Vermont Multifamily Onsite Report

FINAL REPORT

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Executive Summary

Onsite inspections were conducted by the NMR team at 52 multifamily complexes in Vermont, between September 2011 and February 2012. These multifamily complexes included 20 newly constructed buildings and 32 existing buildings. At each complex, data was collected at one building and one housing unit. The objective of these inspections is to assess the energy characteristics of buildings and housing units in order to provide baseline data regarding the multifamily buildings market in Vermont.[1]

As discussed in the *Final Definitions for 2011 Residential Market Characterization Study*[2] memo, multifamily housing was defined to include all residential housing projects with three or more housing units in buildings of three or fewer stories.[3] This definition is consistent with the Residential Building Energy Standards (RBES) definition of multifamily buildings.[4]

Potential bias is a concern in any sample based on voluntary participation. Due to the lack of publicly available data on the multifamily market, it is difficult to assess the extent to which the onsite samples represent their respective populations, particularly for existing buildings. However, it appears that the new construction sample may over-represent ENERGY STAR buildings although the inconsistent definition of multifamily buildings (see Section 1.1) complicates the comparison of multifamily data from different sources.

In the next section we present the key findings from the multifamily onsite visits. Afterwards we summarize the savings opportunities separately for new construction and existing buildings.

ES.1 Findings

Complex Characteristics

- Seventy percent of the 20 newly constructed complexes[5] consist exclusively of affordable units, compared with 28% among existing complexes; conversely, two-thirds of the 32 existing complexes are rented at market rate, compared to one quarter of new complexes (Table ES-1).
- All eleven newly-constructed ENERGY STAR complexes are entirely affordable housing, compared to just three of the nine non-ENERGY STAR complexes.[6] In contrast,

[1] Note that the visits did not include blower door tests or duct blaster testing, therefore we do not assess air infiltration or duct leakage in multifamily buildings.
[2] *Final Definitions for 2011 Residential Market Characterization Study*. April 14, 2011
[3] The Commercial Baseline Study team visited larger multifamily buildings and provided the data collected within the seven housing units located in those buildings for this report.
[4] The RBES definition of multifamily buildings is not consistent with the Vermont program definition used for reporting performance metrics. The current definition is available from the Public Service Department upon request.
[5] We define a multifamily complex to include the building(s) located together under the same ownership or management. Each complex may include one or more buildings.
[6] The prevalence of ENERGY STAR certification among affordable new construction may be due to the U.S. Department of Housing and Urban Development's (HUD) Energy Action Plan, which seeks to reduce energy costs

all seven existing owner-occupied complexes are entirely market rate properties, as well as 14 of the 25 existing rental complexes.

- On average, new multifamily complexes include fewer buildings though more housing units per building than existing multifamily complexes. The average newly constructed complex has 29.3 housing units located in 2.3 buildings, compared to 17.3 housing units and 3.5 buildings for existing complexes.
- New multifamily buildings are entirely rentals, as are existing buildings classified as "affordable."

Table ES-1: Characteristics of Multifamily Complexes

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Complexes	*11*	*9*	*20*	*7*	*25*	*32*
Property Type						
Affordable Housing	11	3	70%	-	9	28%
Market rate	-	5	25%	7	14	66%
Combination	-	1	5%	-	2	6%
Housing Units						
Total number of units	117	469	586	254	301	555
Average # units per complex	10.6	52.1	29.3	36.3	12.0	17.3
Median # units per complex	9	16	10	33	5	7
% Units rented at afford. rate	100%	20%	36%	0%	68%	37%
% Units rented at market rate	0%	80%	64%	4%	31%	18%
% Units owned at market rate	0%	0%	0%	96%	1%	45%

- Newly constructed complexes are predominantly made up of one-bedroom units (77%). In contrast, existing complexes mostly consist of two-bedroom units (66%).
- Newly constructed complexes are more likely than are existing buildings to be managed by a property management firm (45% vs. 19%).
- Responsibility for paying heating and cooling bills in existing buildings belongs to the occupant of the unit at one-half of the complexes. In new buildings, the landlord or building management pays heating and cooling bills two-thirds of the time. In most new and existing buildings, occupants pay for their electricity bills.
- Only one-third of multifamily complexes have a staff person onsite who is assigned to monitor energy usage, although, in some cases, this simply entails limiting thermostats to a maximum temperature in a building where utilities are included in the rent.
- According to the building owners or managers, 50% of the new complexes have participated in an energy efficiency program, compared to 31% of existing complexes.

in public and publicly-subsidized housing. Energy efficiency improvements are now considered eligible costs under a number of HUD grants, particularly Community Development Block Grants and HOME grants.

Common Areas

- Interior common areas often include hallways, stairways, and laundry rooms. In existing buildings, these areas are lit most often with CFL bulbs (46%), though fluorescent tube bulbs are also relatively common (30%). In new buildings, 61% of interior common area bulbs are fluorescent tubes and 39% are CFLs; none are incandescents.
- Twenty-two of the 52 buildings (42%) have laundry equipment in their common areas. One-half of the 20 new buildings have common area laundry facilities. No owner-occupied existing buildings have common laundry areas, though 48% of the 25 existing rental buildings do.
- In new buildings, 50% of common area washers have the ENERGY STAR label, though just 8% of the washers in existing buildings do. Existing buildings also have machines in poorer condition, although the majority (seven of 12) are still rated as 'good.'
- Most dryers in common areas are electric. In existing buildings, most of the dryers are rated as being in good condition.

Wall Insulation

- Sixty-six percent of the conditioned/ambient wall area in existing buildings is insulated with fiberglass batts. Similarly, 51% of the wall area in new buildings has fiberglass batts installed. Spray foam insulation represents 46% of wall area in new buildings, and cellulose accounts for 19% of wall area in existing buildings.
- While less than one-half (48%) of existing buildings have average wall insulation R-values of R-19 or greater, 95% of new buildings do.

Flat Ceiling Insulation

- All of the new multifamily buildings and all but one of the existing multifamily buildings have some flat ceiling area.
- Cellulose is the most common insulation material across all flat ceiling area in new buildings (64%), followed by spray foam alone (21%), and cellulose blown-in on top of spray foam (12%). Cellulose is also the most common insulation material across all flat ceiling area in existing multifamily buildings as well (42%), followed by fiberglass batts alone (28%).
- Almost all new buildings (93%) with flat ceilings have an average of R-38 or higher insulation, and the remaining 7% are greater than R-30. In contrast, only 52% of existing buildings with flat ceilings have an average flat ceiling R-value greater than R-30.

Cathedral Ceiling Insulation

- Fiberglass batts are the most common insulation material (56%) across all cathedral ceiling[7] area in existing multifamily buildings.[8] Cellulose, spray foam, and fiberglass

[7] Cathedral ceilings, for the purposes of this report, are also known as vaulted or sloped ceilings. These refer to vaulted ceiling areas with no attic above them.

batts laid over rigid foam each make up between 11% and 16% of the cathedral ceiling insulation area.

- Of the ten existing buildings with known cathedral ceiling R-values, six have an average of at least R-30 insulation. Auditors did not find any uninsulated cathedral ceilings in existing buildings.

Floor Insulation

- Existing buildings are more likely than new buildings to have floors over unconditioned space (75% versus 45% respectively). Nevertheless, they are more likely to be insulated in new buildings (67% compared to 25%), and therefore they have a higher R-value on average as well (R-20 compared to R-5.4).

Foundation Walls and Slabs

- A total of seven buildings in the sample have foundation walls more than 50% above grade. The sole newly constructed building is insulated, though none of the six existing buildings are insulated.
- The majority of multifamily homes where onsites were performed (38 out of 52) include below grade foundation walls, either in a basement or a crawlspace. On the whole, 25% of those walls are insulated in existing buildings and 56% are insulated in new buildings.
- Among the 39 buildings overall that have a basement or crawlspace – that is, buildings that are not slab-on-grade – 20 have both a frame floor and a foundation wall that are each at least partially uninsulated. Eleven existing buildings, 10 of which are rentals, had neither insulated foundation walls nor insulated frame floors.
- Eighty-one percent of the slab area in the nine buildings with known slab insulation information have insulation of R-10 or greater. However, the remaining 19% of slab area is not insulated.

Windows

- Just over one-half (52%) of total window area in newly-constructed buildings is double pane, low-E glass with argon. Double pane low-E argon windows account for 79% of total glass area in ENERGY STAR buildings, with double pane low-E windows (without argon) and triple pane windows representing the remainder. In comparison, 58% of window area in non-ENERGY STAR new buildings is double pane clear glass and 38% is double pane low-E glass.
- In existing buildings, double pane clear glass accounts for 63% of all window area and single pane windows represent 14%. Storm windows are installed on 38% of the single-pane window area in existing buildings, or about 5% of total window area.

[8] Only one new multifamily building in the sample has any cathedral ceiling area, and auditors were not able to determine the construction or insulation of this small ceiling area.

Rim and Band Joist Insulation

- Conditioned/ambient rim joists and band joists in existing buildings tend to be insulated with fiberglass batts (52%) or fiberglass batts plus another material (12%). In new buildings, however, rim and band joists are most commonly insulated with spray foam, followed closely by fiberglass batts (46% and 31%, respectively).
- The R-value of conditioned/ambient joist insulation in new buildings is nearly twice that of existing buildings, with an average R-value of R-22.5 compared to R-12.8.

Heating

- Thirty-five percent of newly constructed buildings use oil as their primary heating fuel, 35% use natural gas, 15% use propane, and 10% use wood pellets. In existing buildings, 41% use oil, 34% use natural gas, 13% use propane, and 9% use electricity.
- Seventy-five percent of new buildings have boilers, 15% have combination hydronic heating/DHW appliances, two buildings (10%) have furnaces (one also has a boiler), and one building (5%) has a hydro-air boiler. However, existing buildings have a greater variety of heating system types: 69% have hydronic boilers, 19% have traditional furnaces, and 9% have electric baseboard heat.
- The average efficiency rating for boilers is 87.7% in new construction and 82.9% in existing buildings. For combination heating/DHW appliances, the average efficiency rating is 93.4% in new buildings and 86.7% in existing buildings.
- In new buildings, all 15 furnaces with efficiency data are in one non-ENERGY STAR building with an AFUE of 95.5%. The average efficiency rating of furnaces in seven existing buildings is 84.4%.
- Seventy-one percent of new buildings have insulation on their hydronic heat lines, compared to only 35% of existing buildings. Among the new buildings with hydronic piping insulation, the average R-value of the insulation is R-5.4, and in existing buildings it is R-4.1. In both cases, however, buildings frequently had hydronic lines that were not insulated along their entire length.
- The majority of housing units in both new and existing buildings use manual thermostats rather than programmable thermostats.

Air Conditioning

- Only three new buildings have central air conditioning: one ENERGY STAR building (a standard central AC system) and two non-ENERGY STAR buildings (one with a ductless mini split, and one with a commercial AC system).
- Auditors found only two existing buildings with central air conditioners, both of which are rental properties (one with a ducted central AC system, the other with a ductless mini-split system).
- Window air conditioning units were not visible during the onsite visits, which were conducted mostly during the heating season.

Renewables

- Two of the newly constructed buildings – one ENERGY STAR and one non-ENERGY STAR – have photovoltaic systems installed though none of the buildings visited have wind turbines.
- Eleven of the 20 new buildings heat water using solar energy in conjunction with another fuel source, including nine of eleven ENERGY STAR buildings and two of nine non-ENERGY STAR buildings. None of the existing buildings visited have a solar-assisted domestic hot water system.

Ducts

- Overall, 23% of multifamily buildings have ductwork. All five new buildings with ductwork have their ducts installed exclusively in conditioned space. None of the existing owner-occupied buildings have ductwork and among the existing rental buildings, five of seven have ductwork installed in unconditioned space.
- The five existing rental buildings with ducts in unconditioned space all have some metal ductwork, and two of them have some flex ductwork as well. Two of these five buildings have duct insulation, with an average R-value of R-5.

Water Heating

- Integrated systems are present in over one-half of the 20 new buildings. In contrast, stand-alone storage tanks are most common in existing buildings; they are present in 53% of existing buildings and integrated systems with storage tanks are present in 34%. Instantaneous/on-demand water heaters are less common; they are present in 10% of new buildings and 6% of existing buildings.
- Fifty-five percent of new buildings heat water using solar energy in conjunction with another fuel source including oil (35%), oil and wood pellets (10%), gas (5%), and propane (5%). These solar systems are installed only in buildings with affordable units. Another 25% of new buildings use only natural gas, and 10% use only propane. In existing buildings, natural gas (34%), oil (28%), and electricity (22%) are the most common water heating fuels; none use solar power.
- The average energy factor of integrated tank water heaters is 0.82 in new buildings, and 0.76 in existing buildings. The average energy factor of integrated tankless water heaters (tankless coils) is 0.48 for six existing buildings, and 0.65 in one new building.
- Fossil fuel stand-alone tanks have an average energy factor of 0.60 in existing buildings, and 0.78 in one new non-ENERGY STAR building that has a storage tank water heater.[9]

[9] The solar-assisted systems are not included in any of the efficiency reporting because auditors were unable to collect information on the efficiency of such systems.

- The average energy factor for instantaneous/on demand[10] water heaters in new buildings is 0.93, and 0.85 in existing buildings. All of the instantaneous systems are fueled by natural gas or propane.
- The average energy factor for electric water heaters in new buildings is 0.92, and 0.91 in existing buildings. All of the electric water heaters are stand-alone storage tanks.
- Auditors saw insulation on water heating pipes in 72% of new buildings. In existing buildings this figure was much lower – only 38% of existing buildings have insulation on their DHW pipes, though even these do not always have insulation on the entire length of the pipes. The average R-value of this insulation in new buildings is R-5.2 and in existing buildings is R-3.3.
- Many more housing units in new buildings have low-flow showerheads (85%) than in existing buildings (44%). Similarly, 85% of housing units in new buildings have at least one faucet aerator, compared to 50% for existing buildings.

Appliances in Housing Units

- All of the housing units visited have at least one refrigerator and a range or oven. Less than 10% of newly constructed units have both a clothes washer and dryer compared to 41% of existing units. Dishwashers are present in about one-third of all housing units. Freezers, dehumidifiers, and second refrigerators are rarely found in multifamily housing units.
- For the most part, we emphasize the findings for existing housing rather than newly constructed housing, as that is where the larger opportunity for energy savings lies for appliances.

Refrigerators

- Eighty percent of the refrigerators found in existing units are in good condition.[11]
- Thirteen percent of refrigerators in existing units are estimated to be 20 years or older.
- In newly constructed units, 82% of refrigerators are ENERGY STAR qualified[12] compared to 25% of refrigerators in existing units.

[10] These are referred to as "instantaneous," "on demand," or sometimes "tankless" water heaters. They are characterized by a lack of a water storage tank, and they heat water continuously for as long as there is demand from a running sink or shower fixture. These are different from less efficient "tankless coil" or "integrated tankless" systems, where the boiler heats water in a tankless coil inside the main boiler.

[11] See Section 7 for a description of the three condition ratings for appliances: poor, fair, and good.

[12] The estimated percentage of ENERGY STAR appliances is likely a conservative estimate, particularly in existing housing with older appliances. Because the ENERGY STAR website only lists models that meet the current ENERGY STAR criteria, those models that may have met the criteria in effect at the time of sale but do not meet current criteria will not be listed.

Dishwashers

- Sixty-two percent of the dishwashers found in existing units are in good condition.
- In newly constructed units, four of eight dishwashers are ENERGY STAR qualified, compared to 8% of dishwashers in existing units.

Clothes Washers

- Three-quarters of clothes washers in existing units are in good condition with the remainder being in fair condition.
- In existing units, 70% of the clothes washers are top loading models.
- In newly constructed units, one of two clothes washers are ENERGY STAR qualified. In existing units, 19% of clothes washers are ENERGY STAR qualified.

Lighting in Housing Units

- CFL bulbs are installed in the interior of 86% of the newly constructed units and 70% of the existing units. Just over one-half (55%) of newly constructed units and three-quarters of existing units have incandescent bulbs installed. One-half of newly constructed units and just under one-half (46%) of existing units have fluorescents installed. LEDs and dimmable bulbs are found in relatively few units.
- Newly constructed units have a mean of 7.8 CFL bulbs and median of 5.5 CFL bulbs installed, representing 63% of the average 12.3 light bulbs installed in each unit. Existing units have a mean of 8.2 CFL bulbs and a median of 6.0 CFL bulbs installed, representing 37% of the average 22.3 light bulbs installed in each unit.
- Stored CFL bulbs were found at only 9% of new units and 22% of existing units. The average number of CFLs in storage is 0.8 bulbs across all housing units.

Auditor Ratings of Buildings and Energy Features

- Auditors were asked to rate the level of opportunity for improving energy efficiency in the multifamily buildings they visited, with one representing the lowest level of opportunity and five representing the highest level of opportunity. Opportunities for improvement are rare among newly constructed buildings, and ENERGY STAR buildings in particular. In contrast, existing rental buildings have the highest level of opportunity for improvements (32% rated as a four or five). Among all existing buildings, 28% were rated a four or five.
- Auditors were asked to rate the level of energy savings opportunities missed by the builder for newly-constructed buildings, with one representing the smallest level and five representing the largest level. Almost 60% of the 17 buildings (including seven of nine ENERGY STAR buildings) received a rating of one, 29% received a two, and 12% received a three (both non-ENERGY STAR buildings).
- Each auditor provided a list of up to four ‘worst energy features’ for each building. The features most commonly listed for existing buildings are ‘Basement insulation R-value

(including no insulation)' (38%), 'Interior lighting' (31%), 'Furnace/boiler efficiency' (28%), 'Basement air leakage' (25%), and 'Wall insulation R-values' (22%). For new construction, auditors did not cite a negative energy feature for 65% of the buildings; 'Interior lighting' was the most common feature (20%) cited.

ES.2 Savings Opportunities

In this section we discuss the savings opportunities separately for newly constructed multifamily buildings and existing multifamily buildings.

Newly Constructed Buildings

Table ES-2 compares key characteristics from the 2008 multifamily new construction baseline study to the results of the current baseline study. Because of the differing definition[13] of multifamily projects that qualified for the study in 2008 and in 2011, the results may not be directly comparable between the two studies. Nonetheless, we believe there is value in comparing these results.

Overall, the 2011 buildings exhibit an improvement in energy efficiency, in particular wall insulation, flat ceiling insulation, oil boiler efficiency, glazing percentage, ENERGY STAR refrigerators, and CFL bulb saturation in housing units. However, a few areas exhibit a slight decline, such as gas boiler efficiency and the presence of programmable thermostats.

Table ES-2: Comparison of Key 2008 and 2011 Multifamily New Construction Results

Characteristic	Measurement	2008	2011
*Number of Buildings**		*20*	*20*
ENERGY STAR status	Percent of new buildings that are ENERGY STAR certified	85%	55%
Wall insulation	Average R-value	R-20	R-24
Flat ceiling insulation	Average R-value	R-41	R-51
Glazing	Average glazing percentage	17%	15%
Heating system efficiency	Average efficiency of oil boilers	84.5%	86.6%
	Average efficiency of natural gas & propane boilers	92.8%	89.5%
Thermostats	Percent of units with programmable thermostats	39%	30%
Hot water piping insulation	Percent of buildings with pipe insulation	50%	71%
Interior common area lighting	CFL, fluorescent, & LED bulb saturation	99%	100%
Interior housing unit lighting	CFL bulb saturation	61%	67%
Refrigerators in hsg. unit	Percent ENERGY STAR	26%	82%

*The sample size for a particular table row may be less as not all items are applicable to each site.

[13] In 2008, multifamily buildings were defined as "two or more unit buildings completed after January 1, 2006 with no ground-to-roof walls separating the units and/or with one water and sewer bill for the whole building." The definition also included "mixed use buildings if the square footage is 50% or more residential" and "institutional housing units, including education and age-restricted (senior housing)."[13] In 2011, multifamily buildings were defined to include all residential housing projects (including attached homes) with three or more housing units in buildings of three or fewer stories.

In 2011, affordable housing – which include subsidized units for low-income families, individuals with disabilities, and the elderly – are more efficient than market-rate housing units across nearly every measure of efficiency, primarily because eleven of the fourteen affordable housing complexes achieved ENERGY STAR certification.

Notably, the affordable buildings exceed market rate buildings in terms of average insulation R-value for walls, flat ceilings, and rim joists (Table ES-3). Affordable housing also have a higher proportion of high efficiency window area, heating pipe insulation, and ENERGY STAR appliances as well as more efficient gas boilers and water heaters (including more solar-assisted systems). However, market rate buildings are on par with affordable buildings in terms of energy-efficient interior lighting and glazing percentage.

Table ES-3: Summary of 2011 Affordable vs. Market Rate Multifamily New Construction Results

Characteristic	Measurement	Affordable	Market Rate
*Number of Buildings**		*14*	*6*
Number of ENERGY STAR Buildings		*11*	*0*
Wall insulation	Average R-value	R-24.3	R-19.7
Flat ceiling insulation	Average R-value	R-53.1	R-44.8
Rim joist insulation	Average R-value	R-23.8	R-19.5
Windows	Average glazing percentage	16%	15%
	Percent of window area that is double pane low-E argon or triple pane	66%	21%
Heating system efficiency	Average efficiency of oil boilers	86.6%	--
	Average efficiency of gas boilers	93.9%	83.0%
Heating pipe insulation	Percent of buildings with pipe insulation	86%	0%
Thermostats	Percent of units with programmable thermostats	29%	33%
Water heating efficiency	Energy factor of integrated tank systems	0.84	0.76
	Percent of buildings with solar-assisted	79%	0%
Hot water pipe insulation	Percent of buildings with pipe insulation	93%	0%
Interior common area lighting	CFL, fluorescent, & LED bulb saturation	100%	100%
Common area clothes washers	Percent ENERGY STAR	57%	0%
Refrigerators in hsg. unit	Percent ENERGY STAR	93%	50%
Interior housing unit lighting	CFL and LED bulb saturation	52%	56%
Low-flow showerheads	Percent of units with low flow showerheads	93%	67%
Faucet aerators	Percent of units with faucet aerators	86%	83%

*The sample size for a particular table row may be less as not all items are applicable to each site.

