Vermont
Multi-family New Construction
Analysis of On-site Audits

Final Report

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Submitted by:

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Executive Summary

This report presents the findings of on-site audits conducted at 20 multi-family complexes across Vermont. Data were collected at three levels—multi-family building (28 individual buildings audited representing, in many cases, multiple buildings in a complex), common area, and individual housing unit (38 individual units audited). Data collection covered building characteristics, heating and cooling equipment, water heating equipment, appliances, and lighting. Site contacts at each audited complex provided information on property ownership, management, and involvement with utility programs during project development and construction. In addition, tenants and owners were asked to complete a short questionnaire to assess obstacles to their improving the energy efficiency of their home based on the findings of the on-site audit.

Participants were recruited by RLW staff from a list of newly constructed buildings, or buildings under construction, from the Vermont Division of Fire Safety (DFS), which reviews fire safety plans. RLW recruited every eligible potential site for which they had contact information and where someone was willing to allow an on-site audit.

Potential bias is a concern in any sample based on voluntary participation. There are many factors that may influence a potential participant's willingness to participate in an audit. In particular, multi-family site contacts who are familiar with or have participated in Efficiency Vermont (EVT) programs may be more willing to participate. This was clearly the case in recruiting multi-family projects. All but one of the 20 audited projects worked with EVT. Furthermore, 17 of the 20 audited projects were ENERGY STAR certified through the Vermont ENERGY STAR Homes (VESH) Program. EVT staff believe they work with a significant portion of multi-family new construction projects, but also say it is hard to identify privately funded rental projects and they do not know what portion of the overall market they work with. Based on our analysis of the DFS database, it appears that EVT worked with 79% of the 57 multi-family projects that were eligible for the on-site inspections. This indicates that, while the on-site sample is biased towards projects that participated in EVT programs, it is not significantly biased.

Based on interviews with the site contacts, nine of the audited projects are owned by private partnerships, eight by private individuals, one by a condominium association and two by non-profits. Audits were conducted at six apartment complexes, six condominium complexes, five senior housing complexes, one co-housing project, one college dormitory, and one duplex. The size of audited complexes ranges from 1,664 to 116,080 square feet. The size of audited multi-family housing units ranges from 255 to 2,471 square feet; the average is 1,058 square feet and the median is 932 square feet.

Opportunities for Increased Energy Efficiency

Overall, audited multi-family complexes are very energy efficient. The average Home Energy Rating System (HERS) Index[1] of the 17 ENERGY STAR-certified complexes is 60. The RBES Home Energy Rating compliance path requires homes or multi-family units to achieve a HERS Index of 85 or lower. The HERS scale represents a one percent increase in energy efficiency for every one point decrease in the HERS Index. Therefore, the 17 ENERGY STAR-certified projects, with an average HERS Index of 60, are 25% more energy efficient than required to comply with RBES code requirements. The Home Energy Rating compliance path does not have minimum requirements for insulation levels, window U-values, etc. Projects that fall short of meeting specific RBES minimum requirements under prescriptive compliance paths may meet or exceed code requirements under the HERS compliance path. Of the three audited projects that are not ENERGY STAR certified, all three meet or exceed RBES prescriptive path minimum requirements for wall insulation and window U-value; two meet or exceed prescriptive path minimum ceiling insulation requirements and auditors were not able to determine the R-value of ceiling insulation in the third non-ENERGY STAR project.

Audited multi-family complexes tend to meet minimum prescriptive RBES insulation code requirements, but few exceed them. Most audited complexes have high efficiency boiler heating systems. Only slightly more than one-half of complexes with central air conditioned housing units have high efficiency systems. All audited complexes have efficient double pane Low-E or double pane Low-E with argon windows. In most cases opportunities for increasing energy efficiency are relevant for all types of multi-family housing, but particularly rental housing. Opportunities exist for increasing energy efficiency in multi-family buildings by addressing building shell characteristics, HVAC equipment efficiency, and appliance choices.

- **Walls Insulation Type.** Almost all audited complexes (17 of 20 or 85%) have fiberglass batt wall insulation. Two complexes have rigid foam wall insulation—one apartment complex (R-22) and one condominium complex (R-25); one senior housing project has R-19 cellulose wall insulation. The high incidence of fiberglass batt wall insulation in all types of multi-family housing suggests Vermont programs should target educating all multi-family project developers about the benefits of using more efficient and effective insulation materials and ways to cost effectively incorporate these insulation products in their projects.
- **Wall Insulation Levels.** All 20 audited complexes have at least R-19 wall insulation, but only four complexes have more than R-19 wall insulation. The four complexes with more than R-19 wall insulation are one senior housing project (R-21), one apartment complex (R-22), one co-housing complex (R-25), and one condominium complex (R-25). The high proportion of multi-family complexes of all housing types just meeting minimum wall insulation prescriptive code requirements suggest Vermont programs

[1] A relative energy use index called the HERS® Index – a HERS Index of 100 represents the energy use of the "American Standard Building" and an Index of 0 (zero) indicates that the Proposed Building uses no net purchased energy (a Zero Energy Building). http://www.natresnet.org/about/resnet.htm

should target educating all multi-family project developers about the benefits of increased wall insulation levels and ways to cost effectively incorporate higher insulation levels in their projects.

- **Ceiling Insulation Type.** In all but two of the 16 complexes where auditors were able to determine the type of insulation installed (88%), the ceilings are insulated with either cellulose (75%) or rigid foam (13%); only two complexes (13%) have R-38 fiberglass batt insulation. It appears most multi-family project developers are currently choosing efficient ceiling insulation products.
- **Ceiling Insulation Levels.** Auditors were able to determine the level of ceiling insulation in 18 of the 20 audited complexes. In six (33%) of these 18 complexes ceiling insulation levels exceed R-38: the cohousing complex (R-40), two condominium complexes (one R-42 and one R-50), one apartment complex (R-44), a senior housing complex (R-44), and the duplex (R-57). The high proportion (66%) of multi-family complexes of all housing types just meeting minimum ceiling insulation prescriptive code requirements suggest Vermont programs should target educating all multi-family project developers about the benefits of increased ceiling insulation levels and ways to cost effectively incorporate higher insulation levels in their projects.
- **Heating Systems—Boilers.**[2] Just over one-half of audited complexes have super high efficiency boiler heating systems (gas boilers with Annual Fuel Utilization Rate (AFUE) or Thermal Efficiency (TE) ratings over 90 or oil boilers with AFUE or TE ratings over 87). Only three complexes have low efficiency boiler heating systems—commercial boilers with thermal efficiencies below 84% (82.7% to 83.3%). The high incidence of super high efficiency boilers suggests that Vermont programs should encourage developers of multi-family complexes who are not yet installing very high efficiency boilers to install at least 90 AFUE or TE gas boilers or over 85 AFUE or TE oil boilers.
- **Central Air Conditioning.** Four out of seven complexes that have housing units with central air conditioning have high efficiency air conditioning systems (ENERGY STAR and/or SEER 14 or higher). Similar to heating systems, the relatively high incidence of high efficiency central air conditioning suggests that Vermont programs should encourage developers of multi-family complexes who are not yet installing high efficiency central air conditioning to install ENERGY STAR-qualified systems. Also, additional savings can be achieved by verifying that cooling systems are installed properly and performing efficiently.
- **Water Heating.** Water heating systems in all but two of the complexes are integrated tank systems—one complex has electric stand alone tanks and one has natural gas instantaneous systems. All observed water heating systems have higher Energy Factors than gas- or oil-fired stand alone tank systems and, therefore, can be considered high efficiency systems. However, we understand there are condensing multi-family water heaters with 90 plus Energy Factors that may be worth examining for additional potential savings.
- **Appliance Choices.** Only 26% of refrigerators are ENERGY STAR labeled, which indicates that there is an opportunity to increase the penetration of ENERGY STAR refrigerators in multi-family new construction.

[2] Eight of the audited complexes have commercial boilers (300,000 BTUH or higher input capacity) for which AFUE ratings are not typically available. Based on conversations with EVT staff it was decided to use GAMA thermal efficiency ratings to approximate AFUE ratings for all commercial boilers.

Finally, although compact fluorescent light (CFL) bulbs are a high percentage of both common area interior lighting (65% of bulbs) and lighting in individual multi-family units (61% of bulbs), auditors identified several additional opportunities for increasing lighting efficiency in the audited complexes:

- Install more CFLs in the units and replace incandescent light bulbs with CFLs in common areas and bathrooms
- Install photocells or occupancy sensors in stairwells that get natural light
- Where there are two sets of lights in a hallway—one set for the hall and another set for the doorways—perhaps one set could be on occupancy sensors
- Install occupancy sensors in common laundry rooms, bathrooms, and boiler rooms

At the operational level, auditors suggested property managers lower thermostat settings in vacant units and put timers on hot tubs.

Energy Efficiency by Complex Category

Although the sample sizes are small, we are able to look at differences between units in complexes that are located in geographically targeted regions versus the remainder of Vermont, differences between units in complexes where units are owned versus rented, and differences among units in four complex categories—apartments, condominiums, senior housing, and "other." Overall, complexes in targeted regions have more energy-efficient characteristics than complexes in the remainder of Vermont. (Program staff verified that the VESH Program has not conducted any special marketing in the geographically targeted regions and that the incentives available in the targeted regions are the same as in the rest of the state.) Complexes where the units are owned rather than rented have more energy-efficient characteristics, and condominium complexes have more energy-efficient characteristics than apartment or senior housing complexes. In general, rental and senior housing complexes appear to be the multi-family housing categories least likely to incorporate the highest-efficiency options and, therefore, should be targeted.

Table ES– 1 looks at complexes located in geographically targeted regions versus the remainder of Vermont. The cells highlighted in green indicate the more energy-efficient rating. As shown, the five ENERGY STAR-certified complexes in the targeted region have a lower average HERS Index than the twelve ENERGY STAR-certified complexes in the remainder of Vermont (55 vs. 62). In addition, complexes in targeted regions have higher average wall and flat ceiling insulation R-values, a lower average glazing percentage, a higher average water heating Energy Factor, a higher average boiler efficiency, and a higher percentage of super high efficiency boilers than complexes in the remainder of Vermont. Windows are slightly more energy efficient and central air conditioning equipment is more likely to be high efficiency in complexes in the remainder of Vermont.

Table ES– 1: Energy Efficiency Characteristics—Complexes in Targeted Regions versus Remainder of Vermont

Characteristic	Targeted Region Complexes (n=6)	Remainder of Vermont Complexes (n=14)
Number of ENERGY STAR-Qualified Complexes	5	12
Average HERS Index of ENERGY STAR Complexes	**55**	62
Average Wall Insulation R-value	**22**	19
Average Flat Ceiling Insulation R-value	**42**	40
Average Window U-value	0.33	**0.32**
Average Glazing % (Window/Wall Ratio)	**18%**	21%
Average Water Heating Energy Factor	**0.86**	0.82
Average Boiler AFUE/TE	**93.0**	88.7
Percent of Boilers Super High Efficiency	**83%**	43%
Percent with High Efficiency Central Air Conditioning*	50%	**60%**

*Two complexes in targeted regions and five complexes in the remainder of Vermont have central air conditioned housing units.

Table ES– 2 looks at complexes where individual units are owned versus complexes where units are rented. As shown, the six ENERGY STAR-certified complexes where units are owned have a lower average HERS Index than the eleven ENERGY STAR-certified complexes where units are rented (58 vs. 61). In addition, complexes where units are owned rather than rented have a higher average flat ceiling insulation R-value, slightly more energy-efficient windows, a higher average water heating Energy Factor, a higher average boiler efficiency, and higher percentages of super high efficiency boilers and high efficiency central air conditioning.

Table ES– 2: Energy Efficiency Characteristics—Complexes Where Units Owned versus Rented

Characteristic	Owned Unit Complexes (n=7)	Rental Unit Complexes (n=13)
Number of ENERGY STAR-Qualified Complexes	6	11
Average HERS Index of ENERGY STAR Complexes	**58**	61
Average Wall Insulation R-value	20	20
Average Flat Ceiling Insulation R-value	**41**	40
Average Window U-value	**0.32**	0.33
Average Glazing % (Window/Wall Ratio)	20%	20%
Average Water Heating Energy Factor	**0.86**	0.82
Average Boiler AFUE/TE	**91.7**	89.1
Percent of Boilers Super High Efficiency	**71%**	46%
Percent with High Efficiency Central Air Conditioning*	**75%**	33%

*Four complexes in which housing units are owned and three complexes in which housing units are rented have central air conditioned housing units.

Table ES– 3 shows that the three "other" housing category projects (dormitory, co-housing, and duplex) have the highest average wall and flat ceiling insulation levels, the lowest average glazing percentage, and the highest average water heating Energy Factor. In addition, the average HERS Index of 54 for the two ENERGY STAR-certified complexes in the "other" housing category is lower than the average HERS Indices for ENERGY STAR-certified apartment complexes, condominiums or senior housing complexes. Condominium complexes have the most energy-efficient windows, the highest average boiler efficiency, and the highest percentages of super high efficiency boilers and high efficiency central air conditioning. Rental and senior housing complexes stand out as the multi-family housing categories with the most potential for incorporating cost effective energy efficiency upgrades.

Table ES– 3: Energy Efficiency Characteristics—Complexes by Housing Type

Characteristic	Apartment Complexes (n=6)	Condos Complexes (n=6)	Senior Housing Complexes (n=5)	Other Complexes (n=3)
Number of ENERGY STAR-Qualified Complexes	4	6	5	2
Average HERS Index of ENERGY STAR Complexes	61	58	63	**54**
Average Wall Insulation R-value	20	20	19	**21**
Average Flat Ceiling Insulation R-value	39	40	40	**45**
Average Window U-value	0.34	**0.31**	0.32	0.32
Average Glazing % (Window/Wall Ratio)	21%	20%	21%	**16%**
Average Water Heating Energy Factor	0.82	0.85	0.81	**0.86**
Average Boiler AFUE/TE	89.1	**92.7**	88.3	89.4
Percent of Boilers Super High Efficiency	50%	**83%**	40%	33%
Percent with High Efficiency Central Air Conditioning*	0%	**75%**	50%	na**

*One apartment, four condominium, and two senior housing complexes have central air conditioned housing units.
**No housing units with central air conditioning.

Complex Building and Common Area Findings

RLW audited 28 buildings in 20 multi-family complexes. In several cases the individual audited buildings represent multiple buildings in a complex—the total number of buildings represented by the 28 audited buildings is 70. Findings include:

- All audited buildings have 2x6 wall construction.
- All audited buildings have double pane Low-E (43%) or double pane Low-E with argon (57%) windows.
- Building glazing percentages (window to wall ratio) range from 8% to 37%—the average is 17% and the median is 16%. (RBES maximum allowable glazing percentages under prescriptive RBES compliance paths range from 15% to 30% for multi-family buildings, depending on the compliance path and package followed.) Three buildings in two complexes have over 30% glazing.
- Sixteen of the twenty complexes have non-basement common areas. All common area conditioned/ambient walls are insulated to at least R-19 (minimum prescriptive code requirement) and ceilings in all but two of the 14 complexes where ceiling insulation levels could be determined are insulated to at least R-38 (minimum prescriptive code requirement).
- Fifteen of the twenty complexes have heated common areas; 80% of the common area in these complexes is heated. Heating system efficiencies for these complexes range from TE 82.7% to AFUE 95.1; nine (60%) have super efficient boilers, three (20%) have high efficiency boilers, and three (20%) have low efficiency boilers.
- Six of the twenty complexes have air conditioned common areas; 75% of the common area in these complexes is air conditioned. Four of the cooling systems serving common areas are split systems, one is central, and one is wall mounted.[3]
- Eleven of the twenty complexes have water heaters in a common area. All the water heaters are integrated tanks—there is no solar water heating.
- Eighteen of the twenty complexes have common area exterior lighting; eleven of these complexes use multiple types of lighting in different areas. Metal halide lights are most common, next most common are CFLs, followed by T8s, high pressure sodium lamps, and incandescent bulbs.
- Fifteen of the twenty complexes have more than one type of exterior lighting control; eleven of the complexes have timers, eight have photocells, and three have both timers and photocells. Two of the complexes have a portion of their exterior lighting

[3] Auditors did not collect efficiency information on the cooling systems serving common areas, only on the systems serving the individual audited units. Audited units in two of the complexes with cooled common areas are not air conditioned, so we have no idea of what the efficiencies are of the cooling systems (one wall mounted and one split system) serving the common areas in these complexes. In three additional complexes the audited individual units in the complexes are air conditioned, but the cooling systems serving the individual units are split systems and the systems serving the common areas are not; in one of these complexes the split system equipment serving audited individual units is low efficiency, in one the equipment is standard efficiency, and in one the equipment is high efficiency. Only one of the complexes with air conditioned common area has the same type of cooling system for both common area and individual units; the systems serving the individual units are high efficiency SEER 14 central air conditioners.

continuously on, and one complex has a manual switch for a portion of their exterior lighting.

