Vermont Single-Family Existing Homes On-site Report

REVISED DRAFT

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Vermont Public Service Department

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ES Executive Summary

This report presents the findings of on-site inspections conducted at 140 existing homes across Vermont between November 2015 and July 2016. The study included owner-occupied, single-family homes built before 2005. The objective of these inspections was to provide baseline data on the energy characteristics of the existing single-family homes market in Vermont. Data collection encompassed general home construction, insulation, windows, heating and cooling equipment, water heating, ducts, appliances, and lighting. In addition, 111 homes underwent blower door testing to measure air leakage through the building shell.

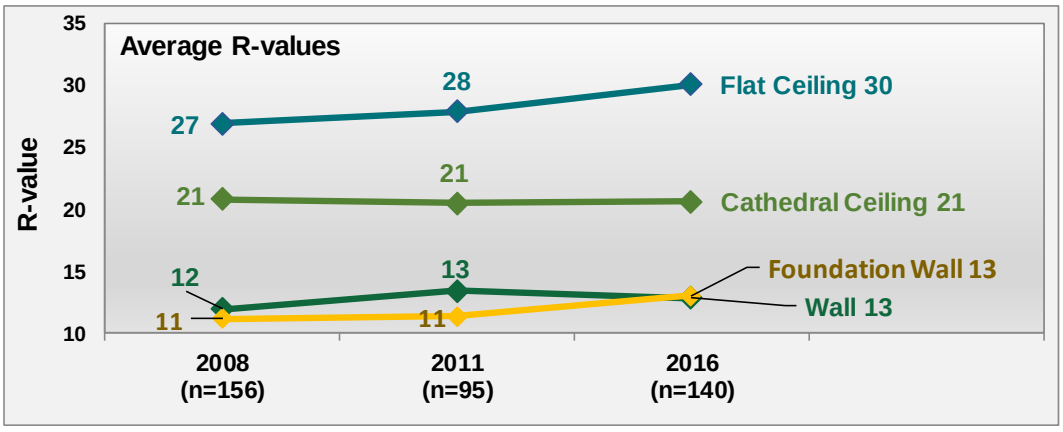
The NMR team recruited participants from a telephone survey of 508 owners of single-family homes in Vermont. The on-site homes are similar to the 2009-2013 American Community Survey (ACS) data for Vermont single-family homes in terms of decade of construction and average number of occupants. On average, the on-site homes are 61 years old with 2,147 square feet of conditioned floor area. Nearly all (95%) of the on-site homes are detached and most (87%) have a basement. About one-third of the on-site homes use oil for heating (32%), about one-quarter use either wood (24%) or propane (23%), 12% use natural gas, and 3% use electricity.[1]

In this section we present the statewide trends and opportunities.

TRENDS

Average cathedral ceiling and wall insulation R-values have remained relatively consistent since the 2008 baseline study. However, average flat ceiling and foundation wall insulation R-values have increased slightly since 2008 (Figure 1).

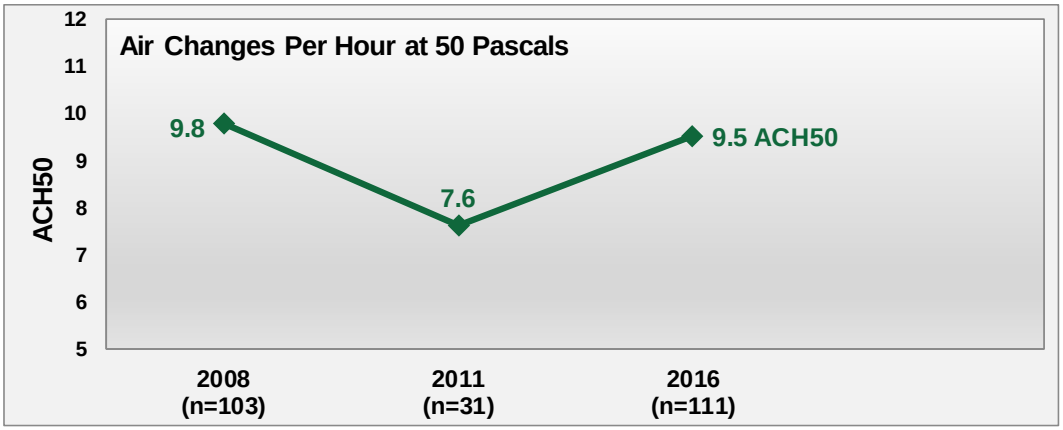
Figure 1: Average Wall and Ceiling Insulation R-values Over Time



[1] The remaining homes use kerosene (2%) or a combination of fuels (3%).

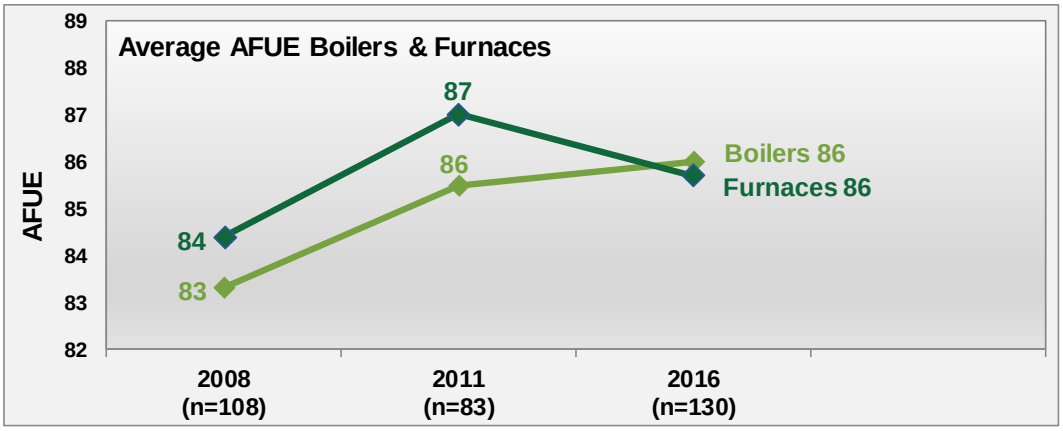
Air leakage, measured in air changes per hour at 50 pascals (ACH50), decreased between 2008 and 2011 but then increased in 2016 (Figure 2). Note, however, that far fewer homes (31 homes) received blower door tests in 2011 than in 2008 or 2016 (100+ homes) so this dip may be an artifact of the small sample size in 2011.

Figure 2: Air Leakage Over Time



Both boiler and furnace efficiencies increased between 2008 and 2011. However, since 2011, boiler efficiencies increased by less than one percentage point, while furnace efficiencies decreased by one percentage point (Figure 3). In addition, 4% of homes have a ductless heat pump and <1% have a Wi-fi thermostat in 2016[2].

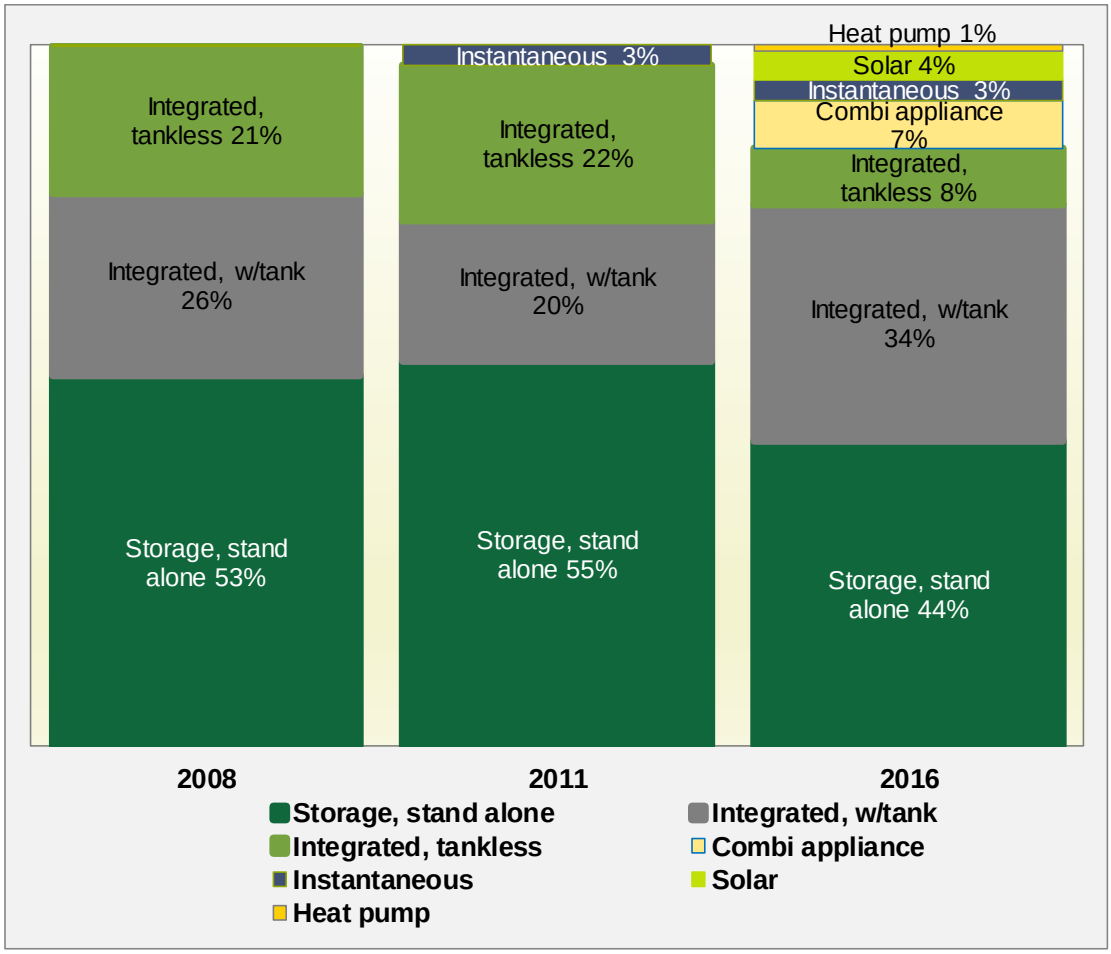
Figure 3: Boiler and Furnace Efficiencies Over Time



[2] A Wi-Fi thermostat provides the user with the ability to connect remotely via a Wi-Fi internet connection to control the operation of the associated HVAC system via a computer or smartphone.

For the first time, some inspected homes have water heaters that are solar assisted (4%), heat pump (1%)[3], or a combination appliance[4] (7%) (Figure 4). Compared to the previous studies, more homes have integrated tank water heaters (34%), while fewer homes have integrated tankless (8%) or stand alone storage (44%) water heaters.

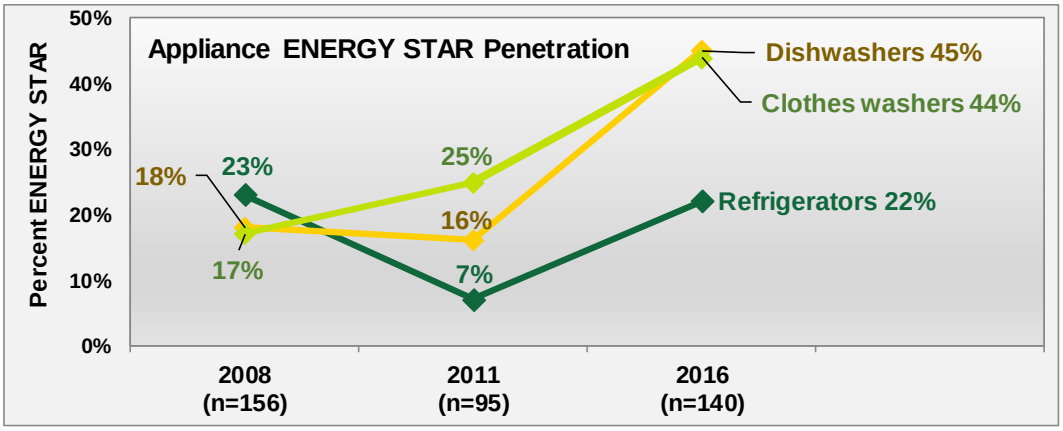
Figure 4: Water Heater Types Over Time



[3] The on-site visits occurred between November 2015 and July 2016, before the rapid growth of the heat pump water heater market.
[4] A combination appliance is both a high efficiency boiler and high efficiency water heater combined in the same unit.

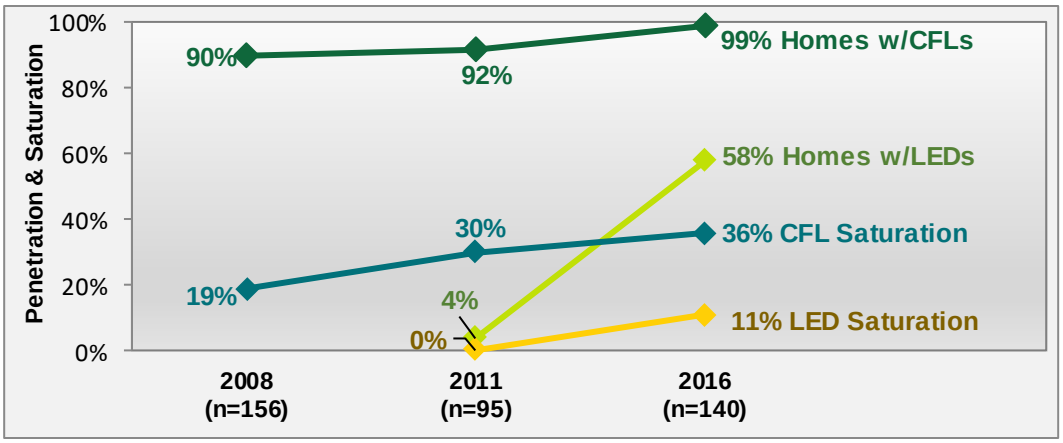
The proportions of dishwashers and clothes washers that are ENERGY STAR® certified have increased since 2008, to 45% and 44%, respectively. However, the proportion of primary refrigerators that are ENERGY STAR certified has fluctuated since 2008 (Figure 5).

Figure 5: ENERGY STAR Clothes Washers, Dishwashers and Primary Refrigerators Over Time



The percentage of homes with at least one LED rose to 58% in 2016, when 11% of sockets contained an LED. CFL penetration[5] and saturation[6] also increased in 2016, to 99% and 36%, respectively (Figure 6). Combined, LEDs and CFLs filled 47% of all sockets in 2016, after filling 30% of all sockets in 2011.

Figure 6: CFL and LED Lighting Over Time



OPPORTUNITIES

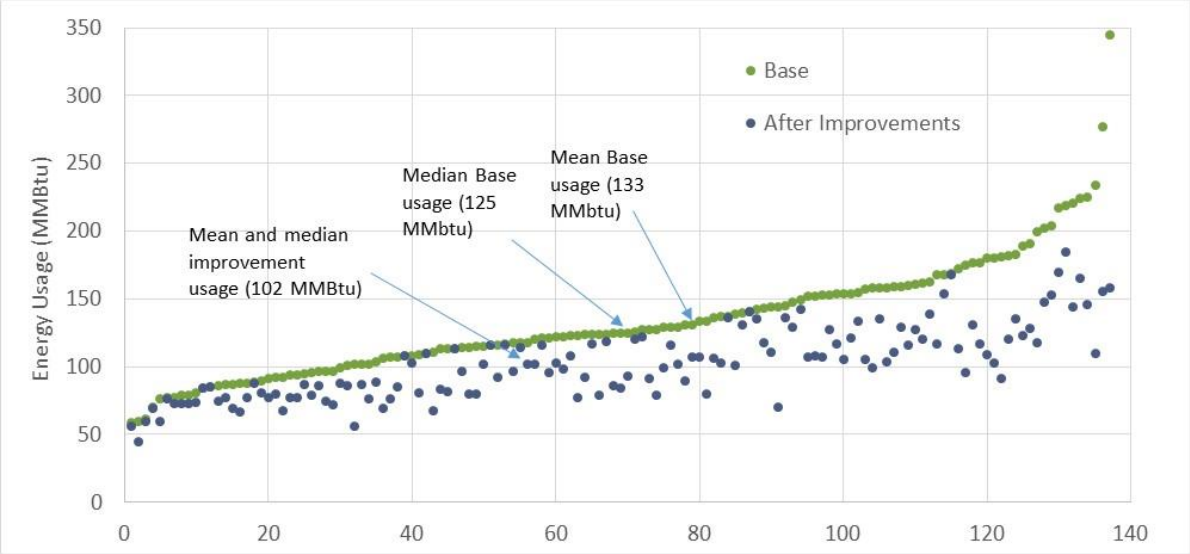
This section provides a summary of the distribution and type of energy savings opportunities in Vermont single-family existing homes. It also provides three separate

[5] Penetration equals the percent of homes with at least one of a given bulb type installed.
[6] Saturation equals the percent of sockets that contain a given bulb type.

assessments of the savings opportunities from: 1) measurements of key home characteristics, 2) auditor assessment, and 3) the Home Energy Score models. Lastly, we summarize the energy savings opportunities that incorporate information from all three sources.

The Home Energy Score (HES) is a Department of Energy rating system that models the energy efficiency of homes based on features of the building envelope, glazing, mechanical systems, and home area.[7] Figure 7 illustrates the larger energy savings opportunities that are available at homes with higher energy usage. The figure displays the HES-modeled annual energy consumption before and after all recommended HES improvements are implemented for each home sorted by base energy usage in ascending order. The average base energy usage is 133 MMBTu, which declines by 23% to 102 MMBtu after all recommended improvements.

Figure 7: Statewide Average Energy Consumption with and without Improvements



[7] The HES tool does not include lighting, appliances, or thermostat set points among its input variables.

Figure 8 displays the HES-modeled current annual energy usage and estimated energy savings by quartile. The first quartile represents the 25% of homes with the lowest annual energy consumption; in contrast, the fourth quartile represents the 25% of homes with the highest annual energy consumption. The 25% of homes in the fourth quartile are estimated to represent 36% of total energy consumption and 50% of the total energy savings. This analysis highlights the importance of targeting high consumption homes in reducing overall energy usage.

Figure 8: Distribution of Energy Usage and Savings by Quartile

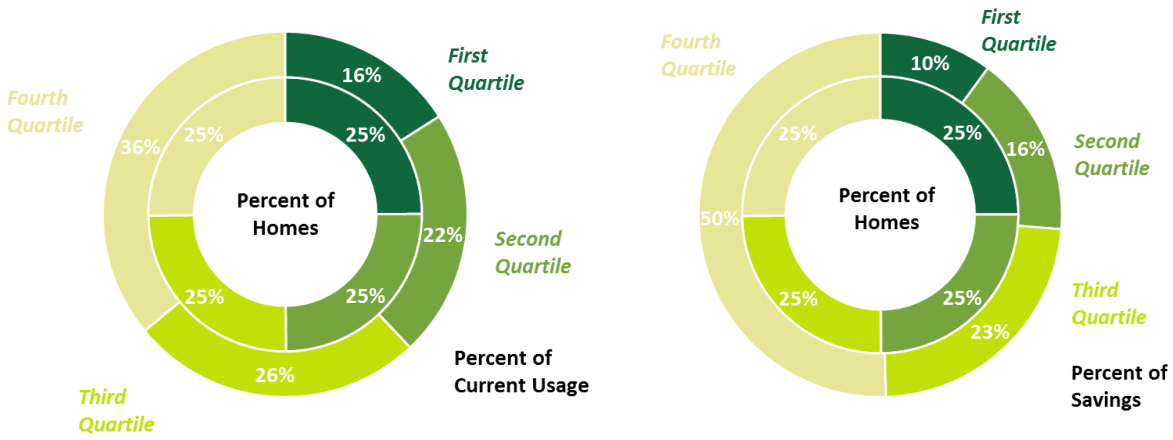


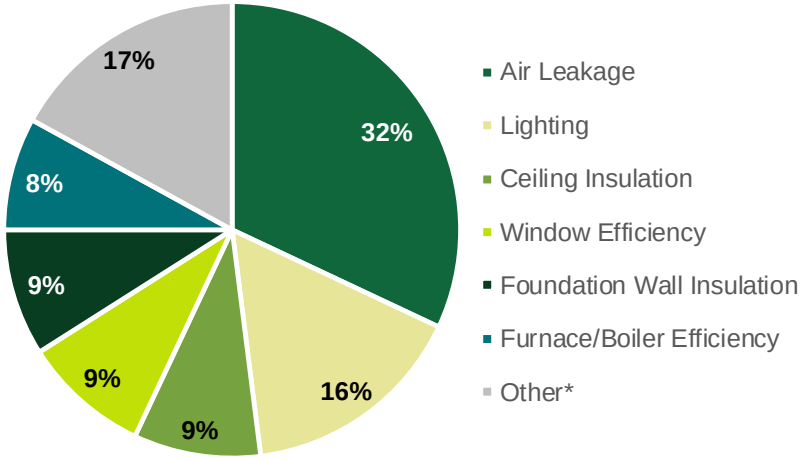
Table 1 summarizes the characteristics of various savings opportunities. Overall, a minority of homes present a substantial savings opportunity in each category, with the exception of water heater pipe insulation (64%) and manual thermostats (69%).

Table 1: Savings Opportunities

Characteristic	Measurement	Percent
Ceiling Insulation	Percent of homes with <= R-19 in flat ceilings	13%
	Percent of homes with <= R-19 in cathedral ceilings	23%
Wall Insulation	Percent of homes with no wall insulation	3%
Basement Insulation	Percent of homes with unconditioned basements that have uninsulated frame floors and foundation walls	45%
Windows	Percent of window area that is single pane	20%
	Percent of single pane window area that does not include storm windows	27%
Air Infiltration	Percent of homes > 10.0 ACH50	30%
HVAC	Percent of homes with a furnace or boiler > 20 years old	23%
	Percent of homes with manual thermostats	69%
Water Heaters	Percent of homes with tankless coil systems	8%
	Percent of homes with electric storage tanks	25%
	Percent of all storage tanks > 15 years old	34%
	Percent of homes without any pipe insulation	64%
Refrigerators	Percent of primary refrigerators 15 or more years old	28%
	Percent of secondary refrigerators 15 or more years old	46%
Lighting	Socket saturation of incandescent and halogen bulbs	43%

Figure 9 displays the distribution of the total energy efficiency opportunities identified by auditors. Nearly one-third of the energy efficiency opportunities identified pertain to air leakage (32%), followed by lighting (16%), ceiling insulation (9%), windows (9%), foundation wall insulation (9%), and boiler or furnace efficiency (8%).

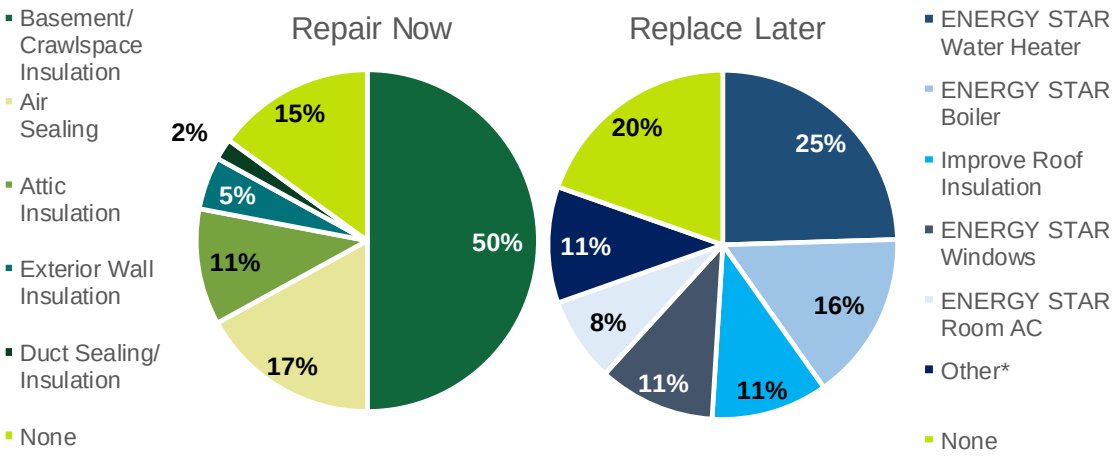
Figure 9: 2016 Auditor Identified Energy Efficiency Opportunities



*Includes duct insulation/sealing, water heater efficiency, wall, frame floor, door, and knee wall insulation.

