Vermont
Residential New Construction
Baseline Study
Analysis of On-Site Audits

Final Report

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Executive Summary

This report presents the findings of on-site audits conducted at 97 recently constructed homes across Vermont. The study targeted detached single-family homes and two-unit homes. Data collection covered building envelope characteristics, heating and cooling equipment, water heating equipment, heating and cooling system ducts, appliances, and lighting. Blower door tests were conducted at 22 non-ENERGY STAR® homes where the homeowners agreed to the testing and Efficiency Vermont (EVT) provided blower door test results for the 33 inspected ENERGY STAR homes.

Participating homes were recruited by KEMA staff from homeowners who participated in the telephone survey of 249 owners of newly constructed homes and who said they would be willing to have their home audited. Potential bias is a concern in any sample based on voluntary participation. There are many factors that may influence a homeowner's willingness to have their home audited. Homeowners familiar with EVT programs may be more willing to participate; homeowners who think their home is very energy efficient may be more willing to participate because they are proud of their home or less interested in participating because they feel confident their home is energy efficient and that the audit would not tell them anything they do not already know; conversely, homeowners who think their home may not be as energy efficient as they thought it would be may be more interested in participating to learn what they could do to improve the energy efficiency of their home or less interested because they feel their home might not meet Vermont code standards; homeowners who acted as the general contractor for their home or who played an active role in specifying construction materials and mechanical equipment may be more interested in participating to see if they made wise choices.

Inspected homes include some homes that are very energy efficient and some that are not. Some homes have simple designs and some have complex designs. There are a mix of custom and spec built homes; site built and modular homes; large and small homes; ENERGY STAR and non-ENERGY STAR homes; homes that were purchased completed and homes where the owner played a major role in specifying materials and mechanical equipment.

Most audited homes are primary residence, single-family detached, custom homes built on site. Only six of the homes are attached single-family homes—two of these homes are ENERGY STAR. Only three homes are seasonal, and 18 homes are in housing developments. Nine homes are modular homes. Only one home is a complete rehab.

The percentage of single-family detached homes in the sample of audited homes (94%) is virtually the same as the percentage of homeowner telephone survey respondents living in single-family detached homes (95%). Based on American Community Survey (ACS) existing housing stock data1, the comparable percentage of single-family housing that is single-family detached homes is 90%. The percentage of ENERGY STAR homes in the final sample (34%) is

[1] http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk

consistent with the penetration of single-family ENERGY STAR homes in Vermont (36% in 2009; 29% in 2010; 43% in 2011).[2]

All findings are presented at the state level, for homes in the combined Geographically Targeted (GT) regions, homes in non-GT regions, homes in Vermont Gas territory, ENERGY STAR homes, and non-ENERGY STAR homes. Because homes in the GT regions were over sampled, in order to estimate the statewide results we weight the results from the GT regions and the non-GT regions by the percent they represent of all new homes in Vermont. All differences between homes in the GT and non-GT regions, and between ENERGY STAR and non-ENERGY STAR homes, that are significantly different at the 90% confidence level are noted. When there are ten or fewer observations for a measure, tables include both the percentage and number of observations; if there are ten or fewer observations in the GT regions or non-GT regions, statewide data are not weighted.

There are three methods for showing code compliance in Vermont: Prescriptive (Fast Track); REScheck and HERS (Home Energy Rating System) Rating. In the tables in this report, percentages of homes meeting code requirements for specific building characteristics are the percentages of homes meeting prescriptive code requirements. It is important to note that a home that does not meet the prescriptive RBES code requirement for an individual building component may very well comply with all the requirements of the REScheck or HERS rating compliance paths.

Results Show Improvement

The energy efficiency of new homes has improved since the last baseline study was conducted in 2008. The sampling approaches for the 2002, 2008 and 2011 studies are very similar, which suggests comparing the findings from these studies presents a realistic picture of changes in construction practices. The 2002 study used a nested sampling approach, similar to the 2008 study, where potential participants were asked to participate in an on-site audit after completing a telephone survey.[3] It is not clear how comparable the findings of the 1995 study are to any of the more recent studies. As described in the 1995 study, there was a three year time lag between data collection and reporting, and during that time key information regarding the sampling process was lost.[4]

Table ES 1 on the next page highlights selected areas where the results of the 1995[5], 2002[6], 2008[7] and 2011 Vermont new residential construction baseline studies[8] show continuing

[2] http://www.energystar.gov/index.cfm?fuseaction=qhmi.showHomesMarketIndex

[3] *Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency.* Prepared by West Hill Energy & Computing, Inc. for The Vermont Public Service Department. January 2, 2003.

[4] *Report on the 1995 Vermont Residential New Construction Baseline Data.* Prepared by West Hill Energy and Computing for The Vermont Public Service Department. October 21, 1999. (page 2)

[5] Ibid.

improvement in energy efficiency. As shown, the average R-value of conditioned/ambient wall insulation has consistently increased. The percentages of homes meeting or exceeding RBES prescriptive code requirements for cathedral ceiling and below grade foundation wall insulation in the current study are higher than in previous studies. Envelope leakage is lower, and heating systems are more efficient. A higher percentage of homes have CFL bulbs; in 2011 the average number of CFL bulbs per home is almost double what it was in 2008 and nine times higher than in 2002. The percentage of refrigerators that are ENERGY STAR is more than double what it was in 2008. The percentage of clothes washers that are ENERGY STAR is also higher than in 2008. See Section 12 Comparisons to Earlier Vermont Baseline Studies for a full discussion of all changes in all building characteristics across the 1995, 2002, 2008 and 2011 studies.

Table ES 1: Selected Areas Showing Continuing Energy Efficiency Gains

Feature	Vermont 1995 Baseline (n=151)*	Vermont 2002 Baseline (n=158)*	Vermont 2008 Baseline (n=106)*	Vermont 2011 Baseline (n=97)*
Average Conditioned/Ambient Wall Insulation R-value**	19	20	21	22
Sloped/Cathedral Ceiling Insulation Meets or Exceeds Code Requirements (R-30)	65%	64%	80%	90%
Below Grade Basement Wall Insulation Meets or Exceeds Code Requirements (R-10)	48%	62%	73%	87%
Average Natural Air Changes Per Hour (ACHnat)	0.45	.31	0.28	0.18
Average Air Changes Per Hour at 50 Pascals (ACH 50)***	8.1	5.6	5.1	3.2
Average AFUE of Central Heating System	n/a	85.0	87.8	91.5
Percent of Homes with CFL Bulbs	≈33%	47%	81%	94%
Average Number of CFL Bulbs per Home	n/a	3.0	14.2	27.4
Percent ENERGY STAR Refrigerators	n/a	27%	30%	62%
Percent ENERGY STAR Clothes Washers	n/a	47%	48%	59%

*The numbers of homes are the total number of homes in the studies. Not all homes have all features; therefore, the numbers of homes with a specific feature vary.
**Average R-value of conditioned/ambient wall insulation has increased, but percentage of homes meeting or exceeding prescriptive RBES code requirement of R-19 dropped from 95% in 2008 to 91% in 2011.
***1995 and 2002 results converted from ACHnat to ACH 50 by multiplying ACHnat by 18. For explanation of conversion see: http://www.energystar.gov/ia/home_improvement/home_sealing/ES_HS_Spec_v1_0b.pdf

[6] *Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency.* Prepared by West Hill Energy & Computing, Inc. for The Vermont Public Service Department. January 2, 2003.
[7] *Vermont Residential New Construction Baseline Study Analysis of On-site Audits. Submitted to Vermont Public Service Department by Nexus Market Research, Inc., RLW Analytics, Inc. and Dorothy Conant. July 2009.*
[8] Some reports available on VPSD website:
http://publicservice.vermont.gov/topics/energy_efficiency/eeu_evaluation

Room for Further Improvement

Looking at the study results from a different perspective shows opportunities for further improving the energy efficiency of new home construction in Vermont. Table ES 2 on the next page shows that 9% of inspected homes have less than R-19 conditioned/ambient wall insulation, 40% of homes with flat ceilings have less than R-38 insulation, and 10% of homes with cathedral ceilings have less than R-30 insulation. In 13% of homes with below grade foundation walls enclosing conditioned space, these walls are not insulated to R-10; in 70% of homes with above grade conditioned foundation walls, these walls are not insulated to R-19. Over one in ten homes with slabs do not meet RBES prescriptive code insulation requirements. One-half of tested homes have envelope leakage exceeding 3.0 ACH 50. There are still some homes with no screw-in or pin-based CFL bulbs and there is still room to increase the penetration of ENERGY STAR appliances in new homes. Again, it is important to note that a home that does not meet the prescriptive RBES code requirement for an individual building component may very well comply with all the requirements of the REScheck or HERS rating compliance paths.

Table ES 2: Selected Areas with Room for Improvement

Areas with Room For Improvement	Vermont 1995 Baseline (n=151)*	Vermont 2002 Baseline (n=158)*	Vermont 2008 Baseline (n=106)*	Vermont 2011 Baseline (n=97)*
Conditioned/Ambient Walls Fail to Meet Code (R-19)	n/a	10%	5%	9%
Flat Ceiling Insulation Fails to Meet Code (R-38)	38%	28%	26%	40%
Sloped/Cathedral Ceiling Insulation Fails to Meet Code (R-30)	35%	36%	20%	10%
Floors over Unconditioned Basements Fail to Meet Code (R-38)	n/a	73%	100%	85%
Floors Over Outside Air Fail to Meet Code (R-28)	n/a	73%	75%	80%
Below Grade Foundation Wall Insulation Fails to Meet Code (R-10)	52%	38%	27%	13%
Above Grade Foundation Wall Insulation Fails to Meet Code (R-19)	n/a	n/a	28%	70%
Slab Insulation Fails to Meet Code (R-10)	n/a	63%	46%	16%
Air Infiltration—ACH 50 Greater than 3.0	n/a	n/a	79%	50%
Percent of Homes with No Screw-in or Pin-based CFL Bulbs	≈67%	53%	19%	6%
Percent Non-ENERGY STAR Refrigerators	n/a	73%	70%	36%**
Percent Non- ENERGY STAR Dishwashers	n/a	64%	31%	17%**
Percent Non-ENERGY STAR Clothes Washers	n/a	53%	52%	36%**

*The numbers of homes are the total number of homes in the study. Not all homes have all features; therefore, the number of homes with a specific feature varies.

**ENERGY STAR and non-ENERGY STAR percentages of refrigerators and clothes washers in Table ES 1 and Table ES 2 do not add to 100% because the ENERGY STAR status is unknown for 2% of refrigerators and 5% of clothes washers. Also, ENERGY STAR status is unknown for 17% of dishwashers.

ENERGY STAR and Non-ENERGY STAR Homes Compared

The Vermont ENERGY STAR Home (VESH) services haves been in place for several years. Hundreds of builders and developers who have built at least one ENERGY STAR-certified home have collectively built almost 8,000 ENERGY STAR-certified homes in Vermont.[9] Assuming VESH services have been successful in encouraging builders to build more energy-efficient homes and providing the training and support builders need to build ENERGY STAR-certified homes, we would expect to see measurable differences between ENERGY STAR and non-ENERGY STAR homes. Table ES 3 on the following page shows the differences between ENERGY STAR and non-ENERGY STAR homes that are statistically significant at the 90% confidence level—in all cases ENERGY STAR homes are more energy efficient.

Compared to non-ENERGY STAR homes, ENERGY STAR homes have higher average levels of flat ceiling, conditioned/garage floor, conditioned/outside floor, and conditioned/ambient joist insulation; are more likely to use something other than, or in addition to, fiberglass batt insulation in ceilings; and more likely to have foundation walls insulated to RBES code requirements. ENERGY STAR homes have, on average, lower U-value windows and lower air infiltration. ENERGY STAR homes have higher AFUE heating systems, especially higher AFUE propane furnaces, and a higher CFL bulb saturation. These differences between ENERGY STAR and non-ENERGY STAR homes suggest that VESH services have been successful in helping participating builders build more energy-efficient homes. There are clearly opportunities for Vermont to reach out to builders who want to learn how to increase their competitiveness by incorporating cost effective energy-efficient construction practices.

[9] http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showAreaResults&s_code=VT&msa_id=all

Table ES 3: Significant Differences between ENERGY STAR and Non-ENERGY STAR Homes

Areas Where ENERGY STAR Homes are Significantly More Efficient than Non-ENERGY STAR Homes	Non-ENERGY STAR Homes (n=64)**	ENERGY STAR Homes (n=33)**
Average Flat Ceiling Insulation R-value	R-40*	R-50*
Non-Fiberglass Batt Flat Ceiling Insulation	71%*	100%*
Non-Fiberglass Batt Cathedral Ceiling Insulation	48%	100%*
Average Conditioned/Garage Floor Insulation	R-25*	R-45*
Average Conditioned/Outside Floor Insulation	R-19*	R-34*
Average Conditioned/Ambient Joist Insulation	R-19*	R-22*
All Foundation Walls Insulated to RBES Prescriptive Compliance Path Minimum Requirements	54%*	80%*
Average Window U-value	U-0.34*	U-0.31*
Air Infiltration—Average ACHnat	0.20*	0.13*
Air Infiltration—Average ACH 50	3.6*	2.4*
Air Infiltration—Total CFM50	1,166*	786*
Average Heating System AFUE	90.6*	93.1*
Average Natural Gas & Propane Furnace AFUE	87.7*	95.3*
Average Natural Gas Furnace AFUE	None	95.8
Average Propane Furnace AFUE	87.7*	94.4*
CFL Socket Saturation***	37%*	50%*
Proportion of Incandescent and CFL Bulbs that are CFLs	41%*	59%*

*Significantly different at the 90% confidence level.
**The numbers of homes are the total number of homes in the study. Not all homes have all features; therefore, the numbers of homes with a specific feature vary.
***This is the percent of the total number of installed CF, incandescent, LED, and fluorescent, bulbs plus bubs in storage, and empty sockets.

Building characteristics where the differences between ENERGY STAR and non-ENERGY STAR homes are not statistically significant at the 90% confidence level are listed below.

- Average insulation R-values not significantly different between ENERGY STAR and non-ENERGY STAR homes
  - Conditioned/Ambient Walls
  - Conditioned/Garage Walls
  - Conditioned/Attic Walls
  - Cathedral Ceilings
  - Above and Below Grade Foundation Walls
  - Above and Below Grade Slabs

- Average Mechanical Equipment Efficiencies not significantly different between ENERGY STAR and non-ENERGY STAR homes
  - Oil Boiler Heating System AFUEs
  - Natural Gas Boiler Heating System AFUEs
  - Propane Boiler Heating System AFUEs
  - Water Heater Energy Factors by Type of Water Heating System

- ENERGY STAR Appliance Saturations not significantly different between ENERGY STAR and non-ENERGY STAR homes
  - Primary Refrigerators
  - Clothes Washers
  - Dishwashers

RBES Code Compliance

Compliance for all non-ENERGY STAR homes was assessed using REScheck software. All ENERGY STAR-qualified homes complied with RBES via the Home Energy Rating (HER) path and therefore were not assessed using the REScheck software. Seventy-two of the 97 inspected homes passed the 2005 RBES via the HER compliance path or the REScheck software, yielding a compliance rate of 74%. These results show continued improvement over the 2002 new construction study[10] (58%) and a slight improvement over the 2008 new construction study (72%).[11] The compliance rates listed in Table ES 4 include all single-family homes in the new construction study – both ENERGY STAR and non-ENERGY STAR homes.

Table ES 4: RBES Technical Compliance Rates Over Time

	2002 Study (n=158)	2008 Study (n=106)	2011 Study (n=97)
Compliance Rate	58%*	72%*	74%

*There is a statistically significant difference at the 90% confidence level between the 2002 results and the 2008 results. However, there is *not* a statistically significant difference at the 90% confidence level between the 2008 results and the 2011 results.

All 64 non-ENERGY STAR homes were assessed using the REScheck software. The 39 homes that complied using this approach had significantly more efficient characteristics than the 25 non-compliant homes. Table ES 5 presents a comparison of key home characteristics across compliant and non-compliant non-ENERGY STAR homes, ENERGY STAR homes and the entire statewide sample of homes. Table ES 5 also provides information on the 2005 RBES

[10] Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency. Prepared by Westhill Energy and Computing for the Vermont Public Service Department. January 3, 2003.

[11] Residential Building Energy Standards Compliance Analysis. Prepared by Nexus Market Research, Dorothy Conant and KEMA. June 10, 2009.

prescriptive requirements. It is important to note that the RBES prescriptive requirements given in the last column are for comparison only; these values do not apply to any home that passes RBES compliance via the REScheck or HER compliance paths. For most items, the statewide average values met or exceeded 2005 RBES prescriptive requirements, however frame floor insulation over unconditioned basements was much lower, insulated on average to R-11, rather than the R-30 required in the prescriptive paths. In addition, above-grade foundation walls are insulated to an average of R-13, less than the R-19 value from the prescriptive requirements.

Table ES 5: Comparison of Key Home Characteristics

	Non-Compliant Non-ENERGY STAR Homes (Unweighted)	Compliant Non-ENERGY STAR Homes (Unweighted)	ENERGY STAR Homes (Unweighted)	Statewide (Weighted)	2005 RBES Prescriptive Requirements
RBES Compliance Path	*REScheck*	*REScheck*	*HER Path*	*REScheck & HER path*	*Fast-Track & Trade-Off paths*
Average Heating System AFUE	**88.6%*** (n=22)	**91.8%*** (n=37)	93.1% (n=30)	91.5% (n=89)	80-87%**
Flat Attic Average R-value	**36.7*** (n=21)	**42.6*$^{\sigma}$** (n=30)	**50$^{\sigma}$** (n=29)	44 (n=80)	38-49**
Cathedral Ceiling Average R-value	37.1 (n=9)	39.1 (n=27)	41 (n=15)	39 (n=51)	30
Conditioned/Ambient Wall Average R-value	**17.9*** (n=25)	**23.7*** (n=39)	22 (n=33)	22 (n=97)	19-21**
Floor Over UC Bsmt Average R-value	**0*** (n=12)	**26.3*** (n=8)	n/a (n=0)	11 (n=20)	30
Cond. Bsmt Below Grade Foundation Wall Average R-value	**7.2*** (n=11)	**14.0*** (n=26)	12.2 (n=30)	12.0 (n=67)	10-15**
Cond. Bsmt Above Grade Foundation Wall Average R-value	9.2 (n=7)	14.4 (n=12)	15.0 (n=8)	13.2 (n=27)	19-21**
Average Glazing Percentage	**14%*** (n=25)	**16%*** (n=39)	16% (n=33)	15% (n=97)	12%-18%**

*Indicates that the values for compliant and non-compliant non-ENERGY STAR homes are significantly different at the 90% confidence level.

**These numbers represent the range allowed by different prescriptive compliance packages, whereby some tradeoffs are allowed.

$^{\sigma}$ Indicates that values for compliant non-ENERGY STAR homes and ENERGY STAR homes are significantly different at the 90% confidence level.

As shown in Table ES 5, compliant non-ENERGY STAR homes had significantly higher average R-values, at the 90% confidence level, than non-compliant non-ENERGY STAR homes for flat attic insulation (R-42.6 vs. R-36.7, respectively), conditioned/ambient wall insulation (R-23.7 vs. R-17.9, respectively), insulation in floors over unconditioned basements (R-26.3 vs. R-0, respectively), and conditioned basement below-grade foundation wall insulation (R-14.0 vs.

R-7.2, respectively). In addition, the compliant homes had significantly higher heating system AFUEs (91.8% vs. 88.6% respectively). However, the compliant homes also had a significantly higher glazing percentage than did non-compliant homes (16% vs. 14% respectively). The large differences for insulation in floors over unconditioned basements and conditioned basement foundation walls are driven by the fact that 12 of the 25 homes that failed to meet code had both uninsulated foundation walls and uninsulated frame floors over unconditioned basements.

Auditors found an RBES certificate in 19 of the 97 homes inspected (20%). Eighteen of these 19 homes (95%) were ENERGY STAR homes, and the RBES certificate was often located on the electric panel along with an ENERGY STAR certificate. All 19 homes were found to be correctly labeled as RBES compliant. While this is a relatively low incidence of displaying RBES certificates, this is a significantly higher percentage than was found in the 2008 study, where only 11% of homes had an RBES certificate available.

See Section 3 RBES Code Compliance for a full discussion of RBES code compliance.

Remainder of Report

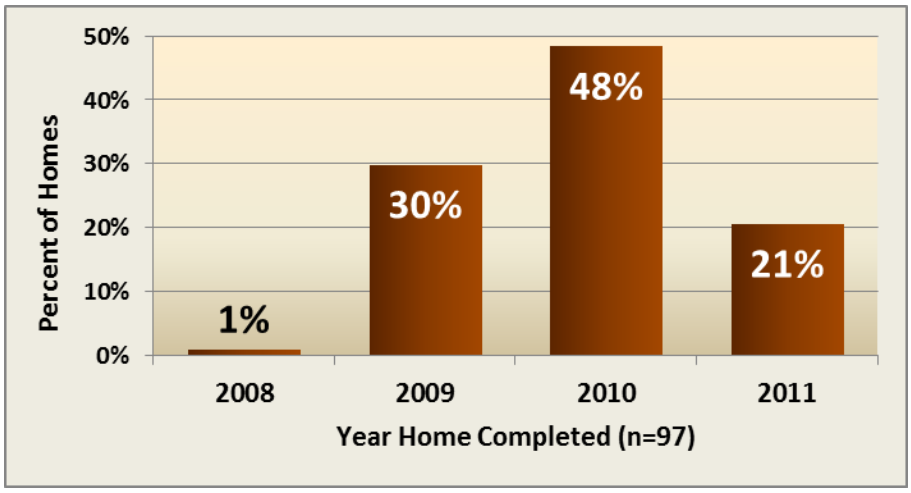
The remainder of this report presents a more detailed discussion of the RBES code compliance analysis, the detailed results of the on-site audits, and a comparison of the results of the current study to the results of previous Vermont baseline studies. Examples of good and bad building practices are presented in Appendix A Good and Bad Practices and Appendix B Insulation Grades explains how insulation installations were graded.

This report does not explore differences in home groupings other than between homes in geographically targeted regions and non-geographic targeted regions, and between ENERGY STAR and non-ENERGY STAR homes. The next report in this series—the overall report on new construction—will integrate the results of the homeowner telephone surveys, the on-site audits, and HVAC contractor interviews.

1 Introduction

A total of 97 usable on-site audits were conducted from October 2011 through early February 2012 at a mix of recently constructed non-ENERGY STAR and ENERGY STAR-qualified single-family homes across Vermont.[12] All inspected homes were completed when 2005 Vermont RBES requirements were in effect. The objective of the inspections is to assess the energy related characteristics of the homes in order to provide baseline data reflecting the current residential new construction market in Vermont. Figure 1-1 shows the majority of homes (69%) were completed in 2010 or 2011.[13]

Figure 1-1: Year Homes Completed



Single-family homes are defined to include both detached and attached single-family homes:

- Detached single-family home
  - Constructed on site using a foundation; usually built with wood framing, but also could be built from brick, metal, or another material
  - Modular home that is built at a factory in separate units then assembled and set onto a foundation
- Attached single-family home
  - Two-family home or duplex—this includes single-family attached homes if there are not more than two units attached

[12] Audits were conducted at 100 homes. Three homes were later removed from the sample. Two homes were removed because they were determined to be manufactured housing. One ENERGY STAR home that was in the process of being certified when the audit was conducted has not yet had its final inspection so no REM/Rate file data on building shell and mechanical equipment were available for analysis.

[13] The study targeted homes completed in January 2009 or later based on information from the homeowner; one home was later identified as being completed in August 2008.

Table 1-1 shows how the characteristics of inspected homes vary based on what year the homes were completed. As shown, the characteristics of homes completed in 2010 and 2011 are consistently more energy efficient than in homes completed in 2009, with one exception—the average AFUE of oil boilers was higher in homes completed in 2009 than in homes completed in 2010 or 2011. No differences between 2010 and 2011 homes are statistically significant at the 90% confidence level. Differences in flat ceiling insulation R-values, average heating system AFUEs, and average propane boiler AFUEs between 2009 and 2010 homes are statistically significant at the 90% confidence level.

Table 1-1: Home Characteristics by Year Completed—Unweighted Data

Year Home Completed →	2009	2010	2011	All Years
Conditioned Floor Area	(N=30)	(N=47)	(N=20)	(N=97)
Average Square Feet	2,102	2,069	2,503	2,169
Conditioned/Ambient Walls	(n=30)	(n=47)	(n=20)	(n=97)
Average R-value	19.5	21.8	25.0	21.7
Flat Ceilings	(N=27)	(N=38)	(N=15)	(N=80)
Average R-value	39*	46*	46	44
Cathedral Ceilings	(N=12)	(N=26)	(N=13)	(N=51)
Average R-value	37	40	40	39
Floors Conditioned/ Unconditioned Basement	(N=5)	(N=10)	(N=5)	(N=20)
Average R-value	5	11	15	11
All AFUE Heating Systems	(n=26)	(n=44)	(n=19)	(n=89)
Average AFUE	89.6*	92.5*	91.4	91.4
Below Grade Foundation Walls	(N=22)	(N=32)	(N=13)	(N=67)
Average R-value	11.9	12.0	12.9	12.2
Above Grade Foundation Walls	(N=11)	(N=10)	(N=6)	(N=27)
Average R-value	11.9	14.4	13.8	13.2
Natural Gas & Propane Boilers	(n=17)	(n=33)	(n=10)	(n=60)
Average AFUE	89.7*	92.7*	91.9	91.7
Natural Gas Boilers	(n=3)	(n=5)	(n=0)	(n=8)
Average AFUE	87.3	88.7	n/a	88.2
Propane Boilers	(n=14)	(n=28)	(n=10)	(n=52)
Average AFUE	90.2*	93.4*	91.9	92.2
Oil Boilers	(n=2)	(n=3)	(n=5)	(n=10)
Average AFUE	88.2	87.2	86.9	87.3
Natural Gas & Propane Furnaces	(n=7)	(n=8)	(n=4)	(n=19)
Average AFUE	89.9	93.9	96.0	92.9
Natural Gas Furnaces	(n=2)	(n=4)	(n=2)	(n=8)
Average AFUE	95.3	95.8	96.5	95.8
Propane Furnaces	(n=5)	(n=4)	(n=2)	(n=11)
Average AFUE	87.7	92.1	95.5	90.7

*Significantly different at the 90% confidence level.

1.1 Sampling

Volunteers for the on-site audits were recruited from the telephone surveys of 249 owners of newly constructed homes in Vermont.

1.2 New Construction Housing Market

Census Bureau reports of new housing unit permits issued in Vermont for single-family housing units and units in two-unit buildings report 953 units in 2009, 1,018 units in 2010, and 883 units in 2011.[14] The 2011 market assessment study targets detached single-family homes and two-unit homes; it excludes single-family attached homes if more than two units are attached. The Census Bureau housing permit reports include all single-family attached housing with ground to roof walls separating the units as one-unit single-family homes regardless of how many units are attached—this means the number of housing permits issued for the types of housing specifically targeted in this study (single-family detached homes and two-unit homes) is lower than the number of one- and two-unit housing permits in the Census Bureau reports.

1.3 Geographic Targeting

The Vermont Public Service Department (PSD) requested detailed information on the housing stock located in four Geographically Targeted (GT) regions in Vermont: Northern Chittenden, St. Albans, Rutland, and the Southern Loop. Information is presented separately for the Vermont Gas Systems (VGS) service territory. Data from Efficiency Vermont (EVT) regarding the number of GT accounts in each GT town were analyzed in order to identify towns where GT accounts are highly concentrated; these towns were then selected to represent the GT regions. Therefore, we can be reasonably assured that homes from these towns are in fact GT customers. See Appendix C Towns Representing GT Regions for a list of the towns selected to represent each region, and the percent of GT accounts in each town.

1.4 Sampling Error

In developing the on-site sample design, we drew from experience in similar studies in determining a coefficient of variation (CV); now we are able to utilize actual coefficients to estimate the final precisions of key home characteristics.

The coefficient of variation is of central importance to determining the final precisions. A primary objective of this study is to document the building and equipment status of new single-family homes by feature. Since there is no single variable that quantifies a home's construction features, we identified results that we believe are influential in the determination of a home's overall efficiency. Table 1-2 lists these key parameters along with the coefficient of variation

[14] http://www.census.gov/construction/bps/stateannual.html

associated with their measurement. Based on these coefficients, we used the poorest (highest) coefficient of variation to provide a sense of the precision around the final results.

Table 1-2: Coefficients of Variation for Key Residential Measurements

Parameter	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide (n=97)
Conditioned/Ambient Wall Insulation (R-value)	0.29	0.37	**0.36**	0.32	0.36	0.35
Flat Ceiling Insulation (R-value)	0.33	0.37	0.35	0.39	0.29	0.36
Cathedral Ceiling Insulation (R-value)	0.23	0.27	0.22	0.18	0.30	0.26
Heating System Efficiency (AFUE)	0.05	0.05	0.04	0.04	0.05	0.05
Air Infiltration Natural Air Changes per Hour or Air Changes per Hour at 50 Pascals ACH 50	**0.49**	**0.52**	0.33	**0.49**	**0.42**	**0.50**

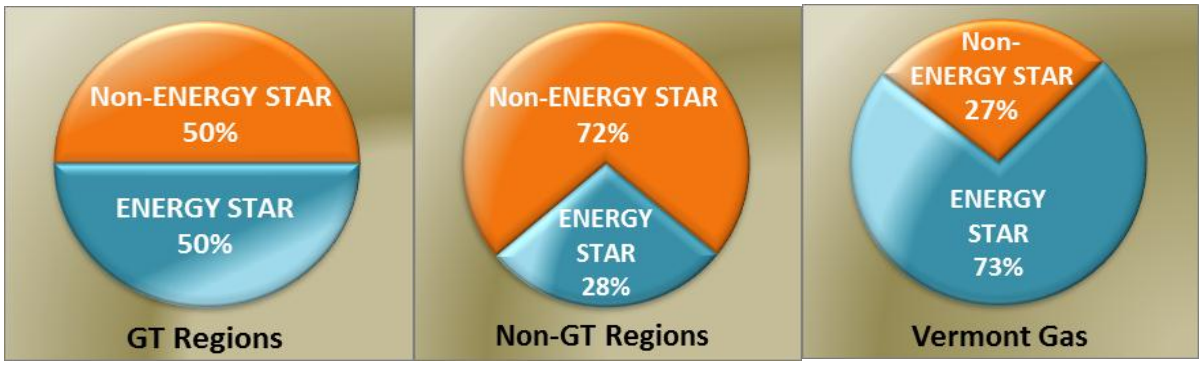
Table 1-3 shows the relative precisions are ±14.9% for the combined GT regions, ±10.1% for the non-GT regions, ±11.3% for Vermont Gas territory, ±13.9% for ENERGY STAR homes and ±8.5% for non-ENERGY STAR homes. Statewide, the relative precision is ± 8.3%.

Table 1-3: Relative Precisions

Geographic Area or Home Category	Number of On-site Audits	Coefficient of Variation	Relative Precision
GT Regions	28	0.49	+/- 14.9%
Non-GT Region	69	0.52	+/- 10.1%
Vermont Gas	26	0.36	+/- 11.3%
ENERGY STAR Homes	33	0.49	+/- 13.9%
Non-ENERGY STAR Homes	64	0.42	+/- 8.5%
All Vermont New Single-Family Homes	**97**	**0.50**	**+/- 8.3%**

Figure 1-2 shows the percentages of inspected ENERGY STAR and non-ENERGY STAR homes in the GT Regions, the non-GT Regions and Vermont Gas territory.

Figure 1-2: GT Regions, Non-GT Regions & Vermont Gas Sample Composition



1.5 Weighting

Because homes in the GT regions were over sampled, in order to estimate the statewide results we weight the results from the GT regions and the remainder of Vermont. The weights for each of the GT regions, the combined GT regions, and non-GT region of Vermont are developed by dividing the number of new single-family homes in the individual regions by the total number of new single-family homes in Vermont. Table 1-4 shows the estimated number of new single-family homes in each region and the weighting factor for each region.

Given the small number of on-site audits conducted in some individual GT regions, the on-site results are reported for the combined GT regions and the non-GT region. Weighted state level results weight combined GT region results by the combined target region weighting factor (21.8%) and non-GT region results by the non-GT region weighting factor (78.2%). In cases where the number of observations for a particular home feature is ten or fewer for either homes in the GT regions or the non-GT region, state level data is presented unweighted.

Table 1-4: Table Weighting for On-Site Audit Results

Region	Number of On-site Audits Completed	Estimated Number of New Single-Family Homes	Percent of New Single-Family Homes (Weighting Factor)
Northern Chittenden	6	92	4.8%
St. Albans	17	172	8.9%
Rutland	1	16	0.8%
Southern Loop	**4**	**139**	**7.2%**
Combined GT Regions	**28**	**419**	**21.8%**
Non-GT Region	**69**	**1,507**	**78.2%**
State Total	97	1,926	100.0%

1.6 Recruiting

On-site sample recruiting and scheduling was performed by KEMA staff and an independent auditor in Vermont who recruited and inspected four homes. Homeowners were introduced to the on-site audits through the telephone survey of 249 owners of new homes. Survey respondents were told what the on-site audit would involve, how long it would take, and about the incentives they would receive if they agreed to and were selected to have their home audited. KEMA staff recruited from the list of survey participants who were willing to have their home audited. The following steps were taken in order to minimize customer intrusion, improve recruiting rates, and minimize bias in the selection of homes.

- *Advance Notice.* The pool of homeowners saying they would be willing to have their home audited were told during the telephone survey that if they were selected for an audit someone would be calling them within the next few weeks to schedule an appointment.
- *Use of incentives.* An incentive of $50 was offered to all homeowners.

- *Confirmation Calls.* Each homeowner was called within 48 hours of their scheduled appointment to confirm their availability.

Potential Bias Issues. Potential bias is a concern in any sample based on voluntary participation. There are many factors that may influence a homeowner's willingness to have their home audited. Homeowners familiar with EVT programs may be more willing to participate; homeowners who think their home is very energy efficient may be more willing to participate because they are proud of their home or less interested in participating because they feel confident their home is energy efficient and that the audit would not tell them anything they do not already know; conversely, homeowners who think their home may not be as energy efficient as they thought it would be may be more interested in participating to learn what they could do to improve the energy efficiency of their home or less interested because they feel their home might not meet Vermont code standards; homeowners who acted as the general contractor for their home or who played an active role in specifying construction materials and mechanical equipment may be more interested in participating to see if they made wise choices.

Inspected homes include homes that are very energy efficient and some that are not. There are a mix of custom and spec built homes; site built and modular homes; large and small homes; ENERGY STAR and non-ENERGY STAR homes; homes that were purchased after they were finished and homes where the owner played a major role in specifying construction materials and mechanical equipment.

The percentage of single-family detached homes in the sample of audited homes (94%) is virtually the same as the percentage of homeowner telephone survey respondents living in single-family detached homes (95%). Based on American Community Survey (ACS) existing housing stock data15, the comparable percentage of single-family housing that is single-family detached homes is 90%. The percentage of ENERGY STAR homes in the final sample (34%) is consistent with the penetration of single-family ENERGY STAR homes in Vermont (36% in 2009; 29% in 2010; 43% in 2011).[16]

1.7 On-site Audit Data Collection

The on-site audits included collecting information on a multitude of home features. All but four inspections were conducted by NMR and KEMA auditors—one independent auditor in Vermont recruited and inspected four homes. The main areas data collection focused on are:

- *General Information.* Home style; stand alone or in a development, primary or seasonal residence, etc.
- *Basic Home Characteristics.* Total square footage, number of stories, type of basement, conditioned space square footage, etc.

[15] http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk
[16] http://www.energystar.gov/index.cfm?fuseaction=qhmi.showHomesMarketIndex

- *Building Envelope.* Wall, ceiling, floor, foundation wall, and slab construction; square footage; insulation type and level; and glazing type, square footage, orientation, U-value, etc.
- *Heating, Cooling and Water Heating Equipment.* Manufacturer and model, age, type, location, fuel, size, efficiency and, for heating systems, the number and type of thermostats and number of control zones
- *Supplemental Heating.* Number of fireplaces, stoves and portable space heaters and what fuel they use
- *Heating and Cooling Distribution Ducts.* Duct type (supply or return), location, insulation type and level, and how sealed
- *Envelope Leakage.* Blower door testing at a sample of sites if acceptable to the homeowner[17]
- *Appliances in the Home.* Dishwashers, clothes washers, clothes dryers, ranges, ovens, refrigerators, freezers, televisions, and computers. Data collected include make and model, type, age, general use, approximate age and, when available, appliance size and efficiency
- *Lighting*. Light bulb inventory including all hardwired and plug-in fixtures. Includes a count by type of bulb and room

Two data collection forms were developed—one for non-ENERGY STAR homes and one for ENERGY STAR homes. ENERGY STAR homes were not specifically targeted; they were recruited during the normal recruiting process. EVT provided the REM/Rate files for sampled ENERGY STAR homes. Building shell and mechanical equipment data for ENERGY STAR homes were extracted from the REM/Rate files and auditors collected the remaining information during the on-site inspections. (Appendix D Non-ENERGY STAR Data Collection Form and Appendix E ENERGY STAR Data Collection Form)

Auditors defined conditioned space using the RESNET definition of conditioned floor area (CFA). In the 2008 study, conditioned space was defined as intentionally heated space, which is the same definition used in the 2002 baseline study, but different from the definition used in the 1995 baseline study (finished living space) and different from the definition in the Vermont Residential Building Energy Code Handbook. The handbook definition of conditioned space is:

> A space is "**conditioned**" if heating and/or cooling is deliberately supplied to it or is indirectly supplied through uninsulated surfaces of water or space heating equipment, through uninsulated ducts, or though adjacent uninsulated building surfaces. Basements and crawl spaces without ceiling insulation are considered conditioned space.

[17] Due to concerns about health and safety, blower door tests were not conducted at homes where the homeowner reported the presence of asbestos or vermiculite insulation.

The RESNET definition of Conditioned Floor Area (CFA) includes all finished space that is within the (insulated) conditioned space boundary (that is, within the insulated envelope), regardless of HVAC configuration.

- CFA does not include spaces such as insulated basements or attics that are unfinished, if there is no intentional HVAC supply, or minimal supply (inadequate to be considered directly conditioned space).
- CFA does not include heated garages.
- CFA includes unfinished spaces that are directly conditioned, that is, they have "fully ducted" intentional HVAC supply (or other intentional heat source).

It does not appear that the changes in how conditioned space was defined across the different baseline studies had a significant impact on reported conditioned floor areas. Table 1-5 shows that, across the studies, the only statistically significant differences at the 90% confidence level are:

- The percentage of inspected homes with less than 1,000 square feet of conditioned floor area was significantly lower in the 2002 study than in the 1995 study and significantly higher in the 2008 study than in the 2002 study.
- The percentage of inspected homes with 1,000 to 1,499 square feet of conditioned floor area was significantly higher in the 2008 study than in the 2002 study and significantly lower in the 2008 study than in the 2011 study.
- The percentage of inspected homes with 2,500 to 2,999 square feet of conditioned floor area was significantly lower in the 1995 study than in the 2002 study.

Table 1-5: Vermont Studies—Home Size

Home Size (Heated Area) Square Feet	Vermont 1995 Baseline	Vermont 2002 Baseline	Vermont 2008 Baseline Weighted Data (n=106)	Vermont 2011 Baseline Weighted Data (n=97)
< 1,000	**4%**	**0%**	**3%**	3%
1,000 to 1,499	12%	**8%**	**12%**	**21%**
1,500 to 1,999	29%	25%	20%	28%
2,000 to 2,499	21%	25%	25%	18%
2,500 to 2,999	**11%**	**19%**	17%	13%
3,000 to 3,499	10%	9%	10%	9%
3,500 to 3,999	6%	8%	6%	3%
4,000 to 4,499	4%	3%	5%	2%
4,500 to 4,999	2%	2%	1%	0%
5,000 or More	2%	2%	3%	1%
Average	**2,380**	**2,510**	**2,507**	**2,187**
Median	2,130	2,390	2,352*	1,958*

*Not weighted

1.7.1 Data Cleaning

As part of the data review process, the NMR team reviewed the population of data in each audit data field for reasonableness and consistency. Questions were referred to the auditors for resolution.

1.8 The Sample

Audits were performed in 97 homes in 63 towns across Vermont. Figure 1-3 shows the location of the on-site audits.

Figure 1-3: Location of On-site Audits

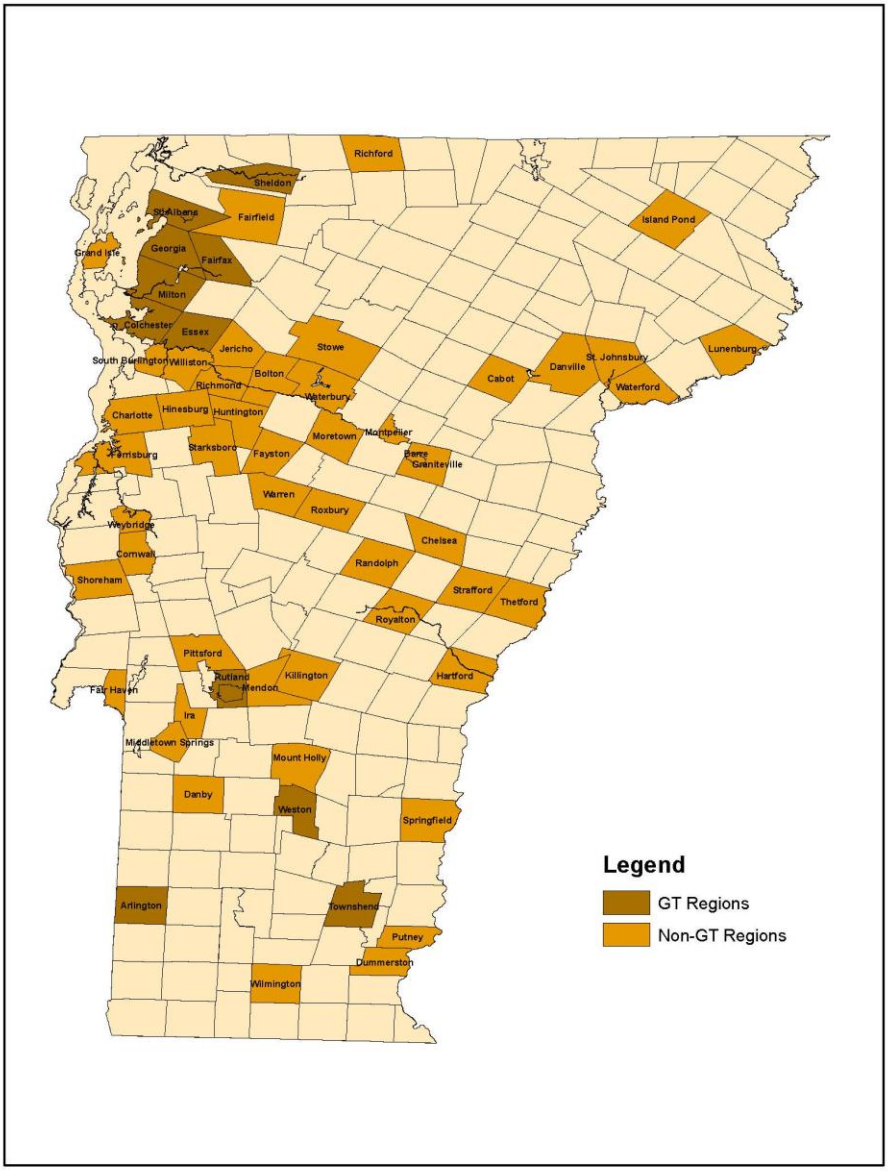
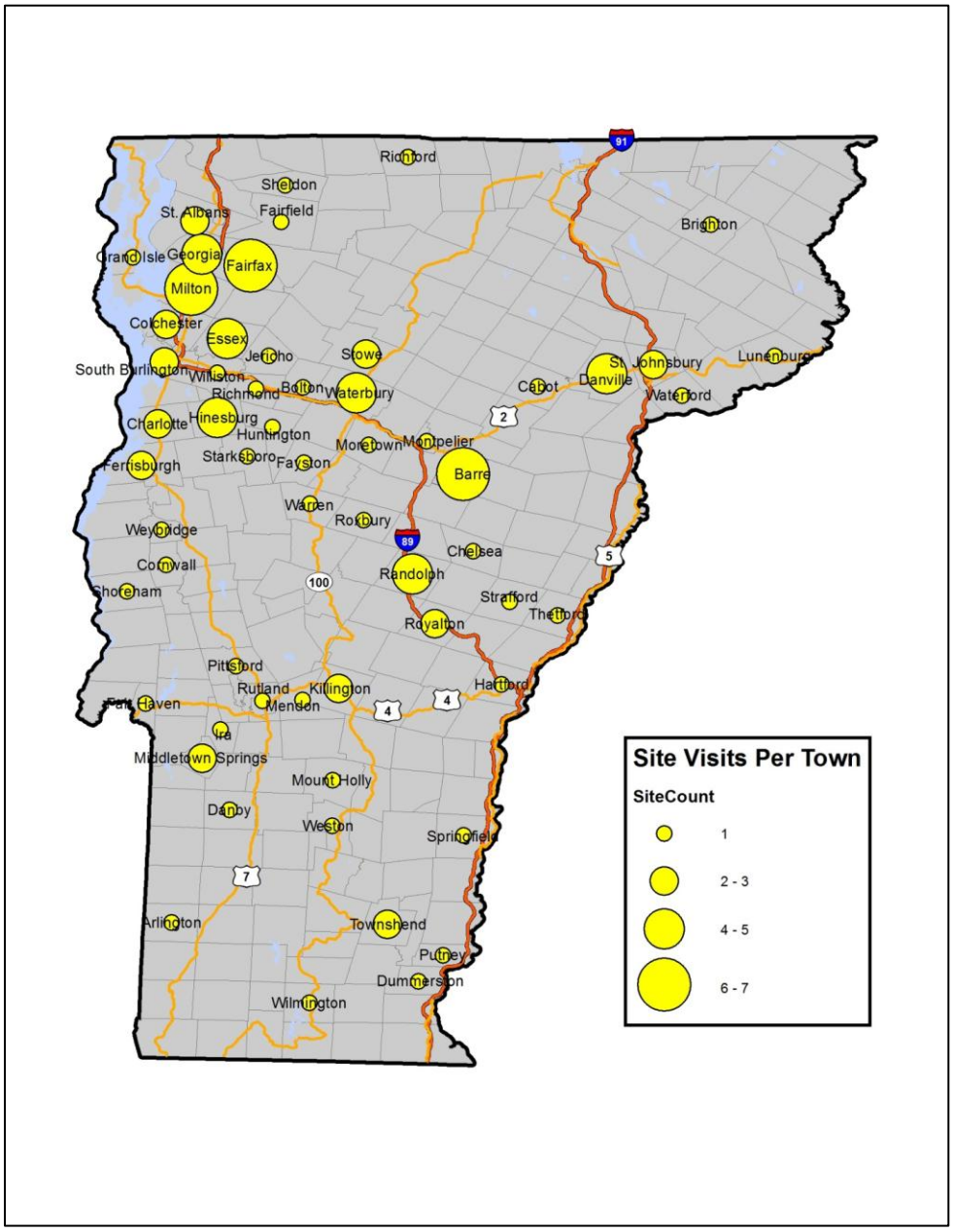


Figure 1-4 displays the towns where the on-site audits were located, and the relative number of site visits conducted in each town. Note that 70% of the towns had only a single on-site audit; the town with the most audits is Milton, with seven.