The most frequent interior common area spaces with lighting are hallways, stairs, lobbies, and laundry rooms. CFLs are installed in 72% of the fixtures in common areas, representing 65% of installed light bulbs; T8 fluorescent tubes are installed in 26% of the fixtures, representing 34% of light bulbs. Thus, nearly all interior light bulbs are either CFLs or T-8 fluorescent tubes.

Multi-family Unit Audits

This section summarizes the results of the individual unit audits and compares them to the results of the new construction single-family home audits. RLW audited 38 individual housing units—one to three units in each of the 20 audited complexes. The average size of the audited multi-family units is 1,058 square feet of conditioned space, which is 42% of the new single-family home average of 2,507 square feet. In addition, the multi-family units have smaller sized households; the average number of night-time occupants in 24 occupied multi-family units is 1.5 versus an average of 2.6 night-time occupants in 102 audited new single-family homes.

All differences between multi-family units and single-family homes that are statistically significant at the 90% confidence level are marked in the tables. Unless otherwise noted, the single-family home results are weighted state-level results. In general, audited multi-family units appear to have more energy-efficient characteristics than audited single-family homes. This is likely a reflection of the higher percentage of audited multi-family units compared to audited single-family homes being ENERGY STAR certified (82% vs. 28%).

Conditioned/Ambient Wall Insulation. The most common type of wall insulation found at both multi-family and single-family audited sites is fiberglass batts—89% of multi-family units and 67% of single-family homes. Table ES– 4 shows that all audited multi-family units have at least R-19 conditioned/ambient wall insulation, but are less likely than audited single-family units to have more than R-19 insulation (13% vs. 28%). The range of insulation levels observed is much narrower for the multi-family units (R-19 to R-25 for multi-family units compared to R-7[4] to R-48 for single-family homes), but the average and median insulation levels are very similar; the average multi-family and single-family wall insulation levels are R-20 and R-21, respectively, and the median for both multi-family units and single-family homes is R-19, which is the minimum required under RBES prescriptive code compliance paths. Only five units in three multi-family complexes have conditioned/ambient wall insulation exceeding R-19: three units in a co-housing project have R-25 fiberglass batts, one unit in a luxury condominium complex has R-25 rigid foam, and one unit in an apartment complex has R-22 rigid foam wall insulation.

Table ES– 4: Conditioned/Ambient Wall Insulation Levels

Conditioned/Ambient Wall Insulation R-value	Multi-family Units		Single-family Homes
	Number (n=38)	Percent (n=38)	Percent (n=106)
Less than R-19	0	0%*	5%*
R-19	33	87%*	67%*
>R-19	5	13%*	28%*
R-value Statistics			
Minimum R-value	19		7
Maximum R-value	25		48
Average R-value	20*		21*
Median R-value	19		19

*Significantly different at the 90% confidence level

Flat Ceiling Insulation. The most common type of insulation found in flat ceilings at both multi-family and single-family audited sites is cellulose—58% of multi-family units and 45% of single-family homes. Table ES– 5 shows that auditors were unable to determine the level of ceiling insulation for four audited multi-family units and that an additional four units have less than R-38 insulation, which is the RBES required minimum under prescriptive compliance paths. The four multi-family units with less than R-38 insulation are ENERGY STAR certified and are reported to have cellulose insulation with R-values of 36 or 37, which are so close to R-38 that they may simply reflect settling where the insulation depth was measured. Similar to wall insulation, the range of ceiling insulation levels observed is much narrower for multi-family units (R-36 to R-57) compared to single-family homes (R-19 to R-100[5]), but the average and median insulation levels are very similar; the average multi-family and single-family flat ceiling insulation levels are R-41 and R-39, respectively, and the median for both multi-family units and single-family homes is R-38. Thirteen units (11 ENERGY STAR and 2 non-ENERGY STAR) in six multi-family complexes have cellulose or rigid foam flat ceiling insulation with an R-value

[4] A log home.

[5] Only one audited single-family home has R-100 flat ceiling insulation (over 30 inches of blown in cellulose), the next highest flat ceiling insulation level in audited single-family homes is R-70 blown in cellulose.

greater than R-38: two non-ENERGY STAR units in a duplex have R-57 cellulose, one luxury condominium has R-50 cellulose, one unit in an apartment complex and three units in a senior housing complex have R-44 cellulose, three units in a condominium project have R-42 rigid foam, and three units in a co-housing project have R-40 cellulose ceiling insulation.

Table ES– 5: Flat Ceiling Insulation Levels

Flat Ceiling Insulation R-value	Multi-family Units		Single-family Homes
	Number (n=38)	Percent (n=38)	Percent (n=94)
Less than R-38	4	11%*	26%*
R-38	17	45%	46%
>R-38	13	34%	28%
Unknown	4	11%	0%
R-value Statistics			
	(n=34)		(n=94)
Minimum R-value	36		19
Maximum R-value	57		100
Average R-value	41*		39*
Median R-value	38		38

*Significantly different at the 90% confidence level

Windows. At the complex level (20 complexes), 65% have double pane Low-E and 35% have double pane Low-E with argon windows; findings for the audited multi-family units are very similar. Table ES– 6 shows that, at the individual unit or home level, multi-family units are slightly more likely than single-family homes to have double pane Low-E windows (63% vs. 58%) or Low-E with argon windows (37% vs. 33%); the only significant difference is that 6% of audited single-family homes have double pane clear windows and none of the audited multi-family units have double pane clear windows

Table ES– 6: Type of Window Glazing

Window Glazing	Multi-family Units		Single-family Homes
	Number (n=38)	Percent (n=38)	Percent (n=105)
Double Pane Low-E	24	63%	58%
Double Pane Low-E Argon	14	37%	33%
Double Pane (clear)	0	0%*	6%*
Triple Pane Low-E Argon	0	0%	2%

*Significantly different at the 90% confidence level

The average U-value of windows is lower (more energy efficient) in audited multi-family units than in audited single-family homes (U-0.32 vs. U-0.34). Windows in audited multi-family units, compared to windows in audited single-family homes, are more likely to have vinyl frames (74% vs. 42%) and slightly more likely to have a thermal break (89% of multi-family units versus 84% of single-family homes).

Glazing percentages (window area as a percentage of exterior wall area) tend to be higher in multi-family buildings than in single-family homes. RBES maximum allowable glazing percentages under prescriptive compliance paths range from 12% to 18% for single-family homes and from 15% to 30% for multi-family buildings, depending on the compliance path and package followed. Auditors reported glazing percentages for 68 of the 70 multi-family-complex buildings represented by the 28 individual buildings audited. Three buildings in two complexes have glazing percentages over 30%—two buildings in an apartment complex (33% glazing) and one building in a condominium complex (37% glazing). Table ES– 7 shows that the average glazing percentage is 17% for multi-family buildings and 13% for single-family homes, and that the median glazing percentage is 16% for multi-family buildings and 13% for single-family homes.

Table ES– 7: Building Glazing Percentages

Glazing Percentage	Multi-family Buildings Percent (n=68)	Single-family Homes Percent (n=105)
Minimum Glazing %	8%	5%
Maximum Glazing %	37%	30%
Average Glazing %	17%*	13%*
Median Glazing %	16%	13%

*Significantly different at the 90% confidence level.

Below Grade Foundation Wall Insulation. RBES prescriptive compliance paths require that below grade foundation walls be insulated to at least R-10. Auditors were unable to determine the level of foundation wall insulation in four of 22 multi-family units with below grade foundation walls. Table ES– 8 shows that in 73% of single-family homes and 88% of multi-family units with known insulation levels, the foundation walls are insulated to at least R-10. The average foundation wall insulation level is R-11 in both multi-family units and single-family homes; the median foundation wall insulation level is R-10 for multi-family units and R-11 for single-family homes. Again, the average and median insulation levels are very close to prescriptive code requirements.

Table ES– 8: Below Grade Foundation Wall Insulation

Below Grade Foundation Wall Insulation R-value (Units and Homes with Known Insulation Levels)	Multi-family Units Number (n=18)	Multi-family Units Percent (n=18)	Single-family Homes Percent (n=88)
No Insulation	1	6%*	22%*
< R-10	1	6%	6%
=R-10	8	44%*	14%*
>R-10	8	44%	59%
R-value Statistics —Units and Homes with Known Insulation Levels			
Minimum R-value	0		0
Maximum R-value	14		35
Average R-value	11		11
Median R-value	10		11

*Significantly different at the 90% confidence level.

Slab Insulation. RBES prescriptive compliance paths require slab on grade floors to have at least R-10 perimeter insulation and slab edge insulation. Auditors were able to determine the level of slab (on or below grade) insulation in the buildings of 28 audited multi-family units. Table ES– 9 shows that, of sites with known slab insulation levels, multi-family units are much less likely to be in a building with no slab insulation than single-family homes (4% vs. 34%). Similar percentages of multi-family units and single-family homes have slab insulation levels exceeding R-10—43% of multi-family units and 38% of single-family homes. The average slab insulation level is higher in multi-family units than in single-family homes (R-11 vs. R-8); the median slab insulation level for both multi-family units and single-family homes is R-10.

Table ES– 9: Slab Insulation

Slab Insulation R-values	Multi-family Units		Single-family Homes
	Number (n=28)	Percent (n=28)	Percent (n=84)
No Insulation	1	4%*	34%*
< R-10	5	18%	12%
=R-10	10	36%*	16%*
>R-10	12	43%	38%
R-value Statistics —Units and Homes with Known Insulation Levels			
Minimum R-value	0		0
Maximum R-value	14		30
Average R-value	11*		8*
Median R-value	10		10

*Significantly different at the 90% confidence level

Heating Systems. All audited multi-family complexes have boiler heating systems. Of the 20 audited complexes, 35% heat with natural gas, 35% with propane, 25% with oil, and 5% with pellets (oil boiler backup). Audited multi-family complexes are much more likely than audited single-family homes to heat with natural gas (35% vs. 10%) and less likely to heat with propane (35% vs. 49%) or oil (25% vs. 39%). The higher penetration of natural gas in multi-family complexes simply reflects a higher proportion of multi-family complexes being located in areas with access to natural gas; as with single-family homes, all audited multi-family complexes with access to natural gas have natural gas heating systems.

Auditors reported efficiencies for heating systems serving multi-family-complex common areas and audited multi-family units. Heating system efficiencies for the audited multi-family units range from TE 82.7 to AFUE 95.4. Over one-half (58%) of audited units are served by super high efficiency heating systems.

Table ES– 10 shows boiler efficiency statistics for the 38 audited multi-family units and 86 single-family homes with gas or oil boilers. As shown, the average AFUE/TE of gas boilers is higher for multi-family units than single-family homes (AFUE/TE 92.8 vs. AFUE 88.4), the average AFUE/TE of oil boilers is lower for multi-family units than single-family homes (AFUE/TE 84.5 vs. AFUE/TE 85.9), and the average AFUE/TE over all gas and oil boilers is higher for multi-family units than single-family homes (AFUE/TE 90.2 vs. AFUE 87.4).

Table ES– 10: Boiler AFUE or Thermal Efficiency

Boiler AFUE or Thermal Efficiency	Natural Gas and Propane Boilers		Oil Boilers		All Gas and Oil Boilers	
	Multi-family Units (n=26)	Single-family Homes (n=50)	Multi-family Units (n=12)	Single-family Homes (n=36)	Multi-family Units (n=38)	Single-family Homes (n=86)
Min AFUE or TE	87.2	80.5	82.7	83.3	82.7	80.5
Max AFUE or TE	95.4	95.2	86.2	87	95.4	95.2
Average AFUE or TE	92.8*	88.4*	84.5*	85.9*	90.2*	87.4*
Median AFUE or TE	93.2	87.2	85.0	86.2	92.8	86.6

*Significantly different at the 90% confidence level.

Table ES– 11 allocates all boilers serving individual audited multi-family units and audited single-family homes into one of four efficiency categories—low, standard, high or super high efficiency. As shown, multi-family units compared to single-family homes are less likely to have high efficiency boilers (29% vs. 65%) and more likely to have super high efficiency boilers (58% vs. 20%); these differences are statistically significant. Of the seven non-ENERGY STAR multi-family units audited, five have super high efficiency boilers and two have high efficiency boilers.

Table ES– 11: All Boilers by Efficiency Category

Boiler Efficiency Category	Boiler AFUE or TE* Efficiency Levels	All Gas and Oil Boilers	
		Percent Multi-family Units (n=38)	Percent Single-family Homes (n=86)
Oil and Gas Boiler ENERGY STAR Minimum AFUE 85 Vermont Prescriptive Code Minimum AFUE 84			
Low Efficiency	Gas or Oil < 84	13%	6%
Standard Efficiency	Gas or Oil 84 to < 85	0%**	9%**
High Efficiency	Gas 85 to 90 Oil 85 to 87	29%**	65%**
Super High Efficiency	Gas >90 Oil > 87	58%**	20%**

*Thermal Efficiency

**Significantly different at the 90% confidence level.

Cooling Systems. Twenty of the 38 inspected multi-family housing units have some type of air conditioning. Six units in four complexes have only window or wall mounted air conditioners

and fourteen units in seven complexes have central air conditioning—six of the central systems in two complexes are water source heat pumps. Of the six water source heat pump cooling systems, which do not have SEER ratings, three in one complex are EER 13 and COP 3.8 and three in another complex are EER 12 and COP 4.3. Keeping in mind the low number of observations, Table ES– 12 shows that the average EER of room and wall mounted air conditioners is slightly higher for multi-family units than for single-family homes (EER 10.5 vs. EER 10.1), and the average SEER of central air conditioners is higher for multi-family units than for single-family homes (SEER 13.4 vs. SEER 12.6).

Table ES– 12: Air Conditioning Efficiency

Cooling System Efficiency (air conditioners with known EER or SEER)	Window and Wall Mounted EER		Central AC SEER	
	Multi-family AC Units (n=4)*	Single-family AC Units (n=25)	Multi-family AC Units (n=7)**	Single-family Raw Data AC Units (n=11)
Min Efficiency	10.2	8.0	10.0	10.8
Max Efficiency	10.8	10.8	19.0	15.0
Average Efficiency	10.5*	10.1*	14.9*	12.7*
Median Efficiency	10.5	10.0	14.0	13.0

*No EER information available for three of the seven window/wall units
**No SEER information available for one of the eight central air conditioning systems.
***Significantly different at the 90% confidence level.

Table ES– 13 allocates all cooling equipment serving individual audited multi-family units and single-family homes into one of four efficiency categories—low, standard, high or unknown efficiency. As shown, multi-family units compared to single-family homes are less likely to have standard efficiency air conditioning (33% vs. 46%) and more likely to have high efficiency air conditioning (38% vs. 10%). Of the seven non-ENERGY STAR units audited, six have standard efficiency cooling equipment and for one unit the efficiency of the cooling equipment is unknown.

Table ES– 13: All Cooling Equipment by Efficiency Category

Air Conditioning Efficiency Category	Air Conditioning Efficiency Levels	Air Conditioning Units	
		Percent Multi-family AC Units ((n=21)	Percent Single-family AC Units ((n=50)
Low Efficiency	CAC* SEER <13	10%	16%
Standard Efficiency	Non-ENERGY STAR Window/Wall Units CAC SEER = 13 WSHP = EER 12 COP 4.3	33%	46%
High Efficiency	ENERGY STAR and/or CAC SEER ≥14 to 15	38%**	10%**
Unknown Efficiency		19%	28%

*Central Air Conditioner
**Significantly different at the 90% confidence level.

