NAVIGANT

2011 Vermont Market Characterization and Assessment Study

Business Sector (Commercial and Industrial) Existing Buildings
FINAL

Prepared for:
Vermont Public Service Department

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1. Introduction

This baseline study provides Vermont estimates for the saturations of key energy efficiency measures from primary data collected via telephone surveys and on-site inspections conducted during July 2011 to July 2012. The baseline study estimates Vermont business' awareness of major energy efficiency measures and Vermont efficiency programs. The study also provides valuable information, such as characteristics of existing buildings and new construction markets,[1] remaining life of existing equipment, and building characteristics.

The key tasks included the following:

1. Develop forms to capture data relevant to Vermont commercial and industrial (C&I) buildings
2. Design samples to adequately represent each market population in terms of key variables (such as program administrator, region, consumption, and market sector and segment)
3. Sample and conduct telephone surveys with 237 Vermont businesses
4. Sample and conduct on-site surveys and inspections of 120 existing facilities and 58 newly constructed or major renovation buildings[2]
5. Tabulate results

1.1 Purpose of the Study

The key purpose of this study is to characterize Vermont's current baseline position in commercial/industrial markets by documenting the range and saturation levels of lighting, heating, ventilation, and air conditioning (HVAC), hot water, appliances/equipment, and process systems, and building shell characteristics. The baseline data characterizes the existing building and equipment stock in the Vermont business sector and identifies opportunities for increased energy efficiency statewide and within discrete Energy Efficiency Utility (EEU) jurisdictions, including Efficiency Vermont (EVT), Burlington Electric Department (BED), VT Gas Systems' (VT Gas) service territory and Transmission and Distribution (T&D) constrained Geographically Targeted (GT) areas..

The Vermont Commercial and Industrial Market Characterization and Assessment Study accomplishes three core objectives:

1. Characterizes the existing building and equipment stock in the business sector in Vermont, to develop comprehensive information that can be used to support Vermont EEU's demand-side management (DSM) program planning, program design, and continuous improvement functions.
2. Identifies opportunities for increased energy efficiency statewide and within discrete Energy Efficiency Utility jurisdictions, by estimating Vermont businesses' awareness of EEU DSM

[1] The new construction market characterization report is presented in a separate volume.
[2] Newly constructed since 2008, when the Vermont nonresidential energy code became effective. For this study, a major renovation includes upgrades to at least two "major" building systems such as HVAC, lighting, or building envelope.

programs and major DSM measures, as well as missed opportunities in new construction and remaining potential in existing buildings.

3. Characterizes the state as a whole, as well as select GT areas, BED service territory, and VT Gas service territory, by developing information to support Vermont-specific estimates for the saturations of key DSM measures in five defined service areas,[3] which were split further into four strata based on annual electrical energy consumption.[4]

1.2 *Organization of the Report*

The remainder of this report includes the following sections:

Section 1 – Introduction

Section 2 – Study Methodology

Section 3 – Existing Buildings Commercial and Industrial Market Characterization

Section 4 – Assessment of Remaining Potential

Section 5 – Assessment of EEU Service Quality and Process-Related Insights

The report includes the following appendices in a separate document:

Appendix A – Survey Instruments

Appendix B – Remaining Potential – Qualitative Assessment

[3] The five areas: Area A = BED/VT Gas; Area B = Non-GT/VT Gas; Area C = GT/VT Gas; Area D = GT/Non-VT Gas; Area E = Non-GT/Non-VT Gas.

[4] The four strata: Stratum 1 = 2-79 MWh/year; Stratum 2 = 80-560 MWh/year; Stratum 3 = 561-9,999 MWh/year; Stratum 4 = 10,000–54,000 MWh/year.

2. Study Methodology

This section provides an overview of the data sources and methods used to develop the baseline characterization.

2.1 Data Sources

The on-site surveys collected primary data from Vermont C&I facilities in designated regions. Telephone surveys collected reported information on awareness and willingness of key energy efficiency measures and energy efficiency program services, recent energy efficient decision-making and behavior, and on efficient equipment and building construction from a large sample. On-site surveys, of a smaller sample, also collected awareness/willingness data but focused principally on in-depth and accurate data collection of equipment and building envelope by inspection of professionally trained surveyors. Together these sources reflect the 2011-2012 baseline efficiency of Vermont businesses. Telephone and on-site survey participants were recruited randomly from a stratified sample of Vermont businesses. A telephone survey of market actors knowledgeable about energy management systems (EMS) also was conducted. . The results of this survey will inform opportunities for increased automation of energy-using equipment in the C&I sector.

2.2 Sampling Approach

The on-site survey and telephone survey samples were designed to represent a broad cross section of Vermont businesses and to achieve a reasonable confidence interval and margin of error. For the C&I sector, Navigant considered energy usage and EEU service territory as the primary sampling points. Information on business and building type was not available for the population, but was tracked throughout the execution phase of on-sites and telephone surveys to ensure an evenly distributed sample.

Customer data from all C&I customers was collected from Efficiency Vermont, public sources (the Vermont Department of Public Safety, Division of Fire Safety), and InfoUSA[5] to characterize the population according to certain variables. The following sections show the resulting stratified sample design.

2.2.1 Existing Buildings On-Site Surveys

The Navigant team targeted and completed on-site surveys at 120 existing building sites, with approximately 20 each in four areas: BED, Vermont Gas, GT, and Non-GT areas, and 40 in the rest of the state. This number of surveys is sufficient to provide statistical confidence of 80% and +/- 10% precision or margin of error (80/10) for each of the three EEU areas and 90/10 in the state as a whole. This level of statistical confidence and precision is generally accepted as industry standard. For example, this is the

[5] http://www.infousa.com/

level of statistical confidence and precision is required by Independent System Operator New England (ISO NE) for verification of demand response (DR) resource savings.[6]

The following tables summarize the results of the on-site data collection efforts for the existing buildings portion of the study. Table 2-1 compares the targeted to actual sample sizes by area and stratum. Navigant surveyed 120 existing buildings across five sample areas and four strata.[7] Navigant defined the sample areas by EEU service areas. The EEU service areas include BED, Vermont Gas, and EVT. Vermont Gas territory overlaps with both BED and EVT. Within Efficiency Vermont's territory, there are four distinct GT areas. Navigant divided the four strata based on annual electric energy use, where Stratum #1 is the lower energy users and stratum #4 is the higher energy users.

Table 2-1. Comparison of Targeted to Actual Site Visits

Strata Boundaries:		On-Site Surveys (Target / Actual) [1] 2-79 MWh	[2] 80-560 MWh	[3] 561-9,999 MWh	[4] 10,000-54,000 MWh	On-Site Sample Size-Total
Sample Area[a]	**Share of Total Electric Use**	**Low Use**	**Medium Use**	**High Use**		**Target / Actual**
A—BED/VT Gas	9%	3 / 3	5 / 6	11 / 9	1 / 1	20 / 19
B—Non-GT/VT Gas	11%	3 / 2	4 / 5	12 / 12	1 / 1	20 / 20
C—GT /VT Gas	11%	4 / 4	4 / 4	10 / 9	2 / 2	20 / 19
D—GT/Non-VT Gas	15%	4 / 5	5 / 5	9 / 10	2 / 1	20 / 21
E—Non-GT/Non-VT Gas	54%	11 / 11	8 / 8	19 / 20	2 / 2	40 / 41
Totals	**100%**	**27 / 25**	**21 / 28**	**65 / 60**	**8 / 7**	**120 / 120**

a. BED = Burlington Electric Department; GT = Geotargeted areas; VT Gas = Vermont Gas Systems

Source: Navigant on-site surveys

[6] ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources Manual M-MVDR, Revision: 2, Effective Date: June 1, 2010, Prepared by ISO New England Inc., section 7.2 Statistical Sampling, pages 45 and 51, see http://www.iso-e.com/rules_proceds/isone_mnls/.

[7] The top two energy-using strata were combined into one category, referred to as "High Use" for reporting purposes.

Table 2-2 shows the distribution of targeted and completed sites across the five sample areas. Navigant completed 34% of all sites in Area E, which is in neither a GT area nor VT Gas territory.[8]

Table 2-2. Summary of Site Visits by Sample Area

Sample Area	Number of Targeted Sites	Number of Completed Sites	Percent of Total Sample (Completed Sites)
A—BED/VT Gas	20	19	16%
B—Non-GT/VT Gas	20	20	17%
C—GT /VT Gas	20	19	16%
D—GT/Non-VT Gas	20	21	18%
E—Non-GT/Non-VT Gas	40	41	**34%**
Total	**120**	**120**	**100%**

Source: Navigant on-site surveys

Table 2-3 summarizes the completed on-site visits across the four consumption strata. For reporting purposes, strata three and four are consolidated into the *high energy use* consumption category.

Table 2-3. Summary of Completed Site Visits by Consumption Stratum

Consumption Stratum	Consumption Stratum for Reporting Purposes	Number of Completed Sites in Stratum	Percent of Total Sample
1	Low Use	25	21%
2	Medium Use	28	23%
3	High Use	60	50%
4	High Use	7	6%
Total		**120**	**100%**

Source: Navigant on-site surveys

[8] The proposal for the study also refers to this area as "balance of state".

Navigant selected the existing buildings sample from utility data provided by the EEUs. This data did not consistently report building types (or SAIC codes). Navigant did not use the building type as a primary sampling point, but tracked building types surveyed and course-corrected along the way to develop a reasonable distribution across all building types. As seen in Table 2-4, manufacturing represents the highest share of surveyed building types (21%), with office and retail comprising 11% and 9%, respectively. For reporting purposes, all other building type categories are consolidated into the *balance of commercial* category.

Table 2-4. Summary of Completed Site Visits by Building Type

Building Type	Building Type for Reporting Purposes	Number of Completed Sites	Percent of Total Sample
Manufacturing	Manufacturing	25	21%
Office	Office	13	11%
Retail	Retail	11	9%
Services	Balance of Commercial	12	10%
Lodging		8	7%
School		8	7%
Healthcare		5	4%
Food Store		8	7%
Restaurant		6	5%
Warehouse		6	5%
Public Assembly		4	3%
College/University		2	2%
Multifamily		3	3%
Ski Resort		1	1%
Other[a]		8	7%
Total		**120**	**100%**

a. "Other" includes (3) waste-water management facilities, (2) dairy farms, (2) nursing homes and (1) slaughter house
Source: Navigant on-site surveys

Table 2-5 shows the final on-site sample results by sample area and strata, as well as weightings used to extrapolate the results of the on-site surveys to the population.

Table 2-5. Final On-Site Sample Results and Weightings

Area	Strata	Population Size	Target Sample Size	Final Sample Size	Weight[a]
A - BED/VT Gas	1	1,232	3	3	411
A - BED/VT Gas	2	222	5	6	37
A - BED/VT Gas	3	67	11	9	7
A - BED/VT Gas	4	1	1	1	1
B - Non-GT/VT Gas	1	1,752	3	3	584
B - Non-GT/VT Gas	2	384	4	5	77
B - Non-GT/VT Gas	3	75	12	11	7
B - Non-GT/VT Gas	4	1	1	1	1
C - GT/VT-Gas	1	1,694	4	4	424
C - GT/VT-Gas	2	284	4	4	71
C - GT/VT-Gas	3	67	10	9	7
C - GT/VT-Gas	4	5	2	2	3
D - GT/Non-VT Gas	1	3,414	4	5	683
D - GT/Non-VT Gas	2	517	5	5	103
D - GT/Non-VT Gas	3	92	9	10	9
D - GT/Non-VT Gas	4	4	2	1	4
E - Non-GT/Non-VT Gas	1	15,893	11	10	1,589
E - Non-GT/Non-VT Gas	2	2,046	8	8	256
E - Non-GT/Non-VT Gas	3	304	19	21	14
E - Non-GT/Non-VT Gas	4	15	2	2	8
Total		**28,069**	**120**	**120**	

a. Weight =Population Size/Final Sample Size
Source: Navigant analysis

2.2.2 Existing Buildings Telephone Surveys

The Navigant team conducted telephone surveys with 237 customers, split approximately evenly between the following areas: EVT (including GT and Non-GT areas), BED, Vermont Gas, and the rest of the state. This number of surveys was sufficient for results with statistical confidence of 90% and +/- 10% precision or margin of error. Table 2-6 compares the targeted to actual sample sizes by area and stratum for the telephone surveys.

Table 2-6. Comparison of Targeted to Actual Telephone Surveys

Strata Boundaries:		Telephone Surveys (Target / Actual) [1] 2-79 MWh	[2] 80-560 MWh	[3] 561-9,999 MWh	[4] 10,000-54,000 MWh	Telephone Survey Sample Size-Total
Sample Area[a]	Share of Total Electric Use	Low Use	Medium Use	High Use		Target / Actual[b]
A—BED/VT Gas	9%	7 / 8	8 / 19	24 / 9	1 / 0	40 / 36
B—Non-GT/VT Gas	11%	7 / 7	9 / 17	23 / 15	1 / 1	40 / 40
C—GT /VT Gas	11%	7 / 8	7 / 9	21 / 18	5 / 2	40 / 37
D—GT/Non-VT Gas	15%	9 / 9	9 / 11	18 / 19	4 / 1	40 / 40
E—Non-GT/Non-VT Gas	54%	21 / 23	16 / 18	38 / 38	5 / 5	80 / 84
Totals	**100%**	**51 / 55**	**49 / 74**	**124 / 99**	**16 / 9**	**240/237**

a. BED = Burlington Electric Department; GT = Geotargeted areas; VT Gas = Vermont Gas Systems

b. There were three customers that were re-classified as new construction/major renovation and removed from the sample, making the final telephone survey population 237 customers.

Source: Navigant telephone surveys

Table 2-7 summarizes the completed telephone surveys by sample area.

Table 2-7. Summary of Telephone Surveys by Sample Area

Sample Area	Number of Targeted Customers	Number of Completed Customers	Percent of Total Sample (Completed Customers)
A—BED/VT Gas	40	36	15%
B—Non-GT/VT Gas	40	40	17%
C—GT /VT Gas	40	37	16%
D—GT/Non-VT Gas	40	40	17%
E—Non-GT/Non-VT Gas	80	84	35%
Total	**240**	**237**	**100%**

Source: Navigant on-site surveys

Table 2-8 summarizes the completed telephone survey sample by consumption stratum. For reporting purposes, strata three and four are consolidated into the *high energy use* consumption category.

Table 2-8. Summary of Completed Telephone Surveys by Consumption Stratum

Consumption Stratum	Consumption Stratum for Reporting Purposes	Number of Completed Surveys in Stratum	Percent of Total Sample
1	Low Use	55	23%
2	Medium Use	74	31%
3	High Use	99	42%
4	High Use	9	4%
Total		**237**	**100%**

Source: Navigant on-site surveys

Table 2-9 summarizes the completed telephone surveys by building type. Manufacturing represented 22% of respondents, with office and retail comprising 11% and 12%, respectively. For reporting purposes, all other building type categories are consolidated into the *balance of commercial* category.

Table 2-9. Summary of Completed Telephone Surveys by Building Type

Building Type	Building Type for Reporting Purposes	Number of Completed Surveys	Percent of Total Sample[a]
Manufacturing	Manufacturing	53	22%
Office	Office	27	11%
Retail	Retail	28	12%
Warehouse	Balance of Commercial	19	8%
Public Assembly		19	8%
School		18	8%
Lodging		12	5%
Restaurant		9	4%
Multifamily		8	3%
College/University		6	3%
Services		6	3%
Food Store		4	2%
Healthcare		4	2%
Ski Resort		2	1%
Other		22	9%
Total		**237**	**100%**

a. "Other" includes (6) senior/assisted living centers, (3) waste water management facilities, (3) multi-use recreational resort facilities, (2) agricultural facilities, (2) military facilities, (1) ice skating rink, (1) water treatment facility, (1) multimodal transit center, (1) fire station, (1) mortuary and (1) child care facility

Source: Navigant on-site surveys

Table 2-10 shows the final on-site sample results by sample area and strata, as well as weightings used to extrapolate the results of the on-site surveys to the population.

Table 2-10. Final Telephone Sample Results and Weightings

Area	Strata	Population Size	Target Sample Size	Final Sample Size	Weight[a]
A - BED/VT Gas	1	1232	7	8	154
A - BED/VT Gas	2	222	8	19	12
A - BED/VT Gas	3	67	24	9	7
A - BED/VT Gas	4	1	1		
B - Non-GT/VT Gas	1	1752	7	7	250
B - Non-GT/VT Gas	2	384	9	17	23
B - Non-GT/VT Gas	3	75	23	15	5
B - Non-GT/VT Gas	4	1	1	1	1
C - GT/VT-Gas	1	1694	7	8	212
C - GT/VT-Gas	2	284	7	9	32
C - GT/VT-Gas	3	67	21	18	4
C - GT/VT-Gas	4	5	5	2	3
D - GT/Non-VT Gas	1	3414	9	9	379
D - GT/Non-VT Gas	2	517	9	11	47
D - GT/Non-VT Gas	3	92	18	19	5
D - GT/Non-VT Gas	4	4	4	1	4
E - Non-GT/Non-VT Gas	1	15893	21	23	691
E - Non-GT/Non-VT Gas	2	2046	16	18	114
E - Non-GT/Non-VT Gas	3	304	38	38	8
E - Non-GT/Non-VT Gas	4	15	5	5	3
Total		**28069**	**240**	**237**	

a. Weight =Population Size/Final Sample Size
Source: Navigant analysis

2.2.3 Final Reporting Segments

Navigant presents the results of this baseline study according to designated reporting segments, illustrated in Table 2-11 and Table 2-12. Sample area categories encompassed each unique combination of EEU service territory, ensuring broad representation for reporting EEU and statewide results. As shown in Table 2-11, certain reporting segments are mutually exclusive (i.e., BED and EVT) while others overlap (i.e., VT Gas).

Table 2-11. Reporting Segments for EEU Areas

<table>
<tr><th>Original Sample Area (Below) / Reporting Segment (Across)</th><th>BED</th><th>EVT</th><th>VT Gas</th><th>GT</th><th>Non-GT</th></tr>
<tr><td>A—BED/VT Gas</td><td>X</td><td></td><td rowspan="3">X</td><td>N/A</td><td>N/A</td></tr>
<tr><td>B—Non-GT/VT Gas</td><td rowspan="4"></td><td rowspan="4">X</td><td></td><td>X</td></tr>
<tr><td>C—GT /VT Gas</td><td rowspan="2">X</td><td rowspan="2"></td></tr>
<tr><td>D—GT/Non-VT Gas</td><td rowspan="2"></td></tr>
<tr><td>E—Non-GT/Non-VT Gas</td><td></td><td>X</td></tr>
</table>

Source: Navigant analysis

Table 2-12 shows the reporting segments associated with each consumption stratum number used during the sampling phase. Strata three and four are consolidated into the high energy use stratum.

Table 2-12. Reporting Segments for Consumption Stratum

Reporting Segment	Low Use	Medium Use	High Use
Sampling Consumption Stratum ID	1	2	3 & 4
Energy Boundaries	<80 MWh	≥80 and <560 MWh	≥560 MWh

Source: Navigant analysis

2.3 *Data Collection Approach*

All survey participants were recruited at random according to the stratified sample designs. Forms for all surveys are included in the appendices.

2.3.1 On-Site Surveys

Professionally trained surveyors surveyed the sites of 120 existing Vermont businesses that were randomly recruited by telephone according to the stratified sample design. Surveyors conducted a brief decision-maker survey with the building manager or the person most knowledgeable about equipment. The surveyors collected detailed inventories of energy-using equipment and building characteristics by inspection and, at larger sites, by customer-provided schedules of equipment. Surveyors also collected operation and power management behavior by interview.

The site inspection covered all relevant energy aspects of customer facilities and businesses:

- Building size and orientation
- Building envelope information, such as insulation levels and wall and window sizes
- Complete inventories of energy-using equipment covering all end uses, including lighting, HVAC, motors, water heating, commercial refrigeration, cooking, office equipment, air compressors, and other types of process equipment
- Equipment and operation schedules and controls

Table 2-13 shows the response rate for scheduling the on-site surveys. The scheduling team attempted to contact 50% of the sample, with 16% refusing to participate and 9% successfully scheduling a site visit.

Table 2-13. Existing Building On-Site Survey Response Rates

	Total Counts	Percentage
Total Sample	1373	
Total Customers Dialed	684	50%
Total Customers Reached	345	25%
Refused	225	16%
Completed	120	9%

Source: On-site survey scheduling disposition

2.3.2 Telephone Surveys

Telephone surveys were conducted with 237 Vermont businesses and generally took about 20 minutes to complete. The surveys were conducted by a third party using a computer-assisted telephone interviewing (CATI) system and were conducted with the person who was identified to be the building manager or the most knowledgeable person about cooling, heating, and lighting equipment at the facility. The survey focused on awareness of efficiency measures and EEU programs and on decision-making of recent retrofits. Customers were also surveyed on general building characteristics, general operations, energy management, and business outlook. Table 2-13 shows the response rates for the existing buildings telephone survey.

Table 2-14. Existing Building Telephone Survey Response Rates

	Total Counts	Percentage
Total Sample	1410	
Total Customers Dialed	1410	100%
Total Customers Reached	727	52%
Refused	482	34%
Completed	245	17%

Source: Telephone survey disposition

2.4 *Data Analysis Approach*

The approach for data analysis involved quality control, descriptive statistics, comparison of results across data sets, and summary of corroborated results to describe the market baselines. All data collected were reviewed for quality control. Responses to open-ended telephone survey questions were reviewed and coded. All on-site survey responses were reviewed for validity and completeness by engineers who worked closely with surveyors to ensure data quality throughout the survey period. Analysis of vetted data involved tabulating frequencies of responses and calculating saturations of standard and efficient equipment by reporting segments.

3. Existing Buildings Commercial and Industrial Market Characterization

This chapter presents the results for C&I buildings in the following segments:

» Statewide results weighted to the Vermont C&I population
» Three strata based on annual electrical energy consumption (High, Medium, and Low)
» Four building types (Retail, Office, Manufacturing and Balance of Commercial)
» Results by EEU including BED, Efficiency Vermont (EVT) and VT Gas
» Results within EVT territory for Geotargeted (GT) and Non-GT buildings

The results are based on on-site surveys conducted between August and December of 2011 and telephone surveys conducted between September and November of 2011.

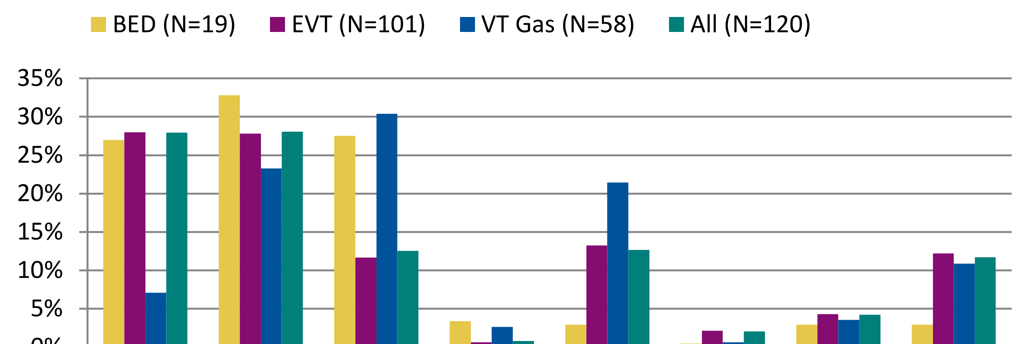
3.1 General Building Information

Surveyors collected information regarding general building characteristics such as age, size, operating schedules, and more. The following sections present the results for key building characteristics.

3.1.1 Facility Age

Figure 3-1 shows the distribution of building construction year by EEU territory. For both BED and EVT, the majority of buildings were constructed before 1960, with equal proportions before 1900 and between 1900 and 1959. Nearly 30% of all buildings in BED and VT Gas territories were constructed in the 1960s. Burlington's building stock is the oldest, with only 10% of buildings constructed after 1970. EVT and VT Gas territories both saw significant new building construction in the 1980s (13% and 21%, respectively). Statewide, the average age of Vermont C&I buildings is 88 years old (constructed in 1923) and the median age is 72 years old (constructed in 1939).

Figure 3-1. Year of Building Construction by EEU (N = 120)

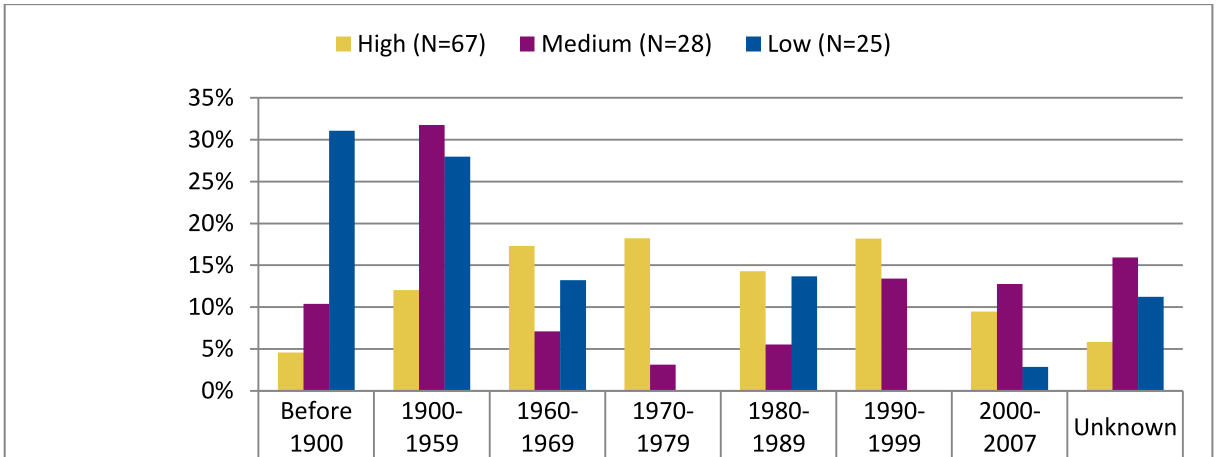


	Before 1900	1900-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007	Unknown
BED (N=19)	27%	33%	28%	3%	3%	0%	3%	3%
EVT (N=101)	28%	28%	12%	1%	13%	2%	4%	12%
VT Gas (N=58)	7%	23%	30%	3%	21%	1%	4%	11%
All (N=120)	28%	28%	13%	1%	13%	2%	4%	12%

Source: On-Site Survey, Question 7

Correlating the year of construction to energy consumption, as shown in Figure 3-2, demonstrates that the majority of high energy users (77%) are actually in buildings built after 1960. Low energy use businesses are predominantly in buildings built before 1960. An important corollary to these findings is that energy use in commercial buildings is typically a function of overall building size and function, and not directly proportional to building vintage.[9] The following section 3.1.2 discusses building size and shows that high energy users occupy significantly larger buildings, and Figure 3-2 indicates that these buildings have mostly been built in the last 50 years.

Figure 3-2. Year of Building Construction by Consumption Strata (N = 120)



	Before 1900	1900-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007	Unknown
High (N=67)	5%	12%	17%	18%	14%	18%	9%	6%
Medium (N=28)	10%	32%	7%	3%	6%	13%	13%	16%
Low (N=25)	31%	28%	13%	0%	14%	0%	3%	11%

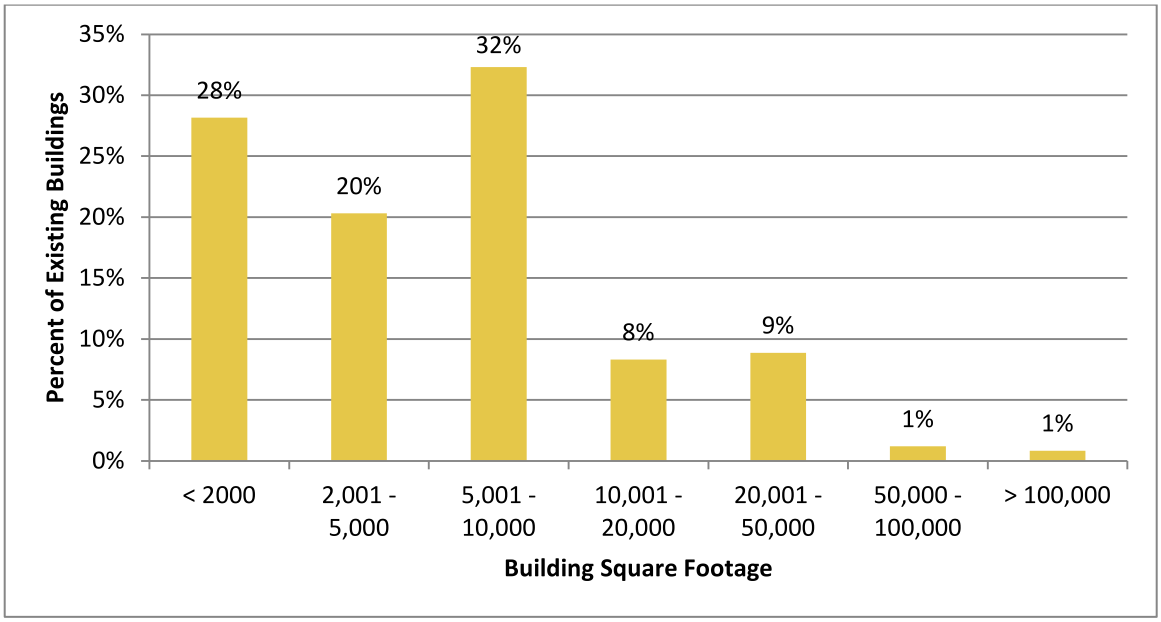
Source: On-Site Survey, Question 7

[9] In other words, sites classified as "high" energy users happen to be occupying newer buildings (i.e., built after 1960), but these buildings are not high energy users *because* they were built after 1960. Square footage, number of employees, and function drive commercial/industrial energy use more than building age.

3.1.2 Building Size

Nearly half (48%) of Vermont's C&I buildings are less than 5,000 square feet (SF)[10] in size, and 32% of buildings are between 5,000 and 10,000 SF. Only two percent of all buildings are greater than 50,000 SF. Figure 3-3 shows the distribution of building square footage for all existing buildings.

Figure 3-3. Total Square Footage for All Buildings (N = 120)



Source: On-Site Survey, Question 8

[10] Square footage does not include parking garages.

Table 3-1 shows building square footage by consumption strata and EEU. This breakout illustrates two significant findings not seen in the results for all buildings:

» As expected, there is a clear correlation between energy use and building size. 80% of buildings in the high consumption stratum are larger than 20,000 SF.
» 88% of buildings in Burlington are less than 5,000 SF, compared to 48% for the statewide average.
» 70% of buildings in VT Gas territory are less than 5,000 SF, compared to 48% for the statewide average.
» The median size of buildings in BED's service area is 2,200 SF, which is significantly less than the statewide average of 6,000 SF. Buildings in EVT territory have a median size of 7,000 SF, while the median in VT Gas territory is 4,000 SF.

Table 3-1. Total Square Footage by Consumption Stratum and EEU (N = 120)

Building Square Footage[a]	Consumption Stratum			EEU			All Buildings (N=120)
	High (N=67)	Medium (N=28)	Low (N=25)	BED (N=19)	EVT (N=101)	VT Gas (N=58)	
< 2000	2%	13%	31%	27%	28%	17%	28%
2,001 - 5,000	1%	24%	20%	61%	18%	53%	20%
5,001 - 10,000	7%	25%	34%	2%	34%	11%	32%
10,001 - 20,000	8%	10%	8%	0%	9%	13%	8%
20,001 - 50,000	30%	21%	7%	8%	9%	4%	9%
50,000 - 100,000	12%	7%	0%	0%	1%	1%	1%
> 100,000	38%	0%	0%	1%	1%	1%	1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Mean	**86,590**	**17,081**	**6,407**	**6,559**	**9,693**	**9,110**	**9,523**
Median	**53,000**	**6,000**	**5,000**	**2,200**	**7,000**	**4,000**	**6,000**

a. Does not include parking garages
Source: On-Site Survey, Question 8

3.1.3 Facility Ownership

The majority of C&I customers (59%) own their buildings. Figure 3-4 illustrates the following findings:

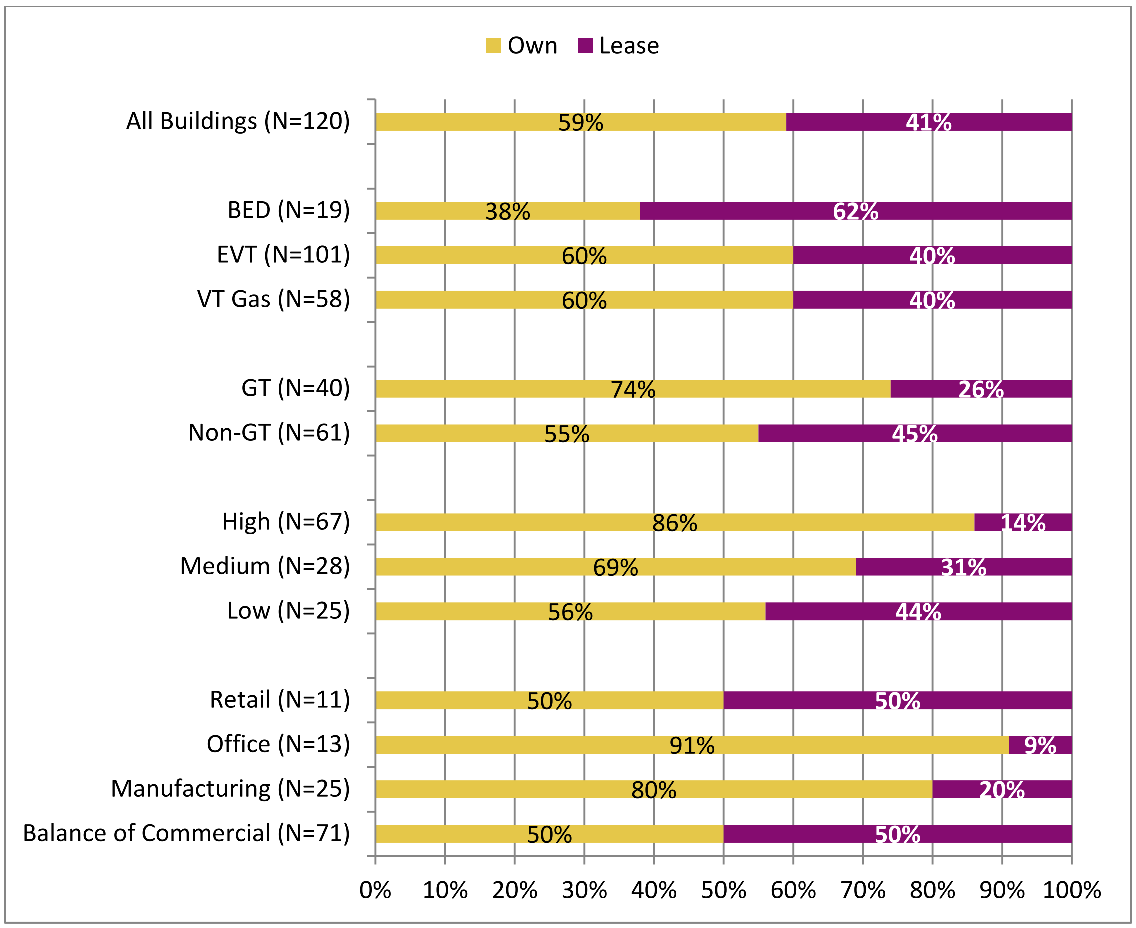
» The BED service area is distinct from the rest of the state, with only 38% owning buildings and the remaining 62% leasing. This is characteristic of Burlington's urban setting where the commercial real estate market is dominated by tenant/lease arrangements.

» Geotargeted areas within EVT's service territory show a higher ownership rate (74%) than the Non-GT areas (55%).

» There is a trend of higher ownership rates for high energy-using buildings (86%) and lower ownership rates for the low energy users (56%).

» Office and manufacturing building types show the highest ownership rates, at 91% and 80%, respectively.

Figure 3-4. Facility Ownership (N = 120)



Source: On-Site Survey, Question 4

3.1.4 Business Information

The average (mean) number of full-time equivalent (FTE) employees in Vermont's businesses is ten, while the median number of FTEs is five, as shown in Table 3-2. BED and VT Gas territories both have average FTEs higher than the statewide average, at 18 and 14, respectively. High energy users have significantly higher numbers of FTEs, with an average of 143 FTEs and a median of 80. The high number of FTEs in the manufacturing sector contributes to this finding, where the average number of FTEs is 50 with a median of 28.

Table 3-2. Full-Time Equivalent Employees (N = 120)

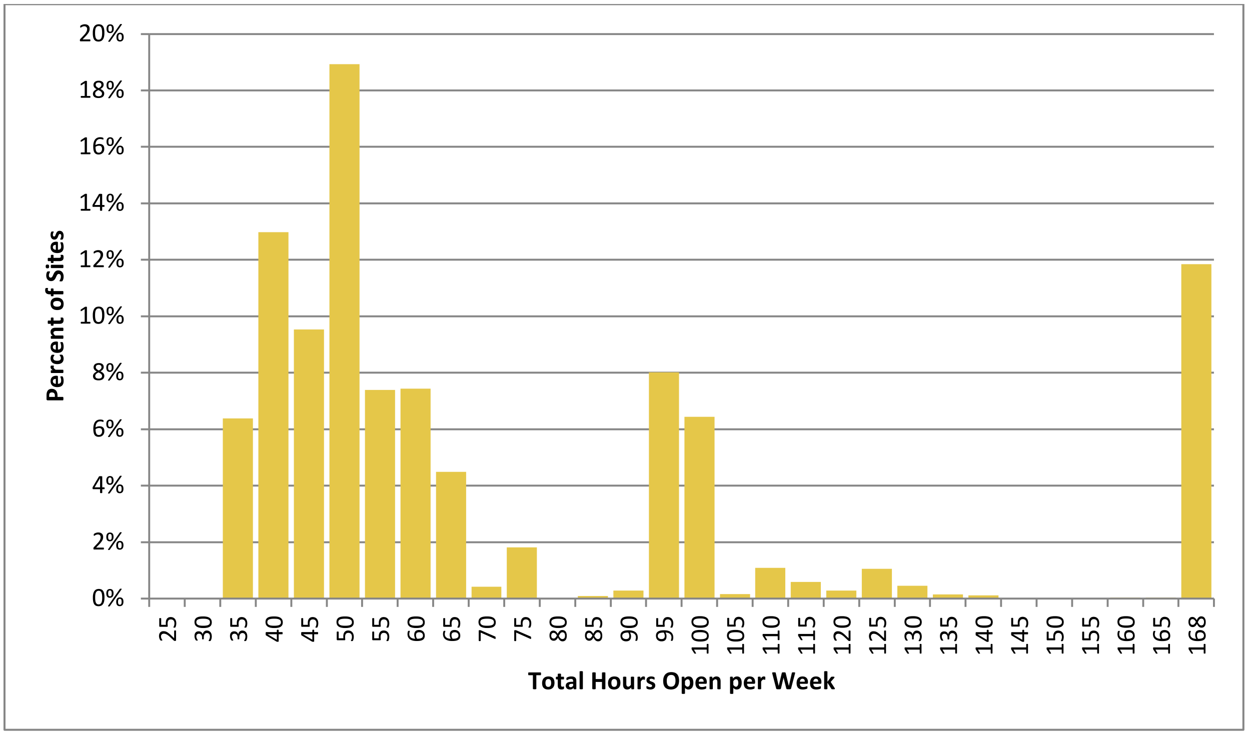
Category	Mean FTEs	Median FTEs
All Buildings (N=120)	10	5
BED (N=19)	18	5
EVT (N=101)	9	5
VT Gas (N=58)	14	6
GT (N=40)	12	9
Non-GT (N=61)	8	4
High (N=67)	143	80
Medium (N=28)	17	8
Low (N=25)	5	4
Retail (N=11)	5	6
Office (N=13)	11	7
Manufacturing (N=25)	50	28
Balance of Commercial (N=71)	9	3

Source: On-Site Survey, Question 5

3.1.5 Business Hours

Figure 3-5 shows the distribution of open hours for all C&I buildings in Vermont. Approximately 56% of buildings are open between 40-60 hours per week, and approximately 12% of all businesses are always open (24/7). The chart also shows a cluster of buildings (14%) that are open between 95-100 hours per week (approximately 13-14 hours/day).

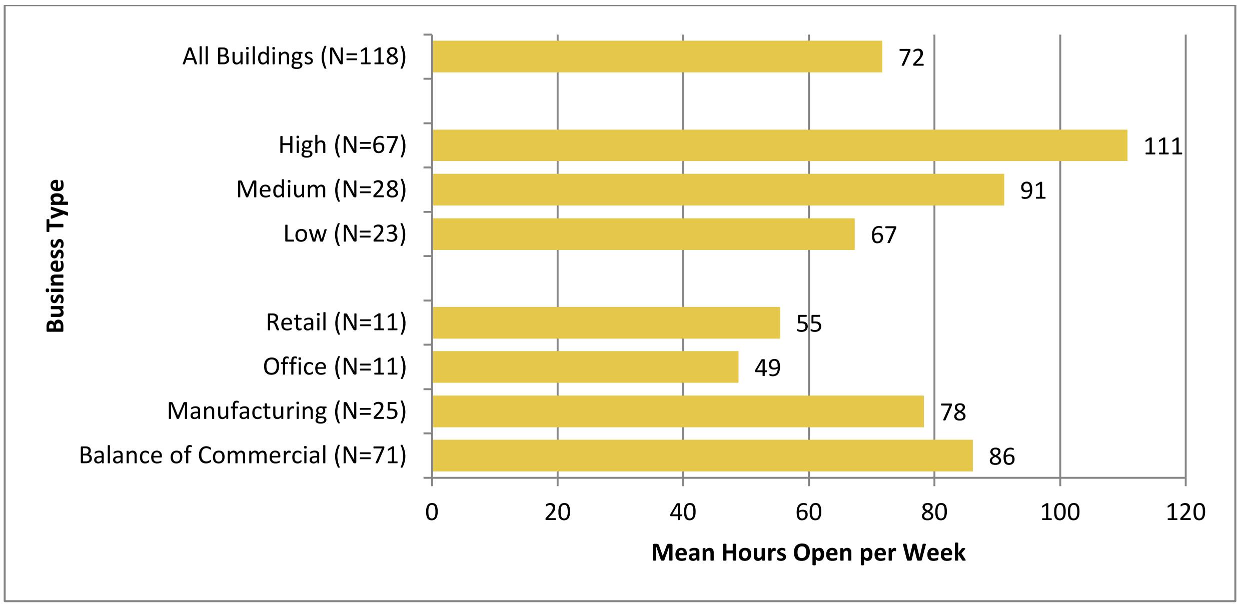
Figure 3-5. Distribution of Weekly Open Hours for All Buildings (N = 118)



Source: On-Site Survey, Questions 22-29

Vermont businesses are open an average of 72 hours per week, as shown in Figure 3-6. Open hours are directly correlated with energy consumption, and high energy users are open for an average of 111 hours per week, followed by medium users at 91 hours, and then low users at 67 hours. The results by building type indicate that both retail and office buildings are open less than the overall average, at 55 and 49 hours per week, respectively. The manufacturing sector averages 78 open hours per week, only slightly above the statewide average.

Figure 3-6. Mean Open Hours per Week by Category (N = 118)[11]



Source: On-Site Survey, Questions 22-29

[11] Two sites in low energy use stratum had less than 10 operating hours per week. This chart excludes these sites from the weighted results.

3.1.6 EEU Market Characterization – General Building Information

Table 3-4 provides a summary characterization of building envelope measures for Vermont's EEUs.

Table 3-3. EEU Market Characterization – General Building Information

Measure/Characteristic	BED	EVT	VT Gas
Facility Age	» The majority of buildings were constructed before 1960, with equal proportions before 1900 and between 1900 and 1959 » Burlington's building stock is the oldest, with only 10% of buildings constructed after 1970	» The majority of buildings were constructed before 1960, with equal proportions before 1900 and between 1900 and 1959 » Significant new building construction in the 1980s (13%)	» Nearly 30% of all buildings were constructed in the 1960s » Significant new building construction in the 1980s (21%)
Building Size[a]	» 88% of buildings are less than 5,000 SF, compared to 48% for the statewide average » Median size of 2,200 SF	» 46% of buildings are less than 5,000 SF, compared to 48% for the statewide average » Median size of 7,000 SF	» 70% of buildings are less than 5,000 SF, compared to 48% for the statewide average » Median size of 4,000 SF
Facility Ownership[b]	» Distinct from the rest of the state, with only 38% owning buildings and the remaining 62% leasing	» 60% ownership, equals statewide average » GT areas within EVT service territory show a higher ownership rate (74%) than the Non-GT areas (55%)	» 60% ownership, equals statewide average
Business Information[c]	» 18 FTE's, higher than the statewide average	» 9 FTEs, similar to the statewide average » GT areas average 12 FTEs. Slightly higher than statewide average	» 14 FTEs, higher than the statewide average

a. Statewide median building size is 6,000 SF.
b. Statewide, 59% of all buildings are owned and 41% are leased.
c. Statewide, mean FTEs statewide is ten employees, and median is five.
Source: Navigant analysis

3.2 Building Envelope

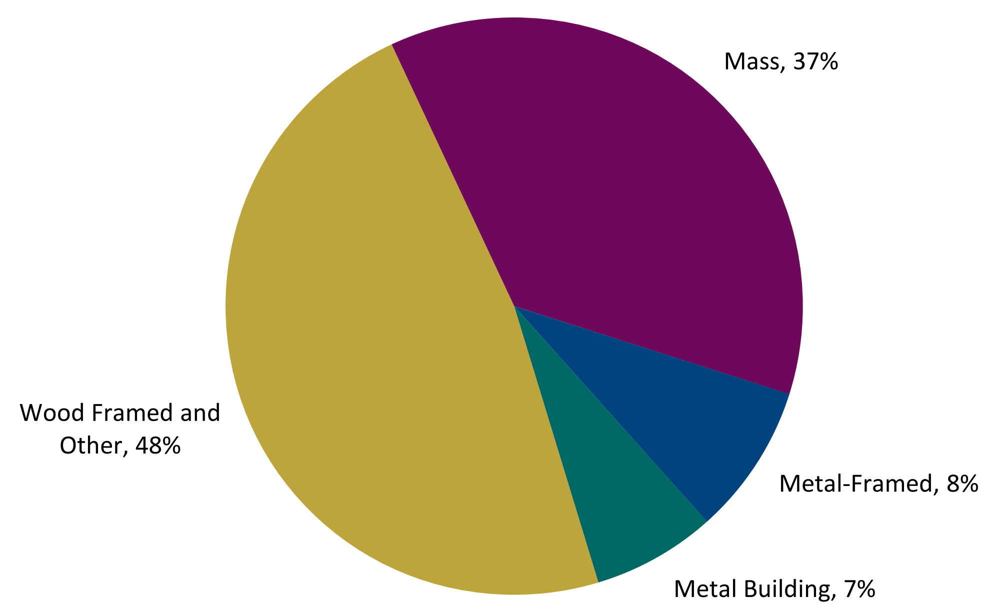
Surveyors inspected each site for building characteristics, including details about wall, roof, and floor construction and insulation as well as window specifications. The following sections present the results for each major envelope component.

3.2.1 Exterior Walls

3.2.1.1 Exterior Wall Construction Types

Navigant consolidated exterior wall construction types into the four categories found in the then current Vermont nonresidential energy code – 2005 Commercial Building Energy Standards (CBES). Nearly half (48%) of Vermont's C&I exterior walls fall into the *wood framed and other* category, while 37% of walls are described as *mass* walls (i.e., brick, block, solid concrete). Only 8% of existing buildings are metal-framed, and 7% classified as metal buildings. Figure 3-7[12] shows the distribution for all existing buildings.

Figure 3-7: Frequency of Exterior Wall Construction Types for All Buildings (N= 189 observations)



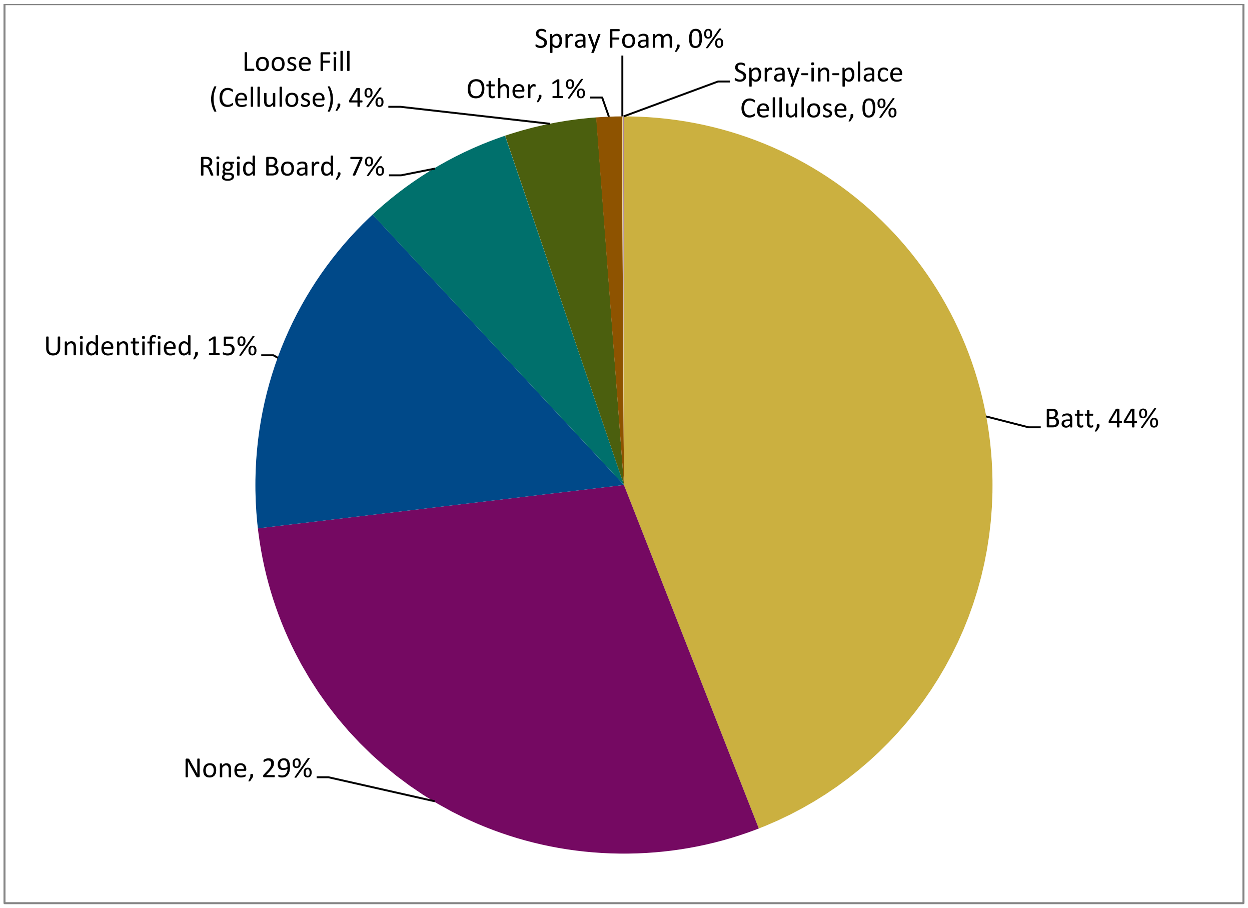
Source: On-Site Survey, Question 81

[12] Wall types exclude observations of *adiabatic* walls, defined as walls through which there is no heat transfer (i.e., walls that have conditioned space on the other side). These instances often occur with adjoining commercial businesses, where the boundary wall of a surveyed business connects to a separate business.

3.2.1.2 *Exterior Wall Insulation Types*

Surveyors inspected exterior walls and/or consulted with knowledgeable on-site staff to determine the insulation types used in the walls. Figure 3-8 shows that 44% of exterior walls have batt insulation, and notably surprising, 29% of walls have no insulation. Rigid board and loose fill cellulose comprise 7% and 4% of insulation types, respectively. Surveyors were unable to identify approximately 15% of wall insulation types, not an unexpected finding given the difficulty of visually verifying what lies behind the walls.

Figure 3-8. Frequency of Wall Insulation Types (N = 189 observations)



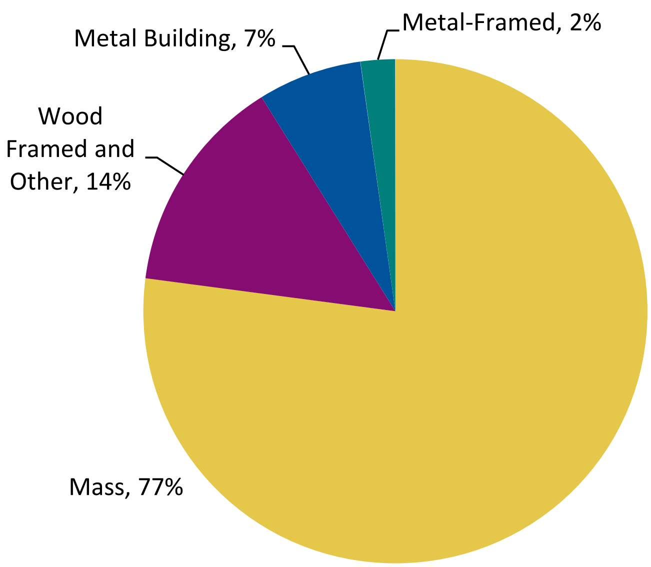
Source: On-Site Survey, Question 82

As shown in Figure 3-8, surveyors found 29% of walls had no insulation. The analysis team investigated these results further to determine if there is any correlation between wall construction type and/or building type. Figure 3-9 shows that a significant majority (77%) of the cases with no wall insulation were found in mass walls, while 14% were in the wood framed/other category. The table within Figure 3-9 further breaks out the instances of mass wall types with no insulation, revealing that most of these walls were either brick (69%), concrete block (25%), or solid concrete (6%).

Figure 3-10 shows that there is little correlation between building type and cases with no wall insulation, as most (54%) were observed in the "Balance of Commercial" category, followed by 25% and 18% in offices and retail buildings, respectively. Manufacturing buildings often have high internal process heat loads, making insulation less critical; however, only 3% of the cases with no insulation were found in the manufacturing sector.

In conclusion, there are a high proportion of buildings in Vermont with mass walls and no insulation.[13] Recent energy codes require insulation for all construction types, but given the older vintage of Vermont's building stock (see Section 3.1.1), the lack of insulation in these mass walls is not surprising. The instances of no insulation on wood framed buildings are not easily explained, and may likely be due simply to older buildings. The field findings also do not explain the lack of insulation in metal buildings.

Figure 3-9. Wall Construction Types for Cases with No Insulation (N = 60 observations)

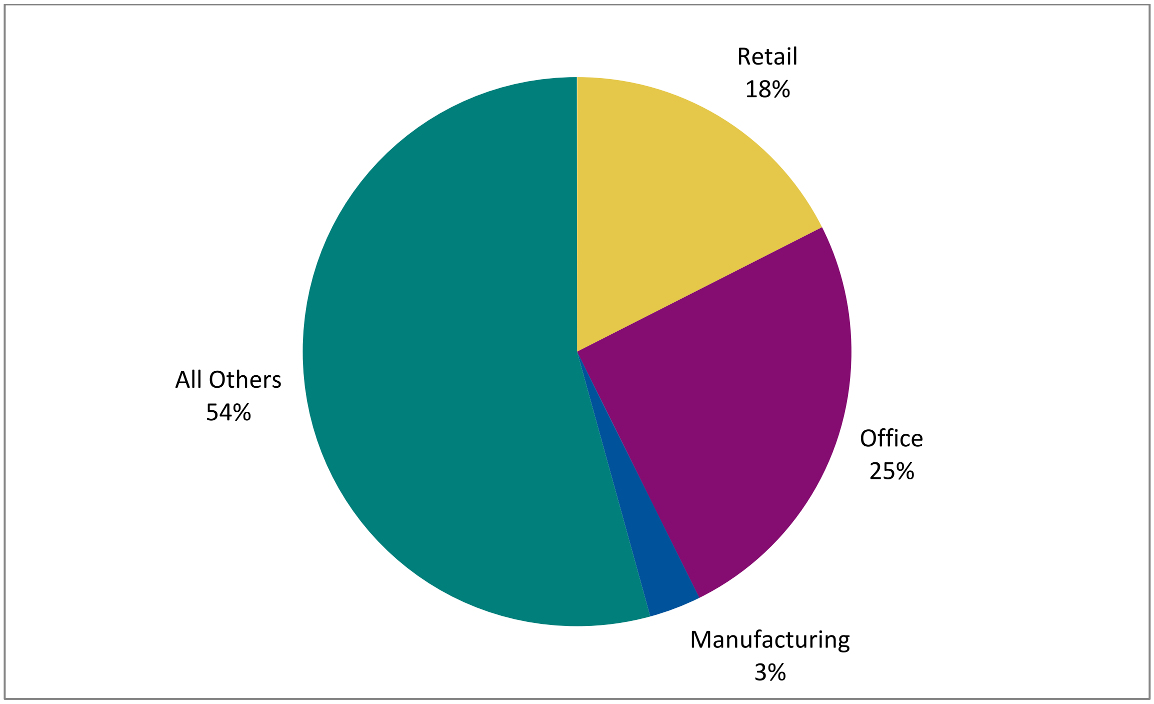


Mass Wall Construction Type	Percent of Mass Wall Types with No Insulation
Brick	69%
Concrete Block	25%
Solid Concrete	6%

Source: On-Site Survey, Question 82

[13] It should be noted that non-insulated mass walls are not necessarily leaky in nature, and in some cases (depending on thickness and construction) perform as well as a properly insulated wall. Furthermore, insulating and air sealing mass walls can be cost prohibitive in most cases.