Figure 1-4: Location and Number of On-site Audits



ENERGY STAR Homes: Several of the audited homes are ENERGY STAR-certified homes. All results in this report are presented separately for ENERGY STAR and non-ENERGY STAR homes. Information on all audited homes was sent to EVT and they verified that 33 of the audited homes have been certified as ENERGY STAR homes through the Vermont ENERGY STAR Homes Service. ENERGY STAR homes are 34% of inspected homes. This percentage is consistent with the penetration of ENERGY STAR homes in Vermont (36% in 2009 and 29% in 2010[18]).

Access to Natural Gas: To the best of our knowledge 26 of the audited homes have access to natural gas. The NMR team matched the street addresses of audited homes to Vermont Gas maps of streets where they provide service. Of the 26 homes with access to natural gas:

- Thirteen are ENERGY STAR homes in GT regions
- Six are non-ENERGY STAR homes in GT regions
- Six are ENERGY STAR homes outside the GT regions
- One is a non-ENERGY STAR home outside the GT regions

[18] http://www.energystar.gov/index.cfm?fuseaction=qhmi.showHomesMarketIndex

2 Home Characteristics

Most audited homes are single-family detached, primary residences built on site. Homes in GT regions are significantly more likely than homes in non-GT regions to be attached – 18% compared to 1% (Table 2-1). All of the detached modular homes are non-ENERGY STAR homes. Almost one in five homes (18%) is located in a housing development (Table 2-2). ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to be located in a housing development. Only three homes, all non-ENERGY STAR homes, are not a primary residence.

Table 2-1: Homes by Attached/Detached

Homes by Attached/Detached	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Detached	82%*	99%*	85%	94%	94%	95%
Attached**	18%*	1%*	15%	6%	6%	5%
Detached Homes with On Site/Modular Construction Information	**GT Regions (n=23)**	**Non-GT Regions (n=68)**	**Vermont Gas (n=22)**	**ENERGY STAR (n=31)**	**Non-ENERGY STAR (n=60)**	**Statewide Weighted (n=91)**
On Site	96%	88%	100%	100%*	85%*	90%
Modular	4%	12%	0%	0%*	15%*	10%

*Significantly different at the 90% confidence level.
**One duplex is included in the attached homes for this table.

Table 2-2: Development/Stand Alone and Primary/Seasonal Homes

Home Characteristics	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Home Location						
Stand-Alone Property	71%	86%	54%	67%*	89%*	82%
Housing Development	29%	14%	46%	33%*	11%*	18%
Primary or Seasonal Home						
Primary	93%	99%	96%	100%*	95%*	97%
Weekends (year round)	4%	1%	0%	0%	3%	2%
Mainly Summer	4%	0%	4%	0%	2%	1%

*Significantly different at the 90% confidence level.

Almost one-half of homes statewide (46%) were built by custom builders; 26% were built by developers, and 16% were built by the homeowner. Homes in GT regions and ENERGY STAR homes are significantly more likely to have been built by a developer, and significantly less likely to have been built by the homeowner (Table 2-3).

Table 2-3: Homes by Type of Builder

Builder Type	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Custom	46%	46%	31%	52%	44%	46%
Developer	43%*	22%*	65%	45%*	19%*	26%
Homeowner	4%*	19%*	0%	0%*	22%*	16%
Modular	4%	12%	0%	0%*	14%*	10%
Gut Rehab	4%	0%	4%	0%	2%	1%
Other**	0%	1%	0%	3%	0%	1%

*Significantly different at the 90% confidence level.
**Other includes one Habitat for Humanity home.

Not surprising for New England, the most popular home style is colonial. Table 2-4 shows that over one-third (34%) of homes are colonials; 27% are ranches, 22% are capes, 11% are contemporary, and 6% are other styles. Homes in non-GT regions are significantly more likely than homes in GT regions to be capes – 25% compared to 11%.

Table 2-4: House Styles

House Type	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Colonial	43%	32%	38%	42%	31%	34%
Ranch	21%	29%	19%	18%	31%	27%
Cape	11%*	25%*	15%	24%	19%	22%
Contemporary	7%	12%	12%	12%	9%	11%
Other	18%*	3%*	15%	3%	9%	6%

*Significantly different at the 90% confidence level.
**Other includes three townhouses, a log house, a duplex, a cottage, and a straw bail concept house.

Table 2-5 shows that almost one-half (46%) of homes are two to two and one-half stories; 43% are one to one and one-half stories, and 10% are three or more stories.[19] Statewide, homes have an average of 1.8 stories. Homes in non-GT regions are significantly more likely than homes in GT regions to have one and one-half stories. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have three or more stories, and significantly less likely to have one and one-half stories. The average number of stories for ENERGY STAR homes (2.1) is significantly greater than the average number of stories for non-ENERGY STAR homes (1.6).

Table 2-5: Stories per Home

Stories	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
1.0	25%	26%	19%	18%	30%	26%
1.5	**7%***	**20%***	0%	**0%***	**25%***	17%
2.0	57%	42%	65%	58%	41%	45%
2.5	0%	1%	0%	0%	2%	1%
3 or More	11%	10%	15%	**24%***	**3%***	10%
Stories per Home Statistics**						
Min Stories	1.0	1.0	1.0	1.0	1.0	1.0
Max Stories	3.0	3.5	3.0	3.0	3.5	3.5
Average Stories	**1.8**	**1.8**	**2.0**	**2.1***	**1.6***	**1.8**
Median Stories	2.0	2.0	2.0	2.0	1.5	2.0

*Significantly different at the 90% confidence level.
**Only the average is weighted.

[19] In homes with conditioned walk-out basements the basement is counted as a story.

Home sizes, measured in square feet of conditioned space, range from 392 to 8,531 square feet. Table 2-6 shows that statewide, the average home size is 2,187 square feet and the median is 1,958 square feet. Most homes (80%) are 1,000 to 2,999 square feet in size. Figure 2-1 shows examples of the different sizes of homes inspected.

Table 2-6: Home Size—Conditioned (Heated) Area

Conditioned (Heated) Area (Sq. Ft.)	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
< 1,000	0%*	4%*	0%	0%*	5%*	3%
1,000 to 1,499	25%	20%	15%	33%*	16%*	21%
1,500 to 1,999	39%	25%	38%	33%	27%	28%
2,000 to 2,499	11%	20%	12%	6%*	23%*	18%
2,500 to 2,999	14%	13%	15%	12%	14%	13%
3,000 to 3,499	11%	9%	15%	9%	9%	9%
3,500 to 3,999	0%*	4%*	4%	6%	2%	3%
4,000 to 4,499	0%	3%	0%	0%	3%	2%
4,500 to 4,999	0%	0%	0%	0%	0%	0%
5,000 or More	0%	1%	0%	0%	2%	1%
Conditioned Area Square Feet Statistics**						
Min	1,008	392	1,344	1,065	392	392
Max	3,372	8,531	3,620	3,670	8,531	8,531
Average	**1,988**	**2,242**	**2,227**	**1,999**	**2,256**	**2,187**
Median	1,850	2,080	1,952	1,856	2,152	1,958

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Figure 2-1: Examples of Inspected Homes

Most homes have fully conditioned (62%) or partially conditioned (3%) basements (Table 2-7). Over one in ten homes (13%) has slab on grade construction. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have conditioned basements.

Table 2-7: Basement Types

Basement Types	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Conditioned	68%	61%	92%	85%*	52%*	62%
Unconditioned	21%	16%	8%	0%*	27%*	17%
Slab on Grade	11%	13%	0%	9%	14%	13%
Partially Conditioned	0%*	4%*	0%	0%*	5%*	3%
Enclosed Crawl space	0%	3%	0%	0%	3%	2%
Combination Conditioned & Slab on Grade	0%	3%	0%	6%	0%	2%

*Significantly different at the 90% confidence level.

Most homes (70%) are heated with propane or natural gas. In over one in ten homes (12%) wood is the primary heating fuel. Homes in GT regions are more likely than homes in non-GT regions to heat with natural gas, reflecting limited access to natural gas in the non-GT regions. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to heat with natural gas, and significantly less likely to heat with oil (Table 2-8).

Table 2-8: Primary Heating Fuel

Primary Heating Fuel	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Propane	43%	61%	31%	48%	59%	57%
Natural Gas	39%*	6%*	58%	33%*	6%*	13%
Wood	0%*	16%*	4%	6%	14%	12%
Oil	11%	9%	4%	3%*	13%*	9%
Electric	4%	3%	4%	6%	2%	3%
Propane/Wood 50/50	4%	3%	0%	0%*	5%*	3%
Pellet	0%	1%	0%	3%	0%	1%
Solar Electric	0%	1%	0%	0%	2%	1%

*Significantly different at the 90% confidence level.

Table 2-9 shows the number of occupants at home during the day ranges from none to five. In over one-quarter of homes (28%) no one is home during the day. The average number of occupants at home during the day is 1.3. Table 2-10 shows that at night the number of occupants increases to from one to eight. The average number of night time occupants is 2.7.

Table 2-9: Number of Day Time Occupants

Number of Day Time Occupants	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
0	21%	30%	23%	27%	28%	28%
1	39%	26%	35%	39%	25%	29%
2	18%	32%	23%	18%	33%	29%
3	14%	7%	12%	15%	6%	9%
4	4%	1%	4%	0%	3%	2%
5	4%	1%	4%	0%	3%	2%
unknown	0%	1%	0%	0%	2%	1%
Number of Day Time Occupants Statistics*						
Min Occupants	0	0	0	0	0	0
Max Occupants	5	5	5	3	5	5
Average Occupants	**1.5**	**1.3**	**1.5**	**1.2**	**1.4**	**1.3**
Median Occupants	1	1	1	1	1	1

*Only the average is weighted.

Table 2-10: Number of Night Time Occupants

Number of Night Time Occupants	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
1	7%	10%	8%	9%	9%	9%
2	50%	45%	50%	39%	50%	46%
3	18%	20%	15%	24%	17%	20%
4	25%	14%	27%	24%	14%	17%
5	**0%***	**6%***	0%	**0%***	**6%***	5%
6	0%	0%	0%	0%	0%	0%
7	0%	1%	0%	3%	0%	1%
8	0%	1%	0%	0%	2%	1%
unknown	0%	1%	0%	0%	2%	1%
Number of Night Time Occupants Statistics**						
Min Occupants	1	1	1	1	1	1
Max Occupants	4	8	4	7	8	8
Average Occupants	**2.6**	**2.7**	**2.6**	**2.8**	**2.7**	**2.7**
Median Occupants	2	2	2	3	2	2

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 2-11 and Table 2-12 on the next page show that homes are more likely to have faucet aerators than low flow shower heads. Statewide, homes have an average of 2.9 faucet aerators and 1.5 low flow shower heads. About one in five homes (19%) has no faucet aerators. One in five homes (20%) does not have any low flow shower heads. On average, ENERGY STAR homes have significantly more faucet aerators and low flow shower heads than non-ENERGY STAR homes, and are significantly less likely to have neither. The average number of faucet aerators in GT regions (3.6) is significantly greater than the average number of faucet aerators in non-GT regions (2.7).

Table 2-11: Number of Faucet Aerators

Number of Faucet Aerators	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
0	7%*	22%*	4%	9%*	22%*	19%
1	0%*	7%*	0%	3%	6%	6%
2	11%	7%	4%	6%	9%	8%
3	25%	29%	31%	21%	31%	28%
4	18%	13%	15%	15%	14%	14%
5	25%*	7%*	23%	18%	9%	11%
6	7%	6%	12%	9%	5%	6%
7	0%	1%	4%	3%	0%	1%
8	0%	1%	4%	3%	0%	1%
unknown	7%	6%	4%	12%	3%	6%
Number of Faucet Aerators Statistics**						
Minimum	0	0	0	0	0	0
Maximum	6	8	8	8	6	8
Average	3.6*	2.7*	4.2	3.8*	2.6*	2.9
Median	4	3	4	4	3	3

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 2-12: Number of Low Flow Shower Heads

Number of Low Flow Shower Heads	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
0	11%	23%	8%	3%*	28%*	20%
1	32%	19%	31%	27%	20%	22%
2	32%	48%	38%	45%	42%	44%
3	14%*	1%*	12%	9%	3%	4%
4	4%	4%	8%	6%	3%	4%
unknown	7%	4%	4%	9%	3%	5%
Number of Low Flow Shower Head Statistics**						
Minimum	0	0	0	0	0	0
Maximum	4	4	4	4	4	4
Average	1.7	1.4	1.8	1.9*	1.3*	1.5
Median	2	2	2	2	2	2

*Significantly different at the 90% confidence level.
**Only the average is weighted.

3 RBES Code Compliance

This section assesses the technical compliance of the 97 audited homes with the 2005 Vermont Residential Building Energy Standards (RBES). On-site audits were performed in 63 towns across Vermont. Of the 97 audited homes, 64 were non-ENERGY STAR homes and 33 were ENERGY STAR-qualified homes. Compliance for all non-ENERGY STAR homes was assessed using the REScheck software. In addition, non-ENERGY STAR home compliance with the additional RBES requirements that are not considered in the REScheck analysis is discussed.[20] All ENERGY STAR-qualified homes complied with RBES via the Home Energy Rating (HER) path and therefore were not assessed using the REScheck software.

Seventy-two of the 97 inspected homes passed the 2005 RBES via the HER compliance path or the REScheck software, yielding a compliance rate of 74%. These results show continued improvement over the 2002 new construction study[21] (58%) and a slight improvement over the 2008 new construction study (72%).[22] Compliance rates in Table 3-1 include all single-family homes in the new construction study–both ENERGY STAR and non-ENERGY STAR homes.

Table 3-1: RBES Technical Compliance Rates over Time

	2002 Study (n=158)	2008 Study (n=106)	2011 Study (n=97)
Compliance Rate	58%*	72%*	74%

*There is a statistically significant difference at the 90% confidence level between the 2002 results and the 2008 results. However, there is *not* a statistically significant difference at the 90% confidence level between the 2008 results and the 2011 results.

As stated in the 2005 RBES manual, the HER method credits homes for air tightness, solar heat gain, efficient hot water systems, and efficient lighting and appliances, which are not accounted for in the REScheck compliance path. In order to comply with the 2005 RBES via the HER compliance method, a single-family home must meet certain basic requirements[23] and receive a HERS score of 82 or greater.

[20] Vermont Residential Building Energy Code Handbook, Edition 2.0, November 2004. Accessed August 10, 2012. http://publicservice.vermont.gov/topics/energy_efficiency/rbes

[21] Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency. Prepared by Westhill Energy and Computing for the Vermont Public Service Department, January 3, 2003.

[22] Residential Building Energy Standards Compliance Analysis. Prepared by Nexus Market Research, Dorothy Conant and KEMA. June 10, 2009.

[23] These requirements are listed in Table 7-1 in the 2005 RBES handbook.

Before 2006, a higher score indicated better performance; under current HERS guidelines, a lower index indicates better performance.[24] NMR confirmed that each ENERGY STAR home received a HERS score of 82 or higher (equivalent to a HERS index of 90 or lower).

Table 3-2 shows the HERS indexes for the 33 ENERGY STAR homes in the sample. The ENERGY STAR homes scored much better than the HER compliance path requirements; the least efficient ENERGY STAR home received a HERS index of 73; the most efficient achieved an impressive index of 41, and the ENERGY STAR homes received an average HERS index of 58, far below (more efficient than) the cutoff of 90.

Table 3-2: HERS Indexes of ENERGY STAR Homes

ENERGY STAR Homes	HERS Index (n=33)
RBES Requirement	*90 max.*
Minimum	41
Maximum	73
Average	58
Median	61

Auditors found an RBES certificate in 19 of the 97 homes inspected (20%). Eighteen of these 19 homes (95%) were ENERGY STAR homes, and the RBES certificate was often located on the electric panel along with an ENERGY STAR certificate. All 19 homes were found to be correctly labeled as RBES compliant. While this is a relatively low incidence of displaying RBES certificates, this is a significantly higher percentage than was found in the 2008 study, where only 12 of the 106 homes (11%) had an RBES certificate available. Of the 106 homes in the 2008 study, 30 were ENERGY STAR qualified.

Table 3-3: RBES Certificates Displayed in Homes

	2008 Study (n=106)	2011 Study (n=97)
Homes with RBES Certificates Displayed	**11%***	**20%***

*Indicates that the values are significantly different at the 90% confidence level.

[24] Prior to 2006, HERS ratings produced HERS Scores. Under the HERS Score approach, a home built to the specifications of the HERS Reference Home (based on the 1993 Model Energy Code) has a HERS Score of 80 and each 1-point increase in a HERS Score is equivalent to a 5% increase in energy efficiency. In 2006 the HERS Index approach was introduced. The HERS Index is a scoring system established by the Residential Energy Services Network (RESNET) in which a home built to the specifications of the HERS Reference Home (based on the 2004 International Energy Conservation Code) scores a HERS Index of 100, while a net zero energy home scores a HERS Index of 0. The lower a home's index, the more energy efficient it is in comparison to the HERS Reference Home. Each 1-point decrease in the HERS Index corresponds to a 1% reduction in energy consumption compared to the HERS Reference Home. Changes in both rating standards and the reference home make it difficult to make a direct comparison between the old HERS Score and the new HERS Index. RESNET recommends using the following formula to convert a HERS Score to a HERS Index: HERS Index = 100 – (HERS Score – 80)*5. http://www.resnet.us/professional/home-energy-ratings

All together, results indicate that compliance rates with the 2005 RBES remained relatively stable between 2008 and 2011. About three-quarters of new single-family homes appear to comply with the RBES technical requirements.

3.1 RBES Compliance Analysis

Each of the 64 non-ENERGY STAR homes was run through the REScheck software in order to assess compliance. As discussed earlier, the 33 ENERGY STAR-qualified homes were assumed to be compliant with the 2005 RBES via the Home Energy Rating compliance method. In order to run all of the non-ENERGY STAR homes through REScheck, it was necessary to make several assumptions because some data were not observable or verified during the on-site audits. These assumptions are listed below:

- **Windows.** National Fenestration Rating Council **(**NFRC) stickers were only available at five of the 64 non-ENERGY STAR homes, and auditors were able to identify U-values in three other cases from plans or specific make and model information they collected. For these eight homes the verified U-value was input into the model. For all other homes a U-value of 0.34 was used for windows. See Section 4.3 Windows
- **Doors.** NFRC stickers for doors were not available at any of the inspected homes. Table 3-4 lists the U-values that were assumed for various door types. These values are based on common door U-values referenced in the REM/Rate™ software used to model ENERGY STAR homes. These values are similar to those modeled in the REM/Rate files for the 33 ENERGY STAR homes inspected for this study. Any door with more than 50% glazing (e.g., a sliding glass door) was given a U-value of 0.34, as if it were a window.

Table 3-4: Door Default R-values and U-values

Door Type	R-value	U-value
1-3/4" insulated steel or wood door	4.4	0.23
2-1/4" solid core wood door	2.8	0.36
1-3/4" solid core wood door	2.1	0.48
1-3/8" solid core wood door	1.7	0.59
1-3/8" hollow core wood door	1.3	0.77
1-3/4" wood panel wood door	1.3	0.77
1-3/8" wood panel wood door	0.9	1.11
Opaque Insulated fiberglass door*	5.0	0.20

*There is no default for an insulated fiberglass door in REM/Rate. The following information was used in selecting the default value for these types of doors: http://www.energysavers.gov/your_home/windows_doors_skylights/index.cfm/mytopic=13620.

- **Slab on Grade Insulation.** Auditors were often unable to determine the presence and/or R-value of slab on grade insulation. In thirteen cases auditors were able to determine the presence and R-value of slab on grade insulation, and the recorded R-values were input

into the model.[25] If the foundation walls appeared to have been insulated at the time of construction with rigid foam and there was some slab on grade, then the R-value of the slab insulation was assumed to be the same as that of the foundation walls. If the foundation walls were insulated with something other than rigid foam (e.g., fiberglass batts or insulated concrete forms) or the home was purely slab on grade construction, then auditors modeled the slab as having R-10 insulation; this is the predominant prescriptive requirement for unheated slabs in the 2005 RBES. A slab insulation depth of six feet was used for all homes where the entire slab was insulated (both underneath and on the perimeter), while a slab insulation depth of four feet was used for all other homes where slab insulation was entered into the model. In REScheck, the depth is the sum of the total vertical and horizontal distance of any slab insulation.

- **Foundation Wall Insulation.** The presence and R-value of foundation wall insulation was verified at almost every site. That said, the depth of exterior foundation wall insulation was not verifiable. Exterior foundation wall insulation that completely covered the above grade portion of foundation walls was assumed to extend the full depth of the foundation wall in all applicable models. This assumption is consistent with the 2005 RBES requirement for basement walls which states that basement wall insulation must cover the full height of the basement wall. For Insulated Concrete Form (ICF) foundation walls, the total R-value modeled was the sum of the R-value of the interior and exterior rigid foam. Per REScheck's instructions, concrete foundation walls that were more than 50% above grade and located in conditioned basements were entered as above grade walls, rather than basement walls.
- **Skylights.** Only five non-ENERGY STAR homes had skylights while none of the ENERGY STAR homes had skylights. Auditors were able to verify the U-value in two of these homes. For all five homes with skylights a U-value of 0.43 was used in the models, which was the U-value that auditors verified at two separate homes.

3.2 RBES Compliance Results

Thirty-nine out of 64 non-ENERGY STAR homes complied with the 2005 RBES using REScheck. As mentioned previously, all 33 ENERGY STAR homes were assumed to be compliant with the 2005 RBES using the HER compliance path.[26] Overall, 72 of the 97 homes passed 2005 RBES using either the REScheck or the HER compliance path, yielding an overall compliance rate of 74%.

[25] However, in some cases, homes had what could be seen as two thermal boundaries (e.g., an insulated frame floor over a basement with insulated foundation walls and slab), and the insulated slab may not have been modeled. In such cases, the home was run through REScheck twice, once using the frame floor as the boundary, and once using the foundation walls and slab as the boundary. The highest performing model was chosen to judge the home's RBES compliance.

[26] The Home Energy Rating compliance path requires a HERS index of 90 or lower for single-family homes. The highest HERS index among the 33 inspected ENERGY STAR homes was 73.

REScheck assesses RBES compliance by multiplying the U-value of individual building shell components by their area to compute an overall UA value[27] and then compares it to the maximum allowable UA value for a home with the same dimensions. For example, a home with a UA value greater than the maximum allowable UA value for a similarly-sized home would be "below code;" a home with a UA value less than the maximum allowable UA value for a similarly-sized home would be "above code." Of the 64 non-ENERGY STAR homes, 25 failed to meet code with an average percent below code of -35%; 39 homes met or exceeded code with an average percent above code of +18%.

One reason for the non-compliant homes being so far below code is that 12 of the 25 homes that failed to meet code had both uninsulated foundation walls and uninsulated frame floors over unconditioned basements. The non-ENERGY STAR home with the highest efficiency exceeds code by 35%, while the non-ENERGY STAR home with the lowest efficiency is 93% below code.[28] This home scored particularly poorly because it had neither foundation wall nor frame floor insulation, its ceiling was insulated with R-21 fiberglass batts, and its boiler was of moderate efficiency – AFUE of 87.3%.

On average, the non-ENERGY STAR homes that were code compliant outperformed those that were non-compliant in every major category. In fact, compliant homes have significantly higher average R-values than non-compliant homes in the following categories: flat attic insulation, conditioned/ambient wall insulation, frame floor insulation over unconditioned basements, and below-grade foundation wall insulation. All of these components are critical pieces to determining compliance as they typically have large areas, and therefore play an important role in the overall UA calculation.

Additionally, heating system efficiency seemed to have a significant impact on whether or not homes complied and also how far above or below code they fell. Mechanical efficiencies were often the last variable input into the model, and these variables seemed to shift a number of homes from non-compliant to compliant, particularly those with high efficiency boilers or furnaces. As shown in Table 3-5, compliant homes had significantly higher heating system AFUEs than non-compliant homes.

Table 3-5 also compares how ENERGY STAR homes fare on these key home characteristics as compared to the compliant and noncompliant non-ENERGY STAR homes. The only characteristic for which ENERGY STAR homes are significantly greater (at the 90% confidence level) than compliant non-ENERGY STAR homes is flat ceiling insulation (R-50 vs. R-42.6, respectively).

[27] UA=U-value*Area.
[28] The REScheck maximum allowable UA for this home is 259 and it has a calculated UA of 500.

Table 3-5: Comparison of Key Home Characteristics

	Non-Compliant Non-ENERGY STAR Homes (Unweighted)	Compliant Non-ENERGY STAR Homes (Unweighted)	ENERGY STAR Homes (Unweighted)	Statewide (Weighted)	2005 RBES Prescriptive Requirements
RBES Compliance Path	*RESCheck*	*RESCheck*	*HER Path*	*RESCheck & HER path*	*Fast-Track & Trade-Off paths*
Average Heating System AFUE	**88.6%*** (n=22)	**91.8%*** (n=37)	93.1% (n=30)	91.5% (n=89)	80-87%**
Flat Attic Average R-value	**36.7*** (n=21)	**42.6*$^{\sigma}$** (n=30)	**50$^{\sigma}$** (n=29)	44 (n=80)	38-49**
Cathedral Ceiling Average R-value	37.1 (n=9)	39.1 (n=27)	41 (n=15)	39 (n=51)	30
Conditioned/Ambient Wall Average R-value	**17.9*** (n=25)	**23.7*** (n=39)	22 (n=33)	22 (n=97)	19-21**
Floor Over UC Bsmt Average R-value	**0*** (n=12)	**26.3*** (n=8)	n/a (n=0)	11 (n=20)	30
Cond. Bsmt Below Grade Foundation Wall Average R-value	**7.2*** (n=11)	**14.0*** (n=26)	12.2 (n=30)	12.0 (n=67)	10-15**
Cond. Bsmt Above Grade Foundation Wall Average R-value	9.2 (n=7)	14.4 (n=12)	15.0 (n=8)	13.2 (n=27)	19-21**
Average Glazing Percentage	**14%*** (n=25)	**16%*** (n=39)	16% (n=33)	15% (n=97)	12%-18%**

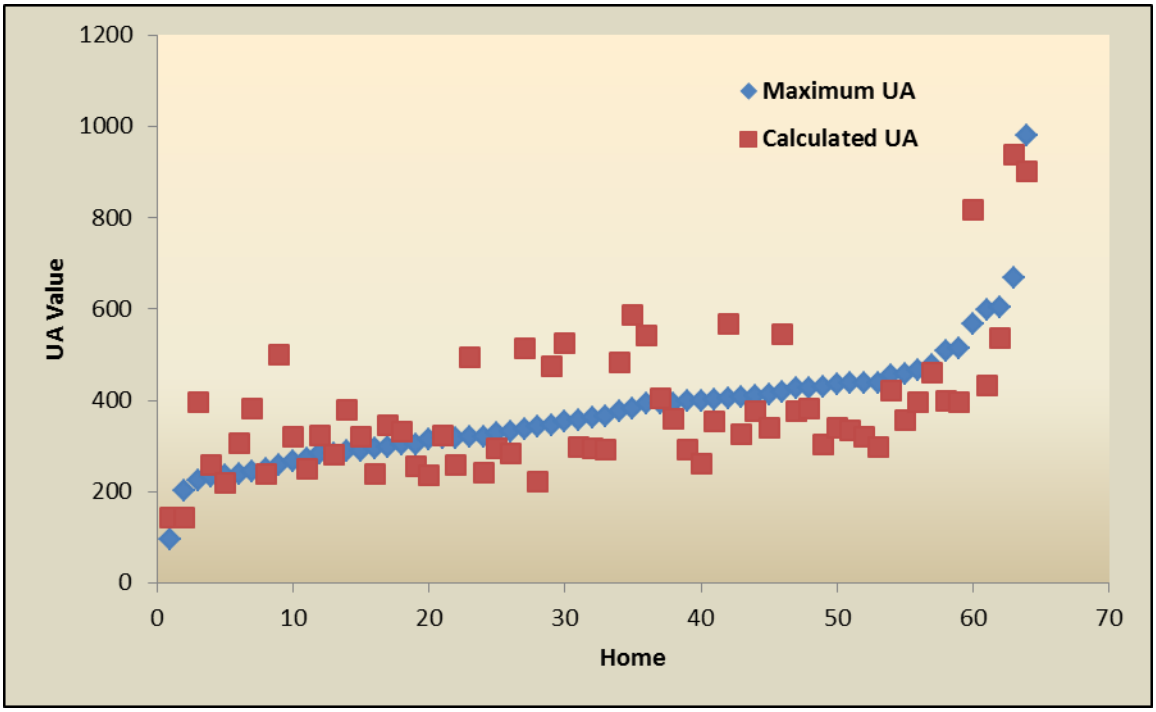
*Indicates that the values for compliant and non-compliant non-ENERGY STAR homes are significantly different at the 90% confidence level.

**These numbers represent the range allowed by different prescriptive compliance packages, whereby some tradeoffs are allowed.

$^{\sigma}$ Indicates that values for compliant non-ENERGY STAR homes and ENERGY STAR homes are significantly different at the 90% confidence level.

Below is a chart of the maximum allowable UA value and calculated UA value for the 64 non-ENERGY STAR homes that were run through REScheck (Figure 3-1). The homes are sorted ascending, on the horizontal axis, using their maximum allowable UA value; the vertical axis displays the maximum allowable UA value and the calculated UA value. The calculated UA values above the maximum UA value line signify homes that are below code and the calculated UA values at or below the maximum UA value line signify homes that meet code.

Figure 3-1: Maximum and Calculated UA Values for non-ENERGY STAR Homes



3.3 Additional Requirements and Factors

This section provides an overview of factors that may influence the compliance rate, including additional RBES requirements and the definition of conditioned floor area.

- **Additional Requirements.** RBES includes additional requirements beyond insulation levels, window U-values, glazing, and heating system efficiency known as "Basic Requirements" and "Ventilation Requirements." These additional requirements include air leakage, duct insulation and sealing, pipe insulation, and ventilation. However, because the on-site audits focused on collecting information on thermal shell characteristics, auditors did not always have sufficient time on-site to collect data regarding some of these requirements. In some cases the auditors were unable to collect information for certain characteristics due to the inaccessibility of certain spaces and equipment in finished homes.

  Because there is not sufficient information available to consistently assess the compliance of non-ENERGY STAR homes with all of the additional requirements, we do not factor

in compliance with these additional requirements into our estimate of compliance rate. A similar approach was undertaken in prior code compliance studies for Vermont[29]. However, in order to provide a sense of compliance with these additional requirements, Table 3-6 lists each of the requirements along with compliance notes where data were available.

If compliance with these additional requirements was able to be assessed in a consistent and comprehensive manner, it is likely that the 74% compliance rate would overstate actual compliance because any home that fails a single requirement would be considered non-compliant. However, we are unable to estimate the magnitude of any potential overstatement of compliance rates.

- **Definition of Conditioned Space.** Auditors defined conditioned space using the Residential Energy Service Network (RESNET) definition of conditioned floor area (CFA) adopted at the end of 2010[30]. The RESNET definition of CFA includes all finished space that is within the (insulated) conditioned space boundary (that is, within the insulated envelope), regardless of HVAC configuration[31]. This definition differs from the definition used in the 2005 RBES Handbook[32]. The RESNET definition of unconditioned space is broader than the RBES definition, therefore more spaces are considered unconditioned than RBES would define as unconditioned. Thus, our analysis overstates the number of homes where additional requirements for unconditioned spaces, such as duct sealing/insulation and pipe insulation, would apply. This would likely lead to an underestimation of compliance rates, though we are unable to estimate the magnitude of any potential understatement of compliance rates.

Overall, our sense is that the magnitude of the potential overstatement due to the exclusion of the additional requirements is greater than the magnitude of the potential understatement due to the differing definitions of conditioned space. However, we are unable to estimate the magnitude of any net overstatement of compliance rates. Therefore, we believe the 74% figure remains a reasonable indicator of technical code compliance in Vermont.

[29] Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency. Prepared by Westhill Energy and Computing for the Vermont Public Service Department. January 3, 2003.
Residential Building Energy Standards Compliance Analysis. Prepared by Nexus Market Research, Dorothy Conant and KEMA. June 10, 2009.

[30] http://www.resnet.us/standards/Floor_Area_Interpretation.pdf.

[31] CFA does not include spaces such as insulated basements or attics that are unfinished, if there is no intentional HVAC supply, or minimal supply (inadequate to be considered directly conditioned space). CFA does not include heated garages. CFA includes unfinished spaces that are directly conditioned, that is, they have "fully ducted" intentional HVAC supply (or other intentional heat source).

[32] The RBES handbook definition of conditioned space is: A space is "conditioned" if heating and/or cooling is deliberately supplied to it or is indirectly supplied through uninsulated surfaces of water or heating equipment, through uninsulated ducts, or though adjacent uninsulated building surfaces. Basements and crawl spaces without ceiling insulation are considered conditioned space.

Table 3-6: 2005 RBES Basic Requirements and Ventilation Requirements

Summary of Requirements	Compliance Notes
Air Leakage: Seal all joints, access holes and other such openings in the building envelope, as well as connections between building assemblies. In insulated ceilings, recessed lights must be either (1) Insulation Contact (IC) rated and designed as airtight or (2) installed inside an airtight assembly, with a 0.5-inch clearance from combustible materials and a 3-inch clearance from insulation.	This would require an extensive inspection (possibly before drywall installation) of the entire building shell and removal of recessed light fixtures. However, the average air infiltration for the 22 non-ENERGY STAR homes that received blower door tests was 3.6 ACH 50, which is lower than the new 2011 RBES air infiltration requirement of 5.0 ACH 50. Eighteen of 22 non-ENERGY STAR homes (82%) that received blower door tests had an ACH 50 of 5.0 or less.
Vapor Retarder: For non-vented framed ceilings, wall and floors, install a vapor retarder (i.e., 6 mil. plastic or vapor-barrier paint) on the warm-in-winter side of the insulation.	Of the 51 homes with flat ceilings, 33% were found to have vapor barriers covering the entire ceiling assembly. Of the 36 homes with cathedral ceilings, 64% were found to have vapor barriers.
Duct Insulation: In unconditioned basements, crawlspaces and attics, insulate supply and return ducts for heating and cooling systems to R-5. Insulate ducts outside the building to R-8.	Of the two homes with data on ducts in unconditioned spaces, neither met the insulation requirement.
Duct Sealing: In unconditioned spaces, seal ducts using mastic with fibrous backing tape. (Pressure sensitive tape maybe used only for duct-board systems, in accordance with NAIMA standards.) Duct tape is not permitted.	Of the two homes with data on ducts in unconditioned spaces, neither met the sealing requirement.
HVAC System Efficiency: As of June 1, 2007, all installed products must meet the following AFUE values: • Natural gas and propane furnaces—90 AFUE • Oil-fired furnaces—83 AFUE • Natural gas, propane, and oil-fired hot water boilers—84 AFUE • Natural gas, propane, and oil-fired steam boilers—82 AFUE http://www.leg.state.vt.us/statutes/fullsection.cfm?Title=09&Chapter=074&Section=02795	• Of the six homes with natural gas or propane furnaces, three had below 90 AFUE furnaces. • No homes had oil furnaces. • All homes with natural gas, propane or oil hot water boilers had AFUE 85 or higher boilers • No homes had steam boilers
Temperature Controls: Each separate HVAC zone must have its own thermostat.	The number of thermostats is equal to the number of zones in all homes.

Table 3-6: 2005 RBES Basic Requirements and Ventilation Requirements (Continued)

Summary of Requirements	Compliance Notes
HVAC Piping Insulation: In unconditioned crawlspaces, basements or attics, insulate HVAC piping to R-4 (i.e., with a 1" thickness of foam or compressed fiberglass). Insulate HVAC piping outside the building to R-6.	Of the 18 homes with boilers in unconditioned spaces, only one home had piping insulation. This home had piping insulation of R-6.8.
Swimming Pools: All swimming pools must have a time clock to control the pump. Heated swimming pools must have both a heater on/off switch in an accessible location and a pool cover.	None of the 64 homes had a swimming pool.
Domestic Hot Water: Domestic hot water tanks must meet minimum federal efficiency standards that apply to all equipment manufactured after 1992. Except when the warranty would be voided by installing a tank wrap, tanks must have a minimum total R-value of 14. Stand-alone domestic water heaters must incorporate at least one of the following: (a) internal heat traps; (b) external heat traps; or (c) pipe insulation for the first accessible 6 feet on non-circulating hot and cold water pipes. For circulating systems, refer to Section C4c.	• Three of 56 homes (5%) with tanks had additional tank wrap insulation. One home had R-4 tank wrap, one had R-5 tank wrap, and one had R-10 tank wrap insulation. Note, most water heaters have insulation within the outer shell, but auditors could not verify the level of this insulation, and manufacturer energy factor ratings take into account the performance of this insulated shell. • Four of 64 homes had hot water piping insulation, and all four homes had at least the first six feet of accessible piping insulated. • Internal heat traps are installed by the manufacturer and thus are not visible.
Fireplaces: Fireplaces must incorporate tight-fitting doors and either a tight-fitting chimney damper or a chimney cap damper (preferably both).	Sixteen of the 17 homes (94%) with fireplaces had fireplaces with tight-fitting doors and tight-fitting chimney damper or chimney cap damper.
Exhaust Fans: Exhaust dampers are required for kitchen, bath and dryer fans.	All 64 homes with kitchen, bath, or dryer fans had dampers installed on the exterior of the building.

Table 3-6: 2005 RBES Basic Requirements and Ventilation Requirements (Continued)

<table>
<tr><th>Summary of Requirements</th><th>Compliance Notes</th></tr>
<tr><td>Ventilation & Combustion Air: All homes must have an automatically controlled ventilation system. Chimney-vented combustion devices must have combustion air.</td><td>Only 10 of the 64 non-ENERGY STAR homes (16%) met the whole house ventilation requirement.</td></tr>
<tr><td>• Whole house ventilation fans must be rated for (1) continuous duty, (2) <= 50 watts power, (3) <= 2 sones. ENERGY STAR labeled fans meet these criteria</td><td>Unable to consistently collect model information for installed fans.</td></tr>
<tr><td>• Whole house ventilation systems have an automatic control or are capable of being set remotely for continuous operation</td><td>Only 10 non-ENERGY STAR homes had a whole house ventilation system: five had an ERV or HRV installed and another five had at least one fan on timer control.</td></tr>
<tr><td><table><tr><th># Bedrooms</th><th>Min # fans</th><th>Min CFM</th></tr><tr><td>1</td><td>1</td><td>50</td></tr><tr><td>2</td><td>1</td><td>75</td></tr><tr><td>3</td><td>1</td><td>100</td></tr><tr><td>4</td><td>2</td><td>125</td></tr><tr><td>5</td><td>2</td><td>150</td></tr><tr><td>>3,000 s.f.</td><td>2</td><td>0.05 x s.f.</td></tr></table></td><td>Only 10 of the 64 non-ENERGY STAR homes (16%) met the CFM requirement.</td></tr>
<tr><td>• Sealing of fan housing and inlet grilles to ceiling or wall</td><td>Unable to collect because it would require removal of fan housings.</td></tr>
<tr><td>• Fan duct runs >8 ft. are smooth wall ducts</td><td>Fan ducts are generally inaccessible.</td></tr>
<tr><td>• Fan ducts in unconditioned space sealed and insulated per HVAC duct requirements</td><td>Fan ducts are generally inaccessible.</td></tr>
<tr><td>• Clothes dryers vented to outside</td><td>All 55 homes with clothes dryers had dryers that vented to the outside.</td></tr>
<tr><td>• Combustion air and dilution air drawn from outside for chimney-vented oil and gas appliances</td><td>Fourteen of fifteen oil or gas fired appliances complied with the combustion air requirements.</td></tr>
<tr><td>• Solid-fuel appliances have tight-fitting metal, glass, or ceramic doors and ducted combustion air from outdoors</td><td>Of the 24 homes with stoves, 21 have stoves with tight-fitting doors and an outdoor air supply.</td></tr>
</table>

3.4 RBES Compliance Summary

Seventy-two of the 97 inspected homes passed the 2005 RBES via the HER compliance path or the REScheck software, yielding a technical compliance rate of 74%. These results show continued improvement over the 2002 new construction study[33] (58%) and a slight improvement over the 2008 new construction study (72%).[34]

NMR confirmed that all 33 ENERGY STAR homes received a HERS score of 82 or greater, sufficient to satisfy the RBES HER compliance path. All 64 non-ENERGY STAR homes were assessed using the REScheck software. The 39 homes that complied using this approach had more efficient characteristics than the 25 non-compliant homes. The compliant non-ENERGY STAR homes had significantly higher average R-values, at the 90% confidence level, than non-compliant non-ENERGY STAR homes for flat attic insulation, conditioned/ambient wall insulation, insulation in floors over unconditioned basements, and conditioned basement below-grade foundation wall insulation. In addition, the compliant homes had significantly higher heating system AFUEs. However, the compliant homes also had a significantly higher glazing percentage than did non-compliant homes. The large differences for insulation in floors over unconditioned basements and conditioned basement foundation walls are driven by the fact that 12 of the 25 homes that failed to meet code had both uninsulated foundation walls and uninsulated frame floors over unconditioned basements.

Auditors found an RBES certificate in 19 of the 97 homes inspected (20%). All 19 homes were found to be correctly labeled as RBES compliant. While this is a relatively low incidence of displaying RBES certificates, this is a significantly higher percentage than was found in the 2008 study, where only 12 of the 106 homes (11%) had an RBES certificate available.

The auditors were unable to comprehensively assess compliance with the RBES Basic Requirements and Ventilation Requirements due to the inaccessibility of certain spaces and equipment in finished homes. In addition, for most homes we made assumptions in order to estimate U-values for windows and doors and in order to estimate R-values for foundation wall insulation and slab insulation.

[33] Vermont Residential New Construction 2002: Baseline Construction Practices, Code Compliance, and Energy Efficiency. Prepared by Westhill Energy and Computing for the Vermont Public Service Department. January 3, 2003.

[34] Residential Building Energy Standards Compliance Analysis. Prepared by Nexus Market Research, Dorothy Conant and KEMA. June 10, 2009.

4 Building Envelope

4.1 Walls

Auditors recorded insulation information on conditioned/ambient, conditioned/garage, and conditioned/attic walls. Auditors recorded insulation and framing information including how each wall was framed and the type, R-value and grade of the insulation installation. All the fiberglass batt insulation R-values used in calculations are nominal R-values—the R-values printed on the batts.[35]

4.1.1 Conditioned/Ambient Walls

Table 4-1 and Table 4-2 show the characteristics of conditioned/ambient walls in inspected homes located in GT and non-GT regions and in Vermont Gas territory; in ENERGY STAR and non-ENERGY STAR homes; and the weighted statewide average of homes in GT and non-GT regions. As shown, average R-values vary little across the different groups of homes and the weighted average R-value of conditioned/ambient wall insulation is R-22.

Table 4-1: Conditioned/Ambient Wall Framing

Conditioned/Ambient Walls	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Average R-value	21	22	22	22	22	22
Framing						
2 x 6 x 16 inch on-center	75%	64%	69%	67%	67%	66%
2 x 4 x 16 inch on-center	4%	10%	4%	0%*	13%*	9%
2 x 6 x 24 inch on-center	4%	3%	8%	9%*	0%*	3%
SIPS	4%	3%	0%	0%*	5%*	3%
2 x 4 x 24 inch on-center	4%	1%	4%	3%	2%	2%
2 x 8 x 16 inch on-center	4%	1%	4%	3%	2%	2%
ICF	0%	3%	0%	3%	2%	2%
Other	7%	14%	12%	15%	11%	13%

* Significantly different at the 90% confidence level.

[35] In some cases, auditors downgraded the R-value of fiberglass insulation if it was compressed. This was done for some of the ENERGY STAR homes and some of the non-ENERGY STAR homes. To ensure consistency, all fiberglass batt R-value entries for all exterior walls, ceilings, floors, conditioned/ambient rim and band joists, and foundation walls that had been downgraded were converted to nominal R-values. 2005 RBES prescriptive compliance paths are based on nominal insulation R-values.

Table 4-2: Conditioned/Ambient Wall Insulation Types and Installation Grades

Conditioned/Ambient Walls	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Insulation Type						
Fiberglass Batts	79%*	45%*	77%	58%	53%	52%
Fiberglass Batts & Rigid Foam	7%	13%	8%	9%	13%	12%
Spray Foam	0%*	13%*	0%	9%	9%	10%
Cellulose	4%	7%	4%	6%	6%	6%
Panel Construction	4%	3%	0%	0%	5%	3%
Rigid Foam	0%*	4%*	0%	3%	3%	3%
Fiberglass Batts & Spray Foam	7%	0%	8%	6%	0%	2%
Other	0%	14%*	4%	9%	11%	11%
Insulation Installation Grade						
Grade I	11%*	39%*	23%	39%	27%	33%
Grade II	71%*	46%*	65%	48%	56%	52%
Grade III	18%	13%	12%	12%	16%	14%
Grade Unknown	0%	1%	0%	0%	2%	1%

* Significantly different at the 90% confidence level.