Water Heating. All but four of the 38 audited multi-family units have integrated tank water heating; two have electric stand alone tanks and two have natural gas instantaneous water heaters. Table ES– 14 shows water heater Energy Factor statistics for all multi-family and single-family audited sites and, separately, for those with integrated tanks. Looking at all water heaters, the average and median Energy Factors for multi-family units are measurably higher than for single-family homes (0.83 vs. 0.76 average and 0.85 vs. 0.79 median). The lower average single-family Energy Factor reflects some single-family homes having inefficient tankless coil water heating. Looking at only gas and oil integrated tanks, again the multi-family Energy Factors are higher than the single-family Energy Factors (0.83 vs. 0.81 average and 0.85 vs. 0.80 median). Integrated tank water heating Energy Factors for multi-family units are less likely to be 0.78 to 0.85 and more likely to be in the over 0.85 to 0.90 range than in single-family homes.

Table ES– 14: Water Heating Energy Factors

Water Heating Energy Factors	All Water Heaters		Integrated Tank Water Heating	
	Multi-family Units (n=38)	Single-family Homes (n=106)	Multi-family Units (n=34)	Single-family Homes (n=78)
Less Than 0.78	13%*	28%*	15%	13%
0.78 to 0.80	18%*	37%*	21%*	49%*
> 0.80 to 0.85	11%	16%	6%*	18%*
> 0.85 to 0.90	53%*	17%*	59%*	21%*
Over 0.90	5%	2%	0%	0%
Water Heating Energy Factor Statistics				
Min Energy Factor	0.76	0.40	0.76	0.74
Max Energy Factor	0.92	0.95	0.88	0.88
Average Energy Factor	0.83*	0.76*	0.83*	0.81*
Median Energy Factor	0.85	0.79	0.85	0.80

*Significantly different at the 90% confidence level

Appliances. Multi-family units are only about half as likely as single-family homes to have dishwashers, clothes washers and dryers, separate freezers or second refrigerators (Table ES–15). The lower proportion of multi-family units with clothes washers and dryers reflects access to common laundry areas in several complexes. Table ES– 16 shows that clothes washers and separate freezers are more likely to be ENERGY STAR labeled in multi-family units (53% vs. 48% of clothes washers and 20% vs. 12% of separate freezers); dishwashers and refrigerators are less likely to be ENERGY STAR labeled in multi-family units (57% vs. 69% of dishwashers and 26% vs. 30% of refrigerators).

Table ES– 15: Appliance Saturations

Appliance	Multi-family Units		Single-family Homes
	Number (n=37)	Percent (n=37)	Percent (n=105)
Dishwasher	21	57%*	92%*
Clothes washer	17	46%*	97%*
Clothes dryer	16	43%*	94%*
Appliance	**Occupied Multi-family Units**		**Single-family Homes**
	Number (n=26)	Percent (n=26)	Percent (n=105)
Separate freezer	5	19%	33%
Second refrigerator	2	8%*	19%*

*Significantly different at the 90% confidence level.

Table ES– 16: ENERGY STAR Appliances

Appliance	Multi-family Units		Single-family Homes	
	Number of Appliances	Percent ENERGY STAR	Number of Appliances	Percent ENERGY STAR
Dishwashers	21	57%	96	69%
Clothes washers	17	53%	101	48%
Refrigerators	39	26%	125	30%
Separate freezers	5	20%	36	12%

Lighting. All audited multi-family units have screw-in CFLs installed, compared to 81% of audited single-family homes (Table ES– 17), which is consistent with all but two of the audited multi-family units being in complexes that worked with EVT. Multi-family units are less likely than single-family homes to have screw-in CFL bulbs in storage (8% vs. 28%). Thirteen percent of both multi-family units and single-family homes have dimmable incandescent bulbs installed.

Table ES– 17: Proportion of Homes with CFL Bulbs and Dimmable Bulbs

Type of Bulb	Multi-family Units Percent (n=38)	Single-family Homes Percent (n=105)
Screw-in CFLs Installed	100%*	81%*
Screw-in CFLs in Storage	8%*	28%*
Dimmable Incandescent Bulbs Installed	13%	13%

*Significantly different at the 90% confidence level.

Audited multi-family units have a higher proportion of CFL bulbs than audited single-family homes. Table ES– 18 shows that at least 11% of bulbs in all audited multi-family units are CFL bulbs while 19% of audited single-family homes have no CFL bulbs installed and an additional 18% have less than 11% CFL bulbs. In roughly two-thirds (66%) of audited multi-family units over one-half of installed bulbs are CFLs compared to only 24% of single-family homes.

Table ES– 18: Proportion of CFL Bulbs Installed

Proportion of CFL Bulbs Installed	Multi-family Units Percent (n=38)	Single-family Homes Percent (n=105)
None	0%*	19%*
1% to 10%	0%*	18%*
11% to 25%	16%	20%
26% to 50%	18%	19%
51% to 100%	66%*	24%*

*Significantly different at the 90% confidence level.

The average square feet of heated area in audited multi-family units (1,058 square feet) is 42% of the average square feet of heated area in audited single-family homes (2,057 square feet). Similarly, the average number of total bulbs installed in audited multi-family units (21.2 bulbs) is 38% of the average number of total bulbs installed in audited single-family homes (56.3 bulbs). However, as shown in Table ES– 19, the proportion of all bulbs that are CFLs is almost twice as high in multi-family units (61%) as in single-family homes with CFL bulbs (33%) and more than twice as high as in all single-family homes (25%).

Table ES– 19: Average, Median, and Proportion of CFL Bulbs Installed

Proportion of CFL Bulbs Installed	Multi-family Units	Single-family Homes	
	Percent (n=38)	Percent (n=81 homes with CFL bulbs)	Percent (n=105 all homes)
Average Number of CFLs	13.0*	17.4*	14.2
Median Number of CFLs	11.0	12.0	8.0
Average Number of all Bulbs	21.2*	56.1*	56.3*
Proportion of Screw-in Bulbs that are CFLs	61%*	33%*	25%*

*Significantly different at the 90% confidence level.

Table ES– 20 shows that audited multi-family units are more likely than audited single-family homes to have T8 fluorescent fixtures (68% vs. 35%) and Circline fixtures (58% vs. 13%) and less likely to have T12 fluorescent fixtures (5% vs. 20%).

Table ES– 20: Proportion of Homes with Fluorescent Fixtures

Homes with Fluorescent Fixtures	Multi-family Units	Single-family Homes
	Percent (n=38)	Percent (n=105)
T12	5%*	20%*
T8	68%*	35%*
T5	11%	10%
Circline	58%*	13%*

*Significantly different at the 90% confidence level.

Remainder of Report

The remainder of this report presents the detailed results of the on-site audits and on-site tenant/owner questionnaire. The next report in this series—the overall report on multi-family new construction—will integrate the results of the multi-family on-site audits and interviews with multi-family decision makers.

1 Introduction

On-site audits were conducted of 28 buildings and 38 individual dwelling units in 20 multi-family complexes. In several cases the individual audited buildings represented multiple similar buildings in a complex resulting in the 28 audited buildings representing 70 buildings.

1.1 Sampling

In order to identify newly constructed multi-family buildings in Vermont, we obtained a list of newly constructed buildings, or buildings under construction, from the Vermont Division of Fire Safety (DFS), which reviews fire safety plans. The list included project name, town, number of units, and description but did not include contact information. Efficiency Vermont (EVT) was able to provide contact information for some projects and Internet searches produced contact information for other projects. The DFS list identified just over 90 unique projects, and we were able to find contact information for nearly all projects; however, in some cases the contact information was out of date. A substantial portion of the projects did not qualify for an audit because they did not meet our multi-family building definition (most were single-family attached buildings) or were still under construction. In the end, an estimated 57 multi-family projects qualified for the study.

Eligible newly constructed multi-family 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. In addition, eligible buildings include:

- Existing buildings that underwent a major renovation that included gutting the building and replacing major systems—heating, lighting, building shell, etc. Renovations limited to interior remodeling do not qualify.
- Mixed use buildings if the square footage is 50% or more residential
- Institutional housing units, including educational and age-restricted (senior housing)

A total of 38 audits of individual units were conducted at 20 different complexes. In the complexes where multiple units were audited, units with different layouts and glazing percentages were targeted. In addition, tenants and owners often dictate the type and number of lighting, appliances, and electronics installed. Because the multi-family new construction market in Vermont is relatively small and the project's definition of multi-family buildings excludes many side-by-side buildings, this approach was adopted in order to gather more information on the complexes visited.

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

The coefficient of variation is of central importance to determining the final precisions. A primary objective of this study is to document the existing building and equipment status of new

multi-family housing units by feature. Since there is no single variable that quantifies a housing unit's construction features, we identified results that we believe are influential in the determination of a unit's overall efficiency. Table 1–1 lists these key parameters along with the coefficient of variation associated with their measurement. Based on these coefficients, we used the poorest coefficient of variation (0.13) to provide a sense of the precision around the final results. Using a coefficient of variation of 0.13 the estimated relative precision is ± 3.4% at the 90% confidence level.

Table 1–1: Coefficients of Variation for Key Measurements

Parameter	Coefficient of Variation
Conditioned/Ambient Wall Insulation (R-value)	0.10
Ceiling Insulation (R-value)	0.13
Heating System Efficiency (AFUE/TE)	0.05
Water Heating Energy Factor	0.05

1.2 Recruiting

On-site sample recruitment and scheduling was performed by RLW Analytics, Inc. (RLW) staff. The following steps were undertaken to minimize customer intrusion, improve recruiting rates, and minimize bias in the selection of homes visited.

- *Use of incentives.* An incentive of $50 was offered to property managers and owner occupants or tenants (if the unit was occupied).
- *Confirmation Calls.* Each scheduled appointment was called approximately 48 hours before the visit to confirm the appointment.

RLW recruited every potential site for which they had contact information and where someone was willing to allow an on-site audit. Potential candidates were contacted multiple times if necessary to explain the purpose of the project and the on-site audit and to encourage participation; however, despite multiple calls and conversations, some candidates were simply not interested in participating. Of the 37 eligible projects that refused, 70% participated in EVT programs; this compares to a 95% participation rate among the 20 projects that did agree to on-site inspections.

1.3 On-site Audit Data Collection

The on-site audits included collecting information at three different levels: multi-family building (28 individual buildings audited representing 70 buildings), common area, and individual housing unit (38 individual housing units audited). Site contacts at each audited complex provided information on property ownership and management, and involvement with utility programs during project development and construction. In addition, tenants and owners were

asked to complete a short questionnaire to assess obstacles to their improving the energy efficiency of their home based on the findings of the on-site audit. No blower door or duct blaster testing was conducted as part of the multi-family audits.

Building Level Data Collection. At the building level, auditors collected the following information on each unique building type in a complex:

- Building purpose, age, number of similar buildings, and number of individual housing units per building
- Building footprint square footage, number of stories, and total square footage
- Common area square footage, including retail and garage space
- Type of construction, type of windows, glazing percentage, and wall and attic insulation R-value

Common Area Data Collection. For common areas in each unique building type, auditors collected the following information:

- Percentage of common area heated, heating fuel, type of heating system and heating system efficiency
- Percentage of common area cooled and type of cooling system
- Type of water heater(s), if any, in common areas
- Clothes washer information
- Exterior lighting information
- Interior lighting information

Housing Unit Data Collection. The data collection form used at the individual housing unit level is the same form used for newly constructed single-family homes. Data collected includes:

- *General Information.* Primary or seasonal residence, etc.
- *Basic Home Characteristics.* Total square footage, number of stories, type of basement (if applicable), conditioned space square footage, etc.
- *Building Envelope.* Wall, ceiling, floor, foundation wall, and slab construction (if applicable), square footage, insulation type and level, etc., and glazing type, square footage, orientation, U-value, etc.
- *Heating, Cooling and Water Heating Equipment.* Manufacturer and model, age, type, location, fuel, size, and efficiency
- *Supplemental Heating.* Number of fireplaces, stoves and portable space heaters and what fuel they use
- *Heating and Cooling Distribution Ducts.* Duct type (supply or return), location, insulation type and level, and how sealed
- *Appliances in the Home.* Dishwashers, clothes washers, clothes dryers, ranges, ovens, refrigerators, freezers, televisions, and computers. Data collected include make and model, type, age, general use, approximate age and, when available, appliance size and efficiency.

- *Lighting*. Main area lighting fixture inventory including all plug-in fixtures. Includes a count by type of bulb and fixture, wattages, control types, and number of sockets

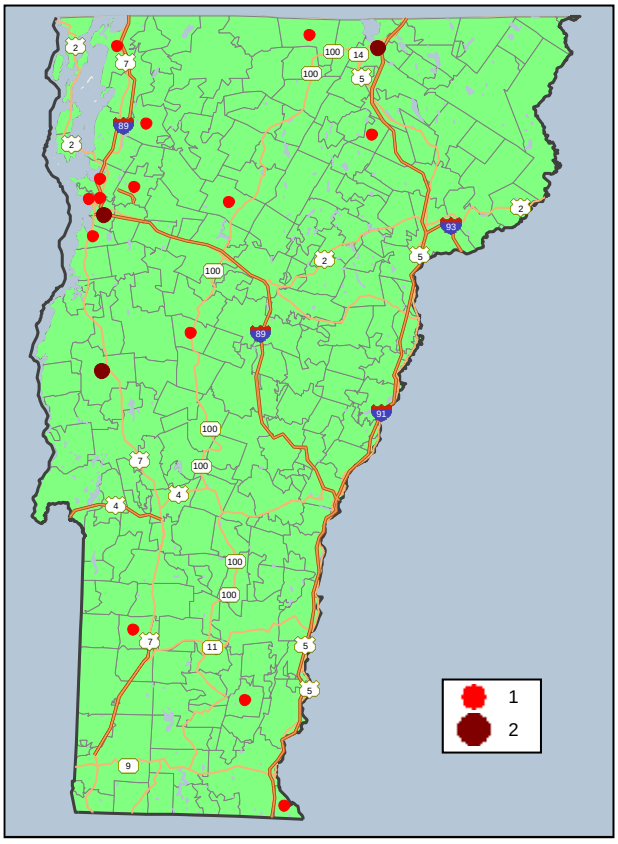
Brief Tenant/Owner questionnaire. If the housing unit was occupied, and the tenant/owner was on site, a short questionnaire was administered to the tenant/owner to assess their views on obstacles to improving the efficiency of their unit based on the findings of the on-site inspection.

Data cleaning. As part of the data review process, the NMR team reviewed the population of data in each audit data field for reasonableness and consistency. Questions were referred to the RLW audit team leader for resolution. In addition, because it is difficult to determine the type of glazing in windows if the National Fenestration Rating Council (NFRC) sticker has been removed, EVT provided window U-values for the 19 audited complexes they worked with.

1.4 The Sample

Multi-family projects in 17 towns across the state were audited. Figure 1–1 shows the location of the on-site audits. Six audits were conducted on projects in towns that are in the geographically targeted regions of northern Vermont: Burlington, Colchester, Essex Junction, Newport, and Winooski. Program staff verified that the VESH Program has not conducted any special marketing in the geographically targeted regions and that the incentives available in the targeted regions are the same as in the rest of the state.

