A Proposal for Amendment to the City of Lawrence Building Code Concerning Basement Wall Insulation

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April, 2008

Background

The city of Lawrence has adopted the 2006 International Residential Code (IRC) which prescribes the minimum use of either R-13 cavity insulation or R-10 continuous insulation on basement walls to a depth of ten feet or over the entire wall. While this requirement is of vital importance to the overall energy efficiency of structures, it ignores the many practical difficulties faced by compliance. The motivation for this proposed amendment is the concern over how builders will choose to conform to this requirement in unfinished areas.

The methods builders are likely to use and the difficulties that will be faced by each are outlined below.

Method 1 – Stud Wall with Batt Insulation

The most obvious method of conformance is to simply construct a stud wall with R-13 batt insulation that is left exposed and unsecured.

The issues with exposed batt insulation are:

Figure 1 – Unfaced fiberglass batts

1) True R-Value – In order for batt insulation to yield its rated R-value it should be installed in an <u>enclosed cavity</u>.

2) Fire Hazard – The Kraft backing on batt insulation is not fire-rated for exposure. Unfaced batts must then be used which have only friction to hold them in place over the life of the structure.

3) Human Exposure – Research has suggested that fiberglass is a carcinogen. OSHA requires that bags of fiberglass insulation carry a cancer warning label.

The insulated stud wall could be covered with drywall to alleviate the problems above. However, this would greatly increase costs and require partial removal and destruction for future renovations which is costly and wasteful.

Method 2 – Exterior Foam Board

An alternative method is to use high-density polystyrene on the exterior of walls to full depth. This method involves many of the same obstacles as slab insulation, which precipitated an amendment to allow its exclusion. These obstacles include: termite shield, protection against damage, brick ledge issues and porch or patio connections.

Method 3 – Interior Foam Board

Another alternative is to use interior foam board insulation. According to International Building Code (IBC) 2603.4, foam plastic insulation must be separated from the interior with ½" drywall. Two inch thick polystyrene foams are rated R-10 and cost about $0.69/square foot, while 1-1/2" polyisocyanurate (polyiso) is R-9 and costs $0.60/square foot. However, polyiso has a low permeability that makes it a poor candidate for use on sub-grade concrete (see attachment A). This is because sub-grade concrete cannot dry to the exterior. Even small amounts of moisture from cracks or small imperfections in the damp-proofing can cause serious implications if it is not allowed to dry to the interior.

Proposed Methods

Polyiso foam board (see attachment B) can be installed to a depth of 3 feet below grade on the interior of concrete walls, which allows the wall to dry to the inside through the bottom of the wall. The foam board along with its drywall covering can be secured to the wall with Tapcons™ or an equivalent fastener through 1-1/2" washers.

This method has the following benefits:

1) It is easy to install and remove in case of future renovations
2) Low cost ($ 3.60 per lineal foot)
3) Nearly the same performance as the code prescribes
4) Greatly reduced moisture issues
5) Secure, safe and durable

Figure 2 – R-9 polyiso foam board

A similar alternative is to build a stud wall and insulate with R-13 batts to a depth of 3 feet below grade, which could then be covered with drywall. This method would allow most future wiring to be easily installed without major destruction.

Neither of these proposed methods currently conforms to code because of the depth requirement. However, the following analysis will show that this compromise has little effect on a home's energy efficiency.

To demonstrate the effectiveness of the proposed methods, a simulation was run on a test home. The test home (attachment C) is a simplified two story with a full-in basement. It has 1008 square feet on each of three levels (28'x36') with half of the basement level finished. Using the REScheck software two different scenarios were simulated to compare them to the absence of insulation. In each scenario the attic was insulated with R-38, walls in finished areas with R-13, Low-E windows were used (10% of above grade finished space), and standard fiberglass front and rear doors. REScheck determined the maximum UA for the structure to be 356.

