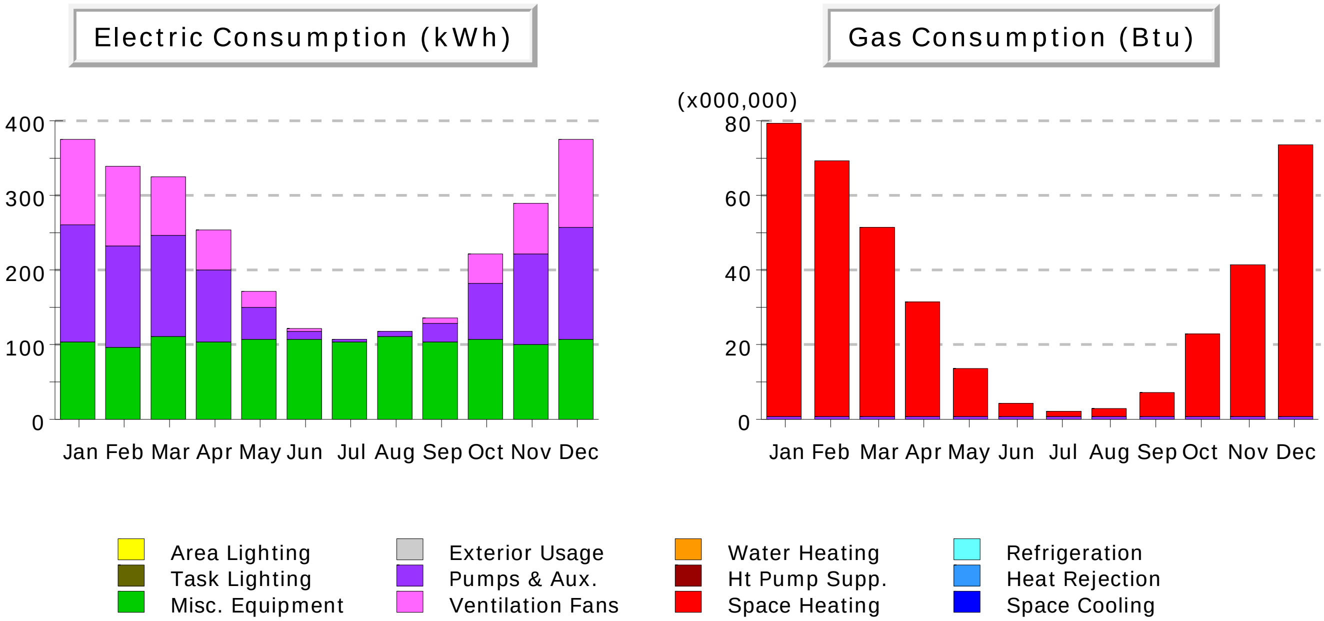


Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	142.2	130.5	100.0	64.8	26.4	7.3	2.1	3.4	13.3	48.9	86.8	145.1	771.0
Pumps & Aux.	148.8	131.7	131.5	94.9	43.7	11.1	1.7	6.3	22.5	77.6	119.9	143.1	932.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	395.1	358.9	341.3	264.9	176.9	124.4	108.7	119.5	140.4	232.3	306.8	395.4	2,964.6

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	85.02	76.02	56.71	35.39	15.35	4.78	1.64	2.56	8.05	27.20	47.77	81.66	442.15
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.47	0.43	0.51	0.52	0.57	0.57	0.59	0.59	0.56	0.55	0.50	0.47	6.34
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	85.49	76.45	57.22	35.91	15.92	5.35	2.23	3.15	8.61	27.76	48.27	82.13	448.50

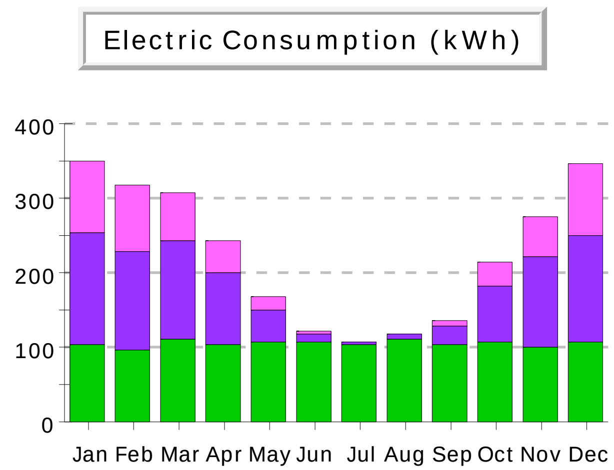


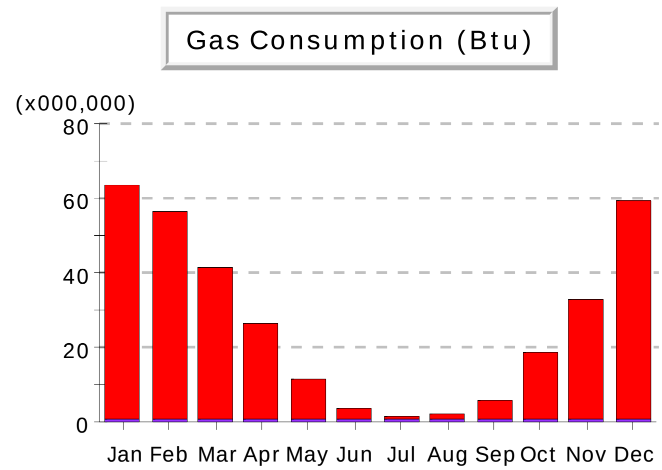
Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	114.9	106.8	81.3	52.4	20.8	5.8	1.4	2.3	9.9	37.3	68.5	117.6	619.1
Pumps & Aux.	157.6	136.8	135.1	96.5	44.0	11.3	1.7	6.4	22.6	78.1	122.2	148.6	960.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	376.5	340.3	326.2	254.1	171.7	123.1	107.9	118.5	137.0	221.2	290.7	373.5	2,840.8

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	79.00	69.07	50.63	30.67	12.86	3.98	1.22	1.99	6.27	21.96	40.75	73.05	391.45
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.49	0.44	0.52	0.53	0.58	0.57	0.59	0.59	0.57	0.56	0.51	0.48	6.42
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	79.49	69.51	51.15	31.19	13.43	4.55	1.81	2.58	6.84	22.52	41.26	73.53	397.87





Electric Consumption (kWh)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	95.3	87.8	67.0	44.3	17.4	4.5	0.8	1.8	7.0	30.1	54.7	95.7	506.4
Pumps & Aux.	150.2	132.9	131.5	94.9	43.7	11.1	1.7	6.3	22.5	77.8	120.1	143.7	936.4
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	104.0	96.6	109.8	105.2	106.8	106.0	104.8	109.8	104.5	105.8	100.1	107.3	1,260.8
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	349.5	317.3	308.2	244.4	167.9	121.6	107.3	117.9	134.1	213.7	274.9	346.7	2,703.6

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	63.25	56.20	40.93	25.70	11.04	3.35	0.87	1.71	4.83	18.21	32.51	58.70	317.29
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.50	0.45	0.53	0.53	0.58	0.57	0.59	0.59	0.57	0.57	0.52	0.50	6.50
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	63.75	56.65	41.46	26.23	11.62	3.92	1.46	2.31	5.39	18.77	33.03	59.20	323.80

APPENDIX D

CODE EXCERPTS AND CLARIFICATIONS

Code excerpts and clarifications:

RCNYS- 2010

§RN1101.1.2.2 Historic buildings. An alteration or renovation to an existing building or structure that (1) is listed in the New York State Register of Historic Places, either individually or as a contributing building to a historic district, or (2) is listed in the National Register of Historic Places, either individually or as a contributing building to a historic district, or (3) has been determined to be eligible for listing in either the New York State or National Register of Historic Places, either individually or as a contributing building to a historic district, by the New York State Commissioner of Parks, Recreation and Historic Preservation, or (4) has been determined to be eligible for listing in the National Register of Historic Places, either individually or as a contributing building to a historic district, by the U.S. Secretary of the Interior, need not comply with this code.

§RN1101.3.1 Additions, alterations, or renovations. Additions, alterations, or renovations to an existing building, building system or portion thereof shall conform to the provisions of this chapter as they relate to new construction without requiring the unaltered portion(s) of the existing building or building system to comply with this chapter.
Exception: The following need not comply provided the energy use of the building is not increased:
3. Alterations, renovations or repairs to roof/ceiling, wall or floor cavities which are insulated to full depth with insulation having a minimal nominal value of R-3.0/inch.

ECCCNYS-2010

N1102.5 Vapor retarders (Mandatory). Class I or II vapor retarders are required on the interior side of frame walls in Zones 5 and 6.
Exceptions:
1. Basement walls.
2. Below grade portions of any wall.
3. Construction where moisture or its freezing will not damage the materials.

Code Clarifications

http://www.dos.ny.gov/DCEA/energy_faq.html

Question No. 6

Can a residential building compliant with the ECCCNYS-2010 or the RCNYS-2010 use uncovered spray foam to seal the sill plate rim joist area at the perimeter of the basement ceiling?

Answer

Yes. Spray foam insulation with a density of 0.5 to 2.0 pounds per cubic foot sprayed to a thickness of 3 1/4 inches or less is permitted to be spray applied to a sill plate, header, and rim joists without a thermal barrier.

Question No. 10

In a residential building built to comply with the ECCCNYS-2010 or the RCNYS-2010, is it permitted to use uncovered spray foam to seal a sill plate rim joist area around a basement ceiling perimeter?

Answer

Yes, spray foam insulation of a density of 0.5 to 2.0 pounds per cubic foot sprayed to a thickness of 3 1/4 inches or less shall be permitted to be spray applied to a sill plate, header, and rim joists without the thermal barrier specified in the RCNYS-2010, Section RR314.4.

Question No. 11

Does the ECCCNYS-2010 allow in certain conditions, the use of latex or enamel paint (on the inside surface of the sheetrock or other interior materials) to meet mandatory vapor retarder requirements of the ECCCNYS-2010, Section E402.5 (instead of sheets of Polyethylene or Kraft paper behind the sheetrock)?

Answer

Class III vapor retarders are accepted in design, and climate conditions which are defined in the ECCCNYS-2010 and/or RCNYS. 2010. Research indicates that the use of flexible vapor retarders, rather than vapor barriers are more advantageous, allowing building insulation to "dry out" rather than using a very low perm rating barrier, which tend to trap moisture within the building cavity. This approach (as well as others contained here) has been vetted nationally by the ICC process. Polyethylene vapor retarders (which are actually vapor barriers) are seen as undesirable in today's advanced construction techniques.

The code states that latex or enamel paint as the interior finish shall be considered a class III vapor retarder (class III defined as 1.0 < perm < 10 perm) which is now permitted to be the required vapor retarder in certain conditions, such as the use of a vented building cladding.

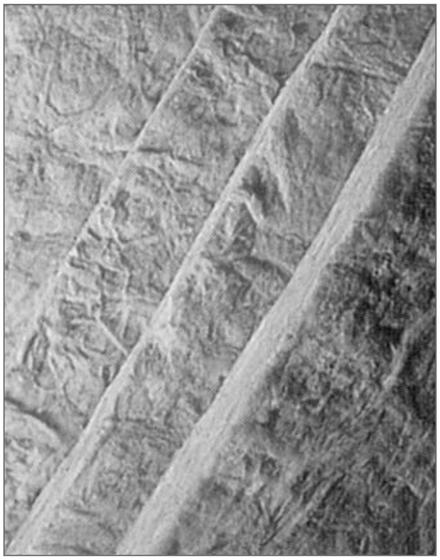
APPENDIX E

PRODUCTS

OWENS CORNING®
INNOVATIONS FOR LIVING®

EcoTouch® PINK® FIBERGLAS™ Insulation with PureFiber® Technology

Product Data Sheet



Surface Burning Characteristics/Building Code Construction Classification

Products	Flame Spread	Smoke Developed	ICC
Unfaced	<25	<50	All Types
Foil Faced	<75	<150	III, IV, V
Kraft Faced	N/R	N/R	III, IV, V

EcoTouch® Insulation complies with ICC (International Building Code), model code requirements for building construction types listed above.

Kraft and standard foil facing will burn. Do not leave exposed. Facing must be installed in substantial contact with an approved ceiling, floor or wall material. Keep open flame and other heat sources away from facing. Do not place insulation within 3" of light fixtures or similar electrical devices unless device is labeled for contact with insulation. Use only unfaced insulation between wood framing and masonry chimneys. Do not use insulation in spaces around metal chimneys, fireplaces, or flues. EcoTouch® Unfaced insulation is considered non-combustible by model building codes. Flame Spread 25 products are flame spread rated and can be left exposed where codes allow. See package for warnings, fire hazard and installation instructions, or call 1-800-GET-PINK.®

Due to the potential for skin irritation, EcoTouch® Unfaced Insulation should not be used for exposed applications where it will be subject to human contact.

EcoTouch® PureFiber® Technology

Description

Owens Corning™ EcoTouch® Insulation with PureFiber® Technology is flexible insulation and is made in R-values from 11 to 38. EcoTouch® Insulation is available plain, or faced with either a kraft or foil vapor retarder. The product is manufactured in thicknesses from 3½" to 12."

Uses

EcoTouch® Insulation can be used in a wide range of exterior wall and roof/ceiling applications. The product can be installed in wood or metal framing cavities, or can be installed between furring strips.

Features and Benefits

Excellent Thermal Control
With the range of R-values and thicknesses available, EcoTouch® Insulation can meet most thermal specifications with ease. The R30C and R38C provide excellent thermal performance in the limited space of cathedral ceilings.

Effective Acoustical Control
EcoTouch® Insulation enhances interior noise control by improving the Sound Transmission Class (STC) of walls and floor/ceiling assemblies.

Long Term Performance
EcoTouch® Insulation is dimensionally stable and will not slump within the wall cavity. Due to its inorganic fibers, EcoTouch® Insulation will not rot or mildew[1] and is noncorrosive to steel, copper, and aluminum.