Figure 1–1: Location of Multi-family On-site Audits



2 Complexes

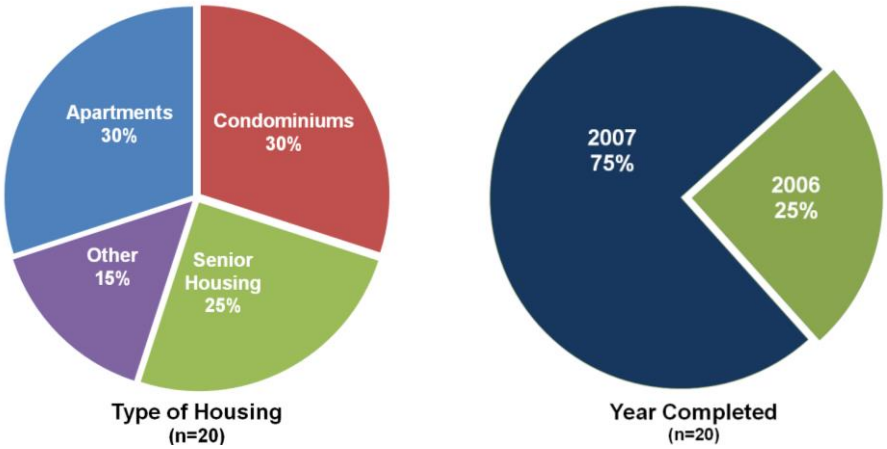
RLW completed audits on 28 buildings (representing 70 buildings) and 38 housing units in 20 multi-family complexes. Table 2–1 shows that almost one-half (45%) of the audited properties are owned by private partnerships, 40% by private single owners, 10% by non profits, and one (5%) by a condominium association. Close to three-fourths of the properties (70%) are managed by the property owner or an agency; 20% are managed by a property management firm; one property, a college dormitory, is managed by the college; and one condominium complex is managed by the homeowners association. All but one of the 20 audited projects worked with EVT—site contacts at 17 of the 20 audited projects said they worked with EVT, and EVT verified that they worked with an additional two projects where the site contacts were not sure if they worked with EVT.

Table 2–1: Multi-family Complex Ownership, Management, and EVT Involvement

Property Ownership	How Property Managed	Worked with EVT	Number of Projects (n=20)	Percent of Projects (n=20)
Private Partnership	By owner or agency	Yes	7	35%
Private Partnership	College manages the building	Yes	1	5%
Private Partnership	Property management firm	Yes	1	5%
Private Single Owner	By owner or agency	Yes	4	20%
Private Single Owner	Homeowners association	Yes	1	5%
Private Single Owner	Property management firm	Yes	2	10%
Private Single Owner	By owner or agency	No	1	5%
Non Profit	By owner or agency	Yes	2	10%
Condominium Association	Property management firm	Yes	1	5%

Audited complexes represent several types of housing. Figure 2–1 shows 30% of the audited complexes are apartments, 30% are condominiums, and 25% are senior housing; the "other" category (15%) includes a college dormitory, a co-housing project, and a duplex. Most audited buildings (75%) were completed in 2007.

Figure 2–1: Audited Complexes by Type of Housing and Year Completed



2.1 Individual Complex Details

Table 2–2 provides details of the 20 individual audited complexes. Some buildings in eight of the audited complexes were completed in 2005, but only buildings completed in 2006 or later were audited, and all information in Table 2–2 relates only to buildings completed in 2006 or later. As shown, the number of buildings per complex completed in 2006 or 2007 ranges from one to 22 and the number of housing units per complex ranges from two to 74.[6] The number of individual units audited per complex ranges from one to three. The sizes of the individual complexes (total area all buildings completed in 2006 or 2007) range from 1,664 to 116,080 square feet; the overall total is 789,033 square feet. All but three audited complexes have common areas; overall, common areas account for 111,677 square feet or 14% of total building area. Only two complexes include retail space.

Table 2–2: Individual Complex Information

Project Description (n=20)	Total Buildings Represented	Total Units	Audited Units	Total Footprint all Buildings (Sq. Ft.)	Total Area all Buildings (Sq. Ft.)	Total Common Area (Sq. Ft.)	Total Retail Space (Sq. Ft.)
Apartments (Extended Stay Rentals)	1	35	2	7,260	21,780	2,865	0
Apartments	1	30	2	11,904	35,712	4,882	0
Apartments (Affordable)	1	26	2	14,270	28,540	4,642	0
Apartments	7	20	2	11,340	18,680	0	0
Apartments	1	4	1	2,600	5,200	480	0
Apartments	2	Unknown*	3	29,020	116,080	14,560	0
Condominiums	1	74	3	24,714	98,856	13,059	0
Condominiums	2	32	2	17,324	54,372	5,173	17,324
Condominiums (Vacation)	10	20	1	27,680	46,880	6,640	0
Condominiums (Vacation)	2	13	2	6,418	19,254	700	0
Condominiums	1	6	1	6,085	12,170	1,230	0
Condominiums	1	5	1	4,375	13,125	0	0
Senior Housing (With Long Term Care)	22	55	3	60,364	71,756	5,126	0
Senior Housing	2	52	3	18,882	45,074	13,044	0
Senior Housing	1	46	1	19,825	59,475	10,490	0
Senior Housing	1	24	1	11,076	22,152	7,364	0
Senior Housing	1	12	2	5,489	16,467	1,494	4,482
Dormitory Suites	7	40	1	18,360	55,080	9,144	0
Co-housing	5	32	3	17,208	46,716	10,774	0
Duplex	1	2	2	1,664	1,664	0	0
Totals:	**70**	**528**	**38**	**315,858**	**789,033**	**111,667**	**21,806**

*There are17 different types of units in this complex, the number of each type of unit is unknown.

[6] The number of units in the audited buildings in one complex is unknown. This is a complex offering 17 different apartment layouts and the total number of units in this complex is 213, but some of the units are in buildings completed in 2005, which were not audited, and the number of units in the audited buildings is not known.

2.2 Complex Building Shell Characteristics

In some instances auditors did not have access to specific building components and relied on information provided by the site contact, RBES certificate, or HERS rating sheet. Site contacts at 9 of the 20 audited complexes (45%) either were able to show the auditor an RBES certificate or a HERS rating sheet (5 complexes) or said they had received the RBES certificate but did not have it available to show the auditor (4 complexes). At eight of the remaining eleven complexes the site contacts were not sure if they had received an RBES certificate.

Complex Construction and Glazing. All audited buildings have 2x6 wall construction. RLW audited 28 individual buildings, but in several cases the individual audited buildings represent multiple buildings in a complex. The total number of buildings represented by the 28 audited buildings is 70. Table 2–3 shows the percentage of projects, the percentage of buildings, and the percentage of total building area with various types of windows. As shown 65% of projects, representing 43% of buildings and 68% of total building area, have double pane Low-E windows; 35% of projects, representing 57% of buildings and 32% of total building area, have double pane Low-E with argon windows. One-fourth (25%) of projects, representing 56% of buildings and 25% of total building area, have wood-framed windows; 75% of projects, representing 44% of buildings and 75% of total building area, have vinyl-framed windows.

Table 2–3: Window Glazing by Building, Complex, and Building Area

Window Type	Number of Projects (n=20)	Percent of Projects (n=20)	Number of Buildings (n=70)	Percent of Buildings (n=70)	Percent of Total Building Areas (n=789,033 Sq. Ft.)
Double Pane Low-E: Vinyl Frame	10	50%	23	33%	58%
Double Pane Low-E: Wood Frame	3	15%	7	10%	10%
Double Pane Low-E with Argon: Vinyl Frame	5	25%	8	11%	17%
Double Pane Low-E with Argon: Wood Frame	2	10%	32	46%	15%
Total Double Pane Low-E	13	65%	30	43%	68%
Total Double Pane Low-E with Argon	7	35%	40	57%	32%
Total Wood Frame	5	25%	39	56%	25%
Total Vinyl Frame	15	75%	31	44%	75%

Auditors were able to determine glazing percentages for 68 of 70 buildings. The percentage of glazing (window to wall ratio) in buildings ranges from 8% to 37%. Overall, the average glazing percentage in buildings is 17% and the median is 16%. Table 2–4 shows the number of buildings falling into different glazing percentage ranges and, because the size of individual buildings vary significantly, the percentage of total building area that the buildings in a given glazing percentage range represent. As shown, 77% of buildings (54 of 70) have glazing percentages of 20% or less; these are smaller buildings accounting for only 33% of total building area. Sixteen percent of buildings (11 of 70) have glazing percentages over 20% but not more

than 30%; these buildings account for 39% of total building area. Only four percent of buildings (3 of 70) have glazing percentages over 30%, but these are large buildings accounting for 27% of total building area. The three buildings with over 30% glazing are in two complexes, the largest two audited complexes in terms of total square footage. One of these complexes, with 33% glazing, is a two-building 116,080 square foot apartment complex with double pane Low E windows; the other complex, with 37% glazing, is a one-building 98,856 square foot condominium complex with double pane Low E windows. Thirteen percent of the total square footage in each of these two complexes is common area.

Table 2–4: Building Glazing Percentages

Percent Glazing	Number of Buildings (n=70)	Percent of Buildings (n=70)	Percent of Total Building Areas (n=789,033 Sq. Ft.)
<10%	1	1%	0.2%
10 to 12%	13	19%	8%
>12 to 15%	16	23%	12%
>15 to 18%	24	34%	13%
>18 to 20%	0	0%	0%
>20to 25%	5	7%	18%
>25to 30%	6	9%	21%
>30%	3	4%	27%
Unknown	2	3%	1%
Percent Glazing Statistics (n=68)			
Minimum% Glazing	8%		
Maximum % Glazing	37%		
Average % Glazing	17%		
Median % Glazing	16%		

3 Common Area Audits

For each of the 17 audited projects with common areas, auditors reported wall and attic insulation R-values; percentage of common area heated, heating fuel, type of heating system, heating system efficiency, percentage of common area cooled, and type of cooling system.

Auditors determined the type and thickness of insulation through visual inspection in most situations, if this was not possible they relied on RBES certificate information, HERS reports, or information provided by the site contact. If the auditor was not reasonably certain of making a reliable estimate, the insulation data field was left blank. In areas with differing R-values, the average R-value for the entire area was calculated using the method prescribed in the RBES Handbook.

3.1 Common Area Wall and Attic Insulation

Wall and attic insulation information was collected for 16 of the 17 projects with common areas; in one project the only common area is basement storage space. RBES prescriptive compliance paths require R-19 or higher above grade wall insulation. Table 3–1 shows that all projects with non-basement common areas have at least R-19 wall insulation; three-fourths (75%) have R-19 insulation and one-fourth (25%) have R-21 to R-25 wall insulation. The average wall insulation level is R-20 and the median is R-19. All projects with wall insulation exceeding R-19 are ENERGY STAR certified.

Table 3–1: Common Area Wall Insulation

Wall Insulation R-value	Number of Projects with Non-Basement Common Areas (n=16)	Percent of Projects with Non-Basement Common Areas (n=16)
Less than R-19	0	0%
R-19	12	75%
More than R-19	4	25%
Common Area Wall Insulation Statistics		
Minimum R-value	19	
Maximum R-value	25	
Average R-value	20	
Median R-value	19	

RBES prescriptive compliance paths require R-38 or higher attic (flat ceiling) insulation. Table 3–2 shows that two projects (13%) have less than R-38 attic insulation (one has R-36 and one has R-37), six (38%) have R-38 attic insulation, six (38%) have more than R-38 attic insulation (R-40 to R-50), and auditors were unable to determine the level of attic insulation in two projects with non-basement common areas. The average attic insulation level is R-40 and the median is R-38,. The two projects with less than R-38 ceiling insulation and the six projects with more than R-38 ceiling insulation are ENERGY STAR certified.

Table 3–2: Common Area Attic Insulation

Attic Insulation R-value	Number of Projects with Non-Basement Common Areas (n=16)	Percent of Projects with Non-Basement Common Areas (n=16)
Less than R-38	2	13%
R-38	6	38%
More than R-38	6	38%
Unknown	2	13%
Common Area Attic Insulation Statistics (n=16)		
Minimum R-value	36	
Maximum R-value	50	
Average R-value	40	
Median R-value	38	

3.2 Heated Common Areas

Fifteen of the audited projects have heated common areas: five apartment, three condominium, five senior housing projects; and the dormitory and co-housing projects. All 15 projects have boiler heating systems. Table 3–3 shows total common area square footage, the percent of common area heated, the square footage of heated common area, the heating fuel, and the heating system efficiency (AFUE or TE) for each project with heated common area. As shown, in ten (67%) of the projects with heated common area all common area is heated; in the five remaining projects, 33% to 90% of common area is heated. Senior housing projects are less likely than apartment or condominium projects to have all common area heated. Overall, 80% of the common area in the 15 projects with heated common areas is heated. The most frequently observed heating fuel is natural gas (47%, seven projects), followed by oil (33%, five projects—one with the oil boiler as backup to a pellet boiler), and propane (20%, three projects). Heating system efficiencies range from TE 82.7 to AFUE 95.1: 20% of the boilers are low efficiency, 20% are high efficiency, and 60% are super high efficiency. Two non-ENERGY STAR-certified projects have heated common area and both projects have super high efficiency boilers.

Table 3–3: Heated Common Area Information by Project

Project Type (n=15 projects with heated common area)	Total Common Area (Sq. Ft.)	Percent of Common Area Heated	Heated Common Area (Sq. Ft.)	Heating Fuel	Heating System (Boiler) AFUE or TE*
Apartments--Extended Stay Rentals	2,865	33%	945	Nat. gas	92.8
Apartments	4,882	100%	4,882	Oil	83.1
Apartments--Affordable	4,642	100%	4,642	Oil	82.7
Apartments	480	100%	480	Propane	95.1
Apartments	14,560	100%	14,560	Nat. gas	94.4
Condominiums	13,059	100%	13,059	Nat. gas	92.9
Condominiums	5,173	100%	5,173	Nat. gas	92.8
Condominiums	1,230	100%	1,230	Propane	95.1
Senior Housing & Long Term Care	5,126	100%	5,126	Nat. gas	95.1
Senior Housing	13,044	50%	6,522	Pellets/Oil	85.7
Senior Housing	10,490	39%	4,090	Propane	92.8
Senior Housing	7,364	90%	6,628	Oil	83.3
Senior Housing	1,494	100%	1,494	Oil	85
Dormitory Suites	9,144	40%	3,658	Nat. gas	87.2
Co-housing	10,774	100%	10,774	Nat. gas	93.4
Total or Average:	**104,327**	**80%**	**83,263**		**90.1**

*Thermal Efficiency

3.3 Common Area Cooling

Six of the 20 audited projects have air conditioned common areas: four senior housing projects, one apartment project, and one condominium project. Table 3–4 shows total common area square footage, the percent of common area air conditioned, the square footage of air conditioned common area, and the type of air conditioning system for each project with air conditioned

common area. As shown, all common areas in one senior housing project, the apartment project, and the condominium project are air conditioned. In three senior housing projects the percentage of common area cooled ranges from 32% to 61%. Overall, 75% of the common area in the six projects with cooled common areas is air conditioned. Four of the cooling systems are split systems, one is central, and one is wall mounted.

Table 3–4: Common Area Cooling

Project Type	Total Common Area (Sq. Ft.)	Percent of Common Area Cooled	Cooled Common Area (Sq. Ft.)	Cooling System Type
Apartments	14,560	100%	14,560	Split
Condominiums	13,059	100%	13,059	Split
Senior Housing & Long Term Care	5,126	100%	5,126	Central
Senior Housing	13,044	61%	7,896	Split
Senior Housing	10,490	32%	3,362	Wall Mount
Senior Housing	7,364	50%	3,682	Split
Total or Average:	**63,643**	**75%**	**47,685**	

3.4 Common Area Water Heaters

Eleven audited projects have water heaters in a common area. All the water heaters are integrated tanks; there is no solar water heating.

3.5 Common Area Lighting and Appliances

In this section, we present data on lighting and appliances installed in the interior common areas and lighting installed in the exterior common areas.

Exterior Lighting. Eighteen of the twenty complexes have common area exterior lighting; two complexes only have exterior lighting on the individual housing units. The areas that receive exterior lighting tend to most often be parking lots or garages, followed by walkways, building facades, and porches. Of the 18 complexes with common area exterior lighting, 11 use multiple types of lighting in different areas. Metal halide lights are most common, being used at 14 of the 20 complexes; next most common are CFLs (10 complexes) followed by T8s and high pressure sodium lamps (four complexes each). Incandescent bulbs are used at two complexes.

Fifteen complexes have more than one type of lighting control; eleven of the complexes have timers, eight have photocells, and three have both timers and photocells. Two of the complexes have a portion of their exterior lighting continuously on, and one complex has a manual switch for a portion of their exterior lighting.

