NAVIGANT

2011 Vermont Market Characterization and Assessment Study

Business Sector (Commercial and Industrial) New Construction and Major Renovation 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 of newly-constructed buildings and major renovated spaces conducted during January 2012 to August 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 new construction/major renovations and existing buildings markets,[1] and building characteristics, and compliance with the 2005 Vermont Commercial Building Energy Standards (CBES).

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 106 Vermont businesses regarding new construction/major renovation; and personal interviews with seven market actors knowledgeable about energy management systems (EMS)
4. Sample and conduct on-site surveys and inspections of 58 newly-constructed or major renovation buildings and 120 existing facilities[2]
5. Tabulate results

The definition of new construction and major renovation utilized for this study is as follows:

1. Construction of a new building;
2. Construction of an addition of 500 square feet or more;
3. Major rehabilitation of an existing building. Major rehabilitation is defined as any of the following:
    a. stripping an existing building down to the building shell
    b. replacement of at least two complete or substantially complete building systems (HVAC, lighting, and/or building shell)
    c. Substantial reconfiguration of at least 5,000 square feet or at least 60% of the space with major system reconfiguration or replacement.

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[1] The existing buildings 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.

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 newly-constructed or major renovation building and equipment stock in the Vermont business sector and identifies missed 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 (within EVT areas). The study also assessed compliance with the Vermont commercial energy code in place at the time of construction or major renovation.

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

1. Characterizes the new construction/major renovation 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 missed opportunities in new construction/major renovation, as well as remaining potential in existing buildings for increased energy efficiency statewide and within discrete Energy Efficiency Utility jurisdictions, by estimating Vermont businesses' awareness of EEU DSM programs and major DSM measures.
3. Characterizes the state as a whole, as well as 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]

[3] The five areas: BED, EVT (including GT and non-GT subset areas) and VT Gas

1.2 *Organization of the Report*

The remainder of this report includes the following sections:

Section 1 – Introduction

Section 2 - Study Methodology

Section 3 – New Construction Commercial and Industrial Market Characterization

Section 4 – Assessment of CBES Compliance

Section 5 – Assessment of EEU Program Awareness and Participation

Section 6 - Assessment of Missed Opportunities

The report includes the following appendices in a separate document:

Appendix A – Survey Instruments

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. Navigant also conducted a telephone survey of market actors knowledgeable about energy management systems (EMS). The results of this survey informs opportunities for increased automation of energy-using equipment in the C&I sector.

Navigant utilized two primary sources of data to conduct the on-site visits and telephone surveys:

1. A list of all "projects" reported to the Vermont Department of Public Safety, Division of Fire Safety (DFS) from January 1, 2008 through November 22, 2011.
    a. These projects were submitted to the DFS by building owners and contractors to comply with permitting requirements.
    b. The list originally contained approximately 1,000 line items, representing projects from all over the state, including Burlington.
    c. Navigant screened the list to eliminate buildings that were duplicates, non-building projects, and not new construction or major renovations, based on the available data.
    d. The final sample from DFS contained 305 potential projects.

2. BED provided a list of new meter ID numbers connected with commercial accounts from January 1, 2008 through December 31, 2011.
    a. The original list contained 78 line items.
    b. Navigant screened the list and eliminated buildings that were duplicates, non-building projects, and not new construction or major renovations, based on the available data.
    c. The final BED sample contained 40 projects.

2.2 Sampling Approach

The on-site survey and telephone survey samples were designed to represent a broad cross section of Vermont businesses. Navigant utilized the project data from the Vermont DFS and BED to characterize the population according to certain variables. The following sections show the resulting sample design.

2.2.1 New Construction/Major Renovation Buildings On-Site Surveys

The Navigant team targeted and completed on-site surveys at 58 newly-constructed/major renovation building sites, within five areas: 12 in BED, 46 in EVT (10 in GT areas and 36 in non-GT areas) and 24 in Vermont Gas areas. This number of surveys is sufficient to provide statistical confidence of 80% and +/- 16% precision or margin of error (80/16) 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 level of statistical confidence and precision is required by Independent System Operator New England (ISO NE) for verification of demand response (DR) resource savings.[4]

Table 2-1 for the new construction/major renovations buildings portion of the study and shows the distribution of completed sites across the five sample areas.

Table 2-1. Summary of Completed Site Visits by Area

Area[a]	Estimated Population[b]	Number of Completed Sites	Ratio (Completed to Population)
BED	60	12	20%
EVT	285	46	16%
Total	**345**	**58**	**17%**
VT Gas	140	24	17%
GT-Areas	77	10	13%
Non-GT Areas	208	36	17%

a. BED and EVT are mutually exclusive. VT Gas territory overlaps all areas, and GT and non-GT are distinct subsets within EVT.
b. Population estimates based on sample provided by Vermont Division of Fire Safety (DFS) and BED. Navigant screened the original DFS list (~1,000 "line-items") to eliminate buildings that were duplicates, non-building projects, and not new construction or major renovations, based on the available data.
Source: Navigant on-site surveys

Due to the limited sample size, Navigant aimed to complete as many on-sites as possible within budget and time constraints. The Division of Fire Safety sample data did not contain consistent site characteristics that could be used to create a robust description of the population and sample. For example, some projects contained data such as square footage (though it was unclear whether it was only for renovation or whole building, etc.), cost of project and occupancy classification. Not all projects contained these data points, and projects also had no unique identifier to correlate back to utility

[4] 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/.

accounts and/or energy use data.[5] Additionally, the data from BED did not contain the same data points as found in the DFS sample, such as occupancy classification, square footage or cost of the project.

Navigant researched available information such as business name and location, or SIC code where available (in the BED data) in order to estimate the building type for each project. Table 2-2 shows the estimated population and number of completed site visits by building type. Within this study, Navigant reports the results of eight individual building types. All other building type categories are consolidated into the *balance of commercial and industrial (C&I)* category. The new construction/major renovation sample is not weighted to this estimated population because of the lack of consistent data and the resulting lack of certainty in the population characteristics.

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

Building Type	Building Type for Reporting Purposes	Estimated Population	Number of Completed Sites	Percent of Total Completed Sample[a]
Retail	-	60	10	21%
Office	-	59	8	11%
College/University	-	30	4	9%
Warehouse	-	22	4	10%
Healthcare	-	21	7	7%
Restaurant	-	16	3	7%
Public Assembly	-	12	3	4%
School	-	6	3	7%
Other[b]	Balance of C&I	55	6	5%
Services	Balance of C&I	16	2	5%
Multifamily	Balance of C&I	14	2	3%
Manufacturing	Balance of C&I	13	2	2%
Lodging	Balance of C&I	10	2	3%
Food Store	Balance of C&I	8	1	1%
Ski Resort	Balance of C&I	3	1	7%
Total		**345**	**58**	**100%**

a. Total may not add up to 100% due to rounding
b. "Other" includes (2) recreational camp facilities, (1) wastewater treatment facility, (1) fire station, (1) miscellaneous transportation building and (1) museum
Source: Navigant on-site surveys

[5] Additionally, some projects did not have valid addresses and many had no valid business or building name (due to the nature of a new construction project).

Table 2-3 shows that 40 (70%) of the 58 completed on-site surveys were performed in new construction buildings, while the remaining 18 (30%) were in buildings that had undergone major renovations.

Table 2-3. Summary of Completed On-Site Surveys by New Construction or Major Renovation

Construction Category[a]	All Sites	BED	EVT	VT Gas
New Construction	40	2	38	12
Major Renovation	18	10	8	12
Total	**58**	**12**	**46**	**24**

a. Since January 1, 2008
Source: Navigant on-site surveys

2.2.2 New Construction/Major Renovation Telephone Surveys

The Navigant team conducted telephone surveys with 106 customers as shown in Table 2-4. This number of surveys was sufficient for results with statistical confidence of 90% and +/- 10% precision or margin of error.

Table 2-4. Summary of Telephone Surveys by Area

Area[a]	Estimated Population[b]	Number of Completed Telephone Surveys	Ratio (Completed to Population)
BED	60	16	27%
EVT	285	95	33%
Total	**345**	**111**	**32%**
VT Gas	140	31	22%
GT-Areas	77	31	40%
Non-GT Areas	208	59	28%

a. BED and EVT are mutually exclusive. VT Gas territory overlaps all areas, and GT and non-GT are distinct subsets within EVT.
b. Population estimates based on sample provided by Vermont Division of Fire Safety
Source: Navigant on-site surveys

Table 2-5 shows that 68 (60%) of the 111 completed telephone surveys were conducted for facilities that had undergone major renovations, while the remaining 43 (40%) were for new construction buildings. It is important to note that Section 3.7 (Cross-Cutting C&I Market Insights) presents the results of the telephone survey for new construction and major renovation buildings separately. Therefore, there is no issue with aggregate survey results distorted by the dominance of major renovation as compared to new construction facilities.

Table 2-5. Summary of Completed Telephone Surveys by New Construction or Major Renovation

Construction Category[a]	All Sites	BED	EVT	VT Gas
New Construction	43	3	40	15
Major Renovation	68	13	55	32
Total	**111**	**16**	**95**	**47**

a. Since January 1, 2008
Source: Navigant on-site surveys

2.2.3 Final Reporting Segments

Navigant presents the results of this baseline study according to designated reporting segments, illustrated in Table 2-6. Sample area categories encompassed each unique combination of EEU service territory, ensuring broad representation for reporting EEU and statewide results. As shown in Table 2-6, certain reporting segments are mutually exclusive (i.e., BED and EVT) while others overlap (i.e., VT Gas).

Table 2-6. 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

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. The Navigant team contacted customers to schedule on-site visits and telephone surveys in two separate efforts. Navigant conducted the on-site scheduling calls in late 2011 and early 2012, and completed the telephone survey calls in summer 2012. The response rates shown in the following sections are therefore mutually exclusive, and customers that participated in the on-site visits may or may not have also participated in a telephone survey.

2.3.1 On-Site Surveys

Professionally trained surveyors surveyed the sites of 58 new construction/major renovation Vermont businesses that were randomly recruited by telephone. 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 2-7 shows the response rate for scheduling the on-site surveys. The scheduling team attempted to contact 41% of the sample, with 6% refusing to participate and 17% successfully scheduling a site visit.

Table 2-7. New Construction/Major Renovation On-Site Survey Response Rates

	Total Counts	Percentage
Total Sample	345	
Total Customers Dialed	142	41%
Total Customers Reached	80	23%
Refused	22	6%
Completed	58	17%

Source: On-site survey scheduling disposition

2.3.2 Telephone Surveys

Telephone surveys were conducted with 106 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 for new construction and major renovation customers focused on background and decisions related to their project.

The telephone survey instrument designed for this study allowed the surveyor to qualify a customer as one of the following:

» Existing building,
» Major renovation since 2008,
» New construction (includes addition) since 2008,or
» Both new construction and major renovation (since 2008)

The first round of phone surveys, in late 2011, was aimed at completing existing building surveys. However, 54 customers had qualifying major renovation projects and were thus able to complete the stand-alone section related to their renovation project (in addition to the general sections for all customers). Additionally, five customers were qualifying new construction (NC) customers and completed the stand-alone new construction portion of the survey (also in addition to the general sections for all customers).

In 2012, Navigant conducted a second round of telephone surveys, using the sample provided by the VT DFS, and completed an additional 52 surveys, with 36 new construction, 13 major renovation and three completes for customers with both new construction and renovation. Table 2-8 shows the breakdown of new construction and major renovation survey responses from each round of survey efforts. Navigant consolidated the responses from these customers for the new construction/major renovation market characterization.

Table 2-8. Summary of Completed Telephone Surveys

	First Round Responses (EB)	Second Round Responses (NC)	Total Completed Surveys
Renovation Only	54	13	67
New Construction Only	5	36	41
Both New Construction and Renovation	0	3	3
Total Sample	59	52	111

Source: Navigant telephone surveys

Table 2-9shows the response rates for the new construction/major renovation telephone survey.

Table 2-9. New Construction/Major Renovation Telephone Survey Response Rates (Second Round)[a]

	Total Counts[b]	Percentage
Total Sample	345	
Total Customers Dialed	345	100%
Total Customers Reached	95	28%
Refused	43	12%
Completed	52	15%

a. Results of the second round of phone surveys conducted in 2012, focused only on securing new construction and major renovation surveys.
b. The response rates for the telephone survey are mutually exclusive from the on-site scheduling effort. Customers that participated in the on-site visits may or may not have also participated in a telephone survey.
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. New Construction Commercial and Industrial Market Characterization

This chapter presents the results for C&I new construction/major renovation buildings in the following segments:

» Results for "All NC Buildings," representing the full sample of new construction/major renovation facilities, not weighted to a larger population
» Nine building types (Retail, Office, College/University, Warehouse, Healthcare, Restaurant, Public Assembly, School, and Balance of C&I)
» 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 January and August of 2012 and telephone surveys conducted over two separate efforts, with the first between September and November of 2011and the second between July and August of 2012.

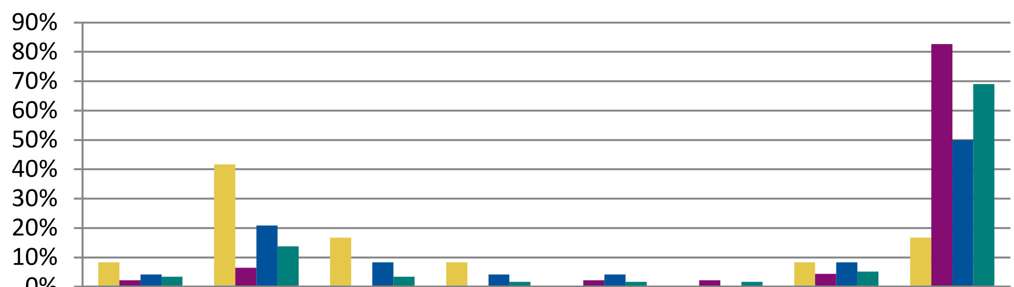
3.1 *General Building Information*

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.

Facility Age

Figure 3-1 shows the distribution of building construction year by EEU territory. Most buildings (69%) were newly constructed facilities built since January 1, 2008, and the remaining buildings consisted of major renovations on facilities of varying ages. BED has the highest share of renovated buildings, with 75% of the qualifying facilities built before 2008. Most (83%) of the buildings in EVT areas and half (50%) of VT Gas facilities were constructed since 2008.

Figure 3-1. Year of Building Construction by EEU (N = 58)



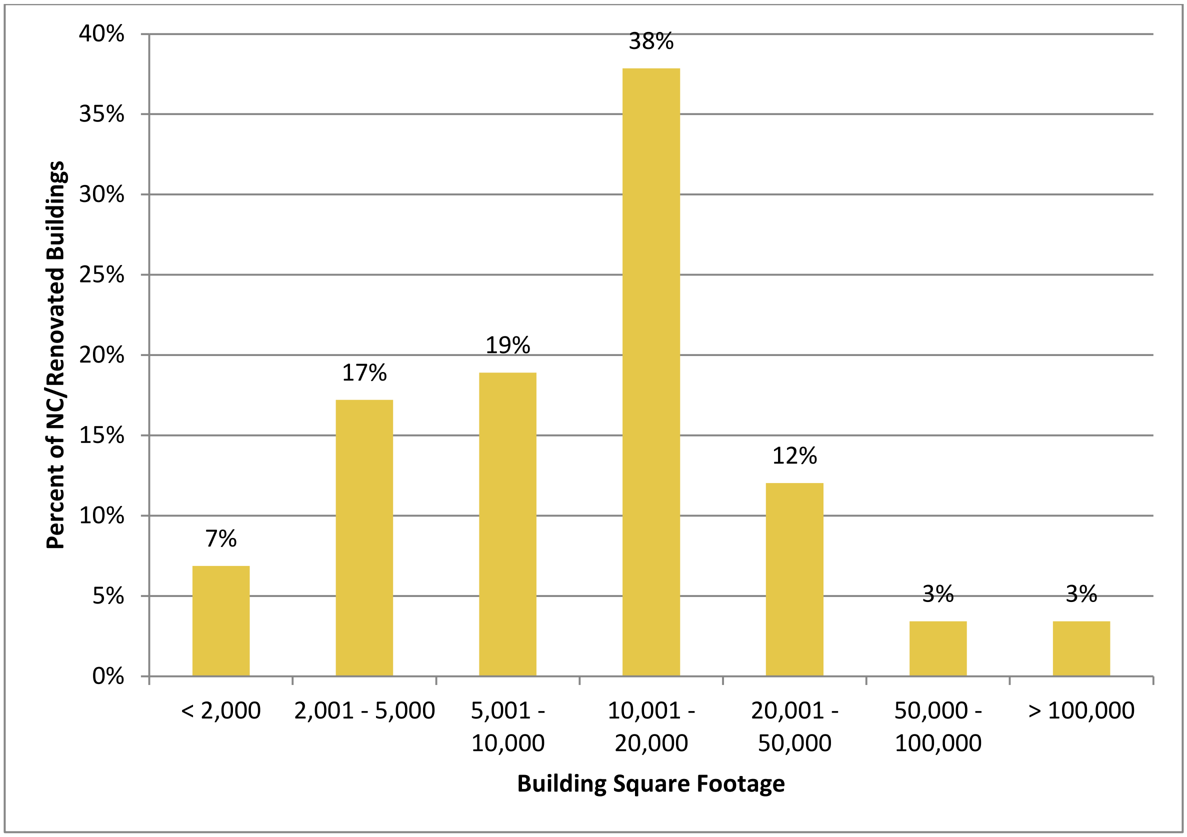
	Unknown	Before 1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2007	2008-2011
BED (N=12)	8%	42%	17%	8%	0%	0%	8%	17%
EVT (N=46)	2%	7%	0%	0%	2%	2%	4%	83%
VT Gas (N=24)	4%	21%	8%	4%	4%	0%	8%	50%
All NC Buildings (N=58)	3%	14%	3%	2%	2%	2%	5%	69%

Source: On-Site Survey, Question 7

3.1.1 Building Size

Approximately 40% of Vermont's new and renovated buildings are between 10,000 and 20,000 square feet (SF)[6] in size, and 43% of the facilities are less than 10,000 SF. Approximately three percent of all buildings are greater than 50,000 SF but less than 100,000 SF, and an additional three percent are greater than 100,000 SF, as shown in Figure 3-2.

Figure 3-2. Total Square Footage for All Buildings (N = 58)



Source: On-Site Survey, Question 8

[6] Square footage does not include parking garages. For renovated buildings, square footage refers only to the total area included in the renovation.

Table 3-1 shows building square footage by EEU. The average size of al NC buildings is approximately 29,000 SF while the median size is approximately 11,000 SF. The distribution of buildings by size is very similar across all EEUs.

Table 3-1. Total Square Footage by EEU

Building Square Footage[a]	EEU			All Buildings (N=58)
	BED (N=12)	EVT (N=46)	VT Gas (N=24)	
< 2000	8%	7%	4%	7%
2,001 - 5,000	8%	20%	8%	17%
5,001 - 10,000	0%	24%	13%	19%
10,001 - 20,000	58%	33%	50%	38%
20,001 - 50,000	17%	11%	17%	12%
50,000 - 100,000	0%	4%	4%	3%
> 100,000	8%	2%	4%	3%
Total[b]	**100%**	**100%**	**100%**	**100%**
Mean	**22,766**	**30,346**	**21,749**	**28,778**
Median	**11,000**	**10,000**	**13,000**	**11,000**

a. Does not include parking garages. For renovated buildings, square footage refers only to the total area included in the renovation.

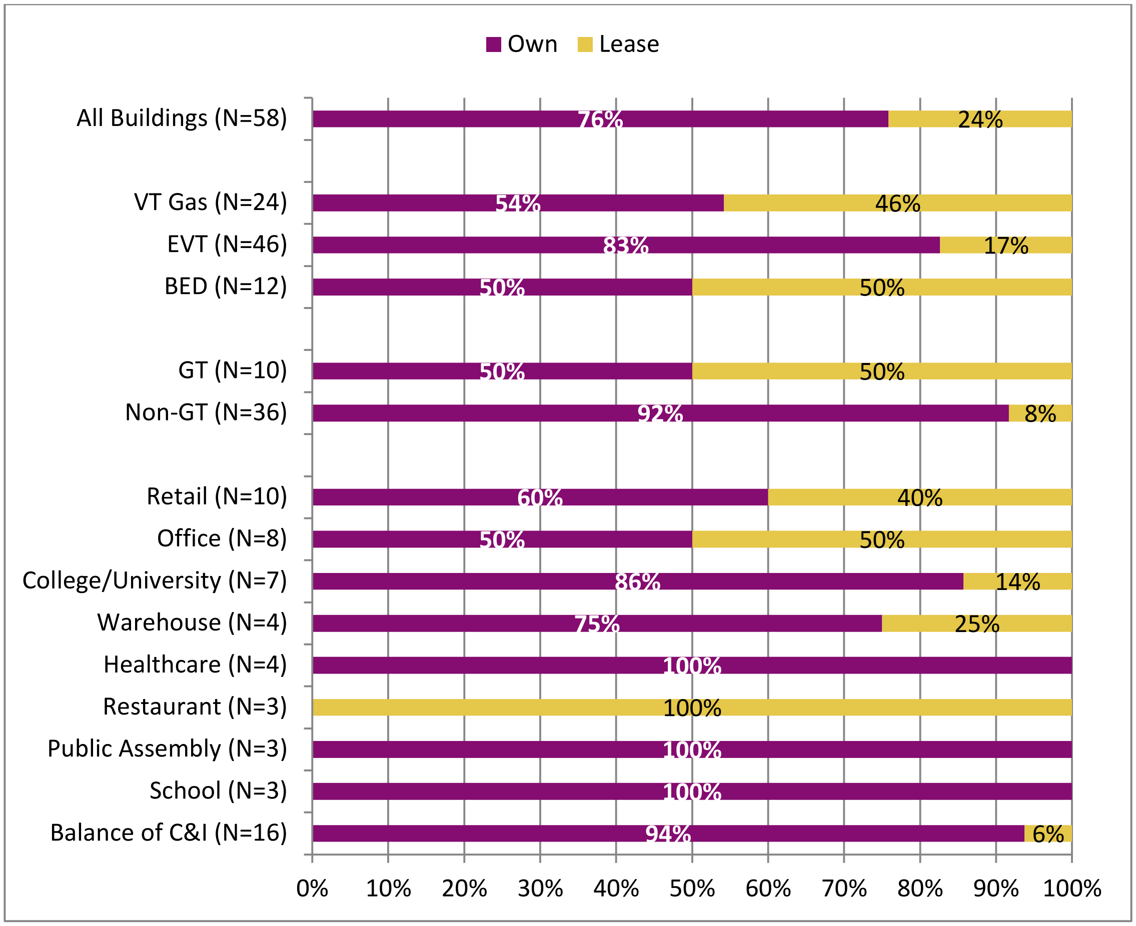
b. Totals may not add to 100% due to rounding.

Source: On-Site Survey, Question 8

3.1.2 Facility Ownership

The majority of C&I customers in NC buildings (76%) own their buildings. Figure 3-3 illustrates that the BED service area is distinct from the rest of the state, with 50% owning buildings and the 50% leasing. Additionally, half of the facilities in GT areas are owned and half are leased, compared to an ownership rate of 92% in non-GT areas.

Figure 3-3. Facility Ownership (N = 58)



Source: On-Site Survey, Question 4

3.1.3 Business Information

The average (mean) number of full-time equivalent (FTE) employees in Vermont's NC facilities is 28, while the median number of FTEs is nine, as shown in Table 3-2.

Table 3-2. Full-Time Equivalent Employees

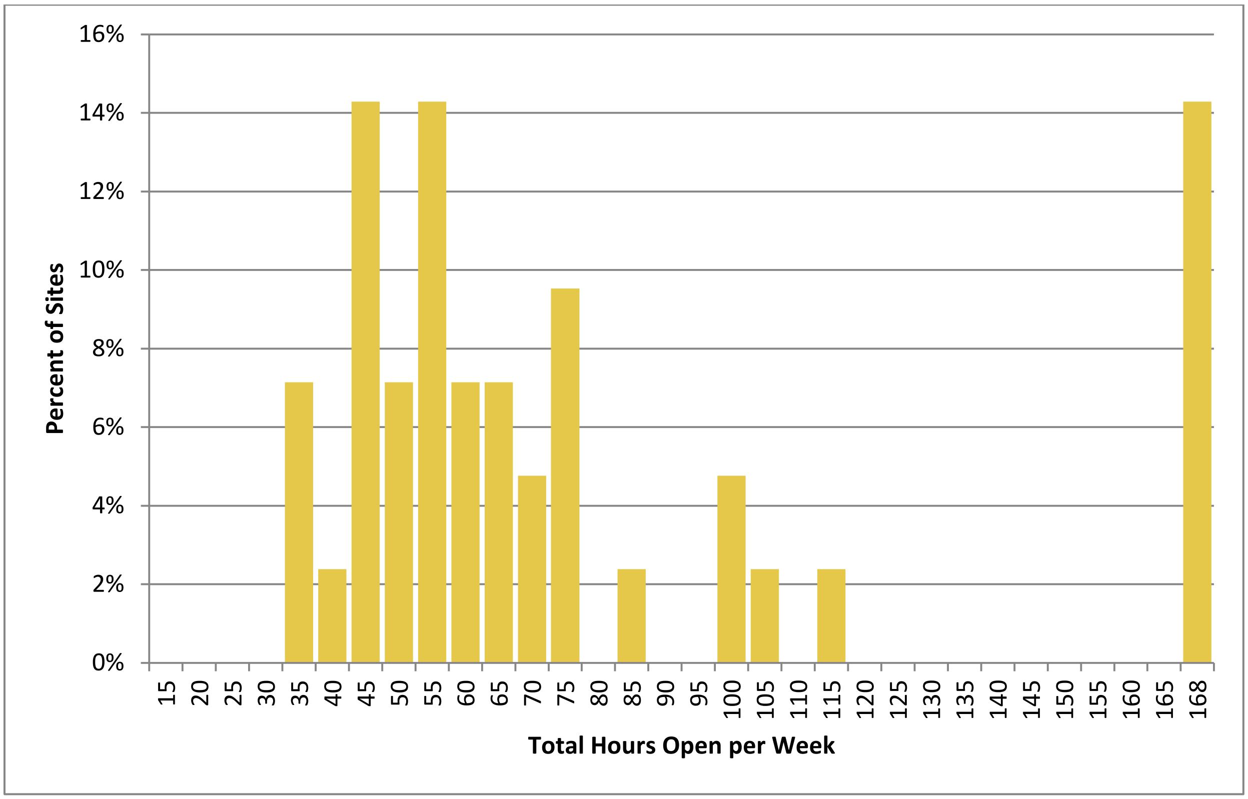
Category	Mean FTEs	Median FTEs
All Buildings (N=51)	28	9
BED (N=11)	17	9
EVT (N=40)	31	9
VT Gas (N=21)	36	11
GT (N=9)	59	10
Non-GT (N=31)	23	6
Retail (N=9)	18	9
Office (N=6)	22	17
College/University (N=5)	26	20
Warehouse (N=4)	5	4
Healthcare (N=4)	100	7
Restaurant (N=3)	19	12
Public Assembly (N=3)	3	2
School (N=3)	17	17
Balance of C&I (N=14)	34	4

Source: On-Site Survey, Question 5

3.1.4 Business Hours

Figure 3-4 shows the distribution of open hours for C&I NC buildings in Vermont. Approximately 64% of buildings are open between 45-75 hours per week, and approximately 14% of all businesses are always open (24/7).

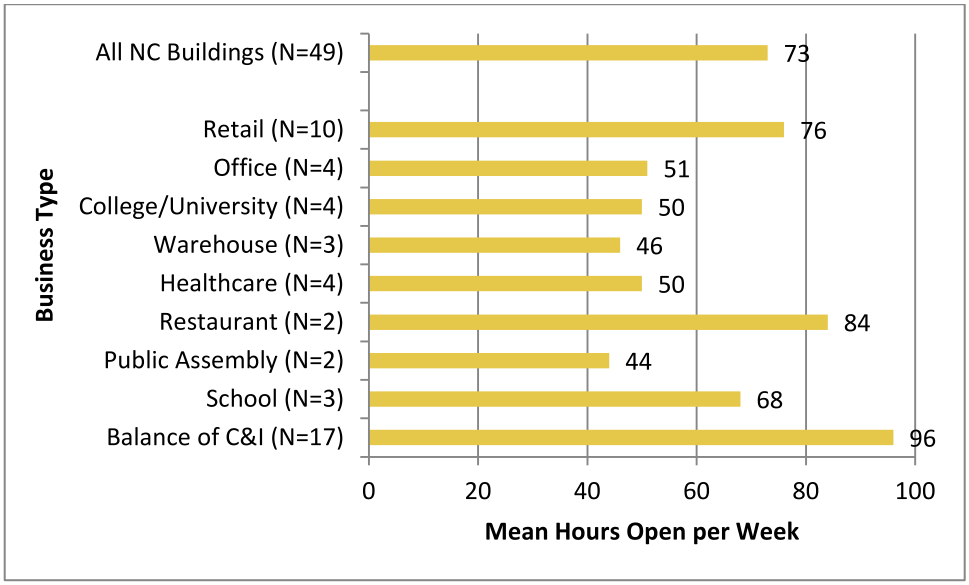
Figure 3-4. Distribution of Weekly Open Hours for All Buildings (N =49)



Source: On-Site Survey, Questions 22-29

Vermont NC businesses are open an average of 73 hours per week, as shown in Figure 3-5. Retail, restaurant and balance of C&I building types have the highest weekly operating hours, at 76, 84 and 96 hours respectively, while warehouses and public assembly buildings are the lowest, at 46 and 44 hours per week, respectively.

Figure 3-5. Mean Open Hours per Week by Building Type (N = 49)



Source: On-Site Survey, Questions 22-29

3.1.5 EEU Market Characterization – General Building Information

Table 3-3 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 (59%) of the buildings was constructed before 1969 and underwent major renovations.	» Most buildings were built new since 2008 (83%) » About 17% of the buildings underwent major renovation, with about half of those built before 1959. »	» Approximately 50% of the buildings were constructed since 2008. » The remaining 50% of buildings underwent major renovation, with about half built before 1959.
Building Size[a]	» 58% of the buildings fall under the 10,001-20,000 SF category compared to the 38% for the statewide average » Median size of 11,000 SF	» 33% of the buildings fall under the 10,001-20,000 SF category compared to the 38% for the statewide average » 77% of all buildings are under 20,000 SF. » Median size of 10,000 SF	» 50% of the buildings fall under the 10,001-20,000 SF category compared to the 38% for the statewide average » Median size of 13,000 SF
Facility Ownership[b]	» 54% ownership with the remaining 46% leasing	» 83% ownership is greater than statewide average of 76% » Non GT areas within EVT service territory show a higher ownership rate (92%) than GT areas (50%)	» VT Gas is distinct from the statewide average with only 54% owning buildings.
Business Information[c]	» 17 FTEs is lower than the statewide average of 28 FTEs	» 31 FTEs, similar to the statewide average » GT areas averages 59 FTEs which is higher than statewide average	» 36 FTEs, higher than the statewide average

a. Statewide median building size is 11,000 SF.
b. Statewide, 76%% of all buildings are owned and 24% are leased.
c. Statewide, mean FTEs statewide is 28 employees, and median is nine.
Source: Navigant analysis

3.2 *Building Envelope*

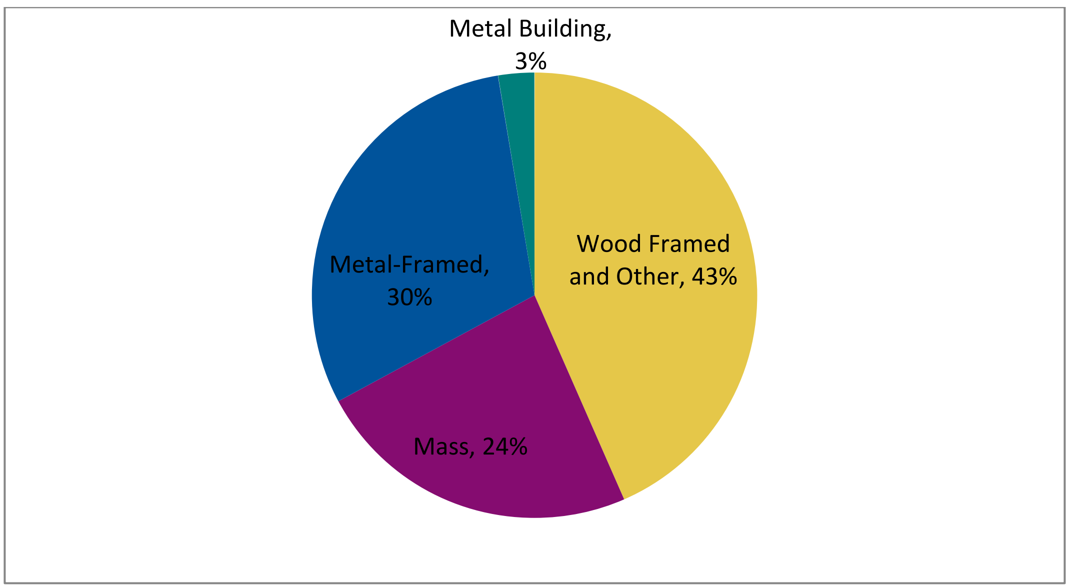
Surveyors inspected each site for building characteristics, including details about wall, roof, and floor construction and insulation as well as window specifications. In buildings that had undergone major renovation, surveyors only recorded information for the areas that had been affected by the renovation. The following sections present the results for each major envelope component.

3.2.1 Exterior Walls

3.2.1.1 Exterior Wall Construction Types

Less than half (43%) of the exterior walls in Vermont's new construction buildings are in the *wood framed and other* category, while 30% of exterior walls are metal-framed. Approximately one-quarter (24%) of walls are described as *mass* walls (i.e., brick, block, solid concrete). Only 3% of new construction buildings are classified as metal buildings. Figure 3-6[7] shows the distribution for all new construction buildings.