The HES tool provides *Repair Now*[8] and *Replace Later*[9] recommendations to improve the home's energy efficiency. Figure 10 displays the statewide distribution of the primary[10] *Repair Now* and *Replace Later* recommendations. Adding basement or crawlspace insulation was the primary *Repair Now* recommendation for one-half (50%) of the homes, followed by air sealing (17%) and attic insulation (11%). Installing an ENERGY STAR water heater was the primary *Replace Later* recommendation for one-quarter (25%) of the homes, followed by installing an ENERGY STAR boiler (16%), improving roof insulation (11%), and installing ENERGY STAR windows (11%).

Figure 10: HES Primary Recommendations



*Includes ENERGY STAR furnace, heat pump, CAC, and efficient wood stove.

The following bullets summarize the major energy savings opportunities.

- **Air Leakage**. Air leakage represents almost one-third (32%) of the energy efficiency opportunities identified by auditors. In addition, 30% of homes have ACH50 > 10.0 and air sealing was the primary *Repair Now* recommendation for almost one-fifth (17%) of homes.
- **Lighting**. While both CFL and LED bulb saturation has continued to increase, there still remains a significant opportunity as 43% of sockets contain incandescent or halogen bulbs. In addition, lighting represents the second most common opportunity cited by auditors, identified in 16% of homes.
- **Basement Insulation**. Nearly one-half (45%) of the homes with unconditioned basements lack both frame floor and foundation wall insulation. Adding basement or crawlspace insulation was the primary *Repair Now* recommendation for one-half (50%) of homes, and represents 9% of opportunities identified by auditors.

[8] Improvements that "will save you money, conserve energy, and improve your comfort now."
[9] Improvements that "will help you save energy when it's time to replace or upgrade."
[10] The primary recommendation is the recommendation from each home associated with the largest annual energy cost savings.

Foundation walls provide a substantial opportunity for insulation and air sealing, depending on the level of finish of the basement interior.

- **Ceiling Insulation**. Attic/roof insulation was the primary *Repair Now* and the primary *Replace Later* recommendation for 11% of homes. In addition, ceiling insulation represents 9% of the energy efficiency opportunities identified by auditors. Accessible flat ceiling spaces, in particular, present clear opportunities for both air sealing and insulation upgrades.
- **Water Heaters**. While only 8% of homes have tankless coil water heaters, 25% have electric resistance storage tanks. In addition, about one-third of all storage tanks are more than 15 years old and will need to be replaced in the near future. Upgrading to an ENERGY STAR water heater was the primary *Replace Later* recommendation for 25% of homes. Lastly, nearly one-third (30%) of homes had sufficient space, temperature, and drainage for a heat pump water heater though only 1% of homes have such a unit currently installed.
- **Heating Systems**. At least one-fifth of the boilers (20%) and furnaces (28%) are over 20 years old, and will need to be replaced in the near future. In addition, upgrading to an ENERGY STAR boiler was the second most common *Replace Later* recommendation (16%), and upgrading other types of heating and cooling equipment was the primary *Replace Later* recommendation for 11% of homes.
- **Thermostats**. Nearly all thermostats have either programmable (60%) or manual controls (39%). With less than 1% of homes containing Wi-fi thermostats, there is a large opportunity for smart thermostats.
- **Ducts**. Approximately one-third of sampled homes (31%) have ductwork, and two-thirds of these homes (67%) have ducts located outside of conditioned space. Most of these ducts are unsealed, uninsulated sheet metal. Although sealing and insulating ducts does not represent a large proportion of either auditor or HES recommendations, it can be done in conjunction with air sealing to increase energy savings with minimal additional costs.
- **Pipe Insulation**. Nearly two-thirds of homes have no insulation on their hot water pipes. Although the potential savings from insulating these pipes is relatively low, adding insulation is a relatively inexpensive proposition.
- **Refrigerators**. Over one-quarter (28%) of primary refrigerators are 15 or more years old, which may present an opportunity for appliance retirement.

1 Section 1 Introduction

On-site inspections were conducted at 140 existing single-family homes in Vermont between November 2015 and July 2016. 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 2 summarizes the housing characteristic data for single-family, owner-occupied Vermont homes built before 2005 from the 2009-2013 American Community Survey (ACS). About one-quarter (26%) of the buildings were constructed before 1939, and over one-half (57%) were constructed between 1960 and 1999. About one-half (51%) are heated with oil, one-fifth (22%) are heated with wood, 14% are heated with bottled gas, and 11% are heated with natural gas. On average, 2.4 people reside in these homes.

Table 2: Summary of ACS data for Vermont Single-Family Owner-Occupied Homes

Characteristic	Vermont ACS 2009-2013[a]
Number of Housing Units	*164,600*
When Structure Built	
Before 1939	26%
1940 to 1959	11%
1960 to 1979	27%
1980 to 1999	30%
2000 or later	6%
Primary Heating Fuel	
Fuel oil	51%
Wood	22%
Bottled gas	14%
Natural gas from underground pipes	11%
Electricity	1%
Other	2%
Average Household Size	2.4

[a] ACS base = owner-occupied, single-family units built before 2005.

1.2 On-site Audit Data Collection

The scheduling of the on-site visits followed the recruitment of volunteers through the telephone survey of owners of 508 existing single-family homes. 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 $100 and a brief energy efficiency report on their home was offered to all customers.
- *Confirmation Calls.* Each homeowner with a scheduled appointment was called at some point 48 hours before the visit to confirm the appointment.

On-site Inspection Data Collection. The primary objective of the on-site 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 location, type of sealing (if any), insulation type, and estimated R-value.
- Appliances and electronics present at the home including dishwashers, clothes washers, dryers, ovens, refrigerators, freezers, room air conditioners, dehumidifiers, 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 111 of the 140 existing single-family homes. Due to concerns about health and safety, blower door tests were not conducted at homes where the homeowner reported certain conditions, such as the presence of asbestos or vermiculite insulation, a wood stove or fireplace has recently been used, or ongoing renovations opened the building envelope.

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

1.3 SAMPLE PLAN

1.3.1 Sample Definition

As discussed in the *Final Definitions for 2011 Residential Market Characterization Study*[11] memo, single-family homes were defined to include the following types of homes:

- Detached single-family home

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

  - 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

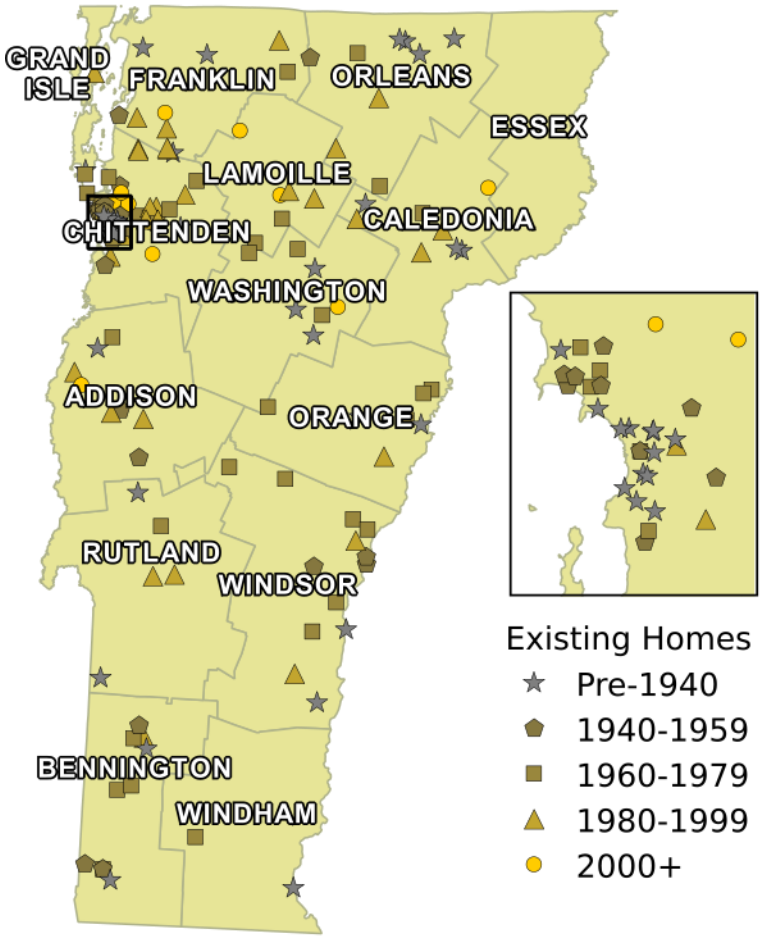
This definition of single-family homes excludes the following types of homes:

- 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.

Figure 11 shows the geographic distribution of on-site audits across the state.

Figure 11: Map of On-site Audits in Vermont



1.4 Sampling Error

To inform the sample design for existing single-family homes, the maximum coefficient of variation (CV) found in the prior study (0.50) was assumed. The chosen sample design was anticipated to provide precision estimates of about a ±7% sampling error at the 90% confidence level when aggregated at the statewide level. The service territory sample sizes targeted precisions of approximately ±16% at the 90% confidence level for Burlington Electric, ±8% for Efficiency Vermont, and ±14% for Vermont Gas. Using the data collected during the study, actual coefficients of variation and estimates of precision can be calculated for key home characteristics. The equation used to calculate the relative precision is as follows:

$$Relative\ precision(\hat{x}) = \frac{z \cdot \widehat{SE}(\hat{x})}{\hat{x}}$$

Where:

$\hat{x} =$ estimated value from sample data

$z =$ z-score, 1.645 for a 90% confidence level

$\widehat{SE} =$ estimated standard error of the value

Table 3 and Table 4**Error! Reference source not found.** display the CVs and relative precisions for key building measures. Coefficient of variation is a measure of the amount of variability in the population and is calculated by dividing the standard error by the average value. Generally, CVs of 0.50 or less are considered to represent a homogenous population while CVs of 1.0 or higher reflect a heterogenous population.

Some features in existing homes are far more variable than others. Air infiltration exhibits wider relative precisions than anticipated. Conversely, fossil fuel-fired heating efficiency shows the lowest levels of variability with no relative precision values beyond ±2.1% at the 90% confidence level. In Burlington Electric homes, all measures except vaulted ceiling R-values and air infiltration come in below the anticipated ±16% sampling error for the sample. In Vermont Gas homes, relative precisions fall under the anticipated ±14% range for all measures except air infiltration. In the Efficiency Vermont and statewide samples, relative precision values do no exceed sampling error targets with the exception of vaulted ceiling R-values and air infiltration.

Table 3: Coefficients of Variation for Key Measures

	Burlington Electric		Vermont Gas		Efficiency Vermont		Statewide	
Parameter	**N**	**CV**	**N**	**CV**	**N**	**CV**	**N**	**CV**
Base HES Score	23	0.46	35	0.42	114	0.49	137	0.49
AFUE of Fossil-Fuel Fired Heating Systems	24	0.06	38	0.07	109	0.09	133	0.08
Conditioned/Ambient Wall Insulation R-value	138	0.46	180	0.42	564	0.38	702	0.40
Vaulted Ceiling Insulation R-value	15	0.43	24	0.38	76	0.47	91	0.46
Flat Ceiling Insulation R-value	35	0.55	52	0.48	142	0.50	177	0.52
Air Infiltration—ACH50	20	0.55	31	0.70	91	0.68	111	0.66

Table 4: Relative Precisions of Key Measures at 90% Confidence Level

	Burlington Electric		Vermont Gas		Efficiency Vermont		Statewide	
Parameter	**N**	**RP**	**N**	**RP**	**N**	**RP**	**N**	**RP**
Base HES Score	23	±15.7%	35	±11.5%	114	±7.6%	137	±6.9%
AFUE of Fossil-Fuel Fired Heating Systems	24	±2.1%	38	±1.9%	109	±1.3%	133	±1.2%
Conditioned/Ambient Wall Insulation R-value	138	±6.4%	180	±5.2%	564	±2.6%	702	±2.5%
Vaulted Ceiling Insulation R-value	15	±18.2%	24	±12.7%	76	±8.9%	91	±8.0%
Flat Ceiling Insulation R-value	35	±15.4%	52	±11.0%	142	±6.9%	177	±6.4%
Air Infiltration—ACH50	20	±20.2%	31	±20.7%	91	±11.8%	111	±10.2%

1.5 BIAS

Potential bias is a concern in any sample based on voluntary participation. Compared to the 2009-2013 American Community Survey for Vermont, the on-site homes are similar in terms of decade of construction and average number of occupants (Table 5). The on-site homes are also generally similar to the ACS in terms of primary heating fuel, although there are fewer homes heated with oil (32% compared to 51%), and more homes heated with bottled gas (23% compared to 14%). Overall, this comparison suggests that the sample of on-site homes in this study is generally consistent with ACS data on the existing housing stock in Vermont.

Table 5: Comparison of Statewide On-site data to ACS data

Characteristic	Statewide Weighted Sample	Vermont ACS 2009-2013[a]
Number of Homes	*140*	*164,600*
When Home Built		
Before 1939	23%	26%
1940 to 1959	13%	11%
1960 to 1979	31%	27%
1980 to 1999	26%	30%
2000 or later	8%	6%
Primary Heating Fuel		
Fuel oil	32%	51%
Wood	24%	22%
Bottled gas	23%	14%
Natural gas from underground pipes	12%	11%
Electricity	3%	1%
Other	5%	2%
Average Household Size	2.1	2.4

[a] ACS base = owner-occupied, single-family units built before 2005.

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.

1.6 WEIGHTING

Most tables in this document present unweighted results for Burlington Electric Department (BED) and Efficiency Vermont (EVT), while the Vermont Gas Systems (VGS) and statewide

results are weighted. We developed the statewide weights in Table 6 because we oversampled in the Burlington Electric and Vermont Gas territories. The statewide weight for each region is developed by dividing the proportion of single-family homes in the population by the proportion of completed visits in each region. Table 6 displays the estimated number and percent of single-family homes and on-site visits, as well as the calculated weight.

Table 6: Statewide Weighting Scheme

Region	Owner-Occupied Single-Family Homes		Completed On-sites		Statewide Weight
	Count	Percent	Count	Percent	
Burlington Electric	5,366	3%	25	18%	0.18
Efficiency Vermont and Vermont Gas	15,371	9%	14	10%	0.90
Efficiency Vermont without Vermont Gas	150,585	88%	101	72%	1.22
Statewide	171,322	100%	140	100%	n/a

In addition, because the Vermont Gas territory includes an oversample of Burlington Electric homes, we have used a similar approach to weight the Vermont Gas results. We apply a weight of 2.08 to Efficiency Vermont homes and a weight of 0.34 to Burlington Electric homes when estimating the Vermont Gas results.

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 Section 2 Home Characteristics

As part of this study, the Team targeted owner-occupied single-family and two-family homes for the on-site inspections. As a result, nearly all of the on-site visits took place at detached single-family homes (95%) (Table 7).

Table 7: Types of Homes

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*	Vermont ACS 2009-2013[a]
Number of Homes	*25*	*37*	*115*	*140*	*164,600*
Detached Single-Family	92%	81%	95%	95%	97%
Two-family/duplex	8%	19%	5%	5%	3%

[a] ACS base = owner-occupied, single-family units built before 2005.
*Results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.

Figure 12**Error! Reference source not found.** shows pictures of three typical homes visited for this study.

Figure 12: Examples of Existing Homes Visited



Table 8 shows that statewide, a majority of homes (78%) are two stories in height. The rest of the sites consist of single story (20%) and three-story (2%) homes.

Table 8: Number of Stories of Homes

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
One	32%	19%	20%	20%
Two	64%	81%	78%	78%
Three	4%	<1%	2%	2%

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

Table 9Table 9: When Home was Built 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.

Table 9: When Home was Built

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*	Vermont ACS 2009-2013[a]
Number of Homes	*25*	*37*	*115*	*140*	*164,600*
Before 1939	52%	12%	22%	23%	26%
1940 to 1959	28%	17%	12%	13%	11%
1960 to 1979	16%	14%	30%	31%	27%
1980 to 1999	4%	40%	27%	26%	30%
2000 or later	-	17%	9%	8%	6%
Average Age (years)	83	44	59	61	n/a
Median Age (years)	77	34	44	47	n/a

[a] ACS base = owner-occupied, single-family units built before 2005.

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

The average conditioned floor area[12] statewide is 2,147 square feet and the median is 2,014 square feet (Table 10).

Table 10: Square Feet of Conditioned Area
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Minimum	423	423	624	423
Maximum	3,673	4,243	4,435	4,435
Average	1,866	2,530	2,175	2,147
Median	1,748	2,258	2,048	2,014
Std. Deviation	758	928	848	839

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

[12] 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 11 displays the foundation type associated with the inspected homes and whether or not the space is conditioned. If a space contains either conditioned floor area or conditioned volume, then it is considered to be conditioned.[13] In partially conditioned spaces, a portion of the area is conditioned while a portion of the same space is not conditioned.

Nearly two-thirds of the sampled homes have a below grade basement (63%), 24% have a mixed grade basement, and 13% do not have a basement. Two-thirds (66%) of the full below grade basements are fully unconditioned whereas 67% of the mixed grade basements (typically walkout basements) are fully conditioned.

Table 11: Foundation Type
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*24*	*36*	*115*	*139***
Below Grade Basement	**63%**	**70%**	**63%**	**63%**
Fully Conditioned	27%	54%	27%	26%
Unconditioned	73%	38%	65%	66%
Partially Conditioned	-	8%	8%	8%
Mixed Grade Basement	**33%**	**23%**	**24%**	**24%**
Fully Conditioned	50%	37.5%	67%	67%
Unconditioned	38%	37.5%	11%	12%
Partially Conditioned	12%	25%	22%	21%
No Basement**	**4%**	**7%**	**13%**	**13%**
Enclosed Crawl Space	-	-	40%	40%
Enclosed Crawl Space and Slab	-	-	13%	14%
Conditioned Crawl Space and Slab	-	-	20%	20%
Open Crawl Space and Slab	100%	-	-	1%
Slab on Grade	-	100%	27%	25%

*Results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.
**Sites with only Enclosed/Open/Conditioned Crawl Spaces were considered “No Basement.”
***One site in Burlington Electric (and Vermont Gas) was a second story apartment. That site was omitted from analysis.

[13] 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 1,138 square feet (Table 12). For homes with partial basements, the average size is 1,042 square feet. For homes with partially conditioned basements, on average, 57% of the basement area is conditioned.

Table 12: Basement Size and Conditioning
(all homes with basements)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
All Below Grade				
Number of Homes	*15*	*25*	*73*	*88*
Average Basement Area (s.f.)	972	1,145	1,145	1,138
Median Basement Area (s.f.)	880	1,002	1,117	1,070
Partial Grade				
Number of Homes	*8*	*10*	*27*	*35*
Average Basement Area (s.f.)	1,050	993	1,041	1,042
Median Basement Area (s.f.)	905	905	1,020	1,012
All Partially Cond. Basements				
Number of Homes	*1*	*3*	*12*	*13*
Average % Conditioned	56%	57%	56%	57%

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

Twenty percent of homes have a dedicated office space for running a business or working from home (Table 13). Most of the home offices are between 100 square feet and 200 square feet in size.

Table 13: Home Offices
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Homes with Home Offices	40%	36%	20%	20%
Number of Home Offices	*10*	*13*	*23*	*28*
Less than 100 square feet	4	3	4	5
100 to 200 square feet	6	6	12	15
Over 200 square feet	-	4	7	8

*Percentage results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.

Six percent of homes have a swimming pool; all nine of these pools are unheated and one of them is not in use (Table 14). Less than one percent of homes have a hot tub statewide.

Table 14: Swimming Pools & Hot Tubs
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*36*	*115*	*140*
Homes with swimming pools	-	6%	8%	6%
Homes with hot tubs	-	-	<1 %	<1%

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

3 Section 3 Building Envelope

This section presents the on-site results for walls, ceilings, framed floors, slabs, windows, and doors.

In this report, we present average R-values for a given assembly type (exterior walls, ceilings, etc.), calculating an area-weighted average R-value for each relevant home. Unless otherwise stated, tables showing mean R-values reflect only those homes with that insulation present; each home has one average R-value, and these results are averaged together to create an average of averages. In this type of analysis, larger and smaller homes count equally.

3.1 Walls

In the field, auditors recorded information about the physical characteristics of the above-grade walls that form the thermal boundary of the inspected homes by grouping them according to the types of spaces that they separate. We report separately on walls that divide the following types of spaces:

- Conditioned spaces and ambient (outdoor) conditions
  - These are the main walls of a home's thermal boundary.
- Conditioned spaces and garages
  - These are walls dividing a home from an abutting garage.
- Conditioned spaces and attics
  - These are common on Cape Cod-style homes, homes with dormers on upper levels, or in homes with other attic spaces that abut the conditioned space.
  - Knee-walls, the short walls on upper floors that support the sloping roof rafters, are common examples of walls separating conditioned space from attics.

The fiberglass batt insulation R-values used in calculations are nominal R-values—the R-values printed on the batts.[14]

[14] In some cases, auditors downgraded the R-value of fiberglass insulation if it was severely compressed into a cavity too small for that thickness of insulation.

3.1.1 Conditioned/Ambient Walls

In Table 15 **Error! Reference source not found.**, sites are classified by the most common construction materials and techniques observed in the conditioned/ambient (exterior) walls of a home. Three-fifths of homes use predominantly 2×4 framing in exterior walls and another quarter have 2×6 walls. Almost all dimensional lumber walls (as opposed to walls built out of brick, logs, etc.) use 16 inch on-center stud spacing.

Statewide, 18% of existing homes have more than one type of wall construction. On average, these secondary assemblies account for 30% of wall area when present. The categories in the following table are exclusive categories, such that each home is counted once.

Table 15: Type of Construction for Conditioned/Ambient Walls

Conditioned/Ambient Construction	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
2×4, 16” center**	76%	49%	59%	60%
2×6 ,16” center**	12%	48%	27%	26%
Log**	0%	0%	6%	6%
2×4, 24” center**	4%	1%	4%	4%
2×6, 24” center**	4%	1%	2%	2%
6×6, 24” center	0%	0%	1%	1%
Insulated Concrete Block***	0%	0%	1%	1%
Brick**	4%	1%	0%	0%

*Vermont Gas and Statewide results are weighted; all other results are unweighted.
**Some homes in this category have a secondary assembly with a different framing type.
*** Not to be confused with insulated concrete forms (ICF), these are pre-cast concrete blocks with foam board insulation-filled channels.

Similar to the previous wall construction table, Table 16 is based on the most common form of insulation present in each home's exterior walls. Nearly three fourths of homes have exterior walls that are insulated primarily with fiberglass batts. All other insulation types are uncommon, except for cellulose, which is present in over one quarter of Burlington Electric homes. An insulation type with a plus sign, as in—"Fiberglass Batts + Rigid Foam"—indicates multiple types of insulation were present in the same cavity.

Table 16: Type & Grade of Conditioned/Ambient Wall Insulation by Percent of Homes

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Insulation Type				
Fiberglass Batts**	48%	89%	75%	73%
Cellulose**	28%	6%	7%	8%
Fiberglass + Rigid Foam**	4%	0%	6%	6%
Log**	0%	0%	6%	6%
Rock Wool**	8%	2%	2%	2%
Brick**	4%	1%	1%	1%
Rigid Foam Board	0%	0%	1%	1%
None	8%	2%	3%	3%
Insulation Installation Grade				
Number of Homes	*23*	*34*	*112*	*135*
Grade I Installation	4%	1%	9%	9%
Grade II Installation	57%	63%	71%	72%
Grade III Installation	39%	36%	20%	20%

Vermont Gas and Statewide results are weighted; all other results are unweighted.
**Some homes in this category have a secondary assembly with a different framing type.

Table 17 describes the insulation type and installation quality across the entire sample by the percent of total exterior wall area. The vast majority of exterior wall area in sampled homes (72%) is insulated solely with fiberglass batts. Similarly, three fourths (73%) of the insulation installed in these walls is Grade Ⅱ. Excluding walls that are built of log or brick (7%), only three percent of exterior wall area across all sample homes is uninsulated.