Interior Lighting. The most frequent interior common area spaces with lighting are hallways (32% of spaces), stairs (26%), lobbies (9%), and laundry rooms (7%). CFLs are installed in 72%

of the 2,122 fixtures found in common areas, representing 65% of the 3,020 installed light bulbs. T8 fluorescent tubes are installed in 26% of the fixtures, representing 34% of light bulbs.

Clothes Washers. Eleven of the 20 complexes have buildings with common area laundry rooms that include a total of 52 clothes washers. Presumably, each common area that contained clothes washers also contained clothes dryers, although the audit did not collect data on clothes dryers.

4 Audited Multi-family Units

The on-site audits included collecting information on wall, attic, floor, foundation wall and slab insulation; windows and doors; space heating, space cooling, and water heating systems; and heating and cooling ducts. In some cases the audited multi-family units are above or below other units; in these cases, whenever possible, information is provided for building characteristics.

Almost all of the audited multi-family units (35 out of 38) are primary residences—two are seasonal and one is a timeshare. Table 4–1 shows that the size of audited multi-family units, measured in square feet of conditioned space, ranges from 255 to 2,471 square feet; only two units are smaller than 500 square feet (senior housing) and three over 2,000 square feet (condominiums). The average audited multi-family unit size is 1,058 square feet and the median is 932 square feet. The average size of audited multi-family units is less than one-half (42%) the average size of audited new single-family homes (2,507 square feet).

Table 4–1: Housing Unit Size—Conditioned (heated) Area

Conditioned (Heated) Area (Sq. Ft.)	Multi-family Units	
	Number (n=38)	Percent (n=38)
<500	2	5%
500 to 999	19	50%
1,000 to 1,499	10	26%
1,500 to 1,999	4	11%
2,000 to 2,499	3	8%
Conditioned Area Square Feet Statistics*		
Min Sq. Ft.	255	
Max Sq. Ft.	2,471	
Average Sq. Ft.	1,058	
Median Sq. Ft.	932	

4.1 Walls

All 38 audited units have 2x6 framed conditioned/ambient walls and two units have conditioned/garage walls. Table 4–2 shows that the conditioned/ambient walls in most (89%) of the audited units are insulated with fiberglass batts; the conditioned/garage walls in two units are also insulated with fiberglass batts (R-19). Two audited units have cellulose and two have rigid foam conditioned/ambient wall insulation.

Table 4–2: Type of Conditioned/Ambient Wall Insulation

Type of Conditioned/Ambient Wall Insulation	Multi-family Units	
	Number (n=38)	Percent (n=38)
Fiberglass Batts	34	89%
Cellulose	2	5%
Rigid Foam	2	5%

Table 4–3 shows that the average level of conditioned/ambient wall insulation is R-20 and the median is R-19; none of the inspected units have wall insulation levels lower than R-19, which is the minimum requirement under prescriptive RBES compliance paths. Thirty-three (87%) of inspected units have R-19 wall insulation and in five (13%) of the inspected units the wall insulation level exceeds R-19 (R-22 to R-25). All five units with greater than R-19 wall insulation are ENERGY STAR certified.

Table 4–3: Conditioned/Ambient Wall Insulation Levels

Conditioned/ Ambient Wall Insulation R-value	Multi-family Units	
	Number (n=38)	Percent (n=38)
Less than R-19	0	0%
R-19	33	87%
>R-19	5	13%
R-value Statistics*		
Minimum R-value	19	
Maximum R-value	25	
Average R-value	20	
Median R-value	19	

4.2 Ceilings

Auditors recorded information on ceiling construction and insulation. All the ceilings in the buildings where units were inspected are flat ceilings. Table 4–4 shows that for all but two of the inspected units the ceilings are constructed using trusses and for all but three units the flat joists are covered with insulation. Seven (18%) ceilings have a vapor barrier and 23 (61%) do not; in eight cases the auditor was unable to verify whether or not there was a vapor barrier.

Table 4–4: Ceiling Characteristics

Ceiling Construction	Multi-family Units		Flat Joists Covered with Insulation	Multi-family Units		Ceiling Vapor Barrier	Multi-family Units	
	Number (n=38)	Percent (n=38)		Number (n=38)	Percent (n=38)		Number (n=38)	Percent (n=38)
Truss	36	95%	**Yes**	35	92%	**Yes**	7	18%
2x10	2	5%	**No**	3	8%	**No**	23	61%
						Unknown	8	21%

Table 4–5 shows that 58% of the ceilings inspected are insulated with cellulose, 11% with fiberglass batts, and 11% with rigid foam; auditors were unable to determine the type of insulation in eight cases.

Table 4–5: Flat Ceilings Type of Insulation

Ceiling Insulation Type	Multi-family Units	
	Number (n=38)	Percent (n=38)
Cellulose	22	58%
Fiberglass Batts	4	11%
Rigid foam	4	11%
Unable to Determine	8	21%

Table 4–6 shows that four of the inspected units are in buildings with less than R-38 ceiling insulation, which is the minimum requirement under prescriptive RBES compliance paths. These four multi-family units are reported to have cellulose insulation with R-values of 36 or 37, which are so close to R-38 that they may simply reflect settling where the insulation depth was measured. Almost one-half of the inspected units (45%) have R-38 insulation and one-third (34%) have insulation exceeding R-38 (R-40 to R-57). Auditors were unable to determine the level of insulation in four cases. The overall average insulation level, based on the 34 units with known R-value ceiling insulation levels, is R-41 and the median level is R-38. The four units with less than R-38 ceiling insulation and 11 of the 13 units with greater than R-38 ceiling insulation are ENERGY STAR certified.

Table 4–6: Ceiling Insulation Levels

Ceiling Insulation R-value	Multi-family Units	
	Number (n=38)	Percent (n=38)
Less than R-38	4	11%
R-38	17	45%
>R-38	13	34%
Unknown	4	11%
R-value Statistics (n=34)		
Minimum R-value	36	
Maximum R-value	57	
Average R-value	41	
Median R-value	38	

4.3 Windows

For windows, auditors recorded the type of glazing and U-value, window area, frame material, type of window (operable, fixed, skylight), orientation, if windows had a thermal break, and if they had storm windows. All audited units have double pane Low-E or Low-E with argon windows; 74% have vinyl frames and 26% have wood frames. All the windows in audited units are operable and none have storm windows; windows in 89% of audited units have a thermal break.

Auditors were able to document window U-value information for only seven of the 38 audited units. EVT was able to document the U-value for 36 of the 38 audited units. For two units, auditors reported the type of glazing, but not the U-value. When documentation on the type of glazing and/or U-value is not available, auditors use a Low-E coating detector to determine if windows are Low-E and make their best guess as to whether or not windows are argon filled. Assuming auditors correctly identify the type of glazing, default U-values based on the type of glazing can be used to estimate the average U-value of windows in inspected units. The default U-values for operable windows provided in the Vermont Residential Building Code Handbook appear inconsistent with windows currently on the market. All default U-values in the handbook are higher than the ENERGY STAR level for Vermont (U-0.35): the lowest default U-value is 0.37 for a vinyl/wood framed operable window with double pane Low-E with argon glazing.

Table 4–7 shows the Vermont Residential Building Code Handbook default U-values and the default U-values that more closely reflect the U-values of currently available windows used to estimate the average U-value of windows in inspected units.[7]

Table 4–7: Default Window U-values

Glazing → Frame ↓	Single Pane	Double Pane	Double Pane Low-E	Double Pane Low-E with Argon
Vermont Residential Building Code Handbook default U-values				
Wood/Vinyl	0.94	0.56	0.40	0.37
Updated Default U-values				
Wood/Vinyl	.094	0.48	0.35	0.31

Using the default U-values described above for the two units without documented U-values, Table 4–8 shows that all of the audited units have ENERGY STAR windows; the average and median U-value is 0.32.

Table 4–8: Window U-values

Window U-value	Multi-family Units Number (n=38)	Multi-family Units Percent (n=38)
ENERGY STAR = U-0.35 or Lower		
Higher than U-0.35	0	0%
U-0.35	8	21%
Lower than U-0.35	30	79%
U-value Statistics (n=38)		
Minimum U-value	0.28	
Maximum U-value	0.35	
Average U-value	0.32	
Median U-value	0.32	

[7] The default U-values used to estimate the average U-value of windows in inspected units are based on NFRC performance data on currently available double-hung windows manufactured by Andersen, Harvey Industries, Loewen, Marvin, Pella, Silverline, American Integrity, Jeld-Wen, K&C Industries, Paradigm, and Peachtree. Source of performance data: http://cpd.nfrc.org/pubsearch/psMain.asp.

Figure 4–1 through Figure 4–4 show the percentage of audited units and the percentage of total window area by type of glazing, by U-value, by frame type, and by thermal break. As shown, the percentages by audited units and total window area are similar.

Figure 4–1: Glazing Type Percentage by Units and Total Window Area

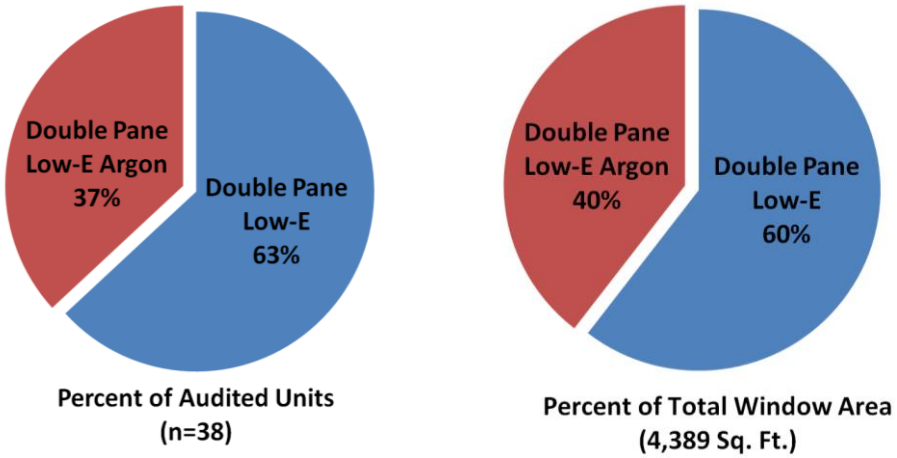


Figure 4–2: U-value Percentage by Units and Total Window Area

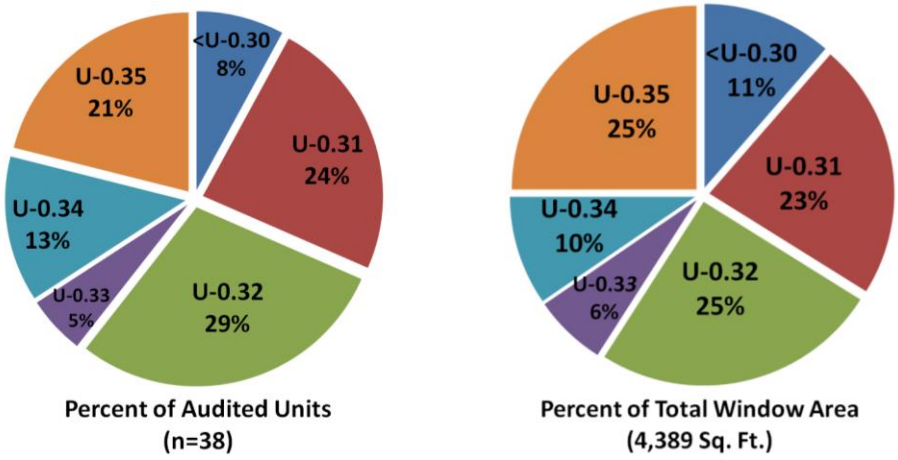


Figure 4–3: Frame Type Percentage by Units and Total Window Area

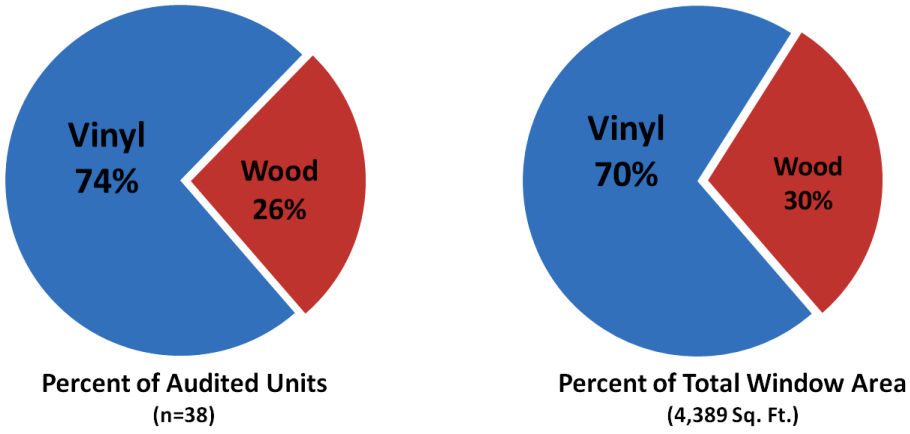
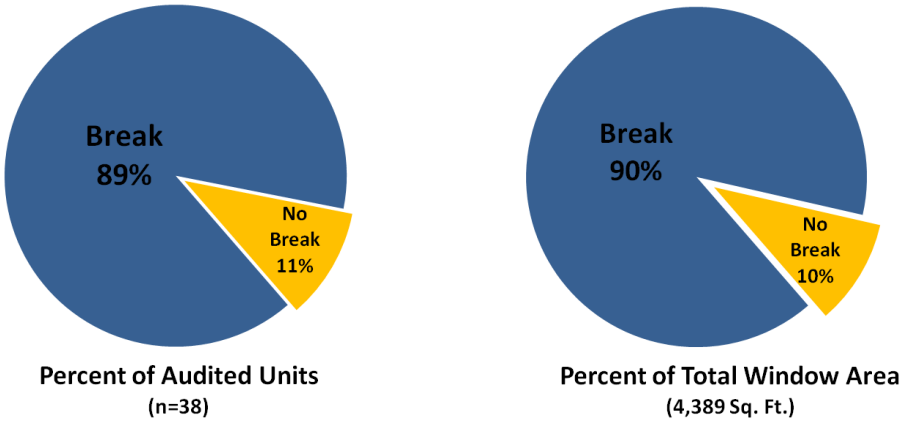
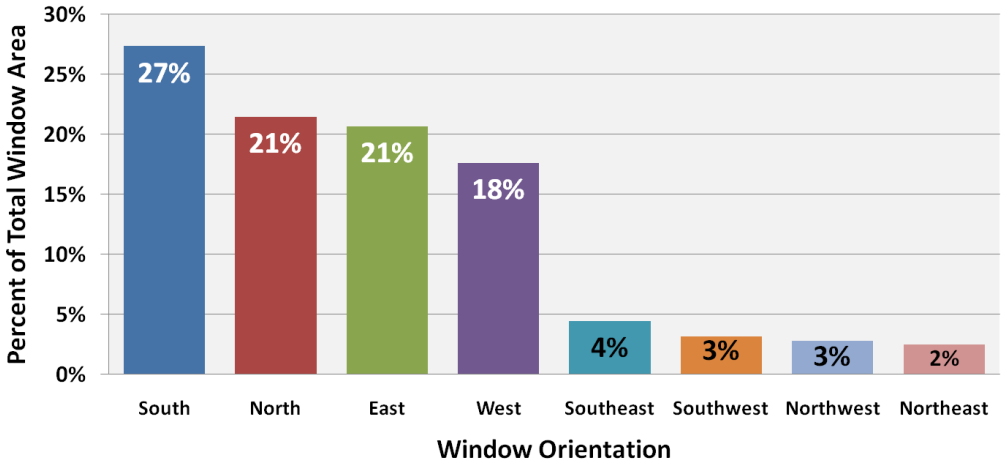


Figure 4–4: Thermal Break Percentage by Units and Total Window Area



Orientation: Figure 4–5 shows the percentage of total window area by orientation; over one-fourth (27%) of window area is oriented to the south.

