# Vermont Single-Family Existing Homes Onsite Report

## *FINAL*

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**Submitted to:**

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# Executive Summary

Onsite inspections were conducted at 95 owner-occupied existing single-family homes in Vermont between August 2011 and February 2012. The objective of these inspections was to assess the energy characteristics of these homes in order to provide baseline data regarding the existing single-family homes market in Vermont. The inspections collected data on the general construction of the home, insulation, windows, heating and cooling equipment, water heating, ducts, appliances, and lighting. In addition, 31 homes underwent blower door testing to measure air leakage through the building shell.

Because 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) these GT regions were oversampled in the study.

The remainder of this section provides an overview of the key findings of the onsite visits. Because we over-sampled homes in the four geographically targeted regions, in order to estimate the statewide results we weight the results from the four regions and the remainder of Vermont.

## Findings

### Home Characteristics

The homes examined in this study included only owner-occupied single-family and two-family homes built before 2005 and occupied for at least six months of the year. Given these criteria, nearly all the homes visited are detached single family homes (95%). Below are additional details regarding the existing homes that received visits.

- The average conditioned floor area for homes is 1,972 square feet and the median is 1,793 square feet.
- Homes are, on average, about 66 years old with a median age of about 50 years.
- Statewide, about two-thirds of homes (63%) have full basements and 31% of homes have partial basements. The remaining 6% of homes do not have basements. Most basements are either fully conditioned or partially conditioned.
- Statewide, about one-half of all sampled homes depend on oil as the primary heating fuel, about 20% use natural gas, 15% use propane, and 12% use wood.
- Statewide, nearly every home sampled (98%) is the primary residence of the owner and is occupied year round. The average number of nighttime occupants is 2.3.
- Twenty-three percent of homes have a dedicated office space for running a business or working from home.

Compared to the 2007-2009 American Community Survey for Vermont, the onsite homes are similar in terms of primary heating fuel and average number of occupants. However, because this study targeted owner-occupied homes, it is biased towards detached single-family homes (95% vs. 66%). In addition, although the onsite sample excluded homes built after 2004, the distribution of homes by construction decade remains similar though fewer onsite homes are built after 2000 (1% vs. 7%). Overall, this comparison suggests that the sample of onsite homes in this study is consistent with ACS data on the existing housing stock in Vermont.

**Table ES-1: Comparison of Statewide Onsite data to ACS data**

| Characteristic | Statewide Weighted Sample | Vermont ACS 2007-2009 |
|---|---|---|
| *Number of Homes* | *95* | *313,370* |
| **Percent of homes that are detached Single-family** | 95% | 66% |
| **When Home Built** | | |
| Before 1939 | 33% | 29% |
| 1940 to 1959 | 13% | 10% |
| 1960 to 1979 | 32% | 25% |
| 1980 to 1999 | 20% | 29% |
| 2000 or later | 1% | 7% |
| **Primary Heating Fuel** | | |
| Fuel oil | 51% | 52% |
| Natural gas from underground pipes | 21% | 15% |
| Bottled gas | 15% | 15% |
| Electricity | 1% | 4% |
| Coal | <1% | <1% |
| Wood | 12% | 13% |
| **Average Number of Occupants** | 2.3 | 2.5 |

## Wall Insulation

- Fiberglass batts are installed in 56% of the conditioned-to-ambient wall area, followed by cellulose at 17%.
- Nine percent of homes have walls with no insulation; these walls represent 8% of conditioned-to-ambient wall area.
- Statewide, the average and median R-value for insulation in conditioned-to-ambient walls is R-13.4 and R-13.5, respectively.
    - Overall, about one-quarter of homes have an average of less than R-11 wall insulation; R-11 is the typical R-value for older fiberglass batts installed in 4" stud walls, the most common wall type and insulation type found in homes.
    - In contrast, 40% of homes were found to have an average R-value of R-19 or higher.

- Ninety percent of homes across the state with graded insulation in conditioned-to-ambient walls are either Grade II or Grade III quality. Grade I is the highest quality rating while Grade III is the lowest.[1]

## Ceiling Insulation

- Nearly all homes have some flat ceiling area and nearly 60% have some cathedral ceiling area.
- The most common flat ceiling insulation is fiberglass, representing 59% of flat ceiling area. Cellulose represents 29% of flat ceiling area.
    - The average and median R-value for flat ceiling insulation is about R-28.
    - Eighteen percent of homes with flat ceilings have an average of R-38 or higher insulation.
    - In contrast, about one-quarter of homes have an average of R-19 or less insulation installed in the flat ceilings. Three percent of homes have no insulation in their flat ceilings.
    - Most homes have either Grade II flat ceiling insulation (66%) or Grade III (23%).
- Fiberglass batts are the predominant insulation in cathedral ceilings, installed in 64% of the cathedral ceiling area. Rigid foam and SIPs each comprise about 13% of the cathedral ceiling area.
    - The average and median statewide R-values for cathedral ceiling insulation are R-20.5 and R-23, respectively.
    - Nearly one-quarter of homes with cathedral ceilings are insulated to an average of R-30 or higher.
    - In contrast, 38% of homes have cathedral ceilings with an average of R-19 insulation or lower. Six percent of homes with cathedral ceilings do not have any insulation installed in their cathedral ceilings.

[1] Bear in mind that auditors estimated the insulation installation grade of certain building components. This is unavoidable when conducting audits in completed and occupied homes. In instances where auditors could not access an insulated assembly, they made informed assumptions about the installation grade, typically based on the insulation installation quality observed elsewhere in the home. Viewing the quality of the attic insulation, insulation in basement walls, frame floor over basements, or kneewalls typically gave auditors an idea of the general level of care exercised in the installation of the insulation throughout the home. Appendix D provides examples of how auditors identified insulation installation grades.

## Floor Insulation

- Just 11% of the 44 homes with floors over unconditioned basements have insulation in those floors, although 23% of homes with floors over unconditioned basements have either insulated frame floors or insulated foundation walls. The average R-value of floor insulation over unconditioned space is R-13.
- Three of the eight homes with floors over unconditioned crawlspaces have insulation.
- Seventy-two percent of the 18 homes with floors over garages are insulated; these floors are insulated to an average R-value of R-24.
- Sixty percent of homes with exposed floors are insulated, representing 50% of the exposed floor area; the average R-value is R-21.5.

## Foundation Walls and Slabs

- Over three-quarters of the 20 homes with foundation walls 50% or more above grade have insulated foundation walls.
    - Of the 13 homes with insulated foundation walls, all have either fiberglass batts or rigid foam.
    - The average and median R-value of insulation is about R-11.
- Just-under thirty percent of the 82 homes with foundation walls less than 50% above grade have insulated foundation walls.
    - Ten of these 24 homes use fiberglass batts, 11 homes use rigid foam, and one home uses both types of insulation.
    - The average R-value of this insulation is about R-12 and the median is R-11.

## Rim and Band Joist Insulation

- Statewide, 52% of homes with conditioned to ambient joists have insulated joists. For joists that are insulated, the most common insulating material is fiberglass batts (37% of homes).

## Windows

- Double pane clear windows are the most common window type, representing 53% of all window area. Double pane low e windows represent 28% of all window area.
- Single pane windows represent 13% of all window area. Sixty-six percent of single-pane window area has storm windows.

## Building Shell Leakage

- A random sample of 31 homes was subjected to blower door tests of air infiltration at 50 Pascals. The test results yielded an average of 7.6 air changes per hour ACH50 statewide, with a median of 7.0 ACH50. The average CFM50 value is 1,990.

## Heating Systems

- Fifty-five percent of all homes have a single boiler, while 26% of homes have a single furnace. Other homes have a mix of multiple heating systems.
- The average age of boilers and furnaces is thirteen years and fourteen years, respectively; the median age is ten years for both boilers and furnaces.
- The average rated efficiency[2] of the natural gas and propane boilers was slightly higher than the oil boilers – 86% as compared to 85%.
- The average rated efficiency of gas furnaces was 89%, compared to 83% for oil furnaces.

## Temperatures and Controls

- Statewide, 60% of homes have manual thermostats; programmable thermostats are installed in about one-third of homes.

## Supplemental Heating Systems

- Statewide, 29% of homes have a fireplace; 71% of these fireplaces are fueled by wood, 26% use natural gas and 3% use propane.
- Forty-three percent of homes have one or more stoves, most of which are fueled by firewood (68%), although 18% use wood pellets.
- About one-quarter of homes have portable space heaters. Almost all of these space heaters are fueled by electricity. However, because some of the onsite visits were conducted in the early fall season, space heaters may not have been in use and therefore these figures may under-report the number in use during winter months.

## Air Conditioning

- Statewide, 17% of homes have a window air conditioning (AC) unit. Because most of the onsite visits were conducted in the fall and winter season, window AC units may have been removed and therefore these figures may under-report the number in use during summer months.
    - The window AC units with data available are an average of about nine years old, with an average efficiency of 10.9 EER.
- Only 2% of homes have central AC systems; the average age of the systems is about ten years, with an average efficiency of 11.3 SEER.

## Renewables

- Only two out of the ninety-five inspected homes have photovoltaic systems installed while none of the homes visited have wind turbines.
- One home has a solar-assisted water heating system.

[2] Auditors recorded AHRI-based AFUE figures whenever possible, and in other cases substituted manufacturer rated efficiencies or capacity calculations (output divided by input). Auditors did not measure steady state efficiencies.

## Ducts

- Statewide, 34% of homes have ducts installed. Of these 40 homes with ductwork, about two-thirds have duct runs in unconditioned basements and 5% in attics.
- Of the 27 homes with ducts in unconditioned space, 23 homes have rigid metal ducts and four have flexible metal ducts. Duct seams are sealed in about one-quarter of the homes with ducts in unconditioned space.
- Ducts are insulated in five of the 27 homes with ducts in unconditioned spaces. All five of these duct runs are insulated with fiberglass wrap, with R-values of R-5 to R-6.

## Water Heating

- Over one-half of homes (55%) have stand-alone tank water heaters, while the other one-half have a water heater integrated with their space heating system, either with a storage tank (20%) or a tankless coil system (22%). Only 3% have instantaneous water heaters.
- Statewide, 37% of homes have water heaters that use oil, 31% use electric, 20% use natural gas, and 12% use propane.
- The average energy factor for integrated tank water heaters is about 0.79.[3] The average energy factor for electric water heating systems is 0.91. Fossil fuel stand-alone water heating systems have an average energy factor of 0.60. The non-electric instantaneous water heaters have an average energy factor of 0.82. The average energy factor for tankless coil systems is 0.43.
- Statewide, 27% of the 82 homes with water heater tanks have tank insulation.
- Statewide, 24% of homes have insulation on their water heater piping. Among the homes with water heater piping insulation, 83% have about R-2 insulation.

## Low Flow Shower Heads and Faucet Aerators

- Statewide, about 41% of homes have low flow shower heads. Faucet aerators are found in 53% of all homes.

## Refrigerators

- All of the homes visited have at least one refrigerator and 6% have a second refrigerator.
- Seven percent of refrigerators are ENERGY STAR qualified.[4]
- Most refrigerators (80%) are in good condition, according to auditors; very few (4%) are considered to be in poor condition.
- About one-half of all refrigerators are less than ten years old. Eleven percent of refrigerators statewide are estimated to be 20 years or older.

[3] The energy factor of integrated tank water heaters is calculated by multiplying the boiler AFUE by 0.92.
[4] The ENERGY STAR database identifies only those models that meet the current ENERGY STAR criteria; older models that met the ENERGY STAR criteria in effect when sold would not be listed if they do not meet the current criteria. Therefore, the estimated penetration of ENERGY STAR appliances is likely a conservative estimate.

### Separate Freezers

- Separate freezers are found in 35% of homes.
- Nine percent of freezers are ENERGY STAR qualified.
- Seven out of ten separate freezers statewide are in good condition. Only 14% are rated in poor condition.
- Close to one-half of separate freezers are less than ten years old. Fourteen percent of separate freezers are 20 years or older.

### Dishwashers

- Dishwashers are found in about three-quarters of homes.
- Sixteen percent of dishwashers are ENERGY STAR qualified.
- Just over seventy percent of dishwashers are in good condition; only 6% are rated as poor.
- Two-thirds of dishwashers are under 10 years old. Thirteen percent of dishwashers are 20 years or older.

### Clothes Washers & Dryers

- Almost all homes have a clothes washer (96%).
    - Over two-thirds of clothes washers are top-loading models.
    - Twenty-five percent of clothes washers are ENERGY STAR qualified.
    - Two-thirds of clothes washers are in good condition; a small amount (6%) are rated as poor.
    - Close to one-half of all clothes washers are under 10 years old. Fourteen percent are 20 years or older.
- Almost all homes have a clothes dryer (96%).
    - Eighty-four percent of all clothes dryers use electricity. One-quarter of clothes dryers in the BED and VGS region use natural gas.
    - Almost 70% of clothes dryers are in good condition with very few (1%) rated as poor condition.
    - About one-half of clothes dryers are under ten years old. Statewide, 6% of all clothes washer are 20 years or older.

### Televisions and Peripherals

- Almost all homes (99%) have at least one TV set; one-half have at least two TV sets.
- Just under one-half (46%) of the TVs are CRT models. Over 40% are LCD models.
- Thirty-five percent of TVs are 31” in size or larger.

### Computers

- Nearly all homes (93%) have a computer, with 44% having two or more computers.
- Most homes (79%) also have a printer.

- Statewide, 81% of all computers are desktops .

## Lighting

- CFL bulbs are installed in 92% of all homes and 45% of homes have CFLs in storage.
- Statewide, homes have an average of 14.8 and median of 15 CFL bulbs installed, representing 33% of all CFL, incandescent, and LED bulbs.
- LED bulbs are installed in 4% of all homes representing <1% of bulbs.

## Auditor Ratings of Homes and Energy Features

- 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.' Overall, auditors rated 79% of homes as average (three out of five rating) or better. Sixteen percent of homes were rated a two and 6% were rated a one – indicating poor construction quality.
- Auditors were asked to rate the level of energy savings opportunities in each home, using a scale of one to five, where one means 'low' and five means 'high.' Statewide, 30% of homes were rated as a four or five, meaning they had a higher than average level of savings opportunities.
- Auditors ranked the worst energy features in each home, with up to four features listed per home. Overall, basement insulation R-value (including no insulation) was cited most frequently, for 58% of homes across the state. Interior lighting was noted in 51% of homes[5], followed by appliances (38%). Other poor energy features commonly noted include ceiling insulation R-value (29%), air infiltration (23%), duct insulation R-value (17%), and wall insulation R-value (16%).
- Basement insulation R-value was most often noted as the "worst" energy feature (28%) in homes, followed by ceiling insulation R-value (17%), and duct insulation R-value (10%). Basement insulation R-value also was most often noted as the second worst energy feature (21%), followed by interior lighting (16%) and appliances (14%).

[5] Although there are an average of almost 15 CFL bulbs per home representing 33% of CFL, incandescent, and LED bulbs installed, there still remains ample opportunity to increase the saturation of CFLs in Vermont homes.

## Savings Opportunities

In this section we discuss the savings opportunities for single-family existing homes in Vermont. The auditors rated 30% of homes across the state as having significant opportunities for energy efficiency upgrades. Below is a summary of the key savings opportunities in the building shell (Table ES-2). While the following tables present data separately for the GT regions and the non-GT regions (where the sample sizes are sufficient), for the most part the opportunities are similar in both regions.

- **Ceiling insulation.** Twenty-five percent of homes have R-19 or less insulation installed in flat ceilings. In addition, 38% of homes with cathedral ceilings have R-19 or less insulation installed. Auditors cited ceiling insulation as a poor energy feature in 29% of homes, and as the top-ranked worst feature in 17% of homes. Accessible flat ceiling spaces, in particular, present clear opportunities for insulation upgrades as well as air sealing.
- **Rim joist insulation.** Thirty-eight percent of homes with conditioned/ambient rim joists do not have insulation installed, which provides an opportunity for insulation upgrades as well as air sealing.
- **Basement insulation.** Seventy-seven percent of homes with unconditioned basements have neither foundation wall insulation nor frame floor insulation. In addition, 69% of homes with basement walls <50% above grade have no foundation wall insulation. Lastly, auditors noted basement insulation as a poor energy feature in 58% of homes, and as the top-ranked worst feature in 28% of homes. Foundation walls or frame floors provide a substantial opportunity for insulation and air sealing, depending on the level of finish of the basement interior.
- **Air Infiltration.** Almost one-third of the 31 homes tested for air infiltration are above 10.0 ACH50. In addition, auditors cited air infiltration as a poor energy feature in 23% of homes. Therefore, air sealing may present another savings opportunity.

## Table ES-2: Building Shell Summary

| Characteristic | Measurement | GT Regions | Non-GT Regions* | Statewide* |
|---|---|---|---|---|
| *Total Number of Homes*** | | *55* | *40* | *95* |
| Wall insulation | Average R-value | 14.2 | 13.1 | 13.4 |
| | Percent of homes with no insulation | 9% | 7% | 8% |
| Flat ceiling insulation | Average R-value | 28.8 | 27.6 | 27.9 |
| | Percent of homes ≤ R-19 | 23% | 26% | 25% |
| Cathedral Ceiling Insulation | Average R-value | 22.9 | 19.7 | 20.5 |
| | Percent of homes with cathedral ceilings ≤ R-19 | 29% | 44% | 38% |
| Rim joist insulation | Average R-value | 11.6 | 6.1 | 7.5 |
| | Percent of homes with no insulation | 31% | 40% | 38% |
| Basement Insulation | Percent of 44 homes with unconditioned basements that have no frame floor or foundation wall insulation | n/a | n/a | 77% |
| | Percent of 20 homes with basement walls >50% above grade with no foundation wall insulation | n/a | n/a | 22% |
| | Percent of 82 homes with basement walls <50% above grade with no foundation wall insulation | n/a | n/a | 69% |
| Windows | Percent of window area that is single pane | 21% | 9% | 13% |
| | Percent of single pane window area with storms | 55% | 79% | 66% |
| Air Infiltration | Average ACH50 value | 7.2 | 8.0 | 7.6 |
| | Percent of homes > 10.0 ACH50 | 27% | 38% | 32% |
| | *Number of Homes Tested* | *15* | *16* | *31* |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.
**These counts are the sample size for characteristics that apply to all homes visited for the study; in some cases the number of homes is lower for certain characteristics.

Below is a summary of the energy efficiency data for heating and hot water systems (Table ES-3). Given the high cost of replacement and moderate efficiency level of existing heating systems, there appear to be few clear opportunities for savings from heating system upgrades. However, there appear to be opportunities to seal and insulate ducts in nearly one-quarter of those homes with ducts located in unconditioned spaces; auditors noted that duct insulation was a poor energy feature in 17% of all homes. In addition, there may be some higher cost opportunities to improve water heater efficiency: install storage tanks for tankless coil systems (present in 22% of all homes) and replace electric storage tanks (present in almost one-quarter of homes) with heat pump water heaters.

**Table ES-3: Heating & Hot Water Summary**

| Characteristic | Measurement | Statewide* | *Number of Homes* |
|---|---|---|---|
| Heating system efficiency | Average efficiency of oil boilers | 85.0% | *25* |
| | Average efficiency of natural gas boilers | 85.7% | *14* |
| | Average efficiency of oil furnaces | 82.6% | *12* |
| | Average efficiency of natural gas furnaces | 89.5% | *18* |
| Heating system age | Percent units older than 20 years | 18% | *83* |
| Ducts | Percent of homes with ducts located in unconditioned space that are sealed | 26% | *27* |
| | Percent of homes with ducts located in unconditioned space that are insulated | 19% | *27* |
| Water heating efficiency | Average Energy factor of natural gas integrated tank systems | 0.80 | *8* |
| | Average Energy factor of oil integrated tank systems | 0.80 | *10* |
| | Average Energy factor of oil tankless systems | 0.42 | *12* |
| | Average Energy factor of natural gas storage tanks | 0.60 | *20* |
| | Average Energy factor of electric storage tanks | 0.91 | *15* |

*Results for the Statewide column are weighted.

Below is a summary of the key savings opportunities for appliances, lighting, and other products (Table ES-4).

