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ORNL/TM-2008/017

Supporting Documentation for the 2008 Update to the Insulation Fact Sheet

January 31, 2008

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Engineering Science and Technology Division

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ABSTRACT

The DOE Insulation Fact Sheet is designed to help homeowners make informed decisions about home insulation. The Fact Sheet was recently updated to accomplish multiple goals. First, the insulation cost data and energy prices used to calculate life-cycle costs for insulation applications were updated. Second, insulation materials and practices have progressed. Third, the evolution of the Fact Sheet from a paper pamphlet form to an interactive web site was in need of improvement. The information provided in this supporting documentation describes the basis for these changes.

1. INTRODUCTION

The DOE Insulation Fact Sheet was first published in 1978 with updates in 1982, 1988, 1997, and 2002.[1, 2] The Fact Sheet was designed to provide general insulation information to consumers, including recommended R-values. The information was applicable to both new and existing houses. Related information was provided regarding air sealing and moisture. Before the 1997 update, the Fact Sheet was distributed in paper form to about 40,000 readers/year. The web site received about 500 hits/day between 2002 and 2005. The recommended R-values are also used by a number of other web sites, including those provided by insulation manufacturers and other government energy conservation programs. The purpose of this supporting documentation is to report the revisions that were made in 2008 to the cost and performance databases and to the content of the fact sheet. The updated version was published on the Internet in January of 2008 and is based on the latest available information in mid- to late-2007.

The initial intent of the 2008 Fact Sheet Update was limited in scope, and the main goal was to revise the recommended R-values to reflect current insulation and energy prices. However, comments were solicited from the public during 2006 and 2007 and the results focused attention on several other areas as well. These public comments are summarized in Appendix A and can be found in their entirety on the Building Technology Program web site for envelopes and windows (http://www.govforums.org/E&W/). On many issues, reviewers provided opposing points of view.

Many comments dealt with a comparison between the recommendations found in the 2006 International Energy Conservation Code (IECC) and those produced for the Fact Sheet by the ZipCode analysis tool.[3, 4] Some reviewers felt that we should rely solely on the IECC values and should not make any other calculations. Other reviewers felt that we should use the IECC values as a lower limit and recommend higher levels whenever they could save energy at a reasonable cost. Still others pointed out that the new IECC climate zone definitions have been broadly adopted by other agencies and that our recommendations should conform to that format as well.

These comments were carefully considered. The 2008 revision reflects the reviewers' input in many ways. We have attempted to balance the competing points of view and also to work within the confines of the resources available for the project. All of the cost and performance databases were revised, as described in Section 2. The revised databases are all included in Appendix B. The updated fact sheet text is included in Appendix C

2. REVISIONS TO THE CALCULATIONS

2.1 THE ZIPCODE INSULATION PROGRAM METHODOLOGY

The DOE Insulation Fact Sheet originally used a computer model called the ZipCode Insulation program, developed by Stephen Peterson at the National Institute of Standards and Technology (NIST) in the 1980s.[4] This computer program has many strengths, including the use of local values for weather variables, fuel prices, and insulation prices for new and existing homes. However, this same local focus has always made it difficult to summarize the results for broader regions. Also, the calculations rely upon "modified one-dimensional heat transfer" calculations. Whole-house computer models are now the state of the art for evaluating energy conservation options. These whole house models do a better job of reflecting the many inter-related and dynamic energy flows in a structure.

One of the early goals in this revision was to compare the ZipCode's one-dimensional results to a whole house model. In the ZipCode Users Guide, Stephen Petersen describes how the one-dimensional savings estimates are based on whole-house correction factors developed for the PEAR program.[4] Further investigation revealed that these correction factors resulted from a regression analysis of savings due to varying insulation levels using the output from over 10,000 whole house DOE-2 computer models, covering 45 climates and 5 residential building types.[5] Although the family of whole-house computer models, including the DOE-2 computer code, has been significantly improved over the last 25 years, the resources to duplicate this extensive modeling effort do not exist in today's budget. Also, one of our reviewers compared the ZipCode results to a modern whole-house model, and we were heartened to learn that the corrected one-dimensional methodology produced surprisingly similar results for the cases and climates considered. We therefore elected to continue to use the whole house correction factors developed for the PEAR program. These equations and correction factors are therefore unchanged from those shown in the 1997 Supporting Documentation.[6]

The recommended insulation levels correspond to the insulation level that produces the optimal life-cycle savings for the consumer. (The life-cycle savings balances the current expense for installed insulation against the present value of the future energy savings.) Some reviewers noted that this is a "shallow solution space". That is, there are many answers that produce life cycle savings very close to the optimal savings. Our analysis supported this view, and the results of this approach were helpful in developing the recommendations for the IECC climate regions, which cover a very broad range of energy costs and insulation prices. To select the levels recommended for each region, the ZipCode was processed to calculate the life-cycle savings for a broad range of possible insulation levels. Every insulation level that produced life-cycle savings of at least 95% of the optimal savings was then output for consideration. For new buildings, the range was then restricted to levels at or greater than the 2006 IECC code-recommended level. For existing buildings, the analysis considered both uninsulated buildings and buildings with some insulation already in place.

Although we considered updating the cooling degree-hour database to more recent data, the newer data bases did not include cooling hours relative to the 74°F base used in the derivation of the correction factors. However, we were able to update the heating degree-days to more current climatic data.[7] The postal service has reassigned a number of the 3-digit level zip codes to new areas and has begun to use some of the numbers that were previously reserved. Appendix B includes a full list of the zip-code specific climate and cost factor data used in this update.

2.2 PERFORMANCE ASSUMPTIONS

The thermal performance of most insulation measures was unchanged from previous editions of the fact sheet, with some changes for foam insulation based on recent formulations. Also, the U-factors for both wood and metal-framed walls were revised based on research that has been completed during the last 10 years, including both experimental and finite difference analyses.[8,9] Furthermore, ASHRAE has recently reassessed wall framing factors in a detailed survey effort.[10] The California Energy Commission extended that effort to the state of California.[11] Both studies found that approximately 25% of the wall area, net of the window area, was comprised of framing. The experimental wall heat transfer work found a roughly one to one correspondence between the framing factor and the difference between the nominal and the whole wall performance for wood-framed walls. The wood wall U-values were adjusted accordingly as summarized in Table 1. The experimental results for multiple metal wall framing arrangements were used to estimate the framing loss for these systems and the resulting heat transfer coefficients are summarized in Appendix B.

For wood-framed attics, a parallel path heat transfer model was used to include the heat transfer through the framing members in the estimate of the overall U-values. For metal-framed attics, the U-values were calculated based on experimental and modeling work, using the more conservative of the values for either a truss system or a joist and rafter system.[12] The thermal performance of cathedral ceilings and band joists were unchanged. These U-factors are summarized in Appendix B.

For foundation insulation measures, including basements, floors, crawl spaces, and slab edges, the thermal performance was unchanged from previous editions of the fact sheet. The savings factors, based on an extensive finite difference analysis for multiple climates, are summarized in Appendix B.[13]

Table 1 Summary of wall U-value factors

Outside film coefficient	0.17 h-ft^2-°F/Btu
Inside film coefficient	0.68 h-ft^2-°F/Btu
Gypsum	0.45 h-ft^2-°F/Btu
Cavity insulation	Rated R-value (or 0.9 h-ft^2-°F/Btu for an empty cavity)
Plywood	1.32 h-ft^2-°F/Btu
Siding	0.81 h-ft^2-°F/Btu
Total Reduced Clear Wall	0.75 * Sum above [metal-framed walls: 0.40*Sum]
Foam Sheathing	Rated R-value (h-ft^2-°F/Btu)
Total R	Sum Reduced Clear Wall + foam sheathing
Total U	1/Total R

The performance of heating and cooling systems was updated to reflect technology and market improvements, as summarized in Table 2.

Table 2 Heating and cooling system performance assumption changes

New electric air conditioner seasonal energy efficiency ratio (SEER), BtuW-h	13
Existing electric air conditioner SEER, Btu/W-h	9.7
New heat pump heating seasonal performance factor (HSPF) used in Eq. 1 in Ref. 6, Btu/W-h	7.7
Existing heat pump HSPF , Btu/W-h	6.6
New heat pump SEER, Btu/W-h	13.
Existing heat pump SEER, Btu/W-h	9.7

2.3 COST ASSUMPTIONS

Based upon comments, economic lifetimes have been extended to 40 years for new houses and 30 years for existing houses. The previous values were 30 years for new houses and 20 years for existing houses. (In fact, this change made little difference in the results because the additional ten years of savings occurs far in the future and are therefore heavily discounted in the savings calculation.)

Current energy prices, on a state-average basis, come from the Energy Information Administration (EIA), as in previous editions of the fact sheet.[14] For natural gas, fuel oil, and propane, the price represents the average retail price from October 2006 to March 2007. For electricity, summer prices from 2006 were used. The National Institute of Standards and Technology provides escalation factors for energy.[15] These energy prices and escalation factors are all summarized in Appendix B. A number of reviewers objected to the near-level nature of the official energy price projections, arguing that energy prices are likely to rise significantly. However, we are interested in the increase in price relative to general inflation, and much of the general inflation index is driven by energy costs. Also, we doubted that any other crystal ball would be demonstrably better than the National Energy Modeling System used by the DOE to develop the projections. (The reader may be interested in looking at the EIA's own assessment of its predictions vs. reality.[16])

Because the Fact Sheet analysis has always been focused on finding the optimal life-cycle savings, the least cost option that provides a given level of thermal performance is used in the database. That is, if two products provide the same R-value but have different costs, the lower cost is used. It also follows that the database will not include an option for a given R-value if a higher R-value is available at a lower cost. The results have never specified products by name or material, only by R-value.

Prior to 1997, insulation cost data were based on a 1986 survey by the National Association of Home Builders (NAHB). The NAHB survey defined costs for insulation measures in new construction only, but was also used to represent retrofit costs. Because insulation amounts often increase in discrete steps, the recommendations for insulation are very sensitive to the cost assumptions used in the life-cycle analysis. A sensitivity study was made in 1995 varying the cost of insulation by ±20%. This changed the recommended level of insulation by a factor of two in many parts of the country. Given this sensitivity, a survey of insulation costs was commissioned as a part of the 1997 revision to the fact sheet.[17] That survey, which began with the lofty goal of obtaining regional data from a large number of installers, cost ~ $100K, and in the end received complete survey results from a relatively small number of contractors, even after the survey program was modified to reimburse the contractors for their time. That survey solicited separate estimates for retrofit and new construction.

There were five main sources for the cost data used in the 2008 Fact Sheet update:

- Original database used in development of the 1988 Fact Sheet: ("Costs were developed from the NAHB/RF's cost data base and verified by telephone calls to local builders, subcontractors, and building material suppliers.")[18]
- Survey performed for the 1997 update to the Insulation Fact Sheet: approximately 30 contractors and 18 builders responded,[17]
- Database for Energy Efficient Resources (DEER), California Public Utilities Commission, 2005 Update,[19]
- RS Means Building Construction Cost Data, 2007 (which was also the source for historical escalation factors and zip-code specific city cost factors),
- Informal review of insulation material prices on the Internet and by phone during the summers of 2006 and 2007, and
- BNi Building News Home Builder's 2008 Costbook and BNi Building News Home Remodeler's 2008 Costbook[20,21](provided a point of comparison between new construction and retrofit applications).

Each of these sources provided useful, if limited, information. The original database had arguably the best resource of contractor and builder price information, but is now almost 20 years old. The 1996 survey was ambitious in intent, but received responses from a relatively small number of contractors and builders, and is now 10 years old. In 1997, the Fact Sheet was updated using a combination of the 1988 and 1996 surveys. These prices were updated to 2007 using the R. S. Means historical cost factor, and are referred to here as the "1997 Fact Sheet Updated". The DEER database is more current, but reflects California prices, which tend to be 5 to 20% greater than the national average based upon the R.S. Means city cost indices. Also, the DEER documentation is not specific about the ultimate source of the data provided in the DEER database for envelope measures. The R.S. Means database is comprehensive, but is based upon union labor costs for large building projects and many reviewers have noted that its prices are significantly higher than typical residential construction costs. Considering the wide diversity in these sources, they were surprisingly often in the same ballpark, as shown in Table 3. The phone review of materials prices summarized in Table 4 is a useful touch point, but provides retail prices, higher than the prices that would be paid by many contractors.

The prices used in this update are shown in Appendix B and were based upon the following considerations:

Location Indices: The RS Means city cost indices are current and specific to thermal and moisture protection.

Historical Cost Factors: The RS Means historical cost factors are based on national averages and are not specific to thermal and moisture protection. The R. S. Means historical update factor from 1996 to 2007 was 1.5.

Attics: The contractors provided blown-in loose fill data in 1996 which, when updated to 2007, was within a few cents of the DEER database. The RS Means values were 42% to 67% higher for comparable R-values. The updated 1996 values were selected.

Cathedral Ceilings: The contractors provided installed batt prices in 1996. There is no comparable entry in the DEER database. The RS Means values for blown-in open-celled foam are more than 10 times higher on a per R-value basis than the updated batt prices. Therefore, the updated 1996 values were selected.

Walls: In 1996, contractors provided information for batts used in combination with foam sheathing boards. The R13, R15, and R21 products were new and had premium prices at that time. This is demonstrated by comparing the updated prices for these insulation levels to the 2005 DEER prices for California, as shown in Table 3. A comparison of retail prices for a single brand in 2007 showed a $0.05 premium for R13 compared to R11, not the escalated difference of $0.09. The price for R13 was therefore conservatively set at $0.51, six cents more than R11 and ten cents less than R15. For R15 and the R5/R13 combination, the DEER prices of $0.61 and $1.37, respectively, were used. For the thicker walls, the DEER prices don't include the extra cost of framing as do the escalated 1996 values. The polyisocyanurate foam board was not included in the previous data base. For this level, the price premium of $0.08/ft^2-R found in the material survey was used to determine the price differential between the extruded polystyrene (XPS) at R5 and the polyiso at R6. The mass wall prices are based on the assumed placement of expanded polystyrene (EPS) between concrete block and a brick façade (unchanged approach since 1986). Other mass wall options were considered, but it's problematical to separate out the cost of the wall from the cost of the insulation system, as was carefully done by the NAHB in 1986. Structural Insulated Panels (SIP) and Exterior Insulation and Finish Systems (EIFS) were also examined. Using R. S. Means prices, an attempt was made to determine the incremental costs for these two wall systems beyond the traditional insulated wall cost. The results were higher than the other wall insulation options for comparable R-values, and so were not included here, although these two options are included in the design options portion of the fact sheet.

Floors: The updated 1996 prices were slightly less than the DEER prices and were selected. R-30 was not considered in 1996, so the DEER price was used for that level.

Slab Edge: The updated 1996 prices were used for R4 and R8 for the 2-foot depth. These prices were used, along with the current retail material prices, to estimate the installation cost. This cost, was used along with increased material costs to estimate the R12 price. For the 4-foot depths, it was assumed that both the installation and material costs would double.

Crawl Space Walls, Basement Walls, and Band Joists: These measures were not included in the DEER or R. S. Means data bases so the updated 1996 values were used. The premium for R13 in a crawl space was only $0.06/ft^2 above R11, so that price was used unchanged. For crawl spaces, the premium for R15 was much higher, so that was reduced to a price difference of $0.10/ft^2 relative to R13 (consistent with the price differential for walls). R25 was not included in 1996, so that price was calculated by adding $0.12/ft^2 to the R19 price, based on an average cost of $0.02/ft^2-R for the batt products. For crawl spaces, the coverage was quoted for a four-foot high wall with the insulation extending two feet over the ground (i.e., six square feet for each foot of perimeter length). For basements, the height is assumed to be eight feet, and the cost of framing to accommodate the insulation is included, but the final layer of wallboard or paneling is not. A batt product with a special facing is also included for unfinished basements. An Internet examination found batt products rated at R3 and R6 to fit within furring strip dimensions, but no prices were available so these were not included.

3. SUMMARY OF REVISIONS TO THE INSULATION FACT SHEET

Traditionally, the Fact Sheet's role has been to provide the best guidance possible for the individual homeowner. That goal has shaped the calculation approach – which has been to find the insulation level that offers the optimal life cycle cost for a particular homeowner, considering their own fuel costs and other factors. There were always major differences between the calculations used to develop code requirements and those that produce the Fact Sheet's recommendations. Most importantly, the code values are generic with respect to fuel, are focused on new construction, and provide values for broad climatic regions. After considering these factors, we decided to continue to provide recommendations based upon specific fuels and local insulation costs, including variations between costs for new and retrofit installations. This process can provide supplemental information to the individual homeowner beyond that needed for code compliance.

The old 3-layered tables used in the printed version of the fact sheet, that called for using your zip code, house type, and fuel type to identify your "insulation zone" are gone. Most readers will either use the Internet's active look-up table for their zip code or will run the interactive Java version of the ZipCode computer model. Ranges of recommended R-values were prepared for those who need a quick visual summary consistent with the IECC climate zones.

There were many requests to expand the scope of the Insulation Fact Sheet. But we were concerned that the document was in danger of morphing from a consumer-friendly fact sheet into a less useful reference book. To address both the need to provide information about related topics, such as super-efficient homes, and to restrict the overall size of the fact sheet, we expanded the use of web links to other DOE web sites. Thus, the discussion of air sealing and moisture was reduced somewhat, but links were added to other fact sheets that provide much more extensive and detailed information on these topics.

To improve the usability of the web site, the material was more clearly separated into information for existing homes and information for new homes. A new section was added to discuss design options for new homes, including structural insulated panels, insulated concrete forms, massive construction techniques, and cathedralized attics. Insulation materials that were not on the market in 1997, such as icynene foam, were added.

Using the email links provided at the bottom of each fact sheet web page, consumers contact us on a regular basis. We'll be watching this feedback over the next several months to assess whether any further changes or modifications are needed to meet the needs of the fact sheet readers.

Table 3 Comparison of selected installed costs for insulation measures in new houses

Sheathing Insulation R-Value (h-ft^2-°F/Btu)	**Cavity Insulation R-Value** (h-ft^2-°F/Btu)	**1997 Fact Sheet Updated to 2007**	**DEER**	**RS MEANS**
		Attic		
	11	\$0.36		\$0.60
	19	\$0.50	\$0.62	\$0.71
	30	\$0.68	\$0.76	
	38	\$0.84	\$0.86	\$1.53
	49	\$1.02	\$0.86	
		Floor		
	13	\$0.62	\$0.69	
	19	\$0.80	\$0.89	
		Wall		
	11	\$0.45		\$0.70
	15	\$0.84	\$0.61	
	19	\$1.91	\$0.65(a)	\$0.81(a)
	21	\$2.07	\$0.68(a)	
5	13	\$1.41	\$1.37	
5	19	\$2.78	\$1.56(a)	
5	21	\$2.94	\$1.84(a)	
		Mass wall		
3.8		\$0.33		\$0.87 or 2.16
7.6		\$0.78		\$3.74
		Optimal Value Engineering wall		
2.5	19	\$1.37		
5	19	\$1.53	\$1.56	
5	21	\$1.70	\$1.84	
	19	\$0.66	\$0.65	
	21	\$0.83	\$0.68	
(a) These costs don't appear to include the extra framing costs associated with the greater wall depth.				

Table 4 Retail material costs in 31 states reviewed in 2006 and 2007

Material	Number of data points	$/ft^2-R (standard deviation)	
		2006	2007
Fiberglass batts			
R11	1		$0.034
R13	28 in 2006, 3 in 2007	$0.027 ($0.005)	$0.030 ($0.005)
R15	1		$0.031
R19	3	$0.025 ($0.001)	
R30	4	$0.017 ($0.009)	
Extruded polystyrene			
0.5 in.	16	$0.114 ($0.030)	
0.5 in foil-faced	1	$0.197	
0.75 in. foil-faced	1	$0.097	
0.75 in.	2	$0.092	
1.5 in.	1	$0.088	
Polyisocyanurate			
.5 in. foil-faced	4	$0.172 ($0.058)	
1 in. foil-faced	1	$0.186	
2 in. foil-faced	1	$0.161	
Expanded polystyrene			
0.75 in. R2.9	1		$0.113
1 in. R3.9	1		$0.095
2 in. R7.8	1		$0.090
Cellulose			
	22	$0.011 ($0.003)	

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APPENDIX A PUBLIC REVIEW COMMENTS

The following tables summarize the comments received.

Table 5 Presentation Issues

Completely re-write and improve focus on consumer - add more practical advice - make it shorter. Convert into separate brochures, one for new and one for existing houses.
Add more regarding air infiltration and air sealing, comfort issues - refer to Weatherization and Building America programs. Add 'performance - based compliance to construction'.
Add more warnings about poor installations
Point out that insulation is typically enclosed and difficult to upgrade at a later date.
Get rid of awkward tables
Add embodied energy issues. Talk about environmental benefits, emissions savings in terms of equivalent car miles driven.
Improve comparisons between material types: compression, combustibility, air sealing. Add more information regarding low-density foam and cellulose, Eliminate mention of R-11 and R-15 batts, De-emphasize fiberglass.
Update to include recent research on cathedralized/unvented attics
Revise or eliminate references
Moisture section - make it shorter while adding more 'actionable items'
De-emphasize R-value. Focus on super-efficient homes, especially use of cellulose, but don't go as far as zero energy homes, add information on HVAC sizing, duct placement, windows, radon, IAQ, etc.