Figure 3-10. Distribution of Building Types for Cases with No Wall Insulation (N = 60)



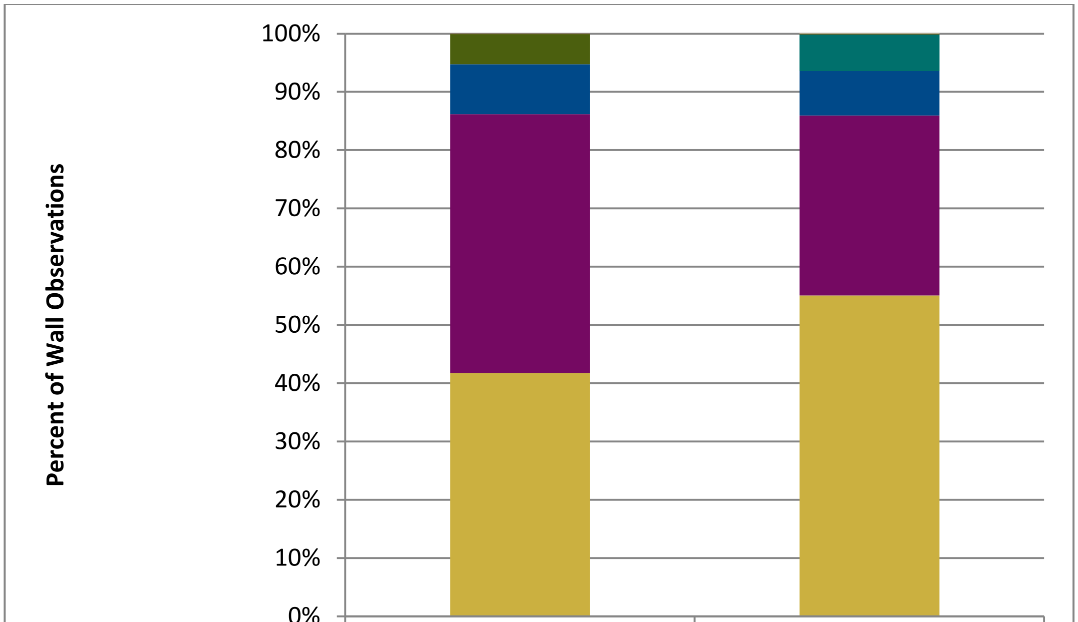
Source: On-Site Survey, Question 82

Figure 3-11 shows the wall insulation types for buildings in VT Gas territory versus the rest of the state. VT Gas territory differs from the rest of the state in three significant ways:

- The share of buildings with batt insulation (42%) is lower than in Non-VT Gas areas (55%).
- The share of buildings with no wall insulation (44%) is higher than outside of VT Gas areas (33%).
- Loose fill cellulose insulation is found more often in Non-VT Gas parts of the state, while there were more instances of "other" insulation types found at VT Gas sites.

The most notable of these differences is the higher number of cases with no insulation within VT Gas service territory. The preceding discussion on this topic indicates that mass walls make up the majority of exterior walls with no insulation. Neither the field data nor the surveyors' observations of remaining potential provide any conclusions for this finding regarding VT Gas territory.

Figure 3-11. Distribution of Wall Insulation Types – VT Gas vs. Non-VT Gas (N = 189 observations)



	VT Gas (N=91)	Non VT Gas (N= 98)
Spray-in-place Cellulose	0%	0%
Spray Foam	0%	0%
Other	5%	0%
Loose Fill (Cellulose)	0%	6%
Rigid Board	9%	8%
None	44%	31%
Batt	42%	55%

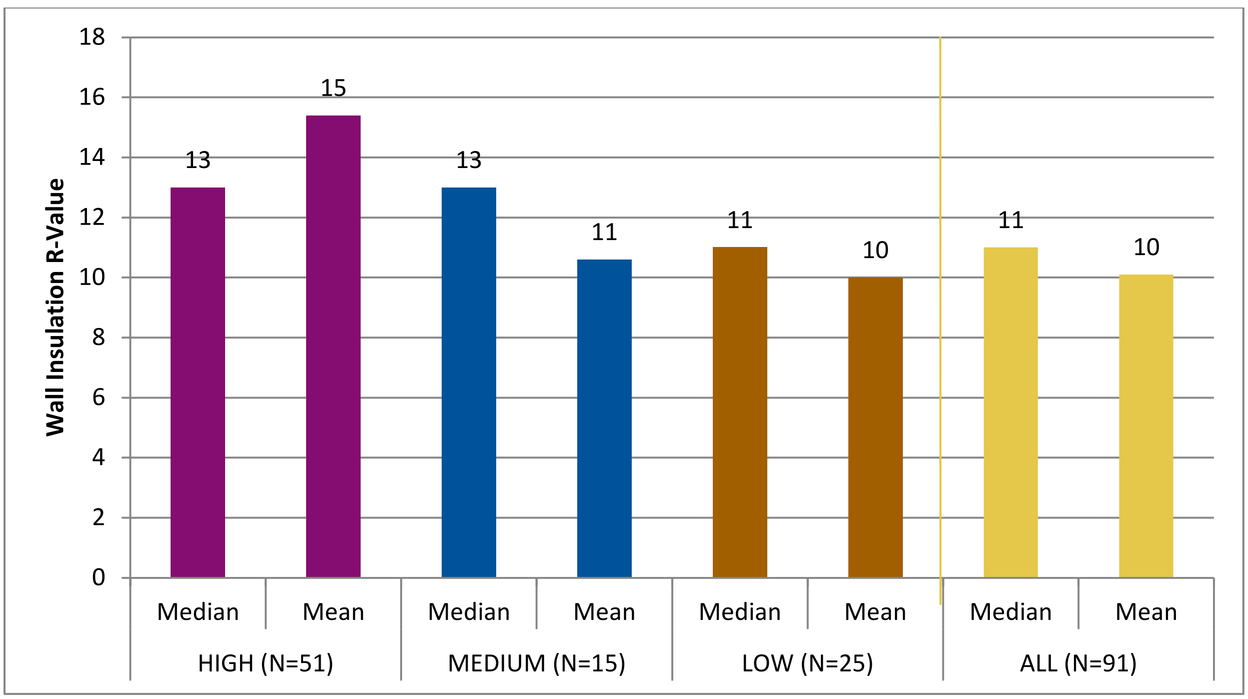
*Unidentified insulation types were removed from the weighted results for this comparison. When included, surveyors only had 3% of insulation types unidentified within VT Gas territory, and 18% outside of these areas.
Source: On-Site Survey, Question 82

3.2.1.3 *Exterior Wall Insulation R-Values*

Surveyors estimated exterior wall insulation R-values by assessing the insulation type and the estimated thickness of the insulation material. The median wall insulation R-value for all existing buildings is R-11, as shown in Figure 3-12. Median wall insulation R-values do not vary significantly between energy consumption strata, as high and medium energy use buildings have median values of R-13, and low energy users have the same value as all buildings (R-11). High energy use buildings have the highest mean R-value of R-15, compared to the statewide mean value of R-10.

The existing building wall R-values shown in Figure 3-12 are generally lower than the prevailing energy code requirements at the time of the study (2005 CBES). Code-required cavity insulation R-values vary between R-9.5 for mass walls and R-19 for wood framed walls, with a weighted average based on actual distribution of R-15.[14]

Figure 3-12. Wall Insulation R-Values by Consumption Strata

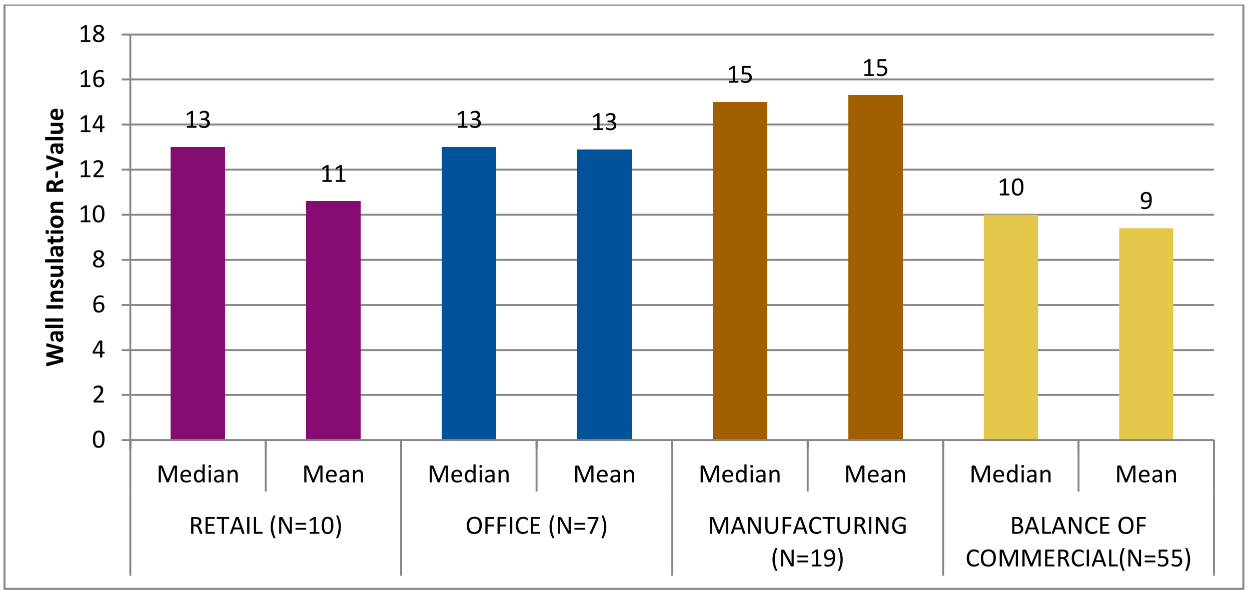


* Zero values are included in all mean/median values.
Source: On-Site Survey, Question 83

[14] Accounting for the mix of wall construction types presented in Figure 3-7: wood-framed: 48%; mass: 37%, metal-framed: 8%; metal building: 7%

Figure 3-13 illustrates median and mean R-values by building type. The results do not differ significantly from the statewide averages, though the manufacturing sector displays the highest R-values, with R-15 for both median and mean.

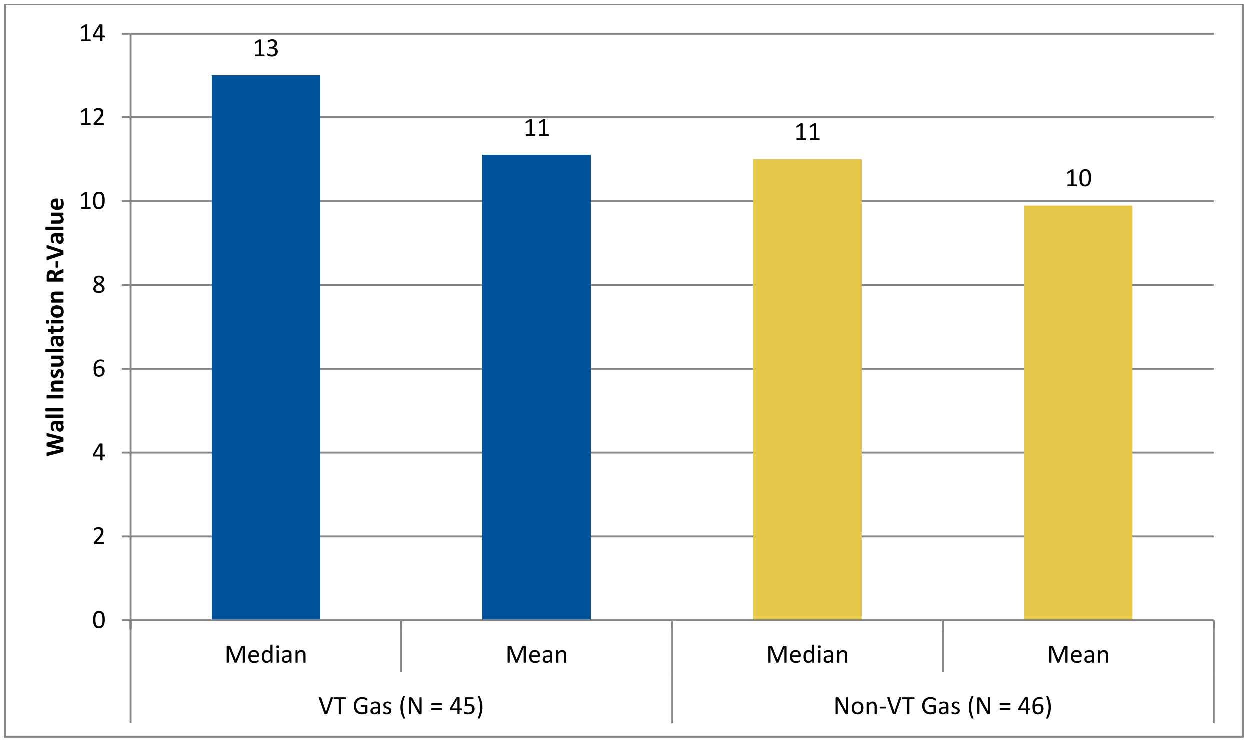
Figure 3-13. Wall Insulation R-Values by Building Type



Source: On-Site Survey, Question 83

Median and mean exterior wall R-values in VT Gas service territory are R-13 and R-11, respectively, and are slightly higher than non-gas areas, as shown in Figure 3-14.

Figure 3-14. Wall Insulation R-Values by VT Gas vs. Non-VT Gas



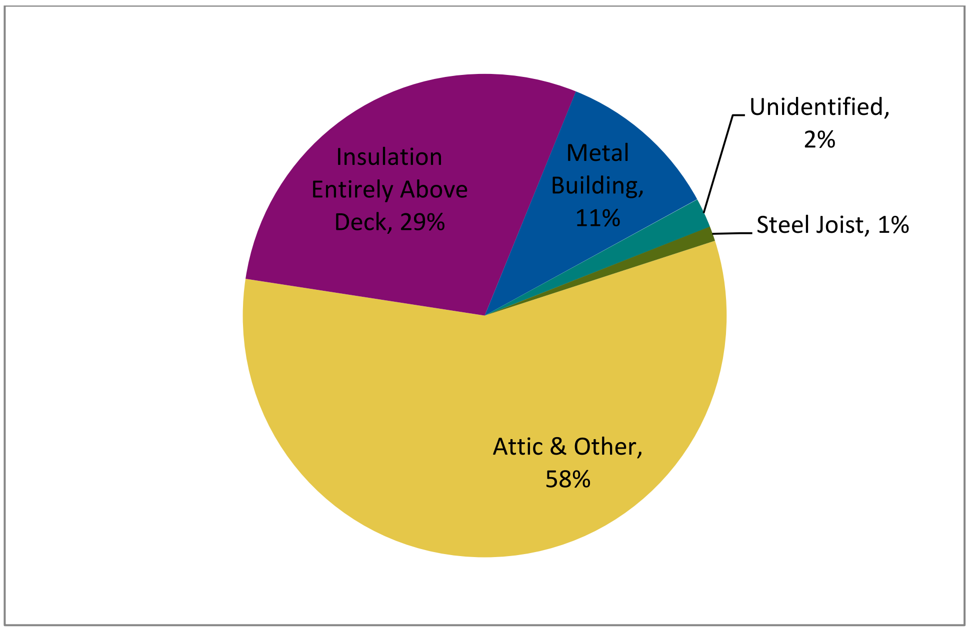
Source: On-Site Survey, Question 83

3.2.2 Roofs

3.2.2.1 Roof Construction Type

The majority (58%) of existing buildings in Vermont have a roof construction type that falls into the energy code category of *attic and other*, as shown in Figure 3-15. Nearly one-third of all buildings have roofs with *insulation entirely above deck*, while surveyors classified 11% as *metal building* roofs.

Figure 3-15. Frequency of Roof Construction Type for All Buildings (N = 160 observations)



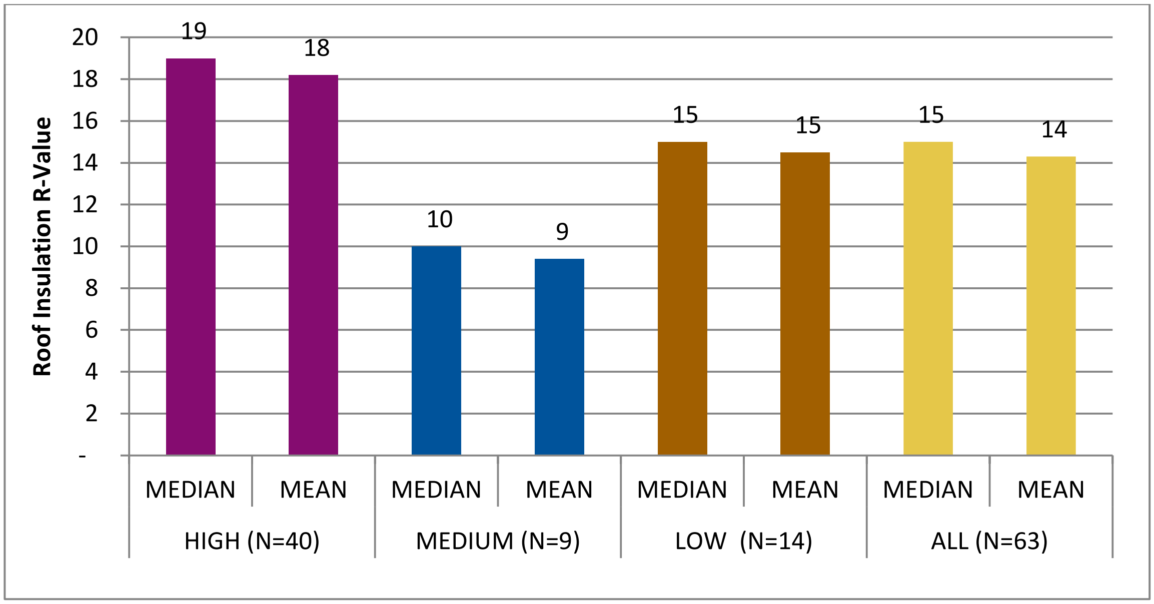
Source: On-Site Survey, Question 86

3.2.2.2 Roof Insulation R-Values

The median R-value for all existing building roof insulation is R-15, with a mean value of R-14, as shown in Figure 3-16. High energy users have roofs with significantly higher R-values than others, with a median roof R-value of R-19. The medium energy use stratum has a median of R-10, which is significantly lower than the R-15 for all buildings.

The existing building roof R-values shown in Figure 3-16 are significantly lower than the prevailing energy code requirements at the time of the study (2005 CBES). Code-required insulation R-values vary between R-24 continuous insulation for roofs classified as *insulation entirely above deck* and R-38 for the *attic and other* category, with a weighted average based on actual distribution of R-33.[15] Installed roof insulation R-values are approximately half of the code-required values, representing an important opportunity for energy efficiency improvements where physical constraints do not limit additional insulation.

Figure 3-16. Roof Insulation R-Values by Consumption Strata

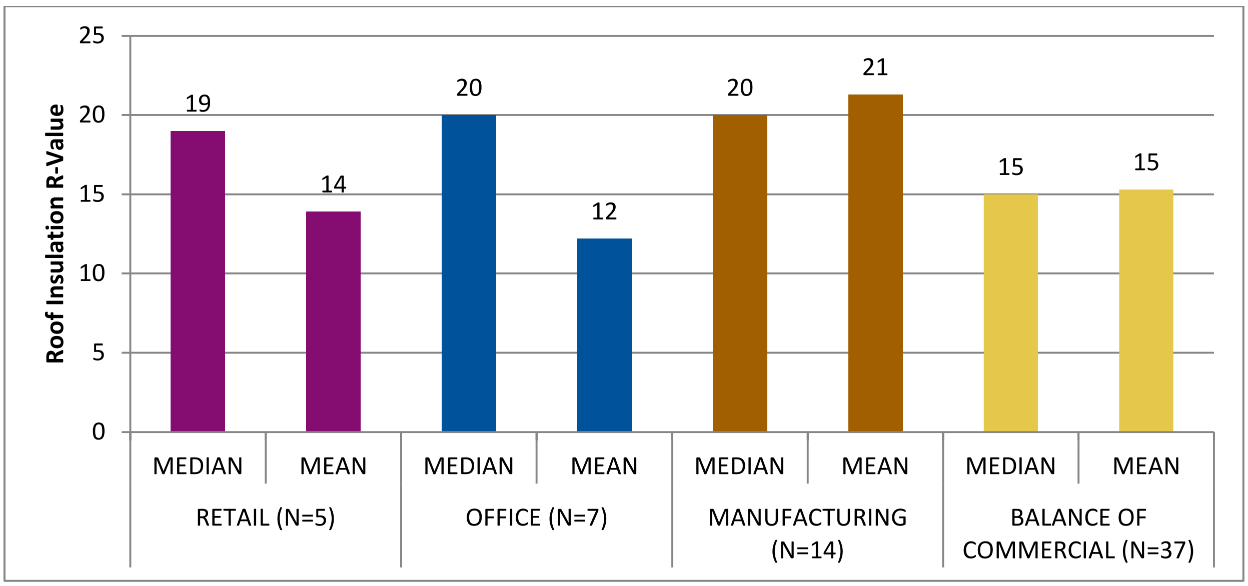


Source: On-Site Survey, Question 87

[15] Accounting for the mix of roof construction types presented in Figure 3-15: attic and other: 58%; insulation entirely above deck: 29%, metal-building: 11%; steel joist: 1%.

Figure 3-17 shows the roof insulation R-values by building type. Similar to the findings for exterior walls, the manufacturing sector has the highest observed R-values, with a median of R-20 and mean of R-21. Both office and retail buildings have median R-values higher than the statewide values, with R-19 and R-20, respectively. Additionally, the difference between the median and mean R-values in both retail and office categories indicates that some buildings in these categories have very high roof insulation levels.

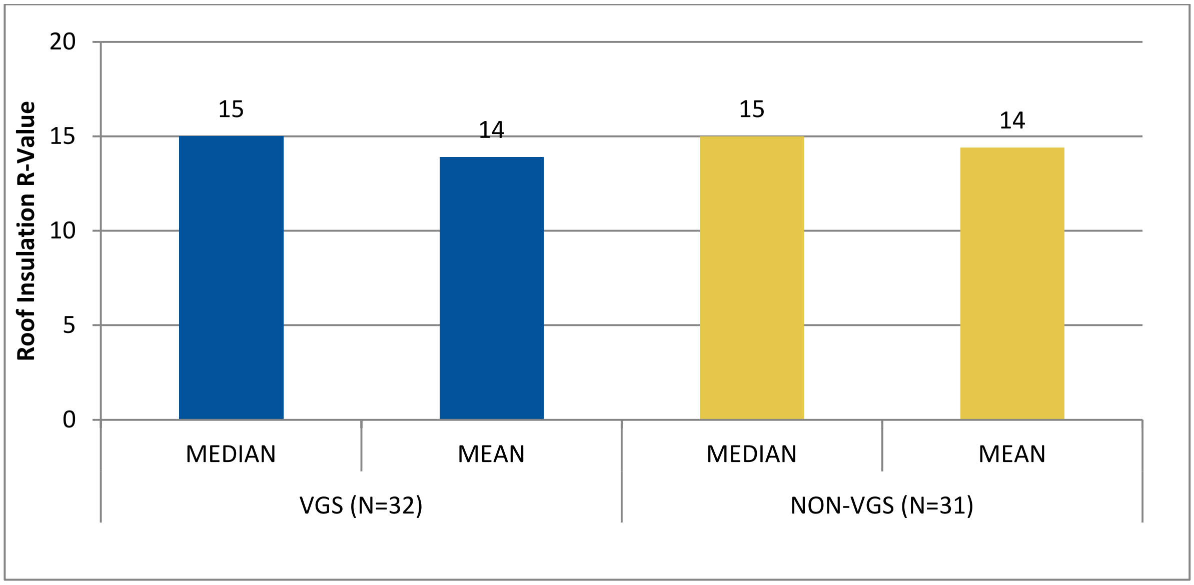
Figure 3-17. Roof Insulation R-Values by Building Type



Source: On-Site Survey, Question 87

The roof insulation R-values for buildings in VT Gas territory are identical to those in non-gas areas, as shown in Figure 3-18.

Figure 3-18. Roof Insulation R-Values – VT Gas vs. Non-VT Gas

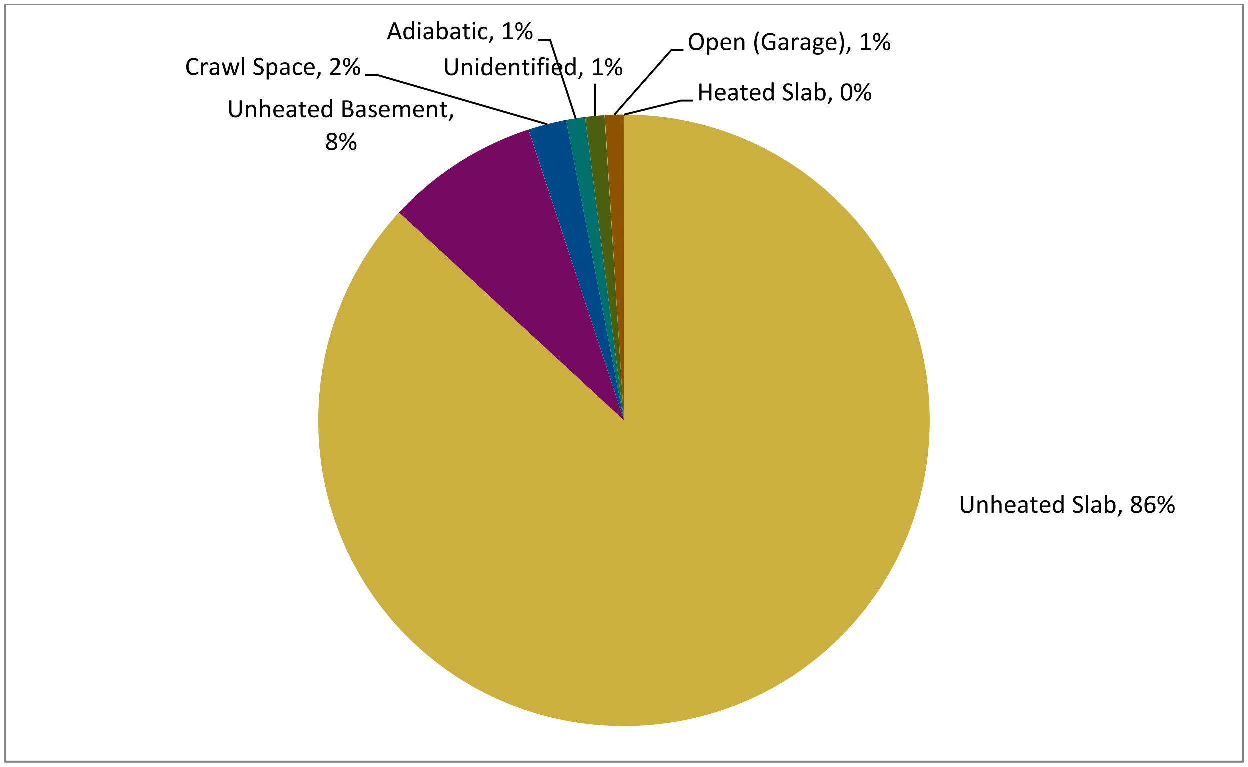


Source: On-Site Survey, Question 87

3.2.3 Floor

Unheated slabs dominate the floor construction types for Vermont's existing buildings stock, as surveyors identified 89% of all floors as unheated slabs. Unheated basements comprise the next largest portion of floors, at 8%. Heated slabs made up less than 1% of all floor construction types. Figure 3-19 shows the distribution for all existing buildings in the state. Surveyors only noted four instances of floors with non-zero insulation values, which align well with the predominance of unheated slab floors.

Figure 3-19. Frequency of Floor Construction Type (N = 143 observations)

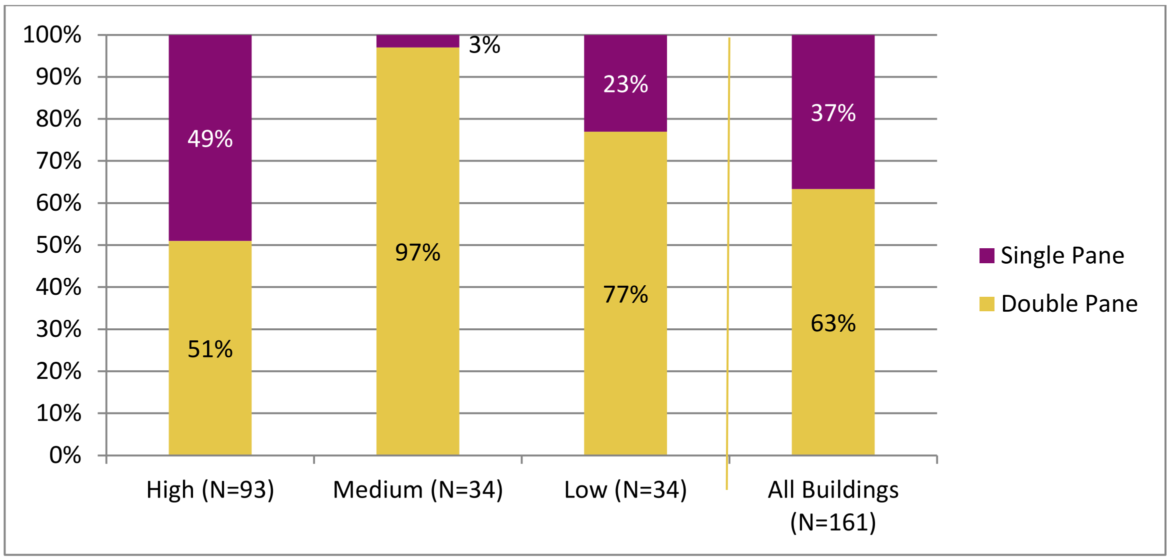


Source: On-Site Survey, Question 91

3.2.4 Windows/Fenestration

Double-pane windows make up 63% of all existing building window types, as shown in Figure 3-20. The remaining 37% of windows are single-pane.[16] The medium energy use buildings are saturated with double-pane windows, which make up 97% of all observed windows. Half of all windows in high energy use buildings are double-pane, while most (77%) of low energy use buildings have double-pane windows.

Figure 3-20. Number of Window Panes by Consumption Strata (N = 161 observations)

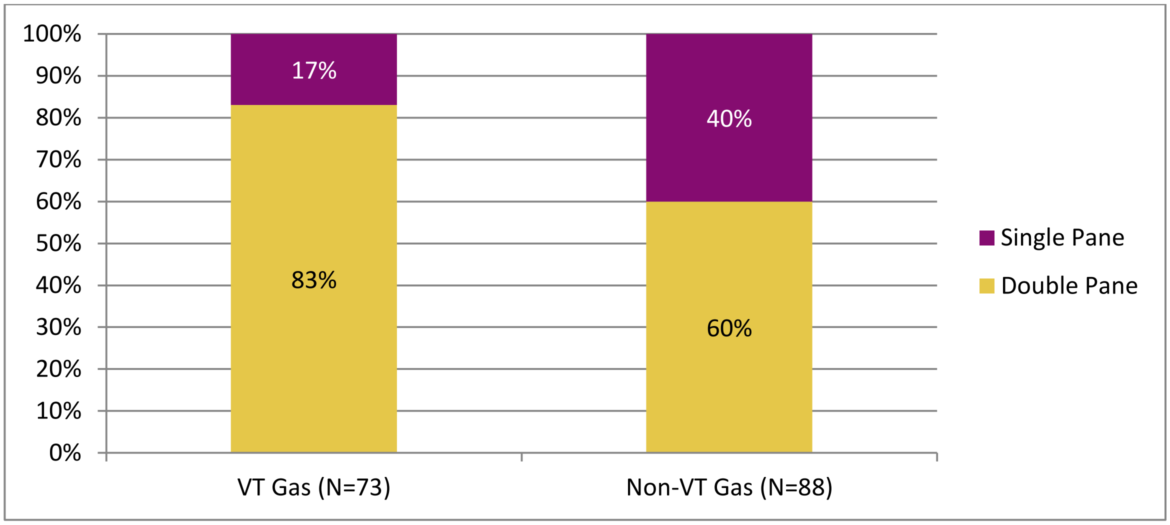


Source: On-Site Survey, Question 96

[16] Surveyors identified no instances of triple-pane windows during the existing building site visits. The survey form does not capture whether windows also have "storm windows," which are sometimes found on single-pane window cases.

Saturation of double-pane windows in VT Gas buildings is significantly higher than in non-VT Gas buildings, with 83% for VT Gas and only 60% in non-natural gas areas as shown in Figure 3-21.

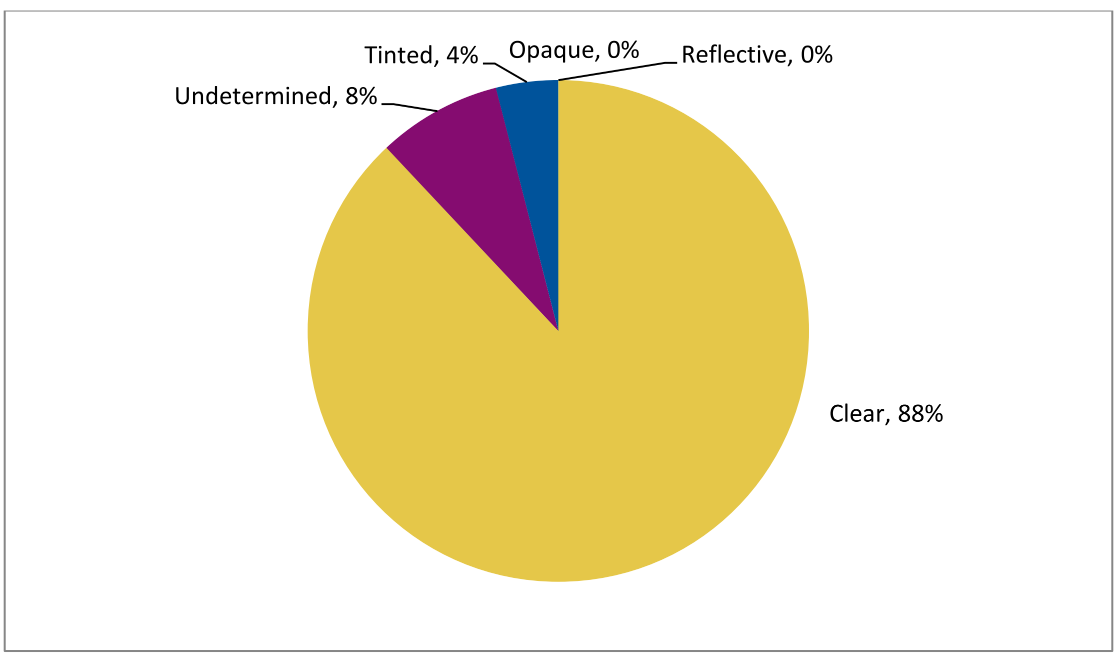
Figure 3-21. Number of Window Panes – VT Gas vs. Non-VT Gas (N = 161 observations)



Source: On-Site Survey, Question 96

Most (88%) windows in Vermont's existing building stock have clear glazing, while only 4% have tinted glazing, as shown in Figure 3-22. Surveyors classified 8% of all window glazing types as undetermined.

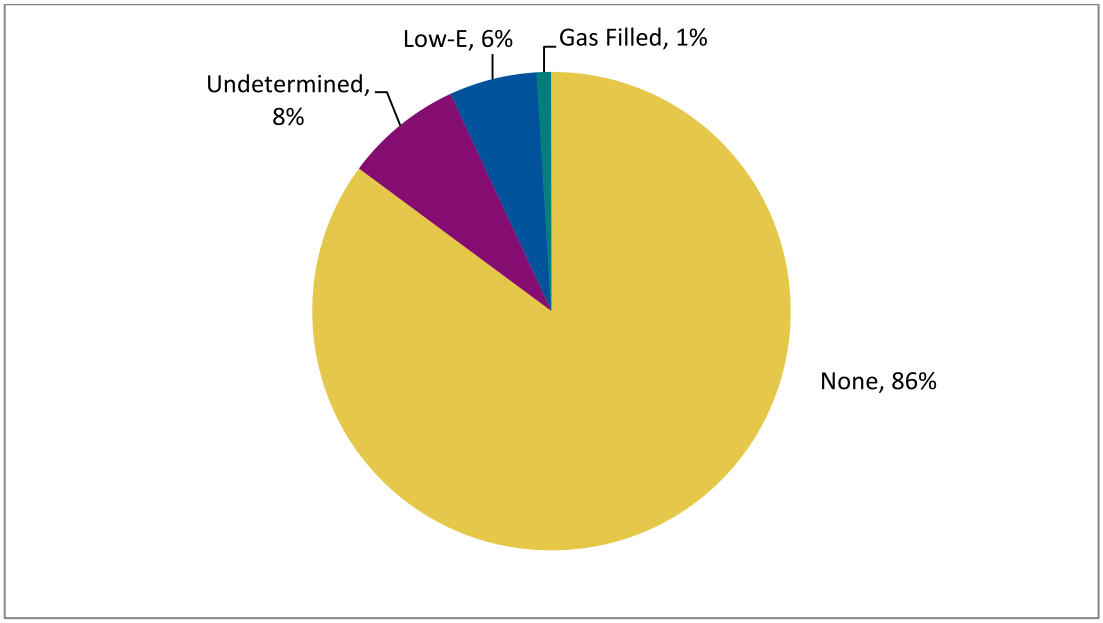
Figure 3-22. Distribution of Glazing Types (N = 161 observations)



Source: On-Site Survey, Question 97

Similarly, Figure 3-23 shows that most (86%) windows contain no additional glazing features, with low-e windows making up only 6% and gas-filled comprising 1%.

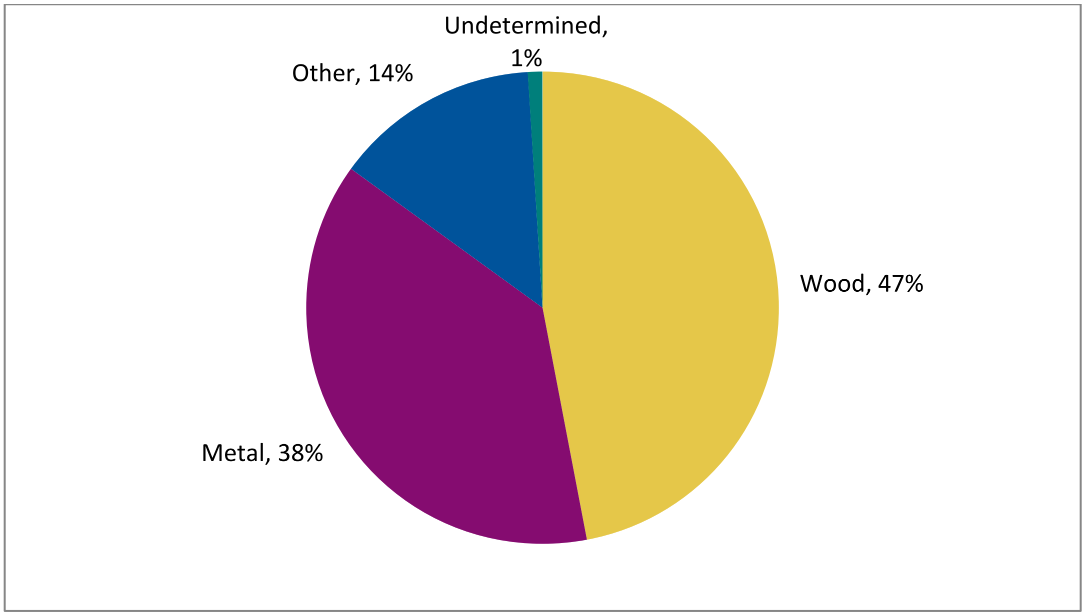
Figure 3-23. Distribution of Glazing Features (N = 161 observations)



Source: On-Site Survey, Question 98

Wood framing makes up the largest portion of window frame types in existing buildings, comprising 47% of all windows. Metal-framed windows make up 38% and 14% of window frames are classified as "other." Figure 3-24 shows the distribution of window framing types for all buildings.

Figure 3-24. Distribution of Window Framing Types



Source: On-Site Survey, Question 98

3.2.5 EEU Market Characterization – Building Envelope

Table 3-4 provides a summary characterization of building envelope measures for the VT Gas vs. Non-VT Gas service territories.

Table 3-4. EEU Market Characterization – Building Envelope (VT Gas vs. Non-VT Gas)[17]

Measure/Characteristic	VT Gas vs. Non-VT Gas
Exterior Walls	» The share of buildings with batt insulation (42%) is lower than in Non-VT Gas areas (55%). » The share of buildings with no wall insulation (44%) is higher in VT Gas areas than outside of VT Gas areas (33%). » Loose fill cellulose insulation is found more often in Non-VT Gas parts of the state, while there were more instances of "other" insulation types found at VT Gas sites. » Median and mean exterior wall R-values in VT Gas service territory are R-13 and R-11, respectively, and are slightly higher than non-VT Gas areas (R-11 and R-10, respectively).
Roofs	The roof insulation R-values for buildings in VT Gas territory are identical to those in non-VT Gas areas, with a median of R-15 and mean of R-14.
Windows	Saturation of double-pane windows in VT Gas buildings is significantly higher than in non-VT Gas buildings, with 83% for VT Gas and only 60% in non-gas areas.

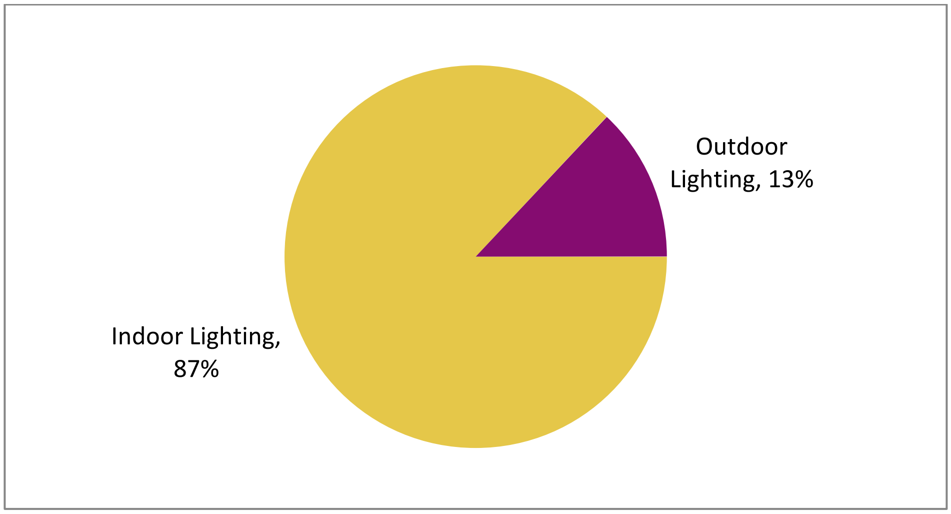
Source: Navigant analysis

[17] BED and EVT primarily focus on electric efficiency, as opposed to thermal efficiency, and are not disaggregated for building envelope measures.

3.3 Lighting

The majority of lighting in Vermont's C&I buildings is located indoors. Figure 3-25 shows that 87% of all installed lighting (weighted by wattage) is indoors with the remaining 13% located outdoors.

Figure 3-25. Distribution of Indoor and Outdoor Lighting Wattage (N = 118)*

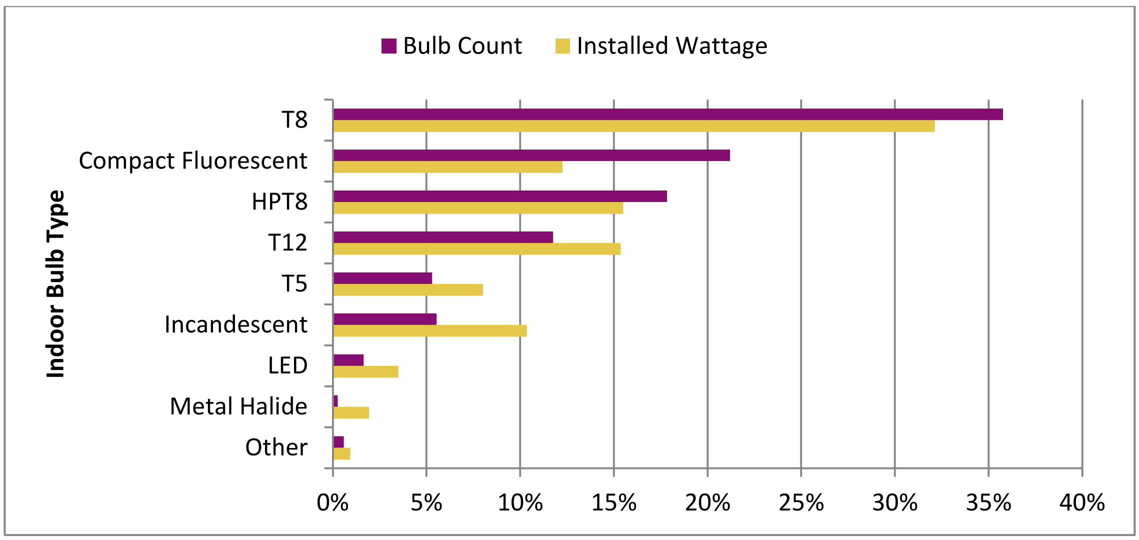


*Weighted by Installed Wattage
Source: On-Site Survey, Section 25/26

3.3.1 Indoor Lighting

Surveyors identified lighting types during on-site visits. The analysis team compared the distribution of lamp types by raw counts versus installed wattage. Figure 3-26 shows that T8 lamps comprise the single largest share of any type, making up nearly one-third of all indoor lights, both by count and wattage.[18] Compact fluorescent lights (CFLs) are second by counts, but comprise a smaller share by wattage (due to lower rated power draw of CFLs). High-Performance T8 lamps make up a larger share than T12s. Light-emitting diode (LED) lights are emerging as a distinct market share, making up approximately 3% of all installed wattage.

Figure 3-26. Distribution of Indoor Lamp Types – All Buildings (N = 118)



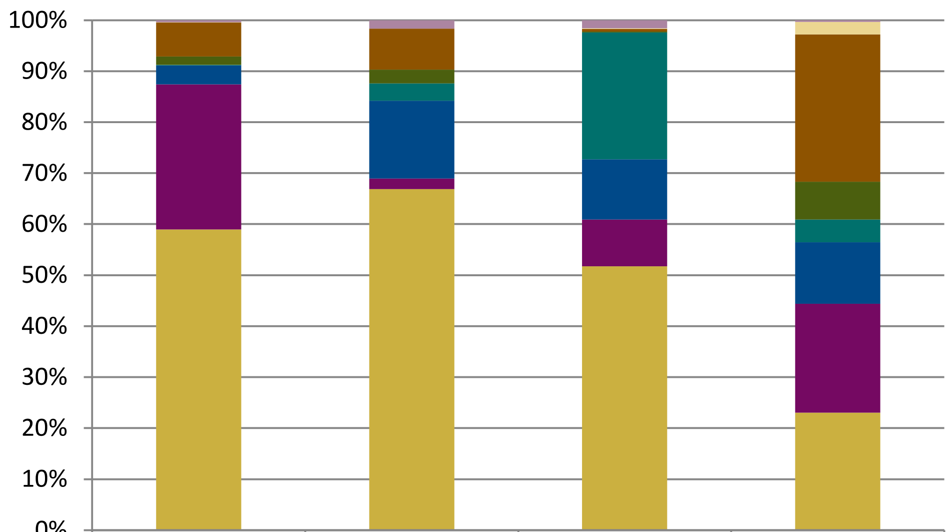
Other includes: Electrodeless/Induction, Quartz/Halogen, High-Pressure Sodium Vapor, Mercury Vapor, Metal Halide, Neon and T16 fluorescent lamp types.
Source: On-Site Survey, Questions 387-403

[18] During the on-site visits, every attempt was made to identify whether a T8 lamp/ballast combination qualified as a HPT8 fixture or a standard T8 fixture, as standard T8 is now considered the baseline technology in VT. However, in many cases access to fixtures was limited, so verifying ballast model numbers was not possible. Therefore, it is possible that some HPT8 fixtures may have been incorrectly categorized as standard T8 fixtures. Furthermore, many HPT8 fixtures may have been re-lamped with standard T8 lamps since the HPT8 equipment was originally installed. The resulting energy consumption of such a fixture would be identical to HPT8 but the light output would be different.

Figure 3-27 shows the distribution of indoor lamp types by building type, weighted by fixture counts. Key findings include:

- T8 lamps make up the largest share in each building type category.
- The share of T12 lamps is the lowest in retail buildings, where T8 and HPT8 lamps make up 87% of all lighting types.
- The share of T12 lamps is the highest in office buildings, comprising 15% of all lights.
- T5 lamps, typically used in high bay applications, comprise 25% of all lights in manufacturing buildings, a higher share than in any other building type.
- LEDs do not represent a major share in any building type category, with 2% market share in the "balance of commercial" category.

Figure 3-27. Distribution of Indoor Lamp Types by Building Type*



	Retail (n=10)	Office (n=13)	Manufacturing (n=25)	Balance of Commercial (n=70)
Other	0%	2%	2%	0%
LED	0%	0%	0%	2%
CFL	7%	8%	0%	29%
Incandescent	2%	3%	0%	7%
T5	0%	3%	25%	4%
T12	4%	15%	12%	12%
HPT8	28%	2%	9%	21%
T8	59%	67%	52%	23%

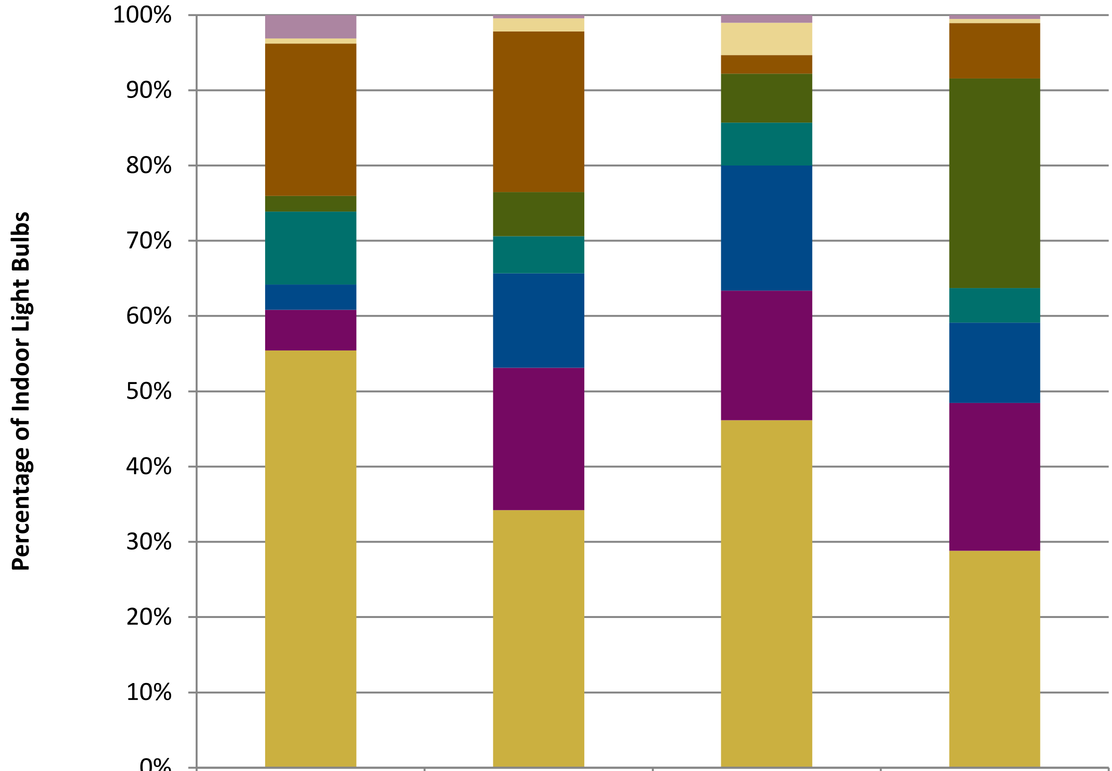
*Weighted by Fixture Counts
Other includes: Electrodeless/Induction, Quartz/Halogen, High-Pressure Sodium Vapor, Mercury Vapor, Metal Halide, Neon and T16 fluorescent lamp types.
Source: On-Site Survey, Questions 387-403

Figure 3-28 compares the distribution of indoor lighting in BED and EVT service territories, including a breakout of GT and Non-GT areas. Key findings include:

- The share of T12 lighting is notably higher in EVT areas than within BED, making up 13% of installed lighting versus only 3% in BED.
- HPT8 lighting comprises a greater share in EVT areas (19%) than in BED (5%).
- The share of incandescent lighting is higher in EVT areas than in BED, at 6% and 2%, respectively.
    - LEDs are typically considered cost-effective replacements for incandescent lighting, while replacing CFLs with LEDs is generally not cost-effective. Using BED as an example, LEDs comprise 1% of all lighting and incandescents make up 2%, and the remaining incandescent lighting represents the potential for replacement with LEDs.[19]
- CFLs comprise 20% of all lighting in BED and 21% in EVT territory.
- GT areas show a high saturation of T8 and HPT8 lamps (63% combined).
- Incandescent lighting accounts for 28% of all lights in Non-GT areas, representing considerable remaining potential compared to only 7% in GT areas.
- Less efficient T12s make up a slightly higher share of installed lighting in GT areas than in Non-GT areas (17% and 11%, respectively).

[19] As the cost of LEDs drops, the potential for LEDs to become more widely used is likely to increase beyond incandescents. For example, while LEDs currently may not be viewed as a cost-effective option compared to CFLs, LEDs could replace CFLs (and other lighting sources).

Figure 3-28. Distribution of Indoor Lamp Types by EEU and GT Area*



	BED (n=19)	EVT (n=99)	GT (n=40)	Non-GT (n=59)
Other	3%	0%	1%	1%
LED	1%	2%	4%	1%
CFL	20%	21%	2%	7%
Incandescent	2%	6%	7%	28%
T5	10%	5%	6%	5%
T12	3%	13%	17%	11%
HPT8	5%	19%	17%	20%
T8	55%	34%	46%	29%

Utility

*Weighted by Fixture Counts
Other includes: Electrodeless/Induction, Quartz/Halogen, High-Pressure Sodium Vapor, Mercury Vapor, Metal Halide, Neon and T16 fluorescent lamp types.
Source: On-Site Survey, Questions 387-403

Table 3-5 shows that T8 and HPT8 lighting accounts for 51% and 25%, respectively, of all linear fluorescent lighting, while T5 lamps account for an additional 8%. The remaining 17% of linear fluorescent lighting is still equipped with T12 lamps and represents the remaining potential for this critical lighting category.

Key findings across multiple categories include:

- T12 lighting technology has been nearly eliminated in BED territory, comprising only 5% of linear fluorescent lighting.
- 18% of linear fluorescents in EVT territory are still equipped with T12 lamps.
- The remaining potential to replace T12s is 19% in both GT and 17% in Non-GT areas.
- The low energy use stratum represents the highest share of existing T12 lighting, comprising 21% of all linear fluorescents in that group.