A majority of homes (weighted average 66%) have 2x6 16 inch on center framing and have only fiberglass batt insulation (weighted average 52%). Homes in GT regions are significantly more likely than homes in non-GT regions to have only fiberglass batt insulation and significantly less likely to have spray foam or rigid foam insulation. The "other" insulation category includes ten homes with the following types of insulation:

- A combination of spray foam and no insulation
- Cellulose and rigid foam
- Insulated concrete forms (ICF)
- A combination of fiberglass batts, spray foam and panel construction
- An 8" thick mixture of clay and straw between wood
- A 22" bale of hay plus lime plaster
- Log wall
- Log wall and spray foam
- Rock wool and rigid foam
- A double stud wall with unknown insulation type

Homes in GT regions are significantly less likely than homes in non-GT regions to have a Grade I insulation installation and significantly more likely to have a Grade II insulation installation. Weighted averages for insulation installation are 33% Grade I, 52% Grade II and 14% Grade III.

Table 4-3 shows conditioned/ambient wall insulation levels in individual homes range from R-8 to R-54; the weighted average is R-22. There are no significant differences between inspected homes in the GT and non-GT regions or between ENERGY STAR and non-ENERGY STAR homes.

Table 4-3: Conditioned/Ambient Wall Insulation Levels

Conditioned/Ambient Wall Insulation Levels	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Less than R-19	4%	10%	4%	3%	11%	9%
R-19	57%	39%	65%	52%	41%	43%
>R-19 to R-21	21%	19%	12%	21%	19%	19%
>R-21 to R-30	11%	22%	8%	15%	20%	19%
Over R-30	7%	10%	12%	9%	9%	9%
R-value Statistics*						
Minimum	11	8	11	14	8	8
Maximum	45	54	45	45	54	54
Average	**21**	**22**	**22**	**22**	**22**	**22**
Median	19	19	19	19	19	19

* Only the average is weighted.

Figure 4-1, Figure 4-2 and Figure 4-3 chart the individual recorded R-values for conditioned/ambient wall insulation in all 97 inspected homes. Figure 4-1 separately identifies homes in GT and non-GT regions. Figure 4-2 separately identifies ENERGY STAR and non-ENERGY STAR homes. Figure 4-3 charts homes in Vermont Gas territory.

Figure 4-1: Recorded R-values for Conditioned/Ambient Walls — GT and Non-GT Regions

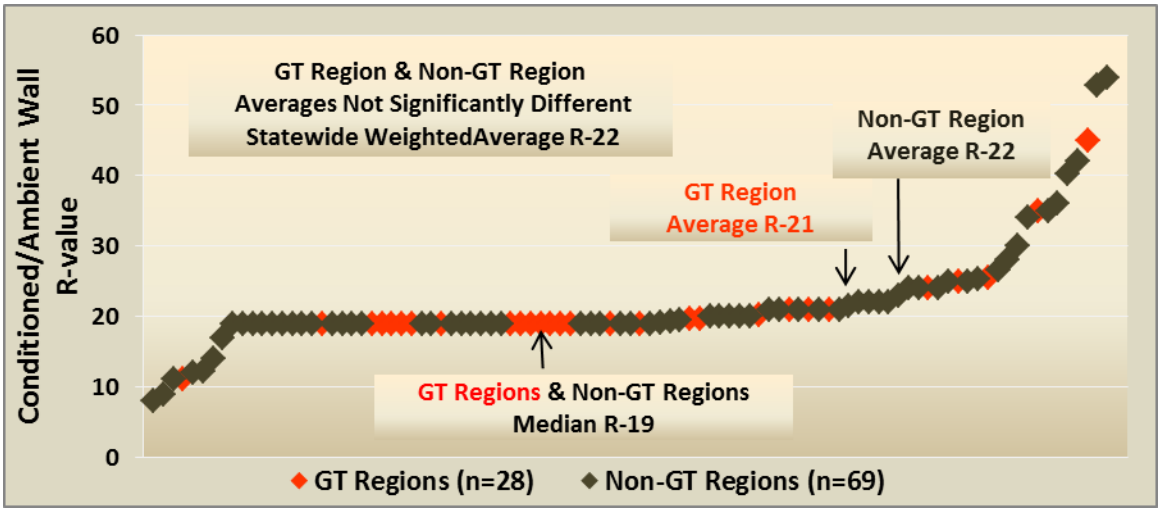


Figure 4-2: Recorded R-values for Conditioned/Ambient Walls —ENERGY STAR and Non-ENERGY STAR Homes

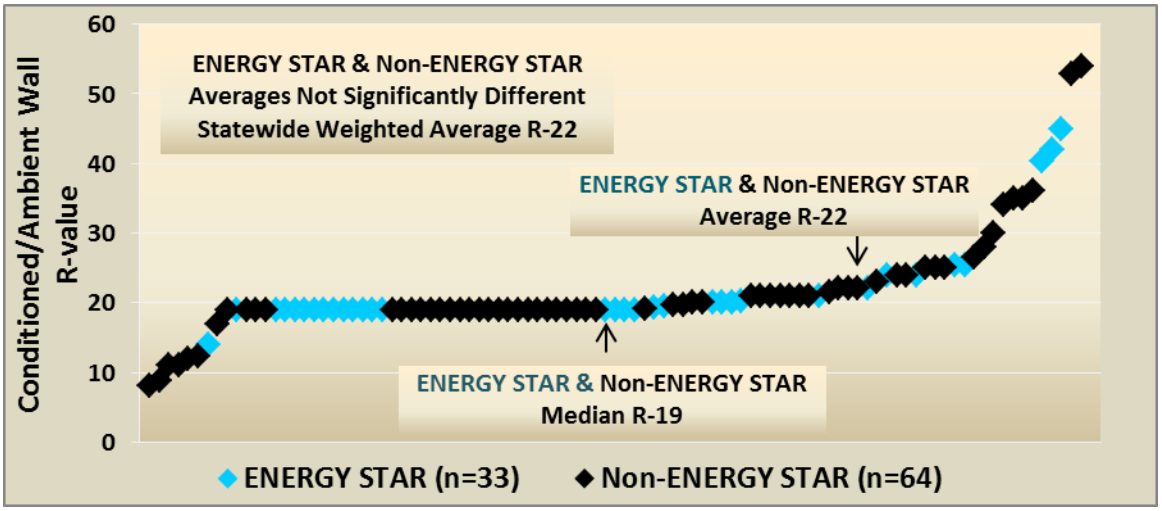
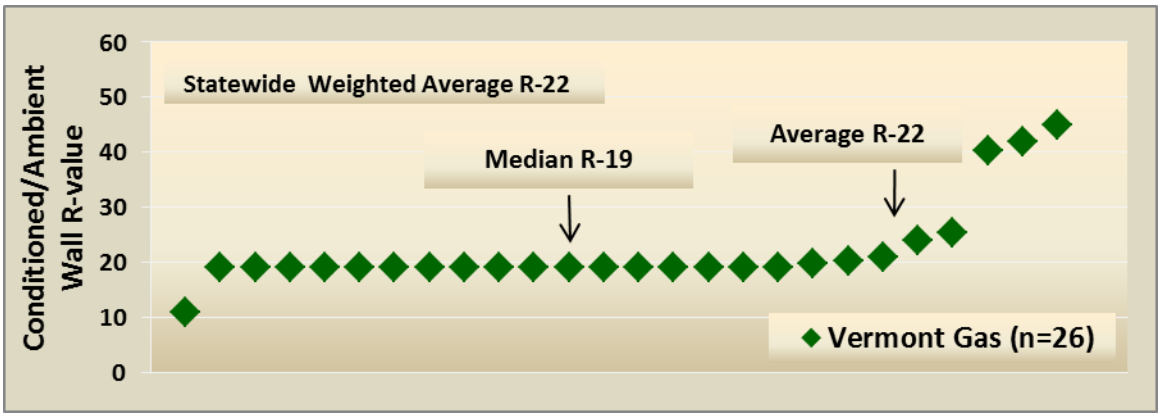


Figure 4-3: Recorded R-values for Conditioned/Ambient Walls —Vermont Gas Homes



4.1.2 Conditioned/Garage Walls

Table 4-4 shows the characteristics of conditioned/garage walls in inspected homes located in GT and non-GT regions and in Vermont Gas territory; in ENERGY STAR and non-ENERGY STAR homes; and the weighted statewide average of homes in GT and non-GT regions. As shown, average R-values vary little across the different groups of homes and the weighted average R-value of conditioned/garage wall insulation is R-21.

Table 4-4: Conditioned/Garage Walls

Conditioned/Garage Walls	GT Regions (n=22)	Non-GT Regions (n=24)	Vermont Gas (n=22)	ENERGY STAR (n=20)	Non-ENERGY STAR (n=26)	Statewide Weighted (n=46)
Average R-value	20	21	20	21	20	21
Framing						
2 x 6 x 16 inch on-center	82%	79%	77%	80%	81%	80%
2 x 4 x 16 inch on-center	14%	8%	14%	10%	12%	9%
2 x 4 x 24 inch on-center	0%	4%	5%	5%	0%	3%
2 x 8 x 16 inch on-center	0%	4%	5%	5%	0%	3%
ICF	0%	4%	0%	0%	4%	3%
SIPS	5%	0%	0%	0%	4%	1%
Insulation Type						
Fiberglass Batts	86%	75%	86%	80%	81%	77%
Spray Foam	0%*	13%*	0%	5%	8%	10%
Fiberglass Batts & Spray Foam	9%	0%	9%	10%	0%	2%
Cellulose	0%	4%	5%	5%	0%	3%
Panel Construction	5%	0%	0%	0%	4%	1%
Rigid Foam	0%	4%	0%	0%	4%	3%
Rock Wool & Rigid Foam	0%	4%	0%	0%	4%	3%
Insulation Installation Grade						
Grade I	14%	33%	23%	30%	19%	29%
Grade II	73%*	42%*	68%	60%	54%	48%
Grade III	14%	25%	9%	10%	27%	23%

* Significantly different at the 90% confidence level.

A majority of homes with conditioned/garage walls (weighted average 80%) have 2x6 16 inch on center framing and have only fiberglass batt insulation (weighted average 77%). Homes in non-GT regions are significantly more likely than homes in GT regions to have only spray foam insulation.

Homes in GT regions are significantly more likely than homes in non-GT regions to have a Grade II insulation installation. Weighted averages for conditioned/garage wall insulation installation are 29% Grade I, 48% Grade II and 23% Grade III.

Table 4-5 shows conditioned/garage wall insulation levels in individual homes range from R-11 to R-42; the weighted average is R-21. No ENERGY STAR homes have conditioned/garage walls with less than R-19 insulation, but 12% of non-ENERGY STAR homes have

conditioned/garage walls with less than R-19 insulation; this difference is statistically significant at the 90% confidence level.

Table 4-5: Conditioned/Garage Wall Insulation Levels

Conditioned/Garage Wall Insulation Levels	GT Regions (n=22)	Non-GT Regions (n=24)	Vermont Gas (n=22)	ENERGY STAR (n=20)	Non-ENERGY STAR (n=26)	Statewide Weighted (n=46)
Less than R-19	9%	4%	9%	**0%***	**12%***	5%
R-19	64%	75%	68%	75%	65%	73%
>R-19 to R-21	14%	4%	9%	10%	8%	6%
>R-21 to R-30	9%	4%	9%	10%	4%	5%
Over R-30	5%	13%	5%	5%	12%	11%
R-value Statistics**						
Min	11	11	11	19	11	11
Max	35	42	42	42	36	42
Average	**20**	**21**	**20**	**21**	**20**	**21**
Median	19	19	19	19	19	19
Count	22	24	22	20	26	46

* Significantly different at the 90% confidence level.
** Only the average is weighted.

4.1.3 Conditioned/Attic Walls

Table 4-6 shows the characteristics of conditioned/attic walls in inspected homes located in GT and non-GT regions and in Vermont Gas territory; in ENERGY STAR and non-ENERGY STAR homes; and the unweighted[36] statewide average of homes in GT and non-GT regions. As shown, average R-values do not vary across the different groups of homes—the average R-value of conditioned/attic wall insulation is R-19.

Table 4-6: Conditioned/Attic Walls

Conditioned/Attic Walls	GT Regions (n=5)	Non-GT Regions (n=19)	Vermont Gas (n=6)	ENERGY STAR (n=5)	Non-ENERGY STAR (n=19)	Statewide Unweighted (n=24)
Average R-value	19	19	19	19	19	19
Framing						
2 x 4 x 16 inch on-center	3 (60%)	47%	4 (67%)	5 (100%)*	37%*	50%
2 x 6 x 16 inch on center	1 (20%)	53%	1 (17%)	0 (0%)*	58%*	46%
2 x 4 x 24 inch on center	1 (20%)	0%	1 (17%)	0 (0%)	5%	4%
Insulation Type						
Fiberglass Batts	4 (80%)	74%	5 (83%)	4 (80%)	74%	75%
Spray Foam	0 (0%)*	16%*	0 (0%)	0 (0%)*	16%*	13%
Cellulose	1 (20%)	5%	1 (17%)	1 (20%)	5%	8%
Fiberglass Batts & Rigid Foam	0 (0%)	5%	0 (0%)	0 (0%)	5%	4%
Insulation Installation Grade						
Grade I	0 (0%)*	16%*	0 (0%)	0 (0%)*	16%*	13%
Grade II	5 (100%)*	47%*	6 (100%)	5 (100%)*	47%*	58%
Grade III	0 (0%)*	37%*	0 (0%)	0 (0%)*	37%*	29%

* Significantly different at the 90% confidence level.

Half of the 24 homes with conditioned/attic walls have 2x4 16 inch on center framing and roughly half (46%) have 2x6 16 inch on center framing. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have 2x4 16 inch on center framing and significantly less likely to have 2x6 16 inch on center framing.

Most homes (75%) have only fiberglass batt insulation. Homes in non-GT regions are significantly more likely than homes in GT regions and non-ENERGY STAR homes are significantly more likely than ENERGY STAR homes to have spray foam insulation.

Homes in GT regions are significantly more likely than homes in non-GT regions to have a Grade II insulation installation and significantly less likely to have a Grade I or Grade III insulation installation. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have a Grade II insulation installation and significantly less likely to have a Grade I or Grade III insulation installation. Overall statewide percentages are 13% Grade I, 58% grade II and 29% Grade III.

[36] When there are ten or fewer observations in targeted or non-targeted regions, then statewide results are not weighted.

Table 4-7 shows conditioned/attic wall insulation levels in individual homes range from R-11 to R-35; the average is R-19. No ENERGY STAR homes have conditioned/attic walls with less than R-19 insulation, but 26% of non-ENERGY STAR homes have conditioned/attic walls with less than R-19 insulation; this difference is significantly different at the 90% confidence level. Also, no inspected homes in GT regions have conditioned/attic walls with less than R-19 insulation, but 26% of inspected homes in non-GT regions have conditioned/attic walls with less than R-19 insulation; this difference is significantly different at the 90% confidence level

Table 4-7: Conditioned/Attic Wall Insulation Levels

Conditioned/Attic Wall Insulation Levels	GT Regions (n=5)	Non-GT Regions (n=19)	Vermont Gas (n=6)	ENERGY STAR (n=5)	Non-ENERGY STAR (n=19)	Statewide Unweighted (n=24)
Less than R-19	0 (0%) *	5 (26%)*	0 (0%)	0 (0%)*	26%*	21%
R-19	4 (80%)	9 (47%)	5 (83%)	4 (80%)	47%	54%
>R-19 to R-21	1 (20%)	3 (16%)	1 (17%)	1 (20%)	16%	17%
>R-21 to R-30	0 (0%)	1 (5%)	0 (0%)	0 (0%)	5%	4%
Over R-30	0 (0%)	1 (5%)	0 (0%)	0 (0%)	5%	4%
R-value Statistics						
Minimum	19	11	19	19	11	11
Maximum	19	35	19	19	35	35
Average	**19**	**19**	**19**	**19**	**19**	**19**
Median	19	19	19	19	19	19

* Significantly different at the 90% confidence level.

4.2 Ceilings

Auditors recorded insulation information on flat and cathedral (sloped) ceilings. Looking at the statewide weighted results in Table 4-8, estimated percentages are 45% of new homes have only flat ceilings, 19% have only cathedral ceilings, and 36% have a mix of flat and cathedral ceilings. Overall, an estimated 55% of new homes have at least some cathedral ceilings. The following differences between homes in GT regions and non-GT regions in the percentage of homes with specific types of ceilings are statistically significant:

- Homes in GT regions are more likely than homes in the non-GT regions to have only flat ceilings (75% vs. 36%).
- Homes in the GT regions are less likely than homes in the non-GT regions to have only cathedral ceilings (0% vs. 25%).

Table 4-8: Ceiling Types

Ceiling Types	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Flat	75%*	36%*	62%	55%	44%	45%
Flat & Cathedral	25%	39%	38%	33%	36%	36%
Cathedral	0%*	25%*	0%	12%	20%	19%

* Significantly different at the 90% confidence level.

Table 4-9 shows the percentage of flat ceilings that have a vapor barrier and Table 4-10 shows the percentage of cathedral ceilings that have a vapor barrier. Statewide results show cathedral ceilings (51% unweighted) are more likely than flat ceilings (29% weighted) to have a vapor barrier. In addition, an estimated 4% of homes with cathedral ceilings and 5% with flat ceilings have vapor barriers in some ceiling areas. Statistically significant differences include:

- Inspected homes in the non-GT regions are more likely than homes in the GT regions to have a vapor barrier in both flat and cathedral ceilings.
- Non-ENERGY STAR homes are more likely than ENERGY STAR homes to have a vapor barrier in both flat and cathedral ceilings.

Table 4-9: Flat Ceiling Vapor Barriers

Attic Vapor Barriers	GT Regions (n=28)	Non-GT Regions (n=52)	Vermont Gas (n=26)	ENERGY STAR (n=29)	Non-ENERGY STAR (n=51)	Statewide Weighted (n=80)
Yes	11%*	35%*	15%	14%*	33%*	29%
No	86%*	52%*	77%	72%	59%	59%
Some Areas	0%*	6%*	0%	0%*	6%*	5%
Unknown	4%	8%	8%	14%*	2%*	7%

* Significantly different at the 90% confidence level.

Table 4-10: Cathedral Ceiling Vapor Barriers

Cathedral Ceilings: Vapor Barriers	GT Regions (n=7)	Non-GT Regions (n=44)	Vermont Gas (n=10)	ENERGY STAR (n=15)	Non-ENERGY STAR (n=36)	Statewide Unweighted (n=51)
Yes	1 (14%)*	57%*	1 (10%)	20%*	64%*	51%
No	5 (71%)*	32%*	7 (70%)	53%	31%	37%
Some Areas	0 (0%)	5%	0 (0%)	0%	6%	4%
Unknown	1 (14%)	7%	2 (20%)	27%*	0%*	8%

* Significantly different at the 90% confidence level.

4.2.1 Flat Ceilings

Statewide weighted results show the most common flat ceiling construction is 2x10 16 inch on center (24%) followed closely by 2x4 24 inch on center (20%) (Table 4-11). The following differences in the percentage of homes with specific types of ceiling construction between homes in GT regions and non-GT regions, and between ENERGY STAR and non-ENERGY STAR homes, are statistically significant:

- Homes in GT regions, compared to homes in non-GT regions, are much less likely to have 2x10 16 inch on center construction (7% vs. 29%), much more likely to have 2x4 24 inch on center construction (43% vs. 13%) and much less likely to have 2x6 16 inch on center construction (4% vs. 13%).
- ENERGY STAR homes, compared to non-ENERGY STAR homes, are much less likely to have 2x10 16 inch on center construction (0% vs. 33%), much more likely to have 2x4 24 inch on center construction (62% vs. 2%), much less likely to use a truss system (0% vs. 18%), and much less likely to have 2x8 16 inch on center construction (0% vs. 16%) or 2x12 16 inch on center construction (0% vs. 10%).

ENERGY STAR homes are also much more likely than non-ENERGY STAR homes to use some "other" type of flat ceiling construction. The "other" category includes 14 homes: one home with Structural Insulated Panel (SIP) construction; one home each with 2x10 48 inch on center, 4x8 24 inch on center, 2x8 36 inch on center construction; two homes with 2x4 16 inch on center construction; and eight homes using a mix of different size joists and spacing in different flat ceiling areas.

Table 4-11: Flat Ceiling Types of Construction

Flat Ceiling Construction	GT Regions (n=28)	Non-GT Regions (n=52)	Vermont Gas (n=26)	ENERGY STAR (n=29)	Non-ENERGY STAR (n=51)	Statewide Weighted (n=80)
2 x 10 x 16" On Center	7%*	29%*	8%	0%*	33%*	24%
2 x 4 x 24" On Center	43%*	13%*	65%	62%*	2%*	20%
Truss	14%	10%	4%	0%	18%*	11%
2 x 6 x 16" On Center	4%*	13%*	8%	10%	10%	11%
2 x 8 x 16" On Center	11%	10%	8%	0%*	16%*	10%
2 x 12 x 16" On Center	4%	8%	0%	0%*	10%*	7%
Other	18%	17%	8%	28%*	12%*	17%

* Significantly different at the 90% confidence level.

Cellulose and fiberglass batts are the most common types of insulation in flat ceilings. Statewide weighted estimates, shown in Table 4-12, are 51% cellulose, 21% fiberglass batts, and 15% a combination of cellulose and fiberglass batts. The only statistically significant differences are that homes in GT regions are less likely than homes in non-GT regions to have only fiberglass insulation (7% vs. 25%) and ENERGY STAR homes are less likely than non-ENERGY STAR homes to have only fiberglass batt insulation (0% vs. 29%).

Table 4-12: Flat Ceiling Insulation

Flat Ceiling (Attic) Insulation	GT Regions (n=28)	Non-GT Regions (n=52)	Vermont Gas (n=26)	ENERGY STAR (n=29)	Non-ENERGY STAR (n=51)	Statewide Weighted (n=80)
Cellulose	61%	48%	65%	62%	47%	51%
Fiberglass Batts	7%*	25%*	4%	0%*	29%*	21%
Fiberglass Batts & Cellulose	14%	13%	19%	21%	10%	14%
Blown-in Fiberglass	4%	2%	4%	0%	4%	2%
Cellulose & Rigid foam	4%	2%	4%	7%	0%	2%
Panel Construction (SIPs)	4%	2%	0%	3%	2%	2%
Spray Foam	0%	4%	0%	0%	4%	3%
Rigid Foam	4%	0%	0%	0%	2%	1%
Cellulose & Spray Foam	4%	0%	4%	3%	0%	1%
Fiberglass Batts & Rigid Foam	0%	2%	0%	0%	2%	2%
Fiberglass Batts, Cellulose & Rigid Foam	0%	2%	0%	3%	0%	2%

* Significantly different at the 90% confidence level.

Table 4-13 shows the statewide weighted average R-value of flat ceiling insulation is R-44. As shown, insulation levels vary widely, from R-19 to R-110. The only statistically significant difference is that the average R-value of flat ceiling insulation is much higher in ENERGY STAR homes than in non-ENERGY STAR homes (R-50 vs. R-40).

Table 4-13: Flat Ceiling R-value Statistics

Flat Ceiling R-value Statistics	GT Regions (n=28)	Non-GT Regions (n=52)	Vermont Gas (n=26)	ENERGY STAR (n=29)	Non-ENERGY STAR (n=51)	Statewide Weighted** (n=80)
Min	21	19	25	37	19	19
Max	92	110	92	110	74	110
Average	**43**	**44**	**45**	**50***	**40***	**44**
Median	37	38	37	41	38	38

* Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 4-14 shows the statewide weighted percentage of homes with flat ceilings that have less than R-38 insulation is 40%; R-38 is the minimum requirement under prescriptive RBES compliance paths. Statewide weighted percentages are 13% R-38 insulation, 21% over R-38 to R-50, and 26% over R-50 insulation. The only statistically significant differences are that homes in GT regions are less likely than homes in non-GT regions to have R-38 insulation (4% vs. 15%) and ENERGY STAR homes are less likely than non-ENERGY STAR homes to have R-38 insulation (3% vs. 16%).

Table 4-14: Flat Ceiling Insulation Levels

Flat Ceiling Insulation Levels: R-Values	GT Regions (n=28)	Non-GT Regions (n=52)	Vermont Gas (n=80)	ENERGY STAR (n=29)	Non-ENERGY STAR (n=51)	Statewide Weighted (n=80)
Less than R-38	54%	37%	43%	45%	41%	40%
R-38	4%*	15%*	11%	3%*	16%*	13%
>R-38 to R-50	21%	21%	21%	17%	24%	21%
> R-50	21%	27%	25%	34%	20%	26%

* Significantly different at the 90% confidence level.

Figure 4-4, Figure 4-5, and Figure 4-6 chart the individual recorded values for flat ceiling insulation in all 80 inspected homes with flat ceilings. Figure 4-4 separately identifies homes in GT regions and non-GT regions. Figure 4-5 separately identifies ENERGY STAR and non-ENERGY STAR homes. Figure 4-6 charts homes in Vermont Gas territory. In several cases, homes have different levels of insulation in different flat ceiling areas. For these homes, the average insulation level was calculated using the RBES Handbook procedure for determining the average R-value for a building component with two or more thermal values.

Figure 4-4: Recorded R-value for all Flat Ceilings—GT and Non-GT Regions

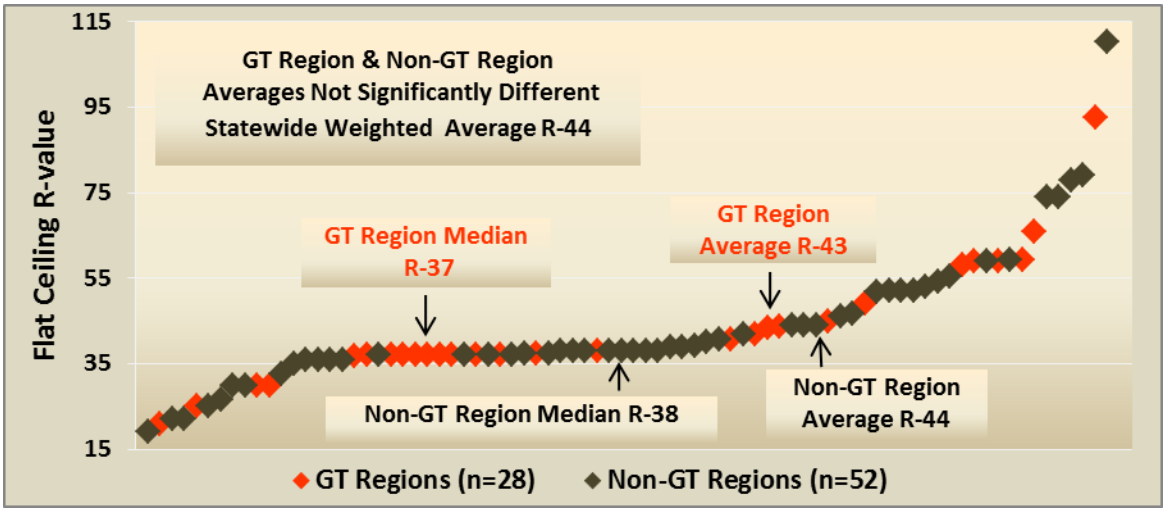


Figure 4-5: Recorded R-value for all Flat Ceilings—ENERGY STAR and Non-ENERGY STAR Homes

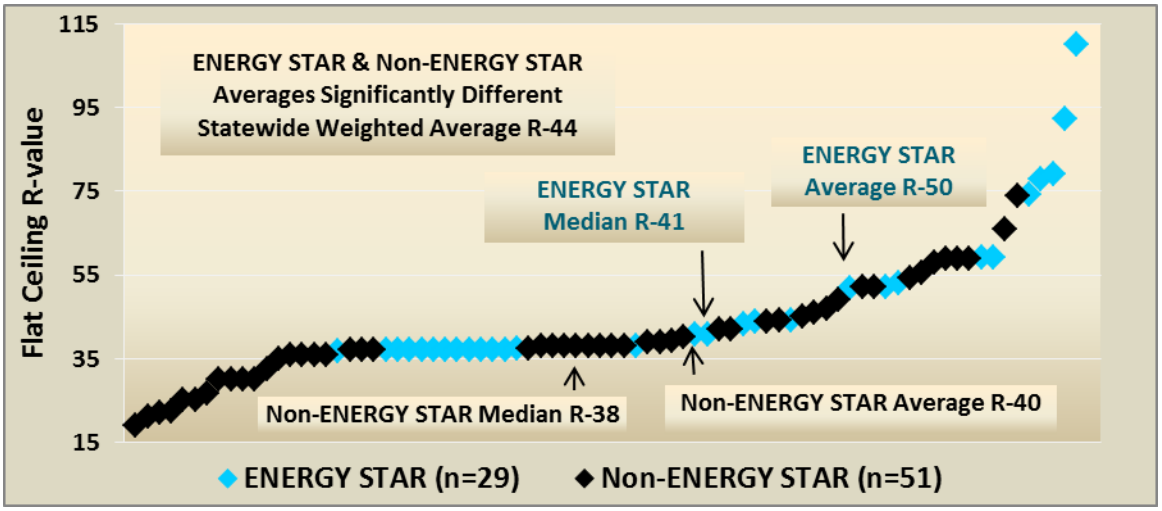
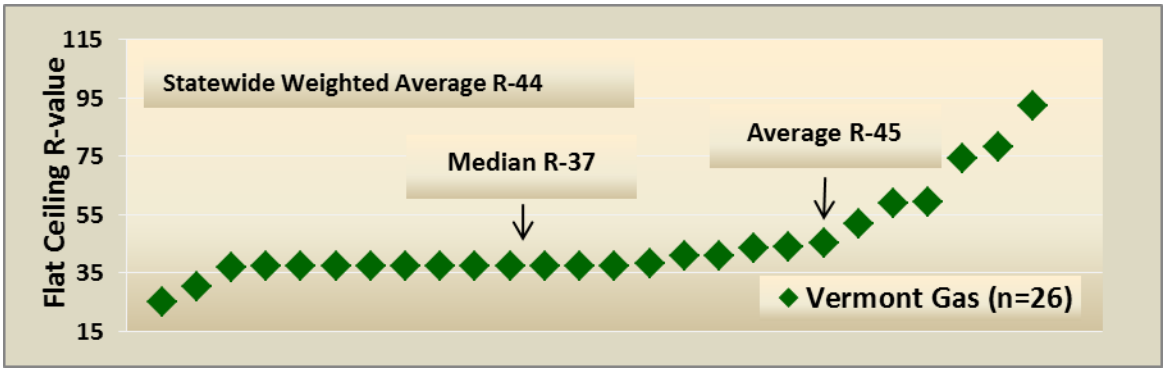


Figure 4-6: Recorded R-value for all Flat Ceilings—Vermont Gas Homes



4.2.2 Cathedral Ceilings

Fifty-one of the 97 inspected homes have cathedral ceilings. Auditors found a variety of cathedral construction practices. Looking at statewide unweighted estimates, Table 4-15 shows that using 2x12 16 inch on center framing is the most common practice for constructing cathedral ceilings (31%) followed by 2x10 16 inch on center framing (22%). The only statistically significant difference between homes in GT regions and non-GT regions is that cathedral ceilings in homes in GT regions are less likely to be 2x6 16 inch on center construction.

Differences between the percentages of ENERGY STAR and non-ENERGY STAR homes using different cathedral ceiling framing practices are statistically significant for almost every framing practice. Only four inspected homes, all non-ENERGY STAR homes, use structural insulated panels (SIPs). ENERGY STAR homes are more likely than non-ENERGY STAR homes to use

some "other" type of cathedral ceiling construction. The "other" category includes six homes: one home with cellulose between rigid foam; one with 2x4 24 inch on center, one with 2x8 16 inch on center, and one with 2x16 24 inch on center construction; and two homes with a mix of different size joists and spacing in different cathedral ceiling areas.

Table 4-15: Cathedral Ceiling Types of Construction

Cathedral Ceiling Framing	GT Regions (n=7)	Non-GT Regions (n=44)	Vermont Gas (n=10)	ENERGY STAR (n=15)	Non-ENERGY STAR (n=36)	Statewide Unweighted (n=51)
2 x 12 x 16" On Center	2 (29%)	32%	2 (20%)	13%*	39%*	31%
2 x 10 x 16" On Center	1 (14%)	23%	1 (10%)	7%*	28%*	22%
2 x 10 x 24" On Center	1 (14%)	7%	2 (20%)	27%*	0%*	8%
2 x 12 x 24" On Center	1 (14%)	7%	2 (20%)	20%	3%	8%
2 x 6 x 16" On Center	0 (0%)*	9%*	0 (0%)	0%*	11%*	8%
SIP	1 (14%)	7%	0 (0%)	0%*	11%*	8%
2 x 4 x 16" On Center	0 (0%)	5%	0 (0%)	0%	6%	4%
Other	1 (14%)	11%	3 (30%)	33%*	3%*	12%

* Significantly different at the 90% confidence level.

Just as in flat ceilings, fiberglass batts and cellulose are the most common types of insulation in cathedral ceilings. Looking at statewide unweighted estimates, Table 4-16 shows 29% of the cathedral ceilings are insulated with fiberglass batts and 24% with cellulose. Statistically significant differences include:

- Homes in the GT regions are much less likely than homes in non-GT regions to have spray foam insulation (0% vs. 18%), a combination of fiberglass batt and rigid foam insulation (0% vs. 9%), or rigid foam insulation (0% vs. 7%).
- ENERGY STAR homes are much more likely than non-ENERGY STAR homes to have cellulose insulation (60% vs. 8%) and less likely to have fiberglass batt insulation (0% vs. 42%), a combination of fiberglass batt and rigid foam (0% vs. 11%), SIPs (0% vs. 11%), or rigid foam insulation (0% vs. 8%).

Table 4-16: Cathedral Ceiling Insulation

Cathedral Ceiling Insulation	GT Regions (n=7)	Non-GT Regions (n=44)	Vermont Gas (n=10)	ENERGY STAR (n=15)	Non-ENERGY STAR (n=36)	Statewide Unweighted (n=51)
Fiberglass Batts	2 (29%)	30%	2 (20%)	0%*	42%*	29%
Cellulose	3 (43%)	20%	6 (60%)	60%*	8%*	24%
Spray Foam	0 (0%)*	18%*	0 (0%)	20%	14%	16%
Fiberglass Batts & Rigid Foam	0 (0%)*	9%*	0 (0%)	0%*	11%*	8%
Panel Construction (SIPs)	1 (14%)	7%	0 (0%)	0%*	11%*	8%
Rigid Foam	0 (0%)*	7%*	0 (0%)	0%*	8%*	6%
Cellulose & Rigid Foam	0 (0%)	7%	0 (0%)	7%	6%	6%
Fiberglass Batts & Cellulose	1 (14%)	2%	2 (20%)	13%	0%	4%

* Significantly different at the 90% confidence level.

Table 4-17 shows the statewide unweighted average R-value of cathedral ceiling insulation is R-39. As shown, insulation levels vary widely, from R-11 to R-60.

Table 4-17: Cathedral Ceiling R-value Statistics

Cathedral Ceiling Insulation R-values	GT Regions (n=7)	Non-GT Regions (n=44)	Vermont Gas (n=10)	ENERGY STAR (n=15)	Non-ENERGY STAR (n=36)	Statewide Unweighted (n=51)
Min	30	11	29	29	11	11
Max	58	60	55	55	60	60
Average	**40**	**39**	**39**	**41**	**39**	**39**
Median	38	39	38	39	38	39

Table 4-18 shows the statewide unweighted percentage of homes with cathedral ceilings that have less than R-30 insulation is 10%; R-30 is the minimum requirement under prescriptive RBES compliance paths. Statewide unweighted percentages are 18% R-30 insulation, 31% over R-30 to R-40, and 41% over R-40 insulation. A high percentage of homes have over R-40 cathedral ceiling insulation, ranging from 30% of Vermont Gas homes with cathedral ceilings to 43% of homes in GT regions with cathedral ceilings. No homes in GT regions, compared to 11% of homes in non-GT regions, have less than R-30 cathedral ceiling insulation; this difference is statistically significant. No ENERGY STAR homes, compared to 25% of non-ENERGY STAR homes, have R-30 insulation and 53% of ENERGY STAR homes, compared to 22% of non-ENERGY STAR homes, have more than R-30 to R-40 cathedral ceiling insulation; these differences are statistically significant.

Table 4-18: Cathedral Ceiling Insulation Levels

Cathedral Ceiling Insulation Levels R-values	GT Regions (n=7)	Non-GT Regions (n=44)	Vermont Gas (n=10)	ENERGY STAR (n=15)	Non-ENERGY STAR (n=36)	Statewide Unweighted (n=51)
Less than R-30	**0 (0%)***	**11%***	1 (10%)	7%	11%	10%
R-30	1 (14%)	18%	1 (10%)	**0%***	**25%***	18%
>R-30 to R-40	3 (43%)	30%	5 (50%)	**53%***	**22%***	31%
>R-40	3 (43%)	41%	3 (30%)	40%	42%	41%

* Significantly different at the 90% confidence level.

Figure 4-7 and Figure 4-8 chart the individual recorded values for cathedral ceiling insulation in all 51 inspected homes with cathedral ceilings. Figure 4-7 separately identifies homes in GT regions and non-GT regions. Figure 4-8 separately identifies ENERGY STAR and non-ENERGY STAR homes. Figure 4-9 charts homes in Vermont Gas territory.

Figure 4-7: Recorded R-value for all Cathedral Ceilings—GT and Non-GT Regions

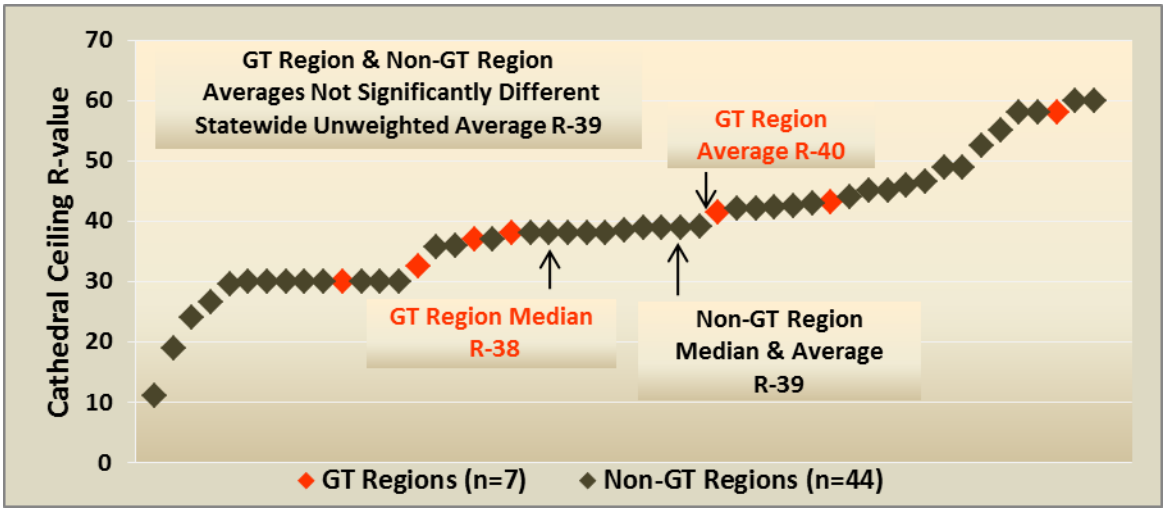


Figure 4-8: Recorded R-value for all Cathedral Ceilings—ENERGY STAR and Non-ENERGY STAR Homes

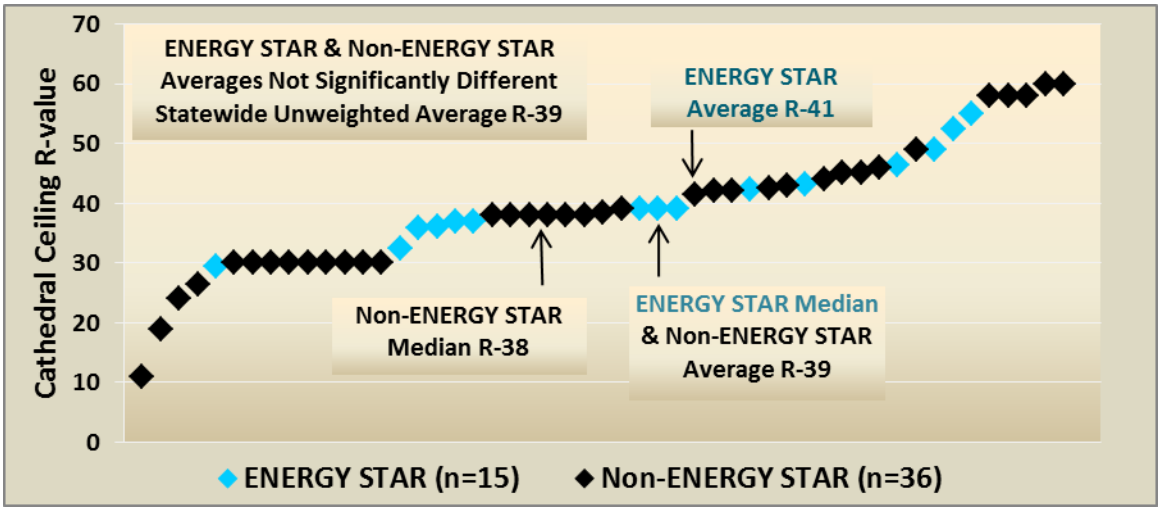
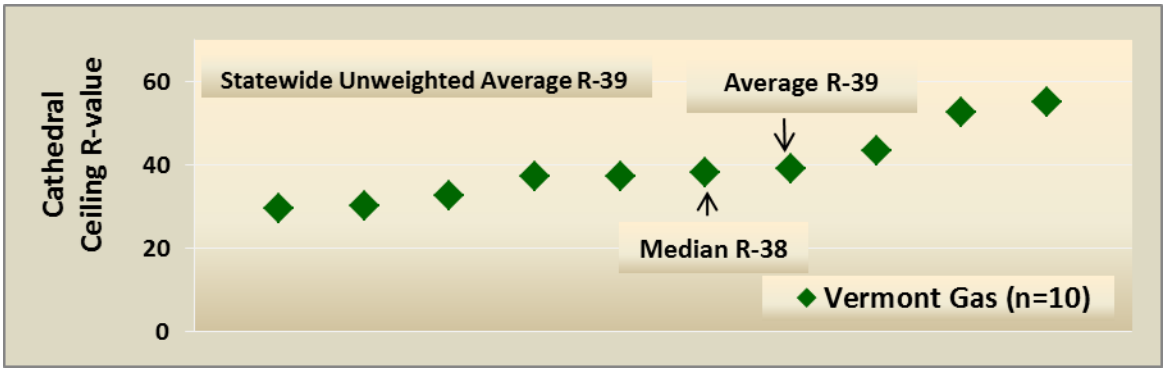


Figure 4-9: Recorded R-value for all Cathedral Ceilings—Vermont Gas Homes



4.3 Windows

Auditors recorded the area in square feet and the orientation of windows in the homes. U-value information was available for all 33 ENERGY STAR homes, but auditors found it difficult to verify the U-value for most windows in non-ENERGY STAR homes. Documented U-value information was available for only five non-ENERGY STAR homes where the original NFRC (National Fenestration Rating Council) sticker was visible. The U-values auditors gathered at these five homes range from 0.30 to 0.32, with an average of 0.31. The default U-values for operable windows provided in the Vermont Residential Building Code Handbook appear inconsistent with windows currently on the market. All default U-values in the handbook are higher than the current ENERGY STAR level for Vermont (U-0.30): the lowest default U-value is U-0.37 for a vinyl/wood framed operable window with double pane Low-E with argon glazing.

In an effort to develop more realistic default window U-values, NMR evaluation team members talked to staff personnel at two large lumber yards that sell windows to builders of new homes and with five major window companies exhibiting at Build Boston: Andersen, Harvey, JELD-WEN, Marvin and Pella. Everyone said basically the same thing, that the standard today is an ENERGY STAR-qualified Low-E with argon window.

Representatives for Andersen, Pella, and Marvin windows say that, in most cases, Low-E windows without argon are special order. When asked what they estimated their share of the New England market for new construction windows was, the Andersen representative estimated 13% (7% nationally), the Marvin representative estimated 8%, and the Pella representative estimated 6%. All window representatives pointed out that there are many, many small manufacturers of windows selling to builders, and that some of these companies produce high quality windows and others produce low-end windows for builders unwilling to pay for ENERGY STAR-qualified windows.

One of the lumber yard representatives commented:

> *"Anecdotally, I see builders typically opting for the least expensive way to build which would mean Vinyl windows from Harvey Industries or Anderson 200 series. As far as custom houses designed by Architects, I would say 99% are specified as an ENERGY STAR-rated window. There is really a huge difference between those custom homes and the spec houses being built out there."*

Given that representatives of the major window manufacturers say their standard windows are ENERGY STAR-rated Low-E with argon, and the current Version 3 ENERGY STAR window criteria for Vermont is U-0.32 or lower, we propose an overall default window U-value of 0.34. A U-0.34 window does not meet current ENERGY STAR criteria for Vermont, and the U-value is higher than the standard U-value reported by the representatives of major window manufacturers; it may even be conservative. Without more information on what the large number

of small window manufacturers are promoting and selling, it seems premature to assume a lower default U-value.

Table 4-19 displays the U-value statistics for all homes, including the 33 ENERGY STAR homes and five non-ENERGY STAR Homes with documented U-values, and the 59 remaining non-ENERGY STAR Homes with the default U-value of 0.34. The statewide weighted average U-value is 0.33 and the median is 0.34. The average and median U-value for ENERGY STAR homes is 0.31; the average and median U-value for non-ENERGY STAR homes is 0.34. The difference in the average U-value of windows in ENERGY STAR and non-ENERGY STAR homes is statistically significant.

Table 4-19: Window U-values

Window U-value	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted** (n=97)
Minimum	0.24	0.21	0.24	0.21	0.30	0.21
Maximum	0.39	0.34	0.39	0.39	0.34	0.39
Average	**0.32**	**0.33**	**0.32**	**0.31***	**0.34***	**0.33**
Median	0.33	0.34	0.32	0.31	0.34	0.34

*Significantly different at the 90% confidence level. **Only the average is weighted.

Glazing percentages, defined as window area not including windows in unconditioned basements as a percentage of wall area, range from a low of 3% to a high of 26% (Table 4-20). RBES maximum allowable glazing percentages under prescriptive RBES compliance paths range from 12% to 18% depending on the compliance path; 27% of inspected homes have glazing percentages over 18%. Statewide, the average and median glazing percentage is 15%. ENERGY STAR homes are significantly less likely than non-ENERGY STAR homes to have less than 10% glazing.