Table 6 Code Related Issues

Stick with code R-values
Use code as minimum R-value considered
Comparison of 03 to current codes that shows many reduced levels due to combination of more climate zones into fewer climate zones
Don't increase above code R-values
Use DOE, IECC, and International Residential Code climate zones

Table 7 Economic Calculation Issues

Gather new cost data from more contractors, include sub-state price variability (urban, rural), consider future price decreases due to increased market penetration
If we don't gather new information, update old
Update fuel prices
Report results for ranges of energy and insulation costs - then make max R the recommended level
Account for future increases in insulation installation cost as an avoided cost now.
Assign value to future emissions reductions (use European Kyoto credit value)
Savings due to reducing HVAC-duct system size
Higher discount rate, longer lifetime (50 years), add energy price taxes, demand charges, etc.,

Consider relative magnitude of energy price increases and insulation price
Use statistically mixed bag of fuel types and house
Change assumptions to produce a "high efficiency" home; do not use assumptions that produce results similar to code. Points to Energy Star that uses codes as 'base'.
Add windows glazing and related impact on recommended R-values
Perform independent projection of fuel price increases instead of using DOE projections

Table 8 Thermal Calculation Issues

Use best models available to achieve highest accuracy and apply to statistically defined house type and fuel
Continue to use 1-D models
Use better models to more properly represent massive systems. New models show that summer energy penalties outweigh winter savings for basement insulation in many zones.
Don't evaluate R-15 high density batts because they are only produced by fiberglass manufacturers
Change the assumed duct location to inside the envelope.
Credit foam and cellulose with air sealing so lower R-value has added value

APPENDIX B VALUES USED IN THE 2008 UPDATE TO THE INSULATION FACT SHEET

Table 9 Insulation cost and performance parameters used for 2008 fact sheet analysis for above-ground measures

Cavity Insulation R-Value (h-ft^2-°F/Btu)	**Sheathing Insulation R-Value** (h-ft^2-°F/Btu)	**Total Composite U-Value**	**Cost, new construction (retrofit)$/ft^2**
Wood-framed attic, Base U-Value = 0.254			
11		0.0688	0.36 (0.41)
19		0.0455	0.50 (0.56)
30		0.0333	0.68 (0.74)
38		0.0241	0.84 (0.90)
49		0.0199	1.02 (1.16)
60		0.0193	1.23 (1.37)
Cathedral Ceiling, Base U-Value = 0.2616			
13		0.0666	0.62
15		0.0607	0.72
19		0.0493	0.80
22		0.0434	0.93
30		0.0332	1.10
38		0.027	1.31
49		0.0216	3.03
60		0.0178	3.44
Wood-framed wall, Base U-Value = 0.3079			
13		0.0812	0.51 (1.32)
15		0.0723	0.61
13	2.5	0.0675	1.21
15	2.5	0.0613	1.28
13	5	0.0577	1.37
15	5	0.0531	1.43
15	6	0.0504	1.91
21	2.5	0.048	2.64
21	5	0.0429	2.81
21	6	0.0411	3.29
	2.5	0.1480	(0.76)
	5	0.1210	(0.92)
	6	0.1160	(1.40)
11 pre-existing	2.5	0.0700	(0.76)
11 pre-existing	5	0.0630	(0.92)
11 pre-existing	6	0.0620	(1.40)
Optimum Value Engineered Wall, Base U-Value = 0.3079			
19		0.0662	0.65
21		0.0546	0.68

Cavity Insulation R-Value (h-ft^2-°F/Btu)	**Sheathing Insulation R-Value** (h-ft^2-°F/Btu)	**Total Composite U-Value**	**Cost, new construction (retrofit)$/ft^2**
21	2.5	0.048	1.40
21	5	0.0429	1.53
21	6	0.0411	2.18
Mass wall insulation, Base U-Value = 0.2525			
3.9		0.1437	1.06(1.11)
7.8		0.0921	1.41(1.46)
11.7		0.0678	1.76(1.81)
15.6		0.0536	2.11(2.16)
Metal-framed attic, Base U-Value = 0.592			
11		0.386	0.36(0.41)
19		0.278	0.50(0.56)
30		0.047	0.68(0.74)
38		0.034	0.84(0.90)
49		0.025	1.02(1.16)
38	5	0.025	1.71
49	5	0.020	1.89
49	10	0.018	2.30
Metal-framed wall, Base U-Value = 0.5774			
0	2.5	0.2363	0.71(0.76)
0	5	0.1485	0.87(0.92)
13	2.5	0.1102	1.21
15	2.5	0.1013	1.28
13	5	0.0864	1.37
15	5	0.0808	1.43
13	6	0.0795	1.85
15	6	0.0748	1.91
13	10	0.0603	2.23
15	10	0.0576	2.25
19	10	0.0554	3.65
21	10	0.0506	3.68
13		0.1522	(1.32)
11 pre-existing	2.5	0.1209	(0.76)
11 pre-existing	5	0.0928	(0.92)
11 pre-existing	6	0.0849	(1.40)
Band joist insulation, Base U-Value = 0.197			**Cost, $/ linear foot**
13		0.059	0.54
19		0.044	0.68
30		0.031	0.90

Table 10 Insulation cost used for 2008 fact sheet analysis for foundation measures

	Energy saving factors[a]		**New construction**	**Retrofit**
R-Value (h-ft^2-°F/Btu)	β_h	β_c	**$/ft^2**	**$/ft^2**
Wood floor				
13	1.8	0.12	0.62	0.69
19	1.96	0.12	0.80	0.87
25	2.12	0.12	0.93	1.14
30	2.22	0.12	1.34	1.34
Metal-framed floor				
13	1.14	0.07	0.62	0.69
19	1.33	0.09	0.80	0.87
25	1.45	0.1	0.93	1.14
30	1.52	0.11	1.34	1.34
			$/linear foot of perimeter	**$/linear foot of perimeter**
Slab edge				
4, 2 ft	2.79	0.23	2.10	
8, 2 ft	3.25	0.25	2.73	
12, 2ft	3.53	0.25	3.36	
4, 4 ft	3.56	0.23	4.20	
8, 4 ft	4.25	0.25	5.46	
12, 4 ft	4.72	0.25	6.72	
Crawl space wall				
13	22.2	0.94	3.69	3.96
15	22.5	0.93	4.29	4.56
19	22.9	0.94	4.68	4.95
25	23.3	0.96	5.40	5.67
Basement exterior				
4	28.57	0.45	9.30	
5	30	0.47	10.52	
8	32.75	0.5	13.95	
10	34	0.51	16.31	
12	35.03	0.52	18.45	
15	35.35	0.54	21.83	
Basement interior finished				
11	34.24	0.51	9.72	10.12
13	34.59	0.51	10.80	11.20
15	34.85	0.52	11.60	12.00
19	35.2	0.52	13.95	14.35
25	35.8	0.53	14.91	15.31
Basement interior unfinished				
111	34.24	0.51	6.36	6.41

[a] See Ref. 17, Eqs. 4 and 5

Table 11 Residential Energy Prices for 2008 Update

State	Electricity (cents/kWh)	Oil (cents/gal)	Propane (cents/gal)	Gas ($/1000 ft^3)
AL	9.07	242	199	18.11
AK	15.40	242	199	7.77
AZ	9.76	242	199	16.75
AR	8.95	242	199	12.47
CA	14.90	242	199	10.96
CO	9.12	242	199	8.95
CT	17.25	249	221	15.91
DE	12.47	244	246	16.32
DC	10.37	273	236	15.52
FL	11.33	231	215	20.02
GA	9.37	231	215	16.26
HI	24.00	242	199	33.66
ID	6.29	242	199	11.92
IL	9.00	231	179	9.80
IN	8.58	230	189	10.84
IA	10.02	226	150	11.45
KS	8.68	231	179	12.12
KY	7.39	220	202	11.13
LA	9.16	242	199	13.19
ME	15.13	227	243	16.54
MD	10.29	243	252	14.62
MA	16.90	233	228	16.21
MI	10.34	235	193	10.53
MN	8.94	232	171	10.78
MS	9.67	242	199	12.45
MO	8.10	231	166	13.09
MT	8.46	242	199	9.58
NE	8.10	215	144	10.49
NV	11.04	242	199	14.08
NH	14.98	238	238	15.82
NJ	13.35	248	259	14.66
NM	9.14	242	199	11.58
NY	17.06	253	227	14.87
NC	9.21	228	204	15.37
ND	7.79	231	148	9.14
OH	9.94	220	203	13.04
OK	8.82	231	179	12.19
OR	7.45	242	199	14.68
PA	10.80	235	229	14.15
RI	15.35	238	292	17.06
SC	9.16	231	215	16.86
SD	8.31	231	149	10.21
TN	7.97	231	179	13.74
TX	13.05	242	199	11.78

State	Electricity (cents/kWh)	Oil (cents/gal)	Propane (cents/gal)	Gas ($/1000 ft^3)
UT	7.86	242	199	9.65
VT	13.71	256	249	15.22
VA	8.86	232	230	14.82
WA	6.77	234	199	13.88
WV	6.49	231	215	15.00
WI	10.64	231	178	11.43
WY	8.20	242	199	9.29
VI	24.00	242	199	33.66
PR	24.00	242	199	33.66
GU	24.00	242	199	33.66

Table 12 Projected fuel price escalation indices (excluding general inflation) for Census Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont)

	Electricity	Distillate Oil	LPG	Natural Gas
2008	0.98	0.99	1.03	0.97
2009	0.98	0.93	1.01	0.94
2010	0.97	0.87	0.99	0.91
2011	0.96	0.82	0.98	0.89
2012	0.96	0.79	0.97	0.87
2013	0.97	0.74	0.96	0.86
2014	0.96	0.73	0.96	0.85
2015	0.96	0.73	0.96	0.85
2016	0.97	0.73	0.96	0.85
2017	0.97	0.74	0.96	0.87
2018	0.98	0.74	0.96	0.87
2019	0.98	0.75	0.96	0.87
2020	0.98	0.76	0.96	0.88
2021	0.98	0.77	0.96	0.87
2022	0.98	0.78	0.96	0.88
2023	0.98	0.78	0.97	0.89
2024	0.99	0.78	0.97	0.9
2025	0.99	0.79	0.97	0.9
2026	0.99	0.79	0.97	0.91
2027	0.99	0.8	0.98	0.91
2028	1	0.8	0.98	0.92
2029	1	0.81	0.98	0.93
2030	1	0.82	0.99	0.94
2031	1	0.82	0.99	0.94
2032	1.01	0.82	0.99	0.95
2033	1.01	0.82	0.99	0.95
2034	1.01	0.82	0.99	0.96
2035	1.01	0.82	0.99	0.97
2036	1.02	0.82	0.99	0.97
2037	1.02	0.82	0.99	0.98

Table 13 Projected fuel price escalation indices (excluding general inflation) for Census Region 2 (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin)

	Electricity	Distillate Oil	LPG	Natural Gas
2008	1.01	0.98	1.05	0.97
2009	1.02	0.93	1.03	0.93
2010	1.02	0.86	1.01	0.9
2011	1.02	0.8	1	0.87
2012	1.01	0.74	0.99	0.85
2013	1.01	0.7	0.98	0.84
2014	1	0.68	0.98	0.84
2015	1	0.68	0.97	0.83
2016	1	0.68	0.98	0.84
2017	1.01	0.69	0.99	0.86
2018	1.02	0.7	0.99	0.86
2019	1.02	0.71	0.98	0.86
2020	1.02	0.71	0.99	0.86
2021	1.02	0.72	0.99	0.86
2022	1.02	0.73	0.99	0.87
2023	1.02	0.73	1	0.89
2024	1.02	0.73	1	0.9
2025	1.02	0.74	1	0.9
2026	1.02	0.74	1	0.9
2027	1.02	0.75	1.01	0.91
2028	1.02	0.75	1.01	0.92
2029	1.02	0.76	1.02	0.93
2030	1.02	0.77	1.02	0.94
2031	1.02	0.77	1.02	0.95
2032	1.02	0.77	1.02	0.95
2033	1.02	0.77	1.02	0.96
2034	1.02	0.77	1.02	0.97
2035	1.02	0.77	1.02	0.97
2036	1.02	0.77	1.03	0.98
2037	1.02	0.77	1.03	0.99

Table 14 Projected fuel price escalation indices (excluding general inflation) for Census Region 3 (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee

	Electricity	Distillate Oil	LPG	Natural Gas
2008	0.99	0.99	1.03	0.97
2009	0.98	0.93	1.01	0.94
2010	0.97	0.88	1	0.91
2011	0.96	0.83	0.98	0.88
2012	0.94	0.79	0.97	0.86
2013	0.93	0.74	0.96	0.85
2014	0.93	0.73	0.96	0.85
2015	0.93	0.73	0.96	0.85
2016	0.93	0.73	0.96	0.86
2017	0.93	0.74	0.97	0.87
2018	0.94	0.75	0.97	0.88
2019	0.94	0.75	0.97	0.88
2020	0.94	0.76	0.97	0.89
2021	0.94	0.77	0.97	0.89
2022	0.94	0.78	0.98	0.89
2023	0.94	0.78	0.98	0.91
2024	0.94	0.78	0.99	0.92
2025	0.95	0.79	0.99	0.92
2026	0.95	0.79	0.99	0.92
2027	0.95	0.8	0.99	0.93
2028	0.95	0.81	0.99	0.94
2029	0.95	0.81	1	0.95
2030	0.95	0.82	1	0.95
2031	0.95	0.82	1	0.96
2032	0.95	0.82	1	0.96
2033	0.96	0.82	1	0.97
2034	0.96	0.82	1	0.98
2035	0.96	0.82	1	0.98
2036	0.96	0.82	1	0.99
2037	0.96	0.83	1	1

Table 15 Projected fuel price escalation indices (excluding general inflation) for Census Region 4 (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming)

	Electricity	Distillate Oil	LPG	Natural Gas
2008	1	0.96	1.03	0.97
2009	0.99	0.92	1.02	0.95
2010	0.97	0.86	1	0.92
2011	0.95	0.81	0.99	0.89
2012	0.93	0.76	0.98	0.88
2013	0.93	0.71	0.97	0.86
2014	0.93	0.71	0.97	0.86
2015	0.93	0.7	0.97	0.86
2016	0.93	0.71	0.97	0.86
2017	0.94	0.71	0.98	0.88
2018	0.94	0.72	0.97	0.86
2019	0.94	0.74	0.96	0.85
2020	0.94	0.75	0.96	0.85
2021	0.94	0.76	0.97	0.86
2022	0.94	0.77	0.97	0.87
2023	0.95	0.77	0.98	0.89
2024	0.95	0.78	0.98	0.9
2025	0.95	0.79	0.99	0.9
2026	0.96	0.8	0.99	0.91
2027	0.96	0.81	0.99	0.91
2028	0.96	0.82	1	0.93
2029	0.96	0.83	1	0.94
2030	0.97	0.84	1	0.95
2031	0.97	0.84	1.01	0.96
2032	0.98	0.84	1.01	0.96
2033	0.98	0.84	1.01	0.97
2034	0.98	0.84	1.01	0.98
2035	0.99	0.84	1.01	0.98
2036	0.99	0.84	1.01	0.99
2037	1	0.84	1.01	1

Table 16 Zip codes, heating degree days (HDD, base 65, ÷1000), cooling degree hours (CDH, base 74F, ÷1000), fuel price escalation region (FER), insulation cost factor (ICF), IECC region

Zip	Location	State	HDD	CDH	FER	ICF	IECC
1	ZIP_NOT_ASSIGNED		0	0	0		0
2	ZIP_NOT_ASSIGNED		0	0	0		0
3	ZIP_NOT_ASSIGNED		0	0	0		0
4	ZIP_NOT_ASSIGNED		0	0	0		0
5	Holtzville	NY	5.4	3.7	1	127	4
6	Puerto Rico	PR	0	55.2	3	93	1
7	Puerto Rico	PR	0	55.2	3	93	1
8	Virgin Islands	VI	0	55.1	3	93	1
9	Puerto Rico	PR	0	55.2	3	93	1
10	Amherst	MA	6.9	2.9	1	104	5
11	Springfield	MA	6.9	5.2	1	104	5
12	Pittsfield	MA	7.4	1.2	1	103	5
13	Greenfield	MA	6.9	2.9	1	103	5
14	Fitchburg	MA	6.8	3.3	1	113	5
15	Worcester	MA	6.8	1.5	1	113	5
16	Worcester	MA	6.8	1.5	1	113	5
17	Framingham	MA	6.1	4.2	1	115	5
18	Lawrence	MA	6.5	3.6	1	114	5
19	Glouchester	MA	5.7	1.1	1	115	5
20	Boston	MA	5.6	5.4	1	117	5
21	Boston	MA	5.6	5.4	1	117	5
22	Boston	MA	5.6	5.4	1	117	5
23	Brockton	MA	6	3.4	1	115	5
24	Wellesley	MA	6	4.2	1	117	5
25	Buzzards Bay	MA	5.7	0.9	1	114	5
26	Hyannis	MA	6	2	1	114	5
27	New Bedford	MA	5.7	6.4	1	114	5
28	Kingston	RI	6	1.7	1	104	5
29	Providence	RI	5.8	3.6	1	104	5
30	Nashua	NH	6.8	1.6	1	95	5
31	Manchester	NH	7.5	1.6	1	94	6
32	Plymouth	NH	8.3	1.3	1	94	6
33	Concord	NH	7.5	2	1	94	6
34	Keene	NH	7.5	2.2	1	77	6
35	Bethlehem	NH	8.3	1.2	1	78	6
36	Charlestown	NH	7.5	2.2	1	76	6
37	Hanover	NH	7.3	1.9	1	76	6
38	Durham	NH	6.7	2.2	1	97	5
39	Kittery	ME	7.6	2.2	1	81	6
40	Bridgton	ME	8.2	1.1	1	83	6
41	Portland	ME	7.3	1.1	1	83	6
42	Lewiston	ME	7.1	2.3	1	82	6

Zip	Location	State	HDD	CDH	FER	ICF	IECC
43	Augusta	ME	7.4	2.2	1	80	6
44	Bangor	ME	7.7	1.2	1	82	6
45	Bath	ME	7.3	1.1	1	82	6
46	Ellsworth	ME	7.5	1	1	82	6
47	Caribou	ME	9.6	0.9	1	82	6
48	Rockland	ME	7.4	1	1	82	6
49	Waterville	ME	8	1.8	1	81	6
50	Woodstock	VT	8.1	1.1	1	74	6
51	Bellows Falls	VT	7.2	2.2	1	80	6
52	Bennington	VT	7.9	0.8	1	81	6
53	Brattleboro	VT	7.2	2.2	1	81	6
54	Burlington	VT	7.7	2.6	1	80	6
55	ZIP_NOT_ASSIGNED		0	0	0	0	0
56	Montpelier	VT	8.2	1.4	1	80	6
57	Rutland	VT	7.3	1.8	1	80	6
58	St. Johnsbury	VT	7.8	1.9	1	76	6
59	Canaan	VT	8.9	1.5	1	76	6
60	Hartford	CT	6.1	4.8	1	108	5
61	Hartford	CT	6.1	4.8	1	108	5
62	Storrs	CT	6.4	1.3	1	107	5
63	Norwich	CT	5.9	1.7	1	107	5
64	Milford	CT	5.4	5	1	107	5
65	New Haven	CT	5.4	5	1	108	5
66	Bridgeport	CT	5.4	5	1	109	5
67	Waterbury	CT	6.1	2	1	108	5
68	Danbury	CT	6.1	2.9	1	110	5
69	Stamford	CT	5.6	3.6	1	110	5
70	Boonton	NJ	5.8	3.9	1	111	5
71	Newark	NJ	4.8	9.1	1	111	4
72	Elizabeth	NJ	4.8	9.1	1	111	4
73	Jersey City	NJ	5.4	7	1	110	5
74	West Milford	NJ	6.4	3.9	1	108	5
75	Paterson	NJ	4.8	6.1	1	108	4
76	Hackensack	NJ	4.8	6.1	1	108	4
77	Long Branch	NJ	5.2	5.2	1	111	4
78	Newton	NJ	6.4	2.8	1	111	5
79	Morris Plains	NJ	5.9	4	1	111	5
80	Hammonton	NJ	5	7.6	1	108	4
81	Camden	NJ	4.8	8.9	1	108	4
82	Atlantic City	NJ	5.1	6.2	1	108	4
83	Millville	NJ	4.8	7.4	1	108	4
84	Atlantic City	NJ	5.1	6.2	1	108	4
85	Hightstown	NJ	5.4	5.5	1	107	5
86	Trenton	NJ	5.4	7.4	1	107	5
87	Toms River	NJ	5.2	7.6	1	111	4
88	Somerville	NJ	5.8	5.7	1	110	4
89	New Brunswick	NJ	5.3	5.7	1	110	4
90	ZIP_NOT_ASSIGNED		0	0	0	0	0