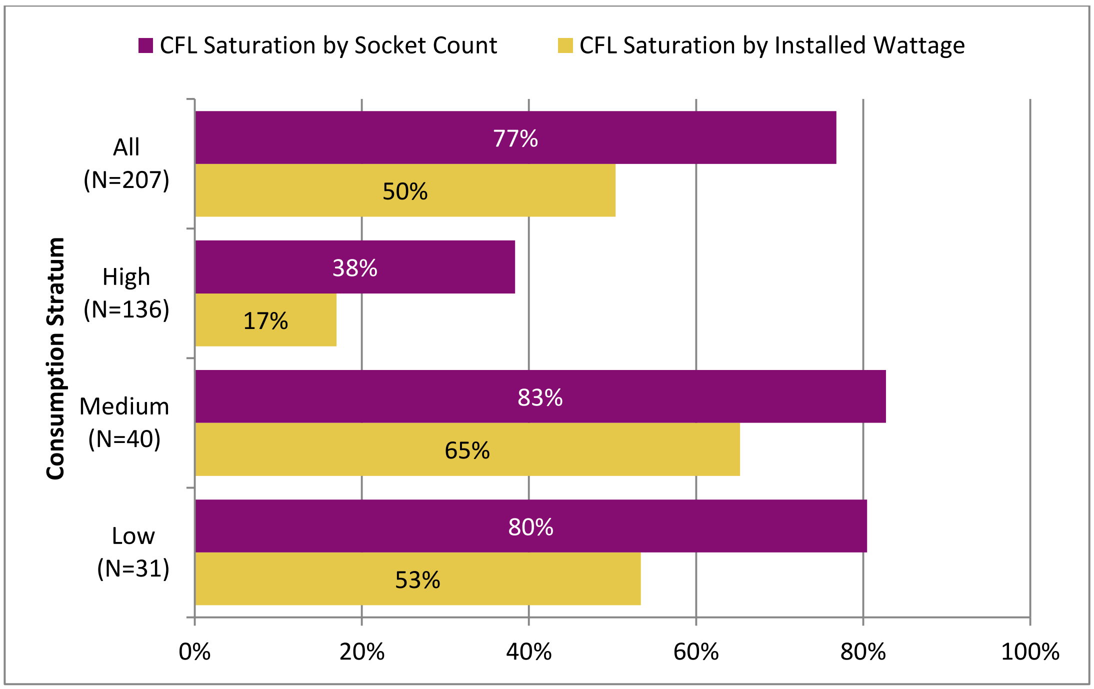
Table 3-5. Distribution of Linear Fluorescent Lighting*

Category	T8	HPT8	T12	T5
All Buildings (N=118)	51%	25%	17%	8%
BED (N=19)	75%	7%	5%	13%
EVT (N=99)	48%	27%	18%	7%
GT (N=40)	54%	20%	19%	7%
Non-GT (N=61)	45%	31%	17%	7%
High Use (N=66)	58%	22%	3%	17%
Medium Use (N=28)	58%	21%	14%	6%
Low Use (N=24)	51%	25%	21%	4%
Retail (N=10)	65%	31%	4%	0%
Office (N=13)	76%	2%	17%	4%
Manufacturing (N=25)	53%	9%	12%	25%
Balance of Commercial (N=70)	38%	35%	20%	7%

*Weighted by Fixture Counts
Source: On-Site Survey, Questions 387-403

CFLs comprise 77% of all screw-based sockets in Vermont's C&I buildings, but make up half (50%) of all the installed wattage of screw-based sockets, as shown in Figure 3-29. Most screw-based sockets in medium and low energy use buildings have CFLs (83% and 80%, respectively), though the saturation of CFLs is lower in these buildings in terms of installed wattage. The saturation of CFLs by socket count and wattage is lowest in the high energy use buildings, where CFLs comprise only 38% of all sockets and 17% of all wattage. These findings indicate that there is a significant remaining potential to replace high-wattage incandescent lights with CFLs in all buildings, and particularly in high energy use facilities.

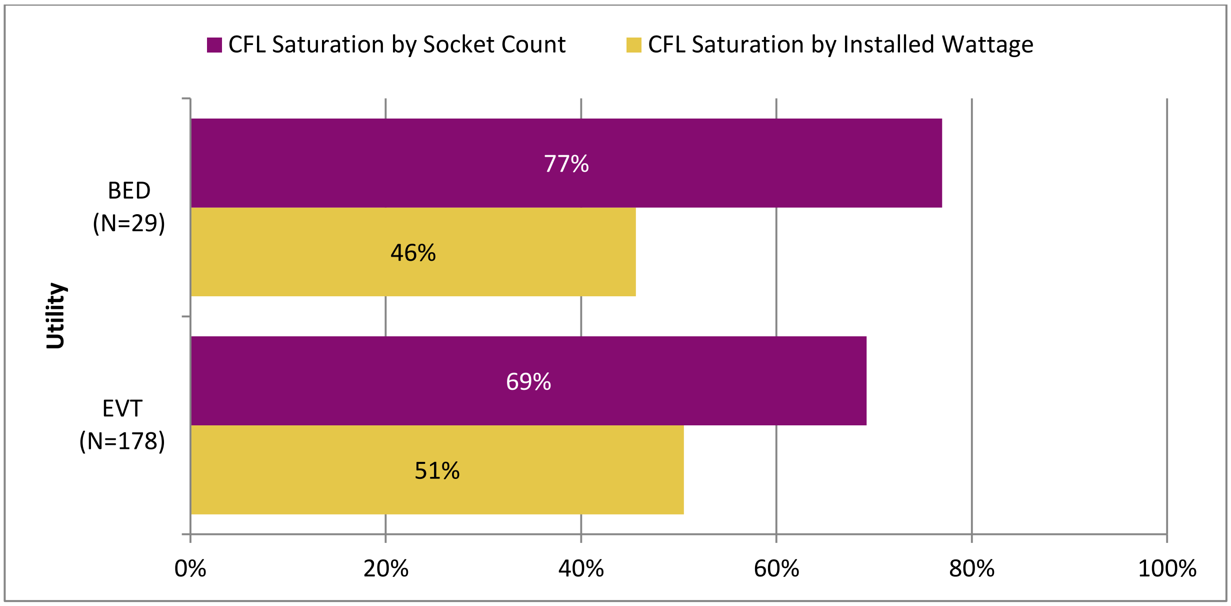
Figure 3-29. CFL Saturation of Screw-Based Sockets by Consumption Stratum



*Sample size (N) refers to total observations of CFL lighting sequences.
Source: On-Site Survey, Question 392

The saturation of CFLs in screw-based sockets is very similar when comparing BED to EVT territory, as shown in Figure 3-30. Nearly half of all the installed wattage in screw-based sockets is fitted with CFLs in both areas, with slightly more (51%) in EVT than in BED (46%). Most sockets in both areas have CFLs, though the analysis indicates that there are high-wattage incandescent lights in each EEU territory remaining to be replaced with CFLs.

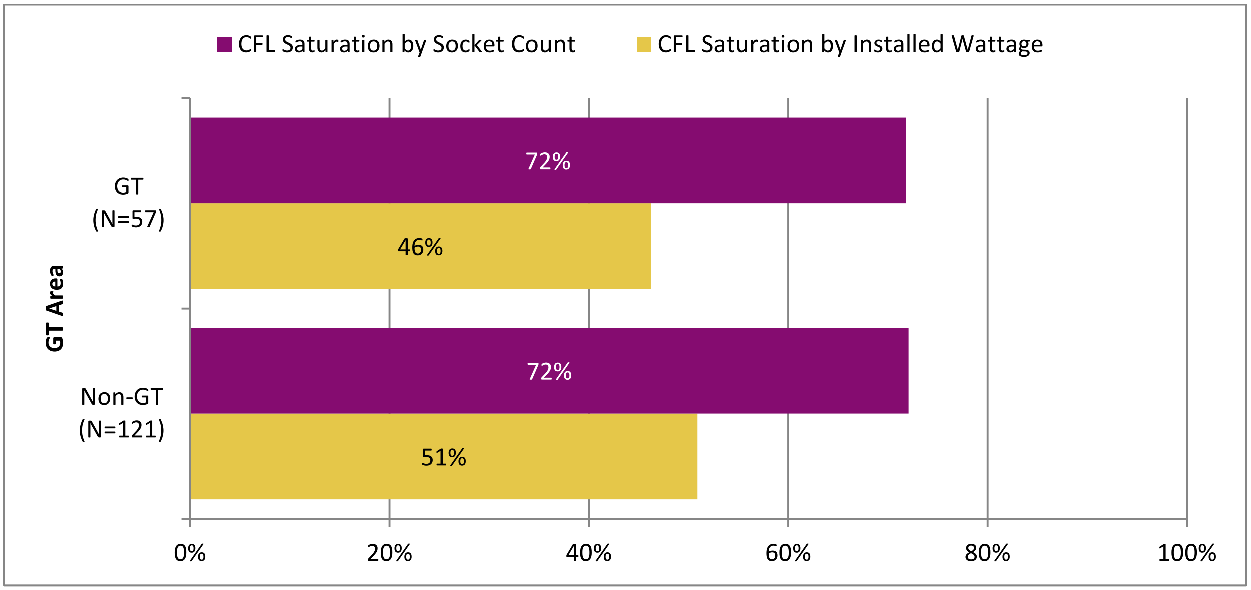
Figure 3-30. CFL Saturation of Screw-Based Sockets by EEU



* Sample size (N) refers to total observations of CFL lighting sequences.
Source: On-Site Survey, Question 392

CFLs comprise an equal amount (72%) of screw-based sockets in both GT and Non-GT areas, as shown in Figure 3-31. There is no significant difference in the saturation of installed wattage between GT and Non-GT areas, as CFLs comprise 46% and 51%, respectively.

Figure 3-31. CFL Saturation of Screw-Based Sockets – GT vs. Non-GT



* Sample size (N) refers to total observations of CFL lighting sequences.
Source: On-Site Survey, Question 392

Manual on/off controls for indoor lighting are present in all buildings, while motion/occupancy sensors are used in 19% of Vermont's C&I buildings, as shown in Table 3-6. EMS were identified in only 6% of high energy use buildings, and effectively have not penetrated Vermont's existing building stock. Dimmers and daylighting controls were identified in 2% and 1% of all buildings, respectively, though buildings in BED territory have a notably higher penetration of dimming controls (27%) than in EVT territory (1%). Twelve percent of buildings do not control lights at all and leave them on 24/7.

Table 3-6. Penetration of Indoor Lighting Control Types*

Category	Manual On/Off Switch	Motion/ Occupancy Sensor	Always On (24/7)	Timeclock/ EMS	Dimmer	Daylighting Controls	Not Identified
All Buildings (n=118)	100%	19%	12%	0%	2%	1%	2%
Consumption Stratum							
High Use (n=66)	97%	45%	21%	6%	6%	4%	7%
Medium Use (n=28)	98%	18%	21%	0%	5%	7%	17%
Low Use (n=24)	100%	19%	11%	0%	2%	0%	0%
EEU							
BED (n=19)	100%	4%	8%	0%	27%	0%	0%
EVT (n=99)	100%	20%	13%	0%	1%	1%	3%
GT vs. Non-GT							
GT (n=40)	99%	12%	18%	0%	3%	0%	0%
Non-GT (n=59)	100%	23%	11%	0%	0%	1%	3%

*Weighted by installed wattage
Source: On-Site Survey, Question 381

Table 3-7 shows the saturation of indoor lighting control types only for linear fluorescent lighting, and reveals that 18% of all linear fluorescent lights are controlled by motion/occupancy sensors. Only one percent of linear fluorescent lighting in Vermont's C&I buildings are controlled by EMS systems. About 92% of indoor lights in BED territory are controlled manually, with only 3% controlled by motion/occupancy sensors. Comparatively, 78% of lighting in EVT territory is manually controlled and 19% is controlled with motion/occupancy sensors.

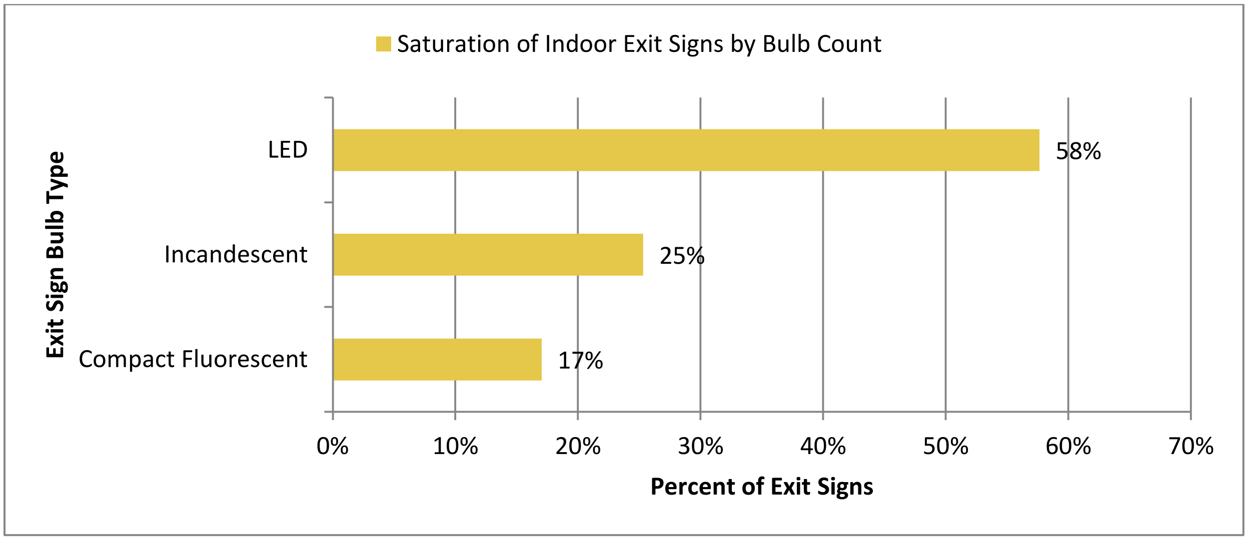
Table 3-7. Saturation of Indoor Lighting Control Types for Linear Fluorescents Only*

Category	Manual On/Off Switch	Motion/ Occupancy Sensor	None (24/7)	Timeclock/EMS	Dimmer	Daylighting Controls	Not Identified
Overall (N=118)	79%	18%	1%	1%	0%	0%	1%
Consumption Stratum							
High Use (N=66)	65%	25%	3%	5%	0%	0%	1%
Medium Use (N=28)	71%	26%	1%	0%	0%	0%	2%
Low Use (N=24)	88%	12%	0%	0%	0%	0%	0%
EEU							
BED (N=19)	92%	3%	4%	0%	0%	0%	1%
EVT (N=99)	78%	19%	1%	1%	0%	0%	1%
GT vs. Non-GT							
GT (N=40)	85%	13%	2%	0%	0%	0%	0%
Non-GT (N=59)	74%	23%	0%	2%	0%	0%	1%

*Weighted by installed wattage
Source: On-Site Survey, Question 381

LED lamps comprise 58% of all exit signs, while incandescent lamps still comprise 25% of exit sign lighting, as shown in Figure 3-32, while 17% of exit signs use efficient CFLs.

Figure 3-32. Saturation of Indoor Exit Sign Lamp Types (N = 18)

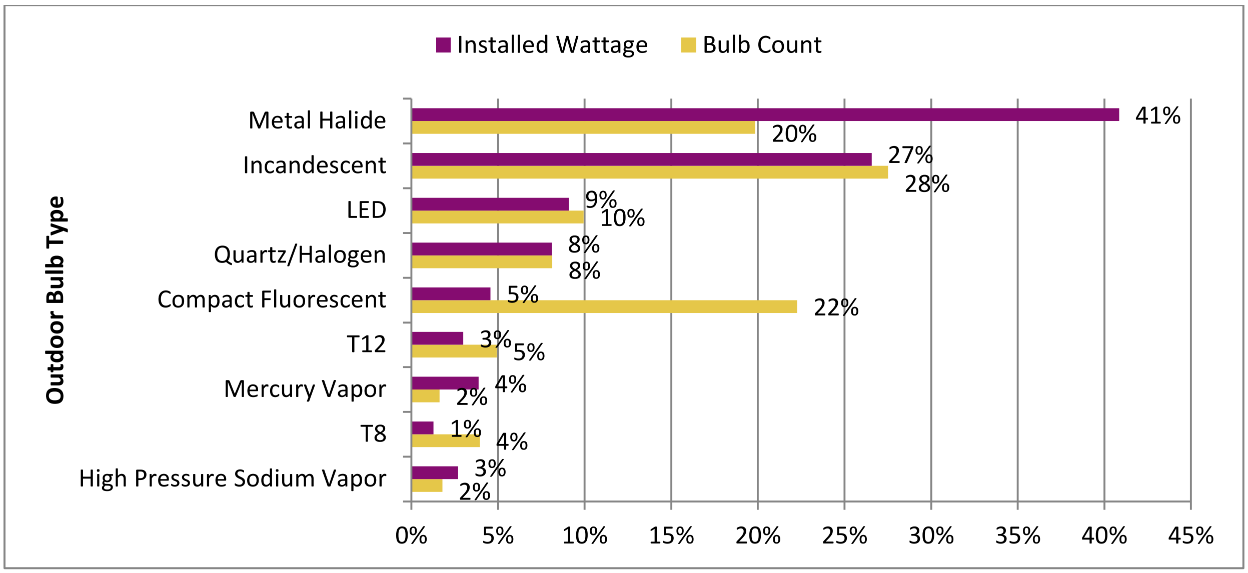


Source: On-Site Survey, Question 392

3.3.2 Outdoor Lighting

As shown in Figure 3-33, metal halide lighting comprises the largest share of outdoor lighting wattage, making up slightly more than 40% of connected outdoor lighting power. Incandescent lighting has the second highest share of outdoor lighting wattage (27%), and the highest share (28%) of any lamp type based on lighting counts. LED lighting makes up a significant portion of outdoor lighting for Vermont's C&I buildings, comprising approximately 10% of both lamp counts and installed wattage. Compact fluorescent lamps are frequently used in outdoor lighting applications, making up 22% of all lamp counts, but only 5% of installed wattage.

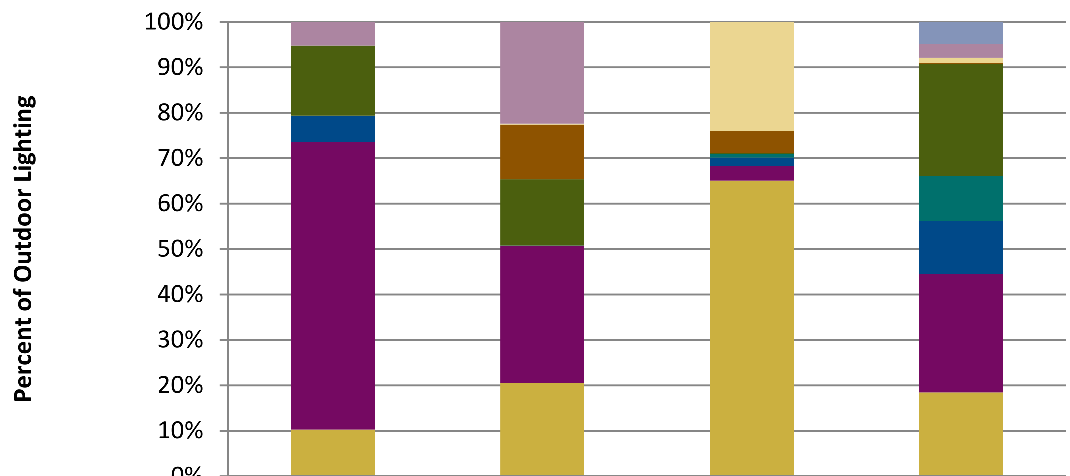
Figure 3-33. Distribution of Outdoor Lamp Types (N = 118)



Source: On-Site Survey, Questions 345-361

Metal halide and incandescent lighting dominate most building type categories except the manufacturing sector, where high-pressure sodium (HPS) makes up 24% of outdoor lighting, a larger share than any other category. Figure 3-34 shows the distribution of outdoor lighting types by building type. Office buildings have higher shares of T12 and mercury vapor lighting (22% and 12%, respectively), while LED lighting makes up 12% in the balance of commercial category and represents 6% of outdoor lighting in the office sector. Most (63%) retail outdoor lighting is incandescent.

Figure 3-34. Distribution of Outdoor Lamp Types by Building Type**



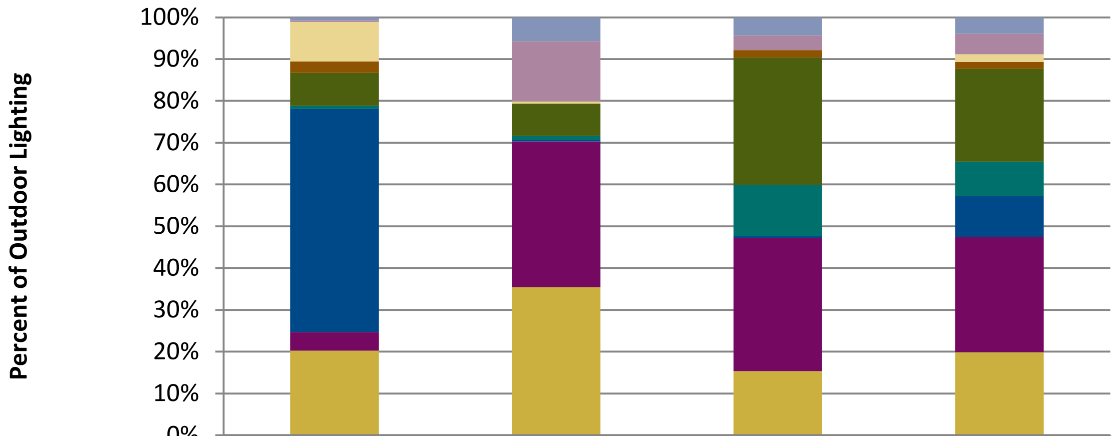
	Retail (n=10)	Office (n=13)	Manufacturing (n=25)	Balance of Commercial (n=70)
Other*	0%	0%	0%	5%
T12	5%	22%	0%	3%
HPS	0%	0%	24%	1%
Mercury Vapor	0%	12%	5%	0%
CFL	15%	15%	0%	25%
Quartz/Halogen	0%	0%	1%	10%
LED	6%	0%	2%	12%
Incandescent	63%	30%	3%	26%
Metal Halide	10%	21%	65%	18%

Building Type

*Other includes T8 and T5 linear fluorescent lamp types.
**Weighted by fixture counts
Source: On-Site Survey, Questions 345-361

Figure 3-35 shows the distribution of outdoor lighting types by consumption stratum. The key finding here is that among the high energy use buildings, incandescent lighting has essentially been eliminated (4%) and LED lamps make up a higher share (53%) than metal halides (20%). Incandescent lighting still comprises a large share of outdoor lighting in the medium and low energy use strata at 35% and 32%, respectively.

Figure 3-35. Distribution of Outdoor Lamp Types by Consumption Stratum**



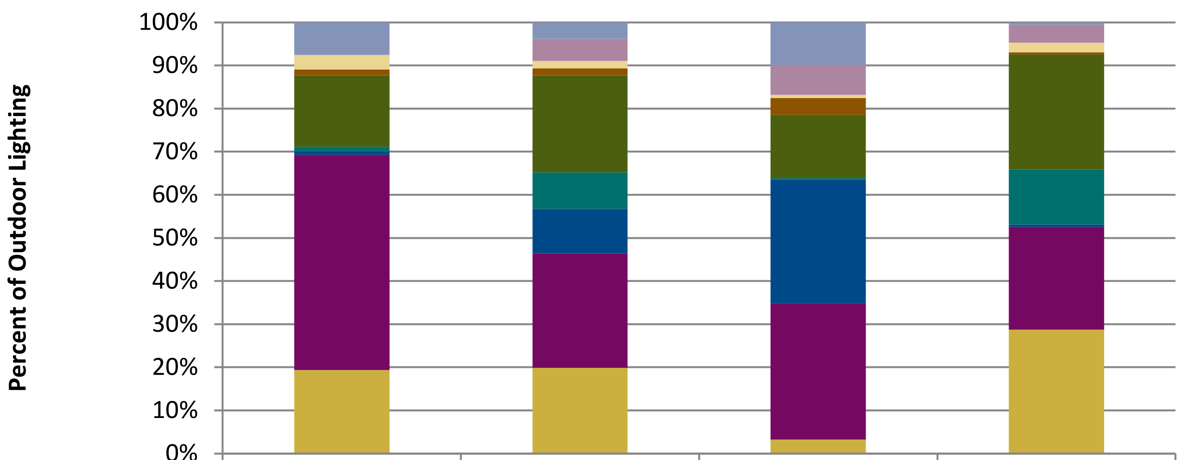
	High (n=66)	Medium (n=28)	Low (n=24)	All Buildings (n=118)
Other*	1%	6%	4%	4%
T12	0%	14%	4%	5%
HPS	9%	1%	0%	2%
Mercury Vapor	3%	0%	2%	2%
CFL	8%	8%	30%	22%
Quartz/Halogen	1%	1%	12%	8%
LED	53%	0%	0%	10%
Incandescent	4%	35%	32%	28%
Metal Halide	20%	35%	15%	20%

Consumption Stratum

*Other includes T8 and T5 linear fluorescent lamp types.
**Weighted by fixture counts
Source: On-Site Survey, Questions 345-361

Incandescent lighting dominates outdoor lighting in BED territory, making up 50% of all lights, compared to 27% in EVT territory, as shown in Figure 3-36. LED lamps comprise 10% of outdoor lighting in EVT territory and less than 1% in BED service territory. Comparing GT areas to Non-GT areas reveals that LED lighting comprises 29% of lighting in GT area buildings, and has supplanted metal halides, which only make up 3%. In Non-GT areas, metal halides account for 29% of lighting, CFLs make up 27% and incandescents comprise 24%, while LED lighting comprises less than 1%.

Figure 3-36. Distribution of Outdoor Lamp Types by EEU and GT Area**



	BED (n=19)	EVT (n=99)	GT (n=40)	Non-GT (n=59)
Other*	8%	4%	10%	1%
T12	0%	5%	7%	4%
HPS	3%	2%	1%	2%
Mercury Vapor	1%	2%	4%	0%
CFL	17%	23%	15%	27%
Quartz/Halogen	1%	8%	0%	13%
LED	1%	10%	29%	0%
Incandescent	50%	27%	32%	24%
Metal Halide	19%	20%	3%	29%

EEU

*Other includes T8 and T5 linear fluorescent lamp types.
**Weighted by fixture counts
Source: On-Site Survey, Questions 345-361

Photocell controls account for the largest share (33%) of outdoor lighting control types, followed by timeclocks and manual controls, each comprising 27% of all control types, as shown in Table 3-8. EMS control less than 1% of outdoor lighting in Vermont's buildings, and are more frequently used in high energy use buildings (3%) than in any other category. High energy use buildings show the greatest use of automated controls, with only 3% of outdoor lights controlled manually, compared to 43% and 32% for medium and small energy users, respectively.

The remaining potential to replace manual controls is higher in BED territory than in EVT areas, with 46% of outdoor lighting in BED territory controlled manually, compared to 26% in EVT buildings. GT areas also have less manually controlled outdoor lighting, accounting for 20% of all control types compared to 29% in Non-GT areas.

Table 3-8. Saturation of Outdoor Lighting Control Types*

Category	Photocell	Manual On/Off Switch	Timeclock	Photocell/ Timeclock	Motion Sensor	EMS	Not Identified
Overall (n=118)	33%	27%	27%	6%	5%	1%	1%
Consumption Stratum							
High (n=66)	19%	3%	49%	25%	0%	3%	1%
Medium (n=28)	45%	43%	8%	1%	2%	0%	0%
Low (n=24)	35%	32%	24%	0%	8%	0%	1%
EEU							
BED (n=19)	35%	46%	5%	15%	0%	0%	0%
EVT (n=99)	33%	26%	28%	6%	5%	1%	1%
GT vs. Non-GT							
GT (n=40)	38%	20%	36%	1%	3%	0%	2%
Non-GT (n=59)	31%	29%	25%	8%	6%	1%	0%

*Weighted by installed wattage
Source: On-Site Survey, Question 339

3.3.3 EEU Market Characterization – Lighting

Table 3-4 provides a summary characterization of lighting measures for Vermont's EEUs.

Table 3-9. EEU Market Characterization – Lighting

	Measure/Characteristic	BED	EVT	GT Areas
Indoor Lighting	T12s	» T12s comprise only 5% of linear fluorescents.	» T12s comprise 18% of linear fluorescents.	» T12s comprise 19% of linear fluorescents
	T8/HPT8	» 7% of linear fluorescents are HPT8 lights while 75% are standard T8s (82% combined).	» 27% of linear fluorescents are HPT8 lights while 48% are standard T8s (75% combined).	» 20% of linear fluorescents are HPT8 lights while 54% are standard T8s (74% combined)
	CFLs	» CFLs make up 17% of all indoor lighting and have saturated 77% of screw-in sockets (by count) and 46% of screw-in sockets (by wattage).	» CFLs make up 12% of all indoor lighting and have saturated 69% of screw-in sockets (by count) and 51% of screw-in sockets (by wattage).	» CFLs make up 3% of all indoor lighting and have saturated 72% of screw-in sockets (by count) and 46% of screw-in sockets (by wattage)
	LEDs	» LEDs account for less than 1% of all indoor lighting.	» LEDs account for 4% of all indoor lighting.	» LEDs account for 11% of all indoor lighting (compared to less than 1% in Non-GT areas)
	Automated Indoor Lighting Controls	» 3% of linear fluorescent lighting is controlled by motion/occupancy sensors and 1% by timeclock or EMS systems.	» 19% of linear fluorescent lighting is controlled by motion/occupancy sensors and 1% by timeclock or EMS systems.	» 13% of linear fluorescent lighting is controlled by motion/occupancy sensors and less than 1% by timeclock or EMS systems

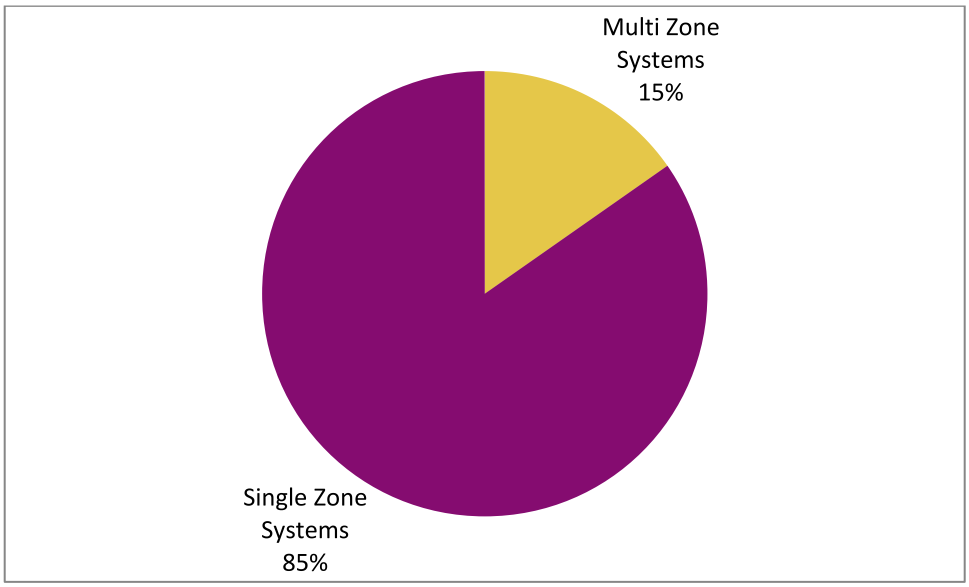
	Measure/Characteristic	BED	EVT	GT Areas
Outdoor Lighting	LEDs	» LEDs make up less than 1% of all outdoor lighting.	» LEDs make 10% of all outdoor lighting.	» LEDs make up 31% of all outdoor lighting
	CFLs	» CFLs make up 2% of all outdoor lighting.	» CFLs make up 5% of all outdoor lighting.	» CFLs make up 3% of all outdoor lighting
	Automated Outdoor Lighting Controls	» 54% of outdoor lights are controlled automatically. Most controls are photocells or photocell/timeclock combinations.	» 74% of outdoor lights are controlled automatically. Most controls are photocells or timeclocks.	» 80% of outdoor lights are controlled automatically. Most controls are photocells or timeclocks

Source: Navigant analysis

3.4 HVAC

The majority (85%) of HVAC systems in Vermont's existing buildings are single-zone systems while only 15% are multi-zone systems, as shown in Figure 3-37. Single-zone systems are typically considered "simple" systems in the commercial energy code, and multi-zone systems are categorized as "complex" systems. Each system type has different requirements to comply with the energy code, which affects HVAC systems at time of replacement.

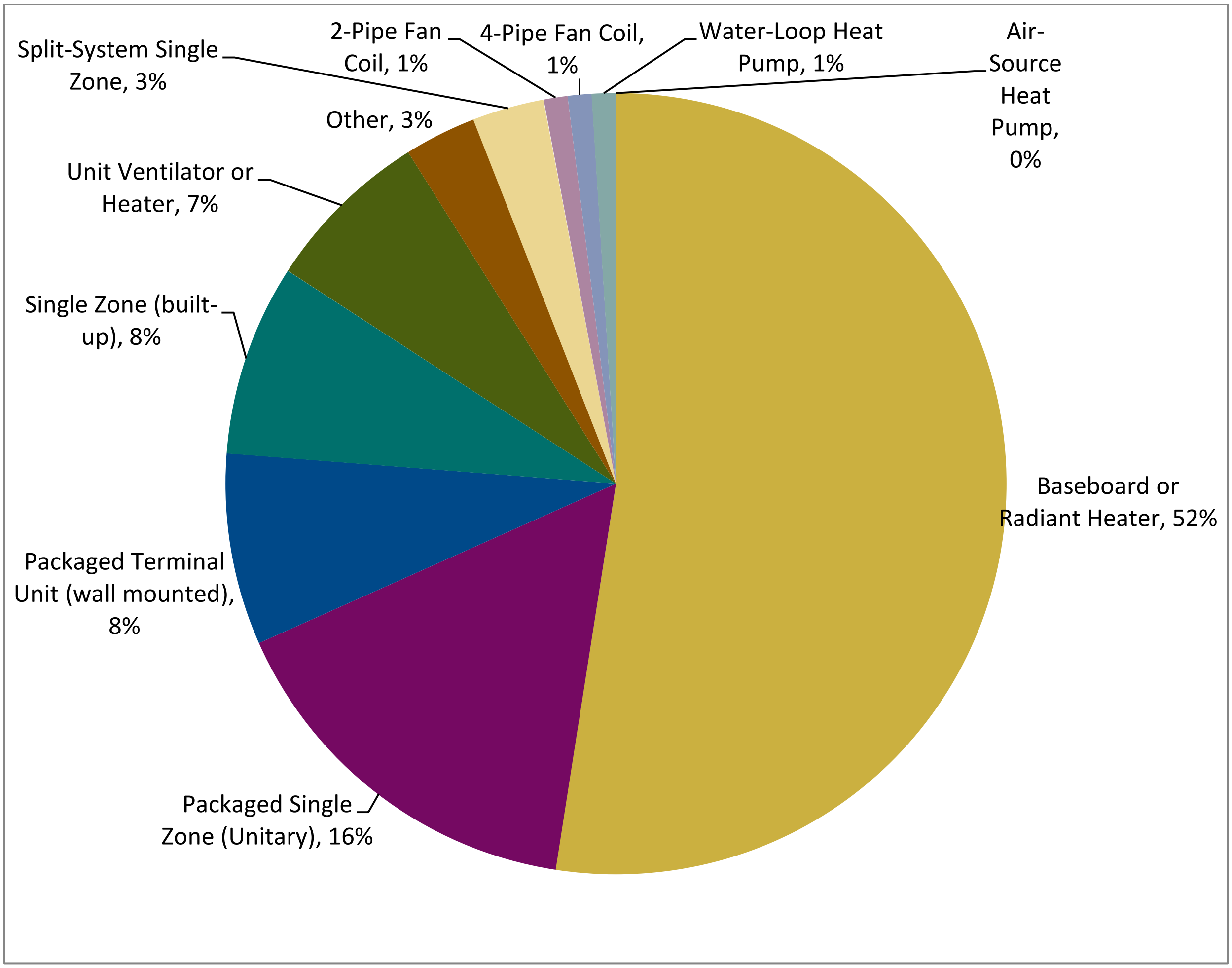
Figure 3-37. Distribution of Single-Zone and Multi-Zone Systems (N = 539)



3.4.1 Single-Zone Distribution Systems

The on-site surveyors identified 489 single-zone HVAC distribution systems and gathered all available data for each system.[20] Figure 3-38 shows that over half (52%) of single-zone HVAC systems are baseboard/radiant systems followed by unitary packaged systems (16%).

Figure 3-38. Distribution of Single-Zone HVAC Systems (N = 489 observations)

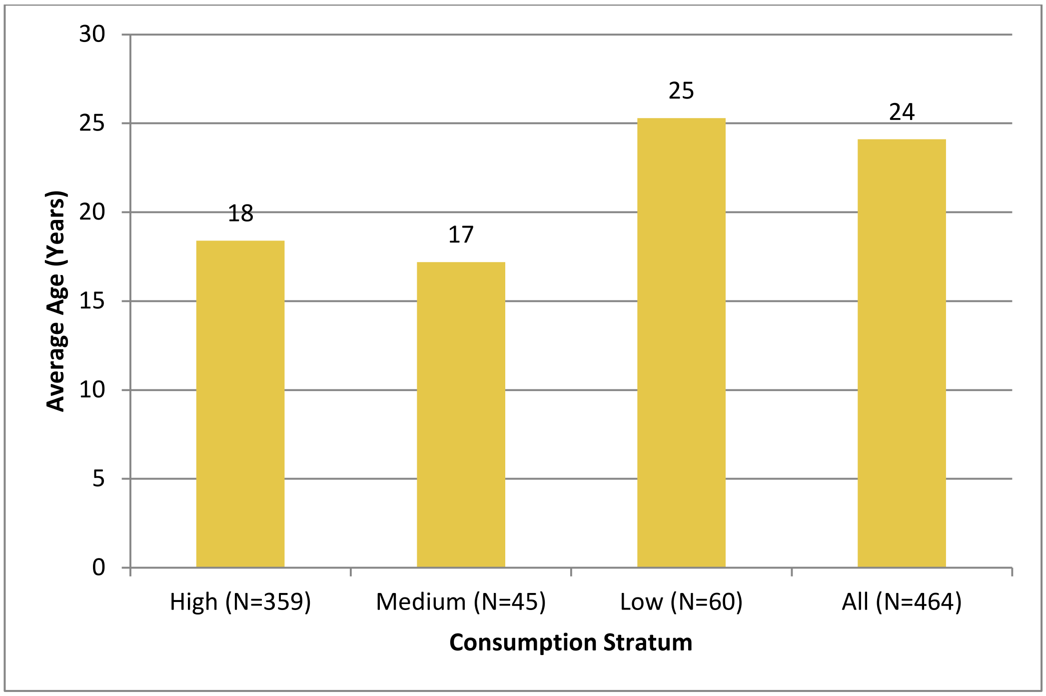


Source: On-Site Survey, Questions 119

[20] Complete data was not available for every system.

Surveyors estimated the age of HVAC equipment based on nameplate data, customer input or professional judgment. The average age of single-zone equipment is 24 years old, as shown in Figure 3-39. The HVAC equipment in the high and medium consumption strata is somewhat newer than the overall average at 18 and 17 years old, respectively. Average age for systems in low energy use buildings is 25 years old, just slightly above the overall average age.

Figure 3-39. Average Age of Single-Zone HVAC Systems by Consumption Stratum



Source: On-Site Survey, Question 121

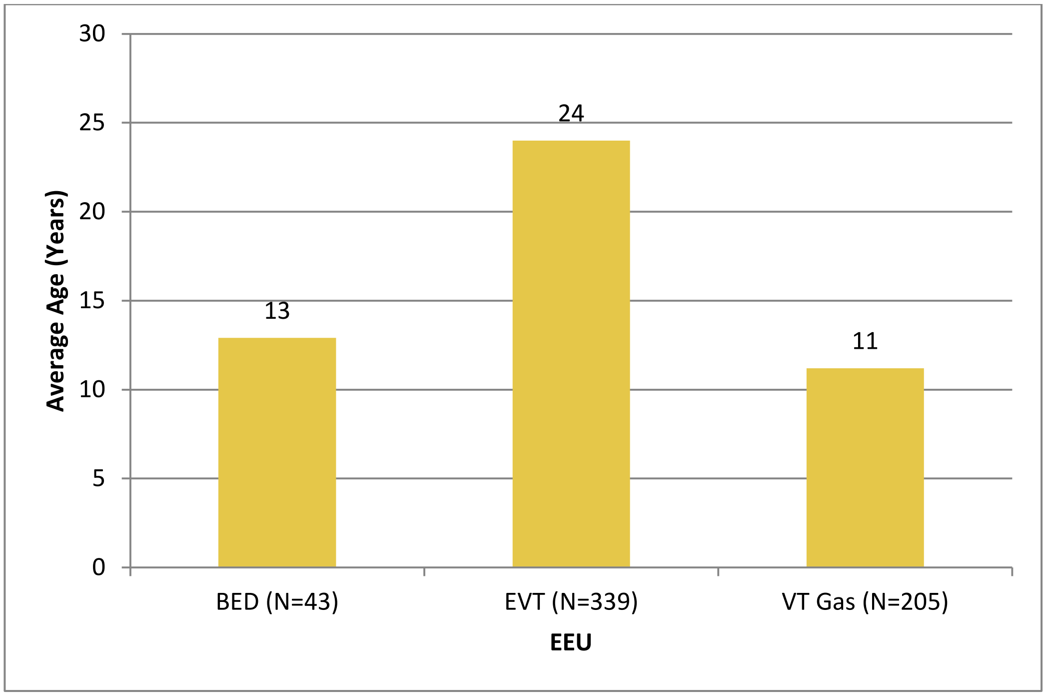
Figure 3-40 presents the average age of single-zone HVAC systems by building type. The average system age in offices is 34 years old, significantly higher than the overall average. Retail buildings have the newest systems while manufacturing and the balance of commercial buildings have an average system age of 17 years old.

Figure 3-40. Average Age of Single-Zone HVAC Systems by Building Type

Source: On-Site Survey, Question 121

Single-zone HVAC systems are significantly older in EVT areas than in VT Gas and BED, as shown in Figure 3-41. The average age of systems in VT Gas service territory is 11 years old, compared to 13 years old in BED and 24 years old in EVT territory. The potential to replace outdated equipment is considerably higher in EVT areas than in VT Gas and BED areas.

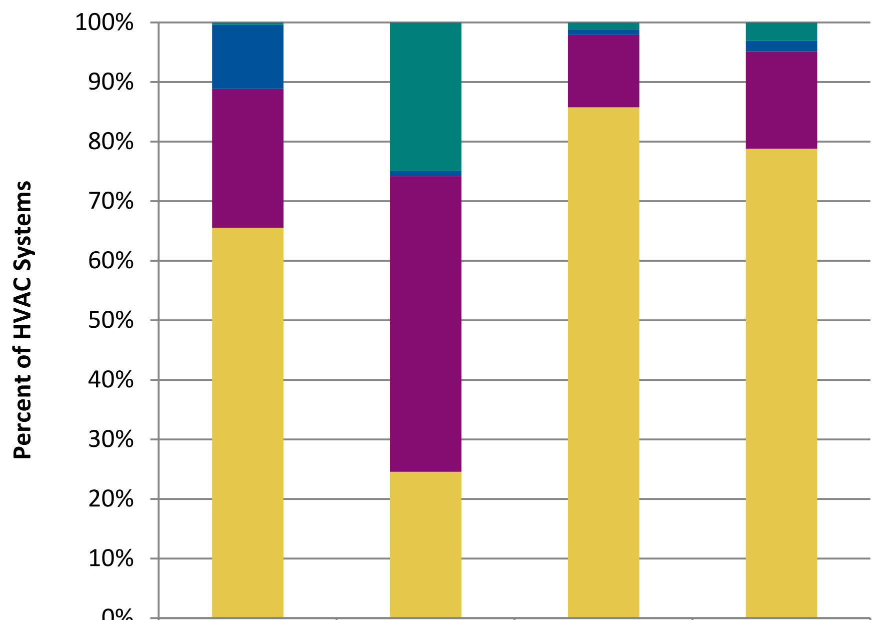
Figure 3-41. Average Age of Single-Zone HVAC Systems by EEU



Source: On-Site Survey, Question 121

Surveyors attempted to identify the overall condition of HVAC systems during the site visits, providing a rating of good, fair, poor or unknown. It is important to note that judging the condition of HVAC systems is highly subjective and the surveyors do not perform detailed inspections on the equipment. Figure 3-42 shows that the majority (79%) of HVAC systems are in good condition, with 16% in fair condition. Surveyors identified 11% of systems in the high energy use buildings as poor condition, the highest in any category, even though overall only 2% of all systems are in poor condition.

Figure 3-42. Condition of Single-Zone HVAC Systems by Consumption Stratum

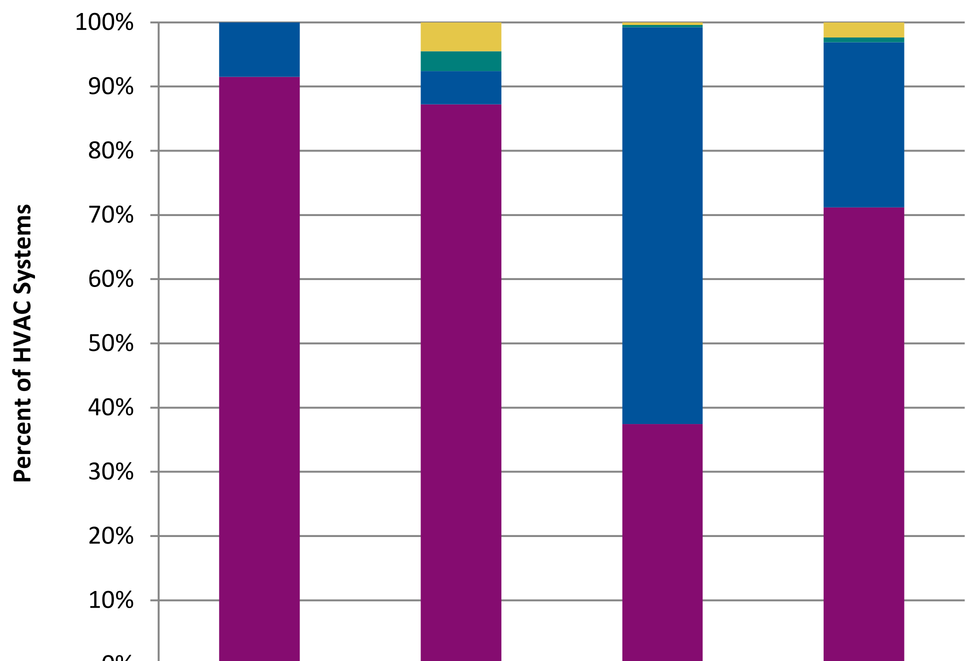


	High (N=359)	Medium (N=45)	Low (N=60)	All (N=464)
Unknown	0%	25%	1%	3%
Poor	11%	1%	1%	2%
Fair	23%	50%	12%	16%
Good	66%	25%	83%	79%

Source: On-Site Survey, Question 122

Figure 3-43 shows that the majority of single-zone HVAC systems are in good condition across all building types, with the exception of the manufacturing sector, where 62% of systems are in fair condition. The subjectivity of this data may be apparent given that the average age for HVAC systems in office buildings was estimated at 34 years old (see Figure 3-40), but 87% are in good condition.

Figure 3-43. Condition of Single-Zone HVAC Systems by Building Type

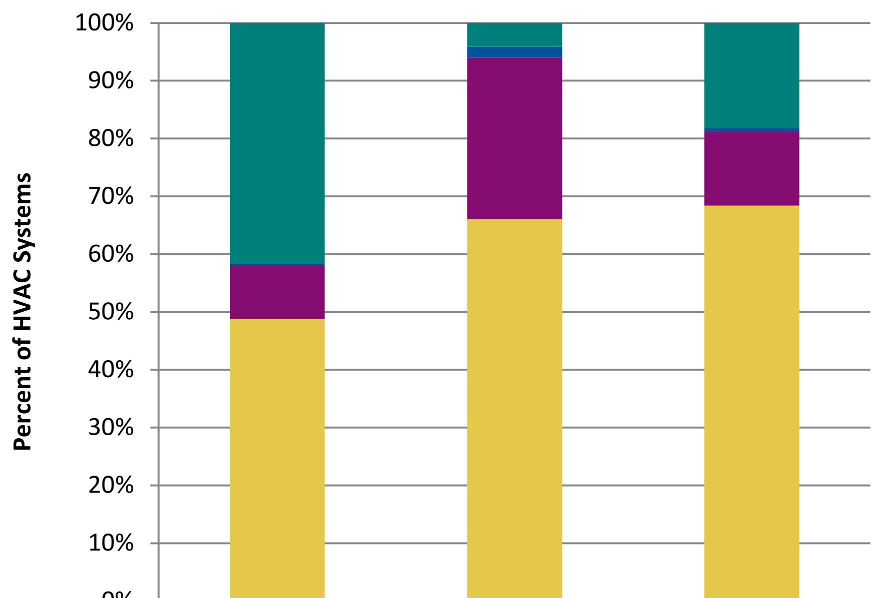


	Retail (N=22)	Office (N=40)	Manufacturing (N=130)	Balance of Commercial (N=272)
Unknown	0%	5%	0%	2%
Poor	0%	3%	0%	1%
Fair	8%	5%	62%	26%
Good	92%	87%	37%	71%

Source: On-Site Survey, Question 122

Surveyors identified the majority of single-zone HVAC systems in VT Gas and EVT areas as in good condition (68% and 65%, respectively), as shown in Figure 3-44. Over one-quarter (27%) of systems in EVT territory are in fair condition, considerably higher than in VT Gas areas (13%) or BED territory (9%). Surveyors were unable to identify the condition of many systems in BED service territory due to lack of accessibility.

Figure 3-44. Condition of Single-Zone HVAC Systems by EEU



	BED (N=59)	EVT (N=430)	VT Gas (N=257)
Unknown	42%	4%	18%
Poor	0%	2%	1%
Fair	9%	27%	13%
Good	49%	65%	68%

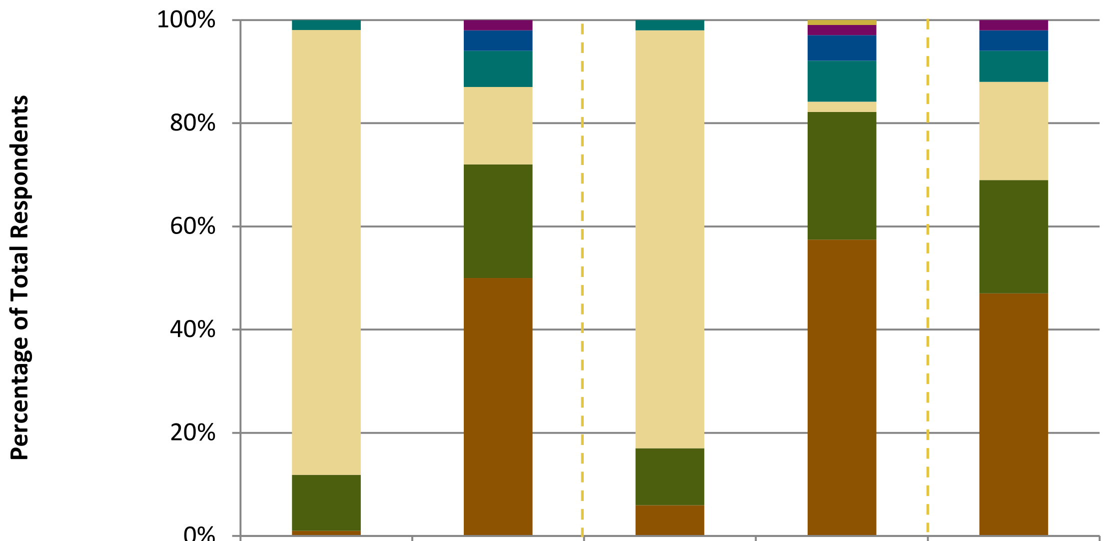
Source: On-Site Survey, Question 122

3.4.2 Heating Systems

3.4.2.1 Heating Fuel Type

The telephone survey of 237 existing building customers indicates that nearly half (47%) of all buildings in the state use fuel oil as the primary heating fuel, as indicated in Figure 3-45. Liquefied petroleum gas (LPG) is the second most frequently used heating fuel.

Figure 3-45. Heating System Fuel Type by EEU



	BED (N=36)	EVT (N=199)	VT Gas (N=113)	Non-VT Gas (N = 124)	All (N=237)
Multiple	0%	0%	0%	1%	0%
Other	0%	2%	0%	2%	2%
Wood	0%	4%	0%	5%	4%
Electricity	2%	7%	2%	8%	6%
Natural gas	87%	15%	81%	2%	19%
LPG/Propane Gas	11%	22%	11%	25%	22%
Fuel Oil	1%	50%	6%	58%	47%

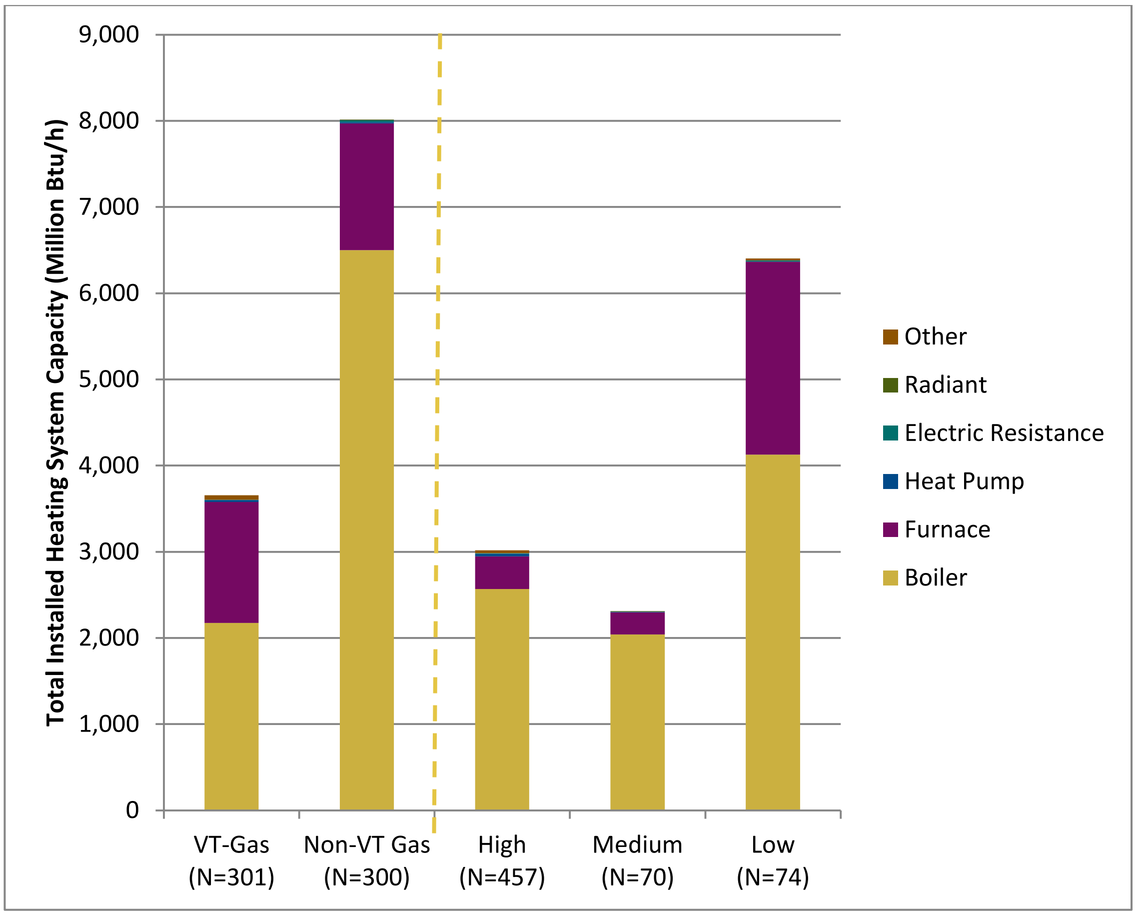
EEU/Area

Source: Telephone Survey, Question SH1

3.4.2.2 *Heating System Type*

Figure 3-46 shows that most of the installed heating capacity is found in boilers, with furnaces comprising the second largest share. Low energy use buildings have a larger share of furnaces than other strata, but heat pumps and other heating system types comprise a relatively insignificant amount of heating capacity across all categories. There is more than double the installed heating capacity outside of VT Gas territory, though the breakdown of boilers and furnaces is very similar inside and outside of VT Gas territory.

Figure 3-46. Distribution of Heating System Types by Consumption Strata and VT Gas Territory



Source: On-Site Survey, Question 146

Table 3-10 shows heating system efficiencies for furnaces and boilers, broken out by energy code categories and size (input capacity) thresholds. Average furnace efficiency meets or exceeds the 2005 CBES requirements for both size categories. There were nine steam boilers observed in the field, and all meet or exceed the code minimum efficiency level. Similarly, hot water boiler efficiency exceeds code minimums for all size categories.