- **Refrigerators.** One-quarter of refrigerators are 15 years or older, which may present an opportunity for appliance retirement. In addition, auditors cited appliances (though not specifically refrigerators) as a poor energy feature in 38% of homes.
- **Lighting.** While the overall CFL bulb saturation is relatively high (33%), there still remains a significant opportunity to replace incandescent bulbs with CFLs in homes. In addition, interior lighting was cited as a poor energy feature by auditors at 51% of the homes.
- **Piping Insulation.** About one-quarter of the homes have hot water pipe insulation. In addition, of the homes that do have pipe insulation, it typically does not cover the full length of exposed pipes. While some of these pipes may be located in conditioned spaces, adding insulation is a relatively inexpensive proposition.

**Table ES-4: Appliance, Lighting, & Products Summary**

| Characteristic | Measurement | GT Regions | Non-GT Regions* | Statewide* |
|---|---|---|---|---|
| *Total Number of Homes*** | | *55* | *40* | *95* |
| Refrigerators | Percent ENERGY STAR | 15% | 5% | 7% |
| | Percent 15 years or older | 19% | 28% | 26% |
| Clothes washers | Percent ENERGY STAR | 25% | 26% | 25% |
| Dishwashers | Percent ENERGY STAR | 8% | 13% | 16% |
| Lighting | CFL bulb saturation as a percent of CFL, incandescent, and LED bulbs | 31% | 35% | 33% |
| Thermostats | Percent of homes with programmable thermostats | 35% | 34% | 33% |
| Hot water pipe insulation | Percent of homes with hot water pipe insulation | 9% | 28% | 24% |
| Low-flow showerheads | Percent of homes with low flow showerheads | 31% | 45% | 41% |
| Faucet aerators | Percent of homes with faucet aerators | 44% | 55% | 53% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

**This count is the sample size for characteristics that apply to all homes visited for the study; in some cases the number of homes is lower.

# 1 Introduction

Onsite inspections were conducted at 95 existing single-family homes in Vermont between August 2011 and February 2012. The objective of these inspections is to assess the energy characteristics of these homes in order to provide baseline data regarding the existing single-family homes market in Vermont.

## 1.1 Existing Homes Market in Vermont

Table 1-1 summarizes the housing characteristic data for Vermont homes, which includes both single-family and multi-family homes. Of the 313,370 housing units in Vermont, 66% are single-family detached homes and 13% are two-family buildings. Over one-half of the buildings were constructed between 1960 and 1999, and 52% are primarily heated with oil. Eighty percent of the housing units are occupied, of which 72% are owner-occupied with an average of 2.5 occupants each. We estimate that 150,101 of the housing units in Vermont match the eligibility criteria for this study: owner-occupied single-family detached or two-unit homes built prior to 2005.

**Table 1-1: Summary of ACS data for Vermont**

| Characteristic | Vermont ACS 2007-2009 |
|---|---|
| *Number of Housing Units* | *313,370* |
| **Type of Home** | |
| Detached Single-Family | 66% |
| Attached Single-Family | 4% |
| Two-family/duplex | 13% |
| Five or more Units | 10% |
| Other | 7% |
| **When Structure Built** | |
| Before 1939 | 29% |
| 1940 to 1959 | 10% |
| 1960 to 1979 | 25% |
| 1980 to 1999 | 29% |
| 2000 or later | 7% |
| **Primary Heating Fuel** | |
| Fuel oil | 52% |
| Natural gas from underground pipes | 15% |
| Bottled gas | 15% |
| Electricity | 4% |
| Coal | <1% |
| Wood | 13% |
| **Occupation of Housing Units** | |
| Percent Occupied | 80% |
| Percent Vacant | 20% |
| **Tenure of Occupied Housing Units** | |
| Owner-occupied | 72% |
| Renter-occupied | 28% |
| **Average number of occupants** | |
| Owner-occupied housing units | 2.5 |
| Renter-occupied housing units | 2.1 |

## 1.2 Onsite Audit Data Collection

The scheduling of the onsite visits followed the recruitment of volunteers through the telephone survey of owners of 289 existing single-family homes.[6] The following steps were undertaken to minimize customer intrusion, improve recruitment rates, and minimize bias in the selection of homes visited.

- *Advance Notice.* The pool of potential recruits was provided advance notice through the telephone surveys.
- *Use of incentives.* An incentive of $50 and a brief energy efficiency report on their home was offered to all customers.
- *Confirmation Calls.* Each scheduled appointment was called at some point 48 hours before the visit to confirm the appointment.

***Onsite Inspection Data Collection.*** *The primary objective of the onsite visit is to collect data on the following features of the home:*

- General information including: house type, number of stories, size of conditioned space in main home and basement, occupancy, etc.
- Envelope features on thermal boundary of home including: wall, ceiling and floor insulation locations, types, and R-values; window type and location; and door type.
- Heating, cooling, and water heating equipment including: manufacturer and model, age, type, location, fuel used, size, and efficiency rating.
- Duct insulation including whether it is on the supply or return ducting, location, insulation type and estimated R-value.
- Type of duct sealing, if any.
- Appliances and electronics present at the home including dishwashers, clothes washers, dryers, ovens, refrigerators, freezers, room air conditioners, televisions, and computers. Data collected includes manufacturer and model, type, approximate age and size.
- Inventory of light bulbs by bulb type.

In order to measure air infiltration through the building shell, we conducted blower door tests at 31 randomly selected homes among the 95 existing single-family homes. 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.

**Data cleaning.** As part of the data review process, the NMR team reviewed the population of data in each field for reasonableness, cleaned skip patterns, and ensured all data are in consistent units. The NMR team reviewed individual input forms as necessary and discussed resolution of inconsistencies with the auditor who conducted the onsite inspection.

[6] Survey Analysis of Owners of Existing Homes in Vermont, DRAFT. September 14, 2011. Submitted to Vermont Public Service Department. Submitted by NMR Group, Inc.

## 1.3 Sample Plan

### 1.3.1 Sample Definition

As discussed in the *Final Definitions for 2011 Residential Market Characterization Study*[7] memo, single-family homes were defined to include the following types of 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.
- Two-family home or duplex

This definition of single-family homes excludes the following types of homes:

- Part of a building with three or more units (including attached homes)
- Manufactured home that was built at a factory and delivered as a single unit, often known as a mobile home, or single or double-wide trailer

The definition of existing homes includes only those homes built prior to 2005, according to the homeowner. Because owner occupants are the primary decision-makers for their homes (rather than landlords, who are the primary decision-makers for rental homes), the sample was restricted to owner-occupied homes. Owner-occupied vacation homes were included only if the respondent reported residing in the home for at least six months of each year.

Three manufactured homes were inspected due to inaccurate home descriptions provided by the homeowners; these manufactured homes are analyzed separately from other single-family homes in Appendix C.

[7] *Final Definitions for 2011 Residential Market Characterization Study.* April 14, 2011

### 1.3.2 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. In addition, the information is presented separately for the Burlington Electric Department (BED) service territory and 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.

Table 1-2 on the next page displays each GT region, the towns selected to represent the GT region, and the number and percent of GT accounts in each town.

## Table 1-2: 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% |
| 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% |

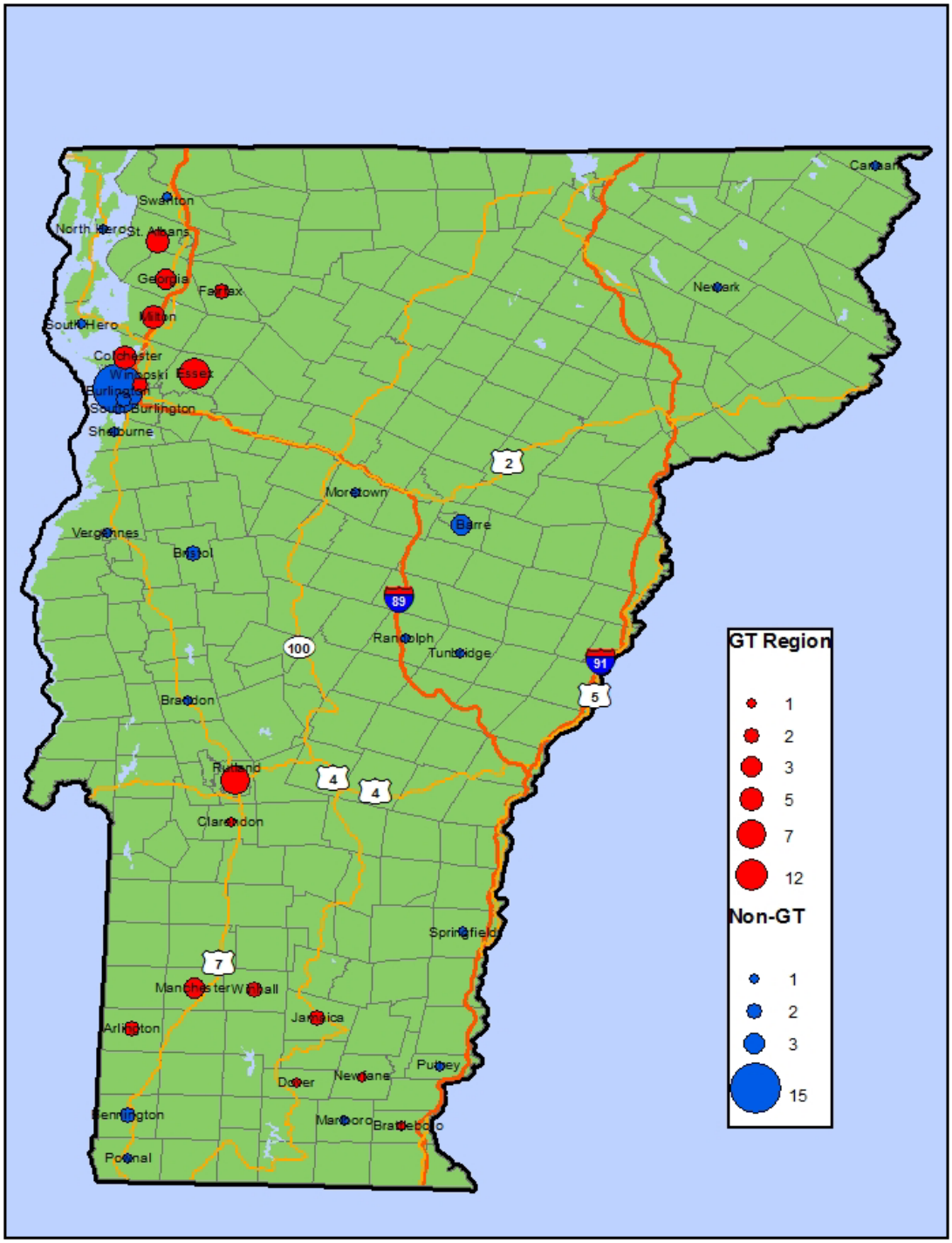
Four of the eleven towns located in the Northern Chittenden region were selected; these four towns represent 94% of the GT accounts in the Northern Chittenden region. Three of the fourteen towns located in the Rutland region were selected; these three towns represent 93% of the GT accounts in the Rutland 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 1-3).

**Table 1-3: 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% |

Figure 1-1 shows the geographic distribution of onsite audits across the state. The relative size of the circles corresponds to the number of audits conducted in that town. GT regions are identified with red circles, and non-GT regions are in blue.

**Figure 1-1: Map of Onsite Audits in Vermont**



## 1.4 Sampling Error

In developing the onsite sample design, we drew from our experience in the 2008 Baseline Study to determine a coefficient of variation (CV); however, at this stage in the study we are able to utilize actual coefficients from this study to estimate the final precisions of key home characteristics. The equations to estimate the required sample size based upon known data relationships are as follows:

$$n_0 = \left( \frac{z \times CV}{R} \right)^2 \qquad n_1 = \left( \frac{n_0}{1 + \frac{n_0}{N}} \right)$$

where,

$n_0$ = the required sample size before adjusting for the size of the population,

$z$ = a constant based on the desired level of confidence, e.g., 1.645 for the 90% level of confidence,

CV = Coefficient of variation describing the level of variability within the data,

R = the desired relative precision,

$n_1$ = the required sample size after adjusting for the size of the population using the *finite population correction factor*,

$N$ = the population size, i.e., the number of sample points in a particular treatment group.

The CV is of central importance in determining the final precisions. A primary objective of this study is to document the existing building and equipment status of single-family existing homes by feature. Because there is no single variable that quantifies a home's construction features and this study provides results for multiple variables, we identified several items that we believe are influential in the determination of a home's overall efficiency. Table 1-4 lists the key parameters that were measured during the onsite visits in Vermont along with the CV associated with these measurements. We use the largest CV for each region in order to provide a conservative estimate of the relative precision for the results from each region (Table 1-5).

**Table 1-4: Coefficients of Variation for Key Measurements**

| Parameter | GT Regions | Non-GT Regions | BED | VGS | Statewide |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Wall Insulation (R-Value) | 0.47 | 0.55 | 0.62 | 0.52 | 0.50 |
| Heating system (efficiency) | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Air Infiltration (ACH50) | 0.53 | 0.43 | 0.49 | 0.41 | 0.47 |
| Flat Ceiling Insulation (R-Value) | 0.35 | 0.43 | 0.38 | 0.36 | 0.39 |

**Table 1-5: Estimated Relative Precision by Region**

| Geographic Area | Sample Size | Population | Relative Precision at 90% Confidence level |
|---|---|---|---|
| Burlington Electric | 15 | 4,401 | ±26% |
| Vermont Gas | 36 | 40,139 | ±14% |
| GT Regions | 55 | 37,116 | ±12% |
| Non-GT Regions | 40 | 112,985 | ±14% |
| Statewide | 95 | 150,101 | ±8% |

## 1.5 Bias

Potential bias is a concern in any sample based on voluntary participation. Compared to the 2007-2009 American Community Survey for Vermont, the onsite homes are similar in terms of primary heating fuel and average number of occupants (Table 1-6). However, because this study targeted owner-occupied homes, it is biased towards detached single-family homes (95% vs. 66%). In addition, although the onsite sample excluded homes built after 2004, the distribution of homes by construction decade remains similar, although fewer onsite homes are built after 2000 (1% vs. 7%). Overall, this comparison suggests that the sample of onsite homes in this study is consistent with ACS data on the existing housing stock in Vermont.

**Table 1-6: Comparison of Statewide Onsite data to ACS data**

| Characteristic | Statewide Weighted Sample | Vermont ACS 2007-2009 |
|---|---|---|
| *Number of Homes* | *95* | *313,370* [a] |
| **Percent of homes that are detached Single-family** | 95% | 66% |
| **When Home Built** | | |
| Before 1939 | 33% | 29% |
| 1940 to 1959 | 13% | 10% |
| 1960 to 1979 | 32% | 25% |
| 1980 to 1999 | 20% | 29% |
| 2000 or later | 1% | 7% |
| **Primary Heating Fuel** | | |
| Fuel oil | 51% | 52% |
| Natural gas from underground pipes | 21% | 15% |
| Bottled gas | 15% | 15% |
| Electricity | 1% | 4% |
| Coal | <1% | <1% |
| Wood | 12% | 13% |
| **Average Number of Occupants** | 2.3 | 2.5 |

There are many factors that may influence a homeowner's willingness to have their home audited. Owners who think their home is energy efficient may be more willing to participate because they are proud of their home or, conversely, less willing because they feel confident their home is energy efficient and that the audit would not be useful. In contrast, owners who think their home may not be energy efficient may be more interested in order to learn what they could do to improve its energy efficiency or, conversely, less interested because they are not able or willing to invest in upgrades. Overall, there is no clear indication of bias in terms of the energy efficiency of audited homes; some are energy efficient and some are not.

Only 31 of the 95 audited homes received blower door tests; in addition, homes with asbestos or vermiculite insulation did not receive blower door tests due to health and safety concerns. Therefore, we compare the size and age of homes that did and did not receive blower door tests in Table 1-7. The homes that did not receive blower door tests appear to be slightly larger and

slightly older, although neither of the average values are significantly different at the 90% confidence level.

**Table 1-7: Comparison of Homes that received Blower Door Tests**

| Characteristic | Received Blower Door Test | Did Not Receive Blower Door Test |
|---|---|---|
| *Number of Homes* | *31* | *64* |
| **Conditioned Floor Area** | | |
| Average | 2,015 | 2,050 |
| Median | 1,770 | 1,872 |
| **Age of Home** | | |
| Average | 54.5 | 63.8 |
| Median | 48.0 | 48.5 |

## 1.6 Weighting

Because we over-sampled homes in the four geographically targeted regions, in order to estimate the statewide results we weight the results from the four regions and the remainder of Vermont.

The statewide weight for each of the five regions is developed by dividing the proportion of single-family homes in the population by the proportion of completed visits in each region. Table 1-8 displays the estimated number and percent of single-family homes and onsite visits, as well as the calculated weight. Note that these statewide weights are used only when estimating results for the entire state.

**Table 1-8: Statewide Weighting Scheme**

| Region | Estimated Number of Single-Family Homes | Percent of Homes | Number of Completed Onsites | Percent of Onsites | Weight |
|---|---|---|---|---|---|
| N. Chittenden | 10,966 | 7.3% | 19 | 20.0% | 0.37 |
| Rutland | 6,287 | 4.2% | 8 | 8.4% | 0.50 |
| Southern Loop | 11,374 | 7.6% | 13 | 13.7% | 0.55 |
| St. Albans | 8,489 | 5.7% | 15 | 15.8% | 0.36 |
| Remainder of VT minus Burlington | 108,584 | 72.3% | 25 | 26.3% | 2.75 |
| Burlington | 4,401 | 2.9% | 15 | 15.8% | 0.19 |

In addition, because the Non-GT region includes an oversample of Burlington respondents, we have used a similar approach to weight the Non-GT region data. We apply a weight of 1.54 to the Remainder respondents and a weight of 0.10 to Burlington respondents only when estimating the Non-GT region results.

Most tables in this document present unweighted results for the GT regions, BED respondents, and VGS respondents, while the non-GT region and statewide responses are weighted. In some

cases, due to limited sample sizes, unweighted percentages or counts are presented; table notes indicate when this is the case. In addition, due to the small sample size for some data, only statewide results are presented.

Note that the sample sizes may vary between tables, depending on whether the characteristic is applicable to some or all of the homes visited. In addition, sometimes the sample sizes vary within a table; for example, auditors may be able to identify the type of insulation present but not inspect it closely enough in order to grade its installation quality.

# 2 Home Characteristics

Because the onsites targeted owner-occupied single-family and two-family homes, nearly all of the onsite homes are detached single-family homes (95%) (Table 2-1). According to the 2007-2009 American Community Survey (ACS) for Vermont, detached single-family homes represent 66% of all housing units in Vermont.

**Table 2-1: Types of Homes**

(all homes)

| | GT Regions | Non-GT Regions** | BED | VGS | Statewide* | ACS |
|---|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* | *313,370*[a] |
| Detached Single-Family | 93% | 95% | 100% | 94% | 95% | 66% |
| Attached Single-Family | 5% | 0% | 0% | 3% | 2% | 4% |
| Two-family/duplex | 2% | 5% | 0% | 3% | 3% | 13% |
| Five or more Units | 0% | 0% | 0% | 0% | 0% | 10% |
| Other | 0% | 0% | 0% | 0% | 0% | 7% |

[a] ACS base = all housing units

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Figure 2-1 shows pictures of three typical homes visited for this study.

**Figure 2-1: Examples of Existing Homes Visited**

Statewide, about two-thirds of the onsite homes are less than two stories in height and about one-third are two stories or greater in height (Table 2-2).

**Table 2-2: Number of Stories of Homes**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| One to One-and-a-half | 60% | 70% | 27% | 50% | 68% |
| Two to Two-and-a-half | 40% | 30% | 73% | 50% | 32% |
| Three or more | 0% | 0% | 0% | 0% | 0% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 2-3 displays the age of homes in this study versus the age of homes from the Vermont ACS. The distribution of homes by age range is similar, although there tend to be fewer onsite homes built after 2009 (1% vs. 7%). As noted earlier, the onsite homes were screened to only include those built before 2005, which may cause this discrepancy.