Figure 3-6: Frequency of Exterior Wall Construction Types for All Buildings (N= 76 observations)



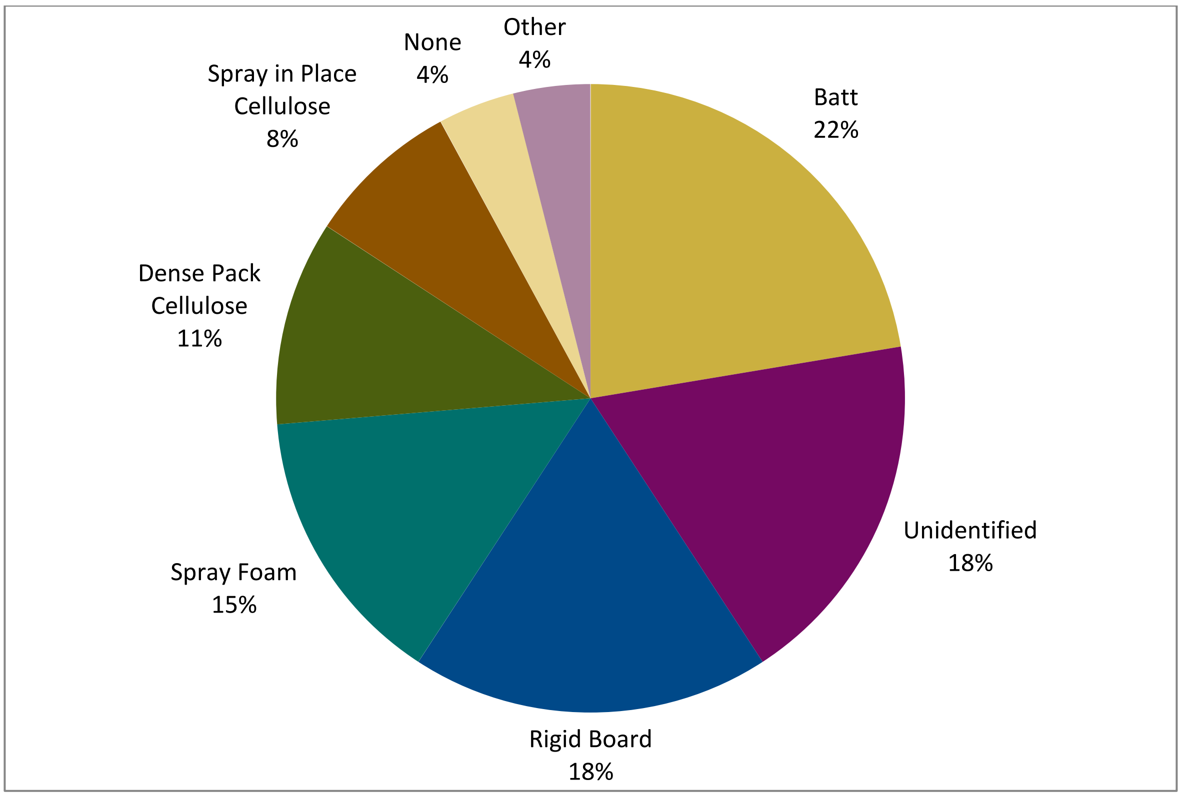
Source: On-Site Survey, Question 81

[7] 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, consulted with knowledgeable on-site staff, and/or reviewed as-built plans to determine the insulation types used in the walls. Figure 3-7 shows that 22% of exterior walls have batt insulation, rigid board makes up 18%, and spray foam comprises 15% of insulation types. Dense-pack cellulose and spray-in place cellulose account for 11% and 8% of all insulation types, respectively. Surveyors were unable to identify approximately 18% of wall insulation types.

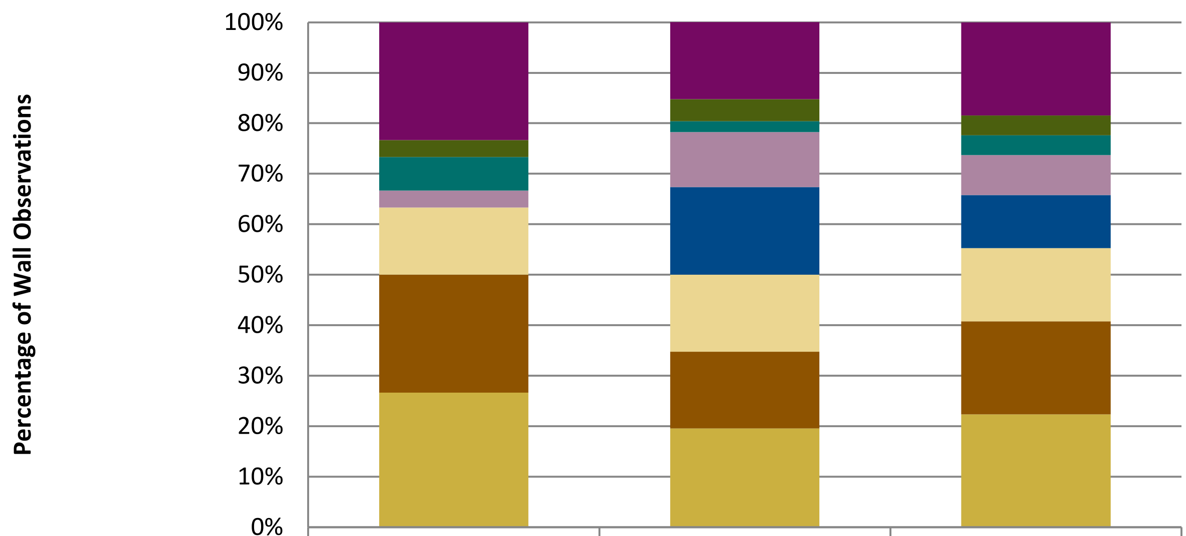
Figure 3-7. Frequency of Wall Insulation Types (N = 76 observations)



Source: On-Site Survey, Question 82

Figure 3-8 shows the wall insulation types for buildings in VT Gas territory versus the rest of the state. The distribution of insulation types is very similar between VT Gas and non-VT Gas areas; though VT Gas customers installed no dense pack cellulose while this type comprised approximately 17% of insulation types in other areas of the state.

Figure 3-8. Distribution of Wall Insulation Types – VT Gas vs. Non-VT Gas (N = 189 observations)



	VT GAS (N=30)	Non-VT GAS (N=46)	ALL NC Buildings (N=76)
Unidentified	23%	15%	18%
Other	3%	4%	4%
None	7%	2%	4%
Spray in Place Cellulose	3%	11%	8%
Dense Pack Cellulose	0%	17%	11%
Spray Foam	13%	15%	14%
Rigid Board	23%	15%	18%
Batt	27%	20%	22%

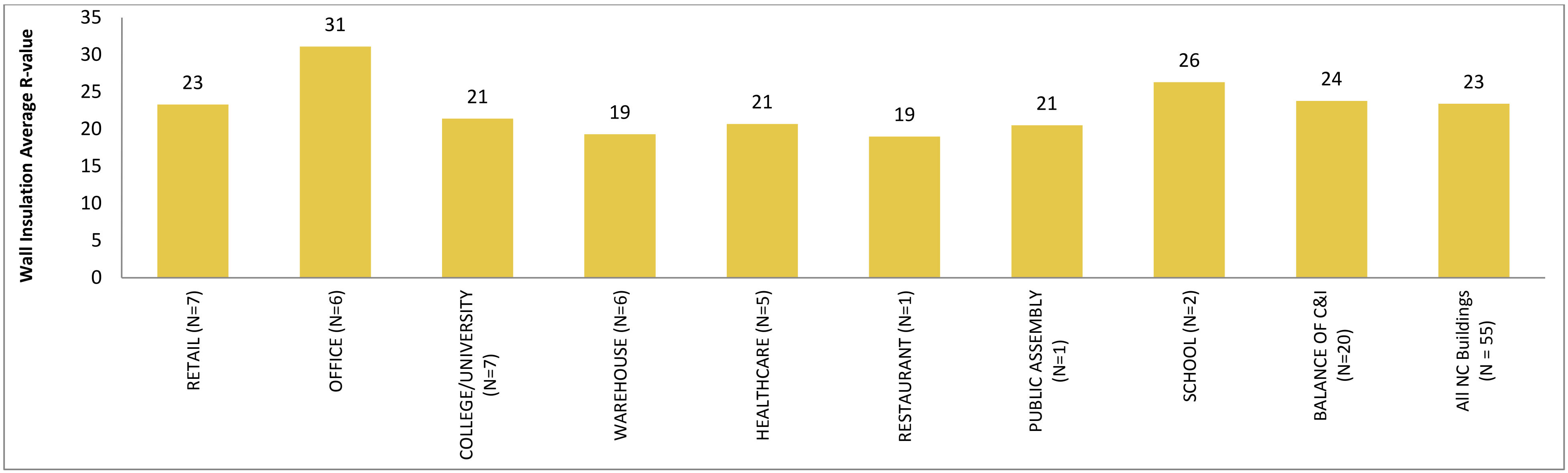
Source: On-Site Survey, Question 82

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. Surveyors inspected exterior walls, consulted with knowledgeable on-site staff, and/or reviewed as-built plans to determine the insulation type and R-value present in the walls. The average wall insulation R-value for all NC buildings is R-23, as shown in Figure 3-9. Office buildings have the highest average R-value of R-31, and warehouses have the lowest at R-19.

The new construction exterior wall R-values are notably higher 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.[8]

Figure 3-9. Wall Insulation R-Values by Building Type

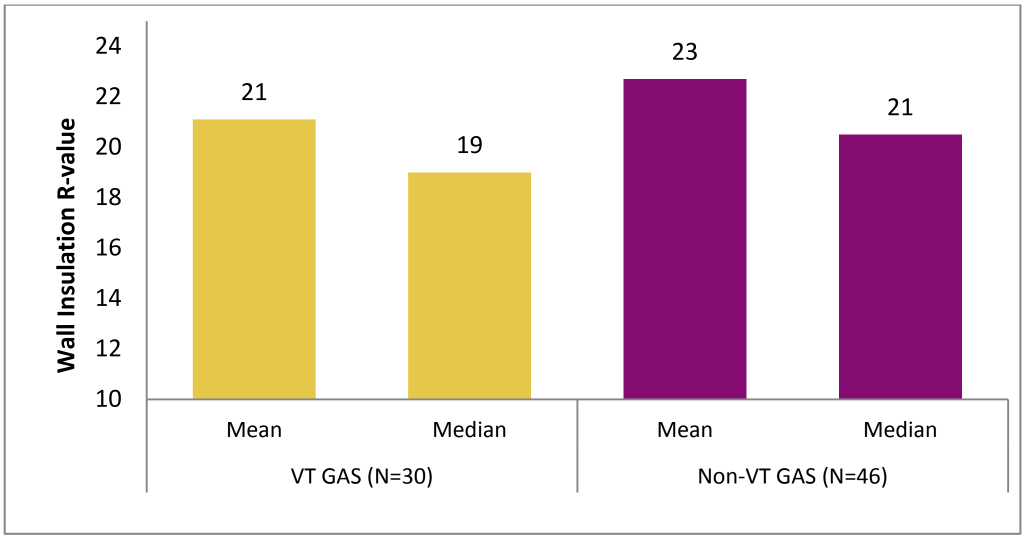


Source: On-Site Survey, Question 83

[8] Accounting for the mix of wall construction types presented in Figure 3-6: wood-framed: 43%; metal-framed: 30%; mass: 24%, metal building: 3%

Mean and median exterior wall R-values in VT Gas service territory are R-21 and R-19, respectively, and are slightly lower than non-VT Gas areas, as shown in Figure 3-10.

Figure 3-10. Wall Insulation R-Values by VT Gas vs. Non-VT Gas



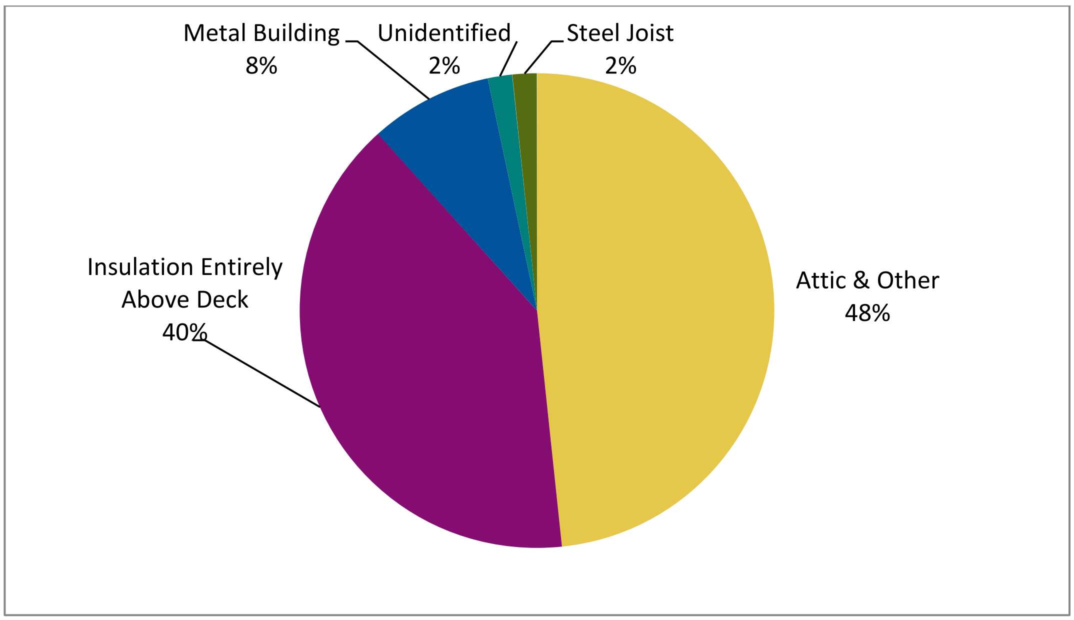
Source: On-Site Survey, Question 83

3.2.2 Roofs

3.2.2.1 Roof Construction Type

Approximately half (48%) of the NC buildings in Vermont have a roof construction type that falls into the energy code category of *attic and other*, as shown in Figure 3-11. Approximately 40% of all buildings have roofs with *insulation entirely above deck*, while 8% have *metal building* roofs.

Figure 3-11. Frequency of Roof Construction Type for All Buildings (N = 60 observations)

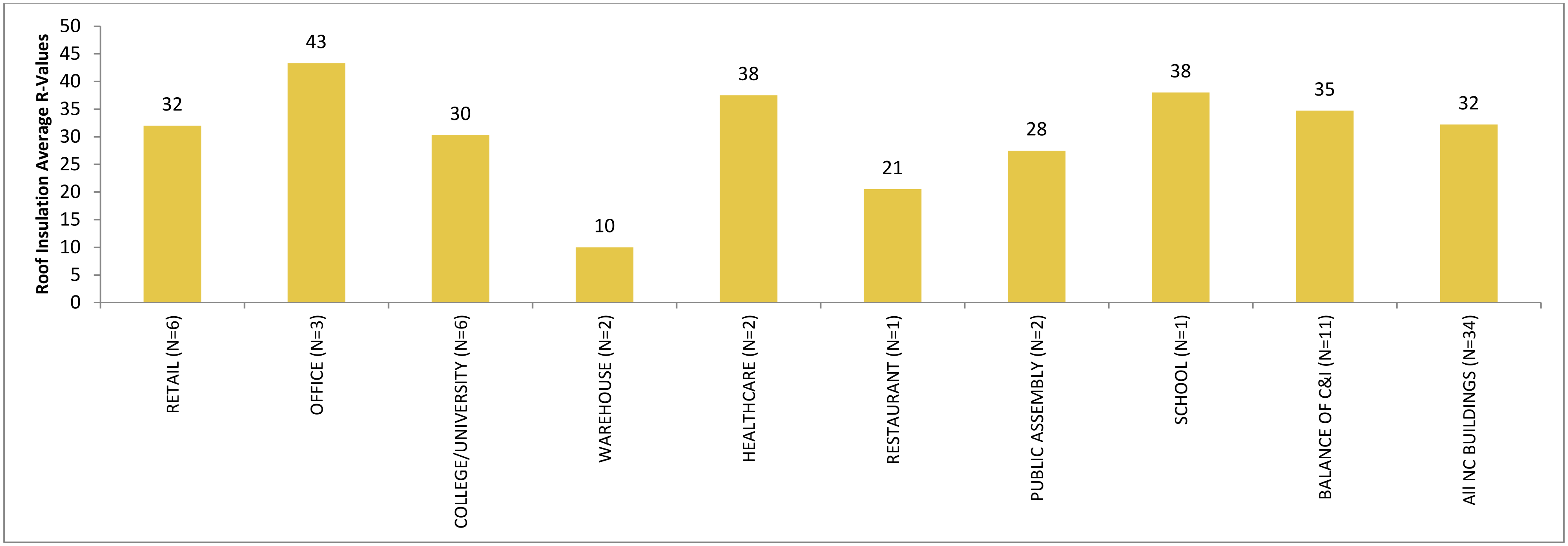


Source: On-Site Survey, Question 86

3.2.2.2 *Roof Insulation R-Values*

The average R-value for all NC building roof insulation is R-32, as shown in Figure 3-12. 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-31.[9] Installed roof insulation R-values are generally slightly higher than the code-required values (2005 CBES).

Figure 3-12. Roof Insulation R-Values by Building Type

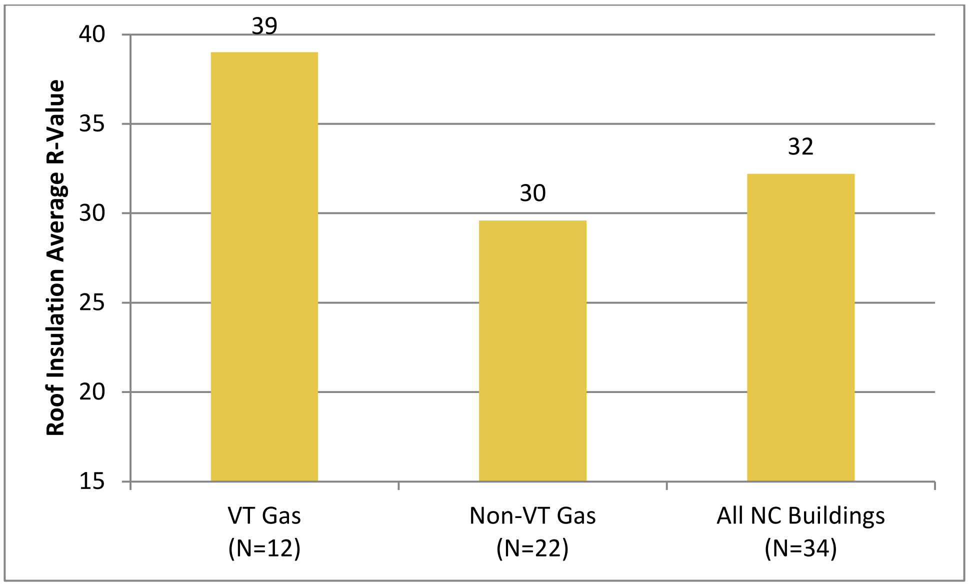


Source: On-Site Survey, Question 87

[9] Accounting for the mix of roof construction types presented in Figure 3-11: attic and other: 48%; insulation entirely above deck: 40%, metal-building: 8%; steel joist: 2%.

The roof insulation R-values for buildings in VT Gas territory are notably higher than those in non-VT Gas areas, with an average of R-39 and R-30, respectively, as shown in Figure 3-13.

Figure 3-13. Roof Insulation R-Values – VT Gas vs. Non-VT Gas

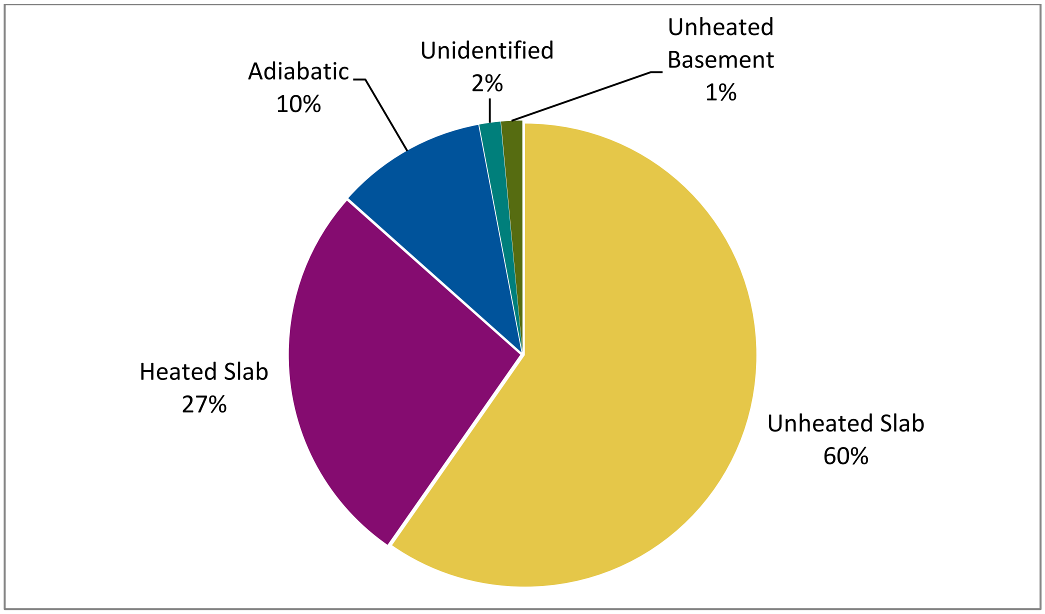


Source: On-Site Survey, Question 87

3.2.3 Floor

Most (60%) floors in Vermont's NC buildings are unheated slabs. Heated slabs comprise a significant portion of floor construction types, at 27%. Figure 3-14 shows the distribution for all NC buildings. Surveyors recorded an average R-value for heated slabs of R-13, which is slightly higher than the code-required R-10 for the entire slab (under slab and perimeter).

Figure 3-14. Frequency of Floor Construction Type (N = 67 observations)

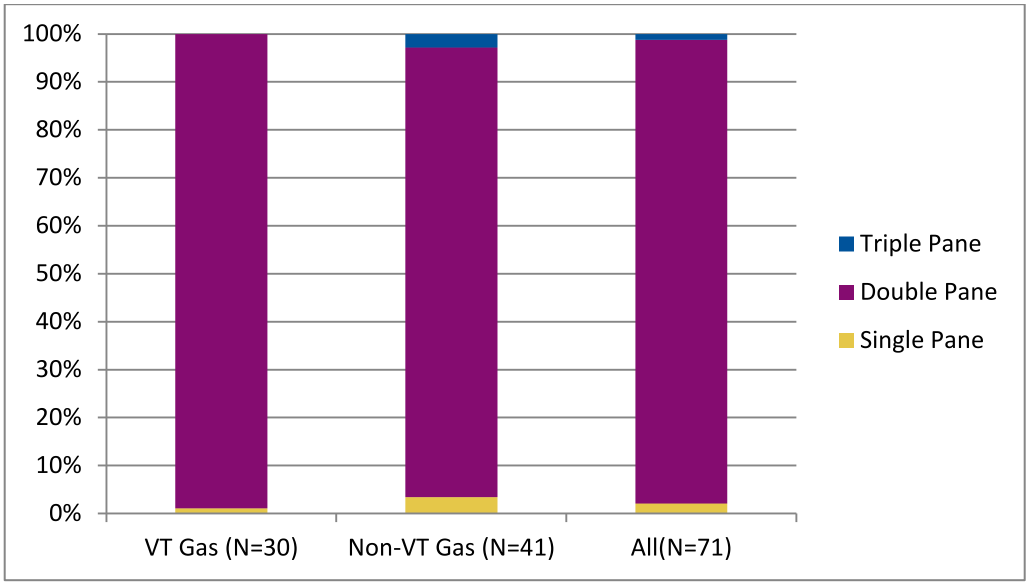


Source: On-Site Survey, Question 91

3.2.4 Windows/Fenestration

Double-pane windows dominate all NC buildings, comprising over 97% of all windows, as shown in Figure 3-15. VT Gas facilities do not differ significantly from non-VT Gas buildings; however, a small percentage of triple-pane windows were identified in non-VT Gas areas. Triple-pane windows comprise only 1% of all windows in the NC building stock.

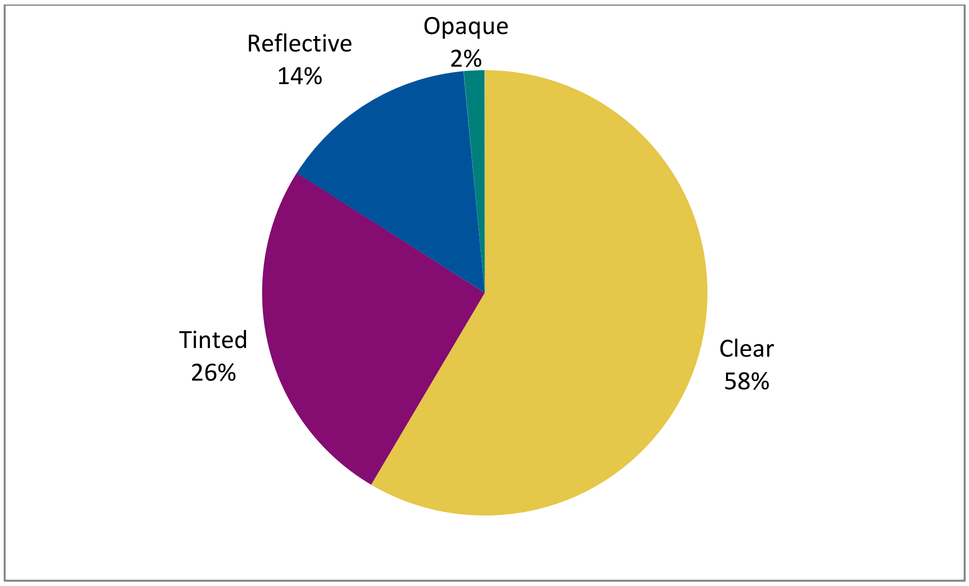
Figure 3-15. Number of Window Panes – VT Gas vs. Non-VT Gas



Source: On-Site Survey, Question 96

Most (58%) windows in Vermont's new construction building stock have clear glazing; while over one-quarter (26%) have tinted glazing, as shown in Figure 3-16. Approximately 14% of all windows have reflective glazing properties.

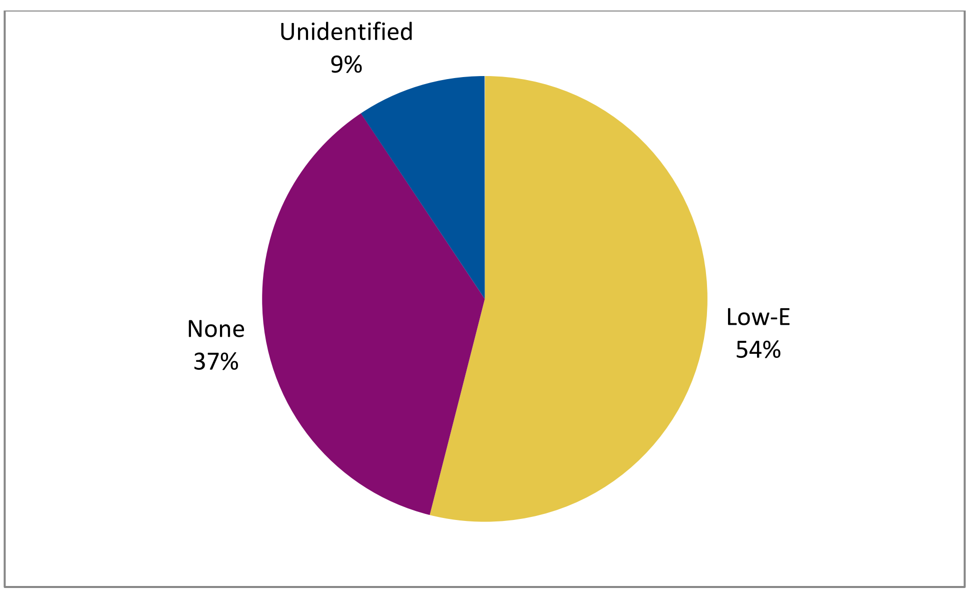
Figure 3-16. Distribution of Glazing Types (N = 71 observations)



Source: On-Site Survey, Question 97

Similarly, Figure 3-17 shows that 54% of windows in NC buildings are low-e windows. Approximately 37% of windows have no additional glazing features.

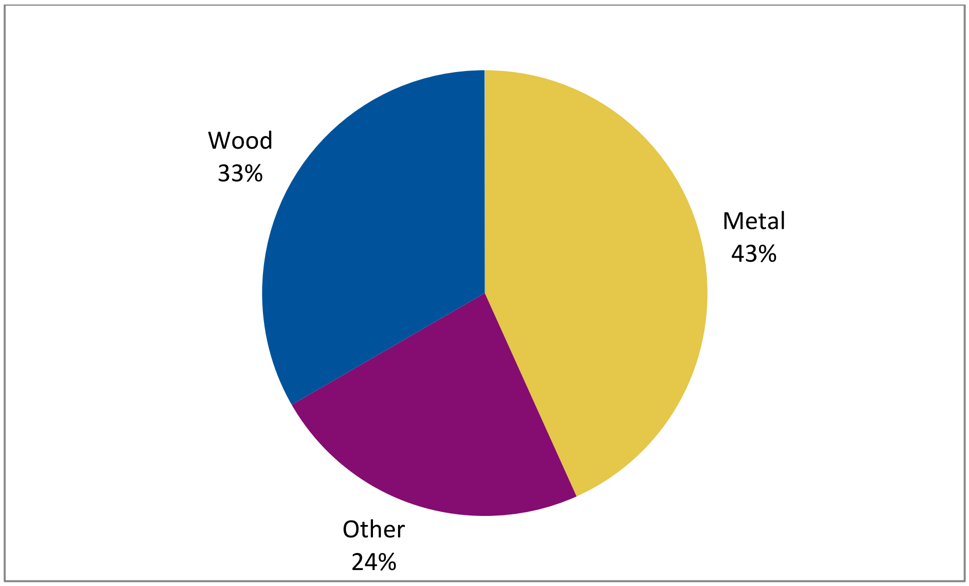
Figure 3-17. Distribution of Glazing Features (N = 71 observations)



Source: On-Site Survey, Question 98

Metal framing makes up the largest portion of window frame types in new construction buildings, comprising 43% of all windows. Wood-framed windows make up 33% and 24% of window frames are classified as "other," most likely indicating vinyl window frames. Figure 3-18 shows the distribution of window framing types for all buildings.

Figure 3-18. 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)[10]

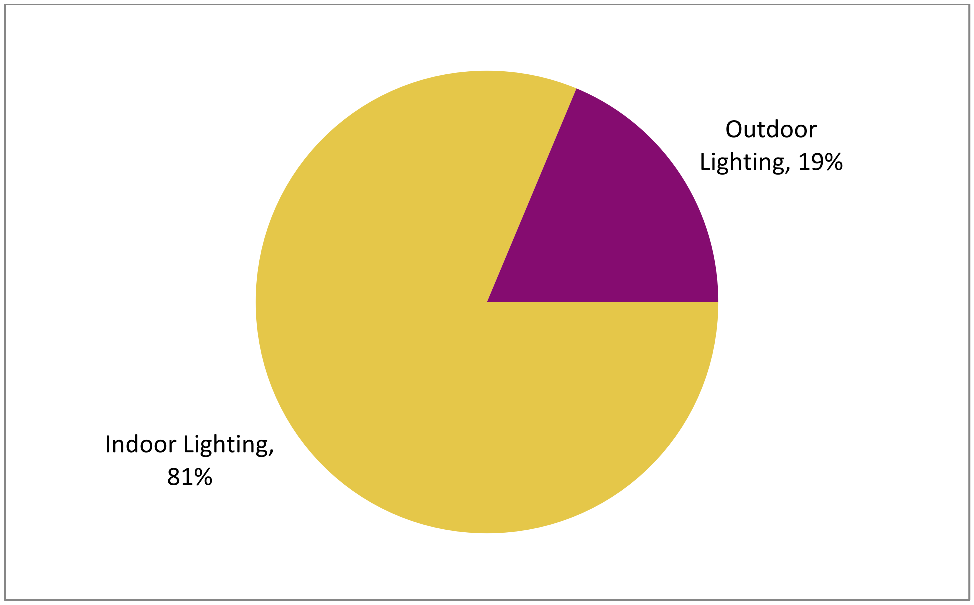
Measure/Characteristic	VT Gas vs. Non-VT Gas
Exterior Walls	» The share of buildings in VT Gas areas with batt insulation (27%) is higher than in Non-VT Gas areas (20%). » The share of buildings with rigid board insulation (27%) is higher in VT Gas areas than in Non-VT Gas areas (15%). » Dense Pack cellulose insulation is found more often in Non-VT Gas parts of the state, while there were more instances of spray in cellulose insulation types found at VT Gas sites. » Mean and median and exterior wall R-values in VT Gas service territory are R-21 and R-19, respectively, and are slightly lower than non-VT Gas areas (R-23 and R-21, respectively).
Roofs	The average roof insulation R-value for buildings in VT Gas territory is R-39, and is higher than those in non-VT Gas areas (R-30).
Windows	New construction buildings in VT Gas areas are saturated with double-pane windows, which is identical to the findings in non-VT Gas areas. About 3% of the buildings have triple-pane windows in the non-VT Gas areas, while none were identified in VT Gas areas.
Source: Navigant analysis	

[10] 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 3-19 shows that 81% of all installed lighting (weighted by wattage) is indoors with the remaining 19% located outdoors.

