Commercial Baseline Study Final Report

submitted to

Efficiency Maine Trust

energy & resource solutions

Primary Authors
Bruce Harrington, Energy & Resource Solutions
Brian McCowan, Energy & Resource Solutions
Timothy Clark, GDS Associates
Bob Fratto, GDS Associates

Corporate Headquarters:
120 Water St., Suite 350
North Andover, Massachusetts 01845
(978) 521-2550
Fax: (978) 521-4588

July 7, 2011

Contents

APPENDICES

1. Executive Summary

This report describes the results of a baseline energy consumption study of small and medium sized commercial buildings built prior to the adoption of the Maine Uniform Building and Energy Codes. The study was commissioned by the Efficiency Maine Trust on behalf of the Maine State Planning Office and conducted by ERS during May and June of 2011. The study provides information regarding baseline construction practices for commercial buildings started between 2006 and 2010 throughout the State of Maine.

The primary activities of the study included sample design and site selection, recruitment, building plan and specification review, site visits, data collection, and building owner/operator interviews. Data analysis involved code compliance and energy usage intensity comparisons.

1.1 Commercial Buildings Key Observations

The conclusion reached by this study is that standard construction practice is highly variable in Maine and is, on average, considerably below current energy code levels adopted by the state. This is not to say that the quality of construction is low. Of the buildings surveyed approximately 40% of the buildings were constructed within 75% of the standards established by the current code. There are clearly opportunities for training the building community not only on the benefits of higher levels of insulation and energy efficiency in general, but also on proper installation techniques and overall building science.

1.1.1 Envelope

Where we were able to accurately determine insulation levels, we found that approximately 40% of the buildings surveyed were constructed with insulation levels that do not meet current code levels. Many insulation levels were made more stringent with the 2009 IECC so a number of those buildings would have met the Maine voluntary code in place at the time of construction. However, it is clear that standard practice in Maine falls below current code levels in terms of insulation levels as well as required installation protocol.

1.1.2 Mechanical Systems

Approximately 80% of air conditioning and heat pump units met current code levels and 93% of service water heaters met the current efficiency levels. HVAC controls installed do not meet the same high levels of compliance as the equipment efficiency levels and range from 18% to 80%

depending on the control type. Our surveyors found that there was a high degree of compliance with the current requirements of delivery system insulation.

1.1.3 Lighting Systems

With no mandatory code in place, 66% of the buildings surveyed had lighting power densities (LPDs) at or below those allowed by the current code. This can be seen as a fairly positive result and is associated with two intersecting factors: energy code lighting power allowances (LPAs) and lighting technologies.

1.1.4 Lighting Controls

Ninety-six percent of the buildings surveyed met the basic requirement that a manual switch be installed in each enclosed area, and 93% had controls on the exterior lighting. Outside of those two measures, lighting control provisions were met in less than half of the buildings.

1.1.5 Code Compliance

1. **Overall** - Of the seventy-four buildings surveyed approximately 40% were constructed within 75% of the standards established by the current code. About 20% reached 50%-75% of code level, 20% fell within the 25%-50% range, and about 15% met less than 25% of energy code provisions. We were unable to make an accurate determination on 5% of the buildings.

   Of the buildings We were unable to make an accurate determination of 5% of the buildings.

2. **By Building Type** - Across most of the building types there is little variation as to the rate of compliance with current code provisions. There are, however, two exceptions: grocery stores and K-12 schools.

3. **By Region** - Compliance with envelope energy code provisions is the worst in Northern Maine. This is especially unfortunate as it is also the area with the most severe climate. This is somewhat offset by the fact that lighting and lighting controls were in compliance at a higher rate than other regions.

   It should be noted that with the state of the economy in Northern Maine over the past several years, there has been little commercial new construction and therefore our sample of buildings was very limited.

2. Sample Design – Site Surveys

The sample for this study was selected from a list of commercial buildings in Maine with construction start dates between 2006 and 2010. This 5-year time period was chosen to provide a large enough population of newly constructed commercial buildings from which a representative sample of new commercial buildings built before the adoption of the Maine Uniform Building and Energy Codes could be selected.