Figure 4–5: Window Orientation—Percent of Total Window Area



Glazing Percentages: Glazing percentages in audited units, defined as window area as a percentage of conditioned/ambient wall area, range from a low of 11% to a high of 42%. Glazing percentages in multi-family units are higher than in single-family homes because, typically, only some of the walls of individual multi-family units are conditioned/ambient walls and all the windows are on these walls.

Table 4–9 shows that window area is 12% or less of conditioned/ambient wall area in only 8% of audited units; window area in almost one-half of audited units is more than 25%, but not more than 30%, of conditioned/ambient wall area; and in 10% of audited units window area is more than 30% of conditioned/ambient wall area. The overall average glazing percentage, as well as the median glazing percentage, is 21%. The four units with glazing percentages over 30% are apartments or condominiums in multi-unit buildings and the conditioned/ambient wall area of the units are 192 to 384 square feet; for one unit the glazing includes french doors.

Table 4–9: Glazing Percentages

Percent Glazing	Multi-family Units	
	Number (n=38)	Percent (n=38)
11% to 12%	3	8%
>12% to 15%	8	21%
>15% to 18%	4	11%
>18% to 25%	1	3%
>25% to 30%	18	47%
>30%	4	10%
Glazing Percentage Statistics (n=38)		
Minimum Glazing %	11%	
Maximum Glazing %	42%	
Average Glazing %	21%	
Median Glazing %	21%	

4.4 Floors

Roughly one-third (32%) of the inspected multi-family units are in buildings that are slab on grade. The remaining units, or the first floor of the building they are in, have floors over basements, garages, or unvented crawlspace. Table 4–10 shows that in 26% of all audited units all first-story floors of the building are over garages, in 18% of units they are over unconditioned basements, and in 16% of units they are over conditioned basements. Only two units are in buildings with the first-story floors of the building over partially conditioned basements—one of these also has floors over garage space. One unit is in a building with first-story floors over both an unconditioned basement and unvented crawl space.

Table 4–10: Floor Location

Floor Location: Building First-story Floor Over—	Multi-family Units	
	Number (n=38)	Percent (n=38)
Slab on Grade	12	32%
Garage	10	26%
Unconditioned Basement	7	18%
Conditioned Basement	6	16%
Partially Conditioned Basement	1	3%
Partially Conditioned Basement & Garage	1	3%
Unconditioned Basement & Unvented Crawlspace	1	3%

Floor Construction: Table 4–11 shows that the first-story floors of most (73%) of the units in buildings that are not slab on grade are truss (46%) or 2x10 (27%) construction.

Table 4–11: Floor Construction

Floor Construction Units in Non-Slab on Grade Buildings	Multi-family Units	
	Number (n=26)	Percent (n=26)
Truss	12	46%
2 x 10	7	27%
Beam	4	15%
2 x 12	1	4%
Unknown	2	8%

Floors Over Unconditioned Space: Twenty inspected units have floors over unconditioned space—unconditioned or partially conditioned basements or unheated garages. All of the units with insulated floors, where auditors were able to determine the type of insulation[8], are insulated with fiberglass batts.

The minimum insulation level requirement for floors over unconditioned space under prescriptive RBES compliance paths is R-30. Table 4–12 shows that over half (55%) of the units

[8] In some cases the auditor did not have access to the floor insulation and the contact person for the complex was able to provide information on the type and/or level of floor insulation. For two of the inspected units the contact person was able to provide the R-value, but not the type, of insulation.

are in buildings where the first-story floors are over unconditioned space and floors are insulated, but have less than R-30 insulation. Only 15% of units are in buildings with R-30 or higher insulation in first-story floors over unconditioned space. Two units in buildings with unconditioned basements do not have any floor insulation. One inspected unit is in a building with R-19 fiberglass batt insulation in first-story floors over garage space and no insulation in floors over a partially conditioned basement; the average floor insulation level for this unit is R-1.1. Auditors were unable to determine if there was floor insulation between first floor units and unconditioned basement space or common area garage space in four cases; in one case the inspected unit is directly over garage space and in three cases the audited units are upper floor units and the auditor was unable to obtain information on floor insulation between the first floor units and garage or unconditioned basement space. Overall, for the 16 units with known insulation levels, the average and median insulation levels are R-22.

Table 4–12: Insulation in Floors Over Unconditioned Space

Floors Over Unconditioned Space Insulation R-value	Multi-family Units	
	Number (n=20)	Percent (n=20)
No Insulation	2	10%
< R-30	11	55%
=R-30	0	0%
>R-30	3	15%
Unknown	4	20%
R-value Statistics (n=16)		
Minimum R-value	0	
Maximum R-value	38	
Average R-value	22	
Median R-value	22	

Floors Over Conditioned Space: RBES does not require insulation in floors over conditioned space. Six of the inspected units are in buildings where the first floor units are over conditioned basement space. In four cases the first floor units have no floor insulation and in two cases they are insulated with R-19 fiberglass batts.

Floors Over Crawl Spaces: One inspected unit has uninsulated floors over an unvented crawl space; no inspected units have floors over vented crawl spaces. RBES does not have a requirement for insulating floors over unvented crawl spaces.

4.5 Foundation Wall Insulation

Auditors recorded building foundation wall information for 27 inspected units—26 non-slab on grade buildings and one slab on grade building with above grade foundation walls. In several complexes the foundation walls enclose common parking areas with open entry and exit areas. All foundation walls are poured concrete except for the slab on grade building, which has combination masonry and 2x4 stud foundation walls. Auditors were able to determine the type of insulation in 19 cases; in 17 cases the insulation is rigid foam and in two it is fiberglass batts.

Most (81%) units are in buildings with all foundation walls less than 50% above grade and 19% of units are in buildings with all foundation walls more than 50% above grade. RBES prescriptive compliance paths require that below grade foundation walls be insulated to at least R-10 and above grade foundation walls be insulated to at least R-19; however we are not sure how the RBES requirements apply to buildings where the foundation walls enclose parking garages with entries and exists open to outside air.

Table 4–13 shows that of the 22 units in buildings with below grade foundation walls, almost three-fourths (72%) are in buildings with below grade foundation walls insulated to at least R-10. One unit is in a building with no foundation wall insulation—basement is a common garage. Another unit is in a building with some foundation walls insulated to R-11 and others not insulated (average insulation level of R-0.3)—this is a dormitory building with 2x4 framed walls insulated with R-11 batts separating unconditioned storage areas of the basement from a conditioned hallway. For four units, the auditors were unable to determine the level of foundation wall insulation: three of these units are in buildings with below grade common garages and the contacts for these complexes did not know if the garage walls were insulated, and for one unit the auditor was able to determine the type of foundation wall insulation (rigid foam), but not the R-value. Overall, below grade foundation wall insulation levels for the 18 units in buildings with known insulation levels range from no insulation to R-14, the average insulation level is R-11, and the median insulation level is R-10.

Table 4–13: Below Grade Foundation Wall Insulation

Foundation Walls <50% Above Grade (RBES Prescriptive Requirement R-10)	Multi-family Units	
	Number of Units (n=22)	Percent of Units (n=22)
No Insulation	1	5%
< R-10	1	5%
=R-10	8	36%
>R-10	8	36%
Unknown	4	18%
R-value Statistics—Units with Known Insulation Levels (n=18)		
Minimum R-value	0	
Maximum R-value	14	
Average R-value	11	
Median R-value	10	

Five units are in buildings with foundation walls more than 50% above grade—the foundation walls are poured concrete. In two cases the foundation walls enclose common garage space and auditors were unable to determine the type of insulation, but the RBES certificate indicated R-10 insulation. In two cases the above grade foundation walls enclose open garage space and are not insulated. In one case the basement contains common space and storage areas; the walls are insulted with R-14 rigid foam, and 14 inch rim joist areas are insulated with 6 inches of blown-in cellulose.

4.6 Slab Insulation

RBES does not have insulation requirements for the floors of conditioned basements or crawl spaces, but requires slab on grade floors to have at least R-10 perimeter insulation, and prescriptive compliance paths require slab edge insulation. Auditors collected information on the location of slab floors and categorized the slabs as on grade, below grade, or mix (on/below) grade. Table 4–14 shows the percentage of units in buildings with each type of slab. As shown, the percentages of units in buildings with various types of slabs are relatively similar, ranging from 29% in buildings with a mix of on and below grade slabs to 37% in buildings with below grade slabs.

Table 4–14: Slab Floor Location

Slab Floor Location	Multi-family Units	
	Number (n=38)	Percent (n=38)
On Grade	13	34%
Below Grade	14	37%
Mix (on/below) Grade	11	29%

Table 4–15 shows the location of slab insulation for each slab configuration and for all slabs combined. In most cases (65%) there is insulation under the whole slab—47% have insulation only under the slab and 18% have insulation under the slab and on the slab edge. Only one unit is in a building with no slab insulation—this is a building where the basement area is a common garage. In eight cases the auditors were unable to determine the location of slab insulation—in four of these cases the basements are open air common garages.

Table 4–15: Location of Slab Floor Insulation

Location of Slab Insulation	Slab Configuration							
	On Grade		Below Grade		Mix (on/below) Grade		All Slabs	
	Number of Units (n=13)	Percent of Units (n=13)	Number of Units (n=14)	Percent of Units (n=14)	Number of Units (n=11)	Percent of Units (n=11)	Number of Units (n=38)	Percent of Units (n=38)
Under only (whole slab)	8	62%	7	50%	3	27%	18	47%
Unable to Determine	3	23%	3	21%	2	18%	8	21%
Under (whole slab) and Slab Edge	0	0%	1	7%	6	55%	7	18%
Slab Edge and Perimeter (L shape)	2	15%	2	14%	0	0%	4	11%
No Insulation	0	0%	1	7%	0	0%	1	3%

Table 4–16 shows that over one-half (58%) of the units are in buildings with at least R-10 slab insulation and only one unit is in a building with no slab insulation. Five units (13%) are in buildings with less than R-10 slab insulation; two of these units are in buildings with R-7 insulation under the slab and three are in buildings with R-7.5 insulation under the slab and R-10 insulation on the edge (R-7.5 was used for these three units in calculating the average R-value of insulation in all 28 units with known R-values). Overall, slab insulation levels for the 28 units in

buildings with known slab insulation levels range from no insulation to R-14, the average insulation level is R-11, and the median insulation level is R-10. In all cases where auditors could identify the type of slab insulation it is extruded polystyrene.

Table 4–16: Slab Insulation R-value

Slab Floor Insulation R-value (All Slab Locations) (RBES Prescriptive Requirement R-10)	Multi-family Units	
	Number (n=38)	Percent (n=38)
No Insulation	1	3%
< R-10	5	13%
=R-10	10	26%
>R-10	12	32%
Unknown	10	26%
R-value Statistics—Units with Known Insulation Levels (n=28)		
Minimum R-value	0	
Maximum R-value	14	
Average R-value	11	
Median R-value	10	

4.7 Doors

Auditors collected information on 51 doors in 38 housing units. Many of the doors in multi-family units open to interior hallways or common areas. Table 4–17 shows that the most frequently observed door types are insulated steel panel doors (31%), uninsulated solid core wood doors (24%), and uninsulated steel panel doors (10%); all other individual door types account for less than 10% each. Most doors (61%) are insulated.

Table 4–17: Door Types

Door Type	Insulated		Not Insulated		All Doors	
	Number of Doors (n=51)	Percent of All Doors (n=51)	Number of Doors (n=51)	Percent of All Doors (n=51)	Number of Doors (n=51)	Percent of Doors (n=51)
Hollow Core: Fiberglass	3	6%	0	0%	3	6%
Hollow Core: Steel	3	6%	0	0%	3	6%
Hollow Core: Wood	3	6%	0	0%	3	6%
Panel: Fiberglass	4	8%	0	0%	4	8%
Panel: Steel	16	31%	5	10%	21	41%
Panel: Wood	2	4%	3	6%	5	10%
Solid Core: Wood	0	0%	12	24%	12	24%
Totals:	**31**	**61%**	**20**	**39%**	**51**	**100%**

Only eight doors (16% of all doors) have storm doors: four insulated and two uninsulated steel panel doors and two insulated hollow core fiberglass doors. Twenty doors (39% of all doors) have some glass area. Table 4–18 shows that over one-half (55%) of the doors with glass have double pane Low-E glass and 60% of all the glass area in doors is double pane Low-E. Double pane clear glass was observed in just over one-third (35%) of doors with glass and accounts for

22% of all glass area in doors; double pane Low-E with argon glass was found in 10% of doors with glass and accounts for 18% of all glass area in doors.

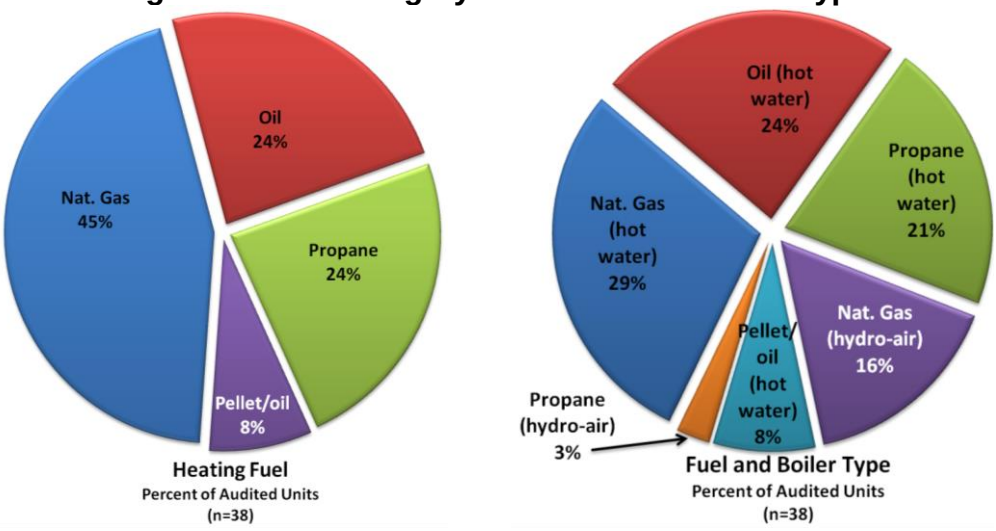
Table 4–18: Door Glass Area

Glass Type	Number of Doors with Glass (n=20)	Percent of Doors with Glass (n=20)	Square Feet of Glass	Percent of Glass Area (n=107 Sq. Ft.)
Double Pane (clear)	7	35%	23	22%
Double Pane Low-E	11	55%	64	60%
Double Pane low E Argon	2	10%	20	18%
Statistics—Glass Area per Door (n=20)				
Minimum Glass Area Sq. Ft.	0.9			
Maximum Glass Area Sq. Ft.	11.5			
Average Glass Area Sq. Ft.	5.3			
Median Glass Area Sq. Ft.	5.1			

4.8 Space Heating

All of the inspected units have boiler heating systems; five units in three projects have hydro-air boiler systems, the rest are hot water boilers. Some units have individual heating systems and in other cases one system serves multiple units. The first pie chart in Figure 4–6 shows that 45% of the inspected units are heated by natural gas, 24% by oil, 24% by propane, and 8% by a pellet boiler with oil boiler backup.[9] The second pie chart in Figure 4–6 shows the percentage of units heated by various fuel/boiler type combinations. As shown, the most frequently observed combination is natural gas hot water boilers (29%), followed closely by oil (24%) and propane (21%) hot water boilers.

Figure 4–6: Heating System Fuel and Boiler Type



[9] The units heated by a pellet hot water boiler are in a 52-unit senior housing project that has a backup oil-fired hot water boiler heating system.

4.8.1 Heating System Efficiencies

AFUE or TE ratings were documented for all the oil and gas boilers serving the inspected units.[10] In some cases the AFUE was listed on the equipment; in all cases we were able to use nameplate model number and output capacity information to look up AFUEs or TEs on Gas Appliance Manufacturer Association (GAMA) listings. Table 4–19 shows that 21% of inspected units are heated by boilers with AFUE or TE ratings lower than 85. Over three-fourths (79%) of inspected units are heated by boilers with AFUE or TE ratings of 85 or higher; over one-half (58%) of inspected units are heated by very efficient boilers with AFUE or TE ratings of over 90. The average heating system AFUE/TE across all 38 inspected units is 90.2 and the median is 92.8. All residential boilers (heat input capacity less than 300,000 BTUH) are ENERGY STAR (AFUE of 85 or higher). All boilers meet RBES code requirements.