Figure 3-19. Distribution of Indoor and Outdoor Lighting Wattage (N = 58)*

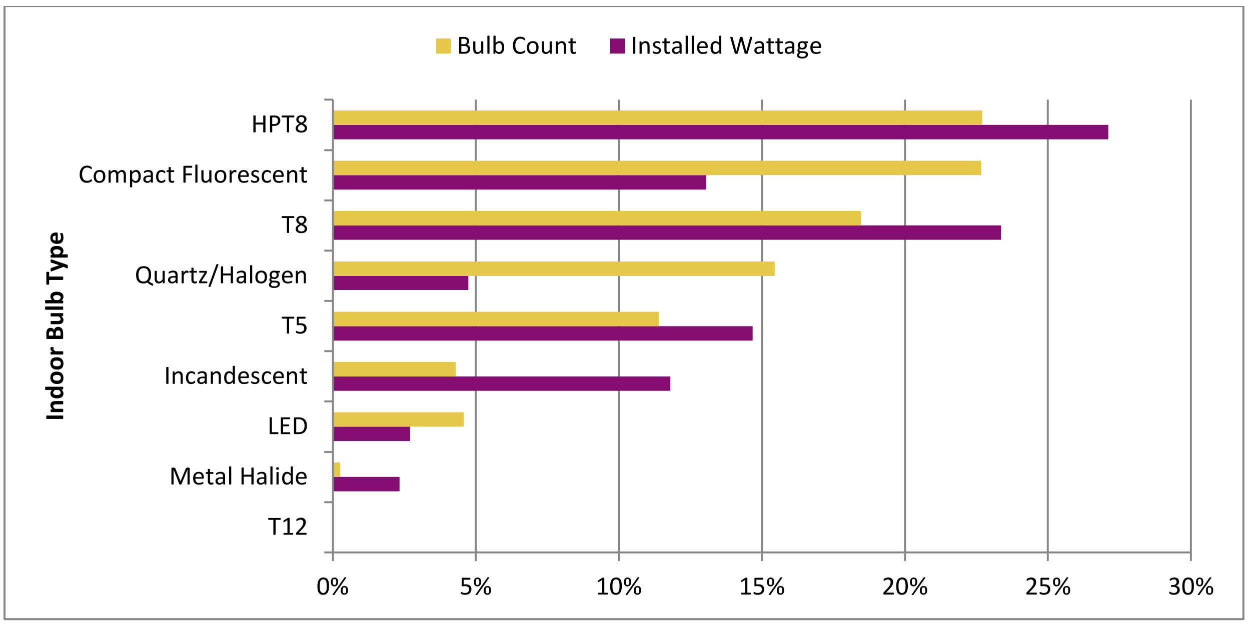


*Weighted by Installed Wattage
Source: On-Site Survey, Section 25/26

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 3-20 shows that High Performance (HP) T8 lamps comprise the single largest share of any type, making up approximately one-quarter of all indoor lights, both by count and wattage.[11] Compact fluorescent lights (CFLs) are second by counts, but comprise a smaller share by wattage (due to lower rated power draw of CFLs). Standard T8 lamps comprise a large share of indoor lighting and the data confirms expectations that there are no T12 lamps in Vermont's NC buildings. Notably, quartz-halogen (a type of incandescent light) lights were frequently observed in NC buildings, comprising approximately 15% of all lighting by counts. Light-emitting diode (LED) lights comprise approximately 5% of all installed indoor lighting.

Figure 3-20. Distribution of Indoor Lamp Types – All Buildings (N = 118)



Source: On-Site Survey, Questions 387-403

[11] 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. It is also possible that 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.

Table 3-5 shows the distribution of indoor lamp types by building type, weighted by lamp counts.

Table 3-5. Distribution of Indoor Lamp Types by Building Type*

Indoor Lighting Type	All Buildings (N=58)	Retail (N=10)	Office (N=8)	College/ University (N=7)	Warehouse (N=4)	Healthcare (N=4)	Restaurant (N=3)	Public Assembly (N=3)	School (N=3)	Balance of C&I (N=16)
HPT8	23%	63%	26%	40%	38%	9%	0%	14%	91%	7%
Compact Fluorescent	23%	1%	30%	10%	1%	21%	29%	21%	7%	31%
T8	18%	5%	12%	2%	1%	68%	41%	43%	0%	18%
Quartz/Halogen	15%	0%	2%	0%	0%	0%	23%	0%	0%	29%
T5	11%	16%	23%	42%	49%	0%	1%	0%	1%	5%
Incandescent	4%	0%	3%	0%	1%	1%	5%	17%	0%	7%
LED	5%	14%	2%	6%	0%	0%	0%	5%	1%	3%
Metal Halide	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%
T12	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

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

Table 3-6 shows that HPT8 and T8 lighting accounts for 43% and 35%, respectively, of all linear fluorescent lighting, while T5 lamps account for the remaining 22%. T12 lamps have been completely phased out of Vermont's new and renovated building stock.

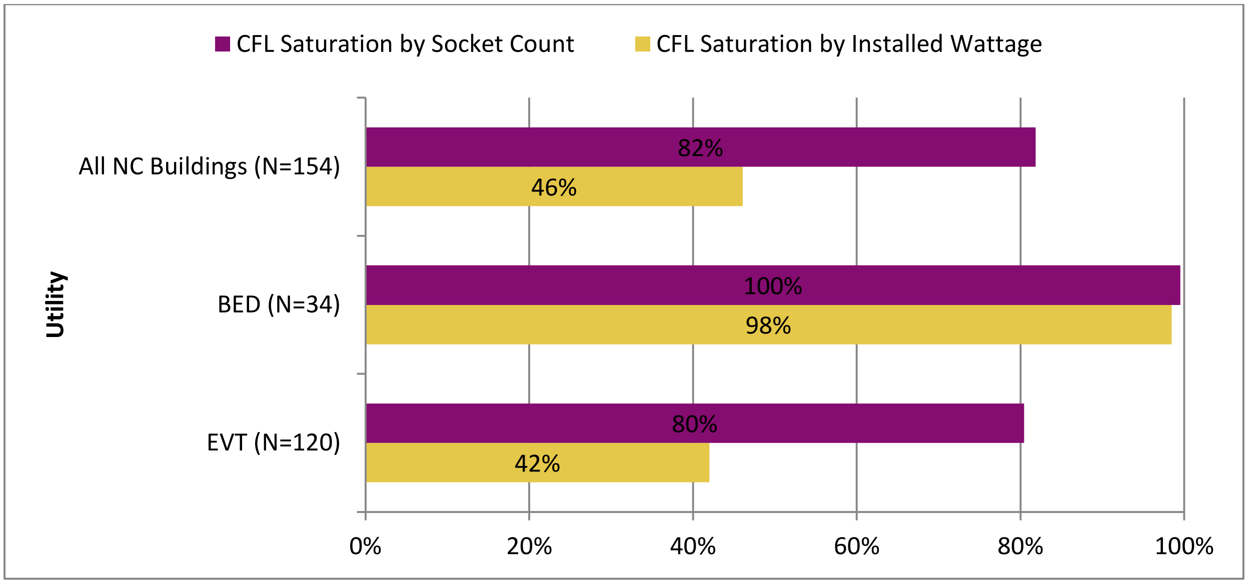
Table 3-6. Distribution of Linear Fluorescent Lighting*

Category	HPT8	T8	T5	T12
All NC Buildings (N=58)	43%	35%	22%	0%
EEU				
BED (N=12)	74%	15%	11%	0%
EVT (N=46)	32%	42%	26%	0%
GT vs. Non-GT				
GT (N=10)	26%	60%	14%	0%
Non-GT (N=36)	34%	35%	30%	0%
Building Type				
Retail (N=10)	75%	6%	19%	0%
Office (N=8)	42%	20%	38%	0%
College/ University (N=7)	47%	2%	50%	0%
Warehouse (N=4)	39%	1%	49%	0%
Healthcare (N=4)	11%	89%	0%	0%
Restaurant (N=3)	0%	97%	3%	0%
Public Assembly (N=3)	24%	75%	0%	1%
School (N=3)	99%	0%	1%	0%
Balance of C&I (N=16)	22%	61%	17%	0%

*Weighted by Lamp Counts
Source: On-Site Survey, Question 387-403

In both BED and EVT areas, CFLs have displaced incandescents in screw-based sockets, as shown in Figure 3-21. Nearly all of the screw-based sockets in BED's NC buildings are using CFLs, while 80% of all sockets in EVT areas are fitted with CFLs. The analysis indicates that there are high-wattage incandescent lights in EVT's territory in new construction that could be replaced with CFLs or LEDs.

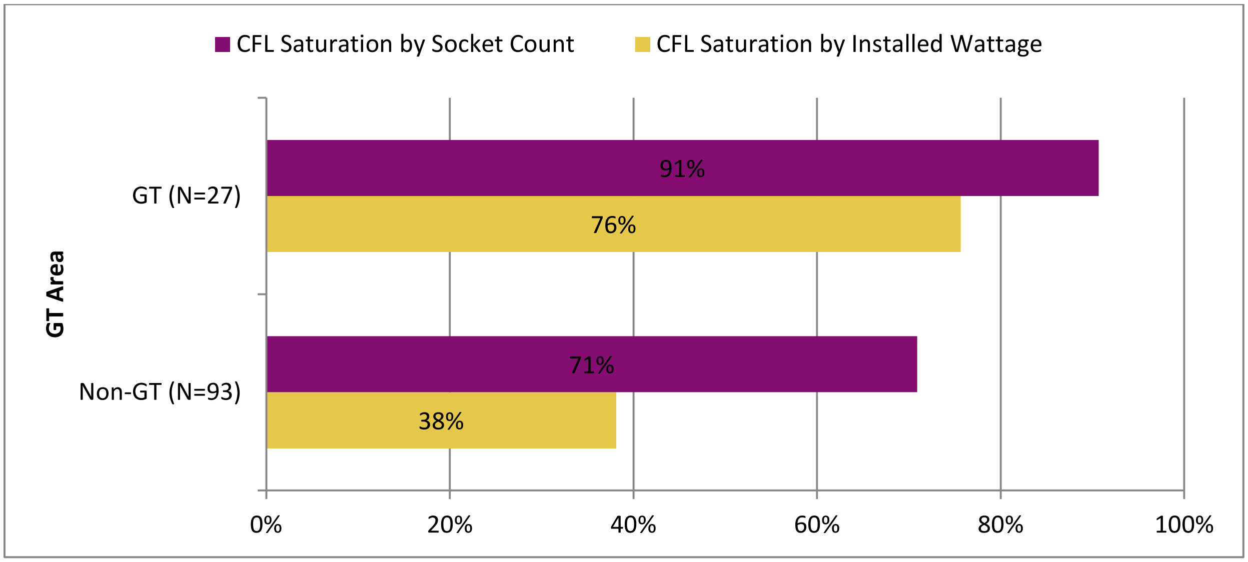
Figure 3-21. CFL Saturation of Screw-Based Sockets by EEU



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

CFLs comprise nearly all (92%) of screw-based sockets in GT areas, compared to 71% in non-GT areas, as shown in Figure 3-22. CFLs only make up 38% of the installed wattage in non-GT areas, indicating high-wattage incandescent lighting in place at some NC facilities.

Figure 3-22. 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 the majority (59%) of Vermont's NC buildings, as shown in

Table 3-7. Energy management systems (EMS) were identified in 14% of all buildings. Dimmers were identified in 16% of NC buildings, and daylighting controls were identified in 5% of all buildings. Penetrations of control strategies do not differ significantly between EEU areas, though daylighting controls were not observed in BED areas. The surveyors identified occupancy sensor controls in most college/university (86%) and healthcare (75%) new construction buildings, and these controls were observed in every public assembly and school building as well. Manual on/off controls are the dominant lighting control type in warehouse buildings, and few other controls types were observed in these buildings. EMS controls were observed in retail (30%), college/university (14%) and restaurants and schools (33% each).

Table 3-7. 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 NC Buildings (N=58)	84%	59%	19%	14%	16%	5%	10%
EEU							
BED (N=12)	92%	50%	25%	17%	17%	0%	8%
EVT (N=46)	83%	61%	17%	13%	15%	7%	11%
GT vs. Non-GT							
GT (N=10)	70%	80%	20%	20%	10%	0%	0%
Non-GT (N=36)	86%	56%	17%	11%	17%	8%	14%
Building Type							
Retail (N=10)	80%	50%	10%	30%	0%	0%	0%
Office (N=8)	88%	38%	13%	0%	13%	0%	25%
College/ University (N=7)	43%	86%	29%	14%	14%	0%	0%
Warehouse (N=4)	100%	25%	0%	0%	0%	0%	0%
Healthcare (N=4)	100%	75%	25%	0%	0%	0%	0%
Restaurant (N=3)	67%	33%	0%	33%	33%	0%	33%
Public Assembly (N=3)	100%	100%	67%	0%	67%	0%	0%
School (N=3)	100%	100%	33%	33%	0%	67%	0%
Balance of C&I (N=16)	94%	56%	19%	13%	25%	6%	6%

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

Table 3-8 shows the saturation of indoor lighting control types only for linear fluorescent lighting, and reveals that 32% of all linear fluorescent lights in NC buildings are controlled by motion/occupancy sensors. Approximately 16% of linear fluorescent lighting in NC buildings is controlled by EMS systems, with 29% of lighting in BED areas using EMS systems. Motion/occupancy sensors make up a much larger share (70%) of the control strategy in GT areas, compared to only 26% in non-GT areas.

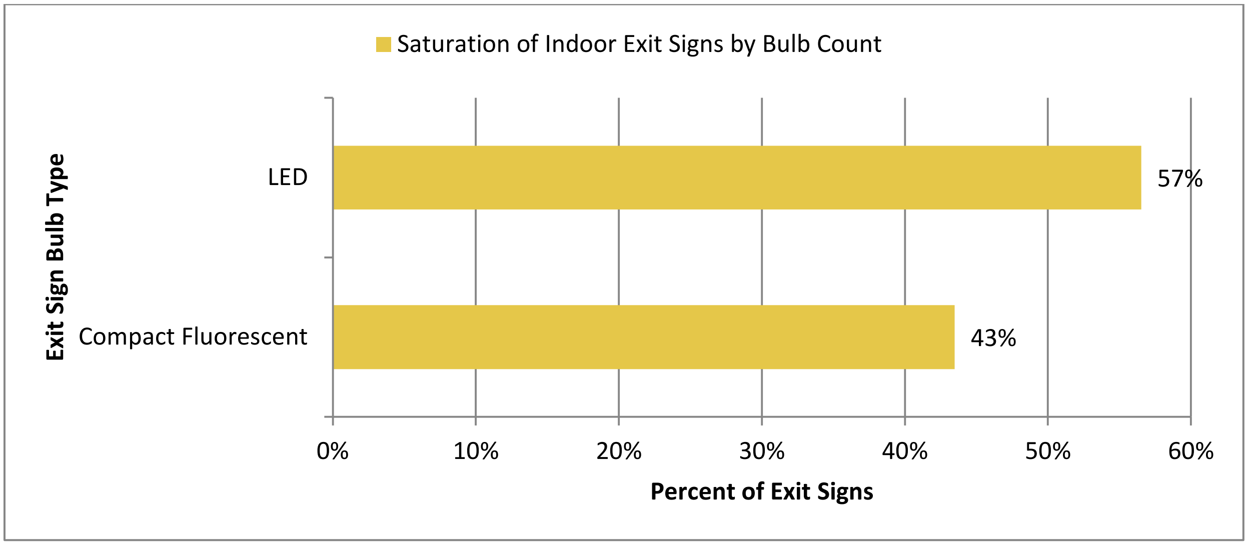
Table 3-8. Saturation of Indoor Lighting Control Types for Linear Fluorescents Only*

Category	Manual On/Off Switch	Motion/ Occupancy Sensor	None (24/7)	Timeclock/EMS	Dimmer	Daylighting Controls	Not Identified
All NC Buildings (N=58)	42%	32%	3%	16%	1%	5%	0%
EEU							
BED (N=12)	44%	16%	10%	29%	1%	0%	0%
EVT (N=46)	42%	38%	1%	12%	1%	6%	0%
GT vs. Non-GT							
GT (N=10)	19%	70%	0%	11%	0%	0%	0%
Non-GT (N=36)	50%	26%	1%	12%	2%	9%	0%

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

LED lamps comprise 57% of all exit signs, while CFLs make up the remaining 43% of exit sign lighting, as shown in Figure 3-23. Surveyors did not record any instances of incandescent exit signs in NC buildings.

Figure 3-23. Saturation of Indoor Exit Sign Lamp Types (N = 115 observations)

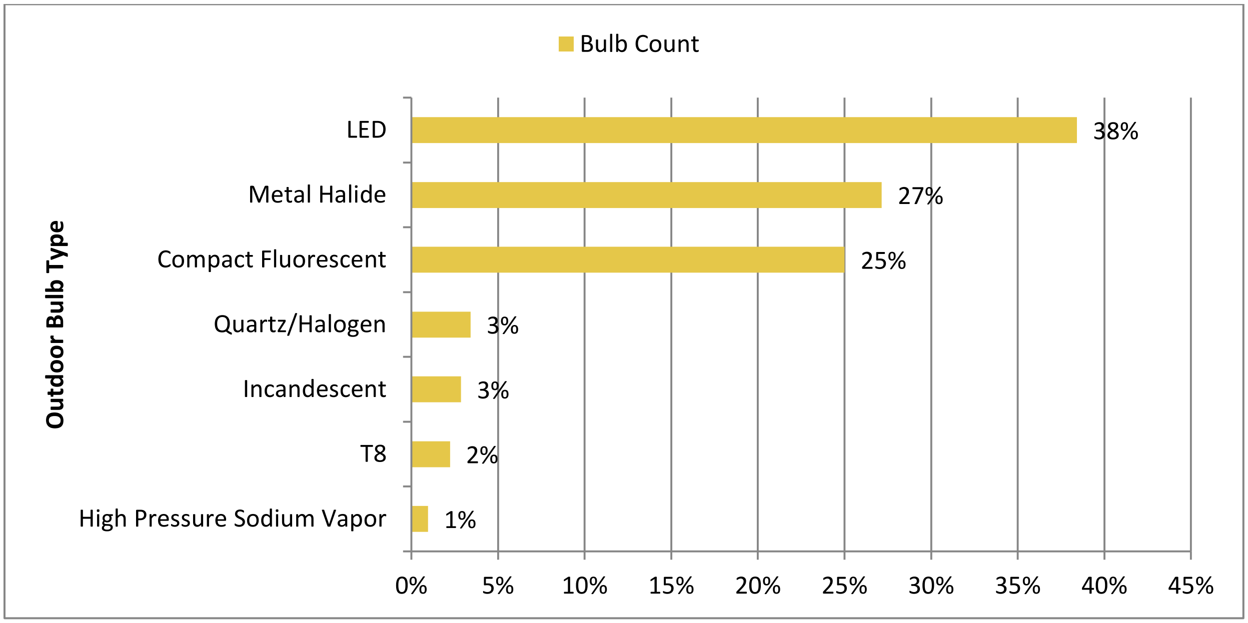


Source: On-Site Survey, Question 392

3.3.2 Outdoor Lighting

As shown in Figure 3-24, LED lighting comprises the highest share (38%) of installed outdoor lighting in Vermont's NC buildings. Metal halide and CFLs each make up approximately one-quarter of the installed outdoor lighting.

Figure 3-24. Distribution of Outdoor Lamp Types (N = 58)



Source: On-Site Survey, Questions 345-361

Table 3-9 shows the distribution of outdoor lighting types by building type. LED lighting dominates the college/university NC facilities, comprising 87% of all outdoor lighting within that sector. Incandescents and metal halides, combined, make up approximately 86% of the installed lighting in the warehouse sector and nearly 88% in the healthcare sector. Approximately 90% of the outdoor lighting in public assembly NC buildings is CFLs.

Table 3-9. Distribution of Outdoor Lamp Types by Building Type*

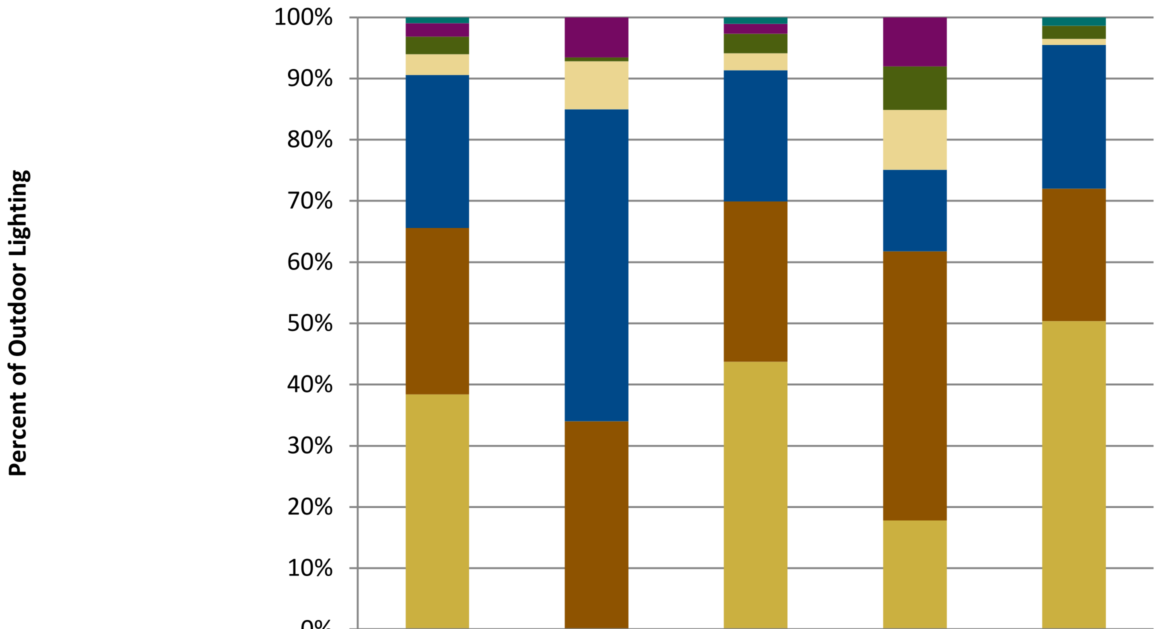
Outdoor Lighting Type	All Buildings (N=58)	Retail (N=10)	Office (N=8)	College/ University (N=7)	Warehouse (N=4)	Healthcare (N=4)	Restaurant (N=3)	Public Assembly (N=3)	School (N=3)	Balance of C&I (N=16)
LED	38%	6%	20%	87%	0%	0%	0%	0%	0%	10%
Metal Halide	27%	64%	24%	5%	48%	75%	15%	3%	9%	60%
CFL	25%	28%	49%	8%	14%	0%	16%	90%	74%	22%
Quartz/Halogen	3%	0%	8%	0%	0%	0%	28%	1%	0%	2%
Incandescent	3%	2%	0%	0%	38%	8%	18%	6%	0%	1%
T8 (Standard and HPT8)	2%	0%	0%	0%	0%	0%	23%	0%	0%	5%
High Pressure Sodium Vapor	1%	0%	0%	0%	0%	13%	0%	0%	17%	0%

*Weighted by Lamp Counts

Source: On-Site Survey, Questions 345-361

LED lamps comprise 44% of outdoor lighting in EVT territory and less than 1% in BED service territory, as shown in Figure 3-25. However, CFLs make up 51% of outdoor lighting in BED territory compared to 21% in EVT areas. LEDs comprise a notably higher share of outdoor lighting in non-GT areas compared to GT areas, with 50% and 18%, respectively.

Figure 3-25. Distribution of Outdoor Lamp Types by EEU and GT Area*



	All NC Buildings (n=58)	BED (n=12)	EVT (n=46)	GT (n=10)	Non-GT (n=36)
High Pressure Sodium Vapor	1%	0%	1%	0%	1%
T8	2%	7%	2%	8%	0%
Incandescent	3%	1%	3%	7%	2%
Quartz/Halogen	3%	8%	3%	10%	1%
Compact Fluorescent	25%	51%	21%	13%	23%
Metal Halide	27%	34%	26%	44%	22%
LED	38%	0%	44%	18%	50%

*Weighted by lamp counts
Source: On-Site Survey, Questions 345-361

Motion sensors account for the largest share (67%) of outdoor lighting control types in NC buildings, followed by photocells (19%) and then photocell/timeclock combinations (7%), as shown in Table 3-10. Motion sensors dominate controls in EVT areas (70%) while in BED territory photocell controls account for approximately 68% of all outdoor control types.[12] Similarly, photocells make up most control types (82%) in GT areas while motion sensors dominate non-GT areas (78%).

Table 3-10. Saturation of Outdoor Lighting Control Types*

Category	Motion Sensor	Photocell	Photocell/ Timeclock	Manual On/Off Switch	Timeclock	Unidentified
All NC Buildings (N=58)	67%	19%	7%	3%	3%	1%
EEU						
BED (N=12)	0%	68%	1%	31%	0%	0%
EVT (N=46)	70%	17%	7%	1%	4%	1%
GT vs. Non-GT						
GT (N=10)	0%	82%	2%	3%	13%	0%
Non-GT (N=36)	78%	9%	8%	1%	3%	1%

*Weighted by Installed Wattage
Source: On-Site Survey, Question 339

[12] The urban setting of Burlington, with more security concerns, may have an impact with the need to keep parking areas and walkways illuminated. This would account for the absence of motion sensor controls found on outdoor lighting in BED service territory.

3.3.3 EEU Market Characterization – Lighting

Table 3-4Table 3-11 provides a summary characterization of lighting measures for Vermont's EEUs.

Table 3-11. EEU Market Characterization – Lighting

	Measure/Characteristic	BED	EVT	GT Areas
Indoor Lighting	T12s	» T12s were not identified in any of the new construction or major renovation buildings		
	T8/HPT8	» 74% of linear fluorescents are HPT8 lights while 15% are standard T8s (89% combined).	» 32% of linear fluorescents are HPT8 lights while 42% are standard T8s (74% combined).	» 26% of linear fluorescents are HPT8 lights while 60% are standard T8s (86% combined).
	CFLs	» CFLs have saturated 100% of screw-in sockets (by count) and 98% of screw-in sockets (by wattage).	» CFLs have saturated 80% of screw-in sockets (by count) and 42% of screw-in sockets (by wattage).	» CFLs have saturated 91% of screw-in sockets (by count) and 76% of screw-in sockets (by wattage)
	T5	» T5s comprise of 11% of linear fluorescents.	» T5s comprise of 26% of linear fluorescents.	» T5s comprise of 14% of linear fluorescents.
	Automated Indoor Lighting Controls	» 50% of lighting is controlled by motion/occupancy sensors and 17% by timeclock or EMS systems.	» 61% of lighting is controlled by motion/occupancy sensors and 13% by timeclock or EMS systems.	» 80% of lighting is controlled by motion/occupancy sensors and 20% by timeclock or EMS systems.

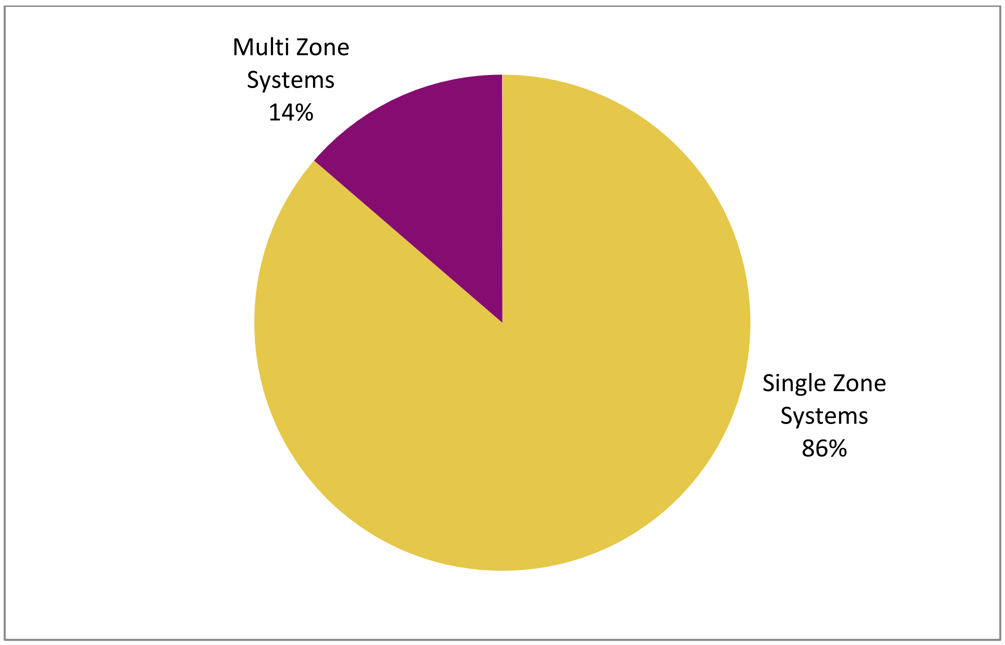
	Measure/Characteristic	BED	EVT	GT Areas
Outdoor Lighting	LEDs	» LEDs were not identified in any of the BED buildings.	» LEDs make 44%% of all outdoor lighting.	» LEDs make up 18% of all outdoor lighting.
	CFLs	» CFLs make up 51% of all outdoor lighting.	» CFLs make up 21% of all outdoor lighting.	» CFLs make up 13% of all outdoor lighting.
	Automated Outdoor Lighting Controls	» Most controls are photocells or photocell/timeclock combinations.	» Most controls are motion sensors (70%).	» Most controls are photocells or timeclocks.

Source: Navigant analysis

3.4 HVAC

The majority (86%) of HVAC systems in Vermont's new construction buildings are single-zone systems while only 14% are multi-zone systems, as shown in Figure 3-26. Single-zone systems are typically considered "simple" systems in Vermont's 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 selection or replacement.

Figure 3-26. Distribution of Single-Zone and Multi-Zone Systems (N = 190 observations)

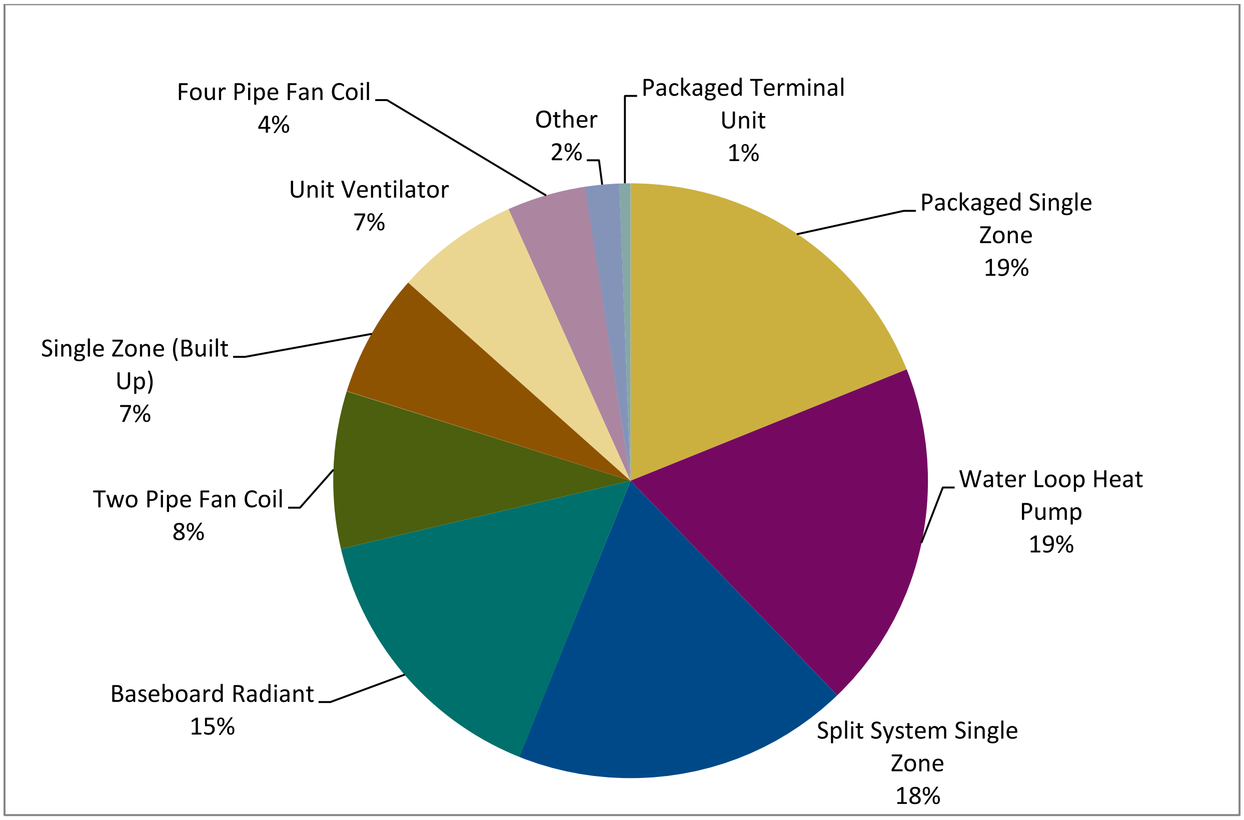


Source: On-Site Survey, Questions 119 and 170

3.4.1 Single-Zone Distribution Systems

The on-site surveyors identified 164 single-zone HVAC distribution systems and gathered all available data for each system.[13] Figure 3-27 shows that packaged single-zone, water-loop heat pumps, split-system single-zone and baseboard/radiant systems together make up over 70% of all systems, and each comprises between 15% to 19% of all systems.

Figure 3-27. Distribution of Single-Zone HVAC Systems (N = 164 observations)



Source: On-Site Survey, Question 119

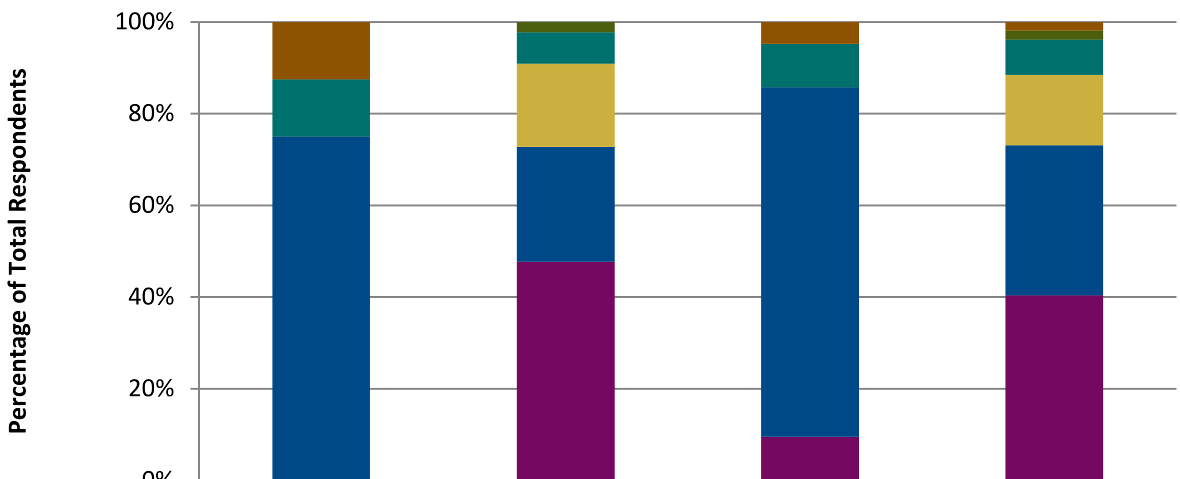
[13] Complete data was not available for every system.

3.4.2 Heating Systems

3.4.2.1 Heating Fuel Type

Figure 3-28 indicates that approximately 40% of all new construction/major renovation buildings in the state use propane (LPG) as the primary heating fuel. Natural gas is the second most frequently used heating fuel (33%), while fuel oil and electricity make up 15% and 8%, respectively.