Easy Installation
EcoTouch® Insulation is easy to handle and install. Sized for installation in either wood or metal stud construction, EcoTouch® Insulation can either be friction-fit or stapled into place. Trimming and fabrication can be done with an ordinary utility knife and is easily installed into odd-shaped cavities and small spaces. With less dust than other fiberglass insulation products, EcoTouch® Insulation has excellent stiffness and recovery characteristics.[2]

Designed with the Environment in Mind
EcoTouch® Insulation with PureFiber® Technology contains more than 99% natural[3] ingredients, and includes a minimum of 58% total recycled content—the highest certified recycled content available in the fiberglass industry.[4] EcoTouch® Insulation is GREENGUARD Children & Schools certified℠ and is verified to be formaldehyde free.[5]

SpaceSaver Packaging
EcoTouch® Insulation is compression packaged in exclusive SpaceSaver packaging from Owens Corning. SpaceSaver packaging reduces freight and speeds job site handling/installation.

OWENS CORNING®
INNOVATIONS FOR LIVING®

EcoTouch® PINK® FIBERGLAS™ Insulation
with PureFiber® Technology

Product Data Sheet

Design Considerations

Kraft and standard foil facings on this insulation will burn and must not be left exposed. Install facings in substantial contact with the finish material. Protect from open flame or other heat source.

Buildings utilizing curtainwall construction may be required to be equipped with a sprinkler system to provide adequate fire protection. Check local building codes for specific requirements.

Commercial roof/ceiling thermal applications require that the building envelope block the movement of air from the outdoor environment to the conditioned space. Neither the insulation nor its facing should be relied upon to provide an air barrier. Failure to provide an adequate air barrier could lead to loss of thermal control, discomfort of the building occupants and frozen pipes.

When insulation is added to the inside perimeter of a structure, the area outside the insulation becomes exposed to greater temperature extremes. Building structures should be inspected to ensure they can withstand the additional expansion and contraction forces. Check for piping which should be protected against freezing.

The need for and placement of a vapor retarder in commercial construction depends on many factors. The architect or specifier should evaluate the requirements of each project. If a vapor retarder is specified, maintaining the facing integrity may be important for

Product Data

	Kraft	Foil
Available Vapor Retarder Facings, Perms Maximum[1]	1	0.5
Water Absorption, Maximum by Volume	Less than 0.05%	
Dimensional Stability, Linear Shrinkage	Less than 0.1%	

1. Products are tested in accordance:
   R-Value ASTM C518
   Surface Burning Characteristics ASTM E84
   Perm Rating ASTM E96

R-values differ. Find out why in the seller's fact sheet on R-values. Higher R-values mean greater insulating power.

EcoTouch® Insulation Technical Data—Wall or Roof/Floor/Ceiling

	Width			Length		Thickness	R-Value[1]
Metal Frame Construction	16" (406mm)		24" (609mm)	48" (1,219mm)	96" (2,438mm)	3½" (89mm)	11
	16" (406mm)		24" (609mm)	48" (1,219mm)	96" (2,438mm)	3½" (89mm)	13
	16" (406mm)		24" (609mm)		96" (2,438mm)	3½" (89mm)	15
	16" (406mm)		24" (609mm)	48" (1,219mm)	96" (2,438mm)	6¼" (159mm)	19
	16" (406mm)		24" (609mm)		96" (2,438mm)	5½" (139mm)	21
Wood Frame Construction Walls	15" (381mm)		23" (584mm)	48" (1,219mm)	93" (2,362mm)	3½" (89mm)	11
	15" (381mm)		23" (584mm)	48" (1,219mm)	93" (2,362mm)	3½" (89mm)	13
	15" (381mm)		23" (584mm)		93" (2,362mm)	3½" (89mm)	15
	15" (381mm)	19¼"	23" (584mm)	48" (1,219mm)	93" (2,362mm)	6¼" (159mm)	19
	15" (381mm)		23" (584mm)		93" (2,362mm)	5½" (139mm)	21
Roof/Floor/ Ceiling	15" (381mm)	19¼"	23" (584mm)	48" (1,219mm)	93" (2,362mm)	6¼" (159mm)	19
	15" (381mm)		23" (584mm)	48" (1,219mm)		6¾" (171mm)	22
	15" (381mm)		23" (584mm)	48" (1,219mm)		8" (203mm)	25
	15½" (394mm)		23¾" (603mm)	48" (1,219mm)		8¼" (209mm)	30
	16" (406mm)	19¼"	24" (609mm)	48" (1,219mm)		9½" (241mm)	30
	15½" (394mm)		23¾" (603mm)	48" (1,219mm)		10¼" (260mm)	38
	16" (406mm)		24" (609mm)	48" (1,219mm)		12" (305mm)	38

EcoTouch® Unfaced Insulation complies with the property requirements of ASTM C665, Type I and ASTM E136. EcoTouch® Kraft-faced Insulation complies with ASTM C665, Type II, Class C. EcoTouch® Foil-faced Insulation complies with ASTM C665, Type III, Class B and C.

1. Higher R-values mean greater insulating power. Find out why in the seller's fact sheet on R-values.

Read This Before You Buy
What you should know about R-Values

The chart shows the R-value of this insulation. R means resistance to heat flow. The higher the R-value, the greater the insulating power. Compare insulation R-values before you buy.

There are other factors to consider. The amount of insulation you need depends mainly on the climate, the type and size of your home, and your fuel use patterns and family size. If you buy too much insulation, it will cost you more than you'll save on fuel.

To get the marked R-value, it is essential that this insulation be installed properly.

EcoTouch® PINK® FIBERGLAS™ Insulation
with PureFiber® Technology

Product Data Sheet

Figure 1

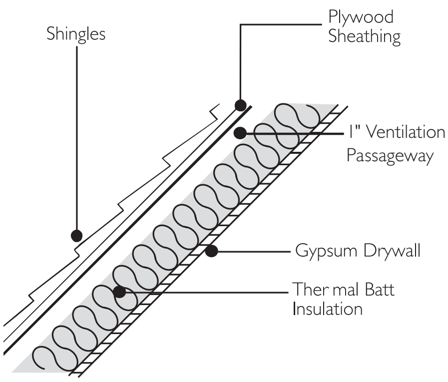
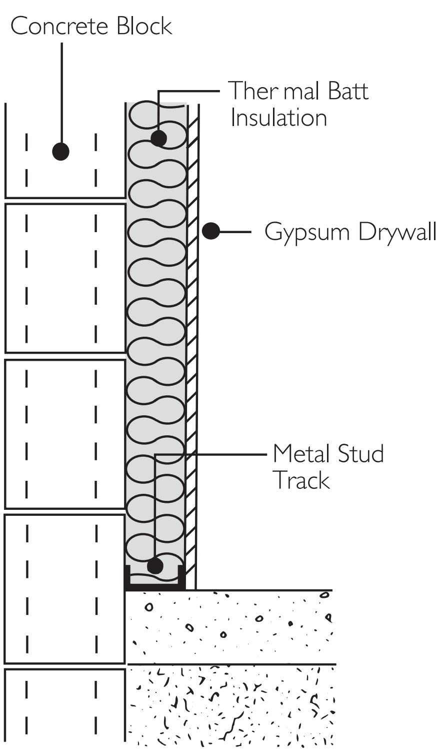


Figure 2



effective moisture/humidity control. Repair any punctures or tears in the facing by taping. Follow the tape manufacturer's application recommendations.

Insulation installed too close to light fixtures may affect the luminaire's performance. Do not install insulation on top of or within 3" of recessed light fixtures unless the fixtures are approved for such use. This is a requirement of the National Electrical Code.

Due to the potential for skin irritation, EcoTouch® Unfaced Insulation should not be used for exposed applications where it will be subject to human contact.

Installation

Between Wood Studs/Rafters
EcoTouch® Insulation fits between studs. If required, the flanges can be stapled to either the face or the side of the stud every 8–12" to prevent gaping or "fishmouthing" of the vapor retarder.

EcoTouch® Unfaced insulation can be friction-fit between studs after the cover material has been installed on one side of the cavity. Use wire or metal straps to hold insulation in place in applications without a cover material, or where the insulation does not fill the depth of the cavity.

Cathedral ceiling products (R30C and R38C) are intended to be friction-fit between rafters. Cathedral ceiling insulation should be installed to provide a minimum 1" ventilation passageway between the roof deck and insulation. (See Figure 1) It is recommended to use a vent baffle to assure proper clearance.

Between Metal Studs
EcoTouch® Insulation can be friction-fit in place until the interior finish is applied. Insulation should fill the cavity and the wall should eventually be closed on both sides. (See Figure 2)

In areas where it will be applied in heights over 8', use wire or metal straps to hold the product in place until the interior finish is applied. When faced insulation is used, the attachment flanges may be taped to the face of the metal stud prior to applying the interior finish. Wire or metal straps should also be used to hold the product in place in applications without a cover material or where the stud depth is larger than the insulation thickness.

Furring Strips
EcoTouch® Insulation can be applied between furring strips, hat channels, or Z-shaped furring in areas where a finish surface will be installed. Contact the furring strip manufacturer for appropriate fastening system.

Caution: FIBERGLAS™ insulation may cause temporary irritation to the skin, eyes and respiratory tract. Avoid contact with eyes and skin, wear loose-fitting, long-sleeved clothing, gloves and eye protection when handling and applying the material. Wash with soap and warm water after handling. Wash work clothes separately and wipe out washer.

EcoTouch® PINK® FIBERGLAS™ Insulation
with PureFiber® Technology

Product Data Sheet

Applicable Standards

EcoTouch® Unfaced Insulation is manufactured in compliance with ASTM Standard Specification C665 and is classified noncombustible per ASTM E136. EcoTouch® Kraft-faced Insulation is manufactured in compliance with ASTM C665, Type II, Class C. EcoTouch® Foil-faced Insulation is manufactured in compliance with ASTM C665, Type III, Class B and C. Federal Specification HH-I-521F has been canceled and is replaced by ASTM C665.

The thermal resistance values for EcoTouch® Insulation were tested in accordance with ASTM C518; R-value for insulation only.

The surface burning characteristics of EcoTouch® Insulation were derived from products tested in accordance with ASTM E84. This standard is used solely to measure and describe properties of products in response to heat and flame under controlled laboratory conditions, and should not be used to describe or approve the fire hazard of materials under actual fire conditions. However, the results of these tests may be used as elements of a fire risk assessment that takes into account all of the factors pertinent to an assessment of the fire hazard of a particular end use. Values are reported to the nearest five rating.

The vapor retarder permeance of the kraft and foil facings on EcoTouch® Insulation were developed from tests conducted in accordance with ASTM E96, desiccant method.

Notes

1. As manufactured, FIBERGLAS™ insulation is resistant to mold growth. However, mold growth can occur on building materials, including insulation, when it becomes contaminated with organic material and when water is present. To avoid mold growth on FIBERGLAS™ insulation, remove any water that has accumulated and correct or repair the source of the water as soon as possible. Insulation that has become wet should be inspected for evidence of residual moisture and contamination, and any insulation that is contaminated should be promptly removed and replaced.
2. According to 2010 clinical trial conducted in Toronto, Canada by Ducker Worldwide on behalf of Owens Corning Insulation Systems, LLC.
3. Unfaced insulation is made with a minimum of 99 percent by weight natural materials consisting of minerals and plant-based compounds.
4. Certified by Scientific Certifications Systems to have a minimum of 58% recycled glass content, with at least 36% post-consumer recycled and the balance of pre-consumer recycled glass content.
5. Owens Corning™ EcoTouch® Unfaced FIBERGLAS™ insulation is verified to be formaldehyde free by the GREENGUARD Environmental Institute.

GREENGUARD Indoor Air Quality and GREENGUARD Children & Schools℠ applies to EcoTouch® Unfaced Batts, EcoTouch® Faced Batts and Unbonded Loosefill Insulation. GREENGUARD Formaldehyde Free applies to EcoTouch® Unfaced Batts and Unbonded Loosefill Insulation.

GREENGUARD Children & Schools℠ applies to Flame Spread 25 FSK Faced; Flame Spread 25 Extended Flanges PSK Faced; Sound Attenuation Batt Insulation; Sonobatts® Insulation Unfaced; Sonobatts® Insulation Kraft-Faced and Metal Building Insulation.

SCS CERTIFIED
Minimum 58% Recycled Content
36% Post-consumer
22% Pre-consumer
SCIENTIFIC CERTIFICATION SYSTEMS
SCS-MC-02676

SCS 50% recycled content applies to EcoTouch® Unfaced Batts and Rolls, EcoTouch® Faced Batts and Rolls, Loosefill Insulation, Metal Building Insulation products and Flexible Air Handling products.

ENERGY STAR PARTNER

Environment
EcoLogo℠ CCD-016

Applies to EcoTouch® Unfaced Insulation

Disclaimer of Liability

Technical information contained herein is furnished without charge or obligation and is given and accepted at recipient's sole risk. Because conditions of use may vary and are beyond our control, Owens Corning makes no representation about, and is not responsible or liable for the accuracy or reliability of data associated with particular uses of any product described herein. Nothing contained in this bulletin shall be considered a recommendation.

The GREENGUARD INDOOR AIR QUALITY CERTIFIED mark is a registered certification mark used under license through the GREENGUARD Environmental Institute.

OWENS CORNING INSULATING SYSTEMS, LLC
ONE OWENS CORNING PARKWAY
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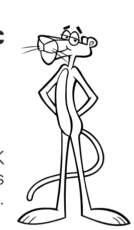
www.owenscorning.com



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ROXUL®
The Better Insulation™

Technical Product Information

ROXUL ComfortBatt
Thermal Home Insulation

BATT INSULATION 07210*
BLANKET INSULATION 07 21 16**

General Product Information:

ROXUL® products are stone wool insulations made from basalt rock and slag. This combination results in a non-combustible product with a melting point of approximately 2150°F (1177°C), which gives it excellent fire resistance properties. ROXUL stone wool is a water repellent yet vapour permeable material.