Table 3-10. Heating System Efficiency by Type and Code Category

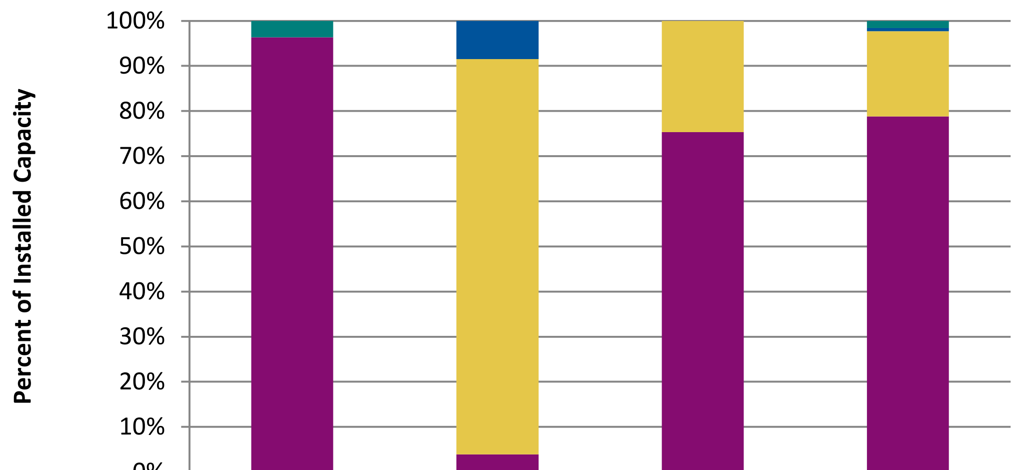
System	Size Category (Input)	Subcategory	Observed Efficiency[b]	2005 CBES Minimum Efficiency	Number of Units
Warm Air Furnaces	<225,000 Btu/h	-	81%	80%	55
	≥225,000 Btu/h	-	80%	80%	20
Boilers[a]	<300,000 Btu/h	Steam	80%	75% (gas) and 80% (oil)	4
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Steam	88%	75%	2
	≥2,500,000 Btu/h	Steam	84%	80%	3
Boilers[a]	<300,000 Btu/h	Hot Water	86%	80% (all fuels)	18
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Hot Water	82%	75% (gas) and 78% (oil)	16
	≥2,500,000 Btu/h	Hot Water	85%	83%	2

a. Gas and oil boilers are not broken out for this analysis.
b. Observed efficiency is the weighted average efficiency of all observed units.
Source: On-Site Survey, Question 150; 2005 CBES Table 803.3.3(4) and Table 803.3.3(5)

3.4.2.3 Boilers

As shown in Figure 3-47, most (79%) boilers in existing buildings are hot water boilers, while steam boilers comprise 19% of all boilers. However, the majority (88%) of boilers (by installed capacity) in the manufacturing sector are steam boilers. Surveyors identified no steam boilers in office buildings.

Figure 3-47. Boiler Delivery Systems by Building Type[21]



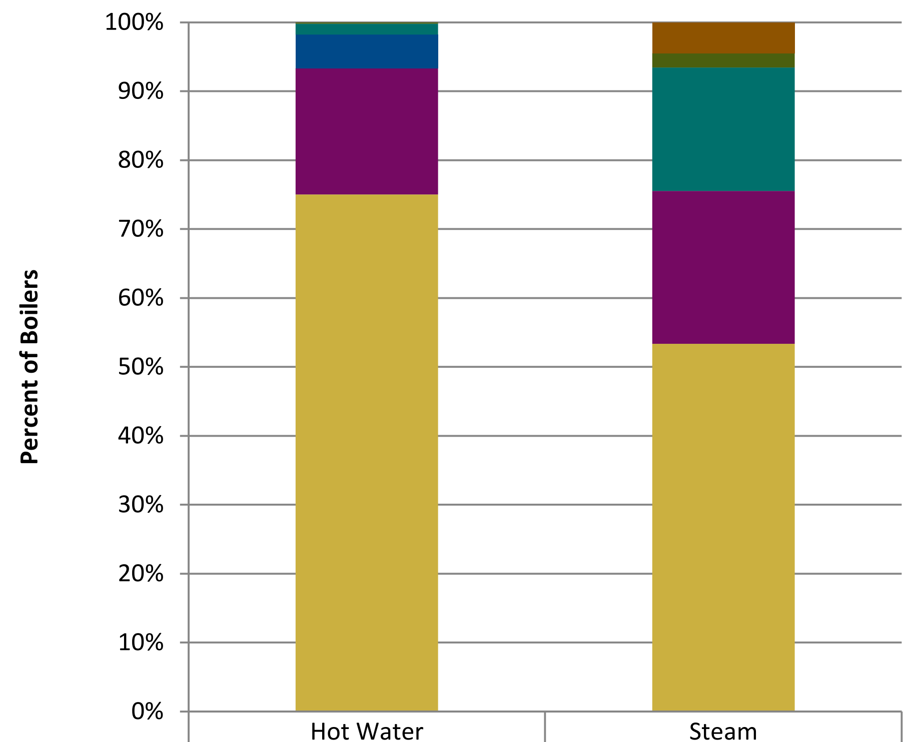
	Office (N=11)	Manufacturing (N=24)	Balance of Commercial (N=77)	All Buildings (N=112)
Other	4%	0%	0%	2%
Unidentified	0%	8%	0%	1%
Steam	0%	88%	25%	19%
Hot Water	96%	4%	75%	79%

Source: On-Site Survey, Question 222

[21] There was only one instance of a boiler in the retail building type, and this is included in the balance of commercial category.

Figure 3-48 shows the breakdown of boiler fuel types by delivery system (steam vs. hot water). 75% of hot water boilers are fueled by fuel oil with 18% and 5% powered by natural gas and LPG, respectively. The majority (53%) of steam boilers is powered by fuel oil, but there is a significant portion (18%) of steam boilers fired with wood as well.

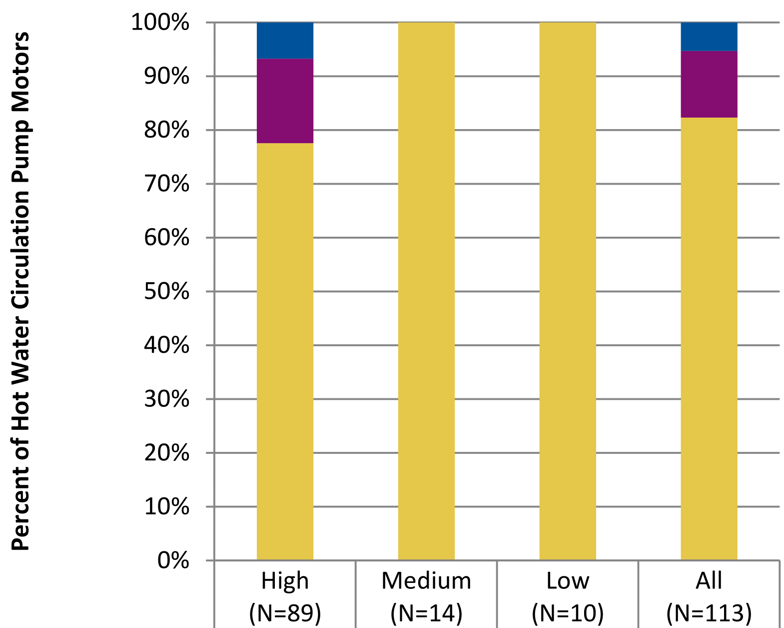
Figure 3-48. Boiler Fuel Types by Delivery System



	Hot Water	Steam
Electric	0%	4%
Other	0%	2%
Wood	2%	18%
LPG	5%	0%
Natural Gas	18%	22%
Fuel Oil	75%	53%

Most (82%) hot water circulation pumps used for space heating (fed by boilers) are constant speed motors, as shown in Figure 3-49. Only 12% of circulation pumps are variable speed. Surveyors identified all instances of variable speed circulation pumps in the high energy use buildings and none were observed in the other consumption strata.

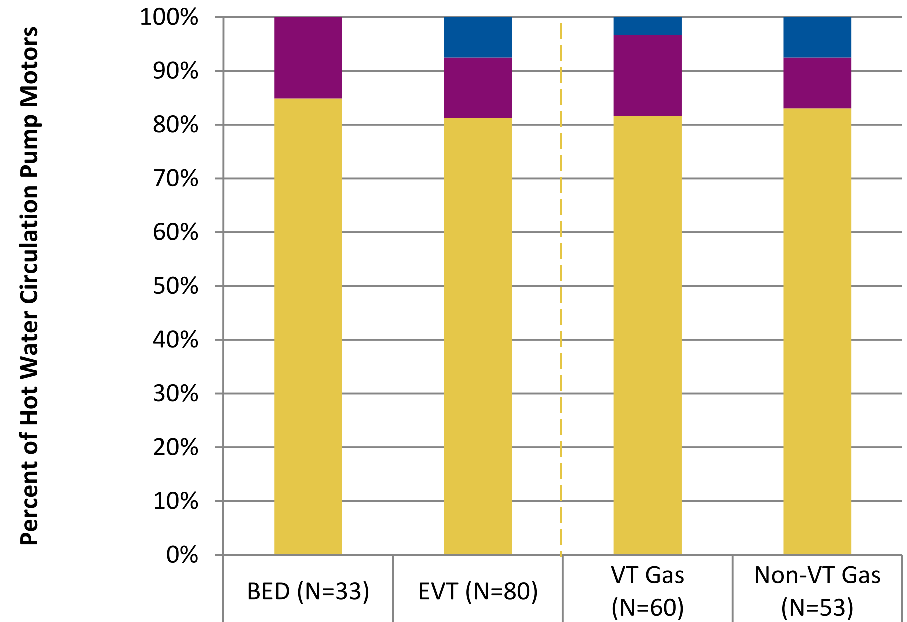
Figure 3-49. Saturation of Speed Controls for Hot Water Circulation Pumps by Consumption Stratum



	High (N=89)	Medium (N=14)	Low (N=10)	All (N=113)
Unidentified	7%	0%	0%	5%
Variable Speed	16%	0%	0%	12%
One Speed	78%	100%	100%	82%

The saturation of variable speed controls in hot water circulation pumps does not significantly vary within each EEU service area, as shown in Figure 3-50. BED and VT Gas have slightly higher saturations of variable speed pump motors than other areas, yet there are also more unidentified control types in those categories.

Figure 3-50. Saturation of Speed Controls for Hot Water Circulation Pumps by EEU

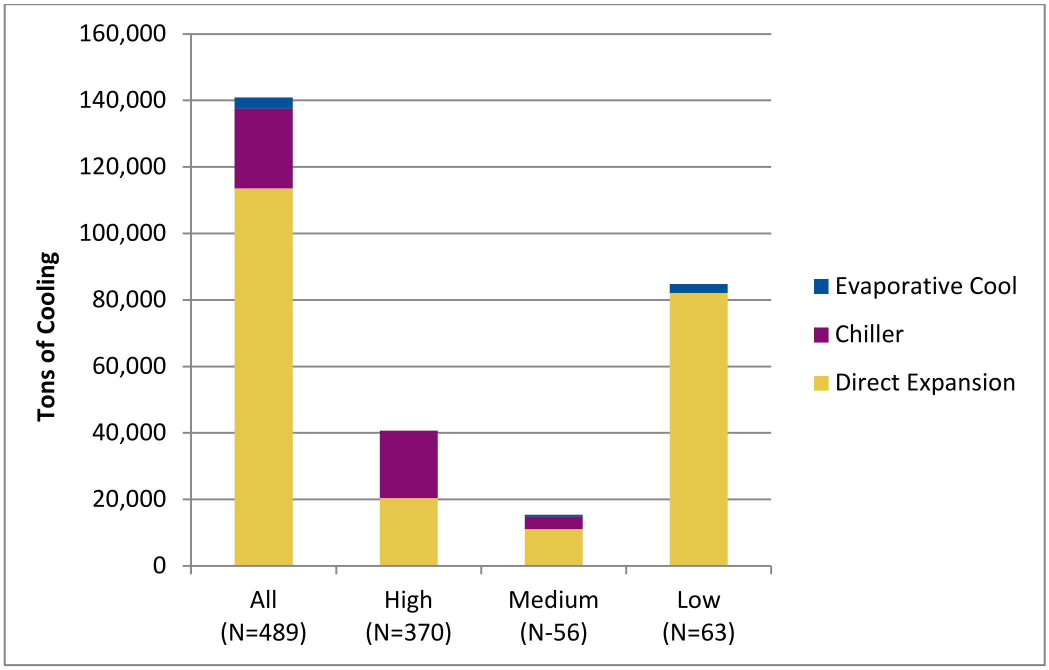


	BED (N=33)	EVT (N=80)	VT Gas (N=60)	Non-VT Gas (N=53)
Unidentified	0%	8%	3%	8%
Variable Speed	15%	11%	15%	9%
One Speed	85%	81%	82%	83%

3.4.3 Cooling Systems

Direct expansion (DX) cooling systems make up nearly all (97%) of all cooling system capacity in Vermont's existing buildings. Chillers account for approximately 17% of all cooling system capacity, and are found in high and medium energy use buildings, as shown in Figure 3-51. Surveyors identified a small percentage of cooling systems as evaporative cooling systems.

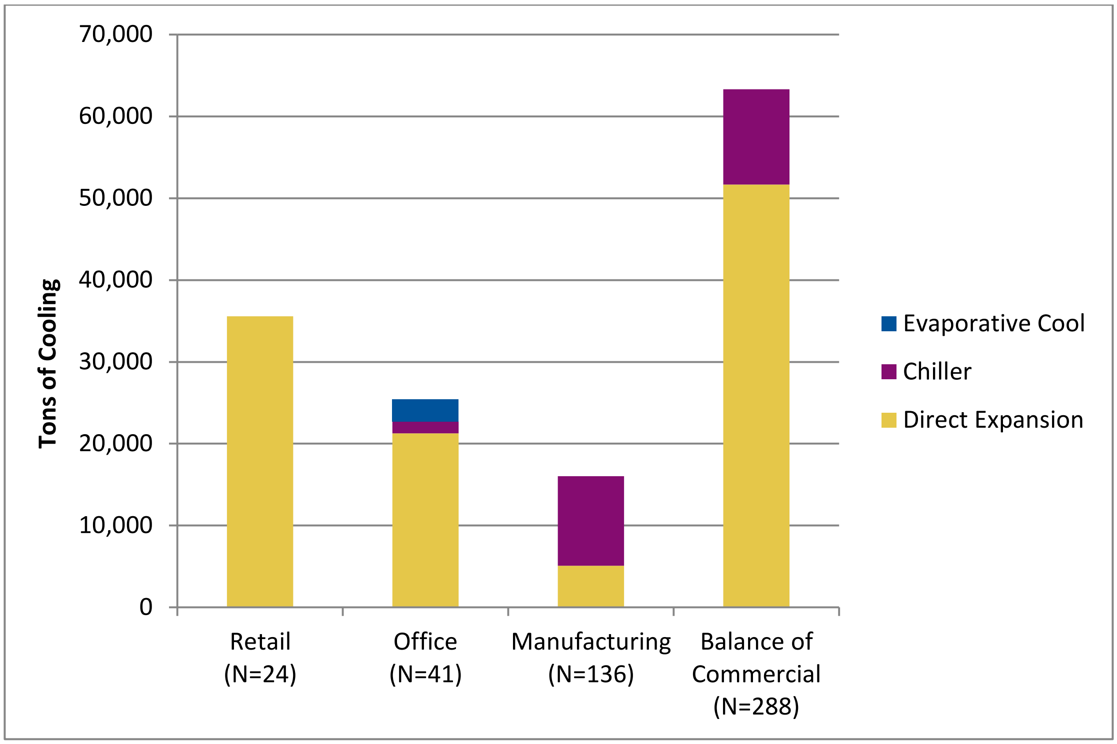
Figure 3-51. Saturation of Cooling System Types by Consumption Stratum



Source: On-Site Survey, Questions 138 and 191

Figure 3-52 shows that direct expansion systems were the only cooling types found in retail buildings, and evaporative coolers were only found in office buildings. Most of the chillers were identified in the manufacturing sector or in other building types.

Figure 3-52. Saturation of Cooling System Types by Building Type



Source: On-Site Survey, Questions 138 and 191

The majority (61%) of small (less than 5.5 tons in cooling capacity)[22] single-zone unitary HVAC systems in Vermont's existing building stock do not meet the prevailing code requirements at the time of the survey (2005 CBES), as shown in Table 3-11. The average Energy Efficiency Ratio (EER) for these systems is 10.2 and average Seasonal Energy Efficiency Ratio (SEER) is 11.2. Nearly 40% of unitary systems (less than 5.5. tons) meet or exceed code efficiency requirements.

Table 3-11. Cooling Efficiency of Single-Zone Unitary HVAC Systems (< 5.5 tons)[23]

	<5.5 tons (Code: 13.0 SEER / 11.0 EER)
Percent of Systems Below Code	61%
Percent of Systems At/Above Code	39%
Mean EER	10.2
Mean SEER	11.2

N = 96 observations
Source: On-Site Survey, Questions 144-145; 2005 CBES Table 803.2.2.(1)

The 2005 CBES required all cooling systems greater than 5.5 tons (65,000 Btu/h) to use supply air economizers. Table 3-12 shows that most cooling systems in Vermont are not equipped with economizers. However, surveyors were unable to determine if economizers were in use on 29% of systems less than 5.5 tons and 46% of systems greater than 5.5 tons.[24] The findings indicate that 7% of systems greater than 5.5 tons use economizers while only 3% of smaller systems use economizers.

Table 3-12. Saturation of Economizers in Cooling Systems

	<5.5 tons	≥5.5 tons (Code Required Minimum Size)
Economizer	3%	7%
No Economizer	69%	46%
Unidentified	29%	46%

N = 243 Systems
Source: On-Site Survey, Question 189; 2005 CBES Section 803.3.3.5

[22] One ton equals 12,000 Btu/h of cooling capacity. 5.5 tons is approximately equal to 65,000 Btu/h.
[23] Ninety-six (96) systems were identified as less than 5.5 tons of cooling capacity. 11 systems were greater than 5.5 tons. The code has modulating EER requirements for systems at thresholds of 5.5 tons, 11.25 tons, 20 tons, and 63 tons. It is not possible to compare each of the 11 systems against their respective requirements. The average EER for systems greater than 5.5 tons is 10.8.
[24] Surveyors often were unable to visually verify the presence of a functioning economizer.

3.4.3.1 Chillers

Surveyors identified 51 chillers in the field. Over half are located in the manufacturing sector (as indicated in the preceding Figure 3-52). 84% of all chillers are electric chillers, and steam and gas chillers each comprise 2%, as shown in Table 3-13. The average age for all chillers is 11 years old.

Table 3-13. Chiller Fuel Type (N = 51)

Chiller Fuel Type	% of Units
Electric	84%
Steam	2%
Gas	2%
Unidentified	12%

N = 51 chiller observations
Source: On-Site Survey, Question 257

Chillers can be used in C&I buildings for multiple purposes, including space cooling, refrigeration, and process uses. The majority (55%) of chillers in Vermont are dedicated to space cooling, while 17% are used exclusively for process loads, as shown in Table 3-14. 6% of chillers serve refrigeration loads and 6% serve multiple end uses.

Table 3-14. Chiller End Uses (N = 51)

Chiller End Use	Percent of Chillers Dedicated to End Use
Space Cooling	55%
Process	17%
Refrigeration	6%
Multiple End Uses	6%
Unidentified	16%

Source: On-Site Survey Questions 275-277

Nearly all (92%) of chillers do not have variable speed drive controls, as shown in Figure 3-53. Only 4% of chillers have variable speed drive (VSD) controls. Surveyors did not identify any instances of VSD controls in the manufacturing or office sectors.

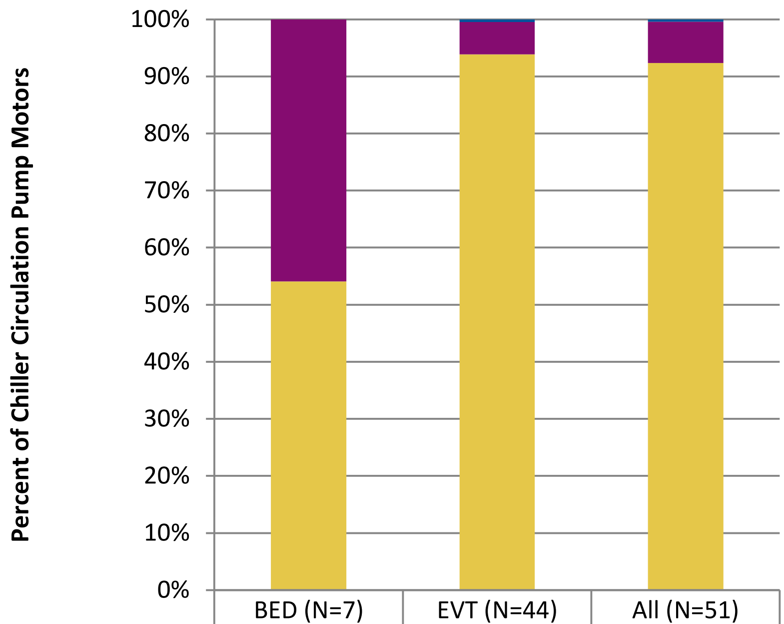
Figure 3-53. Saturation of Variable Speed Drive Controls for Chillers

Control Type	All (N=51)	Consumption Stratum		Building Type		
		High (N=49)	Medium (N=2)	Manufacturing (N=28)	Office (N=2)	Balance of Commercial (N=21)
No VSD	92%	91%	100%	88%	100%	94%
VSD	4%	4%	0%	0%	0%	6%
Unidentified	4%	5%	0%	12%	0%	0%

Weighted by total installed capacity (tons)
Source: On-Site Survey, Question 267

Nearly all (92%) of chilled water circulation pumps are constant speed motors and only 7% are variable speed, as shown in Figure 3-54. Interestingly, of the seven chiller systems identified in BED territory, 46% of the circulation pumps are variable speed. Only 6% of circulation pumps in EVT territory are variable speed.

Figure 3-54. Saturation of VSD Controls for Chilled Water Circulation Pumps by EEU



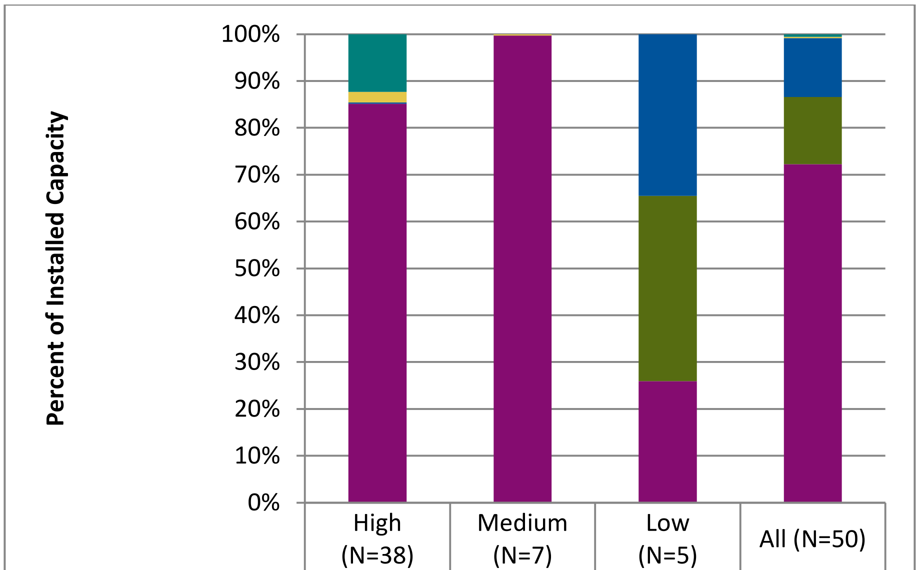
	BED (N=7)	EVT (N=44)	All (N=51)
Unidentified	0%	0%	0.4%
Variable Speed	46%	6%	7%
One Speed	54%	94%	92%

Source: On-Site Survey, Question 287

3.4.4 Multi-Zone Systems

HVAC systems that do not serve a dedicated, single zone are classified as multi-zone systems, or "complex" systems according to the energy code. Figure 3-55 shows that most (72%) multi-zone systems have multi-zone distribution system types, as opposed to constant volume or variable air volume distribution types. Variable refrigerant volume systems are found in the low energy use stratum and comprise approximately 14% of all distribution system types. Variable air volume systems make up less than 1% of complex systems in Vermont's existing buildings.

Figure 3-55. Saturation of Multi-Zone Distribution System Types by Consumption Stratum

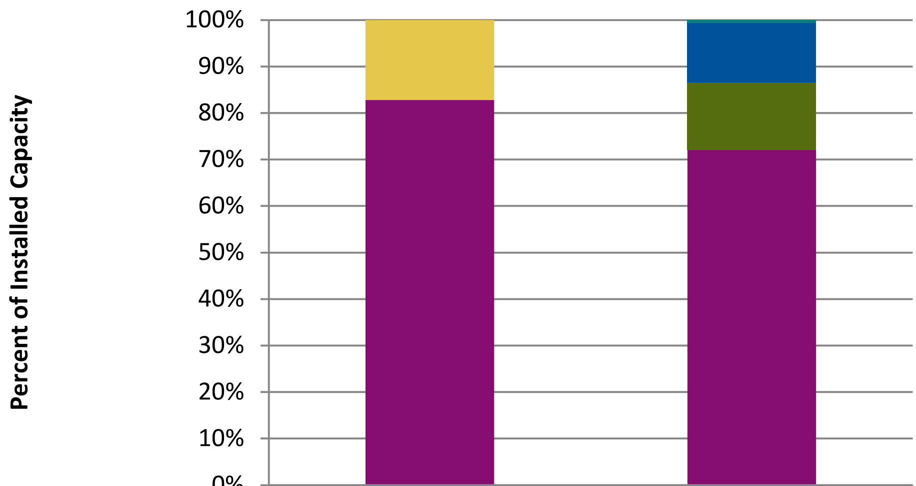


	High (N=38)	Medium (N=7)	Low (N=5)	All (N=50)
Variable Air Volume	12%	0%	0%	1%
Constant Volume	2%	0%	0%	0%
Other	0%	0%	35%	13%
Variable Refrigerant Volume	0%	0%	40%	14%
Multi Zone	85%	100%	26%	72%

Source: On-Site Survey, Question 170

Figure 3-56 presents multi-zone distribution system types by building type. The surveyors only identified these systems in office and balance of commercial building type categories. The majority (83%) of offices have multi-zone distribution types, though 17% are constant volume systems.

Figure 3-56. Saturation of Multi-Zone Distribution System Types by Building Type



	Office (N=8)	Balance of Commercial (N=42)
Variable Air Volume	0%	1%
Constant Volume	17%	0%
Other	0%	13%
Variable Refrigerant Volume	0%	15%
Multi Zone	83%	72%

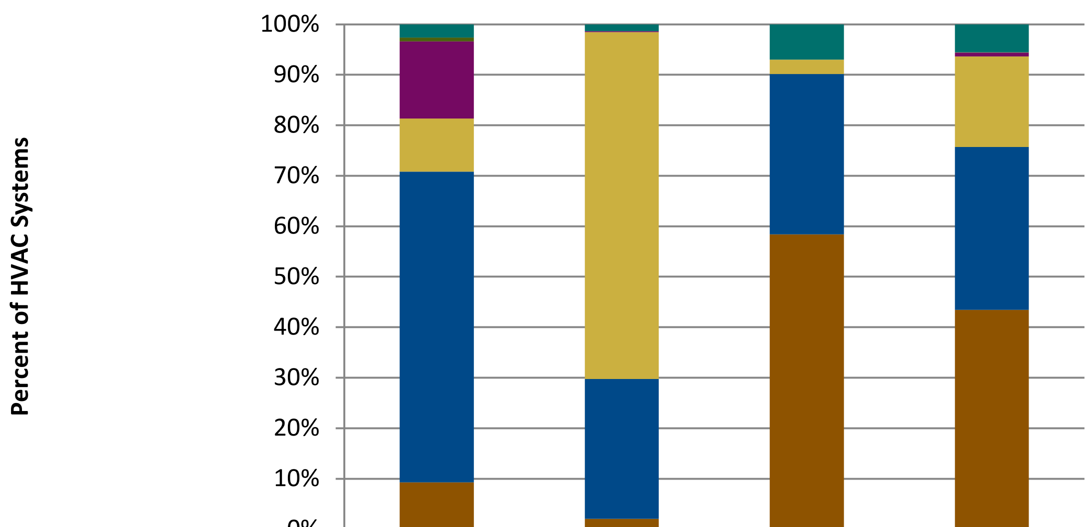
Source: On-Site Survey, Question 170

3.4.5 HVAC Controls

Figure 3-57 shows that 43% of all HVAC systems are controlled by programmable thermostats and nearly one-third (32%) are manually controlled. 18% of HVAC systems are always on (24/7) and only 1% are controlled by an EMS system.

Programmable thermostats make up the majority (58%) of controls for low energy use buildings, but only comprise 9% and 2% of controls for high and medium energy use buildings, respectively. 15% of high energy use buildings do use EMS systems, which is significantly different from the other consumption strata. Medium energy use buildings have the least amount of automatic controls in place, with approximately 69% operating continuously and 28% controlled manually.

Figure 3-57. Saturation of HVAC System Control Types by Consumption Stratum

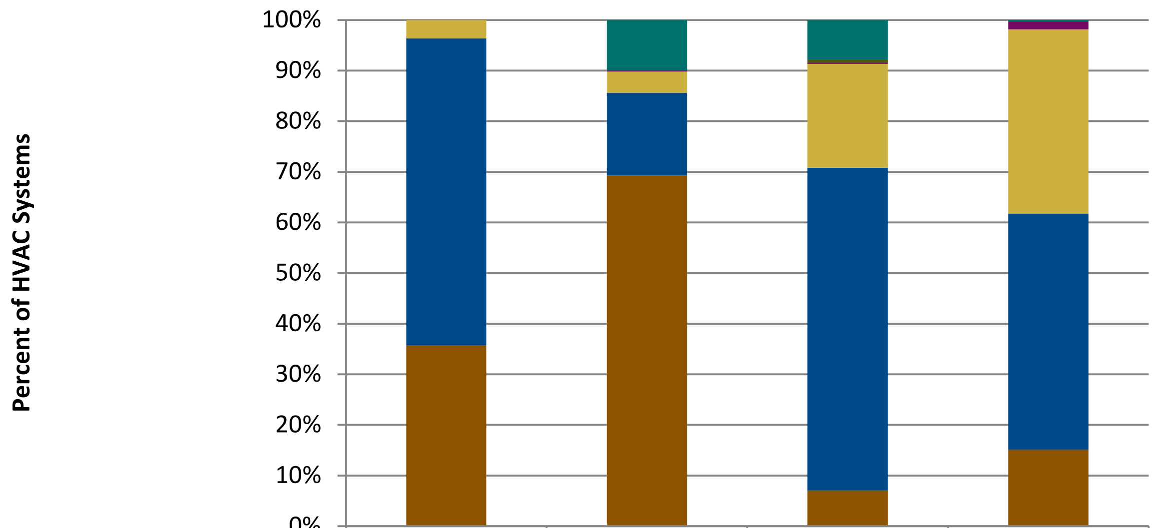


	High (N=144)	Medium (N=34)	Low (N=36)	All (N=214)
Unknown	3%	1%	7%	6%
Time Clock	1%	0%	0%	0%
EMS	15%	0%	0%	1%
Always On	11%	69%	3%	18%
Manual	62%	28%	32%	32%
Programmable Thermostat	9%	2%	58%	43%

Source: On-Site Survey, Questions 124 and 174

HVAC system control types vary widely across building types, as shown in Figure 3-58. Office buildings employ programmable thermostats more than any other control type, with a 69% share for this technology. The manufacturing sector and retail sector rely on manual control for 64% and 61% of HVAC systems, respectively. Surveyors observed EMS controls in only 2% of buildings in the balance of commercial category, and none in the other major building type groups.

Figure 3-58. Saturation of HVAC System Control Types by Building Type



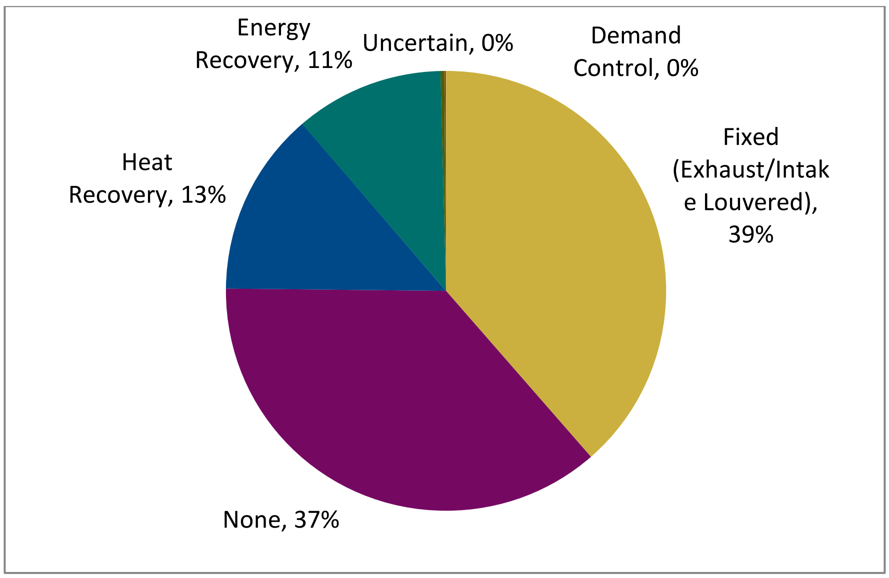
	Retail (N=11)	Office (N=29)	Manufacturing (N=43)	Balance of Commercial (N=131)
Unknown	0%	10%	8%	0%
Time Clock	0%	0%	1%	0%
EMS	0%	0%	0%	2%
Always On	4%	4%	21%	36%
Manual	61%	16%	64%	47%
Programmable Thermostat	36%	69%	7%	15%

Source: On-Site Survey, Questions 124 and 174

3.4.6 Ventilation

One goal of the on-site survey was to identify the "dominant" ventilation strategy for the entire building being surveyed. Fixed intake and exhaust strategies make up 39% of all buildings, while 37% of buildings had no identified ventilation strategy, as shown in Figure 3-59. Heat recovery comprises 13% of all building strategies and energy recovery (which recovers both sensible and latent heat) makes up 11% of all building strategies. Demand control ventilation (DCV) did not register as a dominant control strategy in Vermont's existing buildings. This is expected, as DCV is typically applied to limited areas such as conference rooms and auditoriums.[25]

Figure 3-59. Dominant Ventilation Strategy for All Buildings



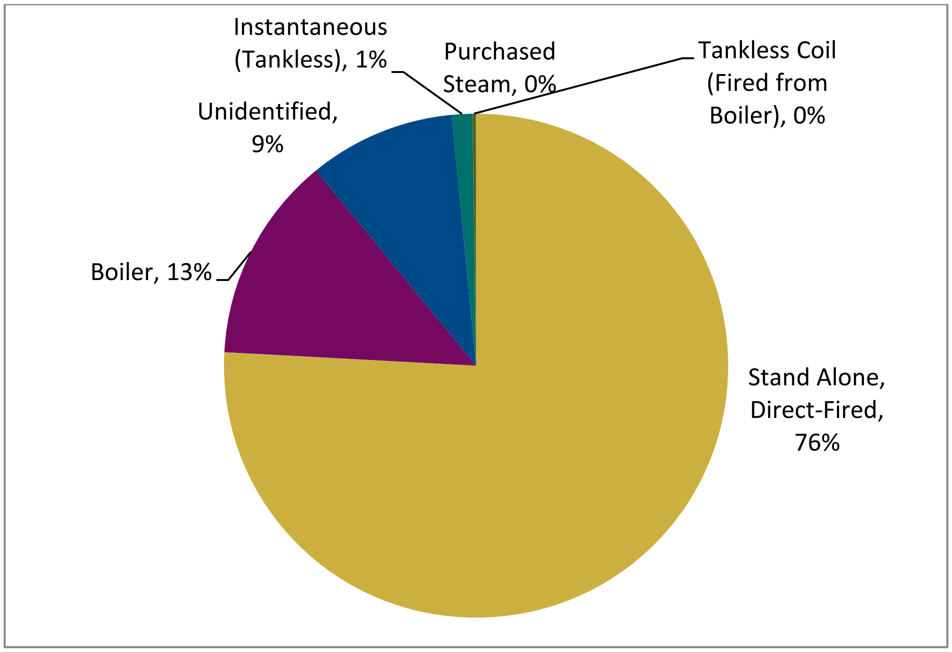
Source: On-Site Survey Section 23

[25] The 2011 CBES does require DCV for spaces meeting certain criteria of size and HVAC system type.

3.4.7 Water Heating

Stand-alone, direct-fired water heating systems make up the majority (76%) of water heating systems in Vermont's existing buildings, as shown in Figure 3-60. Boilers comprise the next largest share, at 13% of all systems. Instantaneous (i.e., tankless) systems only make up 1% of all water heating systems.

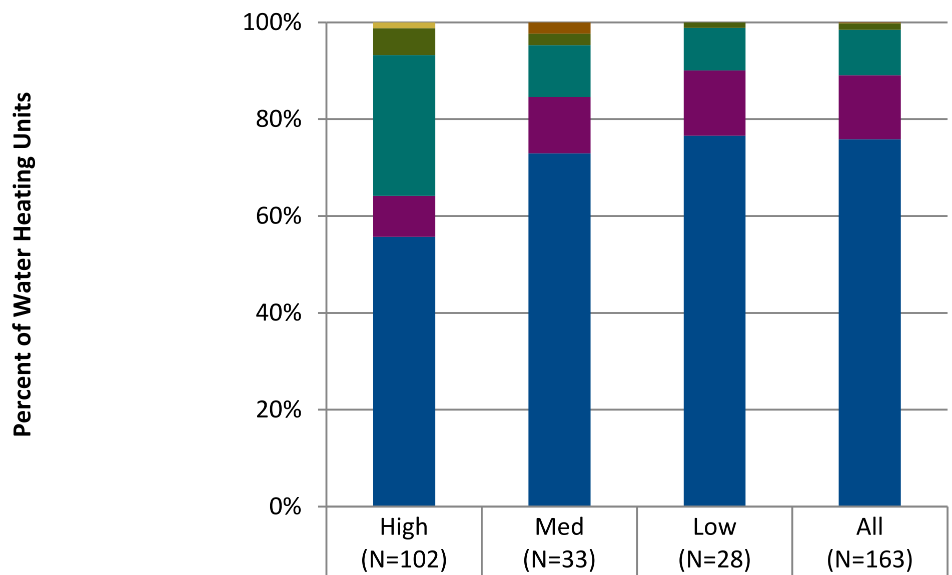
Figure 3-60. Distribution of Water Heating Equipment Types – All Buildings (N = 163 observations)



Source: On-Site Survey Question 319

The saturation of system types does not vary greatly by consumption stratum, as shown in Figure 3-61. Instantaneous systems comprise 6% of systems in the high energy use buildings.[26]

Figure 3-61. Saturation of Water Heating Equipment Types by Consumption Stratum



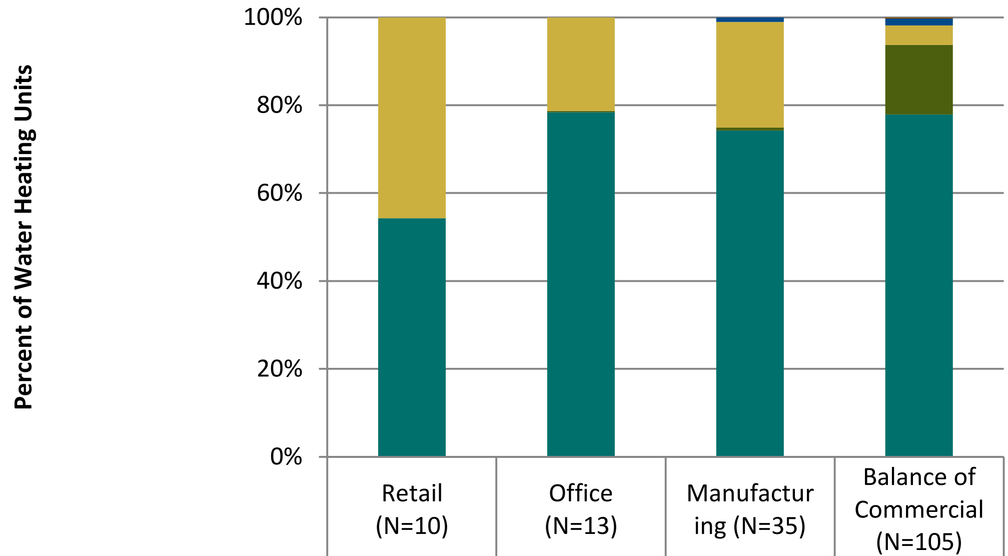
	High (N=102)	Med (N=33)	Low (N=28)	All (N=163)
Tankless Coil (Fired from Boiler)	0%	2%	0%	0%
Purchased Steam	1%	0%	0%	0%
Instantaneous (Tankless)	6%	2%	1%	1%
Unidentified	29%	11%	9%	9%
Boiler	8%	12%	13%	13%
Stand Alone, Direct-Fired	56%	73%	77%	76%

Source: On-Site Survey Question 319

[26] A larger share (29%) of water heating system types was not identified in the high energy use stratum. This is due to the complex nature of these buildings and the potential for water heaters to be located in inaccessible or hard to reach areas.

Figure 3-62 shows saturations of water heating system types by building type. Stand-alone systems comprise the majority of system types across all building type categories.

Figure 3-62. Saturation of Water Heating Equipment Types by Building Type



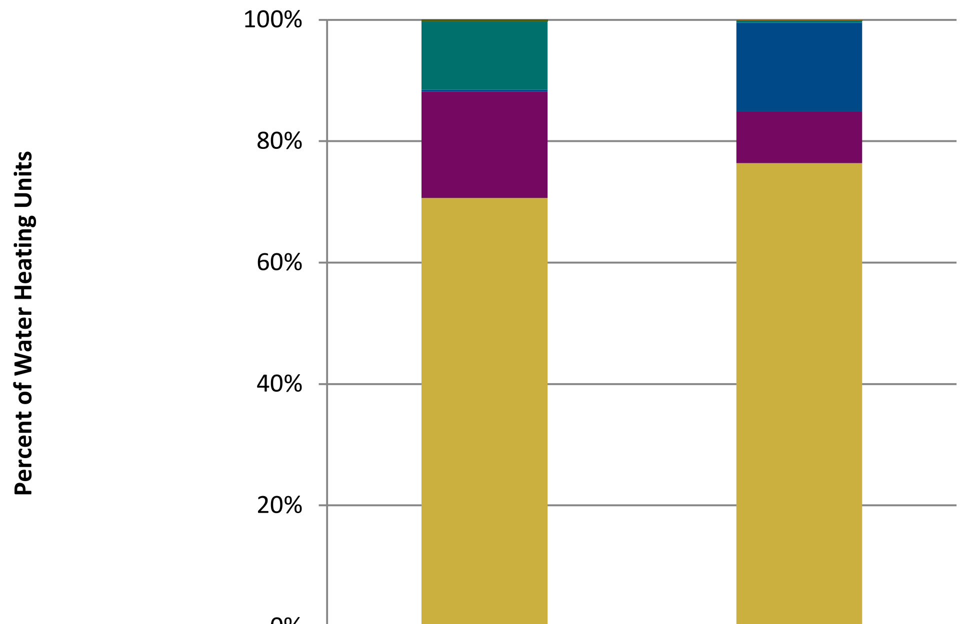
	Retail (N=10)	Office (N=13)	Manufacturing (N=35)	Balance of Commercial (N=105)
Tankless Coil (Fired from Boiler)	0%	0%	0%	0%
Purchased Steam	0%	0%	0%	0%
Instantaneous (Tankless)	0%	0%	1%	2%
Unidentified	46%	21%	24%	4%
Boiler	0%	0%	1%	16%
Stand Alone, Direct-Fired	54%	78%	74%	78%

Source: On-Site Survey Question 319

Figure 3-63 provides the saturations of water heating system types for VT Gas and non-VT Gas territory. Stand-alone systems again comprise the majority of system types across all areas. There are two notable differences when comparing these areas:

» 15% of water heating systems in non-natural gas areas are boilers, while less than 1% are boilers in natural gas areas.
» Instantaneous (tankless) water heaters comprise 11% of systems in VT Gas territory, compared with less than 1% in non-natural gas areas.

Figure 3-63. Saturation of Water Heating Equipment Types – VT Gas vs. Non-VT Gas

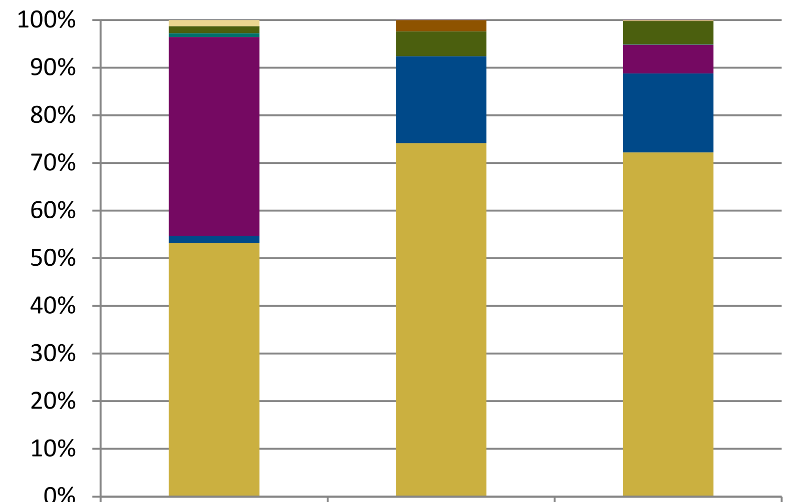


	VT Gas (N=72)	Non VT Gas (N=91)
Tankless Coil (Fired from Boiler)	0%	0%
Purchased Steam	0%	0%
Instantaneous (Tankless)	11%	0%
Boiler	0%	15%
Unidentified	18%	9%
Stand Alone, Direct-Fired	71%	76%

Source: On-Site Survey Question 319

Nearly three-quarters (72%) of water heaters are electric, while 17% utilize fuel oil and only 6% use natural gas, as shown in Figure 3-64. Over half (52%) of all water heaters in VT Gas areas are electric[27] while most (74%) systems are electric in non-gas areas. Natural gas fuels 42% of water heaters in VT Gas areas. In non-natural gas areas, fuel oil and LPG make up 18% and 5% of water heating fuels, respectively. Heat recovery registers as approximately 1% of water heating fuel type in VT Gas areas.

Figure 3-64. Water Heating Fuel Types – VT Gas vs. Non-VT Gas



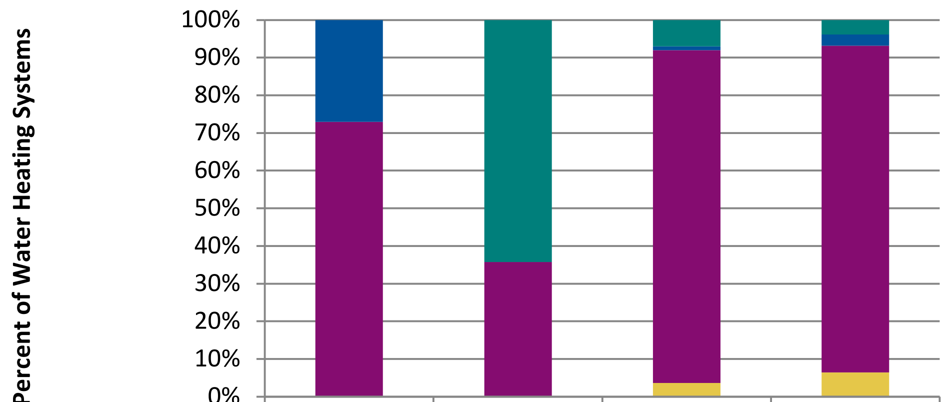
	VT Gas (N=72)	Non-VT Gas (N=91)	All (N=163)
Wood	0%	0%	0%
Other	1%	0%	0%
Unidentified	0%	2%	0%
LPG	1%	5%	5%
Heat Recovery	1%	0%	0%
Natural Gas	42%	0%	6%
Fuel Oil	1%	18%	17%
Electricity	53%	74%	72%

Source: On-Site Survey Question 320

[27] Results are based on counts of water heating systems, not weighted by capacity.

Most buildings maintain a water temperature setting between 110 °F and 140 °F (i.e., medium) as shown in Figure 3-65.[28] Approximately one-quarter (27%) of retail building owners maintained a low temperature setting (< 110 °F). A relatively small amount of water heaters are maintained at high temperature settings (> 140 °F), and these are found in manufacturing and balance of commercial building type categories.

Figure 3-65. Water Heater Temperature Setting by Building Type



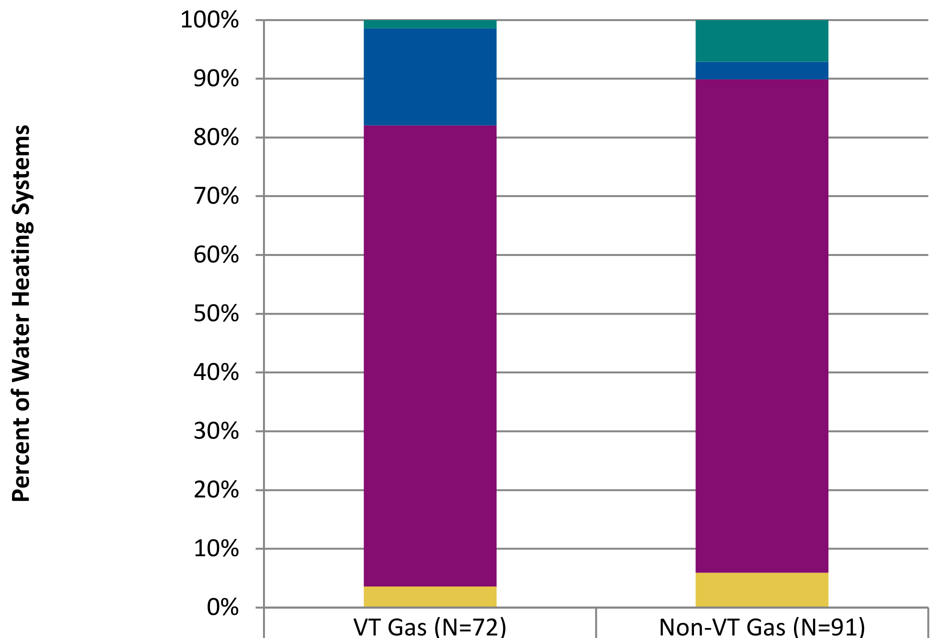
	Retail (N=10)	Office (n=13)	Manufacturing (n=35)	Balance of Commercial (n=105)
Unidentified	0%	64%	7%	4%
Low Temp (<110 F)	27%	0%	1%	3%
Medium Temp	73%	36%	88%	87%
High Temp (>140 F)	0%	0%	4%	6%

Source: On-Site Survey Question 331

[28] The State of Vermont Plumbing Board adopted a rule requiring the installation of a master thermostatic mixing valve to maintain a maximum temperature of 120 degrees at the plumbing fixture. The tank must be set to operate around 140 to achieve the desired outlet temp through the mixing valve. Note that the 2011 VT CBES requires a maximum temperature setting of 110°F in lavatories in public facility rest rooms.

Water heater temperature settings do not vary widely between VT Gas areas and non-natural gas areas, as shown in Figure 3-66, with one exception. There are more systems (16%) using low temperature settings in VT Gas areas than in non-VT Gas areas. This is likely due to the high proportion of retail buildings in VT Gas service territory, which have more instances of low temperature settings (as seen in preceding Figure 3-65).

Figure 3-66. Water Heater Temperature Setting – VT Gas vs. Non-VT Gas

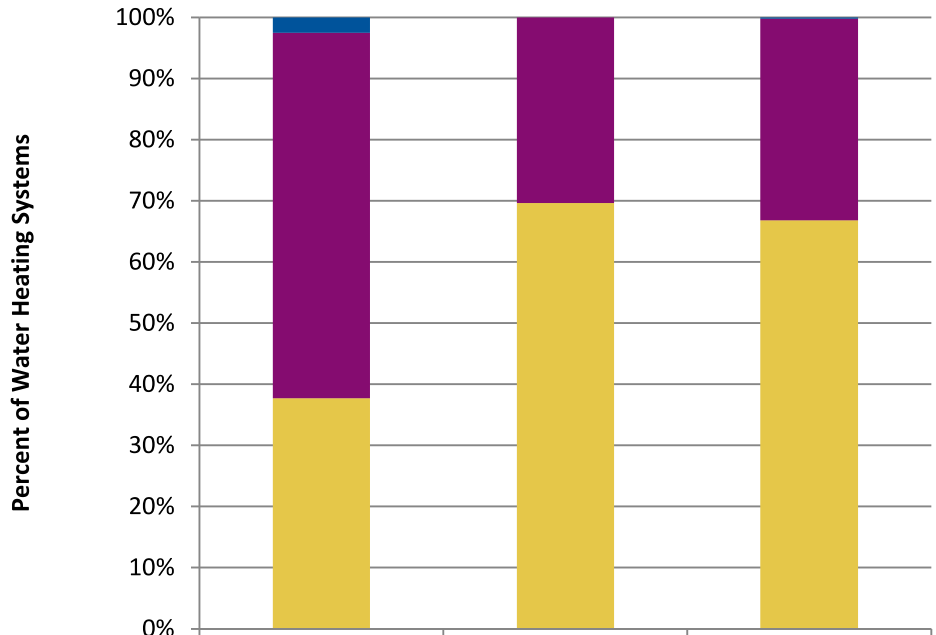


	VT Gas (N=72)	Non-VT Gas (N=91)
Unidentified	1%	7%
Low Temp (<110 F)	16%	3%
Medium Temp	78%	84%
High Temp (>140 F)	4%	6%

Source: On-Site Survey Question 331

Most (67%) water heaters have pipe insulation in Vermont's existing buildings, with 37% having no insulation, as shown in Figure 3-67. This scenario is reversed in VT Gas territory, where only 38% of water heater pipes are insulated. This is likely due to the high percentage of electric water heaters (higher operating costs) in non-gas areas (see Figure 3-64), though it is difficult to speculate.

Figure 3-67. Water Heating Pipe Insulation – VT Gas vs. Non-VT Gas

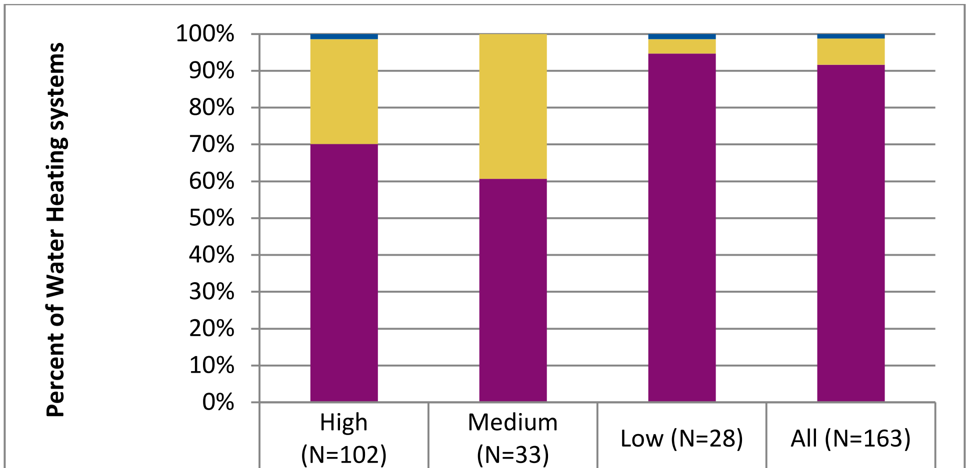


	VT Gas (N=72)	Non-VT Gas (N=91)	All (N=163)
Unidentified	3%	0%	0%
Not Insulated	60%	30%	33%
Insulated	38%	70%	67%

Source: On-Site Survey Question 332

As shown in Figure 3-68, the large majority (92%) of buildings do not use a recirculation pump for service hot water. Buildings in the high and medium energy use strata do employ recirculation pumps to a greater degree, with 28% and 39%, respectively. 95% of low energy use buildings do not use recirculation pumps.

Figure 3-68. Use of Water Heating Recirculation Pump by Consumption Stratum

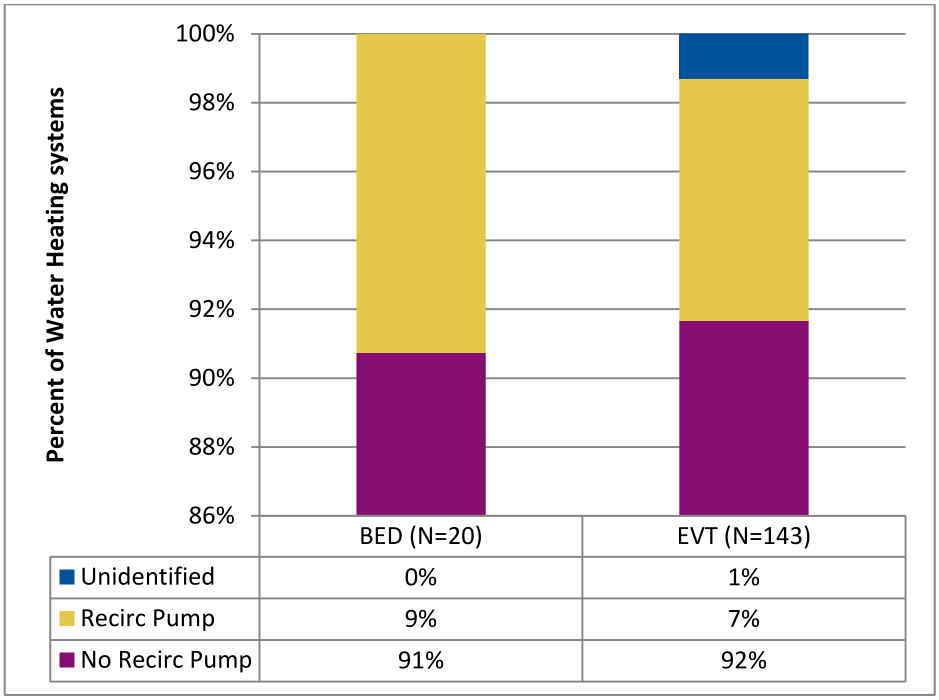


	High (N=102)	Medium (N=33)	Low (N=28)	All (N=163)
Unidentified	1%	0%	1%	1%
Recirc Pump	28%	39%	4%	7%
No Recirc Pump	70%	61%	95%	92%

Source: On-Site Survey Question 335

The use of recirculation pumps does not differ between BED and EVT service territories, as shown in Figure 3-69, where over 90% of all systems do not use recirculation pumps.