Uninsulated

Walls in the unfinished parts of the basement were left uninsulated resulting in a UA of 411.

Proposed Method (R-9 on Top Four Feet)

Walls in the unfinished parts of the basement were insulated with R-9 continuous insulation on the top four feet resulting in a UA of 341. Note that R-9 continuous and R-13 cavity insulation provides nearly identical results.

Code Prescribed Method (R-10 on Entire Wall)

Walls in the unfinished parts of the basement were insulated from top to bottom with R-10 continuous insulation resulting in a UA of 328.

Using no insulation does not meet the minimum UA requirement, though the addition of a 92 AFUE furnace does cause compliance. The proposed method yields an overall envelope improvement of 17%, while the code prescribed method results in a further improvement of just 4% while more than doubling the cost.

This analysis demonstrates the relative importance of insulating the top of the wall where the top is exposed to ambient air and the remainder lies above the frost line. The relative stability of soil temperatures three or more feet below grade acts as an energy sink. This prevents energy conduction through the concrete wall. Intuitively, insulating the wall ten feet below grade makes little sense unless one is also prepared to insulate under the basement floor as well where the soil is nearly the same temperature. The R-value of 9 was used since this is readily available in 1-1/2" thick polyisocyanurate.

It turns out that the difference between four feet of R-9 and eight feet of R-10 is 0.2 UA per lineal foot, independent of the configuration of the structure.   The difference between eight feet of R-10 and no insulation is 1.3 UA per lineal foot. Therefore, according to REScheck, the top four feet accounts for 85% of basement wall UA contribution versus 15% for the lower half.

It must be pointed out that the above analysis is restricted to UA, which is not the same as an analysis of energy savings, especially in our mixed climate. In contrast to above grade walls, subgrade wall insulation applied below 3' is only an advantage in winter months. Though the ambient temperature in summer may be 100 degrees, the soil temperature below three feet will range from 55-60 degrees—a distinct advantage in summer.

To determine the relative impact these scenarios have on actual energy savings, the test home was simulated using REM/Design software. This software is used by most Home Energy Rating System (HERS) inspectors. Attachments D and E show the results of comparisons of the above methods in dollars with the cost of the improvements amortized at a rate of 6% for a cash flow analysis.

Method	UA	Heating & Cooling Cost	Net Savings	Cost of Improvements	Cash Flow	Cost per Lineal foot
Uninsulated	411	$ 1,120	N/A	N/A	N/A	$ 0
Proposed	341	$ 992	$ 128	$ 331	$ 104	$ 5.17
Code Prescribed	328	$ 968	$ 151	$ 671	$ 103	$ 10.48

Table 1 – 2-Story simulation results

Table 1 shows a summary of the results of these software simulations. The comparison of no insulation with the proposed method in attachment D yields a reduction in total heating and cooling costs of 11%. Attachment E compares no insulation with the code prescribed method to yield a reduction in heating and cooling costs of 14%. Also note that both measures show a small monetary loss for cooling costs as expected. Though the code prescribed method offers a 4% improvement in UA, it yields only a 3% savings in direct energy costs over the proposed method. When the extra costs of the improvements are considered, the cash flow is reduced.

Rancher Analysis

Another interesting analysis was performed by deleting the 2nd floor from the test home and leaving the basement entirely unfinished. This simulation represents the opposite extreme configuration. The results are listed in Table 2.

Method	UA	Heating & Cooling Cost	Net Savings	Cost of Improvements	Cash Flow	Cost per Lineal foot
Uninsulated	377	$ 917	N/A	N/A	N/A	$ 0
Proposed	237	$ 662	$ 256	$ 662	$ 208	$ 5.17
Code Prescribed	212	$ 614	$ 303	$ 1,341	$ 206	$ 10.48

Table 2 – Rancher simulation results

These results again show a reduced cash flow for the code prescribed method relative to the proposed method. The proposed method yields a reduction in total heating and cooling costs of 28%, while the code prescribed method achieves a reduction of 33%. Though the code prescribed method offers a 5% greater savings in energy, its additional cost results in $2 negative yearly cash flow.