Table 4-20: Glazing Percentages

Percent Glazing	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Less than 10%	11%	14%	8%	**6%***	**17%***	14%
10% to 11.99%	7%	9%	4%	6%	9%	8%
12% to 14.99%	21%	30%	19%	27%	28%	28%
15 to 17.99%	25%	22%	31%	30%	19%	22%
18% or More	36%	25%	38%	30%	27%	27%
Percent Glazing Statistics**						
Minimum	6%	3%	10%	9%	3%	3%
Maximum	24%	26%	25%	23%	26%	26%
Average	**16%**	**15%**	**17%**	**16%**	**15%**	**15%**
Median	15%	15%	16%	16%	15%	15%

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Figure 4-10 through Figure 4-12 chart the individual glazing percentages for all 97 homes. Figure 4-10 separately identifies homes in GT and non-GT regions, Figure 4-11 charts the individual glazing percentages for homes served by Vermont Gas, and Figure 4-12 separately identifies ENERGY STAR and non-ENERGY STAR homes.

Figure 4-10: Glazing Percentages—GT Regions and Remainder of Vermont

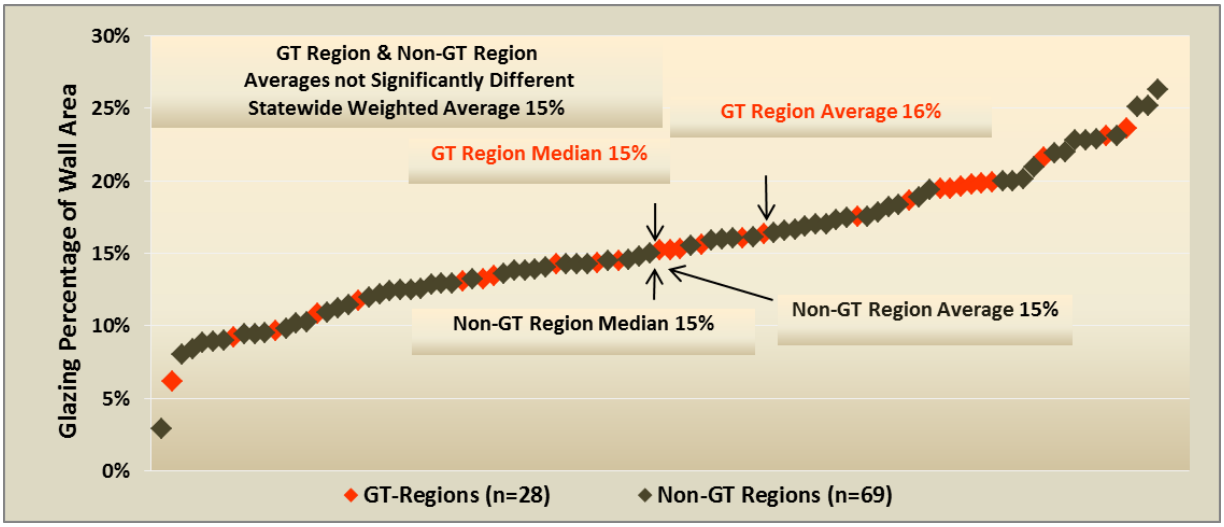


Figure 4-11: Glazing Percentages – Vermont Gas

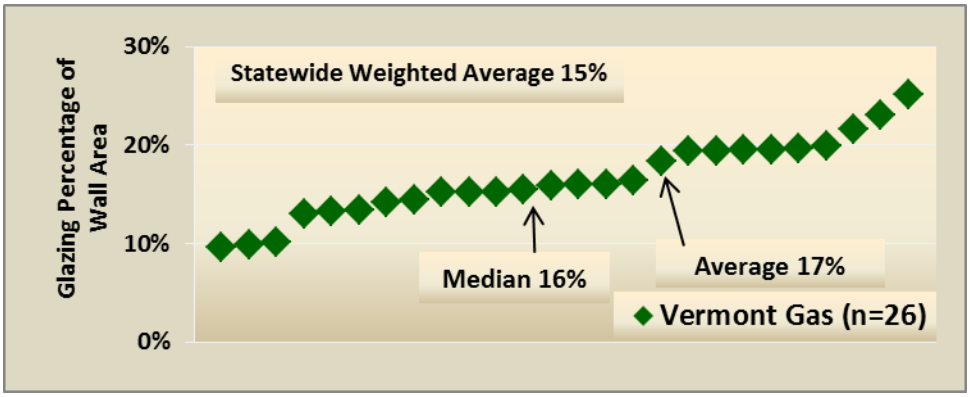


Figure 4-12: Glazing Percentages—ENERGY STAR and Non-ENERGY STAR

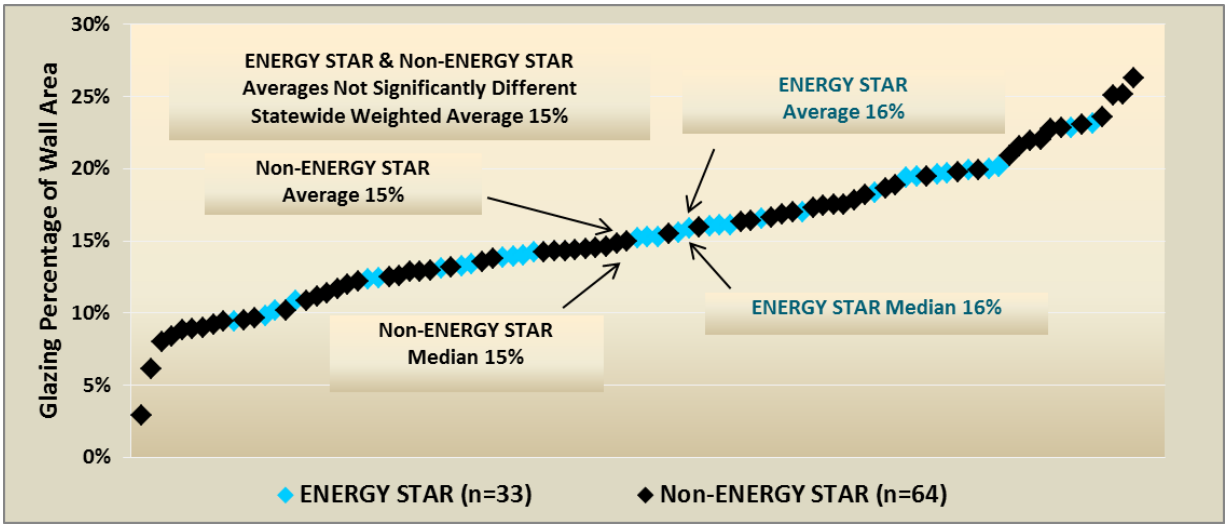


Table 4-21 provides statistics on south oriented glazing percentages. Statewide, the percent of glazing oriented to the south ranges from zero to 82%; the median and average is 36%. Homes in non-GT regions have significantly more glazing oriented to the south than homes in GT regions; 39% compared to 29%. Non-ENERGY STAR homes have significantly more glazing oriented to the south than ENERGY STAR homes; 41% compared to 26%.

Table 4-21: South Oriented Glazing Percentages

Percent South Glazing (S, SE, SW)	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted** (n=97)
Minimum	0%	0%	0%	0%	0%	0%
Maximum	70%	82%	68%	68%	82%	82%
Average	29%*	39%*	29%	26%*	41%*	36%
Median	27%	42%	25%	22%	43%	36%

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Figure 4-13 through Figure 4-15 chart the individual south oriented glazing percentages for all 97 homes. Figure 4-13 separately identifies homes in GT regions and non-GT regions, Figure 4-14 charts the individual glazing percentages for homes served by Vermont Gas, and Figure 4-15 separately identifies ENERGY STAR and non-ENERGY STAR homes.

Figure 4-13: South Oriented Glazing Percentages—GT Regions and Remainder of Vermont

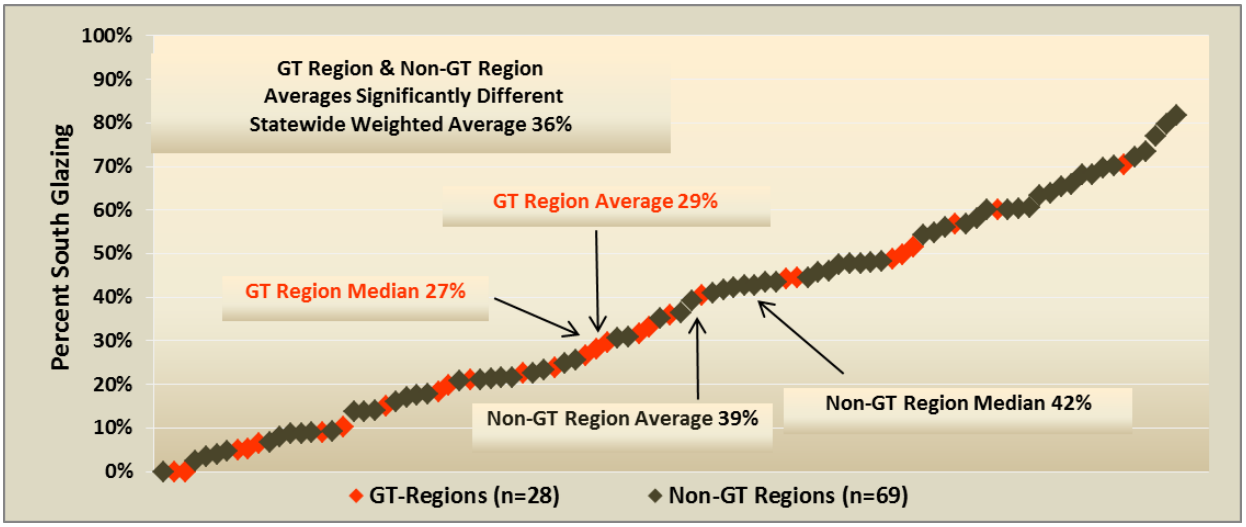


Figure 4-14: South Oriented Glazing Percentages – Vermont Gas

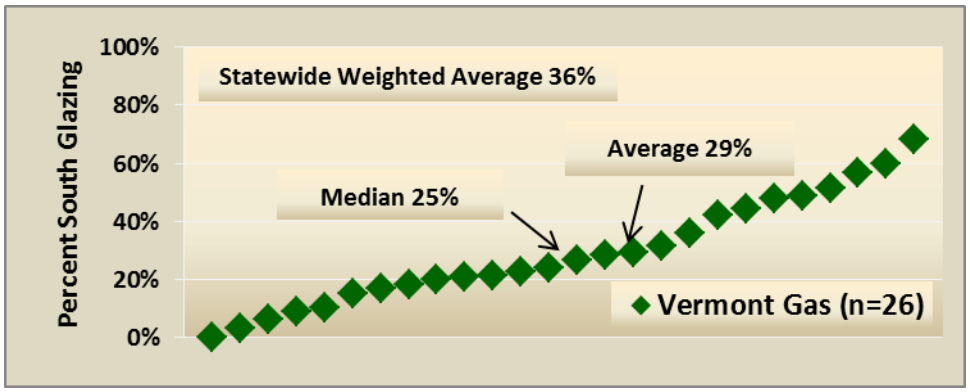
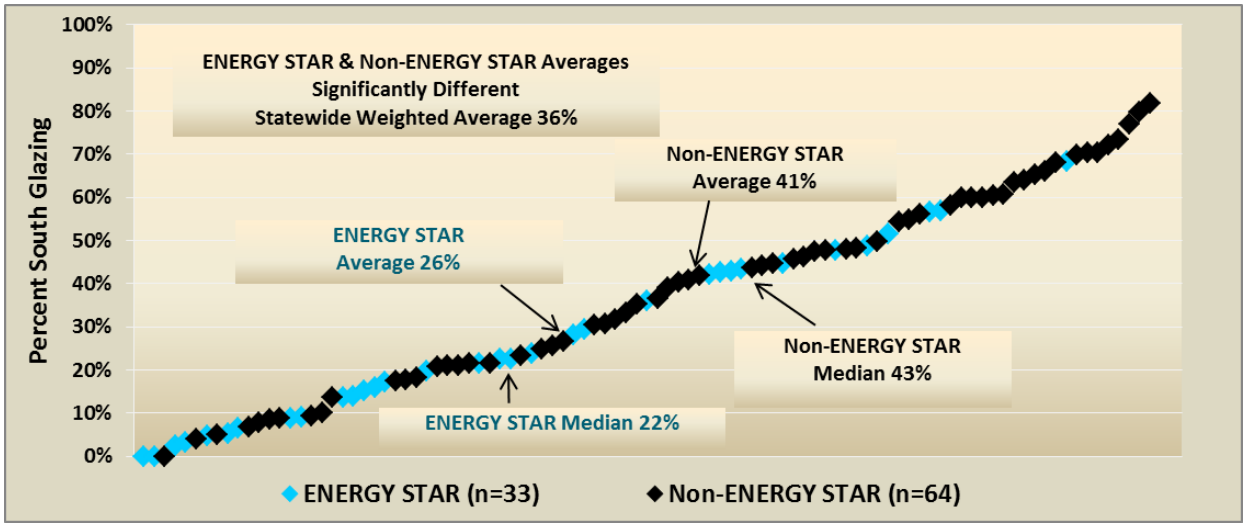


Figure 4-15: South Oriented Glazing Percentages—ENERGY STAR and Non-ENERGY STAR



4.3.1 Skylights

Only five out of 97 homes inspected have skylights. The data for skylights are questionable as auditors were often unable to reach the skylights to test for a Low-E glaze, let alone determine whether or not the skylights are argon filled. Of the five homes with skylights auditors were able to record reliable U- and SHGC values at two homes. In each of these homes the skylights have U-values of 0.43 and SHGC values of 0.23.

4.4 Floors

Auditors recorded insulation information on conditioned/unconditioned basement, conditioned/garage, and conditioned/outside air floors. Auditors recorded insulation and framing information including how the floor was framed and the type, R-value and grade of the insulation installation.

4.4.1 Floors over Unconditioned Basements

Table 4-22 shows the characteristics of conditioned/unconditioned basement floors in inspected homes located in GT and non-GT regions and in Vermont Gas territory; in ENERGY STAR and non-ENERGY STAR homes; and the unweighted statewide averages. As shown, average R-values vary across the different groups of homes and the average R-value of conditioned/unconditioned basement floor insulation is R-11.

Table 4-22: Conditioned/Unconditioned Basement Floors

Floors over Unconditioned Basements	GT Regions (n=6)	Non-GT Regions (n=14)	Vermont Gas (n=2)	ENERGY STAR (n=0)	Non-ENERGY STAR (n=20)	Statewide Unweighted (n=20)
Average R-value	6	13	7	n/a	11	11
Framing						
2 x 10 x 16 inch on-center	5 (83%)	57%	1 (50%)	n/a	65%	65%
2 x 12 x 16 inch on-center	1 (17%)	21%	0 (0%)	n/a	20%	20%
2 x 8 x 16 inch on center	0 (0%)	7%	0 (0%)	n/a	5%	5%
Truss	0 (0%)	14%	1 (50%)	n/a	10%	10%
Insulation Type						
Fiberglass Batts	0 (0%)*	36%*	1 (50%)	n/a	25%	25%
Cellulose	1 (17%)	0%	0 (0%)	n/a	5%	5%
Fiberglass Batts & Spray Foam	0 (0%)	7%	0 (0%)	n/a	5%	5%
Spray Foam	0 (0%)	7%	0 (0%)	n/a	5%	5%
None	5 (83%)	50%	1 (50%)	n/a	60%	60%
Insulation Installation Grade						
Grade I	1 (17%)	7%	0 (0%)	n/a	10%	10%
Grade II	0 (0%)*	21%*	1 (50%)	n/a	15%	15%
Grade III	0 (0%)	14%	0 (0%)	n/a	10%	10%
None (No Insulation)	5 (83%)	50%	1 (50%)	n/a	60%	60%
Unknown	0 (0%)	7%	0 (0%)	n/a	5%	5%

*Significantly different at the 90% confidence level.

A majority of homes (65%) have 2x10 16 inch on center framing and 60% have no insulation in floors over unconditioned basements. Homes in non-GT regions are significantly more likely than homes in GT regions to have only fiberglass batt insulation and have a Grade II insulation installation. Overall statewide insulation installation grade percentages are 10% Grade I, 15% Grade II and 10% Grade III.

Table 4-23 shows conditioned/unconditioned basement floor insulation levels in individual homes range from no insulation to R-38; the average is R-11. Most homes (60%) have no insulation, 25% have less than R-30 insulation and 15% of homes have greater than R-30 insulation; no homes have R-30 insulation in conditioned/unconditioned basement floors.

Table 4-23: Conditioned/Unconditioned Basement Floor R-values

Conditioned/Unconditioned Basement R-values	GT Regions (n=6)	Non-GT Regions (n=14)	Vermont Gas (n=2)	ENERGY STAR (n=0)	Non-ENERGY STAR (n=20)	Statewide Unweighted (n=20)
No Insulation	5 (83%)	50%	1 (50%)	n/a	60%	60%
Less than R-30	**0 (0%)***	**36%***	1 (50%)	n/a	25%	25%
Greater than R-30	1 (17%)	14%	0 (0%)	n/a	15%	15%
R-value Statistics						
Minimum	0	0	0	n/a	0	0
Maximum	37	38	13	n/a	38	38
Average	**6**	**13**	**7**	n/a	**11**	**11**
Median	0	7	7	n/a	0	0

* Significantly different at the 90% confidence level.

4.4.2 Conditioned/Garage Floors

Table 4-24 and Table 4-25 show the characteristics of conditioned/garage floors in inspected homes located in GT and non-GT regions and in Vermont Gas territory; in ENERGY STAR and non-ENERGY STAR home; and the unweighted statewide averages. As shown, average R-values vary across the different groups of homes and the average R-value of conditioned/garage floor insulation is R-32.

Table 4-24: Conditioned/Garage Floor Framing

Conditioned/Garage Floors	GT Regions (n=6)	Non-GT Regions (n=10)	Vermont Gas (n=8)	ENERGY STAR (n=6)	Non-ENERGY STAR (n=10)	Statewide Unweighted (n=16)
Average R-value	**29**	**34**	**37**	**45***	**25***	**32**
Framing						
2 x 12 x 16 inch on-center	4 (67%)	4 (40%)	4 (50%)	4 (67%)	4 (40%)	50%
2 x 10 x 16 inch on center	2 (33%)	2 (20%)	2 (25%)	**0 (0%)***	**4 (40%)***	25%
2 x 8 x 16 inch on center	0 (0%)	2 (20%)	0 (0%)	0 (0%)	2 (20%)	13%
2 x 12 x 19 inch on-center	0 (0%)	1 (10%)	1 (13%)	1 (17%)	0 (0%)	6%
2 x 14 x 16 inch on-center	0 (0%)	1 (10%)	1 (13%)	1 (17%)	0 (0%)	6%

* Significantly different at the 90% confidence level.

Table 4-25: Conditioned/Garage Floor Insulation and Installation Grade

Conditioned/Garage Floors	GT Regions (n=6)	Non-GT Regions (n=10)	Vermont Gas (n=8)	ENERGY STAR (n=6)	Non-ENERGY STAR (n=10)	Statewide Unweighted (n=16)
Insulation Type						
Fiberglass Batts	5 (83%)	7 (70%)	5 (63%)	4 (67%)	8 (80%)	75%
Cellulose	0 (0%)	1 (10%)	1 (13%)	1 (17%)	0 (0%)	6%
Fiberglass Batts & Spray Foam	0 (0%)	1 (10%)	0 (0%)	0 (0%)	1 (10%)	6%
None	1 (17%)	0 (0%)	1 (13%)	0 (0%)	1 (10%)	6%
Unknown	0 (0%)	1 (10%)	1 (13%)	1 (17%)	0 (0%)	6%
Insulation Installation Grade						
Grade I	0 (0%)*	4 (40%)*	3 (38%)	3 (50%)	1 (10%)	31%
Grade II	3 (50%)	3 (30%)	2 (25%)	3 (50%)	3 (30%)	34%
Grade III	1 (17%)	3 (30%)	1 (13%)	0 (0%)*	4 (40%)*	27%
None (No Insulation)	1 (17%)	0 (0%)	1 (13%)	0 (0%)	1 (10%)	4%
Unknown	1 (17%)	0 (0%)	1 (13%)	0 (0%)	1 (10%)	4%

* Significantly different at the 90% confidence level.

Half of the homes with conditioned/garage floors have 2x12 16 inch on center framing and 75% have fiberglass batt insulation. ENERGY STAR homes are significantly less likely than non-ENERGY STAR homes to have 2x10 16 inch on center framing. Homes in GT regions are significantly less likely than homes in non-GT regions to have a Grade I insulation installation and non-ENERGY STAR homes are significantly more likely than ENERGY STAR homes to have a Grade III insulation installation. Overall statewide insulation installation grade percentages are 31% Grade I, 34% Grade II and 27% Grade III.

Table 4-26 shows conditioned/garage floor insulation levels in individual homes range from no insulation to R-58; the average is R-32. One half of the homes have more than R-30 insulation and 25% of homes have R-30 insulation, 19% of homes have less than R-30 insulation and one home (6% of homes) has no insulation in a conditioned/garage floor. All ENERGY STAR homes have more than R-30 insulation.

Table 4-26: Conditioned/Garage Floor Insulation Levels

Conditioned/Garage Floor Insulation Levels	GT Regions (n=6)	Non-GT Regions (n=10)	Vermont Gas (n=8)	ENERGY STAR (n=6)	Non-ENERGY STAR (n=10)	Statewide Unweighted (n=16)
No Insulation	1 (17%)	0 (0%)	1 (13%)	0 (0%)	1 (10%)	6%
Less than R-30	0 (0%)*	3 (30%)*	0 (0%)	0 (0%*)	3 (30%)*	19%
R-30	2 (33%)	2 (20%)	2 (25%)	0 (0%)	4 (40%)*	25%
Greater than R-30	3 (50%)	5 (50%)	5 (63%)	6 (100%)*	2 (20%)*	50%
R-value Statistics						
Minimum	0	19	0	38	0	0
Maximum	38	58	58	58	38	58
Average	**29**	**34**	**37**	**45***	**25***	**32**
Median	34	32	38	44	30	32

* Significantly different at the 90% confidence level.

4.4.3 Conditioned/Outside Floors

Table 4-27 shows the characteristics of conditioned/outside air floors in inspected homes located in GT and non-GT regions, located in Vermont Gas territory, in ENERGY STAR and non-ENERGY STAR homes, and the unweighted statewide averages. As shown, average R-values vary across the different groups of homes and the average R-value of conditioned/outside air floor insulation is R-26.

Table 4-27: Conditioned/Outside Floors

Conditioned/Outside Floors	GT Regions (n=6)	Non-GT Regions (n=9)	Vermont Gas (n=5)	ENERGY STAR (n=7)	Non-ENERGY STAR (n=8)	Statewide Unweighted (n=15)
Average R-value	33*	21*	33	34*	19*	26
Framing						
2 x 10 x 16 inch on-center	4 (67%)	3 (33%)	3 (60%)	4 (57%)	3 (38%)	47%
2 x 12 x 16 inch on-center	2 (33%)	2 (22%)	2 (40%)	3 (43%)	1 (13%)	27%
2 x 8 x 16 inch on center	0 (0%)*	3 (33%)*	0 (0%)	0 (0%)*	3 (38%)	20%
Concrete	0 (0%)	1 (11%)	0 (0%)	0 (0%)	1 (13%)	7%
Insulation Type						
Fiberglass Batts	6 (100%) *	4 (44%)*	5 (100%)	6 (86%)	4 (50%)	67%
None	0 (0%)	2 (22%)	0 (0%)	0 (0%)	2 (25%)	13%
Bubble Wrap	0 (0%)	1 (11%)	0 (0%)	0 (0%)	1 (13%)	7%
Icynene	0 (0%)	1 (11%)	0 (0%)	0 (0%)	1 (13%)	7%
Rigid Foam	0 (0%)	1 (11%)	0 (0%)	1 (14%)	0 (0%)	7%
Insulation Installation Grade						
Grade I	0 (0%)*	3 (33%)*	0 (0%)	2 (29%)	1 (13%)	20%
Grade II	4 (67%)*	1 (11%)*	3 (60%)	4 (57%)*	1 (13%)*	33%
Grade III	2 (33%)	3 (33%)	2 (40%)	1 (14%)	4 (50%)	33%
None (No Insulation)	0 (0%)	2 (22%)	0 (0%)	0 (0%)	2 (25%)	13%

* Significantly different at the 90% confidence level.

Almost half (47%) of the 15 homes with conditioned/outside air floors have 2x10 16 inch on center framing and two-thirds (67%) have fiberglass batt insulation. Homes in GT regions are significantly less likely than homes in non-GT regions to have 2x8 16 inch on center framing and ENERGY STAR homes are significantly less likely than non-ENERGY STAR homes to have 2x8 16 inch on center framing. Homes in GT regions are significantly more likely than homes in non-GT regions to have fiberglass batt insulation. Homes in GT regions are significantly less likely than homes in non-GT regions to have a Grade I insulation installation and significantly more likely to have a Grade II insulation installation. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have a Grade II insulation installation. Overall statewide insulation installation grade percentages are 20% Grade I, 33% Grade II and 33% Grade III.

Table 4-28 shows conditioned/outside air floor insulation levels in individual homes range from no insulation to R-38; the average is R-26. No homes have more than R-38 insulation, the RBES prescriptive requirement for floors over outside air.

Table 4-28: Conditioned/Outside Floor Insulation Levels

Conditioned/Outside Floor R-values	GT Regions (n=6)	Non-GT Regions (n=9)	Vermont Gas (n=5)	ENERGY STAR (n=7)	Non-ENERGY STAR (n=8)	Statewide Unweighted (n=15)
No Insulation	0 (0%)	2 (22%)	0 (0%)	0 (0%)	2 (25%)	13%
Less than R-38	4 (67%)	6 (67%)	3 (60%)	4 (57%)	6 (75%)	67%
R-38	2 (33%)	1 (11%)	2 (40%)	**3 (43%)***	**0 (0%)***	20%
R-value Statistics						
Minimum	30	0	30	30	0	0
Maximum	38	38	38	38	30	38
Average	**33***	**21***	**33**	**34***	**19***	**26**
Median	30	28	30	32	24	30

* Significantly different at the 90% confidence level.

4.5 Foundation Wall Insulation

Auditors found a multitude of foundation wall configurations. Table 4-29 shows that statewide, one-quarter (25%) of homes have all below grade walls enclosing unconditioned basement space, nearly one-quarter (24%) of homes have all below grade walls enclosing conditioned basement space, and almost one-quarter (23%) of homes have a combination of above and below grade foundation walls enclosing conditioned basement space. Over one in ten homes (12%) has slab on grade construction. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have all below grade walls enclosing conditioned basement space, and significantly less likely to have all below grade walls enclosing unconditioned basement space.

Table 4-29: Foundation Wall Location

Location of Foundation Walls	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
>Below Grade Unconditioned	32%	23%	23%	15%*	31%*	25%
>Below Grade Conditioned	32%	22%	46%	48%*	13%*	24%
>Below Grade Conditioned & >Above Grade Conditioned	21%	23%	23%	18%	25%	23%
Slab on Grade	7%	13%	0%	9%	13%	12%
>Below Grade Unconditioned & >Above Grade Unconditioned	4%	7%	4%	6%	6%	6%
>Below Grade Conditioned & >Above Grade Unconditioned	0%	3%	0%	0%	3%	2%
Enclosed Crawl space	0%	3%	0%	0%	3%	2%
>Below Grade Conditioned & >Below Grade Adiabatic	4%	0%	4%	3%	0%	1%
>Below Grade Conditioned & Unconditioned	0%	1%	0%	0%	2%	1%
>Below Grade Conditioned & Unconditioned & >Above Grade Conditioned	0%	1%	0%	0%	2%	1%
>Below Grade Conditioned & Unconditioned & >Above Grade Conditioned & Unconditioned	0%	1%	0%	0%	2%	1%
>Below Grade Unconditioned & >Above Grade Unconditioned	0%	1%	0%	0%	2%	1%

*Significantly different at the 90% confidence level.

RBES prescriptive compliance paths require foundation walls enclosing conditioned space to be insulated. Table 4-30 displays the types of foundation wall insulation observed in the 67 homes with foundation walls enclosing conditioned space. Statewide, in over one-half (61%) of these homes, the foundation walls are insulated with rigid foam; in 12% of homes the foundation walls

are insulated with fiberglass batts,[37] and in 9% of homes the foundation walls are ICF construction. Six percent of homes have uninsulated foundation walls enclosing conditioned space. In three homes with foundation walls enclosing conditioned space, the foundation walls are insulated with a combination of fiberglass batts and rigid foam, and in two homes the foundation walls are insulated with spray-in high density foam. In one home the foundation walls are insulated with a combination of rigid foam and cellulose. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have rigid foam foundation wall insulation, and significantly less likely to have fiberglass batts or no foundation wall insulation.

Table 4-30: Foundation Wall Insulation Types

Foundation Wall Insulation Conditioned Foundation Walls	GT Regions (n=20)	Non-GT Regions (n=47)	Vermont Gas (n=24)	ENERGY STAR (n=30)	Non-ENERGY STAR (n=37)	Statewide Weighted (n=67)
Rigid Foam	60%	62%	63%	77%*	49%*	61%
Fiberglass Batts	15%	11%	17%	3%*	19%*	12%
ICF	5%	11%	0%	7%	11%	9%
None	5%	6%	4%	0%*	11%*	6%
Fiberglass Batts & Rigid Foam	5%	4%	4%	3%	5%	4%
Spray-In High Density Foam	0%	4%	0%	0%	5%	3%
Unknown	10%	0%	8%	7%	0%	2%
Rigid Foam & Cellulose	0%	2%	4%	3%	0%	2%

*Significantly different at the 90% confidence level.

RBES prescriptive compliance paths require that below grade foundation walls enclosing conditioned space be insulated to at least R-10. Statewide, 67 homes have at least some below grade foundation walls enclosing conditioned space. Table 4-31 shows that the statewide average R-value of below grade foundation wall insulation for these homes is R-12.1.

[37] In some cases, auditors downgraded the R-value of fiberglass insulation if it was compressed. To ensure consistency, all fiberglass batt R-value entries for foundation walls that had been downgraded were converted to nominal R-values.

Table 4-31: Below Grade Foundation Wall Insulation Levels

Below Grade Conditioned Foundation Wall R-value	GT Regions (n=20)	Non-GT Regions (n=47)	Vermont Gas (n=24)	ENERGY STAR (n=30)	Non-ENERGY STAR (n=37)	Statewide Weighted (n=67)
No Insulation	5%	6%	4%	0%*	11%*	6%
Less than R-10	0%*	9%*	0%	0%*	11%*	7%
R-10	60%	45%	63%	70%*	32%*	48%
> R-10	35%	40%	33%	30%	46%	39%
Below Grade Foundation Walls R-value Statistics**						
Minimum	0.0	0.0	0.0	10.0	0.0	0.0
Maximum	25.5	25.0	25.5	25.5	25.0	25.5
Average	**11.6**	**12.3**	**11.6**	**12.2**	**12.0**	**12.1**
Median	10.0	10.0	10.0	10.0	10.0	10.0

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Almost one-half (48%) of these homes have R-10 below grade foundation wall insulation; 39% have foundation wall insulation greater than R-10, 7% have foundation wall insulation less than R-10, and 6% have no foundation wall insulation. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have R-10 below grade foundation wall insulation, and significantly less likely to have uninsulated or under insulated conditioned below grade foundation walls. Homes in non-GT regions are significantly more likely than homes in GT regions to have below grade foundation wall insulation less than R-10.

RBES prescriptive compliance paths require that above grade foundation walls enclosing conditioned space be insulated to at least R-19. Statewide, 27 homes have at least some above grade foundation walls enclosing conditioned space. Table 4-32 shows that the average statewide R-value for above grade foundation wall insulation in these homes is R-13.2. In over one-half (63%) of these homes, the above grade foundation walls are insulated to less than R-19; 30% have above grade foundation walls insulated to R-19 or greater, and 7% have uninsulated above grade foundation walls enclosing conditioned space. There are no statistically significant differences in the level of above grade foundation wall insulation between ENERGY STAR and non-ENERGY STAR homes, or between GT and non-GT homes.

Table 4-32: Above Grade Foundation Wall Insulation Levels

Above Grade Conditioned Foundation Wall R-Value	GT Regions (n=6)	Non-GT Regions (n=21)	Vermont Gas (n=6)	ENERGY STAR (n=8)	Non-ENERGY STAR (n=19)	Statewide Unweighted (n=27)
No Insulation	0 (0%)	10%	0 (0%)	0 (0%)	11%	7%
Less than R-19	5 (83%)	57%	5 (83%)	6 (75%)	58%	63%
R-19	0 (0%)	5%	0 (0%)	0 (0%)	5%	4%
>R-19	1 (17%)	29%	1 (17%)	2 (25%)	26%	26%
Above Grade Foundation Walls R-value Statistics						
Minimum	10.0	0.0	10.0	10.0	0.0	0.0
Maximum	25.5	22.0	25.5	25.5	22.0	25.5
Average	**13.3**	**13.2**	**13.9**	**15.0**	**12.5**	**13.2**
Median	10.5	11.0	10.5	12.8	11.0	11.0

Table 4-33 displays the percentage of the 67 homes with foundation walls enclosing conditioned space that meet RBES prescriptive compliance path insulation requirements, which include insulating below grade conditioned foundation walls to at least R-10, and insulating above grade conditioned foundation walls to at least R-19. In over one-half (65%) of homes statewide, all foundation walls enclosing conditioned space are insulated to RBES minimum requirements. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have all foundation walls meet RBES insulation requirements – 80% compared to 54%. In the 20% of ENERGY STAR homes in which not all foundation walls meet RBES insulation requirements, auditors observed above grade foundation walls insulated with rigid foam (or rigid foam and cellulose) with R-values less than R-19.

Table 4-33: Foundation Wall Insulation Compliance with RBES

Compliance with RBES	GT Regions (n=20)	Non-GT Regions (n=47)	Vermont Gas (n=24)	ENERGY STAR (n=30)	Non-ENERGY STAR (n=37)	Statewide Weighted (n=67)
All Foundation Walls Meet Insulation Requirements	70%	64%	75%	80%*	54%*	65%
All Foundation Walls Do Not Meet Insulation Requirements	30%	36%	25%	20%*	46%*	35%

*Significantly different at the 90% confidence level.

4.6 Slab Insulation

RBES does not have insulation requirements for the floors of conditioned basements or crawl spaces, but requires slab on grade floors of conditioned spaces to have at least R-10 perimeter insulation, and prescriptive compliance paths require slab edge insulation. In homes with unconditioned basements, the frame floor over the basement (and not the slab) is the thermal boundary; therefore, auditors generally only collected information on the slab floors for homes in

which the slab floor is the thermal boundary. Because slab insulation is rarely visible in finished homes, in some cases the auditors were unable to determine the location and R-value of slab insulation.

Auditors categorized slabs as on grade, below grade, or a mix (on/below) grade. Table 4-34 displays the percentage of homes with each type of slab. Statewide results show that over one-third (36%) of homes have below grade slabs, one-quarter (25%) have a mix of on grade and below grade slabs, and 13% have slabs on grade. One home was built on a pile of stone.

Table 4-34: Slab Floor Location

Slab Floor Location	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Below Grade	36%	36%	54%	42%	33%	36%
Mix	25%	25%	15%	24%	25%	25%
On Grade	7%	14%	4%	12%	13%	13%
No Slab—Rock Pile	0%	1%	0%	0%	2%	1%
N/A or Unknown	32%	23%	27%	21%	28%	25%

Auditors were able to determine the location and R-value of slab insulation in 44 homes, including 9 homes with on grade slabs, 19 homes with below grade slabs, and 16 homes with mix (on/below) grade slabs. Table 4-35 and Table 4-36 display slab insulation characteristics for all on grade slabs in these 44 homes. Statewide, over one-half (56%) of homes have both under (whole slab) and slab edge insulation insulating on grade slabs, 28% have only under (whole slab) on grade slab insulation, 8% have only perimeter on grade slab insulation, and 8% have uninsulated on grade slabs. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have both under (whole slab) and slab edge insulation insulating on grade slabs—83% of ENERGY STAR homes compared to 31% of non-ENERGY STAR homes.

Table 4-35: On Grade Slab Insulation Location

On Grade Slab Insulation Location	GT Regions (n=5)	Non-GT Regions (n=20)	Vermont Gas (n=3)	ENERGY STAR (n=12)	Non-ENERGY STAR (n=13)	Statewide Unweighted (n=25)
Under (whole slab) and Slab Edge	2 (40%)	60%	1 (33%)	83%*	31%*	56%
Under Only (whole slab)	1 (20%)	30%	0 (0%)	0%*	54%*	28%
Perimeter Only	2 (40%)	0%	2 (67%)	17%	0%	8%
None	0 (0%)	10%	0 (0%)	0%	15%	8%

*Significantly different at the 90% confidence level.

The statewide average R-value of on grade slab insulation is R-10.9. The average R-value of on grade slab insulation for ENERGY STAR homes (R-11.7) is higher than the average R-value of on grade slab insulation for non-ENERGY STAR homes (R-10.2), although this difference is not

statistically significant at the 90% confidence level. Statewide, 44% of homes have R-10 on grade slab insulation, 40% have on grade slab insulation greater than R-10, 8% have on grade slab insulation less than R-10, and 8% have uninsulated on grade slabs. Homes in GT regions are significantly more likely than homes in non-GT regions to have on grade slab insulation greater than R-10.

Table 4-36: On Grade Slab Insulation Levels

On Grade Slab Insulation Levels	GT Regions (n=5)	Non-GT Regions (n=20)	Vermont Gas (n=3)	ENERGY STAR (n=12)	Non-ENERGY STAR (n=13)	Statewide Unweighted (n=25)
No Insulation	0 (0%)	10%	0 (0%)	0%	15%	8%
Less than R-10	0 (0%)	10%	0 (0%)	8%	8%	8%
R-10	1 (20%)	50%	2 (67%)	50%	38%	44%
>R-10	**4 (80%)***	**30%***	1 (33%)	42%	38%	40%
On Grade Slabs Insulation R-value Statistics						
Minimum	10.0	0.0	10.0	9.5	0.0	0.0
Maximum	16.6	20.0	16.6	16.6	20.0	20.0
Average	**12.6**	**10.5**	**12.2**	**11.7**	**10.2**	**10.9**
Median	12.0	10.0	10.0	10.0	10.0	10.0

*Significantly different at the 90% confidence level.

Table 4-37 and Table 4-38 display slab insulation characteristics for all below grade slabs in the 44 homes for which auditors were able to determine the location and R-value of slab insulation. RBES does not require slab insulation for below grade slabs, regardless of whether they abut conditioned space. Statewide, one-third (33%) of homes have only under (whole slab) below grade slab insulation, 32% have uninsulated below grade slabs, 22% have both under (whole slab) and slab edge insulation insulating below grade slabs, and 10% have only perimeter below grade slab insulation. One home has both under (whole slab) and slab edge insulation on one portion of its below grade slab, and perimeter insulation only along another portion of its below grade slab. Homes in GT regions are significantly more likely than homes in non-GT regions to have uninsulated below grade slabs. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have perimeter insulation only along below grade slabs, and significantly less likely to have under only (whole slab) insulation insulating below grade slabs.

Table 4-37: Below Grade Slab Insulation Location

Below Grade Slab Insulation Location	GT Regions (n=11)	Non-GT Regions (n=24)	Vermont Gas (n=14)	ENERGY STAR (n=22)	Non-ENERGY STAR (n=13)	Statewide Weighted (n=35)
Under Only (whole slab)	0%*	42%*	7%	14%*	54%*	33%
None	73%*	21%*	64%	45%	23%	32%
Under (whole slab) and Slab Edge	9%	25%	7%	18%	23%	22%
Perimeter Only	18%	8%	21%	18%*	0%*	10%
Under (whole slab) and Slab Edge & Perimeter Only	0%	4%	0%	5%	0%	3%

*Significantly different at the 90% confidence level.

Statewide, the average R-value of below grade slab insulation is R-7.2. The average R-value of below grade slab insulation for homes in non-GT regions (R-8.5) is significantly higher than the average R-value of below grade slab insulation for homes in GT regions (R-2.9). One-half (50%) of homes with below grade slabs have R-10 below grade slab insulation; 35% have uninsulated below grade slabs, and 15% have below grade slab insulation greater than R-10. Homes in GT regions are significantly more likely than homes in non-GT regions to have uninsulated below grade slabs. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have uninsulated below grade slabs.

Table 4-38: Below Grade Slab Insulation Levels

Below Grade Slab Insulation Levels	GT Regions (n=11)	Non-GT Regions (n=24)	Vermont Gas (n=14)	ENERGY STAR (n=22)	Non-ENERGY STAR (n=13)	Statewide Weighted (n=35)
No Insulation	73%*	25%*	71%	50%*	23%*	35%
Less than R-10	0%	0%	0%	0%	0%	0%
R-10	18%*	58%*	29%	41%	54%	50%
>R-10	9%	17%	0%	9%	23%	15%
Below Grade Slabs Insulation R-value Statistics**						
Minimum	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	12.0	20.0	10.0	16.0	20.0	20.0
Average	2.9*	8.5*	2.9	5.5	8.8	7.2
Median	0.0	10.0	0.0	5.0	10.0	10.0

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 4-39 provides summary insulation level information for homes requiring slab insulation weighted by GT and non-GT regions. A slab requires insulation if 1) it is on grade, and 2) if it abuts conditioned space. There are a total of 24 homes with on grade slabs abutting conditioned space where auditors were able to determine the R-value of slab insulation, including 9 homes with on grade slabs and 15 homes with a mix of on and below grade slabs. Statewide, 84% of homes with slabs that require insulation have all on grade slabs abutting conditioned space

insulated to at least R-10. The average R-value of slab insulation for on grade slabs abutting conditioned space is R-10.6.[38]

Table 4-39: Slab Insulation Levels

Basement Slab Average R-value (all slabs requiring insulation)	Vermont 2011 Baseline Weighted Data		
Minimum RBES Requirement R-10	On Grade Slab (n=9)	Mix** (on/below) Grade Slab (n=15)	All Slabs** (n=24)
R-value Below Code	11%	20%	16%
R-value Meets or Exceeds Code	89%	80%	84%
R-Value Statistics*			
Minimum R-value	8.0	0.0	0.0
Maximum R-value	15.0	16.6	16.6
Average R-value	**11.4**	**10.1**	**10.6**
Median R-value	10.0	10.0	10.0

*Only the average is weighted.
**Only the on grade slab in homes with a mix of on and below grade slabs is required to be insulated by code; the insulation characteristics of below grade slabs in homes with a mix of on and below grade slabs is excluded from the calculations in this table.

4.7 Rim/Band Joist Insulation

Auditors recorded insulation information on all rim and band joists that were part of the thermal boundary and were not encompassed in other shell measures (i.e. frame floor). In general, joist insulation was verified in the basements, but assumed in between floors. In keeping with standard HERS rating practice, auditors assumed joists between floors were insulated similarly to conditioned/ambient walls so long as the walls above and below the joist were insulated when the home was built.[39] Joist insulation between the basement and first floor is often encompassed in the frame floor insulation. In many cases frame floor insulation extends all the way to the joist, in turn insulating the joist. In these cases joist insulation was not recorded as the joist is actually insulated by the frame floor insulation. The most pertinent example of this is in unconditioned basements where the frame floor insulation is separating the living space from the

[38] One home has 6 sq. ft. of R-10 perimeter insulation and 32 sq. ft. of R-19 perimeter insulation along different portions of the on grade slab. The average insulation level for this home was calculated using the procedure described in the RBES Handbook for determining the average R-value for a building component with two or more thermal values. Another four homes have R-8 or R-10 insulation under the whole on grade slab in addition to R-12 or higher perimeter on grade slab insulation. In these four cases, the average slab insulation R-value per home was derived by taking a simple average of the under and perimeter insulation R-values.
[39] In a few instances the rim joist R-value was not the same as the exterior wall R-value. In these cases the joists between floors R-value was assumed to be the same as joist verified in the basement, not the exterior walls.

basement. In most of these cases the floor insulation is insulating the joist, obviating the need to record joist insulation information.

The majority of rim and band joist insulation is located between conditioned spaces and ambient (outside) space. Statewide results show the average R-value of this insulation is R-20.1. Homes in GT regions (R-17.9) have a significantly lower average R-value than homes in non-GT regions (R-20.7). ENERGY STAR homes (R-22.3) have a significantly higher average R-value than non-ENERGY STAR homes (R-18.6). In addition, ENERGY STAR homes are much more likely than non-ENERGY STAR homes to have Grade I insulation installation (90% vs. 37% respectively) (Table 4-40).

Table 4-40: Conditioned/Ambient Rim and Band Joist Insulation Characteristics

Conditioned/Ambient Joists	GT Regions (n=24)	Non-GT Regions (n=60)	Vermont Gas (n=26)	ENERGY STAR (n=29)	Non-ENERGY STAR (n=55)	Statewide Weighted (n=84)
Average R-value	18*	21*	21	22*	19*	20
Insulation Installation Grade**						
Grade I	58%	54%	65%	90%*	37%*	55%
Grade II	29%	32%	31%	7%*	44%*	31%
Grade III	13%	14%	4%	3%*	19%*	14%
No Insulation						
Uninsulated	0%*	7%*	0%	0%*	7%*	78%

* Significantly different at the 90% confidence level.
**Insulation grade is only applied if insulation was present.

4.8 Ducts

Twenty-one audited homes have heating and/or cooling ducts. Table 4-41 displays the location of ducts in all 21 homes with ducts. With the exception of seven homes in which all ducts are located in conditioned space, most homes have ducts in more than one location; therefore the percentages in Table 4-41 do not total 100%. Statewide, the majority (86%) of homes with ducts have ducts located in conditioned space; over one-half (62%) of homes have ducts located in an attic, 10% have ducts located in another unconditioned location (such as a garage or the floor cavity over a garage), and 5% have ducts located in an unconditioned basement. Homes in non-GT regions are significantly more likely than homes in GT regions to have ducts located in conditioned space – 100% (all 11 homes) compared to 70% (7 out of 10 homes). ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have ducts located in an attic – 80% (12 of 15 homes) compared to 17% (1 of 6 homes).