Figure 3-69. Use of Water Heating Recirculation Pump by EEU



Source: On-Site Survey Question 335

3.4.8 EEU Market Characterization – HVAC and Water Heating

Table 3-15 provides a summary characterization of HVAC and water heating measures for Vermont's EEUs.

Table 3-15. EEU Market Characterization – HVAC and Water Heating

	Measure/Characteristic	BED	EVT	VT Gas
HVAC	Single-Zone HVAC System Age	» The average age of systems in BED service territory is 13years old	» The average age of systems in EVT territory is 24 years old	» The average age of systems in VT Gas service territory is 11 years old
	Single-Zone HVAC System Condition	» Half of the systems rated as "good" condition	» Two-thirds (65%) rated as good condition and 27% in fair condition	» Over two-thirds (68%) rated as good condition and 13% in fair condition
	Primary Heating Fuel Type	» Natural gas is primary fuel type for 87% of customers	» Fuel oil is primary fuel type for 50% of customers, followed by22% with LPG and 15% using natural gas	» Natural gas is primary fuel type for 81% of customers, with 6% using fuel oil as primary heating fuel
	Heating System Type	N/A		» Boilers comprise over two-thirds of all systems, followed by warm-air furnaces
	Heating System Efficiency	» Average furnace efficiency meets or exceeds the 2005 CBES requirements for all size categories. There were nine steam boilers observed in the field, and all meet or exceed the code minimum efficiency level. Hot water boiler efficiency exceeds code minimums for all size categories		
	Boiler Delivery Systems	» Most (79%) boilers in existing buildings are hot water boilers, while steam boilers comprise 19% of all boilers. However, the majority (88%) of boilers (by installed capacity) in the manufacturing sector are steam boilers.		
	Hot Water Circulation Pump Speed Controls	» 15% are variable speed	» 11% are variable speed	» 15% are variable speed
	Cooling System Types	» Direct expansion (DX) cooling systems make up nearly all (97%) of all cooling system capacity in Vermont's existing buildings.		

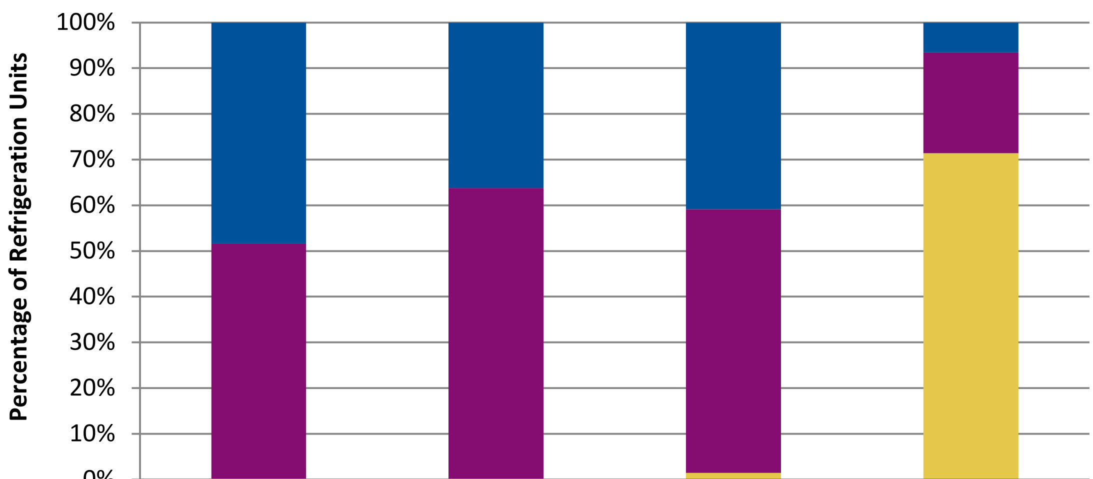
	Measure/Characteristic	BED	EVT	VT Gas
	Cooling Efficiency of Single-Zone Unitary HVAC Systems (< 5.5 tons)	» The majority (61%) of small (less than 5.5 tons in cooling capacity) single-zone unitary HVAC systems in Vermont's existing building stock do not meet the prevailing code requirements at the time of the survey (2005 CBES).		
	Saturation of Economizers in Cooling Systems	» Most cooling systems in Vermont are not equipped with economizers. The findings indicate that 7% of systems greater than 5.5 tons (2005 CBES-required minimum) use economizers while only 3% of smaller systems use economizers		
	VSD Controls for Chilled Water Circulation Pumps	» Nearly half (46%) of chilled water circulation pumps are variable speed	» Only 6% of chilled water circulation pumps in EVT territory are variable speed	N/A
Water Heating	Water Heating Equipment Types	N/A		» Most (71%) systems are stand-alone, direct-fired water heaters. Eleven percent are tankless water heaters.
Water Heating	Water Heating Fuel Types	N/A		» Over half (52%) of all water heaters in VT Gas areas are electric, followed by 42% fueled by natural gas.
Water Heating	Water Heating Pipe Insulation	N/A		» Only 38% of water heater pipes are insulated in VT Gas areas.
Water Heating	Water Heating Recirculation Pump	» Over 90% of all systems do not use recirculation pumps	» Over 90% of all systems do not use recirculation pumps	N/A

Source: Navigant analysis

3.5 *Refrigeration*

Figure 3-70 shows that the saturation of non-commercial ENERGY STAR refrigerators and freezers is negligible for retail, office, and manufacturing buildings types. However, the majority (71%) of non-commercial refrigerators and freezers in the balance of commercial building type category are ENERGY STAR rated.

Figure 3-70. Saturation of Non-Commercial ENERGY STAR Refrigerators and Freezers by Building Type



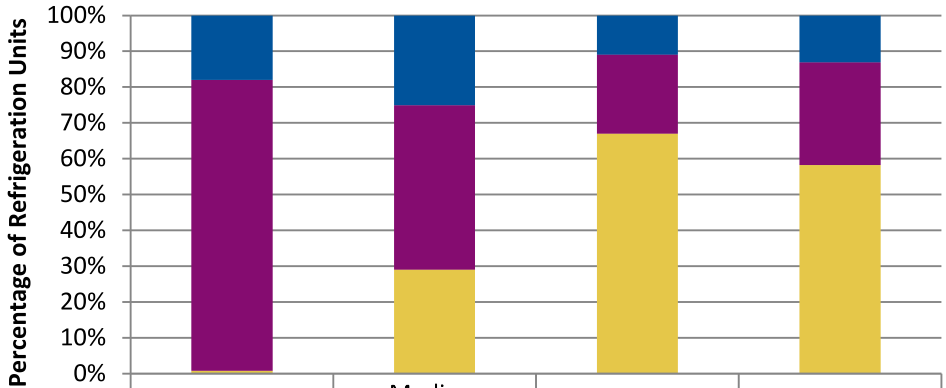
	Retail (N=13)	Office (N=16)	Manufacturing (N=32)	Balance of Commercial (N=86)
Unidentified	48%	36%	41%	7%
Non-Energy Star	52%	64%	58%	22%
Energy Star	0%	0%	1%	71%

Building Type

Source: On-Site Survey Question 474d

The saturation of non-commercial ENERGY STAR refrigerators and freezers is minimal (1%) in the high consumption stratum yet makes up the majority (67%) in the low consumption stratum, as shown in Figure 3-71. There is a large savings potential from efficient refrigerators and freezers in the high use stratum.

Figure 3-71. Saturation of Non-Commercial ENERGY STAR Refrigerators and Freezers by Consumption Stratum

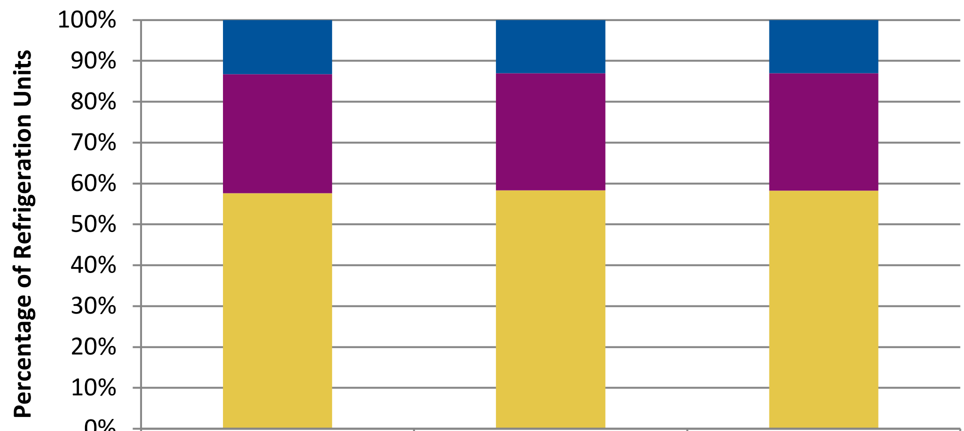


	High (N=86)	Medium (N=37)	Low (N=24)	All (N=147)
Unidentified	18%	25%	11%	13%
Non-Energy Star	81%	46%	22%	29%
Energy Star	1%	29%	67%	58%

Source: On-Site Survey Question 474d

The saturation of non-commercial ENERGY STAR refrigerators and freezers does not differ by EEU, as shown in Figure 3-72.

Figure 3-72. Saturation of Non-Commercial ENERGY STAR Refrigerators and Freezers by EEU



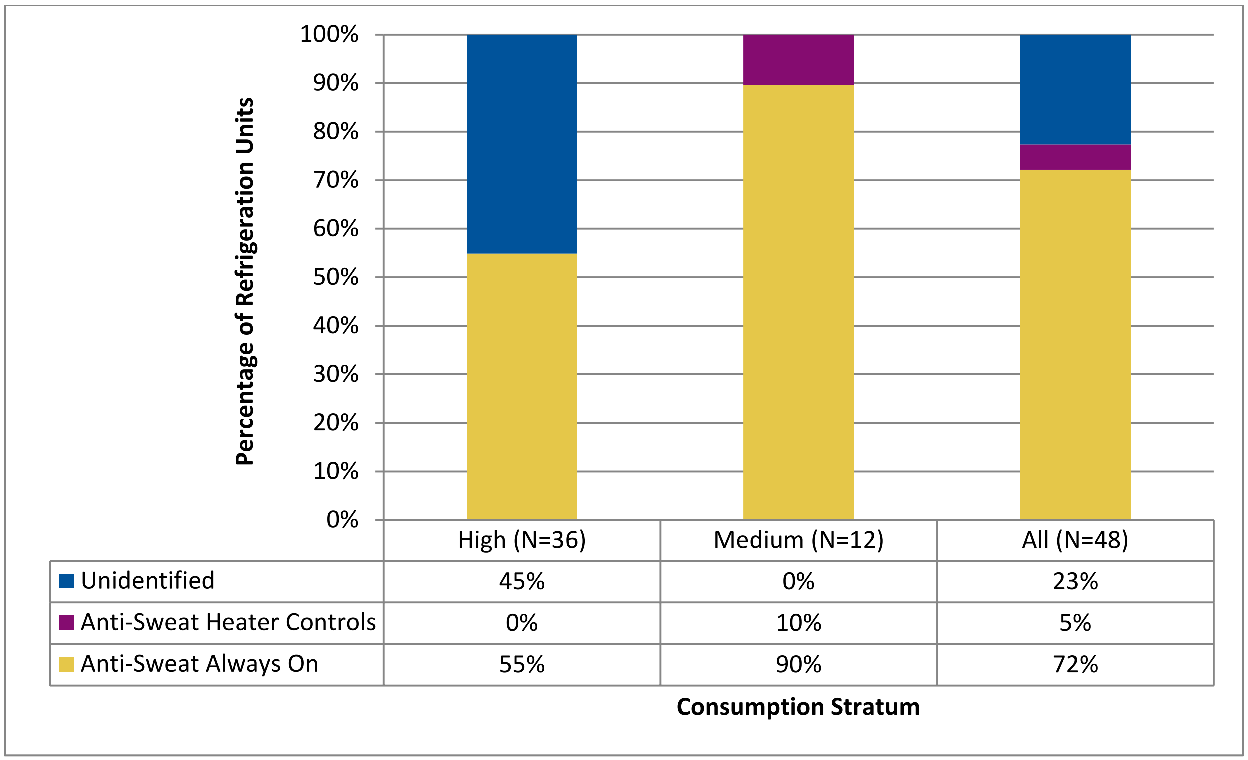
	BED (N=24)	EVT (N=123)	All (N=147)
Unidentified	13%	13%	13%
Non-Energy Star	29%	29%	29%
Energy Star	58%	58%	58%

Source: On-Site Survey Question 474d

Figure 3-73 shows that most (72%) refrigeration units have anti-sweat heaters always on, representing a large potential for capturing energy savings through anti-sweat heater controls.

The majority (55%) of refrigeration units in the high energy consumption stratum do not control the anti-sweat heaters, though surveyors were unable to determine the control strategy for a large percentage (45%) of the units in this stratum. Most (90%) refrigeration units in the medium energy consumption stratum do not have anti-sweat heater controls in place. There were no cases of anti-sweat heaters found in the low consumption stratum.

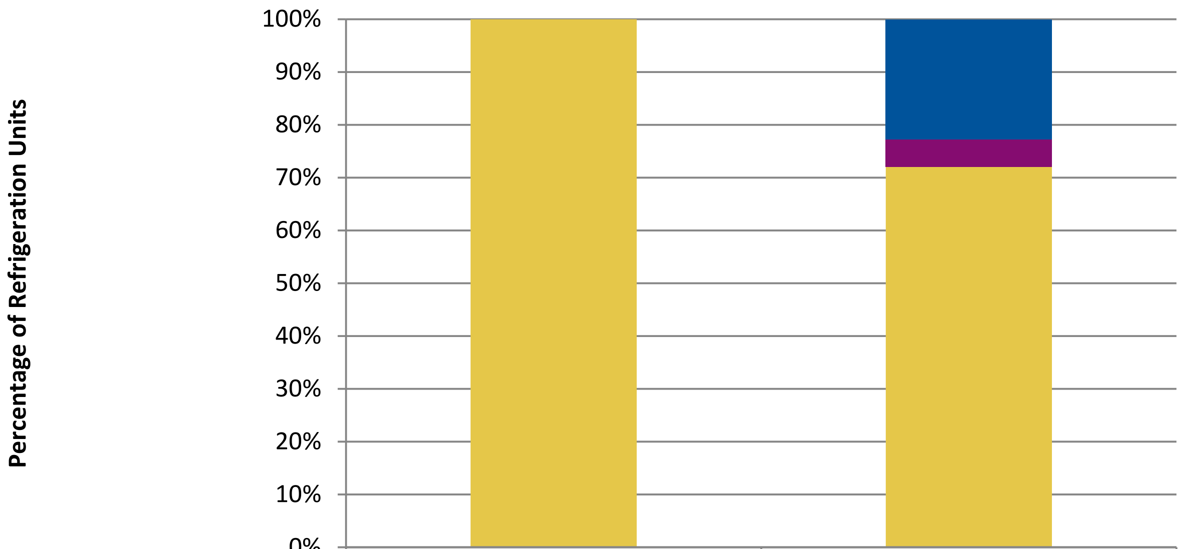
Figure 3-73. Saturation of Anti-Sweat Controls on Refrigeration Units by Consumption Stratum



Source: On-Site Survey Question 499

Within EVT territory, refrigeration units with anti-sweat heaters always on comprise 72% of all refrigeration units, and refrigeration units with anti-sweat heater controls comprise 5%. Only five refrigeration units were analyzed in the BED territory, and all lacked anti-sweat heater controls, as shown in Figure 3-74.

Figure 3-74. Saturation of Anti-Sweat Controls on Refrigeration Units by EEU

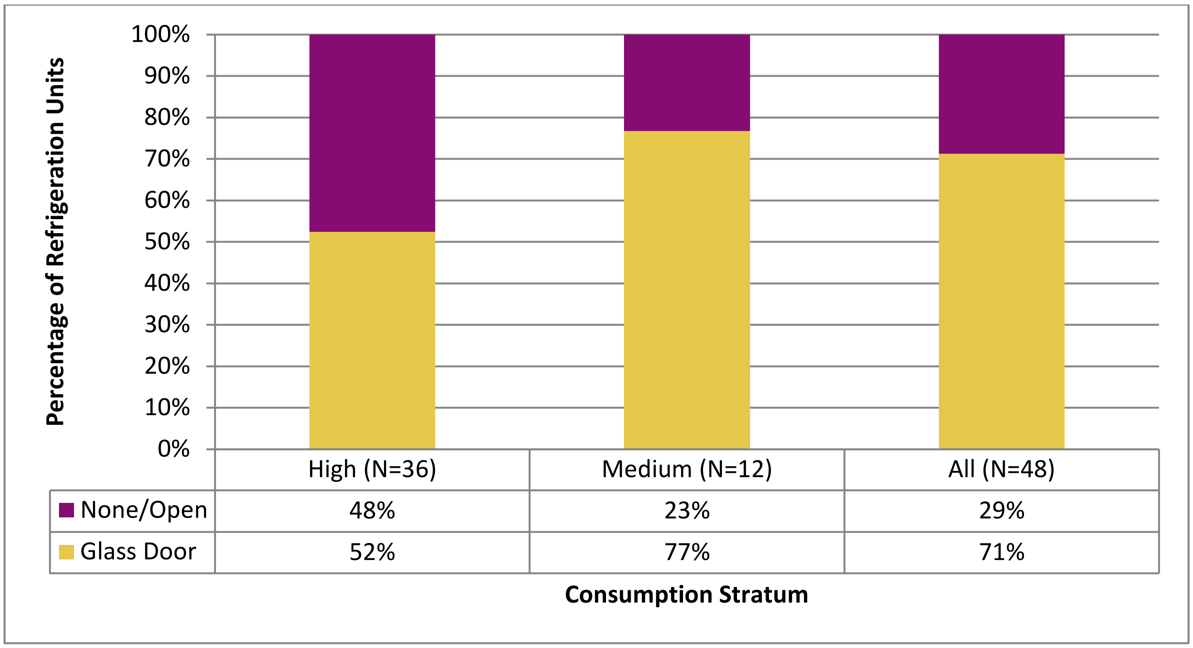


	BED (N=5)	EVT (N=43)
Unidentified	0%	23%
Anti-Sweat Heater Controls	0%	5%
Anti-Sweat Always On	100%	72%

Source: On-Site Survey Question 499

The majority (71%) of refrigerated display cases have glass doors, as shown in Figure 3-75. A higher percentage (77%) of refrigerated display cases in the medium energy use stratum contained a glass door, while approximately half (52%) of the units in the high energy consumption stratum had a glass door. There were no remote display cases in the low consumption stratum. The lack of glass doors within the high use consumption stratum represents a significant opportunity for energy savings.

Figure 3-75. Saturation of Display Case Door Types by Consumption Stratum

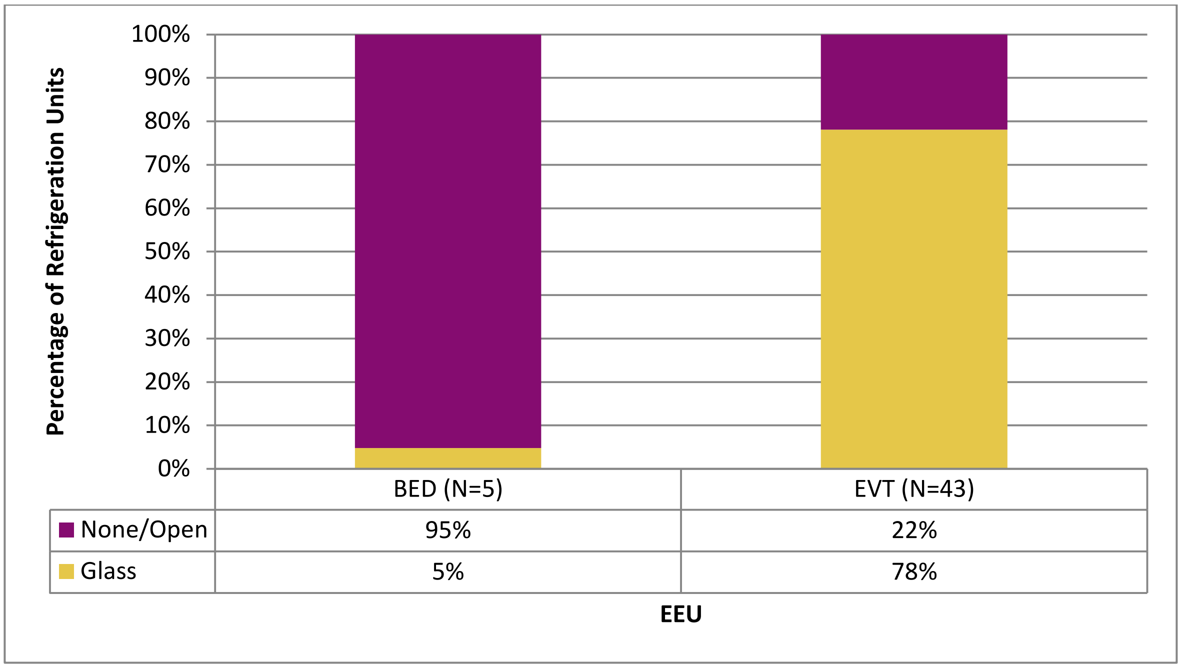


	High (N=36)	Medium (N=12)	All (N=48)
None/Open	48%	23%	29%
Glass Door	52%	77%	71%

Source: On-Site Survey Question 498

A high percentage (78%) of the display cases in EVT territory contained a glass door, as shown in Figure 3-76. A small percentage (5%) contained a glass door in the BED territory, though the sample size was small (5 units).

Figure 3-76. Saturation of Display Case Door Types by EEU

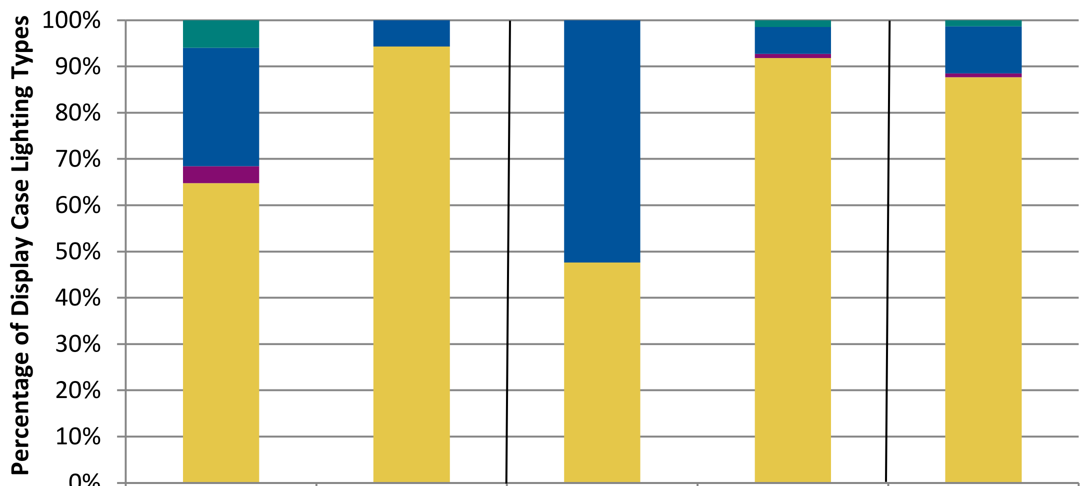


Source: On-Site Survey Question 498

Most (88%) refrigerated display cases use fluorescent lighting while only 1% use LED lighting, as shown in Figure 3-77. The share of LED lighting is higher (4%) in the high energy use stratum, though this group has a higher percentage (26%) of display cases with no lighting at all.

Within EVT territory, 92% of the display case refrigeration units use fluorescent bulbs and 1% use LED bulbs. The BED territory has a fairly even split between fluorescent and no lighting for its display case refrigeration units.

Figure 3-77. Saturation of Display Case Lighting Types by Consumption Stratum and Utility



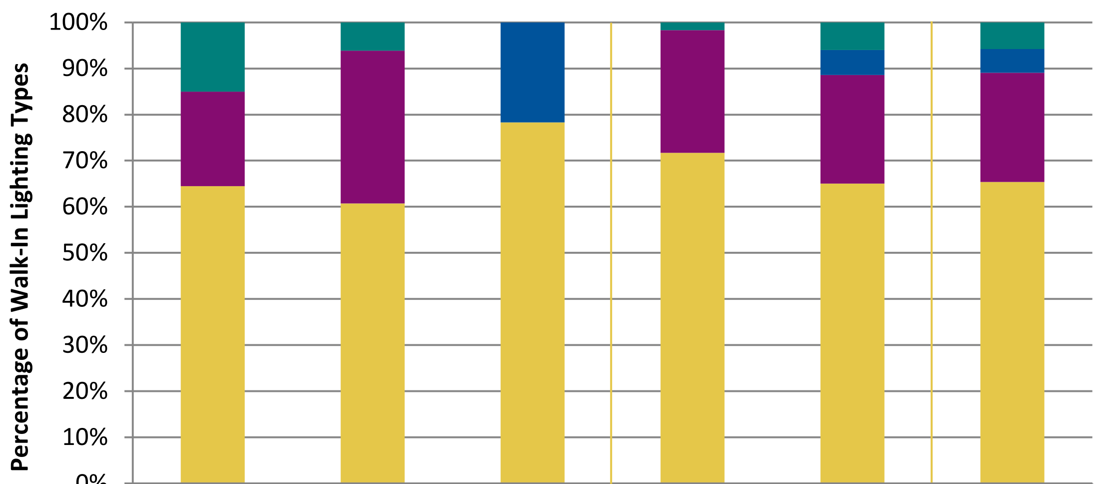
	High (N=36)	Medium (N=12)	BED (N=5)	EVT (N=43)	All (N=48)
Don't Know	6%	0%	0%	1%	1%
None	26%	6%	52%	6%	10%
LED	4%	0%	0%	1%	1%
Fluorescent	65%	94%	48%	92%	88%

Consumption Stratum / EEU

Source: On-Site Survey Question 500

Most (65%) walk-in refrigeration units use fluorescent lighting and approximately one-quarter (24%) of all walk-in coolers use incandescent lighting, as shown in Figure 3-78. LED lighting comprises approximately 5% of all walk-in cooler lighting, and was only observed at low energy use buildings in EVT territory. Comparing BED and EVT utility territories, there is a similar distribution of fluorescent and incandescent lighting in walk-in units.

Figure 3-78. Saturation of Walk-In Refrigeration Unit Lighting Types by Consumption Stratum and Utility

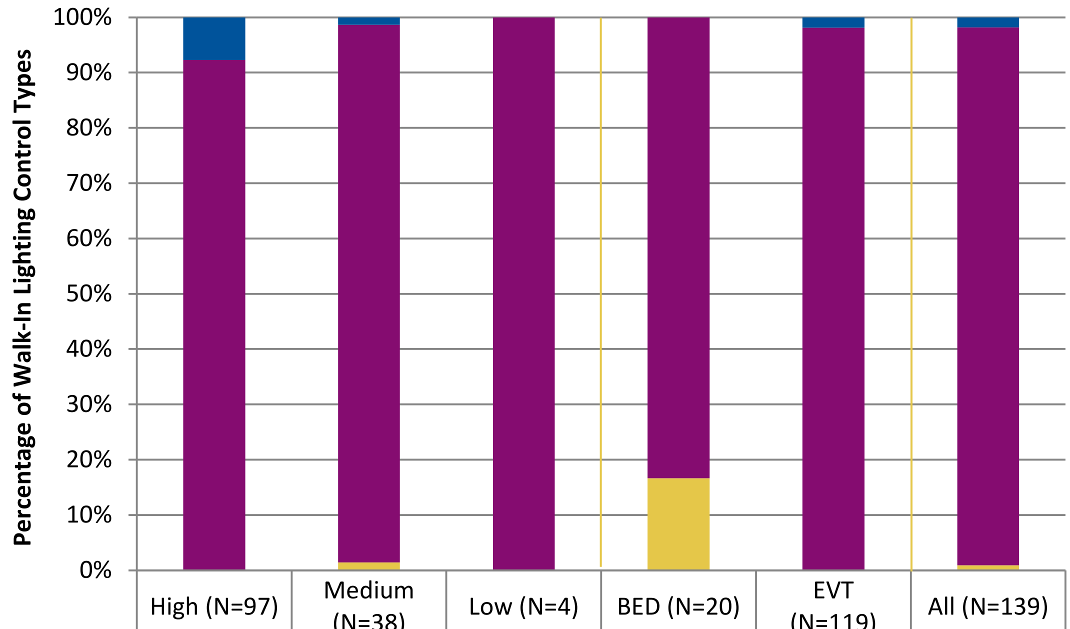


	High (N=97)	Medium (N=38)	Low (N=4)	BED (N=20)	EVT (N=119)	All (N=139)
Unidentified	15%	6%	0%	2%	6%	6%
LED	0%	0%	22%	0%	5%	5%
Incandescent	21%	33%	0%	27%	24%	24%
Fluorescent	64%	61%	78%	72%	65%	65%

Source: On-Site Survey Question 509

Lighting controls in walk-in refrigeration units are dominated by wall switches in all categories, with the largest penetration of occupancy sensors (17%) in the BED territory, as shown in Figure 3-79. These findings indicate a significant opportunity for automatic lighting controls in walk-in refrigeration units.

Figure 3-79. Saturation of Walk-In Refrigeration Unit Lighting Control Types by Consumption Stratum and Utility

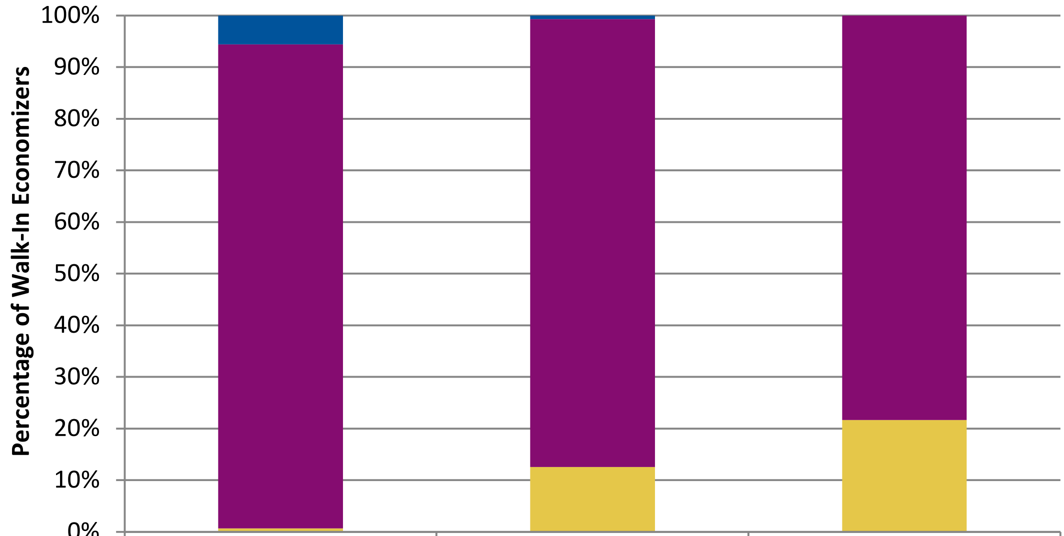


	High (N=97)	Medium (N=38)	Low (N=4)	BED (N=20)	EVT (N=119)	All (N=139)
Unidentified	8%	1%	0%	0%	2%	2%
Wall Switch	92%	97%	100%	83%	98%	97%
Occupancy Sensor	0%	1%	0%	17%	0%	1%

Source: On-Site Survey Question 510

In all buildings, a majority of the walk-in refrigeration units do not have an economizer. Within the low, medium, and high strata, 22%, 13%, and 1% of the units, respectively, have an economizer, as shown in Figure 3-80.

Figure 3-80. Saturation of Walk-In Refrigeration Unit Economizers by Consumption Stratum



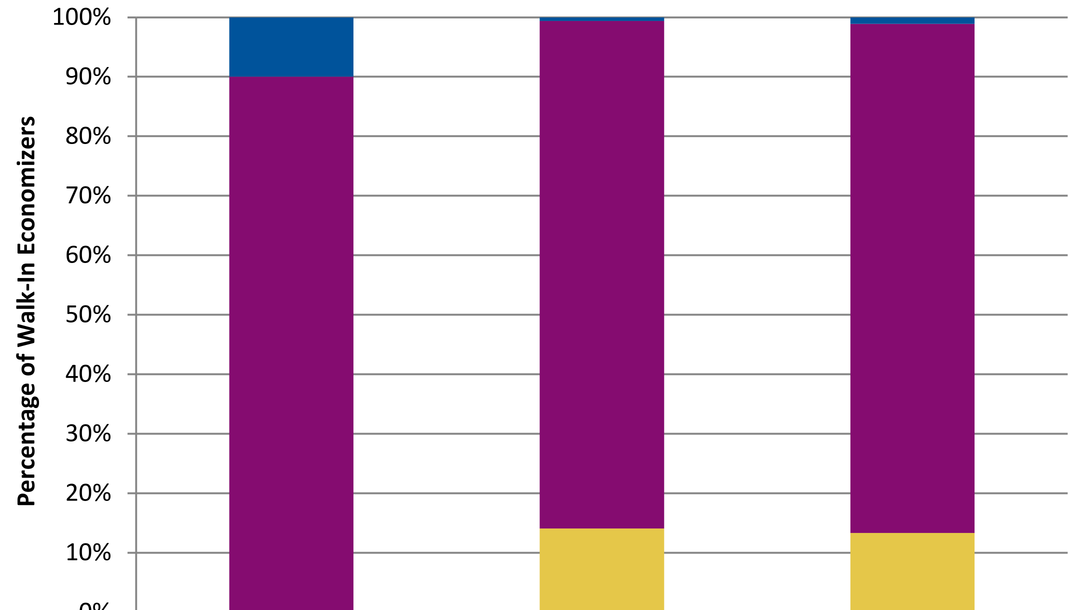
	High (N=97)	Medium (N=38)	Low (N=4)
Unidentified	6%	1%	0%
No Economizer	94%	87%	78%
Economizer	1%	13%	22%

Consumption Stratum

Source: On-Site Survey Question 511

Economizers in walk-in refrigeration units were only observed in the EVT territory with a saturation of 14% as shown in Figure 3-81.[29] Efficiency Vermont offers incentives for economizers in walk-in coolers, and the findings indicate there is still significant potential to implement this measure in existing walk-in coolers.

Figure 3-81. Saturation of Walk-In Refrigeration Unit Economizers by EEU



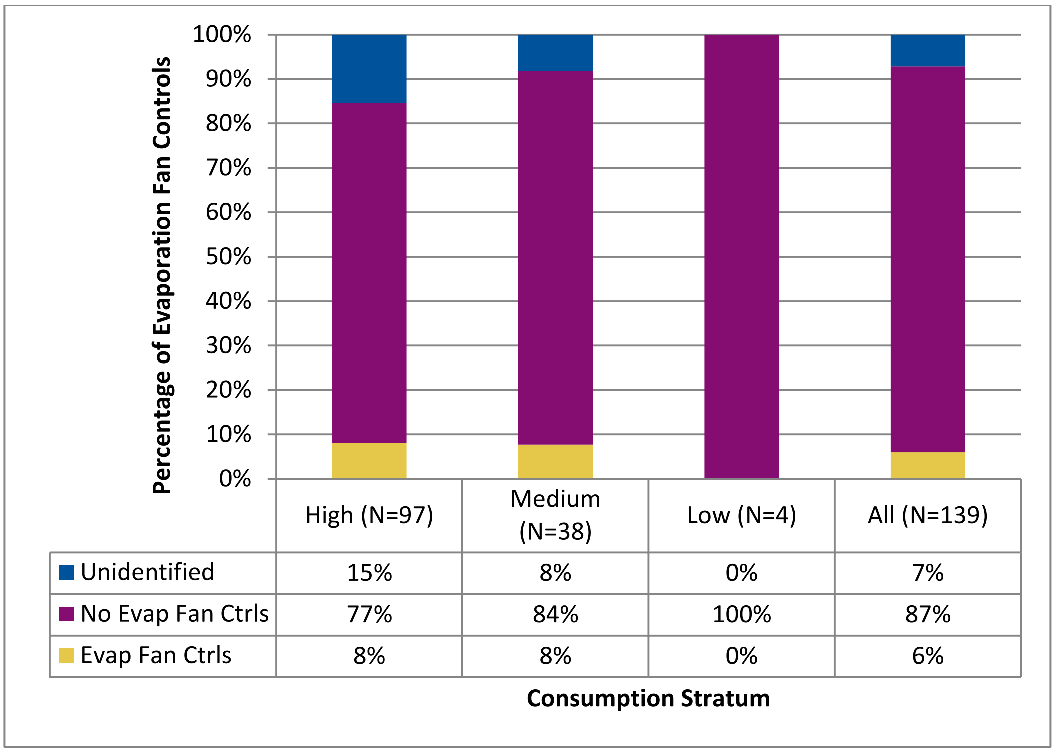
	BED (N=20)	EVT (N=119)	All (N=139)
Unidentified	10%	1%	1%
No Economizer	90%	85%	86%
Economizer	0%	14%	13%

Source: On-Site Survey Question 511

[29] Small sample size (less than five sites comprising 20 walk-in units) in BED territory may not represent the actual saturation of economizers in walk-in refrigeration units.

Evaporator fan motor controls were found in 6% of all walk-in refrigeration units and 8% of walk-in refrigeration units within the high and medium energy use strata, as shown in Figure 3-82. Evaporator fan motor controls manage fan speed based on need and can reduce the amount of energy required to keep the coolers at the appropriate temperature. There is a significant amount of remaining potential for this measure in Vermont's walk-in coolers.

Figure 3-82. Saturation of Walk-In Refrigeration Unit Evaporator Fan Motor Controls by Consumption Stratum

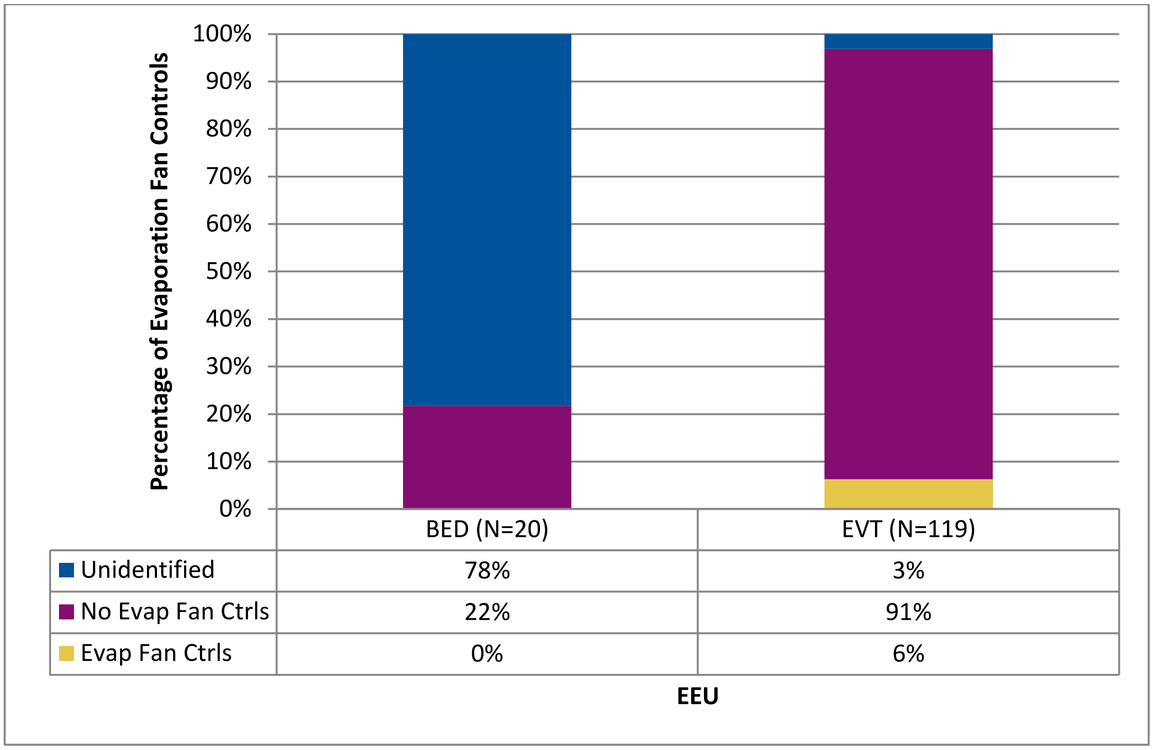


	High (N=97)	Medium (N=38)	Low (N=4)	All (N=139)
Unidentified	15%	8%	0%	7%
No Evap Fan Ctrls	77%	84%	100%	87%
Evap Fan Ctrls	8%	8%	0%	6%

Source: On-Site Survey Question 512

Within the EVT territory, 6% of walk-in refrigeration units were found to have evaporator fan motor controls, as shown in Figure 3-83. The results in BED territory are less conclusive, as the control strategy was undetermined for most evaporator fan motors. [30]

Figure 3-83. Saturation of Walk-In Refrigeration Unit Evaporator Fan Motor Controls by EEU

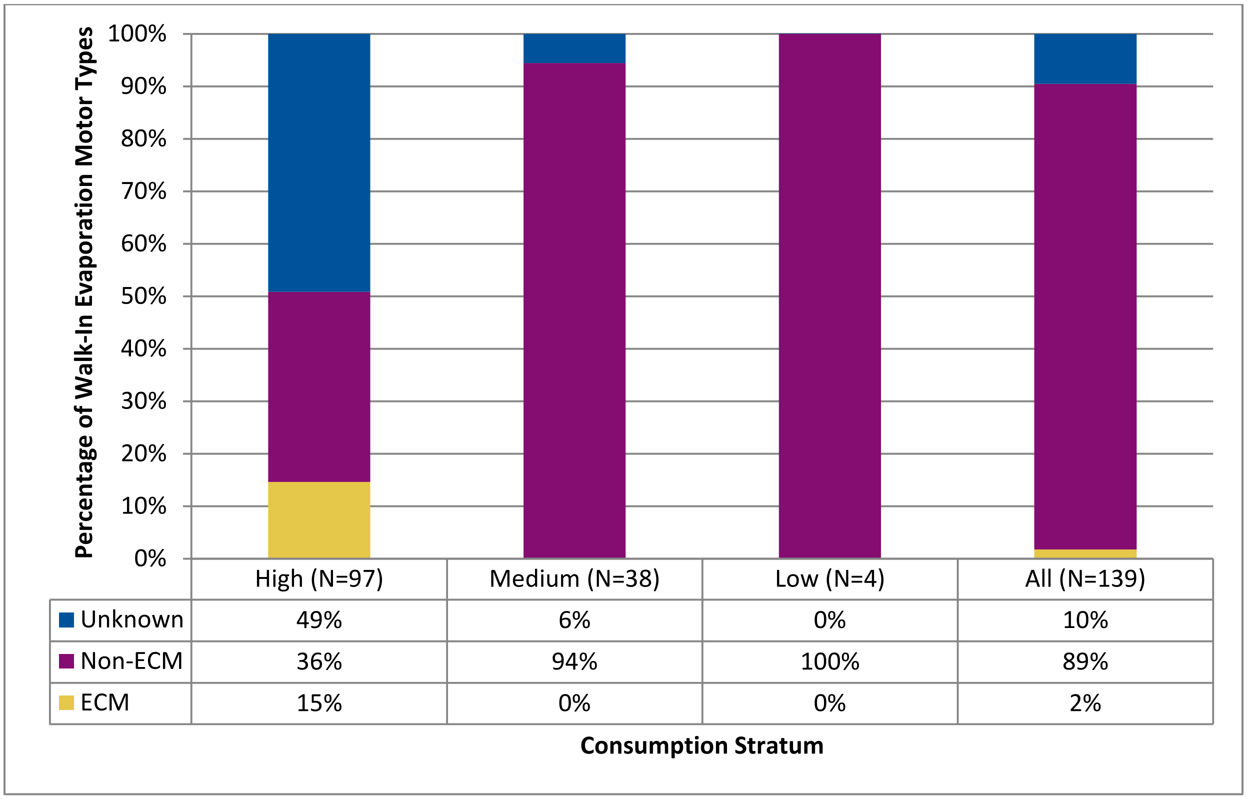


Source: On-Site Survey Question 512

[30] Determining whether evaporator fans have controls in place during an on-site survey can be difficult or impossible in many cases, unless the equipment is off or shuts off while observing the cooler space, or if an on-site staff is aware that these controls are in place.

Only 2% of walk-in refrigeration units have Electrically Commutated Motors (ECM) motors on walk-in cooler evaporator fans, as shown in Figure 3-84. The largest share (15%) of ECM motors is in the high energy use stratum.

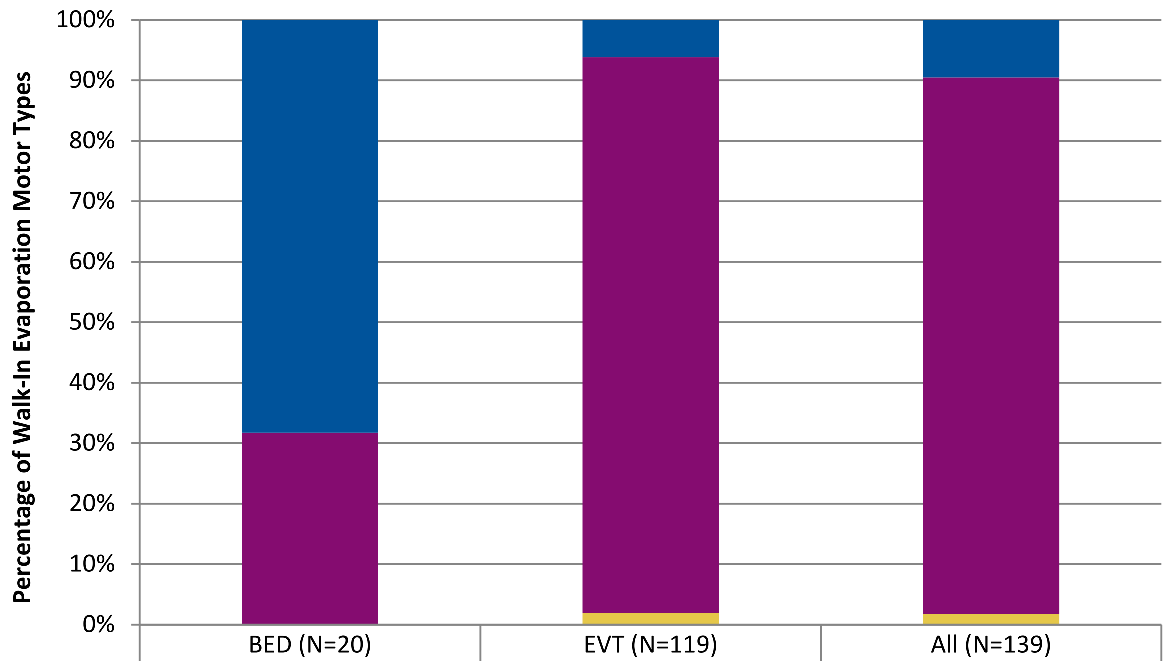
Figure 3-84. Saturation of Walk-in Refrigeration Unit Evaporation Motor Types by Consumption Stratum



Source: On-Site Survey Question 513

In the EVT territory a small percent (2%) of walk-in cooler evaporator fans have ECM motors, as shown in Figure 3-85. Approximately one-third of motors in BED territory are non-ECM motors yet most were unidentified. [31]

Figure 3-85. Saturation of Walk-in Refrigeration Unit Evaporation Motor Types by EEU



	BED (N=20)	EVT (N=119)	All (N=139)
Unknown	68%	6%	10%
Non-ECM	32%	92%	89%
ECM	0%	2%	2%

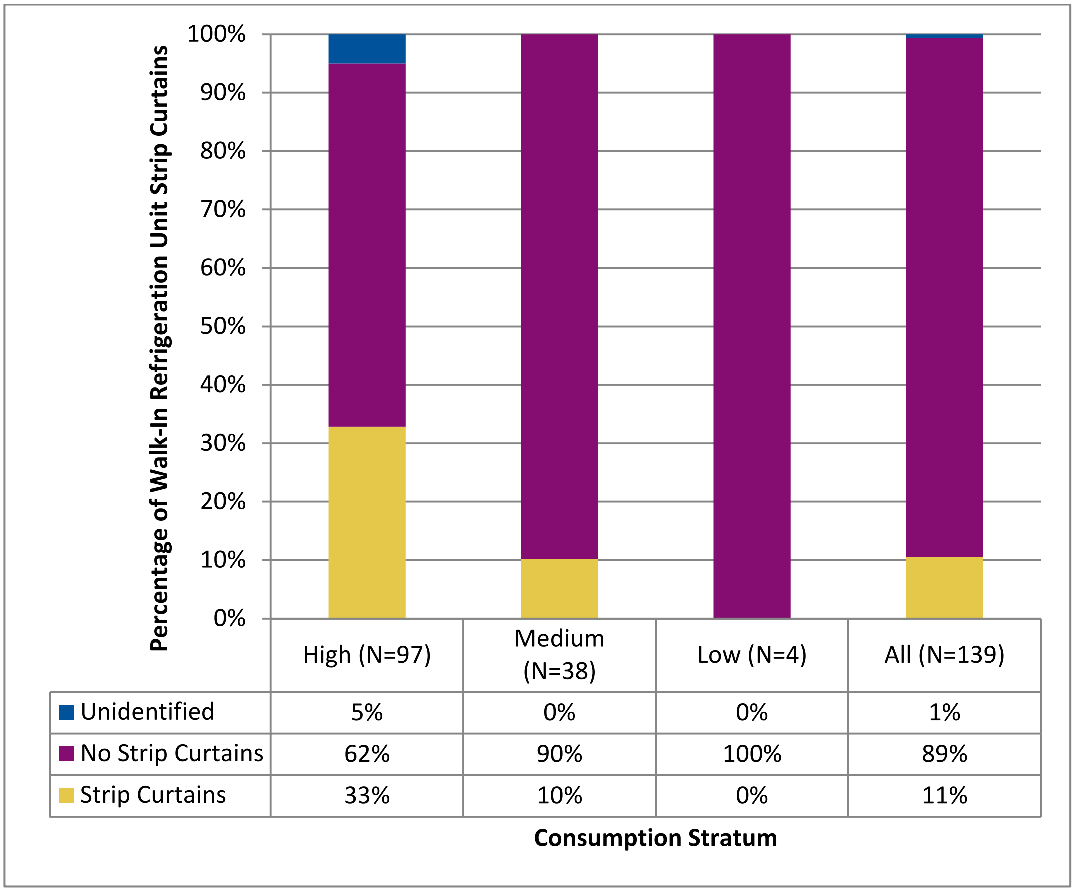
EEU

Source: On-Site Survey Question 513

[31] Limited access to evaporator fans in some cases makes identification of motor type difficult or impossible.

Strip curtains are only found in 11 percent of all walk-in refrigeration units, as shown in Figure 3-86. The high energy use stratum has a higher installation rate (33%) versus ten percent in the medium energy use group and no installations in the low stratum.

Figure 3-86. Saturation of Walk-In Refrigeration Unit Strip Curtains by Consumption Stratum

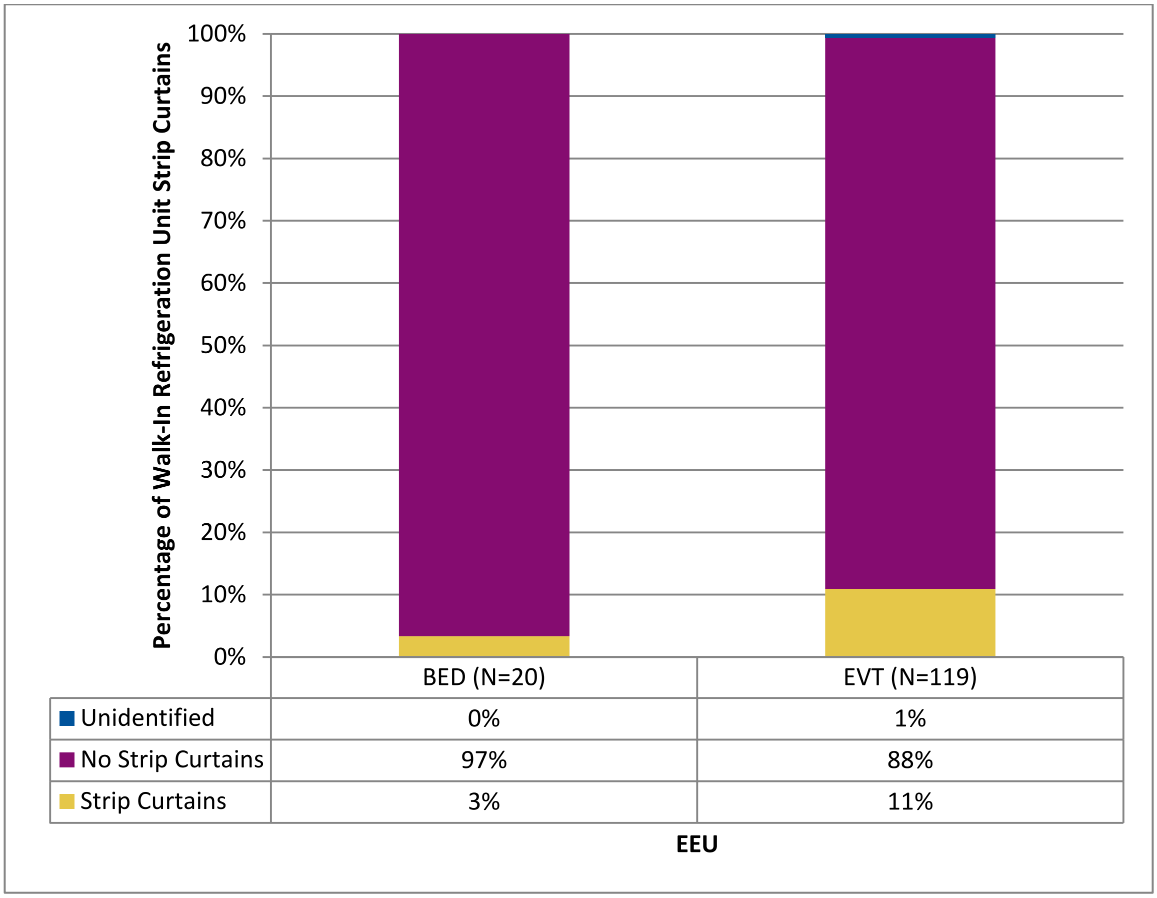


	High (N=97)	Medium (N=38)	Low (N=4)	All (N=139)
Unidentified	5%	0%	0%	1%
No Strip Curtains	62%	90%	100%	89%
Strip Curtains	33%	10%	0%	11%

Source: On-Site Survey Question 515

Comparing the two EEUs, EVT had a higher strip curtain installation rate of 11% compared to BED (3%) as shown in Figure 3-87.