Description & Common Applications:

ROXUL ComfortBatt ™ R10, 15, 23, 24 & 30 are stone wool insulation products for use in both new construction and renovations. This semi-rigid batt has a unique flexible edge designed to compress as the batt is inserted into walls, attics, ceiling and floor frames. The flexible edge springs back, expanding the batt against the frame studs to give a complete fill. ComfortBatt compensates for normal variations in stud centres caused by distortion or warping. The special flexible characteristic at the insulation edge ensures the expected R-value is achieved.

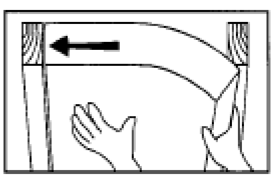
Compliance and Performance:

ASTM C665	Mineral Fiber Blanket Insulation	Type 1, Complies
ASTM E136	Determination of Non-Combustibility	Non-Combustible
ASTM E84	Surface Burning Characteristics	Flame Spread = 0 Smoke Developed = < 5

Installation:

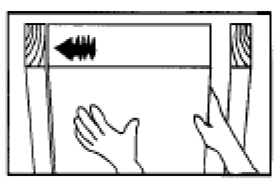
The flexible edge is identified by the marking.

INSERT



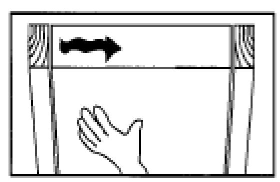
Place ComfortBatt into opening, flexible edge against stud

FIT



Compress ComfortBatt edge and fit batt

RELEASE



Let ComfortBatt expand to give a full fit

The friction fit created by the ComfortBatt expansion principle means the product will perform equally well in horizontal, sloped dormer, vertical or overhead situations. The product is notable for its “stay put” ability when installed. ComfortBatt is easier and faster to install than traditional insulation products and achieves full R-value.

Tests carried out in 1993 by the National Research Council Of Canada (NRC) confirm that accurate fitting of insulation is essential to achieve R-values and to maintain thermal design requirements in practice. ROXUL ComfortBatt has been designed with a flexible edge to ensure the best fit possible.

*MASTER FORMAT 1995 EDITION **MASTER FORMAT 2004 EDITION

ROXUL ComfortBatt
Thermal Home Insulation

Dimensions:

Wood Stud

R15

15.25” x 47” x 3.5”
(387 mm x 1194 mm x 89 mm)

23” x 47” x 3.5”
(584 mm x 1194 mm x 89 mm)

R23

15.25” x 47” x 5.5”
(387 mm x 1194 mm x 140 mm)

23” x 47” x 5.5”
(584 mm x 1194 mm x 140 mm)

R30

15.25” x 47” x 7.25”
(387 mm x 1194 mm x 184 mm)

23” x 47” x 7.25”
(584 mm x 1194 mm x 184 mm)

This product has been specifically designed to meet your needs for wood stud construction.

Density:

>2lbs/ft^3
184mm =
150mm =
89mm =

Steel Stud

R10

16.25” x 48” x 2.5”
(413 mm x 1219 mm x 64mm)

24.25” x 48” x 2.5”
(616 mm x 1219 mm x 64mm)

R15

16.25” x 48” x 3.5”
(413 mm x 1219 mm x 89mm)

24.25” x 48” x 3.5”
(616 mm x 1219 mm x 89mm)

R24

16.25” x 48” x 6”
(413 mm x 1219 mm x 152mm)

24.25” x 48” x 6”
(616 mm x 1219 mm x 152mm)

Key Application Qualifiers:

- Easily cut
- Better fit because the flexible edge compensates for normal frame variability
- Easier and faster to install
- Low moisture sorption
- Water resistant
- Non-combustible
- Fire resistant
- Excellent sound absorbency
- Chemically inert
- Does not rot or sustain vermin
- Does not promote growth of fungi or mildew
- CFC- and HCFC- free product and process
- Made from natural & recycled materials

Children & Schools GREENGUARD℠ Indoor Air Quality Certified

Please consult ROXUL for all your insulation needs. We have an extensive range of products for all applications from pipe insulation to commercial products to residential batts. ROXUL invites all inquiries and will act promptly to service all of your requirements.

Note:
As ROXUL Inc. has no control over installation design and workmanship, accessory materials or application conditions, ROXUL Inc. does not warranty the performance or results of any installation containing ROXUL Inc’s. products. ROXUL Inc’s. overall liability and the remedies available are limited by the general terms and conditions of sale. This warranty is in lieu of all other warranties and conditions expressed or implied, including the warranties of merchantability and fitness for a particular purpose.

ROXUL INC. **Milton, Ontario Tel: 905-878-8474** **Fax: 905-878-8077**
www.roxul.com **Tel: 1-800-265-6878** **Fax: 1-800-991-0110**
Revised: September 13, 2011
Supersedes: July 22, 2011

Material Safety Data Sheet

Effective: May 2010

SECTION 1 – PRODUCT AND COMPANY INFORMATION

Product Identifier: Cellulose Insulation

Product Name: Nu-Wool® Premium Cellulose Insulation, aka WALLSEAL®

Manufacturer: Nu-Wool Co., Inc.
2472 Port Sheldon St., Jenison, Mi. 49428
Emergency Phone Number: 800.748.0128

Nu-Wool® and WALLSEAL® are Registered Trademarks of Nu-Wool Co., Inc.

SECSTION 2 – COMPOSISTION AND INGREDIENT INFRORMATION

COMPONENT/CAS #	% BY WEIGHT	EXPOSURE LIMITS	CANCER DESIGNATION
Newsprint and Other Cellulose Fibers (Cellulose Fiber) #65996-61-4	Not Less Than 85%	OSHA PEL-TWA=15MG/M^3 total dust (PNOR) **PNOR – Particulates Not Otherwise Regulated of Nuisance Dust** OSHA PEL-TWA=5mg/m^3 respirable dust (PNOR) Cal OSHA PEL=10mg/m^3 total dust (PNOR) ACGIH TLV-TWA=10mg/m^3 inhalable (PNOS) **PNOS – Particulates Not Otherwise Specified** ACGIH TLV-TWA=3mg/m^3 respirable (PNOS)	None
Boric Acid H_3BO_3 #10043-35-3	Not more than 15%	OSHA PEL-TWA=15mg/m^3 total dust (PNOR) OSHA PEL-TWA=5mg/m^3 respirable fraction (PNOR) Cal OSHA PEL=5mg/m^3 ACGIH TLV-TWA=2mg/m^3 ACGIH TLV-STEL=6mg/m^3 (inhalable fraction – Borate Compounds, inorganic)	None
Paraffinic Oil # 64742-65-0	Not more than 1%	None (Oil mist not applicable to final product	None

HMIS Rating		**National Fire Protection Association (NFPA)**	
Health	1	Red (Flammability)	1
Flammability	1	Yellow (Reactivity)	0
Reactivity	0	Blue (Acute Health)	1*
Personal Protection	E	* Chronic Effects	

SECTION 3 – HAZARD IDENTIFICATION

Emergency Overview

Avoid extreme heat and open flame. May emit carbon monoxide gas and boric acid and other hazardous particulates during thermal decomposition. This product is a finely divided, light gray material with no perceptible odor. It presents no unusual hazard if involved in a fire.

Physical Characteristics

Boiling Point	Not Applicable
Vapor Pressure (mm Hg)	Not Applicable
Vapor Density	Not Applicable
Solubility in Water	Insoluble: Dispersible
Specific Gravity (H_2O=1)	Not Applicable
Reactivity in Water	None
Melting Point	Not Applicable

Potential Health Effects

Inhalation	Slightly irritating to upper respiratory system. Persons with respiratory problems should avoid breathing dust.
Eyes	Slight irritant. In case of eye contact, flush with water.
Ingestion	Small amounts are not likely to cause harm. Ingestion of large amounts may cause rash, diarrhea, and nausea.
Skin	Does not normally irritate skin. In case of broken skin, wear gloves and wash dust from skin with soap and plenty of water. Large amounts absorbed into bloodstream may cause rash, skin peeling, diarrhea, nausea, and dizziness.
Acute	Not anticipated as discussed above.
Chronic	None
Cancer	Neither the end product nor any of its components.

SECTION 4 – FIRST AID

Eyes	For dust exposure, immediately flush eyes with plenty of water for at least 15 minutes. Seek medical attention if irritation persists.
Skin	If skin is exposed, wash with soap and large amounts of water. If irritation persists, seek medical attention.
Inhalation	If irritation or difficulty in breathing occurs, remove to fresh air. Seek medical attention if conditions persist.
Ingestion	Symptoms may include diarrhea, nausea and vomiting. Seek medical attention if material was ingested and symptoms persist.
Note to Physicians	Exposure to dust may aggravate symptoms of persons with pre-existing respiratory tract conditions and may cause skin and gastrointestinal symptoms.

SECTION 5 – FIRE FIGHTING MEASURES

Flash Point	Not Applicable
Combustible	Material may decompose on contact with extreme temperatures and open flames.
Flammable Limits	LEL: Not applicable UEL: Not applicable
Auto ignition Temperature	Not determined
Explosion Hazard	None expected for product based on particle size. Note: Airborne concentrations for combustible dust, when combined with an ignition source, can create an explosion hazard if the dust concentrations exceed 15 mg/m^3.
Extinguishing Media	Water, dry chemical and other agents rated for a wood fire (Type A fire). Use Type A rated extinguisher.
Fire Fighting Instructions	Evacuate the area and notify the fire department. If possible, isolate the fire by moving other combustible materials. If the fire is small. Use a hoe-line or extinguisher rated for a Type A fire. If possible, dike and collect water used to fight fires. Fire fighters should wear normal protective equipment (full Bunker gear) and positive-pressure, self-contained breathing apparatus.

SECTION 6 – ACCIDENTAL RELEASE MEASURES

Boric Acid may damage trees or vegetation exposed to large quantities. Land: shovel, sweep or vacuum product, place in disposal container. Avoid bodies of water. Water; large quantities may cause localized contamination of surrounding waters depending on the quantity spilled. At high concentrations, may damage localized vegetation, fish and other aquatic life. This product is a non-hazardous waste when spilled or disposed of as defined in the Resource Conservation and Recovery Act (RCRA) regulations (40CFR 261). Refer to regulatory information in Section 15 for additional information regarding EPA and California regulations.

SECTION 7 – HANDLING AND STORAGE

General	No special handling is required. Storage of sealed bags in a dry, indoor location is recommended. To maintain product integrity, handle on a first-in-first-out basis. Use good housekeeping and controls so that dust levels are below the exposure limits listed in Section 2.
Storage Temperature	Ambient
Storage Pressure	Atmospheric
Special Sensitivity	None

SECTION 8 – EXPOSURE CONTROLS AND PERSONAL PROTECTION

General Exposure Controls	No specific controls are needed.
Respiratory Protection	If controls do not maintain nuisance levels below regulatory limits, use a NIOSH approved mask.
Eye Protection	Wear ANSI approved eye protection in excessively dusty environments.
Hand Protection	If skin is broken or sensitive, use gloves.
Other Protective Clothing	None
Ventilation	Normal and adequate ventilation.
Work/Hygienic Practices	Standard hygienic practices.
Occupational Exposure Limits	***This product is listed/regulate by OSHA, Cal/OSHA as "Particulates Not Otherwise Regulated" or "Nuisance Dust." This product is listed by ACGIH as "Particulates Not Otherwise Specified."***

SECTION 9 – PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Gray, odorless fiber	**Boiling/Melting Point**	Not applicable
Specific Gravity	0.7 compressed	**Flash Point**	Not applicable
Vapor Pressure	Negligible @ 20° C	**Ph**	7.0 (2% solution @ 25° C)
Solubility in Water	Product is not soluble	**Viscosity**	Not applicable

SECTION 10 – STABLITY AND REACTIVITY

Stability: Stable **Hazardous Decomposition Products:** None
Hazardous Polymerization: Will not occur

SECTION 11 – TOXICOLOGICAL INFORMATION

BORIC ACID

Eye	Draize test in rabbits produced mild eye irritation effects. No adverse eye effects anticipated.
Skin	Low acute dermal toxicity, LD50 in rabbits is greater than 2000 mg/kg of body weight. Boric acid is poorly absorbed through skin.
Ingestion	TDLo, oral, human, 1`500 mg/kg, diarrhea, nausea, vomiting, LD50, oral, rat, 2840 mg/kg.
Inhalation	Low acute inhalation toxicity; LC50 in rates is greater than 2.0 mg/L (or $g/m^{3)}$.
Reproduction	Animal feeding studies in rat, mouse, and dog, at high doses, have demonstrated effects on fertility.
Mutagenicity	No mutagenic activity was observed for boric acid in a battery of short-term mutagenicity assays.

Boric Acid is classified as hazardous under the OSHA Hazard Communication Standard based on animal chronic toxicity studies. Refer to Sections 3 and 11 for details on hazards.

SECTION 12- ECOLOGICAL INFORMATION

BORIC ACID

Ecotoxicity	Daphnia magna, 48-hr LC50=133 mg B/L. Trout, 32-day LC50=100 B/L
Chemical Fate Information	Boron is naturally occurring and ubiquitous in the environment. Boric acid decomposes in the environment to natural borate. Boric acid is insoluble in water and is leachable through normal soil.

SECTION 13 – DISPOSAL CONSIDERATIONS

Dispose as a non-hazardous waste.

SECTION 14 – TRANSPORT INFORMATION

May be shipped normally as a non-hazardous material.

SECTION 15 – REGULATORY INFORMATION

Superfund: CERCLA/SARA. This product is not listed under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) or its 1986 amendments, the Superfund Amendments and Reauthorization Act (SARA), including substances listed under Section 313 of SARA, Toxic Chemicals, 42 USC 11023, 40 CFR 372.65; Section 302 of SARA Extremely Hazardous Substances, 42 USC 11002, 40 CFR 355; or the CERCLA Hazardous Substances list, 42 USC 9604, 40 CFR 302.

RCRA: This product is not listed as a hazardous waste under any sections of the Resource Conservation and Recovery Act or regulations (40 CFR 261 et seq.).