Conclusion

The addition of basement wall insulation is one of the most cost effective measures to improve energy efficiency in new homes. It can result in energy savings ranging from 10-30% depending on the configuration of the structure. Its use should be encouraged by providing a safe and practical means for its inclusion rather than simply stating a minimum R-value.

This proposal has pointed out that attempting to comply with the code as written can lead to unintended, deleterious effects to building safety. It has also shown that subgrade insulation installed below 3 feet yields only a marginal improvement in overall energy efficiency that cannot be justified by the added monthly costs to the consumer. Therefore, the methods proposed herein should be adopted as an alternative that builders may choose to provide to their customers even if they are not using the prescribed code method.

List of Attachments

A) Building Science Corporation study, Basement Insulation Systems, Pg. 12. The remainder of the report is available at: www.eere.energy.gov/buildings/building_america/pdfs/db/35017.pdf

B) Atlas Roofing Corporation, AC Foam II™ product specifications.

C) Test home floor plan.

D) REM/Design improvement analysis of R-9 polyiso on top four feet of wall.

E) REM/Design improvement analysis of R-10 polyiso on entire wall.

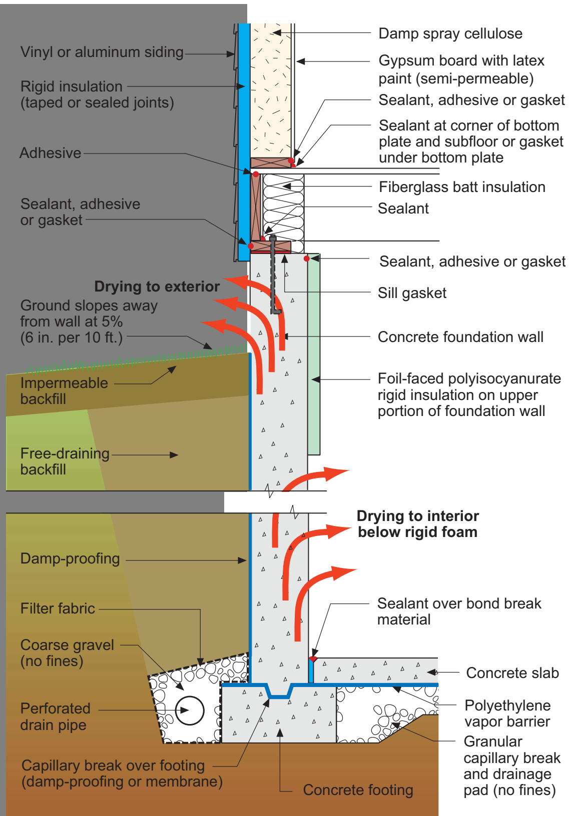


Figure 11

Unfinished basement with half-height insulation

- Lower portion of wall dries to the interior
- Upper portion of wall dries to the exterior