**Table 2-3: When Home was Built**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* | ACS |
|---|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* | *313,370*[a] |
| Before 1939 | 24% | 35% | 33% | 25% | 33% | 29% |
| 1940 to 1959 | 15% | 13% | 40% | 28% | 13% | 10% |
| 1960 to 1979 | 24% | 35% | 13% | 19% | 32% | 25% |
| 1980 to 1999 | 34% | 18% | 14% | 27% | 20% | 29% |
| 2000 or later | 4% | 0% | 0% | 0% | 1% | 7% |
| Average Age (years) | 55.6 | 69.1 | 65.6 | 57.2 | 66.2 | n/a |
| Median Age (years) | 42.0 | 53.7 | 61.0 | 55.0 | 49.7 | n/a |

[a] ACS base = all housing units

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

The average conditioned floor area[8] is 1,972 square feet and the median is 1,793 square feet (Table 2-4). The average figures are similar across the different regions.

**Table 2-4: Square Feet of Conditioned Area**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Minimum | 718 | 952 | 952 | 952 | 718 |
| Maximum | 4,866 | 3,520 | 3,520 | 4,866 | 4,866 |
| Average | 2,106 | 1,929 | 1,976 | 2,092 | 1,972 |
| Median | 1,903 | 1,724 | 1,647 | 1,874 | 1,793 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[8] The RESNET definition of conditioned floor area (CFA) includes all finished space that is within the 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).

Table 2-5 displays the percent of homes with full basements, partial basements, and no basements as well as the level of conditioning. If a basement contains either conditioned floor area or conditioned volume, then it is considered to be a conditioned basement.[9] In a partially conditioned basement, a portion of the basement area is conditioned while a portion is not conditioned.

Almost two-thirds of homes have full basements and nearly one-third have partial basements. An equal amount of homes (39%) have fully conditioned and partially conditioned basements; sixteen percent have unconditioned basements.

**Table 2-5: Basement Type**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| **All Full Basements** | **73%** | **59%** | **53%** | **64%** | **63%** |
| Fully Conditioned | 18% | 22% | 13% | 19% | 22% |
| Unconditioned | 11% | 17% | 27% | 17% | 15% |
| Partially Conditioned | 44% | 20% | 13% | 28% | 26% |
| **All Partial Basements** | **25%** | **32%** | **47%** | **36%** | **31%** |
| Fully Conditioned | 9% | 20% | 13% | 11% | 17% |
| Unconditioned | 4% | 0% | 13% | 8% | 1% |
| Partially Conditioned | 13% | 12% | 20% | 17% | 13% |
| **All No Basement** | **2%** | **10%** | **0%** | **0%** | **7%** |
| Crawl space | 2% | 5% | 0% | 0% | 4% |
| Garage | 0% | 5% | 0% | 0% | 3% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[9] A rule of thumb we used is that if a basement is directly – and fully – heated, it is considered CFA regardless of insulation or finish. Also, if a basement is fully finished, it is also considered CFA regardless of its heating configuration. If the basement is fully insulated but not finished or heated, it is part of the conditioned volume and not CFA.

For homes with full basements, the average basement size is 1,032 square feet (Table 2-6). For those homes with partial basements, the average size is 742 square feet. For those homes with partially conditioned basements, on average 50% of the basement area is conditioned.

**Table 2-6: Basement Size and Conditioning**

(all homes with basements)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| **All Full Basements** | | | | | |
| *Number of Homes* | *40* | *23* | *8* | *23* | *63* |
| Average Basement Area (s.f.) | 1,133 | 988 | 1,127 | 1,068 | 1,032 |
| Median Basement Area (s.f.) | 1,031 | 954 | 966 | 990 | 954 |
| **All Partial Basements** | | | | | |
| *Number of Homes* | *14* | *15* | *7* | *13* | *29* |
| Average Basement Area (s.f.) | 1,041 | 667 | 758 | 852 | 742 |
| Median Basement Area (s.f.) | 997 | 703 | 690 | 752 | 720 |
| **All Partially Cond. Basements** | | | | | |
| *Number of Homes* | *8* | *10* | *6* | *9* | *18* |
| Average % Conditioning | 52% | 49% | 60% | 55% | 50% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Twenty-three percent of homes have a dedicated office space for running a business or working from home (Table 2-7). Most of the home offices are between 100 s.f. and 200 s.f. in size.

**Table 2-7: Home Offices**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Homes with Home Offices | 24% | 23% | 13% | 22% | 23% |
| *Number of Home Offices* | *12* | *8* | *2* | *7* | *20* |
| Less than 100 square feet | 5 | 1 | 2 | 4 | 27% |
| 100 to 200 square feet | 6 | 7 | 0 | 3 | 70% |
| Over 200 square feet | 1 | 0 | 0 | 0 | 3% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Four percent of homes have a swimming pool; three of these five pools are heated though none have timers on their pumps (Table 2-8). Of the three homes with heated pools, two use natural gas as the heating fuel and one uses solar thermal.

Four percent of homes have a hot tub; of the four homes with hot tubs, three use electricity as the heating fuel and one uses propane.

### Table 2-8: Swimming Pools & Hot Tubs

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Homes with swimming pools | 7% | 5% | 0% | 8% | 4% |
| Homes with hot tubs | 2% | 5% | 13% | 3% | 4% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Because the study screened for owners who lived in their homes for at six months of the year, nearly every home in the sample (98%) is the primary residence of the owner for the entire year (Table 2-9).

### Table 2-9: Occupancy

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *36* | *15* | *95* |
| Primary | 95% | 100% | 100% | 100% | 98% |
| Mainly Summer | 2% | 0% | 0% | 0% | 0% |
| Mainly Winter | 4% | 0% | 0% | 0% | 2% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Owner occupied homes have, on average, 2.3 nighttime occupants and 1.2 occupants on workdays (Table 2-10). These figures are consistent with the ACS, where owner occupied households in Vermont had an average of 2.5 people.

**Table 2-10: Nighttime & Workday Occupants**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *53* | *40* | *36* | *15* | *93* |
| **Occupants, Nights** | | | | | |
| Average | 2.8 | 2.2 | 2.5 | 2.7 | 2.3 |
| Median | 2.0 | 1.0 | 2.0 | 2.0 | 2.0 |
| **Occupants, Workdays** | | | | | |
| Average | 1.8 | 1.0 | 2.2 | 1.8 | 1.2 |
| Median | 2.0 | 1.0 | 2.0 | 1.5 | 1.0 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

# 3 Building Envelope

This section presents the onsite results for walls, ceilings, floors, basement slabs, windows, and doors.

## 3.1 Wall Insulation

Wall framing was determined based on the depth of the wall, which was determined either by looking at the width of a door frame or window, or by removing an electrical outlet cover and measuring the depth of the wall.

About one-half of homes statewide have 2x4 construction in conditioned/ambient walls, while about one-third have 2x6 construction (Table 3-1). Homes in the GT regions are more likely than those from the non-GT regions to have 2x6 construction. A few homes have something other than stud walls: structural insulated panels (SIPs), stone, and insulated concrete forms (ICF), for example. The categories in the following table are exclusive categories, such that each home is only counted once.

**Table 3-1: Type of Construction for Conditioned/Ambient Walls**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| 2 x 4, 16” on center | 46% | 52% | 47% | 44% | 50% |
| 2 x 4, 24” on center | 0 | 4% | 0% | 3% | 3% |
| 2 x 4, 16” and 2 x 6, 16” | 6% | 8% | 7% | 8% | 7% |
| 2 x 6, 16” on center | 42% | 32% | 40% | 36% | 35% |
| 2 x 6, 20” on center | 2% | 0% | 0% | 3% | 0% |
| 2 x 6, 16” and 2 x 6, 24” | 2% | 0% | 0% | 0% | 0% |
| 2 x 6, 16” and ICF | 2% | 0% | 0% | 3% | 0% |
| SIPs | 0% | 4% | 0% | 0% | 3% |
| Stone | 0% | 0% | 7% | 3% | 0% |
| Post and beam structure | 2% | 0% | 0% | 0% | 1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted

Wall insulation characteristics were frequently verifiable in the basement or attic knee walls. The default assumption for the type of insulation was fiberglass batts if that was the type of insulation visible in other areas of the home. The default assumptions for the level of fiberglass insulation were R-19 for 2x6 stud walls and R-11 for 2x4 stud walls; these are common insulation values for these size walls.

Over one-half of homes have fiberglass batts installed in at least some conditioned/ambient walls, and 17% have blown-in cellulose installed in at least some walls (Table 3-2). About five percent of homes statewide have more than one type of insulation in conditioned/ambient walls.

The auditors also rated the quality of the insulation installation on a scale from Grade I to Grade III, where Grade I is the highest quality.[10] If the insulation installation was visible, then auditors applied the RESNET definitions to determine the installation grade. When the insulation was not visible (e.g., an enclosed wall cavity) auditors used what was observed in other areas of the home to help estimate the installation grade for that particular component. For example, if interior wall insulation was visible in a basement and assigned a Grade II installation, then the above grade walls for that home were also assigned a Grade II installation. Ninety percent of homes across the state with graded insulation in conditioned/ambient walls received either a Grade II or Grade III assessment.

The categories in the following table are exclusive categories, such that each home is only counted once.

**Table 3-2: Type & Grade of Insulation in Conditioned/Ambient Walls by Percent of Homes**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| **Insulation Type** | | | | | |
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Fiberglass Batts | 64% | 48% | 53% | 61% | 52% |
| Cellulose | 9% | 20% | 13% | 11% | 17% |
| Spray-in high density foam or Icynene | 4% | 0% | 0% | 0% | 1% |
| Blown-in Fiberglass | 2% | 0% | 0% | 0% | 0.4% |
| Rock Wool | 2% | 0% | 0% | 0% | 0.4% |
| ICF | 2% | 0% | 0% | 3% | 0.4% |
| Panel Construction | 0% | 4% | 0% | 0% | 3% |
| Fiberglass Batts & Cellulose | 4% | 0% | 0% | 0% | 1% |
| Fiberglass Batts & Vermiculite | 0% | 4% | 0% | 0% | 3% |
| Fiberglass Batts & None | 0% | 0% | 13% | 6% | 0.4% |
| Rigid Foam & Unknown | 2% | 0% | 0% | 0% | 1% |
| None | 9% | 8% | 7% | 8% | 8% |
| Unknown | 4% | 16% | 13% | 11% | 13% |
| **Insulation Installation Grade** | | | | | |
| *Number of Homes* | *48* | *31* | *11* | *28* | *79* |
| Grade I Installation | 10% | 10% | 0% | 0% | 10% |
| Grade I & Grade II Installation | 4% | 0% | 0% | 7% | 1% |
| Grade II Installation | 63% | 59% | 36% | 54% | 60% |
| Grade II & Grade III Installation | 6% | 15% | 0% | 4% | 13% |
| Grade III Installation | 17% | 17% | 64% | 36% | 17% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[10] The insulation grades are described in Appendix D.

Table 3-3 displays the insulation types by the percent of wall area. Fiberglass batts represent 56% of wall insulation area, followed by cellulose at 17%. Eight percent of wall area has no insulation.

**Table 3-3: Type of Insulation in Conditioned/Ambient Walls by Percent of Area**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| **Insulation Type** | | | | | |
| Fiberglass Batts | 59% | 54% | 59% | 57% | 56% |
| Cellulose | 11% | 18% | 14% | 12% | 17% |
| Spray-in high density foam or Icynene | 6% | 0% | 0% | 0% | 1% |
| Blown-in Fiberglass | 2% | 0% | 0% | 0% | 0.5% |
| Rock Wool | 2% | 0% | 0% | 0% | 0.4% |
| ICF | 2% | 0% | 0% | 2% | 0.3% |
| Panel Construction | 0% | 4% | 0% | 0% | 3% |
| Rigid Foam | 0.3% | 0% | 0% | 0% | 0.1% |
| Vermiculite | 0% | 2% | 0% | 0% | 2% |
| None | 9% | 7% | 14% | 13% | 8% |
| Unknown | 6% | 14% | 8% | 10% | 12% |

Statewide, the average R-value and median R-value for insulation in conditioned/ambient walls is R-13.4 and R-13.5, respectively (Table 3-4).[11] In the BED service territory, the median is R-11.4. The GT regions have a higher R-value than the state average at R-14.2, but this is at least partly due to the presence of one home with R-36 spray-in high density foam insulation.

**Table 3-4: R-value Statistics for Insulation in Conditioned/Ambient Walls**

(homes with known insulation)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *53* | *33* | *12* | *31* | *86* |
| Minimum | 0 | 0 | 0 | 0 | 0 |
| Maximum | 36 | 24 | 19 | 20 | 36 |
| Average | 14.2 | 13.1 | 11.4 | 12.8 | 13.4 |
| Median | 13.3 | 13.5 | 11 | 13 | 13.5 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[11] An area-weighted U-value calculation was used to estimate the average R-value for each home, similar to the approach outlined in the RBES manual. Homes with an unknown R-value of insulation are not included in the calculation, although the homes with no insulation are included assuming an R-value of zero.

Overall, about one-quarter of homes have an average of less than R-11 wall insulation; R-11 is the typical R-value for older fiberglass batts installed in 4" stud walls, the most common wall type and insulation type found in homes (Table 3-5). Nine percent of homes were found to have no insulation in conditioned/ambient walls. In contrast, 40% of homes were found to have an average R-value of R-19 or higher.

**Table 3-5: Ranges of Average R-value for Insulation in Conditioned/Ambient Walls**

(homes with known insulation)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *53* | *33* | *12* | *31* | *86* |
| No Insulation | 9% | 10% | 8% | 10% | 9% |
| Insulation R-Value less than 11 | 4% | 19% | 25% | 16% | 15% |
| Insulation R-Value 11 | 21% | 15% | 25% | 16% | 16% |
| Insulation R-Value > 11 & <19 | 23% | 19% | 17% | 23% | 20% |
| Insulation R-Value 19 | 32% | 28% | 25% | 32% | 30% |
| Insulation R-Value > 19 | 11% | 9% | 0% | 3% | 10% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 3-6 displays the insulation type, installation grade, and R-value statistics for attic kneewalls (i.e., conditioned/attic walls) and walls between conditioned spaces and garages. About 7% of homes with conditioned/attic walls statewide have un-insulated conditioned/attic walls. The most common insulation type in the case of both conditioned/attic and conditioned/garage walls is fiberglass batts (60% and 63% of homes, respectively). Eighty-five percent of insulated conditioned/garage walls were estimated to have a Grade I or Grade II quality insulation installation, compared to 53% of conditioned/attic walls.[12]

The median R-value of insulation in conditioned/attic walls and conditioned/garage walls is R-13.5. However, the average R-value is 12.3 for conditioned/attic walls and R-14.1 for conditioned/garage walls.

[12] Like with other walls and certain assemblies, some amount of estimation is required here; auditors provided insulation ratings based on the insulation installation quality elsewhere in the home. The insulation grades are described in Appendix D.

### Table 3-6: Insulation Type, Installation Grade, & R-value Statistics for Insulation in Conditioned/Attic & Conditioned/Garage Walls

(homes with conditioned/attic or conditioned/garage walls)

| | Conditioned/Attic Statewide* | Conditioned/Garage Statewide* |
|---|---|---|
| **Insulation Type** | | |
| *Number of Homes* | *35* | *43* |
| Fiberglass Batts | 60% | 63% |
| Cellulose | 1% | 0% |
| Spray-in high density foam/Icynene | 1% | 3% |
| Blown-in Fiberglass | 0% | 1% |
| ICF | 0% | 1% |
| Vermiculite | 7% | 0% |
| Rock Wool | 0% | 1% |
| None | 7% | 2% |
| Unknown | 23% | 30% |
| **Insulation Installation Grade** | | |
| *Number of Homes* | *25* | *35* |
| Grade I Installation | 2% | 5% |
| Grade II Installation | 83% | 48% |
| Grade III Installation | 15% | 47% |
| **R-value Statistics** | | |
| *Number of Homes* | *32* | *39* |
| Minimum | 0 | 0 |
| Maximum | 19 | 36 |
| Average | 12.3 | 14.1 |
| Median | 13.5 | 13.5 |

* Data is weighted.

## 3.2 Ceiling Insulation

In a few cases, auditors were not able to access all ceiling areas during their audits, and the following tables reflect this situation. Areas with unknown information are noted in the tables below. Nearly all homes (97%) have some flat ceiling area and nearly 60% have some cathedral ceiling area. The most common configuration is a combination of flat joists and cathedral ceilings (56%), followed by flat joists alone, which account for 41% of homes (Table 3-7). The categories in the following table are exclusive categories, such that each home is only counted once.

**Table 3-7: Type of Construction for Ceilings**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Flat joists NOT covered & Cathedral | 33% | 39% | 20% | 25% | 38% |
| Flat joists NOT covered | 31% | 20% | 20% | 25% | 23% |
| Flat joists covered & Cathedral | 18% | 15% | 7% | 17% | 16% |
| Flat joists covered | 13% | 17% | 27% | 22% | 15% |
| All Cathedral | 2% | 5% | 0% | 0% | 3% |
| Flat joists NOT covered & Flat joists covered | 0% | 5% | 7% | 6% | 3% |
| Flat joists covered, flat joists NOT covered & Cathedral | 4% | 0% | 20% | 6% | 1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Most homes, approximately two-thirds, have no vapor barriers in the ceilings. One-fourth of homes have vapor barriers throughout their entire ceiling area, and the remaining 7% have incomplete vapor barriers or auditors were not able to confirm their presence. Table 3-8 does include homes with SIP or closed cell spray foam among the percentages of homes with vapor barriers, due to those materials' high resistance to moisture penetration.

**Table 3-8: Vapor Barriers in Ceilings**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| No Ceiling Areas | 67% | 68% | 60% | 69% | 67% |
| All Ceiling Areas | 22% | 28% | 7% | 17% | 26% |
| Some Ceiling Areas | 9% | 0% | 7% | 8% | 2% |
| Ceiling Areas with No Vapor Barrier & Some Unable to Determine Areas | 0% | 0% | 7% | 3% | <1% |
| Unable to Determine | 2% | 5% | 20% | 3% | 4% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

### 3.2.1 Flat Ceilings

Table 3-9 displays the type of ceiling construction for homes with flat ceilings, using exclusive categories such that each home is counted only once. Nearly 30% of homes with flat ceilings have solely 2x6 construction, and the same percentage have solely 2x8 construction. Another 6% have a mixture of the two. Eighteen percent of homes with flat ceilings have 2x10 construction.

**Table 3-9: Type of Construction for Flat Ceilings**

(homes with flat ceilings)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *54* | *39* | *15* | *36* | *93* |
| 2 x 4 | 7% | 5% | 0% | 8% | 8% |
| 2 x 6 | 26% | 31% | 33% | 22% | 29% |
| 2 x 6 and 2 x 8 | 0% | 5% | 0% | 3% | 6% |
| 2 x 6 and 2 x 12 | 0% | 3% | 7% | 0% | <1% |
| 2 x 8 | 37% | 26% | 27% | 33% | 29% |
| 2 x 10 | 22% | 21% | 27% | 25% | 18% |
| 2 x 12 | 4% | 5% | 7% | 6% | 4% |
| Truss | 4% | 3% | 0% | 3% | 4% |
| Log | 0% | 3% | 0% | 0% | 3% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Fifty-eight percent of homes with flat ceilings have only fiberglass insulation in those flat ceiling areas, followed by only cellulose (25% of homes) (Table 3-10). Statewide, two-thirds of all homes with flat ceilings have an insulation installation of Grade II in those areas.[13] The following table presents exclusive categories, such that each home is counted only once.