Safe Drinking Water Act: This product is not regulated under SDWA, 42 USC 300g-1, 40 CFR 141 et seq. Consult state and local regulations for possible water quality advisories regarding boron. California Proposition 65: This product is not listed on any Proposition 65 lists of carcinogens or reproductive toxicants.

OSHA Carcinogen: Not listed.

Clean Water Act (Federal Water Pollution Control Act): 33 USC 1251 et seq.: This product is not itself a discharge covered by any water quality criteria of Section 304 of CWA, 33 USC 1314. This product is not on the Section 307 List of Priority Pollutants, 33 USC 1317, 40 CFR 116. This product is not on the Section 311 List of Hazardous Substances, 33 USC 1321, 40 CFR 116.

TSCA No.: This product does not appear on the EPA TSCA inventory list. Boric acid appears on the EPA TSCA inventory list under CAS Number 10043-35-3.

OSHA/Cal/OSHA: This MSDS document meets the requirements of both OSHA and Cal/OSHA hazard communication standards. Refer to Section 8 for regulatory limits.

IARC: The International Agency for Research on Cancer (of the World Health Organization) does not list or categorize this product as a carcinogen.

NTP Annual Report on Carcinogens: Not listed.

SECTION 16 – OTHER INFORMATION

Information presented herein has been compiled from sources considered dependable and is accurate and reliable to the best of our knowledge and belief, but is not guaranteed to be so. Nothing herein is to construed as recommending any practice or any product in violation of any patent or in violation of any law or regulation. The user is responsible to determine the suitability of any material for a specific purpose and adopt necessary safety precautions. We make no warranty as to results to be obtained in using any material and, since conditions or use are not under our control, we must necessarily disclaim all liability with respect to use of any material supplied by us.

ABBREVIATIONS:

CAS	Chemical Abstract Services	**OSHA**	Occupational Safety and Health Administration
Mg/m³	Milligrams per cubic meter	**PNOR**	Particulates Not Otherwise Regulated
LCLo	Lethal concentration low	**PNOS**	Particulates Not Otherwise Specified
LDLo	Lethal dose low	**PEL**	OSHA Permissable Exposure Limit
LC50	Lethal concentration 50%	**Ppm**	Parts per million
LD50	Lethal dose 50%	**RfD**	Reference dose
LOAEL	Lowest Observed Adverse Effect Level	**TDLo**	Toxic dose low
Mg.I/H	Milligrams per liter per hour	**TDLo**	Toxic dose low
Mg/kg	Milligrams per kilogram	**TLV**	ACGIH threshold Limit Value
Mg/m³	Milligrams per cubic meter	**TWA**	8-hour Time Weighted Average Exposure

BIBLIOGRAPHY:

1. The guide to Occupational Exposure Values, American Conference of Government Industrial Hygienists, 1997.
2. Registry of Toxic Effects of Chemical Substances, National Institute of Occupational Safety and Health, Q-1, 1998.
3. Dangerous Properties of Industrial Materials, Sax's, 1997 CD-Folio.
4. Hazardous Substances Data Bank, Canadian Centre for Occupational Health and Safety, Q-1., 1998.
5. Integrated Risk Information System, EPA, on-line.
6. Toxicological Profiles, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service, 1997.
7. TLV's and other Occupational Exposure Values, American Conference of Governmental Industrial Hygienists, 1996.
8. 29 CFR 1910.1000 TABLE Z-1 and Z-3.
9. California OSHA Title 8, Section 5155, Table AC-1.

Specification Sheet

CertainTeed SAINT-GOBAIN

InsulSafe® SP Fiber Glass Blowing Insulation

Product Name	InsulSafe® SP Fiber Glass Blowing Insulation
Manufacturer	CertainTeed Corporation
Address	P.O. Box 860 Valley Forge, PA 19482-0105
Phone	610-341-7000 • 800-233-8990
Fax	610-341-7571 • 610-947-0057
Website	www.certainteed.com/insulation

PRODUCT DESCRIPTION

Basic Use: InsulSafe SP Fiber Glass Blowing Insulation is used in residential and commercial construction as a thermal and acoustical insulation. It is designed for pneumatic installation in open attic areas and for retrofitting enclosed sidewall and floor/ceiling construction assemblies.

Benefits: This product is noncombustible, noncorrosive and odor free. In addition, InsulSafe SP won't settle, contains no chemicals to cause mildew and fungus growth, contains no formaldehyde, provides no sustenance for vermin, contains no asbestos, won't rot or decay and won't absorb moisture.

Composition and Materials: InsulSafe SP is unbonded, white, virgin fiber glass.

Limitations: InsulSafe SP is designed for use at ambient temperatures in interior, weather-protected locations. Pneumatic installation equipment must have an effective shredding section, a uniform controlled feed system and adequate material/air flow capabilities. This product must be kept dry during shipping, storage and installation.

INSTALLATION

Installation procedures and techniques must be as recommended by CertainTeed Corporation, using blowing machines approved for fiber glass insulation. Please refer to InsulSafe SP Installation Instruction Manual 30-24-302.

AVAILABILITY AND COST

For availability and cost, contact your local contractor or distributor, or call CertainTeed Sales Support Group at 800-233-8990.

WARRANTY

Refer to CertainTeed's Lifetime Limited Warranty for Fiber Glass Building Insulation (30-21-1321).

MAINTENANCE

No maintenance required.

TECHNICAL SERVICES

Technical assistance can be obtained either from the local CertainTeed sales representative, or by calling CertainTeed Sales Support Group at 800-233-8990.

TECHNICAL DATA

Applicable Standards

- Model Building Codes:
  - ICC
  - New York City MEA 218-85M
  - New York State NYS UFPBC Article 15
  - California and Minnesota quality standards
- Material Standards:
  - ASTM C764, Mineral Fiber Loose-Fill Thermal Insulation Type 1 – Pneumatic Application Properties:
    - Thermal resistance — ASTM C518 and C687
    - Critical radiant flux — ASTM E970
    - Combustion characteristics — ASTM E136
    - Water vapor sorption — ASTM C1104
    - Odor emission — ASTM C1304
    - Corrosiveness — ASTM C764
    - Fungi resistance — ASTM C1338
  - GREENGUARD® Children & Schools Certified

Fire Resistance

- Fire Hazard Classification:
  - UL 723, ASTM E84
    Max. Flame Spread Index: 5
    Max. Smoke Developed Index: 5
- Noncombustibility:
  - ASTM E136 / Meets requirements

Thermal / Acoustical Properties

- Thermal Performance:
  - ASTM C518 and C687
    Stated R-Value achieved at minimum thickness and minimum weights as stated within coverage chart(s).
- Acoustical Performance:
  - ASTM E90 and E413
    The same STC ratings obtained with fiber glass blanket insulation can be estimated to be achieved by InsulSafe SP. Refer to CertainTeed's Guide for Residential Sound Control brochure (30-28-008).

Quality Assurance

CertainTeed's commitment to quality and environmental management has ensured the registration of the Athens, Chowchilla and Kansas City plants to ISO 9001:2000 and ISO 14001:2004 standards.

OPEN ATTIC APPLICATION

The following thermal performance values are achieved at the thicknesses, weights and coverages specified when insulation is installed with pneumatic equipment in a horizontal open blow application.

COVERAGE CHART

R-VALUE	BAG REQUIREMENTS	MAXIMUM COVERAGE	MINIMUM WEIGHT	MINIMUM INSTALLED THICKNESS	MINIMUM SETTLED THICKNESS
To obtain a thermal resistance (R) of:	Number of bags per 1000 sq. ft. of net area:	Contents of bag shall not cover more than: (sq. ft.)	Weight per sq. ft. of installed insulation shall not be less than: (lbs./sq. ft.)	Should not be less than: (in.)	Should not be less than: (in.)
R-11	5.3	190.5	0.163	4.50	4.50
R-13	6.2	161.7	0.192	5.25	5.25
R-19	9.3	107.4	0.289	7.75	7.75
R-22	10.8	92.9	0.334	8.75	8.75
R-26	12.8	77.9	0.398	10.25	10.25
R-30	14.9	67.1	0.462	11.75	11.75
R-38	19.1	52.5	0.591	14.50	14.50
R-44	22.4	44.6	0.695	16.75	16.75
R-49	25.2	39.7	0.780	18.50	18.50
R-60	31.4	31.9	0.972	22.00	22.00

R-Values are determined in accordance with ASTM C687 and C518. Complies with ASTM C764 as Type 1 pneumatic application.

CLOSED CAVITY (WALLS, FLOORS, CEILINGS) RETROFIT APPLICATIONS

The following thermal performance values are achieved at the thicknesses, weights and coverages specified when insulation is installed with pneumatic equipment in closed wall, floor and ceiling cavities. Based on a design density of 1.6 lb./ft.^{3}

COVERAGE CHART

R-VALUE	BAG REQUIREMENTS	MAXIMUM COVERAGE	MINIMUM WEIGHT	MINIMUM INSTALLED THICKNESS
To obtain a thermal resistance (R) of:	Number of bags per 1000 sq. ft. of net area:	Contents of bag shall not cover more than: (sq. ft.)	Weight per sq. ft. of installed insulation shall not be less than: (lbs./sq. ft.)	Should not be less than: (in.)
R-14	15.1	66.4	0.467	3.50
R-15	16.1	62.0	0.500	3.75
R-16	17.2	58.1	0.533	4.00
R-22	23.7	42.3	0.733	5.50
R-29	31.2	32.1	0.967	7.25

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CertainTeed Corporation
P.O. Box 860
Valley Forge, PA 19482

Professional: 800-233-8990
Consumer: 800-782-8777
www.certainteed.com/insulation

PRODUCT SPECIFICATION

1. PRODUCT NAME

ICYNENE MD-C-200™

ICYNENE MD-C-200™ is a trademark for medium density, closed cell polyurethane spray foam insulation. ICYNENE MD-C-200™ is a 2.0 lb/ft³ density insulation and air barrier material.

2. MANUFACTURER

ICYNENE MD-C-200™ is made on-site from liquid components supplied by Icynene Inc. Installation and on-site manufacturing are supplied by independent Icynene Licensed Dealers.

3. PRODUCT DESCRIPTION

ICYNENE MD-C-200™ is a 2.0 lb/ft³, closed cell insulation and air barrier material. It insulates and air seals at the same time. Convective air movement inside cavities is virtually eliminated, providing more uniform temperatures throughout the building.

The result is superior quality construction, with higher comfort levels and lower heating/cooling costs. Energy savings vary depending on building design, location, etc.

ICYNENE MD-C-200™ expands to fill cavities within the building envelope. It doesn't have to be cut or fitted into the space.

ICYNENE MD-C-200™ is applied by spraying the foam into an open wall, crawlspace, ceiling surface or cathedral ceiling cavities. There it expands in a matter of seconds to provide a foam blanket of millions of tiny closed cells, filling building cavities and sealing cracks and crevices in the process.

4. TECHNICAL DATA

(Based on Core Samples)

Thermal Performance

Thermal Resistance (ASTM C518)

Aged Thermal Resistance
1" aged 90 days @ 140° F,
R – 6.5 (hr.ft² -° F)/BTU

1.5" to 11.25" thickness
Based on 4" aged 90 days @ 140° F
R – 6.0 (hr.ft² -° F)/BTU per inch

ICYNENE MD-C-200™ provides improved performance over traditional air permeable insulations at equivalent R-values. ICYNENE MD-C-200™ is not subject to loss of R-value due to windy conditions, settling, convection or air infiltration; nor is it prone to traditional moisture intrusion via convective air flow or diffusion.

Air Permeance/Air Barrier /Air-Seal

ICYNENE MD-C-200™ fills any shaped cavity, and adheres to most construction materials, creating assemblies with very low air-permeance. Additional interior or exterior air infiltration protection within the building is subject to applicable codes.

Air permeability of core foam:

ASTM E283 data
< 0.02 L/S-m² @ 75 Pa for
1" thickness.

In all buildings insulated and air sealed with ICYNENE MD-C-200™, adequate mechanical ventilation/air supply should be provided for optimum IAQ (Indoor Air Quality). See ASHRAE Guidelines.

Water Vapor Permeance

ICYNENE MD-C-200™ is a Class II vapor retarder which reduces the amount of moisture that can diffuse through the insulation.

Water vapor transmission properties:
ASTM E96 (Desiccant Method):
0.9 Perms @ 1.5"

Water Absorption Properties

ICYNENE MD-C-200™ meets FEMA criteria for resisting water absorption.

Fungi Resistance

ASTM C1338
No Fungus growth

Burn Characteristics

ICYNENE MD-C-200™ is a combustible product and is therefore, consumed by flame, but will not sustain flame upon removal of the flame source. It leaves a charcoal residue. It will not melt or drip. It should be applied in accordance with applicable building codes.

Passed NFPA 285 and ASTM E119
60 minute rated wall assembly testing:

ICYNENE MD-C-200™ is code compliant for IBC construction types I, II, III IV & V and IRC construction.

Surface Burning Characteristics
@ 4" - ASTM E84*:

Flame Spread	≤25
Smoke Development	≤450

*Flame spread rating not intended to reflect hazards under actual fire conditions.

NFPA 286: Thermal Barrier Testing

ICYNENE MD-C-200™ can be applied in wall and ceiling cavities with thicknesses up to 11 1/4". It must be covered with 1/2" of gypsum board or DC-315 intumescent paint coating @ 22 wet mils.

Vented Attic:
ICYNENE MD-C-200™ can be applied in the floor of the attic with thicknesses up to 11 1/4" and it can be left uncovered.

Unvented Attic:
ICYNENE MD-C-200™ can be applied to the underside of the roof deck in thicknesses up to 11 1/4" and it can be left bare.

ICYNENE MD-C-200™ can be applied on walls in thicknesses up to 11 1/4" and it can be left bare.

Environmental / Health / Safety

ICYNENE MD-C-200™ contains no PBDE's.

Not to be installed within (3") of heat emitting devices, where the temperature is in excess of 180° F, in accordance with applicable codes.

5. INSTALLATION

ICYNENE MD-C-200™ is installed by a network of independent Icynene Licensed Dealers.

Formulations are available for all climate zones and altitudes.