Table 4-41: Duct Locations

Duct Location (All Homes with Ducts)	GT Regions (n=10)	Non-GT Regions (n=11)	Vermont Gas (n=13)	ENERGY STAR (n=15)	Non-ENERGY STAR (n=6)	Statewide Unweighted (n=21)
Conditioned Space	70%*	100%*	77%	87%	5 (83%)	86%
Attic	70%	55%	77%	80%*	1(17%)*	62%
Other**	0%	18%	15%	13%	0 (0%)	10%
Unconditioned Basement	10%	0%	8%	0%	1 (17%)	5%

*Significantly different at the 90% confidence level.
**Other includes ducts located in a garage and in the floor cavity over a garage.

Over one-half (67%) of homes with ducts have metal ducts only; 19% have a combination of metal and flexible ducts, and 14% have flexible ducts only. Homes in GT regions are significantly more likely than homes in non-GT regions to have all metal ducts, and significantly less likely to have all flexible ducts.

Table 4-42: Duct Types

Duct Type (All Homes with Ducts)	GT Regions (n=10)	Non-GT Regions (n=11)	Vermont Gas (n=13)	ENERGY STAR (n=15)	Non-ENERGY STAR (n=6)	Statewide Unweighted (n=21)
Metal	90%*	45%*	77%	73%	3 (50%)	67%
Metal & Flexible	10%	27%	23%	20%	1 (17%)	19%
Flexible	0%*	27%*	0%	7%	2 (33%)	14%

*Significantly different at the 90% confidence level.

Statewide, 14 homes have ducts located in unconditioned space. Table 4-43 shows that in 64% of these homes, all ducts located in unconditioned space are sealed with mastic duct sealant. In three of these homes (21%), none of the ducts located in unconditioned space are sealed. In one home, auditors observed both unsealed ducts and ducts sealed with PS tape in the attic. Homes in

GT regions are significantly more likely than homes in non-GT regions to have mastic duct sealing. A greater percentage of ENERGY STAR homes (75%) have mastic duct sealing than non-ENERGY STAR homes (0%); however, the small sample size for non-ENERGY STAR homes with ductwork precludes statistical significance testing.

Table 4-43: Duct Sealing

Duct Sealing (Homes with Ducts Located in Unconditioned Space)	GT Regions (n=8)	Non-GT Regions (n=6)	Vermont Gas (n=11)	ENERGY STAR (n=12)	Non-ENERGY STAR (n=2)	Statewide Unweighted (n=14)
Mastic	7 (88%)*	2 (33%)*	73%	75%	0 (0%)	64%
None	0 (0%)*	3 (50%)*	18%	17%	1 (50%)	21%
PS Tape (Attic) & None (Attic)	0 (0%)	1 (17%)	0%	8%	0 (0%)	7%
Unknown	1 (13%)	0 (0%)	9%	0%	1 (50%)	7%

*Significantly different at the 90% confidence level.

Out of the 14 homes with ducts located in unconditioned space, 9 homes have only attic ducts buried under insulation. Table 4-44 provides R-value statistics for ducts in the remaining five homes with ducts located in unconditioned space other than attic ducts buried under insulation. The average statewide R-value of insulation on ducts located in unconditioned space is R-18.9; the median is R-5. The small sample sizes for homes with ducts located in unconditioned space other than attic ducts buried under insulation preclude statistical significance testing between groups.

Table 4-44: Duct Insulation R-Value Statistics

Duct Insulation R-value (Homes with Ducts Located in Unconditioned Space not Buried Under Insulation)	GT Regions (n=1)	Non-GT Regions (n=4)	Vermont Gas (n=3)	ENERGY STAR (n=3)	Non-ENERGY STAR (n=2)	Statewide Unweighted (n=5)
Minimum	4.2	5.0	4.2	5.0	4.2	4.2
Maximum	4.2	80.0	37.0	80.0	6.0	80.0
Average	**4.2**	**22.2**	**13.6**	**24.3**	**4.8**	**18.9**
Median	4.2	6.0	5.0	12.5	4.2	5.0

RBES requirements include 1) insulating heating and cooling system supply and return ducts in unconditioned basements, crawlspaces and attics to R-5 (or R-3.3 for return ducts in unconditioned basements), and 2) using mastic with fibrous backing tape to seal ducts in unconditioned space. Table 4-45 displays the percentage of the 14 homes with ducts located in unconditioned space that meet both of the duct sealing and insulation requirements, the percentage that meet the sealing requirement, the percentage that meet the insulation requirement, and the percentage that do not meet one or both of the sealing and insulation requirements. Statewide, over one-half (64%) of homes with ducts located in unconditioned

space meet both RBES duct sealing and insulation requirements. Homes in GT regions are significantly more likely than homes in non-GT regions to meet both RBES duct sealing and insulation requirements. A greater percentage of ENERGY STAR homes (75%) meet both RBES duct sealing and insulation requirements than non-ENERGY STAR homes; however, the small sample size for non-ENERGY STAR homes with ductwork precludes statistical significance testing.

Table 4-45: Duct Compliance with RBES

Compliance with RBES (Homes with Ducts Located in Unconditioned Space)	GT Regions (n=8)	Non-GT Regions (n=6)	Vermont Gas (n=11)	ENERGY STAR (n=12)	Non-ENERGY STAR (n=2)	Statewide Unweighted (n=14)
Meet Both Sealing & Insulation Requirements	7 (88%)*	2 (33%)*	73%	75%	0 (0%)	64%
Meet Sealing Requirement	7 (88%)*	2 (33%)*	73%	75%	0 (0%)	64%
Meet Insulation Requirement	7 (88%)	6 (100%)	91%	100%	1 (50%)	93%
Do Not Meet One or Both Sealing & Insulation Requirements	1 (13%)*	4 (67%)*	27%	25%	2 (100%)	36%

*Significantly different at the 90% confidence level.

4.9 Doors

Auditors collected information on 286 doors in 97 homes. Table 4-46 shows the distribution of the types of doors in inspected homes. Statewide results show the most common type of door is an insulated steel door (47%), followed by an insulated fiberglass door (32%), and an uninsulated wood door (12%). Homes in GT regions are significantly more likely than homes in non-GT regions to have insulated steel doors, and are significantly less likely to have uninsulated wood doors. ENERGY STAR homes are significantly more likely to have insulated steel doors and other door types (such as knee wall hatches and sliding glass doors), and significantly less likely to have insulated fiberglass doors, uninsulated wood doors, and insulated wood doors.

Table 4-46: Door Type

Door Type	GT Regions (n=79 doors)	Non-GT Regions (n=207 doors)	Vermont Gas (n=67 doors)	ENERGY STAR (n=68 doors)	Non-ENERGY STAR (n=218 doors)	Statewide Weighted (n=286 doors)
Steel Insulated	57%*	44%*	75%	82%*	37%*	47%
Fiberglass Insulated	27%	33%	15%	0%*	41%*	32%
Wood Uninsulated	3%*	14%*	1%	1%*	14%*	12%
Wood Insulated	6%	5%	0%	0%*	7%*	5%
Other	8%	3%	9%	16%*	0%*	4%

*Significantly different at the 90% confidence level.
**Other includes kneewall hatches and sliding doors comprised primarily of glass.

Table 4-47 shows that the majority (84%) of doors are insulated, and that very few doors (3%) have storm doors. Homes in GT regions are significantly more likely than homes in non-GT regions to have insulated doors.

Table 4-47: Door Characteristics

Door Characteristics	GT Regions (n=79 doors)	Non-GT Regions (n=207 doors)	Vermont Gas (n=67 doors)	ENERGY STAR (n=68 doors)	Non-ENERGY STAR (n=218 doors)	Statewide Weighted (n=286 doors)
Insulated	90%*	83%*	90%	82%	85%	84%
Storm Door	4%	3%	4%	1%	4%	3%

*Significantly different at the 90% confidence level.

4.10 Envelope Leakage

Auditors conducted blower door tests to measure envelope leakage or air infiltration at 22 non-ENERGY STAR homes and EVT provided blower door test results for 33 ENERGY STAR homes. Blower door tests results can be reported in several ways: natural air changes per hour (ACHnat), air changes per hour at 50 Pascals (ACH 50), or total CFM leakage measured at 50 Pascals.[40]

Generally speaking, considering a basement "conditioned" or "unconditioned" can have a significant impact on air infiltration results. The reason for this is that when a basement is considered conditioned it is typically open to the house during the blower door test. This increases the conditioned volume of the home which impacts ACH 50 calculations. Similarly, if a basement is considered unconditioned then the basement would not be directly included in the blower door test and the volume would not be considered in ACH 50 calculations. More often than not basements are quite connected to the house, regardless of whether or not they are intended to be. This can result in raw air leakage values (measured in cubic feet per minute at 50 Pascals) that are similar regardless of the basement configuration (conditioned vs. unconditioned). If raw leakage values are similar, then including or excluding the basement volume will have a major impact on ACH 50. For the homes in this study where blower door tests were conducted, the decision on whether to treat the basement as conditioned or unconditioned was made by the auditor or Home Energy Rating System (HERS) rater conducting the test.

[40] To ensure consistency in how ACHnat was calculated for both ENERGY STAR homes and non-ENERGY STAR homes, ACHnat was calculated using the following equation: ACHnat = (ACH 50) /LBL factor. ACH 50 was determined by the blower door test and an LBL factor of 18 was used based on the Vermont climate region. http://www.energystar.gov/ia/home_improvement/home_sealing/ES_HS_Spec_v1_0b.pdf

Note that the weighted statewide averages in this section use different weights than used in the other sections of this report because ENERGY STAR homes are over represented in the sample of envelope leakage testing results. In this section, ENERGY STAR testing results are weighted by 33%, an estimate of the penetration of ENERGY STAR homes in the Vermont new residential housing construction market, and non-ENERGY STAR home testing results are weighted by 67%. Table 4-48 presents blower door results in ACHnat while Table 4-49 presents results in ACH 50. As shown, the weighted statewide average natural air changes per hour is 0.18 and the weighted statewide average ACH 50 is 3.2.

Table 4-48 shows the average natural air changes per hour is significantly lower for ENERGY STAR homes (0.13 ACHnat) compared to non-ENERGY STAR homes (0.20 ACHnat). Only one of the 55 homes with air leakage information has leakage greater than 0.35 ACHnat—a non-ENERGY STAR modular home with a custom addition that is located outside the GT regions has leakage of 0.40 ACHnat.

Table 4-48: Envelope Leakage Statistics — Natural Air Changes per Hour

Envelope Leakage ACHnat	GT Regions (n=20)	Non-GT Regions (n=35)	Vermont Gas (n=21)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=22)	Statewide Weighted** (n=55)
Min	0.07	0.05	0.07	0.05	0.08	0.05
Max	0.32	0.40	0.31	0.31	0.40	0.40
Average	**0.15**	**0.16**	**0.13**	**0.13***	**0.20***	**0.18**
Median	0.13	0.13	0.11	0.12	0.19	0.13

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 4-49 shows the average air changes per hour measured at 50 Pascals is significantly lower for ENERGY STAR homes (2.4 ACH 50) compared to non-ENERGY STAR homes (3.6 ACH 50).

Table 4-49: Envelope Leakage Statistics — Air Changes per Hour at 50 Pascals

ACH 50	GT Regions (n=20)	Non-GT Regions (n=35)	Vermont Gas (n=21)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=22)	Statewide Weighted** (n=55)
Min	1.3	0.8	1.2	0.8	1.5	0.8
Max	5.7	7.1	5.6	5.6	7.1	7.1
Average	**2.8**	**2.9**	**2.3**	**2.4***	**3.6***	**3.2**
Median	2.3	2.4	2.0	2.2	3.4	2.4

*Significantly different at the 90% confidence level.
**Only the average is weighted.

2005 VT-RBES did not have specific air infiltration requirements but the new VT-RBES, which became effective October 1, 2011, requires 5 ACH 50 or less. EVT's Residential New Construction services now require air infiltration rates of 4 ACH 50 for Energy Code Plus service homes and 3 ACH 50 for Vermont ENERGY STAR-qualified homes. Table 4-50 shows that:

- Homes in non-GT regions are significantly more likely than homes in GT regions to have leakage that is greater than 4 but not higher than 5 ACH 50 (14% vs. 0%).
- ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have leakage of 3 ACH 50 or less (79% vs. 36%).
- ENERGY STAR homes are significantly less likely than non-ENERGY STAR homes to have leakage that is greater than 4 but not higher than 5 ACH 50 (3% vs. 18%).

Statewide weighted percentages are 50% ACH 50 of 3 or less, 22% greater than 3 but not higher than 4 ACH 50, 13% greater than 4 but not higher than 5 ACH 50, and 14% greater than 5 ACH 50.

Table 4-50: Envelope Leakage—Air Changes per Hour at 50 Pascals

ACH 50 Bins	GT Regions (n=20)	Non-GT Regions (n=35)	Vermont Gas (n=21)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=22)	Statewide Weighted (n=55)**
3 ACH 50 or Less	65%	60%	81%	79%*	36%*	50%
Greater than 3 to 4 ACH 50	20%	17%	14%	12%	27%	22%
Greater than 4 to 5 ACH 50	0%*	14%*	0%	3%*	18%*	13%
Greater than 5 ACH 50	15%	9%	5%	6%	18%	14%

*Significantly different at the 90% confidence level.

Figure 4-16 and Figure 4-17 on the next page chart the air changes per hour measured at 50 Pascals (ACH 50) for each of the 55 tested homes. Figure 4-16 separately identifies homes in GT regions and in non-GT Regions and Figure 4-17 separately identifies ENERGY STAR and non-ENERGY STAR homes. Figure 4-18 shows ACH 50 for tested homes in Vermont Gas service territory.

Figure 4-16: ACH 50 Envelope Leakage — GT Regions and Non-GT Regions

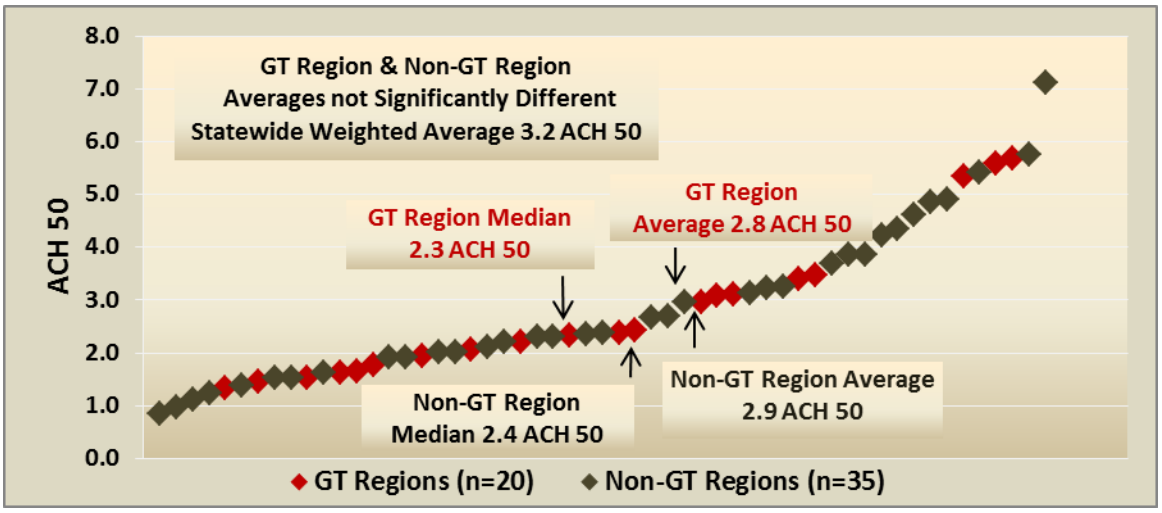


Figure 4-17: ACH 50 Envelope Leakage — ENERGY STAR and Non-ENERGY STAR Homes

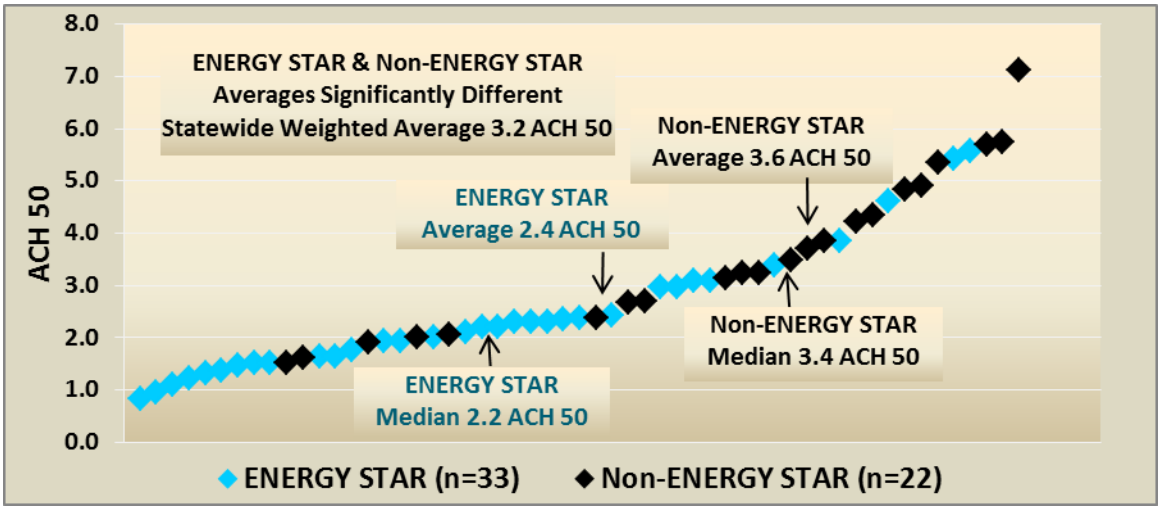


Figure 4-18: ACH 50 Envelope Leakage — Vermont Gas Homes

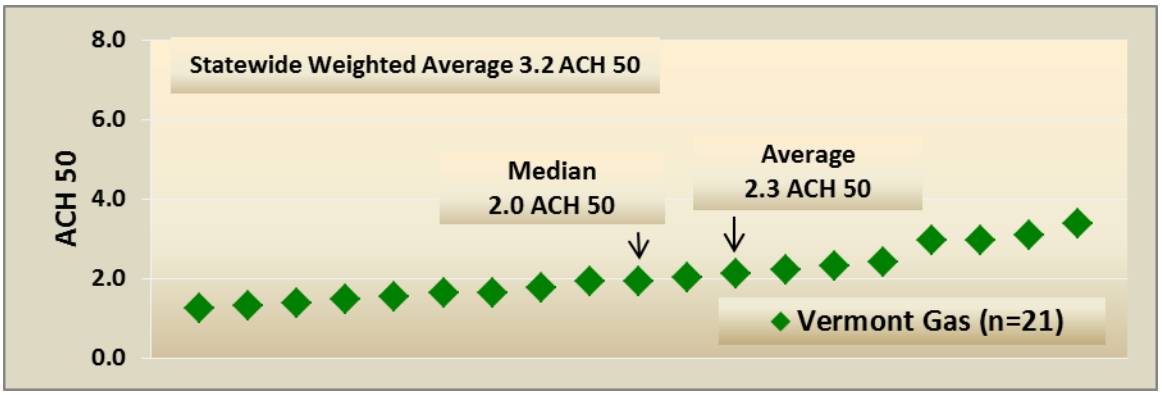


Table 4-51 shows that statewide weighted average total CFM leakage measured at 50 Pascals is 1,041 CFM50 and that total CFM50 leakage is significantly lower for ENERGY STAR homes (786 CFM50) compared to non-ENERGY STAR homes (1,166 CFM50).

Table 4-51: Envelope Leakage Statistics —Total CFM50

CFM50 Air Infiltration	GT Regions (n=20)	Non-GT Regions (n=35)	Vermont Gas (n=21)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=22)	Statewide Weighted** (n=55)
Min	238	296	238	238	638	238
Max	1,470	2,697	1,523	1,872	2,697	2,697
Average	**843**	**992**	**870**	**786***	**1,166***	**1,041**
Median	835	908	930	766	964	895

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 4-52 shows ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have total CFM50 leakage of 750 CFM50 or less (48% vs. 18%). Tested homes in the GT regions are significantly less likely to have over 1,500 to 2,000 CFM50 leakage (0% vs. 17%). Only one tested home, a non-ENERGY STAR home outside the GT regions, has total leakage over 2,000 CFM50.

Table 4-52: Envelope Leakage – Total CFM50

CFM50 Air Infiltration	GT Regions (n=20)	Non-GT Regions (n=35)	Vermont Gas (n=21)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=22)	Statewide Weighted (n=55)
750 or Less	40%	34%	38%	**48%***	**18%***	28%
>750 to 1,000	35%	31%	29%	30%	36%	34%
>1,000 to 1,500	25%	14%	29%	15%	23%	20%
>1,500 to 2,000	**0%***	**17%***	5%	6%	18%	14%
>2,000 to 2500	0%	0%	0%	0%	0%	3%
>2,500 to 3,000	0%	3%	0%	0%	5%	28%

*Significantly different at the 90% confidence level.

Figure 4-19 shows average total CFM50 (unweighted) and Figure 4-20 shows median total CFM50 envelope leakage by home size as well as the minimum and maximum leakage in each home size category. As shown, average and median leakage tend to increase as home size increases, but the range of total CFM50 leakage is broad in almost all home size categories and there are homes with very low leakage in almost every home size category. The home with the highest total leakage (2,697 CFM50) is a 4,184 square foot non-ENERGY STAR single-family detached home in Island Pond, Vermont with R-19 fiberglass batt wall insulation (Grade II installation), a mix of R-30 and R-38 fiberglass batt ceiling insulation (Grade II installation), and double pane Low-E with argon windows; air changes per hour for this home are 0.27 ACHnat and 4.9 ACH 50.

Figure 4-19: Average Total CFM50 Envelope Leakage by Home Size

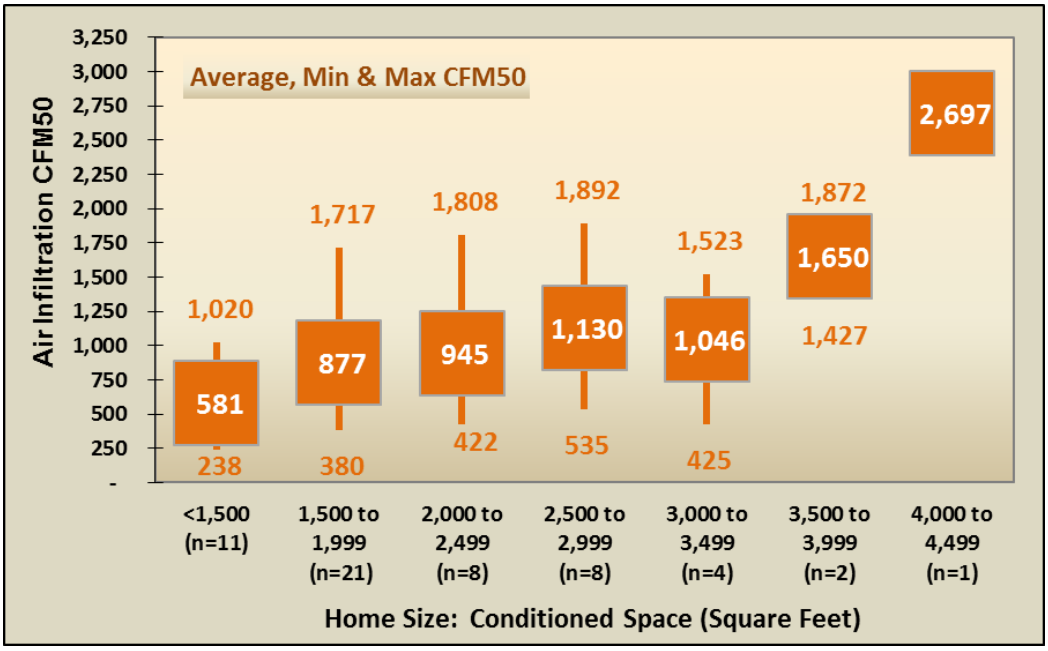
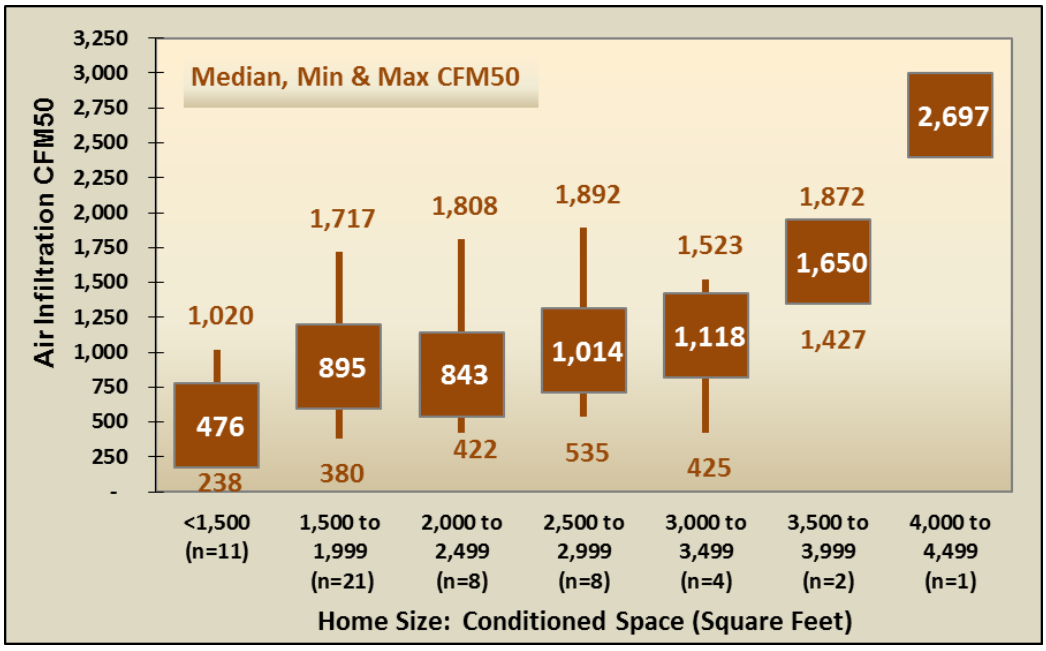


Figure 4-20: Median Total CFM50 Envelope Leakage by Home Size



5 Space Heating

All but four of the 97 inspected homes have a propane, natural gas, oil or wood-fired boiler or furnace, ground source heat pump (GSHP) or electric baseboard heat. Three homes have only wood stoves and one home has a wood stove and a propane stove. Owners of six homes with boilers, furnaces or electric baseboard heat say that wood is their primary heating fuel.

5.1 Heating Systems and Fuels

Most homes have hot water boiler heating systems. Figure 5-1 and Table 5-1 show the percentage of homes by heating system type and fuel. The first chart shows two-thirds (67%) of homes have boilers, 18% have furnaces, 5% have a combined appliance system and 3% have a GSHP. The second pie chart shows that two-thirds (67%) of homes have propane heating systems, 13% have natural gas, 10% have oil, and 4% have electric heating systems. The "other" heating system type category includes one home with electric baseboard heat, four with wood stoves and one with a wood stove and a propane stove. The "other" heating system fuel category includes homes that heat with wood or both wood and propane.

Figure 5-1: Heating System Types and Fuels

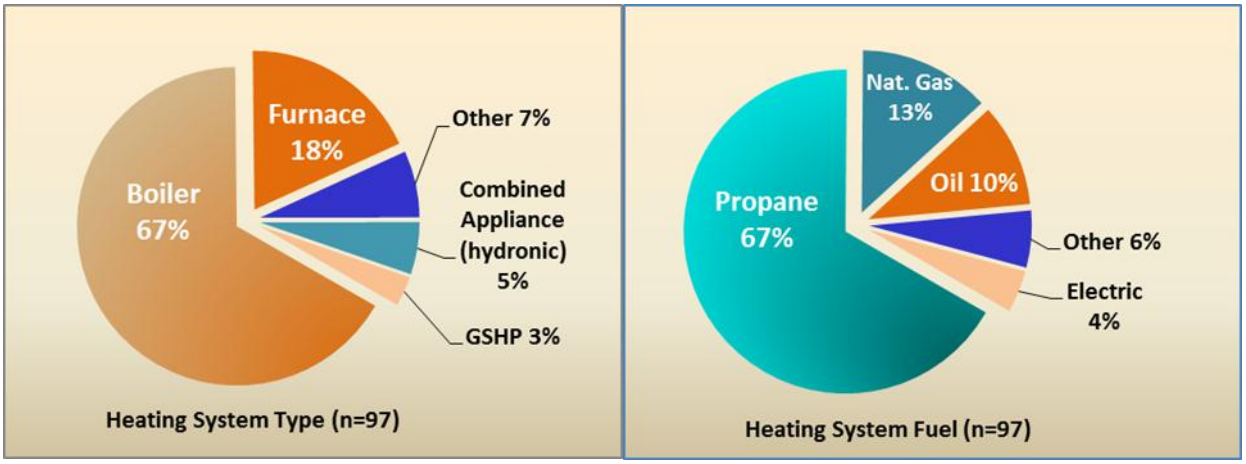


Table 5-1 shows homes located in the GT regions are significantly more likely than homes located in non-GT regions to have furnace heating systems and to have natural gas heating systems. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have a furnace or combined appliance heating system and significantly less likely to have a boiler heating system. ENERGY STAR homes are also significantly more likely than non-ENERGY STAR homes to have a natural gas heating system and significantly less likely to have an oil heating system.

Table 5-1: Heating System Types and Fuels

Heating Systems	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Heating System Type						
Boiler	61%	68%	38%	39%*	80%*	67%
Furnace	32%*	14%*	46%	39%*	9%*	18%
Other	0%*	9%	4%	3%	8%	7%
Combined Appliance (hydronic)	4%	6%	8%	12%*	2%*	5%
GSHP	4%	3%	4%	6%	2%	3%
Heating System Fuel						
Propane	46%*	72%*	31%	55%	70%	67%
Natural Gas	39%*	6%*	58%	33%*	6%*	13%
Oil	11%	10%	4%	3%*	14%*	10%
Other	0%*	7%*	0%	0%*	8%*	6%
Electric	4%	4%	8%	9%	2%	4%

*Significantly different at the 90% confidence level.

Figure 5-2 and Table 5-2 show the percentages of various fuel/heating system type combinations. As shown, 54% of heating systems are propane boilers, followed by propane furnaces (11%) and oil boilers (11%); 7% of homes have natural gas furnaces, 4% have propane combined appliances and 3% have GSHPs. The "other" category includes one electric baseboard heat system, one natural gas combined appliance and one wood-fired boiler.

Figure 5-2: Heating Systems by Fuel and Type

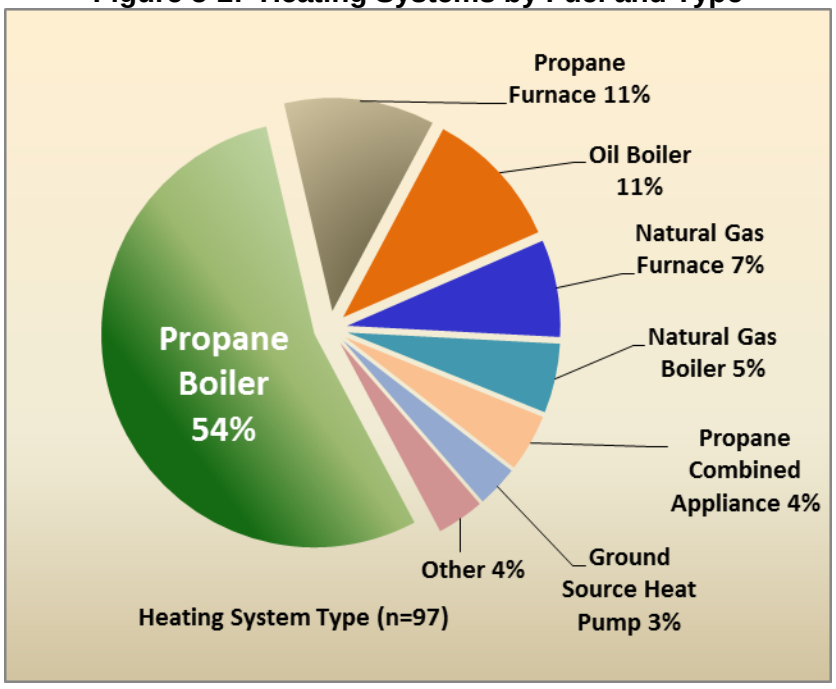


Table 5-2 shows heating systems in GT regions are significantly more likely than heating systems in non-GT regions to be natural gas boilers or furnaces and significantly less likely to be propane boilers. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have a natural gas furnace and significantly less likely to have a propane or oil boiler.

Table 5-2: Heating Systems by Fuel and Type

Heating Systems Fuel & Type	GT Regions (n=29)	Non-GT Regions (n=65)	Vermont Gas (n=27)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=61)	Statewide Weighted (n=94)
Propane Boiler	28%*	62%*	11%	30%*	62%*	54%
Propane Furnace	14%	11%	15%	15%	10%	11%
Oil Boiler	10%	11%	4%	3%*	15%*	11%
Natural Gas Furnace	17%*	5%*	30%	24%*	0%*	7%
Natural Gas Boiler	24%*	0%*	26%	6%	8%	5%
Propane Combined Appliance	3%	5%	4%	9%	2%	4%
Ground Source Heat Pump	3%	3%	4%	6%	2%	3%
Other	0%*	5%*	7%	6%	2%	4%

*Significantly different at the 90% confidence level.

Table 5-3 shows the percentages of homes without access to natural gas that have various heating systems. As shown, most homes without access to natural gas have propane boilers (67%). Heating systems in GT regions are significantly less likely than systems in non-GT regions to be propane furnaces.

Table 5-3: Heating Systems Where Natural Gas not Available

Heating Systems Where Natural Gas not Available	GT Regions (n=9)	Non-GT Regions (n=58)	ENERGY STAR (n=14)	Non-ENERGY STAR (n=53)	Statewide Unweighted (n=67)
Propane Boiler	6 (67%)	67%	57%	70%	67%
Oil Boiler	2 (22%)	12%	7%	15%	14%
Propane Furnace	0 (0%)*	12%*	14%	9%	9%
Propane Combined Appliance	1 (11%)	3%	14%	2%	5%
Ground Source Heat Pump	0 (0%)	3%	7%	2%	3%
Wood Boiler	0 (0%)	2%	0%	2%	1%

*Significantly different at the 90% confidence level.

5.2 Heating System Efficiency

Annual Fuel Utilization Efficiency (AFUE) ratings were determined for all but one heating system—a wood-fired furnace. In some cases the AFUE was listed on the equipment; in other cases we were able to use nameplate model number and output capacity information to look up AFUEs on manufacture websites, EPA's listing of ENERGY STAR-qualified heating systems, or AHRI listings. Table 5-4 shows the weighted average heating system AFUE across all types of heating systems is 91.5 and the median is 93.0. The average heating system AFUE for

ENERGY STAR homes is 93.1 compared to 90.6 for non-ENERGY STAR homes and this difference is statistically significant. Over one-half (weighted 59%) of heating systems are higher than 90 AFUE. Not included in Table 5-4 are three GSHP with coefficients of performance (COP) ranging from 2.9 to 4.2 and an electric baseboard heating system.

Table 5-4: Heating System AFUEs—All Heating Systems

All Heating System AFUEs	GT Regions (n=28)	Non-GT Regions (n=61)	Vermont Gas (n=25)	ENERGY STAR (n=30)	Non-ENERGY STAR (n=59)	Statewide Weighted (n=89)
AFUE<85	0%*	5%*	0%	0%*	5%*	4%
AFUE 85 to 87	29%	26%	24%	20%	31%	27%
AFUE >87 to 90	18%	8%	12%	7%	14%	10%
AFUE > 90	54%	61%	64%	73%*	51%*	59%
Heating System AFUE Statistics**						
Minimum	85.0	80.0	86.9	85.1	80.0	80.0
Maximum	97.5	97.0	97.5	97.5	96.0	97.5
Average	**91.4**	**91.5**	**92.4**	**93.1***	**90.6***	**91.5**
Median	92.3	95.0	95.0	95.1	90.3	93.0

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 5-5 through Table 5-12 show the percentage of homes falling into various AFUE ranges and AFUE statistics for all oil and gas boilers, oil boilers, combined natural gas and propane boilers, natural gas boilers, propane boilers, combined natural gas and propane furnaces, natural gas furnaces, and propane furnaces respectively. Table 5-5 shows that all gas and oil boilers are ENERGY STAR qualified (AFUE of 85 or higher) and over one-half (weighted 54%) have AFUEs over 90. The average AFUE of gas and oil boilers is significantly lower in GT regions than non-GT regions.

Table 5-5: All Gas and Oil Boiler AFUE

Gas & Oil Boiler AFUE	GT Regions (n=19)	Non-GT Regions (n=51)	Vermont Gas (n=13)	ENERGY STAR (n=17)	Non-ENERGY STAR (n=53)	Statewide Weighted (n=70)
AFUE<85	0%	0%	0%	0%	0%	0%
AFUE 85 to 87	42%	31%	46%	35%	34%	34%
AFUE >87 to 90	26%*	8%*	23%	6%	15%	12%
AFUE > 90	32%*	61%*	31%	59%	51%	54%
Gas & Oil Boiler AFUE Statistics**						
Minimum	85.0	85.0	86.9	85.1	85.0	85.0
Maximum	96.0	96.0	96.0	96.0	96.0	96.0
Average	**89.5***	**91.6***	**89.6**	**91.5**	**90.9**	**91.2**
Median	87.3	94.1	87.2	93.0	90.3	92.3

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 5-6 shows the maximum oil boiler AFUE is 90.3. All oil boilers in inspected homes are ENERGY Star qualified (AFUE 85 or higher) and 10% are over 90 AFUE. The average AFUE is 87.3 and the median is 86.9.

Table 5-6: Oil Boiler AFUE

Oil Boiler AFUE	GT Regions (n=3)	Non-GT Regions (n=7)	Vermont Gas (n=1)	ENERGY STAR (n=1)	Non-ENERGY STAR (n=9)	Statewide Unweighted (n=10)
AFUE<85	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%
AFUE 85 to 87	1 (33%)	5 (71%)	1 (100%)	1 (100%)	5 (56%)	60%
AFUE >87 to 90	2 (67%)	1 (14%)	0 (0%)	0 (0%)	3 (33%)	30%
AFUE > 90	0 (0%)	1 (14%)	0 (0%)	0 (0%)	1 (11%)	10%
Oil Boiler AFUE Statistics						
Minimum	86.9	85.1	86.9	86.9	85.1	85.1
Maximum	90.0	90.3	86.9	86.9	90.3	90.3
Average	**88.1**	**86.9**	**86.9**	**86.9**	**87.3**	**87.3**
Median	87.3	86.7	86.9	86.9	86.9	86.9

Table 5-7 shows gas (both natural gas and propane) boiler AFUEs. Gas boiler AFUEs range from 85.0 to 96.0; the median is 93.6 and the weighted average 91.8. Homes in the GT regions are significantly less likely than homes in the non-GT regions to have over 90 AFUE gas boilers and the average AFUE is significantly lower in GT regions.

Table 5-7: Natural Gas and Propane Boiler AFUE

Natural Gas & Propane Boiler AFUE	GT Regions (n=16)	Non-GT Regions (n=44)	Vermont Gas (n=12)	ENERGY STAR (n=16)	Non-ENERGY STAR (n=44)	Statewide Weighted (n=60)
AFUE<85	0%	0%	0%	0%	0%	0%
AFUE 85 to 87	44%	25%	42%	31%	30%	29%
AFUE >87 to 90	19%	7%	25%	6%	11%	9%
AFUE > 90	**38%***	**68%***	33%	63%	59%	61%
Gas Boiler AFUE Statistics**						
Minimum	85.0	85.0	87.0	85.1	85.0	85.0
Maximum	96.0	96.0	96.0	96.0	96.0	96.0
Average	**89.8***	**92.4***	**89.9**	**91.7**	**91.7**	**91.8**
Median	87.4	95.1	87.4	93.6	94.1	93.6

*Significantly different at the 90% confidence level.
**Only the average is weighted.

Table 5-8 and Table 5-9 show natural gas boiler and propane boiler statistics respectively. As shown, ENERGY STAR homes are significantly less likely than non-ENERGY STAR homes to have natural gas boilers with AFUE in the over 87 to 90 range and homes in GT regions are significantly less likely than homes in non-GT regions to have propane boilers in the over 87 to 90 range. The average AFUE of natural gas boilers is 88.2 and the average AFUE of propane boilers is 92.2.

Table 5-8: Natural Gas Boiler AFUE

Natural Gas Boiler AFUE	GT Regions (n=7)	Non-GT Regions (n=1)	Vermont Gas (n=8)	ENERGY STAR (n=3)	Non-ENERGY STAR (n=5)	Statewide Unweighted (n=8)
AFUE 85 to 87	57%	0%	50%	67%	40%	50%
AFUE >87 to 90	43%	0%	38%	**0%***	**60%***	38%
AFUE > 90	0%	100%	13%	33%	0%	13%
Natural Gas Boiler AFUE Statistics						
Minimum	87.0	95.0	87.0	87.0	87.0	87.0
Maximum	87.6	95.0	95.0	95.0	87.6	95.0
Average	**87.2**	**95.0**	**88.2**	**89.7**	**87.3**	**88.2**
Median	87.0	95.0	87.1	87.0	87.2	87.1

*Significantly different at the 90% confidence level.

Table 5-9: Propane Boiler AFUE

Propane Boiler AFUE	GT Regions (n=9)	Non-GT Regions (n=43)	Vermont Gas (n=4)	ENERGY STAR (n=13)	Non-ENERGY STAR (n=39)	Statewide Unweighted (n=52)
AFUE 85 to 87	33%	26%	25%	23%	28%	27%
AFUE >87 to 90	**0%***	**7%***	0%	8%	5%	6%
AFUE > 90	67%	67%	75%	69%	67%	67%
Propane Boiler AFUE Statistics						
Minimum	85.0	85.0	87.0	85.1	85.0	85.0
Maximum	96.0	96.0	96.0	96.0	96.0	96.0
Average	**91.8**	**92.3**	**93.3**	**92.2**	**92.2**	**92.2**
Median	93.0	95.1	95.1	94.1	95.1	95.1

*Significantly different at the 90% confidence level.

Only 19 inspected homes have natural gas or propane furnaces. Table 5-10 shows 16% of these furnaces are not ENERGY STAR (AFUE lower than 90). Gas furnace efficiencies range from 80 to 97.5 AFUE, the average is 92.9 and the median is 95.5. Almost two-thirds of gas furnaces (64%) are over 92 AFUE. Gas furnaces are significantly more likely to be non-ENERGY STAR in non-GT regions than in GT regions. Gas furnaces are significantly more likely to be non-ENERGY STAR in non-ENERGY STAR homes than in ENERGY STAR homes and significantly more likely to be over AFUE 92 in ENERGY STAR homes. The average AFUE is significantly higher in GT regions compared to in non-GT regions and in ENERGY STAR homes compared to non-ENERGY STAR homes.

Table 5-10: Natural Gas and Propane Furnace AFUE

Gas Furnace AFUE	GT Regions (n=9)	Non-GT Regions (n=10)	Vermont Gas (n=12)	ENERGY STAR (n=13)	Non-ENERGY STAR (n=6)	Statewide Unweighted (n=19)
AFUE-<90	0 (0%)*	3 (30%)*	0%	0%*	3 (50%)*	16%
AFUE 90 TO 92	1 (11%)	1 (10%)	8%	8%	1 (17%)	11%
AFUE->92	8 (89%)	6 (60%)	92%	92%*	2 (33%) *	64%
Gas Furnace AFUE Statistics						
Minimum	92.0	80.0	92.0	90.0	80.0	80.0
Maximum	97.5	97.0	97.5	97.5	95.5	97.5
Average	95.3*	90.7*	95.4	95.3*	87.7*	92.9
Median	95.5	95.3	95.5	95.5	87.0	95.5

*Significantly different at the 90% confidence level.

Table 5-11 and Table 5-12 show natural gas furnace and propane furnace statistics respectively. As shown, homes in GT regions are significantly less likely than homes in non-GT regions to have non-ENERGY STAR (AFUE below 90) propane furnaces and ENERGY STAR homes are significantly less likely than non-ENERGY STAR homes to have non-ENERGY STAR propane furnaces. The average AFUE of natural gas furnaces is 95.8 and the average AFUE of propane furnaces is 90.7.

Table 5-11: Natural Gas Furnace AFUE

Natural Gas Furnace AFUE	GT Regions (n=5)	Non-GT Regions (n=3)	Vermont Gas (n=8)	ENERGY STAR (n=8)	Non-ENERGY STAR (n=0)	Statewide Unweighted (n=8)
AFUE->92	100%	100%	100%	100%	n/a	100%
Natural Gas Furnace AFUE Statistics						
Minimum	95.0	95.0	95.0	95.0	n/a	95.0
Maximum	97.5	97.0	97.5	97.5	n/a	97.5
Average	95.8	95.8	95.8	95.8	n/a	95.8
Median	95.5	95.5	95.5	95.5	n/a	95.5

Table 5-12: Propane Furnace AFUE

Propane Furnace AFUE	GT Regions (n=4)	Non-GT Regions (n=7)	Vermont Gas (n=4)	ENERGY STAR (n=5)	Non-ENERGY STAR (n=6)	Statewide Unweighted (n=11)
AFUE-<90	0%*	43%*	0%	0%*	50%*	34%
AFUE 90 TO 92	25%	14%	25%	20%	17%	17%
AFUE->92	75%	43%	75%	80%	33%	50%
Propane Furnace AFUE Statistics						
Minimum	92.0	80.0	92.0	90.0	80.0	80.0
Maximum	95.5	95.5	95.5	95.5	95.5	95.5
Average	94.6*	88.5*	94.6	94.4*	87.7*	90.7
Median	95.5	90.0	95.5	95.5	87.0	95.5

*Significantly different at the 90% confidence level.

Figure 5-3 graphs the heating system AFUEs for the 89 natural gas, propane, and oil heating systems observed in inspected homes; not included on the graph are three GSHPs with coefficients of performance (COP) ranging from 2.9 to 4.2 and an electric baseboard heating system. As shown, in general, the least efficient heating systems observed are propane furnaces and the most efficient heating systems observed are natural gas furnaces and propane boilers.