Table 17: Type & Grade of Conditioned/Ambient Wall Insulation by Percent of Area

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Insulation Type				
Number of Homes	*25*	*37*	*115*	*140*
Fiberglass Batts	51%	90%	74%	72%
Fiberglass + Rigid Foam	4%	0%	0%	7%
Cellulose	29%	6%	6%	7%
Log	0%	0%	6%	6%
Rock Wool	5%	1%	2%	2%
Brick	5%	1%	1%	1%
Rigid Foam Board	0%	0%	1%	1%
Cellulose + Fiberglass	0%	0%	<1%	0%
Spray Foam	0%	0%	<1%	0%
Spray Foam + Cellulose	0%	0%	<1%	0%
None	7%	1%	2%	3%
Insulation Installation Grade				
Number of Homes	*23*	*34*	*112*	*135*
Grade Ⅰ Installation	2%	0%	0%	6%
Grade Ⅱ Installation	55%	63%	64%	73%
Grade Ⅲ Installation	43%	37%	36%	21%

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

As can be seen in Table 18, the average R-value for conditioned/ambient walls is R-12.8. This is driven by the high proportion of 2×4 walls insulated with fiberglass batts, which are typically available in R-11, R-13, and R-15 levels. The average insulation values in the sampled homes range from uninsulated to R-31 (a home with 2×6 ,16" center walls insulated with fiberglass batts and a layer of rigid foam).

Table 18: R-value Statistics for Insulation in Conditioned/Ambient Walls

Conditioned/Ambient Wall R-values	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Minimum	0	0	0	0
Maximum	19	19	31	31
Average	10.5	14.3	12.9	12.8
Median	11	15	11	11

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

Figure 13 displays the broad distribution of conditioned to ambient wall insulation R-values seen in the sampled homes.

Figure 13: Average R-value per Home for Conditioned/Ambient Walls

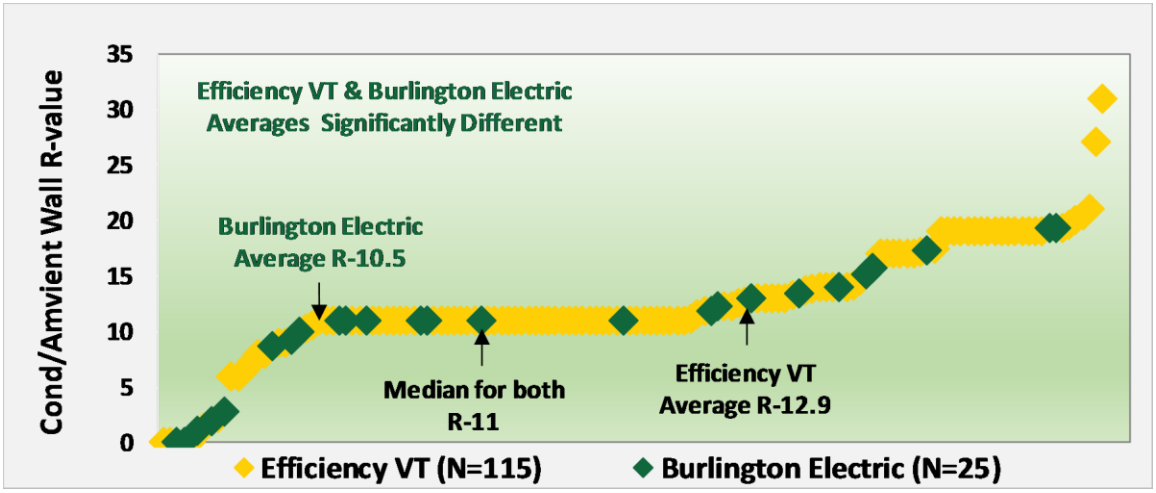
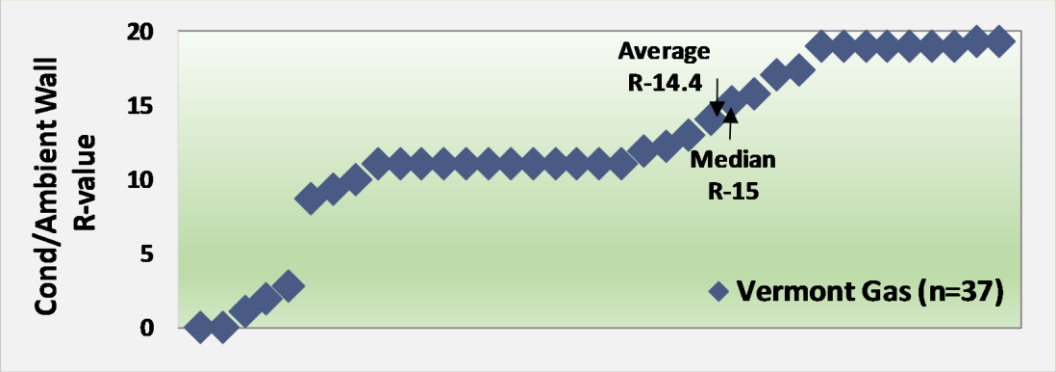


Figure 14 graphs the distribution of ambient wall R-values in the Vermont Gas homes, which have a higher average than statewide.

Figure 14: Average R-value per Home for Conditioned/Ambient Walls in Vermont Gas homes



3.1.2 Conditioned/Attic and Conditioned/Garage Walls

Table 19 describes the dominant insulation type for conditioned/attic and conditioned/garage walls; fewer than 5% of homes have multiple insulation types in these walls. The characteristics of the conditioned walls abutting attics and garages are similar to one another, with high levels of Grade II installations (>60%) and fiberglass batt insulation (>70%). However, a portion of conditioned/attic walls (17%) lack insulation. The average R-value for attic walls (R-11.9) is therefore lower than for garage walls (R-13.2).

Table 19: Insulation for Conditioned/Attic & Conditioned/Garage Walls by Percent of Homes

Statewide*	Attic	Garage
Insulation Type		
Number of Homes	*50*	*63*
Fiberglass Batts	73%	77%
Cellulose	5%	5%
Fiberglass + Rigid Foam	2%	6%
Spray Foam + Cellulose	2%	0%
Cellulose + Rigid Foam	0%	2%
Spray Foam	0%	2%
Rock Wool	0%	2%
None	17%	6%
Insulation Installation Grade		
Number of Homes	*33*	*55*
Grade I Installation	6%	4%
Grade II Installation	66%	62%
Grade III Installation	28%	34%
R-value Statistics		
Number of Homes	*50*	*63*
Minimum	0	0
Maximum	24	27
Average	11.9	13.2
Median	11	11

* Data are weighted.

3.2 CEILING INSULATION

Auditors recorded insulation information on the following types of ceiling areas:

- Flat ceilings
  - This type of ceiling area separates the homes from unconditioned attic space.
- Vaulted ceilings
  - This type of ceiling area separates the conditioned area from ambient conditions; the insulated framing of the roof itself forms the thermal boundary. In such ceilings areas, there is no unconditioned attic space between the

house and the ambient conditions, unlike with flat ceilings, where there is an unconditioned attic space above the conditioned space of the home.

Table 20 outlines what percentage of homes in each region have the types of ceiling listed, as well as what percentage of the total ceiling area is made up of vaulted ceilings, on average. Across the sample, about 41% of homes have only flat ceilings, 8% have only vaulted ceilings, and 51% have both; nearly all observed homes have some flat ceiling (92%) and more than half (58%) have vaulted ceilings. Vaulted ceilings make up 29% of the total ceiling area, across all the sampled homes.

Table 20: Prevalence of Ceiling Types

Types of Ceilings	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Flat & Vaulted	52%	57%	50%	51%
Flat Only	44%	42%	42%	41%
Vaulted Only	4%	1%	8%	8%
Avg. % of total ceiling area that is vaulted	17%	18%	29%	29%

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

3.2.1 Flat Ceilings

Table 21 shows the predominant joist dimensions in flat ceilings.[15] Statewide, about one-half (54%) of homes with flat ceilings are framed with 2×6 joists, while 2×4 joists account for another one-fifth of homes (21%). Framing flat ceilings with members of other dimensions, or multiple sizes of joist is rare.[16]

Table 21: Types of Construction for Flat Ceilings

Majority Flat Ceiling Framing	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*24*	*36*	*106*	*130*
2×6, 16 o.c.**	50%	26%	49%	50%
2x8, 16 o.c.	13%	8%	14%	14%
2x4, 16 o.c.**	17%	43%	15%	14%
2x4, 24 o.c.**	4%	18%	8%	7%
2x10, 16 o.c.	0%	0%	5%	5%
2x6, 24 o.c.	13%	3%	4%	4%
2x12, 16 o.c.	0%	0%	3%	3%
2x8, 24 o.c.**	4%	1%	1%	1%
≥4×4, ≥24 o.c.**	0%	0%	1%	1%

* Vermont Gas and Statewide results are weighted; all other results are unweighted.
** Some homes in this category have a small secondary assembly with a different framing type.

In Table 22, an insulation type with a plus sign, as in—"Cellulose+Fiberglass"—indicates multiple types of insulation were present in the same ceiling assembly. In fact, 7% of homes have attics with this layered combination.[17] Fiberglass batts (FGB) alone remain the most common form of ceiling insulation observed in sampled homes. Table 22 shows that it is the predominant insulation in 49% of homes statewide (accounting for 46% of the total flat ceiling area) as shown in Table 23. Another one-third of attics (30%) across Vermont are insulated with cellulose.

Nearly three-fifths (57%) of homes have Grade Ⅱ insulation installations in their flat ceilings, and around one-fifth each have Grade Ⅰ and Grade Ⅲ (20% and 19%, respectively).

[15] Of all the homes with flat ceilings, 48 (37%) had inaccessible attic spaces representing one-fourth (23%) of total flat ceiling area. In these cases, insulation and framing characteristics were inferred from similar areas in the home, or discussion with the home owner.
[16] Statewide, 80% of flat ceiling area is framed with joists that are 16 inches on center, another 19% with 24 inches on center, and the remaining 2% use joists that are ≥4×4 to span gaps that are 30 inches on center or greater.
[17] Of these homes, 41% have fiberglass batts over cellulose, and 59% have cellulose over fiberglass batts.

Table 22: Type & Grade of Flat Ceiling Insulation by Percent of Homes

Predominant Flat Ceiling Insulation	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Insulation Type				
Number of Homes	*24*	*36*	*106*	*130*
Fiberglass Batt	21%	31%	50%	49%
Blown-in cellulose	29%	57%	32%	30%
Cellulose + Fiberglass	29%	8%	8%	7%
Vermiculite	0%	0%	3%	3%
Rock Wool	0%	0%	1%	2%
Blown-in fiberglass	0%	0%	1%	1%
Cellulose + Rigid Foam	0%	0%	1%	1%
FGB+Rock wool	0%	0%	1%	1%
Rigid Foam Board	0%	0%	1%	1%
Rock Wool+Vermiculite	0%	0%	1%	1%
Vermiculite + Cellulose	4%	1%	1%	1%
Vermiculite + Fiberglass	0%	0%	1%	1%
Rock Wool+Cellulose	4%	1%	0%	<1%
None	13%	2%	0%	2%
Insulation Installation Grade				
Number of Homes	*24*	*36*	*101*	*125*
Grade I Installation	33%	49%	23%	20%
Grade II Installation	33%	42%	59%	57%
Grade III Installation	21%	8%	18%	19%

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

The breakdown of insulation by area in Table 23 reveals similar trends to those in Table 17, though it does more clearly highlight the greater prevalence of cellulose (72%) and Grade I installations (60%) in the Vermont Gas territory.

Table 23: Type & Grade of Flat Ceiling Insulation by Percent of Area

Flat Ceiling Insulation Area	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Insulation Type				
Number of Homes	*24*	*36*	*106*	*130*
Fiberglass Batt	33%	20%	45%	46%
Blown-in cellulose	21%	72%	35%	33%
Cellulose + Fiberglass	34%	7%	7%	8%
Vermiculite	0%	0%	3%	4%
Blown-in fiberglass	0%	0%	1%	1%
Cellulose + Rigid Foam	0%	0%	<1%	1%
FGB+Rock wool	0%	0%	1%	1%
Rigid Foam Board	0%	0%	1%	1%
Rock Wool	0%	0%	1%	1%
Rock Wool+Vermiculite	0%	0%	1%	1%
Vermiculite + Cellulose	4%	1%	1%	1%
Vermiculite + Fiberglass	0%	0%	1%	1%
Rock Wool+Cellulose	3%	1%	0%	<1%
None	6%	1%	<1%	1%
Verified Insulation Grade				
Number of Homes	*24*	*36*	*101*	*125*
Grade I Installation	30%	60%	26%	25%
Grade II Installation	44%	33%	57%	58%
Grade III Installation	26%	7%	16%	17%

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

Only three sample homes, all of which are in the Burlington Electric/Vermont Gas territory, have completely uninsulated attics. As shown in Table 24Table 24, the average R-value for flat ceilings among sampled homes is R-30. Statewide, of homes with flat attics, most (59%) have some continuous insulation over ceiling joists, providing a thermal break from the cold attic air.

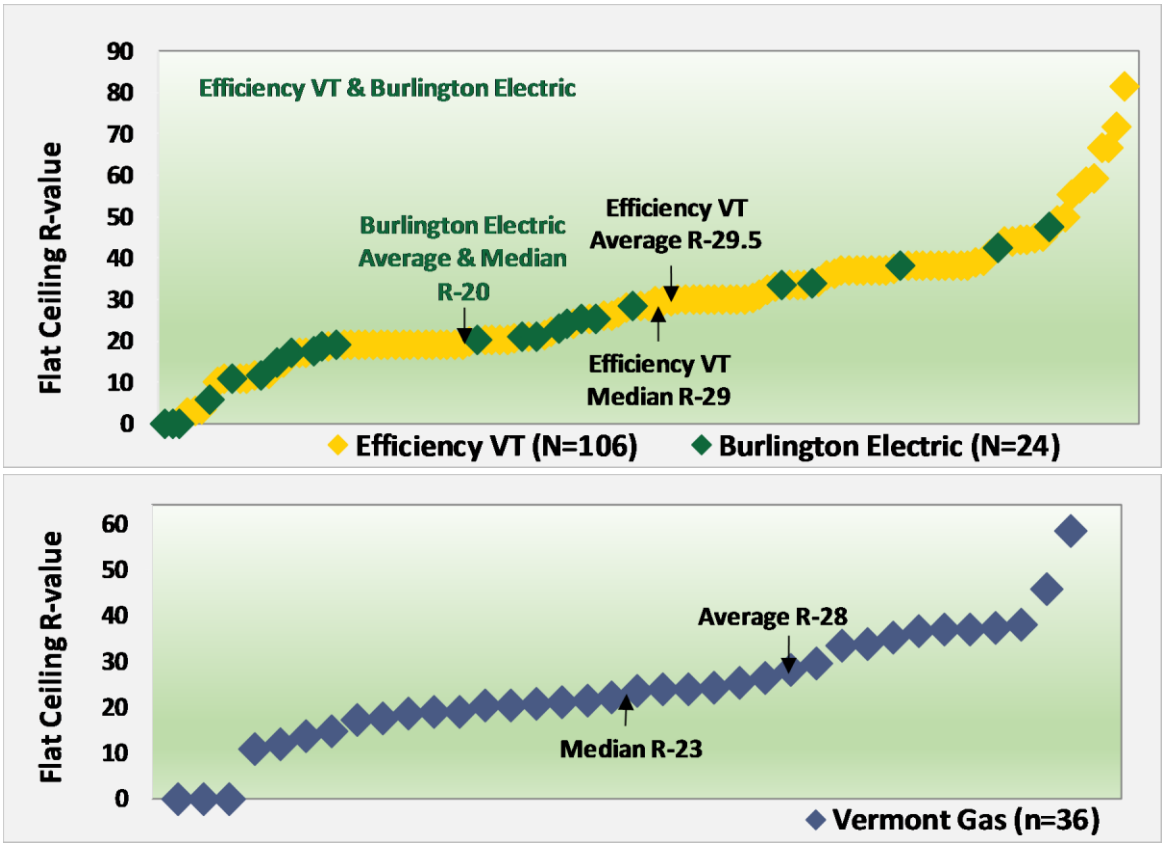
Table 24: R-value Statistics for Insulation in Flat Ceilings

Flat Ceiling R-values	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*24*	*36*	*106*	*130*
Minimum	0	0	2	0
Maximum	48	59	81	81
Average	19.8	28.1	29.5	29.2
Median	20	23	29	26

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

It is worth noting that the distribution of R-values is multi-modal, with many homes clustering at R-19, R-30 and R-38, which are common R-values for fiberglass batts, and the distribution has a long tail due to eight Efficiency Vermont homes insulated to more than R-49. These features are visible in Figure 15.

Figure 15: Average R-value per Home for Flat Ceilings



3.2.2 Vaulted Ceilings[18]

Because they form the actual roof structure, vaulted ceilings are more likely to be constructed with larger lumber than the joists used in flat ceilings (i.e., the floors of attics, which do not bear the weight of a full roof). Consequently, only 40% of homes in Table 25 were primarily constructed with 2×6 rafters, and nearly half of homes (45%) used 2×8 or larger members, compared to 54% and 22% respectively for flat ceilings.[19]

Table 25: Type of Construction for Vaulted Ceilings

Majority Vaulted Ceiling Framing	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*14*	*22*	*67*	*81*
2×6, 16 o.c.**	36%	18%	34%	35%
2×8, 16 o.c.**	14%	23%	27%	27%
2x10, 16 o.c.	14%	32%	15%	14%
2x4, 16 o.c.	21%	14%	10%	11%
2x6, 24 o.c.**	0%	0%	4%	4%
2x4, 24 o.c.	0%	0%	3%	3%
2x12, 16 o.c.	7%	11%	3%	3%
2x12, 24 o.c.	0%	0%	1%	1%
2x8, 24 o.c.	7%	2%	0%	0%
≥4×4, ≥24 o.c.	0%	0%	1%	1%

* Vermont Gas and Statewide results are weighted; all other results are unweighted.
** Some homes in this category have a secondary assembly with a different framing type.

[18] Given that they are usually sealed and are frequently inaccessible, auditors are not always able to visually confirm the insulation materials as often as they can in flat attics. Forty-seven homes with vaulted ceilings (58%) had inaccessible attic spaces representing one-half (53%) of total vaulted ceiling area. In these cases, insulation and framing characteristics were inferred from similar areas in the home, or discussion with the home owner.
[19] Statewide, 85% of vaulted ceiling area is framed with joists that are 16 inches on center, and another 11% are framed with rafters that are 24 inches on center; the remainder are framed with rafters that are 4×4 or larger and 30–60 inches on center.

One-half (54%) of homes with vaulted ceilings are insulated with fiberglass batts, another one-fifth (20%) employ blown-in cellulose, and 7% are uninsulated (compared to only 2% of homes with flat attics). Nearly three-quarters (73%) of the insulation installations are Grade II.

Table 26: Type & Grade of Vaulted Ceiling Insulation by Percent of Homes

Majority Vaulted Ceiling Insulation	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Insulation Type				
Number of Homes	*14*	*22*	*67*	*81*
Fiberglass Batts	29%	65%	55%	54%
Blown-in cellulose	0%	0%	21%	20%
Rigid Foam Board	0%	0%	4%	6%
Fiberglass + Rigid Foam	0%	0%	3%	3%
Rock Wool	7%	2%	1%	2%
Cellulose + Rigid Foam	0%	0%	1%	1%
Rock Wool + Rigid Foam	0%	0%	1%	1%
Spray Foam	0%	0%	1%	1%
Spray Foam + Cellulose	0%	0%	1%	1%
Vermiculite	0%	0%	3%	1%
Fiberglass + Cellulose	7%	2%	0%	<1%
None	0%	0%	6%	7%
Insulation Installation Grade				
Number of Homes	*13*	*21*	*63*	*76*
Grade I Installation	0%	0%	14%	13%
Grade II Installation	85%	87%	74%	73%
Grade III Installation	15%	13%	12%	12%

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

In contrast to flat attics, when looking at vaulted attic insulation by area in Table 27, Vermont Gas homes stand out as having more fiberglass batts and less blown-in cellulose than other regions.

Table 27: Type & Grade of Vaulted Ceiling Insulation by Percent of Area

Vaulted Ceiling Insulation Area	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Insulation Type				
Number of Homes	*14*	*22*	*67*	*81*
Fiberglass Batts	64%	94%	52%	51%
Blown-in cellulose	26%	5%	12%	12%
Rigid Foam Board	1%	<1%	9%	9%
Fiberglass + Rigid Foam	0%	0%	5%	5%
Spray Foam	0%	0%	4%	4%
Cellulose + Rigid Foam	0%	0%	2%	2%
Spray Foam + Cellulose	0%	0%	2%	2%
Rock Wool	5%	1%	1%	1%
Rock Wool + Rigid Foam	0%	0%	1%	1%
Vermiculite	0%	0%	1%	1%
Fiberglass + Cellulose	5%	1%	0%	<1%
None	0%	0%	11%	11%
Verified Insulation Grade				
Number of Homes	*13*	*21*	*63*	*76*
Grade I Installation	0%	0%	17%	17%
Grade II Installation	96%	97%	71%	60%
Grade III Installation	4%	3%	12%	12%

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

Statewide, the average vaulted ceiling has an R-value of R-20.6, and a median of R-19. The average Efficiency Vermont R-value is lower than the average Vermont Gas R-value due to the presence of four homes with uninsulated vaulted ceilings.

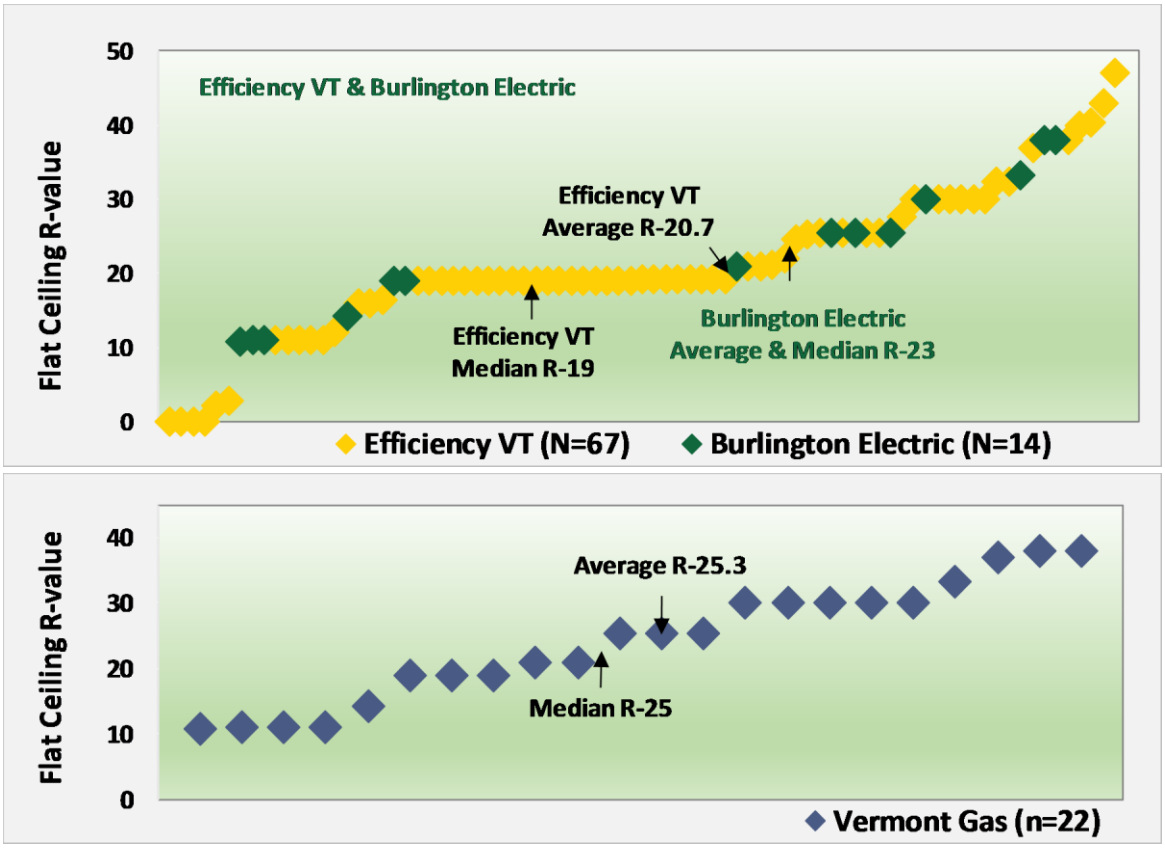
Table 28: R-value Statistics for Insulation in Vaulted Ceilings

Vaulted Ceiling R-values	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*14*	*22*	*67*	*81*
Minimum	11	11	0	0
Maximum	38	38	47	47
Average	23.0	25.3	20.7	20.6
Median	23	25	19	19

* Vermont Gas and Statewide results are weighted; all other results are unweighted.