6. AVAILABILITY

Check regional Yellow Pages™ or contact Icynene Inc. at 800.758.7325 or visit our website at Icynene.com.

7. WARRANTY

WHEN INSTALLED PROPERLY IN ACCORDANCE WITH INSTRUCTIONS, THE COMPANY WARRANTS THAT THE PROPERTIES OF THE PRODUCT MEET PRODUCT SPECIFICATIONS AS OUTLINED IN THIS PRODUCT SPECIFICATION SHEET. SAVE AND EXCEPT ANY EXCLUSIONS REFERENCED IN THE WARRANTY.

8. TECHNICAL

Icynene Licensed Dealers and Icynene Inc. provide support on both technical and regulatory issues.

9. REGULATORY

ESR-3199 has been issued by the ICC-ES for ICYNENE MD-C-200™. Code approvals are outlined in the ESR-3199 document.

ICYNENE MD-C-200™ can be applied in attic and crawl space applications without the requirement for an ignition barrier cover.

DC-315 intumescent coating has been approved as a thermal barrier over ICYNENE MD-C-200™ with a coating weight of 22 wet mils.

For regulatory issues concerning ICYNENE MD-C-200™, contact Icynene at 800.758.7325

10. RELATED REFERENCES

All physical properties were determined through testing by accredited third party agencies. Icynene Inc. reserves the right to change specifications in its effort of continuous improvement. Please confirm that technical data literature is current.

11. PACKAGING AND STORAGE

Packaging

Package	55 US gallon, closed top steel drums
Component 'A'	520 lb. net weight per drum. Polyisocyanate MDI
Component 'B'	480 lb. net weight per drum ICYNENE MD-C-200™ Resin

Storage

ICYNENE MD-C-200™ (Component A) and (Component B) ideally should be stored between 60° F and 85° F.

Component A should be protected from freezing.

12. INSTALLATION SPECIFICATIONS

Refer to the ICYNENE MD-C-200™ Technical Data Sheet.

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Telephone: 905.363.4040
Toll Free: 800.758.7325
Facsimile: 905.363.0102
Website: Icynene.com
E-mail: inquiry@Icynene.com

SL-223-02 May 2011

PRODUCT SPECIFICATION

1. PRODUCT NAME

ICYNENE LD-C-50®

ICYNENE LD-C-50® is a trademark for light density, open celled, flexible, 100% water-blown polyurethane foam insulation manufactured by Icynene Inc. ICYNENE LD-C-50® spray formula is a nominal 0.5 lbs/ft³ density, free rise material.

2. MANUFACTURER

ICYNENE LD-C-50® is made on-site from liquid components manufactured by Icynene Inc. Installation and on-site manufacturing is supplied by independent Icynene Licensed Dealers.

3. PRODUCT DESCRIPTION

ICYNENE LD-C-50®, the "classic" light density formulation of Icynene has been installed in buildings since 1986. Icynene is the pioneer of high yield, 100% water-blown polyurethane foam technology for air-sealing and insulating buildings.

ICYNENE LD-C-50® insulates and air-seals in one step for maximum energy conservation while minimizing the environmental impact during manufacturing and construction. Significantly reducing air leakage means ICYNENE LD-C-50® contributes to a healthier, quieter and more comfortable indoor environment, while reducing energy consumption and related greenhouse gas emissions by as much as 50%.

ICYNENE LD-C-50® is an effective vapor permeable air barrier material that can move with the building to maintain the air barrier characteristic against energy-robbing air leakage for the life of the building. Convective air movement inside wall cavities is virtually eliminated, providing more uniform temperatures throughout the building.

The result is superior quality construction, with higher comfort levels and lower heating and/or cooling costs. Energy savings will vary depending on building design, location, etc.

ICYNENE LD-C-50® is applied by spraying liquid components onto an open wall, crawlspace, ceiling surface or cathedral ceiling. There it expands approximately 100:1 in seconds to provide a flexible foam blanket of millions of tiny air cells, filling building cavities, cracks and crevices in the process. It adheres to most construction materials, sealing out air infiltration.

Excess material is easily trimmed off, leaving a surface ready for drywall or other code-compliant finish.

4. TECHNICAL DATA

(Based on Core Samples)

Thermal Performance

Thermal resistance (ASTM C518)

- R/in = R3.7 hr. ft² °F/BTU

Average insulation contribution in a full fill stud wall:

- 2" x 4" = R13
- 2" x 6" = R20

ICYNENE LD-C-50® provides more effective performance than the equivalent R-value of air permeable insulation materials. ICYNENE LD-C-50® is not subject to loss of R-value due to aging, windy conditions, settling, convection or air infiltration; nor will it be prone to traditional moisture intrusion via air leakage.

A FACT SHEET with R-value data is available upon request.

Air Permeance/Air Barrier /Air-Seal

ICYNENE LD-C-50® fills any shaped cavity, and adheres most construction materials, creating assemblies with very low air permeance. Additional interior or exterior air infiltration protection is subject to applicable codes.

Air permeability of core foam:

ASTM E283 data

- 0.009 L/s·m² @ 75 Pa for 3.5"

Air permeability of a 2" x 6" wood framed wall assembly:

ASTM E 2178 data

- 0.01 L/s·m² @ 75 Pa for 5.5"

All buildings insulated and air-sealed with ICYNENE LD-C-50® must be designed to include adequate mechanical ventilation/ outdoor air supply. See ASHRAE Standard 62 – Ventilation for Acceptable Indoor Air Quality.

Water Vapor Permeance

ICYNENE LD-C-50® is water vapor permeable and allows moisture to diffuse through the insulation and dissipate from the building envelope.

Water vapor transmission properties:

(ASTM E96 Desiccant Method)

- 11 perms @ 5.5"

In those situations that warrant a vapor retarder, a supplemental layer of polyethylene may be used. Alternately, low vapor permeance paint either directly on the foam or as a primer for the interior drywall may be used.

Water Absorption Properties

Water can be forced into the foam under pressure because it is open celled. Water will drain by gravity, given favorable drying potential, and upon drying all chemical and physical properties are fully restored.

Acoustical Properties

Performance in a 2" x 4" wood stud wall:

STC Sound Transmission Class - 37

Hz. Freq.	125	250	500	1000	2000	4000
ASTM E90	19	30	31	42	38	46

NRC Noise Reduction Coefficient - 70

Hz. Freq.	125	250	500	1000	2000	4000
ASTM C423	.11	.43	.89	.72	.71	.67

Burn Characteristics

ICYNENE LD-C-50® is a combustible product and is therefore, consumed by flame, but will not sustain flame upon removal of the flame source. It leaves a charred foam residue. It will not melt or drip. ICYNENE LD-C-50® is subject to all applicable National/State and County building codes regarding fire prevention. Requirements for Thermal Barrier and Ignition Barrier coverings must be met as per the applicable building code having jurisdiction.

U.S. Fire Testing

Surface Burning Characteristics of (ASTM E84) @ 5" Thickness

Flame Spread	≤25
Smoke Development	≤450

*Flame spread rating not intended to reflect hazards under actual fire conditions.

Electrical Wiring

ICYNENE LD-C-50® has been evaluated with energized 14/3 and 12/2 residential wiring (max. 122°F). It is chemically compatible with typical electrical wiring coverings.

Note: For any insulation of knob and tube wiring, please reference local electrical code.

Corrosion

ICYNENE LD-C-50® did not cause corrosion when evaluated in contact with steel at 120°F and 85% relative humidity conditions.

Plastic Piping

ICYNENE LD-C-50® is compatible in direct contact with CPVC piping systems, as per Paschal Engineering Study for the Spray Polyurethane Foam Alliance (SPFA).

Bacterial or Fungal Growth and Food Value

Independent testing conducted by Texas Tech University has confirmed that ICYNENE LD-C-50® is not a source of food for mold; and as an air barrier material, it resists the airborne introduction of moisture, nutrients, and mold spores into the building envelope.

Environmental / Health / Safety

ICYNENE LD-C-50® is 100% water-blown and therefore contains no ozone-depleting blowing agents. It is also PBDE-free. It has been thoroughly evaluated for in-situ emissions by industry and government experts. VOC emissions are below 1/100th of the safe concentration level (TLV) within hours following the application of ICYNENE LD-C-50®.

Proper handling and use is required to avoid exposure to reactive chemicals in their unreacted state. For more information, contact the Spray Polyurethane Foam Alliance or the American Chemistry Council. Newly insulated areas have been shown to be safe for occupancy 24 hours after installation is complete.

ICYNENE LD-C-50® is CHPS E.Q. 2.2/Section 01350 Compliant and listed as such in the Collaborative for High Performance Schools (CHPS) Low Emitting Materials (LEM) Table.

Under LEED guidelines, products that are CHPS E.Q. 2.2/Section 01350 Compliant are considered Environmentally Preferable Products.

The reaction used to create ICYNENE LD-C-50® generates Carbon Dioxide to expand the foam. Carbon Dioxide has a very low Global Warming Potential (GWP of 1).

Not intended for exterior use. Not to be installed within 3" of heat emitting devices or where the temperature is in excess of 200°F, as per ASTM C411 or in accordance with applicable codes.

5. INSTALLATION

ICYNENE LD-C-50® is installed by a network of Licensed Dealers, trained in the installation of ICYNENE LD-C-50®.

Installation is generally independent of environmental conditions. It can be installed in hot, humid or freezing conditions. Surface preparation is generally not necessary. Within seconds, the foaming process is complete.

For information on Health and Safety, refer to the Spray Polyurethane Foam Alliance Health and Safety guidance documents at www.spraypolyurethane.com

6. AVAILABILITY

Check regional Yellow Pages™ or contact Icynene Inc. at 800-758-7325 or our website at www.Icynene.com for a local Icynene Licensed Dealer.

7. WARRANTY

WHEN INSTALLED PROPERLY IN ACCORDANCE WITH INSTRUCTIONS, THE COMPANY WARRANTS THAT THE PROPERTIES OF THE PRODUCT MEET PRODUCT SPECIFICATIONS AS OUTLINED IN THIS PRODUCT SPECIFICATION SHEET. SAVE AND EXCEPT ANY EXCLUSIONS REFERENCED IN THE WARRANTY.

8. TECHNICAL

Icynene Licensed Dealers and Icynene Inc. provide support on both technical and regulatory issues. Architectural specifications in CSI 3-Part format and design details are available upon request.

9. REGULATORY

ICYNENE LD-C-50® has been tested as per the requirements of the International Code Council – Evaluation Service's AC377 Acceptance Criteria (June 2009).

The following evaluation reports apply to this product:

- ICC ESR-1826

Based on the 3rd party test evidence submitted, this product was found to comply with:

- IRC – 2006 – 2009
- IBC – 2006 – 2009
- IECC – 2006 – 2009

10. RELATED REFERENCES

All physical properties were determined through testing by accredited third-party agencies. Icynene Inc. reserves the right to change specifications in its effort of continuous improvement. Please confirm that technical data literature is current.

11. PACKAGING AND STORAGE

Packaging	55 U.S. gallon steel drums
Component 'A'	550 lb. per drum
	Base Seal® MDI
Component 'B'	500 lb. per drum
	ICYNENE LD-C-50® (Gold Seal®) Resin

Storage

Component A, Base Seal® MDI and Component B, ICYNENE LD-C-50® Resin ideally should be stored between 60°F and 90°F.

Component A, Base Seal®, should be protected from freezing.

Component B, ICYNENE LD-C-50® (Gold Seal®) Resin, can be frozen but must be protected from overheating 120°F and prolonged storage above 100°F.

Component B, ICYNENE LD-C-50® (Gold Seal®) Resin, may separate during storage and should be mixed thoroughly prior to use.

12. INSTALLATION SPECIFICATIONS

Must be installed by Icynene Licensed Dealers. Refer to the Icynene Installer's Manual for expanded information.

ICYNENE®

Telephone: 905.363.4040
Toll Free: 800.758.7325
Facsimile: 905.363.0102
Website: www.Icynene.com
E-mail: inquiry@Icynene.com

FOAMULAR®

Extruded Polystyrene Insulation

INNOVATIONS FOR LIVING™

Property Comparison

Insulating Sheathings Comparison Chart[1]

		Thermal Properties		Physical Properties				Product Characteristics				System Requirements		
	Products	Thickness	R Value[2]	Water Absorption (Max % By Volume)	Water Vapor Permeance (Perms)	Compressive Resistance (PSI)	Performance Below Grade	Tongue & Groove Edge	Facing Material	Relative Handling Weight	Cutting	Corner Bracing Required	Interior Vapor Retarder Allowed	Venting Of Wall Cavity Required
Conventional	Plywood	½"	0.62	High	0.60-0.80	N/A	No	No	N/A	Medium	Saw	No	Yes	No
	Wood Fiber (Regular)	½"	0.6	7.0	20-50	N/A	No	No	N/A	Medium	Saw	Yes	Yes	No
	Gypsum Sheathing	½"	0.45	High	Permeable	N/A	No	Some	N/A	Heavy	Easy	Yes	Yes	No
	Oriented Stran Board	7/16"	0.5	High	0.60-0.80	N/A	No	No	N/A	Medium	Saw	No	Yes	No
	Laminated Fiber Bd. (Thermoply)®	⅛"	0.2	0.2	Permeable	N/A	No	No	Foil	Light	Easy	Yes	Yes	No
Polystyrene Foam	FOAMULAR Insulating Sheathing (OC)	1"	5.0	0.05	0.20	15	Excellent	Yes	Film	Light	Easy	Yes	Yes	No
		¾"	3.8	0.05	0.20	25	Excellent	Yes	Film	Light	Easy	Yes	Yes	No
		½"	3.0	0.05	0.20	25	Excellent	No	Film	Light	Easy	Yes	Yes	No
	FOAMULAR 250 (OC)	1"	5.0	0.1	1.1	25	Excellent	Yes	None	Light	Easy	Yes	Yes	No
	FOAMULAR 150 (OC)	1"	5.0	0.1	1.1	15	Excellent	Yes	None	Light	Easy	Yes	Yes	No
	STYROFOAM RS (Dow)	1"	5.0	0.1	0.15	15	Excellent	Yes	Film	Light	Easy	Yes	Yes	No
	STYROFOAM TG (Dow)	1"	5.0	0.1	1.0	25	Excellent	Yes	None	Light	Easy	Yes	Yes	No
	Molded EPS	1"	3.8-4.2	2.5	2.0-3.5	13-25	Poor	No	None	Light	Easy	Yes	Yes	No
Polyisocyanurate Foam	Foil-faced Isocyanurate Sheathings	1"	7.2	0.3	0.03	16	Poor	No	Foil	Light	Easy	Yes	Yes	Optional
	Examples: Tuff-R (Celotex)	¾"	4.5	0.3	0.03	16	Poor	No	Foil	Light	Easy	Yes	Yes	Optional
	Energy Shield (Atlas)	⅝"	5.4	0.3	0.03	16	Poor	No	Foil	Light	Easy	Yes	Yes	Optional
	Thermo Sheath (R-Max)	½"	3.6	0.3	0.03	16	Poor	No	Foil	Light	Easy	Yes	Yes	Optional
	Non Foil-faced Isocyanurate	1"	5.8	1.0	1.0	16	Poor	No	Non Foil	Light	Easy	Yes	Yes	Optional
	Examples: R-Matte (R-Max)	¾"	4.3	1.0	1.0	16	Poor	No	Non Foil	Light	Easy	Yes	Yes	Optional
	R-Board (Atlas)	⅝"	3.9	1.0	1.0	16	Poor	No	Non Foil	Light	Easy	Yes	Yes	Optional
		½"	2.9	1.0	1.0	16	Poor	No	Non Foil	Light	Easy	Yes	Yes	Optional

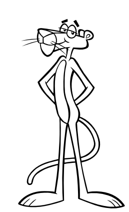
[1]Properties shown are for general comparison purposes only. Values will vary according to manufacturers' products and published data.
[2]R-values shown are from manufactureers' literature determined at 75°F., mean temperature.