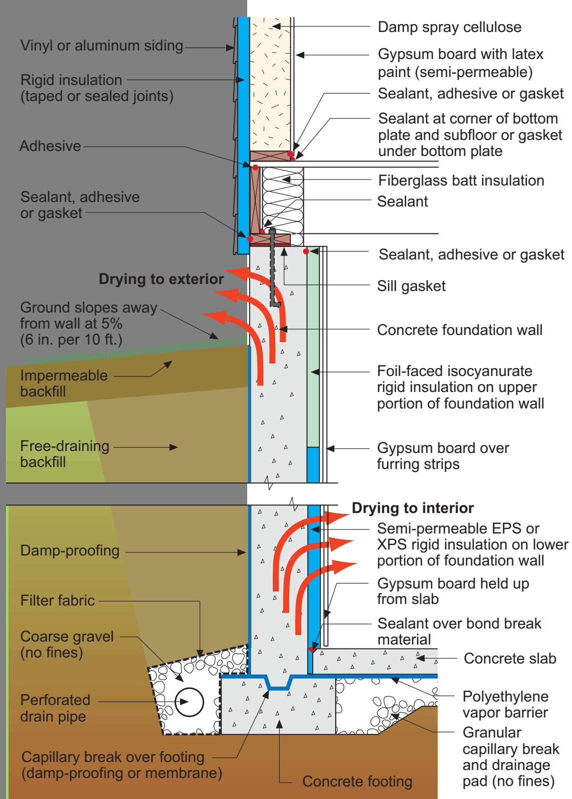


Figure 12

Finishing basement at a later date

- Drying continues to the interior
- Drying to the exterior

HALF WALL INSULATION WITH FIRE- RATED FOAM SHEATHING

The fastest and most cost effective way to provide insulation is covering the upper half of the foundation wall with foil-faced polyisocyanurate foam sheathing that is fire rated for exposed use (**Figure 11**). This will eliminate the greatest source of heat transfer through the foundation wall while still allowing the lower half of the wall to dry to the interior. The joints between pieces of foam sheathing must sealed using foil tape to prevent air leakage that could result in condensation on the cold foundation wall.

If at a later date the wall is to be finished, expanded polystyrene (EPS) can be used to cover the lower half of the wall (**Figure 12**). Expanded polystyrene is semi-permeable to water vapor and will allow the lower portion of the wall to continue to dry inwards. However, the expanded polystyrene will require thermal protection with 0.5 inch of gypsum board or equivalent.

Keeping the gypsum board off the floor a minimum of 0.5 inch will prevent wetting of the gypsum board in the event of small leak or flood. If a frame wall is placed interior to the rigid insulation, cavity insulation without a vapor barrier or retarder can be installed between the studs.

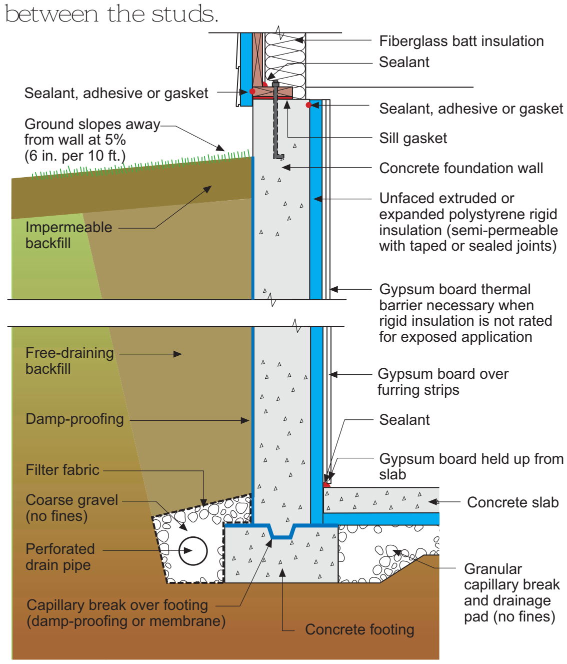


Figure 13

Full height basement insulation

- Upper and lower portion of wall can dry to interior

ACFoam®-II

ENVIRONMENTALLY FRIENDLY "GREEN" POLYISO INSULATION

HCFC FREE ZERO AC Ultra TECHNOLOGY

ACFoam II features ACUltra Technology which means ZERO HCFC´s - a cost effective "Green" building solution. Excellent R-Values reduce energy demands while maintaining compatibility with all types of roofing membranes and fire assemblies. ACFoam-II is offered in a variety of thicknesses, providing long-term thermal resistance (LTTR) values from 6.0 to 25.0. ACFoam-II is a closed-cell, polyiso core integrally laminated to heavy black (non-asphaltic), fiber-reinforced felt facers. ACFoam-II is also available in 25-psi formula. Available in 4´ x 4´ (1220mm x 1220mm) and 4´ x 8´ (1220mm x 2440mm) panels.