One reason for the substantive differences between affordable and marker rate buildings may be due to recent efforts on the part of the Department of Housing and Urban Development (HUD) to reduce its spending on utilities. HUD funding for affordable housing development, e.g. HOME grants and Community Development Block Grants, may be used to finance efficiency

improvements in the pursuit of that goal[14]. This effort may at least partially explain the higher incidence of ENERGY STAR buildings and consequently greater energy efficiency, among newly-constructed affordable housing.

All eleven of the 2011 ENERGY STAR multifamily projects would pass 2005 RBES requirements[15] through the HERS path, and it appears that eight of the nine non-ENERGY STAR projects would meet the key RBES Fast-track requirements regarding wall insulation, ceiling insulation, glazing percentage, and heating system efficiency.[16] In addition, auditors identified few newly-constructed buildings with opportunities for energy savings: auditors rated nearly 60% of new buildings as having a "small" level of energy efficiency opportunities that were missed by the builder and rated 80% of the buildings as currently having a "low" level of energy savings opportunities. This finding is supported by the fact that auditors reported that relatively few new buildings − about one-third − possessed any energy features that could be improved. Interior lighting was the feature most often cited in need of improvement (20%), which is a fairly easy and inexpensive upgrade. These results indicate that multifamily new construction in Vermont, in general, is energy efficient.

[14] "How to Promote ENERGY STAR through HOME." U.S. Department of Housing and Urban Development (HUD), accessed September 20, 2012.
http://www.hud.gov/offices/cpd/affordablehousing/programs/home/energystar.cfm

[15] All newly constructed buildings were built between January 2009 and October 2011, and therefore are subject to the 2005 version of RBES.

[16] One home has a high glazing percentage, which exceeds the Fast-track maximum of 25%. However, this building may still comply with RBES via the Trade-off or REScheck methods.

However, it appears that the ENERGY STAR complexes are more energy efficient than the non-ENERGY STAR complexes, though only clearly so in a few selected areas (Table ES-4). In particular, ENERGY STAR complexes have a higher percentage of high efficiency windows, solar-assisted water heaters, ENERGY STAR refrigerators and clothes washers, piping insulation, and CFLs installed in housing units, as well as higher efficiency gas boilers and a lower glazing percentage. These measures would all appear to be areas where the new construction practices for non-ENERGY STAR buildings could be elevated in order to improve energy efficiency.

Table ES-4: Summary of 2011 ENERGY STAR vs. Non-ENERGY STAR Multifamily New Construction Results

Characteristic	Measurement	ENERGY STAR	Non-ENERGY STAR
*Total Number of Buildings**		*11*	*9*
Wall insulation	Average R-value	R-24.3	R-21.7
Flat ceiling insulation	Average R-value	R-52.8	R-48.0
Rim joist insulation	Average R-value	R-23.4	R-21.0
Windows	Average glazing percentage	14%	17%
	Percent of window area that is double pane low-E argon or triple pane	86%	38%
Heating system efficiency	Average efficiency of oil boilers	86.5%	86.6%
	Average efficiency of natural gas & propane boilers	94.8%	87.3%
Heating pipe insulation	Percent of buildings with pipe insulation	82%	50%
Thermostats	Percent of units with programmable thermostats	36%	22%
Water heating efficiency	Energy factor of integrated tank systems	0.83	0.81
	Percent of buildings with solar-assisted	82%	22%
Hot water pipe insulation	Percent of buildings with pipe insulation	91%	43%
Interior common area lighting	CFL, fluorescent, & LED bulb saturation	100%	100%
Common area clothes washers	Percent ENERGY STAR	100%	16%
Refrigerators in hsg. unit	Percent ENERGY STAR	100%	63%
Interior housing unit lighting	CFL and LED bulb saturation	71%	38%
Low-flow showerheads	Percent of units with low flow showerheads	91%	78%
Faucet aerators	Percent of units with faucet aerators	91%	78%

*The sample size for a particular table row may be less as not all items are applicable to each site.

Obviously, it is important to recognize that a new version of RBES became effective in October 2011. This new version increases the minimum requirements for insulation R-values for ceilings, above grade walls, basements walls, and slabs and also reduces the maximum U-values allowed for windows and doors. In addition, among other changes, it provides guidelines for air infiltration and duct leakage to the outside, and requires high-efficiency lamps. While this new version of RBES should improve the efficiency of windows and interior lighting in multifamily

new construction, it does not appear to address the opportunities in water heating, gas boiler efficiency, pipe insulation and appliances.

Existing Buildings

The auditors rated 28% of existing multifamily buildings as having significant opportunities for energy efficiency upgrades. In addition, according to building owners or managers, only 31% of the existing multifamily complexes have ever participated in an energy efficiency program. These results indicate that there is a substantial opportunity to increase the energy efficiency of existing multifamily buildings. Below is a summary of the key savings opportunities in the building shell of existing multifamily buildings (Table ES-5).[17]

- **Ceiling insulation.** Twelve percent of rental buildings and 25% of owner-occupied buildings have R-19 or less insulation installed in flat ceilings. In addition, 8% of rental buildings and 29% of owner-occupied buildings have R-19 or less insulation installed in cathedral ceilings. Both of these situations, in particular accessible flat ceiling spaces, present clear opportunities for insulation upgrades as well as air sealing.
- **Rim joist insulation.** Twenty-four percent of rental buildings have no rim joist insulation, which provides an opportunity for insulation upgrades as well as air sealing.
- **Basement insulation.** Forty percent of the rental buildings have neither foundation wall insulation nor frame floor insulation. In addition, basement insulation was cited as the worst energy feature in 38% of all existing buildings. Foundation walls or frame floors may provide another good upgrade opportunity for insulation and air sealing, depending on the level of finish of the interior of the basement.

Table ES-5: Existing Multifamily Building Shell Summary

Characteristic	Measurement	Owner-Occupied	Rentals	Statewide
*Total Number of Buildings or Housing Units**		*7*	*25*	*32*
Wall insulation	Average R-value	R-12.3	R-16.4	R-15.4
	Percent with no insulation	0%	11%	8%
Flat ceiling insulation	Average R-value	R-22.0	R-36.0	R-33.3
	Percent ≤ R-19	25%	12%	15%
Cathedral Ceiling Insulation	Average R-value	R-19.0	R-27.9	R-26.1
	Percent ≤ R-19	29%	8%	16%
Rim joist insulation	Average R-value	R-12.6	R-12.9	R-12.8
	Percent with no insulation	0%	24%	19%
Basement Insulation	Percent with no frame floor or foundation wall insulation	15%	40%	34%
Windows	Percent of window area that is single pane	0%	20%	14%
	Percent of single pane window area with storms	n/a	38%	38%

*The sample size for a particular table row may be less as not all items are applicable to each site.

[17] Note that existing multifamily buildings were not included in the prior baseline study, therefore we are unable to compare the 2011 results to earlier baseline study results.

Table ES-6 displays a summary of the key savings opportunities for the HVAC, DHW, appliance, and lighting components of existing multifamily buildings. The more efficient characteristics among existing rental properties, compared to owner-occupied buildings, may be partially attributable to their higher rate of participation in energy efficiency programs: nine of the 25 rental buildings have participated in an energy efficiency program compared to one of the seven owner-occupied buildings.

- **Piping Insulation.** About two-thirds of buildings with heating or hot water pipes do not have pipe insulation. In addition, of the buildings that do have pipe insulation, it typically does not cover the full length of exposed pipes. While some of these pipes may be located in conditioned spaces, adding insulation is a relatively inexpensive proposition.
- **Common area clothes washers.** Thirty-eight percent of existing buildings have a common area laundry room. Only 8% of these clothes washers are ENERGY STAR qualified, and 58% are top load models. Given the frequent use that these washers likely receive by tenants, this may present a good opportunity for replacement.
- **Refrigerators.** All housing units have a refrigerator, and nearly one-quarter of these refrigerators are 15 years or older. This may present an opportunity for appliance retirement.
- **Lighting.** There is little opportunity for improvement to common area lighting, though there may be some opportunity inside of housing units. While the overall CFL & LED bulb saturation is relatively high (38%), there still remains a significant opportunity to replace incandescent bulbs (61%) with CFLs, particularly in owner-occupied units which have a lower CFL & LED bulb saturation (26%) than in rental units (43%). In addition, interior lighting was cited as a poor energy feature by auditors at 31% of the buildings.

Table ES-6: Comparison of Existing Multifamily HVAC and Appliance Results

Characteristic	Measurement	Owner-Occupied	Rentals	Statewide
*Total Number of Buildings or Housing Units**		*7*	*25*	*32*
Heating system efficiency	Average efficiency of oil boilers	n/a	85%	85%
	Average efficiency of natural gas & propane boilers	82%	82%	82%
Heating pipe insulation	Percent of buildings with hydronic boilers which have pipe insulation	0%	42%	35%
Thermostats	Percent of housing units with programmable thermostats	43%	36%	38%
Water heating efficiency	Energy factor of integrated tank systems	n/a	0.76	0.76
	Energy factor of non-electric storage tank systems	0.60	0.60	0.60
Hot water pipe insulation	Percent of buildings with pipe insulation	29%	40%	38%
Interior common area lighting	CFL, fluorescent, & LED bulb saturation	n/a	85%	85%
Common area clothes washers	Percent ENERGY STAR	n/a	8%	8%
Refrigerators in hsg. unit	Percent ENERGY STAR	11%	29%	25%
	Percent 15 years or older	22%	23%	23%
Clothes washers in hsg. unit	Percent ENERGY STAR	13%	25%	19%
Dishwashers in hsg. unit	Percent ENERGY STAR	0%	14%	8%
Interior housing unit lighting	CFL & LED bulb saturation	26%	43%	38%
Low-flow showerheads	Percent of units with low flow showerheads	43%	44%	44%
Faucet aerators	Percent of units with faucet aerators	57%	48%	50%

*The sample size for a particular table row may be less as not all items are applicable to each site.

Existing multifamily buildings with subsidized units are more efficient than their market rate counterparts across a number of measures (Table ES-7). In walls, flat ceilings, and joists, the average insulation R-value in affordable buildings exceeds that of market rate buildings, as well as fewer buildings without any frame floor or foundation wall insulation. In addition, the interior lighting in affordable buildings is more efficient and there is a higher incidence of ENERGY STAR refrigerators, low-flow showerheads, and faucet aerators. However, affordable buildings have more window area that is single-paned and a lower average sloped ceiling R-value.

Table ES-7: Summary of Affordable vs. Market Rate Existing Multifamily Results

Characteristic	Measurement	Affordable	Market Rate
Number of Inspected Buildings		*11*	*21*
Wall insulation	Average R-value	R-19.5	R-13.5
	Percent with no insulation	n/a	12%
Flat ceiling insulation	Average R-value	R-37.2	R-31.3
	Percent ≤ R-19	14%	14%
Cathedral Ceiling Insulation	Average R-value	R-23.7	R-27.2
	Percent ≤ R-19	33%	43%
Rim joist insulation	Average R-value	R-16.4	R-11.4
	Percent with no insulation	14%	22%
Basement Insulation	Percent with no frame floor or foundation wall insulation	9%	48%
Windows	Percent of window area that is single pane	20%	9%
	Percent of single pane window area with storms	41%	33%
Heating system efficiency	Average efficiency of oil boilers	84.5%	84.8%
	Average efficiency of gas boilers	82.8%	81.9%
Heating pipe insulation	Percent of buildings with hydronic boilers which have with pipe insulation	44%	29%
Thermostats	Percent of housing units with programmable thermostats	27%	43%
Water heating efficiency	Energy factor of integrated tank systems	0.76	0.76
	Energy factor of storage tank systems	0.66	0.59
Hot water pipe insulation	Percent of buildings with pipe insulation	46%	33%
Interior common area lighting	CFL, fluorescent, & LED bulb saturation	92%	59%
Common area clothes washers	Percent ENERGY STAR	13%	0%
Refrigerators in hsg. unit	Percent ENERGY STAR	36%	19%
	Percent 15 years or older	9%	30%
Clothes washers in hsg. unit	Percent ENERGY STAR	--	14%
Dishwashers in hsg. unit	Percent ENERGY STAR	--	10%
Interior housing unit lighting	CFL & LED bulb saturation	63%	29%
Low-flow showerheads	Percent of units with low flow showerheads	64%	33%
Faucet aerators	Percent of units with faucet aerators	73%	38%

1 Introduction

Onsite inspections were conducted by the NMR team at 52 multifamily complexes in Vermont between September 2011 and February 2012. These multifamily complexes included both newly constructed and existing buildings. The objective of these inspections is to assess the energy characteristics of buildings and housing units in order to provide baseline data regarding the multifamily building market in Vermont.

As discussed in the *Final Definitions for 2011 Residential Market Characterization Study*[18] memo, multifamily buildings were defined to include all residential buildings with three or more housing units in buildings of three or fewer stories, including the following projects:

- Individual three- or four-unit buildings
- Three or more attached townhouses or row houses
- Market rate and low income projects
- Projects consisting of multiple two-unit buildings

This definition excludes all hotels, motels, barracks, dormitories and nursing homes, assuming they are being captured in the Commercial Baseline Study. The Commercial Baseline Study team visited larger multifamily buildings and provided the data collected within the seven housing units located in those buildings for this report.

1.1 Multifamily market

The 2007-2009 American Community Survey[19] (ACS) estimates that there are 52,157 existing housing units located in buildings with three or more housing units in Vermont. These units represent 16% of all 313,370 housing units (both occupied and vacant) in Vermont. It is important to note that these figures represent multifamily units *not* buildings. The data collected for this study indicate that there is an average of about five housing units per existing multifamily building (see Table 2-1). Therefore, we estimate that there are approximately 10,431 multifamily buildings of three of more units in Vermont.

[18] *Final Definitions for 2011 Residential Market Characterization Study*. April 14, 2011
[19] http://www.census.gov/acs/www/

The Census provides estimates of new constructions permits[20] for multifamily buildings in Vermont. Overall, a total of 106 buildings (representing 1,146 units) with three or more units were permitted in Vermont between 2009 and 2011.

Table 1-1: Census Building Permit Data

	Buildings with Three or Four Units		Buildings with Five or More Units	
Year	**Units**	**Buildings***	**Units**	**Buildings**
2009	56	21	339	18
2010	38	12	258	18
2011	78	11	377	25
Total	172	45	974	61

*Number of three or four unit buildings is calculated by dividing the number of units by 3.5

It is important to note that the ACS and Census definition of multifamily buildings differs from the definition employed by this study in two key ways. This baseline study − following RBES guidelines − defines residential multifamily buildings as those buildings with three or more housing units in buildings of three or fewer stories; this definition includes attached side-by-side homes with ground-to-roof walls separating units (if three or more units are attached). However, the ACS and Census data categorize attached homes as individual single-family housing units, regardless of the number of units attached. In addition, the ACS and Census data include all buildings with three or more units, regardless of the number of stories.

The Vermont ENERGY STAR program completed a total of 37 multifamily projects between 2009 and 2011. Note that the Efficiency Vermont definition of multifamily projects also differs from the definition employed by this study as well as the definition used by the Census. The Efficiency Vermont definition includes buildings with multiple dwelling units in a single building with a management and/or ownership structure that lends itself to a multifamily approach. Examples include apartment buildings, single room occupancy buildings, and assisted living facilities. Attached townhouses, duplexes, and buildings with two to four dwelling units may be classified as either multifamily or single family depending on the management structure and the scale of the project. In addition, mixed-use projects that include both residential and commercial spaces will be split into two projects for reporting purposes, with the residential portion being reported as multifamily regardless of the number of units.

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

1.2 Onsite Data Collection

The NMR team collected data for one building and its common areas as well as the interior of one occupied housing unit at each multifamily complex[21]. The onsite visits collected data on the following building features:

- General information on the building including: ownership, management, number of stories, number of housing units by number of bedrooms
- Common area information including interior lighting, exterior lighting, and laundry
- Envelope features on thermal boundary of building including: wall, ceiling and floor insulation locations, types, and R-values; window type and location; and door type
- Heating, cooling, and water heating equipment including: manufacturer and model, age, type, location, fuel used, size, and efficiency rating.
- Duct insulation including whether it is on the supply or return ducts, location, insulation type and estimated R-value.
- Type of duct sealing, if any.

The onsite visits collected data on the following features of the housing unit:

- Appliances and electronics present including dishwashers, clothes washers, dryers, ovens, refrigerators, freezers, room air conditioners, televisions, and computers. Data collected includes manufacturer and model, type, approximate age, size, and ENERGY STAR status (where feasible).
- Inventory of light bulbs by bulb type.

Note that the visits did *not* include blower door tests or duct blaster testing, therefore we do not assess air infiltration or duct leakage in multifamily buildings.

The NMR team reviewed individual input forms as necessary and discussed resolution of inconsistencies with the auditor who conducted the onsite inspection. In addition, the NMR team reviewed the population of data in each field for reasonableness and ensured all data are in consistent units.

1.3 Sample Plan

The existing buildings include only those built prior to 2005, according to the building owner or manager. The newly constructed buildings include those built in 2009 or later, according to the building owner or manager. All newly constructed buildings that were visited were completed before October 2011, therefore these buildings are required to comply with the 2005 version of RBES.

The team visited ten buildings that recently underwent major renovations. Due to the nature and extent of the renovation work performed on these buildings, nine of these ten buildings are classified as new construction. The classification of a renovation project as new construction or

[21] We define a multifamily complex to include building(s) located together under the same ownership or management. Each complex may include one or more buildings.

as an existing building is often unclear; for the most part, renovation projects were classified as new construction if at least two of the three major building systems (building shell, lighting, HVAC) were replaced.

1.3.1 Sample Sources & Selection

In order to identify multifamily buildings that met the eligibility criteria for this study, we utilized a variety of approaches, as described below.

- The respondents who screened out of the single-family homeowner telephone surveys because they were tenants were asked to provide the name and phone number of their building manager or owner. This approach yielded a total of nine site visits.
- Internet searches for eligible multifamily buildings yielded a total of 25 site visits.
- Vermont Directory of Affordable Housing[22] yielded a total of 15 site visits.
- Utility service requests for new permanent residential electrical service yielded a total of three site visits.

Given the difficulty encountered in identifying eligible multifamily complexes and obtaining cooperation from building managers, we were often not able to select which complexes participated in the study; instead, for the most part, we accepted whichever eligible complexes agreed to an onsite visit. However, in order to provide a reasonable mix of both market rate and affordable housing in the existing buildings sample, we limited the number of visits to affordable housing buildings. In the end, eleven of the 32 visits to existing complexes were affordable housing.

1.3.2 Geographic Targeting

The Vermont Department of Public Service (DPS) requested information on the housing stock located in four Geographically Targeted (GT) regions in Vermont: Northern Chittenden, St. Albans, Rutland, and the Southern Loop. Data from Efficiency Vermont (EVT) regarding the number of GT accounts in each GT town were analyzed in order to identify towns where GT accounts are highly concentrated; these towns were then selected to represent the GT regions. Therefore, we can be reasonably assured that homes from these towns are in fact GT customers.

Table 1-3 on the next page displays each GT region, the towns selected to represent the GT region, and the number and percent of GT accounts in each town.

[22] http://www.housingdata.org/doarh/

Table 1-2: Towns Selected to Represent Geographically Targeted Regions

GT Region	Town	Number of Residential Accounts	Number of Residential GT Accounts	Percent of Accounts that are GT
North Chittenden	Colchester	7,073	6,916	98%
	Essex	3,208	2,787	87%
	Essex Junction	4,647	4,545	98%
	Winooski	3,004	2,976	99%
Rutland	Center Rutland	201	197	98%
	Clarendon	1,128	773	69%
	Rutland	9,042	8,761	97%
Southern Loop	Andover	271	242	89%
	Arlington	1,304	1,277	98%
	Bondville	400	399	100%
	Brookline	160	142	89%
	East Arlington	152	151	99%
	East Dorset	366	358	98%
	East Dover	46	45	98%
	Jamaica	1,016	1,000	98%
	Landgrove	127	125	98%
	Londonderry	907	896	99%
	Manchester	739	657	89%
	Manchester center	1,804	1,731	96%
	Newfane	847	824	97%
	Peru	667	662	99%
	Sandgate	156	131	84%
	Shaftsbury	1,658	1,411	85%
	South Londonderry	522	483	93%
	South Newfane	188	188	100%
	Stratton	1,316	1,310	100%
	Sunderland	445	436	98%
	Townshend	588	540	92%
	Wardsboro	331	329	99%
	West Dummerston	364	295	81%
	West Townshend	203	198	98%
	West Wardsboro	509	503	99%
	Weston	556	548	99%
	Williamsville	120	114	95%
	Windham	295	285	97%
	Winhall	1,311	1,307	100%
St. Albans	East Fairfield	138	134	97%
	Fairfax	1,729	1,121	65%
	Georgia	1,663	1,492	90%
	Milton	4,217	4,094	97%
	Saint Albans	5,719	5,458	95%
	Sheldon	784	457	58%

Four of the eleven towns located in the Northern Chittenden region were selected; these four towns represent 94% of the GT accounts in the Northern Chittenden region. Three of the fourteen towns located in the Rutland region were selected; these three towns represent 93% of the GT accounts in the Rutland region. Twenty-nine of the fifty towns located in the Southern Loop region were selected; these twenty-nine towns represent 88% of the GT accounts in the Southern Loop region. Six of the twenty towns located in the St. Albans region were selected; these six towns represent 90% of the GT accounts in the St. Albans region (Table 1-3).

Table 1-3: Geographically Targeted Regions

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

In order to ensure that the multifamily buildings represented the entire state of Vermont, including the GT and non-GT regions, the site visits covered different regions as shown in Table 1-4.