Zip	Location	State	HDD	CDH	FER	ICF	IECC
91	ZIP_NOT_ASSIGNED		0	0	0	0	0
92	ZIP_NOT_ASSIGNED		0	0	0	0	0
93	ZIP_NOT_ASSIGNED		0	0	0	0	0
94	ZIP_NOT_ASSIGNED		0	0	0	0	0
95	ZIP_NOT_ASSIGNED		0	0	0	0	0
96	ZIP_NOT_ASSIGNED		0	0	0	0	0
97	ZIP_NOT_ASSIGNED		0	0	0	0	0
98	ZIP_NOT_ASSIGNED		0	0	0	0	0
99	ZIP_NOT_ASSIGNED		0	0	0	0	0
100	New York	NY	4.9	9.5	1	132	4
101	New York	NY	4.9	9.5	1	132	4
102	New York	NY	4.9	9.5	1	132	4
103	Staten Island	NY	4.9	7	1	128	4
104	Bronx	NY	4.9	9.2	1	128	4
105	Scarsdale	NY	5.4	5.4	1	122	4
106	White Plains	NY	5.4	5.4	1	122	4
107	Yonkers	NY	5.4	5.4	1	122	4
108	New Rochelle	NY	5.4	5.4	1	122	4
109	Suffern	NY	5.8	6.1	1	120	4
110	Great Neck	NY	4.9	7.6	1	127	4
111	Woodside	NY	4.9	7.6	1	127	4
112	Brooklyn	NY	4.9	7.6	1	127	4
113	Flushing	NY	4.9	7.6	1	127	4
114	Queens	NY	4.9	7.6	1	127	4
115	Minneola	NY	5.2	7.4	1	124	4
116	Far Rockaway	NY	4.9	7.6	1	127	4
117	Mid-Island	NY	4.9	7.6	1	124	4
118	Hicksville	NY	4.9	7.6	1	124	4
119	Riverhead	NY	5.1	4.7	1	124	4
120	Gloversville	NY	7.6	1.8	1	92	6
121	Troy	NY	6.6	3	1	92	5
122	Albany	NY	6.9	3	1	92	5
123	Schenectady	NY	6.6	3	1	92	5
124	Cairo	NY	6.9	1.8	1	119	5
125	Glenham	NY	5.8	6	1	119	5
126	Poughkeepsie	NY	6.4	4.3	1	119	5
127	Liberty	NY	7.5	0.8	1	119	6
128	Saratoga Springs	NY	6.9	1.8	1	91	5
129	Plattsburgh	NY	7.8	1.9	1	94	6
130	Syracuse	NY	6.8	3.5	1	99	5
131	Syracuse	NY	6.8	3.5	1	99	5
132	Syracuse	NY	6.8	3.5	1	99	5
133	Utica	NY	7.2	2.7	1	92	6
134	Old Forge	NY	9	2.7	1	92	6
135	Utica	NY	7.2	2.7	1	92	6
136	Watertown	NY	7.7	2.7	1	91	6
137	Norwich	NY	7.1	1.3	1	96	5
138	Binghamton	NY	7.2	1.6	1	96	6

Zip	Location	State	HDD	CDH	FER	ICF	IECC
139	Binghamton	NY	7.2	1.6	1	96	6
140	Buffalo	NY	6.7	3	1	104	5
141	Buffalo	NY	6.7	3	1	104	5
142	Buffalo	NY	6.7	3	1	104	5
143	Niagra Falls	NY	6.7	3	1	102	5
144	Rochester	NY	6.7	3.8	1	96	5
145	Rochester	NY	6.7	3.8	1	96	5
146	Rochester	NY	6.7	3.8	1	96	5
147	Jamestown	NY	7	3.7	1	96	5
148	Ithaca	NY	7.2	1.6	1	90	6
149	Elmira	NY	6.8	2.5	1	90	5
150	Donora	PA	5.5	8.4	1	102	5
151	Pittsburgh	PA	5.8	5	1	102	5
152	Pittsburgh	PA	5.8	5	1	102	5
153	Washington	PA	6.3	3.9	1	101	5
154	Uniontown	PA	5.7	6.2	1	100	5
155	Everett	PA	6.2	6.1	1	97	5
156	Derry	PA	5.9	8.4	1	101	5
157	Indiana	PA	6	2.6	1	100	5
158	Du Bois	PA	6.8	1.8	1	100	5
159	Johnstown	PA	5.5	5.7	1	99	5
160	Butler	PA	6.6	4.7	1	100	5
161	New Castle	PA	6.2	4.8	1	99	5
162	Clarion	PA	6.9	2.5	1	100	5
163	Franklin	PA	6.5	2.8	1	98	5
164	Corry	PA	6.8	2	1	99	5
165	Erie	PA	6.2	2.2	1	99	5
166	Altoona	PA	6	1.5	1	97	5
167	Bradford	PA	7.7	0.8	1	98	6
168	State_College	PA	6.3	3.5	1	98	5
169	Wellsboro	PA	7.5	1.4	1	97	6
170	Lewiston	PA	5.9	5.3	1	105	5
171	Harrisburg	PA	5.2	9.1	1	105	4
172	Chambersburg	PA	5.6	5.4	1	91	5
173	Hanover	PA	5.3	7.2	1	102	4
174	York	PA	5.2	6.6	1	102	4
175	Lancaster	PA	5.4	6	1	100	5
176	Lancaster	PA	5.4	6	1	100	5
177	Williamsport	PA	6.1	5	1	98	5
178	Selinsgrove	PA	6.1	5	1	101	5
179	Pottsville	PA	5.4	3	1	101	5
180	Palmerton	PA	5.5	5.5	1	103	5
181	Allentown	PA	5.8	5.8	1	108	5
182	Freeland	PA	7.5	1.7	1	101	6
183	Stroudsburg	PA	6.2	5.3	1	94	5
184	Hawley	PA	7	0.6	1	101	5
185	Scranton	PA	6.2	3.8	1	101	5
186	Wilkes-Barre	PA	6.2	3.8	1	102	5

Zip	Location	State	HDD	CDH	FER	ICF	IECC
187	Wilkes-Barre	PA	6.2	3.8	1	102	5
188	Montrose	PA	7.4	1.6	1	99	6
189	Doylestown	PA	5.4	6.5	1	110	5
190	Philadelphia	PA	4.8	8.9	1	116	4
191	Philadelphia	PA	4.8	8.9	1	116	4
192	Philadelphia	PA	4.8	8.9	1	116	4
193	Southeastern_PA	PA	4.8	8.9	1	112	4
194	Southeastern_PA	PA	5.4	8.9	1	113	5
195	Hamburg	PA	5.8	4	1	105	5
196	Reading	PA	5.4	4	1	105	5
197	Newark	DE	4.7	7.6	3	102	4
198	Wilmington	DE	4.9	8.2	3	102	4
199	Dover	DE	4.2	9.3	3	102	4
200	Washington	DC	4.1	12.4	3	98	4
201	Dulles	DC	4.9	7.7	3	98	4
202	Washington	DC	4.1	12.4	3	98	4
203	Washington	DC	4.1	12.4	3	98	4
204	Washington	DC	4.1	12.4	3	98	4
205	Washington	DC	4.1	12.4	3	98	4
206	LaPlata	MD	4.2	8.2	3	94	4
207	Laurel	MD	4.5	10.5	3	94	4
208	Rockville	MD	5	9.8	3	94	4
209	Silver Spring	MD	4.5	9.8	3	96	4
210	Baltimore	MD	4.7	9.5	3	91	4
211	Baltimore	MD	4.7	9.5	3	91	4
212	Baltimore	MD	4.7	9.5	3	91	4
213	Not used	NU	0	0	0	0	0
214	Annapolis	MD	4.7	9.5	3	90	4
215	Cumberland	MD	5.2	7.1	3	90	4
216	Centreville	MD	4.4	9.1	3	75	4
217	Frederick	MD	4.4	7.3	3	86	4
218	Salisbury	MD	4.3	9.2	3	82	4
219	Elkton	MD	4.6	6.6	3	78	4
220	Northern Virginia	VA	4.1	12.4	3	93	4
221	Northern Virginia	VA	4.1	12.4	3	93	4
222	Arlington	VA	4.1	12.4	3	93	4
223	Alexandria	VA	4.1	12.4	3	94	4
224	Fredericksburg	VA	4.5	10.2	3	86	4
225	Colonial Beach	VA	3.8	10.2	3	86	4
226	Winchester	VA	5.1	8.1	3	89	4
227	Culpeper	VA	4.2	8.9	3	91	4
228	Harrisonburg	VA	5.4	6.5	3	91	4
229	Charlottesville	VA	4.1	10.3	3	87	4
230	Amelia	VA	4.4	11	3	88	4
231	Williamsburg	VA	3.6	11	3	88	4
232	Richmond	VA	3.9	12.3	3	88	4
233	Wallops Island	VA	4.2	13.7	3	88	4
234	Wallops Island	VA	4.2	13.7	3	88	4

Zip	Location	State	HDD	CDH	FER	ICF	IECC
235	Norfolk	VA	3.4	13.7	3	88	4
236	Norfolk	VA	3.4	13.7	3	88	4
237	Portsmouth	VA	3.4	13.7	3	87	4
238	Emporia	VA	3.8	11.5	3	89	4
239	Farmville	VA	4	9.4	3	85	4
240	Roanoke	VA	4.3	9.3	3	88	4
241	Blacksburg	VA	5.6	4.5	3	88	4
242	Abingdon	VA	4.9	8.8	3	85	4
243	Pulaski	VA	5.3	3.3	3	85	4
244	Staunton	VA	5.4	6.5	3	87	4
245	Lynchburg	VA	4.4	8.4	3	89	4
246	Richlands	VA	5.3	2.6	3	85	4
247	Bluefield	WV	4.9	2.6	3	96	4
248	Pineville	WV	5	7.9	3	96	4
249	Lewisburg	WV	5.8	3.7	3	98	4
250	Charleston	WV	4.6	8.8	3	98	4
251	Charleston	WV	4.6	8.8	3	98	4
252	Charleston	WV	4.6	8.8	3	98	4
253	Charleston	WV	4.6	8.8	3	98	4
254	Martinsburg	WV	4.8	8.2	3	90	4
255	Dunlow	WV	5	11.2	3	100	4
256	Logan	WV	4.5	7.5	3	100	4
257	Huntington	WV	4.7	11.2	3	100	4
258	Beckley	WV	5.4	2.1	3	98	5
259	Oak Hill	WV	5.4	4.1	3	98	5
260	Wheeling	WV	5.3	6.8	3	97	4
261	Parkersburg	WV	5.1	9.1	3	97	4
262	Buckhannon	WV	5.7	4	3	97	5
263	Clarksburg	WV	5.5	6.4	3	97	5
264	Clarksburg	WV	5.5	6.4	3	97	5
265	Morgantown	WV	5.3	6.9	3	97	4
266	Gassaway	WV	5	6.3	3	97	4
267	Bayard	WV	7	0.9	3	92	5
268	Moorefield	WV	5.3	4	3	93	4
269	ZIP_NOT_ASSIGNED		0	0	0	0	0
270	Mt. Airy	NC	4.5	8	3	82	4
271	Winston Salem	NC	3.8	11.8	3	81	4
272	Burlington	NC	3.6	13.6	3	82	3
273	Reidsville	NC	3.9	12.9	3	82	4
274	Greensboro	NC	3.8	11	3	82	4
275	Raleigh	NC	3.5	11.8	3	82	3
276	Raleigh	NC	3.5	11.8	3	82	3
277	Durham	NC	3.7	11.8	3	83	4
278	Rocky Mount	NC	3.3	13.8	3	75	3
279	Elizabeth City	NC	3	14	3	76	3
280	Gastonia	NC	3.4	15.9	3	82	3
281	Salisbury	NC	3.9	13.4	3	82	4
282	Charlotte	NC	3.2	15.2	3	82	3

Zip	Location	State	HDD	CDH	FER	ICF	IECC
283	Fayetteville	NC	3.1	15.6	3	82	3
284	Wilmington	NC	2.4	17.6	3	81	3
285	Kinston	NC	3.2	15.7	3	76	3
286	Hickory	NC	3.6	11.1	3	81	3
287	Cullowhee	NC	4.3	4.5	3	81	4
288	Asheville	NC	4.3	6.2	3	81	4
289	Andrews	NC	4.2	5.2	3	76	4
290	Columbia	SC	2.6	22	3	79	3
291	Columbia	SC	2.6	22	3	79	3
292	Columbia	SC	2.6	22	3	79	3
293	Spartanburg	SC	3.1	14.1	3	80	3
294	Charleston	SC	2	23.3	3	80	3
295	Florence	SC	2.5	17.9	3	80	3
296	Greenville	SC	3.3	14.1	3	80	3
297	Chester	SC	3.3	15.8	3	74	3
298	Aiken	SC	2.4	20.3	3	91	3
299	Beaufort	SC	2	21.5	3	76	3
300	Covington	GA	3	16.9	3	92	3
301	Rome	GA	3.5	17.7	3	92	3
302	Newnan	GA	3.1	16.3	3	92	3
303	Atlanta	GA	2.8	16.8	3	92	3
304	Swainsboro	GA	2.2	23	3	78	3
305	Gainesville	GA	3.1	14.8	3	81	4
306	Athens	GA	2.9	16.1	3	84	3
307	Dalton	GA	3.4	14.7	3	80	4
308	Augusta	GA	2.5	19.5	3	83	3
309	Augusta	GA	2.5	19.5	3	83	3
310	Macon	GA	2.4	24.4	3	83	3
311	Atlanta	GA	2.8	16.8	3	83	3
312	Macon	GA	2.4	24.4	3	83	3
313	Ft. Stewart	GA	1.6	23.7	3	82	2
314	Savannah	GA	1.8	22.8	3	82	2
315	Waycross	GA	1.7	23.6	3	77	2
316	Quitman	GA	1.8	26.5	3	83	2
317	Albany	GA	2.1	26.5	3	83	2
318	Columbus	GA	2.2	22.1	3	87	3
319	Columbus	GA	2.2	22.1	3	87	3
320	Jacksonville	FL	1.4	24.2	3	82	2
321	Daytona Beach	FL	0.8	27.1	3	86	2
322	Jacksonville	FL	1.4	24.2	3	82	2
323	Tallahassee	FL	1.6	25.2	3	80	2
324	Panama City	FL	1.8	29	3	72	2
325	Pensacola	FL	1.5	29	3	80	2
326	Gainesville	FL	1.1	27.7	3	81	2
327	Titusville	FL	0.7	29.9	3	86	2
328	Orlando	FL	0.6	34	3	86	2
329	Melbourne	FL	0.6	29.7	3	89	2
330	Miami	FL	0.1	39	3	92	1

Zip	Location	State	HDD	CDH	FER	ICF	IECC
331	Miami	FL	0.1	39	3	92	1
332	Miami	FL	0.1	39	3	92	1
333	Fort Lauderdale	FL	0.2	37.1	3	88	1
334	West Palm Beach	FL	0.2	35.2	3	85	1
335	Tampa	FL	0.6	33.7	3	85	2
336	Tampa	FL	0.6	33.7	3	85	2
337	Saint Petersburg	FL	0.5	38.6	3	78	2
338	Lakeland	FL	0.5	34.9	3	85	2
339	Fort Myers	FL	0.3	37.4	3	83	2
340	Not used	NU	0	0	0	0	0
341	Naples	FL	0.3	34.4	3	83	1
342	Bradenton	FL	0.6	29.2	3	85	2
343	ZIP_NOT_ASSIGNED		0	0	0	0	0
344	Ocala	FL	0.9	32.2	3	81	2
345	ZIP_NOT_ASSIGNED		0	0	0	0	0
346	Brooksville	FL	0.7	29.7	3	85	2
347	Kissimmee	FL	0.7	34	3	86	2
348	ZIP_NOT_ASSIGNED		0	0	0	0	0
349	Fort Pierce	FL	0.5	30.4	3	85	2
350	Birmingham	AL	2.8	21	3	92	3
351	Birmingham	AL	2.8	21	3	92	3
352	Birmingham	AL	2.8	21	3	92	3
353	ZIP_NOT_ASSIGNED		0	0	0	0	0
354	Tuscaloosa	AL	2.8	24	3	83	3
355	Jasper	AL	3.2	18	3	75	3
356	Muscle Shoals	AL	3.2	20.7	3	81	3
357	Huntsville	AL	3.3	18.6	3	89	3
358	Huntsville	AL	3.3	18.6	3	89	3
359	Gadsden	AL	3.2	17.1	3	85	3
360	Montgomery	AL	2.2	24.6	3	84	3
361	Montgomery	AL	2.2	24.6	3	84	3
362	Anniston	AL	2.8	18.2	3	73	3
363	Ozark	AL	1.8	24.6	3	76	3
364	Evergreen	AL	2.1	22.2	3	77	3
365	Mobile	AL	1.7	28.2	3	86	2
366	Mobile	AL	1.7	28.2	3	86	2
367	Selma	AL	2.2	26.5	3	78	3
368	Opelika	AL	2.7	19.2	3	85	3
369	Butler	AL	2.7	23.8	3	78	3
370	Nashville	TN	3.7	18.5	3	83	4
371	Nashville	TN	3.7	18.5	3	83	4
372	Nashville	TN	3.7	18.5	3	83	4
373	Chattanooga	TN	3.4	17	3	82	4
374	Chattanooga	TN	3.4	17	3	82	4
375	Memphis	TN	3	24.5	3	86	4
376	Kingsport	TN	4.2	8.8	3	79	4
377	Knoxville	TN	3.7	15	3	78	4
378	Knoxville	TN	3.7	15	3	78	4

Zip	Location	State	HDD	CDH	FER	ICF	IECC
379	Knoxville	TN	3.7	15	3	78	4
380	Dyersburg	TN	3.3	20.2	3	86	3
381	Memphis	TN	3	24.5	3	86	3
382	Union City	TN	4.3	15	3	76	4
383	Jackson	TN	3.5	18	3	72	4
384	Columbia	TN	4.2	16	3	79	4
385	Cookeville	TN	4.2	7	3	77	4
386	Batesville	MS	3.3	20.6	3	68	3
387	Greenville	MS	2.7	25.5	3	74	3
388	Tupelo	MS	3.1	23	3	71	3
389	Grenada	MS	3.1	26	3	67	3
390	Jackson	MS	2.4	25.2	3	74	3
391	Jackson	MS	2.4	25.2	3	74	3
392	Jackson	MS	2.4	25.2	3	74	3
393	Meridian	MS	2.4	23.8	3	73	3
394	Hattiesburg	MS	2	24.3	3	68	2
395	Gulfport	MS	1.5	27.5	3	75	2
396	McComb	MS	1.9	22.8	3	74	3
397	Columbus	MS	2.7	21.8	3	68	3
398	Albany	GA	2.1	26.5	3	83	3
399	Atlanta	GA	2.8	16.8	3	92	3
400	Louisville	KY	4.4	13.3	3	84	4
401	Hardinsburg	KY	4.4	13.8	3	84	4
402	Louisville	KY	4.4	13.3	3	84	4
403	Mt. Sterling	KY	4.9	10	3	95	4
404	Berea	KY	4.2	11.8	3	95	4
405	Lexington	KY	4.7	11.2	3	95	4
406	Frankfort	KY	5.1	9.7	3	90	4
407	Williamsburg	KY	4.6	11.4	3	80	4
408	Baxter	KY	4.6	7.8	3	80	4
409	Middlesboro	KY	4.6	9.5	3	80	4
410	Covington	KY	5.1	9.3	3	98	4
411	Ashland	KY	5.2	11.4	3	93	4
412	Paintsville	KY	4.4	8.1	3	93	4
413	Jackson	KY	4.4	6.3	3	80	4
414	West Liberty	KY	5.2	8.1	3	80	4
415	Pikeville	KY	4.5	9.5	3	79	4
416	Eastern	KY	4.8	8.1	3	79	4
417	Hyden	KY	4.7	9.5	3	79	4
418	Hyden	KY	4.7	9.5	3	79	4
419	ZIP_NOT_ASSIGNED		0	0	0	0	0
420	Paducah	KY	4.3	16.7	3	92	4
421	Bowling Green	KY	4.2	14.7	3	87	4
422	Russellville	KY	4.4	14.4	3	87	4
423	Owensboro	KY	4.2	14.5	3	90	4
424	Henderson	KY	4.4	14.2	3	95	4
425	Somerset	KY	4.4	9.2	3	82	4
426	Monticello	KY	4.6	9.2	3	82	4

