Business Sector Market Assessment and Baseline Study: Commercial New Construction Vol. 1

Final Report

Prepared for the Vermont Department of Public Service

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Objectives

This is the Final Report of the Vermont Business Sector Market Assessment and Baseline Study: Commercial New Construction. It is the second in a set of three reports that characterize the energy –related features and opportunities for cost-effective energy efficiency improvements in Vermont's business facilities. The other two reports address the same topics in regard to existing commercial buildings and existing industrial buildings.

The Vermont Department of Public Service (Department or DPS) commission these reports and their underlying research as part of its ongoing role to guide and support the design and delivery of energy efficiency programs in Vermont. The Department's goals for the project, in order of priority were to:

- Provide baseline data on current new construction practices that will be useful in future evaluations of EEU program effects.
- Identify and provide information about opportunities for achieving increased levels of cost-effective energy efficiency in Vermont for use in program planning and design.

Key Findings

These findings are based on a sample of 27 newly constructed facilities in Vermont. Because of the small sample size and challenges identifying the sample population these results are indicative of the energy characteristics of new facilities. Percentages are provided to give an sense of the relative size of findings.

Building Characteristics

- Overall, around 96 percent of new commercial facilities in our sample are occupied in part or in whole by the facility owners.[1] Owner occupants are more like to be motivated

[1] This is likely an overrepresentation of owner/occupants in the new construction commercial sector. The sample was drawn from lists of newly constructed facilities, which would contain information on the

to invest in energy efficient equipment, as there no split incentives. The barriers are likely to be information and initial costs.

- Propane was the most prevalent heating fuel – found in 38 percent of the square footage in our new construction sample.

- Electricity was found in 22 percent of the square footage, with 7 percent of the overall square footage heated by electric heat pumps (with no other supplemental fuel). Fifteen percent of the new construction space had natural gas heating with electric resistance heating (this was a health rehabilitation facility that may have had special heating needs requiring this supplemental heat.)

- Hot water boilers are the most common space heating system, found in 72 percent of new commercial space. Furnaces are the next most common, heating 22 percent of new commercial space.

- The observed mean Lighting Power Density (LPD) for new commercial facilities is lower than the weighted average maximums contained in the Vermont *Guidelines* and is not significantly different from the mean LPD observed in existing facilities.
- The LPDs in new construction for incandescent and CFLs are not statistically significantly different from the LPDs for existing construction.

- Close to 90 percent of new commercial floor space is served by some fluorescent linear tube lighting. T-12 lighting is almost non-existent in the new facilities, which represents a substantial improvement over existing facilities.

- Most of the linear tube lighting in new construction is standard T-8 lighting, representing substantial opportunity for HP-T8 (or greater efficiency) lighting in new construction. .The on-site engineers indicated that at least 38 percent of the square footage contained lighting that could be upgraded to HPT-8 fixtures. This opportunity was found in 31 percent of the premises.

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person building the facility. Thus we were more likely to contact owner/occupants in our final study. Owners who are not occupants, where occupants pay the energy bills, are less likely to participate in a study of this nature.

- The incidence of HID lighting appears lower than in existing facilities, and T5 lighting is more prevalent. T5 lighting is often recommended for use in high bay situations where HID lighting has been used. The combination of increased T5 lighting and decreased HID lighting indicates that this may be happening in newly constructed facilities.

- Almost 80 percent of new commercial facilities have some outdoor lighting, most frequently lighting parking lots or building façades.

- More than three-quarters of the outdoor lighting wattage is in HID technologies (primarily standard metal halide), with the bulk of the remainder (19 percent) lit by incandescent or quartz lighting. The on-site engineers, did not identify many opportunities for improving the efficiency of the outdoor lighting.

- Roughly one-half of the indoor space is served by cooling equipment. This is similar to the numbers found in existing facilities. Eighty-five percent of the newly constructed buildings contain cooling for some or all of the facility. In other words, most newly constructed buildings in Vermont cool at least part of the facility.

- Chillers and split system HVAC units together make up 75 percent of cooling tonnage in new facilities. Chillers, while much less common, are in 7 percent of premises and serve 12 percent of conditioned floor

- Propane is the most common water heating fuel in new commercial facilities, with a saturation of 35 percent. The next most common fuel type for water heating is fuel oil with 21 percent.

- Boilers with separate tanks are the most common type of equipment in new facilities, while self contained units are also common.

- On-site generators were found in 26 percent of new facilities, with 80 percent running on diesel. All of the generators are currently used to provide emergency power only.

- Vending machines in new facilities show no increase in energy efficiency compared to their existing facility counterparts. This is probably due to the machines being provided by vendors and not owned facility.

- Office equipment is found in 78 percent of sample facilities. In 19 percent of those facilities, the field engineers identified non-ENERGY STAR compliant equipment, which is lower than recent market penetration data published by the national ENERGY STAR program.

- No facilities with office equipment report that they do not enable the ‘sleep mode’ of operation on computers and only five percent do not enable the sleep function on their copiers. Forty-eight percent report not using a hard shut off at night.
- Elevators are found in 30 percent of sample facilities. Seventy-five percent of these facilities report not shutting down elevators during periods of low use to save energy. Seventy-five percent report not programming their elevator controls to optimize positioning of cars when they are not in use.
- The field engineers identified laundry equipment in 26 percent of new facilities. Of these facilities, 14 percent had laundry equipment that was not ENERGY STAR compliant.

Energy Efficiency Opportunities

In the case of Energy Efficiency Opportunities, missing data were left in the denominator so that the reported ratio represents the most conservative estimate of the opportunity based on the data collected.

- LED lighting was identified in less than 1 percent of the square footage in newly constructed buildings. LED lighting is becoming increasingly available for commercial settings for a variety of applications. Prices are dropping and they probably represent the next big opportunity for lighting reduction.
- The on-site engineers identified lighting controls for all lighting types as representing a substantial opportunity in new construction. It is particularly important to address controls at the time of construction, when the opportunities are greater and the upfront costs lower. These opportunities include occupancy sensors, light sensors and dimmers.
- Fluorescent linear tube lighting represents a large portion of the lighting in the new facilities and substantial opportunity to promote increased the efficiency. Roughly 39 percent of the space contains standard T-8 lighting, indicating opportunity to increase the penetration of HP T-8s in newly constructed facilities.
- The engineers identified 8 percent of the space that contained lighting that could be upgraded toT-5 lighting. This could be a subset of the T-8 lighting and other lighting types (such as HIDs).

- Incandescent lighting is still found in new construction – 46 percent of premises contained at least one incandescent fixture. The engineers identified the technical opportunity to switch to CFLs for most of these fixtures. Building owners or occupants may have reasons other than price and awareness of CFLs that keep them from installing CFLs wherever possible in new facilities. Still, there exists some opportunity to decrease the prevalence of incandescent lighting in new facilities. Promotional activities for CFLs in new construction should focus on pin-based fixtures to greatly improve the chances that the lighting will not be removed.

- We found little evidence of LED lighting in the newly constructed facilities (approximately 1 percent of space contained LED lighting). New construction facilities represent a great opportunity for LED lighting as lamp prices come down and options increase.

- There are opportunities to improve the efficiency of outdoor lighting installed in new facilities. The biggest opportunities are for increasing the penetration of pulse-start metal halide fixtures and improving the controls for outdoor lighting. There is some limited opportunity for the installation of CFL in lieu of incandescent lighting.

- Energy efficiency opportunities for cooling equipment are associated with controls at least 43 percent of space), economizers (35 percent of space) and with cooling system motors - NEMA Premium Efficiency Motors for 27 percent or Electric Commutating motors for 20 percent of space.

- Over one-third of the new facilities sampled could benefit from an automatic setback thermostat to reduce cooling loads.

- Overall, space heating opportunities were dominated by the opportunity for more efficient motors and by better controls. More efficient motors for heating systems will also reduce cooling costs for businesses with combined distribution systems.

- Many water heaters could benefit from timers to keep systems from maintaining high water temperatures during non-occupied periods.

- The engineers identified supplemental tank insulation and pipe insulation for many domestic hot water heating systems, regardless of heating fuel. The potential energy savings from additional tank insulation is likely to be small, since newer tanks tend to be well insulated.

- The engineers identified minimal opportunities for improvements in the building shell for newly constructed buildings.

1. Introduction

1.1 Project Objectives

This is the Final Report of the Vermont Business Sector Market Assessment and Baseline Study: Commercial New Construction. It is the third in a set of three reports that characterize the energy-related features and opportunities for cost-effective energy efficiency improvements in Vermont's business facilities. The other two reports address the same topics in regard to existing commercial buildings and industrial facilities.

The Vermont Department of Public Service (Department or DPS) commissioned these reports and their underlying research as part of its ongoing role to guide and support the design and delivery of energy efficiency programs in Vermont. The Department's goals for the project, in order of priority were to:

- Provide baseline data on current market conditions that will be useful in future evaluations of EEU program effects.

- Identify and provide information about opportunities for achieving increased levels of cost-effective energy efficiency in Vermont [for use in] program planning and design.

Working together with KEMA, the Department and other stakeholders in the Study further refined the project objectives to include the following.

- Estimate the saturation of key end-uses, end-use technology shares (e.g. fluorescent v. HID lighting), and efficient technology shares (e.g. high performance (super) T8 fluorescent lamps and ballasts v. conventional T8 technology).
- Assess the extent of opportunities for additional energy-efficient equipment.
- Estimate installed capacity of major end-use equipment groups: lighting power density (w/sf), KBtu/hour of heat, tons of cooling.

To address these objectives, KEMA developed and deployed an on-site survey of a sample of 27 commercial facilities built after 2006. The population of new facilities in Vermont was developed through aggregating data from several sources: F.W. Dodge Reports, EVT billing information screened for new utility-hook ups,Burlington Building Permits and the Department of

Labor and Industry fir permit database. To develop the on-site sample, KEMA conducted screening interviews with a sample of 59 new commercial customers.

1.2 Overview of Data Collection and Analysis Activities

As discussed above, the basic objectives of the on-site survey were to develop information on the saturation and/or installed capacity of end-uses, end-use equipment types, efficient equipment, and opportunities to install additional energy-efficient equipment in Vermont's new commercial facilities. Where appropriate, KEMA designed the data collection and analysis methods to yield saturation estimates in terms of the percentage of total square feet with various end-uses or equipment types. This corresponds to methods used by other commercial energy use surveys as well as the data requirements of energy efficiency potential models.

Given the small sample size of new construction facilities, no disaggregation of results among building types, region or facility size proved meaningful.

Table 1-1 summarizes the data collection and analysis activities undertaken for this project. We present detailed descriptions of the methods used for the on-site survey in Section 2 and for the supply channel surveys in Section 8.