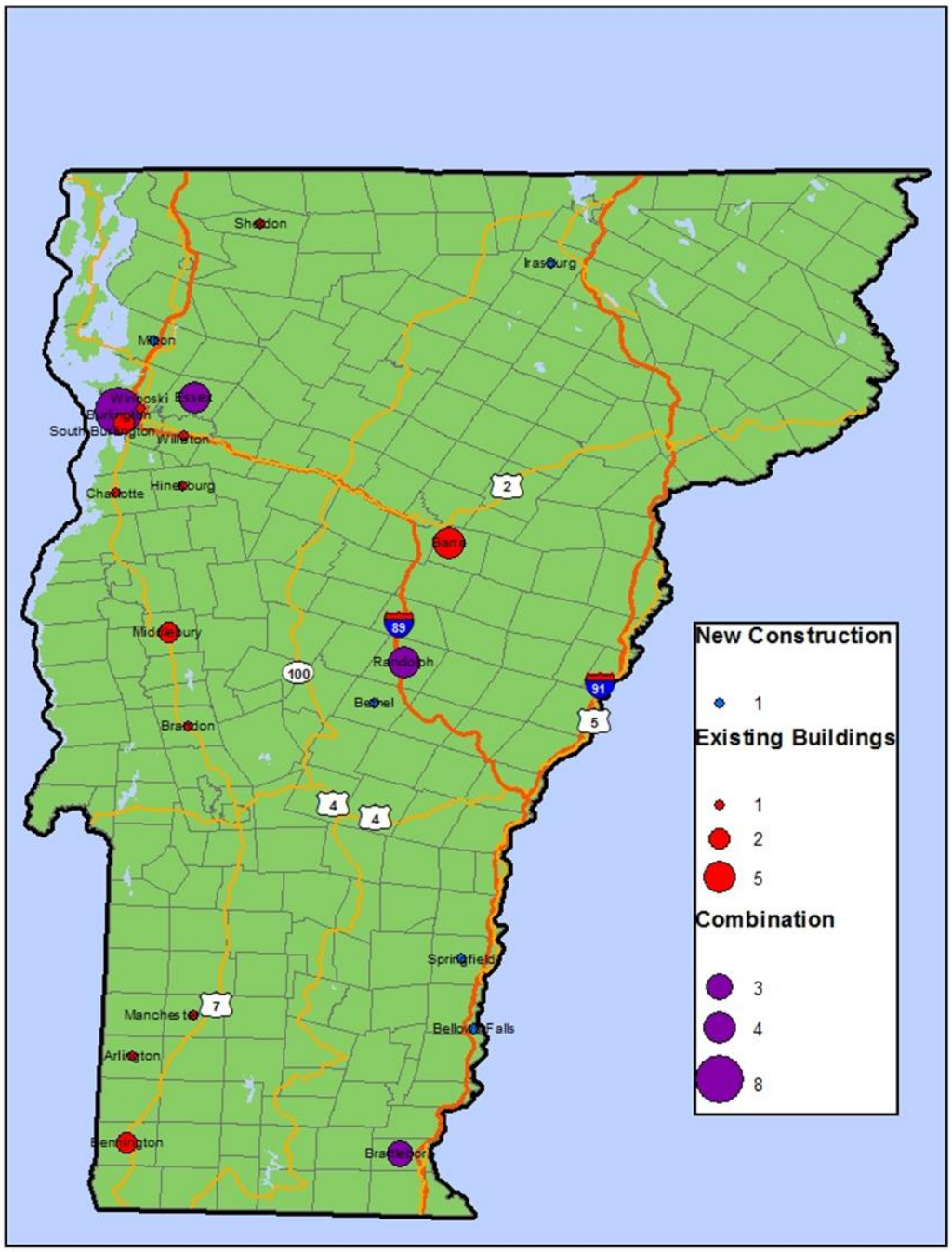
Table 1-4: Number of Multifamily Site Visits by Region

Region	Newly Constructed Buildings	Existing Buildings
North Chittenden	2	3
Rutland	2	1
Southern Loop	0	2
St. Albans	3	1
Non-GT regions	13	25
Total	20	32

Site visits were conducted at five existing multifamily buildings and three newly constructed buildings located in Burlington. In addition, site visits were conducted at twelve existing multifamily buildings and nine newly constructed buildings located in the Vermont Gas Systems service territory.

Figure 1-1 displays the location of the multifamily site visits in Vermont.

Figure 1-1: Map of Site Visits in Vermont



1.4 Sampling Error

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

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

where,

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

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

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

R = the desired relative precision,

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

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

The CV is of central importance in determining the final precisions. A primary objective of this study is to document the building and equipment status of multifamily buildings by feature. Because there is no single variable that quantifies a building's construction features and this study provides results for multiple variables, we identified several items that we believe are influential in the determination of a building's overall efficiency. Table 1-5 lists the key parameters that were measured during the onsite visits in Vermont along with the CV associated with these measurements.

Table 1-5: Coefficients of Variation for Key Measurements

Parameter	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Wall Insulation (R-Value)	0.25	0.30	0.26	0.27	0.52	0.50
Heating system (efficiency)	0.56	0.45	0.50	0.18	0.05	0.05
Flat Ceiling Insulation (R-Value)	0.23	0.13	0.20	0.29	0.47	0.49

We use the largest CV for each segment in order to provide a conservative estimate of the relative precision for the results from each segment (Table 1-6).

Table 1-6: Estimated Relative Precision by Segment

Sector	Segment	Sample Size (n)	Population (N)	Relative Precision at 90% Confidence level
New Construction	ENERGY STAR	11	37	±21%
	Non-ENERGY STAR	9	69	±22%
	Statewide	20	106	±15%
Existing	Owner-occupied	7	2,921	±18%
	Rentals	25	7,150	±17%
	Statewide	32	10,431	±14%

1.5 Bias

Potential bias is a concern in any sample based on voluntary participation. There are many factors that may influence a property manager's willingness to have their building audited. Managers who think their building is energy efficient may be more willing to participate because they are proud of their building or, conversely, less willing because they feel confident their building is energy efficient and that the audit would not be useful. In contrast, property managers who think their building 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 willing to invest the capital to upgrade the building.

Due to the various definitions of multifamily buildings (see Section 1.1) and the lack of publicly available data on the multifamily market, it is difficult to assess the extent to which the onsite samples represent their respective populations, particularly for the existing multifamily market. However, 11 of the 20 newly constructed buildings (55%) visited for the study are ENERGY STAR qualified, compared to 37 program projects out of an estimated 106 newly constructed buildings (35%) from the Census Bureau. This indicates that the new construction sample may over-represent ENERGY STAR buildings, although it is important to note that the multifamily definitions employed by this study, the Vermont programs, and the Census Bureau all differ – which complicates the comparison of data across sources.

1.6 Analysis

As discussed earlier, one building and one housing unit were audited at each multifamily complex. Although the complexes visited vary in terms of the number of buildings and housing units, we *do not* weight the housing unit data based on the number of units in each complex nor weight the building data by the number of buildings in each complex. We believe that unweighted data provide the clearest understanding of the results from the small sample of buildings visited for this study. In addition, it is reasonable to assume that some of the housing unit data, in particular lighting and electronics, may vary considerably between units, therefore having a single unit represent all units in a complex may be inappropriate.

Due to the anticipated difference in the level of energy efficiency between ENERGY STAR and non-ENERGY STAR buildings, the new construction results are presented separately for these two groups. Similarly, the existing building results are presented separately for buildings with owner-occupied units versus rental units due to the different decision-making structure in these buildings.

Note that the sample sizes may vary between tables, depending on whether the characteristic is applicable to only some or all of the buildings 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.

Due to limited sample sizes, counts are presented instead of percentages for ENERGY STAR buildings, non-ENERGY STAR buildings, and owner-occupied rental buildings.

2 Complex Characteristics

Among the twenty site visits conducted for the new construction segment, eleven visits were conducted at ENERGY STAR complexes and nine at non-ENERGY STAR complexes. All of

the housing units at these twenty complexes are rental units. All eleven of the ENERGY STAR complexes are affordable housing, as are four of the nine non-ENERGY STAR complexes.

Among the thirty-two site visits conducted for the existing segment, seven visits were conducted at owner-occupied complexes and twenty-five at rental complexes. None of these existing buildings are ENERGY STAR certified.

On average, new multifamily complexes include fewer buildings though more housing units than existing multifamily complexes (Table 2-1). The average newly constructed complex has 29.3 housing units located in 2.3 buildings, compared to 17.3 housing units and 3.5 buildings for existing complexes. The average number of housing units is higher for new construction primarily because of one large non-ENERGY STAR complex that contains 324 units. The median number of housing units is similar statewide for new construction (10) and existing (7).

Table 2-1: Size of Multifamily Complexes

(all complexes)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Complexes	*11*	*9*	*20*	*7*	*25*	*32*
Housing Units						
Total Number	117	469	586	254	301	555
Average	10.6	52.1	29.3	36.3	12.0	17.3
Median	9	16	10	33	5	7
Buildings						
One building	7	5	60%	-	52%	41%
Two buildings	2	2	20%	1	28%	25%
Three buildings	1	-	5%	1	12%	13%
Four buildings	1	1	10%	1	4%	6%
Five or more buildings	-	1	5%	4	4%	16%
Average	1.6	3.1	2.3	8.6	2.1	3.5

Existing complexes visited for this study are primarily owned by a private, single owner (75%) or a private partnership (13%) (Table 2-2). Conversely, new multifamily buildings are most often owned by a public corporation or real estate investment trusts (REIT) (35%), although private ownership is also common (25%) as is public housing (20%). New buildings are also more likely to be managed by a property management firm (45%) than are existing buildings (19%). Seventy percent of new buildings consist exclusively of affordable units, compared with 28% among existing buildings;[23] conversely, two-thirds of existing buildings are rented at market rate,[24] compared to one quarter of new buildings.

Table 2-2: Multifamily Property Characteristics

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Complexes	*11*	*9*	*20*	*7*	*25*	*32*
Property Type						
Affordable Housing	11	3	70%	-	9	28%
Market rate	-	5	25%	7	14	66%
Combination	-	1	5%	-	2	6%
Property Ownership Type						
Private single owner	1	4	25%	6	72%	75%
Public housing	3	1	20%	-	4%	3%
Private partnership	1	2	15%	1	12%	13%
REIT or public corporation	6	1	35%	-	8%	6%
Other	-	1	5%	-	4%	3%
Property Management Type						
By the owner or agency	6	4	50%	5	76%	75%
Through a property management firm	4	5	45%	-	24%	19%
Other	1	-	5%	2	-	6%

[23] The disparity between the number of units considered "affordable" and the number of buildings that are publicly owned is due to the fact that most of the buildings containing affordable units were affiliated with Section 8, rather than directly owned by a public housing authority.

[24] This information was obtained in an interview with the property manager. "Affordable" most often refers to subsidized senior housing, Section 8 housing, or housing for people with disabilities. "Market rate" units are defined as those with unsubsidized rent.

New multifamily buildings are entirely rented, as are existing buildings classified as "affordable" or "low-income." Market-rate units in existing buildings, however, are owned, rather than rented, 71% of the time (Table 2-3).

The highest percentage of age-restricted units – housing units reserved for the elderly – is among ENERGY STAR buildings, where 39% of units are age-restricted. The lowest is among non-ENERGY STAR new buildings, at 12%. Overall, 16% to 17% of units at complexes where onsites were performed are age-restricted.

Table 2-3: Owned vs. Rented Units

(all units)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Total Units in Complex	*117*	*469*	*586*	*254*	*301*	*555*
Affordable/low-income	**117**	**92**	**209**	**0**	**205**	**205**
% Units Owned	-	-	-	-	-	-
% Units Rented	100%	100%	100%	-	100%	100%
Market Rate	**0**	**377**	**377**	**254**	**96**	**350**
% Units Owned	-	-	-	96%	2%	71%
% Units Rented	-	100%	100%	4%*	98%	29%
Percent of Units that are Age-Restricted	39%	12%	17%	-	29%	16%

*A small portion of the owner-occupied units were rented out

New buildings, regardless of whether or not they are ENERGY STAR buildings, are predominantly made up of one-bedroom units (77%). Existing buildings mostly consist of two-bedroom units (66%), though about one-third of existing rental units are one-bedroom (Table 2-4).

Table 2-4: Number of Housing Units by Number of Bedrooms

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Total Units in Complex	*117*	*469*	*586*	*254*	*301*	*555*
Studio	-	<1%	<1%	-	1%	1%
1-bedroom	73%	79%	77%	-	32%	18%
2-bedroom	21%	15%	16%	89%	47%	66%
3-bedroom	6%	6%	6%	11%	14%	13%
4+bedroom	1%	<1%	<1%	-	6%	3%

Responsibility for paying heating and cooling bills in existing buildings belongs to the occupant of the unit for one-half of the projects (Table 2-5). In new buildings, the landlord or building management pays heating and cooling bills two-thirds of the time. The landlord or management pays these bills at all eleven of the ENERGY STAR buildings, probably due to the fact that all of these buildings consist of affordable units. In most new and existing buildings, occupants pay for their electricity bills.

Table 2-5: Utility Bill Responsibility

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Complexes	*11*	*9*	*20*	*7*	*25*	*32*
Heating and cooling paid by occupant	-	7	35%	7	36%	50%
Heating and cooling paid by landlord/management	11	2	65%	-	64%	50%
Electricity paid by tenant/condo owner	9	8	85%	7	72%	78%
Electricity paid by landlord/management	2	1	15%	-	24%	19%
Some pay, some do not	-	-	-	-	4%	3%

Two-thirds of all multifamily buildings do not have a staff person assigned to monitor energy usage onsite (Table 2-6). For the one-third of buildings that have such a person, monitoring of energy usage is not necessarily a hands-on task; for instance, it may simply consist of a building manager limiting thermostats to a maximum temperature in a building where utilities are included in the rent.

Table 2-6: Energy Usage Monitored Onsite

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Complexes	*11*	*9*	*20*	*7*	*25*	*32*
Yes	6	1	35%	-	40%	31%
No	5	8	65%	7	60%	69%

According to the onsite contacts, 50% of the new buildings have participated in an energy efficiency program (although 55% are ENERGY STAR), compared to 31% of existing buildings (Table 2-7)[25]. Of the 20 multifamily buildings that have participated in an energy efficiency program, all but one did so on a complex-wide basis.

Programs in which new buildings have participated – aside from the ENERGY STAR certification – include programs providing free light bulbs and faucet aerators, as well as the Vermont Gas heating rebate program. Four existing buildings took part in Vermont Gas or Efficiency Vermont heating rebate programs, two participated in weatherization programs, and three received free light bulbs and faucet aerators.

Table 2-7: Energy Efficiency Program Participation

(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Yes	7	3	50%	1	36%	31%
No	3	3	30%	6	48%	56%
Don't know	1	3	20%	-	16%	13%

For both new (55%) and existing buildings (78%), two to two-and-a-half stories is the most common building height (Table 2-8). Note that onsite visits were only conducted at buildings with three or fewer stories.

Table 2-8: Number of Stories of Buildings

(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
One to One-and-a-half	2	1	15%	1	12%	13%
Two to Two-and-a-half	7	4	55%	6	76%	78%
Three	2	4	30%	-	12%	9%

[25] The onsite contact person was asked "Has this complex or individually-owned units within the complex participated in any energy efficiency programs to construct or upgrade the buildings?"

More than one-third of existing buildings (34%) were built before 1939, and slightly less than one-third (31%) were built between 1980 and 1999 (Table 2-9). Among new buildings, eight completed construction in 2009, six in 2010, and six in 2011. As discussed earlier, this includes nine existing buildings that underwent renovations to such an extent that the buildings were classified as new construction.

Table 2-9: When Building was Constructed

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Before 1939	-	-	-	-	44%	34%
1940 to 1959	-	-	-	-	12%	9%
1960 to 1979	-	-	-	2	8%	13%
1980 to 1999	-	-	-	5	20%	31%
2000 or later	11	9	100%	-	8%	6%
Don't know	-	-	-	-	8%	6%

Given the diversity of the multifamily buildings visited, the square feet of conditioned floor area[26] varies widely among the multifamily buildings, ranging from 1,800 s.f. to 69,184 s.f. Overall, the median s.f. is 6,519 for new construction and 4,437 for existing buildings (Table 2-10).

Table 2-10: Square Feet of Conditioned Floor Area
(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Minimum	2,702	3,594	2,702	3,968	1,800	1,800
Maximum	18,500	59,613	59,613	26,824	69,184	69,184
Average	6,818	17,524	11,636	9,451	7,244	7,727
Median	4,960	9,997	6,519	7,268	4,172	4,437

[26] 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).

Figure 2-1 and Figure 2-2 show examples of the newly constructed and existing multifamily buildings visited for this study.

Figure 2-1: Examples of Three Newly Constructed Multifamily Buildings

Figure 2-2: Examples of Three Existing Multifamily Buildings

Two-thirds of new buildings and one-half of existing buildings have a full basement, with varying degrees of conditioning (Table 2-11). If a basement contains either conditioned floor area or conditioned volume, then it is considered to be a conditioned basement.[27] In a partially conditioned basement, a portion of the basement area is conditioned while a portion is not conditioned. About one-third of existing buildings have slab-on-grade.

Table 2-11: Basement Type
(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
All Full Basements						
100% Conditioned	2	-	10%	-	-	-
Unconditioned	-	5	25%	2	48%	44%
Partially Conditioned	-	-	-	-	8%	6%
Conditioned Volume	5	1	30%	-	-	-
All Partial Basements						
Unconditioned	-	2	10%	-	12%	9%
Partially Conditioned	-	1	5%	-	4%	3%
Conditioned Volume	2	-	10%	-	-	-
All No Basement						
Crawl space	-	-	-	-	4%	3%
Slab on Grade	2	-	10%	5	24%	34%

[27] 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.

2.1 Common Areas

Interior common areas often include hallways, stairways, and laundry rooms. In existing buildings, these areas are lit most often with CFL bulbs (46%), though fluorescent bulbs are also relatively common (30%). In new buildings, 61% of interior common area bulbs are fluorescents and 39% are CFLs; none are incandescents (Table 2-12).

Table 2-12: Interior Common Area Lighting

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Number of Bulbs	*219*	*608*	*827*	*0*	*235*	*235*
Incandescent	-	-	-	-	15%	15%
CFL	59%	31%	39%	-	46%	46%
LED	3%	-	1%	-	10%	10%
Fluorescent	38%	69%	61%	-	30%	30%

The types of lighting in exterior common areas – such as walkways, parking lots, porches, and building façades – are far more varied. At new buildings, incandescent and CFL bulbs are most common, appearing in 40% of the buildings each. LEDs are present at 30% of the buildings (Table 2-13). Incandescent bulbs light the exterior common areas at 47% of existing buildings, with 31% only using incandescents. Thirty-four percent of existing building use CFLs but only 9% use solely CFLs, less than the 16% that use a mixture of CFLs and incandescents.

Table 2-13: Exterior Common Area Lighting

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Incandescent only	1	1	10%	1	36%	31%
CFL only	3	-	15%	-	12%	9%
LED only	1	1	10%	-	-	-
Mercury vapor	-	-	-	-	4%	3%
Incandescent & CFL	1	1	10%	1	16%	16%
Incandescent & LED	2	-	10%	-	-	-
Incandescent & Metal halide	1	-	5%	-	-	-
CFL & LED	1	-	5%	-	4%	3%
CFL & Fluorescent	-	1	5%	-	-	-
CFL & Mercury vapor	-	-	-	-	4%	3%
CFL, Fluorescent, & High pressure sodium	-	-	-	-	4%	3%
Incandescent, CFL, & LED	-	1	5%	-	-	-
Incandescents present	*5*	*3*	*40%*	*2*	*52%*	*47%*
CFLs present	*5*	*3*	*40%*	*1*	*40%*	*34%*
LEDs present	*4*	*2*	*30%*	*-*	*4%*	*3%*
Mercury vapor bulbs present	-	-	-	-	*8%*	*6%*

Twenty-two of the 52 buildings (42%) have laundry equipment in their common areas. One-half of the 20 new buildings have common area laundry. No owner-occupied existing buildings have common laundry, though 48% of the 25 rental buildings do.

In new buildings, five of the ten washer models have the ENERGY STAR label, though just one of the 12 washers does in existing buildings (Table 2-14). Washers in existing buildings are also slightly older on average (2.6 years vs. 2.1 years). Existing buildings also have machines in poorer condition, although the majority (seven of 12) are still rated as 'good'.

Table 2-14: Common Area Clothes Washers

(buildings with common area washers)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings with Common Laundry Facility	*4*	*6*	*10*	*0*	*12*	*12*
Number with ENERGY STAR Common Area Washers	*4*	*1*	*5*	-	*1*	*1*
Average age in years	2.1			-	2.6	
Type				-		
Front load	4	3	7	-	5	5
Top load	-	3	3	-	7	7
Condition				-		
Good	4	6	10	-	7	7
Fair	-	-	-	-	4	4
Varies	-	-	-	-	1	1

Common area clothes dryers in new buildings are slightly more than two years old on average, the majority are electric (eight of 10), and all are in good condition (Table 2-15). In existing buildings, common area dryers are mostly electric as well (ten of 12) and just over one-half of these dryers are in good condition (seven of 12).

Table 2-15: Common Area Clothes Dryers

(buildings with common area dryers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings with Common Laundry Facility	*4*	*6*	*10*	*0*	*12*	*12*
Average age in years	2.1	2.2	2.2	-	3.4	3.4
Fuel						
Electric	4	4	8	-	10	10
Propane	-	1	1	-	2	2
Natural gas	-	1	1	-	-	-
Condition						
Good	4	6	10	-	7	7
Fair	-	-	-	-	4	4
Varies	-	-	-	-	1	1

2.2 Home Offices and Occupancy

None of the housing units visited in new buildings include a home office, and just two units in existing buildings do (6%). One of these two home offices took up 88 square feet, and the other 283 square feet (Table 2-16).

Table 2-16: Home Office

(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Units with Home Offices	-	-	-	1	4%	6%
Number of Home Offices	-	-	-	*1*	*1*	*2*
Less than 100 square feet	-	-	-	1	-	1
100 to 200 square feet	-	-	-	-	-	-
Over 200 square feet	-	-	-	-	1	1

Overall, nighttime occupancy in the inspected units hovers between one and two people, with units in existing buildings closer to two people (Table 2-17). Understandably, there are generally fewer people occupying units during the day than at night.