Zip	Location	State	HDD	CDH	FER	ICF	IECC
427	Elizabethtown	KY	4.9	11.8	3	84	4
428	ZIP_NOT_ASSIGNED		0	0	0	0	0
429	ZIP_NOT_ASSIGNED		0	0	0	0	0
430	Columbus	OH	5.5	7.5	2	97	5
431	Lancaster	OH	5.9	8.2	2	97	5
432	Columbus	OH	5.5	7.5	2	97	5
433	Marion	OH	6.3	6.5	2	94	5
434	Bowling Green	OH	6.5	6.6	2	103	5
435	Napoleon	OH	6.6	7.1	2	103	5
436	Toledo	OH	6.5	5.1	2	103	5
437	Cambridge	OH	5.3	5.5	2	95	5
438	Coshocton	OH	5.7	6.6	2	95	5
439	Stuebenville	OH	5.6	5.7	2	103	5
440	Cleveland	OH	6.1	4.8	2	103	5
441	Cleveland	OH	6.1	4.8	2	105	5
442	Akron	OH	5.8	4.8	2	100	5
443	Akron	OH	5.8	4.8	2	100	5
444	Youngstown	OH	6.5	3	2	100	5
445	Youngstown	OH	6.5	3	2	100	5
446	Canton	OH	6.2	4.8	2	98	5
447	Canton	OH	6.2	4.8	2	98	5
448	Mansfield	OH	6.4	4.9	2	99	5
449	Mansfield	OH	6.4	4.9	2	99	5
450	Fairfield	OH	5.3	9.5	2	96	4
451	Hillsboro	OH	5.6	7.1	2	95	4
452	Cincinnati	OH	4.9	10.7	2	95	4
453	Dayton	OH	5.7	8.3	2	96	5
454	Dayton	OH	5.7	8.3	2	96	5
455	Springfield	OH	5.9	8.3	2	96	5
456	Chillicothe	OH	5.6	8	2	96	4
457	Athens	OH	5.7	5.6	2	94	5
458	Lima	OH	5.9	7.5	2	98	5
459	Cincinnati	OH	4.9	10.7	2	95	4
460	Anderson	IN	5.8	9.3	2	92	5
461	Greencastle	IN	5.6	10.2	2	93	5
462	Indianapolis	IN	5.5	9.1	2	93	5
463	Valparaiso	IN	6.3	5.6	2	100	5
464	Gary	IN	6.5	9.1	2	100	5
465	Plymouth	IN	6.5	9.6	2	92	5
466	South Bend	IN	6.3	6.6	2	92	5
467	Fort Wayne	IN	6.2	6.8	2	93	5
468	Fort Wayne	IN	6.2	6.8	2	93	5
469	Kokomo	IN	6.4	11.1	2	91	5
470	Brookville	IN	5.7	7	2	86	5
471	Scottsburg	IN	5.1	10.2	2	78	4
472	Columbus	IN	5.4	8.8	2	87	4
473	Muncie	IN	6	7.1	2	88	5
474	Bloomington	IN	5.3	10.7	2	87	4

Zip	Location	State	HDD	CDH	FER	ICF	IECC
475	Washington	IN	4.6	13.3	2	90	4
476	Evansville	IN	4.6	15	2	91	4
477	Evansville	IN	4.6	15	2	91	4
478	Terre Haute	IN	5.4	9.5	2	90	4
479	Lafayette	IN	6.2	7.7	2	86	5
480	Port Huron	MI	6.8	5.3	2	104	5
481	Ann Arbor	MI	6.5	6.1	2	107	5
482	Detroit	MI	6.4	4.9	2	107	5
483	Milford	MI	7	3.6	2	104	5
484	Flint	MI	7	2.9	2	96	5
485	Flint	MI	7	2.9	2	96	5
486	Saginaw	MI	7.1	3.3	2	96	5
487	Caro	MI	7	3	2	96	5
488	Lansing	MI	7.1	4.1	2	97	5
489	Lansing	MI	7.1	4.1	2	97	5
490	Kalamazoo	MI	6.2	6.3	2	91	5
491	Eau Claire	MI	6.2	5.8	2	91	5
492	Jackson	MI	6.9	4.8	2	94	5
493	Grand Rapids	MI	6.9	4.6	2	78	5
494	Muskegon	MI	6.9	2.9	2	85	5
495	Grand Rapids	MI	6.9	4.6	2	78	5
496	Traverse City	MI	7.6	3	2	81	6
497	Cheboygan	MI	8.4	2	2	80	7
498	Iron Mountain	MI	8.8	1.4	2	89	6
499	Houghton	MI	9.1	1	2	89	7
500	Ames	IA	6.8	7.5	2	92	5
501	Ames	IA	6.8	7.5	2	92	5
502	Ames	IA	6.8	7.5	2	92	5
503	Des Moines	IA	6.4	10.5	2	92	5
504	Mason City	IA	8	6	2	78	6
505	Fort Dodge	IA	7.5	8	2	74	6
506	Waterloo	IA	7.3	6.6	2	79	6
507	Waterloo	IA	7.3	6.6	2	79	6
508	Creston	IA	6.8	9.5	2	82	5
509	Des Moines	IA	6.4	10.5	2	92	5
510	Hawarden	IA	7.6	9.2	2	81	6
511	Sioux City	IA	6.9	10.1	2	81	5
512	Sheldon	IA	8.1	6.6	2	79	6
513	Spencer	IA	7.7	6.1	2	77	6
514	Carroll	IA	7.1	8.2	2	80	5
515	Red Oak	IA	6.5	11.5	2	85	5
516	Shenandoah	IA	6.2	12.7	2	76	5
517	ZIP_NOT_ASSIGNED		0	0	0	0	0
518	ZIP_NOT_ASSIGNED		0	0	0	0	0
519	ZIP_NOT_ASSIGNED		0	0	0	0	0
520	Dubuque	IA	7.3	4.7	2	88	6
521	Decorah	IA	7.4	5.3	2	78	6
522	Cedar Rapids	IA	6.8	7.9	2	92	5

Zip	Location	State	HDD	CDH	FER	ICF	IECC
523	Cedar Rapids	IA	6.8	7.9	2	92	5
524	Cedar Rapids	IA	6.8	7.9	2	92	5
525	Ottumwa	IA	6.1	10	2	82	5
526	Burlington	IA	5.9	10	2	84	5
527	Tipton	IA	7.1	8.8	2	96	5
528	Davenport	IA	6.2	10	2	96	5
529	ZIP_NOT_ASSIGNED		0	0	0	0	0
530	Sheboygan	WI	7.1	2.7	2	104	6
531	Burlington	WI	7.5	3.7	2	100	6
532	Milwaukee	WI	7.1	3.3	2	104	6
533	Not used	NU	0	0	0	0	0
534	Racine	WI	7	5.2	2	100	6
535	Madison	WI	7.5	3.3	2	99	6
536	Not used	NU	0	0	0	0	0
537	Madison	WI	7.5	3.3	2	95	6
538	Platteville	WI	7.5	5.6	2	92	6
539	Portage	WI	7.8	5.5	2	97	6
540	River Falls	WI	8.4	4.6	2	99	6
541	Marinette	WI	7.9	3.7	2	95	6
542	Manitowac	WI	7.6	2.2	2	95	6
543	Green Bay	WI	8	2.5	2	95	6
544	Wausau	WI	8.2	2.5	2	92	6
545	Rhinelander	WI	9.1	2.3	2	93	7
546	La Crosse	WI	7.3	6.8	2	94	6
547	Eau Claire	WI	8.2	3.9	2	94	6
548	Spooner	WI	8.5	2.5	2	99	7
549	Oshkosh	WI	7.6	3.7	2	95	6
550	Forest Lake	MN	7.9	6.8	2	114	6
551	Saint Paul	MN	7.6	6.8	2	114	6
552	ZIP_NOT_ASSIGNED		0	0	0	0	0
553	Hutchinson	MN	8.3	6.8	2	115	6
554	Minneapolis	MN	7.9	6.8	2	115	6
555	Maple Plain	MN	8	5.5	2	115	6
556	Two Harbors	MN	9.1	1	2	108	7
557	Grand Rapids	MN	9.5	1.7	2	108	7
558	Duluth	MN	9.7	0.8	2	108	7
559	Rochester	MN	8.3	3.9	2	102	7
560	Mankato	MN	8	5	2	100	6
561	Windom	MN	8.1	7.2	2	79	6
562	Willmar	MN	8.6	4.7	2	83	6
563	Saint Cloud	MN	8.8	3	2	107	6
564	Brainerd	MN	9.5	3.5	2	103	7
565	Detroit Lakes	MN	9.2	2.3	2	94	7
566	International Falls	MN	10.2	1.6	2	98	7
567	Thief River Falls	MN	9.8	3	2	94	7
568	ZIP_NOT_ASSIGNED		0	0	0	0	0
569	ZIP_NOT_ASSIGNED		0	0	0	0	0
570	Madison	SD	8.4	8.6	2	81	6

Zip	Location	State	HDD	CDH	FER	ICF	IECC
571	Sioux Falls	SD	7.8	8.6	2	81	6
572	Watertown	SD	8.8	4.9	2	79	6
573	Mitchell	SD	7.6	10.3	2	78	6
574	Aberdeen	SD	8.3	6.5	2	79	6
575	Pierre	SD	7.3	10.4	2	78	6
576	Mobridge	SD	8	7.8	2	79	6
577	Rapid City	SD	7.2	8.2	2	79	6
578	ZIP_NOT_ASSIGNED		0	0	0	0	0
579	ZIP_NOT_ASSIGNED		0	0	0	0	0
580	Valley City	ND	9.6	3.8	2	81	7
581	Fargo	ND	9.1	4.3	2	81	7
582	Grand Forks	ND	9.5	4.1	2	82	7
583	Devils Lake	ND	9.4	3.1	2	82	7
584	Jamestown	ND	9	4	2	79	6
585	Bismarck	ND	8.8	4.6	2	81	6
586	Dickinson	ND	8.6	4	2	81	6
587	Minot	ND	9	4	2	82	7
588	Williston	ND	9	4	2	81	7
589	ZIP_NOT_ASSIGNED		0	0	0	0	0
590	Roundup	MT	7	5.5	4	86	6
591	Billings	MT	7	6	4	86	6
592	Wolf Point	MT	8.4	4.8	4	85	6
593	Miles City	MT	7.6	10	4	86	6
594	Great Falls	MT	7.8	3.6	4	86	6
595	Havre	MT	8.3	4	4	84	6
596	Helena	MT	8	2.5	4	86	6
597	Butte	MT	9.4	0.9	4	86	6
598	Missoula	MT	7.6	1.1	4	86	6
599	Kalispell	MT	8.2	1.7	4	84	6
600	Antioch	IL	6.9	5.6	2	110	5
601	DeKalb	IL	7	7	2	110	5
602	Evanston	IL	6.5	6.6	2	110	5
603	Oak Park	IL	6.5	6.6	2	110	5
604	Joliet	IL	6.5	6.4	2	109	5
605	Aurora	IL	6.9	6.4	2	110	5
606	Chicago	IL	6.5	9.7	2	114	5
607	Chicago	IL	6.5	9.7	2	114	5
608	Chicago	IL	6.5	9.7	2	114	5
609	Kankakee	IL	6.4	8.8	2	108	5
610	Freeport	IL	7.3	6.5	2	105	5
611	Rockford	IL	6.9	6.5	2	105	5
612	Rock Island	IL	6.2	10	2	96	5
613	Ottawa	IL	6.3	10	2	97	5
614	Galesburg	IL	6.3	8.9	2	98	5
615	Peoria	IL	6.1	9.5	2	98	5
616	Peoria	IL	6.1	9.5	2	98	5
617	Normal	IL	6.2	9.5	2	99	5
618	Champaign/Urbana	IL	5.9	9.9	2	99	5

Zip	Location	State	HDD	CDH	FER	ICF	IECC
619	Paris	IL	5.7	11	2	99	5
620	Jerseyville	IL	5.4	12.8	2	97	4
621	ZIP_NOT_ASSIGNED		0	0	0	0	0
622	Waterloo	IL	4.9	13.5	2	97	4
623	Quincy	IL	5.7	12.2	2	96	5
624	Effingham	IL	5.5	13.2	2	94	5
625	Decatur	IL	5.5	12.1	2	97	5
626	Jacksonville	IL	5.9	12.3	2	98	5
627	Springfield	IL	5.6	12.4	2	98	5
628	Mount Vernon	IL	5.2	13.5	2	96	4
629	Carbondale	IL	4.9	14.1	2	91	4
630	Union	MO	4.6	13.9	2	101	4
631	Saint Louis	MO	4.8	17.8	2	101	4
632	ZIP_NOT_ASSIGNED		0	0	0	0	0
633	Saint Charles	MO	5.2	17.1	2	97	4
634	Hannibal	MO	5.7	11.8	2	92	5
635	Kirksville	MO	6.1	9.9	2	92	5
636	Farmington	MO	5.1	12.2	2	95	4
637	Cape Girardeau	MO	4.3	16.8	2	89	4
638	Sikeston	MO	4.3	16.9	2	88	4
639	Poplar Bluff	MO	4.2	17.2	2	90	4
640	Independence	MO	5.4	17.5	2	100	4
641	Kansas City	MO	5.2	17.5	2	100	4
642	ZIP_NOT_ASSIGNED		0	0	0	0	0
643	ZIP_NOT_ASSIGNED		0	0	0	0	0
644	Maryville	MO	6.2	11.6	2	94	5
645	Saint Joseph	MO	5.3	16.1	2	94	5
646	Chillicothe	MO	5.8	14.4	2	89	5
647	Nevada	MO	4.8	20.3	2	97	4
648	Joplin	MO	4.3	20.8	2	84	4
649	Kansas City	MO	5.2	17.5	2	100	4
650	Jefferson City	MO	5.2	15	2	87	4
651	Jefferson City	MO	5.2	15	2	87	4
652	Columbia	MO	5.2	14.5	2	88	4
653	Sedalia	MO	5.3	17.2	2	88	4
654	Rolla	MO	4.9	12.8	2	79	4
655	Lebanon	MO	4.6	15.8	2	79	4
656	Springfield	MO	4.6	16.3	2	88	4
657	Springfield	MO	4.6	16.3	2	88	4
658	Springfield	MO	4.6	16.3	2	88	4
659	ZIP_NOT_ASSIGNED		0	0	0	0	0
660	Lawrence	KS	4.7	18.7	2	98	4
661	Kansas City	KS	5.2	17.5	2	98	4
662	Shawnee	KS	5.2	17.5	2	98	4
663	ZIP_NOT_ASSIGNED		0	0	0	0	0
664	Topeka	KS	5.2	16.6	2	86	4
665	Manhattan	KS	5.1	18.8	2	86	4
666	Topeka	KS	5.2	16.6	2	86	4

Zip	Location	State	HDD	CDH	FER	ICF	IECC
667	Fort Scott	KS	4.7	24.1	2	85	4
668	Emporia	KS	5.2	17.4	2	73	4
669	Concordia	KS	5.5	16.7	2	81	5
670	Wichita	KS	4.8	21.2	2	83	4
671	Wichita	KS	4.8	21.2	2	83	4
672	Wichita	KS	4.8	21.2	2	83	4
673	Independence	KS	4.5	20.3	2	83	4
674	Salina	KS	5	19.8	2	80	4
675	Hutchinson	KS	5.1	21.9	2	76	4
676	Hays	KS	5.5	16.3	2	82	5
677	Colby	KS	6.3	11.9	2	81	5
678	Dodge City	KS	5	18.5	2	82	4
679	Liberal	KS	4.8	18.5	2	74	4
680	Omaha	NE	6.3	12	2	83	5
681	Omaha	NE	6.3	12	2	83	5
682	ZIP_NOT_ASSIGNED		0	0	0	0	0
683	Lincoln	NE	6.2	13.6	2	81	5
684	Lincoln	NE	6.2	13.6	2	81	5
685	Lincoln	NE	6.2	13.6	2	81	5
686	Columbus	NE	6.4	12.7	2	70	5
687	Norfolk	NE	6.8	10.6	2	78	5
688	Grand Island	NE	6.4	12	2	80	5
689	Hastings	NE	6.2	12.6	2	75	5
690	McCook	NE	6	13.6	2	71	5
691	North Platte	NE	6.8	8.5	2	75	5
692	Valentine	NE	6.8	8.2	2	69	5
693	Alliance	NE	6.8	6.4	2	75	5
694	ZIP_NOT_ASSIGNED		0	0	0	0	0
695	ZIP_NOT_ASSIGNED		0	0	0	0	0
696	ZIP_NOT_ASSIGNED		0	0	0	0	0
697	ZIP_NOT_ASSIGNED		0	0	0	0	0
698	ZIP_NOT_ASSIGNED		0	0	0	0	0
699	ZIP_NOT_ASSIGNED		0	0	0	0	0
700	New Orleans	LA	1.4	28.6	3	86	2
701	New Orleans	LA	1.4	28.6	3	86	2
702	ZIP_NOT_ASSIGNED		0	0	0	0	0
703	Thibodaux	LA	1.4	27.9	3	85	2
704	Hammond	LA	1.8	24.7	3	85	2
705	Lafayette	LA	1.5	28.5	3	83	2
706	Lake Charles	LA	1.5	28.6	3	83	2
707	Baton Rouge	LA	1.7	26.9	3	81	2
708	Baton Rouge	LA	1.7	26.9	3	81	2
709	ZIP_NOT_ASSIGNED		0	0	0	0	0
710	Shreveport	LA	2.3	28.3	3	81	3
711	Shreveport	LA	2.3	28.3	3	81	3
712	Monroe	LA	2.2	26.6	3	82	3
713	Alexandria	LA	1.9	27.3	3	81	2
714	Natchitoches	LA	2.2	28.9	3	81	3

Zip	Location	State	HDD	CDH	FER	ICF	IECC
715	ZIP_NOT_ASSIGNED		0	0	0	0	0
716	Pine Bluff	AR	2.9	26.7	3	83	3
717	Camden	AR	2.9	23.7	3	74	3
718	Hope	AR	3.1	22.5	3	79	3
719	Hot Springs Nat Pk	AR	3.1	26.6	3	76	3
720	Little Rock	AR	3.1	23.8	3	83	3
721	Little Rock	AR	3.1	23.8	3	83	3
722	Little Rock	AR	3.1	23.8	3	83	3
723	West Memphis	AR	3.4	24.5	3	86	3
724	Jonesboro	AR	3.7	23.2	3	85	3
725	Batesville	AR	4	19	3	80	4
726	Harrison	AR	4.1	18.5	3	80	4
727	Fayetteville	AR	4.2	16	3	81	4
728	Clarksville	AR	3.8	22.7	3	80	3
729	Fort Smith	AR	3.4	23.5	3	82	3
730	Oklahoma City	OK	3.7	23	3	84	3
731	Oklahoma City	OK	3.7	23	3	84	3
732	ZIP_NOT_ASSIGNED		0	0	0	0	0
733	Austin	TX	1.5	35.2	3	77	3
734	Ardmore	OK	3	31.7	3	84	3
735	Lawton	OK	3.3	27.1	3	85	3
736	Clinton	OK	4	26.4	3	84	3
737	Enid	OK	4.3	26.1	3	84	3
738	Woodward	OK	4.7	23.2	3	84	3
739	Guymon	OK	4.6	17.5	3	72	4
740	Bartlesville	OK	3.7	22.7	3	83	3
741	Tulsa	OK	3.6	26.5	3	83	3
742	ZIP_NOT_ASSIGNED		0	0	0	0	0
743	Vinita	OK	3.9	23.2	3	85	3
744	Muskogee	OK	3.7	25.7	3	78	3
745	McAlester	OK	3.2	26.3	3	84	3
746	Ponca City	OK	4.1	24.3	3	84	3
747	Durant	OK	3.2	26.1	3	83	3
748	Seminole	OK	3.5	27.4	3	84	3
749	Poteau	OK	3.1	25.3	3	84	3
750	Sherman	TX	2.9	29.7	3	78	3
751	Corsicana	TX	2.4	32.5	3	77	3
752	Dallas	TX	2.4	36.7	3	83	3
753	Dallas	TX	2.4	36.7	3	83	3
754	Greenville	TX	2.8	27.7	3	74	3
755	Texarkana	TX	2.9	23	3	77	3
756	Longview	TX	2.3	28.7	3	72	3
757	Tyler	TX	2	24.9	3	79	3
758	Palestine	TX	1.9	28.5	3	75	2
759	Lufkin	TX	1.9	30.4	3	74	3
760	Fort Worth	TX	2.4	36.3	3	81	3
761	Fort Worth	TX	2.4	36.3	3	81	3
762	Denton	TX	2.7	31.5	3	78	3

Zip	Location	State	HDD	CDH	FER	ICF	IECC
763	Wichita Falls	TX	3	34.5	3	81	3
764	Stephenville	TX	2.7	27.4	3	76	3
765	Temple	TX	2.2	33.1	3	78	2
766	Hillsboro	TX	2.1	33.4	3	80	2
767	Waco	TX	2.2	36.7	3	80	2
768	Brownwood	TX	2.5	32.4	3	76	3
769	San Angelo	TX	2.4	32.7	3	77	3
770	Houston	TX	1.5	30.5	3	86	2
771	Houston	TX	1.5	30.5	3	86	2
772	Houston	TX	1.5	30.5	3	86	2
773	Conroe	TX	1.6	30.5	3	76	2
774	Bay City	TX	1	33	3	79	2
775	Galveston	TX	1	31.9	3	86	2
776	Port Arthor	TX	1.4	31.7	3	86	2
777	Beaumont	TX	1.5	31.7	3	86	2
778	College Station	TX	1.6	33.2	3	83	2
779	Victoria	TX	1.2	37.3	3	78	2
780	Laredo	TX	0.9	52.6	3	75	2
781	Karnes City	TX	1.4	36.2	3	81	2
782	San Antonio	TX	1.6	36.2	3	81	2
783	Kingsville	TX	1	42.9	3	76	2
784	Corpus Christi	TX	1	42	3	76	2
785	Brownsville	TX	0.6	42.5	3	75	2
786	Austin	TX	1.5	35.2	3	77	2
787	Austin	TX	1.5	35.2	3	77	2
788	Uvalde	TX	1.5	37.1	3	69	2
789	Giddings	TX	1.8	34.2	3	72	2
790	Borger	TX	4	17.5	3	80	4
791	Amarillo	TX	4.3	15.7	3	80	4
792	Childress	TX	3.3	27.1	3	78	3
793	Lubbock	TX	3.5	18.2	3	75	4
794	Lubbock	TX	3.5	18.2	3	75	4
795	Snyder	TX	3.1	25.8	3	79	3
796	Abilene	TX	2.7	31.9	3	79	3
797	Midland	TX	2.7	25	3	76	3
798	Alpine	TX	2.5	16.1	3	81	3
799	El Paso	TX	2.5	23	3	91	3
800	Denver	CO	6.1	5.9	4	93	5
801	Parker	CO	6.3	3.5	4	93	5
802	Denver	CO	6.1	5.9	4	93	5
803	Boulder	CO	5.7	7.7	4	93	5
804	Golden/Dillon	CO	10.9	0	4	92	7
805	Longmont	CO	6.4	3.8	4	89	5
806	Greeley	CO	6	5.1	4	84	5
807	Fort Morgan	CO	6.3	7.2	4	93	5
808	Florissant	CO	9.4	0.1	4	95	7
809	Colorado Springs	CO	6.5	3.7	4	95	5
810	Pueblo	CO	5.6	11	4	93	5