Figure 5-3: Heating System Efficiencies by Type of System

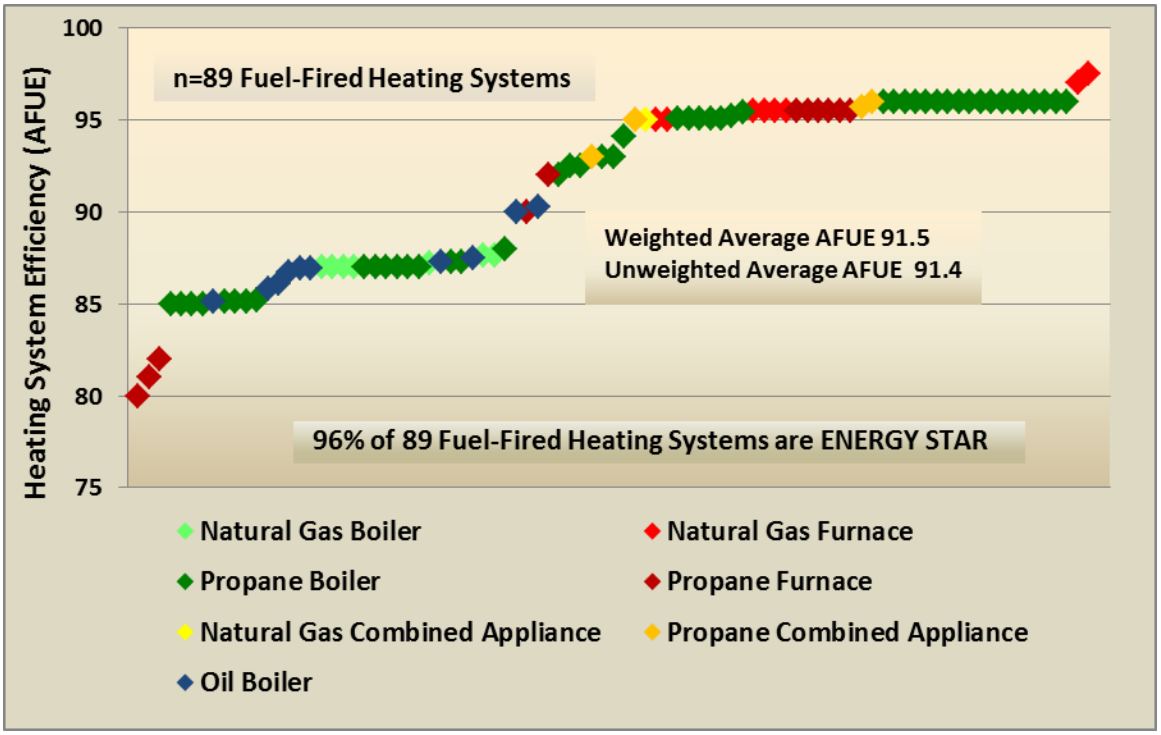


Figure 5-4 and Figure 5-5 on the following page chart heating system AFUEs for oil boilers, gas boilers and gas furnaces. Figure 5-4 separately identifies systems in GT and non-GT regions. Figure 5-5 separately identifies systems in ENERGY STAR and non-ENERGY STAR homes.

Figure 5-4: Heating System AFUE—GT Regions and Non-GT Regions

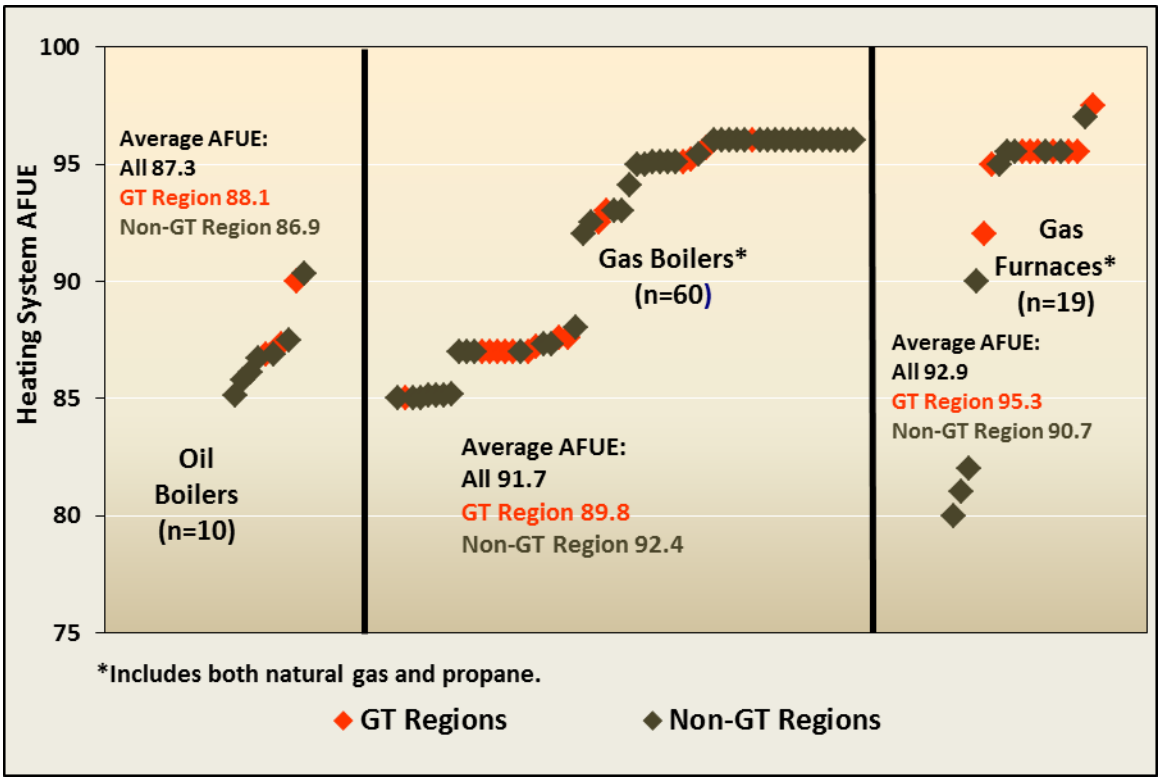
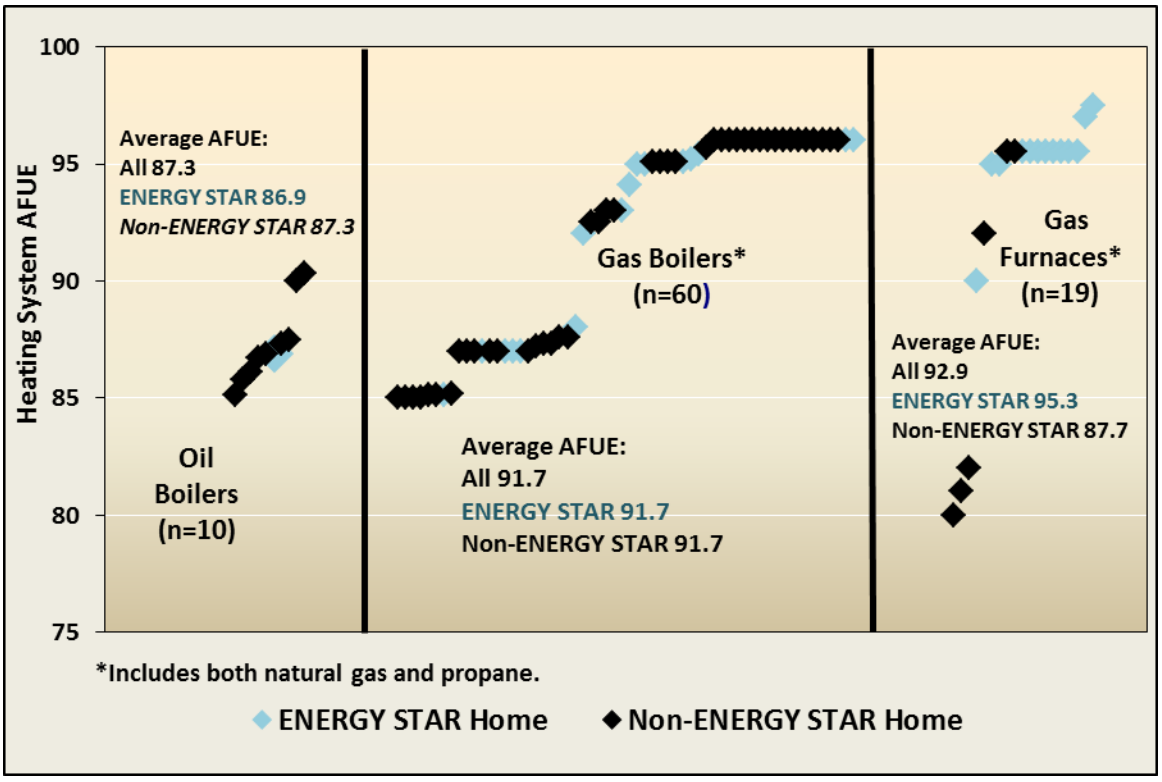


Figure 5-5: Heating System AFUE—ENERGY STAR and Non-ENERGY STAR Homes



5.3 Heating System Capacity

Table 5-13 shows heating system Btuh output per square foot of conditioned floor area for 88 homes with heating system output capacity information. Values range from 18 to 100 Btuh capacity output per square foot of conditioned floor area, the weighted average is 47, and the median is 44. The wide range of values suggests that the heating systems in many homes are oversized. The minimum, maximum, average and median values do not vary widely for homes in GT regions, homes in non-GT regions, ENERGY STAR and non-ENERGY STAR homes.

Table 5-13: Heating System Output Capacity (Btuh) per Square Foot of Conditioned Floor Area

Heating System Output Capacity (Btuh per Sq. Ft. Conditioned Floor Area)	GT Regions (n=27)	Non-GT Regions (n=61)	Vermont Gas (n=24)	ENERGY STAR (n=32)	Non-ENERGY STAR (n=56)	Statewide Weighted (n=88)
30 Btuh per Sq. Ft. or Less	19%	20%	33%	28%	14%	19%
>30 to 45	33%	34%	38%	31%	36%	34%
>45 to 65	19%	31%	13%	22%	30%	28%
>65 Btuh per Sq. Ft.	30%	15%	17%	19%	20%	18%
Heating System Output Capacity (Btuh per Sq. Ft.) Statistics*						
Minimum	19	18	19	18	18	18
Maximum	98	100	73	100	98	100
Average	**49**	**47**	**41**	**45**	**48**	**47**
Median	44	44	37	42	45	44

*Only the average is weighted.

Figure 5-6 and Figure 5-7 chart heating Btuh output per square foot of conditioned floor area for each of the 88 homes with output capacity data. Figure 5-6 separately identifies homes in GT regions and non-GT regions. Figure 5-7 separately identifies ENERGY STAR and non-ENERGY STAR homes. Figure 5-8 charts homes in Vermont Gas territory.

Figure 5-6: Heating Output Capacity per Square Foot—GT Regions and Non-GT Regions

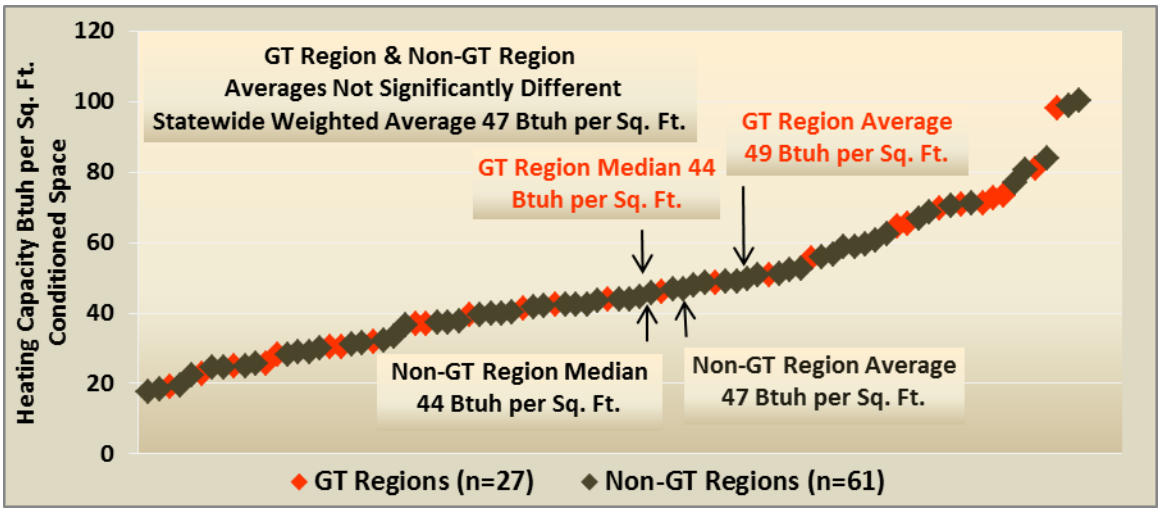


Figure 5-7: Heating Output Capacity per Square Foot—ENERGY STAR and Non-ENERGY STAR Homes

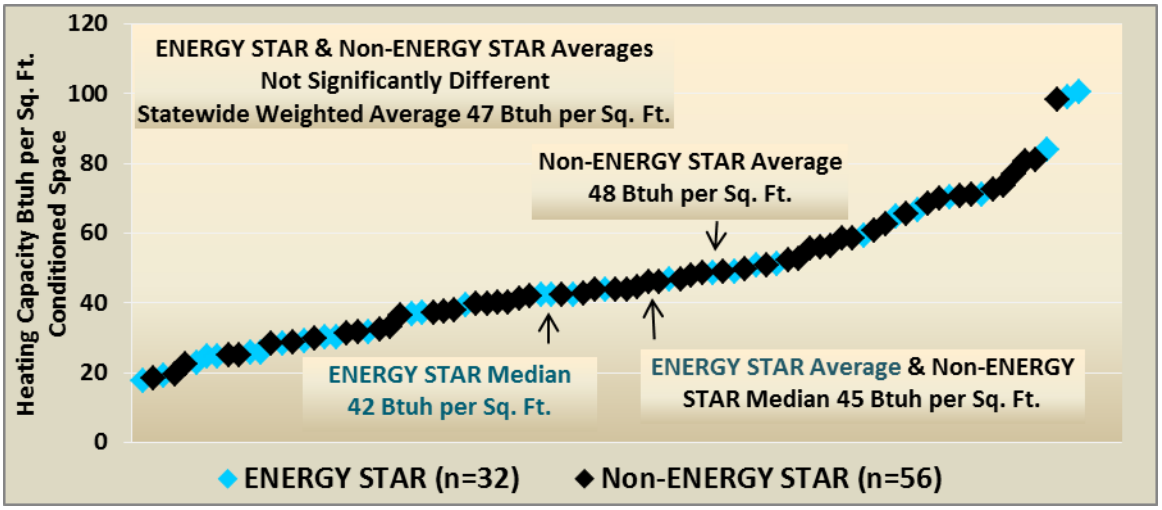
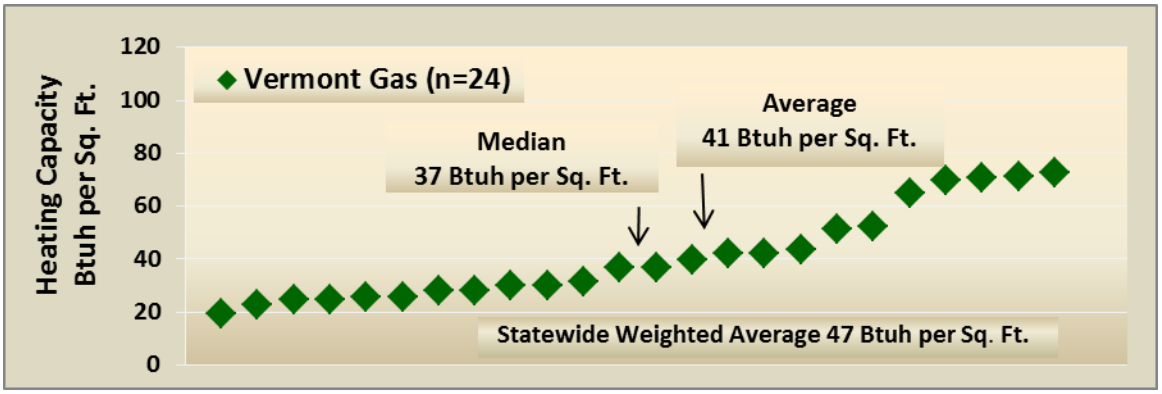


Figure 5-8: Heating Output Capacity per Square Foot—Vermont Gas Homes



5.4 Heating System Location

Table 5-14 shows that roughly three-quarters of heating systems (weighted 76%) are located in conditioned space. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have the heating system in conditioned space.

Table 5-14: Heating System Location

Location Primary Heating System	GT Regions (n=28)	Non-GT Regions (n=65)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=60)	Statewide Weighted (n=93)
Conditioned Area	71%	77%	92%	97%*	63%*	76%
Unconditioned Area	21%	20%	8%	0%*	32%*	20%
Garage	7%	3%	0%	3%	5%	4%

*Significantly different at the 90% confidence level.

5.5 Thermostats and Control Zones

Excluding homes using wood stoves for heating, homes have from one to eight thermostats and from one to eight control zones. Table 5-15 shows that 50% (weighted) of homes have one or two thermostats, 37% have three or four, and 9% have five or more. Together, Table 5-15 and Table 5-16 show homes in the GT regions compared to homes in the non-GT regions are significantly more likely to have two thermostats and control zones and significantly less likely to have three, four or five thermostats and control zones. ENERGY STAR homes, compared to non-ENERGY STAR homes are significantly more likely to have one thermostat and control zone and significantly less likely to have three or five thermostats and control zones.

Table 5-15: Number of Thermostats

Number of Thermostats	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
One	25%	17%	27%	33%*	13%*	19%
Two	57%*	23%*	54%	36%	31%	31%
Three	11%*	30%*	15%	12%*	31%*	26%
Four	4%*	13%*	4%	15%	8%	11%
Five	0%*	6%*	0%	0%*	6%*	5%
Six	4%	1%	0%	3%	2%	2%
Seven	0%	1%	0%	0%	2%	1%
Eight	0%	1%	0%	0%	2%	1%
None-Wood Stove	0%*	6%*	0%	0%*	6%*	5%

*Significantly different at the 90% confidence level.

Table 5-16: Number of Control Zones

Number of Zones	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
One	29%	17%	31%	36%*	13%	20%
Two	54%*	20%*	50%	33%	28%	28%
Three	11%*	30%*	15%	12%*	31%*	26%
Four	4%*	14%*	4%	15%	9%	12%
Five	0%*	6%*	0%	0%*	6%*	5%
Six	4%	1%	0%	3%	2%	2%
Seven	0%	1%	0%	0%	2%	1%
Eight	0%	3%	0%	0%	3%	2%
None-Wood Stove	0%*	6%*	0%	0%*	6%*	5%

*Significantly different at the 90% confidence level.

Table 5-17 shows information from the on-site audits on the type of thermostats in homes and Table 5-18 shows the use of temperature setbacks by type of thermostat. As shown, over one-half of owners (57%) say they do not change temperature settings and almost one-third (32%) lower temperature settings both at night and during the day when appropriate.

Table 5-17: Type of Thermostat

Type of Thermostat	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Programmable	43%	30%	46%	27%	38%	33%
Manual	18%	28%	12%	9%*	33%*	25%
Unknown	32%	16%	42%	61%*	0%*	19%
Electronic Non-programmable	4%*	19%*	0%	3%*	20%*	16%
Wood Stove	0%*	6%*	0%	0%*	6%*	5%
Programmable & Manual	4%	1%	0%	0%	3%	2%

*Significantly different at the 90% confidence level.

Table 5-18: Type of Thermostat and Setback Use

Type of Thermostat → Setback Use ↓	Programmable (n=35)	Manual or Electronic (n=38)	Unknown (n=20)	Wood Stove (n=4)	Statewide Unweighted (n=97)
Night and Day	63%*	3%*	40%	0%	32%
Night Only	3%	3%	5%	0%	3%
Day Only	3%	5%	5%	0%	4%
Neither Night or Day	31%*	89%	50%	0%	57%
Wood stove	0%	0%	0%	100%	4%

*Significantly different at the 90% confidence level.

5.6 Homes that Primarily Heat with Wood

Owners of four homes with an oil boiler, propane boiler, or propane furnace say that wood is their primary heating fuel. All of these homes are non-ENERGY STAR homes in non-GT regions. Even though the oil boiler and the propane boiler in these homes are not the primary heating source, Table 5-19 shows that they are ENERGY STAR-qualified 86.1 and 85.1 AFUE boilers. The two propane furnaces in these homes (AFUE 80 and 82) are not ENERGY STAR-qualified.

Table 5-19: Homes with Non-Wood Heating Systems Heating Primarily with Wood

Non-Wood Heating Source	Heating System AFUE	Wood Heating Source	GT or Non-GT Region	ENERGY STAR or Non-ENERGY STAR Home
Oil Boiler	86.1	Wood Stove	Non-GT Region	Non-ENERGY STAR
Propane Boiler	85.1	Wood Fireplaces	Non-GT Region	Non-ENERGY STAR
Propane Furnace	80.0	Wood Boiler	Non-GT Region	Non-ENERGY STAR
Propane Furnace	82.0	Wood Stove	Non-GT Region	Non-ENERGY STAR

5.7 Supplemental Heating

Over one-half of inspected homes (weighted 58%) have one or more stoves, fireplaces or portable space heaters. Table 5-20 shows weighted percentages are 40% of homes have one stove, fireplace or portable space heater, 17% have two, and 1% has five; 42% of homes do not have a stove, fireplace or portable space heater. Homes in the GT regions are significantly less likely than homes in non-GT regions to have a supplemental heat source.

Table 5-20: Number of Supplemental Heat Sources per Home

Number Fireplaces, Stoves & Heaters	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=26)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
None	**61%***	**36%***	50%	50%	38%	42%
One	39%	41%	46%	46%	42%	40%
Two	**0%***	**22%***	4%	4%	19%	17%
Five	0%	1%	0%	0%	2%	1%

*Significantly different at the 90% confidence level.

Table 5-21 shows that statewide almost one-third (32%) of homes have one or two stoves and that 79% of stoves are wood-fired stoves, 17% are propane, and 4% are pellet stoves. Homes in the GT regions are significantly more likely than homes in non-GT regions and ENERGY STAR homes more likely than non-ENERGY STAR homes to not have a stove for heating.

Table 5-21: Percentage of Homes with Stoves

Number of Stoves	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
None	96%*	61%*	100%	88%*	63%*	69%
One	4%*	30%*	0%	12%*	28%*	25%
Two	0%	9%*	0%	0%	9%*	7%
Percentage of Stoves by Type						
Type Stove	n=1 Stove	n=37 Stoves	No Stoves	n=4 Stoves	n=34 Stoves	Statewide Weighted (n=38)
Firewood	1 (100%)	73%	n/a	2 (50%)	76%	79%
Propane	0 (0%)	22%	n/a	1 (25%)	21%	17%
Pellet	0 (0%)	5%	n/a	1 (25%)	3%	4%

*Significantly different at the 90% confidence level.

Table 5-22 weighted percentages show that 29% of homes have fireplaces; 25% of homes have one fireplace, 3% of homes have two, and 1% (one home) has four fireplaces. Roughly half (49%) are wood fireplaces, 30% are propane, and 21% are natural gas fireplaces. Homes in non-GT regions compared to homes in GT regions are significantly more likely to have two fireplaces and significantly more likely to have a wood fireplace. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have a natural gas fireplace and significantly less likely to have a wood fireplace.

Table 5-22: Percentage of Homes with Fireplaces

Number of Fireplaces	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
None	64%	72%	50%	67%	72%	71%
One	36%	22%	46%	30%	23%	25%
Two	0%*	4%*	4%	3%	3%	3%
Four	0%	1%	0%	0%	2%	1%
Percentage of Fireplaces by Type						
Type Fireplace	n=10 Fireplaces	n=25 Fireplaces	n=14 Fireplaces	n=12 Fireplaces	n=23 Fireplaces	Statewide Weighted (n=35)
Natural Gas	4 (40%)	16%	57%	50%*	9%*	21%
Propane	5 (50%)	24%	36%	42%	26%	30%
Wood	1 (10%)*	60%*	7%	8%*	65%*	49%

*Significantly different at the 90% confidence level.

Only six percent (weighted) of homes (five homes) have a portable space heater; three have propane heaters and two have electric heaters (Table 5-23).

Table 5-23: Percentage of Homes with Space Heaters

Space Heaters	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
None	100%*	93%*	100%	94%	95%	94%
One	0%*	7%*	0%	6%	5%	6%

*Significantly different at the 90% confidence level.

6 Cooling

Auditors reported eight homes with central air conditioning units:

- Four homes each have one central air conditioning system; sizes range from 2.5 to 4.75 tons. In three of these homes the systems are SEER 13.0 and in one the SEER is 13.3. Two of these four homes are ENERGY STAR homes not located in a GT region, but in Vermont Gas territory; two are non-ENERGY STAR homes not located in a GT region and not in Vermont Gas territory.
- Two ENERGY STAR homes have ground source heat pumps (EERs are 16.8 and 19.0). One of these homes is located in a GT region and in Vermont Gas territory and the other is not located in a GT region and not in Vermont Gas territory
- One large home (over 8,000 square feet) has four central air conditioning systems with a total capacity of 8.5 tons—one central air conditioner (SEER 13), one air-source heat pump split system (SEER 13.3), and two ductless mini splits (SEER 16). This home is a non-ENERGY STAR home not located in a GT region and not in Vermont Gas territory.
- One home has a 1.5 ton ductless mini split system (SEER 19.2). This is a non-ENERGY STAR home not located in a GT region and not in Vermont Gas territory. The owner commented that he uses the air conditioning for about two weeks a year.

Auditors reported eight homes with room air conditioners. The sizes of the units range from 5,000 to 9960 Btuh and the EER's range from 9.7 to 11.0. The units range in age from one to five years old.

7 Water Heating

Most of the 97 inspected homes have boiler heating systems with integrated tank water heating. Figure 7-1 shows the percentage of homes by water heating fuel and Figure 7-2 the percentage of homes by type of water heating system. Figure 7-1 shows that almost two-thirds (weighted 63%) of homes use propane to heat water, 14% use natural gas, 10% use oil, 6% use electricity, and 3% use a combination of propane and solar power. There are two homes in the "other" category; one uses a combination of electricity and solar power and the other uses both propane and electricity for water heating.

Figure 7-1: Water Heating Fuel

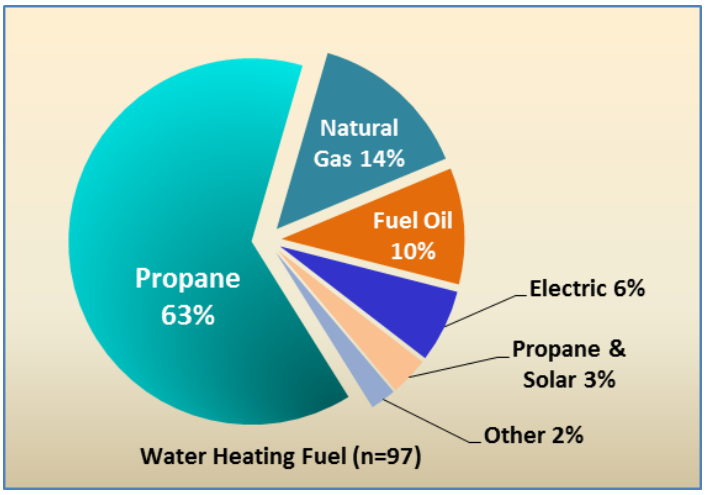


Table 7-1 shows more detailed information on the percentages of homes using different water heating fuels. As shown, homes in GT regions are significantly more likely than homes in non-GT regions to use natural gas for water heating and significantly less likely to use propane or a mix of propane and solar power. ENERGY STAR homes are much more likely than non-ENERGY STAR homes to use natural gas for water heating and significantly less likely to use oil or a mix of propane and solar power.

Table 7-1: Water Heating Fuel

Water Heating Fuel	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Propane	46%*	68%*	31%	55%	66%	63%
Natural Gas	39%*	7%*	62%	36%*	6%*	14%
Fuel Oil	11%	10%	4%	3%*	14%*	10%
Electric	4%	7%	4%	6%	6%	6%
Propane & Solar	0%*	4%*	0%	0%*	5%*	3%
Other	0%	3%	0%	0%	3%	2%

*Significantly different at the 90% confidence level.

Figure 7-2 and Table 7-2 show the percentages of homes with different types of water heating systems. As shown, over half of homes (weighted 58%) have integrated tanks, 14% have instantaneous systems, 6% have conventional electric stand-alone water heaters, 5% have natural gas conventional stand-alone water heaters, 4% have propane conventional stand-alone water heaters, 5% have a combined appliance system that provides both heat and hot water, 1% (one home) has a boiler heating system with tankless coil water heating, and three homes have solar assisted water heating systems. Two homes fall into the "other" category. Each of these homes has two water heaters; one has an instantaneous water heater and a combined appliance that provides hot water and the other has an instantaneous water heater and an integrated tank water heating system.

Figure 7-2: Types of Water Heating Systems

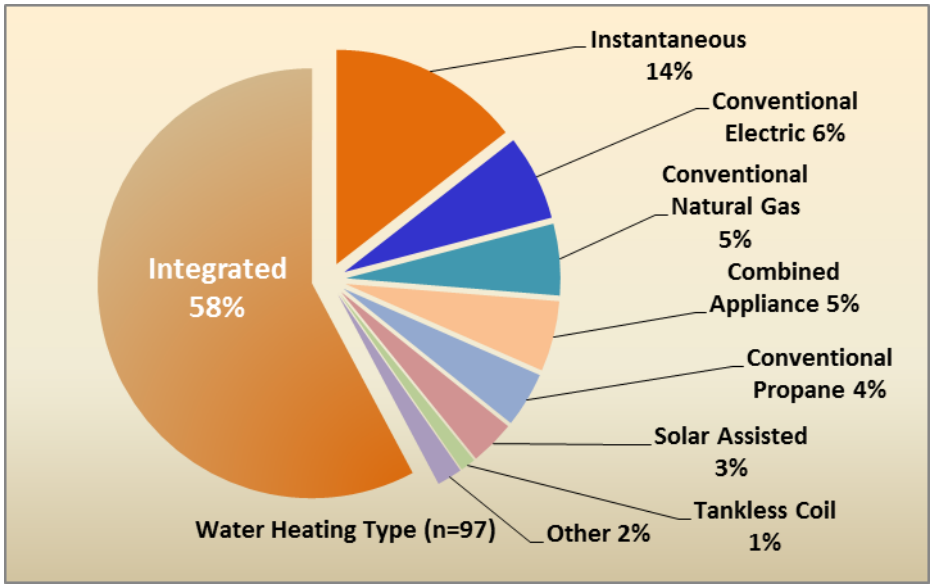


Table 7-2: Types of Water Heating Systems by Home

Water Heater Type	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Integrated	57%	58%	35%	36%*	69%*	58%
Instantaneous	14%	14%	23%	21%	11%	14%
Conventional Electric	4%	7%	4%	6%	6%	6%
Conventional Natural Gas	14%	3%	23%	18%*	0%*	5%
Combined Appliance	4%	6%	8%	12%*	2%*	5%
Conventional Propane	4%	4%	4%	6%	3%	4%
Solar Assisted	0%*	4%*	0%	0%*	5%*	3%
Tankless Coil	0%	1%	0%	0%	2%	1%
Other	4%	1%	4%	0%	3%	2%

*Significantly different at the 90% confidence level.

Homes in the GT regions, compared to homes in the non-GT regions, are significantly less likely to have a solar assisted water heating system. ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have a conventional stand-alone natural gas water heating system or a combined appliance system and are significantly less likely to have an integrated tank or solar assisted water heating system.

7.1 Boiler Heating Systems with Integrated Tank Water Heating

Overall, 92% (weighted percentage) of 64 homes with boiler heating systems have integrated tank water heating. Table 7-3 shows for all boilers, and for boilers by fuel type, the percentage that have integrated tanks for water heating. Only five of the homes with boiler heating systems do not have integrated tank water heating. Three of these homes have instantaneous water heaters, has an electric conventional stand-alone water heater, and one has integrated tankless coil water heating.

Table 7-3: Percentage of Boilers with Integrated Tank Water Heating

Boiler Category and Number of Homes	GT Regions (n=17)	Non-GT Regions (n=47)	Vermont Gas (n=10)	ENERGY STAR (n=13)	Non-ENERGY STAR (n=51)	Statewide Weighted (n=64)
All Boilers (n=64)	**17 (100%)***	**42 (89%)***	10 (100%)	12 (92%)	47 (92%)	92%
Propane Boiler (n=48)	**8 (100%)***	**36 (90%)***	3 (100%)	9 (90%)	35 (92%)	92%
Natural Gas Boiler (n=6)	6 (100%)	None	6 (100%)	2 (100%)	4 (100%)	100%
Oil Boiler (n=10)	3 (100%)	6 (86%)	1 (100%)	1 (100%)	8 (89%)	89%

*Significantly different at the 90% confidence level.

7.2 Water Heater Energy Factors

Table 7-4 on the following pages provides statistics on water heater Energy Factors by type of water heater and fuel. The Energy Factors for integrated water heaters—indirect-fired tanks integrated with a boiler heating system—are calculated as 92% of the boiler AFUE.[41] The weighted average water heater Energy Factor across all homes with Energy Factor data is 0.82 and the median Energy Factor is also 0.82. The only statistically significant differences in average Energy Factors between homes in GT regions compared to homes in non-GT areas or between ENERGY STAR and non-ENERGY STAR homes are:

- For all water heaters with Energy Factors, the average Energy Factor is significantly lower for ENERGY STAR homes than non-ENERGY STAR homes.
- For all integrated water heaters, the average Energy Factor is significantly lower in GT regions than in non-GT regions.

[41] Source: Northeast Home Energy Rating System Alliance Manual 2007, Chapter 4: NE HERS Rating Technical Guidelines. "The annual efficiency of an indirect-fired tank (insulated and set up as a separate zone off the heating boiler) is calculated as 92% of the boiler efficiency."

Table 7-4: Water Heating Energy Factors by Type of Water Heating

All Water Heaters with Energy Factor Data	GT Regions (n=29)	Non-GT Regions (n=68)	Vermont Gas (n=27)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted** (n=97)
Minimum	0.62	0.45	0.57	0.57	0.45	0.45
Maximum	0.96	0.98	0.98	0.98	0.96	0.98
Average	**0.79**	**0.83**	**0.78**	**0.79***	**0.83***	**0.82**
Median	0.80	0.85	0.80	0.80	0.83	0.82
Integrated Water Heaters						
All Integrated Water Heater Energy Factors	**GT Regions (n=17)**	**Non-GT Regions (n=42)**	**Vermont Gas (n=10)**	**ENERGY STAR (n=12)**	**Non-ENERGY STAR (n=47)**	**Statewide Weighted** (n=59)**
Minimum	0.78	0.78	0.80	0.78	0.78	0.78
Maximum	0.88	0.88	0.88	0.88	0.88	0.88
Average	**0.82***	**0.84***	**0.82**	**0.83**	**0.84**	**0.84**
Median	0.80	0.87	0.80	0.83	0.85	0.85
Natural Gas Integrated Water Heater Energy Factors	**GT Regions (n=5)**	**Non-GT Regions (n=0)**	**Vermont Gas (n=5)**	**ENERGY STAR (n=2)**	**Non-ENERGY STAR (n=3)**	**Statewide Unweighted (n=5)**
Minimum	0.80	n/a	0.80	0.80	0.80	0.80
Maximum	0.81	n/a	0.81	0.80	0.81	0.81
Average	**0.80**	**n/a**	**0.80**	**0.80**	**0.80**	**0.80**
Median	0.80	n/a	0.80	0.80	0.81	0.80
Propane Integrated Water Heater Energy Factors	**GT Regions (n=9)**	**Non-GT Regions (n=36)**	**Vermont Gas (n=4)**	**ENERGY STAR (n=9)**	**Non-ENERGY STAR (n=36)**	**Statewide Unweighted (n=45)**
Minimum	0.78	0.78	0.80	0.78	0.78	0.78
Maximum	0.88	0.88	0.88	0.88	0.88	0.88
Average	**0.83**	**0.85**	**0.84**	**0.84**	**0.85**	**0.85**
Median	0.85	0.87	0.84	0.86	0.87	0.87
Oil Integrated Water Heater Energy Factors	**GT Regions (n=3)**	**Non-GT Regions (n=6)**	**Vermont Gas (n=1)**	**ENERGY STAR (n=1)**	**Non-ENERGY STAR (n=8)**	**Statewide Unweighted (n=9)**
Minimum	0.80	0.79	0.80	0.79	0.79	0.79
Maximum	0.83	0.83	0.80	0.79	0.83	0.83
Average	**0.81**	**0.80**	**0.80**	**0.79**	**0.81**	**0.80**
Median	0.80	0.79	0.80	0.79	0.80	0.80

Instantaneous Water Heaters						
All Instantaneous Water Heater Energy Factors	**GT Regions (n=4)**	**Non-GT Regions (n=11)**	**Vermont Gas (n=6)**	**ENERGY STAR (n=7)**	**Non-ENERGY STAR (n=8)**	**Statewide Unweighted (n=15)**
Min	0.81	0.82	0.81	0.81	0.82	0.81
Max	0.95	0.98	0.98	0.98	0.95	0.98
Average	**0.85**	**0.87**	**0.89**	**0.88**	**0.85**	**0.86**
Median	0.82	0.82	0.89	0.82	0.82	0.82
Natural Gas Instantaneous Water Heater Energy Factors	**GT Regions (n=1)**	**Non-GT Regions (n=2)**	**Vermont Gas (n=3)**	**ENERGY STAR (n=3)**	**Non-ENERGY STAR (n=0)**	**Statewide Unweighted (n=3)**
Minimum	0.81	0.95	0.81	0.81	n/a	0.81
Maximum	0.81	0.98	0.98	0.98	n/a	0.98
Average	**0.81**	**0.97**	**0.91**	**0.91**	**n/a**	**0.91**
Median	0.81	0.97	0.95	0.95	n/a	0.95
Propane Instantaneous Water Heater Energy Factors	**GT Regions (n=3)**	**Non-GT Regions (n=9)**	**Vermont Gas (n=3)**	**ENERGY STAR (n=4)**	**Non-ENERGY STAR (n=8)**	**Statewide Unweighted (n=12)**
Minimum	0.81	0.82	0.81	0.81	0.82	0.81
Maximum	0.95	0.95	0.95	0.95	0.95	0.95
Average	**0.86**	**0.85**	**0.86**	**0.85**	**0.85**	**0.85**
Median	0.82	0.82	0.82	0.82	0.82	0.82
Fossil Fuel Conventional Stand Alone Water Heaters						
All Conventional Fossil Fuel Water Heater Energy Factors	**GT Regions (n=6)**	**Non-GT Regions (n=5)**	**Vermont Gas (n=8)**	**ENERGY STAR (n=8)**	**Non-ENERGY STAR (n=3)**	**Statewide Unweighted (n=11)**
Min	0.62	0.57	0.57	0.57	0.58	0.57
Max	0.63	0.66	0.63	0.66	0.63	0.66
Average	**0.65**	**0.61**	**0.62**	**0.62**	**0.61**	**0.62**
Median	0.63	0.62	0.63	0.63	0.63	0.63
Natural Gas Conventional Water Heater Energy Factors	**GT Regions (n=5)**	**Non-GT Regions (n=2)**	**Vermont Gas (n=7)**	**ENERGY STAR (n=6)**	**Non-ENERGY STAR (n=1)**	**Statewide Unweighted (n=7)**
Minimum	0.62	0.57	0.57	0.57	0.63	0.57
Maximum	0.63	0.62	0.63	0.63	0.63	0.63
Average	**0.63**	**0.60**	**0.62**	**0.62**	**0.63**	**0.62**
Median	0.63	0.60	0.63	0.63	0.63	0.63
Propane Conventional Water Heater Energy Factors	**GT Regions (n=1)**	**Non-GT Regions (n=3)**	**Vermont Gas (n=1)**	**ENERGY STAR (n=2)**	**Non-ENERGY STAR (n=2)**	**Statewide Unweighted (n=4)**
Minimum	0.63	0.58	0.63	0.63	0.58	0.58
Maximum	0.63	0.66	0.63	0.66	0.63	0.66
Average	**0.63**	**0.62**	**0.63**	**0.65**	**0.61**	**0.63**
Median	0.63	0.63	0.63	0.65	0.61	0.63

Electric Conventional Stand Alone Water Heaters						
Electric Conventional Water Heater Energy Factors	**GT Regions (n=1)**	**Non-GT Regions (n=5)**	**Vermont Gas (n=1)**	**ENERGY STAR (n=2)**	**Non-ENERGY STAR (n=4)**	**Statewide Unweighted (n=6)**
Min	0.88	0.90	0.88	0.88	0.90	0.88
Max	0.88	0.92	0.88	0.92	0.92	0.92
Average	**0.88**	**0.91**	**0.88**	**0.90**	**0.91**	**0.91**
Median	0.88	0.92	0.88	0.90	0.92	0.92
Combined Appliance Water Heaters						
All Combined Appliance Water Heating Energy Factors	**GT Regions (n=1)**	**Non-GT Regions (n=4)**	**Vermont Gas (n=2)**	**ENERGY STAR (n=4)**	**Non-ENERGY STAR (n=2)**	**Statewide Unweighted (n=5)**
Min	0.96	0.75	0.75	0.75	0.75	0.75
Max	0.96	0.89	0.89	0.89	0.96	0.96
Average	**0.96**	**0.79**	**0.82**	**0.79**	**0.85**	**0.82**
Median	0.96	0.75	0.82	0.75	0.85	0.75
Natural Gas Combined Appliance Water Heating Energy Factors	**GT Regions (n=0)**	**Non-GT Regions (n=1)**	**Vermont Gas (n=1)**	**ENERGY STAR (n=1)**	**Non-ENERGY STAR (n=0)**	**Statewide Unweighted (n=1)**
Minimum	n/a	0.75	0.75	0.75	n/a	0.75
Maximum	n/a	0.75	0.75	0.75	n/a	0.75
Average	**n/a**	**0.75**	**0.75**	**0.75**	**n/a**	**0.75**
Median	n/a	0.75	0.75	0.75	n/a	0.75
Propane Combined Appliance Water Heating Energy Factors	**GT Regions (n=1)**	**Non-GT Regions (n=3)**	**Vermont Gas (n=1)**	**ENERGY STAR (n=3)**	**Non-ENERGY STAR (n=1)**	**Statewide Unweighted (n=4)**
Minimum	0.96	0.75	0.89	0.75	0.96	0.75
Maximum	0.96	0.89	0.89	0.89	0.96	0.96
Average	**0.96**	**0.80**	**0.89**	**0.80**	**0.96**	**0.84**
Median	0.96	0.75	0.89	0.75	0.96	0.82
Tankless Coil Water Heater						
Tankless Coil Water Heater Energy Factor	**GT Regions (n=0)**	**Non-GT Regions (n=1)**	**Vermont Gas (n=0)**	**ENERGY STAR (n=0)**	**Non-ENERGY STAR (n=1)**	**Statewide Unweighted (n=1)**
Min	n/a	0.45	n/a	n/a	0.45	0.45
Max	n/a	0.45	n/a	n/a	0.45	0.45
Average	n/a	**0.45**	n/a	n/a	**0.45**	**0.45**
Median	n/a	0.45	n/a	n/a	0.45	0.45

* Significantly different at the 90% confidence level.
**Only the average is weighted.

7.3 Water Heater Tank Size

Table 7-5 and Table 7-6 show that conventional tanks tend to be larger than integrated tanks. The weighted average integrated tank size is 50 gallons and the median is 50 gallons. The average conventional tank size is 55 gallons and the median is 50 gallons. Integrated tanks in the GT regions are significantly more likely to be 40 gallons or less than in the non-GT regions. Also, the average tank size is significantly lower in GT regions than in non-GT regions. ENERGY STAR homes are significantly less likely to have over 75 gallon integrated tanks than non-ENERGY STAR homes.

Table 7-5: Water Heating Tank Size—Integrated Tanks

Integrated Tank Size	GT Regions (n=17)	Non-GT Regions (n=42)	Vermont Gas (n=10)	ENERGY STAR (n=12)	Non-ENERGY STAR (n=47)	Statewide Weighted (n=59)
40 Gallons or Less	53%	29%	4 (40%)	50%	32%	34%
41 to 50 Gallons	24%	43%	2 (20%)	42%	36%	39%
51 to 60 Gallons	18%	7%	2 (20%)	8%	11%	9%
Over 75 Gallons	6%	19%	1 (10%)	0%	19%	16%
Unknown	0%	2%	1 (10%)	0%	2%	2%
Integrated Tank Size Statistics**						
Min	32	30	32	32	30	30
Max	80	80	80	60	80	80
Average	45*	51*	49	45*	51*	50
Median	40	50	50	45	50	50

*Significantly different at the 90% confidence level.
**Only the average is weighted.

ENERGY STAR homes are significantly less likely than non-ENERGY STAR homes to have 40 gallon or smaller conventional water heating tanks and the average size of conventional tanks in ENERGY STAR homes is significantly larger than in non-ENERGY STAR homes.

Table 7-6: Water Heating Tank Size—Conventional Stand-Alone System Tanks

Conventional Tank Size	GT Regions (n=8)	Non-GT Regions (n=12)	Vermont Gas (n=10)	ENERGY STAR (n=10)	Non-ENERGY STAR (n=10)	Statewide Unweighted (n=20)
40 Gallons or Less	1 (13%)	3 (25%)	1 (10%)	0 (0%)*	4 (40%)*	20%
41 to 50 Gallons	5 (63%)	6 (50%)	6 (60%)	6 (60%)	5 (50%)	55%
51 to 60 Gallons	1 (13%)	0 (0%)	1 (10%)	0 (0%)	1 (10%)	5%
61 to 75 Gallons	0 (0%)	2 (17%)	1 (10%)	2 (20%)	0 (0%)	10%
Over 75 Gallons	1 (13%)	1 (8%)	1 (10%)	2 (20%)	0 (0%)	10%
Conventional Tank Size Statistics						
Min	40	40	40	50	40	40
Max	115	80	115	115	60	115
Average	58	53	59	64*	47*	55
Median	50	50	50	50	48	50

*Significantly different at the 90% confidence level.

7.4 Water Heater Location

Over three-quarters of water heaters are located in conditioned areas (weighted 79%). Table 7-7 shows ENERGY STAR homes are significantly more likely than non-ENERGY STAR homes to have water heaters in conditioned space and significantly less likely to have water heaters in unconditioned areas or garages.