Commercial construction data for the years 2006 through 2010 was acquired from McGraw Hill's Dodge Database, a commercially available private sector data source that tracks commercial new construction. The Dodge database is constructed from detailed building permit and construction data. As buildings move from the permit phase through completion, the Dodge data is augmented by additional survey information to determine construction completion, building size, value, and other project details. McGraw Hill Dodge staff have built long-standing local relationships with owners and the AEC community to enhance and verify the accuracy of the Dodge data.

Consistent with the goals established for this study by the Efficiency Maine Trust, the ERS Team developed a statistically representative sample of small and medium commercial buildings built between 2006 and 2010 for the following commercial building types:

- Grocery store
- Office building
- Retail store
- Warehouse
- Hotel
- Bank/financial institution
- K-12 school
- Residence hall/dormitory

For the purposes of this study, small and medium commercial buildings were defined as follows:

- Small commercial buildings – less than 25,000 ft^2
- Medium commercial buildings – greater than 25,000 ft^2 but less than 65,000 ft^2

The ERS team contracted with McGraw Hill to extract from its Dodge Database all new small and medium commercial construction projects in Maine for the period 2006 - 2010 that met the above criteria. Commercial building additions and renovations were not included in our analysis. Sand and salt storage buildings were also excluded because they use very little energy. The resulting population of new construction projects from the Dodge database is shown in Table 2-1.

Table 2-1
Population – Number of Commercial New Construction Projects (2006-2010)

	Building Size		
Building Type	**Medium Commercial**	**Small Commercial**	**Total**
Bank/financial institution		47	47
Grocery store	7	2	9
Hotels and motel	8	3	11
K-12 school	11	13	24
Office building	4	63	67
Residence hall/dormitory	6	24	30
Restaurant	1	57	58
Retail store	7	82	89
Warehouse	5	41	46
Total	49	332	381

Source: Dodge Database (Excludes Salt/Sand Storage Buildings)

Based on the above population of commercial new construction starts, it was determined that a target sample size of fifty-seven would be required to meet a confidence level of 90% with a plus or minus 10% margin of error. Because the trust indicated in its RFP that it may also be interested in differences between geographic areas around the state, oversampling was conducted to assure the best possible geographic coverage within the budget constraints and timeframe identified by the Trust for this project. Table 2-2 below shows the mapping of counties in Maine to the five geographic regions that were identified by the ERS Team for this study.

Table 2-2
Mapping of Maine Counties to Study Regions

Study Region	County
East	Hancock
East	Penobscot
East	Waldo
East	Washington
Central	Androscoggin
Central	Kennebec
Central	Knox
Central	Lincoln
Central	Sagadahoc
North	Aroostook
South	Cumberland
South	York
West	Franklin
West	Oxford
West	Piscataquis
West	Somerset

Table 2-3 below shows the number of commercial new construction projects from 2006 to 2010 by building type and size for each of the Maine regions shown above.

Table 2-3
Population – Number of Commercial New Construction Projects (2006-2010) by Region & Building Type

		Building Size		
Region	Building Type	Medium Commercial	Small Commercial	Total
Central	Banks/financial institution		12	12
	Grocery store	3		3
	Hotels and motels	1		1
	K-12 school	5	7	12
	Office building	2	9	11
	Residence hall/dormitory	2	3	5
	Restaurant		13	13
	Retail store	1	21	22
	Warehouse	2	7	9
	Total Central Region	16	72	88
East	Banks/financial institution		7	7
	Grocery store		1	1
	Hotels and motels	2		2
	K-12 school	1	1	2
	Office building		3	3
	Residence hall/dormitory	1	2	3
	Restaurant		12	12
	Retail store	2	13	15
	Warehouse	1	11	12
	Total East Region	7	50	57
North	Banks/financial institution		1	1
	Hotels and motels	1		1
	Office building		1	1
	Restaurant		3	3
	Warehouse		1	1
	Total North Region	1	6	7
South	Banks/financial institution		24	24
	Grocery store	4	1	5
	Hotels and motels	3	3	6
	K-12 school	1	4	5
	Office building	2	46	48
	Residence hall/dormitory	2	16	18
	Restaurant	1	29	30
	Retail store	4	45	49
	Warehouse	2	19	21
	Total South Region	19	187	206
West	Banks/financial institution		3	3
	Hotels and motels	1		1
	K-12 school	4	1	5
	Office building		4	4
	Residence hall/dormitory	1	3	4
	Retail store		3	3
	Warehouse		3	3
	Total West Region	6	17	23
Total all regions		49	332	381

2.1 Site Selection

A sample of fifty-seven survey sites was initially selected from the population of 381 new commercial construction projects extracted from the Dodge Database. The following process was used to select the initial target sample and the additional oversampling that was necessary to assure a better representation of building types by region.