In 1998, years ahead of the Environmental Protection Agency timetable for eliminating HCFCs (hydrochlorofluorocarbons), Atlas introduced a line of ACFoam Products that are environmentally sensitive and available for virtually every type of construction system. Through a patented hydrocarbon blowing technology called ACUltra, Atlas began the phaseout of HCFCs in the manufacturing of foam insulation and anticipates the complete removal of HCFCs from all Atlas foam products within the next year.

Long Term Thermal Resistance (LTTR) Values & Thicknesses

ACFoam Typical Physical Properties

MIAMI-DADE COUNTY APPROVED

CODES & COMPLIANCES

- Federal Specification HH-I-1972/GEN and HH-I-1972/2, Class 1 have been cancelled.
- ASTM C 1289, Type II, Class 1.
- Miami-Dade County, Florida Product Control No. 00-0208.04.
- NYC MEA #107-01-M.
- California State Insulation Quality Standards and Title 25 Foam Flammability Criteria (License #TC 1231).
- IBC, NBC, UBC and SBC Sections on Foam Insulation (Chapter 26).
- CCMC No. 12464-L.
- CAN/CGSB-51.26-M86.
- CAN/ULC-S704.

FM Standard 4450/4470 Approval
ACFoam-II is approved for Class 1 insulated steel, wood, concrete and gypsum roof deck construction for 1-60 and 1-90 Windstorm Classifications (may

INSTALLATION

ACFoam® General Installation Instructions
Before installation begins, the roof deck should be firm, well attached, even, clean and dry. Proper attachment of the insulation is necessary to prevent roof failures. Atlas will not be responsible for any damage caused by improper attachment. Atlas Roof Insulation products can be attached to decks that are approved by Factory Mutual and local codes. Atlas is not responsible for determining the suitability of the deck. **ATLAS ROOF INSULATION PRODUCTS SHALL BE KEPT DRY BEFORE, DURING AND AFTER INSTALLATION**. Although Atlas Roof Insulation has been designed to withstand normal foot traffic, protection from damage by construction traffic and/or abuse is extremely important. Roof surface protection such as plywood must be used in areas where storage and staging are

Features & Benefits

ACUltra Technology means ZERO HCFC´s

Excellent R-values reduce energy demand

Compatibility with all types of roof membranes

Superior performance in fire tests

Approved for installation directly on the roof deck without a thermal barrier

Cost-effective, environmentally friendly solution for any roof

Case Studies

Steelcase North America uses ACUltra Technology to cover 650,000 square feet of roof space.

Crowning Achievement: An environmentally sound roofing system tops an environmentally

A New Tradition Rises In The Heart Of The Old Dominion

Innovative Roofing System Keeps New Terminal Roof High and Dry be mopped or mechanically fastened to concrete roof decks). Refer to FM Approval Guide for details on specific systems.

UL Standard 1256 Classification
Insulated metal deck construction assemblies - Construction #120 and #123.

UL Standard 790 (ASTM E 108) Classification
Class A with most roof membrane systems. See UL Roofing Materials & Systems Directory.

UL Standard 263 Fire Resistance Classification (ASTM E 119)
Some classifications for fire resistance are P225, P230, P259, P508, P510, P514, P519, P701, P710, P713, P717, P718, P719, P720, P722, P723, P724, P725, P727, P728, P729, P730, P732, P801, P814, P815, P818, P819, and P828. See UL Fire Resistance Directory for updated listings.

UL Standard 1897 Uplift Resistance
120 psf, 150 psf, 165 psf, 245 psf.