Zip	Location	State	HDD	CDH	FER	ICF	IECC
811	Alamosa	CO	8.7	0	4	93	6
812	Salida	CO	7.3	0	4	93	6
813	Durango	CO	6.8	0.4	4	93	5
814	Montrose	CO	6.3	3.6	4	93	5
815	Grand Junction	CO	5.7	12.1	4	86	5
816	Glenwood Springs	CO	6.7	2.1	4	92	5
817	ZIP_NOT_ASSIGNED		0	0	0	0	0
818	ZIP_NOT_ASSIGNED		0	0	0	0	0
819	ZIP_NOT_ASSIGNED		0	0	0	0	0
820	Cheyenne	WY	7.4	2.1	4	83	6
821	Yellowstone Nat Pk	WY	11.5	0.5	4	82	7
822	Wheatland	WY	6.3	5.4	4	81	5
823	Rawlins	WY	7.9	0.3	4	81	6
824	Thermopolis	WY	8.3	5.2	4	80	6
825	Riverton	WY	8.4	2.6	4	81	6
826	Casper	WY	7.6	4.5	4	81	6
827	Gillette	WY	8	4.3	4	80	6
828	Sheridan	WY	7.7	4.5	4	83	6
829	Rock Springs	WY	8.7	1	4	80	6
830	Jackson	WY	9.5	0.1	4	80	7
831	Kemmerer	WY	9.8	0.3	4	80	7
832	Pocatello	ID	7.1	3.3	4	82	6
833	Twin Falls	ID	6.7	2.8	4	73	5
834	Idaho Falls	ID	7.9	1.4	4	75	6
835	Lewiston	ID	5.2	7.9	4	114	5
836	Payette	ID	5.6	6.8	4	86	5
837	Boise	ID	5.7	8	4	86	5
838	Doeur D Alene	ID	6.5	2.8	4	113	5
839	ZIP_NOT_ASSIGNED		0	0	0	0	0
840	Heber City	UT	7	0.5	4	86	5
841	Salt Lake City	UT	5.6	9.9	4	86	5
842	Ogden	UT	5.9	9	4	84	5
843	Logan	UT	6.7	5	4	85	5
844	Ogden	UT	5.9	9	4	84	5
845	Blanding	UT	5.5	4.2	4	81	5
846	Provo	UT	5.3	9	4	86	5
847	Cedar City	UT	6	5	4	86	5
848	ZIP_NOT_ASSIGNED		0	0	0	0	0
849	ZIP_NOT_ASSIGNED		0	0	0	0	0
850	Phoenix	AZ	1.1	55	4	89	2
851	Not used	NU	0	0	0	0	0
852	Casa Grande	AZ	1.7	49	4	85	2
853	Buckeye	AZ	1.5	55	4	89	2
854	ZIP_NOT_ASSIGNED		0	0	0	0	0
855	Globe	AZ	3.1	24.6	4	84	4
856	Nogales	AZ	2.9	9.9	4	88	2
857	Tucson	AZ	1.6	36	4	88	2
858	ZIP_NOT_ASSIGNED		0	0	0	0	0

Zip	Location	State	HDD	CDH	FER	ICF	IECC
859	Show Low	AZ	4.9	4.6	4	85	5
860	Flagstaff	AZ	7	0.4	4	86	5
861	ZIP_NOT_ASSIGNED		0	0	0	0	0
862	ZIP_NOT_ASSIGNED		0	0	0	0	0
863	Prescott	AZ	4.8	3.8	4	82	4
864	Kingman	AZ	3.3	21.6	4	84	3
865	Window Rock	AZ	6.5	1.9	4	82	5
866	ZIP_NOT_ASSIGNED		0	0	0	0	0
867	ZIP_NOT_ASSIGNED		0	0	0	0	0
868	ZIP_NOT_ASSIGNED		0	0	0	0	0
869	ZIP_NOT_ASSIGNED		0	0	0	0	0
870	Albuquerque	NM	4.3	11	4	88	4
871	Albuquerque	NM	4.3	11	4	88	4
872	Albuquerque	NM	4.3	11	4	88	4
873	Gallup	NM	6.6	1.9	4	89	5
874	Farmington	NM	5.5	5	4	88	5
875	Santa Fe	NM	6.1	1.2	4	88	5
876	ZIP_NOT_ASSIGNED		0	0	0	0	0
877	Las Vegas	NM	5.8	1.1	4	88	5
878	Socorro	NM	4	11	4	88	4
879	Truth or Conseq	NM	3.3	14.6	4	77	4
880	Lordsburg	NM	3.3	19.2	4	77	3
881	Clovis	NM	4.1	10	4	88	4
882	Roswell	NM	3.3	20	4	88	3
883	Carrizozo	NM	4.3	7.2	4	89	3
884	Tucumcari	NM	3.9	15	4	88	4
885	El Paso	TX	2.5	23	3	81	3
886	ZIP_NOT_ASSIGNED		0	0	0	0	0
887	ZIP_NOT_ASSIGNED		0	0	0	0	0
888	ZIP_NOT_ASSIGNED		0	0	0	0	0
889	Las Vegas	NV	2.2	43	4	102	3
890	Tonopah	NV	5.5	5.9	4	102	5
891	Las Vegas	NV	2.2	43	4	102	3
892	ZIP_NOT_ASSIGNED		0	0	0	0	0
893	Ely	NV	7.6	0.7	4	89	5
894	Winnemucca	NV	6.3	4.3	4	94	5
895	Reno	NV	5.6	2.2	4	94	5
896	Not used	NU	0	0	0	0	0
897	Carson City	NV	5.7	2	4	94	5
898	Elko	NV	7.2	3.8	4	91	5
899	ZIP_NOT_ASSIGNED		0	0	0	0	0
900	Los Angeles	CA	0.9	10.6	4	107	3
901	Los Angeles	CA	0.9	10.6	4	107	3
902	Los Angeles	CA	0.9	10.6	4	107	3
903	Inglewood	CA	1.3	4.3	4	106	3
904	Santa Monica	CA	1.8	1.9	4	106	3
905	Torrance	CA	1.5	3.9	4	106	3
906	Montebello	CA	0.9	10.2	4	106	3

Zip	Location	State	HDD	CDH	FER	ICF	IECC
907	San Pedro	CA	1.3	7.8	4	106	3
908	Long Beach	CA	1.3	7.8	4	106	3
909	ZIP_NOT_ASSIGNED		0	0	0	0	0
910	Pasadena	CA	1.4	11	4	104	3
911	Pasadena	CA	1.4	11	4	104	3
912	Glendale	CA	1.6	11.4	4	104	3
913	Canoga Park	CA	1.8	13	4	105	3
914	Van Nuys	CA	1.8	11.4	4	105	3
915	Burbank	CA	1.6	11.4	4	105	3
916	North Hollywood	CA	1.6	11.4	4	105	3
917	Pomona	CA	1.7	10.2	4	105	3
918	Alhambra	CA	1.4	11	4	105	3
919	Alpine	CA	1.9	6.6	4	107	3
920	Escondido	CA	1.5	6.6	4	107	3
921	San Diego	CA	1.1	4.6	4	107	3
922	Palm Springs	CA	0.9	54	4	107	2
923	Redlands	CA	1.9	16.9	4	107	3
924	San Bernadino	CA	1.6	17.8	4	107	3
925	Riverside	CA	1.5	14.2	4	107	3
926	San Clemente	CA	1.8	7.8	4	107	3
927	Santa Ana	CA	1.2	6.9	4	107	3
928	Anaheim	CA	1.3	6.9	4	107	3
929	ZIP_NOT_ASSIGNED		0	0	0	0	0
930	Oxnard	CA	1.9	1.2	4	108	3
931	Santa Barbara	CA	1.9	0.9	4	105	3
932	Visalia	CA	2.6	19	4	104	3
933	Bakersfield	CA	2.1	30	4	104	3
934	San Luis Obispo	CA	2.1	1.1	4	105	3
935	Lancaster	CA	3.2	21	4	104	4
936	Madera	CA	2.7	17.9	4	102	3
937	Fresno	CA	2.4	19.4	4	102	3
938	Fresno	CA	2.4	19.4	4	102	3
939	Monterey	CA	3.1	0.1	4	109	3
940	Half Moon Bay	CA	3.7	0.1	4	121	3
941	San Francisco	CA	2.9	0.2	4	121	3
942	Sacramento	CA	2.7	7.8	4	113	3
943	Palo Alto	CA	2.6	0.7	4	118	3
944	San Mateo	CA	2.6	1.2	4	119	3
945	Napa	CA	2.7	1.4	4	119	3
946	Oakland	CA	2.4	0.4	4	118	3
947	Berkeley	CA	2.9	0.3	4	119	3
948	Richmond	CA	2.9	0.4	4	118	3
949	San Rafael	CA	2.6	1.9	4	120	3
950	Gilroy	CA	2.3	0.1	4	110	3
951	San Jose	CA	2.2	1.4	4	113	3
952	Stockton	CA	2.6	13	4	109	4
953	Merced	CA	2.6	14	4	109	4
954	Santa Rosa	CA	2.7	1.2	4	113	3

Zip	Location	State	HDD	CDH	FER	ICF	IECC
955	Eureka	CA	4.4	0	4	109	4
956	Placerville	CA	3.3	7.8	4	113	4
957	Blue Canyon	CA	5.5	4.1	4	113	5
958	Sacramento	CA	2.7	12	4	113	3
959	Marysville	CA	2.5	15	4	109	3
960	Redding	CA	3	28	4	109	3
961	Susanville	CA	6.2	2.2	4	108	5
962	ZIP_NOT_ASSIGNED		0	0	0	0	0
963	ZIP_NOT_ASSIGNED		0	0	0	0	0
964	ZIP_NOT_ASSIGNED		0	0	0	0	0
965	ZIP_NOT_ASSIGNED		0	0	0	0	0
966	ZIP_NOT_ASSIGNED		0	0	0	0	0
967	Lihui	HI	0	25.6	4	114	1
968	Honolulu	HI	0	36.2	4	116	1
969	Guam	GU	0	53.2	4	93	1
970	Hood River	OR	5.5	1.5	4	103	5
971	Seaside	OR	4.5	0.1	4	103	4
972	Portland	OR	4.4	1.9	4	103	4
973	Salem	OR	4.8	1	4	102	4
974	Eugene	OR	4.8	1.3	4	101	4
975	Medford	OR	4.5	6.2	4	101	4
976	Klamath Falls	OR	6.9	2.4	4	101	5
977	Bend	OR	7	0.6	4	102	5
978	Pendleton	OR	5.3	8.1	4	96	5
979	Ontario	OR	6.1	10	4	95	5
980	Kent	WA	4.6	0.5	4	102	4
981	Seattle	WA	4.8	1	4	102	4
982	Everett	WA	5.2	0.2	4	101	4
983	Port Angeles	WA	5.6	0.2	4	101	4
984	Tacoma	WA	4.7	0.5	4	101	4
985	Olympia	WA	5.5	0.3	4	100	4
986	Vancouver	WA	5	1.7	4	99	4
987	Not used	NU	0	0	0	0	0
988	Wenatchee	WA	6	7.6	4	93	5
989	Yakima	WA	6.1	4.1	4	93	5
990	Spokane	WA	6.8	3.5	4	117	5
991	Newport	WA	7.2	1	4	117	6
992	Spokane	WA	6.8	3.5	4	117	5
993	Richland	WA	5.1	9.8	4	118	5
994	Clarkston	WA	5.2	8	4	116	5
995	Anchorage	AK	10.5	0	4	150	7
996	McGrath	AK	13.9	0.4	4	150	8
997	Fairbanks	AK	14	0	4	150	8
998	Juneau	AK	8.6	0	4	149	7
999	Ketchikan	AK	7.2	0	4	150	7

APPENDIX C TEXT OF THE 2008 DOE INSULATION FACT SHEET

DOE/CE-0180
2008

Department of Energy
Assistant Secretary
Energy Efficiency and Renewable Energy

Insulation Fact Sheet

Contents:

Introduction

Why Insulate Your House?

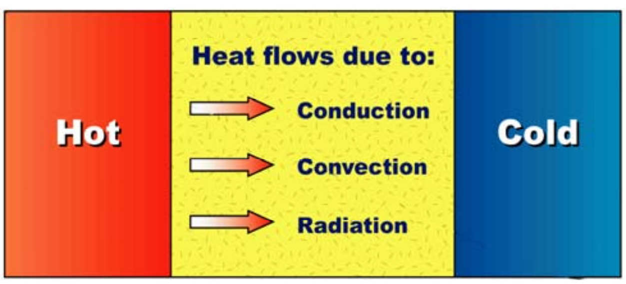
Heating and cooling account for 50 to 70% of the energy used in the average American home. Inadequate insulation and air leakage are leading causes of energy waste in most homes. Insulation:

- saves money and our nation's limited energy resources
- makes your house more comfortable by helping to maintain a uniform temperature throughout the house, and
- makes walls, ceilings, and floors warmer in the winter and cooler in the summer.

The amount of energy you conserve will depend on several factors: your local climate; the size, shape, and construction of your house; the living habits of your family; the type and efficiency of the heating and cooling systems; and the fuel you use. Once the energy savings have paid for the installation cost, energy conserved is money saved - and saving energy will be even more important as utility rates go up.

This fact sheet will help you to understand how insulation works, what different types of insulation are available, and how much insulation makes sense for your climate. There are many other things you can do to conserve energy in your home as well. The Department of Energy offers many **web sites** to help you save energy by sealing air leaks, selecting more energy-efficient appliances, etc.

How Insulation Works



Heat flows naturally from a warmer to a cooler space. In winter, the heat moves directly from all heated living spaces to the outdoors and to adjacent unheated attics, garages, and basements - wherever there is a difference in temperature. During the summer, heat moves from outdoors to the house interior. To maintain comfort, the heat lost in winter must be replaced by your heating system and the heat gained in summer must be removed by your air conditioner. Insulating ceilings, walls, and floors decreases the heating or cooling needed by providing an effective resistance to the flow of heat.

Batts, blankets, loose fill, and low-density foams all work by limiting air movement. (These products may be more familiarly called fiberglass, cellulose, polyicynene, and expanded polystyrene.) The still air is an effective insulator because it eliminates convection and has low conduction. Some foams, such as polyisocyanurate, polyurethane, and extruded polystyrene, are filled with special gases that provide additional resistance to heat flow.

The ability of insulation to limit air movement should not be confused with "air sealing". The insulation reduces air movement only within the space it occupies. It will not reduce air movement through other cracks between building parts. For example, controlling air movement within a wall cavity will not stop air that leaks between the foundation and the sill plate or between the wall joists and a window frame.

Reflective insulation works by reducing the amount of energy that travels in the form of radiation. Some forms of reflective insulation also divide a space up into small regions to reduce air movement, or convection, but not to the same extent as batts, blankets, loose-fill, and foam.

Which Kind Of Insulation Is Best?

Based on our email, this is one of the most popular questions homeowners ask before buying insulation. The answer is that the *'best'* type of insulation depends on:

- how much insulation is needed,
- the accessibility of the insulation location,
- the space available for the insulation,
- local availability and price of insulation, and
- other considerations unique to each purchaser.

Whenever you compare insulation products, it is critical that you base your comparison on equal R-values.

What Is an R-Value?

Insulation is rated in terms of thermal resistance, called R-value, which indicates the resistance to heat flow. ***The higher the R-value, the greater the insulating effectiveness.*** The R-value of thermal insulation depends on the type of material, its thickness, and its density. In calculating the R-value of a multi-layered installation, the R-values of the individual layers are added.

The effectiveness of an insulated ceiling, wall or floor depends on how and where the insulation is installed.

- Insulation which is compressed will not give you its full rated R-value. This can happen if you add denser insulation on top of lighter insulation in an attic. It also happens if you place batts rated for one thickness into a thinner cavity, such as placing R-19 insulation rated for 6¼ inches into a 5½ inch wall cavity.

- Insulation placed ***between*** joists, rafters, and studs does not retard heat flow through those joists or studs. This heat flow is called thermal bridging. So, the overall R-value of a wall or ceiling will be somewhat different from the R-value of the insulation itself. That is why it is important that attic insulation cover the tops of the joists and that is also why we often recommend the use of insulative sheathing on walls. The short-circuiting through metal framing is much greater than that through wood-framed walls; sometimes the insulated metal wall's overall R-value can be as low as half the insulation's R-value.

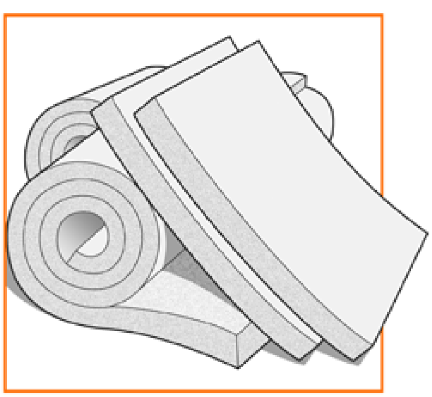
Reading the Label

No matter what kind of insulation you buy, check the information on the product label to make sure that the product is suitable for the intended application. To protect consumers, the Federal Trade Commission has very clear rules about the R-value label that must be placed on all residential insulation products, whether they are installed by professionals, or whether they are purchased at a local supply store. These labels include a clearly stated R-value and information about health, safety, and fire-hazard issues. Take time to read the label BEFORE installing the insulation. Insist that any contractor installing insulation provide the product labels from EACH package (which will also tell you how many packages were used). Many special products have been developed to give higher R-values with less thickness. On the other hand, some materials require a greater initial thickness to offset eventual settling or to ensure that you get the rated R-value under a range of temperature conditions.

Insulation Product Types

Some types of insulation require professional installation, and others you can install yourself. You should consider the several forms of insulation available, their R-values, and the thickness needed. The type of insulation you use will be determined by the nature of the spaces in the house that you plan to insulate. For example, since you cannot conveniently "pour" insulation into an overhead space, blankets, spray-foam, board products, or reflective systems are used between the joists of an unfinished basement ceiling. The most economical way to fill closed cavities in finished walls is with blown-in insulation applied with pneumatic equipment or with sprayed-in-place foam insulation.

The different forms of insulation can be used together. For example, you can add batt or roll insulation over loose-fill insulation, or vice-versa. Usually, material of higher density (weight per unit volume) should not be placed on top of lower density insulation that is easily compressed. Doing so will reduce the thickness of the material underneath and thereby lower its R-value. There is one exception to this general rule: When attic temperatures drop below 0°F, some low-density, fiberglass, loose-fill insulation installations may allow air to circulate between the top of your ceiling and the attic, decreasing the effectiveness of the insulation. You can eliminate this air circulation by covering the low-density, loose-fill insulation with a blanket insulation product or with a higher density loose-fill insulation.



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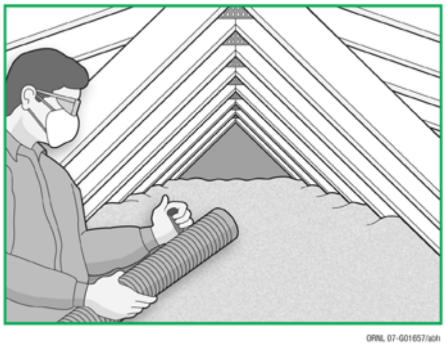
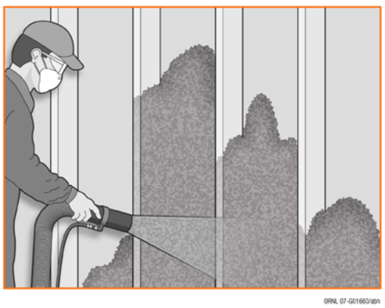
Blankets, in the form of batts or rolls, are flexible products made from mineral fibers, including fiberglass or rock wool. They are available in widths suited to standard spacings of wall studs and attic or floor joists. They must be hand-cut and trimmed to fit wherever the joist spacing is non-standard (such as near windows, doors, or corners), or where there are obstructions in the walls (such as wires, electrical outlet boxes, or pipes). Batts can be installed by homeowners or professionals. They are available with or without vapor-retarder facings. Batts with a special flame-resistant facing are available in various widths for basement walls where the insulation will be left exposed.

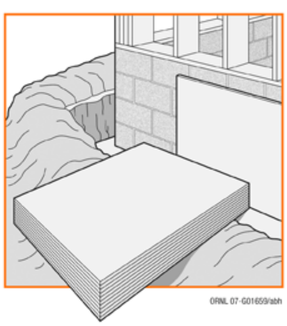


Blown-in loose-fill insulation includes cellulose, fiberglass, or rock wool in the form of loose fibers or fiber pellets that are blown using pneumatic equipment, usually by professional installers. This form of insulation can be used in wall cavities. It is also appropriate for unfinished attic floors, for irregularly shaped areas, and for filling in around obstructions.