Figure 3-28. Heating System Fuel Type by EEU



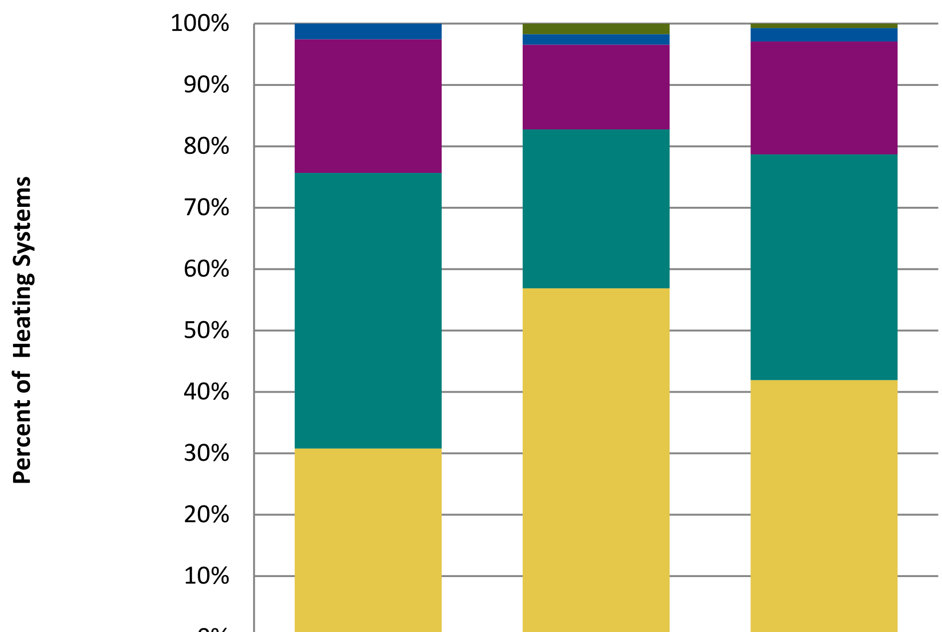
	BED (N=10)	EVT (N=42)	VTGas (N=24)	All NC Buildings (N=52)
Don't know	13%	0%	5%	2%
Other	0%	2%	0%	2%
Electricity	13%	7%	10%	8%
Oil	0%	18%	0%	15%
Natural gas	75%	25%	76%	33%
LPG/Propane	0%	48%	10%	40%

Source: Telephone Survey, Question SH1

3.4.2.2 *Heating System Type*

Figure 3-29 shows that most (42%) heating systems in new construction buildings are boilers, with furnaces comprising the second largest share (37%). Heat pumps comprise 18% of all heating systems.[14] The most notable difference between VT Gas territory and other areas of the state is that furnaces are more prevalent than boilers in areas with natural gas service.

Figure 3-29. Distribution of Heating System Types



	VT Gas (N=78)	Non-VT Gas (N=59)	All NC Buildings (N=137)
Other	0%	2%	1%
Electric Resistance	3%	2%	2%
Heat Pump	22%	14%	18%
Furnace	45%	26%	37%
Boiler	31%	57%	42%

Source: On-Site Survey, Question 146

Table 3-12 shows heating system efficiencies for furnaces, boilers and water-source heat pumps, broken out by energy code categories and size (input capacity) thresholds. All furnaces either meet or exceed the 2005 CBES requirements for both size categories. Most (74%) of the furnaces less than 225,000 Btu/h exceed the code minimum efficiency. All of the hot water boilers observed in new construction buildings exceeded code minimums, with the weighted average efficiency levels significantly exceeding the code

[14] Surveyors identified no air source heat pumps during the new construction surveys. Therefore, all heat pump heating systems are in fact water source heat pumps.

requirements. Only one of the six (17%) water-source heat pumps did not meet the minimum coefficient of performance (COP) for heating.

Table 3-12. Heating System Efficiency by Type and Code Category

System	Size Category (Input)	Subcategory	Observed Mean Efficiency	2005 CBES Minimum Efficiency	Percent of Systems Below/Meet/Above Code	N[c]
Warm Air Furnaces	<225,000 Btu/h	-	84%	80%	0% / 26% / 74%	28
	≥ 225,000 Btu/h	-	80%	80%	0% / 100% / 0%	4
Boilers	<300,000 Btu/h	Steam	No Observed Systems			
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Steam	89%	75%	0% / 0% / 100%	2
	≥2,500,000 Btu/h	Steam	No Observed Systems			
Boilers	<300,000 Btu/h	Hot Water	93%	80% (all fuels)	0% / 0% / 100%	12
	≥300,000 Btu/h and ≤2,500,000 Btu/h	Hot Water	88%	75% (gas) and 78% (oil)	0% / 0% / 100%	12
	≥2,500,000 Btu/h	Hot Water	No Observed Systems			
Water Source Heat Pumps (Heating Mode)[e]	<135,000 Btu/h	68° F Entering Water[d]	4.6	4.2 COP	17% / 0% / 83%	6

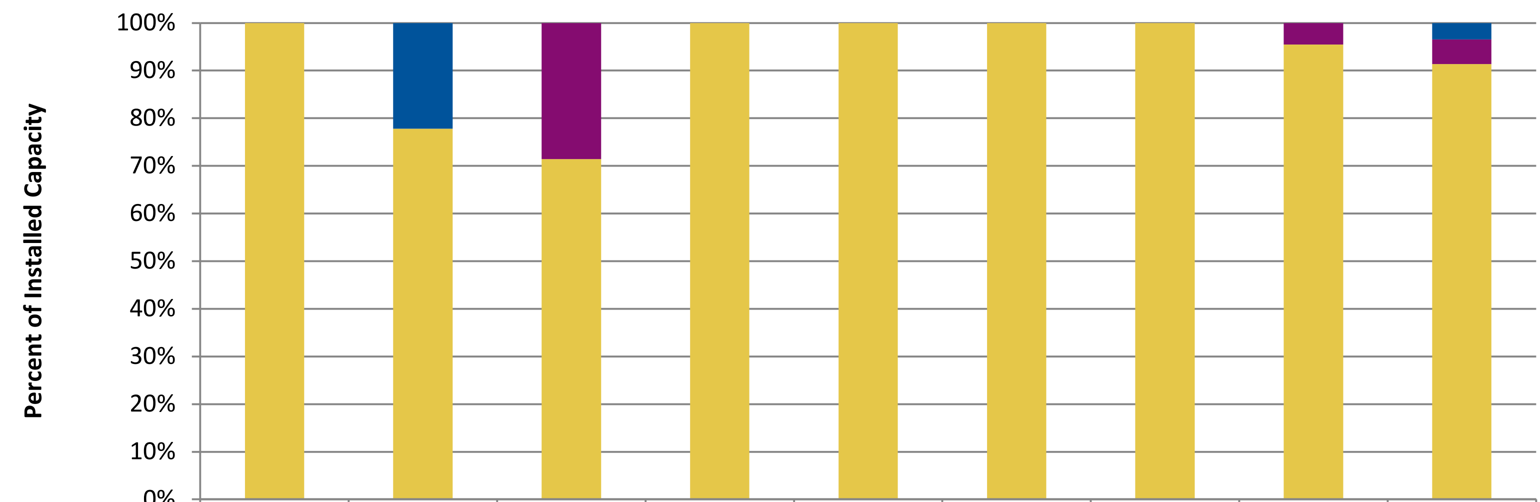
a. Gas and oil boilers are not broken out for this analysis.
b. Observed mean efficiency is the capacity-weighted average efficiency of all observed units.
c. Sample size (N) is for systems with known efficiency ratings.
d. The entering water temperature is the rating condition in the energy code, and is not verified through the on-site survey. Only one of the six (17%) water-source heat pumps did not meet the minimum coefficient of performance (COP) for heating.

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 3-30, most (91%) boilers in new construction buildings are hot water boilers, while steam boilers comprise only 5% of all boilers (only two sites had steam boilers). Colleges and universities are the notable exception, where steam boilers are more common due to campus-wide steam systems.

Figure 3-30. Boiler Delivery Systems by Building Type

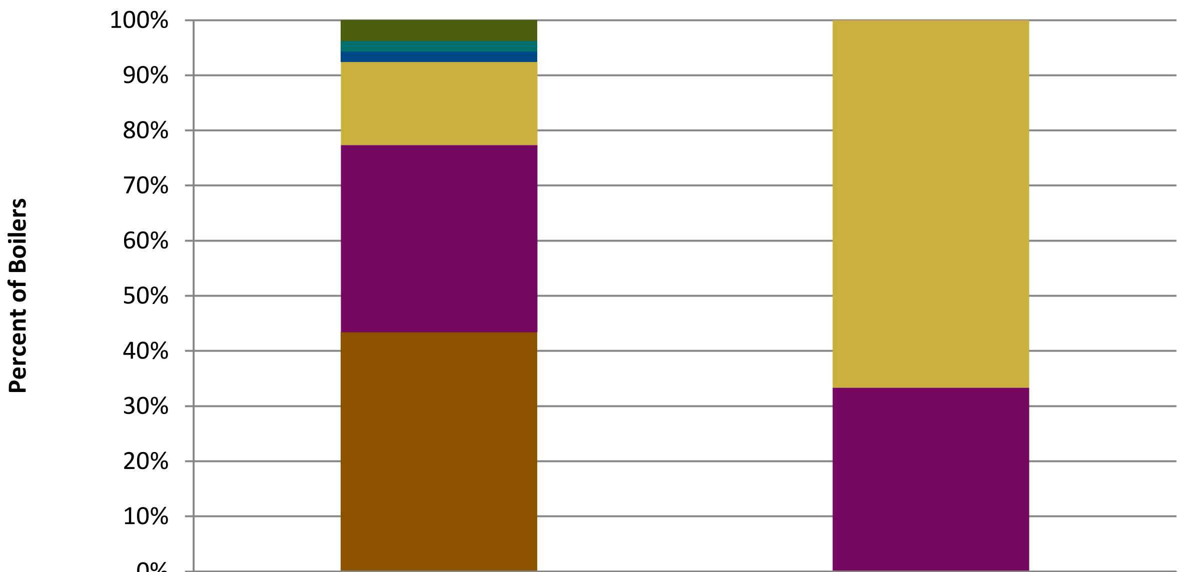


	Retail (N=5)	Office (N=6)	College/University (N=5)	Warehouse (N=3)	Healthcare (N=1)	Public Assembly (N=1)	School (N=3)	Balance of C&I (N=15)	All NC Buildings (N=39)
Unidentified	0%	22%	0%	0%	0%	0%	0%	0%	3%
Steam	0%	0%	29%	0%	0%	0%	0%	5%	5%
Hot Water	100%	78%	71%	100%	100%	100%	100%	95%	91%

Source: On-Site Survey, Question 222

Figure 3-31 shows the breakdown of boiler fuel types by delivery system (steam vs. hot water). Approximately 43% of hot water boilers are fueled by natural gas, and over one-third (34%) are fueled by LPG. Wood chips and wood pellets, combined, comprise 6% of hot water boilers, and waste oil boilers represent two percent of boiler systems in new construction buildings. The majority (67%) of steam boilers are powered by fuel oil while the remainder utilizes LPG. There are no steam boilers fueled by natural gas.

Figure 3-31. Boiler Fuel Types by Delivery System

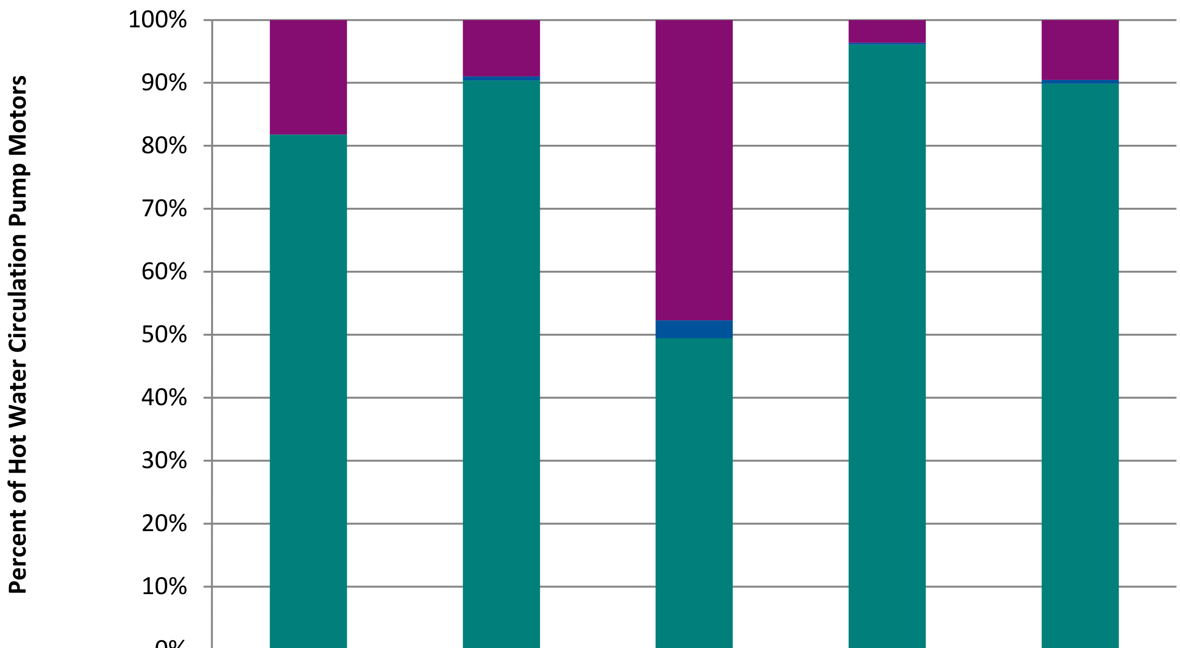


	Hot Water	Steam
Wood Pellets	4%	0%
Wood Chips	2%	0%
Waste Oil	2%	0%
Fuel Oil	15%	67%
LPG	34%	33%
Natural Gas	43%	0%

Source: On-Site Survey, Question 225

The majority (90%) of new construction facilities utilize variable speed controls on hot water circulation pumps, as shown in Figure 3-32. The saturations do not vary significantly between BED and EVT areas, though only approximately half (49%) of the circulation pumps in VT Gas territory are variable speed.[15]

Figure 3-32. Saturation of Speed Controls for Hot Water Circulation Pumps by EEU



	BED (N=8)	EVT (N=55)	VT Gas (N=18)	Non-VT Gas (N=45)	All NC Buildings (N=63)
One Speed	18%	9%	48%	4%	10%
Two Speed	0%	1%	3%	0%	1%
Variable Speed	82%	90%	49%	96%	90%

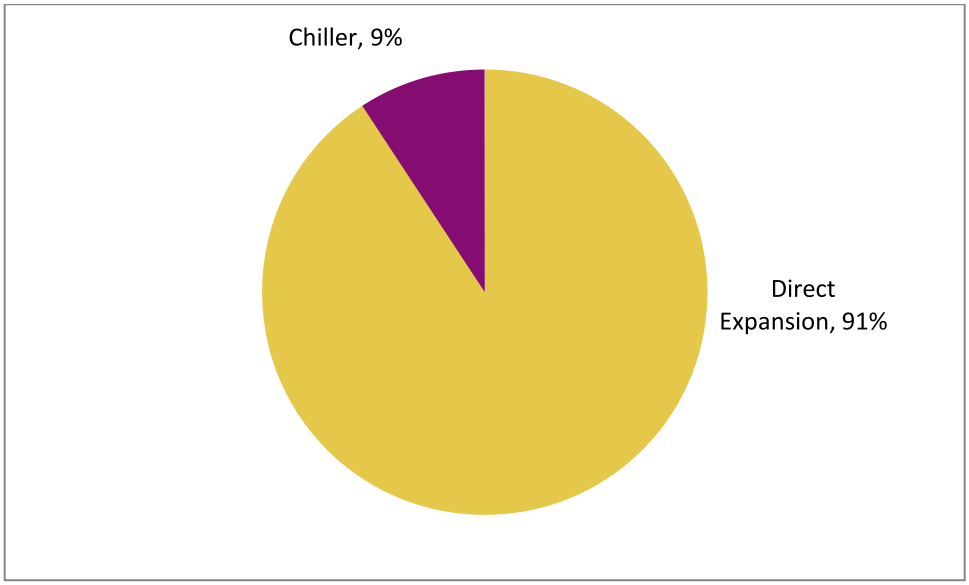
Source: On-Site Survey, Question 250

[15] The results are weighted by pump horsepower (hp). For relative comparison, the total observed horsepower in BED is 39 hp, and 82% is controlled by variable speed drive pumps. For VT Gas, the total observed horsepower is 88 hp, and 49% is controlled by variable speed drive pumps. In EVT areas, the total observed horsepower is 622 hp, and 90% is controlled by variable speed drive pumps.

3.4.3 Cooling Systems

Direct expansion (DX) cooling systems are the most frequently observed (91%) cooling system types in Vermont's new construction buildings. Chillers account for approximately 9% of all cooling system types, as shown in Figure 3-33.

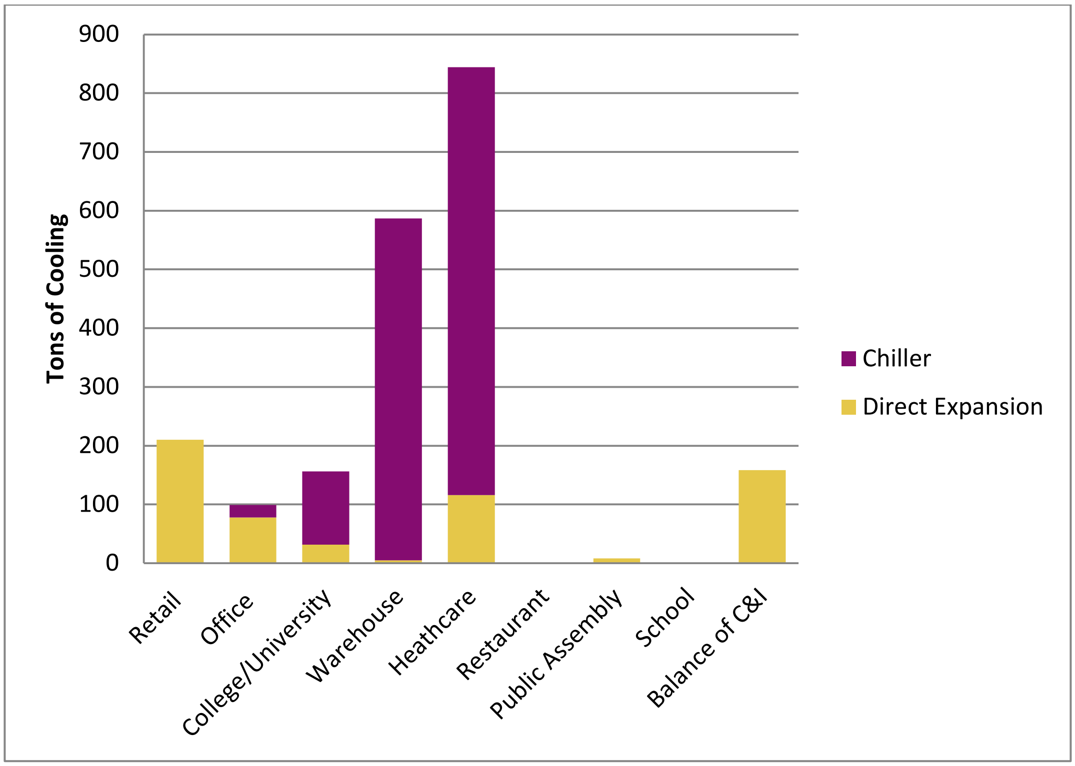
Figure 3-33. Distribution of Cooling System Types – All Buildings (N = 108 Observations)



*Weighted by frequency of system counts
Source: On-Site Survey, Questions 138 and 191

Figure 3-34 contrasts the preceding chart and illustrates that when accounting for total capacity (tons) of cooling, chillers comprise most (71%) of the cooling system capacity in Vermont's new construction buildings. The remaining capacity is met with DX systems. Healthcare facilities, warehouses and college/university buildings utilize chillers more than other building types, though approximately one-quarter of the cooling capacity in office buildings is from chillers.

Figure 3-34. Saturation of Cooling System Types by Building Type*



*Weighted by total capacity of cooling systems (tons)
Source: On-Site Survey, Questions 138 and 191

Nearly all single-zone unitary HVAC systems in Vermont's new construction buildings meet or exceed the prevailing code requirements at the time of the survey (2005 CBES), as shown in Table 3-13. The average Energy Efficiency Ratio (EER) for smaller systems (less than 5.5 tons) is 14.3 and the average Seasonal Energy Efficiency Ratio (SEER) is 14.2. All of the systems greater than 5.5 tons met or exceeded the code efficiency requirements.

Table 3-13. Cooling Efficiency of Single-Zone Unitary HVAC Systems[16]

	<5.5 tons (65,000 Btu/h) (Code: 13.0 SEER / 11.0 EER)	≥5.5 tons and <11.25 tons (135,000 Btu/h) (Code: 10.1 EER)	≥11.25 tons (135,000 Btu/h) (Code: 9.5 EER)
Percent of Systems Below Code	1%	0%	0%
Percent of Systems Above Code	99%	100%	100%
Mean EER[a]	14.3	11.4	12.0
Mean SEER[a]	14.2	N/A	N/A
Number of Observed Systems[b]	16	5	1

a. Mean efficiency is the weighted (by capacity) average efficiency of all observed units.
b. 22 observations with confirmed efficiency ratings.
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 3-14 shows that over half (53%) of qualifying cooling systems in new construction facilities are equipped with economizers. About 16% of qualifying systems did not have economizers. For smaller systems (less than 5.5 tons) that do not require economizers, only 16% of systems utilize this capability. However, surveyors were unable to determine if economizers were in use on 37% of systems less than 5.5 tons and 32% of systems greater than 5.5 tons.[17]

Table 3-14. Saturation of Economizers in Cooling Systems

	<5.5 tons (65,000 Btu/h)	≥5.5 tons (Code Required Minimum Size)
Economizer	16%	53%
No Economizer	47%	16%
Unidentified	37%	32%

N = 173 Systems
Source: On-Site Survey, Question 189; 2005 CBES Section 803.3.3.5

[16] One ton equals 12,000 Btu/h of cooling capacity. 5.5 tons is approximately equal to 65,000 Btu/h.
[17] Surveyors often were unable to visually verify the presence of a functioning economizer due to lack of access to HVAC systems as well as seasonal timing (i.e. , no ability to verify that dampers work properly because cooling systems are not running during site visits) .

3.4.3.1 Chillers

Surveyors identified five chillers in the field of new construction buildings and all were electric chillers. Table 3-15 summarizes key efficiency characteristics. Most (60%) chiller systems employ variable speed drive technology for the compressors, and most chilled water pumps are high efficiency and use variable speed drive controls. Four of five (80%) chillers employ temperature reset controls on the chilled water system.

Table 3-15. Chiller Efficiency Characteristics (N = 5)

Chiller Efficiency Characteristic	Percent of Chillers
Variable Speed Drive Compressor	60%
Chilled Water Pump Motor Efficiency[a]	40% - High Efficiency / 20% - Premium Efficiency
Variable Speed Drive Chilled Water Pump	80%
Utilizes Chilled Water Temperature Reset	80%

a. Two of five systems (40%) had unidentified efficiency levels
Source: On-Site Survey Questions 267, 286, 287 and 270, respectively

Surveyors identified the efficiency level of two of the chillers, and Table 3-16 shows that both systems meet or exceed the code-required minimum efficiency.

Table 3-16. Chiller Efficiency (N = 2)[a]

Chiller Capacity (Tons)	Observed Efficiency (kW/Ton)	Observed Efficiency (COP)[b]	Code-Minimum Efficiency (COP)[c]
55	0.70	5.02	5.00
245	0.54	6.51	5.55

a. Chiller efficiency only observed on two of five chillers
b. Coefficient of Performance (COP) = 12 / (KW/ton) / 3.412
c. 2005 CBES Table 803.3.2(2); Water-cooled, electrically operated, centrifugal chillers
Source: On-Site Survey Questions 269

Most chillers (60%) were dedicated solely to space cooling, but one chiller served process cooling loads and another served a mix of space cooling and refrigeration loads, as shown in Table 3-17.

Table 3-17. Chiller End Uses (N = 5)

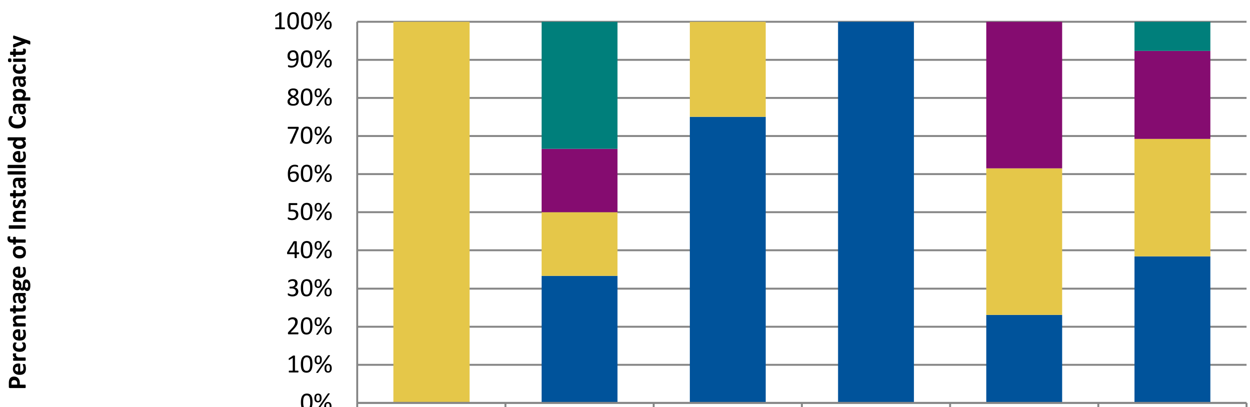
Chiller End Use	Percent of Chillers Dedicated to End Use
Space Cooling (N = 3)	60%
Process (N = 1)	20%
Space Cooling and Refrigeration (N = 1)	20%

Source: On-Site Survey Questions 275-277

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 Vermont's commercial energy code. Figure 3-35 shows that over one-third (38%) of multi-zone systems have variable air volume distribution systems, while approximately 31% are constant volume, and less than one-quarter (23%) are multi-zone distribution systems. Variable refrigerant volume (VRV) systems comprise approximately 8% of all new construction multi-zone system types, and notably, one-third (33%) of systems in office buildings.

Figure 3-35. Saturation of Multi-Zone Distribution System Types by Building Type



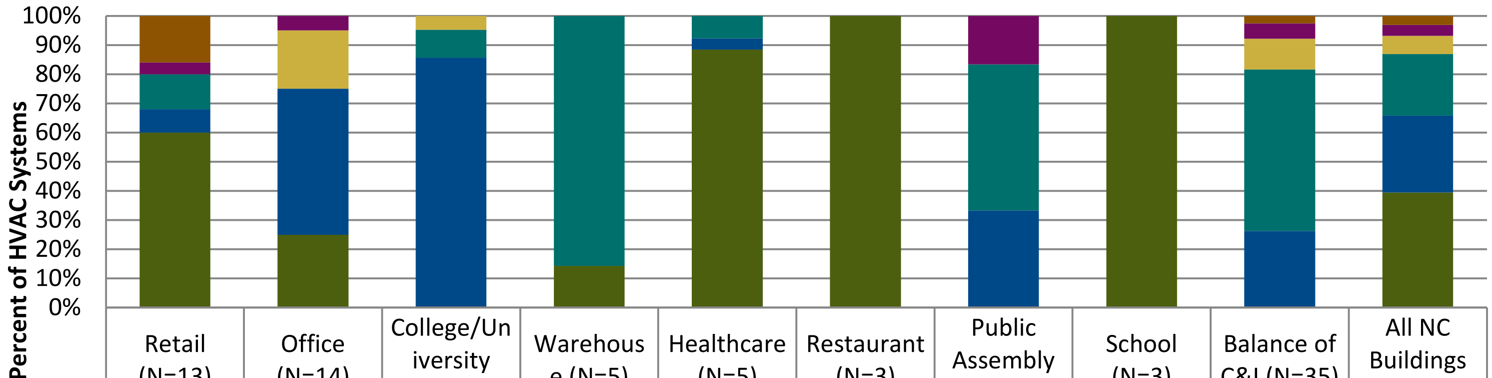
	Retail (N=1)	Office (N=6)	College/University (N=4)	Public Assembly (N=2)	Balance of C&I (N=13)	All NC Buildings (N=26)
Variable Refrigerant Volume	0%	33%	0%	0%	0%	8%
Multi Zone	0%	17%	0%	0%	38%	23%
Constant Volume	100%	17%	25%	0%	38%	31%
Variable Air Volume	0%	33%	75%	100%	23%	38%

Source: On-Site Survey, Question 170

3.4.5 HVAC Controls

Programmable thermostats comprise the largest share of HVAC control strategies in new construction buildings, making up 39%, as shown in Figure 3-36. EMS systems comprise over one-quarter (26%) of control strategies and manual controls make up 21%. HVAC system control types vary widely across building types, with EMS controls making up 86% of college/university HVAC controls, and comprising half (50%) of office building HVAC controls. Warehouse facilities rely on manual controls more than any other sector, with an 86% share for this control type.

Figure 3-36. Saturation of HVAC System Control Types by Building Type



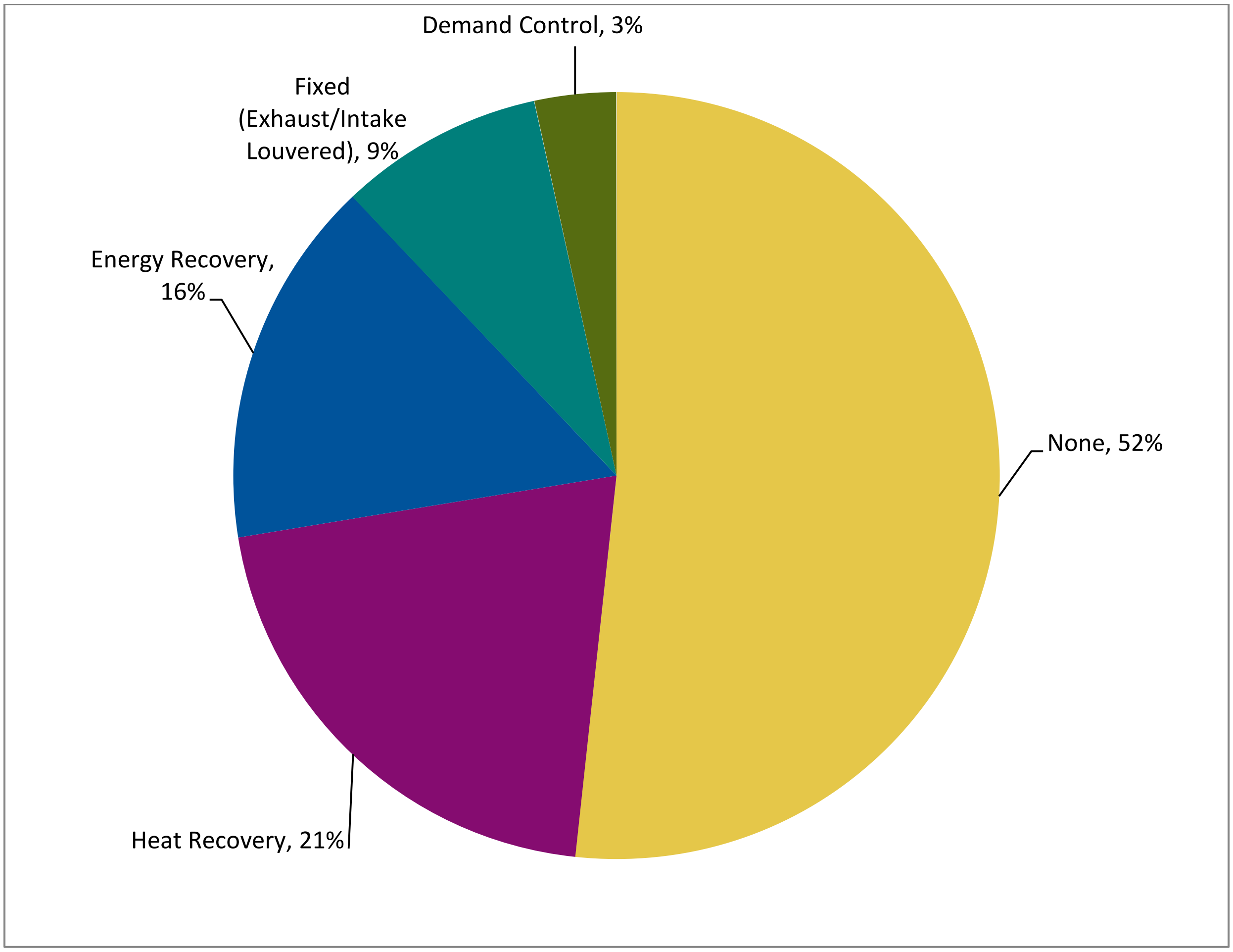
	Retail (N=13)	Office (N=14)	College/University (N=11)	Warehouse (N=5)	Healthcare (N=5)	Restaurant (N=3)	Public Assembly (N=4)	School (N=3)	Balance of C&I (N=35)	All NC Buildings (N=93)
Time Clock	16%	0%	0%	0%	0%	0%	0%	0%	3%	3%
Unknown	4%	5%	0%	0%	0%	0%	17%	0%	5%	4%
Always On	0%	20%	5%	0%	0%	0%	0%	0%	11%	6%
Manual	12%	0%	10%	86%	8%	0%	50%	0%	55%	21%
EMS	8%	50%	86%	0%	4%	0%	33%	0%	26%	26%
Programmable Thermostat	60%	25%	0%	14%	88%	100%	0%	100%	0%	39%

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. Over half (52%) of all buildings had no identified ventilation strategy, as shown in Figure 3-37. Over one-third of all buildings used either heat recovery (21%) or energy recovery (16%) as the dominant ventilation strategy.[18] Demand control ventilation (DCV) comprises only 3% of dominant control strategies in new construction buildings. This is expected, as DCV is typically applied to limited areas, such as conference rooms and auditoriums.[19]

Figure 3-37. Dominant Ventilation Strategy for All Buildings (N=58)



Source: On-Site Survey Section 23

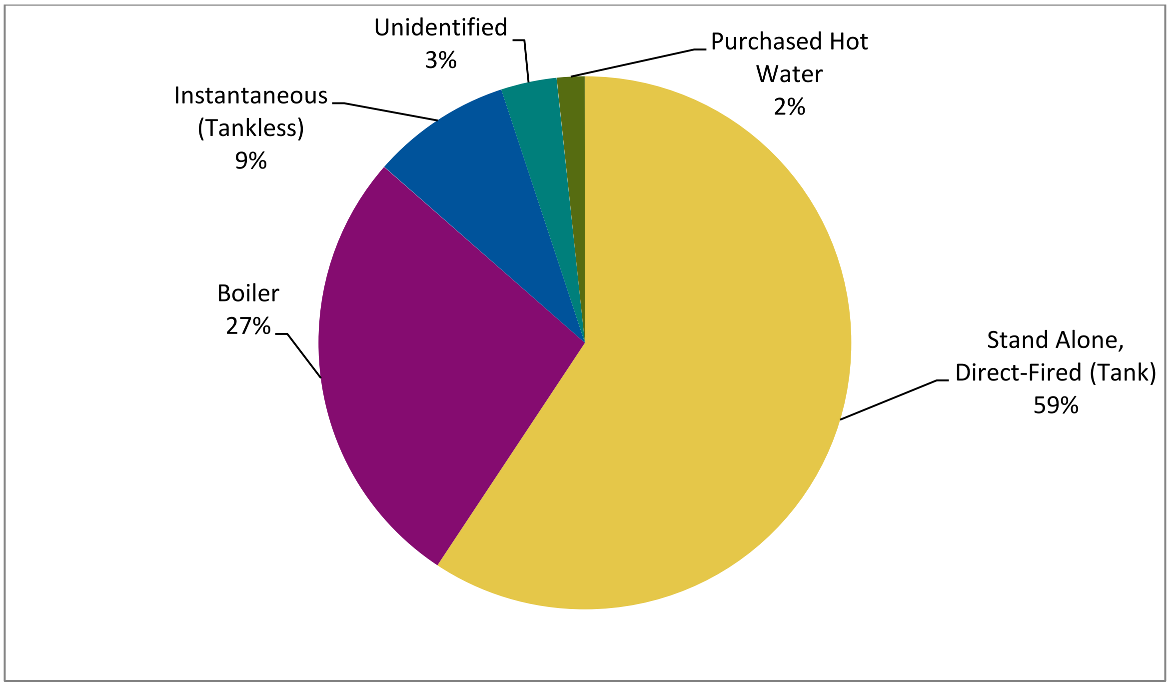
[18] Heat recovery captures only sensible heat while energy recovery recovers both sensible and latent heat

[19] The 2005 CBES, the current code at the time of study, did not require DCV in any spaces. 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 (59%) of water heating systems in Vermont's new construction buildings, as shown in Figure 3-38. Boilers account for over one-quarter (27%) of all systems and instantaneous (i.e., tankless) systems comprise 9% of all water heating systems.