Table 1-1
Data Collection and Analysis Activities:
Existing Commercial Buildings

Activity/ Key Objectives	Sample Frame	Sample Size and Other Details
Screening Survey Identify new construction facilities. Estimate portion of facility population with major systems upgraded within the past 2 years; 5 years Establish weighting system to expand sample results to the population of commercial facilities Identify customers willing to participate in on-site survey.	A combination of: F.W. Dodge Reports EVT billing data Burlington Building Permit Data Vermont Dept. of Labor and Industry Fire Permit data	**59 completed –** stratified by kWh consumption.

Activity/ Key Objectives	Sample Frame	Sample Size and Other Details
On-Site Survey Verify link to billing information General facility information: size, configuration, ownership, age, primary use, operating schedule Schedule and extent of recent renovations and equipment replacement Characterize energy-related O&M practices Characterize building shell elements; identify related energy efficiency opportunities. For the following end uses -- indoor lighting, outdoor lighting, heating, cooling, ventilation, domestic hot water, refrigeration – estimate: Saturation of end-use by fuel Share of key equipment types Share of efficient equipment Extent of opportunities for specified efficiency measures	Customers identified by the screening survey	**27 completed** out of initial target of 50.

1.3 Structure of the Report and Formats for Display of Results

This report is provided in five additional sections. In Section 2 we discuss the sampling and data collection approach. Section 3 provides the overall physical and operating characteristics of the facilities. Section 4 provides the characteristics of the major energy systems and Section 5 identifies the energy efficiency opportunities for these system. In Section 6 we summarize the findings.

Throughout this report, Commercial New Construction study results are shown next to overall results from the Commercial Existing Buildings study. The term “new” is used to refer to the results of the Commercial New Construction study while “existing” refers to results of the Commercial Existing Buildings study.

We were unable to obtain reliable information on the new construction market [2]in Vermont, making it impossible to weight the survey results up to the population. Because of the difficulty obtaining a reasonable population measure, the results from this study should be viewed as indicative of trends in new construction.

Most of the new construction results are weighted by square footage of premise or with a unit weight of one for each premise (unweighted). Existing Commercial study results are weighted to the population. The juxtaposition of the results of the two studies allows the reader to put the results of the new construction study in the context of the overall existing commercial population, though due to differences in the two populations (regarding building composition), and differences in the samples, the results of the two studies are not directly comparable.

Table 1-2
Weighting Comparison

Weight type	New Construction	Existing Premises
Premise	All facilities have a weight of one	Case weights based on sampling strata (Strata Population) / (Strata Sample Count)
Square Foot	Facility Indoor Square feet	(Premise Weight) x (Facility Indoor Square feet)
Conditioned Square Foot	Facility Conditioned Square feet	(Premise Weight) x (Facility Conditioned Square feet)
Wattage (Outdoor Lighting)	Watts	(Premise Weight) x (Watts)
Tons (Cooling)	Tons	(Premise Weight) x (Tons)

The remainder of the report is organized as follows.

- ***Section 2: On-Site Survey Methods –*** discusses the sampling, data collection, data quality control, and analysis methods applied in the on-site survey.
- ***Section 3: Characteristics of the Sample Establishments –*** presents information on the basic characteristics of establishments and facilities in the on-site sample, including:

[2] This is explained in more detail in Section 2.1

primary use, type of owner, form of tenure, facility size and configuration, primary heating fuel, primary heating and cooling equipment. Where appropriate we compare the characteristics of the new construction sample to those of the existing commercial building sample.

- ***Section 4: Characteristics of Major Energy Systems –*** presents detailed information on the saturation, fuel shares, and technology shares, of the major end-uses. This section also contains estimates of installed capacity for indoor lighting, heating, and cooling equipment. Information is generally reported parallel to the results from the existing commercial building study.
- ***Section 5: Opportunities for Energy Efficiency –*** summarizes findings regarding the presence of opportunities for common energy efficiency upgrades in key energy systems, based on the judgment of the KEMA team's field engineers.
- ***Section 6: Conclusions and Recommendations –*** summarizes the findings of the previous sections and explores their implications for the design of programs.

2. On-Site Survey Methods

2.1 Objectives

As discussed in Section 1, the basic goals of the project and the on-site survey were to characterize and quantify additional energy efficiency opportunities for new construction in Vermont, and to provide information to support the development of programs to capture those opportunities. To do accomplish these goals, KEMA worked closely with DPS and other stakeholders to balance a number of objectives under constraints of budget and the amount of time deemed feasible to spend on a given customer's site (one day). These objectives are as follows.

- ***Develop a more detailed and useful quantitative profile of Vermont's population of new commercial facilities than is available from other statistical and secondary sources.*** The original plan was to use Vermont Department of Labor and Industry (DLI) fire permit data to identify the population of newly constructed buildings in Vermont, supplemented with the City of Burlington Building Permit data. KEMA had used this approach in a previous study and found the data to be reliable and useful. After repeated contacts and conversations with staff both in and outside of the (DLI), this approach proved infeasible. Staffing changes at DLI resulted in serious limitations in the data that is currently available. KEMA attempted to use the DLI data with limited success in identifying newly constructed facilities.
- KEMA tried a second approach, using EVT customer and billing data limited to accounts w new meter installations in the prior two years. Again, this approach resulted in the identification of only a few newly constructed facilities. Finally, KEMA used F.W. Dodge data to develop a list of newly constructed commercial buildings in Vermont. We were able to complete 27 on-site surveys from the three data sources, but not a reliable estimate of the population of newly constructed facilities.
- ***Develop relatively accurate information on end use saturations, fuel shares, and equipment shares***. Good information on end use saturation, fuel shares, and equipment shares provide the basis for calculations of energy efficiency potential. They also provide a guide and reality check for estimating total savings available from a given set of measures that apply to a particular end use, fuel, and/or equipment type. Due to the importance of these estimates and multiple observations on which a single saturation

fraction relies, the use of experienced, trained field engineers to collect on-site data was necessary.

- ***Develop estimates of installed capacity for key end-uses.*** Estimates of installed capacity support more certainty and detail in developing estimates of potential energy savings than estimates of saturation can provide. Therefore, the survey incorporated methods to estimate installed capacity based on field engineers' observations, to the extent that equipment capacity characteristics could be determined. For some end-uses such as cooling, it was often difficult to find and record this information during the site visit.
- ***Develop assessments of remaining energy efficiency opportunities based on on-site observation by experienced engineers***. Generally, customers do not have enough information and experience to assess the applicability of various energy efficiency measures in their buildings. Program staff, designers, and installation contractors only get a partial view of opportunities in the course of their work. Therefore, the use of experienced field engineers was required to provide accurate information on the presence of energy efficiency opportunities.
- ***Disaggregate results into meaningful market segments.*** Initially, the Department and other stakeholders requested that the sampling be structured to support the meaningful disaggregation of results along the following dimensions: size (facility's annual electric consumption), region (Geo-Target v. balance of state), and facility type. The budget available for data collection was not sufficiently large to support meaningful disaggregation of the results for the new construction study.

2.2 Sampling

2.2.1 Objectives

The key objective of the sample design was to provide unbiased representation of the full population of new commercial facilities. As discussed above, this objective was not fully achieved.

2.2.2 Development of the Sample Frame

2.2.2.1 Survey Participant Screening and Recruitment

KEMA used the following procedure to contact, qualify, and recruit customers into the sample.

- ***Conduct the screening survey***. KEMA interviewers contacted representatives of the premises in the sample by telephone and administered a short survey. The key objectives of the screening survey were

- To verify that the premise was a commercial or industrial facility with major modifications or newly constructed with the past two years.

- To gather basic information about the size, configuration, primary heating fuel, and presence of cooling, and recent energy system improvements.

- To solicit the respondent's participation in the survey. KEMA forwarded the contact information for willing survey participants to the field engineers, who arranged the schedule for the on-site directly with the participants.

KEMA attempted to complete on-site surveys with all willing participants.

2.3 Data Collection and Quality Control

- ***Collect completed surveys from engineers weekly.*** The surveys were sent to ERS or to KEMA for check-in.

- ***Review completed survey.*** An initial review of the survey was conducted to confirm that the data were provided, the correct site was completed and that energy usage data associated with that premise were correctly tied to the premise.

- ***Coding and data entry.*** All surveys were pre-coded for data entry. At this step some data were corrected for out-of-range codes.

- ***Data cleaning.*** After the data were entered a frequency was run on each of the variables. At this point we identified all remaining out-of-range codes and unusual values. Cross checks of key variables were also run to identify inconsistencies in key variables (such as square footage of areas not adding up to total square footage). For each problem identified we reviewed the paper copy of the survey and resolved any data entry or coding errors that could be identified. When issues could not be resolved from the paper version of the survey we contacted the field engineer, who resolved the issue (based on their notes or recall) or followed up with people at the facility (when possible).

2.4 Data Analysis Approach

Weighting and computation of survey results.

KEMA conducted analysis using two different weighting approaches. In the first approach all analysis was conducted on a premise basis, where each facility was given a weight of one. For equipment saturations that are highly related to the square footage of facilities, we used ratio estimation to calculate the percentage of newly constructed commercial space that had specific characteristics. Ratio estimation was used to determine the penetration of equipment and energy efficiency opportunities for heating, cooling and indoor lighting.

Where the survey seeks responses in the form of a number or percentage — say, the portion of total commercial facility floor space that is illuminated by linear tube fixtures — we calculated survey responses using the combined ratio estimator $\hat{R}_c$:

$$\hat{R}_c = \frac{\sum_h \frac{N_h}{n_h} \sum_i F_{h_i} x_i}{\sum_h \frac{N_h}{n_h} \sum_i x_i},$$

Where

i =	sample facility,	
N_h	=	number of facilities in the population in size stratum *h,*
n_h	=	number of facilities in the sample in stratum *h,*
F_{h_i}	=	Facility *i*'s response (expressed as a number or percentage), and
x_i	=	Square footage consumption for Facility *i*.

If the question elicited a categorical response (e.g., yes/no), a F_{h_i} was created for each possible response. For the selected response (responses if choose all that apply), F_{h_i} = 1. For the response/s not selected, F_{h_i} = 0.

The use of the combined ratio estimator supports the estimate of a standard deviation and standard error for each variable. For surveys of this type, the ratio approach described above generally yields lower variances (more precise estimates) than mean per unit methods, for a given sample size. The standard errors will be used to calculate appropriate measures of precision for various kinds of results. For estimates of totals and ratios, and proportions, we report the 80/20 confidence intervals in the appendices.

Treatment of missing data. For the majority of the analysis cases with missing data were excluded from the analysis and not included in the denominator. For example, if five percent of the respondents for which the question applied did not have sufficient information, the analyses were completed on the remaining 95 percent of respondents. In the case of Energy Efficiency Opportunities, missing data was left in the denominator so that the reported ratio represents the most conservative estimate of the opportunity based on the data collected.

The determination of lighting density was dependent on many individual variables within a single premise. Many premises were missing one or more of the key variables. For these premises we used default values to develop estimates. For example, when the on-site engineer did not report the wattage of a linear tube lamp we substituted an average wattage for a lamp of that type to complete the analysis.

