TECH SOLUTIONS 220.0

Residential Basement Heat Loss and Savings

Introduction

All house envelope components contribute to heat loss and should be appropriately insulated and sealed to reduce air leakage and minimize these energy losses. The use of air barrier systems and insulation in above-grade walls and ceiling spaces, thermally efficient windows and doors, and effective air sealing around doors, windows and other construction joints and penetrations all contribute to energy loss reduction.

The "buried" component of the house envelope – the basement walls and floor – can contribute significantly to energy loss. An uninsulated basement can account for up to 30 percent of the total energy loss of a house.*

Tech Solutions 220.0:

- Quantifies energy losses through basement walls and floors for a specific basement wall/floor configuration for six different U.S. cities
- Quantifies energy savings by progressively increasing the coverage of the basement wall and slab with insulation
- Compares Exterior Basement Wall Insulation (EBWI) to Interior Basement Wall Insulation (IBWI) from an efficiency standpoint

Table 1: Basement Configuration

Length, ft	40
Width, ft	24
Depth below-grade, ft	7
Height above-grade, ft	1
Wall	8" solid concrete
Floor	4" solid concrete

Methodology

BaseCalc, a two-dimensional finite-element program co-developed by the National Research Council – Canada/Division of Building Research and Natural Resources Canada, was used to determine heat loss during the heating season for a basement of configuration shown in Table 1.

The program allows the user to place insulation in a continuous fashion or as wood frame and batt assembly at any location on the interior face of the wall. The use of continuous insulation on the exterior of the basement wall is also an option. The user also may install continuous insulation of any R-value above or below the basement floor slab.

BaseCalc allows the evaluation of energy losses in 10 U.S. cities and 30 Canadian cities. This Tech Solutions evaluates the heating season energy losses for six U.S. cities. BaseCalc uses documented, city-specific technical data to calculate energy loss. Information for each city is in Table 2.

The basement configuration and city data having been determined, the insulation strategies for calculating the basement's energy loss were selected. In the interest of simplification, 2" thick STYROFOAM™ Brand Extruded Polystyrene Foam Insulation (R-10) was used as the insulation for the progressively increasing coverage of the basement wall and under the concrete slab. R-10 is the thermal resistance prescribed in the 2006 and 2009 IECC for basement wall and slab insulation. Figure 1 outlines the insulation position and coverage options used for the heat loss analyses.

Figure 1: Insulation Options for Analyses

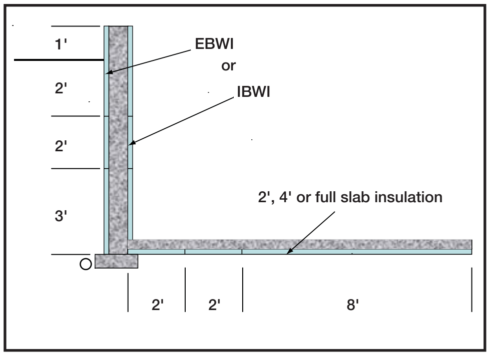


Table 2: City-specific Data

	Portland, Ore.	Denver	Chicago	Detroit	Minneapolis-St. Paul	Madison, Wis.
Average ground temperature, °F	54.8	52.2	53.2	53.4	48.7	49.8
Annual temperature amplitude, °F	50.6	55.3	58.9	58.4	60.0	57.4
Soil conductivity						
above footing	5.5 Btu-in/ft²-hr-°F					
below footing	6.2 Btu-in/ft²-hr-°F					
Heating degree-day (65°F)	4,630	6,020	6,356	6,167	7,980	7,673
Heating season	October 1 to April 30					
Water table, ft	32					
Basement temperature, °F	68°					

*Based on a study conducted by Dow and D.R. Nelson & Associates in which air loss was measured by using blower door tests. Potential energy savings were estimated using REM Home Energy Analysis Software. Results vary based on construction, style, year built and other unique home characteristics. Participating homeowners were current employees of Dow.

Residential Basement Heat Loss and Savings

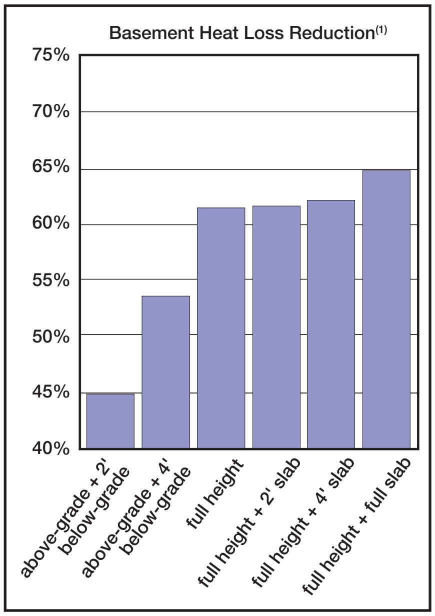
Heat Loss and Savings

BaseCalc tests for the six different cities were carried out, and heat losses for uninsulated basements and progressively insulated basement walls and floor slabs are indicated in Tables 3 and 4 for IBWI and EBWI wall insulation methods.