**Table 3-10: Type & Installation Grade of Flat Ceiling Insulation by Percent of Homes**
(homes with flat ceilings)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *54* | *39* | *15* | *36* | *93* |
| **Insulation Type** | | | | | |
| Fiberglass Batts | 57% | 55% | 33% | 44% | 58% |
| Fiberglass Batts & Cellulose | 13% | 5% | 20% | 17% | 7% |
| Fiberglass Batts & Rigid Foam | 0% | 5% | 0% | 0% | 3% |
| Cellulose | 26% | 25% | 33% | 31% | 25% |
| Cellulose & Some Unknown | 0% | 0% | 7% | 3% | <1% |
| Rock Wool | 2% | 0% | 0% | 0% | <1% |
| High Density Spray Foam | 2% | 0% | 0% | 3% | <1% |
| None | 0% | 5% | 0% | 0% | 3% |
| Unknown Type | 0% | 5% | 7% | 3% | 3% |
| **Insulation Installation Grades** | | | | | |
| *Number of Homes* | *54* | *36* | *14* | *35* | *90* |
| Grade I Installation | 11% | 6% | 14% | 9% | 7% |
| Grade I & II Installation | 2% | 0% | 0% | 0% | 1% |
| Grade I & III Installation | 0% | 6% | 0% | 0% | 3% |
| Grade II Installation | 72% | 63% | 57% | 71% | 66% |
| Grade II & III Installation | 4% | 0% | 14% | 6% | 1% |
| Grade III Installation | 11% | 26% | 14% | 14% | 23% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[13] While auditors did estimate the insulation installation quality for some building components, flat ceiling areas were typically accessible and able to be directly viewed to assess insulation quality. The insulation grades are described in Appendix D.

Fiberglass batts are by far the most common insulation material in flat ceilings in Vermont (59% of flat ceiling area) followed by cellulose (29%) (Table 3-11). Only about 3% of the flat ceiling area is completely uninsulated, though auditors were not able to confirm the insulation material in every ceiling.

**Table 3-11: Type of Flat Ceiling Insulation by Percent of Area**

(total flat ceiling square footage)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| **Insulation Type** | | | | | |
| Fiberglass Batts | 61% | 57% | 36% | 47% | 59% |
| Cellulose covering Fiberglass Batts | 7% | 3% | 9% | 8% | 4% |
| Rigid Foam | -- | 2% | -- | -- | 1% |
| Cellulose | 27% | 31% | 50% | 39% | 29% |
| Rock Wool | 2% | -- | -- | -- | <1% |
| High Density Spray Foam | 3% | -- | -- | 5% | 1% |
| None | -- | 4% | -- | -- | 3% |
| Unknown Type | -- | 3% | 5% | 2% | 3% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 3-12 displays the R-value statistics for flat ceiling insulation. The average and median R-value for flat ceiling insulation is about R-28 with minimal variance amongst regions.[14]

**Table 3-12: R-value Statistics for Insulation in Flat Ceilings**

(homes with flat ceilings and known r-values)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *54* | *37* | *14* | *35* | *91* |
| Minimum | 10 | 0 | 15 | 11 | 0 |
| Maximum | 54 | 57 | 54 | 57 | 57 |
| Average | 28.8 | 27.6 | 30.5 | 30.6 | 27.9 |
| Median | 30 | 28 | 30 | 30 | 28 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[14] An area-weighted U-value calculation was used to estimate the average R-value for each home, similar to the approach outlined in the RBES manual. Homes with an unknown R-value of insulation are not included in the calculation, although the homes with no insulation are included assuming an R-value of zero.

Eighteen percent of homes with flat ceilings have an average of R-38 or higher insulation (Table 3-13). In contrast, about one-quarter of homes have an average of R-19 or less insulation installed in the flat ceilings.

**Table 3-13: Ranges of Average R-value for Insulation in Flat Ceilings**

(homes with flat ceilings)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *54* | *37* | *14* | *35* | *91* |
| No Insulation | 0% | 5% | 0% | 0% | 3% |
| R-11 or Less | 4% | 8% | 0% | 3% | 7% |
| >R-11 to R-19 | 19% | 13% | 21% | 17% | 15% |
| >R-19 to R-30 | 43% | 42% | 29% | 34% | 43% |
| >R-30 to <R-38 | 13% | 13% | 21% | 14% | 13% |
| >= R-38 | 22% | 18% | 29% | 31% | 18% |
| Unknown Insulation Value** | -- | 2 | 1 | 1 | 2 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

** The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

### 3.2.2 Cathedral Ceilings

Cathedral ceiling construction type is mainly split between three construction types: 2x6 (21%), 2x8 (28%), and 2x10 (25%) (Table 3-14).

**Table 3-14: Type of Construction for Cathedral Ceilings**

(homes with cathedral ceilings)

| | GT Regions | Non-GT Regions* | BED** | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *31* | *22* | *7* | *17* | *53* |
| 2 x 4 | 6% | 9% | 1 | 12% | 7% |
| 2 x 6 | 23% | 18% | 1 | 18% | 21% |
| 2 x 8 | 32% | 23% | 1 | 29% | 28% |
| 2 x 10 | 23% | 18% | 0 | 18% | 25% |
| 2 x 12 | 10% | 23% | 4 | 24% | 8% |
| Log | 0% | 5% | 0 | 0% | 5% |
| SIP | 3% | 5% | 0 | 0% | 6% |
| Truss | 3% | 0% | 0 | 0% | 1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

** Because of small sample sizes, unweighted counts are shown for these results.

Fiberglass batts are the predominant insulation in cathedral ceilings, installed in 60% of homes with cathedral ceilings (Table 3-15). All of the cathedral ceilings in about 6% of homes with cathedral ceilings are completely un-insulated. Cellulose, found in 12% of homes with cathedral ceilings, is the second most common cathedral ceiling insulation material, followed by rigid foam in 10% of homes with cathedral ceilings. Around two-thirds of homes with cathedral ceiling areas received a Grade II installation rating on their cathedral ceiling insulation installation.[15]

**Table 3-15: Type & Installation Grade of Cathedral Ceiling Insulation by Percent of Homes**

(homes with cathedral ceilings)

| | GT Regions | Non-GT Regions* | BED** | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *31* | *22* | *7* | *17* | *53* |
| **Insulation Type** | | | | | |
| Fiberglass Batts | 77% | 52% | 5 | 76% | 60% |
| Fiberglass Batts & Cellulose | 3% | 0% | 0 | 0% | 1% |
| Cellulose | 10% | 12% | 1 | 18% | 12% |
| Cellulose & Rigid Foam | 3% | 0% | 0 | 0% | 1% |
| Rigid Foam | 0% | 12% | 0 | 0% | 10% |
| SIPs | 3% | 8% | 0 | 0% | 6% |
| Blown-in Fiberglass | 0% | 0% | 0 | 0% | 0% |
| None | 3% | 8% | 0 | 0% | 6% |
| Unknown | 0% | 8% | 1 | 6% | 5% |
| **Insulation Installation Grades Present (homes with insulation and Grade information)** | | | | | |
| *Number of Homes* | *29* | *19* | *6* | *16* | *48* |
| Grade I Installation | 3% | 10% | 0 | 0% | 7% |
| Grade I & II Installation | 3% | 0% | 0 | 0% | 1% |
| Grade II Installation | 62% | 67% | 4 | 63% | 68% |
| Grade III Installation | 31% | 24% | 2 | 38% | 25% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

** Because of small sample sizes, unweighted counts are shown for these results.

[15] Bear in mind that auditors estimated the insulation installation grade in cathedral ceilings. Auditors typically did not have direct visual access to these ceiling assemblies, and made informed assumptions about the installation grade typically based on the insulation installation quality elsewhere in the home. The insulation grades are described in Appendix D.

Fiberglass batts are the most common insulation material in cathedral ceilings in Vermont, representing 64% of cathedral ceiling area across the state (Table 3-16). Rigid foam is installed in about 13% of the cathedral ceiling area, and SIPs comprise a similar percentage. Only about 4% of the cathedral ceiling area is completely un-insulated, though confirming this in cathedral ceilings is not always possible in existing homes.

**Table 3-16: Type of Cathedral Ceiling Insulation by Percent of Area**

(total cathedral ceiling square footage)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| **Insulation Type** | | | | | |
| Fiberglass Batts | 77% | 60% | 82% | 83% | 64% |
| Rigid Foam | -- | 17% | -- | -- | 13% |
| Cellulose covering Rigid Foam | 1% | -- | -- | -- | <1% |
| Cellulose | 6% | 3% | 10% | 12% | 3% |
| Rock Wool | -- | -- | -- | -- | -- |
| SIP | 15% | 11% | -- | -- | 13% |
| None | 1% | 5% | -- | -- | 4% |
| Unknown Type | -- | 4% | 8% | 4% | 3% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 3-17 displays the R-value statistics for cathedral ceiling insulation. The average and median statewide R-values for cathedral ceiling areas are R-20.5 and R-23, respectively.

**Table 3-17: R-value Statistics for Insulation in Cathedral Ceilings**

(homes with cathedral ceilings and known R-values)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *31* | *20* | *6* | *16* | *51* |
| Minimum | 0 | 0 | 19 | 11 | 0 |
| Maximum | 38 | 38 | 38 | 38 | 38 |
| Average | 22.9 | 19.7 | 29.0 | 26.1 | 20.5 |
| Median | 21 | 23 | 30 | 27 | 23 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Ninety-four percent of homes with cathedral ceilings have insulation installed (Table 3-18). Six percent of homes with cathedral ceilings have no insulation in any of their cathedral ceiling area. Nearly one-quarter of homes with cathedral ceilings are insulated to an average of R-30 or higher. In contrast, 27% of homes have cathedral ceilings with an average of R-11 insulation or lower.

**Table 3-18: Ranges of Average R-value for Insulation in Cathedral Ceilings**

(homes with cathedral ceilings)

| | GT Regions | Non-GT Regions* | BED** | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *31* | *20* | *6* | *16* | *51* |
| No Insulation | 3% | 9% | 0 | 0% | 6% |
| R-11 or Less | 3% | 26% | 0 | 6% | 21% |
| >R-11 to R-19 | 23% | 9% | 1 | 13% | 11% |
| >R-19 to <R-30 | 42% | 35% | 2 | 38% | 38% |
| >=R-30 | 29% | 22% | 3 | 44% | 24% |
| Unknown Insulation Value*** | -- | 2 | 1 | 1 | 2 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

** Because of small sample sizes, unweighted counts are shown for these results.

*** The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

## 3.3 Floor Insulation

Just 11% of the 44 homes with floors over unconditioned basements have insulation in those floors (Table 3-19). However, 23% of homes with floors over unconditioned basements have either insulated frame floors or insulated foundation walls. The average R-value of floor insulation over unconditioned basements is R-13.4.

Four of the 18 homes with floors over partially conditioned basements have insulation over the unconditioned portion of the basement, and three of the nine homes with floors over unconditioned crawlspaces have insulation. Seventy-two percent of the 18 homes with floors over garages are insulated; these floors are insulated to an average R-value of R-24.0. Similarly, 60% of homes with exposed floors are insulated, representing 50% of the exposed floor area; the average R-value is 21.5.

**Table 3-19: Floor Insulation**

(all homes)

| | Floor Over Conditioned Basement/ Crawlspace | Floor Over Unconditioned Basement | Floor Over Partially Conditioned Basement | Floor Over Unconditioned Crawlspace | Floor Over Garage | Exposed Floor- Conditioned/ Outside |
|---|---|---|---|---|---|---|
| *Number of Homes* | *37* | *44* | *18* | *9* | *18* | *19* |
| Percent of Homes with Insulated Floors | 16% | 11% | 22% | 33% | 72% | 60% |
| Percent of Total Floor Square Footage Insulated | 12% | 13% | n/a | 34% | 72% | 50% |
| *Number of Homes with Known Insulation R-Value* | *6* | *5* | *4* | *3* | *13* | *12* |
| Average R-Value of Insulated Floors | 17.0 | 13.4 | 15.8 | 20.3 | 24.0 | 21.5 |

## 3.4 Foundation Walls and Slabs

Over three-quarters of the 20 homes with foundation walls 50% or more above grade have insulation (Table 3-20).[16]

**Table 3-20: Foundation Wall Insulation for Homes with Foundation Walls >50% Above Grade**

(homes with foundation walls >50% above grade)

| | Statewide* |
|---|---|
| *Number of Homes* | *20* |
| Percent of Homes with Insulation | 78% |

* Data is weighted.

Of those homes with insulated foundation walls, most have fiberglass batts (seven homes) or rigid foam (five homes). Over one-half of all insulation installations received a Grade II (Table 3-21). The average and median R-value of insulation was about R-11.

**Table 3-21: Foundation Wall Insulation Type, Installation Grade, & R-value Statistics for Homes with Insulation for Foundation Walls >50% Above Grade**

(homes with insulated >50% above grade foundation walls)

| | Statewide* |
|---|---|
| *Number of Homes* | *13* |
| **Insulation Type** | |
| Fiberglass Batts | 7 |
| Rigid Foam | 5 |
| None | 1 |
| **Insulation Installation Grade** | |
| Grade I Installation | 3 |
| Grade II Installation | 7 |
| Grade III Installation | 2 |
| **R-value Statistics** | |
| Minimum | 5 |
| Maximum | 19 |
| Average | 11.3 |
| Median | 11 |

* Data is unweighted due to low number of homes.

Just-under thirty percent (24 out of 82) of homes with foundation walls less than 50% above grade have insulated foundation walls, leaving more than 70% of these homes with un-insulated foundation walls. Ten of these 24 homes use fiberglass batts, 11 homes use rigid foam, and one

[16] Foundation walls are defined as concrete or masonry walls. Stud walls located on top of masonry/concrete wall (such as for a walkout basement) would be considered above grade walls and are included in the Wall Insulation Section.

home uses both types of insulation. The remaining two homes use spray foam and ICF, respectively. The average R-value of this insulation is about R-12 and the median is R-11.

**Slab Insulation.** Auditors were able to determine the type and R-value of slab insulation for only two homes. While there were no slab-on-grade homes in the sample, 36 homes had basements that contained conditioned floor area. Both homes have rigid foam board, with R-values of R-10 and R-8, respectively.

## 3.5 Windows

When owners could not provide technical documents on the type of glazing in their windows, auditors used a lighter test, a flashlight test, or a low-E coating detector to determine if the windows had a low-E coating.[17] Although auditors were not able to test for argon fill, in some cases they were able to estimate if a window had argon fill based on verbal confirmation from the owner or manager or inspection of the window frame for the presence of plugs in the window frame visible between the panes of glass, which is typical of argon filled windows.

Double pane clear windows are the most common type of windows − installed in 73% of homes (Table 3-22). Double pane low-e and single pane windows are found in about one-half of all homes.

**Table 3-22: Types of Windows by Percent of Homes**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Single Pane | 53% | 48% | 40% | 45% | 49% |
| Double Pane (clear) | 51% | 80% | 87% | 64% | 73% |
| Double Pane low e | 56% | 48% | 53% | 58% | 50% |
| Double Pane low e Argon | 11% | 8% | 7% | 16% | 9% |
| Triple Pane | 4% | 0% | 0% | 3% | 1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[17] It is standard industry practice to use a lighter to determine whether or not a Low-E coating is present on windows; a lighter held up to the glass yields a different color flame if there is a Low-E glaze. If windows are not absolutely clean the Low-E coating detector can give different readings in different areas of a window.

Double pane clear windows are also the most common window type by window area, representing 53% of all window area (Table 3-23). Double pane low e windows represent 28% of all window area, and single pane windows represent 13% of all window area.

Storm windows are installed on 87% and 86% of the single-pane window area in the BED service territory and VGS service territory, respectively. Storm windows are installed on 55% and 79% of the single-pane window area in the GT regions and non-GT regions, respectively. Across the entire state, 66% of single-pane window area has storm windows.

**Table 3-23: Types of Windows by Percent of Area**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Single Pane | 21% | 9% | 17% | 16% | 13% |
| Double Pane (clear) | 29% | 63% | 49% | 28% | 53% |
| Double Pane low e | 37% | 24% | 32% | 41% | 28% |
| Double Pane low e Argon | 12% | 4% | 1% | 15% | 6% |
| Triple Pane | 1% | 0% | 0% | 0% | 0% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Over one-half (54%) of window area is wood framed, and 41% is vinyl framed (Table 3-24).

**Table 3-24: Types of Window Frames by Percent of Area**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Wood | 51% | 55% | 82% | 53% | 54% |
| Vinyl | 42% | 41% | 13% | 43% | 41% |
| Metal | 3% | 3% | 0% | 2% | 3% |
| Fiberglass | 2% | 1% | 4% | 3% | 1% |
| Other | 3% | 0% | 0% | 0% | 1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 3-25 displays the glazing percentage, which is the ratio of window-to-wall area following the approach outlined in the RBES manual. Overall, the average glazing percentage is 13% and median is 11.8%, ranging from 6% to 34%.

**Table 3-25: Glazing Percentage of Exterior Wall Area**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Minimum | 8% | 6% | 9% | 8% | 6% |
| Maximum | 27% | 34% | 29% | 29% | 34% |
| Average | 13.3% | 12.8% | 15.0% | 13.5% | 13.0% |
| Median | 12.6% | 11.7% | 13.0% | 12.1% | 11.8% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 3.6 Skylights

One-quarter of inspected homes have skylights, with an average of 4.0 s.f. of skylight glass per home, all of which is double pane glass (Table 3-26).

**Table 3-26: Percent of Homes with Skylights**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Homes with skylights | 26% | 25% | 27% | 28% | 25% |
| Average s.f. of skylights | 4.8 | 3.5 | 6.2 | 3.9 | 4.0 |
| **Skylight Window Types:** Percent of Homes | | | | | |
| Single Pane | 0% | 0% | 0% | 0% | 0% |
| Double Pane | 100% | 100% | 100% | 100% | 100% |
| Triple Pane | 0% | 0% | 0% | 0% | 0% |

## 3.7 Doors

About two-thirds of exterior doors in homes are of wooden construction and just over one-quarter of doors are made of steel (Table 3-27). Panel doors are the most prevalent type, representing 45% of all doors. About one-third of doors are insulated and 42% have storm doors. Sixty-one percent of doors contain glass.

**Table 3-27: Door Type, Material, & Features**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| | | | | | |
| **Door Material** | | | | | |
| *Number of Doors* | *186* | *127* | *48* | *124* | *313* |
| Wood | 54% | 71% | 75% | 58% | 67% |
| Steel | 33% | 24% | 21% | 30% | 26% |
| Fiberglass | 13% | 5% | 4% | 12% | 7% |
| **Door Type** | | | | | |
| *Number of Doors* | *186* | *127* | *48* | *124* | *313* |
| Panel Doors | 47% | 44% | 17% | 46% | 45% |
| Solid Core Doors | 36% | 35% | 77% | 37% | 20% |
| Hollow Core Doors | 17% | 21% | 6% | 17% | 36% |
| **Door Features** | | | | | |
| *Number of Doors* | *185* | *126* | *47* | *123* | *311* |
| Insulated | 40% | 35% | 19% | 40% | 36% |
| Storm | 31% | 46% | 15% | 27% | 42% |
| With Glass | 58% | 61% | 43% | 53% | 61% |

## 3.8 Rim and Band Joist Insulation

Eighty-three of the 95 homes contained rim or band joists between conditioned and ambient spaces. Statewide, 48% of homes with conditioned to ambient joists have un-insulated joists. Whether a joist is considered a rim joist or band joist[18] has no bearing on if it is insulated.[19]

The most common insulating materials are fiberglass batts (37% of homes), rigid foam (6%), spray-in foam (5%), and cellulose (4%) (Table 3-28).

**Table 3-28: Insulation Type, Installation Grade, & R-value Statistics for Insulation on Conditioned/Ambient Rim & Band Joists**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *49* | *34* | *13* | *33* | *83* |
| **Insulation Type** | | | | | |
| Fiberglass Batts | 59% | 29% | 54% | 61% | 37% |
| Rigid Foam | 6% | 6% | 8% | 6% | 5% |
| Cellulose | 0% | 6% | 0% | 0% | 4% |
| Spray-in Foam or Icynene | 2% | 9% | 0% | 0% | 6% |
| ICF | 2% | 0% | 0% | 3% | 0% |
| Uninsulated or Unconfirmed | 31% | 50% | 38% | 30% | 48% |
| **Insulation Installation Grade** | | | | | |
| Grade I Installation | 21% | 0% | 0% | 13% | 8% |
| Grade II Installation | 42% | 53% | 38% | 42% | 50% |
| Grade III Installation | 36% | 44% | 62% | 46% | 42% |
| **R-value Statistics** | | | | | |
| Minimum | 0 | 0 | 0 | 0 | 0 |
| Maximum | 24 | 20 | 19 | 21 | 24 |
| Average | 11.6 | 6.1 | 8.8 | 11.5 | 7.5 |
| Median | 11 | 2.4 | 11 | 11 | 2.8 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[18] We define a band joist as being located between two conditioned levels and a rim joist as being located between a conditioned level and an unconditioned level.