3. Characteristics of the New Construction Sample Facilities

This section presents information about the general characteristics of the new construction sample facilities. Most of the information presented here is drawn from the results of the on-site survey. Unlike the existing commercial and industrial facility studies, there are no broad surveys of new construction such as *County Business Patterns*, the *Manufacturing Energy Consumption Survey,* or the *Commercial Building Energy Consumption Survey* to provide consistently-collected data on basic facility characteristics such as economic use or tenure arrangements. Therefore, it is difficult to make judgments concerning the representativeness of the new construction sample.

Generally speaking, we would not necessarily expect to see a very close correspondence between the commercial buildings constructed in a given two-year period and the population of existing buildings as a whole. New construction is undertaken in response to current needs, and the range of projects completed in a relatively short time frame is subject to many contingencies. We present the basic characteristics of the facilities in the new construction sample in relationship to the sample used for the existing commercial facilities study and *County Business Pattern* as a point of information only. Similarities and differences between information from these sources should not be regarded as evidence of the representativeness of the new construction sample.

3.1 Characteristics of Organizations in the On-Site Sample

3.1.1 Tenure Arrangement

Table 3-1 displays the distribution of the on-site sample by tenure arrangement. The sample findings indicate that 96 percent of surveyed new commercial facilities are owned by their occupants: 85 percent of commercial facilities are occupied in their entirety by owners; 11 percent are occupied in part by their owners. Owner occupied premises make up the majority of Vermont's new commercial facilities, giving the owners a significant interest in the energy savings and capital appreciation benefits associated with energy efficiency improvements. The remaining four percent of the new commercial facilities in the sample were leased in their entirety to one occupant. These establishments are likely to be directly responsible for their energy bills and thus motivated to make some energy efficiency improvements.

As Table 3-1 shows the percentage of owner-occupied facilities is much higher in the new construction than in the existing premises sample. This result may reflect, in part, the nature of the sample frame for the survey. F. W. Dodge tracks new construction project information associated with the project principals, not with tenants. It is likely that the percentage of newly-constructed buildings has a somewhat higher fraction of lessee occupants than the results in Table 3-1 suggest.

Table 3-1
Distribution of On-Site Sample by Tenure
Premise Weighted

Tenure Arrangement	New Construction n = 27	Existing Premises n = 117
Own and Occupy the Entire Facility	85%	46%
Own the Entire Facility and Occupy a Part of It	11	30
Lease the Entire Facility from another Organization	4	2
Lease part of the Facility from another Organization	0	12
Other Ownership Arrangement	0	6
Unknown	0	4
Total	100%	100%

3.1.2 Primary Economic Use

Table 3-2 shows the distribution of the sample facilities by economic use, along with the same distribution of the sample in the existing buildings survey and County Business Patterns, which are developed from Federal employment records. The sample of new facilities differs from the existing facilities sample in the following ways;

- There are considerably fewer office facilities in the new construction sample than in either the sample of existing facilities or the County Business Patterns universe. This result may again reflect the methods used to compile the sample frame, which focus on obtaining information from construction project principals That approach may result in some undercounting of offices within multi-tenant buildings.

- The new construction sample contains higher percentages of “other health” facilities and schools than the sample of existing facilities or *County Business Patterns.* This result likely reflects the growing need for elderly care facilities and for replacement of schools in established communities.

Table 3-2
On-site Sample by Primary Economic Use and Building Type

	Number of On-sites		Percent of Population			Percent of Population (Square Footage Weighted)	
Primary Economic Use	**New Cons.**	**Existing Com.**	**New Com. On-sites**	**Existing Com. (Premise Weighted)**	**County Business Patterns**	**New Com.**	**Existing Com.**
Retail	6	17	22%	27%	22%	13%	14%
Grocery	0	8	0	7	3%	0	1
Office	4	30	15	29	31%	9	50
Restaurant	1	8	4	6	5%	1	1
Warehouse	1	6	4	2	3%	4	5
Hospital	0	3	0	<1	n/a	0	2
Other Health	4	8	15	2	11%[1]	13	4
Lodging	5	7	19	3	5%	38	3
School	2	7	7	1	2%	15	6
Assembly	1	1	4	0	n/a	3	<1
Other	3	22	11	23	12%	4	12
Total	**27**	**117**	**100%**	**100%**	**100%**	**100%**	**100%**

[1] Includes all health care and social services

3.2 Size and Configuration of New Commercial Facilities

In this subsection we present information on the size and configuration of new facilities in the sample in comparison to the estimated population of existing commercial facilities as characterized by analysis of the results of the on-site survey.

Distribution by total enclosed floor space. As Table 3-3 shows, the population of new commercial buildings in Vermont consists primarily of small buildings. Thirty percent of the new facilities sampled are smaller than 5,000 square feet; over one-half are smaller than 10,000. By way of contrast, 31 percent of existing commercial facilities are smaller than 2,000 square feet, while we found no new facilities in that size range. Again, this finding may reflect the methods by which the F. W. Dodge sample frame was compiled. However, the large size of new facilities relative to the existing population reinforces the importance of the new construction market to meeting overall energy efficiency goals.

Table 3-3
Distribution of Commercial Facilities by Facility Size in Square Feet
Premise Weighted

Facility Size (SF)	New Construction N = 27	Existing Premises n = 117
2000 and Under	0%	31%
2001 – 5000	30	23
5001 – 10000	22	21
10001 – 20000	19	17
20001 – 50000	22	4
Over 50000	7	4
Total	100%	100%
Median square feet	10,000	4,200
Average square feet	17,318	12,034

Distribution by conditioned floor space. Table 3-4 shows the distribution of sample facilities by conditioned floor space. Average conditioned floor space among all new commercial facilities is 16,033 square feet, versus 17,318 square feet of total enclosed floor space. This differential is distributed evenly across size categories: all building sizes have facilities in which some indoor space is unconditioned.

Table 3-4
Distribution of Commercial Facilities
by Square Feet of Conditioned Space
Premise Weighted

Conditioned Space (sf)	New Construction n = 27	Existing Premises n = 117
2000 and Under	4%	36%
2001 – 5000	26	19
5001 – 10000	26	22
10001 – 20000	19	16
20001 – 50000	19	4
Over 50000	7	4
Total	100%	100%
Average square feet	16,033	10,455

Distribution by number of stories. Table 3-5 shows the distribution of facilities in the new commercial sample by number of stories. More than 70 percent of both newly constructed facilities are one or two story buildings. Only four percent of either sample are in buildings four or more stories.

Table 3-5
Distribution of Commercial Facilities
by Number of Stories
Premise Weighted

Number of Stories	New Construction n = 27	Existing Premises n = 117
One	48%	34%
Two	30	37
Three	19	25
Four or more	4	4
Total	100%	100%

3.3 Energy-Related Facility Characteristics

This subsection presents information on the energy-related characteristics of the new commercial facilities sample: heating fuels, the presence of cooling, and the presence of on-site electric generation.

Distribution by heating fuel. Table 3-6 shows the distribution of sample facilities by primary heating fuel. The columns add to more than 100 percent since multiple fuels were found in individual sample facilities. Fuel oil is the most common heating fuel, used in 42 percent of new facilities. Propane has the next highest share, at 35 percent. Natural gas is used in 19 percent, while electric heat is found in only 12 percent of facilities.[3] Twelve percent of facilities visited use other fuels – wood pellets -- for space heat. A significantly smaller fraction of new facilities use electricity for heating compared to existing commercial facilities. Propane accounts for a correspondingly higher percentage of new facilities.

Table 3-6
Distribution of Commercial Facilities
by Heating Fuel
Premise Weighted

Heating Fuel	New Construction n = 26	Existing Premises n = 117
Electric	12%	23%
Natural Gas	15	25
Fuel Oil	42	45
LNG or Propane	35	19
Other	12	10
Unknown but Not Electric Or Natural Gas[1]	12	2
Unknown	8	4

[1] The field engineer did not record the heating fuel.

[3] Electric heating consisted of heat pumps used for primary heating and electric resistance heaters used as a secondary heat source.

Distribution by heating equipment type present. Table 3-7 shows the percentage of commercial facilities in which various types of heating systems are present. The columns add up to greater than 100 percent because multiple heating systems were found in several buildings. The sample of new facilities contained a higher percentage of buildings with boilers and hydronic heat distribution systems compared to the existing facilities: 69 percent v. 46 percent. New facilities appear less likely than existing facilities to contain electric resistance heat: 8 percent versus 15 percent. Finally, new facilities appear to be more likely to have multiple heating systems than existing facilities. This finding may reflect the overall larger size of the new facilities.

Table 3-7
Distribution of Commercial Facilities
by Type of Heating Equipment Present
Premise Weighted

Type of Heating Equipment	New Construction n = 26	Existing Premises n = 116
Boiler	69%	46%
Furnace	31%	51%
Electric Resistance	8%	15%
Unit heater	8%	2%
Cabinet Unit Heater	4%	1%
Heat Pump	4%	1%
Other	8%	7%
Unknown	8%	0%

Distribution of cooling equipment type present. Eighty-one percent of new commercial facilities (square footage weighted) have space cooling equipment installed. The corresponding figure for existing facilities is 76 percent. The sample of new facilities had a higher percentage of facilities with central air conditioners such as split systems and packaged HVAC units than found in the existing facilities population. Window air conditioners were absent from the sample of new facilities, due in part to the greater prevalence of central air conditioning, and in part because window/wall air conditioners are generally a “retrofit” item.

Table 3-8
Distribution of Commercial Facilities
by Type of Cooling Equipment Present

Type of Cooling Equipment	New Construction n = 27	Existing Premises n = 117
None	19%	24%
Packaged HVAC	30%	9%
Split System HVAC	48%	34%
Chiller	7%	2%
Window	0%	24%
Heat Pump	19%	16%
Miscellaneous Cooling	0%	4%

3.4 Patterns of Operating Hours

Median and mean operating hours. As part of the on-site survey, the field engineers posed a series of questions on daily, weekly, and annual hours of operation. In large facilities, these questions were asked about each of the sample spaces surveyed. For these larger sites, the sample space with the most hours of operation was taken to represent the entire facility in the analyses below. Table 3-9 presents mean and median annual hours of operation for the new and existing facility samples. For new commercial buildings, the mean annual hours of operation is 3,832 with an 80 percent confidence interval of ± 14 percent. The estimate of annual hours of operation for new facilities is slightly higher but not significantly different that for existing facilities.

Table 3-9
Annual Hours of Operation
Premise Weighted

	New Construction n = 26	Existing Premises n = 111
Mean	3,832	3,470
80% Confidence Interval	*±548*	*±347*
Median	2,990	2,912

Table 3-10 shows the distribution of new commercial facilities by days per week and hours per day of operation. A little more than a quarter of new facilities are open seven days a week versus nearly half of existing facilities. The difference in operating schedules between new and existing facilities is not statistically significant despite the differences noted earlier in the distribution of facilities by size and economic use.