Table 2-17: Nighttime & Workday Occupants
(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Occupants, Nights:						
Average	1.2	1.0	1.1	1.3	1.6	1.6
Median	1.0	1.0	1.0	1.0	1.0	1.0
Occupants, Workdays:						
Average	0.9	0.6	0.8	1.6	0.8	0.9
Median	1.0	0.0	0.5	2.0	0.5	1.0

Auditors collected information regarding the occupancy tenure (for instance, whether the units are primary residences or inhabited mainly on weekends or seasonally); all of the units are primary residences.

3 Building Envelope

3.1 Wall Insulation

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

In newly constructed multifamily buildings, 2x6 framing is by far the most common type of construction. Framing types in non-ENERGY STAR buildings are less varied than they are in ENERGY STAR buildings, and hew more closely to the 2x6, 16” on center construction which is the minimum required by the 2005 RBES. Conversely, construction in existing buildings is split more evenly between 2x4 and 2x6 framing for both owner-occupied and rented structures (Table 3-1).

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

(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
2 x 4, 16" on center	1	-	5%	4	40%	44%
2 x 4, 24" on center	-	-	-	-	4%	3%
2 x 6, 16" on center	7	8	75%	3	48%	47%
2 x 8, 16" on center	1	-	5%	-	-	-
Cinderblock with Brick Exterior	1	-	5%	-	-	-
Solid Wood, 4"	1	-	5%	-	-	-
2 x 4 x 16 & 2 x 6 x 16		1	5%	-	4%	3%
2 x 4, DK spacing	-	-	-	-	4%	3%

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

Fiberglass batts are present in 72% of existing multifamily buildings and 59% of new buildings statewide (Table 3-2). However, just 29% of new structures have fiberglass batts only, compared to 60% for existing buildings. Twenty-four percent of new structures have conditioned/ambient walls insulated by a combination of fiberglass batts and rigid foam; this is at least partially due to a practice of installing fiberglass batts in wall cavities and a few inches of continuous rigid foam underneath the exterior siding. Spray-in high density foam is most common in newly constructed ENERGY STAR buildings, and cellulose is most common in existing rentals.

The auditors also rated the quality of the insulation installation on a scale from Grade I to Grade III, where Grade I is the highest quality.[28] If the insulation installation was visible, then auditors applied the RESNET definitions to determine the installation grade. When the insulation was not visible (e.g. an enclosed wall cavity) auditors used what was observed in other areas of the home to help estimate the installation grade for that particular component. For example, if interior wall insulation was visible in a basement and assigned a Grade II installation, then the above grade walls for that home were also assigned a Grade II installation.

Unsurprisingly, insulation installation quality in conditioned/ambient walls is significantly better in new buildings than it is in existing ones: statewide, 88% of new multifamily buildings had insulation installation grades of I or II, while only 57% of existing buildings reached that level of quality. Grade I installations are present in 47% of new buildings and 9% of existing buildings.

[28] The insulation grades are described in Appendix B

Note that auditors were unable to determine the type, grade, and R-value of wall insulation at three newly constructed buildings and seven existing buildings.

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

(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Insulation Type						
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Fiberglass Batts	2	3	29%	6	47%	60%
Spray-in high density foam	4	1	29%	-	5%	4%
Cellulose	-	-	-	-	16%	12%
Rigid Foam	1	-	6%	-	-	-
Fiberglass Batts & Rigid Foam	2	2	24%	-	11%	8%
Spray-in high density foam & Rigid Foam	1	-	6%	-	5%	4%
Fiberglass Batts & Spray-in high density foam	-	1	6%	-	-	-
Fiberglass Batts & Uninsulated	-	-	-	-	5%	4%
Uninsulated	-	-	-	-	11%	8%
Unknown**	1	2	3	1	6	7
Insulation Installation Grade						
Number of Buildings	*10*	*7*	*17*	*6*	*17*	*23*
Grade I Installation	5	2	41%	-	12%	9%
Grade I & Grade II Installation	-	1	6%	-	-	-
Grade II Installation	3	4	41%	2	53%	48%
Grade III Installation	2	-	12%	4	6%	39%
Grade III Installation & Uninsulated	-	-	-	-	6%	4%

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

While 72% of existing buildings have fiberglass batts installed, the area of the conditioned/ambient walls insulated with fiberglass represents 66% of total conditioned/ambient wall area (Table 3-3). Similarly, 59% of new buildings have fiberglass batts installed representing 51% of conditioned/ambient wall area in new buildings. Spray foam insulation, conversely, is present in 35% of new buildings but represents 46% of wall area, and cellulose is present in 12% of existing buildings but represents 19% of wall area in those buildings.

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

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Insulation Type						
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Fiberglass Batts	34%	51%	42%	100%	44%	58%
Spray-in high density foam	43%	38%	41%	-	3%	2%
Cellulose	-	-	-	-	26%	19%
Rigid Foam	8%	-	4%	-	-	-
Fiberglass Batts & Rigid Foam	6%	11%	9%	-	11%	8%
Spray-in high density foam & Rigid Foam	9%	-	5%	-	6%	5%
Uninsulated	-	-	-	-	10%	7%
Unknown	1	2	3	1	6	7

Conditioned/ambient walls in new ENERGY STAR buildings have the highest average R-value[29], at about R-24. Non-ENERGY STAR new buildings have an average R-value of about R-22 (Table 3-4). The lowest insulation R-value is in existing owner-occupied buildings, at about R-12 on average.

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

(buildings with known insulation)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
*Number of Buildings**	*10*	*7*	*17*	*6*	*19*	*25*
Minimum	14	19	14	11	0	0
Maximum	34	27	34	19	29	29
Average	24.3	21.7	23.2	12.3	16.4	15.4
Median	24.5	21	21.8	11	19	14

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

As expected, the ranges of R-values in conditioned/ambient walls reveal a similar disparity between new and existing multifamily buildings. While less than one-half (48%) of existing buildings have insulation R-values of R-19 or greater, 95% of new buildings do (Table 3-5).

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

(buildings with known insulation)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*10*	*7*	*17*	*6*	*19*	*25*
No Insulation	-	-	-	-	11%	8%
Insulation R-value >R-0 & < R-11	-	-	-	-	5%	4%
Insulation R-Value 11	-	-	-	5	11%	28%
Insulation R-Value >R-11 & <R-19	1	-	6%	-	16%	12%
Insulation R-Value 19	1	3	24%	1	32%	28%
Insulation R-Value >19	8	4	71%	-	26%	20%

Five new buildings and 18 existing buildings have either conditioned/attic or conditioned/garage walls. In the case of both new and existing buildings, these walls are insulated primarily with fiberglass batts (Table 3-6). Cellulose is also relatively common in existing buildings (21%).

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

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

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Insulation Type						
Number of Buildings	*3*	*2*	*5*	*5*	*13*	*18*
Fiberglass Batts	1	2	3	4	7	79%
Spray-in high density foam or Icynene	1	-	1	-	-	-
Cellulose	-	-	-	-	3	21%
Fiberglass Batts & Rigid Foam	1	-	1	-	-	-
Unknown**	-	-	-	1	3	4
Insulation Installation Grade Present (buildings with insulation and installation grade information)						
Number of Buildings	*3*	*2*	*5*	*4*	*11*	*15*
Grade I Installation	1	1	2	-	-	-
Grade II Installation	1	1	2	2	3	5
Grade III Installation	1	-	1	2	8	10
R-Value Statistics						
Minimum	19.0	19.0	19.0	11.0	11.0	11.0
Maximum	34.0	27.0	34.0	19.0	29.0	29.0
Average	26.0	21.7	23.8	14.2	17.3	16.3
Median	25.0	19.0	22.0	11.0	19.0	19.0

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

*** Note: only one building has both conditioned/garage and conditioned/attic walls, and in that case the type, R-value, and grade are the same.

3.2 Ceiling Insulation

Auditors were not able to access all ceiling areas during their audits, and the following tables reflect this situation. Ceilings with unknown information, e.g., rafter size or insulation type, were typically removed from sample sizes in order to calculate percentages based on confirmed data, and percentages provided throughout this section are accordingly based on a sample size of buildings with confirmed data for each characteristic. Counts of sites with unknown data are provided below most tables.

Table 3-7 shows that statewide, 100% of new multifamily buildings have some flat ceiling area, and only one new multifamily building (5% of the sample) has any cathedral[30] ceiling area. For new multifamily buildings, the most common ceiling configuration is flat joists covered in insulation (75%).

Statewide, 97% of existing multifamily buildings have some flat ceiling area. Unlike new construction that is almost exclusively flat ceiling, however, 47% of existing multifamily buildings have a combination of flat ceiling and cathedral ceiling area. The categories in the following table are exclusive categories, such that each building is only counted once.

Table 3-7: Ceiling Types

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Flat joists covered	9	6	75%	1	28%	25%
Flat joists covered & Cathedral	--	--	--	1	4%	6%
Flat joists NOT covered	1	--	5%	2	12%	16%
Flat joists NOT covered & Cathedral	--	--	--	1	28%	25%
Flat, unknown if joists covered	1	2	15%	2	4%	9%
Flat, unknown if joists covered & Cathedral	--	1	5%	--	16%	13%
All Cathedral	--	--	--	--	4%	3%
Flat joists covered, Flat joists NOT covered, & Cathedral	--	--	--	--	4%	3%

[30] Cathedral ceilings, for the purposes of this report, are also known as vaulted or sloped ceilings. These refer to vaulted ceiling areas with no attic above them. In these instances, the insulated roof rafters serve as the thermal boundary. Small areas of this sloped ceiling type are common in finished attic levels, connecting the top of short kneewalls with the flat ceiling area above.

About 40% of new buildings and only 9% of existing buildings have a complete ceiling vapor barrier installed in the attic or ceiling apparatus. Both new and existing buildings seldom have a mix of areas with vapor barriers and areas without vapor barriers in the same building. Table 3-8 includes rigid foam and closed cell spray foam among the percentages of buildings with vapor barriers due to those materials' high resistance to moisture penetration., although it does not include the use of airtight sheetrock and impermeable paint to create a vapor barrier.

Table 3-8: Vapor Barriers in Ceilings

(buildings with known vapor barrier types)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*9*	*6*	*15*	*5*	*18*	*23*
No Ceiling Areas	4	4	53%	5	72%	78%
All Ceiling Areas	5	1	40%	--	11%	9%
Some Ceiling Areas	--	1	7%	--	17%	13%
Count of sites with unknown vapor barrier**	2	3	5	2	7	9

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

3.2.1 Flat Ceilings

Table 3-9 displays the type of ceiling construction for multifamily buildings with flat ceilings, using exclusive categories such that buildings are not double-counted.[31] Of buildings with observable ceilings, 57% of new buildings have solely 2x10 construction (7% have a mix of 2x10 and 2x8), and 21% have 2x12 flat ceiling construction. The remaining 14% are split between 2x6 and 2x8.

Existing buildings typically have smaller flat ceiling framing than new buildings; 32% have 2x6 construction and 27% have 2x8 construction. Only 23% of existing buildings have solely 2x10 flat ceiling construction (Table 3-9).

Table 3-9: Type of Construction for Flat Ceilings

(buildings with flat ceilings and known construction types)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*8*	*6*	*14*	*5*	*17*	*22*
2 x 6	1	--	7%	3	24%	32%
2 x 8	1	--	7%	--	35%	27%
2 x 8 & 2 x 10	--	1	7%	--	6%	5%
2 x 10	4	4	57%	--	29%	23%
2 x 12	2	1	21%	--	--	--
Truss	--	--	--	2	6%	14%
Count of sites with unknown framing**	3	3	6	2	7	9

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

Table 3-10 shows that cellulose is the most common flat ceiling insulation material in new buildings. Eighty-seven percent of new buildings with flat ceilings have cellulose in the flat ceilings: 67% have only cellulose in flat ceiling areas, and 20% have cellulose in combination with another insulation material (either fiberglass batts or spray foam). Spray foam, either by itself or in conjunction with cellulose, is in 20% of new buildings with flat ceilings. Fiberglass batts are only in 14% of new buildings with flat ceilings.

Cellulose is also the most common flat ceiling insulation material in existing buildings, and fiberglass batts are a close second. Fifty percent of existing buildings have at least some cellulose in flat ceilings and nearly one-half of existing buildings (46%) have some amount of fiberglass batts in their flat ceilings. Auditors found rigid foam in 10% of existing buildings with flat

[31] If they have more than one construction type, 2x8 and 2x10, for example, that is shown here as a separate category from either 2x8 or 2x10.

ceilings, always in addition to another insulation type. Five percent of existing buildings with confirmed insulation data have uninsulated flat ceilings.

About one-half of all buildings with flat ceilings and confirmed insulation have a flat ceiling insulation installation of Grade II. New buildings with flat ceilings are more likely to have Grade I flat ceiling insulation installations (29%) than existing buildings with flat ceilings (15%). Forty percent of existing buildings with confirmed insulation have some Grade III flat ceiling insulation installs, compared to only 7% in new buildings.

Table 3-10: Type & Installation Grade of Insulation in Flat Ceilings by Percent of Buildings

(buildings with flat ceilings and known insulation types)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Insulation Type	*9*	*6*	*15*	*5*	*17*	*22*
Fiberglass Batts	1	--	7%	2	29%	32%
Fiberglass Batts & Cellulose	--	1	7%	--	12%	9%
Fiberglass Batts & Rigid Foam	--	--	--	--	6%	5%
Blown-in Fiberglass	--	--	--	1	6%	9%
Cellulose	7	3	67%	2	35%	36%
Cellulose & Rigid Foam	--	--	--	--	6%	5%
Cellulose & Spray Foam	1	1	13%	--	--	--
Spray foam	--	1	7%	--	--	--
None	--	--	--	--	6%	5%
Count of sites with unknown insulation type**	2	3	5	2	7	9
Insulation Installation Grade Present (buildings with insulation & installation grade information)						
Number of Buildings	*8**	*6**	*14*	*4**	*16*	*20*
Grade I	3	1	29%	1	13%	15%
Grade I & Grade II	--	1	7%	--	--	--
Grade II	5	3	57%	2	44%	45%
Grade II & Grade III	--	--	--	--	6%	5%
Grade III	--	1	7%	1	38%	35%

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

Table 3-11 shows that cellulose is the most common insulation material across all flat ceiling area in new multifamily buildings (64%), followed by spray foam alone (21%), and cellulose blown-in on top of spray foam (12%). Only 3% of flat ceiling area in new buildings is insulated by fiberglass batts alone.

Cellulose is also the most common insulation material across all flat ceiling area in existing multifamily buildings as well (42%), followed by fiberglass batts alone (28%). Blown-in fiberglass is present in 11% of flat ceiling area, and 3% of confirmed flat ceiling area in existing buildings is uninsulated. The remaining 16% of flat ceiling area in existing buildings is cellulose blown-in on top of fiberglass batts or rigid foam, or fiberglass batts laid on top rigid foam.[32]

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

(buildings with flat ceiling square footage and known insulation types)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Insulation Type	*9*	*6*	*15*	*5*	*17*	*22*
Cellulose	79%	51%	64%	34%	46%	42%
Cellulose covering Fiberglass Batts	--	1%	1%	--	5%	4%
Fiberglass Batts	5%	--	3%	19%	33%	28%
Cellulose covering Spray Foam	16%	9%	12%	--	--	--
Spray Foam	--	39%	21%	--	--	--
Cellulose covering Rigid Foam	--	--	--	--	1%	1%
Fiberglass Batts covering Rigid Foam	--	--	--	23%	6%	11%
Blown-in Fiberglass	--	--	--	23%	6%	11%
None	--	--	--	--	4%	3%
Count of sites with unknown insulation types*	2	3	5	2	7	9

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

[32] These figures are based on the confirmed ceiling insulation in the sample, and auditors were not able to confirm the insulation material in every ceiling.

Table 3-12 shows the R-value statistics for flat ceiling insulation. The average new construction flat ceiling R-value is R-50.9, compared to R-33.3 in existing buildings.[33] The highest flat ceiling R-value, R-76, was found in an ENERGY STAR building with crossed R-38 fiberglass batts. Other new buildings with R-60 or greater used fiberglass batts, spray foam, and blown-in cellulose as their attic insulation. R-37 was the lowest flat ceiling insulation R-value found in new buildings (present in an ENERGY STAR building).

Existing building flat ceiling insulation ranged from R-0 to R-67. The average flat ceiling insulation in rental buildings (R-36) was higher than that found in owner occupied buildings (R-22).

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

(buildings with flat ceilings and known R-values)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*9*	*6*	*15*	*4*	*17*	*21*
Minimum	37	43	37	15	0	0
Maximum	76	60	76	30	67	67
Average	52.8	48.0	50.9	22.0	36.0	33.3
Median	51	46	49	22	36	30
Count of sites with unknown R-values**	2	3	5	3	7	10

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

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

Table 3-13 shows that 93% of new buildings with flat ceilings and confirmed insulation values have an average of R-38 or higher insulation, and the remaining 7% are greater than R-30. In contrast, only 52% of existing buildings with flat ceilings have an average flat ceiling R-value greater than R-30. Five percent of existing building flat ceilings are uninsulated, 10% are between R-11 and R-19 (including R-19 values), and 33% are between R-19 and R-30 (including R-30 values).

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

(buildings with flat ceilings and known R-values)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*9**	*6**	*15*	*4*	*17*	*21*
No Insulation	--	--	--	--	6%	5%
R-11 or Less	--	--	--	--	--	--
>R-11 to R-19	--	--	--	1	6%	10%
>R-19 to R-30	--	--	--	3	24%	33%
>R-30 to <R-38	1	--	7%	--	24%	19%
>= R-38	8	6	93%	--	41%	33%
Count of sites with unknown R-value**	2	3	5	3	7	10

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

3.2.2 Cathedral Ceilings

Only one new building in the sample has any cathedral ceiling area[34], and auditors were not able to determine the construction or insulation of this small ceiling area. Accordingly, the new construction cells of the following cathedral ceiling tables are empty.

Cathedral ceiling construction type in existing buildings is split between four construction types: 2x6 (36%), 2x8 (36%), 2x10 (21%), and 2x12 (7%) (Table 3-14).

Table 3-14: Type of Construction for Cathedral Ceilings

(buildings with cathedral ceilings and known construction types)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	--	--	--	*2*	*12*	*14*
2 x 6	--	--	--	2	25%	36%
2 x 8	--	--	--	--	42%	36%
2 x 10	--	--	--	--	25%	21%
2 x 12	--	--	--	--	8%	7%
Count of sites with unknown framing**	--	1	1	--	2	2

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

[34] As noted previously, cathedral ceilings are also known as vaulted or sloped ceilings. These are ceiling assemblies with no attic above; the roof rafters and the ceiling are the same insulated assembly.

As shown in Table 3-15, only ten buildings in the existing sample have cathedral ceilings and insulation information. Of these ten existing buildings, four have fiberglass batts as their sole cathedral ceiling insulation material, three have cellulose, and one each has fiberglass batts and rigid foam, spray foam, and blown-in fiberglass. One-half of these ten existing buildings are estimated to have a Grade III installation in their cathedral ceilings, four were given a Grade II, and only one was confirmed to have a Grade I (a building with visible spray foam installed in the roof rafters).[35]

Table 3-15: Type & Insulation Grade of Cathedral Ceilings Insulation by Percent of Buildings

(buildings with cathedral ceilings and known insulation types)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Insulation Type	--	--	--	*2*	*8*	*10*
Fiberglass Batts	--	--	--	1	3	40%
Fiberglass Batts & Cellulose	--	--	--	--	--	--
Fiberglass Batts & Rigid Foam	--	--	--	--	1	10%
Cellulose	--	--	--	1	2	30%
Cellulose & Rigid Foam	--	--	--	--	--	--
Rigid Foam	--	--	--	--	--	--
Spray Foam	--	--	--	--	1	10%
Blown-in Fiberglass	--	--	--	--	1	10%
None	--	--	--	--	--	--
Count of sites with unknown insulation type**	--	1	1	--	6	6
Insulation Installation Grade Present (buildings with insulation and installation grade information						
Number of Buildings	--	--	--	*2*	*8*	*10*
Grade I Installation	--	--	--	--	1	10%
Grade II Installation	--	--	--	1	3	40%
Grade III Installation	--	--	--	1	4	50%

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

*** There was only one new building with cathedral ceilings, and it did not have insulation grade information.

[35] Bear in mind that auditors made educated guesses about the insulation installation grade in cathedral ceilings. Auditors did not always have direct visual access to these ceiling assemblies, and made informed assumptions about the installation grade typically based on the insulation installation quality elsewhere in the home.

Table 3-16 shows that fiberglass batts are the most common insulation material across all cathedral ceiling area in existing multifamily buildings (56%). Cellulose, spray foam, and fiberglass batts laid over rigid foam each make up between 11% and 16% of the cathedral ceiling insulation area.[36]

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

(total cathedral ceiling square footage and known insulation types)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Insulation Type	--	--	--	*2*	*8*	*10*
Fiberglass Batts	--	--	--	84%	42%	56%
Cellulose	--	--	--	16%	8%	11%
Spray Foam	--	--	--	--	24%	16%
Fiberglass Batts covering Rigid Foam	--	--	--	--	19%	13%
Blown-in Fiberglass	--	--	--	--	6%	4%
None	--	--	--	--	--	--
Counts of sites with unknown insulation types*	--	1	1	--	6	6

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

The average and median existing cathedral ceiling R-values are R-26.2 and R-30, respectively[37] (Table 3-17).

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

(buildings with cathedral ceilings and known R-values)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	--	--	--	*2*	*8*	*10*
Minimum	--	--	--	19	11	11
Maximum	--	--	--	19	42	42
Average	--	--	--	19.0	27.9	26.2
Median	--	--	--	19	30	30
Count of sites with unknown R-values*	--	1	1	--	6	6

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

[36] These figures are based on the confirmed ceiling insulation in the sample, and auditors were not able to confirm the insulation material in every ceiling.