[19] While rim joists are generally visible in existing homes, band joists are rarely visible. Band joist insulation data was usually based on the type, grade, and R-value of the insulation in the corresponding wall.

There are fifteen homes in the sample with conditioned to garage rim/band joists. All but one of these homes have insulated joists, with the majority (13) using fiberglass batts. However, eight of these fourteen joists have Grade III installations, and only two have Grade I.

Only three homes in the sample have conditioned to attic rim/band joists (Table 3-29). All three are insulated, two with fiberglass batts and one with cellulose; all three have Grade III insulation installations. Three homes have conditioned to unconditioned basement rim/band joists, and two of these are uninsulated. The remaining home is insulated with fiberglass batts, with a Grade II installation.

**Table 3-29: Insulation Type, Installation Grade, & R-value Statistics for Insulation on Conditioned/Attic & Conditioned/Garage Rim & Band Joists**

(homes with conditioned/attic, conditioned/garage, or conditioned/UC basement joists)

| | Conditioned/Garage Statewide* | Conditioned/Attic Statewide* | Conditioned/UC Basement Statewide* |
|---|---|---|---|
| *Number of Homes* | *15* | *3* | *3* |
| **Insulation Type** | | | |
| Fiberglass Batts | 13 | 2 | 1 |
| Cellulose | 0 | 1 | 0 |
| Rigid Foam | 1 | 0 | 0 |
| None | 1 | 0 | 2 |
| **Insulation Installation Grade** | | | |
| Grade I Installation | 2 | 0 | 0 |
| Grade II Installation | 4 | 0 | 1 |
| Grade III Installation | 8 | 3 | 0 |
| **R-value Statistics** | | | |
| Minimum | 0 | 11 | 11 |
| Maximum | 19 | 19 | 11 |
| Average | 14.2 | 14.7 | 11 |
| Median | 19 | 14 | 11 |

* Unweighted counts are displayed due to low number of homes.

# 4 Building Shell Leakage

A random sample of 31 homes was subjected to blower door tests of air infiltration at 50 Pascals. The test results yielded an average of 7.6 air changes per hour (ACH50) statewide, with a median of 7.0 ACH50 (Figure 4-1).

**Figure 4-1: Blower Door Test Results – ACH50 (Unweighted)**

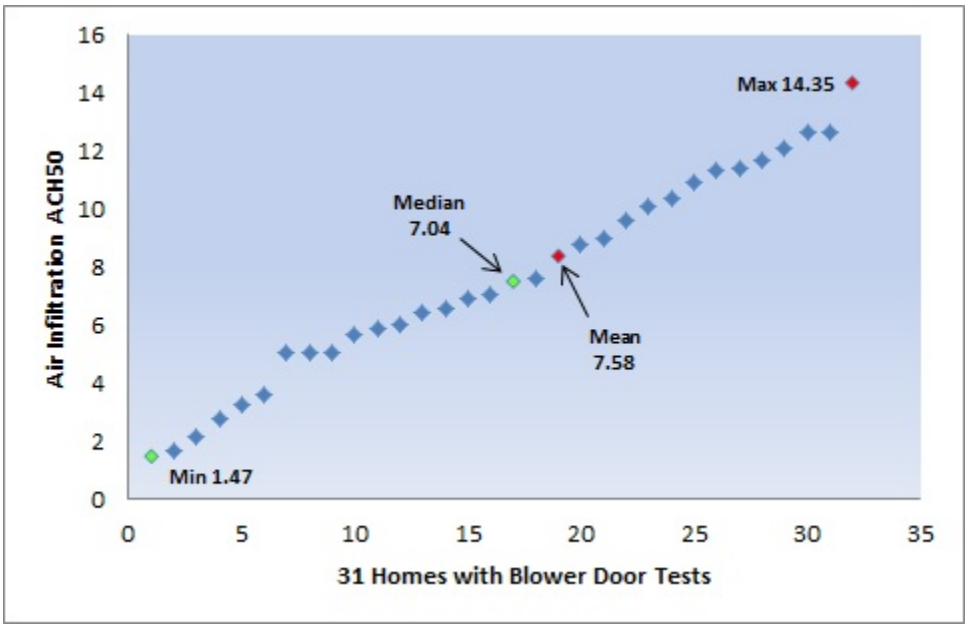
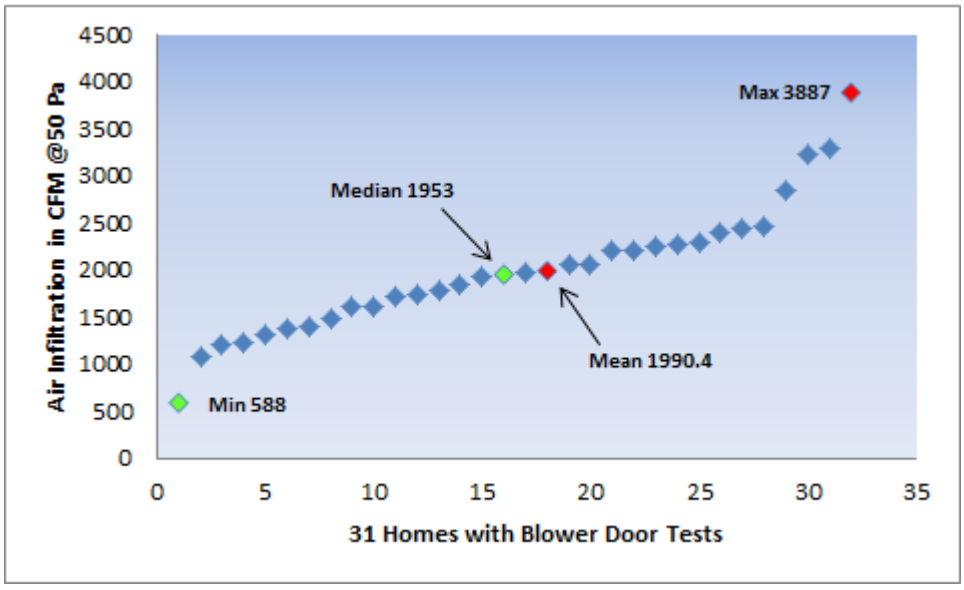



Figure 4-2 displays the CFM50 results for the 31 homes that underwent a blower door test. The average CFM50 value is 1,990.

**Figure 4-2: Blower Door Test Results – CFM50 (Unweighted)**



# 5 Heating and Cooling

Statewide, about one-half of all sampled homes depend on oil as the primary heating fuel, 21% use natural gas, 15% use propane, and 12% use wood (Table 5-1). These figures are consistent with the ACS data for Vermont, as 52% use heating oil, 15% use natural gas, and 15% use bottled (propane) gas, and 13% use wood.[20]

Both the BED (80%) territory and, as expected, the VGS region (94%) are substantially more likely than the state as a whole to have natural gas as the primary heating fuel, due to the greater availability of utility gas.[21]

**Table 5-1: Primary Heating Fuel**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* | ACS |
|---|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* | *250,894* [c] |
| Fuel oil, heating oil, or #2 oil | 47% | 50% | 13% | 3% | 51% | 52% [c] |
| Natural gas from underground pipes | 33% | 18% | 80% | 94% | 21% | 15% |
| Bottled (propane) gas | 15% | 15% | 0% | 0% | 15% | 15% |
| Electricity | 2% | 0% | 0% | 0% | 1% | 4% |
| Coal | 2% | 0% | 0% | 3% | <1% | <1% |
| Kerosene | 0% | 0% | 0% | 0% | 0% | -- [c] |
| Wood pellets | 0% | 5% | 7% | 0% | 3% | 13% |
| Wood (cord) | 2% | 13% | 0% | 0% | 9% | |
| Other | 0% | 0% | 0% | 0% | 0% | 1% |
| No heating fuel | 0% | 0% | 0% | 0% | 0% | <1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[b] ACS base = occupied housing units

[c] ACS data includes kerosene with fuel oil

[20] If a stove is a home's main or only heating source, the fuel of that stove is considered the home's primary fuel.

[21] There were two VGS homes that did not use natural gas as their primary heating fuel. One home used natural gas for their oven and their water heater. The second home used natural gas for their oven and a space heating stove.

While some homes have more than one type of heating system, some also use more than one type of heating fuel. Auditors recorded information about supplemental space heating units, including fireplaces, stoves, and space heaters, which is reported in the following section. Table 5-2, rather, shows instances of homes with more than one main heating fuel, excluding those supplemental space heating systems.[22] This includes homes with more than one type of furnace or boiler, or a GSHP and a propane boiler together in the same house, or a home with a boiler and electric resistance heating, for example. Of these nine homes with multiple main heating fuels, four use electric resistance heat, two use propane, one uses oil, one uses both oil and propane as secondary fuels (these are backup fuels to a wood stove), and one uses oil and natural gas as secondary fuels (secondary to a coal-fired furnace).

**Table 5-2: Homes with Secondary Heating Fuels (Excluding Fireplaces, Stoves, and Portable Space Heaters)**

(all homes)

| | GT Regions* | Non-GT Regions* | BED* | VGS* | Statewide* |
|---|---|---|---|---|---|
| *Count of Homes* | *4* | *5* | *2* | *2* | *9* |
| *Secondary heating fuel types* | | | | | |
| Fuel oil , heating oil, or #2 oil | -- | 1 | -- | -- | 1 |
| Fuel oil & Bottled (propane) gas | -- | 1 | -- | -- | 1 |
| Fuel oil & Nat. gas | 1 | -- | -- | 1 | 1 |
| Bottled (propane) gas | 1 | 1 | 1 | -- | 2 |
| Electric resistance | 2 | 2 | 1 | 1 | 4 |

* Because of small sample sizes, unweighted counts are shown for these results.

[22] If a stove is a home's main or only heating source, the fuel of that stove is considered the home's primary fuel.

## 5.1 Heating Systems

Table 5-3 displays the type of heating systems installed in the homes. Fifty-five percent of homes have a single boiler; while 26% of homes have a single furnace. Other homes have a mixture of multiple heating systems. The furnaces that served as secondary systems were typically direct vent wall mounted units with no ducts that provide localized heating to specific rooms.

**Table 5-3: Type of Heating Systems**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Boiler - Single | 45% | 59% | 47% | 44% | 55% |
| Boiler - Multiple | 0% | 0% | 7% | 0% | 0% |
| Boiler plus other system | 4%† | 7% | 0% | 0% | 7%† |
| Furnace - Single | 42% | 20% | 40% | 42% | 26% |
| Furnace - Multiple | 4% | 5% | 0% | 6% | 4% |
| Furnace plus other system | 0% | 5% | 0% | 0% | 3% |
| Boiler & Furnace | 4% | 0% | 0% | 6% | 1% |
| Stove** or Stove & Elect. Resistance | 2% | 5% | 7% | 3% | 4% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

**Stoves include both wood and natural gas-fired units.

†Includes a home with a GSHP as a secondary system.

Table 5-4 displays the type of heating system for those homes with only one heating system. Two-thirds of these homes have hot water boilers, and about one-third have furnaces.

**Table 5-4: Type of Single Major Heating System**

(homes with a single major heating system)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *48* | *34* | *13* | *31* | *82* |
| Hot Water Boiler | 50% | 65% | 54% | 52% | 62% |
| Steam Boiler | 2% | 6% | 0% | 0% | 4% |
| Furnace | 48% | 24% | 46% | 48% | 31% |
| Stove (wood) | 0% | 6% | 0% | 0% | 4% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Statewide, boilers and furnaces are roughly split between being located in conditioned and unconditioned space. About 60% of boilers and furnaces were in unconditioned space and the remaining roughly 40% were in conditioned space[23] (Table 5-5).

**Table 5-5: Location of Heating System**

(homes with boilers or furnaces)

| | Boiler | Furnace |
|---|---|---|
| *Number of Heating Systems* | *55* | *45* |
| Conditioned Space | 40% | 42% |
| Unconditioned Space | 60% | 58% |

The average age of boilers and furnaces is thirteen years and fourteen years, respectively; the median age is ten years for both boilers and furnaces (Table 5-6).

**Table 5-6: Age of Heating System**

(homes with boilers or furnaces and age data)

| | Boiler | Furnace |
|---|---|---|
| *Number of Heating Systems* | *46* | *37* |
| Minimum | 1 | 1 |
| Maximum | 60 | 40 |
| Average | 13 | 14 |
| Median | 10 | 10 |

[23] Spaces are deemed unconditioned in accordance with guidelines for HERS ratings, which are not entirely consistent with RBES standards. Most frequently, these are uninsulated, unheated basements.

Based solely on age, at least 5% of homes – those with boilers and furnaces older than 30 years – would appear to be strong candidates for HVAC system replacement. Those older than 20 years and up to 30 years old may also be good candidates, and represent an additional 12% of furnaces and boilers (Table 5-7).

**Table 5-7: Age Ranges of Heating Systems**

(homes with boilers or furnaces and age data)

| Age | Boilers & Furnaces |
|---|---|
| *Number of Heating Systems* | *83* |
| 0 to 5 years | 27% |
| 6 to 10 years | 25% |
| 11 to 15 years | 17% |
| 16 to 20 years | 13% |
| 21 to 25 years | 10% |
| 26 to 30 years | 2% |
| 31 to 40 years | 4% |
| 41 to 50 years | 1% |
| More than 50 years | 1% |
| Count of systems with unknown age* | 16 |

*The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

Table 5-8 displays the efficiency of boilers and Table 5-9 displays it for furnaces. Note that auditors recorded AHRI-based AFUE figures whenever possible, and in other cases substituted manufacturer rated efficiencies or capacity calculations (output divided by input). The average efficiency of the natural gas boilers (85.7%) and propane boilers (86.7%) is slightly higher than the oil boilers (85.0%). However, the most efficient gas boilers are much more efficient than the most efficient oil boiler (96.0% vs. 87.9%), and the least efficient gas boilers are much more efficient than the least efficient oil boilers (78.0% vs. 70.3%). In addition to those listed below, there is also a pellet fired boiler with an efficiency of 90%.

**Table 5-8: Boiler Efficiency**

(homes with boilers with efficiency data)*

| | Oil Boiler | Nat. Gas Boiler | Propane Boiler | All Boilers |
|---|---|---|---|---|
| *Number of Heating Systems* | *25* | *14* | *6* | *46* |
| Minimum | 70.3% | 78.0% | 80.3% | 70.3% |
| Maximum | 87.9% | 96.0% | 95.0% | 96.0% |
| Average | 85.0% | 85.7% | 86.7% | 85.5% |
| Median | 85.4% | 84.0% | 83.5% | 85.0% |

* Results not weighted.

The average efficiency of gas furnaces is 89.5% and propane furnaces is 88.0%, compared to 82.6% for oil furnaces. The maximum efficiency of gas boilers is also much higher than that of oil furnaces, 95.0% vs. 85.8%.

**Table 5-9: Furnace Efficiency**

(homes with furnaces with efficiency data)*

| | Oil Furnace | Nat. Gas Furnace | Propane Furnace | All Furnaces |
|---|---|---|---|---|
| *Number of Heating Systems* | *12* | *18* | *7* | *37* |
| Minimum | 79.3% | 80.0% | 75.0% | 75.0% |
| Maximum | 85.8% | 95.0% | 95.5% | 95.5% |
| Average | 82.6% | 89.5% | 88.0% | 87.0% |
| Median | 82.5% | 92.0% | 94.0% | 85.0% |

* Results not weighted.

## 5.2 Supplemental Heating Systems

Statewide, 28% of homes have a fireplace; fireplaces are most common in the VGS territory (47%) (Table 5-10). Most of these fireplaces are fueled by wood (71%), though about one-quarter use natural gas (26%).

**Table 5-10: Fireplaces & Fuel Used**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| **Number of Fireplaces** | | | | | |
| None | 60% | 75% | 60% | 53% | 71% |
| One | 36% | 20% | 33% | 44% | 24% |
| Two or more | 4% | 5% | 7% | 3% | 4% |
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| **Fireplace Fuel** | | | | | |
| Wood | 63% | 75% | 6 | 44% | 71% |
| Natural gas | 29% | 25% | 1 | 56% | 26% |
| Propane | 8% | 0% | 0 | 0% | 3% |
| *Number of Fireplaces* | 24 | 14 | 7 | 18 | 38 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 5-11 indicates that 43% of homes have stoves, with stoves being least common in the BED (14%) and VGS regions (17%). Most of these stoves are fueled by firewood (68%).

**Table 5-11: Stoves & Fuel Used**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| **Number of Stoves** | | | | | |
| None | 69% | 53% | 86% | 83% | 57% |
| One | 29% | 40% | 14% | 17% | 37% |
| Two or more | 2% | 8% | 0% | 0% | 6% |
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| **Stove Fuel** | | | | | |
| Firewood | 50% | 68% | 1 | 1 | 68% |
| Wood Pellets | 39% | 14% | 0 | 2 | 18% |
| Natural gas | 6% | 9% | 1 | 3 | 7% |
| Propane | 6% | 9% | 0 | 0 | 7% |
| *Number of Stoves* | 18 | 16 | 2 | 6 | 34 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

About one-quarter of homes (24%) have portable space heaters, though relatively few occur in the BED (7%) or VGS territories (6%) (Table 5-12). Almost all of these space heaters are fueled by electricity (99%). Because some of the onsite visits were conducted in the early fall season, space heaters may not have been in use and therefore these figures may under-report the number in use during winter months.

**Table 5-12: Portable Space Heaters & Fuel Used**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| **Number of Space Heaters** | | | | | |
| None | 80% | 76% | 93% | 94% | 77% |
| One | 16% | 12% | 7% | 3% | 13% |
| Two or more | 4% | 12% | 0% | 0% | 10% |
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| **Space Heater Fuel** | | | | | |
| Electric | 13 | 10 | 0 | 1 | 99% |
| Kerosene | 0 | 1 | 1 | 0 | 1% |
| *Number of Space Heaters* | 13 | 11 | 1 | 2 | 24 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 5.3 Temperatures and Controls

Statewide, 60% of homes have manual thermostats; programmable thermostats are installed in about one-third of homes (Table 5-13). Homes in the BED (80%) and VGS (67%) territories are much more likely than other regions and the state as a whole to have programmable thermostats.

**Table 5-13: Type of Thermostat**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Manual | 62% | 56% | 20% | 33% | 60% |
| Programmable | 35% | 34% | 80% | 67% | 33% |
| Electronic Non-programmable | 4% | 5% | 0% | 0% | 4% |
| None | 0% | 5% | 0% | 0% | 3% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

About one-third of homeowners setback their thermostats during the night or weekday (Table 5-14). VGS customers appear to be more likely to setback their thermostats.

**Table 5-14: Temperature Setback Use**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *47* | *38* | *15* | *32* | *85* |
| Nighttime | 51% | 32% | 53% | 66% | 35% |
| Daytime | 36% | 30% | 33% | 47% | 31% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

The average and median preferred temperature reported by homeowners is consistent across the state – about 67 or 68 degrees Fahrenheit (Table 5-15).

**Table 5-15: Preferred Winter Indoor Temperature**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *54* | *39* | *15* | *36* | *93* |
| Average | 67 | 68 | 67 | 67 | 68 |
| Median | 68 | 68 | 68 | 68 | 68 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Slightly less than one-half of homes have a single thermostat, one-quarter have two, and 30% have three or more (Table 5-16).

**Table 5-16: Number of Thermostats**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *39* | *15* | *36* | *94* |
| **Number of Thermostats** | | | | | |
| None | 0% | 5% | 0% | 0% | 3% |
| One | 49% | 44% | 47% | 50% | 45% |
| Two | 27% | 24% | 33% | 31% | 25% |
| Three | 18% | 15% | 7% | 19% | 16% |
| Four or more | 6% | 12% | 13% | 0% | 12% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 5.4 Air Conditioning

Statewide, 17% of homes have a window air conditioning (AC) unit (Table 5-17). Because most of the onsite visits were conducted in the fall and winter season, window AC units may have already been removed and therefore these figures may under-report the number in use during summer months.