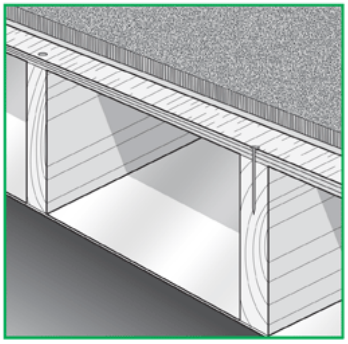


In the open wall cavities of a new house, cellulose and fiberglass fibers can also be sprayed after mixing the fibers with an adhesive or foam to make them resistant to settling.

Foam insulation can be applied by a professional using special equipment to meter, mix, and spray the foam into place. Polyicynene is an open-celled foam. Polyisocyanurate and polyurethane are closed-cell foams. In general, open-celled foam allows water vapor to move through the material more easily than closed-cell foam. However, open-celled foams usually have a lower R-value for a given thickness compared to closed-cell foams. So, some of the closed-cell foams are able to provide a greater R-value where space is limited.



Rigid insulation is made from fibrous materials or plastic foams and is produced in board-like forms and molded pipe coverings. These provide full coverage with few heat loss paths and are often able to provide a greater R-value where space is limited. Such boards may be faced with a reflective foil that reduces heat flow when next to an air space. Rigid insulation is often used for foundations and as an insulative wall sheathing.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Reflective insulation systems are fabricated from aluminum foils with a variety of backings such as kraft paper, plastic film, polyethylene bubbles, or cardboard. The resistance to heat flow depends on the heat flow direction, and this type of insulation is most effective in reducing downward heat flow. Reflective systems are typically located between roof rafters, floor joists, or wall studs. If a single reflective surface is used alone and faces an open space, such as an attic, it is called a radiant barrier.

Radiant barriers are installed in buildings to reduce summer heat gain and winter heat loss. In new buildings, you can select foil-faced wood products for your roof sheathing (installed with the foil facing down into the attic) or other locations to provide the radiant barrier as an integral part of the structure. For existing buildings, the radiant barrier is typically fastened across the bottom of joists, as shown in this drawing. All radiant barriers must have a low emittance (0.1 or less) and high reflectance (0.9 or more).

Insulating a New House (Do It Right the First Time)

If you are buying or building a new house, make sure that energy-saving features are included. The Federal Trade Commission (FTC) home insulation rule requires the seller of a new home to provide information on the type, thickness, and R-value of the insulation that will be installed in each part of the house in every sales contract. Many state or local building codes include minimum requirements for home insulation. Be sure that your new home or home addition meets these building codes. You may wish to install insulation beyond the minimum specified in such codes, especially if those minimum levels are below those recommended here. Also, Energy-Efficient Mortgages are available through both government-insured and conventional loan programs. These mortgages recognize that the homeowner's energy payments will be less for a more energy-efficient home, and therefore enable a buyer to borrow a larger sum to cover the up-front costs of improving the house's energy efficiency.

To keep initial selling prices competitive, many home builders offer standard (not optimal) levels of insulation, although additional insulation would be a good investment for the buyer. Builders participating in the Energy Star Program use third-party inspectors to not only ensure that the correct amount of insulation has been used, but also to ensure that it has been installed correctly.

> *It is always more economical to install the recommended levels of insulation during initial construction rather than adding insulation later. Many insulation locations are enclosed during the construction process and it is very difficult to add insulation to these locations at a later time.*

Now is also the time to make your home air tight. Special products and techniques are available to eliminate air leaks between the walls and floor and between the walls and ceiling. Encourage your builder to make all clearances around doors and windows as tight as possible and to properly caulk and seal all such joints.

Where and How Much?

Figure 1 shows which building spaces should be insulated. Discuss the house plans with your builder, and make sure each of these spaces is properly insulated to the R-values recommended here. Remember to buy the insulation based on this R-value, and to check the product label to determine the insulation's proper thickness, especially if you plan to install it in a confined space, such as in wall cavities and cathedral ceilings.

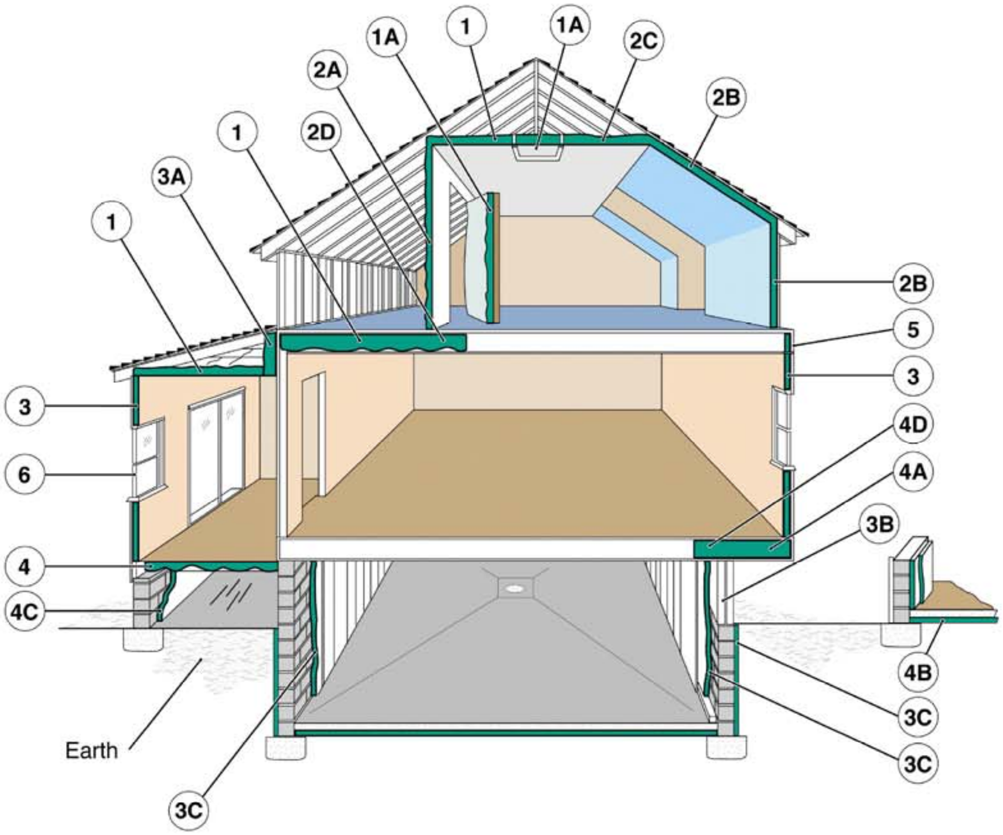

Figure 1. **Examples of Where to Insulate**

1. In unfinished attic spaces, insulate between and over the floor joists to seal off living spaces below.
   1A attic access door

2. In finished attic rooms with or without dormer, insulate...
   2A between the studs of "knee" walls;
   2B between the studs and rafters of exterior walls and roof;
   2C ceilings with cold spaces above;
   2D extend insulation into joist space to reduce air flows.

3. All exterior walls, including...
   3A walls between living spaces and unheated garages, shed roofs, or storage areas;
   3B foundation walls above ground level;
   3C foundation walls in heated basements, full wall either interior or exterior.

4. Floors above cold spaces, such as vented crawl spaces and unheated garages. Also insulate...
   4A any portion of the floor in a room that is cantilevered beyond the exterior wall below;
   4B slab floors built directly on the ground;
   4C as an alternative to floor insulation, foundation walls of unvented crawl spaces;
   4D extend insulation into joist space to reduce air flows.

5. Band joists.

6. Replacement or storm windows and caulk and seal around all windows and doors.

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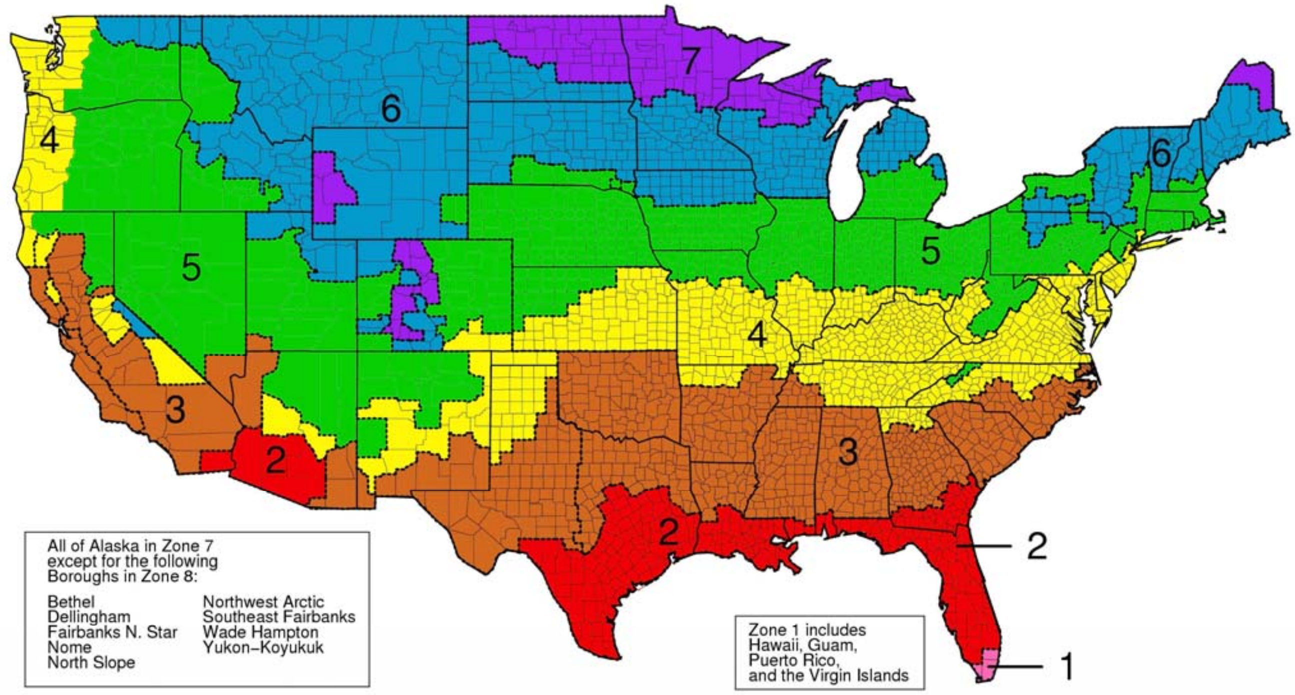
Figure 2. Insulation Recommendations for New Wood-Framed Houses



Zone	Heating system	Attic	Cathedral Ceiling	Wall		Floor
				Cavity	Insulation Sheathing	
1	All	R30 to R49	R22 to R38	R13 to R15	None	R13
2	Gas, oil, heat pump	R30 to R60	R22 to R38	R13 to R15	None	R13
	Electric furnace					R19-R25
3	Gas, oil, heat pump	R30 to R60	R22 to R38	R13 to R15	None	R25
	Electric furnace				R2.5 to R5	
4	Gas, oil, heat pump	R38 to R60	R30 to R38	R13 to R15	R2.5 to R6	R25-R30
	Electric furnace				R5 to R6	
5	Gas, oil, heat pump	R38 to R60	R30 to R38	R13 to R15	R2.5 to R6	R25-R30
	Electric furnace		R30 to R60	R13 to R21	R5 to R6	
6	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25-R30
7	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25-R30
8	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25-R30

Figure 2 shows the Department of Energy's climate zones, along with a short summary of our insulation recommendations for new houses. These recommendations are based on comparing your future energy savings to the current cost of installing insulation. A range is shown for many locations for these reasons:

- Energy costs vary greatly over each zone.
- Installed insulation costs vary greatly over each zone.
- Heating and cooling equipment efficiency varies from house to house.
- Our best estimate of future energy costs may not be exactly correct.

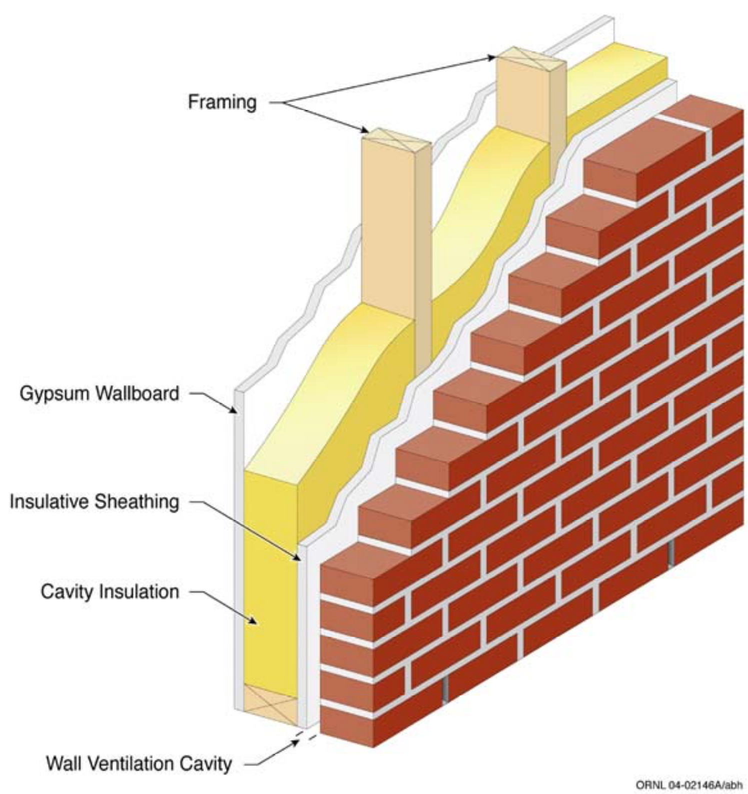
So, how should you decide how much insulation to install?

The future energy savings, of course, depends upon how much energy costs in the future. Our best estimate is that fuel costs will rise at approximately the same rate as general inflation. If you think that fuel costs will increase more than that, you should install the greater amount of insulation shown. Looking at the map, if you think the energy costs in your area are greater than energy costs for other locations in same climate zone, you should install the greater amount of insulation.

We can also give you better guidance for your specific location and recommendations for other insulation locations in your home. The ZIP-Code calculator will actually let you enter your own insulation prices, energy costs, and heating and cooling system efficiencies. However, some personal computer security systems won't allow Java programs to run properly. The recommended R-values table can be helpful in those cases, because it will provide recommendations based on insulation and energy costs for your local area.

Both insulative sheathing and cavity insulation are specified for walls because it is important to use them together as a system. Any combination of sheathing and cavity insulation shown in Figure 2 will give you a similar life-cycle savings.

The band joists, or outside edges of the floor frames, should be insulated while the house is under construction. For most of the country, you should try to install R-30 in this location. If you live in Climate Zone 1, R-19 is adequate. More detailed drawings and insulation techniques for the band joist are shown in the Wall Insulation Technology Fact Sheet.



Foundation insulation options for new construction are broader than for existing homes. The builder may, for example, choose to insulate the exterior of a basement or crawlspace wall. You should discuss termite inspection and control options with your builder when choosing your foundation insulation method. Special sill plate (the joint between the top of the foundation and the bottom of the house frame) mineral fiber sealing products are designed to reduce air leaks if installed during the initial house construction. All flammable insulations or insulation facings must be covered or otherwise protected to meet fire codes. More information is given in the Basement Insulation Technology Fact Sheet.

If water lines and the ducts of your heating or air-conditioning system run through unheated or uncooled spaces, such as attic or crawlspaces, then the water lines and the ducts should be insulated. Make sure your contractor checks the ductwork for air leaks before installing the duct insulation. The contractor should then wrap the ducts with duct wrap insulation of R-6 with a vapor retarder facing on the outer side. All joints where sections of insulation meet should have overlapped facings and be tightly sealed with fiber glass tape; but avoid compressing the insulation, thus reducing its thickness and R-value.

Return air ducts are more likely to be located inside the heated portion of the house where they don't need to be insulated, but they should still be sealed off from air passageways that connect to unheated areas. Drywall-to-ductwork connections should be inspected because they are often poor (or nonexistent) and lead to unwanted air flows through wall cavities.

Air Sealing

Air sealing is important, not only because drafts are uncomfortable, but also because air leaks carry both moisture and energy, usually in the direction you don't want. For example, air leaks can carry hot humid outdoor air into your house in the summer, or can carry warm moist air from a bathroom into the attic in the winter.

Most homeowners are aware that air leaks into and out of their houses through small openings around doors and window frames and through fireplaces and chimneys. Air also enters the living space from other unheated parts of the house, such as attics, basements, or crawlspaces. The air travels through:

- any openings or cracks where two walls meet, where the wall meets the ceiling, or near interior door frames;
- gaps around electrical outlets, switch boxes, and recessed fixtures;
- gaps behind recessed cabinets, and furred or false ceilings such as kitchen or bathroom soffits;
- gaps around attic access hatches and pull-down stairs;
- behind bath tubs and shower stall units;
- through floor cavities of finished attics adjacent to unconditioned attic spaces;
- utility chaseways for ducts, etc., and
- plumbing and electrical wiring penetrations.

These leaks between the living space and other parts of the house are often much greater than the obvious leaks around windows and doors. Since many of these leakage paths are driven by the tendency for warm air to rise and cool air to fall, the attic is often the best place to stop them. ***It's important to stop these leaks before installing attic insulation because the insulation may hide them and make them less accessible.*** Usually, the attic insulation itself will not stop these leaks and you won't save as much as you expect because of the air flowing through or around the insulation.

There are several fact sheets that will help you stop these air leaks:

- Air sealing
- Air Sealing for New Home Construction
- Air Sealing Technology Fact Sheet

When natural ventilation has been sharply reduced, as in a more energy-efficient house, it may be necessary to provide fresh air ventilation to avoid build-up of stale air and indoor air pollutants. Special air-to-air heat exchangers, or heat-recovery ventilators, are available for this purpose. It is also possible to incorporate a supply of fresh outside air into your heating and cooling system. This arrangement can be used to create a slightly higher pressure inside your home, which will prevent uncontrolled outside air infiltration into your home. For more details on this arrangement, see "Integration with forced-air heating and air conditioning systems" in the Whole-House Ventilation Systems Technology Fact Sheet.

Moisture Control and Ventilation

We talk about moisture control in an insulation fact sheet because wet insulation doesn't work well. Also, insulation is an important part of your building envelope system, and all parts of that system must work together to keep moisture from causing damage to the structure or being health hazards to the occupants. For example, mold and mildew grow in moist areas, causing allergic reactions and damaging buildings.

Moisture can enter your home during the construction process. The building materials can get wet during construction due to rain, dew, or by lying on the damp ground. Concrete walls and foundations release water steadily as they continue to cure during the first year after a home is built. During the house's first winter, this construction moisture may be released into the building at a rate of more than two gallons per day, and during the second winter at a slower rate of about one gallon per day. You may need to use dehumidifiers during this initial time period.

When Is Moisture a Problem?

Rain water can leak into your wall cavities if the windows are not properly flashed during installation. Also, when moist air touches a cold surface, some of the moisture may leave the air and condense, or become liquid. If moisture condenses inside a wall, or in your attic, you will not be able to see the water, but it can cause a number of problems.

Four Things You Can Do to Avoid Moisture Problems:

- 1. Control liquid water. Rain coming through a wall, especially a basement or crawlspace wall, may be less apparent than a roof leak, especially if it is a relatively small leak and the water remains inside the wall cavity. Stop all rain-water paths into your home by:
    - Use a Weather-Resistive Barrier.

  - Caulk around all your windows and doors.
  - Direct all water coming off your roof away from your house by sloping the soil around your house so that water flows away from your house.
  - Use wide overhangs to keep the rain away from your walls and windows.
  - Use large gutters and gutter guards to help keep rain from dripping onto the ground near the house.

  Be sure that the condensate from your air conditioner is properly drained away from your house. You should also be careful that watering systems for your lawn or flower beds do not spray water on the side of your house or saturate the ground near the house. It is also a good idea to check the caulking around your tub or shower to make sure that water is not leaking into your walls or floors.

- 2. Ventilate. You need to ventilate your home because you and your family generate moisture when you cook, shower, do laundry, and even when you breathe. More than 99% of the water used to water plants eventually enters the air. If you use an unvented natural gas, propane, or kerosene space heater, all the products of combustion, including water vapor, are exhausted directly into your living space. This water vapor can add up to 5 to 15 gallons of water per day to the air inside your home. If your clothes dryer is not vented to the outside, or if the outdoor vent is closed off or clogged, all that moisture will enter your living space. Just by breathing and perspiring, a typical family adds about 3 gallons of water per day to their indoor air. You especially need to vent your kitchen and bathrooms. Be sure that these vents go directly outside, and not to your attic, where the moisture can cause problems. Remember that a vent does not work unless you turn it on; so select quieter models that you are more likely to use. If your attic is ventilated, it is important that you never cover or block attic vents with insulation. Take care to prevent loose-fill insulation from clogging attic vents by using baffles or rafter vents. These baffles also serve to keep the outside air from penetrating into the insulation. When you think about venting to remove moisture, you should also think about where the replacement air will come from, and how it will get into your house. For more information about controlled ventilation, see the Whole-House Ventilation Systems Technology Fact Sheet.