[37] Only one new building in the sample has cathedral ceilings, and the insulation type and R-value are unknown.

Of the ten existing buildings with known cathedral ceiling R-values, six have an average of at least R-30 insulation. Three of ten have greater than R-11 but not more than R-19, and one is R-11. Auditors did not conirm any uninsulated cathedral ceilings in existing buildings (Table 3-18).

Table 3-18: Ranges of Average R-value for Insulation in Cathedral Ceilings
(buildings with cathedral ceilings and known R-values)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	--	--	--	*2*	*8*	*10*
Uninsulated	--	--	--	--	--	--
>R-0 to <=R-11	--	--	--	--	1	1
>R-11 to <=R-19	--	--	--	2	1	3
>R-19 to <R-30	--	--	--	--	--	--
>= R-30	--	--	--	--	6	6
Count of sites with unknown insulation value**	--	1	1	--	6	6

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

3.3 Floor Insulation

The lowest incidence of floors over unconditioned space[38] is in new ENERGY STAR buildings (9%), and the highest incidence is in new non-ENERGY STAR buildings (89%) (Table 3-19). However, existing buildings are more likely than new buildings to have these floors (75% versus 45%, respectively). Nevertheless, they are more likely to be insulated in new buildings (67% vs. 25%) and therefore have a higher R-value on average as well (R-20 compared to R-5.4).

[38] Unconditioned space includes unconditioned basements and crawlspaces, garages, and ambient conditions.

Table 3-19: Floor Insulation

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Percent of Buildings with Floors Over Unconditioned Space	9%	89%	45%	43%	84%	75%
Percent of Buildings with Floors Over Garages*	-	22%	10%	14%	8%	9%
Percent of Buildings with Insulated Floors over Unconditioned Space	100%	63%	67%	33%	24%	25%
Percent of Total Floor Area Over Unconditioned Space that is Insulated	100%	25%	25%	4%	18%	14%
Number of Buildings with Known Insulation R-Value	*1*	*6*	*7*	*3*	*19*	*22*
Average R-Value of Insulated Floors	R-19.0	R-20.2	R-20	R-3.7	R-5.6	R-5.4

* Garages are also included in unconditioned space.

3.4 Foundation Walls and Slabs

RBES requires foundation walls[39] that are more than 50% above grade to be insulated. A total of seven buildings in the sample have walls fitting this description. One of those is in a new building, which has the only foundation that is insulated (Table 3-20).

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

(buildings with foundation walls >50% above grade)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings with Foundation Walls >50% above grade	*0*	*1*	*1*	*0*	*6*	*6*
Number of Buildings with Insulation	-	1	1	-	0	0

[39] Foundation walls are defined as concrete or masonry walls. Stud walls located on top of masonry/concrete wall (such as for a walkout basement) would be considered above grade walls and are included in Section **Error! Reference source not found.**.

The majority of multifamily homes where onsites were performed (38 out of 52) include below grade foundation walls, either in a basement or a crawlspace. On the whole, 25% of those walls are insulated in existing buildings, and 56% are insulated in new buildings (Table 3-21).

Thirty-nine percent of new buildings (none of which are ENERGY STAR) with below grade foundation walls have walls in unconditioned basements or crawlspaces; none of those walls are insulated. All existing buildings with below grade foundation walls have walls in unconditioned space; 85% of them have no insulation on those walls, and the remaining 15% have insulation on some walls but not others.

Sixty-one percent of new buildings with below grade foundation walls have walls in conditioned space, compared to just one existing building (5%). While one ENERGY STAR building had an unknown insulation type on this kind of foundation wall, all the others were insulated. The one existing building with a foundation wall in conditioned space had insulation.

Table 3-21: Foundation Wall Insulation for Homes with Below Grade Foundation Walls

(buildings with below grade foundation walls)

	New Construction			Existing Homes		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Homes with Below Grade Foundation Walls	*9*	*9*	*18*	*2*	*18*	*20*
Homes with insulation on all below grade foundation walls	8	1	50%	-	-	-
Homes with insulation on some below grade foundation walls	-	1	6%	1	22%	25%
Homes with no insulation on below grade foundation walls	-	6	33%	1	78%	75%
Homes with unknown insulation	1	1	12%	-	-	-
Homes with Below Grade Foundation Walls in Unconditioned Basements/Crawlspaces	-	*7*	*7*	*2*	*18*	*20*
Homes with insulation on all below grade foundation walls in unconditioned basements	-	-	-	-	-	-
Homes with insulation on some below grade foundation walls in unconditioned basements	-	-	-	1	11%	15%
Homes with no insulation on below grade foundation walls in unconditioned basements	-	7	7	1	89%	85%
Homes with Below Grade Foundation Walls in Conditioned Basements	*9*	*2*	*61%*	-	*1*	*5%*
Homes with insulation on all below grade foundation walls in conditioned basements	8	2	91%	-	1	100%
Homes with no insulation on below grade foundation walls in conditioned basements	-	-	-	-	-	-
Homes with unknown insulation	1	-	9%	-	-	-

Among the 39 buildings that have a basement or crawlspace – that is, buildings that are not slab-on-grade – 20 have both a frame floor and a foundation wall that are each at least partially uninsulated (Table 3-22). Eleven existing buildings, 10 of which are rentals, had neither insulated foundation walls nor insulated frame floors.

Table 3-22: Basement Thermal Boundary Insulation

(homes with basements or crawlspaces)

	New Construction			Existing Homes		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings with a Basement or Crawlspace	*9*	*9*	*18*	*2*	*19*	*21*
Number of buildings with at least partially uninsulated foundation wall and frame floor	1	2	17%	2	79%	85%
Number of buildings with completely uninsulated foundation wall and frame floor	-	-	-	1	53%	52%

The majority of new buildings (15 out of 20) have slab floors, most of which are located in conditioned basements rather than slab-on-grade. Two-thirds of these slabs are either totally or partially below grade, primarily due to the practice of bringing basements into the conditioned volume of the building; nine of 15 buildings with slab floor thermal boundaries have basements with foundation wall insulation that are not directly heated, and an additional two have finished, directly heated basements. This is also evident in the relatively low percentage of new buildings with floors over unconditioned space. In contrast, slabs in existing buildings tend to be on-grade (86% fully or partially on-grade).

Eighty-one percent of the slab area in the nine newly constructed buildings with known insulation information has insulation of R-10 or greater (Table 3-23). However, three of these buildings have uninsulated slabs, representing 19% of the total slab area. There is only one existing building for which slab insulation information is known, and that slab is uninsulated.

Table 3-23: Slab Floor Insulation

(buildings with slab floors)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Slab On Grade/Below Grade						
Number of Buildings with Slab Floors	*11*	*4*	*15*	*5*	*9*	*14*
On Grade	3	2	33%	5	6	79%
Below Grade	6	1	47%	-	2	14%
On Grade & Below Grade	2	1	20%	-	1	7%
Slab Insulation R-value						
R-0	2	1	33%	-	1	100%
R-10	3	-	33%	-	-	-
R-12	1	-	11%			
R-15	1	1	22%	-	-	-
Unknown	4	2	6	5	8	13
R-value as a Percent of Area						
Number of Buildings with Known Insulation			*9*			*1*
R-0			19%			100%
R-10			31%			-
R-12			15%			-
R-15			35%			-

3.5 Rim and Band Joist Insulation

Conditioned/ambient rim joists and band joists[40] in existing buildings tend to be insulated with fiberglass batts (52%) or fiberglass batts plus another material (12%). In new buildings, however, joists are most commonly insulated with spray foam followed closely by fiberglass batts (46% and 31% respectively).

More than three-quarters (76%) of new buildings have Grade I or II insulation installations on their conditioned/ambient joists, but only 37% of existing buildings do (Table 3-24). Existing rentals have the highest incidence of Grade III installations (71%), and new ENERGY STAR buildings have the highest incidence of Grade I installations (four of eight). Conditioned/ambient joists in ENERGY STAR buildings also have the highest mean and median R-values (R-23.4 and R-22.6 respectively). The R-value of conditioned/ambient joist insulation in new buildings is nearly twice that of existing buildings, with an average R-value of R-22.5 compared to R-12.8.

[40] We define a band joist as being located between two conditioned levels and a rim joist as being located between a conditioned level and an unconditioned level. While rim joists are generally visible in existing homes, band joists are rarely visible. Band joist insulation data was usually based on the type, grade, and R-value of the insulation in the corresponding wall. This method is consistent with RESNET protocol, which states "If no access can be found [through a garage or utility access trap door], assume insulation exists at the [band] joist between stories if (a) insulation was found at the rim joist at the top of the crawl space or basement in the same house, or (b) insulation is found in the walls of the same house. Otherwise, assume no [band] joist insulation exists."

Table 3-24: Insulation Type, Installation Grade, & R-value Statistics for Insulation on Conditioned/Ambient Rim & Band Joists

(buildings with conditioned/ambient joists)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Insulation Type						
Number of Buildings	*10*	*8*	*18*	*7*	*23*	*30*
Fiberglass Batts	1	3	31%	5	40%	52%
Cellulose	1	-	8%	-	5%	4%
Spray-in high density foam or Icynene	5	1	46%	-	10%	8%
Fiberglass Batts & Rigid Foam	1	1	15%	-	5%	4%
Fiberglass Batts & Cellulose	-	-	-	-	5%	4%
Fiberglass Batts & Spray-in high density foam	-	-	-	-	5%	4%
None	-	-	-	-	30%	24%
Unknown	2	3	5	2	3	5
Insulation Installation Grade						
Number of Buildings	*8*	*5*	*13*	*5*	*14*	*19*
Grade I Installation	4	2	46%	1	7%	11%
Grade II Installation	2	2	30%	2	14%	21%
Grade III Installation	2	1	23%	2	71%	63%
Grade I & Grade II Installation	-	-	-	-	7%	5%
R-value Statistics						
Number of Buildings	*8*	*5*	*13*	*5*	*20*	*25*
Minimum	19	19	19	11	0	0
Maximum	28	27	28	19	27	27
Average	23.4	21	22.5	12.6	12.9	12.8
Median	22.6	19	21	11	13	11

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

No new buildings have conditioned/garage joists, and only two have conditioned/attic joists. Both of these are insulated with fiberglass batts; one has Grade III, R-19 batts, and the other has Grade I, R-27 batts (Table 3-25).

Four existing buildings have conditioned/attic joists, two of which are insulated with fiberglass batts only, one with a combination of fiberglass batts and rigid foam, and one with spray foam. The joist with spray foam has an R-value of R-25 and a Grade I installation. The two joists insulated with fiberglass are both Grade III installations and have R-values of R-11 and R-19. The conditioned/attic joist insulated with both fiberglass batts and rigid foam is Grade II, with a combined R-value of R-27.

Two existing buildings have conditioned/garage joists. Both are insulated with fiberglass batts; one has Grade III, R-11 batts, and the other has Grade II, R-19 batts.

Table 3-25: Insulation Type, Installation Grade, & R-value Statistics for Insulation on Conditioned/Attic & Conditioned/Garage Rim & Band Joists

(buildings with conditioned/attic or conditioned/garage joists)

	Conditioned/Attic in New Construction	Conditioned/Attic in Existing Buildings	Conditioned/Garage in Existing Buildings
Number of Buildings	*2*	*4*	*2*
Insulation Type			
Fiberglass Batts	2	2	2
Fiberglass Batts & Rigid Foam	-	1	-
Spray-in high density foam	-	1	-
Installation Grade			
Grade I Installation	1	1	-
Grade II Installation	-	1	1
Grade III Installation	1	2	1
R-value Statistics			
Minimum	19	11	11
Maximum	27	27	19
Average	23	20.5	15
Median	23	22	15

4 Windows and Doors

4.1 Windows

When owners or managers could not provide information on the type of glazing in their windows, auditors used a lighter test, a flashlight test, or a low-E coating detector to determine if the windows had a low-E coating.[41] Although auditors were not able to test for argon fill, in some cases they were able to estimate if a window had argon fill based on one or more of the following: the window manufacturer and series, verbal confirmation from the owner or manager, or inspection of the window frame for the presence of plugs in the window frame visible between the panes of glass, which is typical of argon filled windows.

Double pane, low-E windows with argon are present in 65% of newly-constructed buildings (Table 4-1). Double pane clear windows are found in 25% of new buildings, while double pane, low-E windows (without argon) are found in 20% of new buildings. Among existing buildings, three-quarters have some kind of double pane window; 43% have low-E coating, and 13% have argon. Triple pane windows are present in one new ENERGY STAR building.

Table 4-1: Types of Windows by Percent of Buildings

(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	11	9	20	7	25	32
Single Pane	0	0	0%	0	32%	25%
Single pane glass block	1	0	5%	0	0%	0%
Double Pane (clear)	0	5	25%	6	52%	59%
Double Pane low-E	2	2	20%	3	28%	31%
Double Pane low-E Argon	9	4	65%	1	12%	13%
Triple Pane	1	0	5%	0	0	0%

[41] 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.

Just over one-half (52%) of total window area in newly-constructed buildings is double pane, low-E glass with argon (Table 4-2). Double pane, low-E argon windows account for 79% of total glass area in ENERGY STAR buildings, compared to 38% in non-ENERGY STAR new buildings. Conversely, the same window type (double pane, low-E argon) accounts for just 4% of total window area in existing buildings. Double pane clear glass accounts for 63% of all window area in existing buildings. Storm windows are installed on 38% of the single-pane window area in existing buildings, or about 5% of total window area.

Table 4-2: Types of Windows by Percent of Total Window Area

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	11	9	20	7	25	32
Single Pane	0%	0%	0%	0%	20%	14%
Single pane glass block	0.4%	0%	0.1%	0%	0%	0%
Double Pane (clear)	0%	58%	38%	68%	61%	63%
Double Pane low-E	14%	4%	7%	31%	14%	19%
Double Pane low-E Argon	79%	38%	52%	1%	5%	4%
Triple Pane	7%	0%	2%	0%	0%	0%

Vinyl window frames is the most common type of frame found statewide (60 % new construction, 41% existing). Wood is the second most common frame type in both new construction (25%) and existing buildings (31%) (Table 4-3).

Table 4-3: Type of Window Frames by Percent of Buildings
(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	11	9	20	7	25	32
Wood	4	1	25%	5	20%	31%
Vinyl	5	7	60%	2	44%	41%
Metal	--	1	5%	--	32%	25%
Fiberglass	2	--	10%	--	4%	3%

Table 4-4 displays the glazing percentage, which is the ratio of window-to-wall area following the approach outlined in the RBES manual. Overall, the average glazing percentage is 15% for both new and existing buildings.

Table 4-4: Glazing Percentage of Exterior Wall Area
(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Minimum	10%	9%	9%	14%	5%	5%
Maximum	22%	27%	27%	27%	31%	31%
Average	15%	16%	15%	18%	14%	15%
Median	14%	17%	14%	17%	13%	14%

4.2 Skylights

Ten percent of newly constructed buildings and nine percent of existing buildings have skylights (Table 4-5). All skylight glass is double pane, with less than two s.f. per building on average.

Table 4-5: Percent of Buildings with Skylights
(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	11	9	20	7	25	32
Buildings with skylights	--	2	10%	--	3	9%
Average s.f. of skylights	--	3.2	1.4	--	1.9	1.8
Skylight Window Types: Percent of Buildings						
Single Pane	--	--	--	--	--	--
Double Pane	--	2	2	--	3	3
Triple Pane	--	--	--	--	--	--

4.3 Exterior Doors

Exterior doors made of steel are most common in new construction (45% of doors) and also very common in existing buildings (41%) (Table 4-6). Fiberglass doors are the second most common type in newly constructed buildings (40%) while wood doors are the most common type in existing buildings (42%).

Forty-seven percent of doors in newly constructed buildings are solid core. Solid core doors (38%) are most common in existing buildings followed by hollow core (33%) and panel (29%). Eighty percent of doors in newly constructed buildings are insulated, compared to 44% of existing buildings.

Existing buildings have a greater saturation of storm doors (37%) than do newly constructed buildings (10%), likely due to the higher efficiency of new doors. Window glass is found in 70% of doors in existing building doors and almost 60% of doors in newly constructed buildings.

Table 4-6: Door Type & Features
(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	11	9	20	7	25	32
Door Material						
Number of Doors	*50*	*39*	*89*	*15*	*107*	*122*
Wood	18%	10%	15%	40%	42%	42%
Steel	24%	72%	45%	27%	43%	41%
Fiberglass	58%	18%	40%	33%	15%	17%
Door Type						
Number of Doors	*50*	*39*	*80*	*15*	*107*	*121*
Panel Doors	16%	38%	26%	43%	27%	29%
Solid Core Doors	70%	18%	47%	29%	39%	38%
Hollow Core Doors	14%	44%	27%	29%	34%	33%
Door Features						
Number of Doors	*50*	*39*	*89*	*15*	*107*	*122*
Insulated	74%	92%	82%	20%	47%	44%
Storm	10%	8%	10%	60%	34%	37%
With Glass	50%	69%	58%	27%	77%	70%

5 Heating and Cooling

Thirty-five percent of newly constructed buildings use oil as their primary heating fuel, 35% use natural gas, 15% use propane, 10% use wood pellets, and in one building, auditors were unable to determine the heating fuel due to lack of access to mechanical areas. Most of the ENERGY STAR buildings sampled use heating oil (six of 11), whereas most of the non-ENERGY STAR new buildings use natural gas (six of nine).

In existing buildings, 41% use oil, 34% use natural gas, 13% use propane, 9% use electricity, and 3% use wood pellets as their primary heating fuel (Table 5-1).

Table 5-1: Primary Heating Fuel

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Fuel oil , heating oil, or #2 oil	6	1	35%	--	52%	41%
Natural gas from underground pipes	1	6	35%	5	24%	34%
Bottled gas, propane, or LP	2	1	15%	1	12%	13%
Electricity	--	--	--	1	8%	9%
Wood pellets	2	--	10%	--	4%	3%
Unknown	--	1	5%	--	--	--

Table 5-2 displays both the types of heating systems installed in multifamily buildings, and whether these buildings have single or multiple heating systems.[42] Seventy-five percent of new buildings have hydronic boilers, 15% have combination hydronic heating/DHW appliances[43], 10% have furnaces, and one building (5%) has a hydro-air boiler.

Existing buildings have a greater variety of heating system types: 69% have hydronic boilers, 19% have traditional furnaces, 9% have electric baseboard heat, 6% have modern direct-vent wall-mounted ductless furnaces, and one building (3%) has older electric ductless furnaces. Also, combination heating/DHW appliances are present in two existing buildings (6%) either as a hydronic heating system or as part of a hydro-air system (Table 5-2).

[42] Auditors recorded the types of heating systems present to the best of their abilities, given that they sometimes had limited access to mechanical areas. Accordingly, it is possible that some of the buildings listed with single systems could have had an additional system whose presence the auditor could not confirm. In five buildings, for example, auditors noted that they only found one heating system, but that there potentially could have been more heating systems.

[43] Auditors reviewed the model-specific technical literature for these systems to confirm that they were true instantaneous, combination heating/DHW boiler systems. These appliances function fully as on-demand hydronic systems providing water for both heating and DHW purposes; analysts confirmed that they are not tankless coil or integrated tank systems.

Forty percent of newly constructed buildings have only one main heating system for the building (mostly hydronic boilers – 35%), and 60% have multiple heating systems in the building, consisting of mostly hydronic boilers (35%) and combination heating/DHW appliances (15%) (Table 5-2).

Forty-seven percent of existing buildings visited have only one main heating system (again, mostly hydronic boilers – 38%), and the remainder consists of buildings with multiple central boilers (19%), and a mix of system types including boilers, furnaces, combination heating/DHW appliances, ductless fossil fuel and electric furnaces, and electric resistance heating (Table 5-2).

Table 5-2: Type of Heating Systems

(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Single Heating System Buildings						
Single Hydronic Boiler	5	2	35%	--	48%	38%
Single Hydro-air Boiler	1	--	5%	--	--	--
Single Furnace	--	--	--	--	8%	6%
Single Electric Resistance	--	--	--	1	--	3%
Multiple Heating System Buildings						
Multiple Hydronic Boilers	4	3	35%	4	8%	19%
Multiple Furnaces	--	1	5%	--	8%	6%
Multiple Comb. Heat/DHW (hydronic)	--	3	15%	--	4%	3%
Multiple Electric Resistance	--	--	--	1	4%	6%
Single Comb. Heat/DHW (hydro-air) & Multiple Hydronic Boilers	--	--	--	--	4%	3%
Multiple Hydronic Boilers & Multiple Furnaces	1	--	5%	--	--	--
Single Furnace & Multiple Hydronic Boilers	--	--	--	--	4%	3%
Single Hydronic Boiler & Multiple Furnaces	--	--	--	--	4%	3%
Single Hydronic Boiler & Multiple Ductless Furnaces (fossil-fuel)	--	--	--	--	4%	3%
Multiple Ductless Furnaces (fossil-fuel)	--	--	--	1	--	3%
Multiple Ductless Furnaces (electric)	--	--	--	--	4%	3%

In new buildings, 69% of boilers are installed in conditioned space and 31% are installed in unconditioned space.[44] In existing buildings, 55% of boilers are in conditioned space and 45% are in unconditioned space. All of the furnaces in new buildings are installed in conditioned space, and nearly three-quarters (72%) of furnaces in existing buildings are installed in conditioned space as well. In new buildings, 43% of the combination heating/DHW appliances are in conditioned space and all six combination heating/DHW systems in existing buildings are in conditioned space as well (Table 5-3).

Table 5-3: Location of Heating System
(buildings with boilers or furnaces)

	New Construction			Existing		
	Boiler*	**Furnace****	**Combination Heating/DHW Appliance***	**Boiler***	**Furnace****	**Combination Heating/DHW Appliance***
Number of Heating Systems	*26*	*17*	*14*	*47*	*32*	*6*
Conditioned Space	69%	100%	43%	55%	72%	6
Unconditioned Space	31%	--	57%	45%	28%	--

*Includes hydro-air heating systems.