**Table 5-17: Number of Window Air Conditioning Units**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| No window AC | 89% | 80% | 80% | 83% | 83% |
| Have at least one unit | 11% | 20% | 20% | 17% | 17% |
| One | 5% | 5% | 13% | 11% | 5% |
| Two | 4% | 8% | 7% | 6% | 7% |
| Three | 2% | 8% | 0% | 0% | 6% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Only 2% of homes have central AC systems; the average age of these five systems is about ten years, with an average efficiency of 11.6 SEER (Table 5-18). The window AC units with data available are an average of about nine years old, with an average efficiency of 10.2 EER.

**Table 5-18: Characteristics of Air Conditioning Systems, Statewide**

(all homes)

| | Central AC | Window AC | Ductless Mini-Splits | GSHP |
|---|---|---|---|---|
| *Number of Homes* | *95* | *95* | *95* | *95* |
| Percent with Air Conditioning* | 2% | 17% | 1% | 1% |
| Average age of units (years)** | 9.6 (n=5) | 9.2 (n=15) | 10.5 (n=2) | 2 (n=1) |
| Average size (tons)** | 3.3 (n=5) | 0.6 (n=15) | 3.5 (n=2) | 4.2 (n=1) |
| Average efficiency** | 11.6 SEER (n=5) | 10.2 EER (n=9) | 12.0 SEER (n=2) | 21.6 EER (n=1) |

* Data weighted. ** Data unweighted due to low sample sizes.

## 5.5 Renewables

Renewable generation systems such as photovoltaic and wind turbines were not commonly found at homes that participated in the study. Only two out of the ninety-five inspected homes have photovoltaic (PV) systems installed and one home has a solar-assisted water heating system. One PV system is 3.2 kW in size and the other is 2.3 kW in size. None of the homes visited have wind turbines.

## 5.6 Ducts

Thirty-four percent of the homes visited have ducts installed in the home. Most of these homes have furnaces, though a few homes have central air conditioning and one home has a heat pump. Statewide, about 40% of these homes have duct runs in conditioned space, 65% have duct runs in an unconditioned basement, and 5% in an attic. About 20% of these homes have duct runs in at least two of these locations (Table 5-19).

**Table 5-19: Characteristics of Ducts***

(homes with ducts)

| | GT Regions | Non-GT Regions | BED | VGS | Statewide |
|---|---|---|---|---|---|
| *Number of Homes* | *27* | *13* | *6* | *18* | *40* |
| Attic | 7% | 0% | 0% | 0% | 5% |
| Conditioned Space | 37% | 46% | 17% | 33% | 40% |
| Unconditioned Basement | 70% | 54% | 83% | 67% | 65% |

*Data is unweighted.

Of the 27 homes with ducts in unconditioned space, 23 homes have rigid metal ducts and four have flexible metal ducts (Table 5-20). Duct seams are sealed in about one-quarter of the homes with ducts in unconditioned space (seven homes). The most common sealing material is mastic (four homes), followed by duct tape (two homes). One home uses PS tape. In the majority of cases (60%), visual inspection reveals "average" duct leakage, as opposed to "leaky" or "tight" ducts.

Ducts are insulated in five of the 27 homes with ducts in unconditioned spaces. All five of these duct runs are insulated with fiberglass wrap, which has an R-value of R-6 in four homes and R-5 in one home. Only one metal duct run in unconditioned space is insulated, but all four of the flexible duct runs are insulated.

**Table 5-20: Characteristics of Ducts & Duct Insulation**

(homes with ducts located in unconditioned space)

| | Statewide |
|---|---|
| *Number of Homes with Ducts in Unconditioned Space* | *27* |
| **Duct Type** | |
| Rigid metal | 27 |
| Flexible metal | 4 |
| **Insulation R-value** | |
| *Number of Homes with Insulated Ducts in Unconditioned Space* | *5* |
| Minimum | 5.2 |
| Maximum | 6 |
| Average | 5.8 |
| Median | 6 |

# 6 Water Heating

Over one-half of homes (55%) have stand-alone tank water heaters, while the other one-half have a water heater integrated with their space heating system, either with a storage tank (20%) or a tankless coil system (22%), and 3% have instantaneous water heaters (Table 6-1).

**Table 6-1: Type of Water Heating Systems**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Storage, stand alone – single | 60% | 48% | 47% | 58% | 52% |
| Storage, stand alone - multiple | 4% | 5% | 0% | 3% | 3% |
| Integrated, w/tank | 20% | 20% | 40% | 28% | 20% |
| Integrated, tankless | 15% | 23% | 0% | 6% | 22% |
| Instantaneous | 2% | 5% | 7% | 6% | 3% |
| Solar-assisted water heater plus Integrated, w/tank | 0% | 0% | 7% | 0% | 0% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Statewide, 37% of homes have water heaters that use oil, 31% use electric, 20% use natural gas and 12% use propane (Table 6-2). There is a strong regional difference due to the availability of natural gas, with 80% of BED homes and 94% of VGS homes using natural gas, compared to 17% of homes from the Non-GT region. The VGS Region is the only region with no inspected homes using oil for water heating.

**Table 6-2: Water Heating System Fuel**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Oil | 27% | 39% | 13% | 0% | 37% |
| Electric | 29% | 32% | 0% | 6% | 31% |
| Nat. Gas | 33% | 17% | 80% | 94% | 20% |
| Propane | 11% | 12% | 0% | 0% | 12% |
| Solar plus Pellet | 0% | 0% | 7% | 0% | 0% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

The average age of water heating systems is about ten years, the median age is eight years (Table 6-3).

**Table 6-3: Age of Water Heating System**

(homes with water heater age data available)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Water Heaters* | *48* | *34* | *15* | *34* | *82* |
| Minimum | 1 | 2 | 2 | 1 | 1 |
| Maximum | 25 | 25 | 25 | 20 | 25 |
| Average | 9.9 | 9.7 | 11.7 | 9.5 | 9.9 |
| Median | 8.5 | 8.0 | 10.0 | 9.5 | 8.0 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Just over one-half (54%) of all water heaters are located in unconditioned spaces[24] (Table 6-4).

**Table 6-4: Location of Water Heating System**

(homes with water heaters)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Water Heaters* | *57* | *42* | *16* | *37* | *99* |
| Conditioned Space | 33% | 50% | 44% | 38% | 46% |
| Unconditioned Space | 67% | 50% | 56% | 62% | 54% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[24] Spaces are called unconditioned in accordance with NEHERS guidelines for HERS ratings, which do not exactly conform to RBES standards. Most frequently, these are uninsulated, unheated basements.

Table 6-5 shows that the average energy factor of integrated tank water heaters is 0.79. The energy factor of integrated tank systems is calculated by multiplying the boiler efficiency by 0.92. The fuel in the below table represents the fuel of the boiler to which the integrated tank is attached. There is also one solar assisted water heater, but the auditor was not able to obtain its energy rating.

**Table 6-5: Efficiency of Integrated w/Tank Water Heaters**

(homes with integrated w/tank water heaters)

| | Nat. Gas | Oil | Pellet | Propane | Total |
|---|---|---|---|---|---|
| *Number of Water Heaters* | *8* | *10* | *1* | *1* | *20* |
| Minimum | 0.74 | 0.78 | 0.83 | 0.74 | 0.74 |
| Maximum | 0.88 | 0.81 | 0.83 | 0.74 | 0.88 |
| Average | 0.80 | 0.80 | 0.83 | 0.74 | 0.79 |
| Median | 0.80 | 0.80 | 0.83 | 0.74 | 0.80 |
| Count of systems with unknown efficiency* | 2 | 1 | -- | -- | 3 |

* The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

The average energy factor of integrated tankless water heaters is 0.43. The energy factors for these tankless coil DHW systems were calculated using a formula provided in the RBES manual, except based on the number of occupants rather than bedrooms. The fuel listed below represents the fuel of the boiler in which the tankless coil is located (Table 6-6).

**Table 6-6: Efficiency of Integrated Tankless Water Heaters**

(homes with integrated tankless water heaters)

| | Nat. Gas | Oil | Total |
|---|---|---|---|
| *Number of Water Heaters* | *2* | *12* | *14* |
| Minimum | 0.40 | 0.40 | 0.40 |
| Maximum | 0.50 | 0.50 | 0.50 |
| Average | 0.45 | 0.42 | 0.43 |
| Median | 0.45 | 0.40 | 0.40 |

* The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

Stand-alone water heating tank systems have an average energy factor of 0.60 in audited homes (Table 6-7).

**Table 6-7: Efficiency of Non-Electric Stand-alone Storage Tank Water Heaters**

(homes with non-electric stand-alone storage tank water heaters)

| | Nat. Gas | Oil | Propane | Total |
|---|---|---|---|---|
| *Number of Water Heaters* | *20* | *2* | *7* | *29* |
| Minimum | 0.54 | 0.63 | 0.55 | 0.54 |
| Maximum | 0.67 | 0.66 | 0.63 | 0.67 |
| Average | 0.60 | 0.65 | 0.62 | 0.60 |
| Median | 0.59 | 0.65 | 0.63 | 0.62 |
| Count of systems with unknown efficiency* | 1 | 2 | 3 | 6** |

* The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.
**Includes a stand-alone tank with unknown fuel type.

The average energy factor of the two non-electric instantaneous water heaters found is 0.82[25] (Table 6-8). There is also one electric instantaneous water heater in the sample, included in Table 6-9.

**Table 6-8: Efficiency of Non-Electric Instantaneous Water Heaters (Energy Factor)***

(homes with non-electric instantaneous water heaters)

| | Nat. Gas | Total |
|---|---|---|
| *Number of Water Heaters* | *2* | *2* |
| Minimum | 0.82 | 0.82 |
| Maximum | 0.82 | 0.82 |
| Average | 0.82 | 0.82 |
| Median | 0.82 | 0.82 |

* The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

[25] The instantaneous category includes combination heating/DHW systems without storage tanks that function as true on-demand systems. For these systems, manufacturers provide AFUE ratings, not separate energy factors, and auditors used this AFUE value as the system's energy factor.

The average energy factor for electric water heaters is 0.91. These are all stand-alone tank water heaters except for one, which is an instantaneous water heater (Table 6-9).

**Table 6-9: Efficiency of Electric Water Heaters**

(homes with electric water heaters)

| *Number of Water Heaters* | *15* |
|---|---|
| Minimum | 0.86 |
| Maximum | 0.99 |
| Average | 0.91 |
| Median | 0.91 |
| Count of systems with unknown efficiency* | 9 |

* The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

Statewide, 27% of 82 homes with water heater tanks have tank insulation (Table 6-10). Eight of the 16 water heater tanks with insulation wrap are electric heaters. Thirteen of these 16 water heaters are stand-alone water heaters and the remaining three are integrated with tank systems, one of which is also a solar assisted system.

**Table 6-10: Water Heater Tank Wrap Insulation & R-Values**

(all homes)

| | **Statewide*** |
|---|---|
| *Number of Tank Water Heaters (stand alone or integrated)* | *82* |
| **Percent with insulation wrap** | *27%* |
| **R-value Statistics** | |
| *Number of tank water heaters (stand alone or integrated) with insulation* | *16* |
| Minimum | 3 |
| Maximum | 11 |
| Average | 7.9 |
| Median | 9.7 |

*Statewide weighted results.

Statewide, just under one-quarter (24%) of homes have insulation on their water heater piping (Table 6-11). The BED region has the highest percent (40%) of homes with pipe insulation. Among the homes that do have water heater piping insulation, the average R-value is 2.1.

**Table 6-11: Water Heater Piping Insulation & R-Values**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | 55 | 40 | 15 | 36 | 95 |
| Percent with Insulation | *9%* | *28%* | *40%* | *22%* | *24%* |
| **R-value Statistics** | | | | | |
| *Number of homes with insulation* | *5* | *15* | *7* | *8* | *18* |
| Minimum | 2 | 2 | 2 | 2 | 2 |
| Maximum | 2 | 3 | 3 | 3 | 3 |
| Average | 2.0 | 2.2 | 2.3 | 2.3 | 2.1 |
| Median | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 6.1 Low Flow Shower Heads and Faucet Aerators

Statewide, about 41% of homes are estimated have low flow shower heads (Table 6-12).[26] Faucet aerators[27] are found in 53% of all homes.

**Table 6-12: Low Flow Shower Heads & Faucet Aerators**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| **Number of low flow shower heads** | | | | | |
| None | 69% | 55% | 60% | 64% | 59% |
| One | 22% | 20% | 20% | 19% | 20% |
| Two or more | 9% | 25% | 20% | 17% | 21% |
| **Number of Faucet Aerators** | | | | | |
| None | 56% | 45% | 47% | 53% | 47% |
| One | 6% | 13% | 13% | 6% | 11% |
| Two | 24% | 13% | 20% | 22% | 15% |
| Three | 6% | 15% | 20% | 11% | 13% |
| Four or more | 9% | 15% | 0% | 8% | 14% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

[26] Low flow shower heads may list the gallons per minute (GPM); less than 2.5 GPM is considered low flow. Otherwise auditors identified low flow showerheads if the flow rate was judged to be lower than typical; they did not measure flow rates.

[27] Faucet aerators may list the gallons per minute (GPM) flow rate; less than 2.2 GPM is common for an aerator. Otherwise auditors identified aerators if the flow rate was judged to be lower than typical; they did not measure flow rates.

# 7 Appliances

All of the homes visited have at least one refrigerator and a range/oven. Statewide, almost all homes have a clothes washer (96%), and clothes dryer (96%) (Table 7-1). Dishwashers are found in most homes − 76%. Separate freezers are found in 35% of homes, dehumidifiers in 23%, and second refrigerators in 6% of homes.

**Table 7-1: Appliance Saturations**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Refrigerator | 100% | 100% | 100% | 100% | 100% |
| Oven / Range | 100% | 100% | 100% | 100% | 100% |
| Clothes washer | 98% | 95% | 93% | 97% | 96% |
| Clothes dryer | 98% | 95% | 67% | 89% | 96% |
| Dishwasher | 86% | 73% | 80% | 86% | 76% |
| Separate freezer | 33% | 35% | 27% | 33% | 35% |
| Dehumidifier | 29% | 20% | 40% | 39% | 23% |
| Second refrigerator | 12% | 5% | 0% | 11% | 6% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 7.1 ENERGY STAR Appliances

Auditors were asked to note the presence of the ENERGY STAR label on any appliances. In addition, model numbers were recorded (when visible) during the on-site visits; the ENERGY STAR status of these models was checked at http://www.energystar.gov/index.cfm?c=appliances.pr_appliances, the ENERGY STAR website. Note, however, that this database identifies only those models that meet the current ENERGY STAR criteria; older models that met the ENERGY STAR criteria in effect when sold would not be listed if they do not meet the current criteria. Therefore, the estimated penetration of ENERGY STAR appliances is likely a conservative estimate.

Clothes washers are most likely to be ENERGY STAR qualified (25%), followed by dishwashers (16%) (Table 7-2). Nine percent of freezers and 7% of refrigerators are ENERGY STAR qualified.

**Table 7-2: ENERGY STAR Appliances**

(all appliances)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| Refrigerators | 15% | 5% | 7% | 13% | 7% |
| *No. of refrigerators* | *62* | *41* | *15* | *36* | *103* |
| Dishwashers | 8% | 13% | 19% | 7% | 16% |
| *No. of dishwashers* | *44* | *26* | *12* | *31* | *70* |
| Clothes washers | 25% | 26% | 36% | 31% | 25% |
| *No. of clothes washers* | *54* | *38* | *14* | *35* | *92* |
| Separate freezers | 0% | 13% | 0% | 0% | 9% |
| *No. of freezers* | *18* | *13* | *4* | *12* | *31* |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Auditors assessed the condition of appliances as good, fair, or poor, based on the physical appearance of the appliance. Appliances that received the good rating appeared to be in new or like new condition on the exterior and interior (if applicable). Those appliances given a rating of fair condition tend to be older but in working condition. An appliance that received a poor rating might be noisy, have a poor door seal, presence of rust or dented exterior, etc. Appliances in poor condition would be ripe for appliance recycling or replacement, while some appliances in fair condition may be suitable for replacement as well.

The remaining sections focus on individual appliance characteristics. The number of appliances listed in each table refers to the number with available data.

## 7.2 Refrigerators

Most refrigerators (80%) are in good condition, according to auditors; very few (4%) are considered to be in poor condition (Table 7-3).

**Table 7-3: Refrigerator Condition**

(all refrigerators)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Refrigerators* | *62* | *41* | *15* | *40* | *103* |
| Good | 87% | 76% | 80% | 85% | 80% |
| Fair | 8% | 19% | 13% | 8% | 16% |
| Poor | 5% | 5% | 7% | 8% | 4% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

About one-half of all refrigerators are less than ten years old (Table 7-4). Eleven percent of refrigerators statewide are estimated to be 20 years or older.

**Table 7-4: Age of Refrigerators**

(all refrigerators with age data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Refrigerators* | *58* | *38* | *14* | *37* | *96* |
| 4 years or less | 36% | 18% | 36% | 38% | 23% |
| 5 to 9 years | 21% | 33% | 29% | 27% | 30% |
| 10 to 14 years | 24% | 21% | 29% | 14% | 22% |
| 15 to 19 years | 12% | 15% | 7% | 16% | 15% |
| 20 years or more | 7% | 13% | 0% | 5% | 11% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

One-half of all refrigerators are between 16 and 19 cubic feet in size, and about one-third are 20 to 24 cubic feet (Table 7-5).

**Table 7-5: Refrigerator Size**

(all refrigerators with size data)

| Cubic Feet | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Refrigerators* | *56* | *36* | *19* | *33* | *92* |
| 10 to 15 | 6% | 6% | 0% | 3% | 5% |
| 16 to 19 | 31% | 54% | 42% | 33% | 50% |
| 20 to 24 | 30% | 40% | 53% | 36% | 36% |
| over 24 | 33% | 0% | 5% | 27% | 9% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Top-freezer models comprise two-third of all refrigerators (Table 7-6).

**Table 7-6: Refrigerator Type**

(all refrigerators with type data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Refrigerators* | *62* | *40* | *15* | *40* | *102* |
| Top freezer | 52% | 74% | 57% | 56% | 68% |
| Bottom freezer | 16% | 12% | 21% | 8% | 13% |
| Side by side | 31% | 14% | 21% | 33% | 19% |
| Single door | 2% | 0% | 0% | 3% | 0% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 7.3 Separate Freezers

Seventy-two percent of separate freezers are in good condition statewide (Table 7-7). Only 14% are rated in poor condition.

**Table 7-7: Separate Freezer Condition**

(all separate freezers with condition data)

| | GT Regions | Non-GT Regions* | BED** | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Separate Freezers* | *18* | *13* | *4* | *12* | *31* |
| Good | 50% | 73% | 4 | 67% | 72% |
| Fair | 22% | 13% | 0 | 8% | 14% |
| Poor | 28% | 13% | 0 | 25% | 14% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

** Unweighted count presented due to low sample size.

Close to one-half of separate freezers are less than ten years old (Table 7-8). Fourteen percent of separate freezers are 20 years or older.

**Table 7-8: Age of Separate Freezers**

(all separate freezers with age data)

| | GT Regions | Non-GT Regions* | BED** | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Separate Freezers* | *15* | *12* | *4* | *11* | *27* |
| 4 years or less | 20% | 19% | 2 | 36% | 34% |
| 5 to 9 years | 20% | 35% | 1 | 0% | 14% |
| 10 to 14 years | 32% | 22% | 0 | 36% | 17% |
| 15 to 19 years | 7% | 16% | 1 | 18% | 21% |
| 20 years or more | 20% | 8% | 0 | 10% | 14% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

** Unweighted count presented due to low sample size.

Most separate freezers (60%) are less than 15 cubic feet in size (Table 7-9).

**Table 7-9: Separate Freezer Size**

(all separate freezers with size data)

| Cubic Feet | GT Regions | Non-GT Regions** | BED** | VGS** | Statewide* |
|---|---|---|---|---|---|
| *Number of Separate Freezers* | *12* | *9* | *4* | *8* | *21* |
| 4 to 6 | 8% | 3 | 1 | 2 | 24% |
| 7 to 9 | 42% | 0 | 2 | 2 | 12% |
| 10 to 14 | 8% | 0 | 1 | 2 | 4% |
| 15 or more | 42% | 5 | 0 | 2 | 40% |

*Results for the Statewide column are weighted; all other results are unweighted.