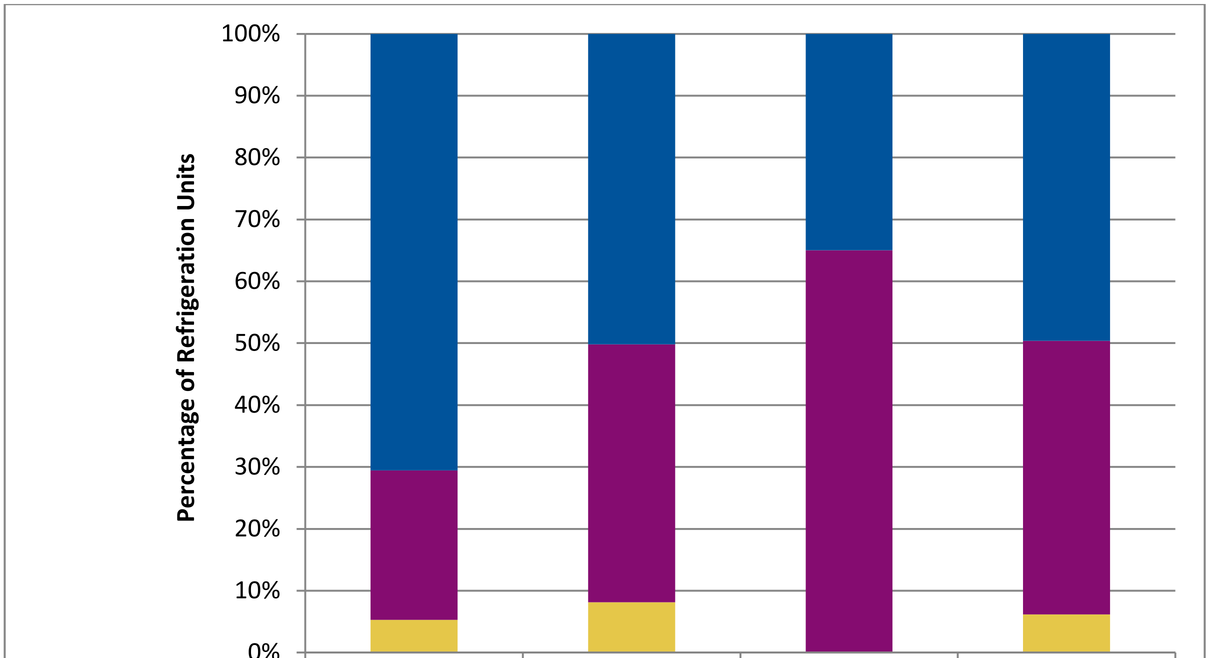
Figure 3-87. Saturation of Walk-In Refrigeration Unit Strip Curtains by EEU



Source: On-Site Survey Question 515

Approximately six percent of refrigeration systems use floating head pressure control to save energy, as shown in Figure 3-88. This measure is not easy to determine during the course of an on-site visit, so half of all systems have an unidentified control strategy. However, nearly half (44%) of all observed refrigeration systems do not use floating head pressure control, so there is a known potential for implementing this measure.

Figure 3-88. Saturation of Refrigeration Systems with Floating Head Pressure Control by Consumption Stratum

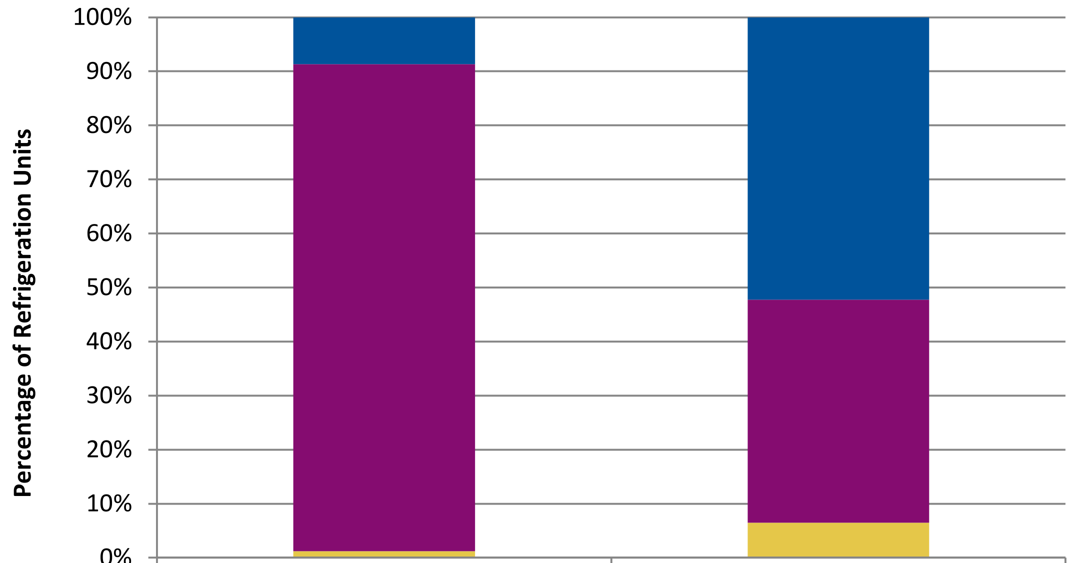


	High (N=87)	Medium (N=48)	Low (N=4)	All (N=139)
Unidentified	71%	50%	35%	50%
No Pressure Control	24%	42%	65%	44%
Pressure Control	5%	8%	0%	6%

Source: On-Site Survey Question 534

Only six percent of EVT customers implement floating pressure head control for refrigeration systems, compared to one percent of BED customers, as shown in Figure 3-89.

Figure 3-89. Saturation of Refrigeration Systems with Floating Head Pressure Control by EEU



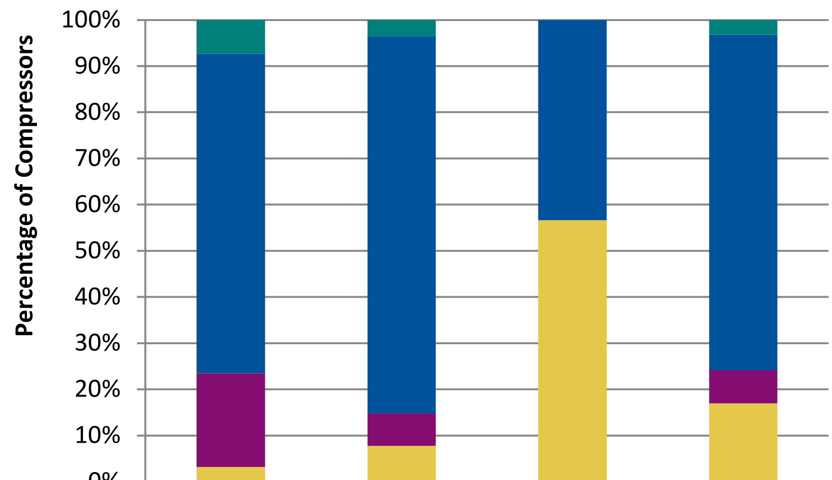
	BED (N=23)	EVT (N=116)
Unidentified	9%	52%
No Pressure Control	90%	41%
Pressure Control	1%	6%

EEU

Source: On-Site Survey Question 534

Approximately 24% of refrigeration systems utilize heat recovery capabilities, with 17% of all systems capturing waste compressor heat for space heating or reheating, and 7% using this to heat water, as shown in Figure 3-90. Most (73%) refrigeration systems do not utilize the waste compressor heat, representing an opportunity to capture additional energy savings. The high energy use stratum had the largest share of waste heat recovery for water heating with a saturation of 20%.

Figure 3-90. Saturation of Compressor Heat Recovery Types by Consumption Stratum



	High (N=87)	Medium (N=48)	Low (N=4)	All (N=139)
Unidentified	7%	3%	0%	3%
None	69%	82%	43%	73%
Water Heating	20%	7%	0%	7%
Space Heating/Reheat	3%	8%	57%	17%

Source: On-Site Survey Question 535

When comparing both EEUs, EVT customers have the highest use of waste heat recovery, with 18% for space heating/reheating and 7% for water heating, as shown in Figure 3-91. The majority of customers in both areas do not utilize waste heat recovery for refrigeration systems, representing a significant energy savings potential.

Figure 3-91. Saturation of Compressor Heat Recovery Types by EEU

	BED (N=23)	EVT (N=116)
Unidentified	1%	3%
None	89%	72%
Water Heating	2%	7%
Space Heating/Reheat	7%	18%

EEU

Source: On-Site Survey Question 535

3.5.1 EEU Market Characterization – Refrigeration

Table 3-4 provides a summary characterization of refrigeration measures for Vermont's EEUs.

Table 3-16. EEU Market Characterization – Refrigeration

Measure/Characteristic	BED	EVT
ENERGY STAR non-commercial refrigerators	» The majority (58%) of non-commercial refrigerators are ENERGY STAR.	» The majority (58%) of non-commercial refrigerators are ENERGY STAR.
Anti-sweat heater controls[a]	» All observed systems had no anti-sweat heater controls in place (sample size of five).	» Refrigeration units with anti-sweat heater controls comprise only 5% of all applicable systems.
Doors on reach-in refrigerated display cases[a]	» Only five percent of observed cases contained a glass door (sample size of five).	» Most (78%) of the display cases in EVT territory contained a glass door.
Refrigerated display case lighting	» Over half (52%) of observed cases (sample size of five) had no lighting and the remaining share had fluorescent lighting (48%).	» Most (92%) display case refrigeration units use fluorescent bulbs and 1% use LED bulbs.
Walk-in cooler lighting	» Most (72%) walk-in coolers have fluorescent lighting, with 27% using incandescents and less than one percent using LEDs.	» Most (65%) walk-in coolers have fluorescent lighting, with 24% using incandescents and 5% using LEDs.
Walk-in cooler lighting controls	» Manual wall switches comprise 83% of all walk-in coolers, with 17% controlled by occupancy sensors.	» Nearly all (985) walk-in coolers are controlled by manual wall switches.
Walk-in cooler economizers	» No economizers were observed in BED territory.	» Economizers in walk-in refrigeration units were only observed in the EVT territory with a saturation of 14%.
Walk-in cooler evaporator fan motor types	» Approximately one-third of motors in BED territory are non-ECM motors, yet a significant portion of motors were unidentified.	» Only two percent of walk-in cooler evaporator fans have ECM motors.
Evaporator fan motor controls in walk-in coolers[c]	» Control strategy undetermined for most evaporator fan motor controls.	» Six percent of walk-in refrigeration units have evaporator fan motor controls,

Measure/Characteristic	BED	EVT
Strip curtains on walk-in refrigeration units	» BED has a strip curtain installation rate of 3%.	» EVT has a strip curtain installation rate of 11%.
Floating head pressure control on refrigeration systems	» Only one percent of BED customers implement floating pressure head control for refrigeration systems.	» Only six percent of EVT customers implement floating pressure head control for refrigeration systems.
Implement heat recovery on refrigeration systems	» About 7% of BED customers recover compressor heat for space heating/reheating and 2% for water heating.	» EVT customers have the highest use of waste heat recovery, with 18% for space heating/reheating and 7% for water heating.

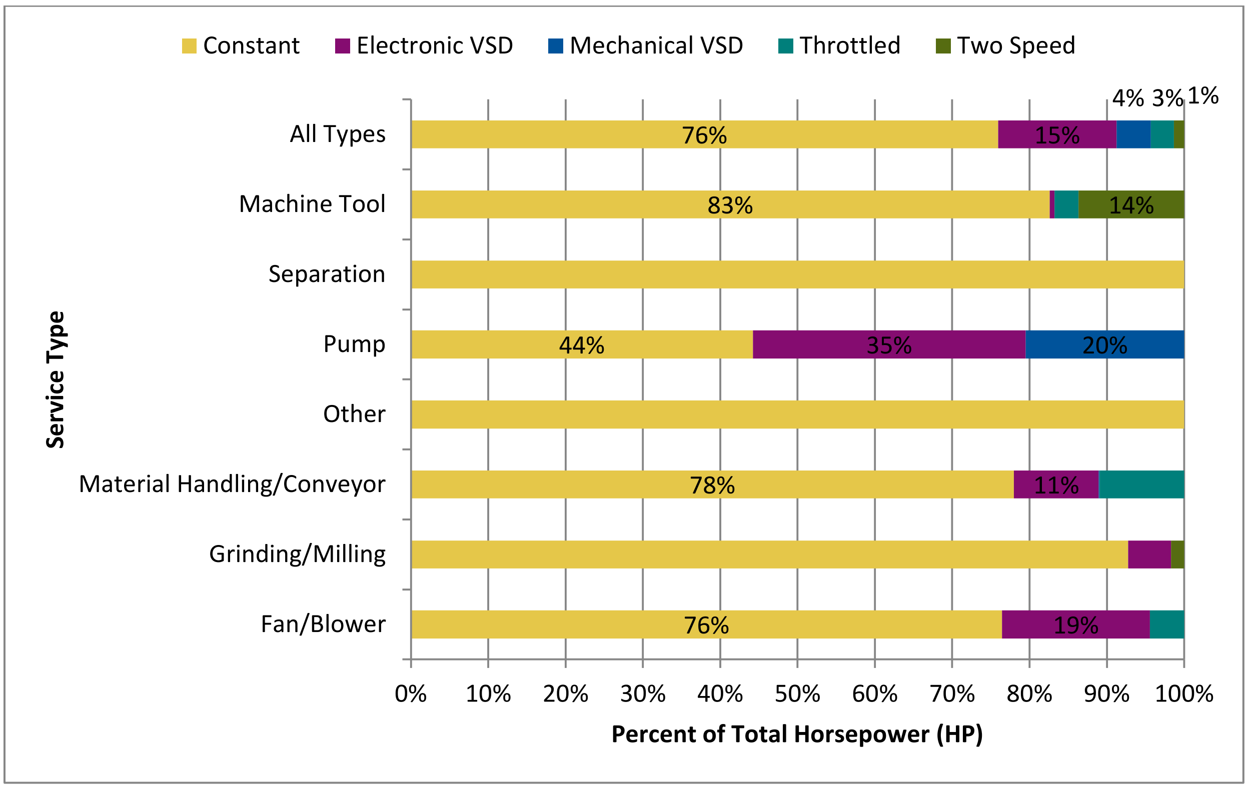
Source: Navigant analysis

3.6 *Motors and Compressed Air*

3.6.1 Motors

The majority (76%) of process motors in Vermont's C&I buildings are constant speed motors, as shown in Figure 3-92. VSD motors comprise 19% of all motor control types, when accounting for both electronic VSD (15%) and mechanical VSD (4%). Pump motors have the largest share of VSD controls, with 35% of all pumps controlled by electronic VSD and 20% by mechanical VSD. 19% of fan/blower motors and 11% of material handling/conveyor motors are controlled by electronic VSD.

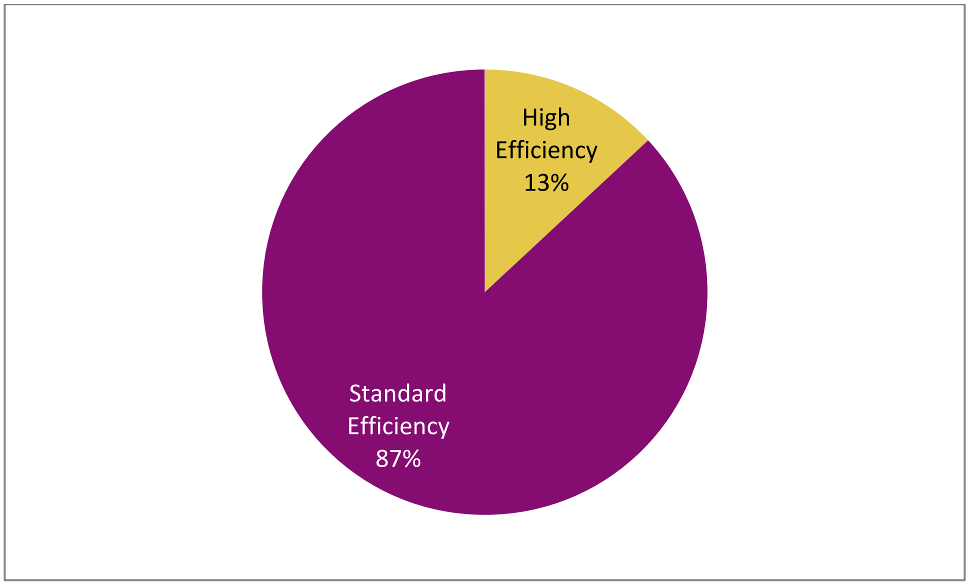
Figure 3-92. Distribution of Process Motor Control Types by Service Type (N = 705 Motors)*



*Excludes 71 motors of unknown control types, and excludes passenger/freight elevator motors
Source: On-Site Survey Section 32 Part (d)

Most (87%) motors are classified as standard efficiency, as shown in Figure 3-93. Opportunities exist to increase efficiency levels of motors, however, most of this is occurring through natural replacement, as higher minimum efficiency levels (in effect since December 2010) have rendered utility/EEU incentives irrelevant.

Figure 3-93: Motor Efficiency (N=390 motors)



*Weighted by frequency of counts. Excludes motors with unidentified efficiency levels. Efficiency based on NEMA standards by horsepower and type (Open Drip-Proof (ODP) or Totally Enclosed Fan-Cooled (TEFC)
Source: On-Site Survey Question 567g

3.6.2 Compressed Air

Compressor types vary by application and segment, with manufacturing customers using much larger and more efficient screw compressors, as shown in Table 3-17. Nearly half (46%) of all air compressors are smaller capacity single-stage models, and nearly one-third (31%) are two-stage compressors, which are more efficient and often longer lasting than their single-stage counterparts. Distribution by EEU is nearly identical, with slightly more rotary screw compressors in EVT areas represented by the higher number of manufacturing facilities than in BED territory.

Table 3-17. Distribution of Air Compressors by Type

Air Compressor Type	All Buildings (N=106)	Building Type		Consumption Stratum		EEU	
		Manufacturing (N=52)	Balance of Comm. (N=54)	High (N=90)	Medium & Low (N=16)	BED (N=18)	EVT (N=88)
Recip. (Single-stage, Single-acting)	46%	1%	55%	12%	52%	47%	46%
Recip. (Single-stage, Double-acting)	0%	1%	0%	1%	0%	0%	0%
Recip. (Two-stage, Double-acting)	5%	27%	0%	2%	5%	7%	5%
Recip. (Two-stage, Single-acting)	31%	5%	37%	30%	31%	35%	31%
Rotary Screw (Two-Stage)	10%	55%	1%	37%	6%	4%	10%
Centrifugal	0%	0%	0%	0%	0%	0%	0%
Unknown	7%	9%	7%	15%	6%	4%	7%
Other	0%	2%	0%	3%	0%	4%	0%
All	100%	100%	100%	100%	100%	100%	100%

*Weighted by frequency of counts
Source: On-Site Survey Question 589b

Industrial customers use compressors more hours per week than commercial customers, with 57% of manufacturing facilities running compressors between 50 and 100 hours per week, compared to only 10% in other building types, as shown in Table 3-18. Where older, less efficient compression technology is in use in industrial settings, these customers will possess the largest opportunity for energy savings with upgrades to more efficient models.

Approximately 15% of all air compressors operate 24/7 and one-quarter (25%) run less than 10 hours per week. Most (81%) compressors in BED's service territory operate between 11 and 50 hours per week, while there is a broader distribution of operating hours for compressors in EVT territory.

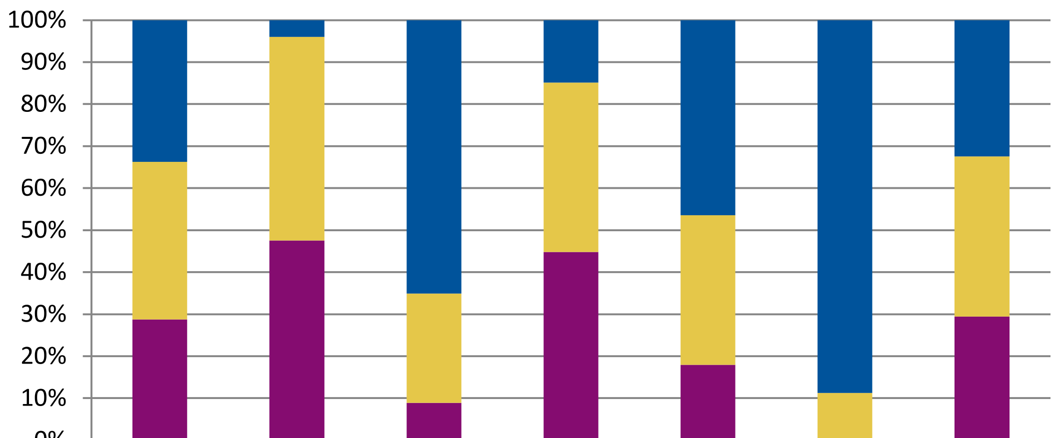
Table 3-18. Air Compressor Hours of Use per Week by Bin

Age	All Buildings (N=86)	Building Type		Consumption Stratum		EEU	
		Manufacturing (N=42)	Balance of Commercial (N=44)	High (N=73)	Medium & Low (N=13)	BED (N=17)	EVT (N=69)
< 10	25%	8%	40%	11%	34%	5%	26%
11 - 49	27%	18%	34%	25%	27%	81%	25%
50 - 99	32%	57%	10%	21%	38%	0%	32%
100 - 167	2%	4%	0%	5%	0%	0%	2%
168	15%	13%	16%	37%	0%	13%	15%

*Weighted by frequency of counts
Source: On-Site Survey Question 589j

Air dryers maintain higher quality compressed air, typically necessary for industrial purposes, but also consume more energy and typically operate continuously. "Cycling refrigerated dryers" run as determined by airflow instead of operating continuously, and represent potential energy savings opportunities. As shown in Figure 3-94, cycling air dryers are found on nearly one-third (29%) of all compressor systems, with approximately half (48%) of the systems in manufacturing facilities using cycling air dryers. Most compressor systems observed in BED territory did not have dryers installed, so cycling dryers are not an applicable measure. In EVT areas, where cycling dryers are incentivized, over half of the systems that have dryers installed do not use cycling dryers, representing a significant energy savings potential.

Figure 3-94. Saturation of Cycling Air Dryers on Compressed Air System



	All Buildings (N=86)	Manufacturing (N=42)	Balance of Comm. (N=44)	High (N=73)	Medium & Low (N=13)	BED (N=17)	EVT (N=69)
No Dryer	34%	4%	65%	15%	46%	89%	32%
Continuous Dryer	38%	48%	26%	40%	36%	11%	38%
Cycling Dryer	29%	48%	9%	45%	18%	0%	29%

*Totals may not sum to 100% due to rounding
Source: On-Site Survey Question 589k

3.6.3 EEU Market Characterization – Motors and Compressed Air

Table 3-4 provides a summary characterization of motor and compressed air measures for Vermont's EEUs.

Table 3-19. EEU Market Characterization – Motors and Compressed Air

Measure/Characteristic	BED	EVT
Process motor control types	» The majority (76%) of process motors in Vermont's C&I buildings are constant speed motors. VSD motors comprise 19% of all motor control types, when accounting for both electronic VSD (15%) and mechanical VSD (4%). Pump motors have the largest share of VSD controls, with 35% of all pumps controlled by electronic VSD and 20% by mechanical VSD.	
Motor efficiency	» Most (87%) motors are classified as standard efficiency	
Air compressor types	» Nearly half (47%) are smaller capacity single-stage models, and over one-third (35%) are reciprocating two-stage compressors. Four percent are rotary screw, two-stage compressors.	» Nearly half (46%) are smaller capacity single-stage models, and over one-third (35%) are reciprocating two-stage compressors. Ten percent are rotary screw, two-stage compressors.
Air compressor hours of use	» Most (81%) compressors in BED's service territory operate between 11 and 50 hours per week.	» Air compressor hours of operation are broadly distributed, with 26% running less than 10 hours per week, 25% between 11 and 50 hours per week, and 32% between 50 and 99 hours per week. Approximately 15% of compressors operate 24/7.
Cycling air dryer on compressed air systems	» Most compressor systems observed in BED territory did not have dryers installed, so cycling dryers are not an applicable measure.	» Over half of the systems that have dryers installed do not use cycling dryers

Source: Navigant analysis

3.7 *Cross-Cutting C&I Market Insights*

3.7.1 Investment Criteria and Financial Decision-Making

Vermont's C&I customers use the return on investment (ROI) indicator as the preferred calculation for energy efficiency project investments (45% of all customers), followed by simple payback (35%) and lifecycle cost (31%). Table 3-20 shows that the results are mostly consistent across the EEU service territories, with the ROI calculation slightly more preferred in BED, VT Gas, and GT areas than in EVT territory.

Table 3-20. Financial Calculations Used to Determine Project Investment

Financial Calculations Used to Determine Project Investment	BED (N=59)	EVT (N=281)	VT Gas (N=169)	GT Areas (N=112)	Overall (N=340)
Return on Investment	63%	44%	61%	48%	45%
Simple payback	30%	36%	45%	35%	35%
Lifecycle cost	28%	31%	28%	19%	31%
Up Front Costs	10%	2%	7%	10%	3%
Availability of funding	0%	0%	1%	1%	0%
Other	1%	7%	1%	7%	7%
Don't know	11%	6%	3%	1%	6%
Refused	0%	3%	0%	0%	0%

a. Totals may not equal 100% due to multiple possible responses.
Source: Telephone Survey, Question IC1

The two most important factors for Vermont C&I customers when making energy conservation decisions are the first cost of the measures (35%) and the financial returns on the investment (31%), as shown in Table 3-21. Retail customers place a greater emphasis on the first cost of measures, while manufacturing customers emphasize the importance of financial returns, with 75% claiming this to be the most important consideration. There is a notable divergence from the statewide results within BED, where the high share of customers citing ease of installation and landlord support (42% each) reflect the different challenges faced by the urban businesses, where disruption to business activity and the owner-tenant relationship drives decision-making.

Table 3-21. What is the Most Important Factor When Making Energy Conservation Decisions?

Most Important Factor	All Buildings (N=104)	Building Type				Consumption Stratum			EEU/Area			
		Retail (N=10)	Office (N=13)	Manuf. (N=22)	Bal. of Comm. (N=59)	High (N=57)	Medium (N=25)	Low (N=22)	BED (N=13)	EVT (N=91)	VT Gas (N=49)	GT Area (N=36)
First cost of conservation measures	35%	58%	13%	4%	36%	12%	15%	38%	1%	36%	12%	1%
Financial returns	31%	23%	66%	75%	19%	55%	48%	28%	11%	32%	48%	0%
Don’t Know	14%	0%	0%	18%	24%	6%	11%	15%	0%	15%	0%	36%
Expected business benefits/improvements	10%	9%	1%	2%	13%	18%	9%	9%	5%	10%	9%	36%
Equipment need	3%	0%	0%	0%	5%	0%	0%	3%	0%	3%	0%	2%
Executive order	2%	0%	11%	0%	0%	0%	0%	3%	0%	2%	11%	8%
Ease of installation	2%	9%	0%	0%	0%	0%	2%	2%	42%	0%	9%	2%
Landlord support	2%	0%	8%	0%	0%	0%	0%	2%	42%	0%	8%	13%
Longevity	1%	0%	0%	0%	2%	0%	8%	0%	0%	1%	0%	0%
Utility conservation programs	0%	0%	0%	1%	1%	1%	3%	0%	0%	0%	0%	0%
Other	0%	1%	0%	0%	0%	5%	2%	0%	0%	0%	2%	0%
Management support	0%	0%	0%	0%	1%	3%	2%	0%	0%	0%	1%	2%
Totals	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

*Other includes durability, energy efficiency, both knowing someone who has done it successfully and financial returns, and don't know.
Source: Decision-Maker Survey, Question 10a

For customers deciding to proceed with an energy efficiency investment, the most preferred cut-off point for a simple payback (regardless of whether customers prefer to use the payback calculation) is 1 to 2 years, with 22% of customers favoring this option (see Table 3-22). Customers are evenly divided among payback periods of 2 to 3 years, 3 to 5 years and over 5 years, at approximately 16%. Customers in VT Gas and GT areas differed from the rest of the state and preferred shorter payback periods. Twenty-one percent of customers in the GT area preferred a 6 months to one year payback period, which is significantly different than the rest of the state.

Table 3-22: Payback Cut-Off Point Used Before Proceeding with Investment

	BED (N=36)	EVT (N=201)	VT Gas (N=113)	GT (N=77)	All (N=237)
0 to 6 months	1%	3%	9%	4%	3%
6 months to 1 year	3%	9%	11%	21%	8%
1 to 2 years	31%	22%	27%	21%	22%
2 to 3 years	14%	16%	18%	19%	16%
3 to 5 years	25%	17%	20%	15%	17%
Over 5 years	13%	16%	5%	9%	16%
Don't know	13%	18%	10%	10%	17%
Refused	0%	0%	1%	1%	0%

Source: Telephone Survey, Question IC2

Nearly half (42%) of C&I customers indicated that energy costs represent less than 5% of total operating costs, as shown in Table 3-23. Over one-quarter of C&I businesses did not know what share of operating costs was spent on energy.

Table 3-23. Percentage of Company's Total Operating Costs Spent on Energy

	Consumption Stratum			Building Type				
	High Use (N=108)	Medium Use (N=74)	Low Use (N=55)	Retail (N=28)	Office (N=27)	Manufacturing (N=53)	Balance of Commercial (N=129)	Overall (N=237)
5% or less	22%	38%	43%	68%	63%	41%	28%	42%
6-10%	22%	19%	10%	6%	16%	6%	11%	11%
11-25%	13%	9%	13%	4%	12%	34%	11%	13%
26% or more	13%	5%	3%	0%	0%	2%	6%	3%
Don’t know	29%	28%	29%	22%	9%	17%	40%	27%
Refused	0%	0%	3%	0%	0%	0%	4%	2%

Source: Telephone Survey, Question EE1

Customers are fairly evenly divided regarding the approach to managing energy use and energy costs, as shown in Table 3-24. Expectedly, customers in the high energy use stratum pay much closer attention to energy use, with nearly half (49%) indicating they review these costs quarterly and nearly one-third (30%) making energy use part of daily operations. Approximately 10% of all customers do not actively manage energy use or costs.

Table 3-24. Approach to Managing Energy Use and Costs by Consumption Stratum

Energy Use and Cost Management Approach	High Use (N=108)	Medium Use (N=74)	Low Use (N=55)	Overall (N=237)
Energy management is a daily part of our operations. We actively monitor and control our usage and costs	30%	23%	29%	28%
We review our energy use and costs at least quarterly and consider energy efficiency when we need to purchase new equipment	49%	26%	33%	33%
We are concerned about energy costs but we don't have a systematic approach to managing them	16%	43%	27%	28%
We pay the bills but don't actively manage energy use or costs	1%	6%	11%	10%
Don't know	2%	3%	0%	0%
Other	1%	0%	0%	0%

Source: Telephone Survey, Question EE2

Most customers in the major building type categories are concerned about energy use and costs but do not have a systematic approach to managing them, as shown in Table 3-25. Nearly one-third (31%) of manufacturing customers consider energy management part of daily operations, compared to only 6% of retail customers.

Table 3-25. Approach to Managing Energy Use and Costs by Building Type

Energy Use and Cost Management Approach	Retail (N=28)	Office (N=27)	Manufacturing (N=53)	Balance of Commercial (N=129)	Overall (N=237)
Energy management is a daily part of our operations. We actively monitor and control our usage and costs	6%	24%	31%	34%	28%
We review our energy use and costs at least quarterly and consider energy efficiency when we need to purchase new equipment	7%	20%	14%	47%	33%
We are concerned about energy costs but we don't have a systematic approach to managing them	66%	35%	55%	13%	28%
We pay the bills but don't actively manage energy use or costs	21%	21%	0%	6%	10%
Don't know	0%	0%	0%	0%	0%
Other	0%	0%	0%	0%	0%

Source: Telephone Survey, Question EE2

Over half (52%) of all C&I customers reported that the owner makes decisions regarding purchasing, repairing or replacing energy-using equipment, as shown in Table 3-26. Over one-third of customers reported other titles or positions that were too specific to aggregate into standard categories. Analysis of the survey results noted no significant differences among building type and EEU area, with the exception of the high energy use stratum, where only approximately one-quarter of customers indicated the owner makes these decisions.

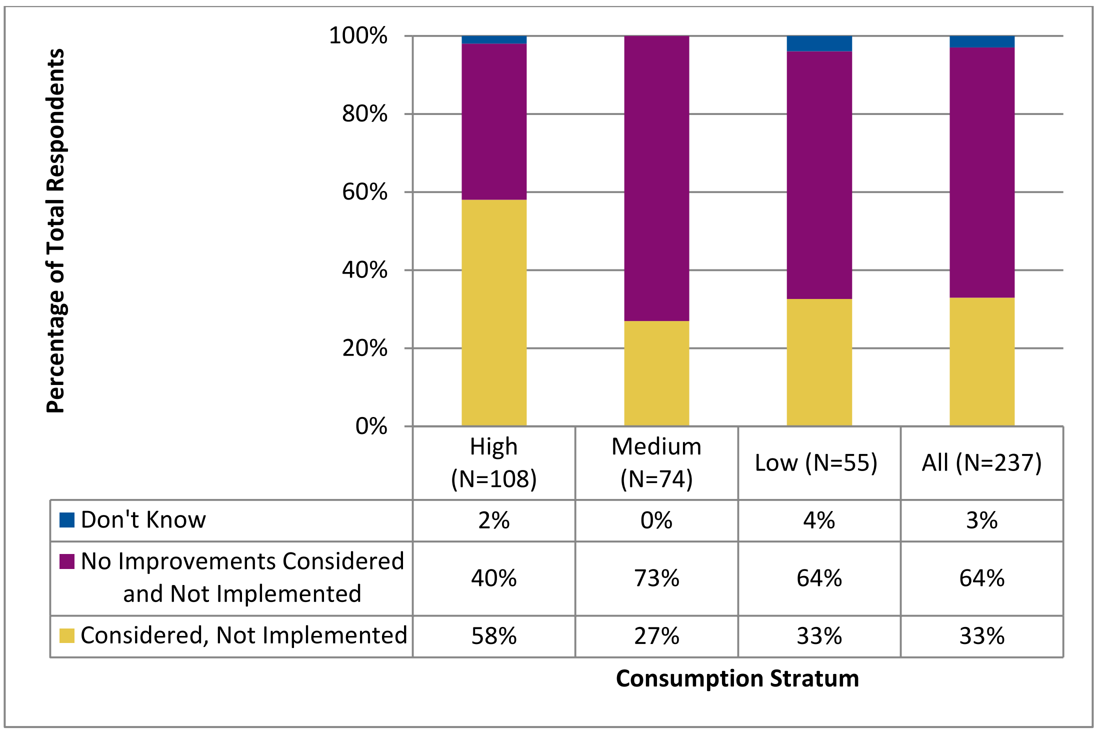
Table 3-26. Who Makes Decisions About Purchasing, Replacing or Repairing Major Energy-Using Equipment?

Decision-Maker	Overall (N=237)
Owner	52%
Other	35%
Board of Directors	8%
Corporate Headquarters	2%
Property Management Company	2%
Unspecified	1%
Maintenance/Facilities Manager	1%
Source: Decision-Maker Survey, Question 7	

3.7.2 Energy Efficiency Improvements Identified but Not Implemented

Over the past two years, one-third (33%) of customers considered improving the energy efficiency of their facilities but did not implement these actions, as shown in Figure 3-95. Most (64%) customers responded that there were no improvements considered that were not implemented, implying that these customers likely took action to improve their facilities. Customers in the high energy use stratum differed significantly from the other groups, with 58% considering energy efficiency improvements over the last two years but not implementing the measures.

Figure 3-95. Considerations to Improve Energy Efficiency over Past Two Years by Consumption Stratum

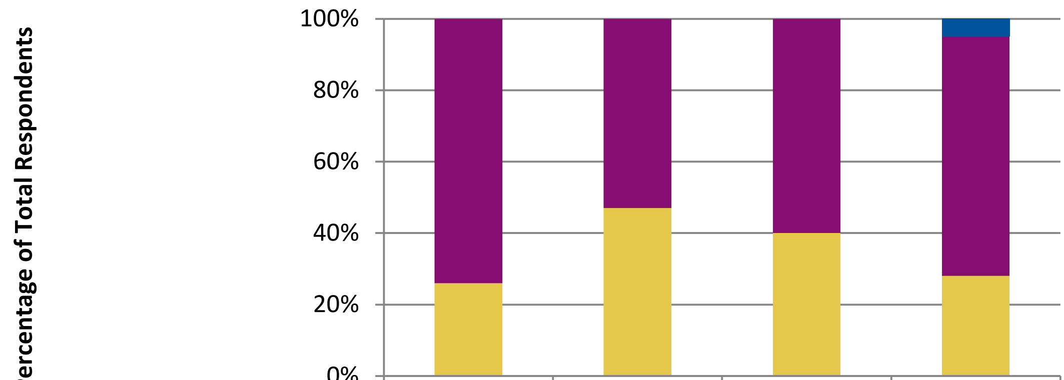


	High (N=108)	Medium (N=74)	Low (N=55)	All (N=237)
Don't Know	2%	0%	4%	3%
No Improvements Considered and Not Implemented	40%	73%	64%	64%
Considered, Not Implemented	58%	27%	33%	33%

Source: Telephone Survey, Question EI1

Figure 3-96 shows that the office sector had the highest percentage (47%) of respondents considering energy efficiency improvements but not implementing these.

Figure 3-96. Considerations to Improve Energy Efficiency over the Past Two Years by Building Type

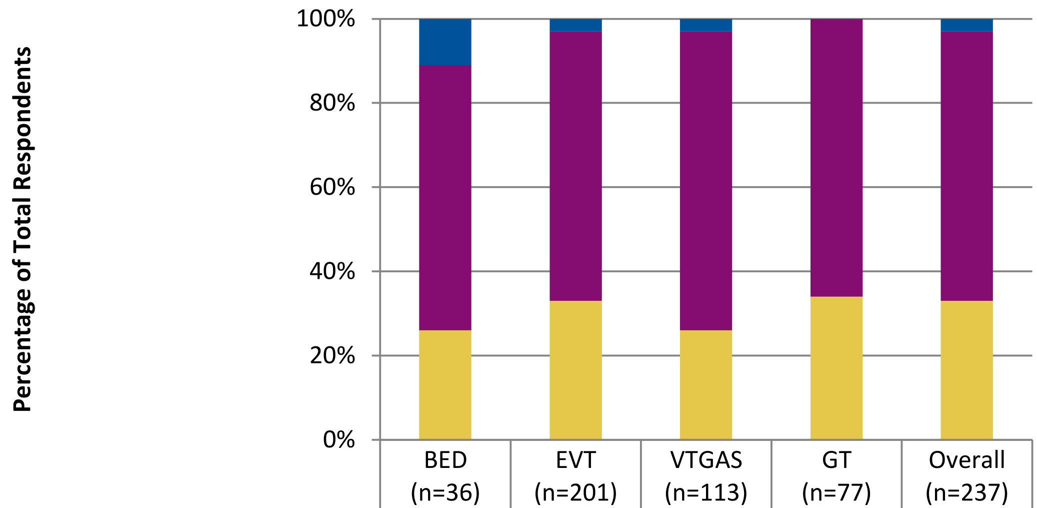


	Retail (N=28)	Office (N=27)	Manufacturing (N=53)	Balance of Commercial (N=129)
Don't Know	0%	0%	0%	5%
No Improvements Considered and Not Implemented	74%	53%	60%	67%
Considered, Not Implemented	26%	47%	40%	28%

Source: Telephone Survey, Question EI1

Across the EEU territories, businesses did not vary significantly when considering energy efficiency improvements over the last two years, and not implementing the measures, as shown Figure 3-97. In BED and VT Gas service territories, approximately one-quarter of customers considered making improvements but did not take action on these plans.

Figure 3-97. Considerations to Improve Energy Efficiency over the Past Two Years by EEU



	BED (n=36)	EVT (n=201)	VTGAS (n=113)	GT (n=77)	Overall (n=237)
Don't Know	11%	3%	3%	0%	3%
No Improvements Considered and Not Implemented	63%	64%	71%	66%	64%
Considered, Not Implemented	26%	33%	26%	34%	33%

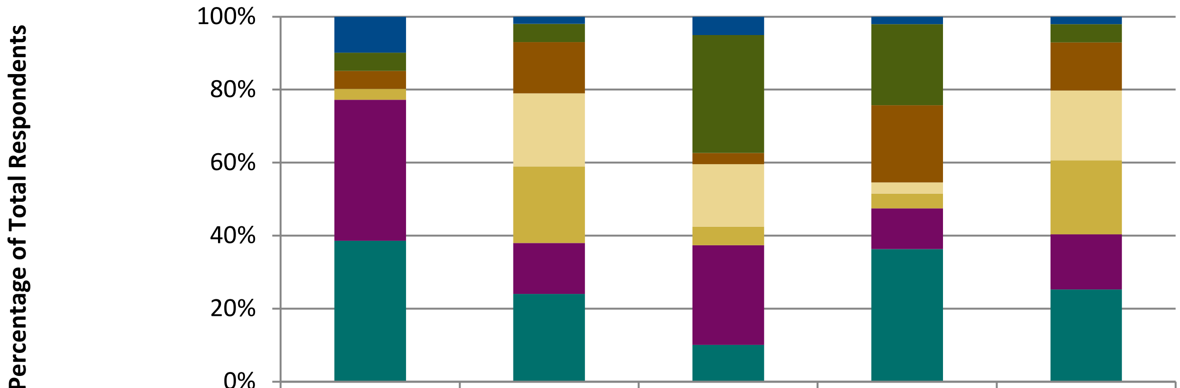
EEU

Source: Telephone Survey, Question EI1

Customers that did consider energy efficiency improvements over the last two years, but did not implement them, were then asked to identify the type of measures considered. Figure 3-98 shows that one-quarter (25%) of respondents considered building envelope improvements but did not implement the measures. Twenty percent of respondents considered multiple measures, while 19% considered solar measures (solar electric or thermal was not specified). Both envelope and solar measures are typically expensive to implement with longer paybacks, so these results are expected.

There is a noticeable difference between EVT and BED territories regarding solar measures, as 20% of EVT respondents considered solar, while no customers in BED considered this.[32] Additionally, only 10% of VT Gas customers considered envelope measures but did not take action to implement, compared to 39% of BED customers, 36% of GT customers, and 24% of customers in EVT territory. Many more customers (32%) in VT Gas areas and GT areas (22%) identified controls/automation projects as possible actions, compared to 5% overall. Approximately 15% of all C&I customers considered lighting-only measures, ranging from 39% of BED customers to 14% of businesses in EVT territory. One-fifth (20%) of all customers considered multiple measures and did not implement them.

Figure 3-98. Energy Efficiency Improvements Identified But Not Implemented by EEU



	BED (N=11)	EVT (N=89)	VTGAS (N=38)	GT (N=37)	All (N=100)
Other Renewables	0%	0%	0%	0%	0%
Other	10%	2%	5%	2%	2%
Controls/Automation	5%	5%	32%	22%	5%
HVAC	5%	14%	3%	21%	13%
Solar	0%	20%	17%	3%	19%
Multiple	3%	21%	5%	4%	20%
Lighting	39%	14%	27%	11%	15%
Building Shell	39%	24%	10%	36%	25%

Utility

Source: Telephone Survey, Question EI1a

[32] Sample size for BED respondents to this question is 11 customers, compared to 89 for EVT.

The majority of respondents (52%) cited the lack of funds available for investment as the most important reason for not taking action to implement energy-saving measures, as shown in Table 3-27. A lack of management time to oversee the project and other priorities for capital spending are the next two most important reasons, at 16% and 10% overall, respectively. However, other priorities for capital spending were more important reasons for not taking action in EVT and VT Gas territories than in BED and GT.

A significant percentage of GT area customers (18%) cited uncertain energy savings as the most important factor, perhaps indicating a need for more reliable or confident estimates of savings. Correlating this response with the answer to the preceding question on specific measures considered (Table 3-26), GT area customers are likely referring to energy savings estimates for building envelope, controls/automation and HVAC measures. Additionally, a high percentage (17%) of EVT customers claimed they could not obtain financing for the investment, possibly indicating a need for additional financing programs or awareness of existing opportunities in this service territory.

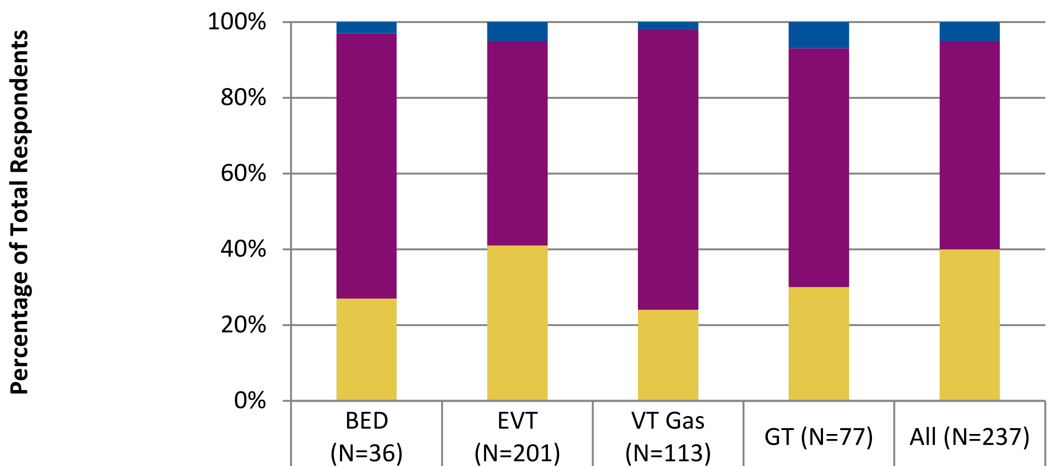
Table 3-27. Most Important Reasons Energy-Saving Actions Were Not Taken

Reasons Energy-Saving Actions Were Not Taken	BED (N=14)	EVT (N=105)	VT Gas (N=46)	GT (N=46)	All (N=119)
No funds available for investment	46%	52%	50%	63%	52%
Not enough management time to oversee project	36%	3%	4%	12%	16%
Other priorities for capital spending	4%	10%	18%	4%	10%
Would have disrupted business operation	4%	0%	0%	0%	6%
Amount of savings did not justify added investment costs	3%	7%	1%	2%	7%
Could not obtain financing for investment	3%	17%	1%	0%	4%
Energy savings were too uncertain	3%	0%	24%	18%	4%
Needed more information to make decision or convince management	0%	7%	0%	0%	0%
Would have taken too much time to get a convincing analysis	0%	4%	0%	0%	0%
Other	0%	0%	1%	0%	0%
Don’t know	0%	0%	1%	0%	0%
Source: Telephone Survey, Question EI1b					

3.7.3 Energy Efficiency Investment Outlook

Most (55%) C&I customers are not planning to invest in energy efficiency over the next two years, while 40% are planning to make investments, as shown in Figure 3-99. Fewer customers in BED, VT Gas, and GT areas (27%, 24%, and 30%, respectively) are planning to invest in energy efficiency than in EVT territory (41%).

Figure 3-99. Capital Investment Plans for Energy Efficiency over the Next Two Years



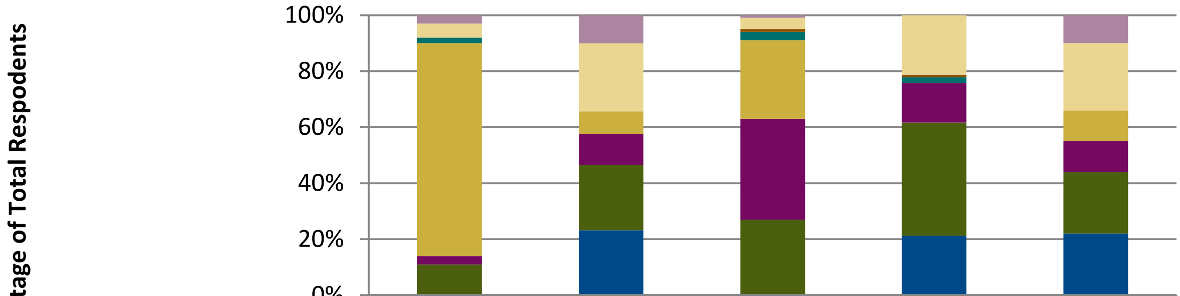
	BED (N=36)	EVT (N=201)	VT Gas (N=113)	GT (N=77)	All (N=237)
Don't know	3%	5%	2%	7%	5%
Not Planning to Invest	70%	54%	74%	63%	55%
Planning to Invest	27%	41%	24%	30%	40%

EEU/Area

Source: Telephone Survey, Question IC3

Customers that are planning to invest in energy efficiency over the next two years indicated that building shell, HVAC, and lighting measures are top priorities, as shown in Figure 3-100. About 24% of respondents in EVT territory indicated "other" specific plans, much more than in VT Gas and BED areas. Most (76%) BED customers are planning to invest in lighting measures, compared to 8% in EVT territory and none in GT areas. However, 23% of EVT customers indicated they will invest in multiple measures, so lighting may be included in that category. Similarly, there were no VT Gas customers planning to invest solely in building envelope measures, with 27% planning to implement multiple measures.

Figure 3-100. Specific Capital Investment Plans for Energy Efficiency over the Next Two Years



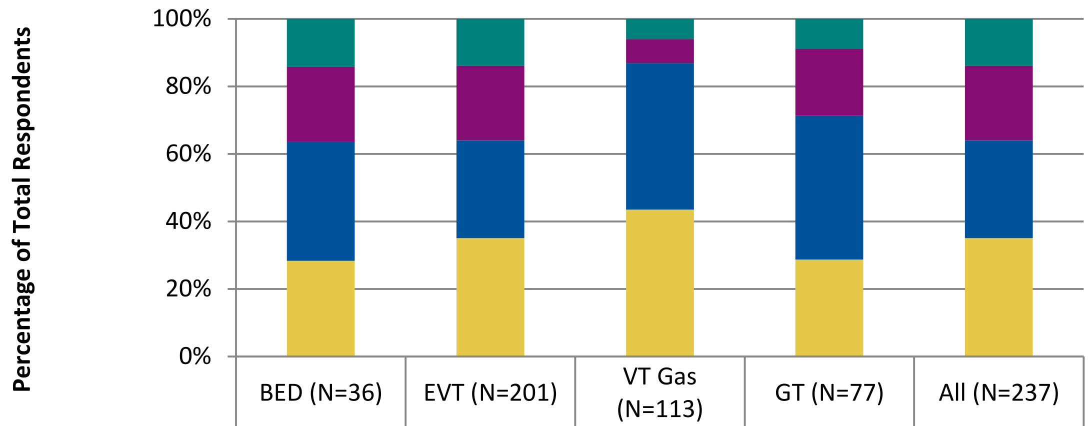
	BED (N=12)	EVT (N=91)	VT Gas (N=46)	GT (N=33)	All (N =103)
Don't know	3%	10%	1%	0%	10%
Other	5%	24%	4%	21%	24%
In the process of determining	0%	0%	1%	1%	0%
Controls/Automation	2%	0%	3%	2%	0%
Lighting	76%	8%	28%	0%	11%
HVAC	3%	11%	36%	14%	11%
Multiple	11%	23%	27%	40%	22%
Building Shell	0%	23%	0%	21%	22%

EEU/Area

Source: Telephone Survey, Question IC4

At the time of the survey, over one-third of C&I businesses projected revenue to increase over the next 24 months, while slightly less (29%) expected revenue to remain constant. Approximately 22% of businesses projected a decrease in revenue, as shown in Figure 3-101. The revenue projections did not differ significantly between EVT and BED service territories, though less (7%) VT Gas customers expected a revenue decrease, with 43% of customers expecting revenue to increase and 43% expecting to remain constant.

Figure 3-101: Current Business Revenue Projection over Next 24 Months



	BED (N=36)	EVT (N=201)	VT Gas (N=113)	GT (N=77)	All (N=237)
Don’t know	14%	14%	6%	9%	14%
Decrease	22%	22%	7%	20%	22%
Remain constant	35%	29%	43%	43%	29%
Increase	28%	35%	43%	29%	35%

EEU/Area

Source: Telephone Survey, Question IC5

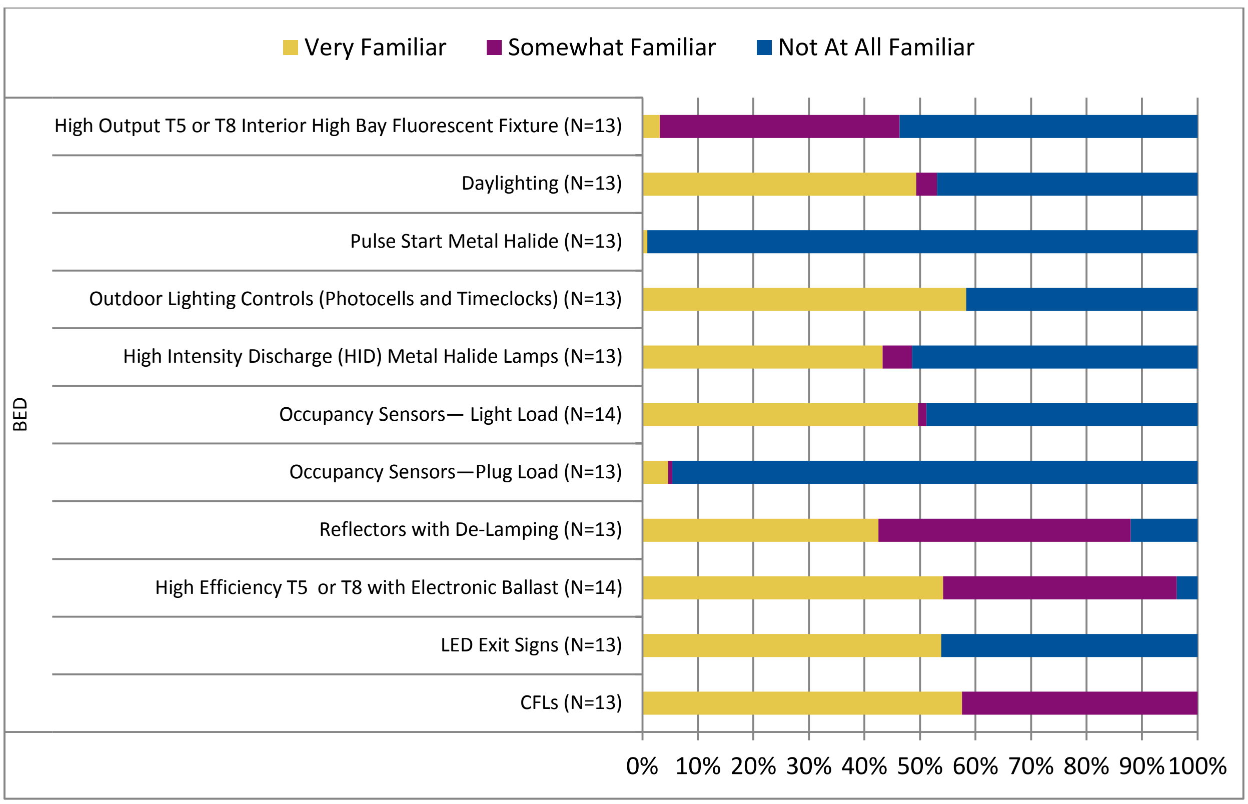
3.7.4 Measure Awareness

On-site surveyors interviewed the appropriate on-site personnel responsible for making decisions related to energy conservation and purchasing of energy-using equipment. The following sections provide customer responses to questions on familiarity with common energy efficient measures. The responses are grouped by measure category and reported by EEU includes responses of VT Gas and GT area customers where relevant.

3.7.4.1 Lighting Measures

Figure 3-102 shows that most customers in BED territory are familiar with common lighting efficiency measures. Occupancy sensors for plug loads and pulse start metal halides stand out for the lack of familiarity among C&I customers.

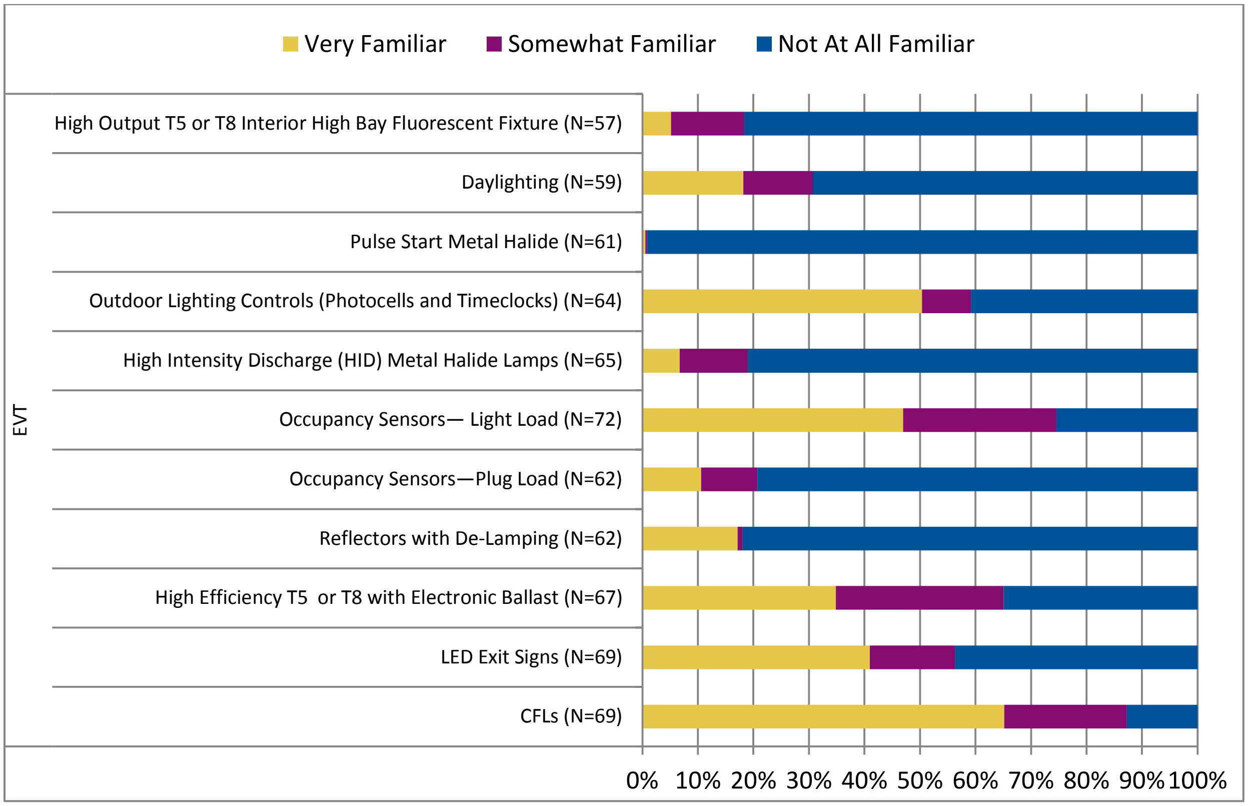
Figure 3-102. Familiarity with Lighting Measures - BED



Source: Decision-Maker Survey, Question 13

Figure 3-103 shows that a large share of C&I customers in EVT territory are not familiar with common lighting efficiency measures. The majority of customers are not aware of measures such as high output, high bay fixtures, daylighting, pulse start metal halide, HID metal halides and occupancy sensors for plug loads.