Table 3-10
Hours of Operation
Premise Weighted

Days Per Week	**New Construction n = 27**	**Existing Premises n = 111**
Less Than 5	4%	5%
5	44	31
6	26	16
7	26	48
Total	100%	100%
Hours Per Day		
Less Than 8	4%	10%
8	11	19
8.1 – 10	37	35
11 – 12	15	12
13 -23	22	11
24	11	14
Total	100%	100%

3.5 On-Site Generation

Table 3-11 summarizes the field engineers' observations of on-site generators found in the sample facilities. The key findings that can be taken from this information are as follows.

- **Operating mode.** All generators installed on-site are currently used to provide emergency back-up power only.
- **Saturation.** Overall, 26 percent of new sample facilities had electric generators on site. These generators serve 20 percent of sampled new commercial floor space. These

results are comparable to those found in existing buildings. We found no pattern in business types with on-site generation equipment. On-site generation equipment was found in lodging, retail, office, other health and other.

- **Rated output.** The mean rated output of the generators on-site is 68 kW. Generators found in new facilities are slightly larger on average than those found in existing facilities. The observed difference between the new and existing samples in installed generation capacity was roughly proportional to the difference between the samples in the average facility size.
- **Cogeneration:** None of the new facilities with on-site generators have cogeneration capable equipment.
- **Input Fuel.** In terms of floor space served, diesel is the most common input fuel for on-site generators. Eighty-one percent of the floor space in new buildings with on-site generation is served by diesel generators. Propane ranks second at 14 percent.

Table 3-11
Saturation and Characteristics of On-Site Generation

	New Construction n = 27	Existing Premises n = 116
Saturation by Facility	26%	18%
Saturation by Floor Space	20%	21%
Mean Rated Output (kW)	68	54
Weighted by Floor Space, n = 7		
Cogeneration Present	0%	10%
Generator Input Fuel		
Fuel: Natural Gas	0%	6%
Fuel: LPG	14	10
Fuel: Diesel	81	72
Fuel: Other	5	12
Operating Mode		
Emergency	100%	84%
Peak Shaving	0	7
Base Load	0	0
Other	0	9

4. Characteristics and Installed Capacity of Major Energy Systems

4.1 Indoor Lighting

4.1.1 Saturation and Technology Shares

Saturation and technology shares by floor space served. All space surveyed has indoor lighting equipment. Table 4-1 shows the saturation of the principal indoor lighting technologies. Percentages in the columns will add to more than 100 percent because individual spaces are often served by more than one type of lighting.

Key observations in regard to lighting technology shares in new construction, both in general and in comparison to existing facilities are as follows.

- **Linear Fluorescent Technologies.** Linear fluorescent fixtures constitute the most frequently used lighting technology in new construction, as they do in existing facilities.[4] Linear fixtures serve areas totaling 77 percent of the floor space in the new construction sample versus 108 percent in existing facilities.[5] At this stage, T-12 fixtures have virtually disappeared from new construction. The field engineers identified T-12 fixtures in only 3 percent of the floor space of the new construction sample, versus 49 percent of the floor space in the existing facility sample. This is consistent with our findings from the supply chain interviews. "In general the contractors agreed that higher efficiency lighting (efficiency beyond code) is becoming the standard in new construction."[6] The engineers identified High Performance T-8 fixtures in 20 percent of the floor space in the new construction sample versus 6 percent in the existing facilities. While these findings indicate that general purpose lighting specification practices are significantly more

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[4] This numbers shown in this paragraph do not include those for T-5 fixtures, which are typically used in high bay, under shelf, and other special applications, as opposed to general overhead lighting.
[5] Many indoor areas are served by more than one kind of lighting technology and, at least in existing buildings, more than one type of linear fluorescent technology.
[6] Business Sector Market Assessment and Baseline Study:
Existing Commercial Buildings, Vol. 1, Page 8-12

efficient in new construction than in older buildings, they also indicate that there is room for improvement in this area. At least two-thirds of the linear fluorescent equipment installed in new construction is not the most efficient available for general area lighting purposes.

- **Incandescent and Compact Fluorescent Technologies.** Incandescent and compact fluorescent technologies serve largely overlapping lighting applications, providing both task and area lighting in situations where more efficient linear technologies are infeasible or inappropriate. Thus, for many applications, compact fluorescent lamps (CFLs) and incandescent bulbs are direct substitutes. Table 4-1 shows that the saturation of these two technologies appears higher in the new construction sample than it is in existing facilities. 93 percent of floor space in new construction, versus 57 percent in existing, has at least one incandescent or fluorescent lamp. The share of CFLs in the areas lit by these complementary technologies is roughly the same in the new versus the existing facility samples: 61 percent v. 56 percent. However, as shown in Table 4-3, the lighting density for CFLs appears higher in new construction. This finding may reflect a number of factors, including trends towards increased substitutability between incandescent bulbs and CFLs and increased use of task and accent lighting in office and retail facilities.

Table 4-1
Percent of Floor Space Served by Lighting Equipment
Square Foot Weighted

Indoor Lighting Technology	New Construction n = 26	Existing Premises n = 116
Incandescent Lighting	36%	25%
Compact Fluorescent Lamps	57%	32%
T5	30%	5%
Standard T-8	39%	42%
High Performance T-8	20%	6%
Unknown T-8	5%	2%
T-12	3%	49%
Unknown Fluorescent Tube	10%	9%
Other Fluorescent	19%	8%
HID	3%	13%
Quartz	5%	5%
Other	25%	20%

- **HID and T-5 Technologies.** Over the past 10 – 15 years, energy efficiency programs, as well as lighting manufacturers, and installation contractors have promoted linear fluorescent technologies as a substitute for high intensity discharge (HID) technologies in high bay lighting applications. In particular, T-5 linear fluorescent technologies have been applied to high-bay lighting needs due their relatively high efficacy and concentrated light output. The results in Table 4-1 are consistent with these developments. Specifically, the saturation of T-5 technologies is 30 percent of new construction floor space versus 5 percent in existing facilities. HID saturation appears lower in new construction, with only 3 percent of floor space compared to13 percent in the existing facilities.[7] The increase in T-5 technologies indicates that they are likely to be installed in situations other than high bay applications, as well.

4.1.2 Overall installed capacity

Installed lighting capacity is usually measured by the lighting power density (LPD) indicator, defined as the ratio of the wattage of installed lighting fixtures to square footage lit. Vermont's *2005 Guidelines for Energy-Efficient Commercial Construction* contains standards for maximum LPDs for various building types and individual space types. These guidelines are taken from the current American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 90.1. The maximum LPD for retail buildings (using the whole building approach) is 1.5 watts/square feet; 1.0 watts/square feet for office buildings. Other whole building guidelines range from 0.8 watts/square feet for warehouses to 1.6 watts/square feet for family restaurants and theaters. Efficient lighting layouts and advances in basic fixture technology now permit designers and contractors to meet lighting requirements at LPDs considerably below the ASHRAE standard levels.

The LPDs presented in this report were calculated from survey data detailing the number, type and wattage of the lamps found in sampled facilities. It was not always possible to collect complete information for each lighting type present in a sampled space. In cases where partial information about the lamps was known, values were used to fill in missing data. The results reported should be considered a minimum LPD estimate: information was only collected for all the lamps that the surveying engineer had time to catalogue, so some small lighting groups may have been overlooked.

Correcting for missing data. Our LPD estimates for individual light types represent the average LPD for the given light type in spaces that have that type of light. In some cases the light type and number of lamps were known, but Watts per lamp was not estimated on-site. In these cases, KEMA used an average Watts per lamp based upon the lighting type and (if the data allowed) the ballast type. This was the only type of correction used in estimating the lighting type specific LPDs and it was used in less than four percent of cases. More than one third of these cases were LED lighting, which is a very small percentage of overall lighting

[7] 100 percent of T-5 technology in new construction is used for area lighting, as is 92 percent of HID technology, weighted by square footage.

wattage. If, after this correction the wattage for the lighting group was still unknown, then the entire space was dropped from the analysis of that light type.

The overall LPD estimates included a further correction for missing data. When presented with a lighting group for which the wattage was impossible to calculate, the estimated LPD from the technology specific LPD analysis for that light type was used to estimate the wattage for the lighting group with missing information. Using the observed average technology and building specific LPDs in this way keeps the overall distribution of light types in the LPD analysis consistent with the technology shares of the lit square footage and provides more accurate results than dropping the spaces with insufficient data from the analysis entirely. This correction was employed in 18 percent of cases.

Lighting Power Density Results. Table 4-2 displays the mean observed LPDs (premise weighted), the 80 percent confidence interval around the estimated mean, and the maximum LPD for the corresponding building types in the Vermont *Guidelines.*[8] The key finding from this analysis is that the observed mean LPD for the sample of new facilities is almost the same as the estimated LPD for the population existing commercial facilities and is lower than the weighted average maximums contained in the Vermont *Guidelines*.

Based on conversations with practitioners the similarity in lighting power densities between new and existing facilities is not totally unexpected. Lighting levels in many existing facilities fall below those required by ASHRAE and other professional guidelines. Many evaluations have found that electricity consumption increases when spaces are renovated in existing buildings despite the application of efficient end-use technologies.

[8] Maximum LPDs for the balance of commercial segment and all commercial are the weighted average maximum LPDs for the building types contained in those categories, using the whole building approach.

Table 4-2
Overall Lighting Power Density

Indoor Lighting Technology	**New Construction n = 26**	**Existing Premises n = 115**
Mean Lighting Power Density (w/sf)*	0.88	0.85
80% confidence interval	*±0.20*	*±0.12*
Maximum standards per Vermont Guidelines	1.21	1.21

*Default values were used for the analysis of LPD when full information was unavailable for a site. These values are provided in Appendix C, Table C-3

Installed capacity by fixture type. Table 4-3 shows the average installed light capacity by fixture type in spaces where the fixture type is present. The key findings to be drawn from the information presented in Table 4-3 are as follows.

- Technologies primarily used for area lighting, fluorescent tube lamps and HIDs, have the highest Watts per square foot.
- Incandescent lamps have a relatively high LPD, at 0.44 watts per square foot, with compact fluorescent lamps at 0.15 Watts per square foot. Since CFL lighting provides roughly 4- 5 times the lumens, per watt, CFL lighting is providing slightly more lumens than incandescent lighting in new facilities, which is consistent with the findings in existing facilities.