Figure 16 displays the range of R-values seen in the sampled vaulted homes, with the particularly wide range seen in Efficiency Vermont homes.

Figure 16: Average R-values per Home for Vaulted Ceilings



3.3 Floor Insulation

Auditors recorded insulation information on floors over unconditioned spaces or ambient conditions that form part of the thermal boundary of the home. We report on the following types of floors:

- Conditioned floors over conditioned basements or crawl spaces
    - Also referred to as basement or crawl space ceilings (the framed floor area over the basement is also the basement ceiling)
- Conditioned floors over unconditioned basements
    - Also referred to as basement ceilings
- Conditioned floors over unconditioned crawl spaces
    - Also referred to as the ceiling of the crawl space
- Conditioned floors over garages

  - Also referred to as garage ceilings
- Conditioned floors over ambient (outdoor) conditions
  - These areas are often small, as they are cantilevered out into space, either with or without support columns below, and can be referred to as bump-out floor area.

Only 18% of the 79 homes with floors over unconditioned basements have insulation in those floors, resulting in an average R-value for those floors of only R-2.5; only 19% of this floor area across the visited homes is insulated.[20] While this may seem to be a deficiency, the preferred approach to basements in cold climates like Vermont's is to insulate (and air-seal) basement walls instead of basement ceilings.[21]

In contrast, floors over garages and ambient conditions are usually insulated: 88% of such homes have floors insulated to R-20.5 on average, and 65% at R-15.4, respectively.

Table 29: Floor Insulation Characteristics & Distribution by Location

Frame Floors	Uncond. Basement	Crawlspace	Garage	Ambient
Number of Homes	*79*	*36*	*24*	*23*
% of Homes with Ins. Floor	18%	36%	88%	65%
% of Total Floor Area Insulated	19%	42%	82%	87%

Table 30 describes the average R-value of frame floors observed in the sampled homes in the relevant jurisdictions.

Table 30: Floor R-Values by Jurisdiction and Location

Average R-Value of Floor Over:	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*21*	*30*	*89*	*110*
Uncond. Basement	0	0	2.5	2.5
Crawlspace	6.5	2.8	6.4	6.5
Garage	24.4	19.6	20.3	20.5
Ambient	15.5	17.7	15.6	15.4

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

Forty-five percent of the observed homes with unconditioned crawlspaces or basements have both uninsulated floors and uninsulated foundation walls.

[20] Only 9% of homes have mixed condition basements, with a median ratio of 2:3 for conditioned to unconditioned basement area in such homes.
[21] This approach ensures that the basements stay "inside" the thermal envelope of the house to take advantage of stand-by losses from heating and hot water equipment and distribution pipes or ducts, keeps the space warmer for wintertime use, and helps avoid potential pipe and other freezing issues.

3.4 Basement Walls, Above Grade Foundation Walls, and Slabs

Foundation walls adjacent to conditioned space and predominately underground are classified as basement walls under RBES.

3.4.1 Basement Walls

As shown in Table 31, 60% of sampled homes have basement walls, of which 65% have at least some insulated basement wall area.

Table 31: Prevalence of Basement Insulation

Basement Walls	Statewide*
Number of Homes	*84*
Homes with Insulated Walls	65%

* Data are weighted.

Fiberglass batts are the most prevalent form of basement insulation in existing homes (33%), although more than one-third of basement wall area remains uninsulated. The average R-value of basement walls is around R-8 (Table 32).

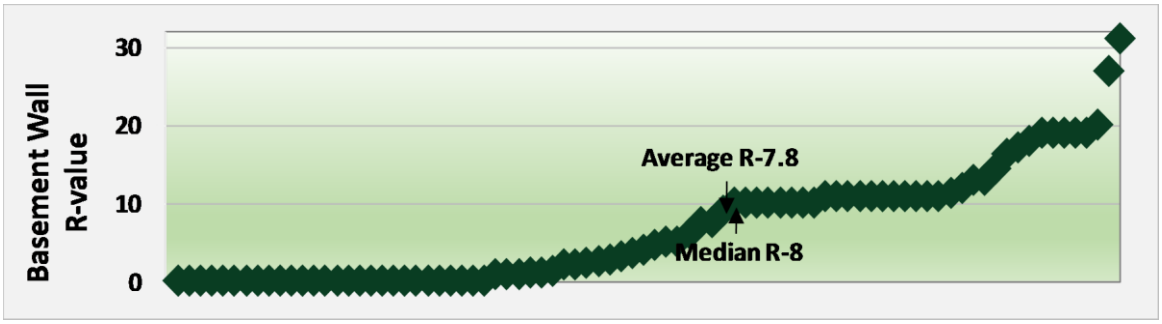
Table 32: Basement Wall Insulation Prevalence and Characteristics by Area

Basement Wall Insulation	Statewide*
Number of Homes	*56*
Insulation Type	
Fiberglass Batts	33%
Rigid Foam	27%
Spray Foam	6%
Fiberglass + Rigid Foam	2%
None	33%
Cavity Grade	*37*
Grade I Installation	23%
Grade II Installation	63%
Grade III Installation	14%
R-value Statistics	*47*
Minimum	0
Maximum	31
Average	7.8
Median	8

* Data are weighted.

In fact, Figure 17 shows a clear clustering of insulation R-values around R-10 and R-11 and R-20, the RBES v2.0 and v3.1 requirements, respectively.

Figure 17: Average R-value per Home for Basement Walls



3.4.2 Above Grade Foundation Walls

Slightly more than one-half (57%) of the 28 homes with majority above-grade conditioned to ambient foundation walls are insulated, significantly less than was found in the last study (78%). These walls average R-8.1 overall, and those that are insulated average R-13.

3.4.3 Slab Insulation

Auditors were only able to determine the type and R-value of slab insulation for five homes: Two slab-on-grade homes with radiant flooring (one insulated to R-5 and the other to R-10), one conditioned basement with radiant flooring (R-10), one conditioned basement without radiant flooring (R-3), and an enclosed crawlspace (R-10). All of these slabs were insulated with rigid foam board except for the non-radiant conditioned basement, which used an insulated sub-floor product, where the insulation was on top of the slab itself (R-3).

3.5 WINDOWS

The following section describes the characteristics of windows located in conditioned walls. Auditors attempted to verify U-values via technical documentation in the field, but that information was almost never available in existing homes. Auditors also tested windows for the presence of a low-E coating with a lighter test,[22] and looked for the presence of an insulating gas, such as argon. Although auditors were not able to test for argon, in some cases they identified it via consultation with the homeowner or by looking for injection plugs in the window frame between the panes of glass, which is common in many gas-filled windows. Due to the imprecision of these methods, the proportion of argon windows may be under-reported.

Table 33 highlights the types of windows present in sampled homes: uncoated (clear) double pane glazing remains the most common type of window. Such windows are present in 80% of sampled homes, and comprise 40% of all window area across the sample, as

[22] 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.

shown in Table 34. Although single pane windows are present in about one-half of homes (48%), they comprise a minority of window area (20%). In addition, nearly three-fourths (73%) of single pane windows (by area) have storm windows installed, versus only one-seventh (14%) of all double-pane window variants combined.[23]

Table 33: Types of Windows Present in Homes**

Window Prevalence	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Single Pane	80%	41%	46%	48%
Double Pane (clear)	80%	84%	80%	80%
Double Pane low e	68%	41%	51%	52%
Double Pane low e, Argon	12%	38%	10%	9%
Triple Pane	0%	0%	9%	9%

*Results for the Vermont Gas and Statewide columns are weighted; Burlington Electric and Efficiency Vermont results are unweighted.
**Percentages do not add to 100% because homes may have multiple window types.

While Table 33 above shows the presence of various glazing types by home, Table 34 below displays the proportion of window area across the sample made up of the various glazing types.

Table 34: Types of Windows by Percent of Total Window Area

Window Area	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Single Pane	23%	15%	20%	20%
Double Pane (clear)	44%	38%	39%	40%
Double Pane low e	29%	34%	32%	32%
Double Pane low e, Argon	3%	14%	4%	4%
Triple Pane	0%	0%	4%	4%

*Results for the Vermont Gas and Statewide columns are weighted; Burlington Electric and Efficiency Vermont results are unweighted.

[23] These figures were calculated independently, and are not present in any of the tables below.

In Table 35, we see that the wood accounts for 69% of window frames (by area), and that the remainder are predominately vinyl (27%).

Table 35: Types of Window Frames by Percent of Window Area

Window Frames	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Wood	76%	65%	69%	69%
Vinyl	24%	31%	27%	27%
Metal	0%	2%	3%	3%
Fiberglass	0%	1%	1%	1%

*Results for the Vermont Gas and Statewide columns are weighted; Burlington Electric and Efficiency Vermont results are unweighted.

Although many existing homes are not subject to RBES, the average existing home complies with the RBES Fast-Track requirement limiting glazing to 20% of conditioned wall area.

Table 36: Glazing Percentage of Exterior Wall Area

Glazing Percentage	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Minimum	8%	8%	5%	5%
Maximum	19%	19%	27%	27%
Average	13%	13%	13%	13%
Median	13%	13%	13%	13%

*Results for the Vermont Gas and Statewide columns are weighted; Burlington Electric and Efficiency Vermont results are unweighted.

Table 37 presents the distribution of window orientations, specifically what fraction of a home's window area is exposed to light from the south (including southeast and southwest).[24] Such south-facing windows reduce summer heat gains while maximizing winter insolation (light and heat gained from the sun's radiation). By area, 37% of all physical window area in the sample faces south, southeast, or southwest; when weighted to account for the off-axis nature of southeast and southwest windows, 30% of window area faces south.

Table 37: Percentage of Glazing Area Exposed to Southern Light

Percent South Glazing (S, SE, SW)	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Minimum	5%	5%	4%	4%
Maximum	43%	44%	66%	66%
Average	25%	28%	27%	27%
Median	24%	26%	26%	26%

*Results for the Vermont Gas and Statewide columns are weighted; Burlington Electric and Efficiency Vermont results are unweighted.

[24] For these calculations, southwestern- and southeastern-facing windows are given a weight of 0.707 due to their oblique orientation, compared to 1.0 for windows facing due south.

4 Section 4 Building Shell Leakage

Auditors were able to conduct blower door tests at 111 of the 140 homes (79%). Blower doors were not conducted at some homes for a variety of reasons, such as: asbestos or vermiculite was found during the audit, wood had been burned in a fireplace or stove in the last 24 hours, in-progress renovations resulted in a temporarily incomplete thermal envelope, or a homeowner refused the blower door test due to the cold weather.[25] The previous baseline study conducted blower door tests at a random selection of 31 out of 95 homes (33%).

Table 38 shows the air change rate for the sampled homes based on the results of the blower door tests. This value, measured in air changes per hour and known as the "ACH50," represents the number of times the air in a home will completely refresh in an hour at a given pressure gradient between the home and outdoor conditions (in this case 50 pascals). Low ACH50 values indicate a tighter building envelope and large numbers indicate a leaky building envelope.

The average ACH50 for the entire sample is 9.54. The minimum ACH50 is 1.5 and the maximum is 33.4. The lowest ACH50 values came from tight homes that are relatively new with well documented, high quality envelope installations, including one home with walls made entirely with insulating concrete forms (ICFs). The highest (worst) ACH50 values came from homes that have little to no insulation, especially on floors above unconditioned area and visible holes in the envelope.

Table 39 shows the natural air changes per hour for each sample group. The statewide average air changes per hour is 0.61.

Table 38: Blower Door Test Results – ACH50 (Unweighted)

	Burlington Electric	Vermont Gas	Efficiency Vermont	Statewide
Number of Homes	*20*	*31*	*91*	*111*
Minimum	3.20	2.21	1.51	1.51
Maximum	23.19	29.10	33.41	33.41
Unweighted Average	10.24	8.79	9.39	9.54
Median	8.58	7.39	7.48	7.75

[25] While homeowners were asked during scheduling not to use wood-burning fireplaces or stoves for 24 hours before the audit, some homeowners could not comply because that was their only source of heat.

Table 39: Blower Door Test Results – Natural Air Changes Per Hour (Unweighted)

	Burlington Electric	Vermont Gas	Efficiency Vermont	Statewide
Number of Homes	*20*	*31*	*91*	*111*
Minimum	0.22	0.15	0.09	0.09
Maximum	1.30	1.57	2.07	2.07
Unweighted Average	0.64	0.55	0.60	0.61
Median	0.51	0.48	0.50	0.50

Figure 18 plots the ACH50 results for all homes in the sample, from the lowest air infiltration to the highest air infiltration.

Figure 18: ACH50 Per Home (Unweighted)

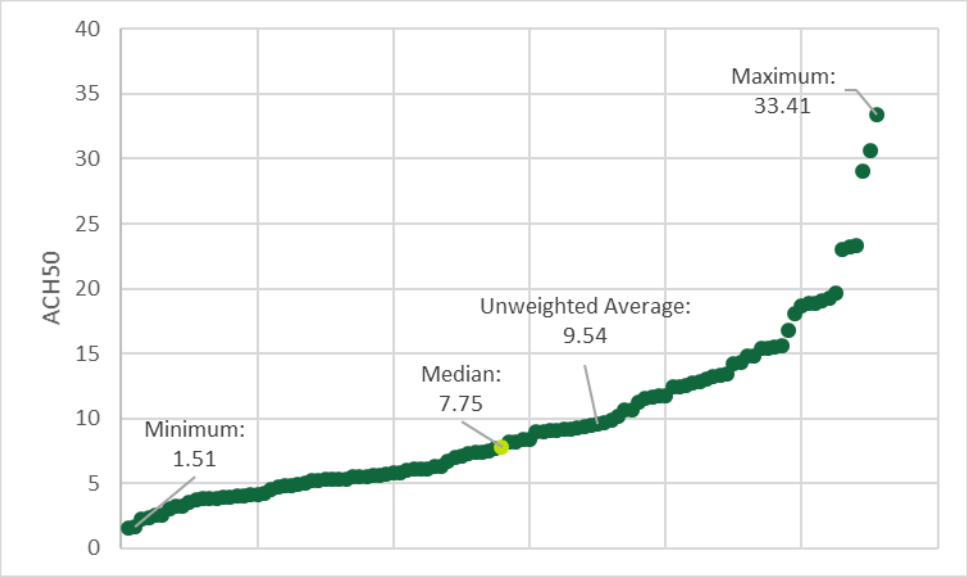


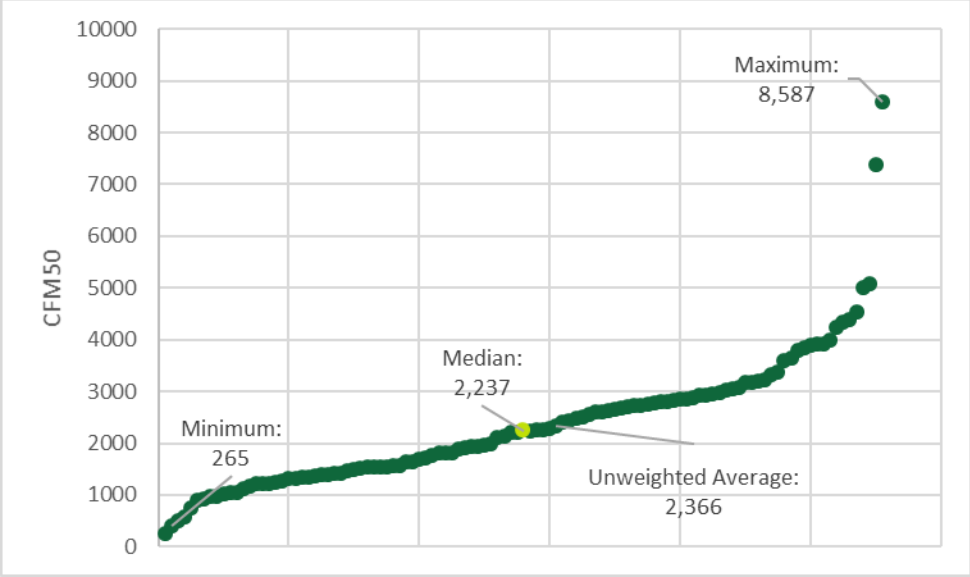
Table 40 shows the measured air infiltration rates during the blower door tests for the 111 homes. Air infiltration is measured as the cubic feet of air per minute that flows through the blower door fan in order to maintain a 50 pascal pressure gradient between the house and outdoors. The average CFM50 is 2,366. The minimum is 265 and the maximum is 8,587.

Table 40: Blower Door Test Results – CFM50 (Unweighted)

	Burlington Electric	Vermont Gas	Efficiency Vermont	Statewide
Number of Homes	*20*	*31*	*91*	*111*
Minimum	510	510	265	265
Maximum	3,372	4,004	8,587	8,587
Unweighted Average	2,189	2,069	2,405	2,366
Median	2,363	1,971	2,237	2,237

Figure 19 shows the measured air infiltration from the blower door tests for the sampled homes, from lowest CFM50 values (best performing) to highest (worst performing).

Figure 19: CFM50 Per Home (Unweighted)



5 Section 5 Heating and Cooling

This section details the heating and cooling equipment that was inspected as part of the on-site visits.

Statewide, about one-third (32%) of visited homes use oil as the primary heating fuel, about one fourth (23%) use propane, 19% use wood, and 12% use natural gas (Table 41). The statewide figures from the on-site inspections have a lower proportion of homes that use fuel oil or kerosene than the American Community Survey (ACS) census data (32% compared to 51%) and slightly more homes that use propane compared to the ACS data (23% to 14%). Homes in both the Burlington Electric (92%) territory and, as expected, the Vermont Gas region (100%) are substantially more likely than homes in the state as a whole to have natural gas as the primary heating fuel, due to the greater availability of utility gas.

Table 41: Primary Heating Fuel
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*	Vermont ACS 2009-2013[a]
Number of Homes	*25*	*37*	*118*	*140*	*164,600*
Fuel oil, heating oil, or #2 oil	8%	--	27%	32%	51%[b]
Bottled (propane) gas	--	--	19%	23%	14%
Wood (cord)	--	--	16%	19%	22%[c]
Natural gas from underground pipes	92%	100%	10%	12%	11%
Wood (pellets)	--	--	4%	5%	See Wood (cord)[c]
Electricity	--	--	2%	3%	1%
Kerosene	--	--	1%	2%	See fuel oil[b]
Wood (cord) and Oil	--	--	1%	1%	--
Wood pellets and Oil	--	--	1%	1%	--
Wood and Propane	--	--	1%	1%	--
Coal or Coke	--	--	--	--	<1%
Other	--	--	--	--	1%

*Results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.
[a] ACS base = owner-occupied, single-family units built before 2005.
[b] ACS data includes kerosene with fuel oil.
[c] ACS data includes pellets with wood (cord).

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 systems, including fireplaces, stoves, and space heaters, which is reported in the following

section (Supplemental Heating Systems). However, Table 42 below shows instances of homes with more than one main heating fuel, excluding those supplemental space heating systems.[26] This includes homes with more than one type of furnace or boiler, electric baseboards, or homes with heat pumps, for example. Of the 15 homes with multiple main heating fuels, four use electricity, three use oil, two use propane, two use wood,[27] one uses both electricity and wood, and one uses oil and propane as secondary fuels.

Table 42: Homes with Secondary Heating Fuels (Excluding Fireplaces, Stoves, and Portable Space Heaters)

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*0*	*2*	*15*	*15*
Electricity	--	2	27%	28%
Fuel oil, heating oil, or #2 oil	--	--	33%	24%
Bottled (propane) gas	--	--	13%	16%
Wood	--	--	13%	16%
Fuel oil & Bottled (propane) gas	--	--	7%	8%
Electricity and wood	--	--	7%	8%

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

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

[27] In both cases, the wood fired system is integrated into the other primary heating system. One home has a wood furnace connected to an oil furnace and the other has a wood boiler connected to an oil boiler.

5.1 HEATING SYSTEMS

Table 43 displays the combination of heating systems types installed in homes. Thirty-five percent of homes have a boiler plus another system; 25% of homes have just a single boiler, and 19% of homes have a furnace plus another system. Other homes have a mixture of multiple heating systems. Two homes use only direct vent wall furnaces, which are gas fired furnaces installed directly into the room they serve. One home has a make shift system in which a storage tank water heater has been outfitted to serve both domestic water heating and space heating needs (from now on referred to as a "combi storage" system); this home is included below in the "Other" row.

Table 43: Type of Heating Systems
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Boiler plus other system	16%	32%	37%	35%
Boiler – Single	40%	32%	25%	25%
Furnace plus other system	12%	14%	19%	19%
Furnace – Single	28%	23%	9%	9%
Stove** or Stove & Elect. Resistance	0%	0%	4%	4%
Boiler – Multiple	0%	0%	2%	2%
Direct vent wall furnace	4%	1%	2%	2%
Furnace – Multiple	0%	0%	1%	1%
Other***	0%	0%	2%	2%

*Results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.
**Stoves include both wood and natural gas-fired units.
*** Includes one home with a "combi storage" system and one home with only electric baseboards.

Error! Reference source not found. Slightly under one-half of homes (44%) have boilers as their primary heating system (Table 44). Stoves are the second most frequent primary heating system (21%) followed by furnaces (20%). One percent of homes have a ductless heat pump as the primary heating system.

Table 44: Type of Primary Heating System
(homes with a single major heating system)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Boiler (forced hot water)	52%	45%	44%	44%
Stove	--	--	22%	21%
Furnace	40%	36%	20%	20%
Combi appliance	4%	18%	6%	5%
Stove and Boiler	--	--	3%	3%
Direct vent wall furnace	4%	1%	2%	2%
Electric baseboard	--	--	2%	2%
“Combi storage”	--	--	1%	1%
Ductless mini-split	--	--	1%	1%

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

Statewide, the majority of both boilers (57%) and furnaces (64%) are located in unconditioned space[28] (Table 45).

Table 45: Location of Heating System
(homes with boilers or furnaces)

	Boiler	Furnace
Number of Heating Systems	*91*	*47*
Unconditioned Space	57%	64%
Conditioned Space	43%	36%

[28] 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.

The average age of boilers and furnaces is thirteen years and fifteen years, respectively; the median age is thirteen years for both boilers and furnaces. Based solely on age, at least 6% of homes – those with boilers and furnaces older than 30 years – would appear to be strong candidates for heating system replacement. Those older than 20 years and up to 30 years old may also be good candidates, and represent an additional 17% of furnaces and boilers (Table 46).

Table 46: Age Ranges of Heating System
(homes with boilers or furnaces and age data)

Years Old	Boiler	Furnace
Number of Heating Systems	*91*	*47*
0 to 5 years	25%	21%
6 to 10 years	14%	19%
11 to 15 years	20%	13%
16 to 20 years	15%	13%
21 to 25 years	10%	9%
26 to 30 years	5%	11%
31 to 35 years	4%	6%
36 to 40 years	1%	0%
More than 40 years	0%	2%
Don't Know	4%	6%

Table 47 displays the efficiency for all boilers that have reliable efficiency data available. Note that auditors recorded AHRI-based AFUE figures whenever possible, and in other cases substituted manufacturer rated efficiencies or age-based defaults[29]. Both combination appliances and boilers are included since both are boiler based. Two wood boilers with AFUEs of 55 and 60 and one kerosene boiler with an AFUE of 85 were excluded from the table. The average efficiency of the natural gas boilers (88.6) and propane boilers (87.8) is slightly higher than that of oil boilers (83.6). In addition to those listed below, there is also a wood fired boiler with an efficiency of 70.

Table 47: Boiler Efficiency
(homes with boilers with efficiency data)*

	Oil Boiler	Nat. Gas Boiler	Propane Boiler	All Boilers
Number of Heating Systems	*39*	*22*	*25*	*86*
Minimum	70.0	70.0	68.0	68.0
Maximum	90.0	95.0	99.0	99.0
Average	83.6	88.6	87.8	86.0
Median	85.0	87.3	87.4	86.0

* Results are unweighted.

[29] Age based defaults are from North East Home Energy Rating Alliance manual for HERS raters version 4.0. Fifteen systems with age based defaults are included in the table. If they are removed, the average AFUE for the remaining 71 boilers is 87.1.