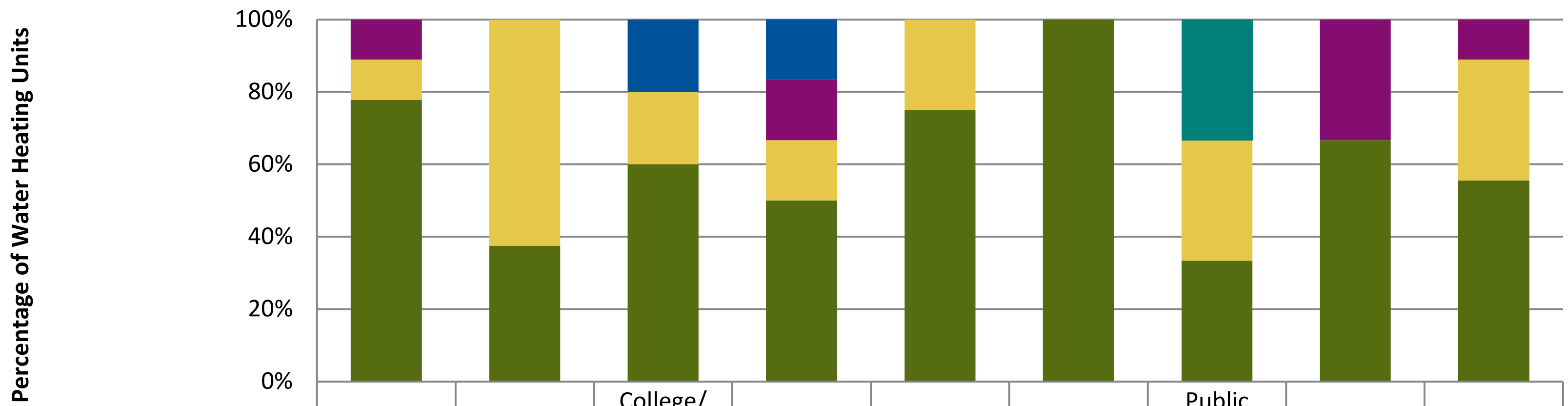
Figure 3-38. Distribution of Water Heating Equipment Types – All Buildings (N = 59 observations)



Source: On-Site Survey Question 319

Figure 3-39 shows saturations of water heating system types by building type. Stand-alone systems comprise the majority of system types across most building type categories, though boilers make up the majority (63%) of systems in office buildings. Tankless water heaters were observed in retail (11%), warehouse (17%) and school (33%) facilities.

Figure 3-39. Saturation of Water Heating Equipment Types by Building Type

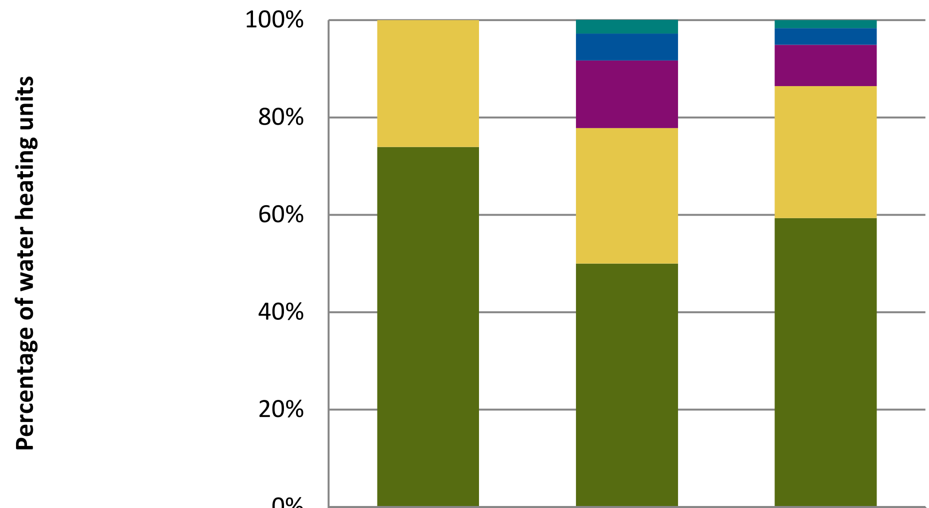


	Retail (N=9)	Office (N=8)	College/ University (N=5)	Warehouse (N=6)	Healthcare (N=4)	Restaurant (N=3)	Public Assembly (N=3)	School (N=3)	Balance of C&I (N=18)
Unidentified	0%	0%	20%	17%	0%	0%	0%	0%	0%
Purchased Hot Water	0%	0%	0%	0%	0%	0%	33%	0%	0%
Instantaneous (Tankless)	11%	0%	0%	17%	0%	0%	0%	33%	11%
Boiler	11%	63%	20%	17%	25%	0%	33%	0%	33%
Stand Alone, Direct-Fired	78%	38%	60%	50%	75%	100%	33%	67%	56%

Source: On-Site Survey Question 319

Figure 3-40 provides the saturations of water heating system types for VT Gas and non-VT Gas territory. Stand-alone systems comprise nearly three-quarters (74%) of systems in VT Gas territory and only 50% of systems in non-VT Gas areas. Tankless water heaters comprise approximately14% of systems in non-VT Gas areas and were not observed in any VT Gas facilities.

Figure 3-40. Saturation of Water Heating Equipment Types – VT Gas vs. Non-VT Gas

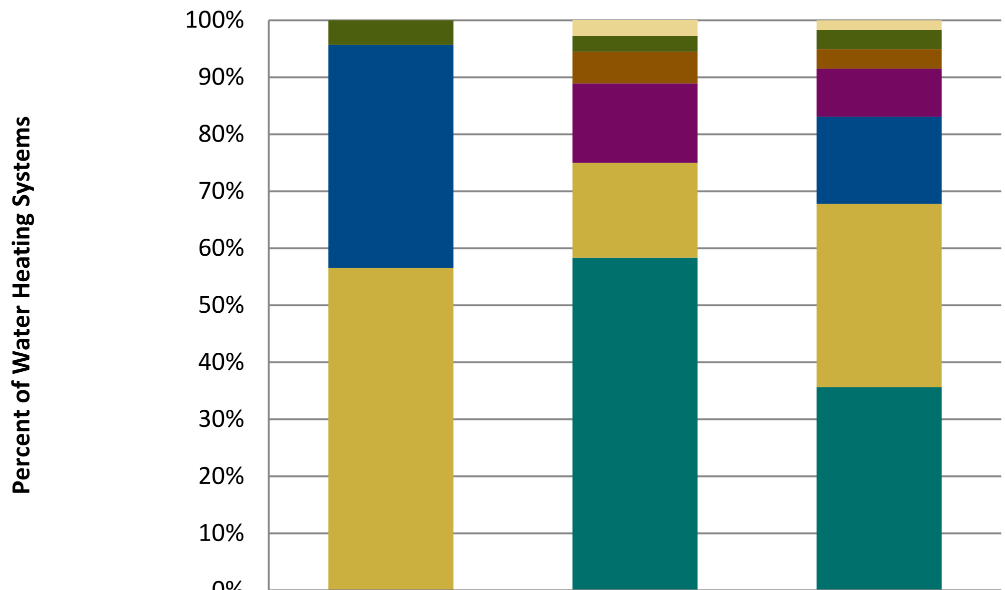


	VT Gas (N=23)	Non VT Gas (N=36)	All (N=59)
Purchased Hot Water	0%	3%	2%
Unidentified	0%	6%	3%
Instantaneous (Tankless)	0%	14%	8%
Boiler	26%	28%	27%
Stand Alone, Direct-Fired	74%	50%	59%

Source: On-Site Survey Question 319

Over one-third (36%) of water heaters in new construction facilities are fueled by propane (LPG) and approximately 32% of water heaters are electric, as shown in Figure 3-41. Approximately 15% of water heaters are fueled by natural gas. Vermont's commercial energy code prohibits electric water heaters greater than 5 kW in size, and most (79%) of the electric water heaters observed on-site complied with this code requirement. Surveyors identified approximately 6% of systems in non-VT Gas areas utilizing commercial solar hot water (with fuel backup) systems and 3% using wood chips or wood pellets for water heating.

Figure 3-41. Water Heating Fuel Types – VT Gas vs. Non-VT Gas

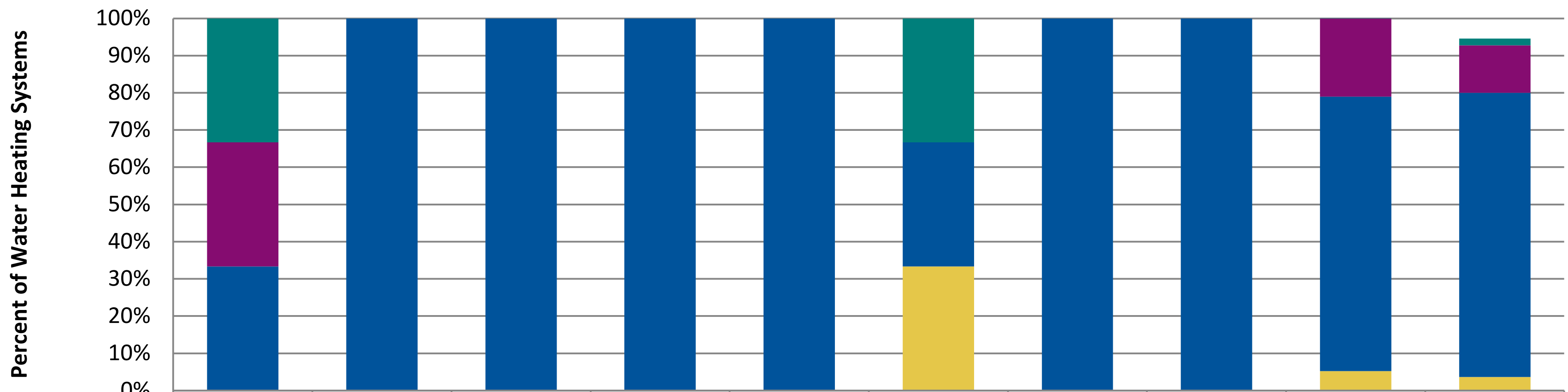


	VT Gas (N=23)	Non VT Gas (N=36)	All (N=59)
Wood	0%	3%	2%
Unidentified	4%	3%	3%
Solar w/fuel backup	0%	6%	3%
Fuel Oil	0%	14%	8%
Natural Gas	39%	0%	15%
Electricity	57%	17%	32%
LPG	0%	58%	36%

Source: On-Site Survey Question 320

Most new construction buildings (76%) maintain a water temperature setting between 110 °F and 140 °F (i.e., medium) as shown in Figure 3-42.[20] Approximately one-third (33%) of retail building owners maintained a low temperature setting (< 110 °F). A relatively small number of water heaters are maintained at high temperature settings (> 140 °F), and these are found in restaurants and balance of C&I building type categories.

Figure 3-42. Water Heater Temperature Setting by Building Type[21]



	Retail (N=9)	Office (N=8)	College/ University (N=5)	Warehouse (N=6)	Healthcare (N=4)	Restaurant (N=3)	Public Assembly (N=3)	School (N=3)	Balance of C&I (N=18)	All NC Buildings (N=59)
Unidentified	33%	0%	0%	0%	0%	33%	0%	0%	2%	2%
Low	33%	0%	0%	0%	0%	0%	0%	0%	21%	13%
Medium	33%	100%	100%	100%	100%	33%	100%	100%	74%	76%
High	0%	0%	0%	0%	0%	33%	0%	0%	5%	4%

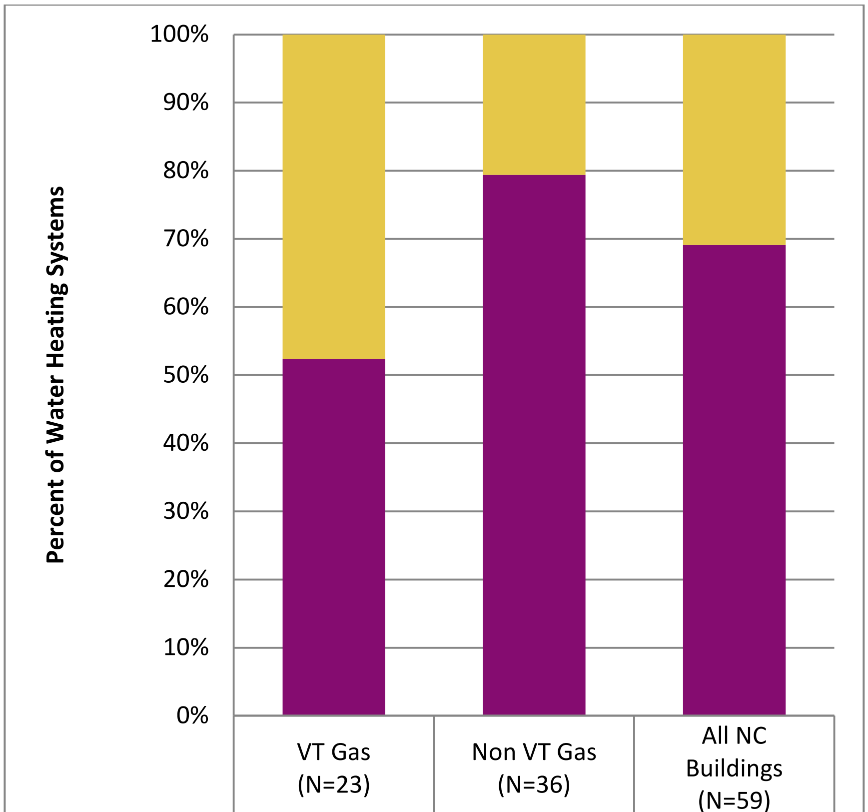
Source: On-Site Survey Question 331

[20]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.

[21] Water heater temperature settings do not vary between VT Gas and non-VT gas areas in new construction facilities, and is thus not explicitly included in the report.

Most (69%) water heaters have pipe insulation in Vermont's new construction buildings, with 31% having no insulation, as shown in Figure 3-43. In VT Gas territory, the share of insulated versus non-insulated pipes is relatively equal, at 52% and 48%, respectively.

Figure 3-43. Water Heating Pipe Insulation – VT Gas vs. Non-VT Gas

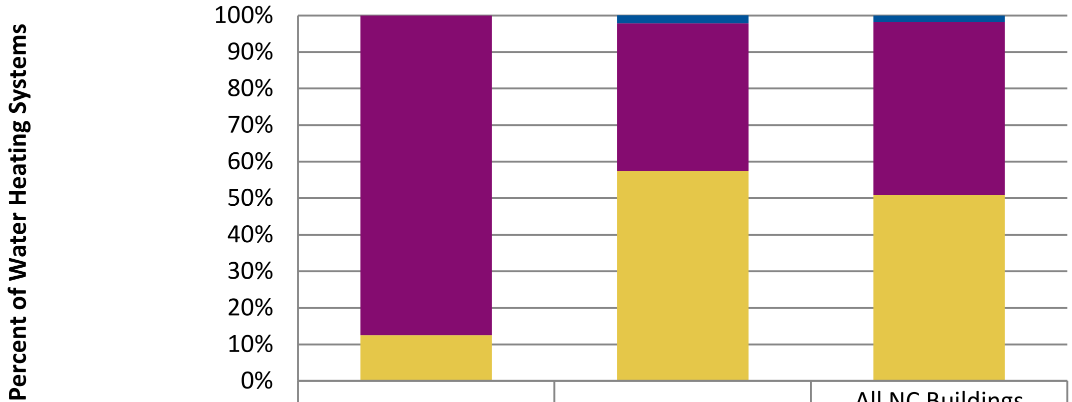


	VT Gas (N=23)	Non VT Gas (N=36)	All NC Buildings (N=59)
Not Insulated	48%	21%	31%
Insulated	52%	79%	69%

Source: On-Site Survey Question 332

As shown in Figure 3-44, a slight majority (51%) of new construction buildings use a recirculation pump for service hot water distribution. In BED territory, most buildings (88%) do not employ a recirculation pump.

Figure 3-44. Use of Water Heating Recirculation Pump by EEU



	BED (N=10)	EVT (N=49)	All NC Buildings (N=59)
Unidentified	0%	2%	2%
No Recirculation Pump	88%	40%	47%
Recirculation Pump	13%	57%	51%

Source: On-Site Survey Question 335

3.4.8 EEU Market Characterization – HVAC and Water Heating

Table 3-18 provides a summary characterization of HVAC and water heating measures for Vermont's EEUs.

Table 3-18. EEU Market Characterization – HVAC and Water Heating

	Measure/Characteristic	BED	EVT	VT Gas
HVAC	Heating System types	N/A		» Furnaces account for 45% of all heating systems followed by boilers (31%). » Water-source heat pumps account for 122% of system types
	Primary Heating Fuel Type	» Natural gas is primary fuel type for 75% of customers.	» LPG is primary fuel type for 48% of customers, followed by 25% with natural gas and 18% using fuel oil.	» Natural gas is primary fuel type for 76% of customers, with 10% using LPG as the primary heating fuel.
	Heating System Efficiency	» 74% of the furnaces less than 225 kBtu/h exceeded the 2005 CBES efficiency requirement and 26% met the requirement. » All of the furnaces greater than 225 kBtu/h exceeded minimum requirements. » All boilers (hot water and steam) exceeded the code minimum efficiency level. » Five of six water-source heat pumps exceeded the minimum COP requirement, and one system did not meet code.		
	Boiler Delivery Systems	» Most (91%) boilers in new construction are hot water boilers, while steam boilers comprise 5% of all boilers.		
	Hot Water Circulation Pump Speed Controls	» 82% are variable speed.	» 90% are variable speed.	» 49% are variable speed.
	Cooling System Types	» Direct expansion (DX) cooling systems make up nearly all (91%) of all cooling system capacity in Vermont's new construction.		
	Cooling Efficiency of Single-Zone Unitary HVAC Systems	» Almost all (99%) of small (less than 5.5 tons in cooling capacity) single-zone unitary HVAC systems in Vermont's new construction buildings exceeded the 2005 CBES requirements. » All systems greater than 5.5 tons exceeded the code requirements.		

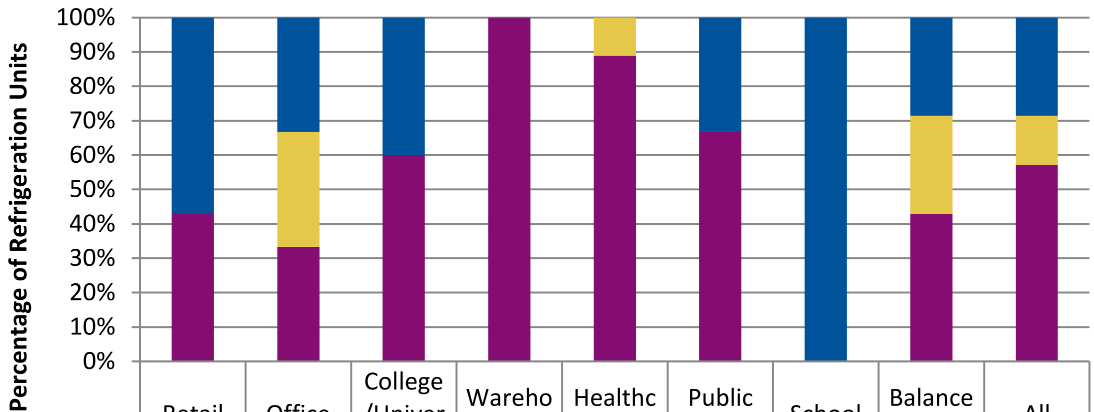
	Measure/Characteristic	BED	EVT	VT Gas
	Saturation of Economizers in Cooling Systems	» The findings indicate that 53% of systems greater than 5.5 tons (2005 CBES-required minimum) use economizers and 16% were not equipped with economizers and did not meet the code. » About 16% of smaller systems (less than 5.5 tons) use economizers, even though this is not required by the energy code.		
	Chiller Systems	» 60% of chiller compressors are variable speed drive. » 40% of chilled water pumps are high efficiency and 20% are premium efficiency motors. » 80% of chilled water pumps use variable speed drive controls. » 80% of chiller systems employed chilled water temperature reset. » Two of the five chiller systems met or exceeded the code minimum efficiency (Remaining efficiency levels were not identified).		
Water Heating	Water Heating Equipment Types	N/A		» Most (74%) systems are stand-alone, direct-fired water heaters. 26% are boilers.
Water Heating	Water Heating Fuel Types	N/A		» Over half (57%) of all water heaters in VT Gas areas are electric, followed by 39% fueled by natural gas.
Water Heating	Water Heating Pipe Insulation	N/A		» Over half 52% of water heater pipes are insulated in VT Gas areas.
Water Heating	Water Heating Recirculation Pump	» Over 85% of all systems do not use recirculation pumps.	» Over half 57% of all systems do not use recirculation pumps while 40% of the systems use them.	N/A

Source: Navigant analysis

3.5 *Refrigeration*[22]

Figure 3-45 shows that 57% of non-commercial (residential-size) refrigerators are not ENERGY STAR rated. Approximately 14% of observed units are ENERGY STAR rated, and nearly one-third were unidentified.[23] Offices have the highest share of ENERGY STAR refrigerators and freezers, while warehouses and healthcare facilities have the highest share of non-ENERGY STAR units.

Figure 3-45. Saturation of Non-Commercial ENERGY STAR Refrigerators/Freezers by Building Type



	Retail (N=13)	Office (N=16)	College /University (N=5)	Warehouse (N=4)	Healthcare (N=9)	Public Assembly (N=3)	School (N=1)	Balance of C&I (N=14)	All (N=49)
Unidentified	57%	33%	40%	0%	0%	33%	100%	29%	29%
Energy Star	0%	33%	0%	0%	11%	0%	0%	29%	14%
Non-Energy Star	43%	33%	60%	100%	89%	67%	0%	43%	57%

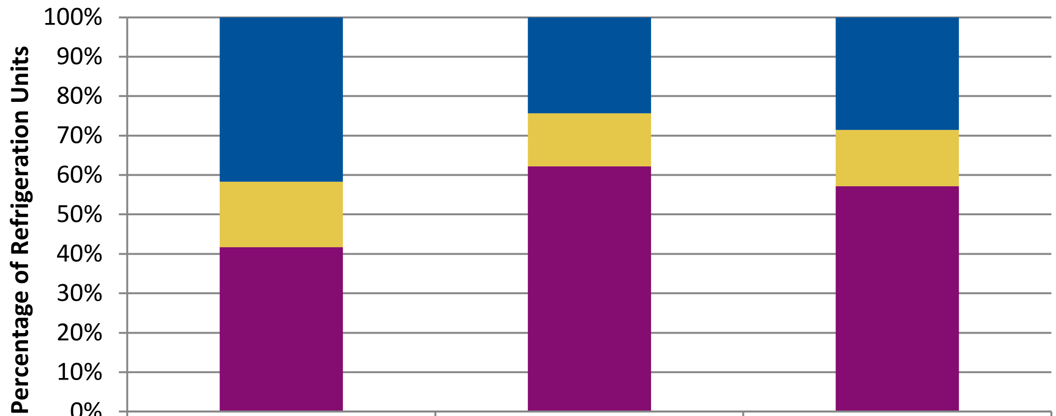
Building Type

Source: On-Site Survey Question 474d

[22] Small sample sizes, particularly in BED service territory, may impact the survey results for refrigeration measures.
[23] Surveyors were not always able to access nameplates or labels where the ENERGY STAR label is placed.

The saturation of non-commercial (residential-sized) ENERGY STAR refrigerators and freezers does not differ significantly by EEU, as shown in Figure 3-46.

Figure 3-46. Saturation of Non-Commercial ENERGY STAR Refrigerators/Freezers by EEU



	BED (N=12)	EVT (N=37)	All (N=49)
Unidentified	42%	24%	29%
Energy Star	17%	14%	14%
Non-Energy Star	42%	62%	57%

Utility

Source: On-Site Survey Question 474d

All refrigerated display cases observed in new construction facilities have glass doors, meaning there were no cases without doors or strip curtains. Table 3-19 shows that the majority of refrigeration units with glass doors either has zero-energy doors or controls the anti-sweat heaters for energy efficiency (23% and 34%, respectively). Approximately 42% have anti-sweat heaters always on, representing a large potential for capturing energy savings through anti-sweat heater controls.

Table 3-19. Saturation of Anti-Sweat Controls on Refrigeration Units

Glass Door Anti-Sweat Control Strategy	All NC Buildings (N=8)
Anti-Sweat Heaters Always On	42%
Anti-Sweat Heater Controls	34%
Zero Energy Doors	23%
Total	**100%**
Source: On-Site Survey Question 499	

Most (75%) refrigerated display cases in new construction facilities use LED lighting, while 25% use fluorescent lighting, as shown in Table 3-20.

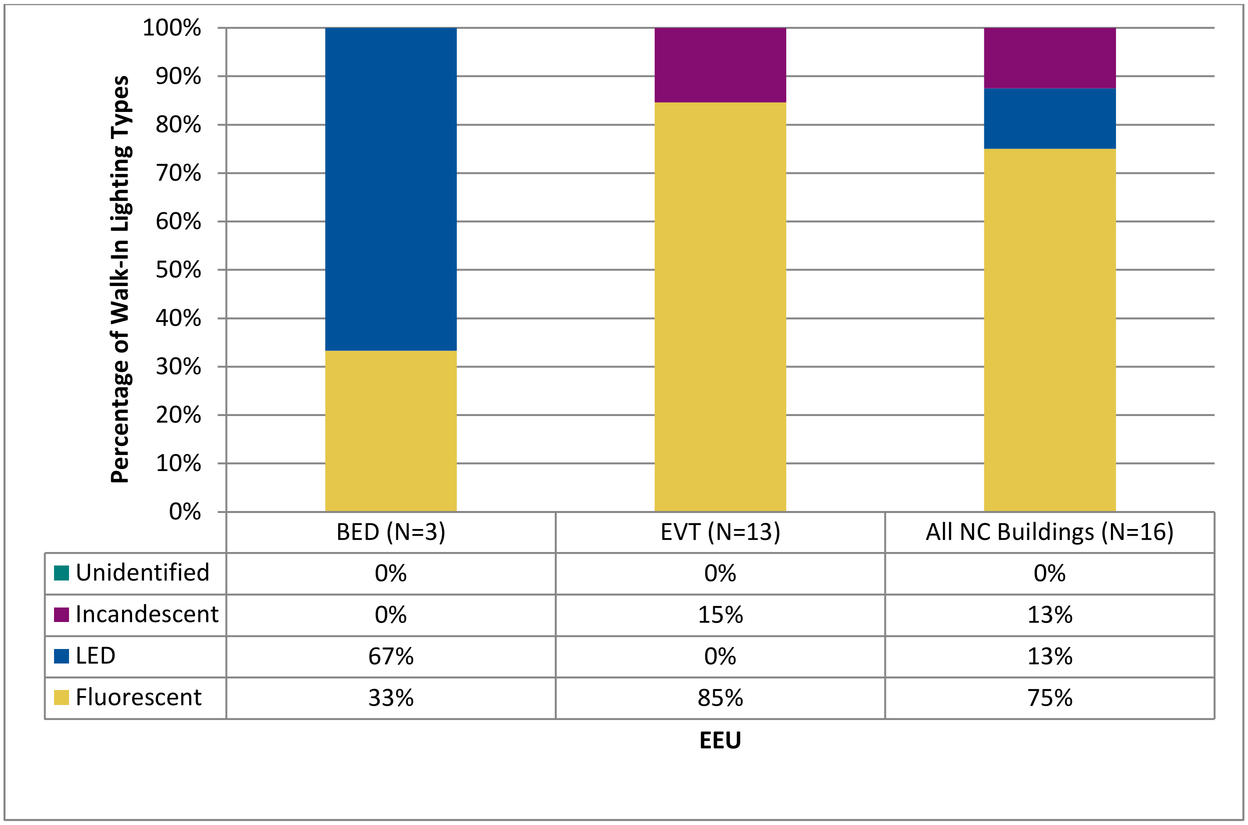
Table 3-20. Saturation of Display Case Lighting Types by Utility

Display Case Lighting	All NC Buildings (N=8)
Fluorescent	25%
LED	75%
Total	**100%**
Source: On-Site Survey Question 500	

Most (75%) walk-in refrigeration units use fluorescent lighting and approximately 13% of all walk-in coolers use LED lighting, and 13% use incandescent lighting, as shown in Figure 3-47. LED lighting comprises approximately 5% of all walk-in cooler lighting, and was only observed at low energy use buildings in EVT territory.

LED lighting was found in most (67%) of the walk-in coolers in BED territory and was not identified in any of the EVT facilities.[24] Additionally, there were no walk-in coolers equipped with occupancy sensors for lighting controls in either BED or EVT territory, as all coolers relied on manual switches.

Figure 3-47. Saturation of Walk-In Refrigeration Unit Lighting Types by Utility

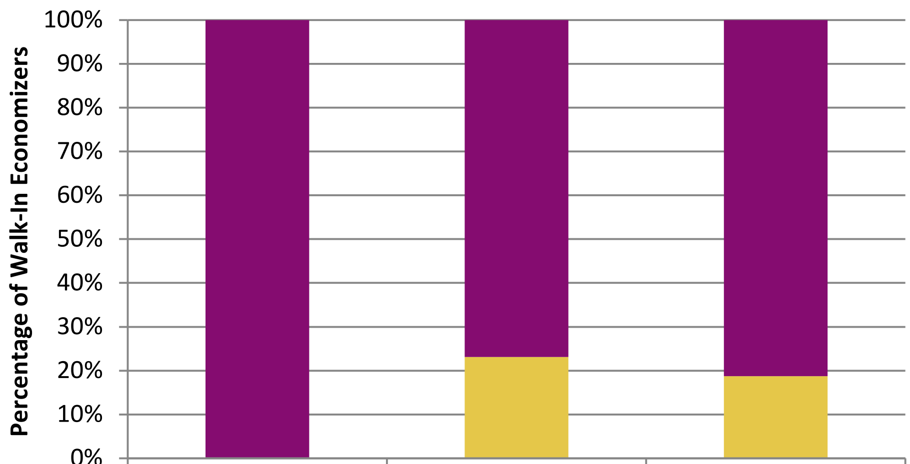


*Note small sample size for BED (N=3)
Source: On-Site Survey Question 509

[24] Note the small sample size for BED (N=3).

Economizers in walk-in refrigeration units were only observed in the EVT territory with a saturation of 23%, as shown in Figure 3-48. Efficiency Vermont offers incentives for economizers in walk-in coolers, and the findings indicate there is significant potential to implement this measure in walk-in coolers in new and renovated buildings. The small sample size (only three walk-in units) in BED territory may not represent the actual saturation of economizers in walk-in refrigeration units.