Table 4-3
Lighting Power Density by Type

Indoor Lighting Technology		**New Construction n = 26**	**Existing Premises n = 115**
Incandescent Lighting	*n=11*	0.44	0.34
Compact Fluorescent Lamps	*n=14*	0.15	0.11
T5	*n=10*	0.73	0.09
Standard T8	*n=8*	0.26	0.44
High Performance T8	*n=7*	0.38	0.51
Unknown T8	*n=5*	0.47	0.22
T12	*n=1*	0.02	0.53
Unknown Fluorescent Tube	*n=3*	0.46	0.82
Other Fluorescent	*n=5*	0.13	0.14
HID	*n=1*	1.46	0.65
Quartz	*n=2*	0.07	0.16
Other	*n=6*	0.05	0.06
Overall Lighting Power Density*		**0.88**	**0.85**

*LPDs reported in this table represent the average LPD of spaces where a lighting technology was found. The overall LPD is not the sum of the technology specific LPDs, rather it is the population weighted sum of all Watts divided by the population weighted total square feet of spaces where wattage could be estimated.

4.1.3 Additional Indoor Lighting Details

Applications. Over ninety-six percent of lamps in new facilities are used for area lighting, which is consistent with the findings of the existing buildings study. The only other significant use of lighting in new facilities is display lighting, which makes up three percent of overall lighting.

Ballast Types. Only 1 percent of the ballasted lamps in the new facilities had anything other than electronic ballasts.

Control Types. Eighty-two percent of lamps in new facilities are controlled by manual on/off switches, which is slightly less than the 93 percent of lamps with manual controls in existing facilities. This suggests that considerable electric savings can still be realized through the introduction of automated lighting controls in new facilities.

4.2 Outdoor Lighting

Because square foot weighting does not provide a reasonable correlation to overall usage for outdoor lighting, results presented for outdoor lighting were weighted by estimated wattage. KEMA was able to estimate lamp wattage for 78 percent of new sample facilities as shown in Table 4-4.

Saturation by percent of all facilities. As Table 4-4 shows, new facilities use the majority of their outdoor lighting to light parking lots (58 percent of watts), while a quarter is used to light building façades (26 percent). Existing facilities devote more lighting to walkways (28 percent) and have less lighting in on the building façade (11 percent).

Table 4-4
Saturation of Outdoor Lighting, by Premise

	New Construction n = 27	Existing Premises n = 117
Premises with known outdoor lighting wattage	78%	81%
Outdoor Lighting Use Type, *n=21*		
Parking lots	58%	51%
Parking garages	1%	1%
Advertising	1%	4%
Building Façade	26%	11%
Walkway lighting	14%	28%

Installed capacity and technology shares. The field engineers identified and counted 1,247 watts of lighting installed per new facility with outdoor lighting, with an 80 percent confidence interval of 254 watts. This is 10 percent higher than what was found in existing facilities. The difference may be attributable to the average size of the new construction sample, as well as a higher saturation of façade lighting. Table 4-5 shows the distribution of total outdoor lighting wattage by lamp type. High Intensity Discharge technologies account for over three-quarters of outdoor lighting capacity. Incandescent and quartz technologies make up most of the remainder.

Generally speaking outdoor lighting associated with new construction is more heavily distributed to efficient technologies than outdoor lighting associated with existing facilities. Incandescent and mercury vapor lamps – the least efficient technologies – account for 39 percent of the installed wattage of outdoor lighting in existing facilities versus 19 percent in new construction. Seventeen percent of the installed outdoor wattage in new construction is in pulse-start metal halides, which are more efficient than standard metal halide. However, high pressure sodium fixtures -- the most efficient of the high intensity discharge technologies – account for a much greater proportion of installed outdoor capacity in existing facilities than in new facilities: 21 percent v. 4 percent. Sodium vapor technologies have lost share to metal halides due largely to poor color rendition.

As is the case with indoor lighting, efficiency levels in new construction exceed those in existing facilities but there is considerable room for improvement in efficiency levels.

Table 4-5
Outdoor Lighting Installed Capacity by Lamp Type

Watts by Lamp Type	**New Construction n = 21**	**Existing Premises n = 89**
HID	78%	52%
*Mercury Vapor**	*0*	*3*
*Standard Metal Halide**	*56*	*26*
*Pulse Start Metal Halide**	*17*	*1*
*High Pressure Sodium**	*4*	*21*
*Low Pressure Sodium**	*0*	*0*
Fluorescent	3	8
Incandescent / Quartz	19	36
Other lamp type	0	4
	100%	100%

*Subset of HID, Percents indicate the percent of overall watts.

Controls. Eighty-three percent of new facility outdoor lighting has automatic controls versus 69 percent in existing facilities. Photocell systems of various types control 47 percent of watts, while controls that include a timing mechanism are used to control 25 percent of watts.

Table 4-6
Outdoor Lighting Controls by Business Type
Wattage weighted

Control Type	New Construction n = 21	Existing Premises n = 89
Manual On/Off Switch	17%	31%
Motion/Occupancy Sensor	1	7
Photocell	34	32
Time clock	12	21
Photocell/Time clock	13	7
Photocell with dimming	0	1
EMS	7	1
	100%	100%

4.3 Cooling

4.3.1 Saturation and Technology Shares

Saturation and technology shares by floor space served. Table 4-7 shows the percentage of total indoor and conditioned new commercial floor space that is served by cooling equipment. For facilities in the new commercial building sample, 48 percent of total indoor floor space is served by cooling equipment, as is 50 percent of total conditioned space. These results are not significantly different from those found in the estimated population of existing commercial buildings. The percentage of indoor total indoor space is somewhat lower than the CBECS estimate of the saturation of cooling equipment: 58 percent for the New England region.

Table 4-7
Percent of Floor Space Served by Cooling Equipment

Served by Cooling Equipment	New Construction n = 27	Existing Premises n = 117
Percent of Total Indoor Floor Space	48%	47%
Percent of Conditioned Floor Space	50%	55%

Table 4-8 displays the saturations of various types of HVAC equipment in new facilities; in terms of percentage of known tons (13 percent of units were missing information on tonnage). Split system HVAC and chillers account for the highest saturation. Chillers provide a greater share of cooling tons in new facilities than in existing, with split systems and window AC units providing less in new facilities. Again, this result is likely related to the generally larger size of facilities in the new construction versus existing facility sample.

Table 4-8
Percent of Overall Tons Cooling by Equipment Type

Type of Equipment Installed	New Construction n = 19	Existing Premises n = 74
Packaged HVAC units	13%	14%
Split system HVAC units	36	58
Chillers	39	12
Window AC	0	5
Heat pumps	12	9
Miscellaneous Cooling	0	2
	100%	100%

Installed capacity. KEMA field engineers recorded information on the installed capacity of cooling equipment in tons. Table 4-9 summarizes findings from these for all space served by cooling equipment of any kind. We present these results in terms of number of square feet served per ton of installed capacity, which is a typical formulation used as a rule of thumb for sizing commercial HVAC installations. Installed capacities of one ton per 400 to 600 square feet are typical in New England.[9] The average cooled area per ton in new facilities falls just under this range, while the average conditioned feet per ton just above. In other words, space that is cooled has systems sized near this range, but much of the conditioned space is not cooled. This is expected for Vermont, one of the northernmost states in the region. New facilities tend to have larger sized systems per square footage cooled than existing which suggests that contractors may be oversizing new cooling equipment. If this is the case, it would present an

[9] This is equivalent to 56 – 84 watts/square meter.

opportunity for achieving energy savings through technical and financial support to “right-size” cooling installations.

Table 4-9
Installed Cooling Capacity

	New Construction n = 19	Existing Premises n = 71
Indoor square feet per ton of AC installed	723	1,026
Conditioned square feet per ton of AC installed	666	868
Cooled square feet per ton of AC installed	352	506
80% confidence interval for cooled feet per ton	*±129*	*±87*

4.4 Chillers

The field engineers observed four chillers in two facilities. Given the custom nature of chiller installations and the huge potential variety of components, configuration, and controls, it is not possible to generalize in any meaningful way from this small sample to the population of facilities with chillers. Also, the field engineers were often unable to observe such important system features as installed cooling capacity or compressor type due a number of factors: lack of access to chiller locations, absence of facility equipment schedules, and occupant’s lack of knowledge of the system in question. Table 4-10 summarizes information from selected chiller items in the on-site survey: compressor type, installed capacity, presence of chilled water loop, control type, and control strategy. There are few “central tendencies” to be seen on any of these dimensions.

Table 4-10
Summary of Chiller Inventory

		New Construction Units	Existing Facilities Units
Number of Sites with Chillers		2	10
Number of Chillers Observed		4	13
Compressor Type	Reciprocating	0	2
	Screw	0	2
	Scroll	4	1
	Centrifugal	0	2
	Unknown	0	6
Chilled Water Loop Present	Yes	1	8
	No	1	2
	Unknown	2	3
Installed Capacity(tons)	0 – 50	4	2
	100 – 200	0	3
	500	0	1
	Unknown	0	7
Control Type	Lead/Lag	2	2
	Base Load	0	1
	On Demand	0	4
	Unknown	2	6
Energy Management System Control Strategy	Constant	0	1
	Reset-Temp.	0	3
	Scheduled	0	1
	None	0	2
	Unknown	4	6

4.5 Space Heating

Saturation and technology shares by floor space served. Table 4-11 shows the distribution of new commercial floor space served by different heating equipment. When viewed in this manner, there appears to be considerable overlap of heating supply. Roughly 33 percent of building space in the Vermont new commercial facility sample is served by at least two different equipment types, significantly less than the 60 percent of space with multiple types in existing facilities. Hot water boilers are the most prevalent, serving 72 percent of total space (versus 69 percent of facilities). Furnaces are present in over half of existing conditioned floor space, while new facilities in our sample had furnaces in only a quarter of conditioned space.

Table 4-11
Heating Equipment Present
Conditioned Square Foot Weighted

Type of Heating Equipment	New Construction n = 26	Existing Premises n = 110
Boiler	72%	77%
Furnace	22%	54%
Electric Resistance*	15%	8%
Unit Heater	7%	3%
Cabinet Unit Heater	4%	4%
Heat Pump	7%	2%
Other	6%	12%
	133%	160%

*Electric resistance heating was found in one building that was primarily heated by a natural gas variable air volume system.

Heating fuels by floor space served. LPG is the most common space heating fuel, found in 38 percent of the square footage of the new construction sample. Approximately 25 percent of the space was heated each by electric, natural gas and fuel oil.. Electric heating in the new facilities consisted of electric heat pumps providing primary heat and electric resistance heaters found in combination with other heating sources.

Table 4-12
Heating Fuel
Conditioned Square Footage Weighted

Fuel Type	New Construction n = 26	Existing Premises n = 110
Electric	22%	16%
Natural Gas	24%	52%
Fuel Oil	25%	44%
LPG	38%	24%
Neither Electric Nor Natural Gas	8%	4%
Other	10%	13%
Unknown*	11%	6%

* The on-site engineer did not identify the heating fuel.

Heating Controls. Energy management systems (EMS) are the most common control type in new facilities with, 43 percent of the new construction premises containing them. This is substantially Roughly one quarter of heating units in both new and existing facilities are controlled by programmable thermostats. The saturation of manual controls is much higher in existing facilities in than in the new construction sample. This finding is consistent with the larger average size of facilities in the new construction sample.