Table 48 shows the efficiency of furnaces. The average AFUE of natural gas furnaces is 90.3 and propane furnaces is 87.4, compared to 81.3 for oil furnaces. The maximum efficiency of gas furnaces is also much higher than that of oil furnaces, 97.0 vs. 86.5. The table does not include direct vent wall furnaces because they were not rated on an AFUE scale. Out of eleven direct vent wall furnaces, the average efficiency was 85.6.

Table 48: Furnace Efficiency
(homes with furnaces with efficiency data)*

	Oil Furnace	Nat. Gas Furnace	Propane Furnace	All Furnaces
Number of Heating Systems	*19*	*15*	*10*	*44*
Minimum	65.0	80.0	70.0	65.0
Maximum	86.5	97.0	95.0	97.0
Average	81.3	90.3	87.4	85.7
Median	81.4	92.1	90.0	84.3

* Results are not weighted.

5.2 SUPPLEMENTAL HEATING SYSTEMS

During onsite inspections auditors recorded information on stoves and fireplaces. Often, homes had inserted a stove technology into the fireplace structure: these were classified as stoves and not as fireplaces. As such, only two wood fireplaces and one natural gas fireplace were found during the onsite inspections.

Table 49**Error! Reference source not found.** indicates that 51% of homes have stoves, with stoves being least common in the Burlington Electric territory (20%). Two-thirds of stoves use firewood (67%), 15% use pellets, 14% use propane, and 4% use natural gas.

Table 49: Stoves & Fuel Used
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Stoves per Home				
Number of Homes	*25*	*37*	*115*	*140*
No stoves	80%	74%	48%	49%
One stove	16%	26%	44%	44%
Two or more stoves	4%	--	8%	7%
Stove Fuel				
Number of Stoves	*6*	*8*	*67*	*73*
Firewood	3	2	66%	67%
Wood Pellets	1	1	15%	15%
Propane	--	--	15%	14%
Natural Gas	2	5	4%	4%

*Percentages for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.

Only 7% of homes have portable space heaters (Table 50). Every portable space heater found was electric. The table does not include seven supplemental direct vent furnaces at six homes as well as electrical plates in the ceiling of one home because they were not portable. Because some of the on-site visits were conducted before or after the typical heating season, auditors asked homeowners about their use of any space heaters during the year in order to mitigate the chance of missing any stored units.

Table 50: Portable Electric Space Heaters
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
No space heaters	92%	88%	92%	93%
One space heater	8%	12%	6%	6%
Two or more space heaters	--	--	2%	1%

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

5.3 THERMOSTATS

Auditors recorded information about permanently installed thermostats (either for central heating and cooling systems or other permanently installed HVAC systems, such as ductless minis-split heat pumps). Statewide, the majority of existing homes (57%) have one thermostat, and 26% use two thermostats.

Table 51: Number of Thermostats per Home

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*114***	*139***
Thermostats per Home				
One	68%	37%	56%	57%
Two	20%	27%	26%	26%
Three	4%	23%	15%	14%
Four	4%	7%	2%	2%
Five	4%	1%	0%	<1%
Six	0%	6%	1%	1%
Total Thermostats	**39**	**69**	**189**	**228**

*Results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.
**One home did not have a working thermostat, and was excluded from the analysis.

A total of 228 thermostats are installed across the 139 existing homes with functional thermostats. Of these, 60% are manual units, 39% are programmable, and the remainder (only two thermostats) are Wi-Fi enabled. Thermostats in the Burlington Electric and

Efficiency Vermont territory are most often manual units (59% in each territory), whereas a similar percentage are programmable in the Vermont Gas territory (60%).

Table 52: Type of Thermostat Installed

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*114***	*139***
Manual	59%	39%	59%	60%
Programmable	36%	60%	41%	39%
Wi-Fi	5%	1%	0%	<1%
Total Thermostats	**39**	**69**	**189**	**228**

*Results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.
**One home did not have a working thermostat, and was excluded from the analysis.

As shown in Table 53, manual thermostats are present in 69% of homes in the statewide sample, and programmable units are present in 39% (9% of homes have both types); only two homes (less than 1%) have Wi-Fi enabled units. Programmable thermostats are in nearly 60% of Vermont Gas homes, but in only 40% of Burlington Electric and Efficiency Vermont homes.

Table 53: Proportion of Homes with Each Thermostat Type***

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*114***	*139***
Manual	60%	41%	68%	69%
Programmable	40%	59%	40%	39%
Wi-Fi	8%	2%	0%	<1%
Multiple Types	**8%**	**8%**	**9%**	**9%**

*Results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.
**One home did not have a working thermostat, and was excluded from the analysis.
***Percentages add to more than 100% due to multiple response; some homes have more than one type of thermostat.

Auditors either recorded the temperature set points or asked the participants what temperature set points they used during the day and night in both the summer and the winter. Statewide, thermostats in existing homes are set to an average temperature of about 65 degrees Fahrenheit in the winter, and for homes with central or permanently installed cooling systems (such as ductless mini-split heat pumps), about 73 degrees in the summer.

Table 54: Thermostat Set Points by Season

Seasonal Set Point Averages	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes with Summer Set Points	*6*	*11*	*25***	*31***
Summer Days	69.7	74.9	74.5	74.1
Summer Nights	70.7	73.6	73.4	72.9
Number of Homes with Winter Set Points	*25*	*37*	*114***	*139***
Winter Days	65.9	65.6	66.1	65.4
Winter Nights	62.9	63.3	64.4	63.8
Summer Overall	**70.2**	**73.5**	**73.9**	**73.3**
Winter Overall	**64.4**	**64.4**	**65.2**	**64.6**

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

**One home did not have a working thermostat, and was excluded from the analysis.

5.4 Air Conditioning

Statewide, 28% of homes have a window air conditioning (AC) unit (Table 55). Since most of the on-site visits were conducted in the fall and winter season, auditors asked homeowners if they use AC units at all during the year in order to mitigate the chance of missing stored units.

Table 55: Number of Window Air Conditioning Units

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
No window AC	60%	59%	72%	72%
Have at least one unit	40%	41%	28%	28%
One	24%	21%	18%	18%
Two	--	6%	6%	6%
Three	12%	7%	2%	2%
More than Three	4%	7%	2%	2%

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

Error! Reference source not found.Error! Reference source not found. No home had more than one type of air conditioning system (Table 56).[30] Note that the unweighted percentage of homes with windows AC units (30%) is presented in Table 56 while the weighted percentage (28%) is presented in Table 55.

[30] The 30% figure in Table 56 differs from the 28% figure in Table 55 because Table 55 is weighted.

Table 56: Characteristics of Air Conditioning Systems, Statewide
(all homes)*

	Central AC	Window AC	Ductless Mini-splits
Number of Systems	*4*	*69*	*6*
Percent of Homes with Air Conditioning Type	2%	30%	4%
Average age of units (years)**	13	9	4
Average size (tons)	3.1	0.68	1.4
Average efficiency	11.4 SEER	10.1 EER***	20.4 SEER

* Data unweighted due to low sample sizes. No home had more than one type of air conditioning.
** For systems in which a range of five years were recorded, the middle year was used to calculate average.
*** Based on only 61 units with EER data.

5.5 DUCTS

Table 57 reveals that approximately one-third of sampled homes (31%) have ductwork, similar to the finding of 34% in the previous report. Two-thirds of homes (67%) with ducts have ducts located outside of conditioned space. Where present, the majority of homes have ducts in conditioned space and unconditioned basements; 58% and 40% of duct area respectively, statewide.

Table 57: Duct Locations

Homes with Ducts	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*10*	*5*	*33*	*43*
Attic, exposed	–	–	6%	6%
Conditioned Space	7	5	73%	71%
Unconditioned Basement	6	1	64%	65%
Open Crawlspace	1	–	3%	3%

*Results for the Vermont Gas and Statewide columns are weighted; Burlington Electric and Efficiency Vermont results are unweighted.
**Many homes have ducts in multiple locations, therefore totals exceed 100%.

Basic physical characteristics of ducts in unconditioned space are compiled in Table 58. These ducts are predominantly unsealed, uninsulated sheet metal. In fact, sealant was observed in only seven homes with ducts in unconditioned space: one instance each of drywall joint compound and duct tape, two occurrences of foil tape, and the remainder had mastic. Insulation was installed in seven homes with unconditioned ducts: one home with bubble wrap (100% insulated at R-2), and the rest fiberglass (28% at R-3, 50% at R-4, 5% at R-6, 28% at R-6, 100% at R-6 and 100% at R-8).[31]

Table 58: Types of Unconditioned Ducts by Home

Unconditioned Ducts	Statewide*
Number of Homes	*29*
Duct Type	
Rigid metal	83%
Mixed metal	10%
Flexible metal	7%
R-value Statistics	
Minimum	0
Maximum	8
Average	0.7
Median	0

*Data are weighted.

[31] There was a 50% overlap between homes with sealed and insulated ducts *i.e*; 3 with insulation, 3 with both, and 4 with sealant, leaving 19 with neither.

6 Section 6 Water Heating

Almost one-half of homes (44%) have stand-alone tank water heaters, one-third (34%) have integrated systems with tanks (i.e., indirect water heaters), 8% have integrated systems without tanks (i.e., tankless coil water heaters), 7% have combined appliances, and 3% have instantaneous water heaters. Four percent of homes have solar-assisted systems or solar systems with no fossil fuel backup. Heat pump water heaters are present in 1% of homes. Finally, one home has a conventional storage tank water heater that is attached to pipes to heat the home. This system is referred to as a "combi storage" system for the rest of this section because it serves both hot water and space heating needs but has a tank capacity of 34 gallons.

Table 59: Type of Water Heating Systems

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Storage, stand alone	44%	37%	43%	44%
Integrated, w/tank	44%	32%	33%	34%
Integrated, tankless	--	6%	8%	8%
Combi appliance	4%	18%	8%	7%
Instantaneous	8%	7%	3%	3%
Solar-assisted**	--	--	3%	3%
Heat pump	--	--	1%	1%
''Combi storage''	--	--	1%	1%
Solar Only	--	--	1%	1%

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

**Along with their solar system, one home had a storage stand alone, and two had integrated w/ tank systems.

Statewide, 31% of homes have water heaters that use propane, 26% use oil, 26% are electric and 12% use natural gas (Table 60). There is a strong regional difference due to the availability of natural gas, with 84% of Burlington Electric homes and 93% of Vermont Gas homes using natural gas for water heating equipment, compared to 13% of homes from the Efficiency Vermont region. Propane is only present in Efficiency Vermont homes, and Vermont Gas is the only group with no inspected homes using oil for water heating.

Table 60: Water Heating System Fuel

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Propane	--	--	32%	31%
Oil	4%	--	24%	26%
Electric	12%	7%	26%	26%
Nat. Gas	84%	93%	13%	12%
Solar and Oil	--	--	2%	2%
Solar and Electric	--	--	1%	1%
Kerosene	--	--	1%	1%
Solar	--	--	1%	1%

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

Table 61 summarizes the ages of water heaters by type excluding the four solar water heaters and the "combi storage" tank.[32] Tankless coils have the largest share of systems older than ten years followed by fossil fuel storage systems (65%). Less than one-half (45%) of electric storage water heaters are older than ten years. Since they are a newer technology, 80% of instantaneous systems and combined appliances are less than ten years old. The majority of tanks used indirectly with boilers are older than ten years as well (59%).

Table 61: Age of Water Heating System
(homes with water heater age data available)

Years Old	Fossil Fuel Storage	Electric Storage*	Instantaneous and Combined	Indirect with Tank	Tankless Coil
Number of Heating Systems	*29*	*34*	*15*	*51*	*9*
0 to 5 years	3%	35%	47%	22%	2
6 to 10 years	28%	15%	33%	20%	--
11 to 15 years	31%	12%	7%	33%	2
16 to 20 years	28%	12%	--	8%	2
21 to 25 years	3%	12%	--	12%	3
26 to 30 years	3%	3%	--	2%	--
31 to 35 years	--	--	--	2%	--
36 to 40 years	--	3%	--	--	--
More than 40 years	--	3%	--	--	--
Don't Know	3%	6%	13%	2%	--

*Includes one heat pump.

Just over one-half (57%) of all water heaters are located in unconditioned spaces[33] (Table 62**Error! Reference source not found.**).

Table 62: Location of Water Heating System
(homes with water heaters)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Water Heaters	*25*	*37*	*118*	*143*
Unconditioned Space	60%	47%	57%	57%
Conditioned Space	40%	53%	43%	43%

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

[32] Of the storage tanks connected to the solar DHW systems, one is less than five years old, two are between 21 and 25 years old and the age of the fourth is unknown. The tank used in the "combi storage" system is between five and ten years old

[33] 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 63 through Table 67 show the energy factor of all water heaters that were found during the onsite inspections. The only water heaters that are excluded are the one "combi storage" system and the four solar water heaters. The "combi storage" system had a California Energy Commission verified energy factor of 0.83, but was not designed for its current use of space heating. Solar water heaters were not included because energy factors are not reported for solar water heaters. Instead, solar water heaters use a Solar Energy Factor (SEF), which is the energy delivered by the system divided by the total gas or electric energy put into the system. Manufacturers of two of the four solar water heaters were not able to provide SEFs but the two SEFs that were available were 1.5 and 2.3. The ENERGY STAR standard for solar water heaters is 1.6.

Table 63 shows that the average energy factor of integrated tank water heaters is 0.80 compared to 0.79 in the previous study. 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. For the two homes that had indirect oil systems with a separate solar storage system, only the indirect oil systems are considered here.

Table 63: Energy Factor of Integrated w/Tank Water Heaters

(homes with integrated w/tank water heaters)

	Nat. Gas	Oil	Kerosene	Propane	Total
Number of Heating Systems	*14*	26	1	*10*	*51*
Minimum	0.77	0.71	0.78	0.76	0.71
Maximum	0.87	0.85	0.78	0.87	0.87
Average	0.82	0.78	0.78	0.82	0.80
Median	0.80	0.78	0.78	0.80	0.80
Count of system with unknown efficiency*	--	1	--	--	--

* When efficiency data was unavailable, age based defaults were assumed based on NEHERS guidelines for HERS ratings

The average energy factor of integrated tankless water heaters is 0.49, which is unchanged from the previous study. The energy factors for these tankless coil DHW systems were calculated using age based defaults from the NEHERS guidelines for HERS ratings. The fuel listed below represents the fuel of the boiler in which the tankless coil is located (Table 64).

Table 64: Energy Factor of Integrated Tankless Water Heaters

(homes with integrated tankless water heaters)

	Nat. Gas	Oil	Propane	Total
Number of Water Heaters	*2*	*5*	*2*	*9*
Minimum	0.50	0.50	0.45	0.45
Maximum	0.50	0.55	0.45	0.55
Average	0.50	0.51	0.45	0.49
Median	0.50	0.50	0.45	0.50

Natural gas and propane stand-alone water heating tank systems have an average energy factor of 0.59, which is slightly lower than the 0.60 energy factor in the previous study (Table 65).

Table 65: Energy Factor of Non-Electric Stand-alone Storage Tank Water Heaters

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

	Nat. Gas	Propane	Total
Number of Water Heaters	*12*	*17*	*29*
Minimum	0.56	0.55	0.55
Maximum	0.66	0.67	0.67
Average	0.59	0.59	0.59
Median	0.56	0.56	0.56
Count of systems with age based defaults*	4	5	9

* When efficiency data was unavailable, age based defaults were assumed based on NEHERS guidelines for HERS ratings.

The average energy factor of instantaneous and combined appliance water heaters is 0.91, compared to 0.82 in the previous study[34] (Table 66).

Table 66: Energy Factor of Instantaneous and Combined Appliance Water Heaters

(homes with non-electric instantaneous water heaters)

	Nat. Gas	Propane	Total
Number of Water Heaters	*8*	*7*	*15*
Minimum	0.82	0.84	0.84
Maximum	0.96	0.99	0.99
Average	0.91	0.91	0.91
Median	0.93	0.91	0.93

The average energy factor for electric resistance water heaters is 0.90 compared to 0.91 in the previous study. These are all stand-alone tank water heaters (Table 67). This does not include the one heat pump water heater which had an energy factor of 2.4.

Table 67: Energy Factor of Electric Resistance Water Heaters

(homes with electric water heaters)

	Energy Factor
Number of Water Heaters	*33*
Minimum	0.86
Maximum	0.95
Average	0.90
Median	0.88
Count of systems with unknown efficiency*	10

* When efficiency data was unavailable, age based defaults were assumed based on NEHERS guidelines for HERS ratings.

[34] 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.

Statewide, just 9% of the 118 homes with water heater tanks have tank insulation (Table 68). Nine of the eleven tanks are stand-alone water heaters and the other two are indirect systems. Five are electric, two use oil, two use propane, one uses natural gas and one is solar. The average R-value of tank wrap insulation is R-9.

Table 68: Water Heater Tank Wrap Insulation & R-Values

(all homes)

	Statewide*
Number of Tank Water Heaters (stand alone or integrated)	*118*
Percent with insulation wrap	9%
R-value Statistics	
Number of tank water heaters (stand alone or integrated) with insulation	*11*
Minimum	3
Maximum	19
Average	9
Median	9

*Statewide weighted results.

Statewide, just over one-third (36%) of homes have any insulation on their water heater piping and only 8% have fully insulated pipes (Table 69).

Table 69: Water Heater Piping Insulation & R-Values

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*118*	*143*
Fully Insulated	4%	7%	8%	8%
Mostly Insulated	8%	12%	13%	13%
Mostly Uninsulated	8%	19%	15%	15%
No Insulation	80%	63%	64%	64%

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

6.1 Faucet Aerators

Aerators restrict the flow rate of water from faucets, thereby saving water and energy (by reducing the amount of hot water that comes out of the faucet). In the statewide sample of existing homes, 92% of faucets have aerators installed, and there is an average of 3.1 aerators installed per home, as seen in Table 70. The faucets in the sampled Vermont Gas homes have the highest rates of aerators (97%), followed closely by faucets in the Efficiency Vermont territory (93%), and then Burlington Electric (84%).

Table 70: Faucet Aerators

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Number of Faucet Aerators per Home				
None	4%	1%	0%	<1%
One	12%	3%	4%	5%
Two	36%	17%	25%	26%
Three	28%	11%	43%	44%
Four	12%	20%	14%	14%
Five	4%	40%	10%	8%
Six	4%	7%	2%	2%
Seven	0%	0%	0%	0%
Eight	0%	0%	2%	2%
Faucet Aerator Statistics per Home				
Minimum	0	0	1	0
Maximum	6	6	8	8
Average	2.6	3.9	3.1	3.1
Median	2	3	3	3
Aerator Saturation	84%	97%	93%	92%

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

6.2 SHOWER HEADS

The current federal standard for all new shower heads is 2.5 gallons per minute (GPM) or lower.[35] Ninety-nine percent of the shower heads for which auditors could confirm the flow rate meet this standard[36], as seen in Table 71.

"Water-efficient" shower heads meet the more stringent EPA WaterSense® flow rate of 2.0 GPM or lower.[37] While nearly all of the shower heads meet the federal performance threshold (which could already be considered a low-flow standard), the even more water-efficient shower heads make up only 5% of all showerheads (where flow-rate information was available).

[35] https://www3.epa.gov/watersense/docs/matrix508.pdf
[36] It is possible that older units (thus not meeting the federal standard) with no GPM data visible account for a portion of the unknown cases, in which case this percentage could be expected to be lower in reality.
[37] Auditors could only confirm these extremely low flow rates, but not whether the product actually achieved WaterSense certification.

Table 71: Shower Heads

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
≤2.5 GPM Shower Heads per Home (Meeting Federal Standards)				
None	4%	0%	1%	1%
One	60%	30%	34%	35%
Two	20%	43%	46%	45%
Three	0%	0%	4%	4%
Four	0%	5%	2%	1%
Unknown	16%	22%	13%	13%
≤2.5 GPM Shower Head Statistics per Home				
Minimum	0	0	0	0
Maximum	2	4	4	4
Average	1.2	1.7	1.7	1.7
Median	1	1	2	2
Low-Flow Shower Head Statistics per Home				
≤2.5 GPM Shower Head Saturation	93%	99%	99%	99%
≤2.0 GPM (Water-Efficient) Shower Head Saturation	15%	18%	5%	5%

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

7 Section 7 Renewables

Renewable generation systems such as photovoltaic and wind turbines were not commonly found at homes that participated in the study. Only one out of the 140 inspected homes has a photovoltaic (PV) system compared to two out of 95 homes in the previous study. The one PV system has a size of 4.2 kW.

Additionally, four homes have solar domestic hot water (DHW) systems. Two are used for water heating only and two are used for both water heating and space heating.[38] The two water heating only systems have capacities of 40 and 80 gallons. The other two systems have capacities of 80 and 115 gallons.

[38] In both cases, the solar DHW systems used for space heating are supplemental to boilers. One of the boilers uses oil, the other propane.

8 Section 8 Appliances

All of the homes visited have at least one refrigerator and a range/oven. Statewide, almost all homes have a clothes washer (98%) and clothes dryer (92%) (Table 72). Dishwashers are found in most homes – 78%. Separate freezers are found in 44% of homes, and dehumidifiers in 37%.

Table 72: Appliance Saturations
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Refrigerator	100%	100%	100%	100%
Oven / Range	100%	100%	100%	100%
Clothes washer	88%	97%	98%	98%
Clothes dryer	84%	92%	92%	92%
Dishwasher	84%	92%	77%	78%
Separate freezer	32%	35%	47%	44%
Dehumidifier	60%	54%	32%	37%

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

8.1 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 on the ENERGY STAR website.[39] 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 a conservative estimate.

Dishwashers and clothes washers (45% and 44%, respectively) are the appliances most likely to be ENERGY STAR qualified (Table 73). Ten percent of freezers and 22% of primary refrigerators are ENERGY STAR qualified.

[39] http://www.energystar.gov/index.cfm?c=appliances.pr_appliances

Table 73: ENERGY STAR Appliances
(all appliances)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Primary Refrigerators	40%	54%	23%	22%
No. of primary refrigerators	*25*	*37*	*115*	*140*
Dishwashers	57%	67%	46%	45%
No. of dishwashers	*21*	*32*	*90*	*111*
Clothes washers	58%	53%	44%	44%
No. of clothes washers	*24*	*36*	*116*	*140*
Separate freezers	1 (11%)	3%	9%	10%
No. of freezers	*9*	*14*	*64*	*73*

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

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

8.2 REFRIGERATORS

One-half of primary refrigerators (50%) and 39% of secondary refrigerators were manufactured after 2005 (Table 74). Over one-quarter of primary refrigerators (28%) and 41% of secondary refrigerators were manufactured prior to 2001.

Table 74: Refrigerator Year of Manufacture

Primary Refrigerator Year of Manufacture	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Primary Refrigerators	*25*	*37*	*115*	*140*
1981-1990	8%	2%	5%	6%
1991-2000	20%	3%	22%	22%
2001-2005	8%	24%	23%	22%
2006-2010	20%	10%	18%	19%
2011-2015	44%	55%	31%	31%
Don't know	--	6%	1%	1%
Secondary Refrigerator Year of Manufacture	**Burlington Electric**	**Vermont Gas***	**Efficiency Vermont**	**Statewide***
Number of Secondary Refrigerators	*8*	*10*	*33*	*41*
Before 1981	--	--	12%	9%
1981-1990	--	--	15%	12%
1991-2000	1 (13%)	2 (20%)	21%	20%
2001-2005	3 (38%)	4 (40%)	3%	10%
2006-2010	1 (13%)	2 (20%)	27%	24%
2011-2015	2 (25%)	2 (20%)	12%	15%
Don't know	1 (13%)	--	9%	10%

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

Over one-third of primary refrigerators (36%) have a volume of less than 20 cubic feet, and thirty-eight percent have a volume of 20 to 24 cubic feet. Secondary refrigerators were smaller, with two-thirds (64%) having a volume of less than 20 cubic feet (Table 75).