1. The population of 381 new commercial construction projects was sorted first by region, then by business type and building size (sq ft). Every nth record, starting from a random point, was then selected to be contacted, where is n is calculated by dividing the total population of 381by 57 (= 6.68). For example the random starting point between 0 and 6.88 (3.42) was rounded up to 4 and the fourth record in the population database was selected as a target site. The next step was to add 6.68 to 3.42 (= 10.1), which was rounded up to 11, and the eleventh record was selected as a target survey site. This process was repeated resulting in a sample of fifty-seven sites being selected. This simple systematic sampling technique is frequently used to select a specified number of records, in this case fifty-seven, from a known and finite population. The following table shows one section of the spreadsheet that contains all 381 new commercial construction projects to help illustrate the process:

Table 2-4
Spreadsheet Sample Section

Project Title	Project City	Region	Building Type	Square Feet (000s)	Building Size
cPort Credit Union	Augusta	Central	Banks/Financial Institution	2.5	Small Commercial
Kennebec Federal Savings Bank	Waterville	Central	Banks/Financial Institution	3.0	Small Commercial
Damariscotta Bank & Trust	Damariscotta	Central	Banks/Financial Institution	3.0	Small Commercial
KeyBank (Lewiston, ME)	Lewiston	Central	Banks/Financial Institution	3.3	Small Commercial
Mechanics Savings Bank (Lewiston ME)	Lewiston	Central	Banks/Financial Institution	3.3	Small Commercial
Androscoggin Bank	Jay	Central	Banks/Financial Institution	3.5	Small Commercial
Bank Branch	Auburn	Central	Banks/Financial Institution	3.5	Small Commercial
Capital Area Federal Credit Union	Augusta	Central	Banks/Financial Institution	3.6	Small Commercial
Bank/Parking Lot (Rockland, ME)	Rockland	Central	Banks/Financial Institution	3.7	Small Commercial
Merrill Bank NEGOTIATED	Waterville	Central	Banks/Financial Institution	3.8	Small Commercial
Downeast Credit Union	Topsham	Central	Banks/Financial Institution	4.2	Small Commercial

Record #4, KeyBank (Lewiston, ME) is the randomly selected starting point discussed above and record #11, Downeast Credit Union, is the next target sample site selected.

2. The ERS Team then visually inspected the resulting sample for geographic coverage and decided to oversample by adding twenty-three additional commercial new construction projects to the original sample of fifty-seven. Adding these twenty-three to the sample resulted in all regions having at least one targeted site survey for each building type and size category, if applicable. Table 2-5 shows the resulting final target sample by building type and Table 2-6 shows how the sample distribution compares with the distribution of the entire population of new commercial construction by building type. As can be seen in Table 2-6, the final target sample his highly representative of the distribution of the entire population of new commercial construction with any variations resulting from the judgmental oversampling that was conducted to improve geographic representation.

Table 2-5
Final Target by Building Type

Building Type	Total
Bank/financial institution	8
Grocery store	2
Hotel and motel	6
K-12 school	7
Office building	12
Residence hall/dormitory	9
Restaurant	10
Retail store	16
Warehouse	10
Grand total	80

Table 2-6
Comparison of Sample and Population Distributions by Building Type

Building Type	Sample	Population
Bank/financial institution	10.0%	12.3%
Grocery store	2.5%	2.4%
Hotel and motel	7.5%	2.9%
K-12 school	8.8%	6.3%
Office building	15.0%	17.6%
Residence hall/dormitory	11.3%	7.9%
Restaurant	12.5%	15.2%
Retail store	20.0%	23.4%
Warehouse	12.5%	12.1%
Total	100.0%	100.0%

2.2 Recruiting Process

Once the sample was selected, building owners and operators were contacted by phone to secure their permission to conduct an on-site survey of their building. The recruiting effort was undertaken by several ERS Team members, with each individual assigned a section of new commercial construction spreadsheet that is illustrated above in the "Site Selection" section. Each individual started by contacting the building owner or operator associated with the first highlighted record in their section, which was part of the original sample of fifty-seven. If that business was not interested in participating, the caller moved to the next business on the list until a participant was recruited or the next highlighted record was reached. At that point the process started again. Applying this segmented calling process to a population that has been sorted by region, business type, and building size allowed for a more accurate representation by building type and size within each region.