Figure 3-48. Saturation of Walk-In Refrigeration Unit Economizers by EEU



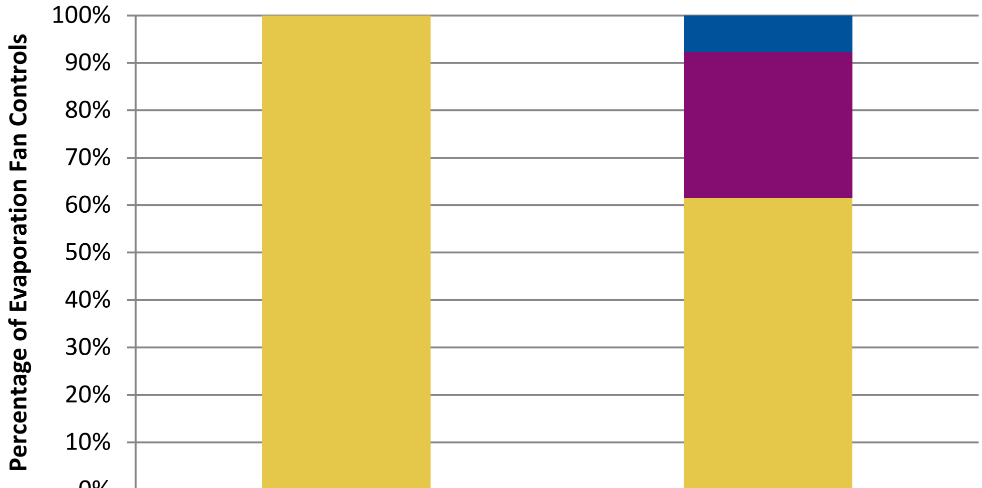
	BED (N=3)	EVT (N=13)	All (N=16)
Unidentified	0%	0%	0%
No Economizer	100%	77%	81%
Economizer	0%	23%	19%

Utility

*Note small sample size for BED (N=3)
Source: On-Site Survey Question 511

Within the EVT territory, the majority (62%) of walk-in refrigeration units were found to have evaporator fan motor controls, as shown in Figure 3-49. All walk-in units in BED territory had evaporator fan motor controls installed.

Figure 3-49. Saturation of Walk-In Refrigeration Unit Evaporator Fan Motor Controls by EEU

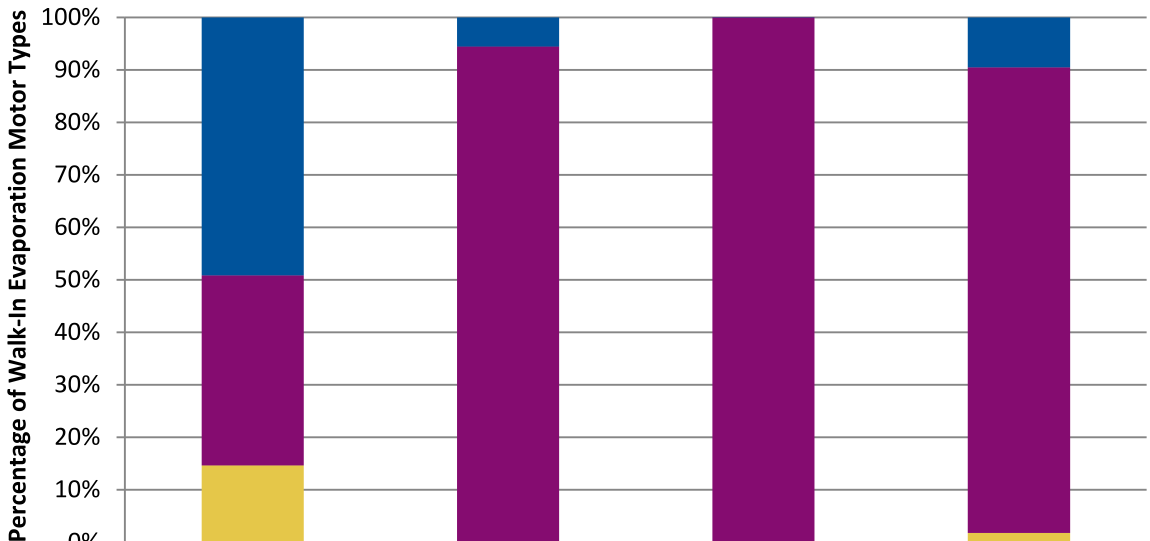


	BED (N=3)	EVT (N=13)
Unidentified	0%	8%
No Evap Fan Ctrls	0%	31%
Evap Fan Ctrls	100%	62%

*Note small sample size for BED (N=3)
Source: On-Site Survey Question 512

Only 2% of walk-in refrigeration units have Electrically Commutated Motors (ECM) motors on walk-in cooler evaporator fans, as shown in Figure 3-50. The largest share (15%) of ECM motors is in the high energy use stratum.

Figure 3-50. Saturation of Walk-in Refrigeration Unit Evaporation Motor Types by Consumption Stratum

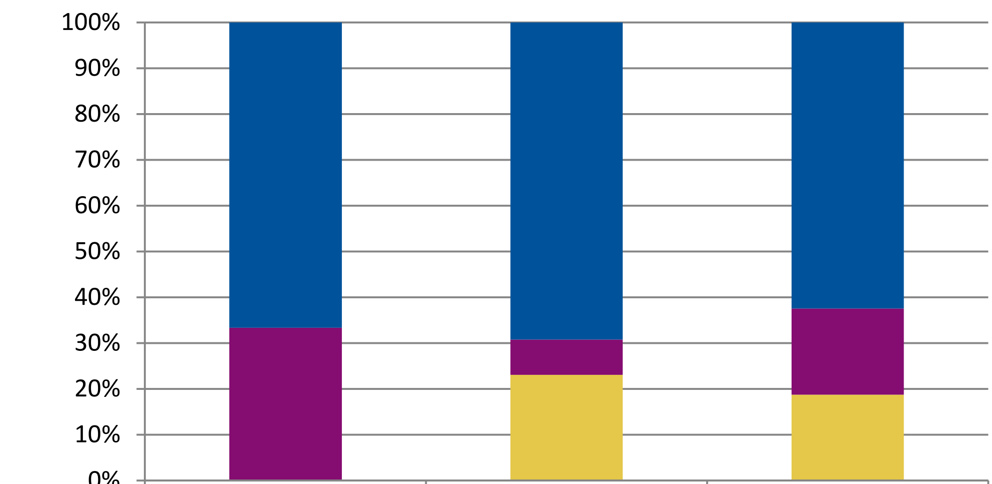


	High (N=97)	Medium (N=38)	Low (N=4)	All (N=139)
Unknown	49%	6%	0%	10%
Non-ECM	36%	94%	100%	89%
ECM	15%	0%	0%	2%

Source: On-Site Survey Question 513

In the EVT territory 23% of walk-in cooler evaporator fans have ECM motors, as shown in Figure 3-51. Approximately one-third of motors in BED territory are non-ECM motors, yet most were unidentified.[25]

Figure 3-51. Saturation of Walk-in Refrigeration Unit Evaporation Motor Types by EEU



	BED (N=3)	EVT (N=13)	All (N=16)
Unknown	67%	69%	63%
Non-ECM	33%	8%	19%
ECM	0	23%	19%

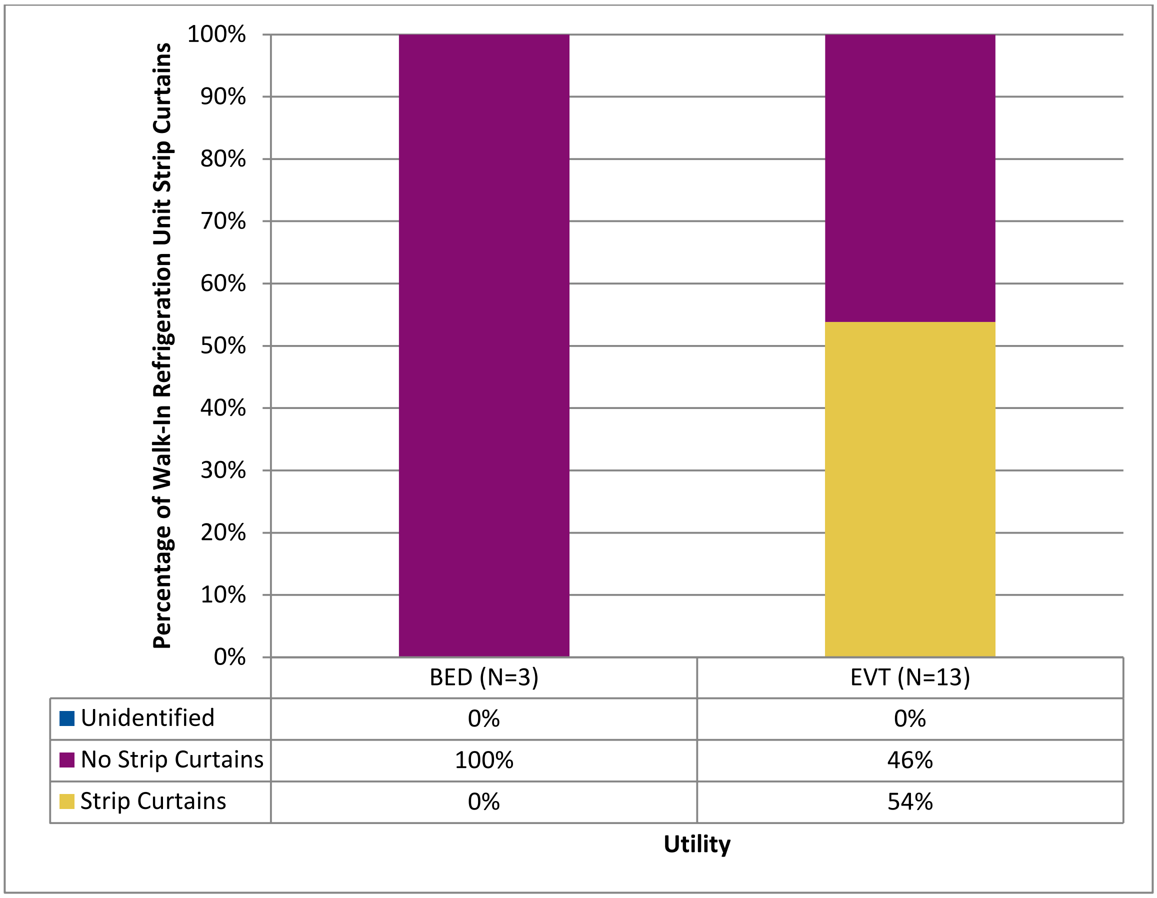
Utility

*Note small sample size for BED (N=3)
Source: On-Site Survey Question 513

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

Over half (54%) of applicable walk-in coolers in EVT areas had a strip curtains installed, as shown in Figure 3-52. None of the walk-in units in BED territory had strip curtains installed, though the sample size was limited in BED territory.

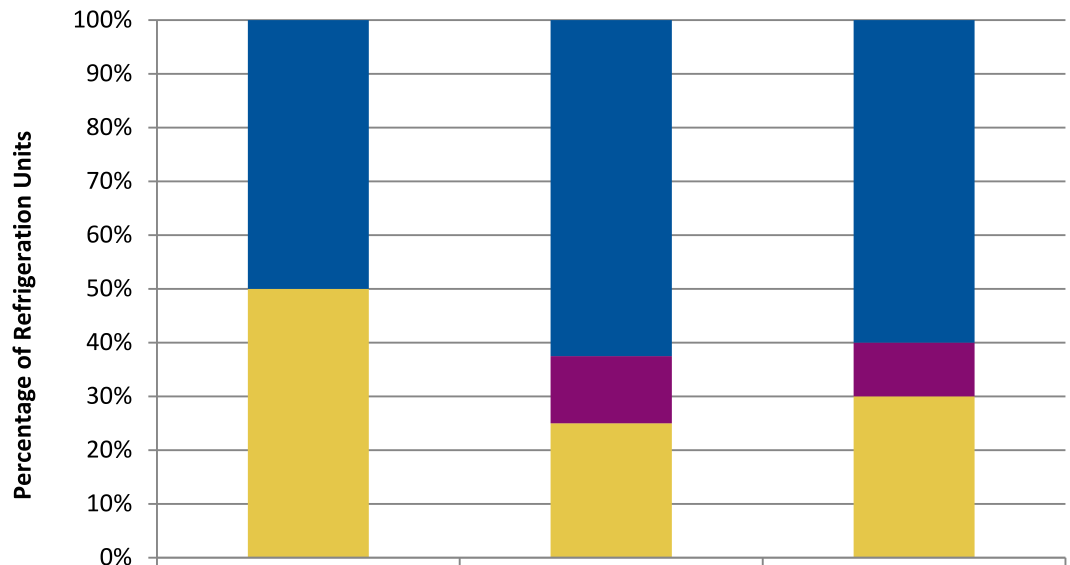
Figure 3-52. Saturation of Walk-In Refrigeration Unit Strip Curtains by EEU



*Note small sample size for BED (N=3)
Source: On-Site Survey Question 515

Approximately 30% of all new construction facilities with refrigeration systems implement floating head pressure control and ten percent do not utilize this strategy. Over half (60%) of all systems had an unidentified control strategy, as shown in Figure 3-53.

Figure 3-53. Saturation of Refrigeration Systems with Floating Head Pressure Control by EEU



	BED (N=3)	EVT (N=14)	All (N=17)
Unidentified	50%	63%	60%
No Pressure Control	0%	13%	10%
Pressure Control	50%	25%	30%

Utility

*Note small sample size for BED (N=3)
Source: On-Site Survey Question 534

3.5.1 EEU Market Characterization – Refrigeration

Table 3-21 provides a summary characterization of refrigeration measures for Vermont's EEUs.

Table 3-21. EEU Market Characterization – Refrigeration

Measure/Characteristic	BED[a]	EVT
ENERGY STAR non-commercial refrigerators	» 17% of non-commercial refrigerators are ENERGY STAR.	» 14% of non-commercial refrigerators are ENERGY STAR.
Anti-sweat heater controls	» 34% of the observed systems had anti-sweat heater controls 23% had zero energy doors (pre-empting the need for anti-sweat heaters).	
Refrigerated display case lighting	» 75% of cases used LED lighting and the remaining used fluorescent lighting.	
Walk-in cooler lighting	» 67% of walk-in coolers have LED lighting, with 33% using fluorescents. All were manually-controlled.	» 85% of walk-in coolers have fluorescent lighting, with remaining 15% using incandescents. All were manually-controlled.
Walk-in cooler economizers	» No economizers were observed in BED territory.	» 23% of walk-in refrigeration units were equipped with economizers.
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.	» 23% of walk-in cooler evaporator fans have ECM motors.
Evaporator fan motor controls in walk-in coolers[c]	» All of the walk-in refrigeration units have evaporator fan motor controls.	» 62% of all walk-in refrigeration units have evaporator fan motor controls.
Strip curtains on walk-in refrigeration units	» BED has no walk-in refrigeration units strip curtains.	» EVT has a strip curtain installation rate of 54%.
Floating head pressure control on refrigeration systems	» Half of BED customers implement floating pressure head control for refrigeration systems.	» 25% of EVT customers implement floating pressure head control for refrigeration systems.
Heat recovery on refrigeration systems	» None of the refrigeration systems observed for the new construction sample utilized heat recovery.	

a. Small sample sizes, particularly in BED service territory, may impact the survey results for refrigeration measures.
Source: Navigant analysis

3.6 *Motors and Compressed Air*

3.6.1 Motors

Surveyors only identified only eight process motors in the new construction facilities. Other than motors serving passenger elevators, all were constant speed motors and approximately 90% were classified as standard efficiency. The small sample sizes prevent further analysis.

3.6.2 Compressed Air

Table 3-22 shows that over half (53%) of all air compressors are smaller capacity single-stage models, and less than one-quarter (21%) are two-stage compressors, which are more efficient and often longer lasting than their single-stage counterparts. Approximately 21% of air compressors in new construction facilities are more efficient screw compressors.

Table 3-22. Distribution of Air Compressors by Type[26]

Air Compressor Type	All NC Buildings (N=17)*
Reciprocating (Single-stage, Single-acting)	53%
Reciprocating (Single-stage, Double-acting)	0%
Reciprocating (Two-stage, Double-acting)	5%
Reciprocating (Two-stage, Single-acting)	16%
Rotary Screw (Two-Stage)	21%
Centrifugal	0%
Unknown	5%
Other	0%
All	100%

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

[26] Surveyors identified only two compressors in BED territory, so further breakout by EEU is not warranted.

Approximately 10% of all air compressors in new construction buildings operate 24/7, but most (64%) run less than 10 hours per week. Approximately one-quarter (25%) operate between 11 and 49 hours per week, as shown in Table 3-23.

Table 3-23. Air Compressor Hours of Use per Week by Bin

Age	All NC Buildings (N=16)
< 10	64%
11 – 49	25%
50 – 99	0%
100 – 167	0%
168	10%

*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 Table 3-24, the majority (76%) of compressor systems in new construction facilities do not have air dryers installed. Of the systems that do have air dryers, approximately two-thirds have more efficient, cycling dryers.

Table 3-24. Saturation of Cycling Air Dryers on Compressed Air System

Compressor Air Dryer Type	All Buildings (N=86)
Continuous Dryer	8%
Cycling Dryer	16%
No Dryer	76%

Source: On-Site Survey Question 589k

3.6.3 EEU Market Characterization – Motors and Compressed Air

Table 3-25 provides a summary characterization of motor and compressed air measures for Vermont's EEUs.

Table 3-25. EEU Market Characterization – Motors and Compressed Air

Measure/Characteristic	BED	EVT
Motor efficiency	» Most (90%) motors are classified as standard efficiency.	
Air compressor types	» More than half (53%) are smaller capacity single-stage models, and 16% are reciprocating two-stage compressors. 21% are rotary screw, two-stage compressors.	
Air compressor hours of use	» 64% of the compressors operated for less than ten hours per week and 25% run between 11-49 hours per week.	
Cycling air dryer on compressed air systems	» Most compressor systems observed did not have dryers installed. 16% compressor systems used cycling dryers.	
Source: Navigant analysis		

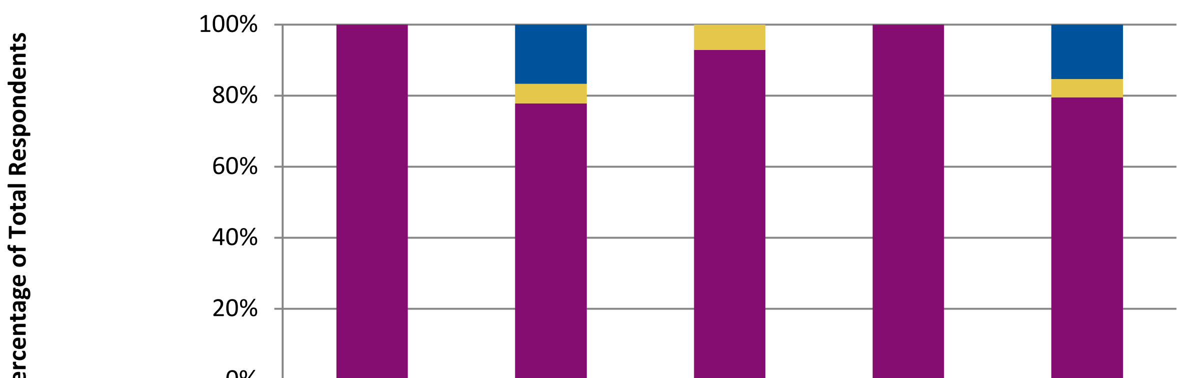
3.7 *Cross-Cutting C&I Market Insights*

The information presented in the Cross-cutting C&I Market Insights section is based on interviews with decision-makers during on-site surveys as well as owners and/or decision-makers as part of the telephone surveys. Navigant screened the interviewee in each case to ensure the person answering the questions was the one responsible for making financial decisions about the cooling, heating, lighting equipment and processes at the facility in question.

3.7.1 New Construction Market Characterization

Figure 3-54 shows that the majority (79%) of all new construction buildings in Vermont were built to the 2005 VT CBES. All of the buildings in BED territory were built to meet the 2005 VT CBES, as were all of the buildings within GT area. About 17% of EVT customers did not know which version of the code the project was built to. Approximately 93% of project sin VT Gas areas were built to the 2005 VT CBES.

Figure 3-54. Energy Code Used in New Construction Project

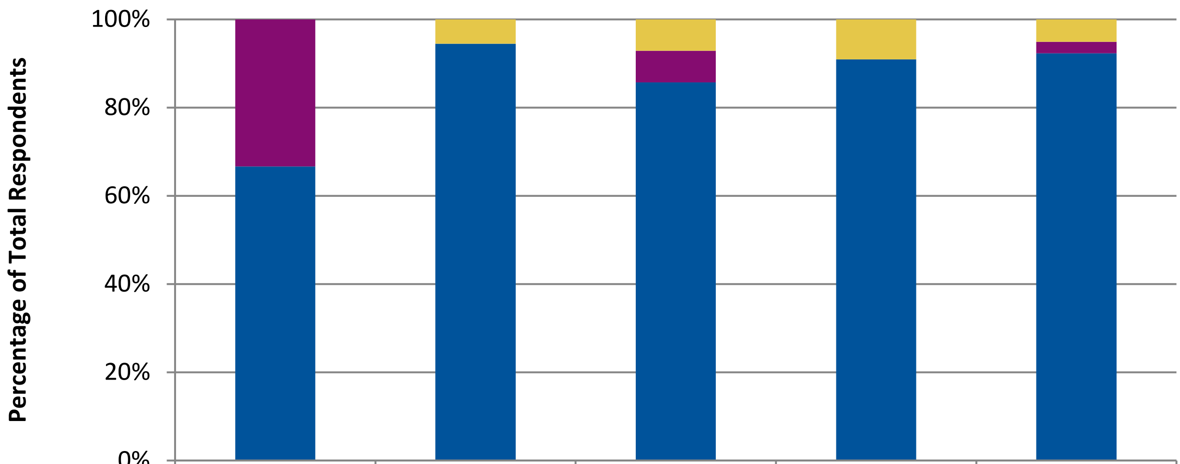


	BED (N=3)	EVT (N=36)	VTGas (N=14)	GT (N=11)	All NC Buildings (N=39)
Don't Know	0%	17%	0%	0%	15%
Built to prior code	0%	6%	7%	0%	5%
Built to 2005 VT CBES	100%	78%	93%	100%	79%

Source: Telephone Survey, Question NC5

Figure 3-55 shows the distribution of respondents who considered making their new construction building more efficient than required by code. Most (92%) respondents confirmed that they had considered making their building more efficient than the code. In BED territory, only 67% of respondents considered making their building more efficient than the code.

Figure 3-55. Did Owner Consider Making Building More Efficient Than Required By Code?



	BED (N=3)	EVT (N=36)	VTGas (N=14)	GT (N=11)	All NC Buildings (N=39)
Don't know	0%	6%	7%	9%	5%
No	33%	0%	7%	0%	3%
Yes	67%	94%	86%	91%	92%

Source: Telephone Survey, Question NC7

The most important consideration for Vermont C&I customers when making energy efficiency related design decisions is the cost of operating the facility long term (48%), followed by construction and other upfront costs (15%) and the desire to be a good citizen for energy and the environment (12%). Table 3-26 shows the responses across all the EEUs and areas.

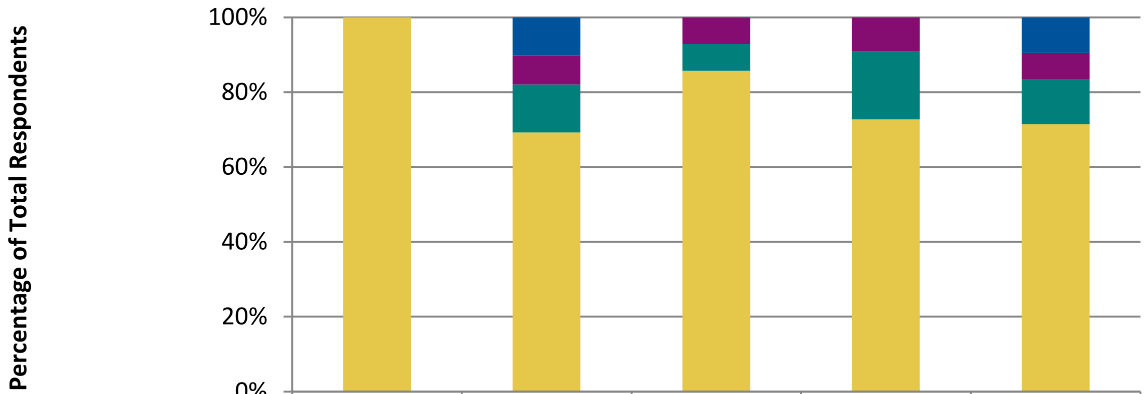
Table 3-26. Most Important Considerations in Energy Efficiency Related Design Decisions

Most Important Considerations in Energy Efficiency Related Design Decisions	BED (N=2)	EVT (N=31)	VT Gas (N=11)	GT (N=10)	All NC Buildings (N=33)
Costs of operating the facility long term	0%	52%	27%	40%	48%
Construction and other upfront costs	0%	16%	0%	10%	15%
Desire to be a good citizen for energy/environment	0%	13%	18%	20%	12%
Don't know	100%	3%	27%	10%	9%
Energy efficient equipment would perform better	0%	3%	0%	10%	3%
Other	0%	3%	9%	10%	3%
Design costs	0%	3%	0%	0%	3%
Facility appearance	0%	3%	9%	0%	3%
Energy efficiency incentives or tax credits	0%	3%	9%	0%	3%

Source: Telephone Survey, NC9

Nearly three-quarters (71%) of Vermont's new construction buildings were designed by an architect, as shown in Figure 3-56. In the BED territory alone, one-hundred percent of new construction projects were designed by an architect.

Figure 3-56. New Construction Project Designer

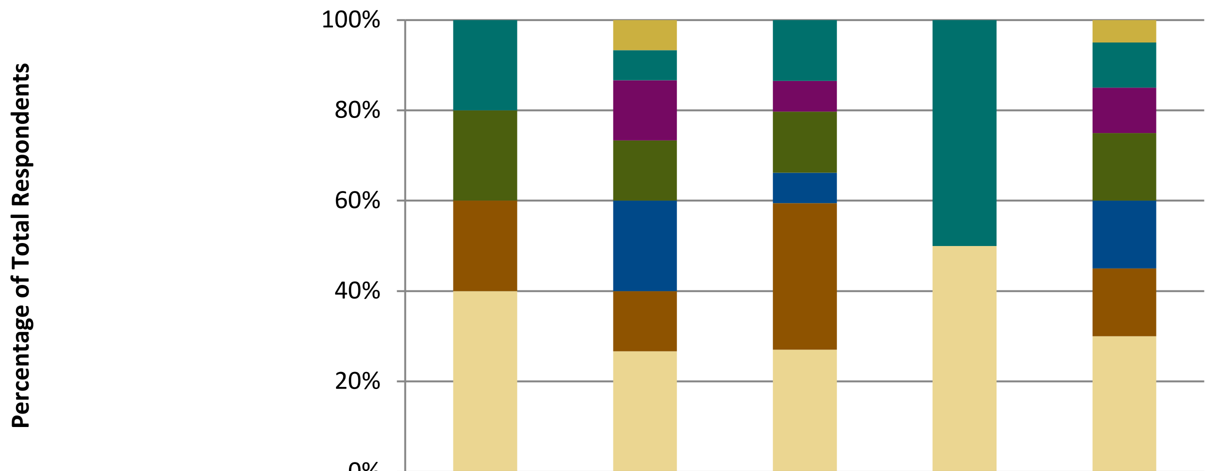


	BED (N=3)	EVT (N=39)	VTGas (N=14)	GT (N=11)	All NC Buildings (N=42)
Don't know	0%	10%	0%	0%	10%
Design Build Company	0%	8%	7%	9%	7%
In House Design	0%	13%	7%	18%	12%
Architect	100%	69%	86%	73%	71%

Source: Telephone Survey, Question NC10

Figure 3-57 shows the distribution of energy efficiency enhancements that were included in the initial design of new construction buildings in Vermont. Seventy-five percent of all new construction buildings included energy efficient lighting enhancements in their designs. BED customers included lighting enhancements in all (100%) of their buildings. Other enhancements included in more than one-third of initial building designs included increased insulation (38%), heating (38%), and cooling (38%).

Figure 3-57. Energy Efficiency Enhancements Included In Initial Design

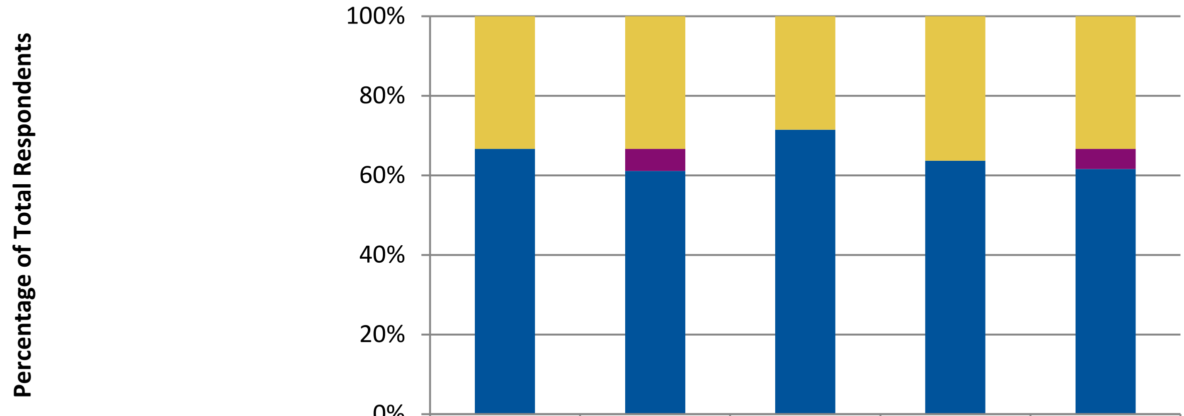


	BED (N=5)	EVT (N=15)	VTGas (N=12)	GT (N=2)	All NC Buildings (N=8)
EFFICIENT WINDOWS (MORE EFFICIENT THAN CODE)	0%	17%	0%	0%	13%
ENERGY MANAGEMENT SYSTEM	50%	17%	17%	50%	25%
PUMPS AND CONTROLS	0%	33%	8%	0%	25%
HEATING	50%	33%	17%	0%	38%
INCREASED INSULATION	0%	50%	8%	0%	38%
COOLING	50%	33%	40%	0%	38%
LIGHTING	100%	67%	33%	50%	75%

Note: Totals may not sum to 100% due to multiple choice responses
Source: Telephone Survey, Question NC13

Figure 3-58 shows that 62% of new construction building projects in Vermont included aspects that exceeded energy code requirements. About one-third of all respondents did not know if their building had exceeded the energy code. It should be noted that respondents were those responsible for making financial decisions about the cooling, heating, lighting equipment and processes at the facility in question.

Figure 3-58. Did Project Exceed Energy Code Requirements in Any Aspect?



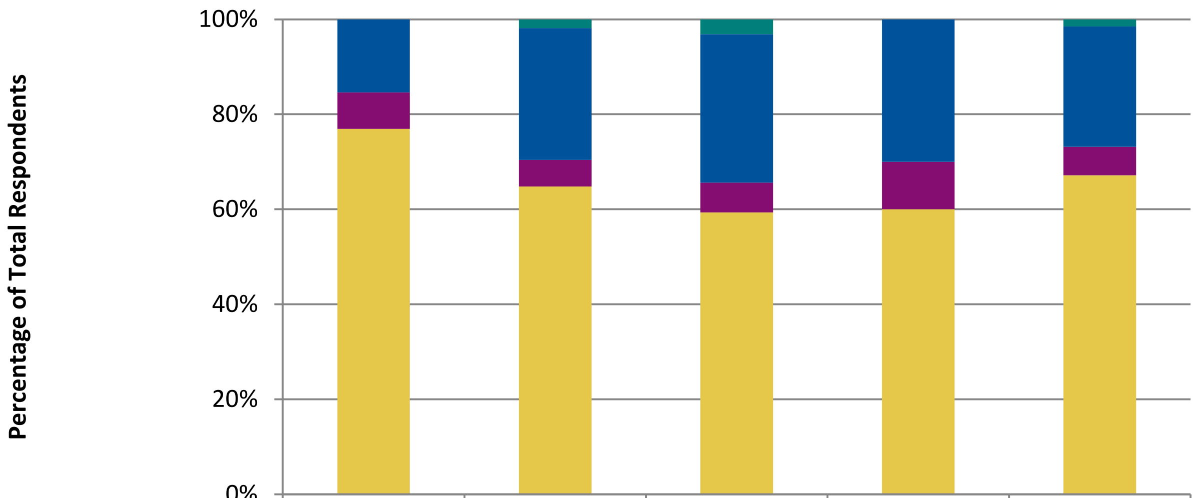
	BED (N=3)	EVT (N=36)	VTGas (N=14)	GT (N=11)	All NC Buildings (N=39)
Don't know	33%	33%	29%	36%	33%
No. The project met energy code standards but did not exceed them	0%	6%	0%	0%	5%
Yes. The project exceeded energy code standards	67%	61%	71%	64%	62%

Source: Telephone Survey, Question NC 16

3.7.2 Major Renovation Market Characterization

Over two-thirds (67%) of all C&I renovations in Vermont were built to the 2005 VT CBES building code, as shown in Figure 3-59. Approximately one-quarter (25%) of all respondents did not know what code their renovation was built to, and one percent of all respondents refused to answer this question.

Figure 3-59. Energy Code Used in Renovation Project

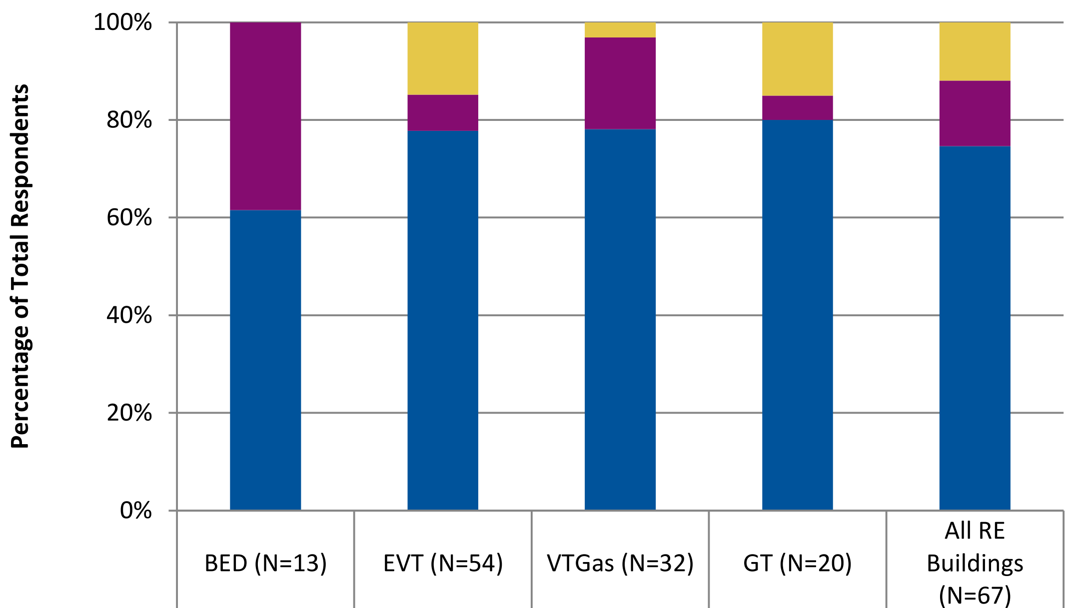


	BED (n=13)	EVT (n=54)	VTGas (n=32)	GT (n=20)	All RE Buildings (N=67)
Refused	0%	2%	3%	0%	1%
Don't Know	15%	28%	31%	30%	25%
Built to prior code	8%	6%	6%	10%	6%
Built to 2005 VT CBES	77%	65%	59%	60%	67%

Source: Telephone Survey, Question RE5

Figure 3-60 shows that three-quarters (75%) of survey respondents stated that they considered making their renovation more efficient than required by code.