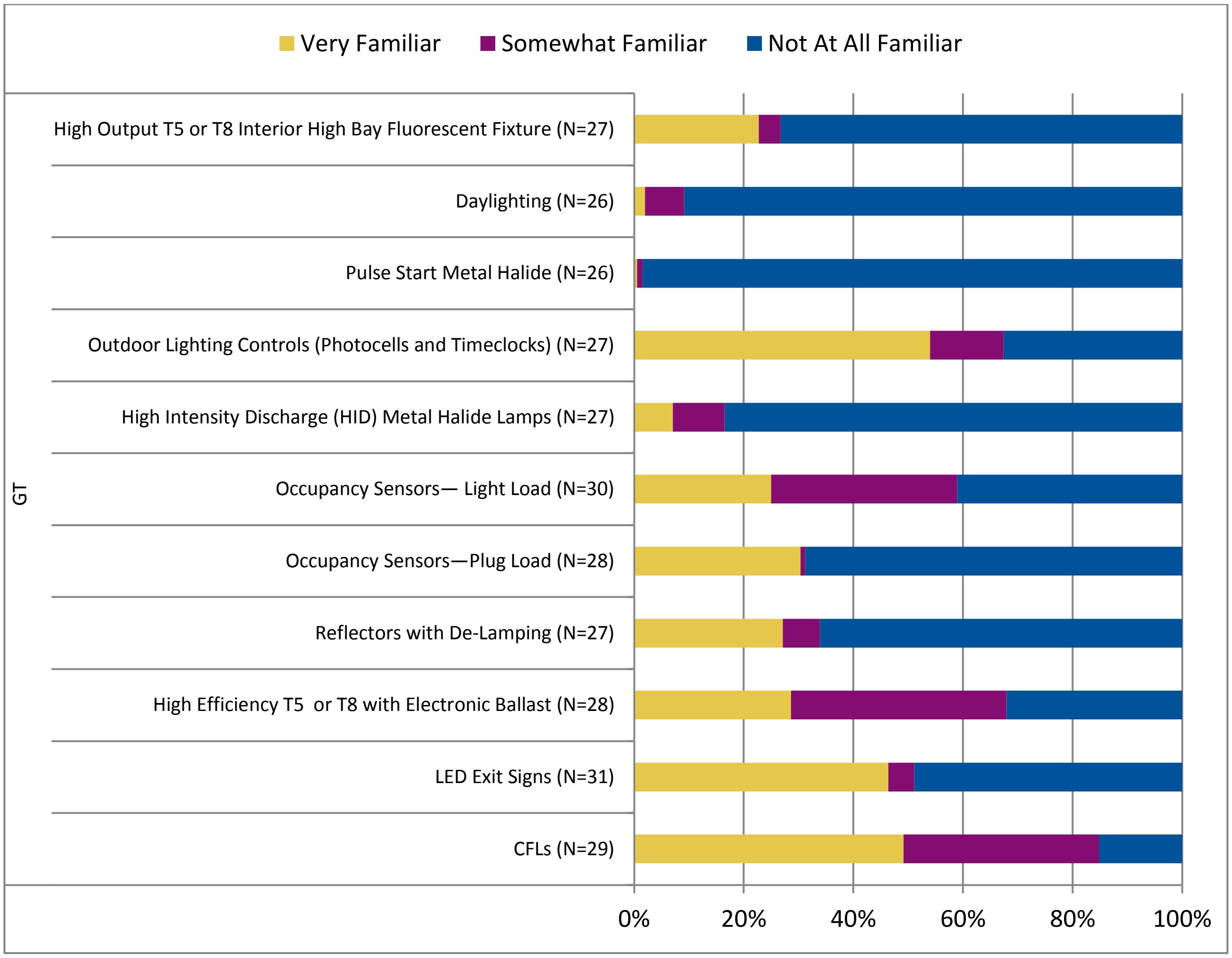
Figure 3-103. Familiarity with Lighting Measures - EVT



Source: Decision-Maker Survey, Question 13

Awareness of lighting measures in GT areas does not differ significantly from that of the larger EVT territory, as shown in Figure 3-104.

Figure 3-104. Familiarity with Lighting Measures – GT Areas

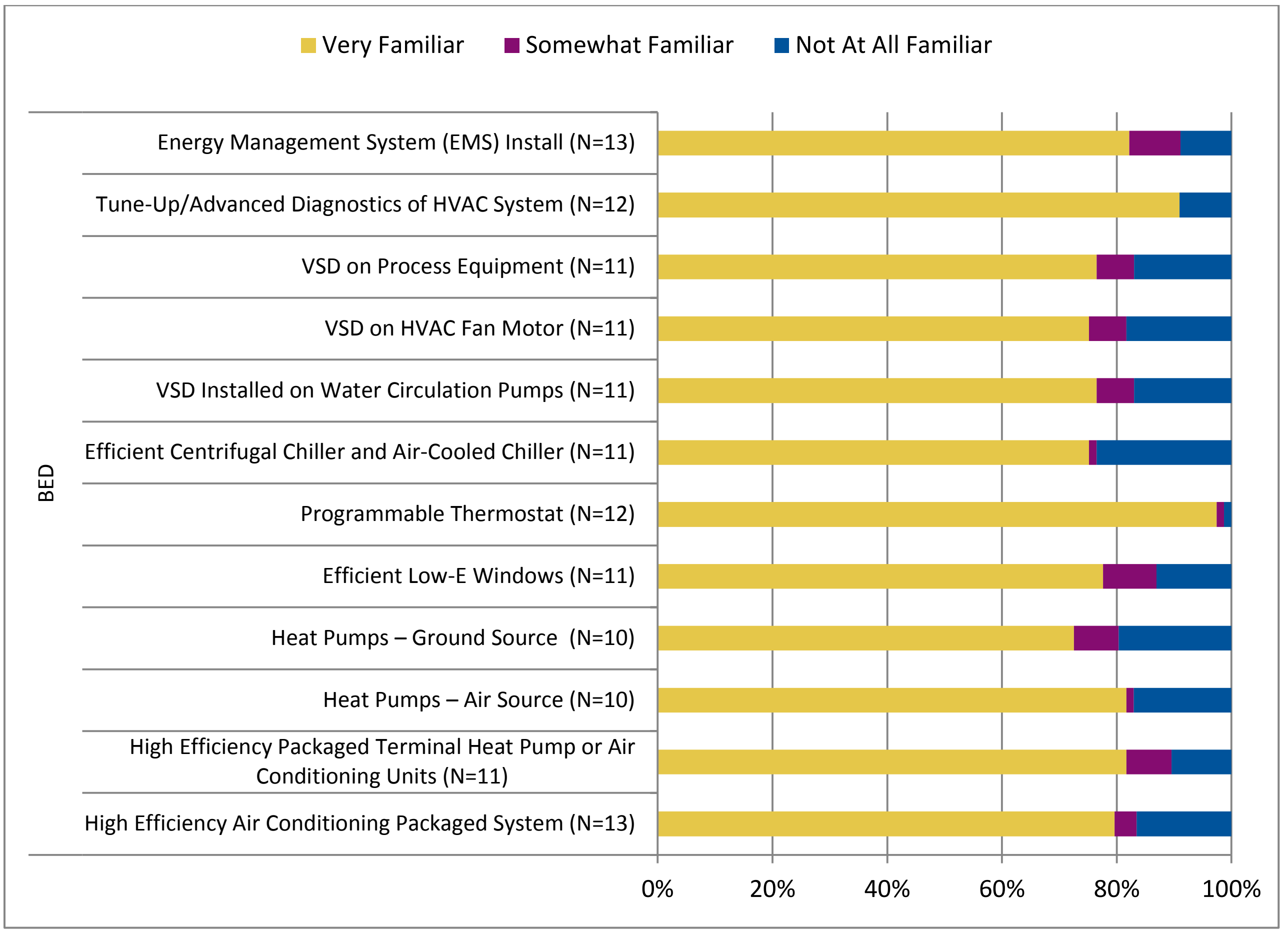


Source: Decision-Maker Survey, Question 13

3.7.4.2 *HVAC Measures*

Figure 3-105 shows that BED customers are very familiar with HVAC measures, with approximately 80% of all customers either very familiar or somewhat familiar.

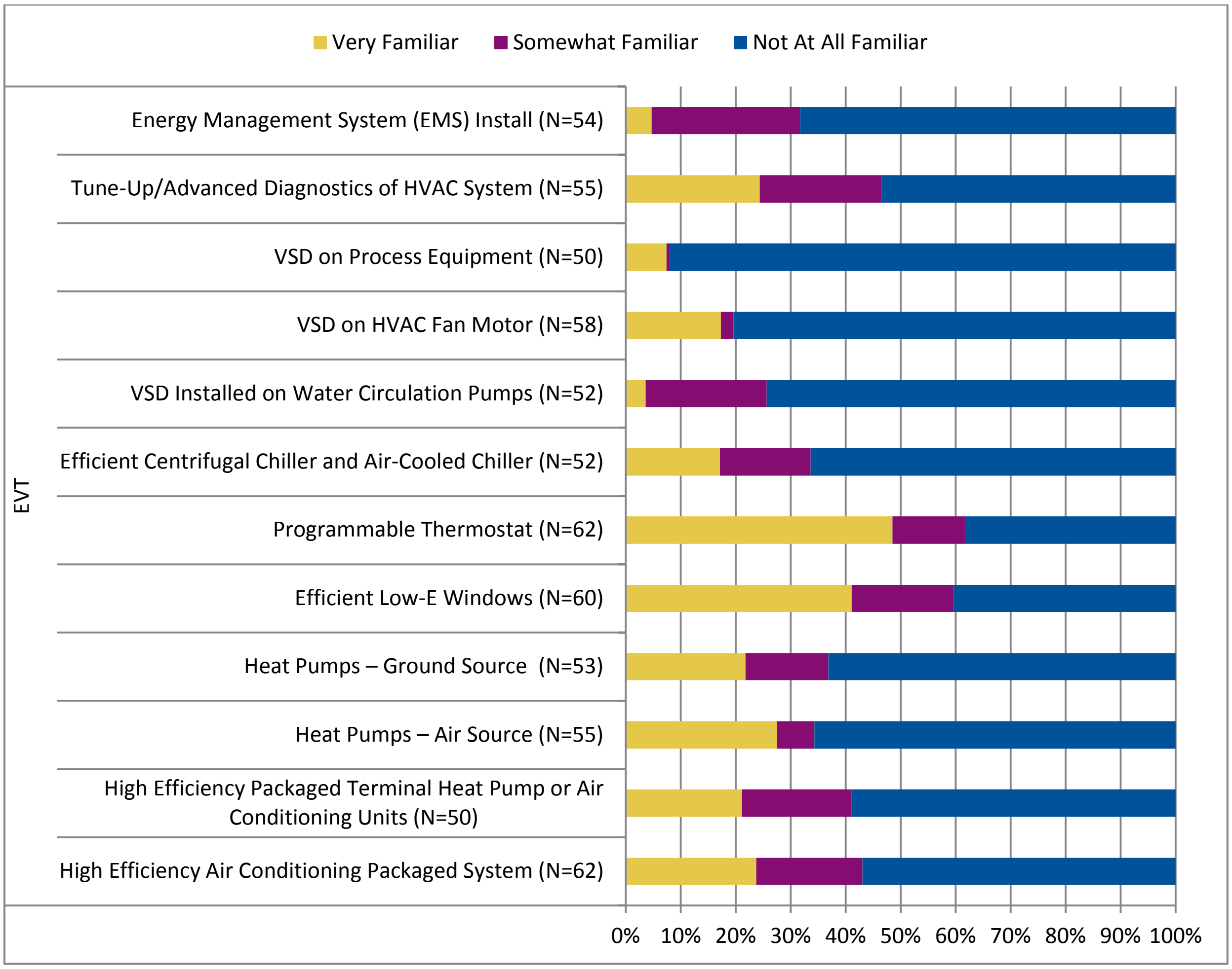
Figure 3-105. Familiarity with HVAC Measures - BED



Source: Decision-Maker Survey, Question 13

Approximately 20-40% of C&I customers in EVT territory are familiar with HVAC efficiency measures, with at least 60% of customers aware of programmable thermostats and efficient low-e windows, as shown in Figure 3-106. Familiarity of VSD measures is notably low.

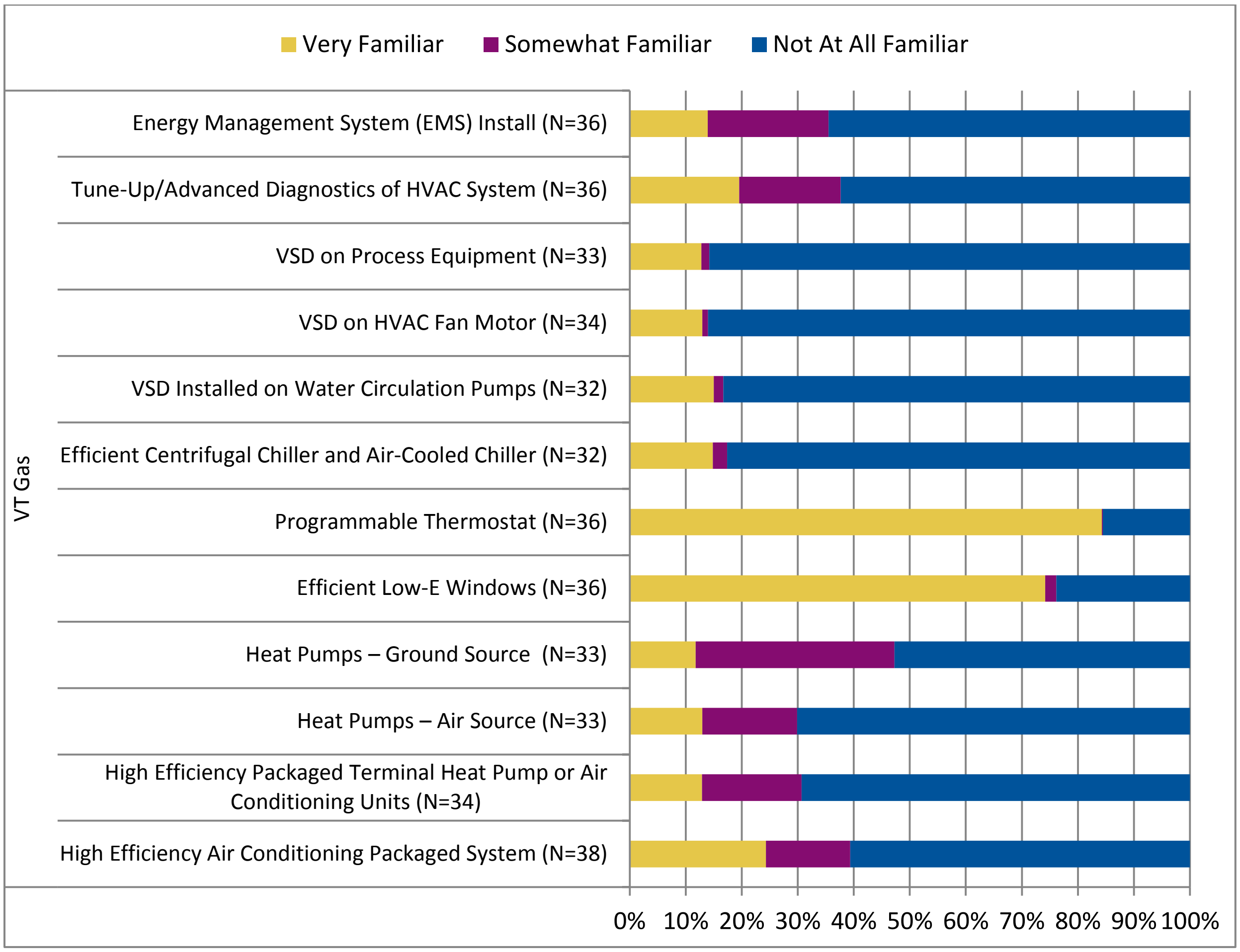
Figure 3-106. Familiarity with HVAC Measures - EVT



Source: Decision-Maker Survey, Question 13

Awareness of HVAC measures varies between 20% and 30% for VT Gas customers, though nearly 80% of customers are aware of programmable thermostats and efficient low-e windows, as shown in Figure 3-107.

Figure 3-107. Familiarity with HVAC Measures – VT Gas

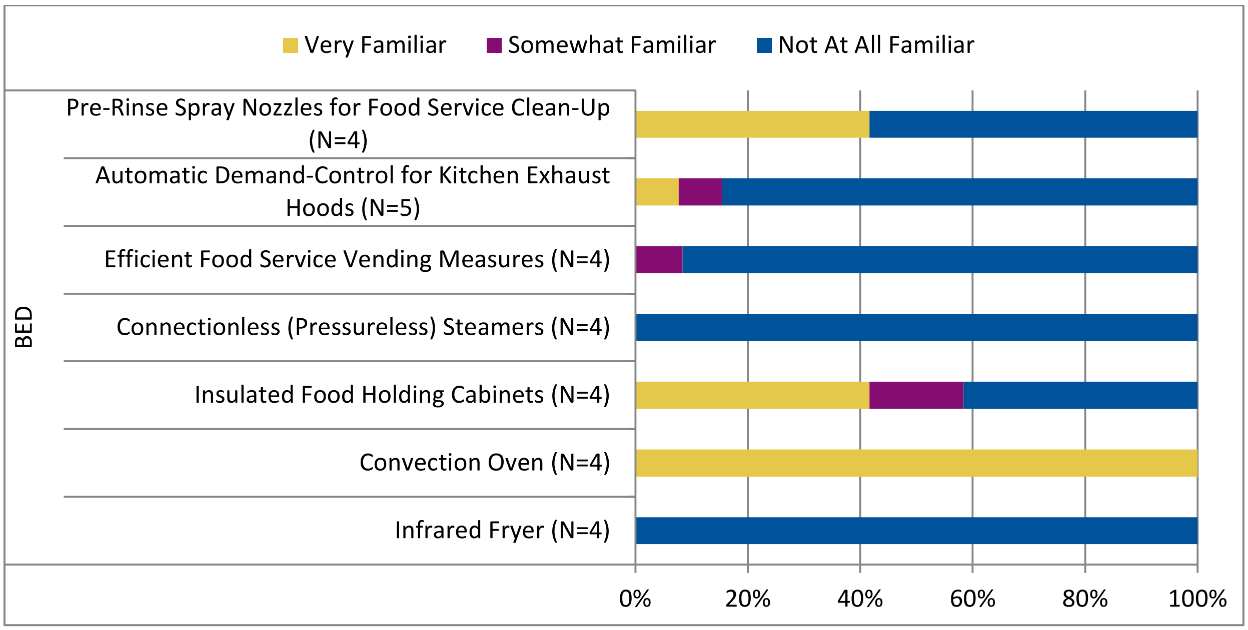


Source: Decision-Maker Survey, Question 13

3.7.4.3 *Cooking Measures*

Figure 3-108 shows that familiarity with cooking equipment measures varies widely in BED territory. Note that sample sizes are small due to the low number of sites that utilize cooking equipment.

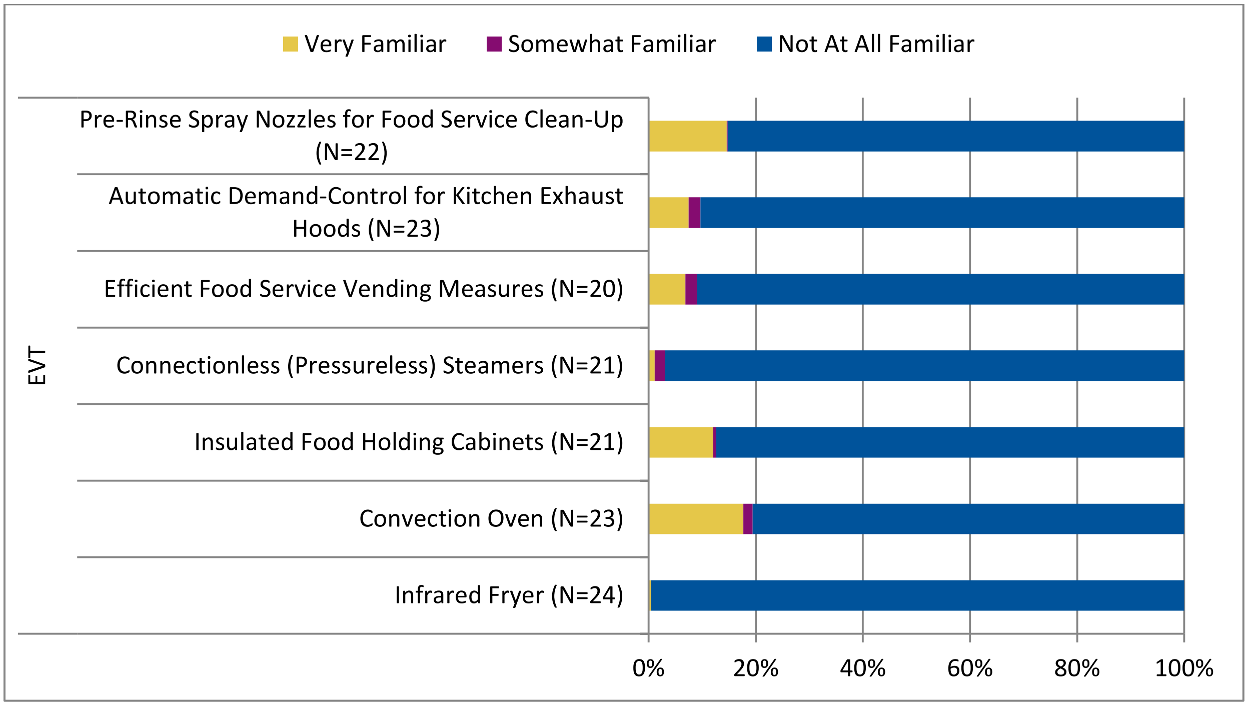
Figure 3-108. Familiarity with Cooking Measures - BED



Source: Decision-Maker Survey, Question 13

Figure 3-109 shows that awareness of cooking measures in EVT territory is generally below 20%, with no customers indicating familiarity with infrared fryer measures.

Figure 3-109. Familiarity with Cooking Measures - EVT

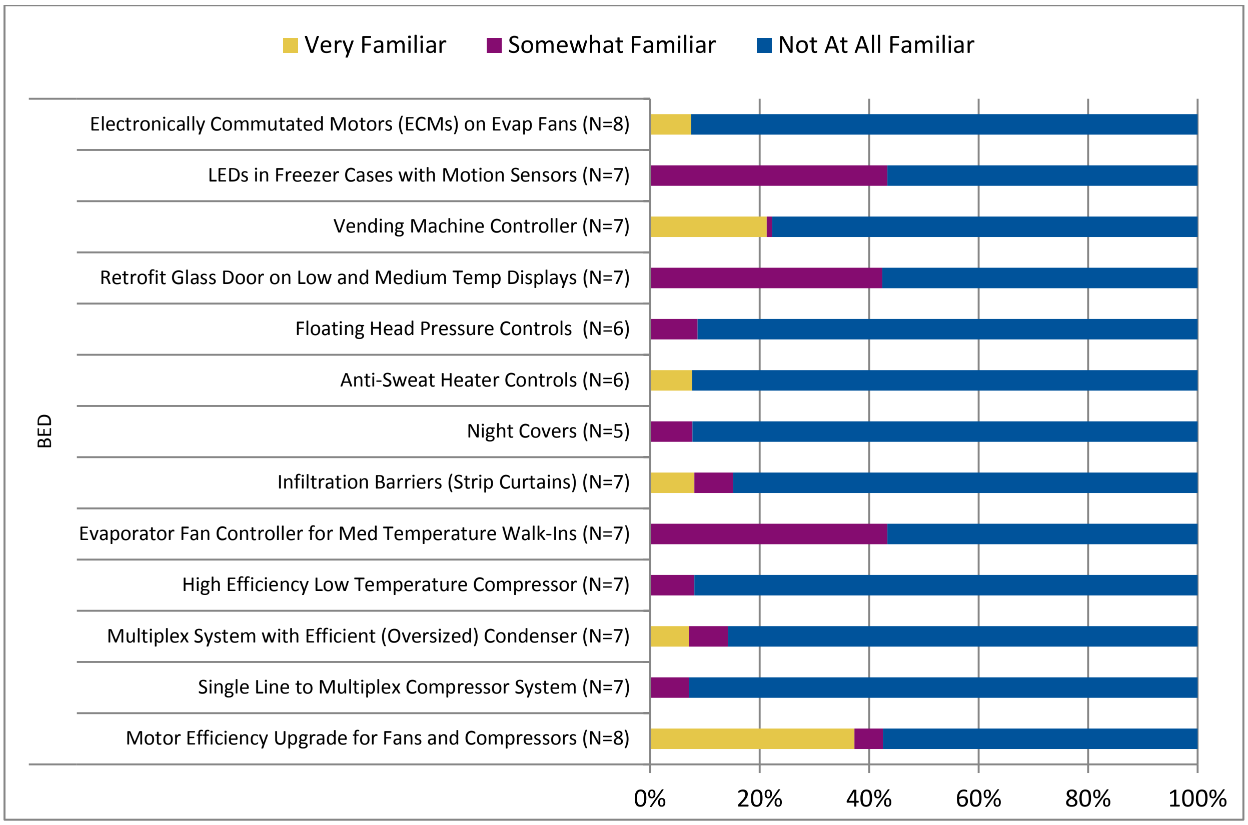


Source: Decision-Maker Survey, Question 13

3.7.4.4 *Refrigeration Measures*

Figure 3-110 shows that most customers in BED service territory that have applicable refrigeration equipment on-site are not aware of refrigeration efficiency measures. Exceptions include LEDs in freezer cases, glass doors on display cases, evaporator fan motor controls for walk-in coolers and motor upgrades for fans and compressors, all which have familiarity approximating 40%.

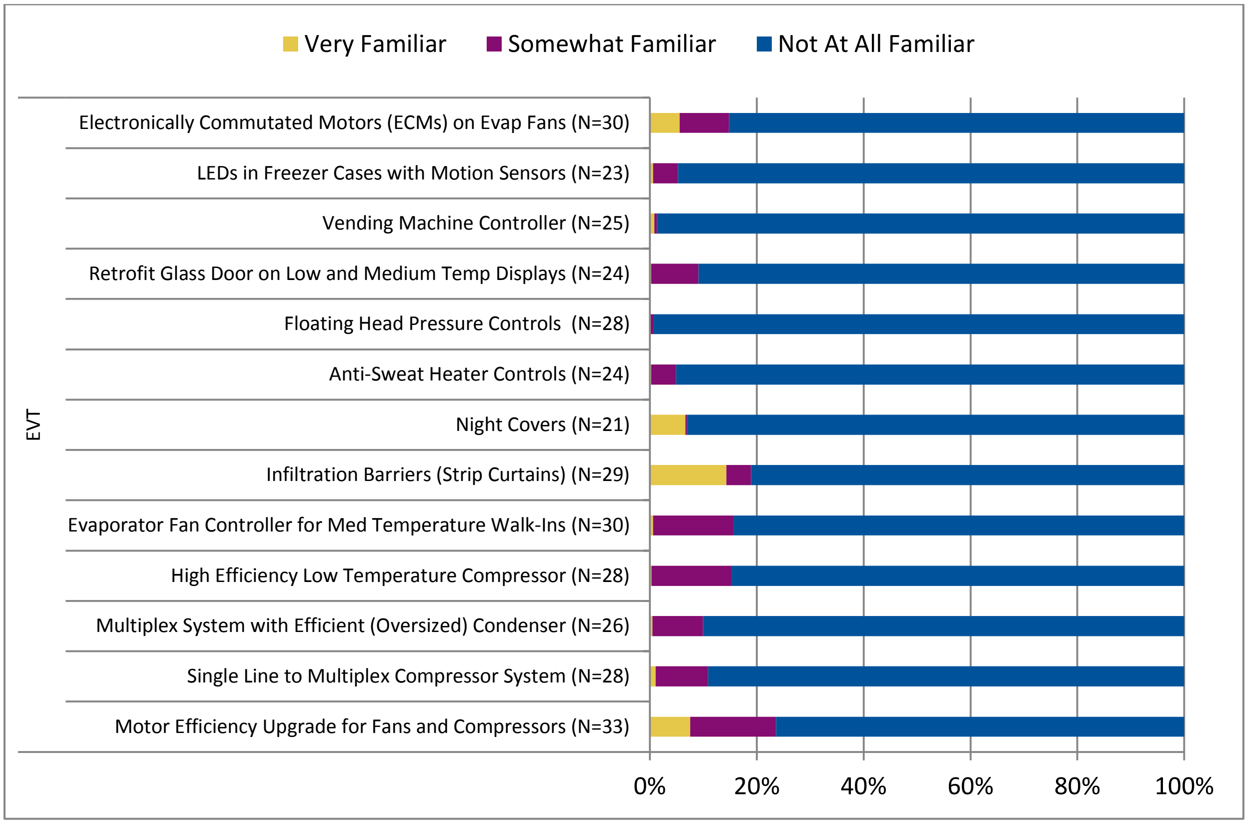
Figure 3-110. Familiarity with Refrigeration Measures - BED



Source: Decision-Maker Survey, Question 13

Figure 3-111 shows that ales than 20% of applicable EVT customers are familiar with refrigeration measures, with the exception of motor upgrades for fans and compressors.

Figure 3-111. Familiarity with Refrigeration Measures -EVT

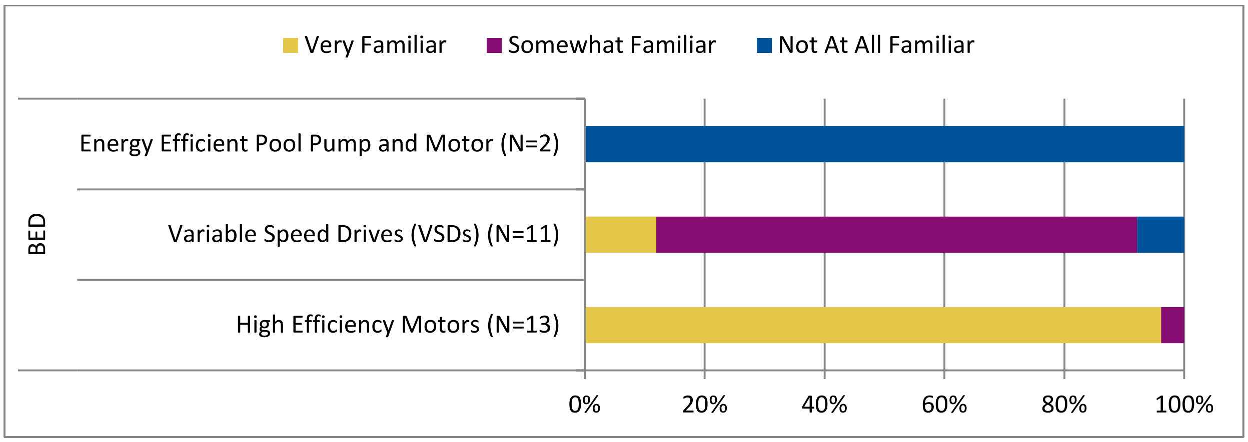


Source: Decision-Maker Survey, Question 13

3.7.4.5 *Motor Measures*

Nearly all BED customers are very aware of high efficiency motors, and over 90% of customers are at least somewhat aware of VSD motor measures, as shown in Figure 3-112.

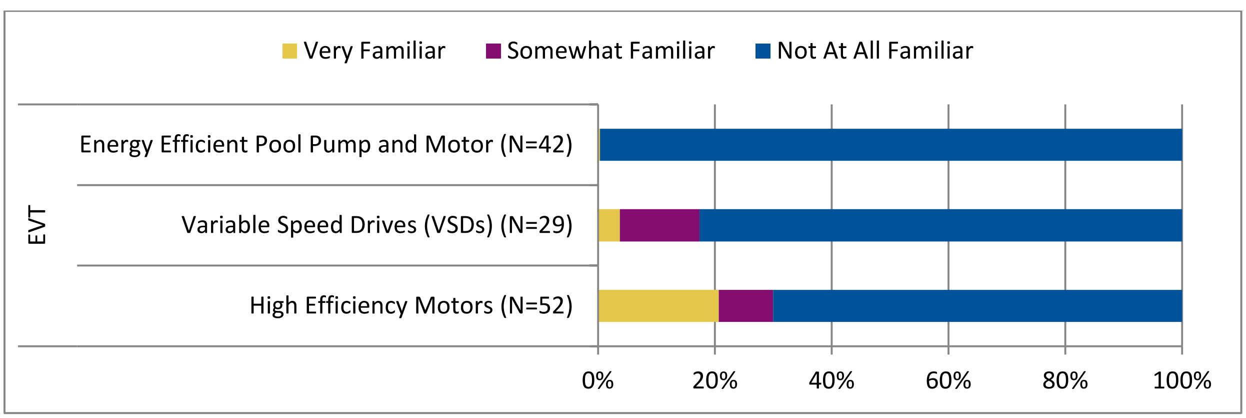
Figure 3-112. Familiarity with Motor Measures - BED



Source: Decision-Maker Survey, Question 13

Figure 3-113 shows that approximately 30% of EVT customers are familiar with high efficiency motor measures, and less than 20% are aware of VSD measures. Nearly all customers are not at all familiar with efficient pool pumps and motors.

Figure 3-113. Familiarity with Motor Measures - EVT

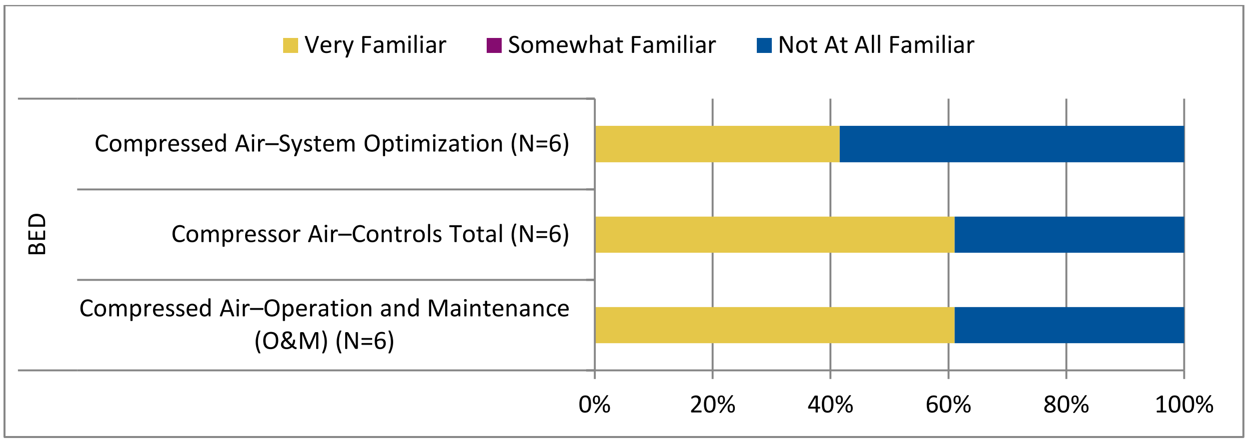


Source: Decision-Maker Survey, Question 13

3.7.4.6 Compressed Air Measures

Figure 3-114 shows that between 40 % and 60% of BED customers that use compressed air on-site are very familiar with efficient measures.

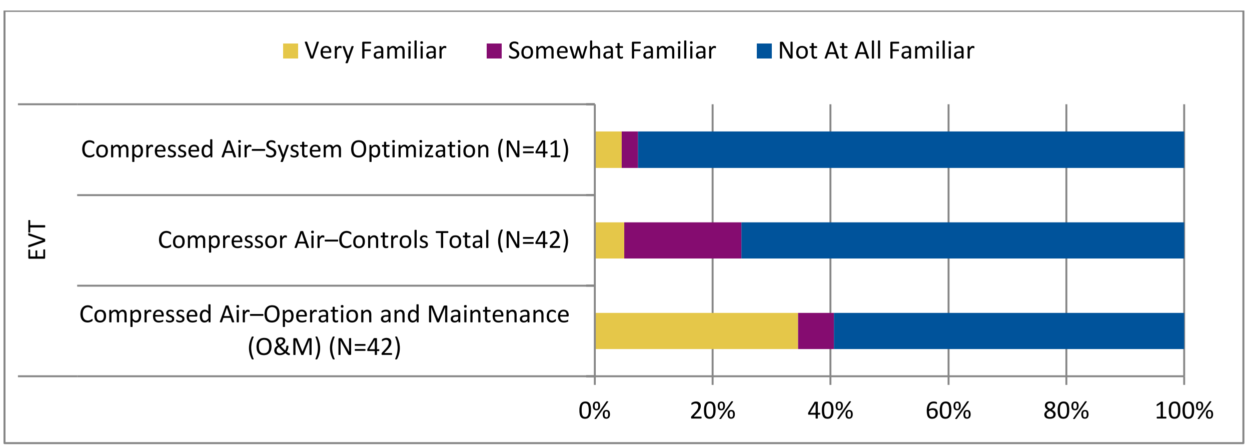
Figure 3-114. Familiarity with Compressed Air Measures - BED



Source: Decision-Maker Survey, Question 13

Among customers in EVT territory with compressed air equipment on-site, most customers are not familiar with compressed air efficiency measures, as shown in Figure 3-115. However, about 40% of customers are familiar with operations and maintenance measures for compressed air equipment efficiency.

Figure 3-115. Familiarity with Compressed Air Measures - EVT

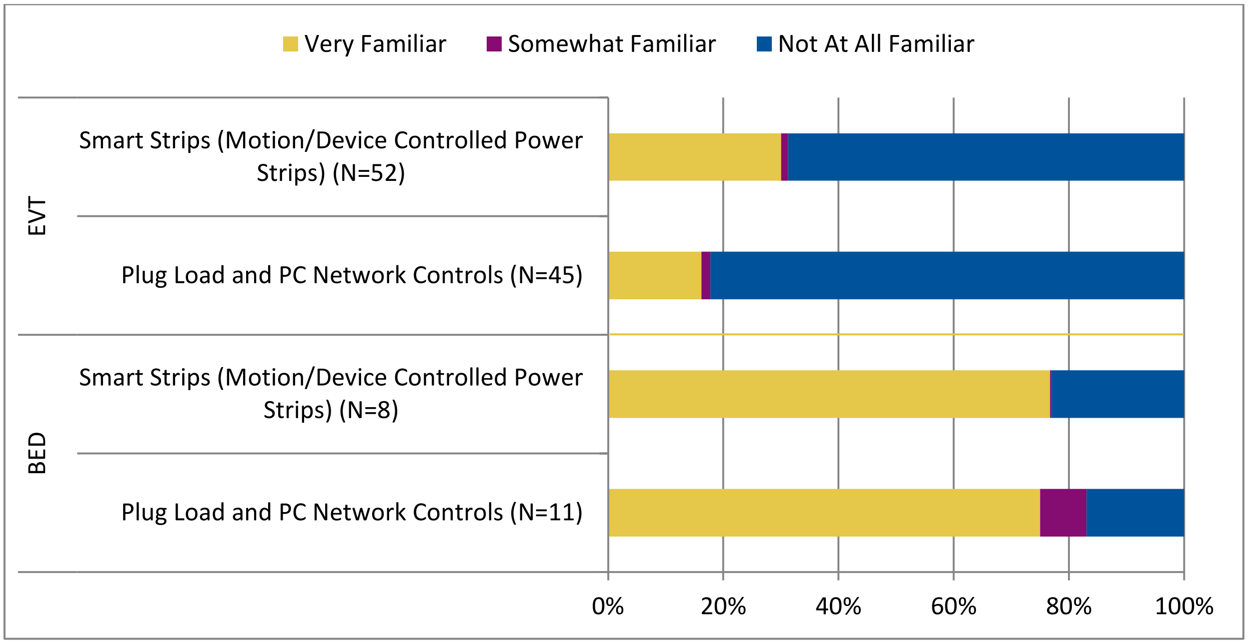


Source: Decision-Maker Survey, Question 13

3.7.4.7 *Miscellaneous Measures*

Customers in BED territory are significantly more aware of miscellaneous measures including smart strips (motion/device controlled power strips) and plug load/PC network controls than customers in EVT service territory, as shown in Figure 3-116.

Figure 3-116. Familiarity with Miscellaneous Measures – BED and EVT



Source: Decision-Maker Survey, Question 13

3.7.5 Implementation Barriers

Where decision-makers indicated they were at least somewhat aware of energy efficient measures, on-site surveyors then inquired about the main implementation barriers for those measures. The following tables summarize the top three barriers for each major measure category for the three EEUs.

Table 3-28 shows that the top implementation barrier for BED customers is either that the measure is already implemented or the existing equipment still works. Second and third top barriers include cost effectiveness concerns and first cost constraints.

Table 3-28. Top Three Barriers for Common Energy Efficient Measures - BED

Measure Category	Top Barrier	2nd Top Barrier	3rd Top Barrier
Lighting	Implemented already (52%)	Existing equipment still works (37%)	Cost effectiveness concerns (10%)
HVAC/Water heating	Existing equipment still works (54%)	Implemented already (31%)	Measure first cost/capital constraints (11%)
Cooking	Implemented already (71%)	Existing equipment still works (25%)	Don't know (4%)
Refrigeration	Existing equipment still works (56%)	Others (18%)	Don't know (11%)
Motors	Existing equipment still works (72%)	Implemented already (18%)	Don't know (8%)
Compressed Air	Implemented already (88%)	Cost effectiveness concerns (12%)	
Misc. Equipment	Existing equipment still works (98%)	Implemented already (1%)	Don't know (1%)

Source: Decision-Maker Survey, Question 13

Customers in EVT territory indicated that the top barrier to implementation of common energy efficient equipment is either that they had implemented the equipment already or they had reliability concerns for miscellaneous measures, including smart strips (motion/device controlled power strips) and plug load/PC network controls. As shown in Table 3-29, many customers were not sure what the top implementation barrier was for refrigeration and motor measures (response of "don't know").

Table 3-29. Top Three Barriers for Common Energy Efficient Measures - EVT

Measure Category	Top Barrier	2nd Top Barrier	3rd Top Barrier
Lighting	Implemented already (53%)	Existing equipment still works (14%)	Don't know (8%)
HVAC/Water heating	Implemented already (32%)	Existing equipment still works (28%)	Don't know (20%)
Cooking	Implemented already (54%)	Don't know (15%)	Existing equipment still works (11%)
Refrigeration	Don't know (50%)	Existing equipment still works (17%)	Implemented already (15%)
Motors	Implemented already (45%)	Don't know (34%)	Existing equipment still works (12%)
Compressed Air	Implemented already (60%)	Don't know (18%)	Existing equipment still works (17%)
Misc. Equipment	Reliability concerns (71%)	Existing equipment still works (15%)	Don't know (10%)

Source: Decision-Maker Survey, Question 13

Table 3-30 shows that most VT Gas customers indicated that the top barrier for implementation was either they had implemented the measure already or that the existing equipment still works. Cost effectiveness concerns and first cost constraints are also top barriers for implementation of HVAC/water heating and cooking measures.

Table 3-30. Top Three Barriers for Common Energy Efficient Measures – VT Gas

Measure Category	Top Barrier	2nd Top Barrier	3rd Top Barrier
HVAC/Water heating	Existing equipment still works (48%)	Implemented already (21%)	Measure first cost/capital constraints (15%)
Cooking	Existing equipment still works (47%)	Implemented already (30%)	Cost effectiveness concerns (12%)

Source: Decision-Maker Survey, Question 13

4. Assessment of Remaining Potential

Remaining potential for the purposes of this study is defined as the saturation of inefficient equipment related to a specific measure. The remaining potential for key measures is broken out by end use in the following sections. Where applicable, the data is presented in tabular format for all existing buildings and relevant EEU.

4.1 Building Envelope – Remaining Potential

Figure 4-1 shows the remaining potential for building envelope measures and reveals that there are significant upgrade opportunities for walls, roofs and windows.

Figure 4-1. Remaining Potential Summary for Building Envelope Measures

Building Envelope Measures	Remaining Potential[a]	
	All Buildings	VT Gas
Increase wall insulation	Nearly one-third of all exterior walls have no insulation. Three-quarters of these walls are mass wall construction, which typically do not have insulation. The remaining share of non-mass wall types represents 7% of all walls, with the potential to improve from no insulation to at least code minimum values. Existing building wall R-values are generally lower than the prevailing energy code requirements at the time of the study (2005 CBES), indicating the potential to increase insulation where economically feasible.	
Increase roof insulation	Installed roof insulation R-values are approximately half of the code-required values, representing significant remaining potential to increase insulation where physical constraints do not limit additional insulation.	
Upgrade single-pane windows	37%	17%

a. Historic preservation concerns may preclude some envelope upgrades.
Source: Navigant analysis of on-site survey results

4.2 *Lighting – Remaining Potential*

Figure 4-2 provides the remaining potential for indoor and outdoor lighting measures and shows there are numerous opportunities to upgrade both lighting equipment and controls.

Figure 4-2. Remaining Potential Summary for Lighting Measures

Lighting Measures		Remaining Potential[a,b]			
		All Buildings	BED	EVT	GT Areas
Indoor Lighting	Replace T12's in linear fluorescent applications	17%	5%	18%	19%
	Replace incandescents in screw-based sockets	50%	54%	49%	54%
	Install automated lighting controls for linear fluorescent lighting[c]	79%	92%	78%	85%
	Replace incandescent exit signs[d]	25%			
Outdoor Lighting	Replace outdoor lighting with CFLs and LEDs	68%	83%	67%	56%
	Install automated outdoor lighting controls[c]	27%	46%	26%	20%

a. All lighting potential is based on frequency of counts, unless otherwise noted.
b. No data indicates the item was not calculated for a particular category.
c. Weighted by installed wattage
d. Results are not available by EEU/GT Area.
Source: Navigant analysis of on-site survey results

4.3 *HVAC – Remaining Potential*

4.3.1 Unitary Systems

In subjective (qualitative) assessment of the remaining potential, surveyors identified the potential to replace outdated, inefficient packaged systems and rooftop units (RTUs) more often than any other HVAC measure. The analysis confirms these assessments and indicates that the average age of single-zone HVAC systems is 24 years old.

Additionally, the majority (61%) of small (less than 5.5 tons in cooling capacity)[33] single-zone unitary HVAC systems in Vermont's existing building stock do not meet the prevailing code requirements for cooling efficiency at the time of the survey (2005 CBES), as shown in Table 4-1. Navigant estimates that the 61% share of systems that do not meet code efficiency requirements represents the remaining potential for unitary system replacement.

Table 4-1. Cooling Efficiency of Single-Zone Unitary HVAC Systems (< 5.5 tons)[34]

	<5.5 tons (Code: 13.0 SEER / 11.0 EER)
Percent of Systems Below Code	61%
Percent of Systems At/Above Code	39%
Mean EER	10.2
Mean SEER	11.2

N = 96 observations
Source: On-Site Survey, Questions 144-145; 2005 CBES Table 803.2.2.(1)

[33] One ton equals 12,000 Btu/h of cooling capacity. 5.5 tons is approximately equal to 65,000 Btu/h.

[34] 96 systems were identified as less than 5.5 tons of cooling capacity. 11 systems were greater than 5.5 tons. The average EER for systems greater than 5.5 tons is 10.8. The code has modulating EER requirements for systems at thresholds of 5.5 tons, 11.25 tons, 20 tons, and 63 tons. It is not possible to compare each of the 11 systems against their respective requirements.

4.3.2 Economizers

The 2005 CBES required all cooling systems greater than 5.5 tons (65,000 Btu/h) to use supply air economizers. Table 3-12 shows that most cooling systems in Vermont are not equipped with economizers. However, surveyors were unable to determine if economizers were in use on 29% of systems less than 5.5 tons and 46% of systems greater than 5.5 tons.[35] The findings indicate that 7% of systems greater than 5.5 tons use economizers while only 3% of smaller systems use economizers. Excluding the unidentified systems, there is the potential for at least 87% of identified systems greater than 5.5 tons to meet the code and utilize economizer capability. The true potential for this measure is likely less than 87% and depends on the replacement cycle of these systems, which are often replaced at the end of useful life or during major renovations.

Table 4-2. Saturation of Economizers in Cooling Systems

	<5.5 tons	≥5.5 tons (Code Required Minimum Size)
Economizer	3%	7%
No Economizer	69%	46%
Unidentified	29%	46%

N = 243 Systems
Source: On-Site Survey, Question 189; 2005 CBES Section 803.3.3.5

[35] Surveyors often were unable to visually verify the presence of a functioning economizer.

4.3.3 Heating Systems

Nominal heating system efficiency observed in Vermont's C&I buildings meets or exceeds code for commercial furnaces and boilers, as shown in Table 4-3. The actual operating efficiency of heating systems is highly dependent on the frequency and level of maintenance, in addition to system age. If systems are not maintained for optimal performance then the actual efficiency will be less than rated efficiency. Based solely on observed, rated efficiency, remaining potential exists to upgrade heating systems, as most units just meet or slightly exceed code minimums. Additionally, there is significant potential to continue to pursue operations and maintenance (O&M) programs aimed at existing heating systems.

Table 4-3. Heating System Efficiency by Type and Code Category

System	Size Category (Input)	Subcategory	Observed Efficiency[b]	2005 CBES Minimum Efficiency	Number of Units
Warm Air Furnaces	<225,000 Btu/h	-	81%	80%	55
	≥225,000 Btu/h	-	80%	80%	20
Boilers[a]	<300,000 Btu/h	Steam	80%	75% (gas) and 80% (oil)	4
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Steam	88%	75%	2
	≥2,500,000 Btu/h	Steam	84%	80%	3
Boilers[a]	<300,000 Btu/h	Hot Water	86%	80% (all fuels)	18
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Hot Water	82%	75% (gas) and 78% (oil)	16
	≥2,500,000 Btu/h	Hot Water	85%	83%	2

a. Gas and oil boilers are not broken out for this analysis.
b. Observed efficiency is the weighted average efficiency of all observed units.
Source: On-Site Survey, Question 150; 2005 CBES Table 803.3.3(4) and Table 803.3.3(5)

4.3.4 Additional HVAC and Water Heating Measures

Figure 4-3 shows the remaining potential for additional HVAC and water heating measures and indicates that significant energy savings opportunities exist across all EEUs.

Figure 4-3. Remaining Potential Summary for Additional HVAC and Water Heating Measures

	HVAC/Water Heating Measures	Remaining Potential[c]			
		All Buildings	BED	EVT	VT Gas
HVAC	Implement variable speed controls for hot water circulation pumps (space heating)	88%	85%	89%	85%
HVAC	Implement variable speed drive controls for chillers	92%	54%	94%	
HVAC	Automated HVAC system controls[a]	32%			
HVAC	Utilize heat/energy recovery systems for ventilation[b]	76%			
Water Heating	Convert electric water heaters to natural gas or propane	72%			53%
Water Heating	Insulate water heating pipes	60%			38%

a. Conservative estimate based on the share of systems that are manually controlled. The remaining potential may be higher by accounting for the systems that operate continuously (18%).
b. Remaining potential includes all systems not observed to utilize heat or energy recovery systems.
c. No data indicates the item was not calculated for a particular category.
Source: Navigant analysis of on-site survey results

4.4 Refrigeration – Remaining Potential

Figure 4-4 provides the remaining potential for refrigeration measures. Except for the first and third measures listed, there exists significant energy savings potential through refrigeration system upgrades.

Figure 4-4. Remaining Potential Summary for Refrigeration Measures

Refrigeration Measures	Remaining Potential[e]		
	All Buildings	BED	EVT
Upgrade non-commercial refrigerators to ENERGY STAR models	29%	29%	29%
Implement anti-sweat heater controls[a]	72%		72%
Install doors on reach-in refrigerated display cases[a]	29%		22%
Upgrade refrigerated display case lighting to LED[a,b]	98%		98%
Upgrade walk-in cooler lighting to LED[a]	95%	100%	95%
Automated walk-in cooler lighting controls	97%	100%	83%
Install economizers on walk-in coolers	86%	90%	85%
Upgrade walk-in cooler evaporator fan motors to ECM motors[c]	89%		92%
Implement evaporator fan motor controls in walk-in coolers[c]	87%		91%
Implement floating head pressure control on refrigeration systems[d]	88%	99%	87%
Implement heat recovery on refrigeration systems	73%	89%	72%

a. Small sample size for this measure (N=5 systems) indicated zero systems with anti-sweat heater controls. Assume remaining potential is at least equivalent to statewide average or greater.
b. Excludes cases where there is currently no lighting installed
c. Insufficient data available as most evaporator fan motor types/controls in BED territory were unidentified.
d. Remaining potential is share of systems with no floating head pressure control out of all systems with an identified control strategy (excludes unidentified systems).
e. No data indicates the item was not calculated for a particular category.
Source: Navigant analysis of on-site survey results

4.5 *Motors and Compressed Air – Remaining Potential*

Figure 4-5 shows the remaining potential for motor and compressed air measures and reveals there are numerous energy savings opportunities.

Figure 4-5. Remaining Potential Summary for Motor and Compressed Air Measures

Motor/Compressed Air Measures	Remaining Potential[c]		
	All Buildings	BED	EVT
Replace motors with higher efficiency models	87%		
Install variable speed drive controls on process motors[b]	76%		
Implement cycling air dryer on compressed air systems[a]	57%	100%	57%

a. Excludes systems with no air dryer installed.

b. Remaining potential may vary depending on process application, as constant speed motors are necessary for certain applications.

c. No data indicates the item was not calculated for a particular category.

Source: Navigant analysis of on-site survey results

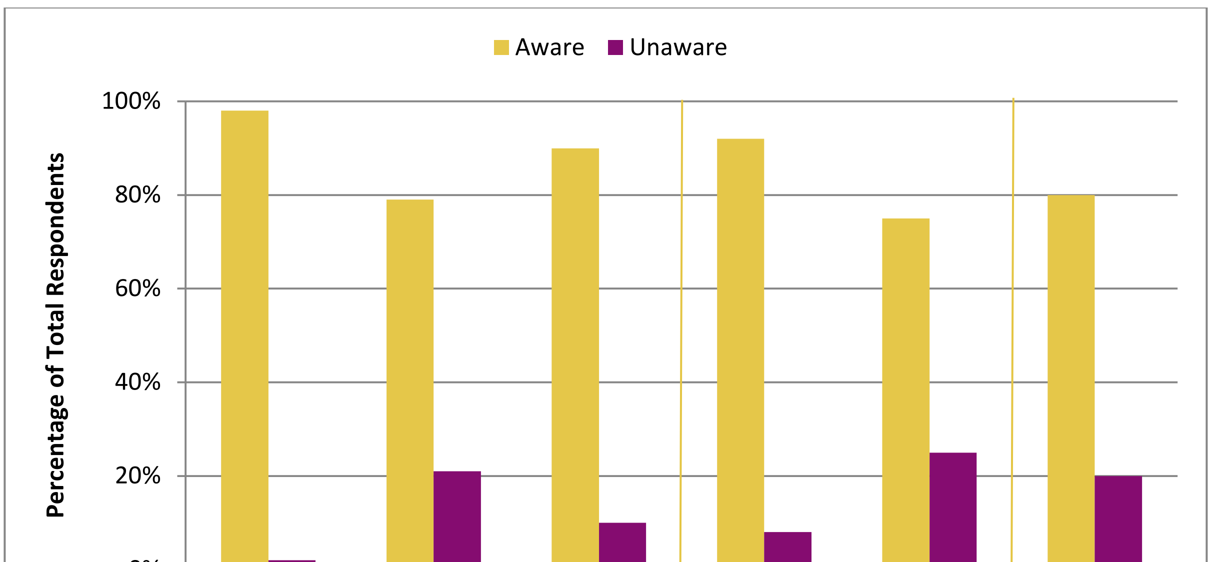
5. Assessment of EEU Service Quality and Process-Related Insights

The following sections provide the results of the telephone survey conducted with 237 customers across all EEU areas. The telephone survey focused on program awareness and participation (section 5.1) and EEU satisfaction (Section 5.2).

5.1 Program Awareness and Participation

As shown in Figure 5-8, most customers (80%) are aware of energy efficiency service offerings available to them. BED claims the highest percentage, with 98% of customers indicating awareness of offerings. Over three-quarters (79%) of customers in EVT territory are aware of service offerings, though there is a notable distinction between the 92% awareness among GT area customers and 75% awareness in Non-GT areas.