Table 4-13
Thermostat Controls by Building Type and Consumption Category
Premise Weighted

Temperature Control	New Construction n = 26	Existing Premises n = 110
Programmable Thermostat	26%	25%
Manual Thermostat	19%	38%
EMS	43%	6%
Other	1%	3%
Unknown	11%	27%

4.6 Domestic Hot Water

4.6.1 Saturation, Fuel and Technology Shares

Table 4-14 shows the percentage of new facilities that have domestic hot water (DHW) equipment and, below that, the DHW fuel shares for those facilities. The incidence of hot water heating in new facilities is about the same as that in existing facilities. While it may seem surprising that a sizable portion of commercial facilities do not have hot water equipment, these findings are consistent with CBECS. The 2003 survey found that only 83 percent of commercial facilities in the Northeast Census region had DHW equipment, with warehouses, retail stores, and miscellaneous service facilities showing the lowest saturations.

Installation of electric water heaters is significantly lower in new facilities, while the usage of LPG and fuel oil is higher. Two facilities in the new construction sample used “other” fuels. These included one heat recovery system and one wood burning hot water heater.

Table 4-14
Saturation and Fuel Shares of Domestic Hot Water Equipment
Premise Weighted

	New Construction n = 27	Existing Premises n = 117
Premises with Water Heater	89%	90%
By Fuel Type, n = 24		
Electric	17%	58%
Natural Gas	14	14
Fuel Oil	21	13
LPG	35	14
Other	7	1
Unknown	11	0
	100%	100%

Table 4-15 shows the saturation of DHW equipment types by fuel. Boilers with separate tanks for water heating are the most popular water heating system in new facilities. Self-contained hot water tanks are the most common type of equipment for electric systems, while both fuel oil and LPG systems are more likely to be a separate tank fed by the boiler. Instantaneous heaters account for about 10 percent of new facility units and use LPG and electricity as a fuel source.

Table 4-15
Saturation and Fuel Shares of Domestic Hot Water Equipment

	Electric		Natural Gas		LPG		Fuel Oil		Total	
	New n=5	Exist n=54	New n=3	Exist n=22	New n=8	Exist n=13	New n=6	Exist n=20	New n=24	Exist n=104
Self contained	80%	93%	50%	51%	20%	34%	0%	77%	35%	76%
Boiler with separate tank	0	0	50	25	60	65	100	1	55	12
Instantaneous	20	8	0	0	20	13	0	2	10	5
HW Generator with separate tank	0	0	0	3	0	0	0	0	0	1
Side arm	0	0	0	0	0	1	0	20	0	3
Unknown	0	0	0	21	0	0	0	0	0	3
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

4.7 Building Envelope

4.7.1 Walls

The majority of new facilities in our sample have framed walls. Twenty-six percent had composite panel walls and less than ten percent had either brick, or brick and block construction.

Above ground wall insulation averaged an R-value of 22, with 30 percent of the sample having an R-value greater than 20. Less than 10 percent of facilities had an R-value under 15. The engineer could not determine the wall R-value fro approximately ¼ of the facilities. This indicates that most of the newly constructed buildings are built to meet Vermont code for wall insulation. For more details see section A-4 in Volume 2.

4.7.2 Windows

Ninety percent of the new facilities sample had windows of some type. Of the facilities with windows, an average of 19 percent of the wall space consisted on windows. Seventy-eight percent of windows were double glazed, while an additional seven percent were triple glazed. One-third of window treatments were clear and an additional 37 percent were Low E.

4.7.3 Roof

Seventy-eight percent of roofs on the sampled new facilities were pitched, with flat roofs making up the remaining 22 percent. Wood was used on 52 percent of roofs, while metal was the material used on 30 percent.

Blown or batt insulation was used in 41 percent of facilities. Rigid insulation was used in 22 percent. The average R-value of roof insulation was 37. Detailed tables can be found in Appendix A-4 in Volume 2.

4.8 Cooking Equipment

Thirty-three percent of the space in the new facilities' (37 percent of premises) have at least some cooking equipment, as shown in Table 4-16 below. This is about the same amount as was found in existing facilities. General ovens are found in 84 percent of facilities with cooking equipment and ranges are found in 51 percent. Around half of new facilities with cooking equipment also have dishwasher booster heaters (44 percent).

Table 4-16
Installed Cooking Equipment
Square Footage Weighted

Equipment Type	New Construction n = 27	Existing Premises n = 117
Premises with cooking equipment	33%	32%
Fryers	28%	46%
Griddle/grill	18%	54%
Range	51%	82%
Oven-Baking	5%	53%
Oven-General	84%	70%
Steam Kettle	18%	47%
Dishwasher Booster Heater	44%	65%
n of subsample with cooking equipment	*10*	*52*

Table 4-17 shows the square footage-weighted portion of various types of cooking equipment that is electrically-fueled. The electric share varies significantly be equipment type. For cooking equipment such as ovens and fryers, the electric share in new construction is generally as high as or even higher than that in existing premises. The opposite is true for dishwasher booster heaters and griddles.

Table 4-17
Percent of Installed Cooking Equipment that is Electric
Square Footage Weighted

Equipment Type	New Construction n = 10	Existing Premises n = 52
Fryers *n=4*	35%	8%
Griddle/grill *n=2*	0%	32%
Range *n=7*	37%	38%
Oven-Baking *n=2*	41%	10%
Oven-General *n=6*	62%	63%
Steam Kettle *n=2*	0%	14%
Dishwasher Booster Heater *n=5*	28%	56%

Convection ovens are the only energy efficient option our engineers found to be used frequently in Vermont commercial kitchens. A quarter of new commercial kitchens have convection ovens. This is likely due to their cooking properties, and not the efficiency aspects. None of the other energy efficiency options specified were found.

4.9 Miscellaneous Systems

The field engineers collected inventory information on miscellaneous electric equipment types which are known to contribute significantly to commercial load: office equipment, elevators, vending machines, and laundry equipment. Table 5-18 displays some key results from observations of miscellaneous energy systems. For each type of energy efficient equipment (or feature) the engineer indicated that it was present, not present, or not applicable to the situation. The results in Table 4-18 show the percent of facilities in which engineers indicated that specific energy saving equipment was *not* present.[10] In other words, this is the percent of facilities with the opportunity for the energy efficient equipment (or feature) that do not have it. This is the minimum opportunity for energy savings, since some data is missing and may represent additional opportunity. They can be summarized as follows.

- **Vending Machines.** Vending machines were found in 19 percent of new facilities. Vending machines in 80 percent of facilities with this equipment were not ENERGY STAR compliant. No machines in the sampled facilities were outfitted with vending misers, a plug device that controls vending machine lighting and refrigeration in response to ambient activity and temperature. The distribution of efficiency measures taken in vending machines in the new construction sample was consistent with what is installed in existing facilities. Vending machines are often provided and stocked by outside providers who rotate machines from facility to facility, so new facilities would not necessarily have newer (or more efficient) machines.
- **Office equipment.** Office equipment is found in sample facilities that represent 78 percent of all commercial facilities. In 19 percent of those facilities, the field engineers identified no ENERGY STAR compliant equipment. This figure is significantly lower than what was found in existing facilities and may be explained by the increasing market share of ENERGY STAR equipment in general. Operating practices strongly affect energy consumption by office equipment. The field engineers queried the occupants of sample facilities regarding three operating approaches that are known to reduce energy consumption in office equipment. None of the facilities with office equipment reported that they did not enable the ‘sleep mode’ of operation on computers and copiers. This practice reduces energy consumption during periods of low use. Only five percent report not using a hard shut off at night, which totally disconnects equipment and eliminates power demand during low-use periods.
- **Elevators.** Elevators were found in 30 percent of sample facilities. Seventy-five percent of these facilities report never shutting down some elevators during periods of low use to save energy. Seventy-five percent also do not program their elevator controls to optimize positioning of cars when they are not in use. Both of these findings are consistent with buildings that have only one or two elevators.

[10] Missing data was treated as possibly present

- **Laundry Equipment.** The field engineers identified laundry equipment in facilities representing 26 percent of the total commercial population. Of these facilities, 14 percent had no laundry equipment that was ENERGY STAR compliant. The lower percent of non-ENERGY STAR equipment in new facilities versus existing facilities is on par with the difference seen in ENERGY STAR office equipment.

Table 4-18
Details of Miscellaneous Equipment Installed

	New Construction n = 27	Existing Premises n = 117
VENDING MACHINES		
Percent Premises with Vending Machines	19%	30%
No Energy Star Vending Machines, n=5	80%	80%
No Vending Miser, n = 5	100%	93%
OFFICE EQUIPMENT		
Office equipment present	78%	82%
No ENERGY STAR Office Equipment, n=21	19%	63%
No Computer Sleep Function Enabled, n=21	0%	26%
No Copier Sleep Function Enabled, n=21	5%	26%
No hard shut-off at night, n=21	48%	44%
ELEVATORS		
Served by Elevators	30%	20%
No Shut down equipment during low-use periods, n=8	75%	62%
Do not use system to optimally position cabs, n=8	75%	70%
LAUNDRY EQUIPMENT		
Laundry Equipment	26%	14%
No ENERGY STAR Laundry Equipment n=7	14%	31%

4.10 Maintenance Practices

In this section, we summarize information from a series of questions that the field engineers posed to occupants of the sampled facilities concerning whether and how often they carried out specified maintenance procedures on key energy-using systems. Some of these questions were contained in a battery of items to be asked at the beginning of the on-site visit. Others were posed as the field engineer toured the facility accompanied by a representative of the occupant's organization. The responses are organized below by major system. Since the facilities are less than 3 years old, the responses may not be indicative of how often maintenance will be conducted as the building ages. They do show that most respondents plan to perform maintenance or checks on their main energy using equipment regularly.

Table 4-19
Maintenance Practices for Packaged HVAC Units
Premise Weighted

MAINTENANCE PROCEDURE/Frequency	New Construction n = 14	Existing Premises n = 49
CLEAN COILS		
Not at all	7%	9%
< 1 Time per Year	14%	2%
Once per Year	36%	27%
Twice per Year	36%	19%
3+ Times per Year	0%	10%
Unknown	7%	33%
CHECK REFRIGERANT LEVEL		
Not at all	7%	18%
< 1 Time per Year	14%	3%
Once per Year	57%	15%
Twice per Year	14%	23%
3+ Times per Year	0%	9%
Unknown	7%	32%
CHECK DAMPER OPERATION		
Not at all	0%	15%
< 1 Time per Year	14%	3%
Once per Year	36%	35%
Twice per Year	21%	22%
3+ Times per Year	14%	6%
Unknown	14%	19%

Packaged HVAC Systems. Sample respondents representing half of all commercial facilities with packaged HVAC units report servicing or checking operations of the system one or more times per year. Seventy-two percent reports cleaning the coils, 71 percent check refrigerant levels and the same amount check damper operation. These maintenance practices are all more prevalent than in existing facilities where nine to 18 percent of respondents report that they never conduct these maintenance activities. In general, the respondents report more frequent maintenance than those in existing facilities.