Figure 3-60 Did Owner Consider Making Renovation More Efficient Than Required By Code?



	BED (N=13)	EVT (N=54)	VTGas (N=32)	GT (N=20)	All RE Buildings (N=67)
Don't know	0%	15%	3%	15%	12%
No	38%	7%	19%	5%	13%
Yes	62%	78%	78%	80%	75%

Source: Telephone Survey, Question RE7

Table 3-27 illustrates the most important energy efficiency-related considerations in design decisions for Vermont's C&I renovation projects. The most important consideration overall was the cost of operating the facility long term (38%).

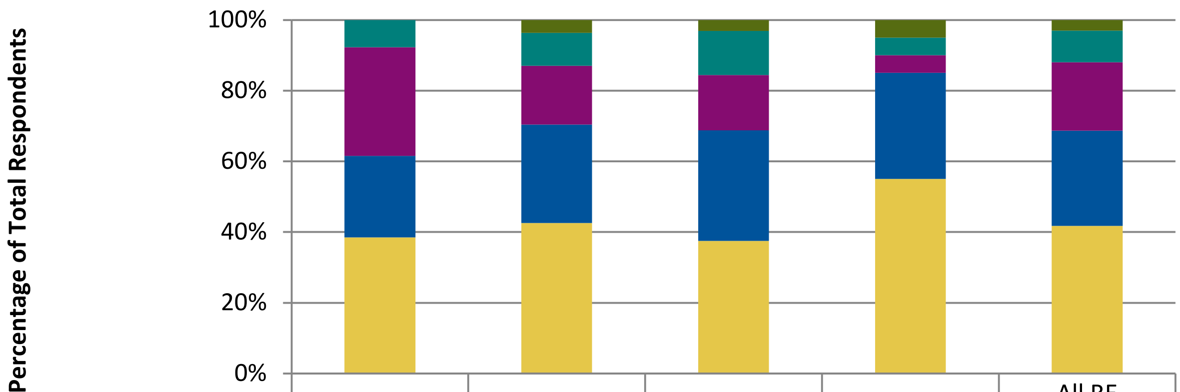
Table 3-27. Most Important Considerations in Energy Efficiency Related Design Decisions

Most Important Considerations in Energy Efficiency Related Design Decisions	BED (N=8)	EVT (N=40)	VT Gas (N=23)	GT (N=15)	All RE Buildings (N=48)
Cost of operating the facility long term	50%	35%	43%	40%	38%
Other	0%	20%	13%	27%	17%
Construction and other upfront costs	25%	8%	17%	0%	10%
Don't know	13%	10%	9%	13%	10%
Desire to be a good citizen for energy/environment	0%	13%	4%	13%	10%
Energy efficient equipment would perform better	13%	8%	13%	7%	8%
Energy efficiency incentives or tax credits	0%	5%	0%	0%	4%
Design costs	0%	3%	0%	0%	2%

Source: Telephone Survey, Question RE9

Less than half (42%) of Vermont's renovation projects were designed by an architect (compared to 71% for new construction projects), as shown in Figure 3-61. About one-quarter (27%) of the renovation projects were designed "in-house", and slightly less than 20% utilized a design-build company.

Figure 3-61. Renovation Project Designer

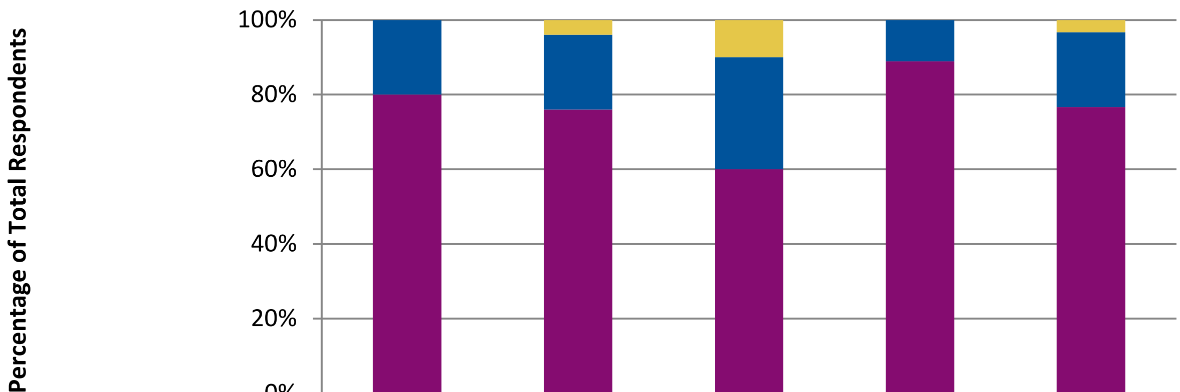


	BED (N=13)	EVT (N=54)	VTGas (N=32)	GT (N=20)	All RE Buildings (N=67)
Don't know	0%	4%	3%	5%	3%
Other	8%	9%	13%	5%	9%
Design Build Company	31%	17%	16%	5%	19%
Designed In House	23%	28%	31%	30%	27%
Architect	38%	43%	38%	55%	42%

Source: Telephone Survey, Question RE10

As shown in Figure 3-62, for projects that used an architect, the designers used a custom set of design plans or specifications in 77% of all renovations in Vermont. Approximately 20% of those projects relied on an existing set of design plans for the work.

Figure 3-62. Did Designer Use An Existing Set of Plans or Design Specifications?

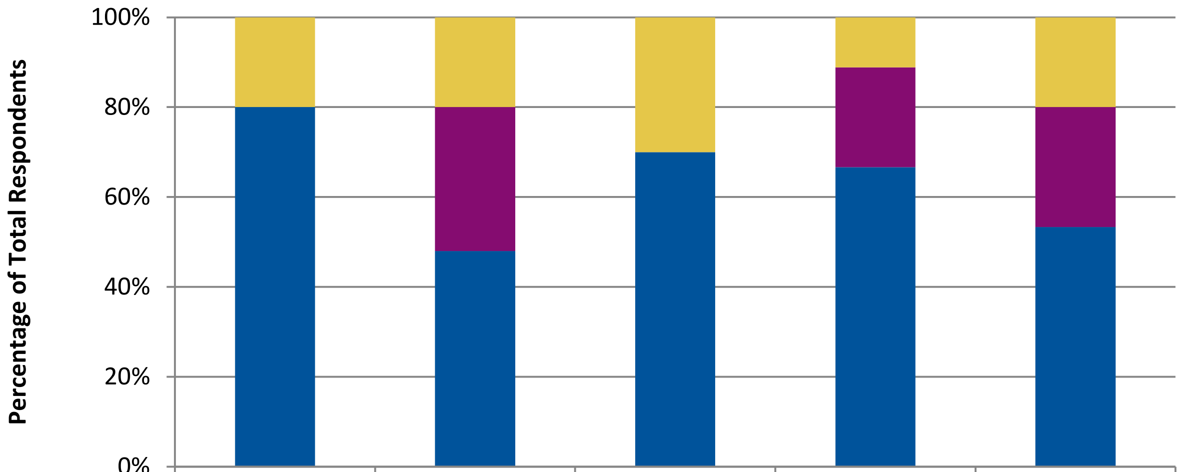


	BED (N=5)	EVT (N=25)	VTGas (N=10)	GT (N=9)	All RE Buildings (N=30)
Don't know	0%	4%	10%	0%	3%
Yes, Existing design plans	20%	20%	30%	11%	20%
No, Custom design plans	80%	76%	60%	89%	77%

Source: Telephone Survey, Question RE11

In more than half (53%) of all additions and renovations the architect or design company proposed to include energy efficiency enhancements, whether in a custom design or in an existing set of design plans, as shown in Figure 3-63.

Figure 3-63. Did Architect or Design Company Propose to Include Any EE Enhancements, Either in a Custom Design or Existing Set of Plans?

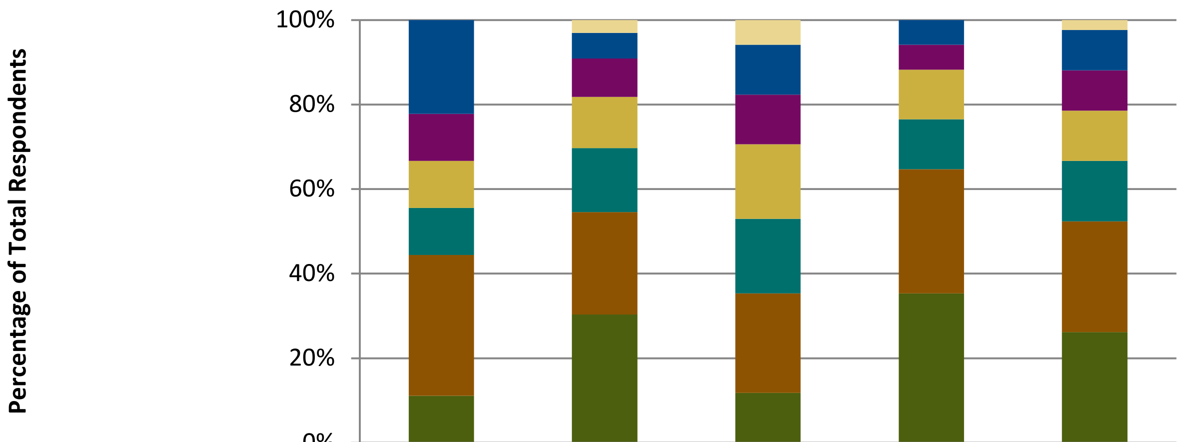


	BED (N=5)	EVT (N=25)	VTGas (N=10)	GT (N=9)	All RE Buildings (N=30)
Don’t know	20%	20%	30%	11%	20%
No	0%	32%	0%	22%	27%
Yes	80%	48%	70%	67%	53%

Source: Telephone Survey, Question RE12

Figure 3-64 indicates that increased insulation and lighting enhancements were included in the initial design for about one-quarter of all renovation projects. Only ten percent of respondents indicated energy management systems (EMS) were a part of the original design, compared to 25% of new construction projects. When asked whether the energy efficient enhancements mentioned were all included in the final design, over 90% of respondents responded affirmatively.

Figure 3-64. Energy Efficiency Enhancements Included In Initial Design



	BED (N=9)	EVT (N=33)	VTGas (N=17)	GT (N=17)	All RE Buildings (N=42)
Pump and Control	0%	4%	10%	0%	2%
Energy Management System	40%	8%	20%	11%	10%
Efficient Windows	20%	12%	20%	11%	10%
Cooling	20%	16%	30%	22%	12%
Heating	20%	20%	30%	22%	14%
Lighting	60%	32%	40%	56%	26%
Increased Insulation	20%	40%	20%	67%	26%

Note: Efficient Windows includes windows that are more efficient than code
Note: Totals may not sum to 100% due to multiple choice responses
Source: Telephone Survey, Question RE13

Respondents undergoing renovation projects were asked why they did not build the project more energy efficient than code requires, and open-ended answers pointed to economic constraints, time constraints and concerns relating to payback on investment. Additional reasons given were that there would have been restrictions of the existing building and that respondents were unsure of how they could make the project any more efficient than they did. One respondent stated that they did not know anything about any codes.

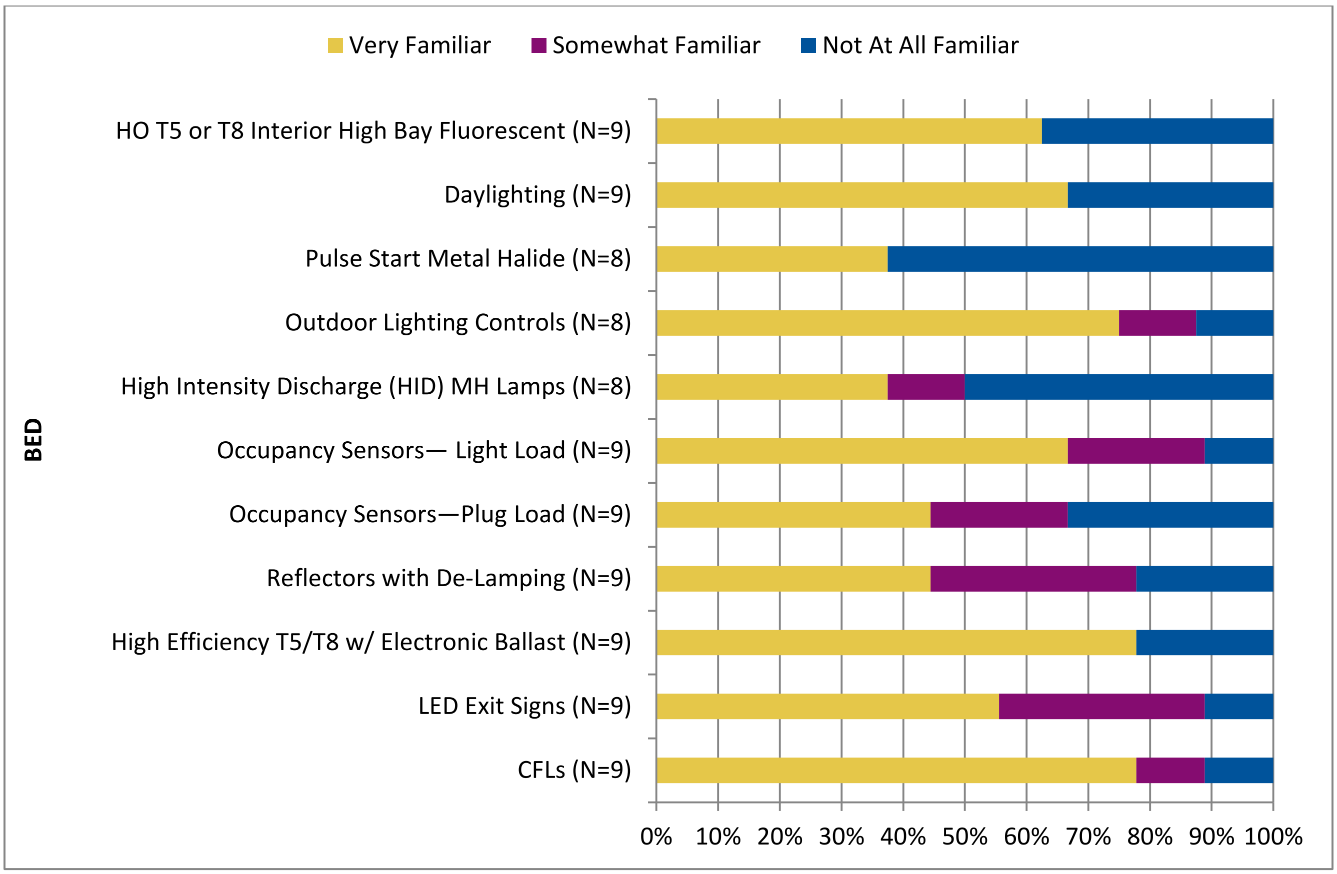
3.7.3 Measure Awareness

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. Refrigeration measure awareness is excluded because sample size across both BED and EVT areas is less than three.

3.7.3.1 *Lighting Measures*

Figure 3-65 shows that most customers in BED territory are familiar with common lighting efficiency measures. Pulse start metal halides stands out for the lack of familiarity among C&I customers.

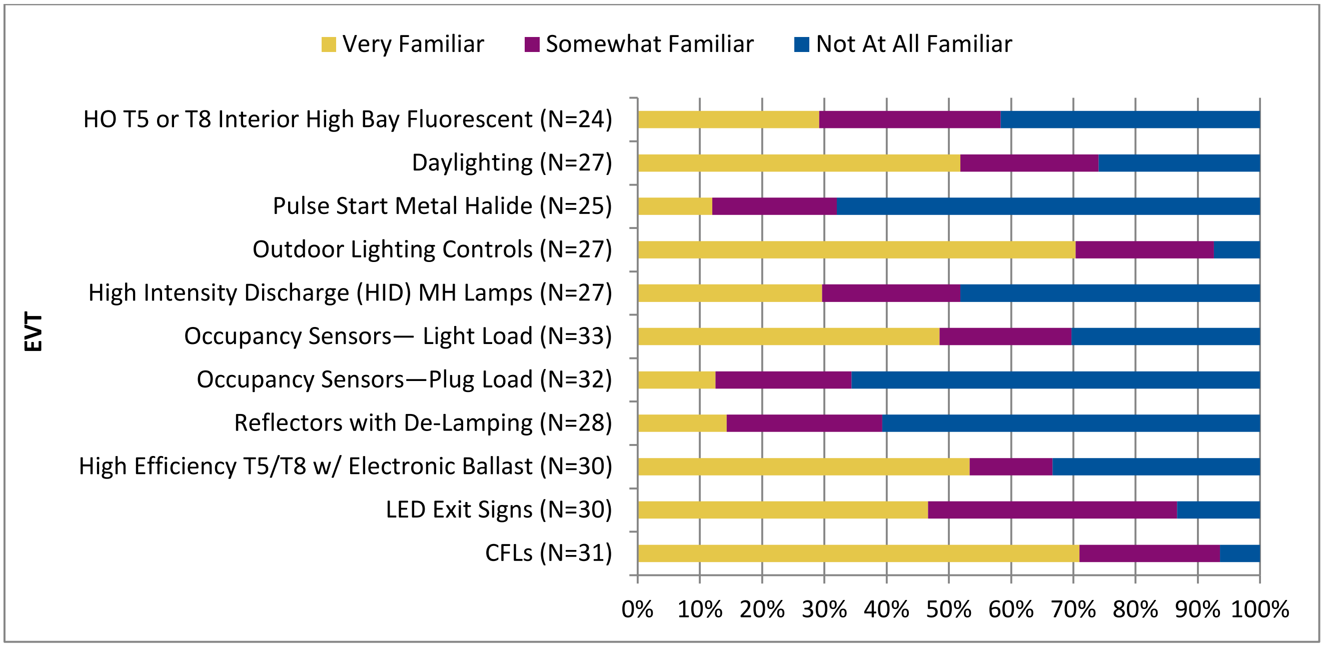
Figure 3-65. Familiarity with Lighting Measures - BED



Source: Decision-Maker Survey, Question 13

Figure 3-66 shows that nearly half of C&I customers in EVT territory are familiar with common lighting efficiency measures. Occupancy sensors for plug loads, pulse start metal halide and reflectors with de-lamping stand out for lack of familiarity with C&I customers.

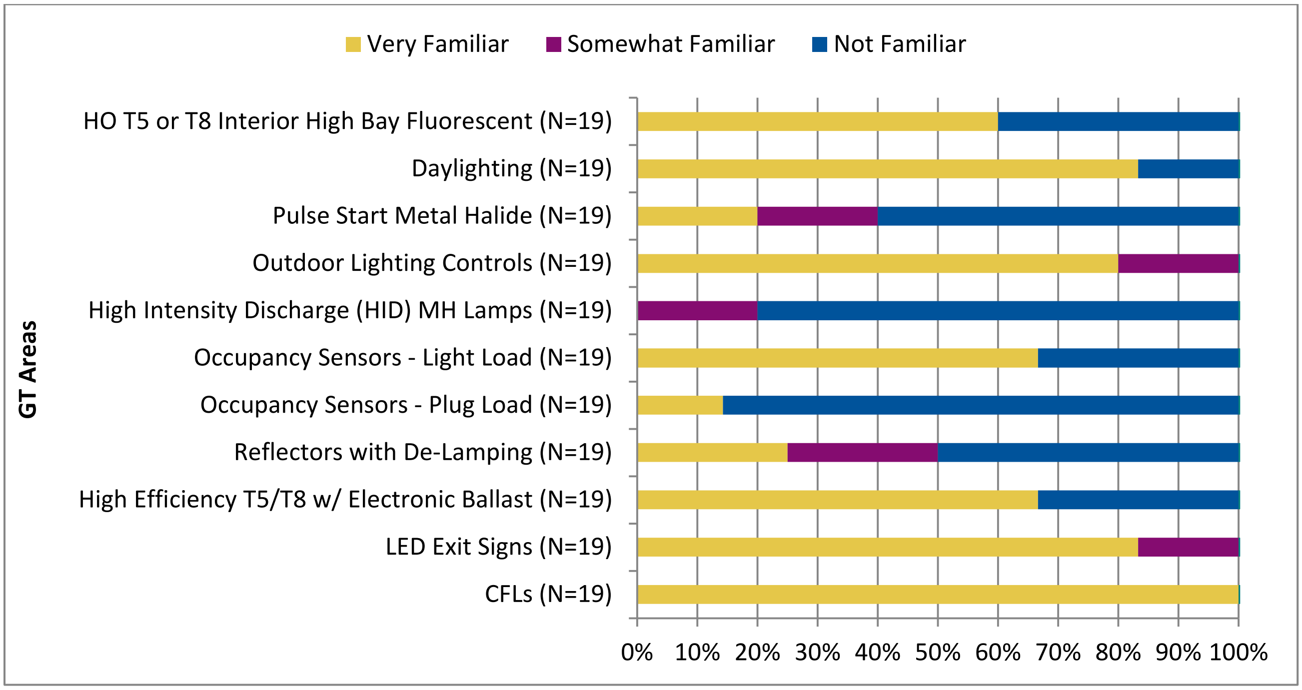
Figure 3-66. Familiarity with Lighting Measures - EVT



Source: Decision-Maker Survey, Question 13

GT-area new construction customers indicated greater awareness of lighting measures than in the larger EVT territory, particularly with CFLs. LED exit signs, high efficiency T5/T8 lighting and daylighting, as shown in Figure 3-67. GT-areas customers are not particularly familiar with HID metal halides.

Figure 3-67. Familiarity with Lighting Measures – GT Areas

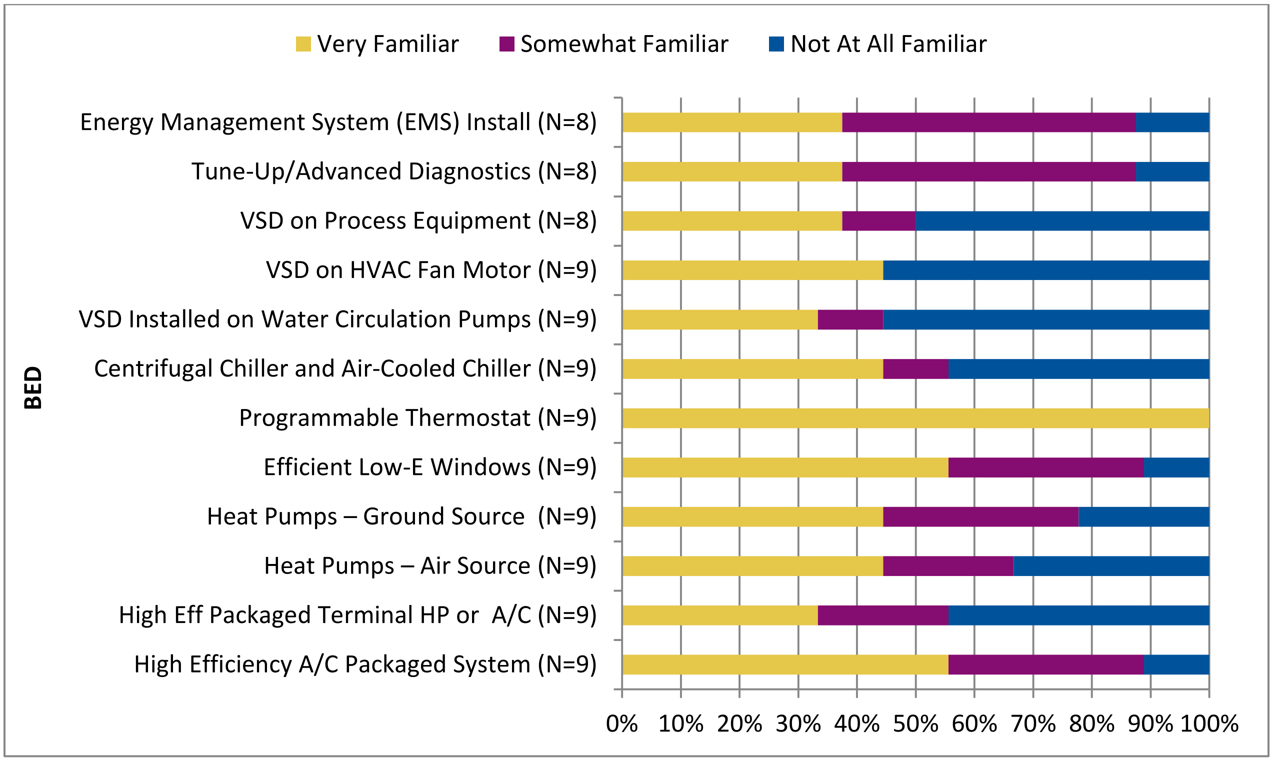


Source: Decision-Maker Survey, Question 13

3.7.3.2 *HVAC Measures*

Figure 3-68 shows that BED new construction customers are familiar with most HVAC measures, with approximately more than 50% of all customers either very familiar or somewhat familiar. All of the customers were aware of programmable thermostats.

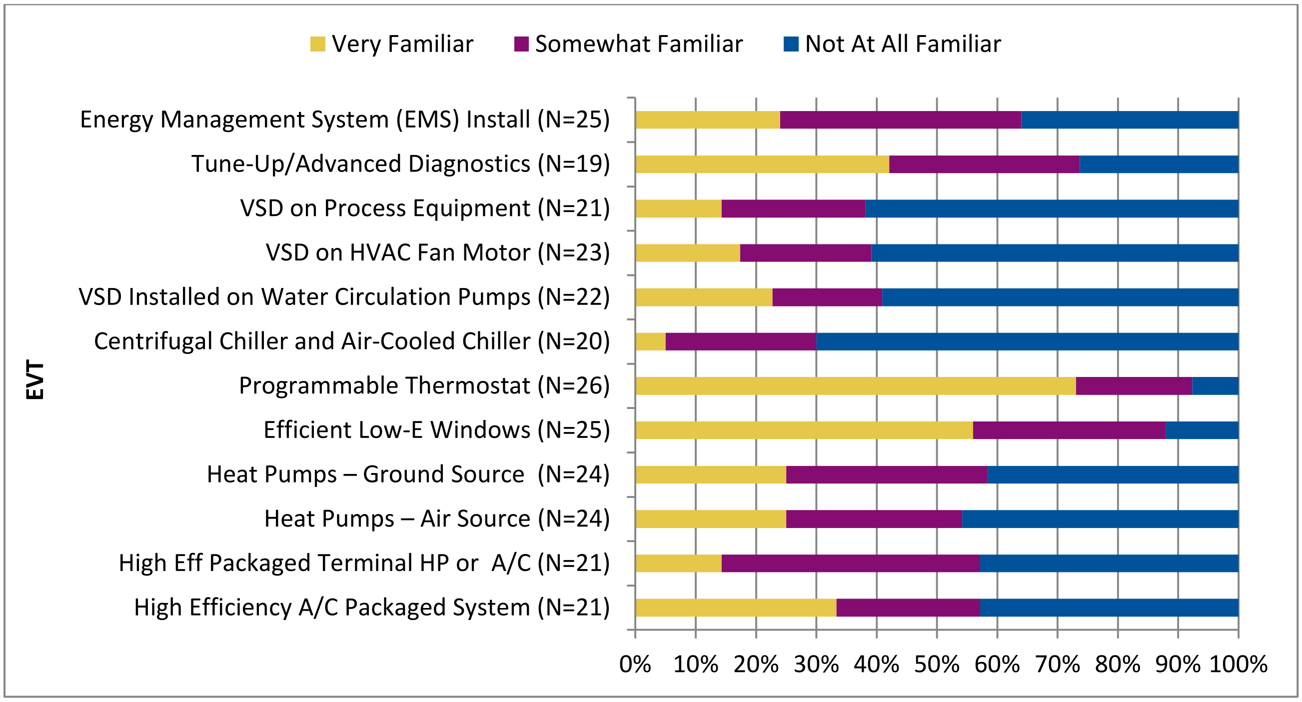
Figure 3-68. Familiarity with HVAC Measures - BED



Source: Decision-Maker Survey, Question 13

Approximately 20%-40% of C&I new construction customers in EVT territory are very familiar with HVAC efficiency measures, with about 70% of customers very aware of programmable thermostats, as shown in Figure 3-69. Familiarity with variable speed drive (VSD) and chiller measures is notably lower than other measures.

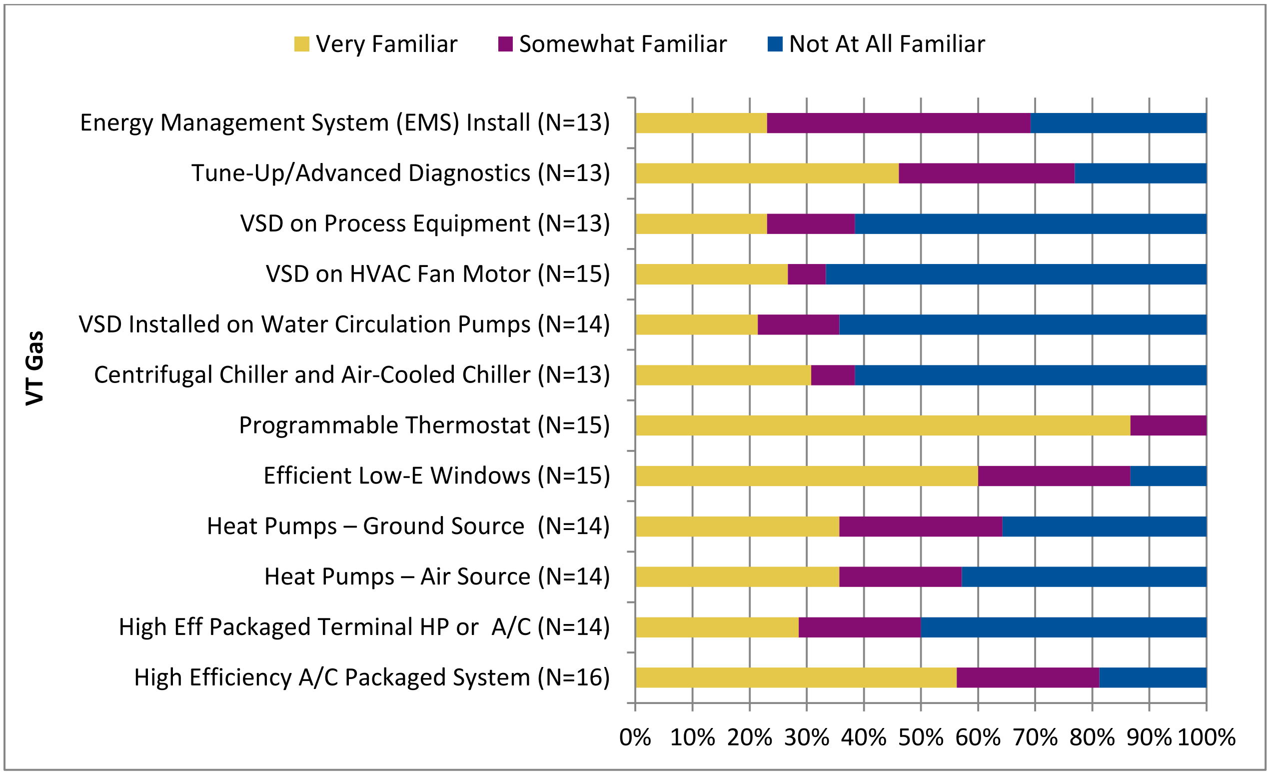
Figure 3-69. Familiarity with HVAC Measures - EVT



Source: Decision-Maker Survey, Question 13

Awareness of HVAC measures varies between 30% and 40% for VT Gas customers, though nearly 90% of customers are very aware of programmable thermostats, as shown in Figure 3-70.

Figure 3-70. Familiarity with HVAC Measures – VT Gas

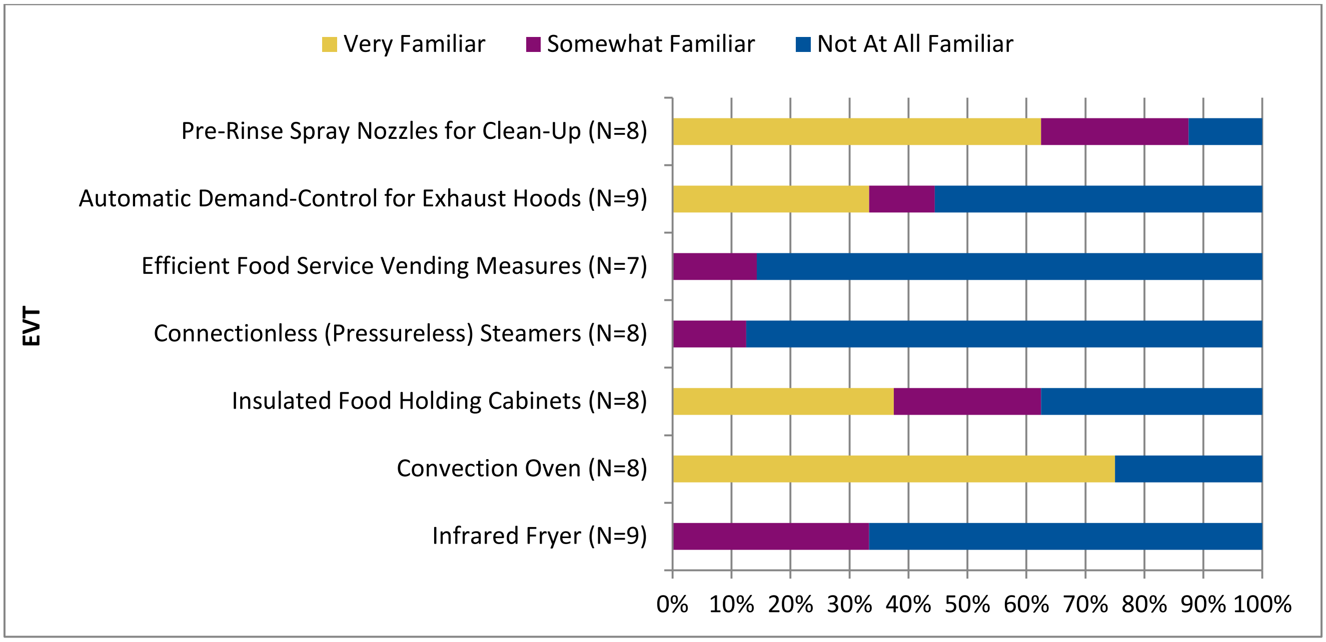


Source: Decision-Maker Survey, Question 13

3.7.3.3 *Cooking Measures*[27]

Figure 3-71 shows that awareness of cooking measures among new construction customers in EVT territory is approximately between 30-40%, with less than 15% of customers being somewhat familiar with efficient food service vending measures and pressureless steamers. About 75% of the customers were very familiar with convection ovens.