**Includes fossil fuel and electric ductless and direct vent wall-mount furnaces.

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

Table 5-4 shows that among the newly constructed buildings, the average and median ages for heating systems are typically one to two years, as might be expected. In existing buildings, the average and median ages (among units with age data) are 16.8 and 15 years for boilers and 17 and 10 for furnaces. Two of the boilers in the new construction sample were found in a repurposed, gut rehabbed commercial building that had been converted into residences, therefore the boilers were 23 years old. Other than these two units, no boilers or furnaces in the new construction sample were more than four years old.

Table 5-4: Age of Heating System
(buildings with boilers or furnaces with age data)

	New Construction			Existing		
	Boiler*	**Furnace**	**Combination Heating/DHW Appliance***	**Boiler***	**Furnace**	**Combination Heating/DHW Appliance***
Number of Heating Systems	*26*	*17*	*14*	*34*	*32*	*1*
Minimum	1	1	1	1	3	1
Maximum	23	2	2	45	45	1
Average	3.5 (1.9)†	1.9	1.2	16.8	17.0	1.0
Median	2	2	1	15	10	1
Count of systems with unknown age data***	--	--	--	7	--	5

*Includes hydro-air heating systems.
**Includes fossil fuel and electric ductless and direct vent wall-mount furnaces.
*** The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.
† Two boilers in a gut rehabilitation project were 23 years old. This cell shows the averages including (3.5) and excluding (1.9) those two boilers.

Table 5-5 displays the efficiency of boilers and Table 5-6 displays the efficiency of furnaces. Note that auditors recorded AHRI-based AFUE figures whenever possible, and in other cases substituted manufacturer rated efficiencies or capacity calculations (output divided by input). Manufacturer-provided thermal efficiencies are used in place of AFUE for the four large commercial boilers with no AFUE data.

The average efficiency rating for boilers is 87.7% in new construction and 82.9% in existing buildings. For combination heating/DHW appliances, the average efficiency rating is 93.4% in new buildings and 86.7% in existing buildings (Table 5-5).

Table 5-5: Boiler Efficiency (AFUE or Thermal Efficiency)
(buildings with boilers with efficiency data)

	New Construction				Existing			
	Oil Boiler	**Nat. Gas & Propane Boiler**	**All Boilers***	**Comb. Heating/ DHW Appliance**	**Oil Boiler**	**Nat. Gas & Propane Boiler**	**All Boilers**	**Comb. Heating/ DHW Appliance**
Number of Heating Systems	*10*	*10*	*21**	*14*	*11*	*21*	*32*	*6*
Minimum	86.0%	83.0%	80.0%	92.5%	81.0%	76.0%	76.0%	85.5%
Maximum	86.9%	96.0%	96.0%	95.1%	87.1%	89.0%	87.2%	92.5%
Average	86.6%	89.5%	87.7%	93.4%	84.6%	82.9%	82.9%	86.7%
Median	86.7%	92.8%	86.7%	92.5%	85.0%	83.2%	83.2%	85.5%
Count of systems with unknown efficiency†	2	1	5**	--	3	5	9*	--

*Includes one pellet boiler not included in oil or gas sections of the table.
**Includes two boilers with unknown fuel type, not included in oil or gas sections of the table.
† The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

In new buildings, all 15 furnaces with efficiency data are in the same building, and of the same type, with an AFUE of 95.5%. The average efficiency rating of furnaces in existing buildings is 84.4%. There was one building with older ductless electric furnace systems in each unit, but those had no rated efficiency information, and are not included in the furnace efficiency figures below (Table 5-6).

Table 5-6: Furnace Efficiency (AFUE or Thermal Efficiency)
(buildings with furnaces with efficiency data)

	New Construction			Existing		
	Oil Furnaces	**Nat. Gas & Propane Furnaces**	**All Furnaces**	**Oil Furnaces**	**Nat. Gas & Propane Furnaces**	**All Furnaces**
Number of Heating Systems	--	*15*	*15*	*3*	*19*	*22*
Minimum	--	95.5%	95.5%	83.4%	80.6%	80.6%
Maximum	--	95.5%	95.5%	85.0%	95.5%	95.5%
Average	--	95.5%	95.5%	83.9%	84.5%	84.4%
Median	--	95.5%	95.5%	83.4%	80.6%	83.4%
Count of systems with unknown efficiency*	2	--	2	--	3	10**

* The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.
**Includes seven ductless, electric furnaces with no efficiency information, not included in oil or gas sections of the table.

Seventy-one percent of new buildings have insulation on their hydronic heat lines, compared to only 35% of existing buildings. Among the new buildings with hydronic piping insulation, the average R-value of the insulation is R-5.4, and in existing buildings it is R-4.1. In both cases, however, buildings frequently had hydronic lines that were not insulated along their entire length.

Table 5-7: Hydronic Heat Piping Insulation & R-Values
(all buildings with hydronic heat)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings with Hydronic Heat	11	6	17	4	19	23
Percent with Insulation	82%	50%	71%	--	42%	35%
*Count of sites with unknown hydronic heat pipe insulation**	--	2	2	--	--	--
R-value Statistics						
Number of Buildings with insulation	9	3	12	--	8	8
Minimum	2	5	2	--	1	1
Maximum	10	6	10	--	6	6
Average	5.3	5.7	5.4	--	4.1	4.1
Median	6.0	6.0	6.0	--	4.5	4.5

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

5.1 Temperatures and Controls

The majority of housing units in both new and existing buildings use manual, rather than programmable thermostats. When electronic thermostats are present, however, they are much more likely to be programmable than not (Table 5-8).

Table 5-8: Type of Thermostat
(all housing units)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Manual	5	6	55%	4	60%	59%
Programmable	4	2	30%	3	36%	38%
Electronic Non-programmable	2	1	15%	-	4%	3%

While about one-quarter of occupants use nighttime temperature setbacks (via either programmable or manual thermostats) and about one-fifth use daytime setbacks, the majority of people do not use temperature setbacks at all, regardless of whether they live in a new or existing building (Table 5-9). In 8% of all buildings (four out of 52), occupants report using temperature setbacks despite not having programmable thermostats; three out of 32 existing buildings report manual setbacks.

Table 5-9: Temperature Setback Use
(all housing units)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Nighttime	4	1	25%	2	24%	25%
Daytime	3	1	20%	2	16%	19%
No setback	4	7	55%	3	60%	56%

During the winter months, occupants of the inspected housing units prefer to keep their housing units at around 68 degrees (Table 5-10).

Table 5-10: Preferred Winter Indoor Temperature
(housing units where a preference was given*)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Housing Units	*10*	*5*	*15*	*7*	*16*	*23*
Average	68	69	68	67	68	68
Median	68	68	68	68	68	68

* While auditors also recorded the actual indoor temperature, this table displays preferred winter temperatures that occupants reported when asked. There is little, if any, difference between the two sets of temperatures.

Nearly all of the inspected units in new buildings (90%) had only one thermostat (Table 5-11). Two-thirds of existing units have one thermostat and 8% have four or more, which is due to a type of thermostat that is affixed to baseboard heating in each room of an apartment.

Table 5-11: Number of Thermostats
(all housing units)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Number of Thermostats						
One	11	7	90%	2	76%	66%
Two	-	2	10%	4	4%	16%
Three	-	-	-	-	12%	9%
Four or more	-	-	-	1	8%	9%

5.2 Supplemental Heating Systems

Fireplaces were not found in any of the housing units at new buildings, though fireplaces were found in the inspected units in four existing buildings (Table 5-12). Three of those are wood fireplaces, and one uses natural gas.

Table 5-12: Fireplaces & Fuel Used
(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Fireplaces						
None	11	9	100%	5	92%	87%
One Fireplace	-	-	0%	2	8%	13%
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Fireplace Fuel						
Natural gas	-	-	-	1	-	1
Wood	-	-	-	1	2	3
Number of Fireplaces	*0*	*0*	*0*	*2*	*2*	*4*

Stoves are not present in any of housing units located in the new buildings either (Table 5-13). Two existing units have stoves: one is a propane stove, and one is a wood stove.

Table 5-13: Stoves & Fuel Used
(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Stoves						
None	11	9	100%	6	96%	94%
One Stove	-	-	-	1	4%	6%
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Stove Fuel						
Propane	-	-	-	1	-	1
Firewood	-	-	-	-	1	1
Number of Stoves	*0*	*0*	*0*	*1*	*1*	*2*

One ENERGY STAR housing unit and one existing rental unit each have portable electric space heaters (Table 5-14).

Table 5-14: Portable Space Heaters & Fuel Used
(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Space Heaters						
None	10	9	95%	7	96%	97%
One Space Heater	1	-	5%	-	4%	3%
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Space Heater Fuel						
Electric	1	-	1	-	1	1
Number of Space Heaters	*1*	-	*1*	-	*1*	*1*

5.3 Window Air Conditioners

Because most of the multifamily audits took place in the late fall and winter, auditors did not find any installed window air conditioning units. The onsite contact people were not always willing or able to tell the auditors if window AC systems were used by the occupants. These onsite contacts specifically told auditors that AC units were allowed to be installed by occupants in five of the 20 new multifamily buildings; however, at two of those sites, the onsite contact mentioned that they did not know of any AC window units in use, even though tenants were allowed to have them.

Out of 32 existing buildings, only one onsite contact person noted that every tenant is provided with a window AC unit (at a 65-unit retirement complex); contacts in three other existing buildings reported that window AC units are allowed, though two noted that most tenants do not use them.

5.4 Central Air Conditioning

Only three new buildings have central air conditioning: one ENERGY STAR building and two non-ENERGY STAR buildings (Table 5-15). The ENERGY STAR building with central AC has two 15 SEER AC split systems. One non-ENERGY STAR building has a small, two-year-old ductless mini-split system just for the building management office. The large commercial AC system identified below serves the entire facility – a repurposed office building that had been converted into residences; the equipment lacked accessible model information, and auditors were only able to identify its age, 23 years.

Table 5-15: Characteristics of Air Conditioning Units in New Construction
(all new buildings)

	ENERGY STAR	**Non-ENERGY STAR**	
Number of Buildings	*11*	*9*	
	Residential Central AC	**Ductless Mini-Splits**	**Commercial AC**
Number of Buildings with Air Conditioning	*1*	*1*	*1*
Average age of units (years)	1	2	23
Average size of units(tons)	2.5	1.3	DK
Total building cooling capacity (tons)	5	1.3	DK
Average efficiency	15 SEER	20 SEER	DK

Auditors found only two existing buildings with central air conditioners, both of which are rental properties (Table 5-16). One existing building has three, 20-year-old ductless mini-split systems. The only other existing building with central air conditioning uses three central split systems to cool the common areas; each system has an average capacity of 3.8 tons and is 14 years old. In this building, each occupant is also provided with a room air conditioner, but auditors were not given access to information about those systems.

Table 5-16: Characteristics of Air Conditioning Units in Existing Buildings
(all existing buildings)

	Statewide	
Number of Buildings	*32*	
	Residential Central AC	**Ductless Mini-Splits**
Buildings with Air Conditioning	1	1
Average age of units (years)	14	20
Average size per system (tons)	3.8	0.9
Total building cooling capacity (tons)	11.5	2.8
Average efficiency	DK	22 SEER/14.2 EER**

** Estimated efficiency based on similar model.

5.5 Renewables

Renewable generation systems such as photovoltaics (PV) and wind turbines were rarely found at multifamily buildings. Only two of the newly constructed buildings − one ENERGY STAR and one non-ENERGY STAR − have PV systems installed while none of the buildings visited have wind turbines. One PV system is 217 square feet in size while the other is 220 square feet in size. As described later in the water heating section, 55% of new buildings heat water using solar energy in conjunction with another fuel source. None of the existing buildings visited have a solar-assisted domestic hot water system.

5.6 Ducts

Overall, 12 multifamily buildings have ductwork: five new buildings and seven existing buildings. All five new buildings with ductwork have their ducts installed exclusively in conditioned space. None of the existing owner-occupied buildings have ductwork, and among the existing rental buildings, five out of seven have their ductwork in unconditioned space. One of those five buildings has ductwork in both the attic and in an unconditioned basement.

Table 5-17: Characteristics of Ducts
(all buildings with ducts, multiple response)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*3*	*2*	*5*	*0*	*7*	*7*
Attic	-	-	-	-	2	2
Conditioned Space	3	2	5	-	2	2
Unconditioned Basement	-	-	-	-	4	4

The five buildings with ducts in unconditioned space all have some metal ductwork, and two of them have some flex ductwork as well. The average R-value for the two buildings with duct insulation is R-5.

Table 5-18: Characteristics of Ducts & Duct Insulation
(buildings with ducts located in unconditioned space)

	Existing Rentals
Duct Type	
Number of Buildings with Ducts in Unconditioned Space	*5*
Metal Ducts Only	3
Metal & Flex Ducts	2
Insulation R-value	
Number of Buildings with Insulated Ducts in Unconditioned Space	2
Minimum	R-4
Maximum	R-6
Average	R-5
Median	R-5

6 Water Heating

As was the case with heating systems, auditors were not always provided access to every mechanical area in a building. As a result, there could have been additional water heaters in the sampled buildings that auditors were not able to find. There were five buildings in particular where auditors suspected that there may have been additional water heaters whose presence they could not confirm.

Table 6-1 shows that solar-assisted hot water systems are present in over one-half (55%) of the 20 new buildings (nine out of 11 ENERGY STAR buildings and two out of 9 non-ENERGY STAR buildings). The solar systems are only installed in buildings with affordable units. In contrast, none of the existing buildings have solar-assisted water heaters; stand-alone storage tanks are present in 53% of existing buildings and integrated systems with storage tanks are present in 34%. On demand water heaters are less common; they are present in 10% of new buildings and 6% of existing buildings.

Table 6-1: Type of Water Heating Systems
(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Storage, stand-alone (single)	--	--	--	1	20%	16%
Storage, stand-alone (multiple)	--	1**	5%	5	24%	34%
Storage, stand-alone (single) & Integrated, tankless (multiple)	--	--	--	--	4%	3%
Instantaneous (single)	--	--	--	--	4%	3%
Instantaneous (multiple) [45]	--	2	10%	--	4%	3%
Integrated, w/tank (single)	2	--	10%	--	36%	28%
Integrated, w/tank (multiple)	--	2	10%	--	8%	6%
Integrated, tankless (multiple)	--	--	--	1	--	3%
Solar-assisted (single)	2	--	10%	--	--	--
Solar-assisted (multiple)	2	--	10%	--	--	--
Integrated, tankless (single) & Solar-assisted (single)	1	--	5%			
Integrated, w/tank (single) & Solar-assisted (single)	2	1	15%	--	--	--
Integrated, w/tank (single) & Solar-assisted (multiple)	2	--	10%	--	--	--
Storage, stand-alone (single) & Solar-assisted (single)	--	1	5%	--	--	--
Unknown type	--	2	10%	--	--	--

**Includes one building with multiple storage tanks and an additional system of unknown type.

[45] Combination heating/DHW boiler systems are counted as instantaneous water heaters, when auditors determined, based on a review of model-specific technical literature, that the systems function as true on-demand systems, and are not in fact tankless coil or integrated tank systems.

Fifty-five percent of new buildings heat water using solar energy in conjunction with another fuel source - most commonly oil (35%). Another 25% of buildings use only natural gas (Table 6-2). In existing buildings, natural gas (34%), oil (28%), and electricity (22%) are the most common water heating fuels.

Table 6-2: Water Heating System Fuel
(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Nat. Gas	--	5	25%	5	24%	34%
Propane	2	--	10%	--	16%	13%
Electric	--	1	5%	2	20%**	22%
Oil	--	--	--	--	36%	28%
Oil & Electric	--	--	--	--	4%	3%
Solar & Oil	6	1	35%	--	--	--
Solar, Oil & Pellet	2	--	10%	--	--	--
Solar & Nat. Gas	1	--	5%	--	--	--
Solar & Propane	--	1	5%	--	--	--
Unknown fuel	--	1	5%	--	--	--

**Includes one building that has electricity as its DHW fuel and another unknown fuel (due to inaccessible DHW system).

The average age of water heating systems in new buildings is 1.8 years, and the median age is two years. In existing buildings, the average water heating system age is 8.1 years, with a median age of 7 years[46] (Table 6-3).

Table 6-3: Age of Water Heating System
(buildings with water heater age data available)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Water Heaters	*24*	*38*	*62*	*30*	*46*	*76*
Minimum	1	1	1	2	1	1
Maximum	3	3	3	20	26	26
Average	1.8	1.8	1.8	7.6	8.3	8.1
Median	2	2	2	6	8	7
Count of systems with unknown age*	--	1	1	8	15	23

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

[46] Age data on water heaters in existing buildings was often more difficult to ascertain than in new buildings. Damaged labels, inaccessible systems, etc. contributed to this issue.

Among water heaters that auditors could access in new buildings, 71% are located in conditioned space and 29% are located in unconditioned space.[47] In existing buildings, 60% are in conditioned space and 40% are in unconditioned space (Table 6-4).

Table 6-4: Location of Water Heating System
(buildings with water heaters)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Water Heaters	*24*	*38*	*62*	*38*	*60*	*98*
Conditioned Space	100%	53%	71%	68%	55%	60%
Unconditioned Space	--	47%	29%	32%	45%	40%
Count of systems with unknown location*	--	1	1	--	1	1

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

The energy factor of integrated tank water heaters is based on the efficiency of the boiler heating the water: multiply the boiler efficiency by 0.92. Table 6-5 shows that the average energy factor of integrated tank water heaters is 0.82 in new buildings, and slightly lower, 0.76, in existing buildings.

Table 6-5: Efficiency of Integrated w/Tank Water Heaters by Building Type
(all buildings with fossil fuel, integrated w/tank water heaters)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Water Heaters	*6*	*7*	*13*	--	*19*	*19*
Minimum	0.79	0.76	0.76	--	0.70	0.70
Maximum	0.88	0.87	0.88	--	0.80	0.80
Average	0.83	0.81	0.82	--	0.76	0.76
Median	0.83	0.76	0.80	--	0.76	0.76
Count of systems with unknown efficiency*	--	--	--	--	1	1

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

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

Table 6-6 shows the same efficiency data for integrated tank water heaters, but split by the type of fuel used by the connected boiler.

Table 6-6: Efficiency of Integrated w/Tank Water Heaters by Boiler Fuel
(buildings with integrated w/tank water heaters)

	New Construction			Existing**		
	Nat. Gas	**Oil**	**Propane**	**Nat. Gas**	**Oil**	**Propane**
Number of Water Heaters	*7*	*3*	*3*	*3*	*7*	*9*
Minimum	0.76	0.79	0.85	0.75	0.75	0.70
Maximum	0.87	0.80	0.88	0.75	0.80	0.76
Average	0.81	0.80	0.87	0.75	0.78	0.75
Median	0.76	0.80	0.87	0.75	0.78	0.76
Count of systems with unknown efficiency*	--	--	--	--	1	--

* The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.
**Integrated tank systems in existing buildings are only present in rental buildings, not owner-occupied buildings.

The average energy factor of integrated tankless water heaters is 0.48 for six existing buildings, and 0.65 in the one new building where this type of system was found. The energy factors for these tankless coil systems were not calculated based on the specific equipment; they were assigned following the assumptions in Table B-3 of the 2005 RBES manual, except based on the number of occupants rather than bedrooms (Table 6-7). Due to the relatively large number of occupants being served by these systems, the calculated EF may be higher than is typical in a single-family home.

Table 6-7: Efficiency of Integrated Tankless Water Heaters by Building Type
(all buildings with fossil fuel, integrated tankless water heaters)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Water Heaters	*1*	--	*1*	*4*	*2*	*6*
Minimum	0.65	--	0.65	0.40	0.65	0.40
Maximum	0.65	--	0.65	0.40	0.65	0.65
Average	0.65	--	0.65	0.40	0.65	0.48
Median	0.65	--	0.65	0.40	0.65	0.40
Count of systems with unknown efficiency*	--	--	--	--	--	--

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

Table 6-8 shows the same efficiency data for integrated tankless water heaters, but split by the type of fuel used by the boiler in which the tankless coil was located. As mentioned previously (Table 6-7), the efficiency for these integrated "tankless coil" systems is based on occupancy, and is not system-specific. The natural gas systems presented below have efficiencies lower than

their oil-fired counterparts due to the higher occupancy and higher demand on the systems in those particular oil-heated buildings.

Table 6-8: Efficiency of Integrated Tankless Water Heaters by Boiler Fuel
(buildings with integrated tankless water heaters)

	New Construction	Existing	
	Oil	Nat. Gas	Oil
Number of Water Heaters	*1*	*4*	*2*
Minimum	0.65	0.40	0.65
Maximum	0.65	0.40	0.65
Average	0.65	0.40	0.65
Median	0.65	0.40	0.65
Count of systems with unknown efficiency*	--	--	--

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

Fossil fuel stand-alone water heating tank systems have an average energy factor of 0.60 in existing buildings, and 0.78 in one new building that has a storage tank water heater. Auditors could not identify the efficiency for a fair number of these systems in existing buildings, given their age, condition, and lack of access in some buildings (Table 6-9). The solar-assisted systems are not included in any of the efficiency reporting because auditors were unable to collect information on the efficiency of such systems.

Table 6-9: Efficiency of Non-Electric, Stand-alone Storage Tank Water Heaters by Building Type
(all buildings with non-electric, stand-alone storage tank water heaters)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Water Heaters	--	*1*	*1*	*15*	*12*	*27*
Minimum	--	0.78	0.78	0.59	0.56	0.56
Maximum	--	0.78	0.78	0.62	0.66	0.66
Average	--	0.78	0.78	0.60	0.60	0.60
Median	--	0.78	0.78	0.59	0.59	0.59
Count of systems with unknown efficiency*	--	--	--	10**	1	11

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

** Includes one system whose manufacturer does not provide an EF or thermal efficiency.

Table 6-6 shows the same efficiency data from Table 6-9 for non-electric, stand-alone storage tank water heaters, but split by the type of fuel used. Given that most of the stand-alone tanks are natural gas-fired, the natural gas EF in existing buildings matches the statewide EF above.