Heat loss is reduced as the coverage of insulation progressively increases. Figure 2 shows the percent reduction in heat loss (compared to the uninsulated scenario) for both IBWI+slab and EBWI+slab configurations. The greatest savings occur as the upper portions of the basement wall are insulated. As insulation depth is increased and under-slab insulation is added, the additional savings become progressively smaller. This is mainly due to the deeper soil's ability to moderate the effect of the outside cold climate/temperatures and the thermal resistance provided by the soils themselves. Similarly, the deep soil "bulb" under the center portion of the floor slab of a deep basement is even more effective in moderating the outside climate's effect on heat loss of the slab.

Determining the annual money savings associated with heat loss reductions in Tables 3 and 4 (vs. uninsulated basements) is crucial to determine the economics of the insulation options. Tables 5 and 6 indicate the money savings corresponding to Tables 3 and 4. It should be noted that these savings are expressed at an assumed energy cost of $1.20/Therm.

Figure 2: Estimated Basement Heat Loss Reduction for Various Insulation Options



(1) Progressively increasing R-10 insulation coverage of interior of basement wall and under floor slab (average of the six cities examined)

Table 3: Estimated Heat Losses[1] for IBWI + Under-slab Insulation

Insulation Scenario	Portland, Ore.	Denver	Chicago	Detroit	Minneapolis-St. Paul	Madison, Wis.
Uninsulated	26.6	33.3	33.5	32.9	41.2	38.2
AG[2] + 2' BG[3]	14.9	18.5	18.4	18.0	22.6	21.1
AG + 4' BG	12.6	15.6	15.3	15.1	19.0	17.7
Full Height	10.5	13.0	12.7	12.5	15.9	14.9
Full Height + 2' Slab	10.3	12.8	12.6	12.3	15.7	14.5
Full Height + 4' Slab	10.2	12.6	12.4	12.1	15.4	14.3
Full Height + Full Slab	9.7	11.6	12.0	11.2	14.1	13.2

(1) Heat losses are in Giga-Joules/year (1 Giga-Joule = 9.48 Therms).
(2) AG = above-grade
(3) BG = below-grade

Table 4: Estimated Heat Losses[1] for EBWI + Under-slab Insulation

Insulation Scenario	Portland, Ore.	Denver	Chicago	Detroit	Minneapolis-St. Paul	Madison, Wis.
Uninsulated	26.6	33.3	33.5	32.9	41.2	38.2
AG[2] + 2' BG[3]	13.6	16.7	16.6	16.3	20.5	19.1
AG + 4' BG	12.1	14.9	14.7	14.4	18.3	17.1
Full Height	10.8	13.3	13.1	12.8	16.3	15.2
Full Height + 2' Slab	10.7	13.2	13.0	12.7	16.1	15.0
Full Height + 4' Slab	10.5	13.0	12.8	12.6	16.0	14.9
Full Height + Full Slab	10.0	12.4	12.1	12.0	15.2	14.1

(1) Heat losses are in Giga-Joules/year (1 Giga-Joule = 9.48 Therms).
(2) AG = above-grade
(3) BG = below-grade

Table 5: Estimated Savings[1] for IBWI + Slab Insulation

IBWI Savings Scenario	Portland, Ore.	Denver	Chicago	Detroit	Minneapolis-St. Paul	Madison, Wis.
AG[2] + 2' BG[3]	$133	$168	$172	$169	$212	$194
AG + 4' BG	$159	$201	$207	$202	$252	$233
Full Height	$183	$231	$237	$232	$288	$265
Full Height + 2' Slab	$185	$233	$238	$234	$290	$270
Full Height + 4' Slab	$187	$235	$240	$237	$293	$272
Full Height + Full Slab	$192	$247	$245	$247	$308	$284

(1) Based on $1.20/Therm and 1 Giga-Joule = 9.48 Therms
(2) AG = above-grade
(3) BG = below-grade