UL Certified for Canada

UL of Canada
Insulated Roof Deck Assemblies - Construction #C34.
CAN/ULC-S126-M86, CAN/ULC-S101-M89, CAN/ULC-S107-M87

Spec this Product

planned and heavy or repeated traffic is anticipated during or after installation. (See Technical Bulletin #00-01)

Moisture/Vapor Control
Vapor retarders are used to impede the passage of water vapor into roofing systems, thereby preventing condensation and resulting damage to the insulation and roof system. All Atlas Roof Insulation Products may be installed with or without a vapor retarder, the need for which is determined by the designer. The designer may consult the NRCA Roofing and Waterproofing Manual for guidance in determining the need for a vapor retarder. Special consideration should be given to construction-generated moisture, as well. For example, construction-generated moisture, such as will be released by placing concrete floor slabs after the roof has been installed, can drive large quantities of moisture into the roof system. Therefore, Atlas cannot be responsible for damage to the insulation when exposed to construction-generated moisture. Refer to the NRCA Roofing and Waterproofing Manual for their recommendations for the use of a vapor retarder when construction-generated moisture is present (4th Edition, Volume 1, p. 121). Refer to Atlas Technical Bulletin #00-01.

Complete Instructions

SALES OFFICES

Camp Hill

East Moline

Northglenn

LaGrange

Diboll

Phoenix

Toronto

Sales Offices

WARRANTY

In response to valid concerns of building designers regarding thermal efficiency of roof assemblies and the long-term insulating value of roof insulation, Atlas offers a 20-year, limited thermal warranty. The "ACFoam" Limited Warranty places Atlas ACFoam products above all others and supports the building owner, designer and contractor by backing up thermal performance. This warranty is available to the building owner at the time the building is completed and is transferable to any subsequent owner for the duration of the 20-year period.

Limitation of Liability
Other than the aforementioned representations and descriptions, Atlas Roofing Corporation (hereafter, “Seller”) makes no other representations or warranties as to the insulation sold herein. The Seller disclaims all other warranties, express or implied, including the warranty of merchantability and the warranty of fitness for a particular purpose. Seller does, however, have a limited warranty as to the R-Value of the insulation, the terms of which are available upon request from the Seller.

The Seller shall not be liable for any incidental or consequential damages including the cost of installation, removal,

EZELL-MORGAN CONSTRUCTION, INC.	TEST 2-STORY	1
	SCALE: 1/8" = 1' REVISION: 1	
	DATE: FEBRUARY, 2008	

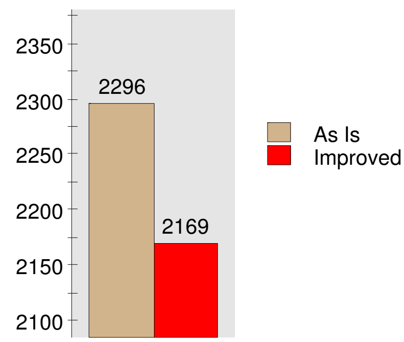
IMPROVEMENT ANALYSIS REPORT

Building Name:		Date:	April 24, 2008
Owner's Name:		Builder's Name:	
Property		Weather Site:	Topeka, KS
Address:	,	File Name:	Code Amendment.blg

Energy Costs ($/yr)

End-Use	As Is	With All Improvements	Savings
Heating	963	833	130
Cooling	157	159	-2
Hot Water	228	228	0
Lights and Appliances	659	659	0
Photovoltaics	-0	-0	0
Service Charge	292	292	0
TOTAL	2299	2171	128

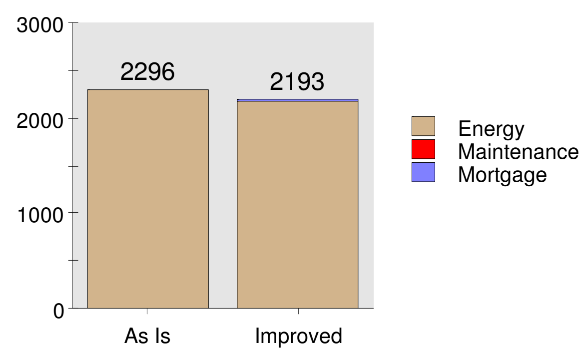
Total Costs ($/yr)