The higher the R-value, the greater the insulating power. Ask your seller for the fact sheet on R-values.

INNOVATIONS FOR LIVING™

OWENS CORNING FOAM INSULATION, LLC
ONE OWENS CORNING PARKWAY
TOLEDO, OHIO, USA 43659

1-800-GET-PINK™
www.owenscorning.com

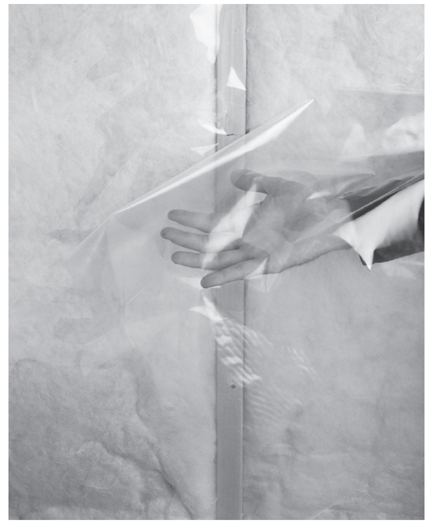


Pub. No. 58101-B. Printed in U.S.A. January 2007.

CertainTeed

Specification Sheet

MemBrain™, The SMART Vapor Retarder



1. PRODUCT NAME

CertainTeed MemBrain™ Smart Vapor Retarder. Patent number US 6,808,772 B2. Other patents pending.

2. MANUFACTURER

CertainTeed Corporation
P.O. Box 860
Valley Forge, PA 19482-0105
Phone: 610-341-7000
800-233-8990
Fax: 610-341-7994
Fax-On-Demand: 800-947-0057
Website: www.certainteed.com

3. PRODUCT DESCRIPTION

Basic Use: CertainTeed MemBrain Smart Vapor Retarder is a vapor retarder sheeting intended for use with unfaced, vapor permeable mass insulation (fiber glass and mineral wool) in wall and ceiling cavities.

Benefits: MemBrain Smart Vapor Retarder is a polyamide film that changes its permeability with the ambient humidity condition. The product's permeance is 1 perm or less when tested in accordance with ASTM E 96, dry cup method, and increases to greater than 10 perms using the wet cup method. This process allows closed building envelope systems to increase their drying potential with seasonal climatic changes. With a high resistance to water vapor in winter, MemBrain reacts to relative humidity by altering pore size, allowing water vapor to pass through it. When conditions change and relative humidity increases above 60%, the pores in the material expand and its permeability increases. This transformation permits drying to occur, in either direction, through the process of vapor diffusion. Thus, its lowered resistance value supports the drying process, therefore decreasing moisture accumulation within the construction and potential moisture damage.

This product can be used in place of traditional vapor retarders with unfaced fiber glass insulation to provide an insulation system that is ideal in some of the more severe climate condition areas in terms of both temperature and humidity. In addition, MemBrain may be installed as an interior air barrier system combined with recommended tapes and sealants.

Composition and Materials: MemBrain Smart Vapor Retarder is formed by blowing a 2-mil thick film of polyamide (Nylon).

Limitations: MemBrain Smart Vapor Retarder is recommended for use in

TABLE 1

PRODUCT SIZES							
Product Size (nom. ft.)	**Nominal Web Width (in.)**	**Actual Web Width (in.)**	**Coverage (square ft.)**	**Box Length (in.)**	**Roll Wgt. (lbs.) with box and core**	**Rolls per Pallet***	**Weight per Pallet (lbs.)**
8	96	100	800	28.3	11.1	45	545
9	108	112	900	31.5	12.5	45	608
10	120	124	1000	34.5	13.7	40	593
12	144	148	1200	41.0	17.0	30	55
PRODUCT SIZES – METRIC							
Product Size (nom. m)	**Nominal Web Width (mm)**	**Actual Web Width (mm)**	**Coverage (square m)**	**Box Length (mm)**	**Roll Wgt. (kg) with box and core**	**Rolls per Pallet***	**Weight per Pallet (kg)**
2.44	2438	2540	74.3	718	5.0	45	247
2.74	2743	2845	83.6	800	5.7	45	276
3.05	3048	3150	92.9	876	6.2	40	269
3.66	3658	3759	111.5	1041	7.71	30	252

*48" (1219 mm) maximum pallet height.

heating and mixed climates. The product is not suited for cooling climates with high outdoor humidities. MemBrain is not suitable in buildings with exceptionally high, constant indoor humidity levels, such as swimming pools and spas. This product should also not be used with specialty-conditioned spaces with relative humidities intentionally greater than 50%. Use of MemBrain is not recommended where residential humidification systems are set at relative humidities greater than 50%. MemBrain's performance in rooms with short peaks of high humidity, such as bathrooms and kitchens, will not be affected because of the buffering action of interior finishes.

Do not use low permeance interior finishes such as vinyl wallpaper or vapor retarding paints with MemBrain. The drying benefits of MemBrain will diminish with the use of low permeance finishes. MemBrain has not been tested for use with wet spray insulation systems and is not recommended at this time. MemBrain should not be used as a vapor barrier between concrete sub floors and flooring materials, or as a ground cover in basements and crawl spaces. This product is not recommended for applications having direct or indirect (reflected) ultraviolet light exposure due to solar or electrical sources. Special care should be taken when working with an open flame. Check local practice and/or building codes for use of vapor retarders. To avoid danger of suffocation, keep this and all plastic film away from babies and small children.

Sizes: This product is manufactured in nominal widths to cover interior walls that are 8, 9, 10 and 12 feet high. The material is folded and rolled to create rolls containing 100 linear feet of product. Available standard sizes are listed in Table 1.

4. TECHNICAL DATA

Applicable Standards:

- Model Building Codes:
  - BOCA, ICBO, SBCCI and ICC
  - National Building code of Canada 2005
    Articles 9.25.4.2(1), (2) and (3)
    Articles 9.25.3.1, 9.25.3.2 and 9.25.3.3 CCMC Evaluation Report #13278-B
- Material Standards:
  - ASTM C 665
    Section 7.4, Water-Vapor Permeance
  - ASTM E 96

Fire Resistance:

- Fire Hazard Classification:
  - ASTM E 84
    Surface burning characteristics
    Max. Flame Spread Index: 20
    Max. Smoke Developed Index: 55

Physical/Chemical Properties:

- Water Vapor Permeance:
  - $\leq$ 1.0 perm (57ng/Pa•s•m^2) (ASTM E 96, Desiccant method)
  - > 10 perms (570ng/Pa•s•m^2) (ASTM E 96, Water method)
- Fungi Resistance:
  - No growth (ASTM C 1338)
- Corrosivity:
  - No unusual aspect of corrosion such as pitting, cracking and adhesive cure inhibition (ASTM C 665)

Quality Assurance: CertainTeed was the first fiber glass insulation manufacturer to have its manufacturing plants, R&D center and corporate headquarters registered to ISO 9001-2000 standards.

5. INSTALLATION

For most areas, vapor retarders should be installed on the warm-in-winter side of the insulation (toward the interior). For some warm and humid areas, the vapor retarder should be installed towards the exterior of the building envelope. MemBrain is not intended to be used as an exterior vapor retarder. Check local practice and/or building codes.

Installation in wood framing: Same as polyethylene sheeting.

Please see MemBrain Smart Vapor Retarder Installation Instructions For Wood Framing (30-28-083) and MemBrain Smart Vapor Retarder Installation Instructions For Steel Framing (30-28-089).

Installation as an Air Barrier System: MemBrain may be installed as a continuous interior air barrier system. Please see MemBrain Air Barrier Installation for Wood Framing (30-28-137).

6. AVAILABILITY AND COST

Manufactured and sold throughout the United States. For availability and cost, contact your local contractor, retailer or distributor, or call CertainTeed Sales Support Group in Valley Forge, PA at 800-233-8990.

7. WARRANTY

This product is covered by a limited one-year warranty against manufacturer's defects.

8. MAINTENANCE

Not required.

9. TECHNICAL SERVICES

Technical assistance can be obtained from either the local CertainTeed sales representative, or by calling CertainTeed Sales Support Group in Valley Forge, PA at 800-233-8990.

10. FILING SYSTEMS

Additional product information is available upon request.

CertainTeed Corporation
P.O. Box 860
Valley Forge, PA 19482

Professional: 800-233-8990
Consumer: 800-782-8777
www.certainteed.com

CertainTeed

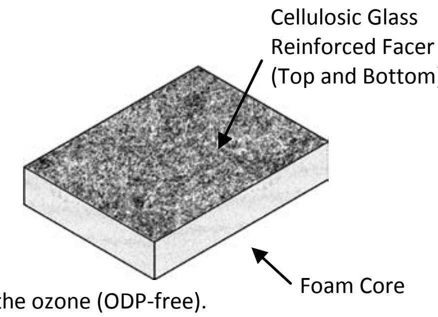
TECHNICAL INFORMATION SHEET

Firestone BUILDING PRODUCTS

ISO 95+™ GL Insulation

TIS 901

Flat and Tapered



Description:

Firestone ISO 95+ GL flat and tapered roof insulation consists of a closed-cell polyiso foam core laminated to a black glass reinforced mat facer on both major surfaces. Flat and tapered ISO 95+ GL insulation provides outstanding thermal performance on commercial roofing applications, while providing positive roof top drainage to help eliminate ponding water when tapered ISO 95+ GL insulation is used.

All Firestone polyiso insulations use EPA accepted blowing agents and qualify under the Federal Procurement Regulation for Recycled Material. Flat and tapered ISO 95+ GL insulation with ISOGARD™ Foam Technology incorporates a HCFC-free blowing agent that does not contribute to the depletion of the ozone (ODP-free).

Method of Application:

Insulation shall be neatly fitted to all roof penetrations, projections and nailers. No more insulation shall be installed than can be covered with membrane and completed before the end of each day's work or before the onset of inclement weather.
Firestone ISO95+ GL board may be installed using:

Firestone fasteners and Plates
Hot Asphalt (requires a coverboard)
Firestone Improved Insulation Adhesives

- I.S.O. Twin Pack™
- I.S.O. Stick™
- I.S.O. Spray™ S
- I.S.O. FIX™ II

For ballasted systems, the top layer of Firestone insulation may not be mechanically attached.

ISO 95+ GL Flute Span Over Metal Decks				
Thickness	1.0”	1.2 5”	1.5”-3.8”	4.0”
Span	2.625”	3.675”	4.375”	4.5”

Storage:

Keep insulation dry at all times.
Elevate insulation above the deck or ground.
Cover insulation with waterproof tarps.

Precautions:

Firestone ISOGARD HD Composite is not suitable as an immediate substrate for a ballasted roof system.
Polyiso foam will burn if exposed to a flame of sufficient heat and intensity. Keep away from heat, sparks, and open flames
Protect against dust that may be generated when insulation is cut with a circular saw during installation.
Refer to Material Safety Data Sheet (MSDS) for additional information.
Use in accordance with Firestone ISO 95+™ Specifications

Specification Compliance:

ASTM C1289, Type II, Class 1
UL Classified
FM Class 1 Approved
Manufactured in an ISO 9002 Registered Facility
CAN/ULC-S704, Type 1, Class 3

FM APPROVED · CLASSIFIED c UL US · MIAMI-DADE COUNTY APPROVED

CCMC 13274-L

Manufactured in an ISO 9001 Registered Facility

Manufacturing Locations: Florence, KY; Bristol, CT; DeForest, WI; Corsicana, TX; Jacksonville, FL; Youngwood, PA; Salt Lake, UT

PIMA QualityMark™ The Certified LTTR-value

Available Sizes:

Flat Boards: 4’ x 4’ (1.22 m x 1.22 m)
4’ x 8’ (1.22 m x 2.44 m)
Thickness ranging 1.0” (25.4 mm) to 4.0” (101.6 mm)
Tapered Boards: 4’ x 4’ (1.22 m x 1.22 m)
4’ x 8’ (1.22 m X 2.44 m) (special order)
Thickness ranging 0.5” (12.7 mm) to 4.0” (101.6 mm)
Slopes ranging 1/16” per foot (.5%) to ½” per foot (4%)

TECHNICAL INFORMATION SHEET

Firestone BUILDING PRODUCTS

ISO 95+ GL Insulation

Typical Thickness (inches)	Thickness, (millimeters)	% Post Consumer	% Post Industrial	TOTAL RECYCLE CONTENT
1.00	25.40	37%	15%	52%
1.25	31.75	33%	15%	48%
1.50	38.10	29%	15%	44%
1.75	44.45	26%	15%	41%
2.00	50.80	24%	15%	39%
2.30	58.42	21%	15%	36%
2.50	63.50	20%	15%	35%
2.80	71.12	18%	15%	33%
3.00	76.20	17%	15%	32%
3.25	82.55	16%	15%	31%
3.50	88.90	15%	15%	30%
3.75	95.25	14%	15%	29%
4.00	101.60	14%	15%	29%

Physical Properties	***ASTM Standard***	*Units*	*Value*	*Units*	*Value*
Compressive Strength	D 1621	psi	20	kPa	138
Density	D 1622	pcf	2	kg/m^2	32
Dimensional Stability	D 2126	%	<2	%	<2
Moisture Vapor Transmission	E96	perm	<1	ng/(Pa•s•m^2)	57.5
Water Absorption	C209	% by volume	<1	% by volume	<1
Service Temperature	----	^{o}*F*	100-200 ^{o}*F*	^{o}*C*	73-121 ^{o}*C*

25 psi (172 kPa) available upon request.