Table 7-7: Water Heater Location

Water Heater Location	GT Regions (n=29)	Non-GT Regions (n=73)	Vermont Gas (n=27)	ENERGY STAR (n=27)	Non-ENERGY STAR (n=69)	Statewide Weighted (n=102)
Conditioned Area	76%	79%	93%	93%*	68%*	79%
Unconditioned Area	21%	18%	7%	7%*	28%*	18%
Garage	3%	3%	0%	0%*	4%*	3%

*Significantly different at the 90% confidence level.

8 Renewables

Auditors collected data on renewable energy during the onsite visits. Three homes, all non-ENERGY STAR homes, have photovoltaic (PV) arrays ranging from 1.84 to 5 kW that are used for on-site power generation. No homes had alternative forms of on-site power generation. Information on renewable energy used for heating and domestic hot water heating can be found in the heating, and domestic hot water heating sections of this report.

9 Appliances

9.1 Appliance Saturations

All of the homes visited have at least one refrigerator and a range with an oven.[42] Over nine in ten homes also have a clothes washer and clothes dryer; homes in GT regions are more likely to have a dishwasher than homes in the rest of the state (96% vs. 84%). About one in five homes has a separate freezer (21%) and fewer than one in five homes (12%) has a second working refrigerator, where only one in ten has a dehumidifier (10%) (Table 9-1).

Table 9-1: Appliance Saturations

Appliances in Homes	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Primary Refrigerator	100%	100%	100%	100%	100%	100%
Clothes Washer	96%	97%	96%	97%	97%	97%
Clothes Dryer	96%	94%	96%	97%	94%	95%
Dishwasher	96%*	84%*	100%	97%*	83%*	87%
Separate Freezer	14%	23%	8%	15%	23%	21%
Second Refrigerator	14%	12%	12%	12%	13%	12%
Dehumidifiers	11%	10%	12%	15%	8%	10%

*Significantly different at the 90% confidence level.

[42] One of the homes visited was still incomplete with few appliances and little lighting installed.

ENERGY STAR Appliances: Dishwashers are most likely to be ENERGY STAR labeled (66%), followed by refrigerators (62%) and clothes washers (59%) then separate freezers (5%). (Table 9-2) Primary refrigerators are much more likely to be ENERGY STAR labeled (62%) than are secondary refrigerators (2%). Homes in GT regions are significantly more likely to have an ENERGY STAR model refrigerator than homes in non-GT regions (75% vs. 58%). Model numbers were recorded for most appliances during the on-site visits; the ENERGY STAR status of these models was checked at the ENERGY STAR website and with the manufacturer when necessary.[43]

Table 9-2: ENERGY STAR Appliances

ENEGY STAR Appliances	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
ENERGY STAR Dishwashers	19 (68%)	45 (65%)	19 (73%)	25 (76%)	39 (61%)	66%
Don't know	2 (7%)*	14 (20%)*	1 (4%)	3 (9%)	13 (20%)	17%
ENERGY STAR Primary Refrigerators	21 (75%)*	40 (58%)*	20 (77%)	23 (70%)	38 (59%)	62%
Don't know	0 (0%)	2 (3%)	0 (0%)	1 (3%)	1 (2%)	2%
ENERGY STAR Secondary Refrigerators	1 (4%)	1 (1%)	1 (4%)	1 (3%)	1 (2%)	2%
Don't know	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%
ENERGY STAR Clothes Washers	16 (59%)	39 (59%)	16 (64%)	20 (63%)	35 (57%)	59%
Don't know	2 (7%)	3 (5%)	1 (4%)	1 (3%)	4 (7%)	5%
ENERGY STAR Separate Freezers	0 (0%)	1 (6%)	0 (0%)	0 (0%)	1 (7%)	5%
Don't know	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%

*Significantly different at the 90% confidence level.

[43] ENERGY STAR website: http://www.energystar.gov/index.cfm?c=appliances.pr_appliances,

9.2 Appliance Characteristics

This section focuses on individual appliance characteristics. The number of appliances listed in each table refers to the number with available data.

Refrigerators: As might be expected in new homes, nearly all refrigerators are rated as being in good condition and less than five years old (Table 9-3).

Table 9-3: Refrigerator Condition

Primary Refrigerator Condition	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Good	100%	99%	100%	100%	98%	99%
Fair	0%	1%	0%	0%	2%	1%
Secondary Refrigerator Condition	**GT Regions (n=4)**	**Non-GT Regions (n=8)**	**Vermont Gas (n=3)**	**ENERGY STAR (n=4)**	**Non-ENERGY STAR (n=8)**	**Statewide Unweighted (n=12)**
Good	3 (75%)	7 (88%)	3 (100%)	3 (75%)	7 (88%)	83%
Fair	1 (25%)	1 (13%)	0 (0%)	1 (25%)	1 (13%)	17%

Ninety percent of primary refrigerators are less than five years old while 25% of second refrigerators are less than five years old (Table 9-4). There is a significant difference in the age of primary refrigerators in ENERGY STAR homes, where 97% are less than five years old as opposed to 88% in non-ENERGY STAR homes.

Table 9-4: Age of Refrigerators

Primary Refrigerator Age	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
4 years or less	96%	88%	100%	97%*	88%*	90%
5 to 9 years	0%	3%	0%	3%	2%	2%
10 to 14 years	0%	3%	0%	0%	3%	2%
15 to 19 years	0%	1%	0%	0%	2%	1%
20 years or more	0%	0%	0%	0%	0%	0%
Don't know	4%	4%	0%	0%*	6%*	4%
Secondary Refrigerator Age	**GT Regions (n=4)**	**Non-GT Regions (n=8)**	**Vermont Gas (n=3)**	**ENERGY STAR (n=4)**	**Non-ENERGY STAR (n=8)**	**Statewide Unweighted (n=12)**
4 years or less	1 (25%)	2 (25%)	1 (33%)	1 (25%)	2 (25%)	25%
5 to 9 years	0 (0%)	2 (25%)	1 (33%)	1 (25%)	1 (13%)	17%
10 to 14 years	2 (50%)	2 (25%)	1 (33%)	2 (50%)	2 (25%)	33%
15 to 19 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%
20 years or more	1 (25%)	1 (13%)	0 (0%)	0 (0%)	2 (25%)	17%
Don't know	0 (0%)	1 (13%)	0 (0%)	0 (0%)	1 (13%)	8%

*Significantly different at the 90% confidence level.

Almost three out of four primary refrigerators are over 20 cubic feet (73%). (Table 9-5) Secondary refrigerators tend to be smaller with almost half of them (42%) 15 cubic feet or less.

Table 9-5: Refrigerator Size

Primary Refrigerator Size	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
15 cubic feet or less	0%	1%	0%	0%	2%	1%
16 to 19 cubic feet	18%	16%	15%	21%	14%	16%
20 to 24 cubic feet	36%	36%	35%	36%	36%	36%
over 24 cubic feet	43%	35%	42%	33%	39%	37%
Don't know	4%	12%	8%	9%	9%	10%
Secondary Refrigerator Size	**GT Regions (n=4)**	**Non-GT Regions (n=8)**	**Vermont Gas (n=3)**	**ENERGY STAR (n=4)**	**Non-ENERGY STAR (n=8)**	**Statewide Unweighted (n=12)**
15 cubic feet or less	1 (25%)	4 (50%)	1 (33%)	1 (25%)	3 (38%)	42%
16 to 19 cubic feet	1 (25%)	2 (25%)	1 (33%)	2 (50%)	2 (25%)	25%
20 to 24 cubic feet	1 (25%)	0 (0%)	0 (0%)	0 (0%)	1 (13%)	8%
over 24 cubic feet	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%
Don't know	1 (25%)	2 (25%)	1 (33%)	1 (25%)	2 (25%)	25%

Bottom freezer models are the most common primary refrigerator in new homes, accounting for almost half of the refrigerators (45%). (Table 9-6) Secondary refrigerators tend to be top freezer models accounting for 50% of them. The non-GT regions had significantly more (38%) single door models of secondary refrigerator than GT regions (0%).

Table 9-6: Refrigerator Type

Primary Refrigerator Type	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Bottom freezer	39%	46%	38%	42%	45%	45%
Side by side	43%	32%	42%	33%	36%	34%
Top freezer	18%	22%	19%	24%	19%	21%
Secondary Refrigerator Type	**GT Regions (n=4)**	**Non-GT Regions (n=8)**	**Vermont Gas (n=3)**	**ENERGY STAR (n=4)**	**Non-ENERGY STAR (n=8)**	**Statewide Unweighted (n=12)**
Top freezer	3 (75%)	3 (38%)	2 (67%)	2 (50%)	4 (50%)	50%
Single Door	**0 (0%)***	**3 (38%)***	1 (33%)	1 (25%)	2 (25%)	25%
Side by side	1 (25%)	2 (25%)	0 (0%)	1 (25%)	2 (25%)	25%

*Significantly different at the 90% confidence level.

Separate Freezers: More than four out of five separate freezers in new homes are in good condition (86%). (Table 9-7) However, separate freezers in non-GT regions and non-ENERGY STAR homes have a significant number which tend to be in fair condition.

Table 9-7: Separate Freezer Condition

Freezer Condition	GT Regions (n=4)	Non-GT Regions (n=17)	Vermont Gas (n=3)	ENERGY STAR (n=6)	Non-ENERGY STAR (n=15)	Statewide Unweighted (n=21)
Good	4 (100%)*	14 (82%)*	3 (100%)	6 (100%)*	12 (80%)*	86%
Fair	0 (0%)*	3 (18%)*	0 (0%)	0 (0%)*	3 (20%)*	14%

*Significantly different at the 90% confidence level.

Separate freezers are older than most appliances in new homes; one-fifth of separate freezers are at least 15 years old (20%). (Table 9-8)

Table 9-8: Age of Separate Freezers

Freezer Age	GT Regions (n=4)	Non-GT Regions (n=17)	Vermont Gas (n=3)	ENERGY STAR (n=6)	Non-ENERGY STAR (n=15)	Statewide Unweighted (n=21)
4 years or less	1 (25%)	3 (18%)	1 (33%)	1 (17%)	3 (20%)	19%
5 to 9 years	2 (50%)	4 (24%)	1 (33%)	3 (50%)	3 (20%)	29%
10 to 14 years	1 (25%)	3 (18%)	1 (33%)	1 (17%)	3 (20%)	19%
15 to 19 years	0 (0%)	2 (12%)	0 (0%)	1 (17%)	1 (7%)	10%
20 years or more	0 (0%)	2 (12%)	0 (0%)	0 (0%)	2 (13%)	10%
Don't know	0 (0%)*	3 (18%)*	0 (0%)	0 (0%)*	3 (20%)*	14%

*Significantly different at the 90% confidence level.

More than half (56%) of separate freezers in new homes are 10 or more cubic feet in size (Table 9-9). Non-ENERGY STAR homes had significantly more separate freezers over 15 cubic feet than the ENERGY STAR homes.

Table 9-9: Separate Freezer Size

Freezer Size	GT Regions (n=4)	Non-GT Regions (n=12)	Vermont Gas (n=2)	ENERGY STAR (n=5)	Non-ENERGY STAR (n=11)	Statewide Unweighted (n=16)
4 to 6 cubic feet	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%
7 to 9 cubic feet	1 (25%)	3 (25%)	1 (50%)	2 (40%)	2 (18%)	25%
10 to 14 cubic feet	2 (50%)	2 (17%)	0 (0%)	2 (40%)	2 (18%)	25%
15 cubic feet or more	1 (25%)	4 (33%)	1 (50%)	0 (0%)*	5 (45%)*	31%
Don't know	0 (0%)*	3 (25%)*	0 (0%)	1 (20%)	2 (18%)	19%

*Significantly different at the 90% confidence level.

Almost two-thirds (60%) of separate freezers are upright models (Table 9-10).

Table 9-10: Separate Freezer Models

Freezer Type	GT Regions (n=4)	Non-GT Regions (n=16)	Vermont Gas (n=2)	ENERGY STAR (n=5)	Non-ENERGY STAR (n=15)	Statewide Weighted (n=20)
Upright	3 (75%)	9 (56%)	1 (50%)	2 (40%)	10 (67%)	60%
Chest	1 (25%)	7 (44%)	1 (50%)	3 (60%)	5 (33%)	40%

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Clothes Washers: The overwhelming majority of clothes washers (95%) in new homes are in good condition. (Table 9-11)

Table 9-11: Clothes Washer Condition

Clothes Washer Condition	GT Regions (n=27)	Non-GT Regions (n=67)	Vermont Gas (n=25)	ENERGY STAR (n=32)	Non-ENERGY STAR (n=62)	Statewide Weighted (n=94)
Good	96%	94%	96%	94%	95%	95%
Fair	4%	6%	4%	6%	5%	5%

The overwhelming majority of clothes washers (91%) in new homes are also less than ten years old (Table 9-12).

Table 9-12: Age of Clothes Washers

Clothes Washer Age	GT Regions (n=27)	Non-GT Regions (n=67)	Vermont Gas (n=16)	ENERGY STAR (n=32)	Non-ENERGY STAR (n=62)	Statewide Weighted (n=94)
4 years or less	85%	81%	81%	88%	79%	82%
5 to 9 years	7%	9%	13%	9%	8%	9%
10 to 14 years	0%	1%	0%	0%	2%	1%
15 years or more	4%	6%	6%	3%	6%	5%
Don't know	4%	3%	0%	0%*	5%*	3%

*Significantly different at the 90% confidence level.

Almost three out of four clothes washers in new homes are front-loading (Table 9-13). Non-ENERGY star homes are more likely to have top-loading clothes washers as opposed to front-loading ones.

Table 9-13: Clothes Washer Type

Clothes Washer Type	GT Regions (n=27)	Non-GT Regions (n=67)	Vermont Gas (n=25)	ENERGY STAR (n=32)	Non-ENERGY STAR (n=62)	Statewide Weighted (n=94)
Top Load	22%	28%	16%	16%*	32%*	27%
Front Load	78%	72%	84%	84%*	68%*	73%

*Significantly different at the 90% confidence level.

Clothes Dryers: Again, the overwhelming majority of clothes dryers (92%) in new homes are in good condition (Table 9-14).

Table 9-14: Clothes Dryer Condition

Clothes Dryer Condition	GT Regions (n=27)	Non-GT Regions (n=65)	Vermont Gas (n=25)	ENERGY STAR (n=32)	Non-ENERGY STAR (n=60)	Statewide Weighted (n=92)
Good	93%	92%	96%	94%	92%	92%
Fair	7%	8%	4%	6%	8%	8%

Close to nine out of ten (89%) clothes dryers in new homes are under ten years old (Table 9-15).

Table 9-15: Age of Clothes Dryer

Clothes Dryer Age	GT Regions (n=27)	Non-GT Regions (n=65)	Vermont Gas (n=25)	ENERGY STAR (n=32)	Non-ENERGY STAR (n=60)	Statewide Weighted (n=92)
4 years or less	81%	75%	88%	84%	73%	77%
5 to 9 years	4%*	14%*	0%	6%	13%	12%
10 to 14 years	4%	2%	8%	3%	2%	2%
15 years or more	7%	5%	4%	3%	7%	5%
Don't know	4%	5%	0%	3%	5%	4%

*Significantly different at the 90% confidence level.

Almost three out of four clothes dryers use electricity (Table 9-16). Non-ENERGY STAR homes own significantly more electric clothes dryers (80%) than ENERGY STAR homes (56%). These homes own a significant number of natural gas dryers instead (19%).

Table 9-16: Clothes Dryer Fuel

Clothes Dryer Fuel	GT Regions (n=27)	Non-GT Regions (n=65)	Vermont Gas (n=25)	ENERGY STAR (n=32)	Non-ENERGY STAR (n=60)	Statewide Weighted (n=92)
Electricity	74%	71%	60%	56%*	80%*	71%
Propane	11%	23%	16%	25%	17%	20%
Natural Gas	15%	3%	24%	19%*	0%*	6%
Don't know	0%	3%	0%	0%	3%	2%

*Significantly different at the 90% confidence level.

Dishwashers: All dishwashers in the new homes visited are in good condition and under five years old.

Ranges and Ovens: Almost all ranges in the new homes visited are in good condition and less than five years old (Table 9-17 and Table 9-18). Non-ENERGY STAR ranges tend to be slightly older with 4% of those found to be five years or older.

Table 9-17: Range Condition

Range Condition	GT Regions (n=28)	Non-GT Regions (n=68)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=63)	Statewide Weighted (n=96)
Good	100%	99%	100%	100%	98%	99%
Fair	0%	1%	0%	0%	2%	1%

Table 9-18: Range Age

Range Age	GT Regions (n=28)	Non-GT Regions (n=67)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=62)	Statewide Weighted (n=95)
4 years or less	96%	94%	100%	100%*	92%*	95%
5 to 9 years	0%	1%	0%	0%	2%	1%
10 to 14 years	0%	0%	0%	0%	0%	0%
15 years or more	0%	1%	0%	0%	2%	1%
Don't know	4%	3%	0%	0%*	5%*	3%

*Significantly different at the 90% confidence level.

More than half of ranges use propane (53%) with a smaller number using electricity (29%) or natural gas (14%). Ranges in ENERGY STAR homes are more likely to use natural gas or propane as opposed to electricity; however, this may be influenced by the availability of natural gas service (Table 9-19).

Table 9-19: Range Fuel

Range Fuel	GT Regions (n=28)	Non-GT Regions (n=68)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=63)	Statewide Weighted (n=96)
Propane	29%*	60%*	23%	48%	52%	53%
Electricity	39%	26%	31%	15%*	38%*	29%
Natural Gas	25%	10%	42%	30%*	6%*	14%
Don't know	7%	3%	4%	6%	3%	4%

*Significantly different at the 90% confidence level.

Auditors observed a standalone oven (either separate from the range, or in addition to a combination range/oven) in seven homes. Most of these standalone ovens (five out of seven) use electricity (Table 9-20). None of the GT homes contains a standalone oven unit.

Table 9-20: Oven Fuel

Oven Fuel	GT Regions (n=0)	Non-GT Regions (n=7)	Vermont Gas (n=1)	ENERGY STAR (n=3)	Non-ENERGY STAR (n=4)	Statewide Unweighted (n=7)
Electricity	0(0%)	5 (71%)	0 (0%)	2 (67%)	3 (75%)	71%
Propane	0(0%)	1 (14%)	0 (0%)	0 (0%)	1 (25%)	14%
Natural Gas	0(0%)	1 (14%)	1 (100%)	1 (33%)	0 (0%)	14%

Dehumidifiers: Ninety percent of dehumidifiers statewide are rated as being in good condition (Table 9-21).

Table 9-21: Dehumidifier Condition

Dehumidifier Condition	GT Regions (n=3)	Non-GT Regions (n=7)	Vermont Gas (n=3)	ENERGY STAR (n=5)	Non-ENERGY STAR (n=5)	Statewide Unweighted (n=10)
Good	3 (100%)	6 (86%)	3 (100%)	4 (80%)	5 (100%)	90%
Fair	0 (0%)	1 (14%)	0 (0%)	1 (20%)	0 (0%)	10%

Four out of five (80%) dehumidifiers are four years old or less (Table 9-22).

Table 9-22: Dehumidifier Age

Dehumidifier Age	GT Regions (n=3)	Non-GT Regions (n=7)	Vermont Gas (n=3)	ENERGY STAR (n=5)	Non-ENERGY STAR (n=5)	Statewide Unweighted (n=10)
4 years or less	2 (67%)	6 (86%)	3 (100%)	4 (80%)	4 (80%)	80%
5 to 9 years	1 (33%)	0 (0%)	0 (0%)	0 (0%)	1 (20%)	10%
10 to 14 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%
15 to 19 years	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%
20 years or more	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0%
Don't know	0 (0%)	1 (14%)	0 (0%)	1 (20%)	0 (0%)	10%

Televisions and Peripherals: More than 90% of homes have at least one TV set and 61% have at least two (Table 9-23).

Table 9-23: TV Set Saturation

TV Saturation	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
None	4%	10%	4%	6%	9%	9%
One	36%	29%	38%	30%	31%	30%
Two	32%	33%	35%	33%	33%	33%
Three or more	29%	28%	23%	30%	27%	28%

About one in five (19%) TVs are cathode ray tube (CRT) models and more than half (54%) are LCD (Table 9-24). Non-GT regions and non-ENERGY STAR homes have significantly more projection TVs than their counterparts.

Table 9-24: TV Set Type

TV Type	GT Regions (n=56)	Non-GT Regions (n=126)	Vermont Gas (n=48)	ENERGY STAR (n=64)	Non-ENERGY STAR (n=118)	Statewide Weighted (n=182)
CRT	27%	17%	27%	22%	19%	19%
LCD	61%	52%	67%	55%	54%	54%
LED	9%	16%	4%	16%	13%	14%
Plasma	2%	6%	2%	5%	4%	5%
Projection	2%*	10%*	0%	3%*	9%*	8%

*Significantly different at the 90% confidence level.

About two out of five (41%) of all TV monitors found in the sample are less than 30 inches in size (Table 9-25). Approximately one out of three (34%) TV monitors is over 40 inches.

Table 9-25: TV Monitor Size

TV Size	GT Regions (n=55)	Non-GT Regions (n=126)	Vermont Gas (n=48)	ENERGY STAR (n=64)	Non-ENERGY STAR (n=117)	Statewide Weighted (n=181)
15 inches or less	7%	6%	6%	8%	5%	6%
16 to 20 inches	18%	10%	15%	8%	15%	11%
21 to 30 inches	20%	25%	21%	23%	23%	24%
31 to 40 inches	20%	27%	19%	25%	25%	25%
Over 40 inches	35%	33%	40%	36%	32%	34%

The most common TV peripherals are DVD players alone (38%) followed by VCRs and DVD players (15%). Non-GT regions and non-ENERGY STAR homes have a significant number of TVs with only a DVR player attached. Over 30% of TVs have no peripherals attached (Table 9-26).

Table 9-26: TV Peripherals

TV Peripherals	GT Regions (n=55)	Non-GT Regions (n=122)	Vermont Gas (n=47)	ENERGY STAR (n=65)	Non-ENERGY STAR (n=112)	Statewide Weighted (n=177)
DVD Player Only	44%	36%	47%	46%	34%	38%
None	24%	33%	19%	28%	31%	31%
VCR and DVD Player	18%	14%	19%	17%	14%	15%
DVR Player Only	0%*	9%*	0%	0%*	10%*	7%
DVD and DVR	7%	3%	9%	5%	4%	4%
VCR Only	7%*	1%*	6%	3%	3%	2%
Game System	0%*	2%*	0%	2%	2%	2%
VCR, DVD, and DVR	0%	2%	0%	0%	2%	1%

*Significantly different at the 90% confidence level.

More than two out of five (41%) TV sets have a cable set top box, whereas more than a third (36%) have a satellite dish (Table 9-27). GT regions have significantly more cable boxes while non-GT regions have more satellite boxes.

Table 9-27: TV Set Top Boxes

Set Top Boxes	GT Regions (n=56)	Non-GT Regions (n=126)	Vermont Gas (n=48)	ENERGY STAR (n=64)	Non-ENERGY STAR (n=118)	Statewide Weighted (n=182)
Cable	61%*	36%*	67%	52%	39%	41%
Satellite	16%*	41%*	10%	31%	35%	36%
None	23%	23%	23%	17%	26%	23%

*Significantly different at the 90% confidence level.

Computers: More than 90% of new homes have at least one computer and about three out of four (74%) at least one printer (Table 9-28 and Table 9-29). Non-GT regions and non-ENERGY STAR homes have significantly fewer printers than GT and ENERGY STAR homes.

Table 9-28: Computer Saturation

Computers	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
None	4%	10%	4%	3%	11%	9%
One	39%	42%	42%	48%	38%	41%
Two or more	57%	48%	54%	48%	52%	50%

Table 9-29: Printer Saturation

Printers	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
None	14%*	29%*	15%	15%*	30%*	26%
One	75%	62%	77%	76%	61%	65%
Two or more	11%	9%	8%	9%	9%	9%

*Significantly different at the 90% confidence level.

Almost three out of five (58%) of all computers found in homes are desktops (Table 9-30).

Table 9-30: Computer Type

Computer Type	GT Regions (n=34)	Non-GT Regions (n=76)	Vermont Gas (n=29)	ENERGY STAR (n=36)	Non-ENERGY STAR (n=74)	Statewide Weighted (n=110)
Desktop	50%	61%	55%	56%	58%	58%
Laptop	47%	38%	41%	42%	41%	40%
Tablet	3%	1%	3%	3%	1%	2%

Almost nine in ten (87%) computers have LCD monitor types (Table 9-31). Non-GT regions have significantly more CRT type monitors attached to computers than those in the GT regions.

Table 9-31: Computer Monitor Type

Monitor Type	GT Regions (n=43)	Non-GT Regions (n=100)	Vermont Gas (n=38)	ENERGY STAR (n=53)	Non-ENERGY STAR (n=90)	Statewide Weighted (n=143)
LCD	88%	86%	95%	83%	89%	87%
LED	12%	9%	5%	15%	7%	10%
CRT	0%*	5%*	0%	2%	4%	4%

*Significantly different at the 90% confidence level.

One-half of computer monitors are between 16 and 20 inches in size (Table 9-32).

Table 9-32: Computer Monitor Size

Monitor Size	GT Regions (n=44)	Non-GT Regions (n=107)	Vermont Gas (n=39)	ENERGY STAR (n=55)	Non-ENERGY STAR (n=96)	Statewide Weighted (n=151)
15 inches or less	55%	38%	49%	51%	39%	42%
16 to 20 inches	36%	53%	44%	42%	52%	50%
Over 20 inches	9%	8%	8%	7%	9%	9%

About one in five (21%) new homes contains a dedicated home office (Table 9-33).

Table 9-33: Do you have a dedicated space for running a business or working from home?

Home Office	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
Yes	21%	20%	31%	24%	19%	21%
No	79%	80%	69%	76%	81%	79%

Over one-half (53%) of home offices are between 100 and 200 square feet in size (Table 9-34). Home office size in the non-GT regions tends to be more variable than in the GT regions.

Table 9-34: Home Office Size

Home Office Size	GT Regions (n=5)	Non-GT Regions (n=14)	Vermont Gas (n=8)	ENERGY STAR (n=8)	Non-ENERGY STAR (n=11)	Statewide Unweighted (n=19)
Less than 100 square feet	**0 (0%)***	**7 (50%)***	3 (38%)	3 (38%)	4 (36%)	37%
100 to 200 square feet	**5 (100%)***	**5 (36%)***	5 (63%)	5 (63%)	5 (45%)	53%
Over 200 square feet	0 (0%)	2 (14%)	0 (0%)	0 (0%)	2 (18%)	11%

*Significantly different at the 90% confidence level.

Swimming Pools: None of the new homes visited has a swimming pool.

10 Lighting

CFL bulbs, including both screw-in and pin-based CFL bulbs, were installed at 94% of homes; not surprisingly, all ENERGY STAR homes have CFL bulbs installed while more than 90% of non-ENERGY STAR homes do (Table 10-1). Over two out of five homes (43%) have screw-in CFLs in storage and 22% have installed dimmable incandescent bulbs. Only 5% of homes have dimmable CFLs installed.

Table 10-1: Proportion of Homes with Bulb Type and Dimmable Bulbs

Homes and Bulb Types	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
CFLs Installed	96%	93%	96%	100%	91%*	94%
CFLs in Storage	57%	39%	62%	64%	34%*	43%
Incandescent Installed	93%	88%	92%	85%	92%	89%
LEDs Installed	11%	10%	15%	15%	8%	10%
Fluorescents Installed	50%	58%	54%	58%	55%	56%
Dimmable CFLs Installed	7%	4%	8%	6%	5%	5%
Dimmable Incandescent Installed	25%	22%	27%	15%	27%	22%

*Significantly different at the 90% confidence level.

The percentage of total sockets filled with CFLs found in the homes visited is 42% (Table 10-2). Approximately the same numbers of sockets are filled with incandescent type bulbs (46%). Non-GT regions tend to have significantly more CFLs and fluorescent bulbs installed than GT regions. LEDs were found in greater numbers in ENERGY STAR homes than in non-ENERGY STAR homes.

Table 10-2: Bulb Type Saturation by Total Sockets

Socket Saturation by Bulb Type	GT Regions (n=2,002)*	Non-GT Regions (n=4,398)*	Vermont Gas (n=2,030)*	ENERGY STAR (n=2,274)*	Non-ENERGY STAR (n=4,126)*	Statewide Weighted (n=6400)
CFLs	38%**	43%*	39%	50%**	37%**	42%
Total Sockets	755	1906	782	1145	1516	2661
Incandescent	52%**	44%**	47%	35%**	53%**	46%
Total Sockets	1033	1949	964	796	2186	2982
LEDs	1%	1%	3%	3%**	1%**	1%
Total Sockets	20	63	51	57	26	83
Fluorescent	3%**	6%**	4%	5%	5%	5%
Total Sockets	65	257	87	119	203	322

*The "n" are the total number of installed CF, incandescent, LED, and fluorescent, bulbs plus bubs in storage, and empty sockets.
**Significantly different at the 90% confidence level.

Table 10-3 displays the proportion of CFL bulbs installed in homes as a proportion of the total incandescent and CFL bulbs installed. Forty-nine percent of homes have between 1% and 50% of CFLs installed; 45% of homes have more than one-half of total bulbs found in the home to be CFLs.. On-site visits found that a significant number (9%) of non-ENERGY STAR homes had no CFLs installed.

Table 10-3: Proportion of CFLs Installed

CFL Bulbs (Percent Of All Bulbs In Home)	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
None	4%	7%	4%	0%*	9%*	6%
1% to 10%	18%	7%	12%	6%	13%	10%
11% to 25%	14%	16%	23%	21%	13%	16%
26% to 50%	29%	22%	23%	18%	27%	23%
51% to 100%	36%	48%	38%	55%	39%	45%

*Significantly different at the 90% confidence level.

Table 10-4 displays various statistics for CFLs installed in all homes. Statewide, an average of 27.4 and median of 28 CFL bulbs are installed per home, representing 47% of all 58.2 incandescent and CFL bulbs installed.[44] In ENERGY STAR homes, an average of 34.7 CFL bulbs were installed, representing 59% of bulbs; in comparison, non-ENERGY STAR homes have an average of 23.7 CFL bulbs installed, representing 41% of bulbs.

Table 10-4: Average, Median, and Proportion of CFLs Installed

CFL Statistics	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Unweighted (n=97)
Average Number of CFLs	26.7	27.6	30.1	34.7	23.7	27.4
Median Number of CFLs	28.0	28.0	29.0	31.0	26.0	28.0
Average Number of Incandescent and CFL bulbs	63.9	55.9	67.2	58.9	57.9	58.2
Proportion of Incandescent and CFL Bulbs that are CFLs	42%	49%	45%	59%*	41%*	47%

*Significantly different at the 90% confidence level.

[44] Sockets were not categorized as eligible or not eligible for CFLs. However, given the expanding array of CFL bulbs available on the market (such as dimmable, three-way, candelabra bulbs, etc.), it is reasonable to assume that nearly all sockets could accommodate a CFL, though some of the specialty designs are less prevalent in retail stores than are standard CFLs.

Table 10-5 displays various statistics for the CFLs found in storage in all homes. Statewide, households stored an average of 3.3 CFL bulbs per home. GT regions and ENERGY STAR homes store more CFLs on average than their counterparts (4.3 to 2.9 and 4.4 to 2.7 respectively).

Table 10-5: Average and Median Number of CFLs in Storage

CFL Storage Statistics	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Unweighted Statewide (n=97)
Average Number of CFLs	4.3	2.9	5.1	4.4	2.7	3.3
Median Number of CFLs	1.5	0.0	3.0	3.0	0.0	0.0
Total CFLs in Storage	120	198	133	146	172	318

11 Auditors Ratings of Homes and Energy Features

Auditors were asked to provide ratings in response to the two questions listed below.

1) In general, how would you rate the overall construction quality of this home, on a scale of 1 (poor) to 5 (excellent)?
2) How large are the opportunities that were missed by the builder that might have improved the energy efficiency of this home? Rate using a scale of 1 (small amount of energy savings) to 5 (large amount of energy savings).

In addition, auditors were asked to offer an explanation for why they chose a particular rating, and they were also asked to list the four worst energy features in each home.

This section presents information on missed energy opportunities and the four worst energy features. Missed opportunities were viewed as any remaining potential for energy efficiency. These opportunities could be items that are very difficult to retrofit (e.g., slab insulation) or items that are relatively easy retrofit (e.g., attic insulation). It should be noted that these ratings are subjective in nature, but they should provide a general idea of where Vermont can focus future energy savings efforts.

As previously mentioned, auditors were asked to rate the construction quality of each home, using a scale of one to five where one means 'poor' and five means 'excellent.' When assessing construction quality, auditors typically looked for details related to energy efficiency. Auditors' ratings and subsequent explanations focus on builders' construction practices and attention to detail, not on the structural integrity of the home, as most new construction is structurally sound.

Table 11-1 shows the ratings for overall construction quality. Statewide, auditors rated more than six out of every ten homes (61%) a five, or excellent construction quality. Eighty-nine percent of homes were rated either a four or a five. As shown, significantly more ENERGY STAR homes (88%) were rated a five than non-ENERGY STAR homes (48%). Not one ENERGY STAR home was rated below four. These results show that the sampled homes are well built and for the most part contain energy-efficient features.

Table 11-1: Rating of Construction Quality

Construction Quality	GT Regions (n=28)	Non-GT Regions (69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted Data (n=97)
1-poor	0%	0%	0%	0%	0%	0%
2	0%	3%	0%	0%	3%	2%
3	7%	13%	4%	0%*	17%*	12%
4	28%	28%	19%	12%*	31%*	28%
5-excellent	75%*	57%*	77%	88%*	48%*	61%

*Significantly different at the 90% confidence level.

Auditors were asked to rate the level of missed energy savings opportunities in each home, using a scale of one to five, where one means 'low' and five means 'high.' As shown in Table 11-2,

auditors rated most sampled homes as either a one or a two, indicating that most of the energy opportunities had been addressed. Statewide results show that 77% of homes were rated a one or a two, and only 5% of homes were rated a five. Significantly more ENERGY STAR homes (76%) than non-ENERGY STAR homes (38%) received a rating of one. Similarly, significantly less ENERGY STAR homes (0%) than non-ENERGY STAR homes (8%) received a rating of five. These data indicate that ENERGY STAR homes are in fact more energy efficient in the eyes of auditors; non-ENERGY STAR homes were consistently rated as having relatively small energy savings opportunities, but still present significantly more opportunities than ENERGY STAR homes.

Table 11-2: Rating of Missed Energy Opportunities

Missed Energy Opportunities	GT Regions (n=28)	Non-GT Regions (n=69)	Vermont Gas (n=26)	ENERGY STAR (n=33)	Non-ENERGY STAR (n=64)	Statewide Weighted (n=97)
1-small	50%	51%	58%	**76%***	**38%***	51%
2	25%	26%	19%	**12%***	**33%***	26%
3	18%	14%	19%	9%	19%	15%
4	7%	1%	4%	3%	3%	2%
5-large	**0%***	**7%***	0%	**0%***	**8%***	5%

*Significantly different at the 90% confidence level.

Table 11-3 shows the number one worst rated energy feature for homes where auditors rated the energy savings opportunities a three, four, or five (five represents the largest savings opportunities). Basement insulation (55%) was most frequently rated as the worst energy feature in homes with substantial savings opportunities. Auditors clearly identified this as the largest area for improvement in homes with large savings opportunities. Auditors listed basement insulation as the number one worst rated energy feature in 12 of the 22 homes that received a rating of three, four, or five for missed energy opportunities. One-half of these homes (50%) were missing both foundation wall insulation and frame floor insulation over the basement.

Table 11-3: Number One Worst Rated Energy Feature for Homes With Energy Savings Rated '3', '4', or '5'

Worst Energy Feature	GT Regions (n=7)	Non-GT Regions (n=15)	Vermont Gas (n=6)	ENERGY STAR (n=4)	Non-ENERGY STAR (n=18)	Statewide Unweighted (n=22)
Basement Insulation R-Value (Including No Insulation)	4 (57%)	53%	3 (50%)	3 (75%)	50%	55%
Ceiling Insulation R-Values	1 (14%)	13%	1 (17%)	0 (0%)*	17%*	14%
Basement Air Leakage	0 (0%)	13%	0 (0%)	0 (0%)	11%	7%
Duct Insulation R-Values	1 (14%)	0%	1 (17%)	1 (25%)	0%	7%
Pipe Insulation	1 (14%)	0%	1 (17%)	0 (0%)	6%	7%
Ceiling Air Leakage	0 (0%)	7%	0 (0%)	0 (0%)	6%	3%
Ceiling Insulation Installation	0 (0%)	7%	0 (0%)	0 (0%)	6%	3%
House Air Leakage Reduction (Overall)	0 (0%)	7%	0 (0%)	0 (0%)	6%	3%

*Significantly different at the 90% confidence level.

Auditors felt that they could not provide a worst energy feature at nearly three out of every ten homes (28%). The selection of "None" (no worst energy feature) was followed by basement insulation R-value (21%) and interior lighting (15%) as the items most often noted as the worst energy feature (Table 11-4).

Table 11-4: Worst Energy Features by Ranking

Worst Energy Feature	First* (n=97)	Second* (n=97)	Third* (n=97)	Fourth* (n=97)
None	28%	51%	76%	71%
Basement Insulation R-Value (Including No Insulation)	21%	0%	1%	1%
Lighting – Interior	15%	16%	6%	8%
Ceiling Insulation R-Values	4%	2%	1%	1%
Furnace/Boiler Efficiency (AFUE)	4%	0%	0%	0%
Pipe Insulation	4%	2%	0%	0%
Basement Insulation Installation (Only if Insulation Present)	3%	3%	1%	1%
Basement Air Leakage	2%	3%	3%	3%
Furnace/Boiler Installation Quality	2%	0%	0%	0%
House Air Leakage Reduction (Overall)	2%	4%	2%	2%
Duct System Insulation R-Value	2%	0%	0%	0%
Slab Insulation	2%	0%	0%	0%
Ceiling Air Leakage	1%	3%	0%	0%
Ceiling Insulation Installation	1%	3%	1%	1%
Duct System Insulation Installation	1%	0%	0%	0%
House Solar Orientation	1%	1%	0%	0%
Need Insulation Around Chimney	1%	0%	0%	0%
Rim Joist Insulation	1%	0%	0%	0%
Wall Air Leakage	1%	0%	0%	0%
Wall Insulation R-Values	1%	3%	0%	0%
Water Heater Efficiency (Energy Factor)	1%	0%	0%	0%
Duct System Installation (Craftsmanship of Duct System, not Including Insulation)	0%	1%	0%	0%
Lighting – Exterior	0%	4%	2%	3%
Water Heater Installation Quality	0%	1%	0%	0%
Wall Insulation Installation	0%	2%	3%	5%
Other	0%	0%	1%	1%

*All data are weighted.

Most of the new homes visited for this study were built to high energy-efficiency standards. While there is room for improvement it is clear that the majority of new construction in the state is extremely efficient, and that is evident by the auditors' ratings of construction quality and energy savings opportunities.

12 Comparisons to Earlier Vermont Baseline Studies

This section compares the results of four Vermont new residential construction baseline studies: the 1995, 2002, 2008, and 2011 studies. Construction practices have improved in almost all areas. Table 12-1 displays summary statistics for key characteristics from all four baseline studies. Rows highlighted in green show improvement over the course of the studies, while rows highlighted in gray show a lack of improvement or inconsistent changes from study to study.

Table 12-1: Summary Comparison of Vermont 1995, 2002, 2008 and 2011 Baseline Study Home Features

Characteristic	Vermont 1995 Baseline (n=151)	Vermont 2002 Baseline (n=158)	Vermont 2008 Baseline Weighted Data (n=106)	Vermont 2011 Baseline Weighted Data (n=97)
Water Heating Median Energy Factors				
Indirect Fired: Fossil Fuel	0.78	0.77	0.80	0.85
Stand Alone: Electric	0.82	0.88	0.90	0.92
Stand Alone: Fossil Fuel	0.52	0.60	0.59	0.63
Instantaneous	n/a	n/a	0.84	0.82
Flat Ceiling Insulation				
Average R-value	33	40	39	44
Cathedral Ceiling Insulation				
Average R-value	33	32	34	39
Conditioned/Ambient Wall Insulation				
Average R-value	19	20	21	22
Below Grade Foundation Wall Insulation				
Average R-value	7	8	11	12
Insulation in Floors Exposed to Outside Air				
Average R-value	30	30	28	26
Insulation in Floors Over Unconditioned Space				
Average R-value	30	30	3	11
Slab Insulation				
Average R-value	n/a	4	8	11
Natural Air Changes per Hour				
Average ACHnat	0.45	0.31	0.28	0.18
Boiler Heating System AFUE				
Average AFUE	n/a	84.8	87.4	91.2
Furnace Heating System AFUE				
Average AFUE	n/a	91.0	89.9	92.9
Screw-in or Pin-based CFL Bulbs				
Percent of Homes with Screw-in or Pin-based CFL Bulbs	About One-Third	47%	81%	94%
Average Number of Screw-in or Pin-based CFLs per Home	n/a	3.0	14.2	27.4

Characteristic	Vermont 1995 Baseline (n=151)	Vermont 2002 Baseline (n=158)	Vermont 2008 Baseline Weighted Data (n=106)	Vermont 2011 Baseline Weighted Data (n=97)
Percent ENERGY STAR Appliances				
ENERGY STAR Refrigerators*	n/a	27%	30%	62%
ENERGY STAR Dishwashers*	n/a	36%	69%	66%
ENERGY STAR Clothes Washers*	n/a	47%	48%	59%
ENERGY STAR Separate Freezers*	n/a	n/a	12%	5%

*Not all homes have these appliances. The percentages are the percentage of the individual appliances observed in homes that were ENERGY STAR qualified.

The remainder of this section is tables from the 2009 Vermont report updated to include 2011 study results.

Table 12-2 shows the average home size in the 2011 study is lower than in the three previous studies. This decrease could be due, in at least part, to a change in the definition of conditioned floor area in 2011. However, the definitions of conditioned space in the most recent three studies, listed below, are very similar.

- 1995 study—finished living space
- 2002 and 2008 studies—intentionally heated space
- 2011 study—all finished space within the insulated envelope and intentionally heated unfinished space

Table 12-2: Vermont Studies—Home Size

Home Size (Heated Area) Square Feet	Vermont 1995 Baseline	Vermont 2002 Baseline	Vermont 2008 Baseline Weighted Data (n=106)	Vermont 2011 Baseline Weighted Data (n=97)
< 1,000	4%	0%	3%	3%
1,000 to 1,499	12%	8%	12%	21%
1,500 to 1,999	29%	25%	20%	28%
2,000 to 2,499	21%	25%	25%	18%
2,500 to 2,999	11%	19%	17%	13%
3,000 to 3,499	10%	9%	10%	9%
3,500 to 3,999	6%	8%	6%	3%
4,000 to 4,499	4%	3%	5%	2%
4,500 to 4,999	2%	2%	1%	0%
5,000 or More	2%	2%	3%	1%
Average Square Feet	**2,380**	**2,510**	**2,507**	**2,187**
Median Square Feet	2,130	2,390	2,352*	1,958*

*Not weighted.

Table 12-3 shows homeowners in the 2011 study continued the 1995 to 2008 trend to be less likely to heat with oil. Homeowners in 2011 are more likely to say they heat with propane than in previous years. Also, the percentage of homeowners in the Electric/Other/Combination category increased sharply from the 2002 and 2008 studies.

Table 12-3: Vermont Studies—Primary Heating Fuel

Primary Heating Fuel	Vermont 1995 Baseline	Vermont 2002 Baseline	Vermont 2008 Baseline Weighted Data (n=106)	Vermont 2011 Baseline Weighted Data (n=97)
Oil/Kerosene	60%	45%	34%	9%
Natural Gas	6%	19%	11%	13%
Propane	29%	29%	40%	57%
Wood	0%	6%	14%	12%
Electric/Other/Combination	5%	1%	1%	9%

Table 12-4 shows the percentage of homes with tankless coil water heating dropped to a low of 1% (1 home) in the current study. The percentage of homes with fossil fuel-fired integrated tank water heating is lower than in both 2002 and 2008, but the average Energy Factor for these systems is higher. The percentage of homes with instantaneous water heaters is five times what it was in 2008.

Table 12-4: Vermont Studies—Water Heating Type and Energy Factor

Water Heating Type	Vermont 1995 Baseline		Vermont 2002 Baseline		Vermont 2008 Baseline Weighted Data		Vermont 2011 Baseline Weighted Data	
	Percent of Homes (n=151)	Median Energy Factor	Percent of Homes (n=137)	Median Energy Factor	Percent of Homes (n=106)	Median Energy Factor*	Percent of Homes (n=97)	Median Energy Factor*
Tankless Coil	32%	0.50	3%	n/a	5%	0.40	1%	0.45
Indirect Fired: Fossil Fuel	50%	0.78	83%	0.77	74%	0.80	58%	0.85
Stand Alone: Electric	8%	0.82	6%	0.88	3%	0.90	6%	0.92
Stand Alone: Fossil Fuel	11%	0.52	11%	0.60	13%	0.59	10%	0.63
Instantaneous	0%	n/a	0%	n/a	4%	0.84	20%	0.82
Other**	n/a	n/a	n/a	n/a	n/a	n/a	5%	n/a

*Median Energy Factors not weighted.

**Other includes 3 homes with solar assisted water heating systems and two homes with two types of water heating; one home has both a stand-alone water heater and an indirect fired water heater and another home has both a stand-alone water heater and an instantaneous water heater.

Table 12-5 shows the percentage of homes meeting or exceeding code for flat ceiling insulation (R-38) decreased from 74% in 2008 to 60% in 2011; however the average R-value actually increased from R-39 in 2008 to R-44 in 2011.

Table 12-5: Vermont Studies—Flat Ceiling Insulation

Flat Ceiling Average R-value Minimum RBES Requirement R-38	Vermont 1995 Baseline	Vermont 2002 Baseline (n=141)	Vermont 2008 Baseline Weighted Data (n=94)	Vermont 2011 Baseline Weighted Data (n=80)
R-value Below Code	38%	28%	26%	40%
R-value Meets or Exceeds Code	62%	68%	74%	60%
R-value Statistics*				
Minimum R-value	n/a	15	19	19
Maximum R-value	n/a	83	100	110
Average R-value	**33**	**40**	**39**	**44**
Median R-value	n/a	38	38	38

*Only the average R-value is weighted for 2008 and 2011.