Chillers. One of the two new facilities sample respondents with chillers report that they have their chiller systems serviced more than three times annually.

Boilers. 65 percent of new commercial facilities sample respondents with oil and natural gas boilers report that they have their boilers serviced once annually. Ten percent report semiannual service calls, and 10 percent report having their units serviced three times per year.

5. Opportunities for Increased Energy Efficiency

In this section we present information on the opportunities for increased energy efficiency among the major energy users in commercial facilities. These include;

- indoor and outdoor lighting,
- cooling,
- space heating,
- domestic hot water, and
- air handlers.

The energy efficiency opportunities were identified by the on-site engineers based on what could be observed in a walk-through audit. Most of the tables presented in this section report the minimum percentage of space that includes the particular opportunity. For example, in Table 5-1 there is the opportunity to switch to CFLs in at least 49 percent of new facility floor space. This floor space may include other opportunities. Some lighting opportunities are wattage weighted, such as Table 5-4, where the percentage represents the minimum percentage of installed lighting wattage that has this opportunity. Other tables are “unweighted” in that they report the percent of premises within our sample that have the opportunity. The appendices, in Volume 2 of this report, include both premise (unweighted) and square foot weighted results for most energy efficiency opportunities[11].

5.1 Indoor Lighting

In this subsection we present information on the opportunities for increased energy efficiency for indoor lighting. In the case of indoor lighting, some of the opportunities overlap. For example, a specific lighting type (for example, standard T-8s) may have multiple opportunities identified (such as switch to HP T-8s and Switch to T-5s).

[11] For some opportunities square footage weighted results were not included because it is not a meaningful number.

The tables of energy efficiency opportunities are presented in this section based on ratio estimation. This means that percentages are based on the percentage of space that contains that lighting type (not the percentage of buildings) or the percentage of wattage. This provides a better measure of the opportunity to increase efficiency. The percent of premises that have the opportunities are reported in the Volume 2, Appendix B.

Overall Lighting Opportunities. In general, the lighting types installed in new construction are more efficient than that in existing facilities. There are, however, opportunities to further improve the lighting efficiency in this sector. The greatest opportunities for lighting overall are for improved lighting controls. Opportunities also exist for promoting the installation of higher efficiency fluorescent tube lighting (to T-5s or HPT-8s) or CFLs instead of incandescent lighting..

Table 5-1
All Indoor Lighting EE Ops
Square Foot Weighted

Energy Efficiency Opportunity	New Construction n = 26	Existing Premises n = 115
Switch to CFLs	49%	24%
Switch to Standard T-8s	4%	37%
Switch to High Performance T-8s	38%	85%
Switch to T-5s	8%	29%
Switch to Pulse-Start Metal Halide	1%	32%
Replace Ballasts with Auto Daylighting	27%	36%
Install Occupancy Sensors	77%	79%
Install Dimmers	15%	18%

Fluorescent Tube Lighting Opportunities. Fluorescent linear tube lighting represents a large portion of the lighting in both existing and newly constructed commercial buildings. The largest opportunity is in the promotion of HP T-8 lighting in new construction, where roughly 38 percent of the space is lit with standard T-8 lighting – a missed opportunity for HP T-8 lighting.

Lighting controls represents another substantial opportunity for improving lighting efficiency. There is no significant difference between existing and newly constructed facilities in our sample that could benefit from improved lighting controls such as auto dayligthing ballasts and occupancy sensors. Although the data were not collected in this study, there may be additional opportunity to have fixtures with multiple ballasts controlled by separate switches, so that only some of the lighting is on during daylight hours. There is also some opportunity for the use of occupancy sensors, although this opportunity is most often available in spaces with high efficiency lights (HP T-8s or T-5s), limiting the real energy savings potential. (see appendix for ee opportunities by lighting type.)

Incandescent and Compact Fluorescent Lighting. Incandescent lighting is still installed in some newly constructed facilities, representing opportunity for greater penetration of CFL lighting. When installed in new construction, pin-based lighting should be promoted to reduce the chances of the CFLs being replaced with incandescent or other less efficient lighting. As noted earlier, the installed capacity of incandescent lighting remains relatively high overall in both new and existing facilities. Some of this lighting is in locations that could benefit from either dimmers or occupancy sensors. The promotion of CFLs in new construction facilities should focus on pin-based fixtures, making it difficult to switch them to incandescent lamps.

Table 5-2
Incandescent Lighting EE Ops
Square Foot Weighted

Energy Efficiency Opportunity	New Construction n = 12	Existing Premises n = 56
Switch to CFLs	86%	55%
Install Occupancy Sensors	10%	31%
Install Dimmers	15%	5%

In new facilities, the engineers identified occupancy sensors (Table 5-3), as an opportunity for some compact fluorescent lighting. This indicates that the CFLs are likely to be in locations that are not occupied all the time, such as bathrooms, meeting rooms or supply closets. Other controls were the only other opportunity for additional savings found for CFLs installed in new facilities. Promotions of compact fluorescent lamps to new construction should address the newer, dimmable products available, as well as control options for lamps in specific applications.

Table 5-3
Compact Fluorescent EE Ops
Square Foot Weighted

Energy Efficiency Opportunity	New Construction n = 15	Existing Premises n = 60
Install Occupancy Sensors	42%	39%
Other Controls	2%	1%

Indoor HID lighting. Indoor HID lighting is rare in new commercial buildings, and when used, generally has fewer watts per fixture than HID lighting in existing facilities. Where the engineers found HID lighting in new commercial facilities, they identified switching to T-5 lights as an available energy efficiency opportunity in 60 percent of space.

5.2 Outdoor Lighting

Less outdoor lighting in new facilities has opportunities for increased efficiency when compared to existing facilities, though some upgrades to the lighting itself and better controls to minimize hours of operation can be better exploited.

Table 5-4
Outdoor Lighting EE Ops
Wattage Weighted

Energy Efficiency Opportunity	New Construction n = 24	Existing Premises n = 89
Switch to CFL	17%	26%
Switch to Pulse Start Metal Halide	17%	49%
Install Astronomical Time clock	13%	42%
Install Light Sensing Controls	4%	37%
HID EE Ops *n=17*		
Switch to Pulse Start Metal Halide	12%	86%
Install Astronomical Time clock	4%	33%

5.3 Cooling

The on-site engineers identified, from a list, energy efficiency opportunities for cooling equipment (Table 5-5). Different cooling system types had different list of opportunities based on their specific characteristics. Two of most common measures identified, cooling system motors (NEMA Premium Efficiency Motors for 35 percent or Electric Commutating Motors for 31 percent of space cooled), were only an option on systems that might have a motor. It is important to maximize uptake of efficient motors and economizers (35 percent) in new facilities as both are only possible to implement in existing facilities when the cooling system is being replaced or significantly reconfigured.

To a greater degree than in existing facilities, the engineers identified control systems energy efficiency opportunity in new facility HVAC systems. This is somewhat inconsistent with the Table 4-13, which indicates that 43 percent of the heating systems are controlled by Energy Management Systems. It does indicate that a substantial portion of the space in new facilities could benefit from an automatic setback thermostat to reduce cooling loads and additional space could save energy with other controls. Economizers present another sizable opportunity: 39 percent of new conditioned space could benefit from their installation.

Table 5-5
Overall Cooling EE Ops
Conditioned Square Footage Weighted

Energy Efficiency Opportunity	New Construction	Existing Premises
Economizer (*n=21*)	39%	25%
NEMA Premium Efficiency Motors (*n=9*)	35%	20%
Electric Commutating Motors (*n=8*)	31%	18%
Automatic Setback Thermostat (*n=22*)	43%	20%
Other HVAC Controls (*n=20*)	16%	4%
Refrigerant Charge (*n=21*)	0%	2%
Other Cooling Opportunities (*n=22*)	3%	15%

5.4 Space Heating

The primary energy saving opportunity for new facility space heating is the installation of more efficient motors. At least 29 percent of new floor space would benefit from the installation of a NEMA premium efficiency motor, while at least 24 percent of floor space would see energy savings from an ECM. Outside of motors, energy saving opportunities in new facility space heat are more limited, with only automatic setback thermostats (35 percent) and outdoor resets (11 percent) presenting an opportunity in more than ten percent of new floor space.

Percentages in the tables below indicate the minimum opportunity available. For example, though only 3 percent of commercial space has the opportunity of additional pipe insulation, this does not mean that the opportunity does not exist for some of the remaining 97 percent of heated space. The onsite engineer may have indicated the opportunity did not apply, or was unable to determine if it existed.

Table 5-6
Overall Heating EE Ops
Conditioned Square Footage Weighted

Energy Efficiency Opportunity	New Construction n = 26	Existing Premises n = 110
NEMA Premium Efficiency Motors	29%	52%
Electric Commutating Motors	24%	47%
VFD on Motors	22%	45%
Economizer	14%	7%
Duct Sealing / Insulation	0%	4%
Pipe Insulation	3%	2%
Automatic Setback Thermostat	35%	13%
Outdoor Cut-off	4%	38%
Outdoor Reset	11%	42%
Balance System	2%	10%

Electric and natural gas space heating was found in very few individual premises, but together they account for the all opportunities for automatic setback thermostats. Fuel oil systems have opportunities for the installation of more efficient motors, outdoor resets and cut-offs and modulating boilers as shown in Table 5-9. LPG systems only have significant opportunities for energy savings through improved motors in new facilities.

Table 5-7
Natural Gas Heating EE Ops
Conditioned Square Footage Weighted

Energy Efficiency Opportunity	New Construction n = 4	Existing Premises n = 47
Automatic Setback Thermostat	69%	11%
Economizer	7%	5%
Balance System	7%	4%
Other O & M	12%	5%
NEMA Premium Efficiency Motors	0%	8%
Electric Commutating Motors	0%	3%
VFD on Motors	0%	4%
Pipe Insulation	0%	0%

Table 5-8
Electric Heating EE Ops
Conditioned Square Footage Weighted

Energy Efficiency Opportunity	New Construction n = 3	Existing Premises n = 20
Automatic Setback Thermostat	87%	50%
Economizer	33%	2%
Balance System	0%	
Other O & M	0%	
NEMA Premium Efficiency Motors	33%	
Electric Commutating Motors	46%	

Table 5-9
Fuel Oil Heating EE Ops
Conditioned Square Footage Weighted

Energy Efficiency Opportunity	New Construction n = 11	Existing Premises n = 46
NEMA Premium Efficiency Motors	33%	35%
Electric Commutating Motors	35%	22%
VFD on Motors	33%	28%
Pipe Insulation	12%	4%
Outdoor Reset	35%	55%
Outdoor Cut-off	16%	47%
Modulating Boiler	25%	34%

Table 5-10
LPG Heating EE Ops
Conditioned Square Footage Weighted

Energy Efficiency Opportunity	New Construction n = 9	Existing Premises n = 17
NEMA Premium Efficiency Motors	38%	68%
Electric Commutating Motors	15%	70%

The primary energy efficiency opportunities for boilers in new facilities include opportunities for more efficient motors on pumps and controls systems (outdoor reset and cut out controls). Opportunities exist in at least 31 percent of new floor space for both NEMA premium motor upgrades and for the addition of a VFD to the pump motor.