Table 75: Refrigerator Size
(all refrigerators with size data)

Primary Refrigerator Cubic Feet	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Primary Refrigerators	*25*	*37*	*115*	*140*
Less than 20 cubic feet	44%	21%	35%	36%
20-24 cubic feet	32%	52%	38%	38%
25-30 cubic feet	16%	15%	17%	17%
Don't know	8%	12%	10%	10%
Secondary Refrigerator Cubic Feet	**Burlington Electric**	**Vermont Gas***	**Efficiency Vermont**	**Statewide***
Number of Secondary Refrigerators	*8*	*10*	*33*	*41*
Less than 20 cubic feet	6 (75%)	8 (80%)	61%	64%
20-24 cubic feet	1 (13%)	1 (10%)	15%	15%
25-30 cubic feet	--	--	3%	3%
More than 30 cubic feet	--	--	3%	3%
Don't know	1 (13%)	1 (10%)	18%	15%

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

Top-freezer models comprise almost one-half of primary refrigerators (49%) and 39% of secondary refrigerators (Table 76). One-third of primary refrigerators (33%) are bottom freezers and 22% of secondary refrigerators are single door models.

Table 76: Refrigerator Type

(all refrigerators with type data)

Primary Refrigerator Type	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Refrigerators	*25*	*37*	*115*	*140*
Top freezer	36%	35%	49%	49%
Bottom freezer	56%	47%	32%	33%
Side by side	8%	19%	18%	18%
Single door	--	--	1%	1%
Secondary Refrigerator Type	**Burlington Electric**	**Vermont Gas***	**Efficiency Vermont**	**Statewide***
Number of Secondary Refrigerators	*8*	*10*	*33*	*41*
Top freezer	3 (38%)	5 (50%)	39%	39%
Single door	3 (38%)	3 (30%)	21%	22%
Mini fridge	1 (13%)	1 (10%)	21%	21%
Side by side	1 (13%)	1 (10%)	9%	9%
Bottom freezer	--	--	6%	6%
Soda machine	--	--	3%	3%

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

8.3 SEPARATE FREEZERS

Forty-three percent of separate freezers were manufactured after 2005, while 19% of freezers were manufactured before 1991 (Table 84).

Table 77: Separate Freezers Year of Manufacture

(all separate freezers with age data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Separate Freezers	*9*	*14*	*64*	*73*
Before 1981	--	--	5%	5%
1981-1990	1 (11%)	3%	14%	14%
1991-2000	1 (11%)	49%	25%	24%
2001-2005	1 (11%)	3%	11%	11%
2006-2010	1 (11%)	3%	27%	27%
2011-2015	4 (44%)	26%	16%	16%
Don't know	1 (11%)	18%	3%	3%

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

Almost one-half of the freezers (47%) are 15 or more cubic feet in size (Table 78).

Table 78: Separate Freezer Size

(all separate freezers with size data)

Cubic Feet	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Separate Freezers	*9*	*14*	*64*	*73*
4 to 6 cubic feet	3 (33%)	8%	8%	9%
7 to 9 cubic feet	2 (22%)	21%	22%	22%
10 to 14 cubic feet	1 (11%)	18%	14%	14%
15 or more cubic feet	1 (11%)	18%	48%	47%
Don't know	2 (22%)	36%	9%	9%

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

Over one-half of separate freezers (56%) are chest type models (Table 79).

Table 79: Separate Freezer Type
(all separate freezers with type data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Separate Freezers	*9*	*14*	*64*	*73*
Chest	7 (78%)	33%	53%	56%
Upright	1 (11%)	64%	47%	43%
Single door	1 (11%)	3%	--	1%

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

8.4 DISHWASHERS

Over one-half of dishwashers (52%) were manufactured in the last 10 years (Table 80). Nearly one in five (19%) dishwashers was manufactured prior to 2001.

Table 80: Dishwashers Year of Manufacture
(all dishwashers with age data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Dishwashers	*21*	*32*	*90*	*111*
1981-1990	5%	1%	2%	2%
1991-2000	19%	22%	17%	17%
2001-2005	14%	34%	29%	28%
2006-2010	19%	29%	27%	26%
2011-2015	43%	14%	26%	26%
Don't know	--	--	1%	1%

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

8.5 CLOTHES WASHERS

Fifty-eight percent of clothes washers were manufactured after 2005; over one-third are less than five years old (Table 81). Nineteen percent were manufactured before 2001.

Table 81: Clothes Washers Year of Manufacture

(all clothes washers with age data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Clothes Washers	*24*	*36*	*116*	*140*
Before 1981	4%	1%	--	<1%
1981-1990	8%	7%	5%	5%
1991-2000	8%	8%	14%	14%
2001-2005	17%	21%	18%	18%
2006-2010	17%	15%	22%	23%
2011-2015	42%	47%	36%	35%
Don't know	8%	2%	5%	6%

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

Sixty percent of clothes washers are top-loading models (Table 82).

Table 82: Clothes Washer Type

(all clothes washers with type data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Clothes Washers	*24*	*36*	*116*	*140*
Top load	71%	49%	59%	60%
Front load	29%	51%	41%	40%

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

8.6 CLOTHES DRYERS

Almost one-half of clothes dryers (46%) were manufactured after 2005. Statewide, almost one-third of clothes dryers (31%) were manufactured before 2001 (Table 83).

Table 83: Clothes Dryers Year of Manufacture

(all clothes dryers with age data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Clothes Dryers	*23*	*34*	*109*	*132*
Before 1981	4%	1%	--	<1%
1981-1990	13%	9%	10%	10%
1991-2000	13%	21%	21%	21%
2001-2005	22%	23%	17%	17%
2006-2010	13%	15%	19%	19%
2011-2015	30%	29%	27%	27%
Don't know	4%	1%	6%	7%

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

Over three-fourths of all clothes dryers (77%) use electricity (Table 84). Seventeen percent use propane and 6% use natural gas. Forty percent of the clothes dryers in the Vermont Gas region and 44% in Burlington Electric use natural gas.

Table 84: Clothes Dryer Fuel

(all clothes dryers with fuel data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Clothes Dryers	*23*	*34*	*109*	*132*
Electricity	57%	60%	77%	77%
Propane	--	--	17%	17%
Natural Gas	44%	40%	6%	6%

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

8.7 RANGES AND OVENS

Forty-two percent of oven/ranges were manufactured after 2005 (Table 85).

Table 85: Ranges & Ovens Year of Manufacture
(all ovens/ranges with age data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Ovens/Ranges	*29*	*46*	*129*	*158*
Before 1981	7%	4%	2%	3%
1981-1990	--	--	6%	5%
1991-2000	10%	11%	18%	17%
2001-2005	31%	33%	26%	27%
2006-2010	14%	13%	16%	16%
2011-2015	31%	33%	25%	26%
Don't know	7%	7%	6%	6%

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

Forty-eight percent of ovens/ranges use electricity as a fuel, while 41% use propane (Table 86). Natural gas is used as the primary fuel for ovens/ranges in Burlington Electric homes (59%) and Vermont Gas homes (50%).

Table 86: Oven/Range Fuel
(all ovens/ranges with fuel data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Ovens/Ranges	*29*	*46*	*129*	*158*
Electricity	38%	49%	49%	48%
Propane	3%	1%	41%	41%
Natural Gas	59%	50%	8%	8%
Wood	--	--	1%	1%

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

8.8 DEHUMIDIFIERS

Sixty percent of dehumidifiers were manufactured after 2010 (Table 87).

Table 87: Dehumidifier Year of Manufacture
(homes with dehumidifiers with age data)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Dehumidifiers	*18*	*20*	*40*	*58*
Before 1981	--	--	3%	2%
1981-1990	--	--	8%	7%
1991-2000	17%	5%	8%	8%
2001-2005	11%	2%	5%	6%
2006-2010	17%	26%	10%	10%
2011-2015	50%	46%	60%	60%
Don't know	6%	2%	8%	7%

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

8.9 TELEVISIONS AND PERIPHERALS

Almost all homes have at least one TV set (96%); over one-half have at least two TV sets (55%) (Table 88).

Table 88: TV Set Saturation
(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
None	8%	5%	3%	4%
One	40%	38%	42%	41%
Two	32%	30%	31%	31%
Three or more	20%	27%	24%	24%

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

Over one-half of the TV sets (52%) are LCD models while about one-fourth are CRT models (26%) (Table 89).

Table 89: TV Set Type
(all TV Sets)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of TV Sets	*42*	*74*	*221*	*263*
LCD	48%	58%	52%	52%
CRT	24%	28%	26%	26%
LED	29%	14%	19%	16%
Plasma	--	--	3%	3%
Projection	--	--	1%	1%

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

Over one-third of TV monitors are 30 inches or less in size (37%) (as measured diagonally); 28% of TVs are over 40” in size (Table 90).

Table 90: TV Monitor Size
(all TV Sets)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of TV Sets	*42*	*74*	*221*	*263*
20 inches or less	17%	25%	20%	19%
21 to 30 inches	21%	12%	18%	18%
31 to 40 inches	43	31%	34%	34%
41 to 50 inches	14%	19%	24%	23%
51 to 60 inches	5%	10%	5%	4%
Over 60 inches	--	2%	1%	1%

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

The most common TV peripheral is a DVD player (48%) (Table 91). One-quarter of TVs have no peripherals attached (25%).

Table 91: TV Peripherals
(all TV Sets)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of TV Sets	*42*	*74*	*221*	*263*
DVD	48%	51%	47%	48%
VCR	20%	11%	16%	17%
Game Console	29%	24%	10%	10%
None	5%	14%	27%	25%

*Results for the Vermont Gas 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 92). Over one-half of Vermont Gas TV sets (54%) have cable.

Table 92: TV Set-top Boxes
(all TV Sets)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of TV Sets	*42*	*74*	*221*	*263*
Cable	36%	54%	30%	30%
Satellite	12%	6%	30%	28%
Streaming Device	19%	12%	5%	5%
None	33%	27%	36%	37%

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

8.10 COMPUTERS

Most homes have either a desktop or a laptop (80%) computer, with 29% having two or more computers. Sixty-two percent of homes also have a printer (Table 93).

Table 93: Computer & Printer Saturation

(all homes)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Computers				
None	24%	24%	19%	20%
One	44%	38%	52%	51%
Two or more	32%	38%	29%	29%
Printers				
None	32%	32%	40%	39%
One	68%	62%	53%	56%
Two or more	--	5%	7%	6%

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

Statewide, fifty-six percent of all computers are desktops (Table 94). Auditors did inquire about laptops that were not visible during the audit.

Table 94: Computer Type

(all computers)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Computers	*29*	*47*	*130*	*159*
Desktop	55%	51%	55%	56%
Laptop	45%	49%	45%	44%

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

Eighty-nine percent of desktop computers have LCD monitors (Table 95).

Table 95: Computer Monitor Type

(all computers)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Computer Monitors	*13*	*30*	*75*	*88*
LCD	100%	100%	89%	89%
CRT	--	--	4%	4%
LED	--	--	7%	7%

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

Sixty-one percent of all monitors are 20 inches or less in size. Thirteen percent are over 25 inches in size (Table 96).

Table 96: Computer Monitor Size
(all computers)

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Computer Monitors	*13*	*30*	*75*	*88*
15 inches or less	23%	18%	13%	13%
16 to 20 inches	31%	23%	47%	48%
21 to 25 inches	46%	50%	27%	26%
Over 25 inches	--	10%	13%	13%

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

Almost one-fourth of the statewide homes have a home office (24%). Compared to all of Vermont, Burlington Electric (40%) and Vermont Gas (38%) homes are more likely to have a home office (Table 97).

Table 97: Presence of a home office

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
No	60%	62%	80%	76%
Yes	40%	38%	20%	24%

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

About one-half of the home offices (52%) are between 100 to 200 square feet in size (Table 98).

Table 98: Home Office Size

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes with Offices	*10*	*14*	*23*	*33*
Less than 100 square feet	4 (40%)	36%	22%	27%
100 to 200 square feet	6 (60%)	50%	48%	52%
Over 200 square feet	--	14%	30%	21%

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

9 Section 9 Lighting

Ninety-nine percent of homes have CFL bulbs (including screw-in and pin-based models) installed and 97% have incandescent bulbs installed. Over one-half (58%) of homes have LED bulbs installed, a substantial increase from the 4% of homes from the prior study. LED bulbs are installed in 75% of the sampled Vermont Gas homes and somewhat less frequently in Burlington Electric and Efficiency Vermont territories, around 60% of homes in each region. These figures include both hard-wired fixtures and plug-in lamps.

Table 99: Proportion of Homes with Specific Bulbs Installed

Installed Bulb Types	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
CFLs	96%	99%	99%	99%
Incandescents	96%	99%	97%	97%
Fluorescents	56%	79%	79%	78%
LEDs	60%	75%	58%	58%
Halogens	72%	77%	57%	56%
Empty Sockets	44%	14%	22%	23%
Dimmable bulbs installed (bulbs included in above categories)				
Dimmable incandescents**	20%	38%	10%	9%
Dimmable LEDs**	12%	3%	2%	2%
Dimmable CFLs**	8%	7%	1%	1%

*Results for the Vermont Gas column and the Statewide column are weighted; all other results are unweighted.
**Bulbs are considered dimmable only if the bulb itself is dimmable and it is installed on a dimmer switch.

Table 100 displays the proportion of sockets with CFLs installed in existing homes statewide. CFL bulbs make up more than one-half of the sockets in 28% of homes, between one-quarter and one-half of sockets in 38% of homes, and one-quarter or less of sockets in 34% of homes.

Table 100: Proportion of CFLs as Percent of All Sockets in Home

% of Sockets	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
None	4%	1%	1%	1%
1% to 10%	8%	24%	14%	13%
11% to 25%	16%	31%	21%	20%
26% to 50%	36%	30%	37%	38%
51% to 100%	36%	14%	27%	28%

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

As shown in Table 99 above, auditors saw LED bulbs in 58% of all homes. Table 101 displays the proportion of sockets with LEDs installed in the visited homes. Statewide, LED bulbs are installed in more than one-half of the sockets in only 6% of homes, between one-quarter to one-half of sockets in 9% of homes, and in up to one-quarter of sockets in 84% of homes. Among only those homes with LED bulbs installed, 11% have a majority of their sockets filled with LED bulbs.

Table 101: Proportion of LEDs as Percent of All Sockets in Home

% of Sockets	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
None	40%	25%	42%	42%
1% to 10%	24%	33%	24%	23%
11% to 25%	12%	31%	20%	19%
26% to 50%	16%	9%	9%	9%
51% to 100%	8%	2%	6%	6%

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

Across all sockets in the sample, the most commonly installed bulb types are incandescents (installed in 38% of all sockets), followed by CFLs (36%), and LEDs (11%). The remaining sockets are filled with fluorescents (9%), halogens (5%), and a small number are empty (1%).

Table 102: Bulb Saturation as a Percent of All Sockets

Bulb Type Saturation		Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes		*25*	*37*	*115*	*140*
Incandescents	%	**37%**	**49%**	**38%**	**38%**
	Count	465	956	2,585	3,050
CFLs	%	**37%**	**26%**	**36%**	**36%**
	Count	487	719	2,270	2,757
LEDs	%	**14%**	**11%**	**11%**	**11%**
	Count	195	333	784	979
Fluorescents	%	**5%**	**8%**	**10%**	**9%**
	Count	86	169	660	746
Halogens	%	**5%**	**5%**	**5%**	**5%**
	Count	68	103	327	395
Empty Sockets	%	**2%**	**1%**	**1%**	**1%**
	Count	21	17	46	67
Total Sockets of All Types		**1,322**	**2,297**	**6,672**	**7,994**

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

On average, homes have about 20 CFL bulbs installed (with a median of 19 bulbs), and seven LED bulbs (with a median of one bulb). Overall in the existing homes sample, 48% of total sockets are filled with CFLs and LEDs. Burlington Electric and Efficiency Vermont homes also have some combination of CFLs and LEDs in about one-half of all sockets, while Vermont Gas homes have CFLs and LEDs in just 38% of sockets.

Table 103: Average Number of LEDs and CFLs per Home

		Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes		*25*	*37*	*115*	*140*
CFL Bulb Count per Home	Average	19.5	19.9	19.7	19.7
	Median	17.0	11.0	19.0	19.0
LED Bulb Count per Home	Average	7.8	9.8	6.8	6.7
	Median	2.0	4.0	1.0	1.0
Proportion of sockets that are CFLs and LEDs		51%	38%	47%	48%

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

10 Section 10 Homeowner Questions

Auditors asked homeowners a series of questions related to emerging technologies during the on-site inspections. Specifically, the questions focused on home energy management systems, solar panels, and heat pump water heaters.

10.1 Home Energy Management Systems

Auditors surveyed homeowners with home energy management systems installed in their home. There were only two existing single-family homes with a home energy management system installed. Both systems controlled heating in the home, with one having additional capabilities to control lighting and security cameras. Both homeowners reported being “very satisfied” with their home energy management systems.

10.2 Solar Net Metering

Homeowners were asked if they were members/owners of a group net metered solar facility and how much of their annual utility bill was offset with energy produced by their solar facility. There were five members/owners of a group net metered solar facility. Two respondents claimed that solar offset their energy bill by “less than 25%”, one claimed it offset their bill by “25%-50%”, and two indicated it offset their bill by “76%-100%”.

10.3 Heat Pumps

Homeowners with heat pumps installed in their home were asked to rate their satisfaction with the system. There are a total of five heat pumps installed at the inspected sites, all of which were ductless mini-splits. All five homeowners reported that they were “very satisfied” with the systems.

Homeowners who use heat pumps for cooling were asked if the heat pumps replaced a room air conditioner. If a room air conditioner was replaced, the homeowner was then asked what was done with the air conditioner. All five homeowners (100%) replaced a room air conditioner with their heat pump. The unused air conditioners were given away (3), put in storage (1), and thrown out (1).

10.4 Heat Pump Water Heaters

One of the goals of the on-site inspections was to assess the potential for heat pump water heater (HPWH) installation in single-family homes. HPWH’s require sufficient space, a minimum temperature of 50 degrees, and a drain in order to be installed. As part of the inspections, auditors identified the necessary characteristics for HPWH installation. Auditors recorded whether or not each home had a HPWH installed, and if not, they recorded whether or not the requirements for installation could be met.

Table 104 presents the requirements for HPWH installation and the proportion of sites that meet those requirements. At least one of the core requirements for HPWH installation (i.e., sufficient space, ceiling height, and maintaining temperature of at least 50 degrees) is present in over 70% of sites statewide. Drains are present in 43% of sites statewide. Just under one-third (30%) of sites meet all the requirements and have drains present however HPWHs are currently installed in just 1% of sites statewide. HPWH capabilities were not identified in 6% of sites statewide.[40]

Table 104: HPWH Capabilities

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*25*	*37*	*115*	*140*
Sufficient space (>750 cu ft) in basement/utility room	84%	93%	89%	88%
Sufficient ceiling height (6.5') in basement/utility room	84%	91%	80%	80%
Temp. at least 50 degrees in the winter	84%	79%	70%	70%
Drain present	52%	56%	44%	43%
All requirements and drain present	**36%**	**53%**	**30%**	**30%**
None Identified	4%	7%	6%	6%
HPWH already installed	**-**	**-**	**1%**	**1%**

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

[40] Sites with no identified capabilities include homes with small crawlspaces that do not meet the space or ceiling height requirements, on-grade slab homes without a utility room or drain present, and unconditioned spaces that did not meet temperature requirements.

11 Section 11 Energy Efficiency Opportunities

Auditors were asked to identify potential opportunities for energy efficiency improvements in the homes that were assessed in this study. Auditors identified specific opportunities (e.g., ceiling air leakage, basement air leakage, etc.) that were then aggregated for reporting purposes. It should be noted that these opportunities are not meant to encompass all of the potential savings in each home. Instead, these represent a qualitative assessment of the measures or areas that represent the largest savings opportunities in the eyes of the auditors.

Table 105 shows the number of energy efficiency opportunities that were identified by auditors at each home. At least one opportunity was identified in 92% of the inspected homes. One to three opportunities (40%) was the most common range per home. The most opportunities identified at a single house was 14. Auditors did not identify any opportunities at 8% of the inspected homes. That said, this does not exclude the possibility of energy savings potential in these homes.

Table 105: Energy Efficiency Opportunities per Home

Opportunities Per Home	Number of Homes	Percentage of Homes
Number of Homes	140	
One to Three	56	40%
Four to Six	46	33%
Seven to Nine	19	14%
Ten or more	8	6%
No opportunities identified	11	8%

Table 106 presents a summary of the opportunities that were identified during the on-site inspections. These are general categories that were created to aggregate similar opportunities into larger, more general groups. The opportunities are ranked based on the frequency that they were cited during the inspections. There were a total of 74 opportunities identified by the auditors which have been aggregated into 14 categories. Air leakage (32%) and lighting (16%) were the most frequently cited opportunities. The subsequent categories of ceiling insulation (9%), window efficiency (9%), foundation wall insulation (9%), and furnace/boiler efficiency (8%) were also identified as opportunities at multiple homes. The other (4%) category consists of opportunities that could not be aggregated

together into a general opportunity and were only found in one instance.[41] There were no opportunities identified at 11 of the 140 assessed sites.

Table 106: Energy Efficiency Opportunities by Category

Category	Total Energy Efficiency Opportunities Identified	Percent of Total Energy Efficiency Opportunities Identified
Number of Homes	*129*	
Air leakage	191	32%
Lighting	94	16%
Ceiling Insulation	55	9%
Window Efficiency	55	9%
Foundation wall insulation	51	9%
Furnace/boiler Efficiency (AFUE)	48	8%
Duct Insulation and Sealing	38	6%
Water Heater Efficiency	22	4%
Wall Insulation R-Values	9	2%
Frame Floor Insulation	8	1%
Door Insulation	3	<1%
Knee Wall Insulation	3	<1%
Other	23	4%

[41] Other category consists of: Renewable energy, HVAC controls, aerators, appliance efficiency, piping insulation, vermiculate removal, dampers, new faucet fixtures, installing exterior doors, and bathroom fan quality/effectiveness.

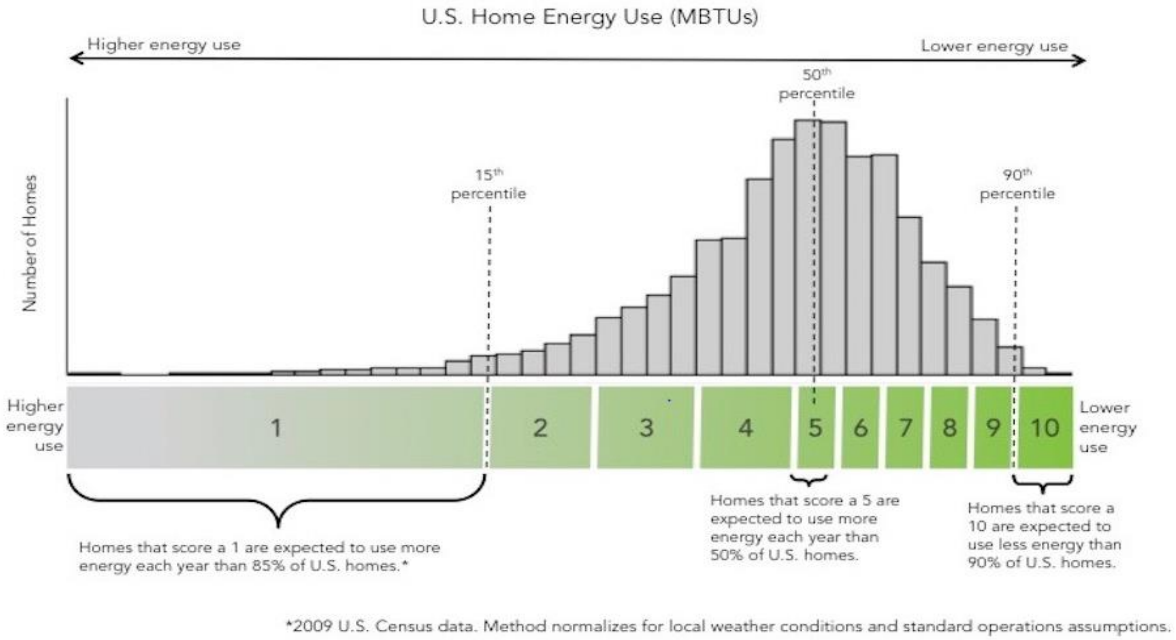
12 Section 12 Home Energy Score

The Home Energy Score (HES) is an energy efficiency rating system launched by the United States Department of Energy in 2012.[42] The software tool models the efficiency of homes based on features of the building envelope, glazing, mechanical systems, and home area.[43] Because the model is intended to help homebuyers compare homes, it provides an asset rating based solely on the home's features and therefore does not reflect occupant behaviors, such as thermostat set points, appliance usage, or plug loads. Additionally, the model normalizes for local weather conditions so that homes across the United States can be compared.