Table 4–19: Boiler AFUE or Thermal Efficiency

Boiler AFUE or Thermal Efficiency (all boilers)	Multi-family Units Number (n=38)	Multi-family Units Percent (n=38)
Oil and Gas Boiler ENERGY STAR Minimum AFUE 85 Vermont Prescriptive Code Minimum Residential Boiler AFUE 84		
AFUE or TE <85	8	21%
AFUE or TE 85 to 87	4	11%
AFUE or TE >87 to 90	4	11%
AFUE or TE > 90	22	58%
AFUE/TE Statistics (n=38)		
Min AFUE or TE	82.7	
Max AFUE or TE	95.4	
Average AFUE or TE	90.2	
Median AFUE or TE	92.8	

Table 4–20 allocates all boilers serving audited multi-family units into one of four efficiency categories—low, standard, high or super high efficiency. As shown, 58% of audited units are heated by super high efficiency boilers. Five of the seven non-ENERGY STAR-certified units are served by super high efficiency boilers and two by high efficiency boilers.

Table 4–20: All Boilers by Efficiency Category

Boiler Efficiency Category	Boiler AFUE or TE Efficiency Levels	Percent Multi-family Units (n=38)
Low Efficiency	Gas or Oil < 84	13%
Standard Efficiency	Gas or Oil 84 to < 85	0%
High Efficiency	Gas 85 to 90 Oil 85 to 87	29%
Super High Efficiency	Gas >90 Oil > 87	58%

[10] Eighteen of the inspected units are heated by commercial boilers (300,000 BTUH or higher input capacity) for which AFUE ratings are not typically available. Based on conversations with EVT staff it was decided to use GAMA thermal efficiency ratings to approximate AFUE ratings for all commercial boilers.

4.8.2 Heating System Location

Table 4–21 shows that just over two-thirds (68%) of inspected units are heated by systems located in unconditioned space, either an unconditioned basement (60.5%) or an unconditioned utility room (7.9%). Almost one-third (32%) of inspected units are heated by systems located in conditioned space: 16% in conditioned basements, 11% in conditioned primary areas, and 5% in conditioned utility closets.

Table 4–21: Heating System Location

Heating System Location	Multi-family Units	
	Number (n=38)	Percent (n=38)
Unconditioned Basement	23	61%
Unconditioned Utility Room	3	8%
Subtotal Unconditioned Space:	**26**	**68%**
Conditioned Basement	6	16%
Conditioned Primary Area	4	11%
Conditioned Utility Closet	2	5%
Subtotal Conditioned Space:	**12**	**32%**

4.8.3 Supplemental Heat

Seven inspected units have fireplaces or stoves: four condominiums each have one propane fireplace, one vacation condominium has two wood-burning fireplaces, and two senior housing units have natural gas stoves. Only one unit, located in a co-housing project, has a portable space heater (electric).

4.8.4 Hydronic Piping Insulation and Thermostats

Hydronic Piping Insulation. RBES prescriptive compliance paths require hydronic heating system piping installed in unconditioned space to be insulated; the required insulation thickness depends on the type of heating system, fluid temperature range, and pipe thickness. Table 4–22 shows that for one-half of the 26 inspected units heated by boilers in unconditioned space the piping is not insulated; 19% have R-3 insulation and 31% have R-5 insulation. The average insulation level is R-1.9 and the median is 1.5.

Table 4–22: Hydronic Piping Insulation

Hydronic Piping Insulation (systems installed in unconditioned space)	Multi-family Units	
	Number (n=26)	Percent (n=26)
No Insulation	13	50%
R-3	5	19%
R-5	8	31%
R-value Statistics—Hydronic Piping Insulation (n=26)		
Minimum R-value	0.0	
Maximum R-value	5.0	
Average R-value	1.9	
Median R-value	1.5	

Thermostats. More than one-half of the 38 audited multi-family units (61%) have manual thermostats; the remaining 39% have programmable thermostats. Auditors collected information on thermostat setback practices from the occupants of 20 of the audited multi-family units. Occupants of five units (25%) say they lower thermostat settings both at night and during the day when they are not home, occupants of three units (15%) say they lower thermostat settings only at night, occupants of one unit (5%) say they lower thermostat settings only during the day, and occupants of eleven units (55%) say they do not lower thermostat settings. Occupants of 20 audited units provided information on their preferred temperature settings; preferred settings range from 68 to 72 degrees Fahrenheit—the average and median are 69.5 degrees Fahrenheit.

4.9 Cooling

Twenty of the inspected multi-family housing units in 11 complexes have some type of air conditioning. Six units, in four different complexes, have window or wall mounted air conditioners; one unit has two window air conditioners, the other five have one air conditioner each. Fourteen units, in seven different complexes, have central air conditioning; two of the units have split systems and six have water source heat pump systems. Air conditioning equipment for all twenty units is located in conditioned space.

Window and Wall Mounted Air Conditioners. The two wall mounted units are one year old; all the window units are less than five years old. Auditors were able to obtain equipment size information for five of the six housing units with window or wall mounted air conditioners. Table 4–23 shows that tons of room air conditioning per housing unit ranges from 0.4 to 2.0 tons; the average is 1.1 ton and the median is 1.0 ton.

Table 4–23: Window and Wall Mounted Air Conditioner Size

Window and Wall Mounted Air Conditioner Size (tons per housing unit)	Multi-family Units	
	Number (n=6)	Percent (n=6)
Less Than 1 Ton	2	33%
1 to 1.5 Tons	2	33%
More Than 1.5 Tons	1	17%
Unknown	1	17%
Tonnage Statistics—Window and Wall Mounted AC (n=5)		
Minimum Tons	0.4	
Maximum Tons	2.0	
Average Tons	1.1	
Median Tons	1.0	

Auditors were able to obtain equipment efficiency information for four multi-family units. ENERGY STAR minimum EER criteria for room air conditioners range from 9.4 to 10.8 depending on the size and other characteristics; auditors were able to get model numbers in three of six housing units with window/wall air conditioners and none of the models are on the EPA list of ENERGY STAR models. Table 4–24 shows that the EERs of window and wall mounted air conditioners range from 10.2 to 10.8; the average and the median EER are 10.5.

Table 4–24: Window and Wall Mounted Air Conditioner Efficiency

Window and Wall Mounted Air Conditioner Efficiency	Multi-family Units	
	Number (n=6)	Percent (n=6)
EER <10	0	0%
EER >10	4	67%
Unknown	2	33%
EER Statistics—Window and Wall Mounted AC (n=4)		
Minimum EER	10.2	
Maximum EER	10.8	
Average EER	10.5	
Median EER	10.5	

Central Air Conditioners. Fourteen inspected units, in seven different complexes, have central air conditioning. In some cases a building's central air conditioning system serves more than one housing unit. Table 4–25 shows the sizes of the central air conditioning systems range from one ton to 10.5 tons; the average is 2.8 tons and the median is 2.0 tons.

Table 4–25: Central Air Conditioner Tonnage

Central Air Conditioner Size	Multi-family Units	
	Number (n=14)	Percent (n=14)
One Ton	1	7%
>1 to 2 Tons	8	57%
>2 to 3 Tons	1	7%
>3 to 4 Tons	2	14%
More Than 4 Tons	1	7%
Unknown	1	7%
Tonnage Statistics—Central AC (n=13)		
Minimum Tons	1.0	
Maximum Tons	10.5	
Average Tons	2.8	
Median Tons	2.0	

Six of the audited units, three each in two large complexes—one condominium and one apartment complex—have water source heat pump cooling systems, which do not have SEER ratings. In one complex the systems are EER 13 and COP 3.8, and in the other complex they are EER 12 and COP 4.3.

Table 4–26 provides information on the eight inspected multi-family units that have central air conditioning systems with SEER efficiency ratings. As shown, we were able to determine the SEER rating for seven of the eight systems. SEER ratings range from SEER 10 to SEER 19. One of the systems (13%) has an efficiency rating below the ENERGY STAR minimum of SEER 14, four systems (50%) are SEER 14, and two systems (25%) are above SEER 14; the average is SEER 14.9 and the median is SEER 14. The SEER 19 system is a split system and is not ENERGY STAR because the EER is 10.4, which does not meet the ENERGY STAR minimum EER criteria of 11.5 for split systems.

Table 4–26: Central Air Conditioning SEER

Central Air Conditioner SEER (Non-Water Source Heat Pump)	Multi-family Units	
	Number (n=8)	Percent (n=8)
ENERGY STAR Minimum SEER = 14		
SEER <13	1	13%
14 SEER	4	50%
>14 SEER	2	25%
Unknown	1	13%
SEER Statistics—Central AC with known SEER (n=7)		
Minimum SEER	10.0	
Maximum SEER	19.0	
Average SEER	14.9	
Median SEER	14.0	

Table 4–27 allocates all the multi-family units with air conditioning into one of four general efficiency categories: low, standard, high or unknown efficiency. As shown, two units (10%) have low efficiency air conditioning equipment, seven (35%) have standard efficiency, eight (40%) have high efficiency, and for three units (15%) we were unable to document the efficiency of air conditioning equipment. Of seven non-ENERGY STAR units with air conditioning, six have standard efficiency air conditioning and for one unit the efficiency of the equipment is unknown.

Table 4–27: Overall Multi-family Unit Air Conditioning Efficiencies

Multi-family Unit Air Conditioning Efficiency Category	Air Conditioning Efficiency Levels	Multi-family Units	
		Number (n=20)	Percent (n=20)
Low Efficiency	CAC* SEER <13	2	10%
Standard Efficiency	Non-ENERGY STAR Window/Wall Units CAC SEER = 13 WSHP = EER 12 COP 4.3	7	35%
High Efficiency	ENERGY STAR and/or CAC SEER ≥14	8	40%
Unknown Efficiency		3	15%

*Central Air Conditioning

4.10 Ducts

Auditors reported information on ducts in eight housing units. No duct blaster tests were conducted. In six of the eight units the ducts are in the walls and could not be visually inspected; in these cases information was provided by the site contact. All the ducts in all eight units are metal. RBES does not require ducts in conditioned space to be insulated or the seams to be sealed. In five of the housing units all ducts are in conditioned space and none of the duct seams are sealed, but in four of the five units both supply and return ducts are insulated—in three units the ducts are insulated with one-inch R-3.3 wrap and in one unit with two-inch R-5 wrap.

Two of the inspected housing units with duct information have supply and return ducts located in the attic, where RBES prescriptive compliance paths require R-5 duct insulation and using mastic with fibrous backing tape to seal duct seams. In both units both supply and return ducts are insulated with two-inch R-5 wrap, but the duct seams are not sealed. One of the inspected housing units has all ducts located in unconditioned space and they are not insulated; the duct joints are sealed with what the auditor described as putty.

4.11 Water Heating

All but four of the inspected housing units have integrated tank water heating systems; two have stand alone tank electric water heaters and two have instantaneous water heating systems. Almost one-third (32%) of water heating systems are located in conditioned space and two-thirds (68%) in unconditioned space. None of the tanks are wrapped.

Figure 4–7 shows the percentage of inspected housing units by water heating fuel and by type of water heating. The first pie chart shows that almost one-half (45%) of housing units have natural gas water heating, 24% use oil to heat water, 18% use propane, 8% use pellets (oil backup), and 5% have electric water heaters. The second pie chart shows that the most frequently observed water heating systems are natural gas integrated tank (39%), oil integrated tank (24%), and propane integrated tank (18%).

Figure 4–7: Water Heating Fuel and Type

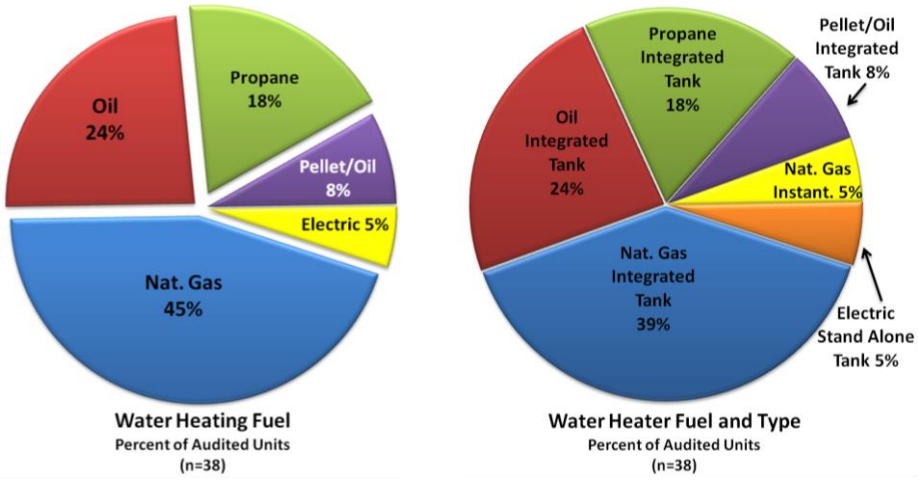


Table 4–28 provides information on water heater Energy Factors. Information is shown for all inspected housing units and, separately, for those with integrated tank water heating. Energy factors for integrated tank water heaters are calculated by multiplying the boiler efficiency (AFUE or TE) by 0.92. As shown, overall, Energy Factors range from 0.76 to 0.92; the average Energy Factor is 0.83 and the median is 0.85. Looking at just integrated tanks, Energy Factors range from 0.76 to 0.88; the average is 0.83 and the median is 0.85. All of the water heating systems in the audited multi-family units have higher Energy Factors than gas- or oil-fired stand alone tank systems and, therefore, can be considered high efficiency systems.

Table 4–28: Water Heater Energy Factors

Water Heating Energy Factor	All Multi-family Units		Multi-family Units with Integrated Tanks	
	Number (n=38)	Percent (n=38)	Number (n=34)	Percent (n=34)
Less Than 0.78	5	13%	5	15%
0.78 to 0.80	7	18%	7	21%
> 0.80 to 0.85	4	11%	2	6%
> 0.85 to 0.90	20	53%	20	59%
Over 0.90	2	5%	0	0%
Water Heater Energy Factor Statistics				
Minimum Energy Factor	0.76		0.76	
Maximum Energy Factor	0.92		0.88	
Average Energy Factor	0.83		0.83	
Median Energy Factor	0.85		0.85	

Table 4–29 provides information on water heater tank size. Clearly, in many cases the water heating system serves more than one housing unit. Only 20% of the inspected housing units with water heating tanks are served by systems with 50 gallon or smaller tanks; 30% are served by 60 to 80 gallon tanks; and half (50%) by 119 or 120 gallon tanks.

Table 4–29: Water Heater Tank Size

Water Heater Tank Size	Multi-family Units with Tanks	
	Number (n=36)	Percent (n=36)
Less Than 50 Gallons	2	6%
50 Gallons	5	14%
60 Gallons	3	8%
76 Gallons	3	8%
80 Gallons	5	14%
119 to 120 Gallons	18	50%
Tank Size Statistics		
Minimum Tank Size	35 Gallons	
Maximum Tank Size	120 Gallons	
Average Tank Size	91 Gallons	
Median Tank Size	100 Gallons	

Faucet Aerators and Low Flow Shower Heads. All but one inspected housing unit have both faucet aerators and low flow shower heads; one housing unit, a room in a long-term care facility, does not have its own shower or bath. Auditors turned on showers and observed the water flow to determine whether or not they were low flow—they did not measure the gallon per minute water flow rate.

Table 4–30 shows that more than one-half of inspected units (53%) have two faucet aerators and slightly fewer than one-half (45%) have more than two. The number of faucet aerators per inspected unit ranges from one to seven; the average is 2.6 and the median is 2. More than one-half (55%) of inspected housing units have one low flow shower head and 42% have more than one. The number of low flow shower heads per inspected unit ranges from none to three; the average is 1.4 and the median is 1.0.