Figure 5-1. Awareness of Energy Efficiency Service Offerings

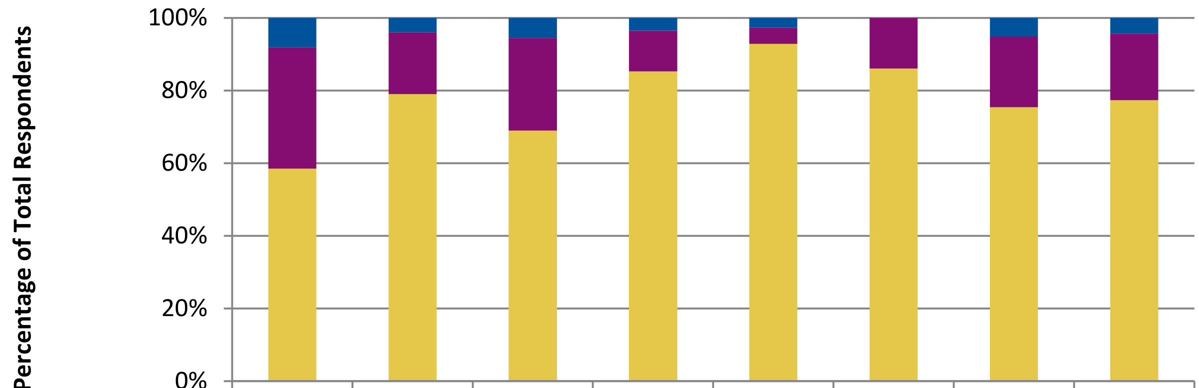


	BED (N=36)	EVT (N=201)	VT Gas (N=113)	GT (N=77)	Non-GT (N=124)	All Buildings (N=237)
Aware	98%	79%	90%	92%	75%	80%
Unaware	2%	21%	10%	8%	25%	20%

Source: Telephone Survey, Question EE3

Over three-quarters (77%) of C&I businesses have participated in some form of energy efficiency program in the last five years, as shown in Figure 5-2. EVT customers claim the highest participation rate of 80%, and EVT customers within GT areas have an even higher rate of 85% program participation, likely reflecting the concentrated efforts of the GT program. The majority (58%) of BED customers and over two-thirds (69%) of VT Gas customers have participated in energy efficiency programs in the past five years. Participation is highest in the high energy consumption stratum at 93%, with 86% of medium energy use customers and three-quarters (75%) of low energy use customers participating in energy efficiency programs in the past five years.

Figure 5-2. Participation in Energy Efficiency Programs in the Past Five Years



	BED (N=36)	EVT (N=201)	VT Gas (N=113)	GT (N=77)	High Use (N=108)	Medium Use (N=74)	Low Use (N=55)	All Buildings (N=237)
Don't Know	8%	4%	6%	4%	3%	0%	5%	4%
Not Participated	33%	17%	25%	11%	4%	14%	19%	18%
Participated	58%	79%	69%	85%	93%	86%	75%	77%

Source: Telephone Survey, Question EE4

Customers indicated the specific energy efficiency programs they participated in during the last five years, and Table 5-1 indicates that some customers participated in programs beyond the expected three offerings of EVT, BED, and VT Gas. These include programs through the Central Vermont Public Service Corporation (CVPS)[36] and the Stimulus/Recovery Act (American Recovery and Reinvestment Act-ARRA). Participation rates are high for EVT and BED programs, though participation in VT Gas programs within the VT Gas service areas was significantly lower (20%) over the last five years. Customers in the high energy use stratum comprise the highest percentage (12%) of participants in VT Gas programs, while customers in the medium and low consumption strata each had a 4% participation rate in VT Gas programs.

Table 5-1. Participation in Specific Energy Efficiency Programs in the Past Five Years[a]

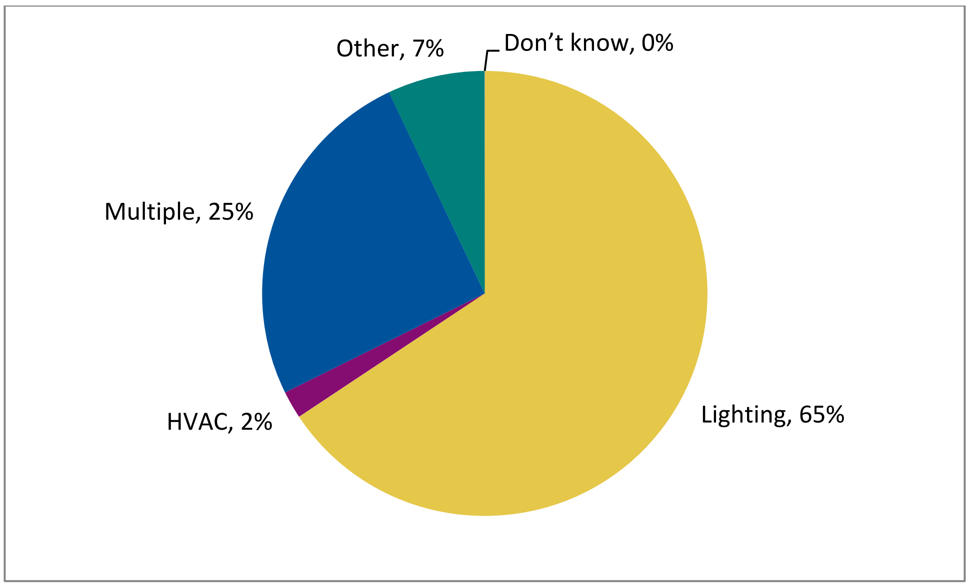
Efficiency Program	EEU/Area				Consumption Stratum		
	BED (N=55)[b]	EVT (N=205)	VT Gas (N=141)	GT (N=84)	High Use (N=184)	Medium Use (N=59)	Low Use (N=47)
Efficiency Vermont	0%	60%	42%	77%	82%	67%	57%
Burlington Electric Department	68%	0%	18%	0%	9%	4%	1%
Vermont Gas	7%	4%	20%	5%	12%	4%	4%
CVPS	0%	1%	0%	1%	1%	5%	0%
ARRA-Stimulus	0%	3%	0%	0%	1%	3%	3%
Other	1%	0%	1%	0%	5%	1%	0%
None	44%	15%	30%	11%	5%	14%	17%
Don't Know	11%	3%	7%	3%	3%	0%	4%

a. Totals may not add to 100% due to multiple possible responses per customer.
b. A significant amount of customers in BED territory indicated they participated in Efficiency Vermont programs. These responses were attributed to participation in BED programs.
Source: Telephone Survey, Question EE4

[36] Customers self-reporting participation in CVPS efficiency programs may simply be referring to CVPS because this is their service provider, and CVPS may have directed them to Efficiency Vermont programs.

The majority (65%) of customers that participated in Efficiency Vermont programs implemented lighting measures, as shown in Figure 5-3. A significant share (25%) of customers implemented multiple measures.

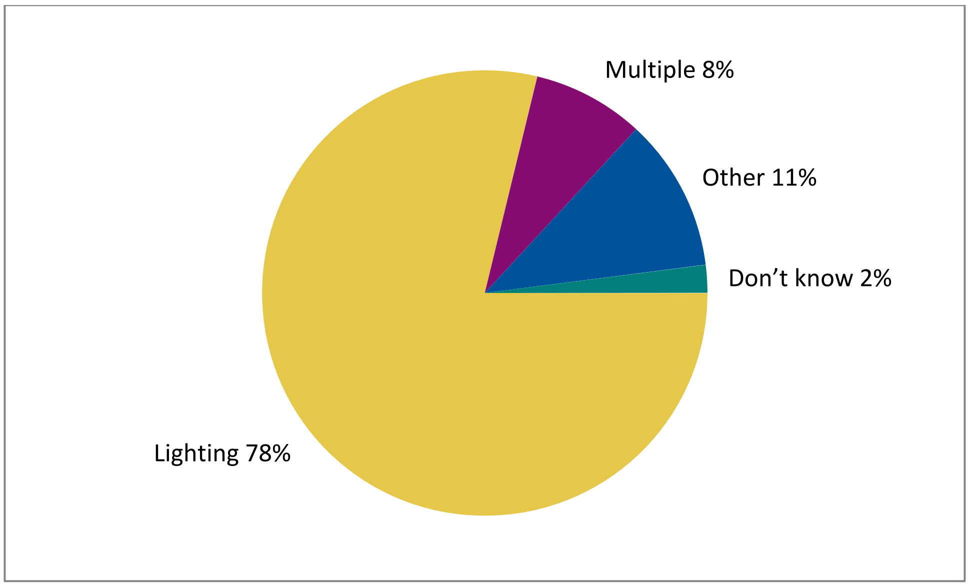
Figure 5-3. Type of Energy Efficiency Improvements Implemented with Technical/Financial Assistance from EVT (N=165)



Source: Telephone Survey, Question EE6

Most (78%) customers that participated in BED programs implemented lighting measures, as shown in Figure 5-4.

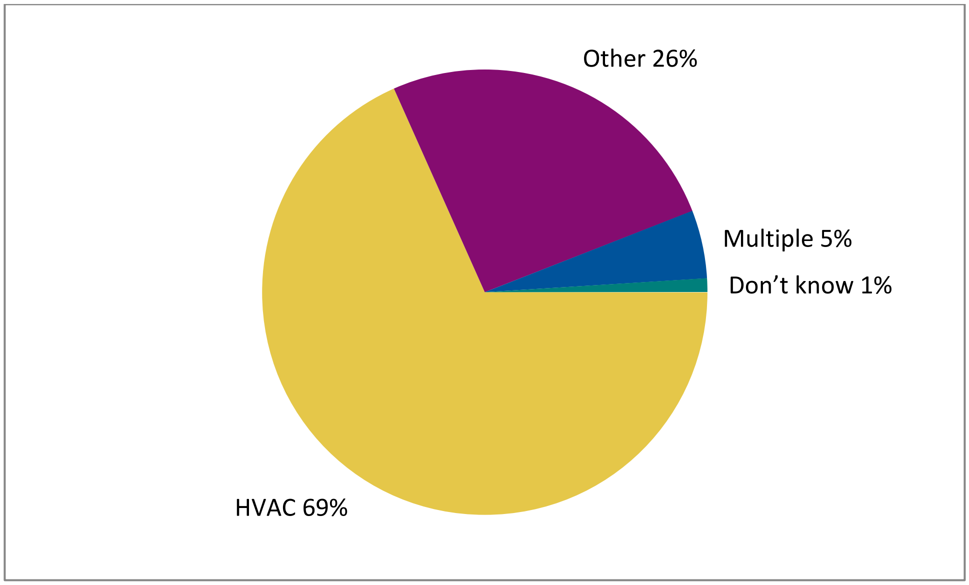
Figure 5-4. Type of Energy Efficiency Improvements Implemented with Technical/Financial Assistance from BED (N=21)



*All BED respondents are also VT Gas customers. The results represent both areas together.
Source: Telephone Survey, Question EE6

Most customers (69%) that participated in VT Gas programs implemented HVAC measures, as shown in Figure 5-5. Nearly one-quarter (26%) indicated they implemented "other" measures, though analysis of the open-ended responses suggests most of these were HVAC-related measures.

Figure 5-5. Type of Energy Efficiency Improvements Implemented with Technical/Financial Assistance from VT Gas (N=26)



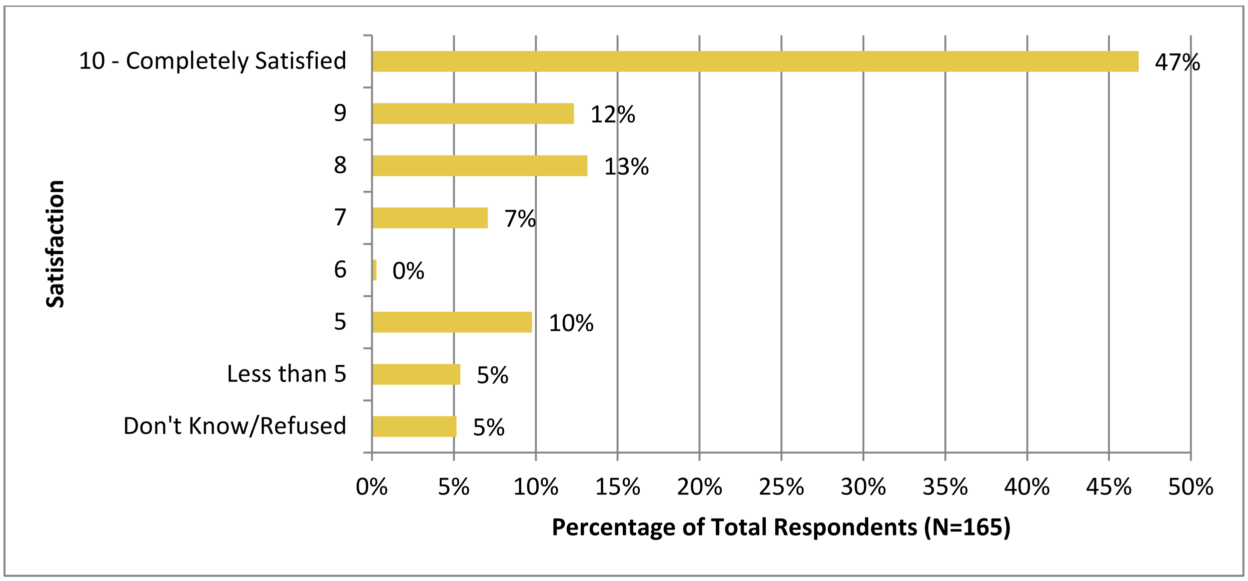
Source: Telephone Survey, Question EE6

5.2 *EEU Satisfaction*

5.2.1 Satisfaction with EVT Services

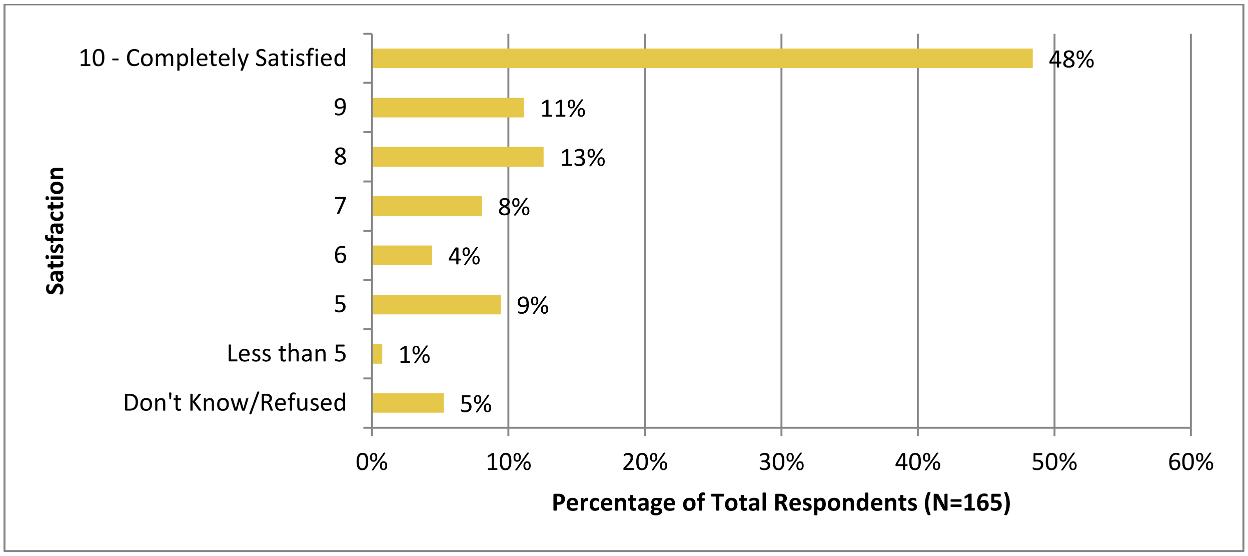
Figure 5-6 through Figure 5-11 provide customer satisfaction ratings related to energy efficiency services provided by EVT. The majority of customers are highly satisfied with the equipment, services, ease of participation, and the quality of measures provided by EVT. Ratings are typically clustered between scores of eight and ten, where ten is completely satisfied. Slightly lower scores were reported for the time taken to process the application and issue the incentive payment, and similarly for the level of incentive provided.

Figure 5-6. Overall Satisfaction with Energy Efficient Equipment and Services Offered by EVT



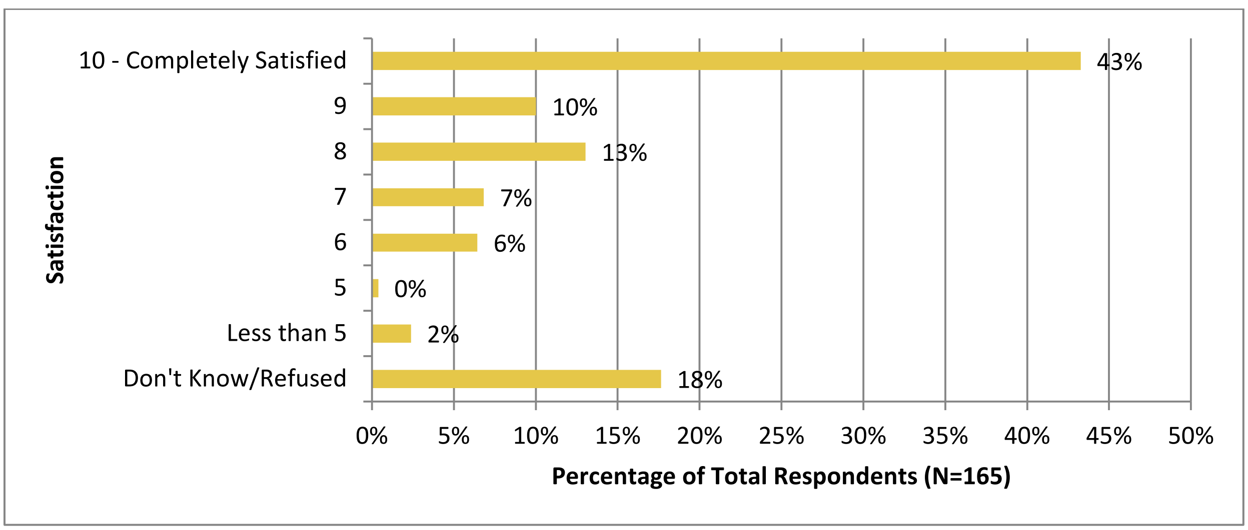
Source: Telephone Survey, Question EE7

Figure 5-7. Overall Satisfaction with Ease of Participation for EVT



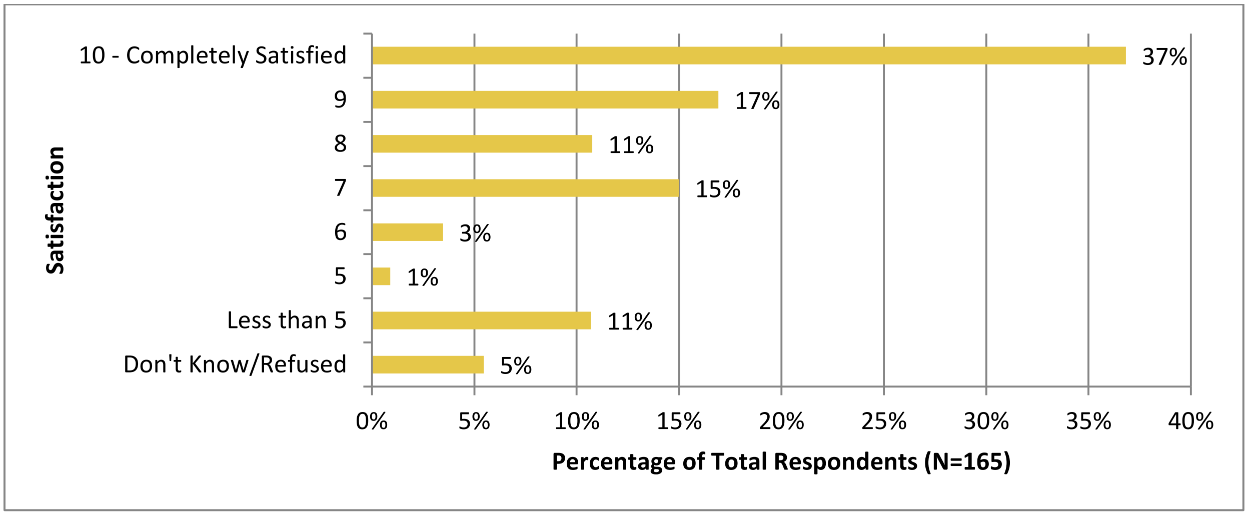
Source: Telephone Survey, Question EE7

Figure 5-8. Overall Satisfaction with Quality of Measures by EVT



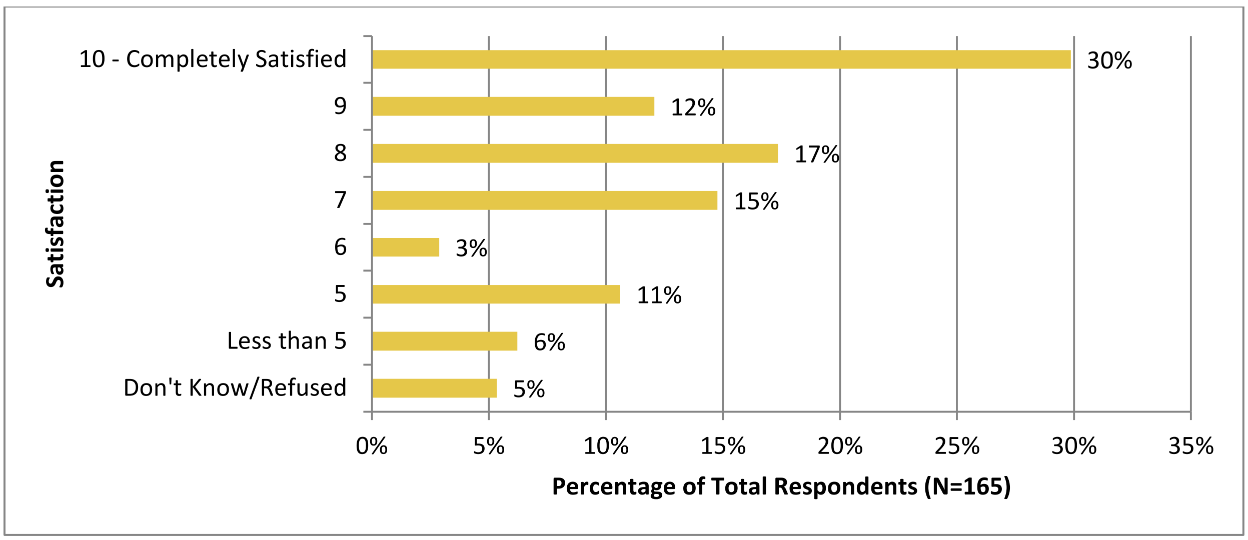
Source: Telephone Survey, Question EE7

Figure 5-9. Overall Satisfaction with Time It Took from Application through Receipt of Incentive for EVT



Source: Telephone Survey, Question EE7

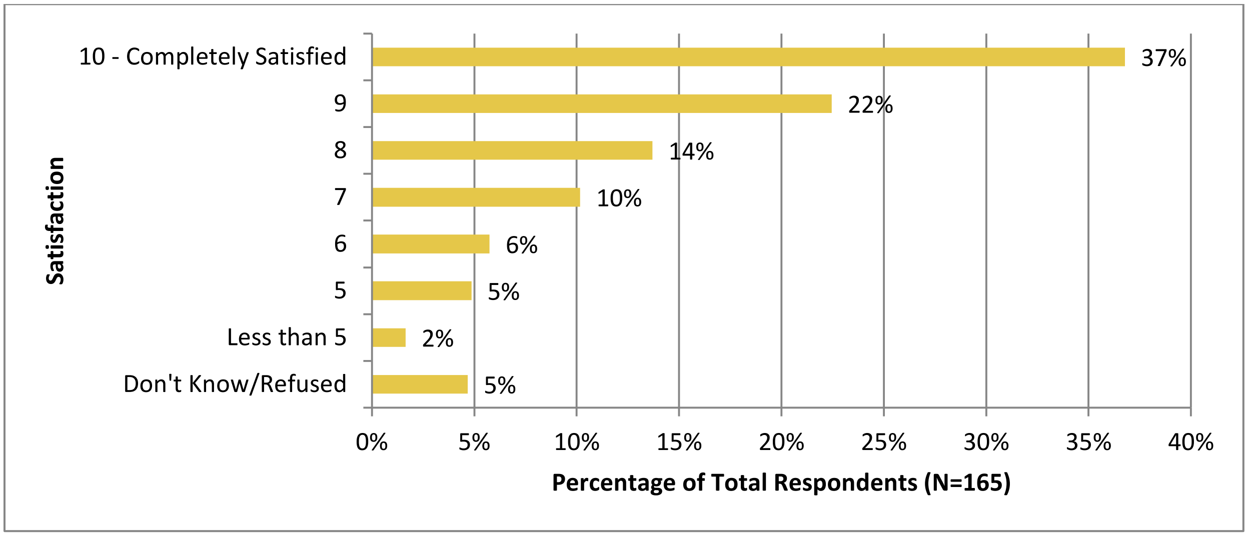
Figure 5-10. Overall Satisfaction with EVT's Level of Incentive for Equipment Installed



Source: Telephone Survey, Question EE7

Figure 5-11 shows that nearly three-quarters of customers in EVT territory rated their overall satisfaction with EVT's programs at an eight or above, with 37% indicating they were completely satisfied.

Figure 5-11. Satisfaction with Overall EVT Program(s)



Source: Telephone Survey, Question EE7

Table 5-2 shows satisfaction with EVT programs by building type and consumption stratum. The results do not vary significantly from the aggregated responses, however, over half (52%) of the retail customers were completely satisfied with the programs. Customers in the office building category tended to provide more slightly lower ratings of seven and six for overall satisfaction.

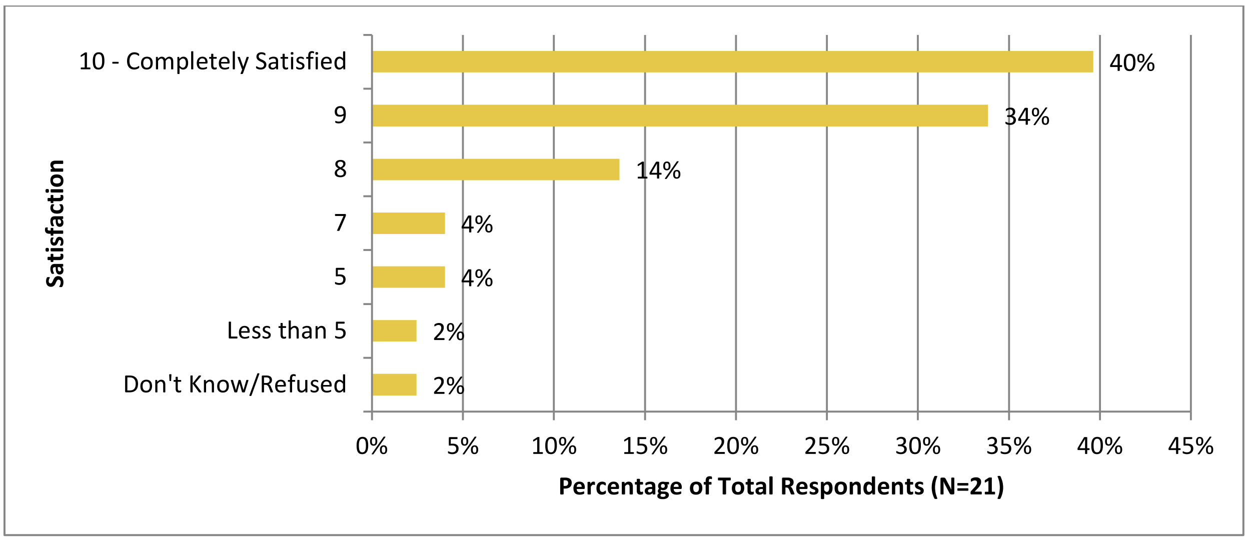
Table 5-2. Satisfaction with Overall EVT Program(s) by Consumption Stratum and Building Type

Satisfaction Rating	10 - Completely Satisfied	9	8	7	6	5	Less than 5	Don't Know/Refused
All Buildings (N=165)	37%	22%	14%	10%	6%	5%	2%	5%
Building Type								
Retail (N=14)	52%	28%	0%	8%	2%	11%	0%	0%
Office (N=19)	23%	35%	1%	15%	17%	9%	0%	0%
Manufacturing (N=43)	22%	53%	6%	0%	3%	1%	11%	4%
Balance of Commercial (N=89)	42%	12%	23%	10%	2%	2%	1%	8%
Consumption Stratum								
High Use (N=90)	32%	20%	29%	5%	9%	4%	2%	0%
Medium Use (N=44)	37%	16%	13%	13%	7%	0%	11%	2%
Low Use (N=31)	37%	24%	13%	10%	5%	6%	0%	5%
Source: Telephone Survey, Question EE7								

5.2.2 Satisfaction for BED Services

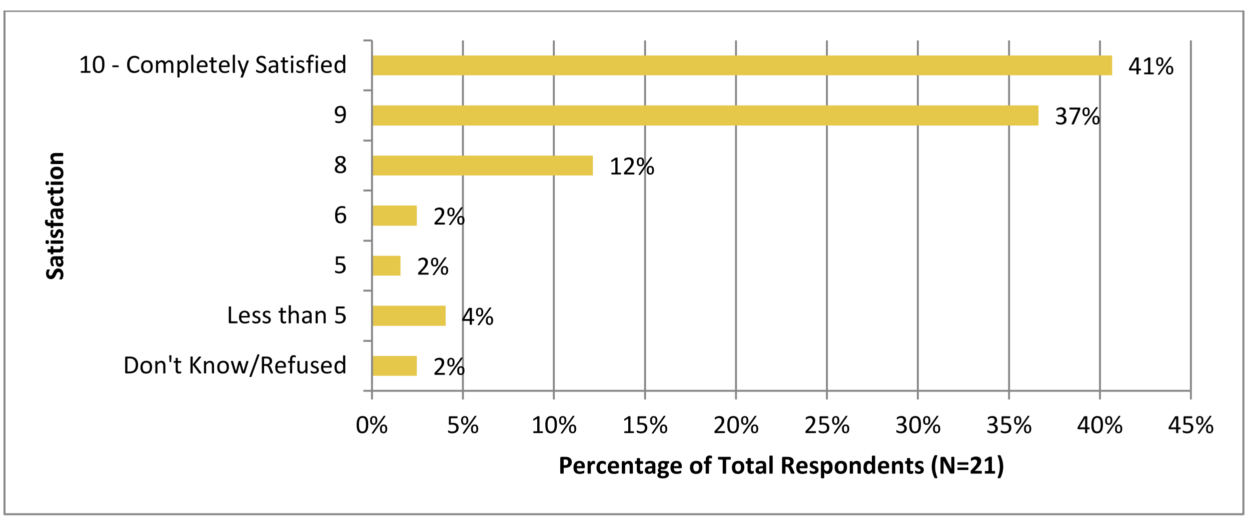
Figure 5-12 through Figure 5-17 provide customer satisfaction ratings related to energy efficiency services provided by BED. The majority of customers are highly satisfied with the equipment, services, ease of participation, quality of measures, and level of incentive provided by BED. Ratings are typically clustered between scores of eight and ten, where ten is completely satisfied. Slightly lower scores were reported for the time taken to process the application and issue the incentive payment, with 37% of customers providing a lower score of six for this area.

Figure 5-12. Overall Satisfaction with Energy Efficient Equipment and Services Offered by BED



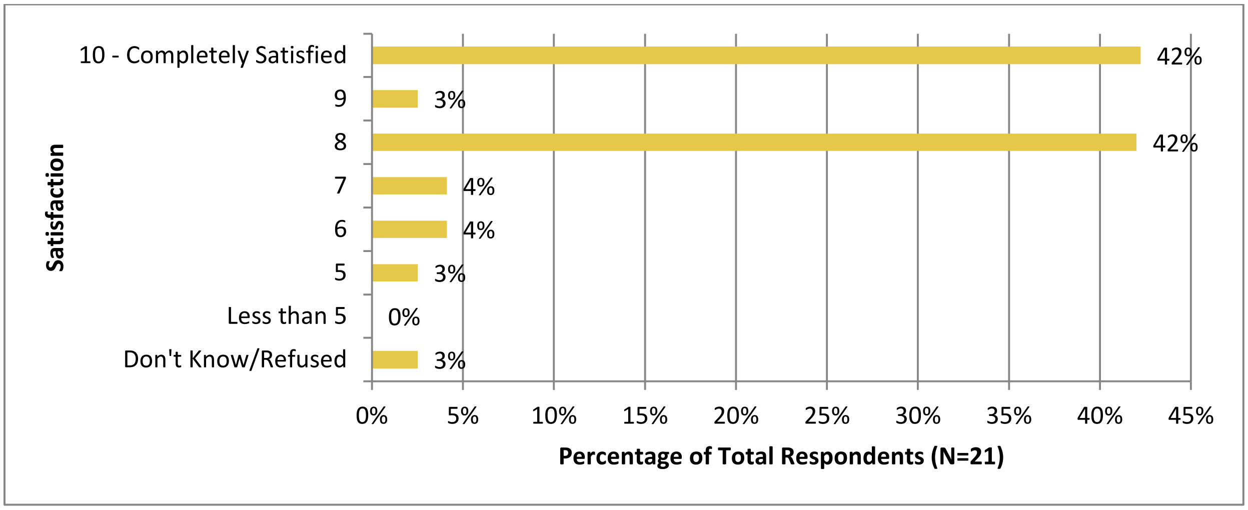
Source: Telephone Survey, Question EE7

Figure 5-13. Overall Satisfaction with Ease of Participation for BED



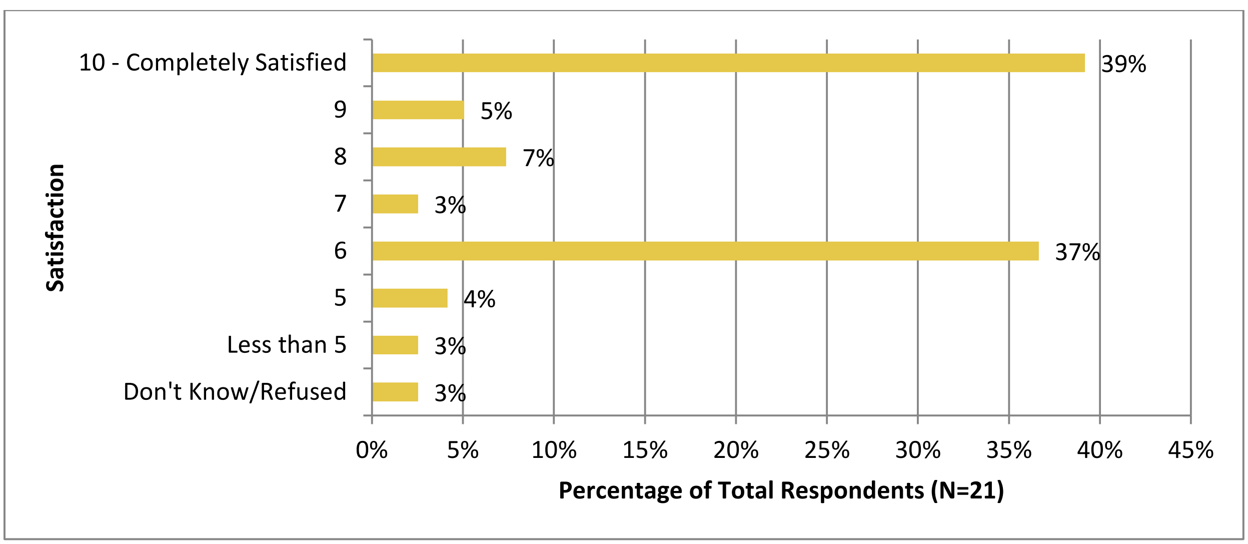
Source: Telephone Survey, Question EE7

Figure 5-14. Overall Satisfaction with Quality of Measures by BED



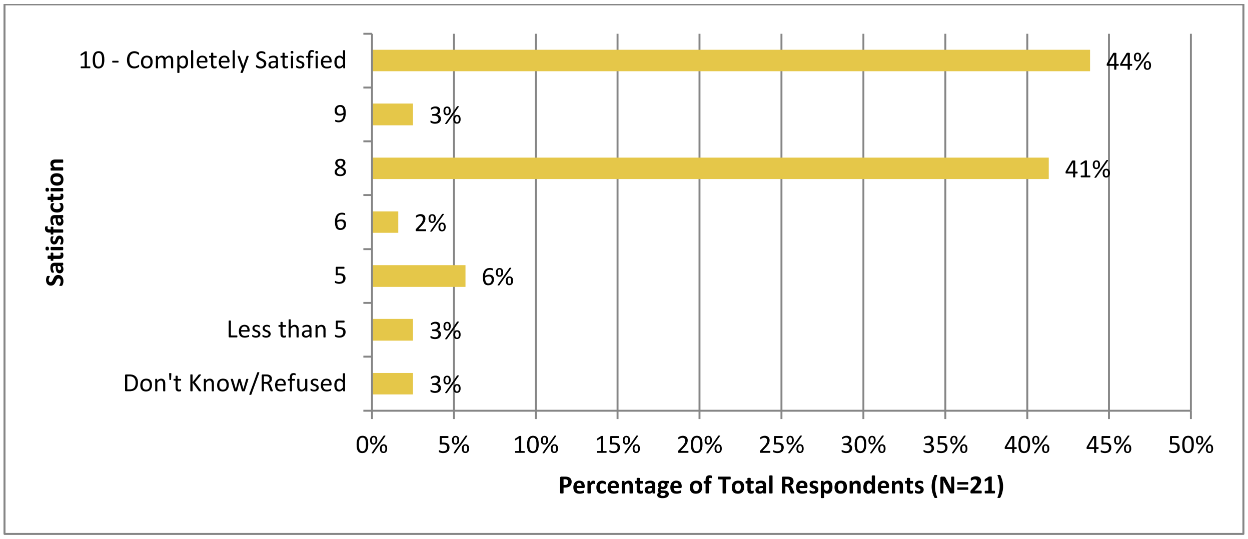
Source: Telephone Survey, Question EE7

Figure 5-15. Overall Satisfaction with Time It Took from Application through Receipt of Incentive for BED



Source: Telephone Survey, Question EE7

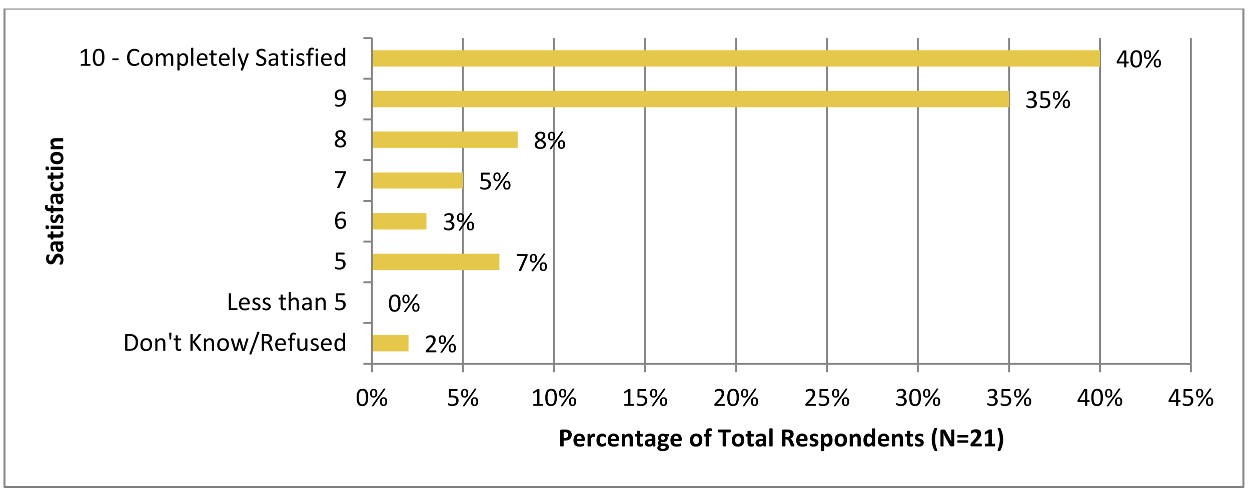
Figure 5-16. Overall Satisfaction with BED's Level of Incentive for Equipment Installed



Source: Telephone Survey, Question EE7

Figure 5-17 shows that three-quarters (75%) of customers in BED territory rated their overall satisfaction with BED's programs at a nine or above, with 40% indicating they were completely satisfied.

Figure 5-17. Overall Satisfaction with BED Program(s)



Source: Telephone Survey, Question EE7

Table 5-3 shows satisfaction with BED programs by consumption stratum. The results do not vary significantly from the aggregated responses, however, customers in the medium energy use stratum provided slightly lower satisfaction ratings than the other categories, with over one-quarter (27%) scoring overall satisfaction at a five out of ten.

Table 5-3. Satisfaction with BED's Program(s) by Consumption Stratum

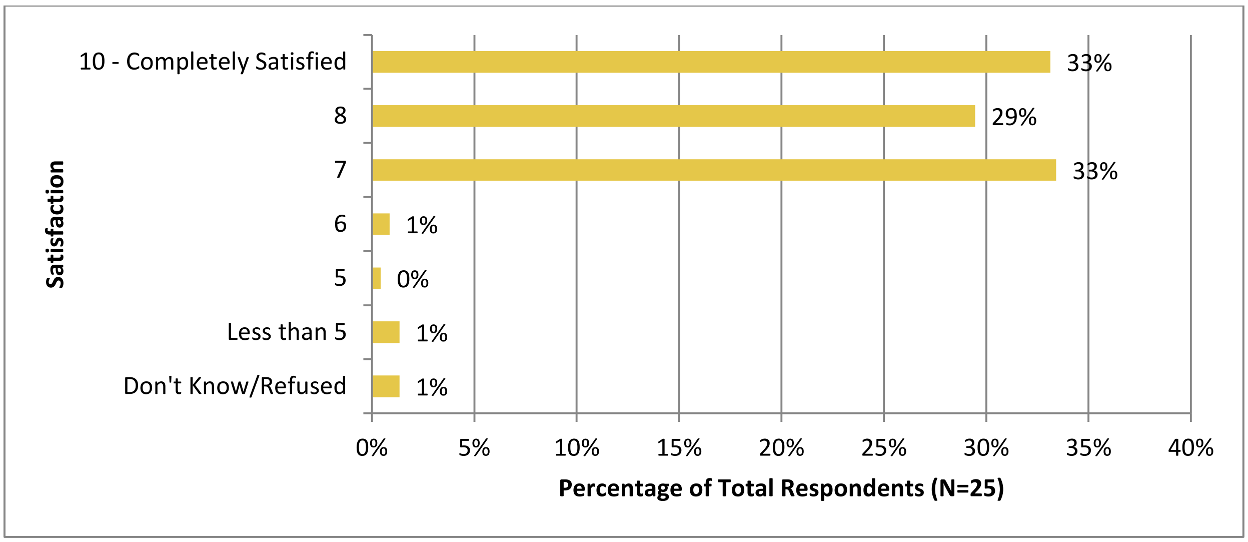
Satisfaction Rating	10 - Completely Satisfied	9	8	7	6	5	Less than 5	Don't Know/Refused
Overall (N=21)	40%	35%	8%	5%	3%	7%	0%	2%
Consumption Stratum								
High Use (N=8)	38%	13%	25%	0%	25%	0%	0%	0%
Medium Use (N=11)	18%	9%	18%	18%	0%	27%	0%	9%
Low Use (N=2)	50%	50%	0%	0%	0%	0%	0%	0%

*A breakout by building type is not provided, as sample sizes within BED territory by building type are too small to provide meaningful results.
Source: Telephone Survey, Question EE7

5.2.3 Satisfaction for VT Gas Services

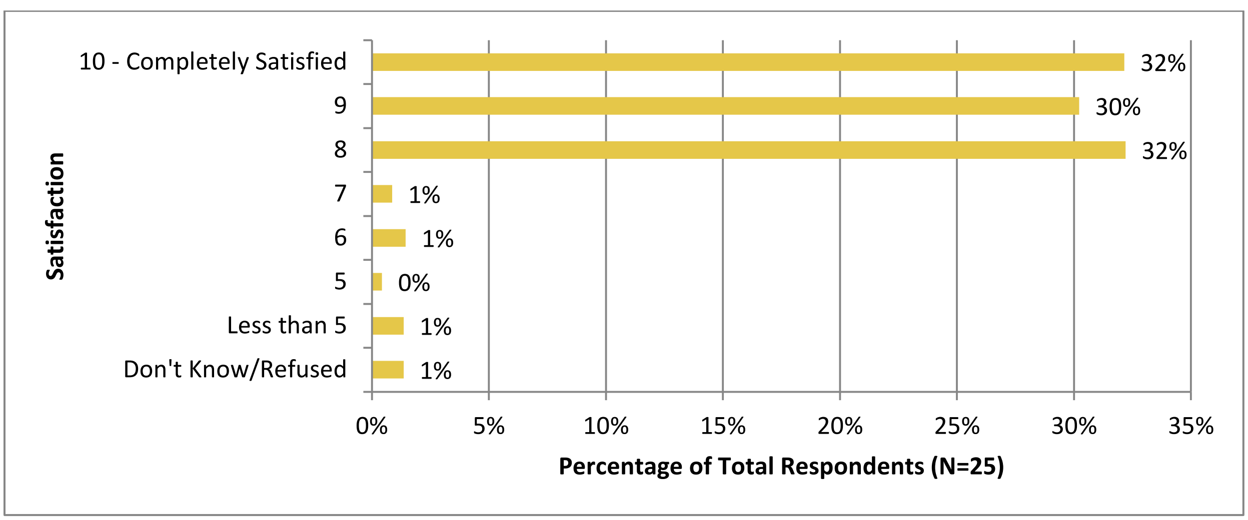
Figure 5-18 through Figure 5-23 provide customer satisfaction ratings related to energy efficiency services provided by VT Gas. The majority of customers are highly satisfied with the equipment, services, ease of participation, quality of measures, and time taken to process the application and issue the incentive payment. Ratings are typically clustered between scores of eight and ten, where ten is completely satisfied. Slightly lower scores were reported for the level of incentive payment, with 32% of customers providing a lower score of five out of ten for this area.

Figure 5-18. Overall Satisfaction with Energy Efficient Equipment and Services Offered by VT Gas



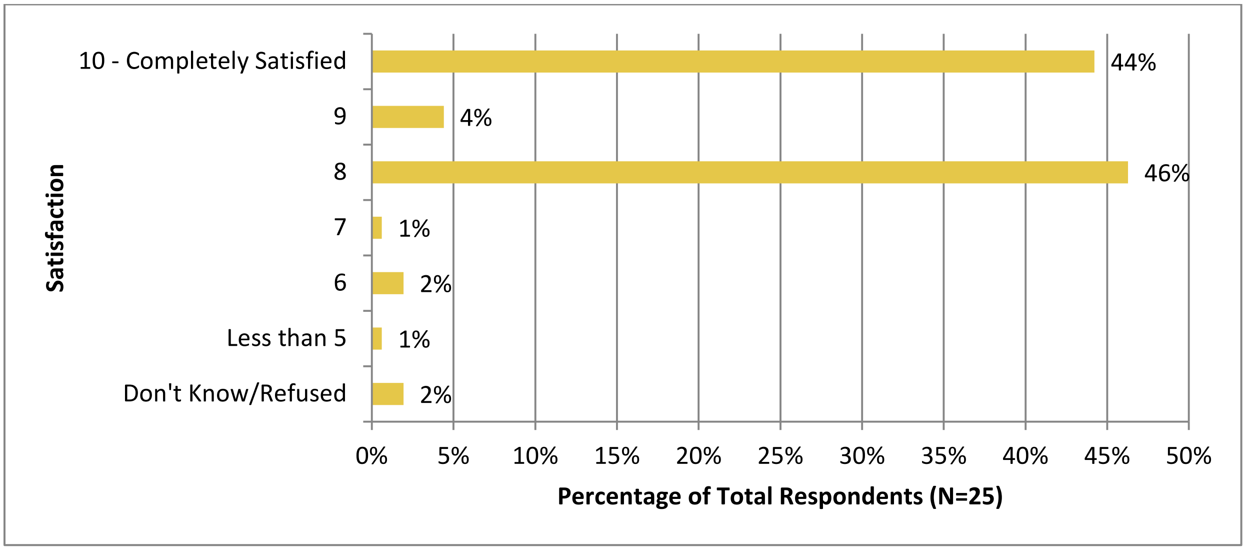
Source: Telephone Survey, Question EE7

Figure 5-19. Overall Satisfaction with Ease of Participation for VT Gas



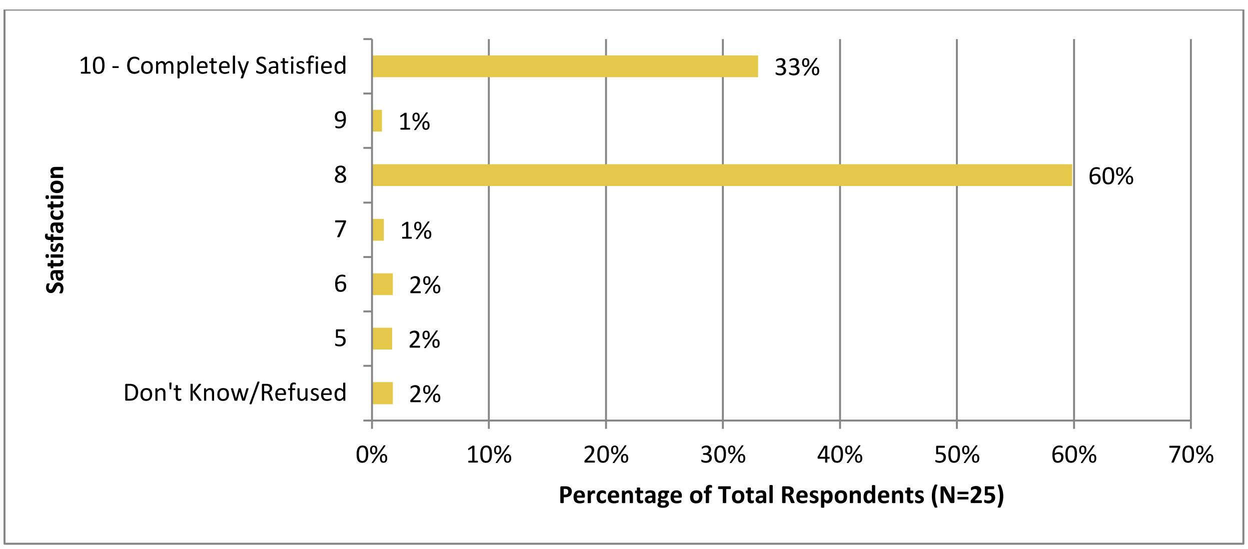
Source: Telephone Survey, Question EE7

Figure 5-20. Overall Satisfaction with Quality of Measures by VT Gas



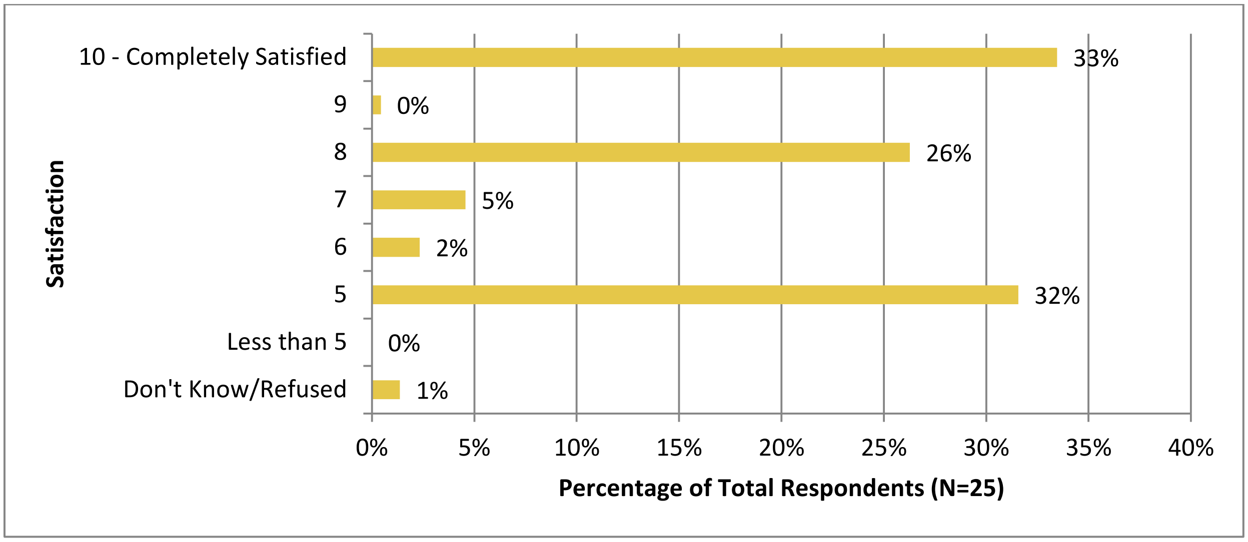
Source: Telephone Survey, Question EE7

Figure 5-21. Overall Satisfaction with Time It Took from Application through Receipt of Incentive by VT Gas



Source: Telephone Survey, Question EE7

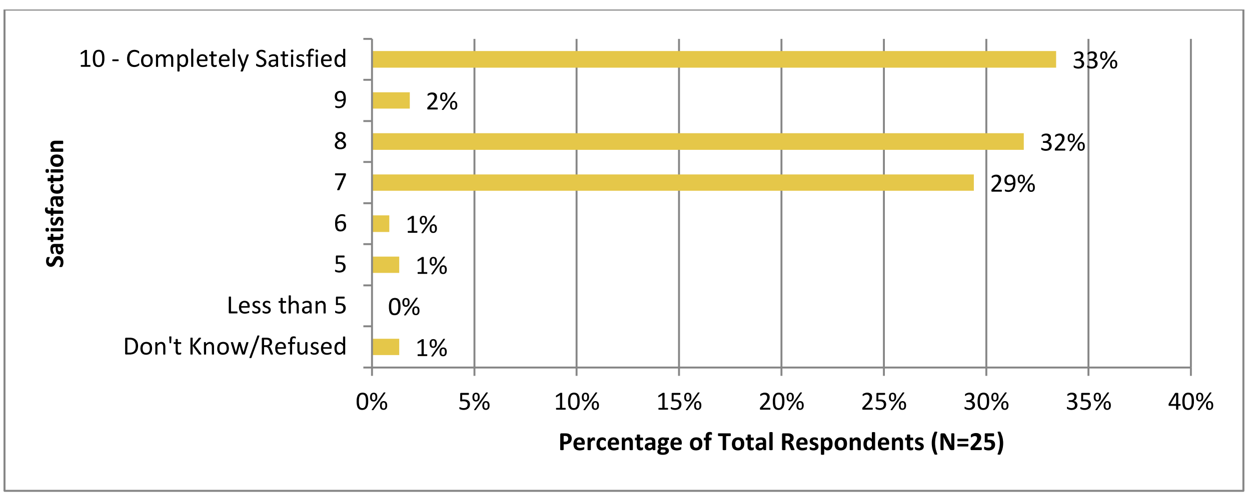
Figure 5-22. Overall Satisfaction with VT Gas' Level of Incentive for Equipment Installed



Source: Telephone Survey, Question EE7

Figure 5-23 shows that over 90% of customers in VT Gas service territory rated their overall satisfaction with VT Gas programs at seven or above, with 33% indicating they were completely satisfied.

Figure 5-23. Overall Satisfaction with VT Gas Program(s)



Source: Telephone Survey, Question EE7

Table 5-4 shows satisfaction with VT Gas programs by building type and consumption stratum. The results do not vary significantly from the aggregated responses, however, nearly one-third (34%) of the medium energy use customers provided overall satisfaction ratings of less than five out of ten.

Table 5-4. Satisfaction with Overall VT Gas Program(s) by Consumption Stratum and Building Type

Satisfaction Rating	10 - Completely Satisfied	9	8	7	6	5	Less than 5	Don't Know/Refused
Overall (N=25)	32%	2%	30%	28%	1%	1%	5%	1%
Building Type								
Retail (N=4)	45%	0%	0%	45%	1%	0%	9%	0%
Office (N=4)	3%	2%	94%	0%	0%	0%	0%	0%
Balance of Commercial (N=7)	25%	8%	43%	5%	3%	8%	0%	8%
Consumption Stratum								
High Use (N=14)	42%	22%	17%	10%	10%	0%	0%	0%
Medium Use (N=8)	9%	0%	40%	0%	0%	9%	34%	9%
Low Use (N=4)	35%	0%	30%	35%	0%	0%	0%	0%
Source: Telephone Survey, Question EE7								

Appendix A. Survey Instruments

[Included in separate document]

Appendix B. Remaining Potential – Qualitative Assessment

[Included in separate document]