- 3. Stop Air Leaks. It is very important to seal up all air-leakage paths between your living spaces and other parts of your building structure. Measurements have shown that air leaking into walls and attics carries significant amounts of moisture. Remember that if any air is leaking through electrical outlets or around plumbing connections into your wall cavities, moisture is carried along the same path. The same holds true for air moving through any leaks between your home and the attic, crawlspace, or garage. Even very small leaks in duct work can carry large amounts of moisture, because the airflow in your ducts is much greater than other airflows in your home. This is especially a problem if your ducts travel through a crawlspace or attic, so be sure to seal these ducts properly (and keep them sealed!). Return ducts are even more likely to be leaky, because they often involve joints between drywall and ductwork that may be poorly sealed, or even not sealed at all.

- 4. Plan a moisture escape path. Typical attic ventilation arrangements are one example of a planned escape path for moisture that has traveled from your home's interior into the attic space. Cold air almost always contains less water than hot air, so diffusion usually carries moisture from a warm place to a cold place. You can let moisture escape from a wall cavity to the dry outdoors during the winter, or to the dry indoors during the summer, by avoiding the use of vinyl wall coverings or low-perm paint. You can also use a dehumidifier to reduce moisture levels in your home, but it will increase your energy use and you must be sure to keep it clean to avoid mold growth. If you use a humidifier for comfort during the winter months, be sure that there are no closed-off rooms where the humidity level is too high.

Should you use vapor retarders?

Moisture can travel from the ground through the foundation and up into your walls, and through slab floors into your home. So your builder should always include a vapor retarder between the foundation and the walls. Should you include a vapor retarder in your wall? If so, where? If the outside air is colder and drier than the inside of a home, then moisture from inside the warm house will try to diffuse through the walls and ceiling toward the cold, dry outside air. If the outside air is hot and humid, then moisture from outside will try to diffuse through the walls toward the dry, air-conditioned inside air. We used to tell people to install vapor retarders to try and stop this moisture diffusion. But we have learned that if moisture moves both ways for significant parts of the year, you're better off not using a vapor retarder in the walls at all.

Installation Issues

Your builder will most likely hire a subcontractor to install the insulation in your new home. However, it is a good idea to educate yourself about proper installation methods because an improper installation can reduce your energy savings.

INSULATION INSTALLATION PRECAUTIONS

- Wear clothing adequate to protect against skin contact and irritation. A long-sleeved shirt with collar and cuffs buttoned, gloves, hat, glasses, and disposable dust respirator are advisable in all do-it-yourself insulation projects. Also, read the label and follow all the manufacturer's directions.
- Do not cover or hand-pack insulation around bare stove pipes, electrical fixtures, motors, or any heat-producing equipment such as recessed lighting fixtures. If you pack insulation around these heat-producing locations, the heat can build up, leading to fire. Electrical fire-safety codes prohibit the installation of thermal insulation within three inches of a recessed fixture enclosure, wiring compartment, or ballast, or above the fixture so that it will trap heat and prevent free circulation of air, unless the fixture is identified by label as suitable for insulation to be in direct contact with the fixture. THIS IS FOR FIRE SAFETY.
- Do not cover attic vents with insulation. Proper ventilation must be maintained to avoid overheating in summer and moisture build-up all year long.

Attics

For blown-in loose fill insulation, each bag of insulating material used by the contractor should be marked with an R-value for the area to be covered. Although these figures may differ among manufacturers, the area figure will tell you the right number of bags to be used. Similarly, packages of other types of insulation should be identified by their R-value. It is important that you check that the proper amount is installed in your residence. Ask the contractor to attach vertical rulers to the joists prior to a loose-fill installation in your attic to help you see that the proper depth was installed. Also, the installer must provide a signed and dated statement describing the insulation installed, stating thickness, coverage area, R- value, and number of bags installed. In some areas, infrared thermography services are offered to help discover any gaps in the insulation.

In some houses, it is easier to get complete coverage of the attic floor with blown-in loose-fill insulation. Loose-fill insulation must be prevented from shifting into vents or from contacting heat-producing equipment (such as recessed lighting fixtures) by using baffles or retainers.

If batts or rolls are used, the first layer should be fit between the joists. The second layer should be placed perpendicular to the first because that will help to cover the tops of the joists themselves and reduce thermal bridging through the frame. Also, be sure to insulate the trap or access door. Although the area of the door is small, an uninsulated attic door will reduce energy savings substantially.

To be effective, Reflective Systems must be installed according to the manufacturer's instructions.

Radiant barriers may be installed in attics in several configurations. The radiant barrier is most often attached near the roof, to the bottom surface of the attic truss chords or to the rafter framing. A radiant barrier should never be placed on top of your insulation or on the attic floor because it will soon be covered with dust and will not work. A separate DOE fact sheet is available for radiant barriers to show which parts of the country are most likely to benefit from this type of system.

Walls

ORNL 07-G01655/abh

When batt insulation is installed, it is fit between the wood frame studs, according to the manufacturer's instructions. The batts must be carefully cut to fit around obstructions, such as window frames, pipes, wires, and electrical boxes with no gaps.

- Don't compress the insulation to fit behind pipes or wires. Instead cut to the middle of the batt's thickness so you have one flap under the pipe or wire and the other flap over the pipe or wire.
- One common mistake is to leave narrow places between close-spaced wall studs uninsulated. Even though these spaces may look like a very small part of the wall, small uninsulated areas can greatly reduce the insulation performance of the whole wall. Strips of insulation should be cut off and stuffed into such tight spaces by hand.
- The kraft paper or foil vapor retarder facings on many blanket insulation products must be covered with gypsum or interior paneling because of fire considerations.

Blown-in cellulose or spray foam can be used to fill wall cavities. Both of these products can do a good job of filling in the space around wires and other obstructions and in filling any oddly-shaped areas. For cellulose, some form of netting is used to hold the cellulose in place until the drywall is installed. For spray-foam, it is important that the application be finished off neatly to avoid problems with the drywall installation.

Masonry walls should be insulated on the exterior surface.

Design Options

Design Option: Crawlspaces and Slabs

Many building codes presently require installation of crawlspace vents to provide ventilation with outside air, but there is no compelling technical basis for crawlspace ventilation requirements. If the crawlspace is vented, the floor should be insulated and any pipes or ducts in the crawlspace should be insulated as well. In some climates, pipes in vented crawlspaces must also be wrapped with heat trace wires to avoid frozen pipes. If the crawlspace is not vented, it is crucial that all of the crawlspace ground area be covered with a durable vapor retarder, such as heavy-weight polyethylene film. (This is also a good practice for vented crawlspaces.) For unvented crawlspaces, the insulation should be placed on the inside wall of the crawlspace instead of under the floor above. The insulation should also extend a few feet over the ground surface inside the crawlspace, lying on top of the durable vapor retarder. For the unvented arrangement, the air within the crawlspace is actually incorporated as a part of the conditioned space within the house, as if it were a basement. The Crawlspace Insulation Technology Fact Sheet gives more details about this design option. If you choose a slab foundation, be sure to follow the recommendations for insulation installation and moisture control found in the Slab Insulation Technology Fact Sheet.

Design Option: Advanced Wall Framing

Advanced wall framing techniques can be used that will reduce the energy losses through the walls with little or no additional costs. Details are given in the Wall Insulation Technology Fact Sheet.

Design Option: Metal Framing

Some new homes are built using metal frames instead of wood. Such frames are not susceptible to insect problems that can damage wood-framed structures. However, when you insulate a metal-framed building, it is important to recognize that much more heat flows through metal studs and joists than through pieces of wood. Because of this difference, placing insulation just between the wall studs, or just between attic or floor joists, doesn't work as well for metal-framed houses as it does for wood-framed houses. If your walls have metal frames, you will need to place continuous insulative sheathing over the outside of the wall frame, between the metal framing pieces and your exterior siding in addition to insulating the space between the studs. (Note that this insulative sheathing cannot take the place of plywood or other seismic bracing.) If your attic has metal joists, you may want to place rigid foam insulation between the joists and the ceiling drywall and to cover the attic joists with insulation to the extent possible.

Design Option: Insulating Concrete Forms

Insulating concrete forms can be used to construct walls for new homes. These special concrete walls come in a variety of configurations and can provide additional thermal mass to your home to help reduce the effect of outdoor temperature swings.

Design Option: Massive Walls

The most common house type in this country is the light-construction frame house. Massive walls are less common, and include buildings made from concrete, concrete block, and log. These buildings will use less energy than wood-frame construction in many parts of the country because they can store heat from the daytime sun to provide needed heat at night, or can cool down at night to reduce air-conditioning loads during the day. Research shows that such massive wall systems perform best if the insulation is located on the outside of the wall. See the ZipCode Calculator or the ZipCode table to find out how much insulation you should use.

Design Option: Structural Insulated Panels

Structural insulated panels can be used to construct a house. These panels sandwich plastic foam insulation between two layers of a wood or composite product, thus eliminating the need for structural wood framing members. These systems save energy in two ways, first by reducing the heat losses that would have gone through the wood frame, and second by reducing air leaks. Both of these changes represent significant energy savings. Just stopping the energy flowing through the wall framing could save 25% of the wall's energy losses.

Design Option: External Insulation Finish System

Some homes are built with an External Insulation Finish System that gives a stucco-like appearance. In the past, there were quality control problems where poor construction led to water leaks into the wall system, usually around window frames. Newer versions of the external insulation finish system have been designed to be more robust and to allow any water entering through a construction defect to drain harmlessly out of the wall. This system can be used to finish wood-framed, metal-framed, and masonry walls. It offers special advantages for the metal-framed and masonry walls because the continuous external insulation layer optimizes the thermal performance of both of those two wall systems.

Design Option: Attic Ventilation or a Cathedralized Attic

It is important that the house design, and construction, minimize the transfer of moisture from the living space to the attic. To handle any moisture that does migrate into the attic, traditional attic design calls for ventilation. Attics may be ventilated with a combination of soffit vents at eaves and continuous ridge vents. Attic vents may also be installed in gable faces. Many codes and standards require one square foot of unobstructed ventilation opening for each 300 square feet of attic floor area if a vapor retarder is included in the ceiling separating the attic from the living space. Twice as much ventilation is recommended if there is no vapor retarder. The net free area of a vent is smaller than its overall dimension because part of the vent opening is blocked by meshes or louvers. The openings should be equally distributed between the soffit and ridge vents or between each gable face. Never cover or block vents with insulation. Use baffles to prevent loose-fill insulation from clogging vents.

During the house design phase, you can choose a cathedralized attic, which is not ventilated, unless attic ventilation is required by code in your area.

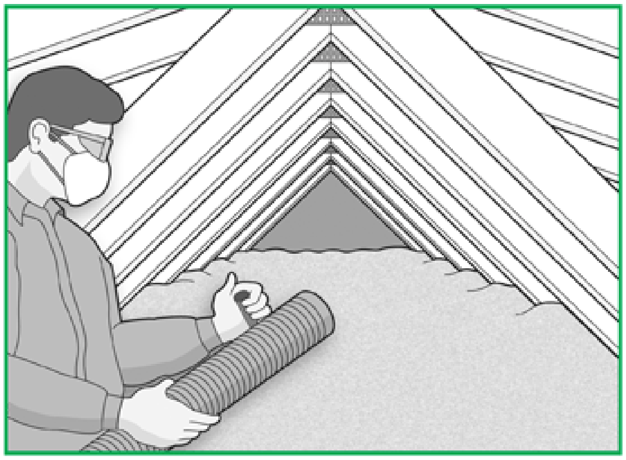
In a cathedralized attic, the insulation is placed on the underside of the roof instead of on the attic floor. (Think of a room with a cathedral ceiling, only this room is the attic and the ceiling is unfinished.) For this arrangement, the attic space is incorporated as a part of the conditioned space within the house. One advantage of this approach is that the attic will retain any energy lost by ductwork in the attic. Up to 25% of your heating and cooling energy can be wasted by leaky ductwork in a traditional attic.

A disadvantage of an unventilated attic is that the underside of the roof has a greater area than the attic floor. This greater area, and the downward-facing geometry, cause this option to be more costly than insulating the attic floor, so that usually the installed insulation R-value is less. The lower R-value and the greater area mean that more heat is lost through the cathedralized attic roof than would have been lost through the traditional attic floor. Also, a ventilated attic can reduce summer air conditioning loads relative to the cathedralized attic. The home owner must balance these two effects, reduced duct energy losses versus increased heating and cooling loads. Of course another option is to ventilate the attic, but locate the ductwork elsewhere within the conditioned part of the house, such as between floors in a multi-story building.

Adding Insulation to an Existing House (Smart Approaches)

Does your home need more insulation? Unless your home was constructed with special attention to energy efficiency, adding insulation will probably reduce your utility bills. Much of the existing housing stock in the United States was not insulated to the levels used today. Older homes are likely to use more energy than newer homes, leading to higher heating and air-conditioning bills.

Where and How Much

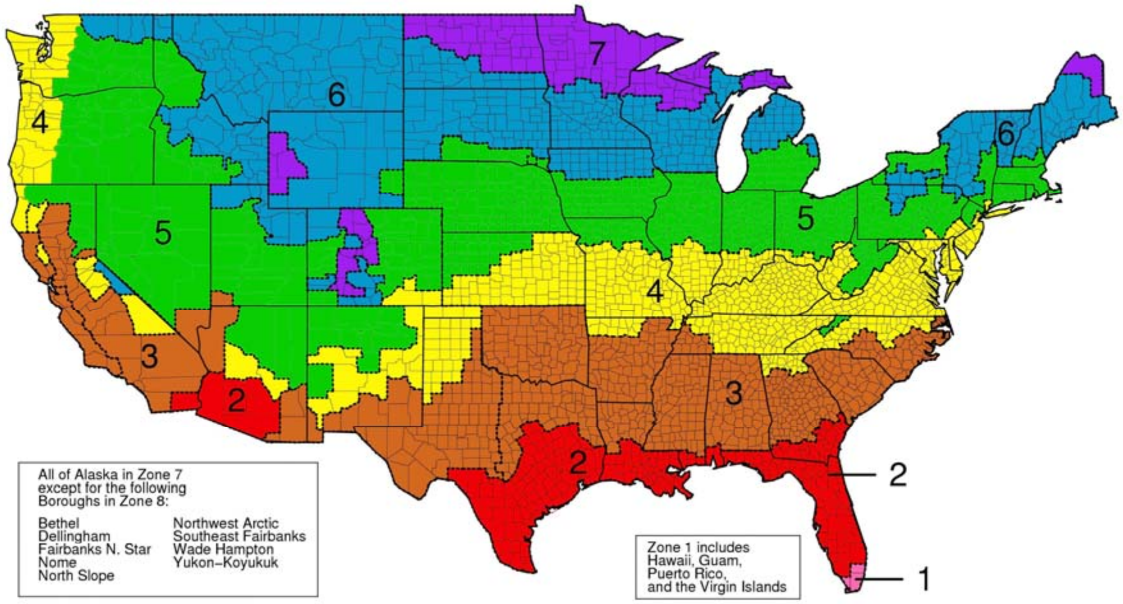


Adding more insulation where you already have some, such as in an attic, will save energy. You can save even greater amounts of energy if you install insulation into places in your home that have never been insulated. Figure 1 shows which building spaces should be insulated. These might include an uninsulated floor over a garage or crawlspace, or a wall that separates a room from the attic. Figure 3 can give you general guidance regarding the appropriate amount of insulation you should add to your home, and the rest of this page will provide more specific information.

A qualified home energy auditor will include an insulation check as a routine part of an energy audit. For information about home energy audits, call your local utility company. State energy offices are another valuable resource for information. An energy audit of your house will identify the amount of insulation you have and need, and will likely recommend other improvements as well. If you don't have someone inspect your home, you'll need to find out how much insulation you already have.

After you find out how much you have, you can use the ZipCode tool to find out how much you should add. This recommendation balances future utility bill savings against the current cost of installing insulation. So the amount of insulation you need depends on your climate and heating fuel (gas, oil, electricity), and whether or not you have an air conditioner. The program is called the ZipCode because it includes weather and cost information for local regions defined by the first three digits of each postal service zip code. The program also allows you to define your own local costs and to input certain facts about your house to improve the accuracy of the recommendations. However, some personal computer security systems won't allow Java programs to run properly. The recommended R-values table can be helpful in those cases, because it will provide recommendations based on insulation and energy costs for your local area.

Figure 3. Insulation Recommendations for Existing Wood-Framed Houses



Zone	Add Insulation to Attic		Floor
	Uninsulated Attic	**Existing 3-4 Inches of Insulation**	
1	R30 to R49	R25 to R30	R13
2	R30 to R60	R25 to R38	R13 to R19
3	R30 to R60	R25 to R38	R19 to R25
4	R38 to R60	R38	R25 to R30
5 to 8	R49 to R60	R38 to R49	R25 to R30

Wall Insulation: ***Whenever exterior siding is removed*** on an
Uninsulated wood-frame wall:

- Drill holes in the sheathing and blow insulation into the empty wall cavity before installing the new siding, and
- Zones 3-4: Add R5 insulative wall sheathing beneath the new siding
- Zones 5-8: Add R5 to R6 insulative wall sheathing beneath the new siding.

Insulated wood-frame wall:

- For Zones 4 to 8: Add R5 insulative sheathing before installing the new siding

How Much Insulation Do I Already Have?

Look into your attic. We start with the attic because it is usually easy to add insulation to an attic. This table will help you figure out what kind of insulation you have and what its R-value is.

What you see:		What it probably is	Depth (inches)	Total R-value
Loose fibers	light-weight yellow, pink, or white	fiberglass	_____	=2.5×depth
	dense gray or near-white, may have black specks	rock wool	_____	=2.8×depth
	small gray flat pieces or fibers (from newsprint)	cellulose	_____	=3.7×depth
Granules	light-weight	vermiculite or perlite	_____	=2.7×depth
Batts	light-weight yellow, pink, or white	fiberglass	_____	=3.2×depth

Look into your walls. It is difficult to add insulation to existing walls unless:

- You are planning to add new siding to your house, or
- You plan to finish unfinished space (like a basement or bonus room).

If so, you need to know whether the exterior walls are already insulated or not. One method is to use an electrical outlet on the wall, but first be sure to turn off the power to the outlet. Then remove the cover plate and shine a flashlight into the crack around the outlet box. You should be able to see whether or not insulation is in the wall. Also, you should check separate outlets on the first and second floor, and in old and new parts of the house, because wall insulation in one wall doesn't necessarily mean that it's everywhere in the house. An alternative to checking through electrical outlets is to remove and then replace a small section of the exterior siding.

Look under your floors. Look at the underside of any floor over an unheated space like a garage, basement, or crawlspace. Inspect and measure the thickness of any insulation you find there. It will most likely be a fiberglass batt, so multiply the thickness in inches by 3.2 to find out the R-value (or the R-value might be visible on a product label). If the insulation is a foam board or sprayed-on foam, use any visible label information or multiply the thickness in inches by 5 to estimate the R-value.

Look at your ductwork. Don't overlook another area in your home where energy can be saved - the ductwork of the heating and air-conditioning system. If the ducts of your heating or air-conditioning system run through unheated or uncooled spaces in your home, such as attic or crawlspaces, then the ducts should be insulated. First check the ductwork for air leaks. Repair leaking joints first with mechanical fasteners, then seal any remaining leaks with water-soluble mastic and embedded fiber glass mesh. Never use gray cloth duct tape because it degrades, cracks, and loses its bond with age. If a joint has to be accessible for future maintenance, use pressure- or heat-sensitive aluminum foil tape. Then wrap the ducts with duct wrap insulation of R-6 with a vapor retarder facing on the outer side. All joints where sections of insulation meet should have overlapped facings and be tightly sealed with fiber glass tape; but avoid compressing the insulation, thus reducing its thickness and R-value.

Return air ducts are often located inside the heated portion of the house where they don't need to be insulated, but they should still be sealed off from air passageways that connect to unheated areas. Drywall- to-ductwork connections should be inspected because they are often poor (or nonexistent) and lead to unwanted air flows through wall cavities. If the return air ducts are located in an unconditioned part of the building, they should be insulated.

Look at your pipes. If water pipes run through unheated or uncooled spaces in your home, such as attic or crawlspaces, then the pipes should be insulated.

Air Sealing

Air sealing is important, not only because drafts are uncomfortable, but also because air leaks carry both moisture and energy, usually in the direction you don't want. For example, air leaks can carry hot humid outdoor air into your house in the summer, or can carry warm moist air from a bathroom into the attic in the winter.

Most homeowners are aware that air leaks into and out of their houses through small openings around doors and window frames and through fireplaces and chimneys. Air also enters the living space from other unheated parts of the house, such as attics, basements, or crawlspaces. The air travels through:

- any openings or cracks where two walls meet, where the wall meets the ceiling, or near interior door frames;
- gaps around electrical outlets, switch boxes, and recessed fixtures;
- gaps behind recessed cabinets, and furred or false ceilings such as kitchen or bathroom soffits;
- gaps around attic access hatches and pull-down stairs;
- behind bath tubs and shower stall units;
- through floor cavities of finished attics adjacent to unconditioned attic spaces;
- utility chaseways for ducts, etc., and
- plumbing and electrical wiring penetrations.

These leaks between the living space and other parts of the house are often much greater than the obvious leaks around windows and doors. Since many of these leakage paths are driven by the tendency for warm air to rise and cool air to fall, the attic is often the best place to stop them. ***It's important to stop these leaks before adding attic insulation because the insulation may hide them and make them less accessible.*** Usually, the attic insulation itself will not stop these leaks and you won't save as much as you expect because of the air flowing through or around the insulation.