Product Data	**Thickness, inches**	**Thickness, mm**	**LTTR R-Value***	**Flute Spanability, inches**
Long Term Thermal Resistance as related to thickness of ISO95+GL	1.00	25.4	6.0	2.265
	1.25	31.7	7.5	3.675
	1.50	38.1	9.0	4.375
	1.75	44.5	10.5	4.375
	2.00	50.8	12.1	4.375
	2.30	58.4	14.0	4.375
	2.50	63.5	15.3	4.375
	2.80	71.1	17.2	4.375
	3.00	76.2	18.5	4.375
	3.25	82.6	20.1	4.375
	3.50	88.9	21.7	4.375
	3.75	95.3	23.4	4.375
	4.00	101.6	25.0	4.500

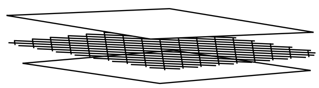
**Long Term Thermal Resistance (LTTR) values provide a 15-Year time weighted average in accordance with CAN/ULC –S770.*

Acceptable Substrates:	Notes:
Structural Concrete, 3000 psi (New and Existing) *Steel, min. 22 gage* *Lightweight Concrete* *Plywood and OSB, min. ½ in.* *Gypsum, min. 2"*	Please consult the SBS Design Guide and Quick Specs on line at www.firestonebpco.com to review specific information regarding fastener types appropriate for the type of deck and insulation in use.
NOT ACCEPTABLE:	Do not use hot asphalt to adhere ISOGARD HD Coverboard to ISO 95+ GL insulation

Please Contact your Firestone Roof Systems Advisor at 1-800-428-4511 for further information.

This sheet is meant to highlight Firestone products and specifications and is subject to change without notice. Firestone takes responsibility for furnishing quality materials which meet published Firestone product specifications. Neither Firestone nor its representatives practice architecture. Firestone offers no opinion on and expressly disclaims any responsibility for the soundness of any structure. Firestone accepts no liability for structural failure or resultant damages. Consult a competent structural engineer prior to installation if the structural soundness or structural ability to properly support a planned installation is in question. No Firestone representative is authorized to vary this disclaimer.

GRIFFOLYN® TYPE-55 FR



Griffolyn® Type-55 FR is a 3-ply laminate combining two layers of fire retardant low density polyethylene and a high-strength cord grid. It is specifically engineered to provide high strength and durability in a lightweight material.

PHYSICAL PROPERTIES AND TYPICAL VALUES

PROPERTY	ASTM TEST METHOD	U.S. VALUE	METRIC VALUE
Weight	D-3776	33 LB/1000 FT^2	16.1 KG/100 M^2
3" Tensile Strength	D-882	85 LBF	378 N
3" Load @ Break	D-882	34 LBF	151 N
		1900 PSI	13.1 MPA
Tongue Tear	D-751 B	14 LBF	62 N
Trapezoidal Tear	D-4533	25 LBF	111 N
PPT Resistance	D-2582	26 LBS	116 N
Dart Impact Strength	D-1709	1.1 LBS	.5 KG
Cold Impact Strength	D-1790	-20°F	-29°C
Permeance	E-96	0.062 Grain/Hr•Ft^2•in.Hg	3.556 NG/(PA•S•M^2)
Fire Retardancy	E-84	5 flame spread, 25 smoke developed	
	NFPA 701	Pass	

Conforms to the following safety codes:

- Passes NFPA 701 Test 2 (Large Scale) – "Standard Methods of Fire Tests for Flame Propagation of Textiles and Films".
- Class I, Class A flame spread rating per UBC-42 and ASTM E-84.

FEATURES

- Fire retardant to meet safety requirements in critical equipment and material areas.
- Multiple layers and cord reinforcement resist punctures and tears.
- Cold-crack resistance eliminates failures in extremely cold temperatures.
- Low permeability greatly inhibits moisture transmission.
- Flexibility and light weight allow for easy handling and quick installation.
- Custom fabrication is available to meet your exact specifications.
- High durability allows for significant savings through reuse and fewer replacements.

The information provided herein is based upon data believed to be reliable. All testing is performed in accordance with ASTM standards and procedures. All values are typical and nominal and do not represent either minimum or maximum performance of the product. Although the information is accurate to the best of our knowledge and belief, no representation of warranty or guarantee is made as to the suitability or completeness of such information. Likewise, no representation of warranty or guarantee, expressed or implied, or merchantability, fitness or otherwise, is made as to product application for a particular use.

TOLLFREE 1.800.231.6074
9209 Almeda Genoa Rd. • Houston, Texas 77075
P: 713.507.4251 • F: 713.507.4295
Email: ri@reefindustries.com

SUGGESTED APPLICATIONS

- Temporary walls, plant dividers, building enclosures and containment tents.
- Shipping container covers and liners.
- Floor covers, dust partitions and cleanroom enclosures.
- Bags and tubing (printing available).
- Industrial Packaging.
- Custom covers and outside storage.
- Architectural vapor retarder in walls, ceilings and in roofing systems.

ORDERING INFORMATION

AVAILABLE COLORS:
Natural, Yellow and Green

SIZES:
Standard rolls from 4' x 100' to 40' x 100' in increments of 4' widths are available for immediate shipment. Standard length and width tolerances are ± 1% (minimum 2")

Custom sizes up to 100' x 125' and custom fabrication are avaiable to meet your exact specifications.

USABLE TEMPERATURE RANGE:
Minimum: -5˚F -20˚C
Maximum: 150˚F 66˚C

OUTDOOR EXPOSURE

Under normal continuous exposure the average life expectancy ranges from 10 to 12 months, depending on color.

TOLLFREE 1.800.231.6074
9209 Almeda Genoa Rd. • Houston, Texas 77075
P: 713.507.4251 • F: 713.507.4295
Email: ri@reefindustries.com

DuPont™ Tyvek® HomeWrap®

PHYSICAL PROPERTIES DATA SHEET

PROPERTIES	METHOD	DUPONT™ TYVEK® HOMEWRAP®
Air Penetration Resistance	ASTM E2178 (cfm/ft²@1.57 psf)	< .004
	Gurley Hill (TAPPI T-460) (sec/100cc)	1200
	ASTM E1677	Type 1
Water Vapor Transmission	ASTM E96-05 Method A (g/m²-24 hrs) (perms)	400 56
	Method B (glm²-24 hrs) (perms)	370 54
Water Penetration Resistance	ATTCC 127 (cm)	250
Basis Weight	TAPPI T-410 (oz/yd²)	1.8
Breaking Strength	ASTM D882 (lbs/in)	30/30
Tear Resistance (Trapezoid)	ASTM D1117 (lbs)	8/6
Surface Burning Characteristics	ASTM E84 Flame Spread Index	15 Class A
	Smoke Developed Index	15 Class A
Ultra Violet Light Exposure (UV)		120 days (4 months)

Test results shown represent roll averages. Individual results may vary either above or below averages due to normal manufacturing variations, while continuing to meet product specifications.

For more information about DuPont™ Tyvek® Weatherization Systems, please call 1-800-44-Tyvek or visit us at www.Construction.Tyvek.com

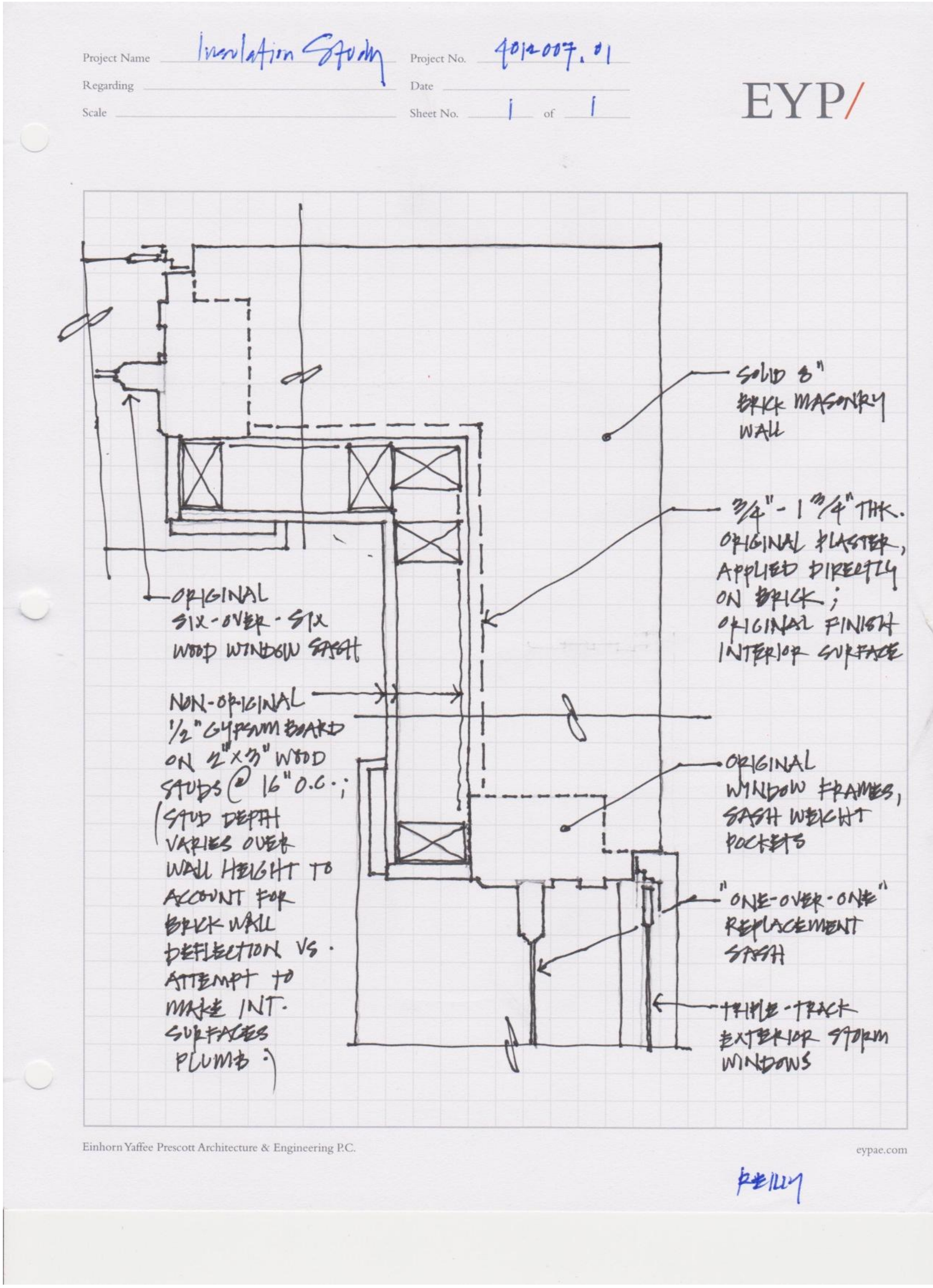
WARNING: DuPont™ Tyvek® is combustible and should be protected from an open flame and other high heat sources. If the temperature of DuPont™ Tyvek® reaches 750 °F (400 °C), it will burn and the fire may spread and fall away from the point of ignition.