Table 5-11
Boiler EE Ops
Conditioned Square Footage Weighted

Energy Efficiency Opportunity	New Construction n = 18	Existing Premises n = 60
NEMA Premium Efficiency Motors	31%	41%
Electric Commutating Motors	12%	31%
VFD on Motors	31%	38%
Outdoor Reset	15%	29%
Outdoor Cut-Off	5%	24%
Modulating Boiler	8%	19%
Pipe Insulation	4%	1%

Table 5-12
Furnace EE Ops[12]
Conditioned Square Footage Weighted

Energy Efficiency Opportunity	New Construction n = 5
NEMA Premium Efficiency Motors	5%
Electric Commutating Motors	39%
Outdoor Reset	39%
Balance System	12%
Outdoor Cut off	5%

[12] These results will be included in the final report.

5.5 Domestic Hot Water

A high percentage of water heaters of all fuel types in new facilities could benefit from timers to keep systems from maintaining high water temperatures during non-occupied periods. This opportunity appears to be especially great for new electric and fuel oil systems, though the sample size is small. Increased insulation on both pipes and tanks presents less of an opportunity in new facilities than in existing, but still can offer some potential savings.

Table 5-13
Overall DHW EE Ops
Unweighted Premises

Energy Efficiency Opportunity	New Construction n = 24	Existing Premises n = 104
Install Timers	38%	53%
Pipe Insulation	17%	50%
Supplemental Tank Insulation	17%	60%
Other Operations and Maintenance	0%	3%
Other Opportunities	4%	8%

Table 5-14
Electric DHW EE Ops
Unweighted Premises

Energy Efficiency Opportunity	New Construction N = 5	Existing Premises n = 52
Install Timers	40%	65%
Pipe Insulation	20%	61%
Supplemental Tank Insulation	20%	64%
Other Operations and Maintenance	0%	1%
Other Opportunities	0%	8%

Table 5-15
Natural Gas DHW EE Ops
Unweighted Premises

Energy Efficiency Opportunity	New Construction N = 3	Existing Premises n = 22
Install Timers	33%	7%
Pipe Insulation	0%	48%
Supplemental Tank Insulation	33%	40%
Other Operations and Maintenance	0%	7%
Other Opportunities	0%	6%

5.6 Air Handlers

Over three-quarters of the heated space in the new facilities sampled contain air handlers, as opposed to approximately one-quarter of heated space in existing facilities. One-half of the space with air handlers could benefit from a VFD on the air handler motor. In addition, one-quarter of air handlers in sampled new facilities could reduce their energy usage through better operation and maintenance practices.

Table 5-16
Air Handlers EE Ops
Square Footage Weighted

	New Construction n = 26	Existing Premises n = 28
Percent of Heated Conditioned Space That Uses Air Handlers	78%	26%
Energy Efficiency Opportunity		
VFD on Air Handler System Motors	48%	46%
Other Operations and Maintenance	26%	7%
Other Opportunities	0%	23%

6. Conclusions

6.1 Building Characteristics

6.1.1 General

- Overall, around 96 percent of new commercial facilities in our sample are occupied in part or in whole by the facility owners.[13] Owner occupants are more like to be motivated to invest in energy efficient equipment, as there no split incentives. The barriers are likely to be information and initial costs.

- Propane was the most prevalent heating fuel – found in 38 percent of the square footage in our new construction sample.

- Electricity was found in 22 percent of the square footage, with 7 percent of the overall square footage heated by electric heat pumps (with no other supplemental fuel). Fifteen percent of the new construction space had natural gas heating with electric resistance heating (this was a health rehabilitation facility that may have had special heating needs requiring this supplemental heat.)

- Hot water boilers are the most common space heating type, found in 72 percent of new commercial space. Furnaces are the next most common, heating 22 percent of new commercial space.

- The observed mean Lighting Power Density (LPD) for new commercial facilities is lower than the weighted average maximums contained in the Vermont *Guidelines* and is not significantly different from the mean LPD observed in existing facilities.

- The LPDs in new construction for incandescent and CFLs are not statistically significantly different from the LPDs for existing construction.

[13] This is likely an overrepresentation of owner/occupants in the new construction commercial sector. The sample was drawn from lists of newly constructed facilities, which would contain information on the person building the facility. Thus we were more likely to contact owner/occupants in our final study. Owners who are not occupants are probably less likely to participate in a study of this nature.

- Close to 90 percent of new commercial floor space is served by some fluorescent linear tube lighting. T-12 lighting is almost non-existent in the new facilities, which represents a substantial improvement over existing facilities.

- Most of the linear tube lighting in new construction is standard T-8 lighting, representing substantial opportunity for HP-T8 (or greater efficiency) lighting in new construction. .The on-site engineers indicated that at least 38 percent of the square footage contained lighting that could be upgraded to HPT-8 fixtures. This opportunity was found in 31 percent of the premises.

- The incidence of HID lighting appears lower than in existing facilities, and T5 lighting is more prevalent. T5 lighting is often recommended for use in high bay situations where HID lighting has been used. The combination of increased T5 lighting and decreased HID lighting indicates that this may be happening in newly constructed facilities.

- Almost 80 percent of new commercial facilities have some outdoor lighting, most frequently lighting parking lots or building façades.

- More than three-quarters of the outdoor lighting wattage is in HID technologies (primarily standard metal halide), with the bulk of the remainder (19 percent) lit by incandescent or quartz lighting. The on-site engineers, did not identify many opportunities for improving the efficiency of the outdoor lighting.

- Roughly one-half of the indoor space is served by cooling equipment. This is similar to the numbers found in existing facilities. Eighty-five percent of the newly constructed buildings contain cooling for some or all of the facility. In other words, most newly constructed buildings in Vermont cool at least part of the facility.

- Chillers and split system HVAC units together make up 75 percent of cooling tonnage in new facilities. Chillers, while much less common, are in 7 percent of premises and serve 12 percent of conditioned floor

- Propane is the most common water heating fuel in new commercial facilities, with a saturation of 35 percent. The next most common fuel type for water heating is fuel oil with 21 percent.

- Boilers with separate tanks are the most common type of equipment in new facilities, while self contained units are also common.

- On-site generators were found in 26 percent of new facilities, with 80 percent running on diesel. All of the generators are currently used to provide emergency power only.

- Vending machines in new facilities show no increase in energy efficiency compared to their existing facility counterparts. This is probably due to the machines being provided by vendors and not owned facility.

- Office equipment is found in 78 percent of sample facilities. In 19 percent of those facilities, the field engineers identified non-ENERGY STAR compliant equipment, which is lower than recent market penetration data published by the national ENERGY STAR program.

- No facilities with office equipment report that they do not enable the ‘sleep mode’ of operation on computers and only five percent do not enable the sleep function on their copiers. Forty-eight percent report not using a hard shut off at night.

- Elevators are found in 30 percent of sample facilities. Seventy-five percent of these facilities report not shutting down elevators during periods of low use to save energy. Seventy-five percent report not programming their elevator controls to optimize positioning of cars when they are not in use.

- The field engineers identified laundry equipment in 26 percent of new facilities. Of these facilities, 14 percent had laundry equipment that was not ENERGY STAR compliant.

6.2 Energy Efficiency Opportunities

In the case of Energy Efficiency Opportunities, missing data were left in the denominator so that the reported ratio represents the most conservative estimate of the opportunity based on the data collected.

- LED lighting was identified in less than 1 percent of the square footage in newly constructed buildings. LED lighting is becoming increasingly available for commercial settings for a variety of applications. Prices are dropping and they probably represent the next big opportunity for lighting reduction.

- The on-site engineers identified lighting controls for all lighting types as representing a substantial opportunity in new construction. It is particularly important to address controls at the time of construction, when the opportunities are greater and the upfront costs lower. These opportunities include occupancy sensors, light sensors and dimmers.

- Fluorescent linear tube lighting represents a large portion of the lighting in the new facilities and substantial opportunity to promote increased the efficiency. Roughly 39 percent of the space contains standard T-8 lighting, indicating opportunity to increase the penetration of HP T-8s in newly constructed facilities.

- The engineers identified 8 percent of the space that contained lighting that could be upgraded toT-5 lighting. This could be a subset of the T-8 lighting and other lighting types (such as HIDs).

- Incandescent lighting is still found in new construction – 46 percent of premises contained at least one incandescent fixture. The engineers identified the technical opportunity to switch to CFLs for most of these fixtures. Building owners or occupants may have reasons other than price and awareness of CFLs that keep them from installing CFLs wherever possible in new facilities. Still, there exists some opportunity to decrease the prevalence of incandescent lighting in new facilities. Promotional activities for CFLs in new construction should focus on pin-based fixtures to greatly improve the chances that the lighting will not be removed.

- We found little evidence of LED lighting in the newly constructed facilities (approximately 1 percent of space contained LED lighting). New construction facilities represent a great opportunity for LED lighting as lamp prices come down and options increase.

- There are opportunities to improve the efficiency of outdoor lighting installed in new facilities. The biggest opportunities are for increasing the penetration of pulse-start metal halide fixtures and improving the controls for outdoor lighting. There is some limited opportunity for the installation of CFL in lieu of incandescent lighting.

- Energy efficiency opportunities for cooling equipment are associated with controls at least 43 percent of space), economizers (35 percent of space) and with cooling system motors - NEMA Premium Efficiency Motors for 27 percent or Electric Commutating motors for 20 percent of space.

- Over one-third of the new facilities sampled could benefit from an automatic setback thermostat to reduce cooling loads.

- Overall, space heating opportunities were dominated by the opportunity for more efficient motors and by better controls. More efficient motors for heating systems will also reduce cooling costs for businesses with combined distribution systems.

- Many water heaters could benefit from timers to keep systems from maintaining high water temperatures during non-occupied periods.
- The engineers identified supplemental tank insulation and pipe insulation for many domestic hot water heating systems, regardless of heating fuel. The potential energy savings from additional tank insulation is likely to be small, since newer tanks tend to be well insulated.
- The engineers identified minimal opportunities for improvements in the building shell for newly constructed buildings.

- Many water heaters could benefit from timers to keep systems from maintaining high water temperatures during non-occupied periods.
- The engineers identified supplemental tank insulation and pipe insulation for many domestic hot water heating systems, regardless of heating fuel. The potential energy savings from additional tank insulation is likely to be small, since newer tanks tend to be well insulated.
- The engineers identified minimal opportunities for improvements in the building shell for newly constructed buildings.