Table 6: Estimated Savings[1] for EBWI + Slab Insulation

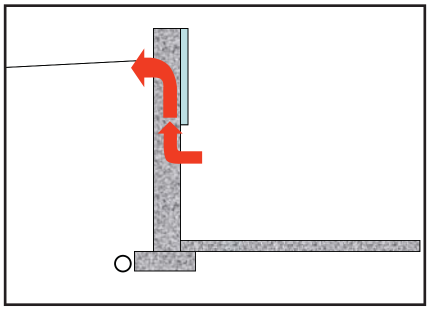
EBWI Savings Scenario	Portland, Ore.	Denver	Chicago	Detroit	Minneapolis-St. Paul	Madison, Wis.
AG[2] + 2' BG[3]	$148	$189	$192	$189	$235	$217
AG + 4' BG	$165	$209	$214	$210	$260	$240
Full Height	$180	$227	$232	$229	$283	$262
Full Height + 2' Slab	$181	$229	$233	$230	$285	$264
Full Height + 4' Slab	$183	$231	$235	$231	$287	$265
Full Height + Full Slab	$189	$238	$243	$238	$296	$274

(1) Based on $1.20/Therm and 1 Giga-Joule = 9.48 Therms
(2) AG = above-grade
(3) BG = below-grade

Exterior vs. Interior Basement Wall Insulation

Exterior basement wall insulation has been touted as providing advantages over interior insulation, including protection of the wall from construction damage, reduction of freeze-thaw damage to the upper portions of the basement wall, providing thermal mass benefit to the interior space, and the reduction of thermal bridging. Thermal bridging is caused by the higher thermal conductivity of solid concrete compared to backfill. The latter is illustrated in Figure 3.

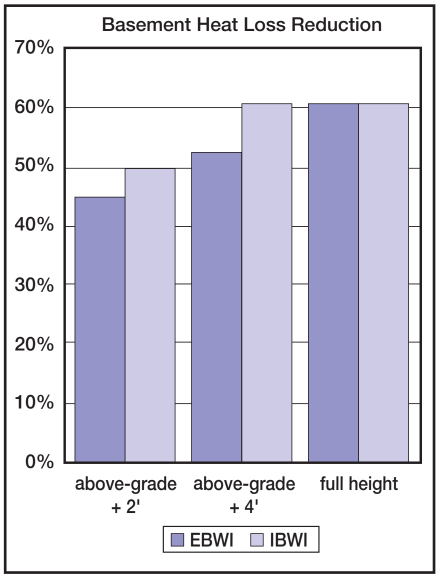
Figure 3: Thermal Bridging from IBWI



The BaseCalc evaluations of EBWI vs. IBWI for insulation installed to a depth of 4' below-grade confirms the superior thermal efficiency of EBWI vs. IBWI and is illustrated in Figure 4.

The thermal bridging advantage of EBWI is virtually eliminated once the wall is insulated to its full height, as illustrated in Figure 4.

Figure 4: Estimated Heat Loss Reduction – EBWI vs. IBWI



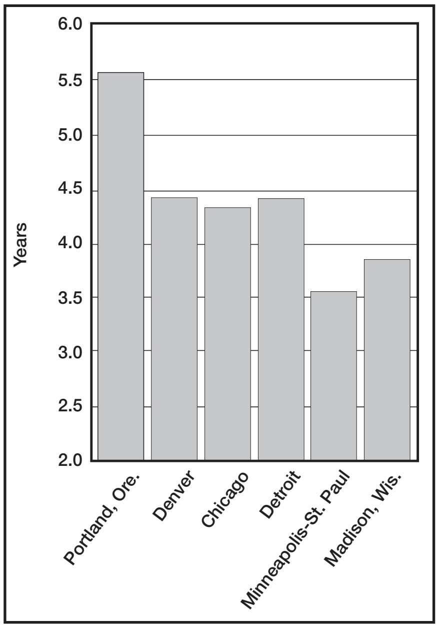
Attractive Payback for R-10 Basement Wall Insulation

The prescriptive R-10 insulation for basement walls and slab insulation by the 2006 and 2009 IECC appears to be a reasonable value. The savings associated with use of R-10 would appear to economically justify full height basement wall insulation at those levels. A simple payback was determined for R-10 full height basement wall insulation and is illustrated in Figure 5.

Conclusions

- Insulation of the full height of deep basement walls, either on the inside or the outside, could generate significant savings, and the prescribed R-10 for wall insulation can be easily justified.
- The use of R-10 insulation below the basement slab of a deep basement may not be justifiable based on energy payback. But insulation below basement slabs can be a crucial way to reduce condensation on basement floors and to ensure performance of floor finishes on the basement slab.
- The use of EBWI is suggested over IBWI for protection from freeze-thaw damage, damp-proofing protection and providing interior thermal mass from the concrete basement wall. The thermal performance of EBWI is apparent only when insulation is installed less than full depth. There appears to be no thermal performance advantage of EBWI over IBWI when the basement wall is insulated over the full height.
- Insulating an unfinished basement wall to R-10 full height can provide significant savings (retrofit or new construction).

Figure 5: Simple Payback[1] for R-10 Full Height IBWI



(1) Based on $1.20/Therm and $0.50/bd ft insulation cost

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