Table 12-6 shows not only did the percentage of homes meeting or exceeding code for cathedral ceilings increase from 80% in 2008 to 90% in 2011, the average R-value increased from R-34 to R-39 and the median increased from R-36 to R-39.

Table 12-6: Vermont Studies—Cathedral Ceiling Insulation

Cathedral Ceiling Average R-value Minimum RBES Requirement R-30	Vermont 1995 Baseline	Vermont 2002 Baseline (n=141)	Vermont 2008 Baseline Weighted Data (n=55)	Vermont 2011 Baseline Weighted Data (n=51)
R-value Below Code	35%	36%	20%	10%
R-value Meets or Exceeds Code	65%	64%	80%	90%
R-value Statistics*				
Minimum R-value	n/a	19	16	11
Maximum R-value	n/a	60	66	60
Average R-value	**33**	**32**	**34**	**39**
Median R-value	n/a	30	36	39

*Only the average R-value is weighted for 2008 and 2011.

Table 12-7 shows the percentage of homes meeting or exceeding code for wall insulation decreased from 95% in 2008 to 91% in 2011. That said, the average R-values barely changed and the median remained the same; the average R-value was R-21 in 2008 and R-22 in 2011, while the median was R-19 in both years.

Table 12-7: Vermont Studies—Conditioned/Ambient Wall Insulation

Conditioned/Ambient Walls Average R-value Minimum RBES Requirement R-19	Vermont 1995 Baseline	Vermont 2002 Baseline (n=141)	Vermont 2008 Baseline Weighted Data (n=106)	Vermont 2011 Baseline Weighted Data (n=97)
R-value Below Code	n/a**	10%	5%	9%
R-value Meets or Exceeds Code	n/a**	90%	95%	91%
R-value Statistics*				
Minimum R-value	n/a	8	7	8
Maximum R-value	n/a	40	48	54
Average R-value	**19**	**20**	**21**	**22**
Median R-value	n/a	19	19	19

*Only the average R-value is weighted for 2008 and 2011.

**Previous baseline reports include multiple estimates of the percentage of homes meeting or exceeding R-19 wall insulation. Reported estimates range from 57% to 94%. Without knowing which estimate is consistent with the 2002 and 2008 data, this cell is not populated.

Table 12-8 shows the percentage of homes meeting or exceeding code requirements for below grade foundation wall insulation has consistently grown from 48% in 1995 to 87% in 2011. The average R-value increased to R-12 in 2011, up from R-11 in 2008.

Table 12-8: Vermont Studies—Below Grade Foundation Wall Insulation

Below Grade Foundation Walls Average R-value Minimum RBES Requirement R-10	Vermont 1995 Baseline	Vermont 2002 Baseline (n=146)	Vermont 2008 Baseline Weighted Data (n=88)	Vermont 2011 Baseline Weighted Data (n=67)
R-value Below Code	52%	38%	27%	13%
R-value Meets or Exceeds Code	48%	62%	73%	87%
R-value Statistics*				
Minimum R-value	n/a	0	0	0
Maximum R-value	n/a	29	35	25.5
Average R-value	**7**	**8**	**11**	**12**
Median R-value	n/a	10	11	10

*Only the average R-value is weighted for 2008 and 2011.

Table 12-9 shows that 20% of the 2011 audited homes meet the insulation code requirement of R-38 for floors exposed to outside air. This is down from 25% in 2008, though the 2008 sample size was very small with only four homes being subject to this requirement.

Table 12-9: Vermont Studies—Insulation in Floors Exposed to Outside Air

Floors Over Outside Air Average R-value Minimum RBES Requirement R-38	Vermont 1995 Baseline	Vermont 2002 Baseline (n=26)	Vermont 2008 Baseline Raw Data (n=4)	Vermont 2011 Baseline Raw Data (n=15)
R-value Below Code	n/a	73%	75%	80%
R-value Meets or Exceeds Code	n/a	23%	25%	20%
R-value Statistics				
Minimum R-value	n/a	8	19	0
Maximum R-value	n/a	43	50	38
Average R-value	**30**	**30**	**28**	**26**
Median R-value	n/a	30	22	30

Table 12-10 shows that 15% of the homes in the 2011 study meet the code requirement of R-30 insulation in floors over unconditioned space compared to 0% meeting code in the 2008 study.

Table 12-10: Vermont Studies—Insulation in Floors Over Unconditioned Space

Floors Over Unconditioned Space Average R-value Minimum RBES Requirement R-30	Vermont 1995 Baseline	Vermont 2002 Baseline (n=26)	Vermont 2008* Baseline Weighted Data (n=41)	Vermont 2011* Baseline Weighted Data (n=20)

R-value Below Code	n/a	73%	100%	85%
R-value Meets or Exceeds Code	n/a	23%	0%	15%
R-value Statistics**				
Minimum R-value	n/a	8	0	0
Maximum R-value	n/a	43	21	38
Average R-value	**30**	**30**	**3**	**11**
Median R-value	n/a	30	0	0

*2008 & 2011 data based on floors over fully unconditioned basements.
**Only the average R-value is weighted for 2008 and 2011.

Table 12-11 shows that homes in the 2011 study are more likely to meet code requirements for slab insulation than in the 2008 study. The average R-value of slab insulation increased to R-11, up from R-8 in the 2008 study.

Table 12-11: Vermont Studies—Slab Insulation

Basement Slab Average R-value Minimum RBES Requirement R-10	Vermont 1995 Baseline	Vermont 2002 Baseline (n=63)	Vermont 2008 Baseline				Vermont 2011 Baseline
			On-Grade Slab* Raw Data (n=19)	Below Grade Slab* Weighted Data (n=51)	Mix (on/below) Grade Slab* Raw Data (n=17)	All Slabs** Weighted Data (n=82)	All Slabs Requiring Insulation (n=24)***
R-value Below Code	n/a	63%	21%	56%	38%	46%	16%
R-value Meets or Exceeds Code	n/a	37%	79%	44%	62%	54%	84%
R-value Statistics**							
Minimum R-value	n/a	0	0	0	0	0	0
Maximum R-value	n/a	11	28	14	16	30	20
Average R-value	**n/a**	**4**	**12**	**6**	**8**	**8**	**11**
Median R-value	n/a	0	14	8	10	10	10

*All homes with known slab insulation location and R-value.
**All homes with known slab insulation R-value.
***Only includes homes required by code to have slab insulation.
****Only the "Below Grade" and "All Slab" averages for 2008 are weighted.

Table 12-12 shows that the percentage of 2011 homes with less than 10% glazing is much lower than in the 2008 study, but only slightly higher than in the 2002 study; the percentage of homes in 2011 with more than 20% glazing is higher than in all three of the previous studies. The average glazing percentage in 2011 (15%) is slightly higher than in the 2002 (14%) and 2008 (13%) studies.

Table 12-12: Vermont Studies—Glazing Percentage

Glazing Area Window to Wall Area Ratio	Vermont 1995 Baseline (n=151)	Vermont 2002 Baseline (n=139)	Vermont 2008 Baseline Weighted Data (n=105)	Vermont 2011 Baseline Weighted Data (n=97)
Less than 10%	23%	10%	27%	14%
10 to 12%	32%	29%	16%	8%
>12 to 15%	30%	26%	28%	28%
>15 to 20%	9%	19%	22%	22%
More than 20%	6%	16%	7%	27%
Glazing Percentage Statistics*				
Min Glazing %	n/a	6%	5%	3%
Max Glazing %	n/a	27%	30%	26%
Average Glazing %	**n/a**	**14%**	**13%**	**15%**
Median Glazing %	n/a	13%	13%	15%

*Only the average is weighted for 2008 and 2011.

Table 12-13 shows that homes in the 2011 study are tighter, on average, than homes in the 2008 and 2002 studies. A larger percentage of homes in the 2011 study have ACHnat of less than 0.31 than in the 2008 and 2002 studies. The average ACHnat was also lower than in 2008, dropping from 0.28 in 2008 to 0.18 in 2011.

Table 12-13: Vermont Studies—Natural Air Changes per Hour

Natural Air Changes per Hour (ACHnat)	Vermont 1995 Baseline (n-151)	Vermont 2002 Baseline (n=156)	Vermont 2008 Baseline Weighted Data (n=82)	Vermont 2011 Baseline Weighted (n=55)
Less than .31	n/a	70%	60%	90%
.31 to .50	n/a	24%	32%	10%
Over .50	n/a	6%	8%	0%
ACHnat Statistics*				
Minimum ACHnat	n/a	n/a	0.04	0.05
Maximum ACHnat	n/a	n/a	0.65	0.40
Average ACHnat	**0.45**	**0.31**	**0.28**	**0.18**
Median ACHnat	n/a	n/a	0.26	0.13

*Only the average is weighted for 2008 and 2011.

Table 12-14 shows the average boiler AFUE continues to rise, increasing from 84.8 in 2002 to 91.2 in 2011. Similarly, the median AFUE increased from 85.0 in 2002 to 92.3 in 2011.

Table 12-14: Vermont Studies—Boiler Heating System AFUE

Heating System AFUE Boilers	Vermont 1995 Baseline	Vermont 2002 Baseline (n=120)	Vermont 2008 Baseline Weighted Data (n=86)	Vermont 2011 Baseline Weighted Data (n=70)
AFUE Statistics*				
Federal Minimum Standard	80.0	80.0	80.0	80.0
ENERGY STAR Minimum	85.0	85.0	85.0	85.0
Minimum AFUE	n/a	80.2	80.5	85.0
Maximum AFUE	n/a	89.0	95.2	96.0
Average AFUE	**n/a**	**84.8**	**87.4**	**91.2**
Median AFUE	n/a	85.0	86.6	92.3

*Only the averages for 2008 and 2011 are weighted.

Table 12-15 shows that both the average and median furnace AFUEs are higher in 2011 than they were in 2008.

Table 12-15: Vermont Studies—Furnace Heating System AFUE

Heating System AFUE Furnaces	Vermont 1995 Baseline	Vermont 2002 Baseline (n=20)	Vermont 2008 Baseline Raw Data (n=15)	Vermont 2011 Baseline Weighted Data (n=19)
AFUE Statistics				
Federal Minimum Standard AFUE	78.0	78.0	78.0	78.0
ENERGY STAR Minimum AFUE[45]	90.0	90.0	90.0	90.0
Minimum AFUE	n/a	78.0	80.0	80.0
Maximum AFUE	n/a	93.0	93.5	97.5
Average AFUE	**n/a**	**91.0**	**89.9**	**92.9**
Median AFUE	n/a	86.5	92.5	95.5

*Only the averages for 2008 and 2011 are weighted

[45] ENERGY STAR minimum AFUE requirement is 90 for gas and 85 for oil furnace.

Table 12-16 presents the CFL bulb results from the previous Vermont baseline studies and the current study. As shown, the percentage of homes with CFL bulbs installed has continued to increase over time with 94% of homes having CFLs in 2011 compared to 81% in 2008 and 47% in 2002. At the same time, the average number of CFLs per home has grown from only 3 in 2002 to 14.2 in 2008 and 27.4 in 2011.

Table 12-16: Vermont Studies—CFL Bulbs

Screw-in or Pin-based CFL Bulbs	Vermont 1995 Baseline	Vermont 2002 Baseline (n=158)	Vermont 2008 Baseline Weighted Data (n=105)	Vermont 2011 Baseline Weighted Data (n=97)
Percent of Homes with Screw-in or Pin-based CFL Bulbs	About one-third	47%	81%	94%
Average Number of Screw-in or Pin-based CFLs per Home	n/a	3.0	14.2	27.4

Table 12-17 compares the saturation of appliances in the current study to previous studies. As shown, the saturations of secondary refrigerators, dishwashers, separate freezers, room air conditioners, and central air conditioning all decreased relative to 2008.

Table 12-17: Vermont Studies—Appliance Saturation

Percent of Homes with …	Vermont 2002 Baseline (n=159)	Vermont 2008 Baseline Weighted Data (n=105)	Vermont 2011 Baseline Weighted Data (n=97)
Primary Refrigerators	100%	100%	100%
Clothes Washer	98%	97%	97%
Clothes Dryer	96%	94%	95%
Dishwashers	90%	92%	87%
Separate Freezer	n/a	33%	21%
Secondary Refrigerators	12%	19%	12%
Room Air Conditioner	15%	20%	9%
Central Air Conditioner	6%	10%	9%

Table 12-18 shows the percentage of homes with ENERGY STAR refrigerators increased dramatically in 2011 with 62% of homes having an ENERGY STAR refrigerator—this is more than double the 30% in 2008. The percentage of ENERGY STAR clothes washers also increased, growing from 48% in 2008 to 59% in 2011.

Table 12-18: Vermont Studies—ENERGY STAR Appliances

Percent of Homes with …	Vermont 2002 Baseline	Vermont 2008 Baseline Weighted Data	Vermont 2011 Baseline Weighted Data
ENERGY STAR Dishwashers	36%	69%	66%
ENERGY STAR Refrigerators	27%	30%	62%
ENERGY STAR Clothes Washers	47%	48%	59%
ENERGY STAR Separate Freezers	n/a	12%	5%

Appendix A Good and Bad Practices

During their visits to new homes, auditors photographed examples of good building practices that contributed to a home's energy efficiency and poor building practices where the builder missed opportunities to improve the home's energy efficiency. Below are examples of the practices that auditors saw in homes, with photos and brief descriptions.

Foundation Walls

Builders often insulated all of the foundation walls, in turn bringing the basement inside the thermal envelope of the home. Figure A-1 shows a home where all of the foundation walls were insulated with R-10 rigid foam. This home had radiant heat in the basement slab, so insulating the foundation walls was a critical step in reducing heat loss. This builder also insulated the frame floor separating the first floor from the basement. This was done to create radiant zones within the house as the first floor was conditioned by radiant heat as well.

Figure A-1: Interior Foundation Wall Insulation

Figure A-2 shows a home where the builder used R-10 blue rigid foam to insulate the exterior of the foundation wall. Note, this is a walkout basement and the builder used a combination of exterior rigid foam and interior R-19 fiberglass batts to insulate the entire basement. The fiberglass batts are located on top of the foundation walls on the walkout portion of the basement. This is a good building practice as it brings the entire basement inside the thermal envelope of the home and also makes it easy for homeowners to finish the basement in the future while still maintaining the integrity of the buildings thermal envelope.

Figure A-2: Exterior Foundation Wall Insulation

Frame Floors

Figure A-3 shows poor frame floor insulation in the crawlspace ceiling of a gut rehab home. This is a case where the homeowners/contractors reinsulate all of the walls in the home, but completely neglected the frame floor insulation in the enclosed crawl space. This insulation could be easily upgraded given the easy access to the crawlspace.

Figure A-3: Poor Frame Floor Insulation in Gut Rehab

Figure A-4 shows a frame floor installation that at first glance seems like a good installation. However, after further review this insulation was designated as a Grade III installation. The

picture shows R-19 fiberglass batts with no compression. However, these batts were installed in a 2x10 floor joist and are flush with the bottom of the joist. A standard R-19 fiberglass batt is only 5.5" thick, which means there was a 4" air gap between the top of the insulation and the bottom of the subfloor above. This is a bad installation practice as convective loops form in these air spaces and ultimately result in heat loss through the frame floor assembly.

Figure A-4: Frame Floor Insulation

Figure A-5 shows another poor frame floor insulation installation with lots of compression. This insulation may actually be performing better than the insulation in **Error! Reference source not ound.**, but it is still representative of a poor installation. Note, this home has ICF construction for the foundation walls, so the frame floor insulation serves more as a zone boundary than anything else. For this reason, the poor installation is not detrimental to the overall efficiency of the home in this particular case.

Figure A-5: Poor Frame Floor Installation

Ceiling Insulation

Most of the new homes in VT had adequate ceiling insulation, while some homes exhibited very good ceiling insulation practices. A number of homes used cellulose insulation as a cost effective way to achieve high R-values and good insulation installation. Figure A-6 shows an example of evenly distributed cellulose insulation in the attic of one home. This was designated a Grade I installation, as it was evenly dispersed, uncompressed, and had no significant voids.

Figure A-6: Cellulose Attic Insulation

Figure A-7 shows a cathedral ceiling insulated with closed cell spray foam. Spray foam is great way to insulated cathedral ceilings because it sticks to the cavity, it is relatively easy to install evenly, it will not compress or sag, and it offers a terrific R-value per inch.

Figure A-7: Closed Cell Spray Foam Cathedral Insulation

Air and Duct Sealing

Figure A-8 shows a plumbing penetration that was sealed with spray foam in order to reduce air flow through the foundation wall. This is a common practice, particularly in ENERGY STAR homes (which this is) and often leads to improved air leakage results.

Figure A-8: Air Sealing of Plumbing Penetrations

Figure A-9 shows a duct system in an ENERGY STAR home that was sealed with mastic. Sealing ducts with mastic drastically decreases duct leakage and typically seals ducts much better than other common duct sealing methods such as aluminum faced tape. The ducts in this basement were uninsulated as they were located in a basement where all of the foundation walls were insulated and therefore were located within the thermal envelope of the home.

Figure A-9: Duct Sealing with Mastic

Advanced Construction Techniques and Practices

Figure A-10 shows a structurally insulated panel (SIP) in an attic knee wall. As the name suggests, SIPs have both structural and insulating characteristics. SIPs have very energy-efficient attributes as they offer high R-values per inch and continuous insulation; continuous insulation is beneficial as the thermal bridges common in typical ceiling construction are completely eliminated. In this case, the builder not only installed SIPs all along the roof line, but they also took the time to seal the section where the SIP meets the top plate with spray foam. This extra step most likely helped reduce the air leakage in this home.

Figure A-10: SIP Cathedral Ceiling Insulation

It was quite common for builders/homeowners to use a reflective insulation in homes with radiant heat. Polyisocyanurate or reflective bubble wrap were often used to reflect the heat from radiant tubes back up towards the frame floor. Figure A-11 shows an example of this where the builder installed Polyisocyanurate rigid foam on the underside of floor joists with radiant tubing. The goal is to reflect the radiant heat back towards the frame floor above, which it is intentionally heating. In this case the homeowner had not finished that process, but the images still show a progressive way of reflecting radiant heat.

Figure A-11: Polyisocyanurate Used as Radiant Barrier in Frame Floor

Figure A-12 shows a home where the builder used insulated concrete forms (ICFs) to insulate the foundation walls. Similar to SIP construction, ICFs have both structural and insulating characteristics. ICFs allow both sides of the concrete foundation walls to be insulated with interlocking pieces of rigid foam. This style of construction provides a high R-value and again allows for continuous insulation, minimizing the number of thermal bridges in the foundation walls.

Figure A-12: Insulated Concrete Forms

Figure A-13 shows an example of unusual, yet progressive and efficient construction. The figure shows a one story home that is largely below grade. This home only had four windows and one door, minimizing the thermal losses associated with those building components. With most of the home located below grade this house likely experiences less drastic temperature variations than most homes. The ground has a relatively neutral temperature; therefore this home is likely cool in the summer through natural causes. Similarly, this home, compared to a typical home with similar insulation values, is less likely to drastically cold in the winter. This means that the mechanical equipment does not need to run as long or work as hard to reach the desired set point of the homeowners.

Figure A-13: Using the Earth's Neutral Temperature to Enhance Building Efficiency

Rim/Band Joist Insulation

Figure A-14 shows rigid foam insulation in the rim joist of an ENERGY STAR home. Insulating rim joists is an important practice as rim joists are notorious for potential thermal losses. Note that this builder went an extra step and spray foamed around the rigid foam in each bay to create a tight seal—this helps to reduce the air leakage in the home as well as increasing the effectiveness of the insulation.

Figure A-14: Rigid Foam Insulation in Rim Joist

Figure A-15 shows a home where the builder used SIP panels to insulate the rim joist. This is another example of a great way to insulate rim joists.

Figure A-15: SIP Insulation in Rim Joist

Mechanical Equipment Practices

An uncommon, but good building practice is to add additional insulation to a water heater storage tank. Figure A-16 shows an example of a home where the builder and/or homeowner added an extra layer of insulation to the water heater tank. This should keep the water in the tank at the appropriate temperature for longer periods of time without having to fire the water heater burner.

Figure A-16: Water Heater Tank Insulation

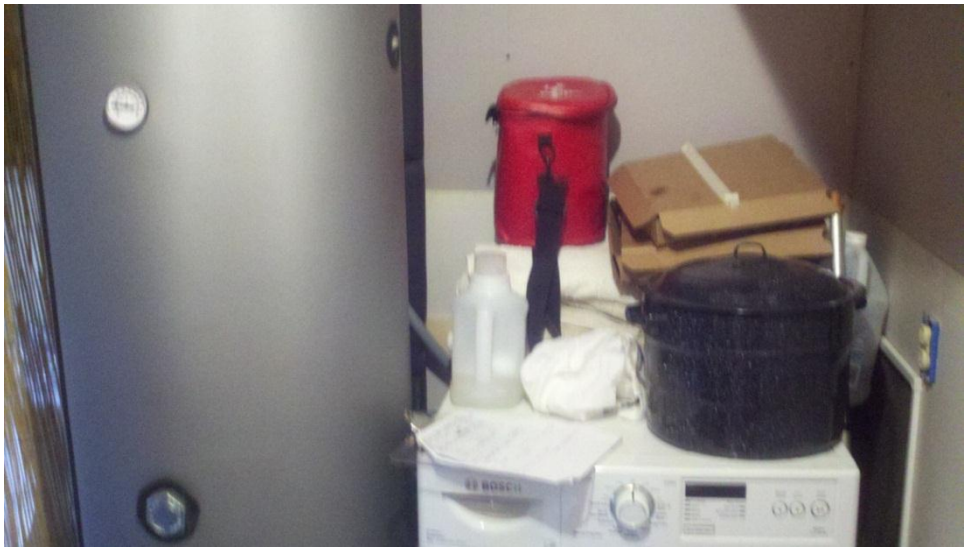
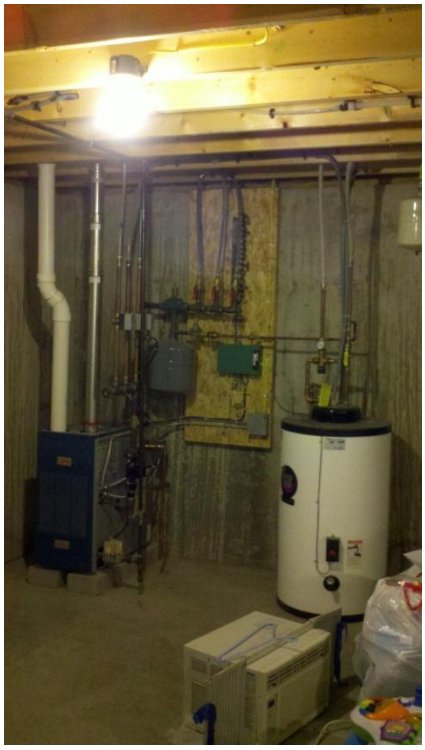


Figure A-17: Mechanical Equipment Located in Conditioned Space

Figure A-18: Mechanical Equipment Located in Unconditioned Space



Appendix B Insulation Grades

The Residential Energy Services Network (RESNET) provides guidelines and definitions for defining the quality of insulation installation. RESNET has specified three grades for designating the quality of insulation installation; the grades range from Grade I (the best) to Grade III (the worst). The RESNET definitions of Grade I, Grade II, and Grade III installation are provided below.[46]

Grade I: ""Grade I" shall be used to describe insulation that is generally installed according to manufacturer's instructions and/or industry standards. A "Grade I" installation requires that the insulation material uniformly fills each cavity side-to-side and top-to-bottom, without substantial gaps or voids around obstructions (such as blocking or bridging), and is split, installed, and/or fitted tightly around wiring and other services in the cavity...To attain a rating of "Grade I", wall insulation shall be enclosed on all six sides, and shall be in substantial contact with the sheathing material on at least one side (interior or exterior) of the cavity…Occasional very small gaps are acceptable for "Grade I"… Compression or incomplete fill amounting to 2% or less, if the empty spaces are less than 30% of the intended fill thickness, are acceptable for "Grade I"."

Grade II: ""Grade II" shall be used to describe an installation with moderate to frequent installation defects: gaps around wiring, electrical outlets, plumbing and other intrusions; rounded edges or "shoulders"; or incomplete fill amounting to less than 10% of the area with 70% or more of the intended thickness (i.e., 30% compressed); or gaps and spaces running clear through the insulation amounting to no more than 2% of the total surface area covered by the insulation."

Grade III: ""Grade III" shall be used to describe an installation with substantial gaps and voids, with missing insulation amounting to greater than 2% of the area, but less than 5% of the surface area is intended to occupy. More than 5% missing insulation shall be measured and modeled as separate, uninsulated surfaces…"

Below are some examples of insulation installation and the corresponding grade applied by auditors. A brief description of the reasoning behind the grade designation is described for each example. Please note that these photographs were not all taken during the site visits for this study, and they are not meant to show the good and bad building practices observed during the site visits. Rather, these pictures are meant to provide visual examples of typical insulation installation grades. .

[46] Residential Energy Services Network. (2006). *2006 Mortgage Industry National Home Energy Rating Systems Standards.* Oceanside, CA: Residential Energy Services Network.

Figure B-1 shows a conditioned attic with closed cell spray foam applied to the walls. This installation received a Grade I installation as the closed cell spray foam has little to no gaps, has no compression, and the cavity is enclosed on all six sides.[47]

Figure B-1: Grade I Closed Cell Spray Foam—Exterior Walls

Figure B-2 shows a Grade II install of unfaced fiberglass batts in a conditioned basement.[48] The insulation has gaps in the corners of certain bays and there is some compression—though relatively minor compression overall. The insulation is enclosed on all six sides (in most places), warranting a Grade II designation.

Figure B-2: Grade II Fiberglass Batts—Basement Walls

[47] In the case of spray foam, a cavity may be open to the attic and still receive a Grade I installation because the spray foam itself is an air barrier.
[48] The basement in this case was considered conditioned volume, not conditioned floor area.

Figure B-3 shows R-21 fiberglass batts in a 2x4 wall cavity. This installation automatically receives a Grade III designation due to the fact that the insulation is not enclosed on the vented attic side. According to the RESNET standards on Grade III installation, "This designation shall include wall insulation that is not in substantial contact with the sheathing on at least one side of the cavity, or wall insulation in a wall that is open (unsheathed) on one side and exposed to the exterior, ambient conditions or a vented attic or crawlspace."

Figure B-3: Grade III Fiberglass Batts—Attic Kneewalls

Figure B-4 shows a Grade II installation of fiberglass batts in a frame floor cavity. While the insulation has a fair amount of compression the gaps are minimal. The primary reason for the Grade II designation is that the fiberglass batts are in substantial contact with the subfloor. This example shows an installation that is right on the boundary of Grade II and Grade III installation. It should be noted that the bay with ductwork on the right side of the image would certainly represent a grade III installation with substantial gaps and compression.

Figure B-4: Grade II Fiberglass Batts—Frame Floor

Figure B-5 shows frame floor insulation that received a Grade III designation. The insulation has gaps, substantial compression in places, and is severely sagging in other places. The sagging insulation creates an air space between the insulation and the subfloor, which ultimately diminishes the insulating characteristics of the fiberglass batts.

Figure B-5: III Fiberglass Batts—Frame Floor

Figure B-6 shows a Grade I installation of blown fiberglass in an attic. This received a Grade I designation as the fiberglass is blown in evenly, filling all of the cavities with no gaps or voids and little to no compression. In addition, this attic has baffles at the eaves, which is required for attic insulation to achieve a Grade I installation.

Figure B-6: Grade I Blown Fiberglass—Attic

Appendix C Towns Representing GT Regions

Table C-1 shows the GT regions, the towns selected to represent each region, and the percent of GT accounts in each town.

Table C-1: Towns Selected to Represent Geographically Targeted Regions

GT Region	Town	Number of Residential Accounts	Number of Residential GT Accounts	Percent of Accounts that are GT
North Chittenden	Colchester	7,073	6,916	98%
	Essex	3,208	2,787	87%
	Essex Junction	4,647	4,545	98%
	Winooski	3,004	2,976	99%
Rutland	Center Rutland	201	197	98%
	Clarendon	1,128	773	69%
	Rutland	9,042	8,761	97%
Southern Loop	Andover	271	242	89%
	Arlington	1,304	1,277	98%
	Bondville	400	399	100%
	Brookline	160	142	89%
	East Arlington	152	151	99%
	East Dorset	366	358	98%
	East Dover	46	45	98%
	Jamaica	1,016	1,000	98%
	Landgrove	127	125	98%
	Londonderry	907	896	99%
	Manchester	739	657	89%
	Manchester center	1,804	1,731	96%
	Newfane	847	824	97%
	Peru	667	662	99%
	Sandgate	156	131	84%
	Shaftsbury	1,658	1,411	85%
	South Londonderry	522	483	93%
	South Newfane	188	188	100%
	Stratton	1,316	1,310	100%
	Sunderland	445	436	98%
	Townshend	588	540	92%
	Wardsboro	331	329	99%
	West Dummerston	364	295	81%
	West Townshend	203	198	98%
	West Wardsboro	509	503	99%
	Weston	556	548	99%
	Williamsville	120	114	95%
	Windham	295	285	97%
	Winhall	1,311	1,307	100%

GT Region	Town	Number of Residential Accounts	Number of Residential GT Accounts	Percent of Accounts that are GT
St. Albans	East Fairfield	138	134	97%
	Fairfax	1,729	1,121	65%
	Georgia	1,663	1,492	90%
	Milton	4,217	4,094	97%
	Saint Albans	5,719	5,458	95%
	Sheldon	784	457	58%

Four of the eleven towns located in the Northern Chittenden region were selected; these four towns represent 94% of the GT accounts in the Northern Chittenden region. Three of the fourteen towns located in the Rutland region were selected; these three towns represent 93% of the GT accounts in the Rutland region. Twenty-nine of the fifty towns located in the Southern Loop region were selected; these twenty-nine towns represent 88% of the GT accounts in the Southern Loop region. Six of the twenty towns located in the St. Albans region were selected; these six towns represent 90% of the GT accounts in the St. Albans region. (Table C-2)

Table C-2: Geographically Targeted Regions

Region	Percent of Accounts that are GT	Percent of all GT accounts represented by selected towns
North Chittenden	96%	94%
Rutland	94%	93%
Southern Loop	96%	88%
St. Albans	90%	90%

Appendix D Non-ENERGY STAR Data Collection Form

VT Baseline Study Field Data Form-2011					Field Data Collection Form		
Site ID Number:		Name:			General Information		
Fill out all data available from recruitment before going to site. Collect more detail during on-site audit.							
Auditor 1			Date of Audit			Ambient Temp.	(Degrees F)
Auditor 2				Evaluation Region			
Street Address				City			
House Type			Attached/Detached			Stories	
						Bedrooms	
RESNET Area conditioned space (calc.)			Volume conditioned space				
Primary Heating Fuel		Total Heated Area (from recruitment data)		Do Blower Door? (from recruitment data)			
Basement type			Bsmt. Area (approx. square feet)		% Cond.		
Completion Date (month/year)		ENERGY STAR Home		Primary/Seasonal		(Time-of-use if seasonal)	
Location of Home				Builder Type			
Own or Rent?							
					Winter	*Summer*	
Type of Thermostat:			Preferred Temperature:				
Use Night Temp. Setback?			No of Occupants, Nights:				
Use Daytime Temp. Setback?			No of Occupants, Workdays:				
Fireplace #1 Fuel		Stove #1 Fuel		Space Heater #1 Fuel			
Fireplace #2 Fuel		Stove #2 Fuel		Space Heater #2 Fuel			
Fireplace #3 Fuel		Stove #3 Fuel		Space Heater #3 Fuel			
New or Existing Home? (from recruitment data)			Indoor Temperature:				
				# Zones:			
				# T'stats:			
# Units in Building		Gut rehab done since Jan 2005?	(ask homeowner)				
		Addition of >500 s.f. since Jan 2005?	(ask homeowner)				

Insulation/Shell

Foundation Wall

For foundations, include ALL insulation (even walls in unconditioned space). Note where insulation was verified.

Wall Type	Int/Ext Insul	Location	Length	Height	Height Above Grade	Insul Type	R-Value

Notes:

Slab Floor

Note where insulation was verified.

Grade/Below Grade	Location of Slab Insulation	Total Perimeter	Exposed Perimeter	Above Grade Exposed Perimeter	Depth Below Grade	Area, SqFt	I-Type	R-Value

Notes:

Frame Floor

Note where insulation was verified.

Floor Description	Location	Area, SqFt	I Type	Cavity?	R-Val/Grade

Notes:

Rim/ Band Joists

Note where insulation was verified.

Joist Description	Location	Area, Linear F	I Type	R-Value	Thickness	Grade	Rim/Band

Notes:

Exterior Walls

Note where insulation was verified.

Wall Description	Location	Area	I Type	Cavity?	R-Val/Grade

Notes:

Windows	*Windows/glass doors and skylights. Note whether or not tested for Low-e*							
Type of Glass	**SqFt**	**Frame**	**Location**	**U-value**	**SHGC**	**T Break**	**O'hang/Dist.To Top**	**Orient**
Notes:								

Ext. Doors

Door Type	Material	Insulated	Storm?	Type of Glass	Dr SqFt	Gl SqFt	Orient.

Notes:

Ceiling Insulation

Note where insulation was verified.

Ceiling Construction	Flat/Cathedral	Area, SqFt	V Barrier	I Type	Cavity?	R-Val/Grade

Notes:

Sky Lights

Type of Glass	SqFt	Frame	Location	U-value	SHGC	T Break	Orient	Angle

Notes:

Mechanicals

Heating Equipment

Manufacturer	Model	Type	Age	Fuel	Location	Cap. Out	Efficiency

For Forced Air System, How is Fan Controlled?

R-value for hydronic piping insulation:

Notes:

Water Heating

Manufacturer	Model	Type	Age	Fuel	Location	Gallons	Energy Factor

R-value for water heater tank wrap:

R-value for water heater piping insulation:

Number of low-flow shower heads:

Number of faucet aerators:

Notes:

Cooling Equipment

Manufacturer	Model	Type	Age	Evap. Location	Tons	Efficiency

Notes:

Duct Insulation

		For Insulation Only					
Supply/Return	Location*	Type	Quality	R-Value	Duct Type	Duct Sealing	Duct Leakage

Notes:

# of return grills

Test Results

Blower door and Duct blaster

Repeat tests as needed to ensure precision.

If RAC installed, repeat test twice: once as-is and again with RAC taped off using duct mask tape

Blower Door Test 1 (at 50 Pa) **As-Is**	
Blower door type	Type 3
Ambient Temperature	
Fan Pressure (Pa)	
House Pressure (Pa)	
Rings/Holes	
CFM Leakage	

Duct Blaster Test 1 (at 25 Pa)	Total Leak Test	Out. Leak Test	System
D.B. Fan Pressure (Pa)			
Duct Pressure	25	25	
Rings			CFA Served
Blower door Fan (Pa)	0		
House Pressure (Pa)	0	25	
CFM Leakage			

Blower Door Test 2 (at 50 Pa) **RAC taped off**	
Blower door type	Type 3
Ambient Temperature	
Fan Pressure (Pa)	
House Pressure (Pa)	
Rings/Holes	
CFM Leakage	

Duct Blaster Test 2 (at 25 Pa)	Total Leak Test	Out. Leak Test	System
D.B. Fan Pressure (Pa)			
Duct Pressure	25	25	
Rings			CFA Served
Blower door Fan (Pa)	0		
House Pressure (Pa)	0	25	
CFM Leakage			

Blower Door Test 3 (at 50 Pa)	
Blower door type	Type 3
Ambient Temperature	
Fan Pressure (Pa)	
House Pressure (Pa)	
Rings/Holes	
CFM Leakage	

Duct Blaster Test 3 (at 25 Pa)	Total Leak Test	Out. Leak Test	System
D.B. Fan Pressure (Pa)			
Duct Pressure	25	25	
Rings			CFA Served
Blower door Fan (Pa)	0		
House Pressure (Pa)	0	25	
CFM Leakage			

Document areas of high leakage that were observed during blower door test:

Light Bulbs

Inventory all interior & exterior light bulbs, whether installed in hard-wired fixtures or plug-in lamps. Include CFLs in storage too.

Room	Number of CFL Bulbs	Number of Incand. Bulbs, incl Halogen,	Number of LED bulbs	Number of Fluorescent tube or Circline bulbs	Number of empty sockets	No. of Bulbs on Dimmer Switch

Appliances

Appliance	Mfg.	Model No	Type	Size/Fuel	Age	Condition	E-Star?
Primary Refrigerator:							
Second Refrigerator:							
Stand-alone Freezer:							
Clothes Washer:							
Clothes Dryer:							
Dehumidifier:							
Dishwasher:							
Range or Combination							
Stand-alone Oven							

TV Sets & Peripherals	Size	Type	Set-top Box	Peripherals	Size	Type	Set-top Box	Peripherals
1,2								
3,4								
5,6								
7,8								

No. of Printers/Type: _____ List other Peripherals: _____

No. of Computers: _____ Is there an in-home office? _____ Ofc. Area _____

Computer Monitors: _____ Is there a Swimming Pool? _____ Heated? _____

Smart Power Strips: _____ Does pool have a pump timer? _____ Pump HP _____

Is there a Hot Tub or Spa? _____ Heated? _____

Computer No	Type	Mon Size	Mon Type	Print Type	E Star?
1					
2					
3					
4					

Is Clothes Dryer properly vented? _____ **Notes:** _____

Notes: _____

								Renewables		
PV Array?		SqFt:		Total kW:						
Wind turbine?		Count:		Total kW:						

								RBES - All Homes		

Inspect ventilation equipment for compliance with Code. Document type of system and note any deficiencies below. Include any bathroom or kitchen fans.										
				Fan Loc.	**Rated CFM**	**Control**	**Notes**			
Type of ventilation system:										
Type of ventilation system:										
Type of ventilation system:										
Type of ventilation system:										
Type of ventilation system:										
Type of ventilation system:										
				Total	0	NA				

ERV/HRV Manufacturer	**ERV/HRV Model No.**	**Efficiency**	**Rated CFM**	**Notes:**

Inspect any combustion equipment for compliance with Code. This includes space and hot water heating equipment, fireplaces, wood and pellet stoves. Does not include cooking equipment (including charcoal or gas grilles) or clothes dryers. Note any deficiencies below.					
Equipment Type	**Fuel**	**Venting**	**Comply?**	**% of Heat**	**Comments, esp. for Non-Compliance**

Notes:

HVAC/Hot Water/Central Air Piping Insulation				
System	**Insulation Type**	**R-value**	**Length of Insulation from unit**	**Notes:**

Miscellaneous Code	
Are exhaust dampers on (a) all kitchen & bathroom fans and (b) clothes dryer vent?	
Do all fireplaces have tight-fitting doors and a tight-fitting chimney damper or a chimney cap damper?	
Do all stoves have tight-fitting doors and outdoor air supply?	
Do circulating service hot water systems have automatic or accessible manual controls?	
Does heated pool have (a) pool cover and (b) accessible manual heater control?	
Is there an RBES certificate in the home? If so, photocopy or photograph the certificate.	
Is there an ENERGY STAR Homes certificate in the home?	

Auditor Ratings

1. Construction Quality

In general, how would you rate the overall construction quality of this home, on a scale of 1 (poor) to 5 (excellent)?

Consider all components of this home.

Explain why you selected this rating

2. Missed Energy Opportunities by Builder (New Homes Only)

How large are the opportunities that were missed by the builder that might have improved the energy efficiency of this home? Rate using a scale of 1 (small amount of energy savings) to 5 (large amount of energy savings).

Explain why you selected this rating

3. Recommendations for Energy Improvements

What is the level of opportunity for improving energy efficiency in this home? Use a scale of 1 (low) to 5 (high).

Explain why you selected this rating

Please make recommendations for the four worst energy features that could be improved in this home.
Rank these in order from #1 (most worst) to #4 (least worst).

#1 Worst Energy Feature: _____
#2 Worst Energy Feature: _____
#3 Worst Energy Feature: _____
#4 Worst Energy Feature: _____

Document noteworthy and valuable information regarding the quality and performance of the home as it pertains to building science and energy usage.

Notes:

Appendix E ENERGY STAR Data Collection Form

VT Baseline Study Field Data Form-2011 ENERGY STAR				Field Data Collection Form		
Site ID Number:		Name:		General Information		
Fill out all data available from recruitment before going to site. Collect more detail during on-site audit.						
Auditor 1		Date of Audit		Ambient Temp.		(Degrees F)
Auditor 2		Evaluation Region				
Street Address		City				
House Type		Attached/Detached		Stories		
				Bedrooms		
RESNET Area conditioned space (calc.)		Volume conditioned space				
Primary Heating Fuel		Total Heated Area (from recruitment data)		Do Blower Door? (from recruitment data)		
Basement type		Bsmt. Area (approx. square feet)		% Cond.		
Completion Date (month/year)		ENERGY STAR Home	Yes	Primary/Seasonal		(Time-of-use if seasonal)
Location of Home				Builder Type		
Own or Rent?						
					Winter	*Summer*
Type of Thermostat:				Preferred Temperature:		
Use Night Temp. Setback?				No of Occupants, Nights:		
Use Daytime Temp. Setback?				No of Occupants, Workdays:		
Fireplace #1 Fuel		Stove #1 Fuel		Space Heater #1 Fuel		
Fireplace #2 Fuel		Stove #2 Fuel		Space Heater #2 Fuel		
Fireplace #3 Fuel		Stove #3 Fuel		Space Heater #3 Fuel		
New or Existing Home? (from recruitment data)	New			Indoor Temperature:		
				# Zones:		
				# T'stats:		
# Units in Building		Gut rehab done since Jan 2005? (ask homeowner)				
		Addition of >500 s.f. since Jan 2005? (ask homeowner)				

Insulation/Shell

Foundation Wall

For foundations, include ALL insulation (even walls in unconditioned space). Note where insulation was verified.

Wall Type	Int/Ext Insul	Location	Length	Height	Height Above Grade	Insul Type	R-Value

Notes:

Slab Floor

Note where insulation was verified.

Grade/Below Grade	Location of Slab Insulation	Total Perimeter	Exposed Perimeter	Above Grade Exposed Perimeter	Depth Below Grade	Area, SqFt	I-Type	R-Value

Notes:

Frame Floor

Note where insulation was verified.

Floor Description	Location	Area, SqFt	I Type	Cavity?	R-Val/Grade

Notes:

Rim/ Band Joists

Note where insulation was verified.

Joist Description	Location	Area, Linear F	I Type	R-Value	Thickness	Grade	Rim/Band

Notes:

Exterior Walls

Note where insulation was verified.

Wall Description	Location	Area	I Type	Cavity?	R-Val/Grade

Notes:

Windows	*Windows/glass doors and skylights. Note whether or not tested for Low-e*							
Type of Glass	SqFt	Frame	Location	U-value	SHGC	T Break	O'hang/Dist.To Top	Orient
Notes:								

Ext. Doors

Door Type	Material	Insulated	Storm?	Type of Glass	Dr_SqFt	Gl SqFt	Orient.

Notes:

Ceiling Insulation

Note where insulation was verified.

Ceiling Construction	Flat/Cathedral	Area, SqFt	V Barrier	I Type	Cavity?	R-Val/Grade

Notes:

Sky Lights

Type of Glass	SqFt	Frame	Location	U-value	SHGC	T Break	Orient	Angle

Notes:

Mechanicals

Heating Equipment

Manufacturer	Model	Type	Age	Fuel	Location	Cap. Out	Efficiency

For Forced Air System, How is Fan Controlled?			
R-value for hydronic piping insulation:			

Notes:

Water Heating

Manufacturer	Model	Type	Age	Fuel	Location	Gallons	Energy Factor

R-value for water heater tank wrap:		Number of low-flow shower heads:	
R-value for water heater piping insulation:		Number of faucet aerators:	

Notes:

Room Air Conditioners

Manufacturer	Model	Type	Age	Evap. Location	Tons	Efficiency

Notes:

Duct Insulation

		For Insulation Only					
Supply/Return	Location*	Type	Quality	R-Value	Duct Type	Duct Sealing	Duct Leakage

Notes:

# of return grills	

Test Results

Blower door and Duct blaster

Repeat tests as needed to ensure precision.

If RAC installed, repeat test twice: once as-is and again with RAC taped off using duct mask tape

Blower Door Test 1 (at 50 Pa) **As-Is**	
Blower door type	Type 3
Ambient Temperature	
Fan Pressure (Pa)	
House Pressure (Pa)	
Rings/Holes	
CFM Leakage	

Duct Blaster Test 1 (at 25 Pa)	Total Leak Test	Out. Leak Test	
D.B. Fan Pressure (Pa)			System
Duct Pressure	25	25	
Rings			CFA Served
Blower door Fan (Pa)	0		
House Pressure (Pa)	0	25	
CFM Leakage			

Blower Door Test 2 (at 50 Pa) **RAC taped off**	
Blower door type	Type 3
Ambient Temperature	
Fan Pressure (Pa)	
House Pressure (Pa)	
Rings/Holes	
CFM Leakage	

Duct Blaster Test 2 (at 25 Pa)	Total Leak Test	Out. Leak Test	
D.B. Fan Pressure (Pa)			System
Duct Pressure	25	25	
Rings			CFA Served
Blower door Fan (Pa)	0		
House Pressure (Pa)	0	25	
CFM Leakage			

Blower Door Test 3 (at 50 Pa)	
Blower door type	Type 3
Ambient Temperature	
Fan Pressure (Pa)	
House Pressure (Pa)	
Rings/Holes	
CFM Leakage	

Duct Blaster Test 3 (at 25 Pa)	Total Leak Test	Out. Leak Test	
D.B. Fan Pressure (Pa)			System
Duct Pressure	25	25	
Rings			CFA Served
Blower door Fan (Pa)	0		
House Pressure (Pa)	0	25	
CFM Leakage			

Document areas of high leakage that were observed during blower door test:

Light Bulbs

Inventory all interior & exterior light bulbs, whether installed in hard-wired fixtures or plug-in lamps. Include CFLs in storage too.

Room	Number of CFL Bulbs	Number of Incand. Bulbs, incl Halogen,	Number of LED bulbs	Number of Fluorescent tube or Circline bulbs	Number of empty sockets	No. of Bulbs on Dimmer Switch

Appliances

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Type of ventilation system:					
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