**Unweighted count presented due to low sample size.

Two-thirds of separate freezers are chest type models (Table 7-10).

**Table 7-10: Separate Freezer Type**

(all separate freezers with type data)

| | GT Regions | Non-GT Regions* | BED** | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Separate Freezers* | *18* | *13* | *4* | *12* | *31* |
| Single door | 0% | 0% | 0 | 0% | 0% |
| Upright | 39% | 38% | 0 | 50% | 37% |
| Chest | 61% | 62% | 4 | 50% | 63% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

**Unweighted count presented due to low sample size.

## 7.4 Dishwashers

Nearly three-quarters of dishwashers are in good condition; only 6% are rated as poor (Table 7-11).

**Table 7-11: Dishwasher Condition**

(all dishwashers with condition data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Dishwashers* | *44* | *26* | *11* | *30* | *70* |
| Good | 82% | 67% | 82% | 77% | 73% |
| Fair | 14% | 25% | 9% | 17% | 21% |
| Poor | 4% | 8% | 9% | 6% | 6% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Over two-thirds of dishwashers are under 10 years old, one-third of which are under five years old (Table 7-12). Thirteen percent of dishwashers are 20 years or older.

**Table 7-12: Age of Dishwashers**

(all dishwashers with age data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Dishwashers* | *43* | *23* | *11* | *31* | *66* |
| 4 years or less | 40% | 31% | 18% | 32% | 36% |
| 5 to 9 years | 28% | 37% | 55% | 39% | 32% |
| 10 to 14 years | 23% | 16% | 18% | 23% | 19% |
| 15 to 19 years | 2% | 0% | 0% | 3% | 0% |
| 20 years or more | 7% | 16% | 9% | 3% | 13% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 7.5 Clothes Washers

Two-thirds of clothes washers are in good condition; a small amount (6%) are rated as poor (Table 7-13).

**Table 7-13: Clothes Washer Condition**

(all clothes washers with condition data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Clothes Washers* | *54* | *38* | *14* | *35* | *92* |
| Good | 72% | 67% | 73% | 83% | 68% |
| Fair | 17% | 28% | 27% | 14% | 26% |
| Poor | 11% | 5% | 0% | 3% | 6% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Close to one-half of all clothes washers are under 10 years old; one-third are less than five years old (Table 7-14). Fourteen percent are 20 years or older.

**Table 7-14: Age of Clothes Washers**

(all clothes washers with age data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Clothes Washers* | *52* | *34* | *13* | *34* | *86* |
| 4 years or less | 40% | 33% | 42% | 38% | 35% |
| 5 to 9 years | 19% | 9% | 25% | 26% | 12% |
| 10 to 14 years | 14% | 33% | 25% | 18% | 28% |
| 15 to 19 years | 15% | 9% | 4% | 6% | 11% |
| 20 years or more | 12% | 16% | 4% | 12% | 14% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Over two-thirds of clothes washers are top-loading models (Table 7-15).

**Table 7-15: Clothes Washer Type**

(all clothes washers with type data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Clothes Washers* | *52* | *38* | *14* | *34* | *90* |
| Top load | 64% | 63% | 50% | 59% | 69% |
| Front load | 36% | 37% | 50% | 41% | 31% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 7.6 Clothes Dryers

Almost 70% of clothes dryers are in good condition with very few (1%) rated as poor condition (Table 7-16).

**Table 7-16: Clothes Dryer Condition**

(all clothes dryers with condition data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Clothes Dryers with Condition Available* | *54* | *36* | *13* | *34* | *90* |
| Good | 74% | 65% | 85% | 79% | 69% |
| Fair | 19% | 35% | 15% | 18% | 30% |
| Poor | 7% | 0% | 0% | 3% | 1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

About one-half of clothes dryers are under ten years old. Statewide, 6% of all clothes washers are 20 years or older (Table 7-17).

**Table 7-17: Age of Clothes Dryers**

(all clothes dryers with age data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Clothes Dryers* | *50* | *31* | *11* | *31* | *81* |
| 4 years or less | 26% | 33% | 36% | 29% | 33% |
| 5 to 9 years | 28% | 15% | 18% | 32% | 18% |
| 10 to 14 years | 26% | 30% | 45% | 29% | 29% |
| 15 to 19 years | 12% | 15% | 0% | 7% | 14% |
| 20 years or more | 8% | 7% | 0% | 3% | 6% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Eighty-four percent of all clothes dryers use electricity (Table 7-18). Eleven percent use propane and 5% use natural gas. One-quarter of the clothes dryers in the BED and VGS region use natural gas.

**Table 7-18: Clothes Dryer Fuel**

(all clothes dryers with fuel data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Clothes Dryers* | *51* | *35* | *12* | *31* | *86* |
| Electricity | 86% | 81% | 75% | 74% | 84% |
| Propane | 6% | 14% | 0% | 0% | 11% |
| Natural Gas | 8% | 5% | 25% | 26% | 5% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 7.7 Ranges and Ovens

Two-thirds of ranges and ovens are rated as being in good condition while just under one-third (31%) are in fair condition and 3% are in poor condition (Table 7-19).

**Table 7-19: Range & Oven Condition**

(all ranges with condition data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Ranges* | *64* | *43* | *18* | *37* | *107* |
| Good | 73% | 63% | 78% | 68% | 66% |
| Fair | 16% | 37% | 17% | 22% | 31% |
| Poor | 11% | 0% | 6% | 11% | 3% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Just over one-third of oven/ranges are under ten years old; 25% are at least twenty years old (Table 7-20).

**Table 7-20: Age of Ranges & Ovens**

(all ranges with age data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Ranges* | *58* | *41* | *14* | *34* | *99* |
| 4 years or less | 16% | 17% | 29% | 15% | 15% |
| 5 to 9 years | 29% | 19% | 14% | 29% | 20% |
| 10 to 14 years | 28% | 29% | 43% | 24% | 26% |
| 15 to 19 years | 12% | 14% | 14% | 26% | 13% |
| 20 years or more | 16% | 21% | 0% | 6% | 25% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Over one-half of all oven/ranges use electricity and one-third use propane (Table 7-21).

**Table 7-21: Oven/Range Fuel**

(all ovens/ranges with fuel data)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Ranges* | *52* | *38* | *14* | *32* | *90* |
| Electricity | 62% | 55% | 57% | 44% | 57% |
| Propane | 19% | 35% | 0% | 0% | 32% |
| Natural Gas | 19% | 10% | 43% | 56% | 11% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 7.8 Dehumidifiers

Eighty-three percent of dehumidifiers statewide are rated as being in good condition (Table 7-22).

**Table 7-22: Dehumidifier Condition**

(homes with dehumidifiers and condition data)

| | GT Regions | Non-GT Regions** | BED** | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Dehumidifiers* | *16* | *10* | *6* | *14* | *26* |
| Good | 88% | 8 | 5 | 86% | 83% |
| Fair | 13% | 1 | 0 | 7% | 17% |
| Poor | 0% | 1 | 1 | 7% | 0% |

*Results for the Statewide column are weighted; all other results are unweighted.

** Unweighted count presented due to low sample size.

Sixty percent of dehumidifiers are four years old or less (Table 7-23).

**Table 7-23: Age of Dehumidifier**

(homes with dehumidifiers with age data)

| | GT Regions | Non-GT Regions** | BED** | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Dehumidifiers* | *15* | *8* | *4* | *12* | *23* |
| 4 years or less | 73% | 4 | 2 | 50% | 61% |
| 5 to 9 years | 20% | 1 | 1 | 25% | 6% |
| 10 to 14 years | 7% | 1 | 0 | 17% | 17% |
| 15 to 19 years | 0% | 0 | 0 | 0% | 0% |
| 20 years or more | 0% | 1 | 1 | 8% | 17% |

*Results for the Statewide column are weighted; all other results are unweighted.

** Unweighted count presented due to low sample size.

## 7.9 Televisions and Peripherals

Almost all homes (99%) have at least one TV set; one-half have at least two TV sets (Table 7-24).

**Table 7-24: TV Set Saturation**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| None | 2% | 0% | 7% | 3% | 1% |
| One | 38% | 53% | 60% | 33% | 49% |
| Two | 20% | 25% | 20% | 75% | 23% |
| Three or more | 40% | 23% | 13% | 39% | 27% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Just under one-half (46%) of the TVs are CRT models. Over 40% are LCD models (Table 7-25).

**Table 7-25: TV Set Type**

(all TV Sets)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of TV Sets* | *126* | *73* | *24* | *84* | *199* |
| CRT | 44% | 47% | 46% | 33% | 46% |
| LCD | 45% | 41% | 50% | 58% | 42% |
| Projection | 9% | 10% | 0% | 5% | 10% |
| LED | 2% | 0% | 4% | 4% | 1% |
| Plasma | 0% | 2% | 0% | 0% | 1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Two-thirds of TV monitors are under 30 inches in size (as measured diagonally); about 11% of TVs are over 40” in size (Table 7-26).

**Table 7-26: TV Monitor Size**

(all TV Sets)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of TV Sets* | *126* | *73* | *24* | *78* | *199* |
| 15 inches or less | 12% | 10% | 13% | 10% | 11% |
| 16 to 20 inches | 21% | 20% | 17% | 20% | 20% |
| 21 to 30 inches | 26% | 37% | 46% | 37% | 35% |
| 31 to 40 inches | 29% | 22% | 17% | 22% | 24% |
| Over 40 inches | 13% | 10% | 8% | 10% | 11% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

The most common TV peripherals are DVD players (32%) or a VCR & DVD player (28%), which are installed in nearly two-thirds of TVs (Table 7-27). One-third of TVs have no peripherals attached.

**Table 7-27: TV Peripherals**

(all TV Sets)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of TV Sets* | *124* | *72* | *24* | *83* | *196* |
| VCR & DVD player | 27% | 27% | 38% | 23% | 28% |
| DVD player only | 26% | 35% | 17% | 29% | 32% |
| VCR only | 7% | 8% | 0% | 2% | 8% |
| None | 40% | 30% | 46% | 46% | 32% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Statewide, an equal portion − about one-third − of TV sets has either cable, satellite, or no set top box (Table 7-28).

**Table 7-28: TV Set Top Boxes**

(all TV Sets)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of TV Sets* | *123* | *71* | *24* | *82* | *194* |
| Cable | 34% | 29% | 58% | 37% | 30% |
| Satellite | 23% | 39% | 0% | 13% | 36% |
| None | 43% | 32% | 42% | 50% | 34% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

## 7.10 Computers

Nearly all homes (93%) have a computer, with 44% having two or more computers. Most homes (79%) also have a printer (Table 7-29).

**Table 7-29: Computer & Printer Saturation**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| **Computers** | | | | | |
| None | 4% | 8% | 7% | 3% | 7% |
| One | 44% | 48% | 40% | 39% | 45% |
| Two or more | 53% | 45% | 53% | 58% | 44% |
| **Printers** | | | | | |
| None | 26% | 20% | 40% | 25% | 22% |
| One | 51% | 75% | 53% | 53% | 70% |
| Two or more | 24% | 5% | 7% | 22% | 9% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Statewide, eight-one percent of all computers are desktops (Table 7-30). The BED region has the greatest percent of laptop computers (43%), followed by VGS (34%). Auditors did inquire about laptops that were not visible during the audit.

**Table 7-30: Computer Type**

(all computers)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Computers* | *52* | *36* | *14* | *35* | *88* |
| Desktop | 79% | 81% | 57% | 66% | 81% |
| Laptop | 21% | 19% | 43% | 34% | 19% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Eighty-three percent of computers have LCD monitors (Table 7-31).

**Table 7-31: Computer Monitor Type**

(all computers)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Computers* | *86* | *54* | *17* | *57* | *140* |
| LCD | 86% | 82% | 94% | 86% | 83% |
| CRT | 11% | 19% | 6% | 11% | 16% |
| LED | 4% | 0% | 0% | 4% | 1% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Ninety-five percent of all monitors are less than 20 inches in size. Just over one-half are 15 inches or less in size (Table 7-32).

**Table 7-32: Computer Monitor Size**

(all computers)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Computers* | *95* | *61* | *25* | *66* | *156* |
| 15 inches or less | 39% | 63% | 52% | 49% | 57% |
| 16 to 20 inches | 50% | 34% | 40% | 42% | 38% |
| Over 20 inches | 12% | 3% | 8% | 9% | 5% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

# 8 Lighting

CFL bulbs, including both screw-in and pin-based models, are installed at 92% of all homes (Table 8-1). Sixty-seven percent of homes have fluorescent bulbs installed and 4% have LEDs installed.

**Table 8-1: Proportion of Homes with Specific Bulbs Installed**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| CFLs installed | 93% | 93% | 100% | 95% | 92% |
| LEDs Installed | 4% | 5% | 7% | 3% | 4% |
| Incandescents installed | 98% | 100% | 100% | 100% | 99% |
| Fluorescents Installed | 78% | 63% | 53% | 72% | 67% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 8-2 displays the proportion of CFLs installed as a proportion of incandescent, CFL, and LED bulbs located in hard-wired fixtures and plug-in lamps. Thirty-three percent of homes have between one-quarter and one-half CFLs and 31% of homes contain more than one-half CFLs. In Table 8-2 and Table 8-3, we exclude fluorescent tube and circline bulbs (aka "fluorescents") from the denominator because a fluorescent pin-based fixture would need to be replaced in order to install screw-in or pin-based CFL bulb. This means that a fluorescent bulb is much less likely to be replaced by a CFL bulb.

**Table 8-2: Proportion of CFLs as Percent of CFLs, Incandescent, and LEDs**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| None | 8% | 8% | 0% | 6% | 8% |
| 1% to 10% | 8% | 17% | 13% | 18% | 15% |
| 11% to 25% | 25% | 8% | 7% | 12% | 13% |
| 26% to 50% | 27% | 36% | 33% | 27% | 33% |
| 51% to 100% | 33% | 31% | 47% | 36% | 31% |
| Mean number of CFL, incandescent, and LED bulbs | 50.6 | 42.2 | 46.2 | 48.8 | 44.4 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 8-3 displays bulb saturation as a percent of CFL, incandescent, and LED bulbs. CFLs represent 33% of these bulbs across the state, and 44% in the BED territory. While LEDs represent 0% of these bulbs in Vermont, they represent 4% in the BED territory.

**Table 8-3: Bulb Saturation as Percent of CFLs, Incandescent, and LEDs**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| CFLs | 31% | 35% | 44% | 35% | 33% |
| Incandescent | 70% | 65% | 52% | 65% | 67% |
| LEDs | 0% | 0% | 4% | 0% | 0% |
| Mean number of CFL, incandescent, and LED bulbs | 50.6 | 42.2 | 46.2 | 48.8 | 44.4 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Statewide there is an average of 14.8 and a median of 15 CFL bulbs installed in each home, representing 30% of all bulbs (including CFL, incandescent, LED, and fluorescent bulbs). The BED region has the highest proportion of CFLs installed (42%) while the GT region has the least (28%) (Table 8-4).

**Table 8-4: CFLs Installed as Percent of all Bulbs**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Mean number of CFLs | 15.6 | 14.6 | 20.1 | 17.1 | 14.8 |
| Median number of CFLs | 12 | 15 | 14 | 13.5 | 15 |
| Proportion of all bulbs that are CFLs | 28% | 31% | 42% | 31% | 30% |
| Mean number of all bulbs | 56.1 | 47.3 | 48.4 | 54.4 | 49.5 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 8-5 displays various statistics for LEDs installed in all homes. Statewide, homes have an average of 0.2 LED bulbs installed, representing 0.4% of all light bulbs installed. In the BED service territory, the average number of LEDs is 1.9 due to one home with 22 under-cabinet LEDs in the kitchen.

**Table 8-5: LEDs Installed as Percent of all Bulbs**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Mean number of LEDs | 0.2 | 0.2 | 1.9 | 0.1 | 0.2 |
| Proportion of bulbs that are LEDs | 0.4% | 0.4% | 4.0% | 0.3% | 0.4% |
| Mean number of all bulbs | 56.1 | 47.3 | 48.4 | 54.4 | 49.5 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Table 8-6 displays the number of CFLs found in storage. Statewide, 45% of all homes have CFL bulbs in storage. Across the entire sample size of 95 homes, statewide there is a mean of 3.3 CFLs in storage.

**Table 8-6: CFLs in Storage**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Percent of Homes with CFLs in Storage | 36% | 48% | 40% | 47% | 45% |
| Mean number of CFLs in Storage across all homes | 2.0 | 3.8 | 3.5 | 3.0 | 3.3 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Statewide, 13% of all homes have dimmable bulbs (Table 8-7). Across the entire sample size of 95 homes, there is a mean of 0.8 dimmable bulbs in each home.

**Table 8-7: Dimmable Bulbs**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Percent of Homes with Dimmable bulbs | 15% | 13% | 20% | 22% | 13% |
| Mean number of Dimmable bulbs across all homes | 1.2 | 0.7 | 1.5 | 1.8 | 0.8 |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

# 9 Auditor Ratings of Homes and Energy Features

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.' Auditors were asked to think about the overall construction quality as it relates to energy efficiency. They generally looked for evidence of a builder's attention to detail and sound efficiency practices; sloppiness of workmanship would have merited a lower rating. Overall, auditors rated over three-quarters (79%) of homes as average (three out of five rating) or better (Table 9-1). Sixteen percent of homes were rated a two and 6% were rated a one – indicating poor construction quality. The ratings were consistent, for the most part, across the different regions.

**Table 9-1: Rating of Construction Quality**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| 1 – poor | 2% | 8% | 0% | 0% | 6% |
| 2 | 15% | 15% | 7% | 8% | 16% |
| 3 | 45% | 40% | 33% | 47% | 41% |
| 4 | 25% | 33% | 40% | 31% | 31% |
| 5 - excellent | 13% | 5% | 20% | 14% | 7% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Auditors were asked to rate the level of energy savings opportunities in each home, using a scale of one to five, where one means 'low' and five means 'high.' Auditors were asked to think of this in terms of how much a given home might be improved. Some homes might have low-hanging opportunities for energy efficiency improvements – duct sealing, or increasing ceiling insulation, for example. Other homes, on the other hand, might not be easily improved, either because making changes would be cost-prohibitive, or the home is efficient enough that not much can be done to improve it at all. Statewide, 30% of homes were rated as a four or five, meaning auditors determined that these homes had a high potential for energy savings through various upgrades (Table 9-2).

**Table 9-2: Rating of the Level of Energy Savings Opportunities**

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| 1 – low | 7% | 8% | 13% | 8% | 8% |
| 2 | 15% | 13% | 33% | 19% | 13% |
| 3 | 38% | 53% | 33% | 42% | 48% |
| 4 | 29% | 15% | 20% | 28% | 19% |
| 5 – high | 11% | 13% | 0% | 3% | 11% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Auditors ranked the worst energy features in each home, with up to four features available per home. Overall, basement insulation R-value (including no insulation) was cited most frequently, for over one-half (58%) of homes across the state (Table 9-3). Interior lighting was noted in 51% of homes, followed by appliances (38%). Other features commonly selected include ceiling insulation R-value (29%), air infiltration (23%), duct insulation R-value (17%), and wall insulation R-value (16%). The features selected were generally similar across the different regions. When insulation is assessed as a worst energy feature, both the R-value and installation grade are taken into consideration.