Information For Lenders and Appraisers

Installed Cost of Improvements ($)	331
Cost Weighted Life of Measure (Years)	30
Mortgage Term (Years)	30
Discount/Mortgage Rate (%)	6.000
Present Value Factor	13.8
Expected Annual Energy Savings ($)	128
Expected Annual Maintenance Costs ($)	0
Expected Annual Savings ($)	128
Increased Annual Mortgage Costs ($)	24
Present Value of Savings ($)	1756
Expected Annual Cash Flow ($)	104

Cost Comparison ($/yr)



REM/Design - Residential Energy Analysis Software v12.41

This information does not constitute any warranty of energy cost or savings.

Recommended Improvements

Measure Costs	Life	Cost	Yr Savings	SIR	PV	SP
1: Add R-9 polyiso. 4 ft	30	331	128	5.3	1425	2.59

Criteria

Ranking Criteria: SIR	Maximum $ Limit: No Limit
Cutoff: 0	Measures: Interactive

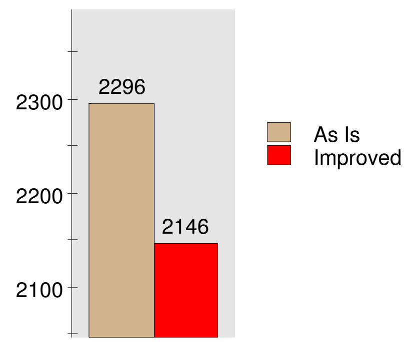
IMPROVEMENT ANALYSIS REPORT

Building Name:		Date:	April 24, 2008
Owner's Name:		Builder's Name:	
Property		Weather Site:	Topeka, KS
Address:	,	File Name:	Code Amendment.blg

Energy Costs ($/yr)

End-Use	As Is	With All Improvements	Savings
Heating	963	809	154
Cooling	157	159	-2
Hot Water	228	228	0
Lights and Appliances	659	659	0
Photovoltaics	-0	-0	0
Service Charge	292	292	0
TOTAL	2299	2148	151

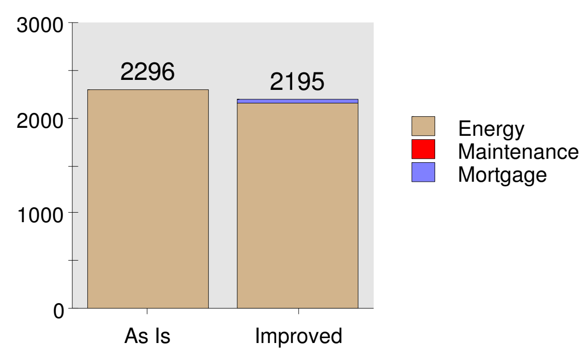
Total Costs ($/yr)



Information For Lenders and Appraisers

Installed Cost of Improvements ($)	671
Cost Weighted Life of Measure (Years)	30
Mortgage Term (Years)	30
Discount/Mortgage Rate (%)	6.000
Present Value Factor	13.8
Expected Annual Energy Savings ($)	151
Expected Annual Maintenance Costs ($)	0
Expected Annual Savings ($)	151
Increased Annual Mortgage Costs ($)	49
Present Value of Savings ($)	2083
Expected Annual Cash Flow ($)	103

Cost Comparison ($/yr)



Recommended Improvements

Measure Costs	Life	Cost	Yr Savings	SIR	PV	SP
1: Add R-10 polyiso. full	30	671	151	3.1	1412	4.43

Criteria

Ranking Criteria: SIR	Maximum $ Limit: No Limit
Cutoff: 0	Measures: Interactive