Table 6-10: Efficiency of Non-Electric, Stand-alone Storage Tank Water Heaters by Fuel

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

	New Construction	Existing		
	Oil	**Nat. Gas**	**Propane**	**Oil**
Number of Water Heaters	*1*	*23*	*4*	--
Minimum	0.78	0.56	0.59	--
Maximum	0.78	0.66	0.59	--
Average	0.78	0.60	0.59	--
Median	0.78	0.59	0.59	--
Count of systems with unknown efficiency*	--	10**	--	1

* The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.
** Includes one system whose manufacturer does not provide an EF or thermal efficiency.

The average efficiency for eleven instantaneous water heaters installed in two new buildings is 0.93, and 0.85 in existing buildings.[48] All eleven of the instantaneous systems in new buildings are fired by natural gas. Of the six instantaneous systems in existing buildings, five use natural gas and one uses propane (Table 6-11).

Table 6-11: Efficiency of Instantaneous (Combination) Water Heaters*

(all buildings with fossil fuel, instantaneous water heaters)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Water Heaters	--	*11*	*11*	--	*6*	*6*
Minimum	--	0.93	0.93	--	0.82	0.82
Maximum	--	0.95	0.95	--	0.86	0.86
Average	--	0.93	0.93	--	0.85	0.85
Median	--	0.93	0.93	--	0.86	0.86
Count of systems with unknown efficiency**	--	--	--	--	--	--

* All but one of the instantaneous systems in the table above (one of the units in an existing home) are instantaneous combination boiler/DHW systems, and AFUE data is used in place of EF for average calculations for these systems.
** The counts for unknown values are not included in the sample sizes and percentages in the rest of the table.

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

The average energy factor for electric water heaters in new buildings is 0.92, and 0.91 in existing buildings. All of the electric water heaters are stand-alone storage tank water heaters (Table 6-12).

Table 6-12: Efficiency of Electric Water Heaters
(all buildings with electric water heaters and efficiency data)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Water Heaters	--	*15*	*15*	*9*	*15*	*24*
Minimum	--	0.92	0.92	0.88	0.86	0.86
Maximum	--	0.92	0.92	0.91	0.93	0.93
Average	--	0.92	0.92	0.88	0.92	0.91
Median	--	0.92	0.92	0.88	0.92	0.92
Count of systems with unknown efficiency*	--	--	--	--	4	4

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

Only two multifamily buildings (both existing buildings) have external insulation on their water heater tanks. One building has a single electric water heater originally wrapped in R-6 fiberglass, but at least one quarter of the insulation had been damaged and removed. The other building has two electric water heaters wrapped in compressed R-10 fiberglass (Table 6-13). Note that tank wrap insulation may not always be necessary due to the presence of internal tank insulation; in addition, tank wrap may not be recommended for direct-fired storage tanks.

Table 6-13: Water Heater Tank Wrap Insulation & R-Values
(all buildings with tank water heaters)

	Existing		
	Owner-occupied	**Rentals**	**Statewide**
Number of Tank Water Heaters (stand-alone, integrated, or solar)	34	52	86
Percent with insulation wrap	--	6%	4%
R-value Statistics			
Number of tank water heaters (stand-alone, integrated, or solar) w/insulation	--	3	3
Minimum	--	R-6	R-6
Maximum	--	R-10	R-10
Average	--	R-8.7	R-8.7
Median	--	R-10	R-10

Auditors saw insulation on water heating pipes in 72% of new buildings (91% for ENERGY STAR and 43% for non-ENERGY STAR). In existing buildings this figure was much lower – only 38% of existing buildings have insulation on their DHW pipes, though even these do not always have insulation on the entire length of the DHW pipes. The average R-value of this insulation in new buildings is R-5.2 and in existing buildings is R-3.3 (Table 6-14).

Table 6-14: Water Heater Piping Insulation & R-Values
(all buildings)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	11	7	18	7	25	32
Percent with Insulation	91%	43%	72%	29%	40%	38%
*Count of sites with unknown DHW insulation**	--	2	2	--	--	--
R-value Statistics						
Number of Buildings with insulation	10	3	13	2	10	12
Minimum	R-2	R-5	R-2	R-2	R-2	R-2
Maximum	R-10	R-6	R-10	R-4	R-6	R-6
Average	R-5.1	R-5.7	R-5.2	R-3.0	R-3.3	R-3.3
Median	R-5.5	R-6.0	R-6.0	R-3.0	R-3.0	R-3.0

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

6.1 Low Flow Shower Heads and Faucet Aerators

Many more housing units in new buildings have low-flow showerheads[49] (85%) than in existing buildings (44%). Similarly, 85% of housing units in new buildings have at least one faucet aerator[50], compared to 50% for existing buildings (Table 6-15).

Table 6-15: Low Flow Shower Heads & Faucet Aerators
(all units)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Housing Units	*11*	*9*	*20*	*7*	*25*	*32*
Number of low flow showerheads						
None	1	2	15%	4	56%	56%
One	6	7	65%	3	40%	41%
Two or more	4	-	20%	-	4%	3%
Number of faucet aerators						
None	1	2	15%	3	52%	50%
One	2	-	10%	-	20%	16%
Two	5	5	50%	1	20%	19%
Three	1	2	15%	3	8%	16%
Four or more	2	-	10%	-	-	-

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

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

7 Appliances in Housing Units

This section provides information on the appliances and electronics located inside housing units. Information regarding the shared clothes washers and clothes dryers located in common areas is provided in Section 2.1.

As noted earlier, the Commercial Baseline Study contractor provided data on appliances, lighting, and electronics for seven housing units located in larger multifamily buildings. While auditors attempted to only visit occupied housing units, this was not feasible for a few newly constructed buildings. Therefore, sample sizes vary regarding appliances and electronics due to some units being unoccupied at the time of the visit.

All of the units visited have at least one refrigerator and a range or oven. Less than 10% of newly constructed units have a clothes washer and dryer compared to 41% in existing buildings. Dishwashers are present in about one-third of units. Freezers and second refrigerators are rarely found in housing units (Table 7-1). Because on-site visits were conducted in the fall and winter, we may underestimate the presence of dehumidifiers.

Table 7-1: Appliance Saturations

(all housing units)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Housing Units	*11*	*11*	*22*	*8*	*29*	*37*
Refrigerator	11	11	100%	8	100%	100%
Oven / Range	11	11	100%	8	100%	100%
Clothes washer	--	2	9%	7	28%	41%
Clothes dryer	--	1	5%	7	28%	41%
Dishwasher	7	1	36%	6	24%	35%
Separate freezer	--	--	--	--	14%	14%
Dehumidifier	--	--	--	--	3%	3%
Second Refrigerator	--	--	--	1	--	8%

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

7.1 ENERGY STAR Appliances

Auditors were asked to note the presence of the ENERGY STAR label on any appliances. In addition, model numbers were recorded (when visible) during the onsite visits; the ENERGY STAR status of these models was checked at the ENERGY STAR website.[51] Note, however, that this database identifies only those models that meet the current ENERGY STAR criteria; older models that met the ENERGY STAR criteria in effect when sold would not be listed if they do not meet the current criteria. Therefore, the estimated penetration of ENERGY STAR appliances is likely a conservative estimate.

In newly constructed housing units, refrigerators are most likely to be ENERGY STAR qualified (82%), followed by dishwashers (four of eight) and clothes washers (one of two) (Table 7-2). In existing housing units, refrigerators are also most likely to be ENERGY STAR qualified (25%), followed by clothes washers (19%) and dishwashers (8%).

Table 7-2: ENERGY STAR Appliances
(all appliances)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
ENERGY STAR Refrigerators	100%	63%	82%	11%	29%	25%
No. of refrigerators	*11*	*11*	*22*	*9*	*31*	*40*
ENERGY STAR Dishwashers	4	--	4	--	1	8%
No. of dishwashers	*7*	*1*	*8*	*6*	*7*	*13*
ENERGY STAR Clothes washers	--	1	1	1	2	19%
No. of clothes washers	--	*2*	*2*	*8*	*8*	*16*

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

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

7.2 Refrigerators

All refrigerators found in newly constructed units are in good condition, compared to 80% of refrigerators found in existing units (Table 7-3). All existing owner occupied units have refrigerators in good condition, though 23% of refrigerators are in fair condition in existing rental units.

Table 7-3: Refrigerator Condition
(all refrigerators)

	New Construction			Existing		
Condition	**ENERGY STAR**	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Refrigerators	11	11	22	9	31	40
Good	11	11	100%	9	74%	80%
Fair	--	--	--	--	23%	18%
Poor	--	--	--	--	3%	3%

All refrigerators in newly constructed units are less than five years old, compared to 43% of refrigerators found in existing units (Table 7-4). Thirteen percent of refrigerators in existing units are estimated to be 20 years or older.

Table 7-4: Age of Refrigerators
(all refrigerators)

	New Construction			Existing		
Age	**ENERGY STAR**	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Refrigerators	11	11	22	9	32	41
4 years or less	11	11	100%	4	42%	43%
5 to 9 years	--	--	--	3	26%	28%
10 to 14 years	--	--	--	--	10%	8%
15 to 19 years	--	--	--	1	10%	10%
20 years or more	--	--	--	1	13%	13%

Over one-half of all refrigerators are between 16 and 19 cubic feet in size, and about one-quarter are between 10 and 15 c.f. (Table 7-5).

Table 7-5: Refrigerator Size
(all refrigerators)

	New Construction			Existing		
Cubic Feet	**ENERGY STAR**	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Refrigerators	11	11	22	8	27	35
10 to 15	5	1	27%	--	31%	24%
16 to 19	6	9	59%	5	50%	53%
20 to 24	--	1	6%	1	--	3%
over 24	--	--	--	2	19%	20%

Top-freezer models comprise all of the refrigerators in newly constructed units and 75% in existing units (Table 7-6).

Table 7-6: Refrigerator Type
(all refrigerators)

	New Construction			Existing		
Type	**ENERGY STAR**	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Refrigerators	11	11	22	9	31	41
Top freezer	11	11	100%	6	77%	75%
Bottom freezer	--	--	--	2	10%	13%
Side by side	--	--	--	1	6%	8%
Single door	--	--	--	--	6%	5%

7.3 Separate Freezers

Three of the five separate freezers at existing units are in good condition; the remaining two are in fair condition (Table 7-7). None of the newly constructed units contained a freezer.

Table 7-7: Separate Freezer Condition
(all separate freezers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Separate Freezers	--	--	--	--	5	5
Good	--	--	--	--	3	3
Fair	--	--	--	--	2	2
Poor	--	--	--	--	--	--

There is a wide range in the age of separate freezers (Table 7-8).

Table 7-8: Age of Separate Freezers
(all separate freezers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Separate Freezers	--	--	--	--	4	4
4 years or less	--	--	--	--	1	1
5 to 9 years	--	--	--	--	1	1
10 to 14 years	--	--	--	--	1	1
15 to 19 years	--	--	--	--	--	--
20 years or more	--	--	--	--	1	1

Four of the five separate freezers are between four and six cubic feet in size (Table 7-9).

Table 7-9: Separate Freezer Size
(all separate freezers)

	New Construction			Existing		
Cubic Feet	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Separate Freezers	--	--	--	--	5	5
4 to 6	--	--	--	--	4	4
7 to 9	--	--	--	--	1	1
10 to 14	--	--	--	--	--	--
15 or more	--	--	--	--	--	--

Three of the five freezers are the chest style models, and two are upright models (Table 7-10).

Table 7-10: Separate Freezer Type
(all separate freezers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Separate Freezers	--	--	--	--	5	5
Single door	--	--	--	--	--	--
Upright	--	--	--	--	2	2
Chest	--	--	--	--	3	3

7.4 Dishwashers

All eight dishwashers found in newly constructed units are in good condition. Sixty-two percent of the 13 dishwashers found in existing units are in good condition (Table 7-11).

Table 7-11: Dishwasher Condition
(all dishwashers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Dishwashers	7	1	8	6	7	13
Good	7	1	8	2	6	62%
Fair	--	--	--	2	1	23%
Poor	--	--	--	2	--	15%

All eight dishwashers in newly constructed units are less than five years old (Table 7-13). Forty-two percent of the 12 dishwashers in existing units are less than five years old.

Table 7-12: Age of Dishwashers
(all dishwashers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Dishwashers	7	1	8	5	7	12
4 years or less	7	1	8	--	5	42%
5 to 9 years	--	--	--	1	--	8%
10 to 14 years	--	--	--	1	1	17%
15 to 19 years	--	--	--	1	1	17%
20 years or more	--	--	--	2	--	17%

7.5 Clothes Washers

Both clothes washers found in newly constructed units are in good condition. Three-quarters of the 16 clothes washers in existing units are in good condition with the remainder being in fair condition (Table 7-13).

Table 7-13: Clothes Washer Condition
(all clothes washers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Clothes Washers	--	2	2	8	8	16
Good	--	2	2	6	6	75%
Fair	--	--	--	2	2	25%
Poor	--	--	--	--	--	--

The two clothes washers in newly constructed units are between five and nine years old. Just over one-half (54%) of the 13 existing clothes washers are less than five years old with 23% between five and nine years old (Table 7-14).

Table 7-14: Age of Clothes Washers
(all clothes washers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Clothes Washers	--	2	2	7	6	13
4 years or less	--	--	--	4	3	54%
5 to 9 years	--	2	2	2	1	23%
10 to 14 years	--	--	--	1	1	15%
15 to 19 years	--	--	--	--	--	--
20 years or more	--	--	--	--	1	8%

One of the clothes washers found in newly constructed units is top-loading and the other is front-loading. In existing units, 70% of the 17 clothes washers are top loading (Table 7-15).

Table 7-15: Clothes Washer Type
(all clothes washers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Clothes Washers	--	2	2	8	9	17
Top load	--	1	1	5	7	71%
Front load	--	1	1	3	2	29%

7.6 Clothes Dryers

Eighty percent of the 15 clothes dryers found in existing units are in good condition (Table 7-16).

Table 7-16: Clothes Dryer Condition
(all clothes dryers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Clothes Dryers	--	1	1	7	8	15
Good	--	1	1	5	7	80%
Fair	--	--	--	1	1	13%
Poor	--	--	--	1	--	7%

Forty-three percent of the 13 clothes dryers in existing units are less than five years old (Table 7-17).

Table 7-17: Age of Clothes Dryers
(all clothes dryers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Clothes Dryers	--	--	--	6	7	13
4 years or less	--	--	--	3	3	43%
5 to 9 years	--	--	--	1	2	21%
10 to 14 years	--	--	--	1	1	14%
15 to 19 years	--	--	--	--	--	--
20 years or more	--	--	--	1	1	14%

Most of the 14 clothes dryers in existing units (93%) are fueled by electricity (Table 7-18).

Table 7-18: Clothes Dryer Fuel
(all clothes dryers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Clothes Dryers	--	--	--	6	8	14
Electricity	--	1	1	5	8	93%
Propane	--	--	--	--	--	--
Natural Gas	--	--	--	1	--	7%

7.7 Ranges and Ovens

All ranges in newly constructed units are in good condition. Fifty-seven percent of ranges in existing units are good condition and 34% in fair condition (Table 7-19).

Table 7-19: Range Condition
(all ranges)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Ranges	10	10	20	9	28	37
Good	10	10	100%	6	54%	57%
Fair	--	--	--	1	39%	34%
Poor	--	--	--	2	7%	11%

All newly constructed units have oven/ranges that are under five years old. Just over half of existing units have oven/ranges that are under ten years old; 29% are twenty years old or more (Table 7-20).

Table 7-20: Age of Ranges
(all ranges)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Ranges	10	10	20	7	21	28
4 years or less	10	10	100%	1	10%	11%
5 to 9 years	--	--	--	3	43%	43%
10 to 14 years	--	--	--	--	10%	7%
15 to 19 years	--	--	--	1	10%	11%
20 years or more	--	--	--	2	29%	29%

Eighty-nine percent of all oven/ranges in newly constructed units are fueled by electricity. In existing units, electric stoves account for eighty-six percent of all stoves (Table 7-21).

Table 7-21: Range Fuel
(all ranges)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Ranges	10	9	19	8	27	35
Electricity	10	7	89%	6	89%	86%
Propane	--	--	--	--	4%	3%
Natural Gas	--	2	11%	2	8%	11%

7.8 Dehumidifiers

The one dehumidifier found in an existing rental unit is in good condition and was less than five years old.

7.9 Televisions and Peripherals

Eighty-six percent of newly constructed units have at least one TV set; 37% have two or more TVs (Table 7-22). Ninety-two percent of existing units have at least one TV set; 52% have two or more TVs.

Table 7-22: TV Set Saturation
(all units)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Housing Units	13	9	22	8	28	36
None	1	2	14%	--	11%	8%
One	7	4	59%	4	36%	39%
Two	5	2	32%	3	32%	33%
Three or more	--	1	5%	1	21%	19%

Existing units have a higher percent of TVs that are cathode ray tube (CRT) models than do newly constructed units (63% vs. 43%, respectively) (Table 7-23). In addition, newly constructed units have a greater percent of liquid crystal display (LCD) models than do existing units (50% vs. 34%, respectively).

Table 7-23: TV Set Type
(all TV Sets)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of TV Sets	17	11	28	13	49	62
CRT	47%	4	43%	5	69%	63%
LCD	41%	7	50%	8	27%	34%
LED	12%	--	7%	--	4%	3%

Most units – about two-thirds – have televisions between 21 and 40 inches in size (Table 7-24). Slightly more than 10% are greater than 40 inches in size.

Table 7-24: TV Monitor Size
(all TV Sets)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of TV Sets	15	11	26	12	46	58
15 inches or less	7%	--	4%	--	13%	9%
16 to 20 inches	--	3	15%	2	15%	17%
21 to 30 inches	47%	2	35%	7	35%	43%
31 to 40 inches	27%	6	35%	2	24%	24%
Over 40 inches	20%	--	12%	1	13%	13%

The most common TV peripheral is a DVD player, which is present in about one-third of all units. However, a large portion of units do not have any peripherals (44% new construction, 36% existing) (Table 7-25).

Table 7-25: TV Peripherals
(all TV Sets)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of TV Sets	17	10	27	11	45	56
VCR & DVD player	12%	--	7%	1	7%	7%
DVD player only	41%	3	37%	3	33%	32%
DVD & DVR	--	1	4%	--	4%	4%
VCR only	6%	1	7%	2	22%	21%
None	41%	5	44%	5	33%	36%

Cable is the most prevalent form of TV set top box found in the inspected units; it is present in 86% of newly constructed units and 67% of existing units (Table 7-26). While satellite boxes are found in existing units (20%) they are not present in the new construction sample.

Table 7-26: TV Set Top Boxes
(all TV Sets)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of TV Sets	17	11	28	11	44	55
Cable	82%	10	86%	8	66%	67%
Satellite	--	--	--	1	23%	20%
None	18%	1	14%	2	11%	13%

7.10 Computers

Forty-one percent of newly constructed units have a computer while just over two-thirds (68%) of existing units do (Table 7-27). Twenty-three percent of newly constructed units and 46% of existing units have a printer.

Table 7-27: Computer and Printer Saturation
(all units)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Housing Units	11	11	22	8	29	37
Computers						
None	6	7	59%	2	34%	32%
One	5	2	32%	5	41%	46%
Two or more	--	2	9%	1	24%	22%
Printers						
None	9	8	77%	3	59%	54%
One	2	2	18%	5	41%	46%
Two or more	--	1	5%	--	--	--

Laptop computers are the most common type of computer (eight of nine) in newly constructed units (Table 7-28). Fifty-seven percent of computers found in existing units are laptops.

Table 7-28: Computer Type
(all computers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Computers	5	4	9	6	17	23
Desktop	1	--	1	3	41%	43%
Laptop	4	4	8	3	59%	57%

Seventy-nine percent of the computers in newly constructed units and 65% of computers in existing units have LCD computer monitors (Table 7-29).

Table 7-29: Computer Monitor Type
(all computers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Computers	5	34	39	3	20	23
LCD	5	76%	79%	2	65%	65%
CRT	--	12%	10%	1	15%	17%
LED	--	12%	10%	--	20%	17%

Nearly all of the computer monitors are less than 20 inches in diameter (Table 7-30).

Table 7-30: Computer Monitor Size
(all computers)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Computers	7	6	13	6	21	27
15 inches or less	3	3	46%	2	43%	41%
16 to 20 inches	3	3	46%	4	52%	55%
Over 20 inches	1	--	8%	--	5%	4%

8 Lighting in Housing Units

Data reported in this section are for light bulbs installed within the housing units. Common area lighting data are reported in Table 2-12 and Table 2-13.

CFL bulbs are installed in the interior of 86% of the newly constructed units and 70% of the existing units (Table 8-1). Just over one-half (55%) of newly constructed units and three-quarters of existing units have incandescent bulbs installed. One-half of newly constructed units and just under one-half (46%) of existing units have fluorescent tubes or circline bulbs installed. LEDs and dimmable bulbs are found in relatively few units.

Table 8-1: Proportion of Units with Light Bulbs by Type
(all units)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Housing Units	11	11	22	8	29	37
CFLs Installed	10	9	86%	7	66%	70%
Incandescents Installed	5	7	55%	7	72%	76%
LEDs Installed	1	--	5%	1	3%	5%
Fluorescents Installed	9	2	50%	7	34%	46%
Dimmable Bulbs Installed	--	1	6%	2	3%	8%

Table 8-2 displays the percent range of CFLs installed as a function of the CFL, incandescent, and LED bulbs installed in hard-wired fixtures and plug-in lamps. At 54% of newly constructed units and 38% of existing units, over one-half of these bulbs are CFLs. In Table 8-2 and Table 8-3, we excluded fluorescent tube and circline bulbs (aka "fluorescent") from the denominator because the pin-based fixture would need to be replaced in order to install a screw-in CFL bulb. This means that a fluorescent bulb is much less likely to be replaced by a CFL bulb.