## Table 9-3: Worst Energy Features by Region

(all homes)

| | GT Regions | Non-GT Regions* | BED | VGS | Statewide* |
|---|---|---|---|---|---|
| *Number of Homes* | *55* | *40* | *15* | *36* | *95* |
| Basement insulation R-value (including no insulation) | 64% | 56% | 60% | 72% | 58% |
| Lighting – interior | 38% | 56% | 47% | 44% | 51% |
| Appliances | 22% | 43% | 20% | 17% | 38% |
| Ceiling insulation R-values | 24% | 31% | 0% | 14% | 29% |
| House air leakage reduction (overall) | 24% | 23% | 0% | 17% | 23% |
| Duct insulation R-value | 18% | 17% | 33% | 31% | 17% |
| Wall insulation R-values | 15% | 16% | 20% | 11% | 16% |
| Window quality | 11% | 12% | 7% | 11% | 12% |
| Window U-value | 29% | 5% | 20% | 17% | 11% |
| Furnace/boiler efficiency | 15% | 4% | 7% | 11% | 7% |
| Lighting – exterior | 4% | 8% | 0% | 0% | 7% |
| Basement air leakage | 11% | 5% | 33% | 22% | 6% |
| Floor insulation | 2% | 8% | 0% | 0% | 6% |
| Furnace/boiler installation quality | 2% | 8% | 0% | 6% | 6% |
| Basement insulation installation | 7% | 4% | 7% | 6% | 5% |
| Pipe Insulation | 9% | 4% | 13% | 11% | 5% |
| Bathroom fan quality/effectiveness | 2% | 4% | 13% | 3% | 4% |
| Ceiling insulation installation | 4% | 4% | 0% | 3% | 4% |
| Other (specify) | 5% | 4% | 0% | 3% | 4% |
| Window air leakage | 2% | 4% | 13% | 8% | 4% |
| House solar orientation | 0% | 4% | 0% | 0% | 3% |
| HVAC controls: thermostats/zoning | 2% | 4% | 0% | 0% | 3% |
| rim joist insulation | 0% | 4% | 0% | 0% | 3% |
| Wall air leakage | 0% | 4% | 0% | 0% | 3% |
| Ceiling air leakage | 7% | 0% | 0% | 3% | 2% |
| Duct system tightness | 7% | 1% | 13% | 11% | 2% |
| Wall insulation installation | 5% | 0% | 0% | 3% | 2% |
| Duct system insulation installation | 2% | 0% | 7% | 3% | 1% |
| Washer & Dryer | 5% | 0% | 0% | 6% | 1% |
| Water heater efficiency | 2% | 0% | 7% | 3% | 1% |
| Central air conditioning efficiency | 2% | 0% | 0% | 3% | 0% |
| Crawlspace window | 0% | 0% | 7% | 3% | 0% |
| Doors | 2% | 0% | 0% | 0% | 0% |

*Results for the Non-GT Regions column and the Statewide column are weighted; all other results are unweighted.

Basement insulation R-value was most often noted as the worst energy feature (28% of homes), followed by ceiling insulation R-value (17%), and duct insulation R-value (10%) (Table 9-4). Basement insulation R-value also was most often noted as the second worst energy feature, with 21%, followed by interior lighting (16%) and appliances (14%).

**Table 9-4: Worst Energy Features by Ranking**

(all homes)

| | Top* | Second* | Third* | Fourth* |
|---|---|---|---|---|
| *Number of Homes* | *95* | *95* | *95* | *95* |
| Basement insulation R-value (including no insulation) | 28% | 21% | 3% | 7% |
| Ceiling insulation R-values | 17% | 7% | 2% | 3% |
| Duct system insulation R-value | 10% | 2% | 3% | 1% |
| Appliances | 6% | 14% | 10% | 8% |
| Wall insulation R-values | 5% | 9% | 1% | 1% |
| Lighting – interior | 4% | 16% | 20% | 11% |
| Window U-value | 4% | 2% | 4% | 0% |
| Basement insulation installation (select only if insulation present) | 3% | 1% | 0% | 1% |
| Floor insulation | 3% | 3% | 0% | 0% |
| Furnace/boiler efficiency (AFUE) | 3% | 1% | 0% | 3% |
| Furnace/boiler installation quality | 3% | 3% | 0% | 0% |
| House air leakage reduction (overall) | 3% | 4% | 13% | 2% |
| Other (specify) | 3% | 0% | 1% | 0% |
| Basement air leakage | 1% | 0% | 5% | 1% |
| Duct system insulation installation | 1% | 0% | 0% | 0% |
| Duct system tightness | 1% | 1% | 0% | 1% |
| Window quality | 1% | 3% | 4% | 3% |
| Bathroom fan quality/effectiveness | 0% | 4% | 0% | 0% |
| Ceiling air leakage | 0% | 1% | 1% | 0% |
| Central air conditioning efficiency (SEER) | 0% | 0% | 0% | 0% |
| Doors | 0% | 0% | 0% | 0% |
| Pipe Insulation | 0% | 3% | 0% | 1% |
| Wall insulation installation | 0% | 2% | 0% | 0% |
| Water heater efficiency (Energy Factor) | 0% | 0% | 0% | 0% |
| Window air leakage | 0% | 0% | 3% | 0% |
| HVAC controls: thermostats/zoning | 0% | 0% | 3% | 1% |
| Lighting – exterior | 0% | 0% | 6% | 1% |
| Rim joist insulation | 0% | 0% | 3% | 0% |
| Washer & Dryer | 0% | 0% | 1% | 0% |
| House solar orientation | 0% | 0% | 0% | 3% |
| Wall air leakage | 0% | 0% | 0% | 3% |

* All results are weighted.

# Appendix A Comparison to 2008 Baseline Study

Table A-1 compares key characteristics from the 2008 baseline study (for owner-occupied homes) to the results of the current baseline study. For the most part, the data is similar given the lapse of only three years between studies. However, there are two items with a noticeable difference: the average air infiltration value declined from 9.8 ACH50 to 7.6 ACH50 and the proportion of light bulbs that are CFLs increased from 19% to 33%. We will explore these issues in more detail in the overall single-family existing homes report.

**Table A-1: Comparison of Key 2008 and 2011 Results**

| Characteristic | Criteria | 2008 | 2011 |
|---|---|---|---|
| Home Type | % of homes that are SF detached | 98% | 95% |
| Age of Home | Average age (years) | 60 | 66 |
| Conditioned Floor Area | Average s.f. | 2,213 | 1,972 |
| Wall Insulation | Average R-value | 11.9 | 13.4 |
| Flat Ceiling Insulation | Average R-value | 26.9 | 27.9 |
| Cathedral Ceiling Insulation | Average R-value | 20.8 | 20.5 |
| Foundation Wall Insulation >50% above grade | Average R-value | 11.1 | 11.3 |
| Air Infiltration | Average ACH50 | 9.8 | 7.6 |
| Heating System Efficiency | Average efficiency of oil boilers | 82% | 85% |
| | Average efficiency of gas boilers | 85% | 86% |
| | Average efficiency of oil furnaces | 83% | 83% |
| | Average efficiency of gas furnaces | 86% | 89% |
| Thermostats | % homes with programmable units | 24% | 33% |
| Duct Insulation | % of homes with insulated ducts in uncond. space | 10% | 19% |
| Water Heater Efficiency | Average Energy Factor for integrated tanks | 79% | 80% |
| Hot Water Piping Insulation | % of homes with pipe insulation | 20% | 24% |
| Refrigerators | % units that are ENERGY STAR | 23% | 7% |
| Dishwashers | % units that are ENERGY STAR | 18% | 16% |
| Clothes washers | % units that are ENERGY STAR | 17% | 25% |
| Separate freezers | % units that are ENERGY STAR | 3% | 9% |
| Lighting | % homes with CFLs installed | 90% | 92% |
| | % bulbs that are CFLs | 19% | 33% |

# Appendix B Major Renovations & Additions

In this appendix, we briefly describe those homes that underwent gut rehab or renovation work and assess whether that work appears to meet 2005 RBES prescriptive requirements. In order to assess whether homes comply with RBES when undergoing major renovations or additions, we asked respondents during the homeowner survey if their homes had undergone a gut rehabilitation (defined as gutting the walls down to the studs in at least one-half of the home) or had an addition of at least 500 s.f. done since January 2005. Twenty homeowners reported a gut rehab and seven homeowners reported an addition.

These 27 homes were targeted for on-site visits, and homeowners were asked to confirm that their home underwent the work that they reported in the homeowner telephone survey. After further probing over the phone, some of these homes were deemed to not meet our criteria for a gut rehab or addition. Other homes received onsite visits where it was determined during the visit that the home did not meet the criteria. In the end, two homes that received an onsite visit appear to meet the criteria for a gut rehab and one home appears to meet the criteria for an addition. In addition, we include information for three other homes that appear to fall just shy of the criteria for an addition because it may be indicative of what may occur in additions greater than 500 square feet.

We compare the insulation R-values and window types for the spaces that underwent rehab or are part of an addition to the 2005 RBES prescriptive requirements. While the gut rehabs are not required to comply with 2005 RBES, the additions over 500 s.f. are required to meet 2005 RBES requirements for the affected space.

**Gut Rehabs**

Of the two home that underwent gut rehabs, one appears to meet fully meet RBES requirements and one appears to partially meet the requirements.

*Burlington*

This 1955 Ranch had a gut rehab done in 2007 where new sheet rock and insulation was installed in the home. Ceiling insulation consists of R-38 blown-in cellulose, while wall insulation consists of R-19 fiberglass batts installed in between 2 x 6 x 16 construction. Both the ceiling and wall insulation appear to meet RBES prescriptive requirements. The majority of the windows found in the home are comprised of double pane low-e glass with wood frames. While auditors were not able to determine window U-values, it is likely that windows with double pane low-e glass meet RBES requirements.

*Southern Loop region*

Originally constructed in 1850, this 2,536 s.f. home underwent renovation work through the installation of insulation in the walls and ceiling. R-19 fiberglass batts are installed in 2 x 6 x 16 wall sections and R-11 cellulose is found in the 2 x 4 x 16 wall sections. Ceiling insulation

consists of R-19 fiberglass batts. Of the installed ceiling and wall insulation, only the insulation found in the 2 x 6 x 16 wall section meet RBES requirements. For the most part, windows were not replaced as the windows are predominantly single-pane.

## Additions

The one home with an addition large enough to trigger RBES compliance appears to meet the RBES requirements for windows but not for wall insulation. For the other three projects that fall just shy of triggering RBES compliance, the windows all appear to meet RBES although the insulation only sometimes does.

*Remainder of Vermont region*

Built during the 1950s, this 3,000+ s.f. Ranch home had the insulation and sheet rock replaced throughout the entire house. During this process the 672 s.f. garage was converted into living space. A combination of double-pane and single-pane windows are present in the pre-existing home with solely double pane low-e windows in the renovated garage; the double pane windows likely meet RBES requirements. The homeowner installed insulation throughout the house, including the former garage, with R-11 fiberglass batts in-between 2 x 4 x 16 framing, which does not meet RBES requirements (R-19).

*Burlington*

Originally built in 1944, this 952 s.f. Cape styled house added a second floor (475 s.f.) to the structure in 2007. Of the verifiable insulation, rigid foam is used as insulation on the 2 x 10 x 16 band joists. Wall and ceiling insulation is not observable and unknown to the homeowner. Five out of the ten windows found in the home are installed in the new addition. The homeowner kept the window style uniform by installing double pane low-e glass with wood frames in the addition. While auditors were not able to determine window U-values, it is likely that windows with double pane low-e glass meet RBES prescriptive requirements.

*Northern Chittenden region*

Over 440 s.f. was added to this Colonial style home after 2005, bringing the conditioned space to just over 3,300 square feet. Fiberglass batts with an insulation value of R-19 are installed between the 2 x 10 x 16 rim and band joists. Exterior walls contain R-19 fiberglass batts placed in-between 2 x 6 x 16 framing. Rim and exterior wall insulation installed in the addition appear to meet RBES prescriptive requirements. The flat ceiling space in the addition has blown in R-30 cellulose, falling short of the R-38 required by RBES. While auditors were not able to determine window U values, it is assumed that the newer sliding door with double pane glass and newer windows with double pane low-e glass meet RBES prescriptive requirements.

*Rutland region*

Built in 1961, this 1,200 s.f. Cape style home had a 416 s.f. space added to the first floor after 2005. R-11 fiberglass insulation is installed between the 2 x 4 x 16 framing found in the new addition. Fiberglass batts are present in both flat (R-19) and cathedral ceilings (R-19). None of this insulation meets the RBES requirements of R-19 wall insulation, R-38 flat ceiling insulation, and R-30 sloped ceiling insulation. Even though auditors were not able to determine window U-values, it is assumed that the windows with double pane low-e glass meet RBES prescriptive requirements.

Table B-1 displays the minimum requirements for the six prescriptive packages under the Fast-Track compliance method of the 2005 RBES requirements.

**Table B-1: 2005 RBES Package Requirements for Fast-Track Compliance Method[28]**

| Component | Package 1 | Package 2 | Package 3 | Package 4 | Package 5 | Package 6 |
|---|---|---|---|---|---|---|
| Ceiling Flats & Exposed Floors R-value | R-38 | R-38 | R-49 | R-49 | R-38 | R-38 |
| Ceiling Slopes R-value | R-30 | R-30 | R-30 | R-30 | R-30 | R-30 |
| Above-Grade Walls R-value | R-19 | R-19 | R-19 | R-21 | R-19 | R-19 |
| Floors over Unconditioned Spaces R-value | R-30 | R-30 | R-30 | R-30 | R-30 | R-30 |
| Basement Walls (full height) R-value | R-10 | R-10 | R-10 | R-10 | R-15 | R-10 |
| Slab Edge R-value | R-10 | R-10 | R-10 | R-10 | R-15 | R-10 |
| Unvented Crawlspace Walls R-value | R-10 | R-10 | R-10 | R-10 | R-15 | R-10 |
| Doors, excluding sliding and patio doors, U-value | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 | 0.40 |
| Basement Window U-value | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| Window, skylights, sliding and patio doors, U-value | 0.40 | 0.34 | 0.50 | 0.40 | 0.34 | 0.34 |
| Heating System AFUE | 0.83 | 0.80 | 0.87 | 0.81 | 0.85 | 0.84 |
| Glazing Percentage | 0.12 | 0.12 | 0.12 | 0.12 | 0.18 | 0.15 |

[28] Vermont Residential Building Energy Code Handbook, Edition 2.0, November 2004. Table 4-1, Page 24. Note that heating system AFUE requirements were increased, effective June 2007 (http://www.ncsg.org/Portals/0/GA/VTHB253.pdf).

# Appendix C Mobile Homes

Mobile homes were included in the existing single-family homeowner telephone survey,[29] but were excluded from the onsite visits in order to preserve the visits for the core site-built homes that represent the majority of homes in Vermont. However, three mobile homes were visited as part of the onsite visits, after the owners reported that the homes met our criteria for site-built homes with foundations. This appendix presents a summary of the onsite data for these three mobile homes.

All three mobile homes are primary residences. They range in age from 8 to 24 years old, and in size from 812 s.f to 1,344 s.f.

**Table C-1: Home Characteristics**

| | Mobile Home #1 | Mobile Home #2 | Mobile Home #3 |
|---|---|---|---|
| Year Built | 2004 | 1989 | 1988 |
| Region | Remainder | Remainder | Remainder |
| Conditioned floor area | 1,344 s.f. | 1,104 s.f. | 812 s.f. |
| Mobile home type | Double-wide | Double-wide | Single-wide |
| Number of bedrooms | 3 | 3 | 2 |
| Number of nighttime occupants | 2 | 1 | 2 |
| Primary/seasonal use | Primary | Primary | Primary |

[29] Survey Analysis of Owners of Existing Homes in Vermont, DRAFT. September 14, 2011. Submitted to Vermont Public Service Department. Submitted by NMR Group, Inc.

All three mobile homes have R-19 fiberglass batts in the walls. Two have blown-in cellulose ceiling insulation, but in one case the R-value of that insulation is just R-19. The oldest of the three mobile homes (#3) appears to the most highly insulated, with homeowner reported ceiling and floor insulation well above what would be necessary to meet code. This homeowner reported that spray foam insulation was added in 2008, though the auditor was unable to access the spaces in order to verify the insulation levels.

**Table C-2: Building Shell**

| | Mobile Home #1 | Mobile Home #2 | Mobile Home #3 |
|---|---|---|---|
| Wall insulation type & R-value | Fiberglass, R-19 | Fiberglass, R-19 | Fiberglass, R-19 |
| Flat ceiling insulation type & R-value | Cellulose, R-19 | Cellulose, R-30 | Spray-in foam, R-36 |
| Floor insulation over unconditioned space type & R-value | Fiberglass, R-24 | DK | Spray-in foam, R-72 |
| Windows | Double pane | Double pane low-e | Single pane |
| Doors | Insulated steel | Insulated fiberglass | Insulated steel |
| Type of skirting | Foam board | DK | Fiberglass |

All three mobile homes heat with furnaces. Two of the three mobile homes heat with fuel oil, and one with propane.

**Table C-3: Heating Equipment**

| | Mobile Home #1 | Mobile Home #2 | Mobile Home #3 |
|---|---|---|---|
| Type | Furnace | Furnace | Furnace |
| Fuel | Propane | Fuel oil | Fuel oil |
| Efficiency | 75% | 80% | 80% |
| Age | 7 | 22 | 23 |

All three homes have stand-alone water heater storage tanks, although none of the water heaters have tank wrap or pipe insulation. One home has an electric water heater with an energy factor of 93%, and the other two have propane heaters with energy factors near 60%.

**Table C-4: Water Heaters**

| | Mobile Home #1 | Mobile Home #2 | Mobile Home #3 |
|---|---|---|---|
| Type | Stand-alone storage | Stand-alone storage | Stand-alone storage |
| Fuel | Propane | Propane | Electric |
| Energy factor | 59% | 57% | 93% |
| Age | 7 | 22 | 10 |
| Tank wrap R-value | 0 | 0 | 0 |
| Pipe insulation R-value | 0 | 0 | 0 |

None of the three mobiles homes have any air conditioning, though all three have supplemental heating equipment. The propane-heated home has a propane space heater, and the oil-heated homes have pellet stoves. Additionally, the propane-heated home uses an electronic thermostat, while the oil-heated homes have manual thermostats.

**Table C-5: Other Mechanical Equipment**

| | Mobile Home #1 | Mobile Home #2 | Mobile Home #3 |
|---|---|---|---|
| Air conditioning type & age | N/A | N/A | N/A |
| Ducts insulation type & R-value | None | None | Fiberglass, R-6 |
| Thermostat type | Electronic | Manual | Manual |
| Supplemental heat | Propane space heater | Pellet stove | Pellet stove |

Only one of the three homes has a dishwasher, although all three have a separate freezer, with two freezers over twenty years old. In addition, mobile home #3 has a clothes washer and dryer over twenty years old as well. Two of the three homes have a high percentage of CFLs installed.

**Table C-6: Appliances and Lighting**

| | Mobile Home #1 | Mobile Home #2 | Mobile Home #3 |
|---|---|---|---|
| Refrigerator age & condition | 7, good | 22, fair | 3, good |
| Freezer age & condition | 7, good | 22, fair | 23, fair |
| Dishwasher age & condition | None | DK, good | None |
| Clothes washer type | Top load | Top load | Top load |
| Clothes washer age & condition | 7, good | DK, good | 23, fair |
| Clothes dryer fuel, age, & condition | Electric, 7, good | Electric, DK, good | Electric, 23, fair |
| Lighting | 85% CFL | 93% CFL | 26% CFL |
| Television #1 | 59" plasma | 27" CRT | 27" CRT |
| Television #2 | 36" CRT | 32" LCD | 25" CRT |
| Television #3 | 32" LCD | n/a | n/a |
| Computers | 2 laptops | None | None |

Overall, the level of opportunity for energy savings is relatively low, with all three mobile homes rated a one or two on a five-point scale. Appliances were mentioned as a negative energy feature in all three mobile homes.

**Table C-7: Auditor Ratings**

| | Mobile Home #1 | Mobile Home #2 | Mobile Home #3 |
|---|---|---|---|
| Construction quality rating (1-poor to 5-excellent) | 4 | 3 | 2 |
| Level of energy savings opportunities rating (1-low to 5-high) | 1 | 2 | 2 |
| Worst energy feature #1 | Furnace/boiler efficiency | Appliances | Window U-value |
| Worst energy feature #2 | Ceiling insulation R-values | - | Doors |
| Worst energy feature #3 | Appliances | - | Appliances |

# Appendix D 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.[30] Bear in mind that auditors made estimates about the insulation installation grade of certain building components. This is unavoidable when conducting audits in completed and occupied homes. In instances where auditors could not access an insulated assembly, they made informed assumptions about the installation grade, typically based on the insulation installation quality observed elsewhere in the home. Viewing the quality of the attic insulation, insulation in basement walls, frame floor over basements, or kneewalls typically gave auditors an idea of the general level of care exercised in the installation of the insulation throughout the home. Appendix D provides examples of how auditors identified insulation installation grades.

**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…"

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