Figure 3-71. Familiarity with Cooking Measures – EVT



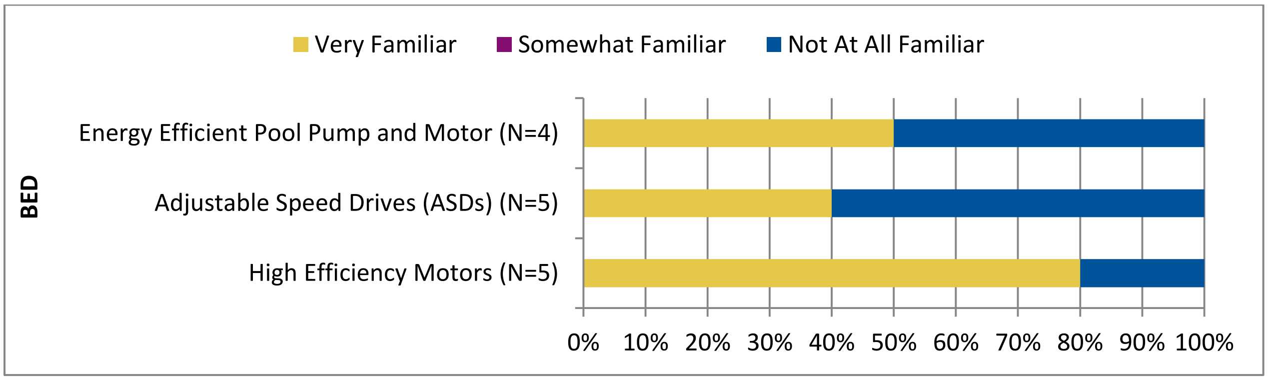
Source: Decision-Maker Survey, Question 13

[27] Only one customer in BED territory responded to cooking measures questions, so these results are not reported.

3.7.3.4 *Motor Measures*

Nearly 80% of BED customers are very familiar with high efficiency motors as shown in Figure 3-71.

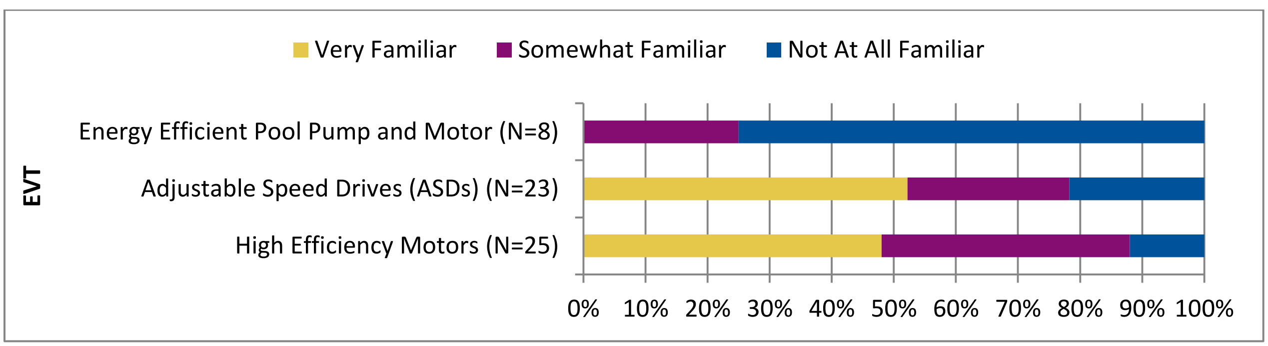
Figure 3-72. Familiarity with Motor Measures - BED



Source: Decision-Maker Survey, Question 13

Figure 3-73 shows that approximately 50% of EVT customers are very familiar with high efficiency motor measures, and 50% are very aware of adjustable speed drives. Nearly 75% of customers are not at all familiar with efficient pool pumps and motors.

Figure 3-73. Familiarity with Motor Measures - EVT

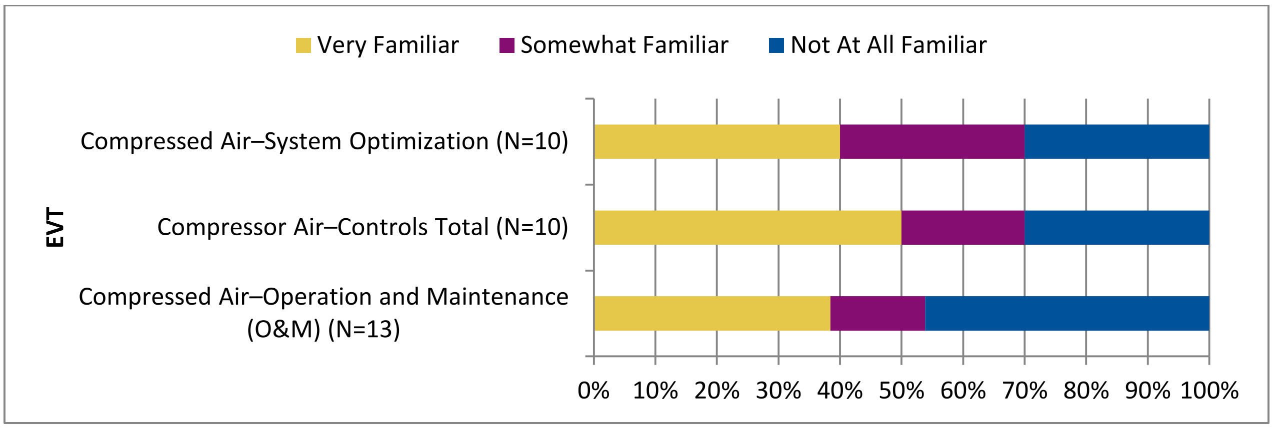


Source: Decision-Maker Survey, Question 13

3.7.3.5 Compressed Air Measures[28]

Among customers in EVT territory with compressed air equipment on-site, more than half of the customers are familiar with compressed air efficiency measures, as shown in Figure 3-74.

Figure 3-74. Familiarity with Compressed Air Measures - EVT



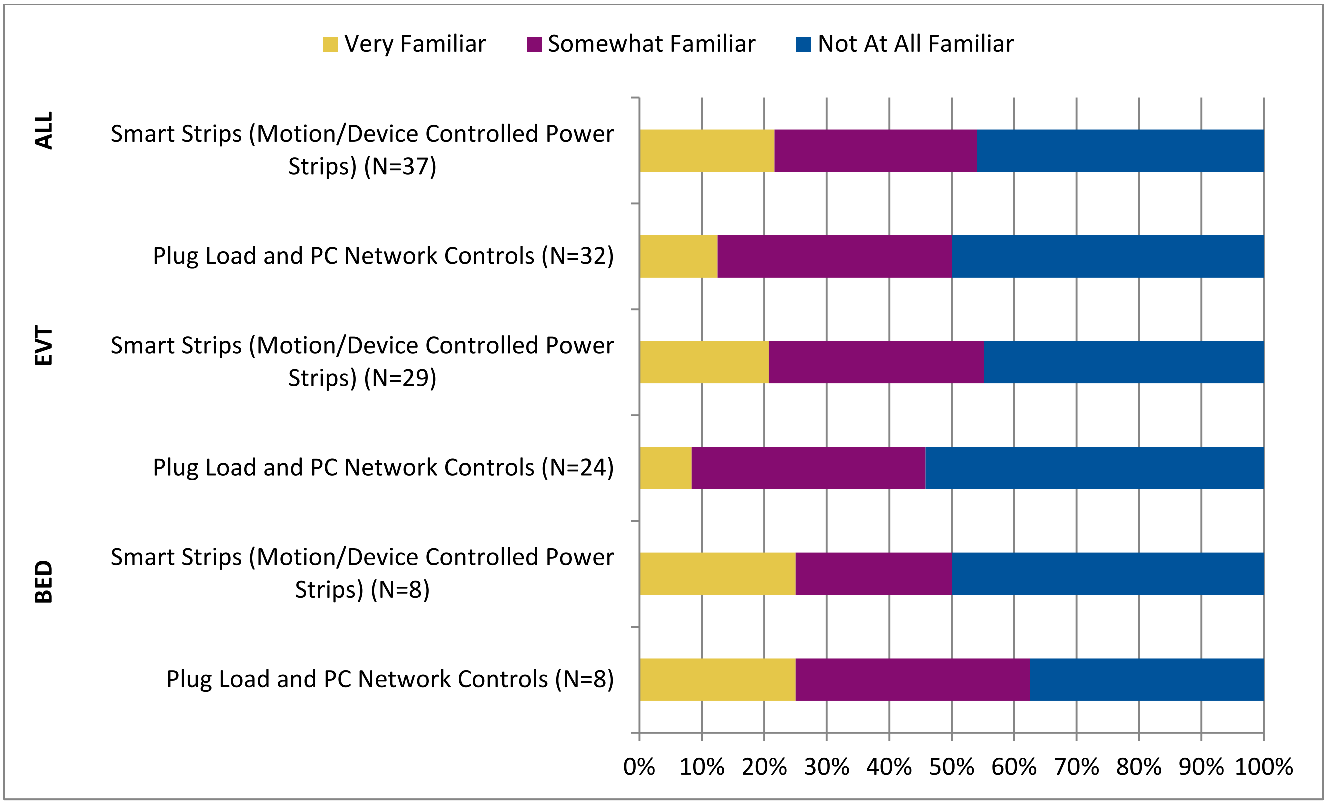
Source: Decision-Maker Survey, Question 13

[28] There were no customers in BED territory that responded to compressed air measure questions.

3.7.3.6 *Miscellaneous Measures*

Customers in BED territory are generally equally aware (approximately 50%) of miscellaneous measures as compared to customers in EVT service territory, as shown in Figure 3-75.

Figure 3-75. Familiarity with Miscellaneous Measures – BED and EVT



Source: Decision-Maker Survey, Question 13

4. Assessment of CBES Compliance

The Vermont PSD directed Navigant to attempt to measure statewide compliance with Vermont's commercial energy code (2005 Commercial Building Energy Standards (CBES)) in buildings meeting one of the following criteria:

- New construction (NC); including additions of 500 SF or greater
- Major renovation

Navigant modified compliance checklists created by the U.S. Department of Energy (DOE) Building Energy Codes Program (BECP) and incorporated the checklists into the on-site survey forms created for the baseline study. The following sections describe the study's methodology, data collection, key findings and highlights of compliance results by major energy end-uses.

4.1 *Study Methodology*

4.1.1 Compliance Checklists

The DOE BECP created energy code compliance checklists for use in determining statewide compliance metrics, as part of an overall effort called *compliance evaluation*. DOE describes the effort as follows:[29]

Energy code compliance evaluation is the process of verifying that new or renovated buildings are meeting the intended requirements of adopted energy codes. DOE has developed a methodology, suggested procedures, and tools to help states and jurisdictions measure and report their rate of compliance. While targeted to assess the rate of compliance in a state or jurisdiction, these resources are openly available to support compliance assessment and evaluation.

In addition to the checklists, DOE developed a methodology and guidelines for conducting statewide compliance evaluations.[30] Navigant followed this methodology to the fullest extent possible, with the notable distinction that the DOE checklists are predicated on conducting assessments during construction, not post-construction. To address adherence to CBES, the Navigant team reviewed the DOE checklists and determined which items listed for compliance can be successfully reviewed post-construction. Navigant then compared these items to the 2005 CBES requirements, the energy code in effect over the period of interest for the study (2008 – 2011). The team then incorporated the Vermont-specific checklists into the on-site data collection forms according to each specific end-use (i.e., HVAC, lighting, water heating, etc.). The full on-site data collection form is included in the appendices, and an example of a CBES compliance checklist is shown in Figure 4-1.

[29] Extensive information about the compliance evaluation program can be found at: http://www.energycodes.gov/compliance/evaluation

[30] http://www.energycodes.gov/sites/default/files/documents/MeasuringStateCompliance.pdf

Figure 4-1. Example of CBES Adherence Checklist

Building Envelope						
Tier	Category	Observable	Not Observable	N/A for this site	Verified Value	Comments/ Assumptions
1	Roof insulation R-value.	☐	☐	☐	R-____ ☐ Above deck ☐ Metal building ☐ Steel joist ☐ Attic	
1	Above-grade wall insulation R-value.	☐	☐	☐	R-____ ☐ Mass ☐ Metal building ☐ Metal framed ☐ Wood and other	
2	Below-grade wall insulation R-value.	☐	☐	☐	R-____	
1	Floor insulation R-value.	☐	☐	☐	R-____ ☐ Mass ☐ Steel ☐ Wood	
2	Slab edge insulation R-value.	☐	☐	☐	R-____ ☐ Unheated ☐ Heated	

Source: Abridged building envelope checklist from the on-site survey form

There are three important differences between the DOE checklists and the Vermont-specific checklists, including:

- The DOE strategy is to have trained code compliance evaluators to determine compliance with individual requirements during the on-site visit. This was not possible within the scope of the baseline study, so surveyors observed the condition needed for each requirement, and Navigant analysts then determined compliance or non-compliance.
- As previously noted, the DOE checklists are designed for on-site visits *during* several phases of construction at the same building. The baseline study visits all occurred post-construction or renovation, rendering many items "non-observable." However, surveyors made every effort to confirm building characteristics with knowledgeable on-site staff and/or building plans, and utilized this information as "observable" data where necessary. Navigant accounted for this issue in the design of the checklists, allowing surveyors to mark each item as "observable," "non-observable," or "non-applicable at this site (N/A)."[31]
- Vermont statute requires that a "certificate of compliance" with the commercial energy code be permanently affixed to the outside of the heating or cooling equipment, to the electrical service panel located inside the building, or in a visible location in the vicinity of one of these three areas. There is one certificate of compliance, but two separate affidavits (one for design and one for construction) that are separately completed and signed by the designer and builder,

[31] The DOE Checklists also allow for an individual item to be marked as non-applicable. i.e., if a commercial building does not have below-grade walls (built on slab) then the insulation requirement for below grade walls does not apply.

respectively. The affidavits are required to be sent to PSD along with a copy of the certificate. Both are signed by the responsible parties (i.e., architect, general contractor, etc.).

- The Vermont compliance checklists include a line item that scores whether the building has the required certificate posted (or even on file, if necessary).
- The "Administrative Compliance" section below summarizes the resulting scores from this line item, and these scores are not included in the "Technical Compliance" score reported in Table 4-4 below.

4.1.2 Scoring Compliance

The methodology for scoring compliance with individual requirements follows the DOE methodology, which clusters the commercial checklist requirements into three tiers, as shown in Table 4-1. In an effort to focus on the most important code requirements, each tier is given a different weight in determining the overall building compliance metric.[32]

Table 4-1. Energy Code Compliance Scoring Matrix

Importance	Tier	Points
Most Important	1	3
Important	2	2
Least Important	3	1

Source: DOE *Measuring State Energy Code Compliance (March 2010)*

At each site, all observable and applicable code compliance line items are indicated by surveyors. During the analysis phase, each line item that was observable and applicable is assigned a total possible points based on the tier level for that line item. If the item complies, all points are received. If it does not comply, zero points are received. If it is not observable, no points are assigned to this line item. Table 4-2 provides an illustrative calculation.

Table 4-2. Example Scoring Calculation (Abbreviated)

Category	Observable?	Complies?	Tier	Points Possible	Points Received
Roof Insulation R-Value	Yes	Yes	1	3	3
Above-grade wall insulation R-value.	Yes	No	1	3	0
HVAC piping insulation thickness.	Yes	Yes	2	2	2
Stair and elevator shaft vents have motorized dampers that automatically close.	No	N/A	3	0	0
			Total	8	5
		Final Score		5/8 = 62%	

Source: Navigant example calculation

[32] Paraphrased from *Measuring State Energy Code Compliance (March 2010):* http://www.energycodes.gov/sites/default/files/documents/MeasuringStateCompliance.pdf

Table 4-3 further expands on this example, showing the final score for an individual building based on the number of points received in each end-use category.

Table 4-3. Example Individual Building Evaluation – Technical Compliance Score

Category	Possible Points	Points Received	Score
Building Envelope	21	15	86%
Mechanical Systems	16	13	81%
Service Water Heating	5	2	40%
Electrical Power and Lighting	4	4	100%
Totals	46	37	80%

$$Compliance\ Percentage = \frac{Points\ Received}{Possible\ Points} \times 100 = \frac{37}{46} \times 100 = \ 80\%$$

Source: Table adapted from DOE *Measuring State Energy Code Compliance,* Page 5.25 (March 2010)

Once individual buildings (sites) are scored, Navigant then generates an overall technical compliance score for the entire sample of buildings. The overall score for the sample of new construction and major renovation buildings is the ratio of the total *points received* to the total *points possible* for all buildings in the sample, excluding the points for CBES certificates (administrative compliance). The individual building results for both the CBES compliance evaluation and the baseline study as a whole are not weighted, as the sampling was performed randomly out of a small population with little known characteristics in which to stratify and thus weight.[33]

[33] DOE suggests stratifying the sample by building size, a statistic that is unknown for the entire population of new construction/major renovation facilities.

4.2 Key Findings

The following sections present the technical compliance score for all buildings in the sample, the administrative compliance score and key drivers of non-compliance.

4.2.1 Technical Compliance Score

The compliance evaluation indicates a technical compliance rate with the 2005 CBES of 88%, as shown in Table 4-4. The highest scoring category is mechanical systems with an overall compliance rate of 93%. Building envelope follows closely behind with a score of 91%, while both service water heating and electrical power and lighting achieved scores of 78%.

Table 4-4. Technical Compliance with 2005 CBES

Category	Points Possible	Points Received	Total Score[a]
Building Envelope	803	732	91%
Mechanical Systems	595	552	93%
Service Water Heating	229	179	78%
Electrical Power And Lighting	289	224	78%
Grand Total	**1,916**	**1,687**	**88%**

a. Sample size of 58 sites

Source: Navigant analysis of new construction/major renovation buildings completed between January, 2008 and 2011

4.2.2 Administrative Compliance Score

The incidence of a posted certificate of compliance was low. Surveyors indicated three of the 58 sites, or five percent, had a posted certificate, which is a code requirement.

4.2.3 Key Drivers of Non-Compliance

Table 4-5 and Table 4-6 summarize the non-compliant code requirements found across all sites in the sample, and illustrates the drivers behind the lower compliance scores (78% compliance each) for the service water heating and lighting end-uses. For service water heating, the lack of piping insulation is the most common issue, and three sites did not comply with the electric water heating prohibition for units greater than 5 kW.[34] In the lighting category, over one-third of sites greater than 5,000 SF did not meet the requirement to install automatic lighting controls to shut off all building lighting. Additionally, many buildings did not meet the requirement for *light reduction controls*, which mandates lighting controls to uniformly reduce the lighting load by at least 50% in qualifying areas.

The major deficiencies in the building envelope category include non-compliant air sealing, insufficient roof insulation and buildings without vestibules as specified in the code. Only one site did not comply with the above-grade wall installation requirement. For mechanical systems, a lack of insulated HVAC

[34] Surveyors identified nineteen electric water heaters comprising nearly one-third (32%) of all systems observed during the onsites, as shown in Section 3.4.7.

ducts and HVAC piping contributed most of the deficiencies. Three sites did not employ energy recovery as required and three sites had electric resistance heating units. The most glaring deficiency is the lack of CBES certificates posted onsite, as 55 out of 58 sites failed to post this information as required.

Table 4-5. Summary of Non-Compliant Energy Code Checklist Requirements (1 of 2)

Category	Tier[a]	2005 CBES Code Requirement	Number of Non-Compliant Sites[b]
Building Envelope	1	All sources of air leakage in the building thermal envelope are sealed, caulked, gasketed, weather stripped or wrapped with moisture vapor-permeable wrapping material to minimize air leakage.	7
	1	Roof insulation R-value	6
	3	Vestibule(s) installed for door(s) separating conditioned space from exterior. (Applies only for "building entrance" doors and doors serving space >3,000 SF).	5
	2	Below-grade wall insulation R-value	4
	2	Slab-edge insulation R-value	2
	1	Floor insulation R-value	1
	1	Above-grade wall insulation R-value	1
	1	Skylight area < 5% of roof area.	1
Mechanical Systems	2	HVAC ducts and plenums insulated. (R-5 Unconditioned / R-8 Exterior)	7
	2	HVAC piping insulation thickness.	5
	1	Exhaust air energy recovery on systems ≥ 5,000 cfm and 70% of design supply air.	3
	1	Building heating **not** achieved with electric resistance units	3
	3	Temperature reset by representative building loads in pumping systems >10 hp for chiller and boiler systems > 300,000 Btu/h.	1
	3	Outdoor air and exhaust systems have motorized dampers that automatically shut when not in use.	1

Table 4-6. Summary of Non-Compliant Energy Code Checklist Requirements (2 of 2)

Category	Tier[a]	2005 CBES Code Requirement	Number of Non-Compliant Sites[b]
Service Water Heating	2	Piping for recirculating and non-recirculating service hot-water systems insulated.	11
	1	Automatic or manual controls installed to switch off the recirculating hot-water system or heat trace.	4
	1	Individual electric service water heating units >5kW total power input.	3
	3	Heat traps installed on non-circulating storage water tanks.	1
Electrical Power and Lighting	2	Automatic lighting control to shut off all building lighting installed in buildings >5,000 SF[c].	15
	1	Light reduction controls (For eligible areas, lighting controls installed to uniformly reduce the lighting load by at least 50%).	12
Certificate of Compliance	1	Certificate of compliance found in a visible location as specified per 2005 CBES.	55

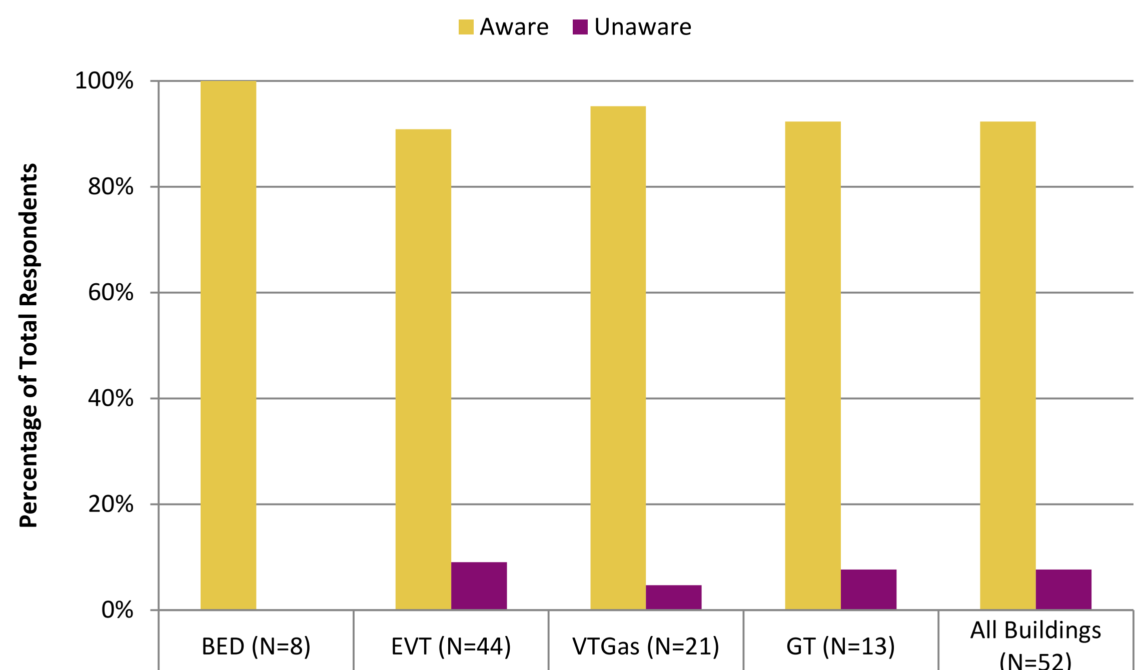
a. Tier levels designate importance in scoring mechanism, where 1 = Most Important (3 points), 2 = Important (2 points) and 3 = Least Important (1 point).
b. Ordered from highest to lowest number of sites where non-compliant measure was recorded. The sample included 58 sites, but each code requirement was not applicable at every site. Therefore, percent of sites is not reported.
c. There were 44 sites in the sample greater than 5,000 SF.
Source: Navigant analysis of on-site CBES compliance checklists

5. Assessment of EEU Program Awareness and Participation

5.1 Program Awareness and Participation

As shown in Figure 5-1, nearly all new construction customers (92%) are aware of energy efficiency service offerings available to them. All of the BED customers interviewed indicated awareness of service offerings.

Figure 5-1. Awareness of Energy Efficiency Service Offerings

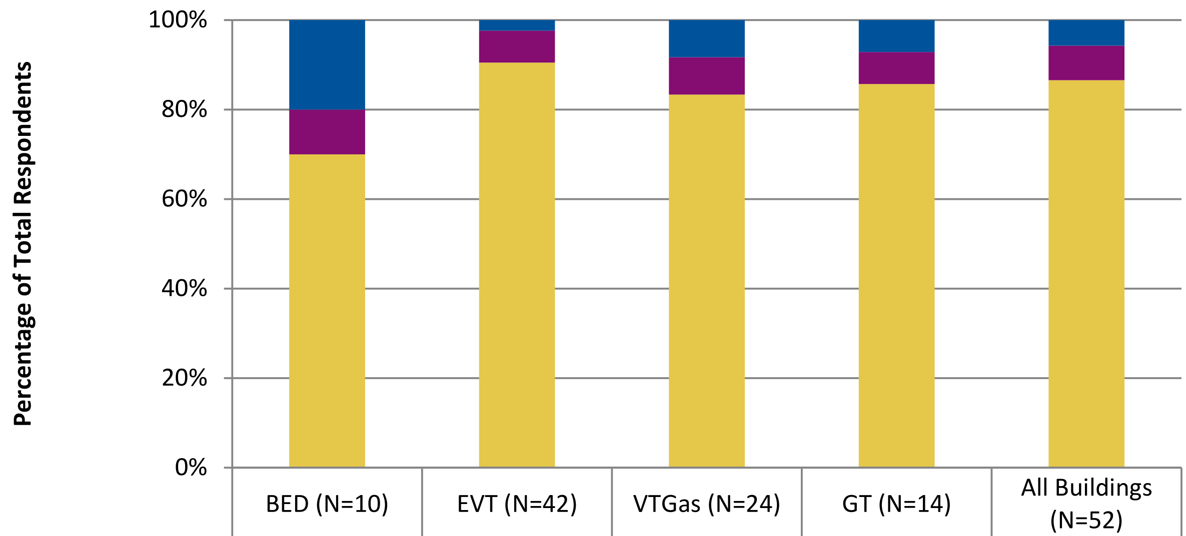


	BED (N=8)	EVT (N=44)	VTGas (N=21)	GT (N=13)	All Buildings (N=52)
Aware	100%	91%	95%	92%	92%
Unaware	0%	9%	5%	8%	8%

Source: Telephone Survey, Question EE3

Most (87%) new construction customers 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 90%.

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



	BED (N=10)	EVT (N=42)	VTGas (N=24)	GT (N=14)	All Buildings (N=52)
Don't Know	20%	2%	8%	7%	6%
Not Participated	10%	7%	8%	7%	8%
Participated	70%	90%	83%	86%	87%

Source: Telephone Survey, Question EE4

Customers indicated the specific energy efficiency programs they participated in during the last five years, as shown in Table 5-1. Participation rates are high for EVT and BED programs, though participation in VT Gas programs within the VT Gas service areas was notably lower (24%) over the last five years. Customers in the GT areas within EVT territory were slightly more likely to have participated in EVT programs.

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

Efficiency Program	EEU/Area					
	BED (N=10)[b]	EVT (N=42)	VT Gas (N=24)	GT (N=14)	Non-GT (N=28)	All NC Buildings (N=52)
Efficiency Vermont	0%	76%	65%	77%	76%	69%
Burlington Electric Department	83%	0%	24%	0%	0%	8%
Vermont Gas	33%	4%	24%	15%	0%	8%
Other	0%	2%	6%	0%	3%	2%
None	17%	7%	12%	8%	0%	8%
Don't Know	33%	2%	12%	8%	0%	6%

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

6. Assessment of Missed Opportunities

During the on-site visits, surveyors identified "missed opportunities" in the new construction or major renovation projects. For the purpose of this study, missed opportunities are defined as follows:

Used for the new construction and major remodel markets, to identify measures that could have been reasonably and likely cost-effectively added in the design/ building phase but were not. Missed opportunities may or may not be cost effective to retrofit, now that the building is constructed. Missed Opportunities identifies things that might be targeted in new construction programs and/or codes. (Note: Failure to meet code is non-compliance, not a "missed opportunity".)

Surveyors recorded the missed opportunities in open-ended comments within the survey form. Analysts transcribed these comments and attempted to quantify the most prevalent comments by grouping them and counting the responses. Table 6-1 shows that lighting, HVAC and building envelope received the most comments on missed opportunities, with each category comprising about one-quarter of all responses. A detailed list of the qualitative observations from the on-site surveys is available upon request from the Public Service Department.

Table 6-1. End-Uses Ranked by Most Observations of Missed Opportunities

Building End-Use	Number of Observations	Percent of Total Observations
Lighting	80	28%
HVAC	69	24%
Building Envelope	60	21%
Water Heating	41	15%
Miscellaneous	19	7%
Refrigeration/Motors	13	5%
Total	282	100%
Source: Navigant on-site surveys		

The missed opportunities are summarized by end-use in the following sections.

6.1 Lighting - Missed Opportunities

Missed opportunities for lighting consisted mostly of observations regarding more efficient lighting choices (43%) followed by the need for occupancy sensors (35%), as shown in Table 6-2. Improved lighting controls comprised nearly one-quarter of all the lighting missed opportunities. Efficient equipment observations were dominated by recommendations to install LEDs and CFLs. Most of the occupancy sensor opportunities simply consisted of adding more sensors, with hallways, common areas and restrooms frequently mentioned. Opportunities to improve controls included adding photocells for indoor daylighting controls, increased controls of outdoor lighting and recommendations for central control systems and bi-level switching.

Table 6-2. Summary of Lighting Missed Opportunities

Missed Opportunity	Number of Observations	Percent of Total Observations
More efficient lighting	34	43%
Occupancy sensors	28	35%
Improved controls	18	23%
Total	80	100%
Source: Navigant on-site surveys		

6.2 *HVAC - Missed Opportunities*

Table 6-3 shows that missed opportunities for HVAC systems were dominated by recommendations for more efficient equipment (60%). These recommendations span a wide range of measures including more efficient heating and cooling systems, employing economizers and using heat recovery ventilators (HRVs) instead of Energy Recovery Ventilators (ERVs). Adding programmable thermostats and improving controls each comprised 16% of all HVAC opportunities.

Table 6-3. Summary of HVAC Missed Opportunities

Missed Opportunity	Number of Observations	Percent of Total Observations
More efficient equipment	42	60%
Programmable thermostat	11	16%
Improved controls	11	16%
Improved duct/piping insulation	4	6%
Occupancy sensors	1	1%
Improved envelope (reduce cooling load)	1	1%
Total	70	100%
Source: Navigant on-site surveys		

6.3 *Building Envelope- Missed Opportunities*

Missed opportunities for the building envelope category include straight-forward recommendations to improve/increase insulation levels in walls and roofs (26%), with 74% of recommendations involving general improvements to the building envelope, as shown in Table 6-4. These are dominated by suggestions to improve air sealing and installing higher performance windows.

Table 6-4. Summary of Building Envelope Missed Opportunities

Missed Opportunity	Number of Observations	Percent of Total Observations
Improved envelope	42	74%
Improved insulation	15	26%
Total	57	100%
Source: Navigant on-site surveys		

6.4 Water Heating – Missed Opportunities

Table 6-5 shows that most (63%) water heating missed opportunities involve increasing insulation on water heating tanks and piping. Better controls and more efficient equipment comprise 22% and 15% of recommendations, respectively.

Table 6-5. Summary of Water Heating Missed Opportunities

Missed Opportunity	Number of Observations	Percent of Total Observations
Improved tank/piping insulation	26	63%
Improved controls	9	22%
More efficient equipment	6	15%
Total	41	100%
Source: Navigant on-site surveys		

6.5 Refrigeration - Missed Opportunities

The majority (85%) of missed opportunities for refrigeration equipment (including commercial and non-commercial equipment) involve purchasing ENERGY STAR equipment and installing economizers in walk-in refrigeration units, as shown in Table 6-6.

Table 6-6. Summary of Refrigeration Missed Opportunities

Missed Opportunity	Number of Observations	Percent of Total Observations
More efficient equipment	13	87%
Improved controls	2	13%
Total	15	100%
Source: Navigant on-site surveys		

6.6 Miscellaneous - Missed Opportunities

Nearly all the miscellaneous missed opportunities involve applying smart strips and other power management systems to desktop office equipment and computers (Table 6-7).

Table 6-7. Summary of Miscellaneous Missed Opportunities

Missed Opportunity	Number of Observations	Percent of Total Observations
Improved controls	18	95%
More efficient equipment	1	5%
Total	19	100%
Source: Navigant on-site surveys		

6.7 Energy Efficiency Features Observed that Exceeded Code

Surveyors cited building envelope measures more than any other features that exceeded energy code requirements, as shown in Table 6-8. HVAC and lighting measures were the second and third most-cited features to exceed the code. A detailed list of the qualitative observations from the on-site surveys is available upon request from the Public Service Department.

Table 6-8. Summary of End-Uses Cited for Exceeding Energy Code

Building End-Use	Number of Observations	Percent of Total Observations
Building Envelope	27	55%
HVAC	9	18%
Lighting	8	16%
Water Heating	3	6%
Refrigeration/Motors	1	2%
Miscellaneous	1	2%
Total	49	100%
Source: Navigant on-site surveys		

Appendix A. Survey Instruments

[Included in separate document]