12.1 Home Energy Score Methodology

The HES model rates homes on a score from 1 to 10 where 1 represent the least energy efficient homes and 10 represents the most energy efficient homes. Each score represents a heterogenous percentile range where homes that score a 5 are estimated to use more energy than 50% of U.S. homes each year; homes that score a 1 are estimated to use more energy than 85% of U.S. homes; and homes that score a 10 are expected to use less energy than 90% of U.S. homes (Figure 20).

Figure 20: Percentile Interpretations for HES[44]



[42] https://betterbuildingssolutioncenter.energy.gov/home-energy-score
[43] See Appendix 0 for data inputs.
[44] https://betterbuildingssolutioncenter.energy.gov/home-energy-score/home-energy-score-methodology, Accessed 10/31/16.

The HES tool produces a brief report for every modeled home that provides a list of recommendations to improve the home's energy efficiency, the base Home Energy Score, and the estimated score after all improvements are completed. The model also calculates the energy consumption and costs by fuel for the home as-is and with improvements.

NMR created HES models for 137 of the 140 inspected homes. The three homes that could not be modeled were units in separate, two-family, two-story buildings that comprised only one floor and thus had an adiabatic ceiling or an adiabatic floor with no foundation.

The HES scores for Vermont homes ranged from a minimum of 1 to a maximum of 10, with an average of 5.3 and a median of 5. See Appendix C for more details on the HES scores.

12.2 ENERGY CONSUMPTION

Table 107 displays the total average annual energy consumption per home by fuel source. The average values are calculated across only those homes that consume each fuel (e.g., statewide average natural gas consumption includes only the 35 inspected homes that used natural gas).

The average total energy consumed across the state is 133 MMBtus per home. The average annual electricity usage is estimated to equal 9,597 kWh, or about 800 kWh per month.[45] Annual average consumption of heating fuels (across those homes using each type of fuel) is estimated to equal 551 gallons of oil, 698 gallons of propane, 648 therms of natural gas, and 3.5 cords of fire wood.

The annual electricity consumption is higher per home in Efficiency Vermont (9,643 kWh) compared to Burlington Electric (8,377 kWh). However, Burlington Electric had noticeably higher annual natural gas consumption (1,051 therms) than Efficiency Vermont homes with natural gas service (634 therms).

[45] The Energy Information Administration estimated that annual residential electric consumption equals 6,588 kWh in Vermont in 2016, which is substantially less than the 9,597 kWh value modeled by the HES tool. Because the HES tool calculates electricity consumption based on the home's "assets" it makes assumptions about appliances, lighting, occupancy, and behavior that may inflate the modeled usage. https://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf

Table 107: Average Annual Energy Consumption per Home in Base Case

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*23*	*35*	*114*	*137*
Avg. Total Energy (MMBtu)	136 *(n=23)*	127 *(n=34)*	133 *(n=112)*	133 *(n=137)*
Avg. Total Electricity (kWh)	8,377 *(n=23)*	9,551 *(n=35)*	9,643 *(n=114)*	9,597 *(n=137)*
Avg. Total Oil (gallons)	770 *(n=2)*	-	550 *(n=56)*	551 *(n=58)*
Avg. Total Propane (gallons)	-	-	698 *(n=37)*	698 *(n=37)*
Avg. Total Natural Gas (therms)	1,051 *(n=21)*	917 *(n=35)*	634 *(n=26)*	648 *(n=47)*
Avg. Total Wood (cords)	2.0 *(n=1)*	2.0 *(n=1)*	3.5 *(n=41)*	3.5 *(n=42)*
Avg. Total Pellet (lbs)	597 *(n=1)*	597 *(n=1)*	4,827 *(n=8)*	4,751 *(n=9)*

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

Table 108 displays the average annual energy consumption per home assuming all recommended HES improvements are completed. The table includes average annual energy consumption by fuel source (again, the averages include only those homes that use each fuel source). Statewide, the average annual energy consumed after improvements is 102 MMBtus per home, a decrease of 23% from the base 133 MMBtu figure.

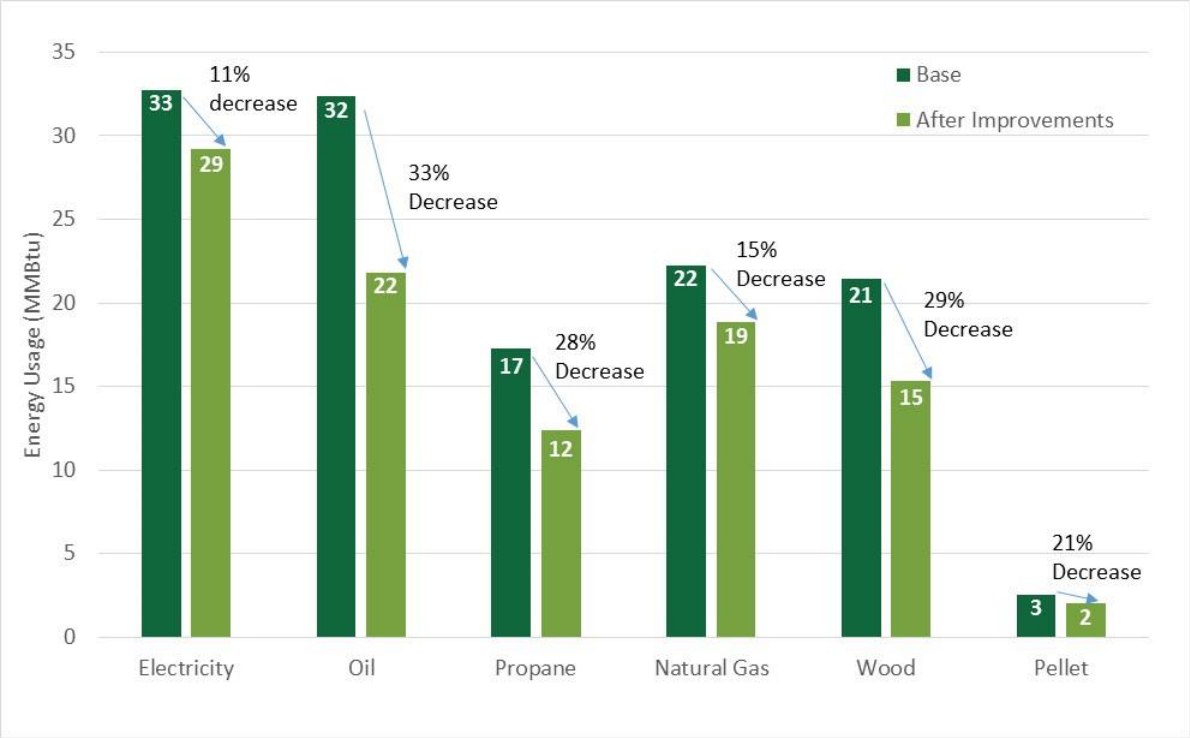
Table 108: Average Annual Energy Consumption per Home After Improvements

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*23*	*35*	*114*	*137*
Avg. Total Energy (MMBtu)	106 *(n=23)*	112 *(n=35)*	102 *(n=112)*	102 *(n=137)*
Avg. Total Electricity (kWh)	7,783 *(n=23)*	9,067 *(n=35)*	8,604 *(n=114)*	8,553 *(n=137)*
Avg. Total Oil (gallons)	532 *(n=2)*	-	371 *(n=56)*	371 *(n=58)*
Avg. Total Propane (gallons)	-	-	502 *(n=37)*	502 *(n=37)*
Avg. Total Nat. Gas (therms)	788 *(n=21)*	794 *(n=35)*	557 *(n=26)*	551 *(n=47)*
Avg. Total Wood (cords)	1.0 *(n=1)*	2.0 *(n=1)*	2.5 *(n=41)*	2.5 *(n=42)*
Avg. Total Pellet (lbs)	556 *(n=1)*	556 *(n=1)*	3,800 *(n=8)*	3,741 *(n=9)*

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

Figure 21 displays the average energy consumption per home across all homes by fuel type, converted into MMBtu to display consumption in equivalent energy units.[46] Heating fuels exhibit the largest decrease after all improvements are implemented, in particular fuel oil (33%), followed by cord wood (29%) and propane (28%).

Figure 21: Statewide Average Energy Consumption with and without Improvements by Fuel Type

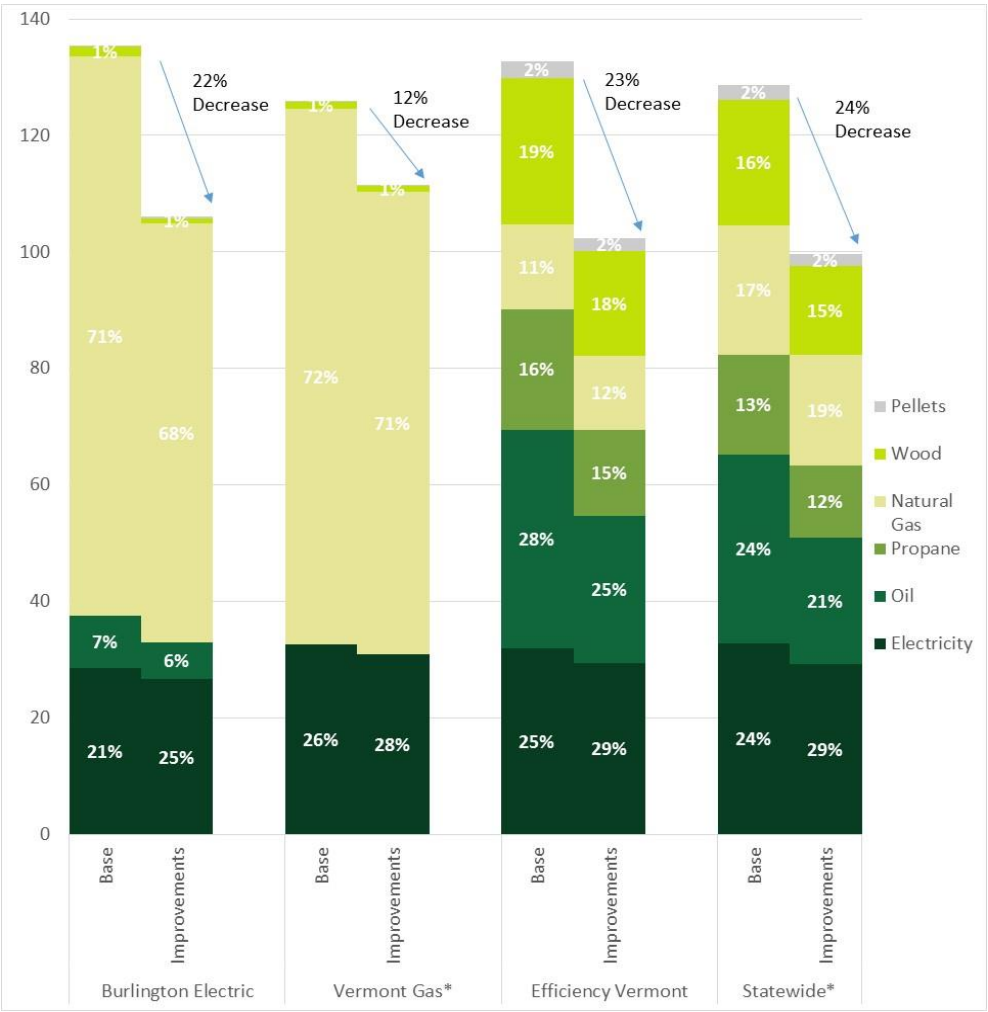


*Statewide results are weighted.

[46] Conversion factors by unit to MMBtu were provided by HES support staff (See Fuel Conversions).

Figure 22 displays average energy consumption calculated across all homes and converted into MMBtu. For each region, we provide the average total MMBtu for the "base" home and the "improved" home, assuming all HES-recommended improvements are completed. The magnitude of energy savings is smallest in the Vermont Gas territory (12%), possibly due to the newer age and better condition of Vermont Gas homes. While overall energy usage declines in each region, the proportional contribution from oil decreases (from 24% to 21% statewide) but the contribution from electricity increases (from 24% to 29% statewide) mostly due to the transition to heat pump technologies.

Figure 22: Average Energy Usage for Homes with and without Improvements by Region



*Results for Vermont Gas and Statewide are weighted; all other results are unweighted.

Figure 23 shows the annual energy consumption before and after all improvements are completed for each of the 137 homes sorted by base energy usage in ascending order. The median and mean base energy usage is 125 MMBtu and 133 MMBTu, respectively; the median and mean energy usage after improvements is 102 MMBtu. The chart illustrates the fact that there are generally greater energy savings opportunities at homes with higher energy usage.

Figure 23: Statewide Average Energy Consumption with and without Improvements

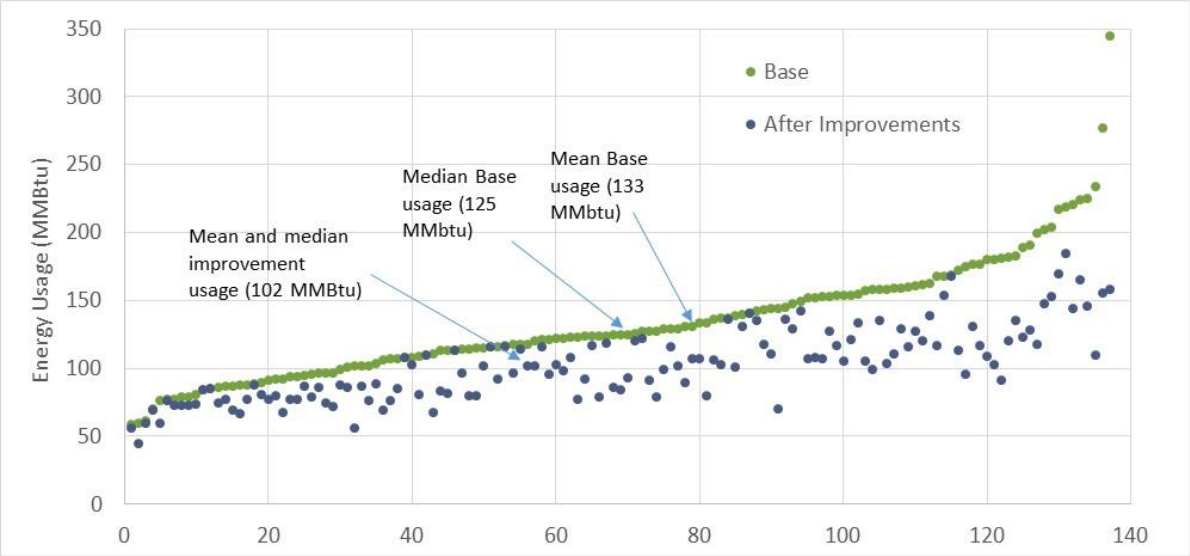


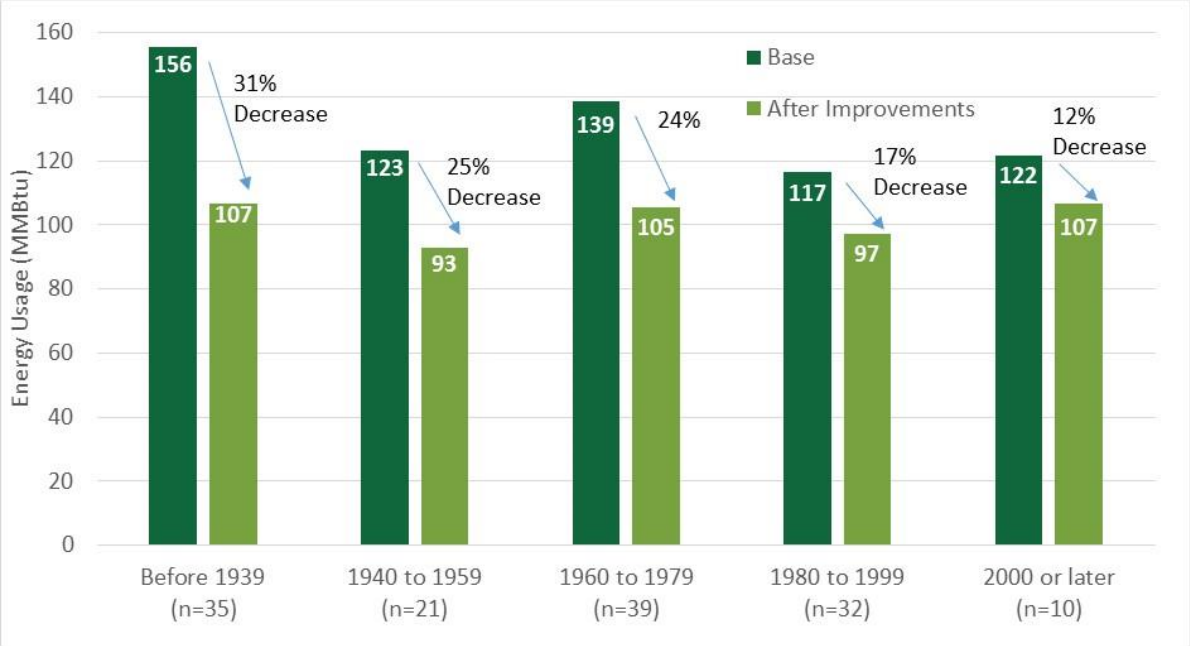
Table 109 provides various data by quartile of statewide average energy consumption. The top quartile represents the 25% of homes with the lowest annual energy consumption; in contrast the bottom quartile represents the 25% of homes with the highest annual energy consumption. On average, the annual energy usage of the bottom quartile declines by 32% after all improvements are completed, compared to only 14% for the top quartile. In addition, the bottom quartile represents 36% of all the base energy usage but 50% of the total energy savings.

Table 109: Statewide Energy Consumption by Energy Usage Quartile (MMBtu)

Quartile	Average Annual Energy Usage per Home			Percent of Total Usage		Percent of total energy savings	Number of homes
	Base (MMBtu)	After Improvements (MMBtu)	Percent Difference	Base	After Improvements		
Top	87	75	14%	16%	18%	10%	34
Second	116	96	17%	22%	23%	16%	34
Third	140	111	20%	26%	27%	23%	34
Bottom	190	130	32%	36%	32%	50%	35

Figure 24 displays the statewide change in energy consumption after all improvements are completed based on the home's decade of construction. Homes built before 1939 exhibit the largest percent decrease in energy consumption after improvements (31%). In contrast, homes built in 2000 or later show the lowest percent decrease (12%). Overall, older homes offer larger opportunities for energy savings than newer homes, as might be expected.

Figure 24: Statewide Average Energy Consumption with and without Improvements by Vintage



*Statewide results are weighted.

Table 110 displays the calculated energy use intensity (EUI), or the energy used per square foot per home. The table breaks down the average EUI by fuel source for only those homes that used each fuel source.

The average total EUI for Vermont was 68 kBtu/s.f., with the highest value in the Burlington Electric territory (73) and the lowest in the Vermont Gas region (56). Notable differences include higher electric EUI in the Burlington Electric territory (4.6) than the Vermont Gas territory (4.0), as well as higher natural gas EUI (0.60 and 0.41, respectively). Burlington Electric's higher EUI may be due to the older age of its housing stock.

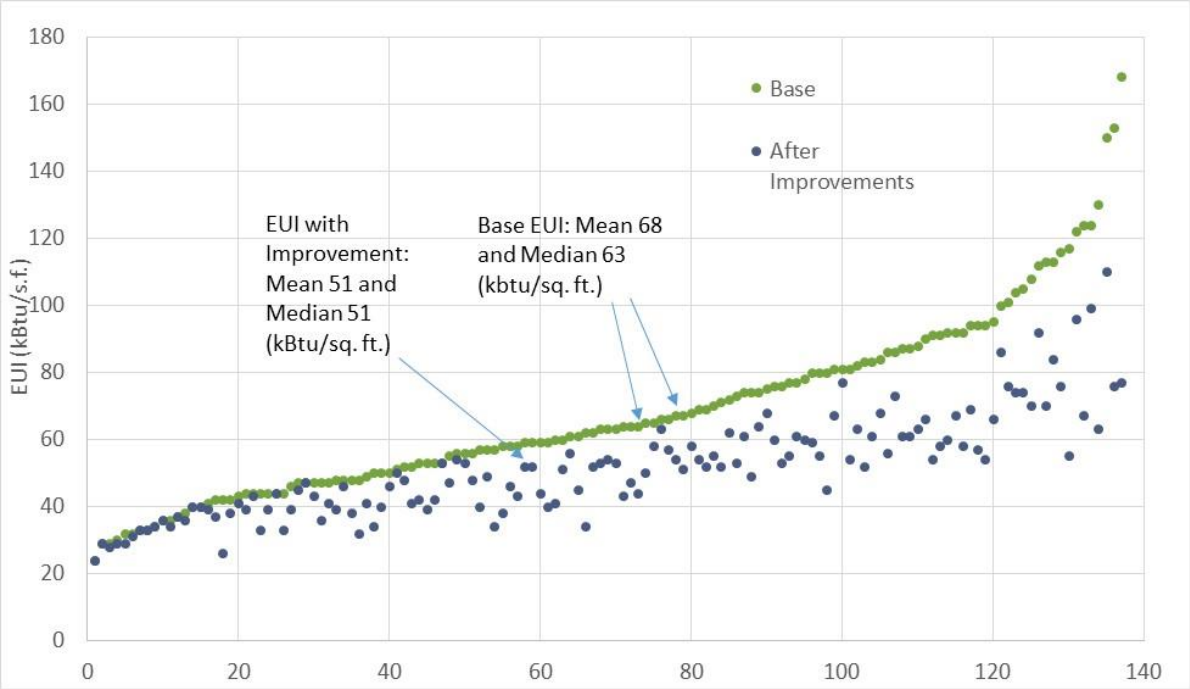
Table 110: Average Energy Use Intensities per Home

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*23*	*35*	*114*	*137*
Avg. Total Energy (kBtu/Sq. Ft.)	73 *(n=23)*	56 *(n=35)*	67 *(n=114)*	68 *(n=137)*
Avg. Total Electricity (kWh/Sq. Ft.)	4.6 *(n=23)*	4.0 *(n=35)*	4.8 *(n=114)*	4.9 *(n=137)*
Avg. Total Oil (gallons/Sq. Ft.)	0.35 *(n=2)*	-	0.29 *(n=56)*	0.29 *(n=58)*
Avg. Total Propane (gallons/Sq. Ft.)	-	-	0.36 *(n=37)*	0.36 *(n=37)*
Avg. Total Nat. Gas (therms/Sq. Ft.)	0.60 *(n=21)*	0.41 *(n=35)*	0.28 *(n=26)*	0.31 *(n=47)*
Avg. Total Wood (cords/Sq. Ft.)	<0.001 *(n=1)*	<0.001 *(n=1)*	<0.002 *(n=41)*	<0.002 *(n=42)*
Avg. Total Pellet (lbs/Sq. Ft.)	<.3 *(n=1)*	<.3 *(n= 1)*	2.7 *(n=9)*	2.7 *(n=9)*
Average year home built	1933	1973	1957	1956

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

Figure 25 shows the statewide EUI values before and after all improvements are completed for each of the 137 homes. The mean and median EUI after improvements is 51 kBtu/s.f., compared to the base mean and median of 68 and 63 kBtu/s.f., respectively.

Figure 25: Statewide Energy Use Intensity with and without Improvements (kBtu/Sq. Ft.)



12.3 RECOMMENDATIONS

The HES report provides specific recommendations to improve the energy efficiency of homes, assigned into *Repair Now* and *Replace Later* categories.

12.4 REPAIR NOW RECOMMENDATIONS

The *Repair Now* section of the HES report is described as follows: "These improvements will save you money, conserve energy, and improve your comfort now." Each recommendation includes the estimated annual energy cost savings. See Appendix C for additional information on how recommendations are generated by HES.

Table 111 lists the frequency of the primary[47] *Repair Now* recommendations from each HES report. Statewide, basement/crawlspace insulation (50% total) was the most frequent primary opportunity. Air sealing (17%) and attic insulation (11%) were the next most

[47] The primary recommendation is the recommendation from each home associated with the largest annual energy cost savings.

common primary opportunities identified in homes. However, 15% of homes had no *Repair Now* opportunities.