There are many fact sheets that will help you stop these air leaks:

- Air sealing
- Air sealing an existing home
- Air Sealing Technology Fact Sheet
- Air Sealing in Occupied Homes (1995)

Moisture Control and Ventilation

We talk about moisture control in an insulation fact sheet because wet insulation doesn't work well. Also, insulation is an important part of your building envelope system, and all parts of that system must work together to keep moisture from causing damage to the structure or being health hazards to the occupants. For example, mold and mildew grow in moist areas, causing allergic reactions and damaging buildings.

When Is Moisture a Problem?

When moist air touches a cold surface, some of the moisture may leave the air and condense, or become liquid. If moisture condenses inside a wall, or in your attic, you will not be able to see the water, but it can cause a number of problems. Adding insulation can either cause or cure a moisture problem. When you insulate a wall, you change the temperature inside the wall. That can mean that a surface inside the wall, such as the sheathing behind your siding, will be much colder in the winter than it was before you insulated. This cold surface could become a place where water vapor traveling through the wall condenses and leads to trouble. The same thing can happen within your attic or under your house. On the other hand, the new temperature profile could prevent condensation and help keep your walls or attic drier than they would have been.

Four Things You Can Do to Avoid Moisture Problems:

1. Control liquid water. Rain coming through a wall, especially a basement or crawlspace wall, may be less apparent than a roof leak, especially if it is a relatively small leak and the water remains inside the wall cavity. Stop all rain-water paths into your home by:

- making sure your roof is in good condition,
- caulking around all your windows and doors, and
- keeping your gutters clean - and be sure the gutter drainage flows away from your house.
- If you replace your gutters, choose larger gutters and gutter guards to help keep rain from dripping onto the ground near the house.

Be sure that the condensate from your air conditioner is properly drained away from your house. You should also be careful that watering systems for your lawn or flower beds do not spray water on the side of your house or saturate the ground near the house. It is also a good idea to check the caulking around your tub or shower to make sure that water is not leaking into your walls or floors. You can place thick plastic sheets on the floor of your crawlspace to keep any moisture in the ground from getting into the crawlspace air, and then into your house.

2. Ventilate. You need to ventilate your home because you and your family generate moisture when you cook, shower, do laundry, and even when you breathe. More than 99% of the water used to water plants eventually enters the air. If you use an unvented natural gas, propane, or kerosene space heater, all the products of combustion, including water vapor, are exhausted directly into your living space.

This water vapor can add 5 to 15 gallons of water per day to the air inside your home. If your clothes dryer is not vented to the outside, or if the outdoor vent is closed off or clogged, all that moisture will enter your living space. Just by breathing and perspiring, a typical family adds about 3 gallons of water per day to their indoor air. You especially need to vent your kitchen and bathrooms. Be sure that these vents go directly outside, and not to your attic, where the moisture can cause problems. Remember that a vent does not work unless you turn it on; so if you have a vent you are not using because it is too noisy, replace it with a quieter model. If your attic is ventilated, it is important that you never cover or block attic vents with insulation. Take care to prevent loose-fill insulation from clogging attic vents by using baffles or rafter vents. When you think about venting to remove moisture, you should also think about where the replacement air will come from, and how it will get into your house. When natural ventilation has been sharply reduced with extra air-sealing efforts, it may be necessary to provide fresh air ventilation to avoid build-up of stale air and indoor air pollutants. Special air-to-air heat exchangers, or heat- recovery ventilators, are available for this purpose. For more information about controlled ventilation, see the Whole-House Ventilation Systems Technology Fact Sheet.

3. Stop Air Leaks. It is very important to seal up all air-leakage paths between your living spaces and other parts of your building structure. Measurements have shown that air leaking into walls and attics carries significant amounts of moisture. Remember that if any air is leaking through electrical outlets or around plumbing connections into your wall cavities, moisture is carried along the same path. The same holds true for air moving through any leaks between your home and the attic, crawlspace, or garage. Even very small leaks in duct work can carry large amounts of moisture, because the airflow in your ducts is much greater than other airflows in your home. This is especially a problem if your ducts travel through a crawlspace or attic, so be sure to seal these ducts properly (and keep them sealed!). Return ducts are even more likely to be leaky, because they often involve joints between drywall and ductwork that may be poorly sealed, or even not sealed at all.

4. Plan a moisture escape path. Typical attic ventilation arrangements are one example of a planned escape path for moisture that has traveled from your home's interior into the attic space. Cold air almost always contains less water than hot air, so diffusion usually carries moisture from a warm place to a cold place. You can let moisture escape from a wall cavity to the dry outdoors during the winter, or to the dry indoors during the summer, by avoiding the use of vinyl wall coverings or low-perm paint. You can also use a dehumidifier to reduce moisture levels in your home, but it will increase your energy use and you must be sure to keep it clean to avoid mold growth. If you use a humidifier for comfort during the winter months, be sure that there are no closed-off rooms where the humidity level is too high.

Insulation Installation, the Retrofit Challenges

INSULATION INSTALLATION PRECAUTIONS

•Wear clothing adequate to protect against skin contact and irritation. A long-sleeved shirt with collar and cuffs buttoned, gloves, hat, glasses, and disposable dust respirator are advisable in all do-it-yourself insulation projects. Also, read the label and follow all the manufacturer's directions.

• Do not cover or hand-pack insulation around bare stove pipes, electrical fixtures, motors, or any heat-producing equipment such as recessed lighting fixtures. If you pack insulation around these heat-producing locations, the heat can build up, leading to fire. Electrical fire-safety codes prohibit the installation of thermal insulation within three inches of a recessed fixture enclosure, wiring compartment, or ballast, or above the fixture so that it will trap heat and prevent free circulation of air, unless the fixture is identified by label as suitable for insulation to be in direct contact with the fixture. THIS IS FOR FIRE SAFETY.

• Do not cover attic vents with insulation. Proper ventilation must be maintained to avoid overheating in summer and moisture build-up all year long.

Whether you install the insulation yourself or have it done by a contractor, it is a good idea to educate yourself about proper installation methods because an improper installation can reduce your energy savings.

Also, if your house is very old, you may want to have an electrician check to see if:

- the electrical insulation on your wiring is degraded,
- the wires are overloaded, or
- knob and tube wiring was used (often found in homes built before 1940).

If any of these wiring situations exists in your house, it may be hazardous to add thermal insulation within a closed cavity around the wires because that could cause the wires to overheat. THIS IS FOR FIRE SAFETY. The National Electric Code forbids the installation of loose, rolled, or foam-in-place insulation around knob and tube wiring.

IF YOU HAVE IT DONE PROFESSIONALLY

You should obtain cost estimates from several contractors for a stated R-value. Make sure you describe the job in writing in the same terms to each one. You may want to ask each contractor about their air- sealing services as well. Remember that you want good quality materials and labor, as well as a low price. **Do not be surprised to find the quoted prices for a given R-value installation to vary by a factor of two or more.** When you talk to a contractor, talk of R-values. Don't forget that R-values are determined by material type, thickness, and installed weight per square foot, not by thickness alone.

Adding thermal insulation to the ceiling or walls of a mobile home is complex and usually requires installation by specialists.

If adding insulation over existing insulation, do NOT use a vapor barrier between the two layers!

Attics

On unfinished attic floors, work from the perimeter toward the attic door. Be careful about where you step in the attic. Walk only on the joists so that you won't fall through the drywall ceiling. You may need to place walking boards across the tops of the joists to make the job easier. Remember that it is important to seal up air leaks between your living space and the attic before adding insulation in your attic.

Installing batts and rolls in attics is fairly easy, but doing it right is very important. Use unfaced batts, especially if reinsulating over existing insulation. If there is not any insulation in your attic, fit the insulation between the joists. If the existing insulation is near or above the top of the joists, it is a good idea to place the new batts perpendicular to the old ones because that will help to cover the tops of the joists themselves and reduce thermal bridging through the frame. Also, be sure to insulate the trap or access door. Although the area of the door is small, an uninsulated attic door will reduce energy savings substantially.

For blown-in loose fill insulation, each bag of insulating material used by the contractor should be marked with an R-value for the area to be covered. Although these figures may differ among manufacturers, the area figure will tell you the right number of bags to be used. Similarly, packages of other types of insulation should be identified by their R-value. It is important that you check that the proper amount is installed in your residence. Ask the contractor to attach vertical rulers to the joists prior to a loose-fill installation in your attic to help you see that the proper depth was installed. Also, the installer must provide a signed and dated statement describing the insulation installed, stating thickness, coverage area, R- value, and number of bags installed. In some areas, infrared thermography services are offered to help discover any gaps in the insulation.

In some houses, it is easier to get complete coverage of the attic floor with blown-in loose-fill insulation. It is best to hire an insulation contractor for this job. Loose-fill insulation must be prevented from shifting into vents or from contacting heat-producing equipment (such as recessed lighting fixtures). Block off those areas with baffles or retainers to hold the loose-fill insulation in place.

When you stack new insulation on top of existing attic insulation, the existing insulation is compressed a small amount. This will slightly decrease the R-value of the existing insulation. This effect is most important if the new insulation is more dense than the old insulation. You can compensate for this stacking effect and achieve the desired total R-value by adding about one extra inch of insulation if the old insulation is fiber glass, or about ½ inch if the old insulation is rock wool or cellulose.

Reflective Systems are installed in a manner similar to placing batts and blankets. Proper installation is very important if the insulation is to be effective. Study and follow the manufacturer's instructions. Often, reflective insulation materials have flanges that are to be stapled to joists. Since reflective foil will conduct electricity, avoid making contact with any bare electrical wiring.

Radiant barriers may be installed in attics in several configurations. The radiant barrier is most often attached near the roof, to the bottom surface of the attic truss chords or to the rafter framing. Do not lay a radiant barrier on top of your insulation or on the attic floor because it will soon be covered with dust and will not work. A separate DOE fact sheet is available for radiant barriers to show which parts of the country are most likely to benefit from this type of system.

If your attic has NO insulation, you may decide to insulate the underside of the roof instead of the attic floor. (This option is more often used in new houses and is described in Design Option: ATTIC VENTILATION OR A CATHEDRALIZED ATTIC). If you choose the cathedralized attic approach, all attic vents must be sealed. Spray-foam is then often used to insulate the underside of the roof sheathing. If batts are used for this purpose, they must be secured in a manner similar to that described below for insulating under floors. It is best to hire an insulation contractor with experience in this type of installation for this job.

Walls

Installing insulation in the cavity of exterior walls is difficult. However, when new siding is to be installed, it is a good idea to consider adding thermal insulation under the new siding. The Retrofit Best Practices Guide provides useful information about adding insulation when you remodel the outside of your house. It usually requires the services of a contractor who has special equipment for blowing loose-fill insulation into the cavity through small holes cut through the sidewall, which later are closed.

It is sometimes feasible to install rigid insulation on the outdoor side of masonry sidewalls such as concrete block or poured concrete. However, if that is not an option, you can use rigid insulation boards or batts to insulate the interior of masonry walls. To install boards, wood furring strips should be fastened to the wall first. These strips provide a nailing base for attaching interior finishes over the insulation. Fire safety codes require that a gypsum board finish, at least ½ inch thick, be placed over plastic foam insulation. The gypsum board must be attached to the wood furring strips or underlying masonry using nails or screws.

The first-floor band joist may be accessible from the basement or crawlspace. Make sure it is properly insulated as shown in Figure 1. More detailed drawings and insulation techniques for the band joist are shown in the Wall Insulation Technology Fact Sheet.

Basement Walls

When using batt or rigid insulation to insulate the inside of concrete basement walls, it is necessary to attach wood furring strips to the walls by nailing or bonding, or to build an interior stud-wall assembly on which the interior finish can be attached after the insulation is installed. The cavity created by the added framing should be thick enough for the desired insulation R-value.

The kraft paper or standard foil vapor retarder facings on many blanket insulation products must be covered with gypsum or interior paneling because of fire considerations. Some blanket products are available without these facings or with a special flame resistant facing (labeled FS25 - or flame spread index 25) for places where the facing would not be covered. Sometimes the flame-resistant cover can be purchased separately from the insulation. Also, there are special fiber glass blanket products available for basement walls that require less framing and can be left exposed. These blankets have a flame-resistant facing and are labeled to show that they comply with ASTM C 665, Type II, Class A.

More information is given in the Basement Insulation Technology Fact Sheet.

Floors and Crawlspaces

If you have a floor over a crawlspace, you can EITHER:

- Insulate the underside of the floor and ventilate the crawlspace, OR
- Leave the floor uninsulated and insulate the walls of an unventilated crawlspace.

When batts or rolls are used on the underside of a floor above an unheated crawlspace or basement, fit the insulation between the beams or joists and push it up against the floor overhead as securely as possible without excessive compaction of the insulation. The insulation can be held in place, either by tacking chicken wire (poultry netting) to the edges of the joist, or with snap-in wire holders. Batts and rolls must be cut and fit around cross-bracing between floor joists or any other obstructions. Strips of insulation may be cut off and stuffed into tight spaces by hand. Don't forget to place insulation against the perimeter that rests on the sill plate. If you insulate above an unheated crawlspace or basement, you will also need to insulate any ducts or pipes running through this space. Otherwise, pipes could freeze and burst during cold weather.

Reflective Systems are installed in a manner similar to placing batts. Proper installation is very important if the insulation is to be effective. Study and follow the manufacturer's instructions. Often, reflective insulation materials have flanges that are to be stapled to floor joists. Since reflective foil will conduct electricity, one must avoid making contact with any bare electrical wiring.

Spray-foam can be used to insulate the underside of a floor. The spray foam can do a good job of filling in the space around wires and other obstructions and in filling any oddly-shaped areas. It is best to hire an insulation contractor with experience in this type of installation.

When a fiberglass blanket is used to insulate the walls of an unventilated crawlspace, it is sometimes necessary to attach wood furring strips to the walls by nailing or bonding. The insulation can then be stapled or tacked into place. Alternatively, the insulation can be fastened to the sill plate and draped down the wall. You should continue the insulation over the floor of the crawlspace for about two feet on top of the required ground vapor retarder. Because the insulation will be exposed, be sure to use either an unfaced product or one with the appropriate flame spread rating. When rigid foam insulation boards are used to insulate the walls of an unventilated crawlspace, they can be bonded to the wall using recommended adhesives. Because the insulation will be exposed, be sure to check the local fire codes and the flame-spread rating of the insulation product. If you live in an area prone to termite damage, check with a pest control professional to see if you need to provide for termite inspections.

Resources and Links

Additional and more detailed information about thermal insulation materials and installation and about energy conservation in buildings is available from the agencies and organizations listed below. Your public utility company may also provide information and assistance on home energy conservation practices and materials.

Internet Sites

Energy Star Programs supported by the Environmental Protection Agency and the Department of Energy. These programs include information about Energy Star new homes and home improvement, http://www.energystar.gov

Building Envelope Research topics, see http://www.ornl.gov/roofs+walls

Building Technology Program Publications, see "Technology Fact Sheets" http://www.eere.energy.gov/buildings/info/publications.html#technology%20fact%20sheets

Computer Programs

ZIP-Code Computer Program:
Operable version found on the internet at: http://www.ornl.gov/~roofs/Zip/ZipHome.html

Home Energy Saver, a do-it-yourself energy audit tool produced by Lawrence Berkeley National Laboratory's Center for Building Science, http://homeenergysaver.lbl.gov

Reference Sources

U.S. Department of Energy, Energy Efficiency and Renewable Energy Program Office Home Page, http://www.eere.energy.gov

A Consumer's Guide to Energy Efficiency and Renewable Energy in the Home
http://www.eere.energy.gov/consumer/your_home/

Tips for Energy Savers http://www1.eere.energy.gov/consumer/tips/

Insulation Contractors Association of America (ICAA) Phone 703-739-0356
http://www.insulate.org/

National Association of Home Builders (NAHB)
1201 15th Street NW
Washington, DC 20005
Phone: 202-266-8200 x0, 800-368-5242, Fax: 202-266-8400
http://www.nahb.org/

NAHB Research Center, Inc.
400 Prince Georges Boulevard
Upper Marlboro, MD 20774
Phone: 800-638-8556
http://www.nahbrc.com

National Institute of Building Sciences
1090 Vermont Avenue, NW, Suite 700
Washington, DC 20005-4905
Phone: 202-289-7800, Fax: 202-289-1092
http://www.nibs.org/

Other Publications

U.S. Department of Energy
Energy Efficiency and Renewable Energy Information Center
http://www1.eere.energy.gov/informationcenter/

Office of Scientific and Technical Information (OSTI)
P.O. Box 62
Oak Ridge, TN 37831
Phone: 865-576-1188, Fax: 865-576-2865 http://www.osti.gov/

- *Retrofit Best Practices Guide*,ORNL/TM-2003/286
- *Radiant Barrier Fact Sheet*, DOE/CE-0335P
- *Builder's Foundation Handbook*, ORNL/CON-295
- *Moisture Control Handbook*, ORNL/SUB--89--SD350/1
- *Supporting Documentation for the 1997 Revision to the DOE Insulation Fact Sheet*, ORNL-6907

U.S. Department of Housing and Urban Development
Washington, DC 20410-6000 Energy Efficient Rehab Advisor

Guidelines for New Home Construction

Building Standards and Guidelines Program (BSGP) http://www.energycodes.gov

Other Building Code Links http://www.energycodes.gov/links.stm#code

ASHRAE STANDARD 90.2-2007 Energy-Efficient Design of New Low-Rise Residential Buildings
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle, NE
Atlanta, GA 30329 http://www.ashrae.org

Thermal Design Guide for Exterior Walls
American Iron and Steel Institute
http://www.toolbase.org/PDF/DesignGuides/ThermalDesignGuide.pdf

Manufacturer's Associations

Air Diffusion Council (ADC) (representing manufacturers of flexible air duct)
1901 N. Roselle Road, Suite 800
Schaumburg, Illinois 60195
Phone: 847-706-6750, Fax: 847-706-6751
http://www.flexibleduct.org/

American Iron and Steel Institute
1140 Connecticut Ave., NW, Suite 705
Washington, D.C. 20036
Phone: 202-452-7100
http://www.steel.org/

Cellulose Insulation Manufacturers Association (CIMA)
136 South Keowee Street
Dayton, OH 45402
Phone: 888-881-CIMA (881-2462) or 937-222-CIMA (222-2462), Fax:937-222-5794
http://www.cellulose.org/

Center for the Polyurethanes Industry
American Chemistry Council
1300 Wilson Blvd., Arlington, VA 22209
http://www.polyurethane.org

Expanded Polystyrene (EPS) Molder's Association
1298 Cronson Boulevard, Suite 201
Crofton, MD 21114
Phone: 800-607-3772
http://www.epsmolders.org

Extruded Polystyrene Foam Association (XPSA)
4223 Dale Boulevard
Woodbridge, VA 22193
Phone: 703-730-0062, Fax: 703-583-5860
http://www.xpsa.com

Home Ventilating Institute
1000 N. Rand Rd., Suite 214
Wauconda, IL 60084
Phone: 847-526-2010, Fax: 847-526-3993
http://www.hvi.org/

Insulating Concrete Form Association
1730 Dewes Street, Suite #2
Glenview, IL 60025
Phone: 888-864-4232, Fax: 847-657-9728
http://www.forms.org/

North American Insulation Manufacturers Association (NAIMA)
44 Canal Center Plaza, Suite 310
Alexandria, VA 22314
Phone: 703-684-0084, Fax: 703-684-0427
http://www.naima.org

Polyisocyanurate Insulation Manufacturers Association (PIMA)
7315 Wisconsin Avenue, Suite 400E
Washington, DC 20814
Phone: 301-654-0000, Fax: 301-951-8401
http://www.pima.org

Reflective Insulation Manufacturers Association
4519 E. Lone Cactus Drive
Phoenix, AZ 85050
Phone 800-279-4123, Fax: 480-513-4749
http://www.rima.net/

Society of the Plastics Industry, Inc.
1667 K St., NW, Suite 1000
Washington, DC 20006
Phone: 202-974-5200, Fax: 202-296-7005
http://www.socplas.org

Spray Polyurethane Foam Alliance
4400 Fair Lakes Court, Suite 105
Fairfax, VA 22033
Phone: 800-523-5154, Fax: 703-222-5816
http://www.sprayfoam.com/

Structural Insulated Panel Association (SIPA)
P.O. Box 1699
Gig Harbor, WA 98335
Phone: 253-858-7472, Fax: 253-858-0272
http://www.sips.org

About This Fact Sheet

The DOE Insulation Fact Sheet offers helpful advice on insulating your existing house and supplies information you need to know if you are building a new home. It is available in two versions - portable document format (pdf) and on-line version you are reading here. In order to view the pdf version you must have **Adobe Acrobat Reader** installed on you computer. The web-based version includes recommended insulation levels based on the ZIP code of a locale.

PDF Version
HTML Version

The insulation levels recommended in this Fact Sheet were chosen based on a life-cycle cost analysis. This analysis includes many assumptions about system efficiencies, and what rate of return you would like to earn on your investment. If you want to find out more about how the recommended insulation levels were chosen, please see the Supporting Documentation.

2008 Addendum to Supporting Documentation
2002 Addendum to Supporting Documentation
Supporting Documentation

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