DUPONT®
The miracles of science™

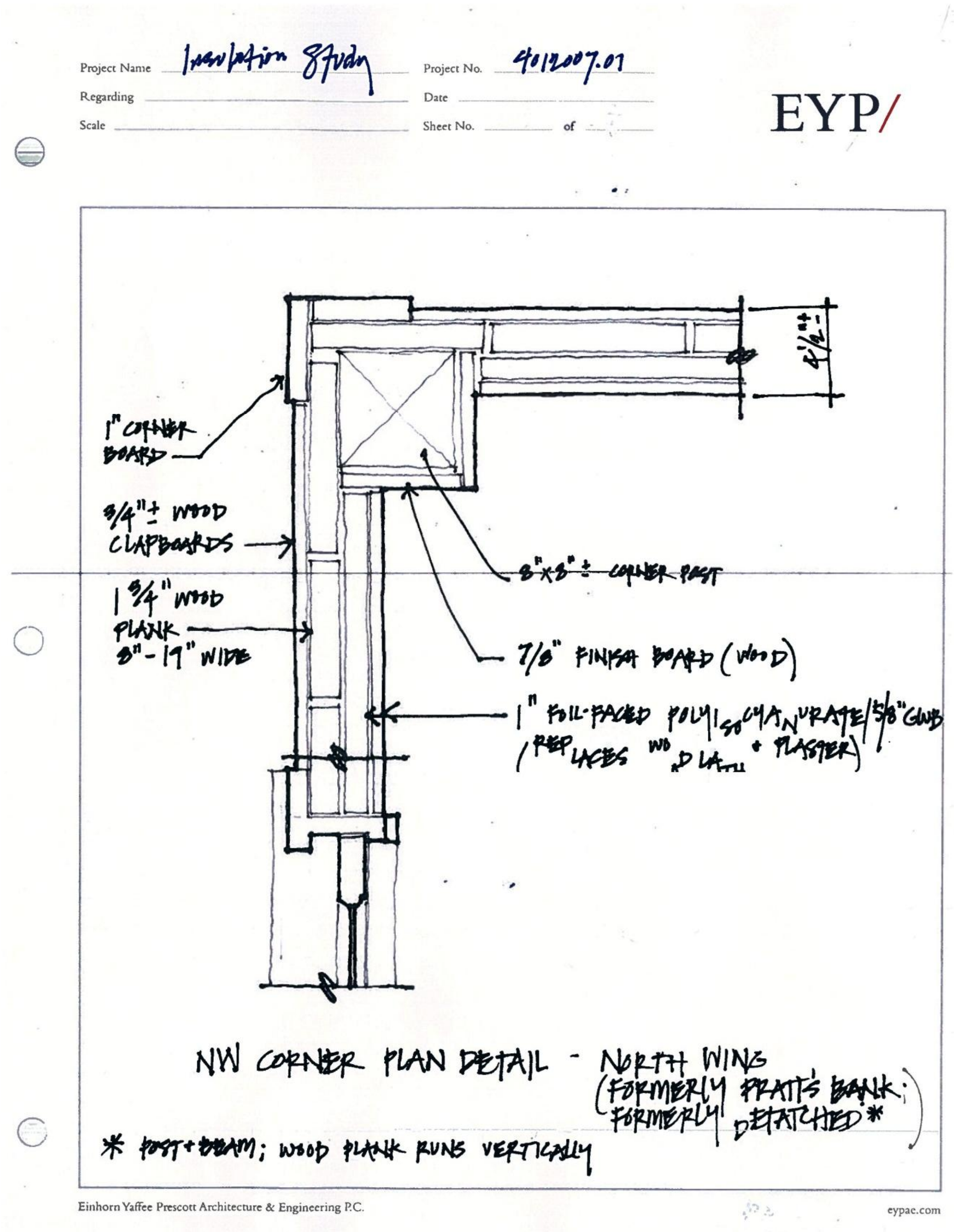
DuPont™ Tyvek® HomeWrap®

APPENDIX F

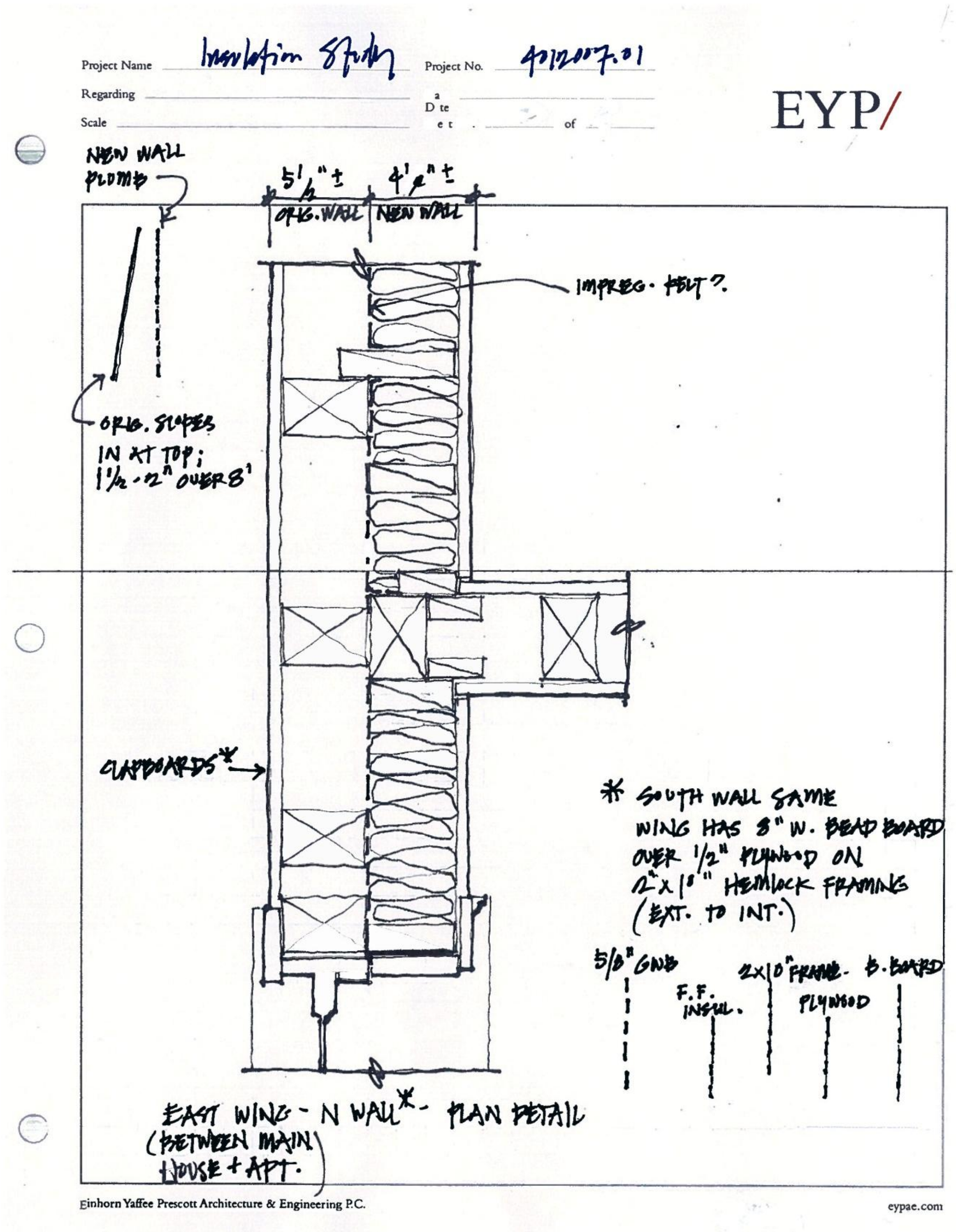
FIELD SKETCHES



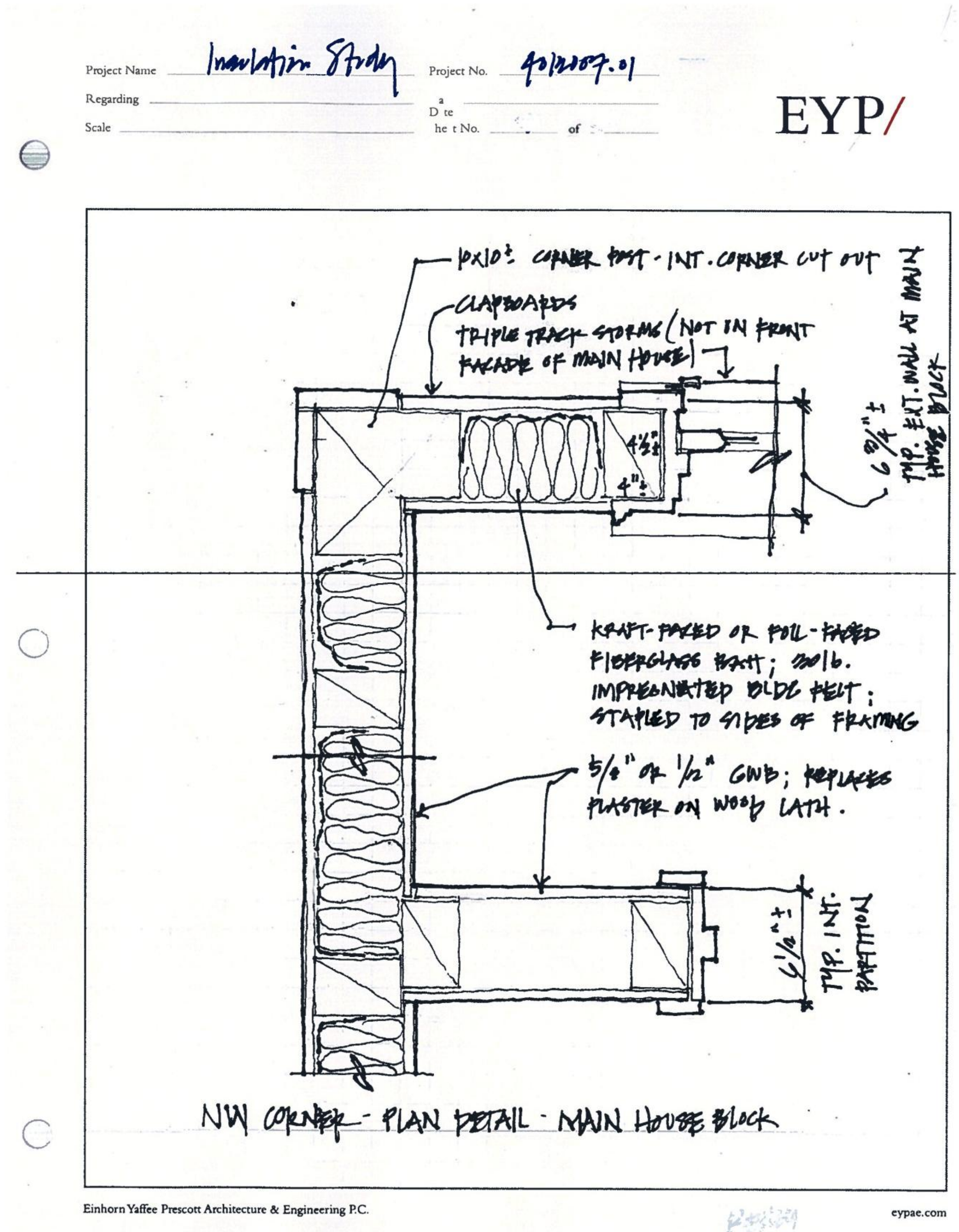
Appendix Figure F-01:.. Cambridge Co-op: Field sketch of typical exterior wall conditions



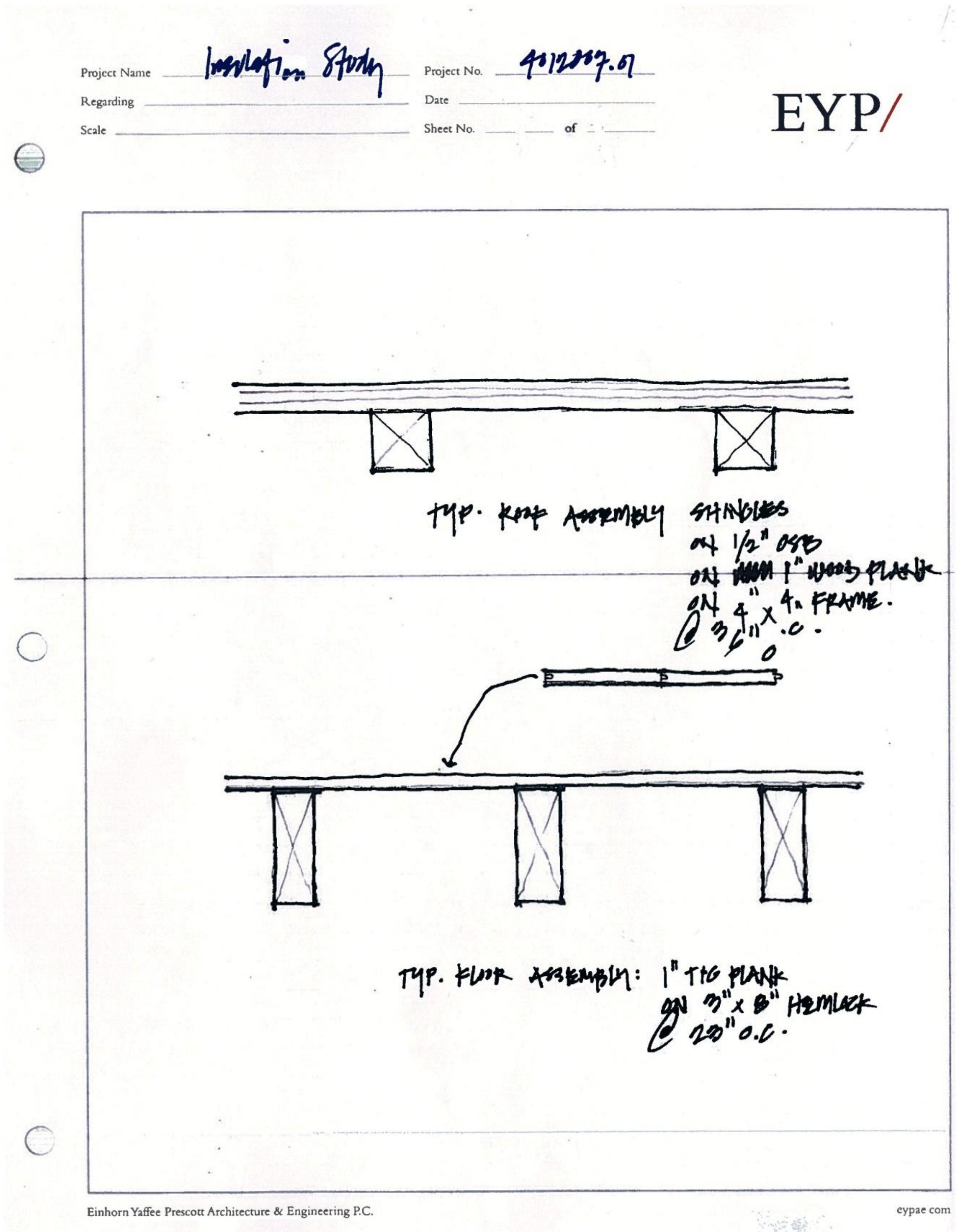
Appendix Figure F-02:.. Pratt Museum: Field sketch of typical exterior wall conditions



Appendix Figure F-03:.. Pratt Museum: Field sketch of typical exterior wall conditions



Appendix Figure F-04:.. Pratt Museum: Field sketch of typical exterior wall conditions



Appendix Figure F-05:.. Pratt Museum: Field sketch of typical exterior wall conditions