Table 8-2: Proportion of CFLs as Percent of CFLs, Incandescents, and LEDs
(all units)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Housing Units	11	11	22	8	29	37
None	1	2	14%	1	24%	30%
1% to 10%	--	1	5%	2	--	5%
11% to 25%	1	1	9%	3	--	8%
26% to 50%	2	2	18%	1	24%	19%
51% to 100%	7	5	54%	1	52%	38%

CFLs account for 67% of the CFL, incandescent, and LED bulbs installed in newly constructed units, but just 37% in existing units (Table 8-3). Conversely, incandescent bulbs account for just 29% of these bulbs in newly constructed units though 62% in existing units. LEDs comprise only 1% to 4% of these light bulbs.

Table 8-3: CFL Bulb Saturation as Percent of CFLs, Incandescents, and LEDs
(all units)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Total Units	*11*	*11*	*22*	*8*	*29*	*37*
Total Bulbs	*82*	*174*	*256*	*293*	*525*	*818*
CFLs	68%	66%	67%	24%	44%	37%
Incandescent	20%	34%	29%	73%	55%	62%
LEDs	12%	--	4%	3%	--	1%

Newly constructed units have a mean of 7.8 CFL bulbs and median of 5.5 CFL bulbs installed, representing 63% of all 12.3 light bulbs installed (including CFLs, incandescents, LEDs, and fluorescent bulbs) (Table 8-4). Existing units have a mean 8.2 CFL bulbs and a median of 6.0 CFL bulbs installed, representing 37% of all 22.3 light bulbs.

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

(all units)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Total Housing units	*11*	*11*	*22*	*8*	*29*	*37*
Total Bulbs	93	*177*	*270*	*300*	*536*	*826*
Mean number of CFLs	5.1	10.5	7.8	8.6	8.0	8.2
Median number of CFLs	2.0	10.0	5.5	6.0	6.0	6.0
Proportion of all bulbs that are CFLs	60%	65%	63%	23%	43%	37%
Mean number of all bulbs	8.5	16.1	12.3	37.5	18.5	22.3

Stored CFL bulbs were found at only 9% of new units and 22% of existing units (Table 8-5). The average number of CFLs in storage is 0.8 bulbs across all housing units.

Table 8-5: CFLs in Storage

(all units)

	New Construction			Existing		
	ENERGY STAR	**Non-ENERGY STAR**	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Housing Units	*11*	*11*	*22*	*8*	*29*	*37*
Units w/CFLs in Storage	1	1	9%	5	10%	22%
Number of CFL Bulbs in Storage	15	2	17	23	8	31
Number of Housing Units	*11*	*11*	*22*	*8*	*29*	*37*
Mean number of CFLs in Storage	1.4	0.2	0.8	2.9	0.3	0.8
Median number of CFLs in Storage	0.0	0.0	0.0	1.5	0.0	0.0

9 Auditor Ratings of Buildings and Energy Features

Auditors were asked to provide ratings in response to three questions that are listed below.

1) In general, how would you rate the overall construction quality of this building, on a scale of 1 (poor) to 5 (excellent)?
2) How large are the opportunities that were missed by the builder that might have improved the energy efficiency of this building? (New construction only.) Rate using a scale of 1 (small amount of energy savings) to 5 (large amount of energy savings).
3) What is the level of opportunity for improving energy efficiency in this building? Use a scale of 1 (low) to 5 (high).

In addition to rating these three areas, auditors were asked to offer an explanation for why they chose a particular rating. Lastly, they were also asked to list the four worst energy features in each building. After reviewing the data it became clear that auditors' explanations of their ratings often mentioned the exact same items listed as the four worst energy features of the building. Therefore, information on the four worst energy features is presented in this section; including information on the auditors explanations of their ratings would be redundant. It should be noted that these ratings are subjective in nature, but they should provide a general idea of where Vermont can focus future programs.

As noted above, auditors were asked to rate the construction quality of each building, using a scale of one to five where one means 'poor' and five means 'excellent.' Among new construction, one non-ENERGY STAR building was rated average (three out of five), and the rest were rated either four or five (Table 9-1). Nineteen of the 32 existing buildings (59%) were rated average. Twenty-two percent were rated either four or five, slightly more than the 19% that were rated one or two.

Table 9-1: Rating of Construction Quality

(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
1 – poor	-	-	-	-	8%	6%
2	-	-	-	-	16%	13%
3	-	1	5%	3	64%	59%
4	3	5	40%	4	8%	19%
5 - excellent	8	3	55%	-	4%	3%

Auditors were asked to identify the level of opportunity for improving energy efficiency in the multifamily buildings they visited, with one representing the lowest level of opportunity and five representing the highest level of opportunity (Table 9-2). Opportunities for improvement are rare among newly constructed buildings, and ENERGY STAR buildings in particular. In contrast, existing rentals have the highest level of opportunity for improvements (32% rated as four or five). Among all existing buildings, 28% were rated a four or five.

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

(all buildings)

	New Construction			Existing		
	ENERGY STAR	Non-ENERGY STAR	Statewide	Owner-occupied	Rentals	Statewide
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
1 – low	10	6	80%	2	4%	9%
2	1	2	15%	1	32%	28%
3	-	1	5%	3	32%	34%
4	-	-	-	1	20%	19%
5 – high	-	-	-	-	12%	9%

Auditors were asked to rate the level of energy savings opportunities missed by the builder for newly-constructed buildings, with one representing the smallest level and five representing the largest level (Table 9-3). Almost 60% of the 17 buildings (including seven of nine ENERGY STAR buildings) received a rating of one, 29% received a two, and 12% received a three (both non-ENERGY STAR).

Table 9-3: Rating of the Level of Missed Opportunities

(newly constructed buildings)

	New Construction		
	ENERGY STAR	Non-ENERGY STAR	Statewide
Number of Homes	*9*	*8*	*17*
1 (small)	7	3	59%
2	2	3	29%
3	-	2	12%
4	-	-	-
5 (large)	-	-	-

For each building, auditors provided a list of up to four 'worst energy features;' these were simply identified as detriments, without regard for retrofit feasibility (Table 9-4).[52] The features most commonly listed for existing buildings were 'Basement insulation R-value (including no insulation)' (38%), 'Interior lighting' (31%), 'Furnace/boiler efficiency' (28%), 'Basement air leakage' (25%), and 'Wall insulation R-values' (22%). For new buildings, auditors did not cite a negative energy feature 65% of the time; 'Interior lighting' was the most common feature (20%).

[52] The majority of features listed are thermal in nature, e.g. insulation R-values, air leakage, and window U-value. Lighting and appliances constitute the only electric features on the list for buildings that do not heat or cool with electricity, although lighting and appliances are two of the most frequently-cited among all energy features.

Table 9-4: Worst Energy Features by Segment

(all buildings)

	New Construction			Existing		
	ENERGY STAR	***Non-ENERGY STAR***	**Statewide**	**Owner-occupied**	**Rentals**	**Statewide**
Number of Buildings	*11*	*9*	*20*	*7*	*25*	*32*
Basement insulation R-value (including no insulation)	-	1	5%	2	40%	38%
Interior lighting	2	2	20%	5	20%	31%
Furnace/boiler efficiency	-	1	5%	2	28%	28%
Basement air leakage	-	-	-	-	32%	25%
Wall insulation R-values	-	-	-	2	20%	22%
Ceiling insulation R-values	1	-	5%	2	16%	19%
Appliances	-	-	-	2	16%	19%
House air leakage reduction (overall)	1	-	5%	-	20%	16%
Window U-value	-	-	-	1	16%	16%
Window quality	-	-	-	-	16%	13%
Wall insulation installation	-	-	-	-	12%	9%
Water heater efficiency	-	-	-	1	8%	9%
Rim joist insulation	-	-	-	-	8%	6%
Pipe insulation	-	-	-	1	4%	6%
Basement insulation installation	-	-	-	-	4%	3%
Wall air leakage	-	1	5%	-	4%	3%
Window air leakage	-	1	5%	-	4%	3%
Water heater installation quality	-	-	-	-	4%	3%
Duct system installation (not including insulation)	-	-	-	-	4%	3%
Electric heater quality	-	-	-	-	4%	3%
Stove quality	-	-	-	-	4%	3%
Bathroom fan quality/effectiveness	2	-	10%	-	4%	3%
Poor ventilation	-	-	-	-	4%	3%
Ceiling insulation installation	1	-	5%	-	-	-
Duct system insulation installation	-	1	5%	-	-	-
None provided	*7*	*6*	*65%*	-	*4%*	*3%*

Auditors were also asked to rank a building's worst energy features based on importance (Table 9-5). Among the 20 new buildings, auditors identified just seven in which any negative energy features stood out. The only features which received more than one top ranking was "Interior lighting", which was cited twice.

The negative features receiving the most top rankings in existing buildings are "Basement insulation R-value (including no insulation)" (six), "Furnace/boiler efficiency" (five), "Ceiling insulation R-values" (four), and "Basement air leakage" (three) and "appliances" (three).

Table 9-5: Worst Energy Features by Ranking

(all buildings)

	New Construction				Existing			
	1st	2nd	3rd	Last	1st	2nd	3rd	Last
Number of Buildings	*20*	*20*	*20*	*20*	*32*	*32*	*32*	*32*
Basement insulation R-value (including no insulation)	1	-	-	-	6	5	1	-
Furnace/boiler efficiency	1	-	-	-	5	2	2	-
Ceiling insulation R-values	1	-	-	-	4	2	-	-
Basement air leakage	-	-	-	-	3	4	1	-
Appliances	-	-	-	-	3	1	2	-
Wall insulation R-values	-	-	-	-	2	2	3	-
Window U-value	-	-	-	-	2	1	1	1
Interior lighting	2	1	1	-	1	3	2	4
House air leakage reduction (overall)	-	1	-	-	1	1	1	2
Basement insulation installation	-	-	-	-	1		-	-
Electric heaters	-	-	-	-	1		-	-
Stove quality	-	-	-	-	1		-	-
Poor ventilation	-	-	-	-	1		-	-
Rim joist insulation	-	-	-	-	-	1	1	-
Wall insulation installation	-	-	-	-	-	1	1	1
Window quality	-	-	-	-	-	1	-	3
Window air leakage	-	1	-	-	-	1	-	-
Water heater installation quality	-	-	-	-	-	1	-	-
Wall air leakage	1	-	-	-	-		1	-
Ceiling insulation installation	-	1	-	-	-		-	-
Water heater efficiency	-	-	-	-	-		2	1
Pipe insulation	-	-	-	-	-		2	-
Duct system installation (not including insulation)	-	-	-	-	-		1	-
Duct system insulation installation	-	1	-	-	-		-	-
Bathroom fan quality/effectiveness	1	-	1	-	-		-	1
None provided	*13*	*15*	*18*	*20*	*1*	*6*	*11*	*19*

Appendix A Comparison to 2008 Multifamily New Construction Baseline Study

Table A-1 compares key characteristics from the 2008 multifamily new construction baseline study to the results of the current baseline study.

The list of measures that are comparable between the 2008 study and the current study is not comprehensive; this is due primarily to differences in the definition of a multifamily building between the two studies. In 2008, multifamily buildings were defined as "two or more unit buildings completed after January 1, 2006 with no ground-to-roof walls separating the units and/or with one water and sewer bill for the whole building." The definition also included "mixed use buildings if the square footage is 50% or more residential" and "institutional housing units, including education and age-restricted (senior housing)."[53]

As discussed in the *Final Definitions for 2011 Residential Market Characterization Study*[54] memo, the current study defines multifamily buildings to include all residential housing projects with three or more housing units in buildings of three or fewer stories including the following:

- Individual three- or four-unit buildings
- Three or more attached townhouses or row houses
- Market rate and low income projects
- Projects consisting of multiple two-unit buildings

This definition excludes all hotels, motels, barracks, dormitories and nursing homes.

[53] *Vermont Multifamily New Construction Analysis of On-site Audits: Final Report*. Submitted by Nexus Market Research, Inc., RLW Analytics, and Dorothy Conant to Vermont Department of Public Service on July 13, 2009.
[54] *Final Definitions for 2011 Residential Market Characterization Study.* April 14, 2011

Because of the differing definition of multifamily projects that qualified for the study in 2008 and in 2011, the measures may not be directly comparable between the two studies. Nevertheless, the majority of building components addressed on page 26 of the RBES Handbook[55] are featured in Table A-1.

In some key areas, the 2011 buildings exhibit an improvement in energy efficiency, in particular wall insulation, flat ceiling insulation, oil boiler efficiency, glazing percentage, ENERGY STAR refrigerators, and CFL bulb saturation in housing units. However, other areas show a decline, such as gas boiler efficiency and programmable thermostats.

Table A-1: Comparison of Key 2008 and 2011 Multifamily New Construction Results

Characteristic	Measurement	2008	2011
ENERGY STAR status	Percent of new buildings that are ENERGY STAR certified	85%	55%
Wall insulation	Average R-value	R-20	R-24
Flat ceiling insulation	Average R-value	R-41	R-51
Heating system efficiency	Average efficiency of oil boilers	84.5%	86.6%
	Average efficiency of natural gas & propane boilers	92.8%	89.5%
Glazing	Average glazing percentage	17%	15%
Thermostats	Percent of units with programmable thermostats	39%	30%
Hot water piping insulation	Percent of buildings with pipe insulation	50%	71%
Refrigerators	Percent ENERGY STAR	26%	82%
Housing unit lighting	CFL bulb saturation	61%	67%
Interior common area lighting	CFL & fluorescent bulb saturation	99%	100%

[55] *Vermont Residential Building Energy Code Handbook: A Guide to Complying with Vermont's Residential Building Energy Standards (Act 20, 1997)*. November 2004. Effective January 1, 2005. Page 26.

Appendix B Insulation Grades

The Residential Energy Services Network (RESNET) provides guidelines and definitions for defining the quality of insulation installation. RESNET has specified three grades for designating the quality of insulation installation; the grades range from Grade I (the best) to Grade III (the worst). The RESNET definitions of Grade I, Grade II, and Grade III installation are provided below.[56]

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…"

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

Appendix C Major Renovations & Additions

In this appendix, we describe the buildings that underwent a gut rehabilitation or renovation and assess whether that work appears to meet 2005 RBES prescriptive requirements. During onsite inspections, ten building owners reported that their building had undergone a gut rehab, and one of these also reported an addition.

Nine of the ten multifamily buildings that had undergone major renovations were ultimately classified as new construction based on the extent of their rehabilitation. These renovations typically entailed stripping a building down to its shell and re-insulating as well as performance upgrades of other building shell measures, replacement of major mechanical systems, lighting upgrades, and/or re-purposing a building. Five of these nine buildings were renovated to ENERGY STAR standards.

A.1 ENERGY STAR Major Renovations Classified as New Construction

All five of the ENERGY STAR multifamily buildings would comply with 2005 RBES requirement via the HERS compliance path, which requires a HERS score of 82 or lower for multifamily buildings. All five ENERGY STAR buildings below also had all new low-E argon windows, new boilers, and new solar DHW systems installed.

1. This school building from the 1930's was converted into residences in 2011, and received a HERS score of 47. Spray foam was installed in all cavities inside the cinder block walls and on the interior surface of the foundation walls (R-14), and 1" foam board was installed under the interior drywall (estimated R-20 for above grade walls). The rim joists and basement ceiling were insulated with spray foam to at least R-14. The ceiling was insulated to R-49 by covering a layer of spray foam with cellulose and an ERV was added.
2. This historic town center building was renovated in 2011 and received a HERS score of 49. The developer insulated the foundation walls with rigid and spray foam (R-14), spray foamed the rim joists (R-21), and left the frame floor over the insulated basement uninsulated. The solid wood walls (no cavities) were insulated with continuous foam board under the drywall (R-14), and the corners were sealed with spray foam. R-56 cellulose was added in the ceiling and ventilation fans were installed.
3. This triple-decker building was renovated in 2010 and received a HERS score of 62. Closed cell spray foam was used to insulate the foundation walls and rim joists (R-23 in both). The exterior walls were heavily insulated to R-32 – spray foam was put in the wall cavities (R-24), and R-8 continuous rigid foam was installed under the siding. The slab floor was redone and insulated with rigid foam (R-15). The developer also installed R-51 cellulose in the ceiling, ventilation fans, and an ERV.

4. This brick, mixed-use building with commercial space was renovated in 2011, with an unknown HERS score.[57] The developer used spray foam to insulate the foundation walls (R-12) and the rim joists and the exterior walls (R-21 in both). Rigid foam was installed under the slab (R-12), and the developer added a large amount of cellulose in the ceiling (R-67), 15 SEER AC units with insulated ductwork, and ventilation fans.
5. This brick triple-decker had been heavily renovated in 2010, achieving a HERS score of 57. The existing foundation was insulated with spray foam and covered with a spray-on fireproofing material (R-15), the slab was fully re-insulated to R-10, the above grade walls and rim joists were insulated with spray foam to R-25, and the frame floor over the insulated basement was also insulated with spray foam (R-15). The ceiling was insulated to R-54 with cellulose and an ERV was added.

A.2 Non-ENERGY STAR Major Renovations Classified as New Construction

1. In 2010, the owner of this two-story brick building from the early 1900's (with a 1980's addition) completed a major upgrade to make it more rentable, fixing mechanical and structural problems, and enhancing the energy efficiency. The building appears to meet RBES prescriptive requirements, including glazing percentages. The owner insulated the foundation walls by adding stud walls with fiberglass batts (R-19), used spray foam on the rim joists (R-21), and insulated the walls of the original structure with spray foam (R-23). Fiberglass batts (R-19) already existed in the walls of the 1980's addition. The owner installed new boilers (87% AFUE), added all new low-E argon windows, and upgraded the ceiling insulation in the old and new part of the building to R-45 and R-60, respectively.
2. This site is a 1950's factory building turned into residences in 2011. All new framing and fiberglass batts were added to the interior of the brick building (R-19). R-30 fiberglass batts were installed in the frame floor over the unconditioned basement, and rim joists were insulated to R-19 with fiberglass batts. The ground-level units did not appear to have insulated slab perimeters. All the old windows were replaced with low-E argon windows. New mechanical systems were installed (92.5% AFUE on–demand combination boiler/DHW appliances), and R-43 cellulose was blown into the attic. All envelope insulation, windows, glazing percentages, and HVAC systems appear to meet RBES prescriptive requirements, except that there did not appear to be slab perimeter insulation for the ground-level units.
3. This two-story multifamily building was gutted down to the shell, and heating systems and insulation were replaced. This was a slab-on-grade building, however, and it did not appear that slab perimeter insulation had been added. The walls were re-insulated with fiberglass batts, and 2" foam board was installed underneath the siding (R-27 total). The

[57] The HERS score was not posted in any area accessible to the auditor.

developer also sprayed foam in the attic ceiling which was then topped with cellulose to increase the R-value to R-49. The developer also installed new low-E argon windows, 93% AFUE boilers, a solar DHW system, and exhaust fans. There was only a small unconditioned basement area, but R-30 fiberglass batts were installed in the basement ceiling. Other than slab perimeter insulation, this building seems to have met RBES prescriptive requirements, including glazing percentages. It was renovated similarly to the ENERGY STAR renovations, though during the audit the tenants complained about leaky windows and doors.

4. This unique renovation was a 1980's brick office building that was converted into residences via a major renovation in 2009, one that resembled ENERGY STAR renovations. The developer insulated the conditioned portion of the foundation walls and above grade stud walls with spray foam (R-21), and added all new low-E argon windows. Building plans reported R-60 of spray foam as the ceiling insulation, and a solar DHW system was installed. The main heating and AC systems – large commercial units that were 23 years old and of unknown efficiency – however, had not been replaced. However, the developer installed a photovoltaic array and multiple ERVs. This building would pass RBES prescriptive requirements for its insulation and window u-values, but the glazing percentage is too high for RBES prescriptive requirements (27%), and the older HVAC system might affect the building's compliance as well.

A.3 Non-ENERGY STAR Gut Rehab *Not* Classified as New Construction.

1. This building had been heavily renovated, but not enough to categorize it as new construction. The building had two parts: a three-story structure from the late-1700's, and a smaller 1990's addition. In the late 2000's, the owner decided to improve the thermal envelope of the older part of the building by adding a layer of framing and insulation (R-19) to the inside of the building. The building was not gutted per se, as not much seemed to have been removed; another layer was simply added to what was already there. The boilers (87% AFUE) and DHW (integrated tank) dated back to the 1990's. In the renovated portion of the building, the above-grade walls, low-E windows (including the glazing percentage), and heating and cooling equipment meet RBES prescriptive requirements. However, the foundation walls and frame floors over the unconditioned basement and the crawlspace do not – none of these were insulated. Auditors suspected that the ceiling insulation was R-30 or greater for both flat and sloped ceilings, but that could not be confirmed.

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

Table C-1: 2005 RBES Multifamily Package Requirements for Fast-Track Compliance Method[58]

Component	Package 1	Package 2	Package 3	Package 4	Package 5	Package 6
Ceiling Flats & Exposed Floors R-value	R-38	R-38	R-38	R-38	R-38	R-49
Ceiling Slopes R-value	R-30	R-30	R-30	R-30	R-30	R-30
Above-Grade Walls R-value	R-19	R-19	R-19	R-19	R-19	R-21
Floors over Unconditioned Spaces R-value	R-30	R-30	R-30	R-30	R-30	R-30
Basement Walls (full height) R-value	R-10	R-10	R-10	R-10	R-15	R-10
Slab Edge R-value	R-10	R-10	R-10	R-10	R-15	R-10
Unvented Crawlspace Walls R-value	R-10	R-10	R-10	R-10	R-15	R-10
Doors, excluding sliding and patio doors, U-value	0.40	0.40	0.40	0.40	0.40	0.40
Basement Window U-value	0.60	0.60	0.60	0.60	0.60	0.60
Window, skylights, sliding and patio doors, U-value	0.40	0.36	0.34	0.30	0.40	0.40
Heating System AFUE	82%	80%	84%	85%	84%	85%
Glazing Percentage	0.12	0.15	0.20	0.25	0.20	0.20

[58] Vermont Residential Building Energy Code Handbook, Edition 2.0, November 2004. Table 4-3, Page 26. Note that heating system AFUE requirements were increased, effective June 2007 (http://www.ncsg.org/Portals/0/GA/VTHB253.pdf).