Table 4–30: Faucet Aerators and Low Flow Shower Heads

Number of Faucet Aerators	Multi-family Units		Number of Low Flow Shower Heads	Multi-family Units	
	Number (n=38)	Percent (n=38)		Number (n=38)	Percent (n=38)
1	1	3%	None	1	3%
2	20	53%	1	21	55%
3	14	37%	2	14	37%
5	2	5%	3	2	5%
7	1	3%			
Number of Faucet Aerators and Low Flow Shower Head Statistics					
Min	1		**Min**	0	
Max	7		**Max**	3	
Average	2.6		**Average**	1.4	
Median	2		**Median**	1	

4.12 Ventilation

Nine of the 38 individual units audited are in buildings with an Energy Recovery Ventilation (ERV) system. Two units are in buildings where the ERV system serves the hallways, three units are in buildings where the ERV system serves only common areas, and four units are in buildings where auditors reported there was an ERV system, but did not indicate what areas the system served.

All audited units have bathroom fans. In 27 of the 38 audited units (71% of all audited units) the fans run continuously (20 units), fan control is integrated (4units), or fans have remote timers (3 units). In five audited units (13% of all audited units) all fans are controlled by local timers with automatic settings available. In each of another five audited units (13% of all audited units) there is one fan controlled by a local switch and another that runs continuously, has a remote timer, or has a local timer with an automatic setting available. Only one home has a fan controlled by a local timer that does not include an automatic setting (30 minute twist timer)—this home has a fan with integrated control in another bathroom.

5 Appliances

Appliance Saturations. All of the housing units visited have at least one refrigerator.[11] Over one-half have a dishwasher and over 40% have a clothes washer and clothes dryer. Saturations of separate freezers and second refrigerators are based on occupied homes; about 20% have a separate freezer, while less than 10% have a second refrigerator (Table 5–1).[12]

Table 5–1: Appliance Saturations

Appliance	Multi-family Units Number (n=37)	Multi-family Units Percent (n=37)
Dishwasher	21	57%
Clothes washer	17	46%
Clothes dryer	16	43%
Appliance	**Occupied Multi-family Units Number (n=26)**	**Occupied Multi-family Units Percent (n=26)**
Separate freezer	5	19%
Second refrigerator	2	8%

ENERGY STAR Appliances. Dishwashers are most likely to be ENERGY STAR labeled (57%) followed closely by clothes washers (53%); however, only a little over a quarter of refrigerators are ENERGY STAR (26%). The number of appliances listed in Table 5–2 and the tables that follow in this section refers to the number with the appropriate data available. Model numbers were recorded for most appliances during the on-sites; the ENERGY STAR status of appliances that did not have ENERGY STAR logos affixed was checked at http://www.energystar.gov/index.cfm?c=appliances.pr_appliances, the ENERGY STAR website.

Table 5–2: ENERGY STAR Appliances

Appliance	Number of Appliances	Percent ENERGY STAR
Dishwashers	21	57%
Clothes washers	17	53%
Refrigerators	39	26%
Separate freezers	5	1 of 5

[11] One of the units visited was a unit in a long-term care facility that had no appliances and has thus been excluded from the analyses in this section; however, it is included in analyses of electronic equipment since it had a TV set. Thus, appliance data, except where noted, are based on 37 multi-family units, not 38 as in other sections.

[12] Only 26 housing units were occupied at the time of the audit, thus we only use the data for these occupied units when analyzing appliances such as separate freezers, second refrigerators, and electronics which are typically installed by the occupant.

Appliance Ages. Not surprisingly, the overwhelming majority of appliances in new multi-family units are under five years old, but there are a few ten-year old freezers, clothes washers, and clothes dryers (Table 5–3).

Table 5–3: Appliance Ages

Appliance Age	Refrigerators (n=38)	Freezers (n=5)*	Clothes Washers (n=17)	Clothes Dryers (n=16)	Dishwashers (n=21)	Ranges (n=36)
4 years or less	100%	1	94%	94%	100%	100%
5 to 9 years	0%	2	0%	0%	0%	0%
10 years	0%	2	6%	6%	0%	0%

*Columns with less than ten observations are presented as numbers rather than percents.

Appliance Conditions. Not surprisingly, all the appliances in new multi-family units are in good condition with the exception of one housing unit where the clothes washer and clothes dryer are ten years old, both judged to be in fair condition.

Appliance Sizes. Most refrigerators are between 16 and 19 cubic feet (Table 5–4). It should be noted that refrigerators in new multi-family units are considerably smaller than those found in the new single-family home on-sites; 27% of refrigerators in new multi-family units are 20 or more cubic feet versus 68% in new single-family homes.

Table 5–4: Refrigerator and Separate Freezer Size

Refrigerator and Freezer Size	Refrigerators (n=37)	Freezers (n=5)*
10 cubic feet or less	3%	2
11 to 15 cubic feet	13%	1
16 to 19 cubic feet	57%	2
20 to 24 cubic feet	27%	0

*Columns with less than ten observations are presented as numbers rather than percents.

Appliance Types. Top freezer refrigerator models are most common in new multi-family units accounting for over 70% of refrigerators (Table 5–5).

Table 5–5: Refrigerator Type

Refrigerator Type	Refrigerators (n=40)
Top freezer	71%
Bottom freezer	13%
Side by side	11%
Single door	5%

Three of the five separate freezers are upright types and two are chest types. This is fairly consistent with new single-family home data.

Just over one-half (53%) of clothes washers in new multi-family units are top loading and 47% are front loading; a slightly higher proportion (61%) of clothes washers in new single-family homes are front loading.

Appliance Fuels. More than 60% of clothes dryers and close to 80% of ranges in new multi-family units use electricity (Table 5–6). Dryers in new multi-family units are less likely to use electricity (62%) than those in new single-family homes; ranges, however, are more likely to use electricity (78%) than in new single-family homes where 41% use electricity.

Table 5–6: Clothes Dryer and Range Fuels

Appliance Fuel	Clothes Dryers (n=16)	Ranges (n=36)
Electricity	62%	78%
Natural Gas	19%	14%
Propane	19%	8%

5.1 Electronics

Televisions and Peripherals. Almost all new occupied multi-family units have at least one TV set, but more than one-half have only one, in contrast to new single-family homes where more than 70% have at least two TV sets (Table 5–7).

Table 5–7: TV Set Saturation

Number of TV Sets	Occupied Units (n=26)
None	4%
One	55%
Two	30%
Three or more	11%

Most TVs are cathode ray tube (CRT) models; the TV set type distribution is similar to new single-family homes (Table 5–8).

Table 5–8: TV Set Type

TV Set Type	All TV Sets (n=40)
CRT	70%
LCD	27%
Projection	3%

Most TV monitors (78%) are less than 30 inches; as would be expected, TV set monitors in new multi-family units are somewhat smaller than those found in new single-family homes (Table 5–9).

Table 5–9: TV Monitor Size

TV Monitor Size	All TV Sets (n=40)
15 inches or less	10%
16 to 20 inches	30%
21 to 30 inches	38%
31 to 40 inches	15%
Over 40 inches	7%

The most common TV peripherals are VCR and DVD players together (30%) followed by DVD players alone (25%). Just over 20% of TVs have no peripherals attached (Table 5–10).

Table 5–10: TV Peripherals

TV Peripherals	All TV Sets (n=40)
VCR and DVD player	30%
DVD player only	25%
VCR only	23%
None	22%

Computers. More than 40% of housing units have at least one computer; a similar proportion has one printer (Table 5–11). Computer saturation is considerably lower than in new single-family homes where there is at least one computer in three-quarters of audited homes.

Table 5–11: Computer and Printer Saturation

Number of Computers or Printers	Occupied Units (n=26)	
	Computers	Printers
None	56%	59%
One	37%	41%
Two or more	7%	0%

Most computers (71%) in new multi-family units have LCD monitors; the remainder have CRT monitors. This distribution is similar to new single-family homes. Two-thirds of computer monitors (67%) are 15 inches or less and the remaining one-third is between 16 and 19 inches; computer monitors in new multi-family units are somewhat smaller than those found in new single-family homes.

Three of the 26 occupied new multi-family units (12%) contain a dedicated home office. All three home offices are about 80 square feet. As expected, there are fewer home offices in new multi-family units and they are smaller than those found in new single-family homes.

6 Lighting

CFL bulbs, both screw-in and pin-based, were installed at all 38 housing units (Table 6–1). Eight percent of all 38 homes have screw-in CFLs in storage; this figure rises to 12% after excluding the twelve unoccupied units. Thirteen percent of units have dimmable incandescent bulbs installed.

Table 6–1: Proportion of Homes with CFL Bulbs and Dimmable Bulbs

Type of Bulb	Multi-family Units (n=38)
Screw-in CFLs Installed	100%
Screw-in CFLs in Storage	8%
Dimmable Incandescent Bulbs Installed	13%

Table 6–2 displays the proportion of CFL bulbs installed in homes, as a percentage of all CFL bulbs and incandescent bulbs. Sixteen percent of units have between 11% and 25% CFLs, 18% have between 26% and 50% CFLs, and 66% have more than one-half CFLs.

Table 6–2: Proportion of CFL Bulbs Installed

Proportion of CFL Bulbs Installed	Multi-family Units (n=38)
None	0%
1% to 10%	0%
11% to 25%	16%
26% to 50%	18%
51% to 100%	66%

Table 6–3 displays various statistics for CFLs installed in the audited housing units. Statewide, an average of 13.0 and median of 11.0 CFL bulbs are installed, representing 61.3% of all 21.2 bulbs installed.[13]

Table 6–3: Mean, Median, and Proportion of CFL Bulbs Installed

CFL Bulb Statistics	Multi-family Units (n=38)
Mean Number of CFLs	13.0
Median Number of CFLs	11.0
Mean Number of all Bulbs	21.2
Proportion of Screw-in Bulbs that are CFLs	61.3%

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

Five percent of housing units have T12 fluorescent tube fixtures installed, about two-thirds have T8 tubes installed, 11% have T5 tubes installed, and 58% have circlines installed (Table 6–4).

Table 6–4: Proportion of Homes with Fluorescent Fixtures

Homes with Fluorescent Fixtures	Multi-family Units (n=38)
T12	5%
T8	68%
T5	11%
Circline	58%

7 Questionnaire

The on-site audit included brief interviews with the owners or tenants of 30 newly constructed housing units in order to gather information on energy efficiency in these homes.[14] The objective of these interviews is to understand the energy issues facing Vermont residents in order to provide additional information to support the analysis of the on-site audits.

Energy Use. Sixty percent of respondents state that there are no changes in their homes they can think of that would help save energy. A handful of respondents believe that practicing energy conservation, sealing air leaks, or installing insulation, a solar system, or CFLs could save energy (Table 7–1).

Table 7–1: Respondent's Opinion of Additional Changes at Home that Could Save Energy

Changes that Could Save Energy	All Multi-family Respondents (n=30)*
Nothing	60%
Turn off products	13%
Air sealing; fix infiltration problem	13%
Add insulation	10%
Install solar system	10%
Install CFL bulbs	7%
Install wind turbine	3%
Add energy-efficient windows	3%
Install geothermal system	3%
Add storm doors	3%
Other	6%

*Multiple responses.

[14] Twelve of the 38 audited units were unoccupied at the time of the on-site audit, thus no tenant was available to complete the questionnaire; in addition, tenants were not home for some audits. However, in some cases building owners (or their representatives) who live in the building were able to answer the questionnaire, yielding a total of 30 completed questionnaires.

Respondents were asked why they had not made the energy-saving changes to their homes that they mentioned. Four of the twelve respondents considered the high cost of such changes to be a major obstacle (Table 7–2). Four respondents mention the fact that they are not the building owner, and three consider a lack of time as an obstacle.

Table 7–2: Factors that have Caused Respondents to Avoid Making Changes for Greater Energy Efficiency in their Home

Why Have not Made Changes	Multi-family Respondents (n=12)
Cost too much / can't afford it / don't have the money / etc	4
Not the building owner	4
Lack of time	2
In the process of fixing	1
Other	3

*Multiple responses.

Thermal Comfort. Ninety-seven percent of respondents report being satisfied with the thermal comfort in their homes (Table 7–3). The one respondent who is not satisfied with their thermal comfort says that the building's heating system is not sufficient as the boilers do not provide enough heat to the five-plex units. The respondent says on cold days the heating system might only be able to get the home to 60 or 65 degrees. There are two central boilers in the main common building that provide heat to the whole development. They are considering adding a third boiler to address this problem.

Table 7–3: Respondents Satisfaction with the Thermal Comfort of their Homes

Satisfaction with the Thermal Comfort	All Multi-family Respondents (n=30)
Satisfied	97%
Not Satisfied	3%

Respondents were asked about the one thing they would most like to change in order to improve the thermal performance of their homes; nearly one-half of respondents would not do anything (Table 7–4). Eighteen percent would like to improve the distribution of heat in their home, and 9% would like to insulate windows. Six percent would like to install air conditioning or switch from propane to oil, which they believe heats faster.

Table 7–4: What Respondents Would Consider Changing in their Homes for Improving Thermal Performance

Would Consider Changing to Improve Thermal Performance	All Multi-family Respondents (n=30)*
Nothing	46%
Improve heat distribution	18%
Insulate windows	9%
Air conditioning	6%
Switch from propane to oil	6%
Install HRV system	3%
Tenant pay own utilities	3%
Other	3%

*Multiple responses.

Energy Conservation Programs. Respondents were asked to rate on a scale of zero to ten, where zero is "not important at all" and ten is "very important," how important they consider each of the factors provided in Table 7–5 for participating in energy conservation programs. The factors considered to be very important (rated an 8 or higher) by a large majority of respondents include "It is good for the "environment" (97%), "It saves money on your fuel bill" (90%), and "It saves money on your electric bill" (92%). Respondents were least likely to participate in energy conservation programs because of a recommendation from a friend or a neighbor.

Table 7–5: Respondents Rating of Reasons to Participate in Energy Conservation Programs as 'Very Important'

Reasons to Participate in Energy Conservation Programs Rated "Very Important"	All Multi-family Respondents (n=30)
It is good for the environment	97%
It saves money on your fuel bill	90%
It saves money on your electric bill	90%
It prolongs the life of my HVAC equipment	77%
It helps to keep everyone's electric rates down	77%
It makes your home more comfortable	67%
It prolongs the life of my home	60%
It will reduce the need for new power plants	60%
Your neighbors/friends recommended it	33%

Respondents were asked if they would consider searching on the Internet for information for energy conservation programs, and if they had visited EVT's website. Thirty percent of respondents report having visited EVT's website when searching for energy conservation information. Respondents who did not mention visiting EVT's website report that they would search for energy-efficiency information via newspapers, utility companies, magazines, the phone book, and friends.

Willingness to Pay for Audit. When respondents were asked if they would be willing to pay $250 for an assessment of their homes by a certified contractor, only 13% of respondents say they would (Table 7–6). Because these are all owners or tenants of newly constructed housing units, it is understandable that most are unwilling to pay for an audit.

Table 7–6: Would you be Willing to Pay $250 for an Assessment by a Certified Contractor?

(Willing to Pay $250 for an Assessment	All Multi-family Respondents (n=30)
Yes	13%
No	87%

Freezer and Refrigerators. All five respondents who have a second refrigerator or freezer in use report that the appliance is plugged in at all times. None of the respondents have considered removing the appliance. When asked what might encourage them to consider removing their appliance, two say they need the storage space, one says nothing would encourage them, one reports that they just purchased the appliance and are not interested in removing it, and one says if they had a larger refrigerator.

When asked how they would dispose of the refrigerator, two respondents say they wouldn't dispose of the appliance, one says they would recycle it, one would sell it, and one would give it away.

VT Residential Building Energy Standards Certificate. Respondents were asked if their builder posted in their home or gave them an RBES construction certificate. Only one-quarter of respondents report that such a certificate was provided to them (Table 7–7). Because some of these respondents are tenants, they would not be expected to receive the RBES certificate from the builder.

Table 7–7: Did the Respondents receive a "VT Residential Building Energy Standards" (RBES) Certificate?

Received RBES Certificate	All Multi-family Respondents (n=30)
Yes	26%
No	22%
Maybe / Don't Know	52%