Table 111: Primary *Repair Now* Recommendations by Category[48]

Primary *Repair Now* Opportunities	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*23*	*35*	*114*	*137*
Basement/Crawlspace insulation	30%	41%	50%	50%
Air sealing	17%	3%	17%	17%
Attic insulation	26%	16%	11%	11%
Exterior Wall insulation	4%	1%	4%	5%
Duct sealing/insulation	13%	3%	2%	2%
None	9%	36%	16%	15%

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

Table 112 displays the annual energy cost savings for each primary *Repair Now* opportunity that was identified in the HES report. Increasing basement/crawlspace insulation is estimated to yield the largest energy cost savings (57%). Attic insulation (21%) and air sealing (12%) were the next most beneficial categories, followed by exterior wall insulation (9%).

Table 112: Statewide Primary *Repair Now* Annual Cost Savings by Category

Primary *Repair Now* Opportunity	Count of Homes	Average Annual Cost Savings per Home	Percent of Annual Cost Savings Across All Homes
Number of Homes	*137*		*$40,004*
Basement/Crawlspace insulation	64	$355	57%
Attic insulation	19	$463	21%
Air sealing	23	$202	12%
Exterior Wall insulation	6	$618	9%
Duct sealing/insulation	5	$120	1%
None	20	n/a	n/a

*Statewide results are weighted.

[48] Each category provides a brief description on the details of type of repair. While every recommendation is not the same, an example for each recommendation is provided. Basement crawlspace: “Insulate the floor above unconditioned space to at least R-38.” Basement/crawlspace: “Insulate walls to at least R-19.” Air tightness: “Have a professional seal the gaps and cracks that leak air into your home.” Ducts: “Have your ducts professionally sealed to reduce leakage.” Attic: “Increase attic floor insulation to at least R-60.” Ducts: “Have your ducts professionally sealed to reduce leakage.” Exterior walls: “Insulate to at least R-13.”

12.5 REPLACE LATER RECOMMENDATIONS

Replace Later is another component of the HES report that provides recommendations where "these improvements will help you save energy when it's time to replace or upgrade." The recommendations also include an estimated annual energy cost savings for each home repair.

Table 113 shows the frequency of the primary *Replace Later* categories from the HES reports. Statewide, water heaters (25%) were the most common upgrade opportunity in homes. Boilers (16%), roofs (11%), and windows (11%) were the next most common replacement opportunities. However, no upgrade opportunities were found in 20% of homes.

Table 113: Primary *Replace Later* Recommendations by Category[49]

Primary *Replace Later* Recommendation	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*23*	*35*	*114*	*137*
ENERGY STAR Water heater	26%	10%	25%	25%
ENERGY STAR Boiler	-	6%	16%	16%
Improve Roof Insulation/Efficiency	13%	9%	11%	11%
ENERGY STAR Windows	9%	13%	11%	11%
ENERGY STAR Room Air Conditioner	26%	23%	8%	8%
Efficient Wood stove	4%	-	4%	4%
ENERGY STAR Furnace	4%	7%	3%	3%
ENERGY STAR Heat Pump	-	-	3%	3%
ENERGY STAR Central Air Conditioner	4%	7%	1%	1%
None	13%	26%	20%	20%

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

[49] Each category provided a brief description on the details of what needed to be replaced. Examples descriptions from each category are provided, however this is not a comprehensive list of descriptions. Furnace: "Pick one with an ENERGY STAR label." Water Heater: "Pick a heat pump water heater with an ENERGY STAR label". Boiler: "Pick one with an ENERGY STAR label". Roof: "Add rigid insulation sheathing." or "Pick materials that have high solar reflectance (a "cool roof") and an ENERGY STAR label." Windows: "Pick ones with an ENERGY STAR label." Room air conditioner: "Pick one with an ENERGY STAR label." Heat pump: "Pick one with an ENERGY STAR label." Central Air: "Pick one with an ENERGY STAR label."

Table 114 displays the estimated annual energy cost savings from replacing/upgrading various home features. Similar to the previous table, the largest opportunities are with water heaters (29%), boilers (21%), and windows (14%). Other opportunities include wood stoves (9%) and heat pumps (8%).

Table 114: Primary *Replace Later* Annual Cost Savings by Category

Primary *Replace Later* Recommendation	Count of Homes	Average Annual Savings per Home	Percent of Annual Cost Savings Across All Homes
Number of Homes	*137*		$31,342
ENERGY STAR Water heater	34	$271	29%
ENERGY STAR Boiler	18	$363	21%
ENERGY STAR Windows	15	$291	14%
Improve Roof Insulation/Efficiency	15	$195	9%
Efficient Wood Stove	5	$566	9%
ENERGY STAR Heat Pump	3	$867	8%
ENERGY STAR Furnace	4	$491	6%
ENERGY STAR Room Air Conditioner	15	$48	2%
ENERGY STAR Central Air Conditioner	2	$93	1%
None	26	n/a	n/a

*Statewide results are weighted.

Appendix A Comparison to Prior Baseline Studies

Table 115 compares key characteristics from the 2008 and 2011 baseline studies to the results of the current baseline study. For the most part, the data is similar given the lapse of about three years between studies. However, there are a few items with a noticeable difference:

- The proportion of homes with programmable thermostats increased from 24% to 33% to 39%
- The proportion of dishwashers that are ENERGY STAR increased from 16%-18% to 45%
- The proportion of clothes washers that are ENERGY STAR increased from 17% to 25% to 44%
- The proportion of homes with LEDs increased from 4% to 58%
- The proportion of light bulbs that are LEDs increased from <1% to 11%

We will explore these issues in more detail in the overall single-family existing homes report.

Table 115: Comparison to Prior Baseline Study Results

Characteristic	Criteria	2008	2011	2016
Home Type	% of homes that are SF detached	98%	95%	95%
Age of Home	Average age (years)	60	66	61
Conditioned Floor Area	Average s.f.	2,213	1,972	2,147
Wall Insulation	Average R-value	11.9	13.4	12.8
Flat Ceiling Insulation	Average R-value	26.9	27.9	30.1
Cathedral Ceiling Insulation	Average R-value	20.8	20.5	20.6
Foundation Wall Insulation >50% above grade	Average R-value	11.1	11.3	13.0
Air Infiltration	Average ACH50	9.8	7.6	9.5
Heating System Efficiency	Average efficiency of oil boilers	82%	85%	84%
	Average efficiency of gas boilers	85%	86%	89%
	Average efficiency of oil furnaces	83%	83%	81%

Characteristic	Criteria	2008	2011	2016
	Average efficiency of gas furnaces	86%	89%	90%
Thermostats	% homes with programmable units	24%	33%	39%
Duct Insulation	% of homes with insulated ducts in uncond. space	10%	19%	6%
Water Heater Efficiency	Average Energy Factor for integrated tanks	79%	80%	80%
Hot Water Piping Insulation	% of homes with pipe insulation	20%	24%	36%
Refrigerators	% units that are ENERGY STAR	23%	7%	22%
Dishwashers	% units that are ENERGY STAR	18%	16%	45%
Clothes washers	% units that are ENERGY STAR	17%	25%	44%
Separate freezers	% units that are ENERGY STAR	3%	9%	10%
Lighting	% homes with CFLs installed	90%	92%	99%
	% bulbs that are CFLs	19%	30%	36%
	% homes with LEDs installed	n/a	4%	58%
	% bulbs that are LEDs	n/a	<1%	11%

B Appendix B Major Renovations and Additions

The 2011 RBES requires all addition and renovation projects to comply with the energy code, including major renovations, room additions, and piecemeal renovations. The NMR team anticipated that a representative sample of single-family renovation and addition projects would be identified through the homeowner telephone survey, where respondents were asked if their home had undergone any renovations, the nature of the renovations, and when the renovations had occurred. Respondents who indicated their homes had undergone some type of renovation or addition after October 1st, 2011 (the effective date of 2011 RBES) were targeted for on-site inspections. During on-site recruiting calls, homeowners were asked to confirm if renovations occurred and to provide details about them. The NMR team targeted five to ten on-sites at homes that had undergone renovations. Any sites that were identified as having undergone a gut rehab, here defined as the replacement of at least two of the major building systems—the building shell, HVAC systems, or lighting—after October 1st, 2011 were considered new construction and therefore included in the sample for the single-family new construction portion of the baseline study.

Five homes included among the final sample of on-site homes were identified as having undergone renovations or additions that would be subject to 2011 RBES.[50] It should be noted here that while some parts of these additions or renovations can be inspected for compliance with RBES, other parts, namely fenestration U-factors, can be more difficult to ascertain and are not included in this analysis.

Additions

Two homes were identified as having additions built that could be subject to 2011 RBES, with one site confirmed to have made the addition in 2015.

- A second floor was added to a home, however the insulation installed in the new building shell assemblies (walls and ceiling) did not meet 2011 RBES requirements.
- Another home had a kitchen added to the first floor. Visual inspection of other areas of the home as well as information from the homeowner indicated that insulation levels were below 2011 RBES requirements for the ceilings and walls.

Renovations

Four sites were identified as having undergone renovations within the timeframe that would require compliance with 2011 RBES.

- One home (the same home mentioned above that had a kitchen addition done) had most above grade walls gutted, with new framing sistered to existing framing in

[50] Homeowners were not always able to identify the exact timing of renovations or additions, however we did our best to identify those renovations that occurred in the window between 10/1/2011 and the date of the on-site.

some areas and most insulation replaced. The new insulation was slightly below RBES requirements.

- One home was damaged by flooding and had all above grade walls renovated and reinsulated to R-27, exceeding RBES requirements comfortably.
- One home had its roof and ceiling assembly replaced, with the new assembly insulated to R-55, exceeding the R-49 requirement.
- The final home had undergone piecemeal renovations to several parts of the house. Above grade walls were gutted in these areas and insulation was replaced with R-21 of spray foam, bringing them up to RBES requirements.

Table 116: 2011 RBES Package Requirements for Fast-Track Compliance Method[51]

Component	Package 1	Package 2	Package 3	Package 4
Ceiling R-Value	R-49	R-38	R-38 or R-30+10 Cont.	R-28 Cont.
Above-Grade Wall R-value	R-20 or R-13+5 Cont.	R-20+5 Cont. or R-13+7.5	R-20 or R-13+5	R-21 Cont.
Floors over Unconditioned Spaces R-value	R-30	R-30	R-30	R-30
Conditioned Basement Walls/Crawl Space (full height) R-value	R-15 Cont. or R-20 Cavity	R-15 Cont. or R-20 Cavity	R-20 Cont.	R-15 Cont. or R-20 Cavity
Slab Edge R-value	R-15, 4 ft.	R-15, 4 ft.	R-15, 4 ft.	R-15, 4 ft.
Window and Door U-value	0.32	0.32	0.30	0.32
Skylight U-value	0.55	0.55	0.55	0.55
Glazing Percentage	≤20%	≤20%	≤20%	≤20%

[51] Vermont Residential Building Energy Code Handbook, Edition 3.0, October 2011. Table 4-1, Page 24.

C Appendix C Home Energy Scores and HES Model Inputs

C.1 Home Energy Scores

The minimum, maximum, average, and median scores for home energy scores before and after improvements are shown in Table 117. The average statewide difference in home energy scores after all recommended improvement are completed is 2.3. The percent change of average HES scores is similar between Burlington Electric (46%), Efficiency Vermont (43%), and statewide (43%). However, Vermont Gas sites had a lower average improvement of 1.3, with only a 23% change.

Table 117: Base and Improvement HES Scores

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*23*	*35*	*114*	*137*
Base HES Scores				
Min	1	1	1	1
Max	9	9	10	10
Average	5	5.7	5.3	5.3
Median	5	6	5.5	5
HES Score with Improvements				
Min	3	3	3	3
Max	10	10	10	10
Average	7.3	7.0	7.6	7.6
Median	7	7	8	8
Difference in Average HES Scores				
Avg. HES Score Difference	2.3	1.3	2.3	2.3
Percent Change of Avg. HES Scores	46%	23%	43%	43%

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

Table 118 provides the change in average annual energy consumption per home before and after all recommended improvements are completed, by the age of the home. Homes built before 1939 have the largest energy reduction after improvements (32%), and the amount of the reduction generally declines for the more recent vintage homes.

Table 118: Average Base and Improvement Energy Consumption by Year Built

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*23*	*35*	*114*	*137*
Site Energy Consumption by Year (MMBtu)				
Before 1939 (n=35)	143.4 (n=11)	143.4 (n=11)	156.6 (n=24)	155.8 (n=35)
1940-1959 (n=21)	125.3 (n=7)	124.9 (n=8)	123.1 (n=14)	123.2 (n=21)
1960-1979 (n=39)	146.8 (n=4)	132.2 (n=5)	138.4 (n=35)	138.7 (n=39)
1980-1999 (n=32)	77.0 (n=1)	110.6 (n=8)	116.8 (n=31)	116.7 (n=32)
2000 and Later (n=10)	-	144.0 (n=3)	123.3 (n=10)	121.5 (n=10)
Site Energy Consumption with Improvements by Year (MMBtu)				
Before 1939 (n=35)	109.5 (n=11)	109.5 (n=11)	106.5 (n=24)	106.7 (n=35)
1940-1959 (n=21)	94.7 (n=7)	95.5 (n=8)	93.1 (n=14)	92.9 (n=21)
1960-1979 (n=39)	124.3 (n=4)	121.4 (n=5)	105.3 (n=35)	105.5 (n=39)
1980-1999 (n=32)	76.0 (n=1)	104.9 (n=8)	97.9 (n=31)	97.1 (n=32)
2000 and Later (n=10)	-	130.0 (n=3)	108.6 (n=10)	106.8 (n=10)
% Change in Average Site Energy Consumption (MMBtu)				
Before 1939 (n=35)	-24% (n=11)	-24% (n=11)	-32% (n=24)	-32% (n=35)
1940-1959 (n=21)	-24% (n=7)	-24% (n=8)	-24% (n=14)	-25% (n=21)
1960-1979 (n=39)	-15% (n=4)	-8% (n=5)	-24% (n=35)	-24% (n=39)
1980-1999 (n=32)	-1% (n=1)	-5% (n=8)	-16% (n=31)	-17% (n=32)
2000 and Later (n=10)	-	-10% (n=3)	-12% (n=10)	-12% (n=10)

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

C.2 ENERGY COST SAVINGS

Statewide, each home on average saves $862 on annual energy costs after all recommended improvements are completed according to the HES tool (Table 119). The annual energy costs and savings costs are high mostly due to the HES fuel cost assumptions, which could not be adjusted. This represents a 21% average reduction in fuel costs.

Table 119: Base and Improvement Energy Average Cost Per Home

	Burlington Electric	Vermont Gas*	Efficiency Vermont	Statewide*
Number of Homes	*23*	*35*	*114*	*137*
Base Energy Costs	$3,248	$3,120	$4,015	$4,021
Energy Costs with Improvements	$2,675	$2,836	$3,165	$3,159
Difference in Energy Costs	$574	$284	$850	$862
Percent Change in Energy Costs	-18%	-9%	-21%	-21%

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

MODEL INPUT VARIABLES

Below is a list of the inputs for the HES models used for this study. Note, new versions of the model include inputs for photovoltaic systems that were not present in the 2015 or 2016 versions. Also, the model only allows for the inclusion of two separate HVAC systems. For homes that had more than two types of HVAC systems, similar systems were combined per the HES model guidelines.

- About this Home:
  - Assessment date
  - Comments
- Home details:
  - Year built
  - Number of bedrooms
  - Stories above ground level
  - Interior floor-to-ceiling height
  - Conditioned floor area (all stories combined)
  - Direction faced by front of house
  - Was a blower door test conducted on this house (Y/N)
    - If yes: Air leakage rate (CFM50)
  - Has the house been professionally air-sealed
- Roof/Attic
  - Attic area
  - Construction type
  - Exterior finish
  - Insulation level (in roof) (R-value)

    - Roof color
    - Attic or ceiling type
    - Attic floor insulation (R-value)
- Foundation
    - Foundation area
    - Foundation type
    - Floor insulation above basement or crawl space (R-value)
    - Foundation walls insulation level (R-value)
- Walls
    - Is this a home a townhouse or duplex (Y/N)
        - If yes: Position of townhouse unit
    - Is the exterior wall construction the same on all sides (Y/N)
        - If yes:
            - Construction type
            - Exterior finish
            - Insulation level (R-value)
        - If no:
            - Wall construction front:
                - Construction type
                - Exterior finish
                - Insulation level (R-value)
            - Wall construction back:
                - Construction type
                - Exterior finish
                - Insulation level (R-value)
            - Wall construction right:
                - Construction type
                - Exterior finish
                - Insulation level (R-value)
            - Wall construction left:
                - Construction type
                - Exterior finish
                - Insulation level (R-value)
- Skylights
    - Does the house have skylights (Y/N)
        - If yes:
            - Skylight area
            - Do you know the actual skylight specification (Y/N)
                - If yes:
                    - U-factor
                    - Solar heat gain coefficient
                - If no:
                    - Panes
                    - Frame material

        - Glazing type
- Windows
    - Windows area: front
    - Windows area: back
    - Windows area: right
    - Windows area: left
    - Are the window types the same on all sides (Y/N)
        - If yes:
            - Do you know the actual window specification (Y/N)
                - If yes:
                    - U-factor
                    - Solar heat gain coefficient
                - If no:
                    - Panes
                    - Frame material
                    - Glazing type
        - If no:
            - Window type: front
                - Do you know the actual window specifications (Y/N)
                    - If yes:
                        - U-factor
                        - Solar heat gain coefficient
                    - If no:
                        - Panes
                        - Frame material
                        - Glazing type
            - Window type: back
                - Do you know the actual window specifications (Y/N)
                    - If yes:
                        - U-factor
                        - Solar heat gain coefficient
                    - If no:
                        - Panes
                        - Frame material
                        - Glazing type
            - Window type: right
                - Do you know the actual window specifications (Y/N)
                    - If yes:
                        - U-factor
                        - Solar heat gain coefficient
                    - If no:
                        - Panes
                        - Frame material

                - Glazing type
            - Window type: left
                - Do you know the actual window specifications (Y/N)
                    - If yes:
                        - U-factor
                        - Solar heat gain coefficient
                    - If no:
                        - Panes
                        - Frame material
                        - Glazing type
- Systems
    - Percent of conditioned floor area served by system
    - Type of heating system
    - Do you know the actual heating system efficiency (Y/N)
        - If yes: Efficiency value
        - If no: Year installed
    - Type of cooling systems
    - Do you know the actual cooling system efficiency (Y/N)
        - If yes: Efficiency value
        - If no: Year installed
    - Ducts
        - Duct location 1
            - Percentage of ducts at this location
            - Are the ducts insulated (Y/N)
            - Are the ducts sealed (Y/N)
        - Duct location 2
            - Percentage of ducts at this location
            - Are the ducts insulated (Y/N)
            - Are the ducts sealed (Y/N)
        - Duct location 3
            - Percentage of ducts at this location
            - Are the ducts insulated (Y/N)
            - Are the ducts sealed (Y/N)
    - Water heater type
        - Do you know the actual water heater energy factor (Y/N)
            - If yes: Energy factor
            - If no: Year installed

C.3 HES Model Recommendations

Below is the list of recommendations that the HES model generates (Table 120). It should be noted that total savings for the entire package will not equal the sum of all individual recommendations, as the HES model accounts for interactive effects for some energy

improvements. For example, installing insulation reduces energy use for heating/cooling. The HES model accounts for the insulation upgrade and reduces the potential savings for upgrading HVAC system.

Table 120: **HES Model Recommendations by Category**[52]

Category	Measure
Basement wall insulation	R11
	R19
Central air conditioner	Energy Star (SEER 14)
Attic insulation	R19
	R30
	R38
	R49
	R60
Cool roof	High Slope - 15% reflectivity
Foundation wall insulation	R11
	R19
Duct insulation	R6
Duct sealing	Reduce leakage to 3% of total airflow
Floor insulation	R11
	R19
	R25
	R38
Gas boiler	Energy Star (85% AFUE)
Gas Furnace	Energy Star (90% AFUE)
Heat pump	Energy Star (SEER 14.5, HSPF 8.2)
Envelope/Air sealing	75% of existing leakage (25% reduction)
Oil boiler	Energy Star (85% AFUE)
Oil furnace	Energy Star (85% AFUE)
Propane furnace	Energy Star (90% AFUE)
Propane Boiler	Energy Star (85% AFUE)
Room air conditioner	Energy Star v 3.0 (EER 11.3)
Roof EPS insulation	Add R5 exterior foam sheathing
Skylights	Energy Star (Double-pane solar-control low-E argon gas wood frame)
Wall insulation	R13
	Add R5 exterior foam sheathing (only available for wood frame construction w/ wood, aluminum or vinyl siding)
Water heater, electric	Energy Star (heat pump, EF 2.76)
Water heater, natural gas storage	Energy Star (0.67 energy factor)
	Premium Efficiency (energy factor 0.81, 88% recovery efficiency)
Water heater, propane storage	Energy Star (0.67 energy factor)
Windows	Energy Star (Double-pane solar-control low-E argon gas wood frame)

C.4 FUEL CONVERSIONS

Upon request, the DOE support staff for the HES model provided conversion factors from the original unit of measure to the BTU equivalent. The assumptions are shown in Table 121.

Table 121: Fuel Conversion Factors for Vermont

Fuel Type	Conversion Factor to Btu	Original Unit
Electricity	3,412.76	kWh
Natural Gas	100,000	therm
Propane	91,500	gallon
Oil	138,960	gallon
Wood	20,000,000	cord
Pellets	16,400,000	ton

Upon request, the support staff for the HES model provided the price assumptions used for each fuel. The assumptions are shown in Table 122. Note that we are unable to modify the fuel cost inputs for the HES tool.

Table 122: Fuel Price Assumptions for Vermont

Fuel Type	Price	Unit
Electricity	$0.171	kWh
Natural Gas	$1.587	therm
Propane	$3.156	gallon
Oil	$4.051	gallon
Wood	$250	cord
Pellets	$294	ton

[52] https://betterbuildingssolutioncenter.energy.gov/home-energy-score/home-energy-score-methodology, Accessed 3/28/2017.

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.[53]

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

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

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

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

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

Figure 26 shows a conditioned attic with closed cell spray foam applied to the walls. This installation received a Grade I installation as the closed cell spray foam has little to no gaps, has no compression, and the cavity is enclosed on all six sides.[54]

Figure 26: Grade I Closed Cell Spray Foam—Exterior Walls in Newly Constructed Home

Figure 27 shows a Grade II install of unfaced fiberglass batts in a conditioned basement.[55] The insulation has gaps in the corners of certain bays and there is some compression—though relatively minor compression overall. The insulation is enclosed on all six sides (in most places), warranting a Grade II designation.

Figure 27: Grade II Fiberglass Batts—Basement Walls in Newly Constructed Home

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

Figure 28 shows R-21 fiberglass batts in a 2x4 wall cavity. This installation automatically receives a Grade III designation due to the fact that the insulation is not enclosed on the vented attic side. According to the RESNET standards on Grade III installation, “This designation shall include wall insulation that is not in substantial contact with the sheathing on at least one side of the cavity, or wall insulation in a wall that is open (unsheathed) on one side and exposed to the exterior, ambient conditions or a vented attic or crawlspace.”

Figure 28: Grade III Fiberglass Batts—Attic Kneewalls in Newly Constructed Home

Figure 29 shows a Grade II installation of fiberglass batts in a frame floor cavity. While the insulation has a fair amount of compression the gaps are minimal. The primary reason for the Grade II designation is that the fiberglass batts are in substantial contact with the subfloor. This example shows an installation that is right on the boundary of Grade II and Grade III installation. It should be noted that the bay with ductwork on the right side of the image would certainly represent a grade III installation with substantial gaps and compression.

Figure 29: Grade II Fiberglass Batts—Frame Floor in Newly Constructed Home

Figure 30 shows frame floor insulation that received a Grade III designation. The insulation has gaps, substantial compression in places, and is severely sagging in other places. The sagging insulation creates an air space between the insulation and the subfloor, which ultimately diminishes the insulating characteristics of the fiberglass batts.

Figure 30: Grade III Fiberglass Batts—Frame Floor in Newly Constructed Home

Figure 31 shows a Grade I installation of blown fiberglass in an attic. This received a Grade I designation as the fiberglass is blown in evenly, filling all of the cavities with no gaps or voids and little to no compression. In addition, this attic has baffles at the eaves, which is required for attic insulation to achieve a Grade I installation.

Figure 31: Grade I Blown Fiberglass—Attic in Newly Constructed Home