In addition, as previously discussed the ERS Team decided to oversample to improve the geographic representation of the sample. Adding twenty-three target sites to the original sample of fifty-seven assured that the final target sample would have at least one targeted site survey for each building type and size category, if applicable. These additional twenty-three commercial new construction projects were identified as "must gets" because in many cases there were no matching replacements. The ERS staff made every attempt to secure the permission of these additional target sample sites to participate in the survey. If they did not agree to participate, then a matching replacement (same region, building type and size) was contacted, if such a replacement existed.

2.3 Final Results

After completing the recruiting process the ERS Team was able to successfully recruit seventy-four on-site survey participants. Table 2-7 shows the number of on-site surveys completed by building type. Banks/financial Institutions, office buildings, retail stores, and warehouses represent 60.8% of the on-site survey participants, which compares favorably to 65.4% of all new commercial construction (2006-2010) for the same building types. Differences in other individual building categories such as grocery stores, which represented 2.4% of the all new commercial construction compared to 8.1% of completed on-site surveys, were ultimately driven by the willingness of building owners and operators to participate in the survey and the decision to oversample to better capture regional differences.

Table 2-7
Final Count of On-Site Survey Participants by Building Type

Building Type	Number of On-Site Survey Participants	Percent of Total Participants
Bank/financial institution	8	10.8%
Grocery store	6	8.1%
Hotel and motel	5	6.8%
K-12 school	6	8.1%
Office building	14	18.9%
Residence hall/dormitory	7	9.5%
Restaurant	5	6.8%
Retail store	12	16.2%
Warehouse	11	14.9%
Totals	74	100.0%

Table 2-8 shows how the distribution of completed on-site surveys by region compares with the overall population of new construction. As can be seen our oversampling did result in a reasonable representation of regional levels of new construction, but again it was affected by the willingness of building owners and operators to participate.

Table 2-8
Number of On-Site Survey Participants by Region

Region	Number of On-Site Survey Participants	Percent of Total On-Site Surveys	Percent of Population
South	32	43%	54%
East	16	22%	15%
Central	15	20%	23%
West	7	9%	6%
North	4	5%	2%
Total	74	100%	100%

Table 2-9 shows the breakdown of on-site surveys by building size. The large percentage (72%) of on-site surveys that were conducted in small commercial buildings (less than 25,000 ft^2) is representative of the dominance of small commercial buildings in Maine.

Table 2-9
Number of On-Site Survey Participants by Building Size

Building Size	Number of On-Site Survey Participants
Small commercial	53
Medium commercial	21
Total	74

3. Data Entry and Quality Control

In an effort to provide consistent data collection procedures and ensure high levels of data accuracy training was conducted with all staff associated with the study. All documentation and survey forms were reviewed and questions were answered regarding possible obstacles to obtaining accurate information while on-site. To insure that procedures were followed, site survey personnel were required to submit completed data collection sheets within 48 hours of completing the site survey. This allowed project management staff to review forms for completeness and consistency.

Upon completion of the on-site survey all documents were reviewed for accuracy and understanding. Once it was determined that the survey was accurate and complete the data was entered into a custom designed database with oversight provided by the project management staff to ensure consistency of data input and ultimately analysis.

Once all seventy-four surveys were entered into the database the resulting information was again reviewed for accuracy and consistency.

4. Standard Practice and IECC Review

This section presents the results of our comprehensive baseline survey and a comparison between current standard practice for commercial new construction and the provisions of the 2009 IECC which became, by reference, the energy code for the construction of commercial buildings as of June 1, 2010 (an extension from the original January 1, 2010 deadline). In addition to comparisons involving overall construction practices, we have analyzed the collected data and are able to reach conclusions regarding various building types and also geographical differences across the state.

The commercial buildings that were assessed for this study were not constructed under a statewide mandatory energy code or building code. Instead, Maine has had in place a voluntary "model code" that designers and contractors are encouraged to follow and local jurisdictions may adopt. As a result, this study provides valuable information as to the veracity of voluntary codes and the performance of buildings constructed with such codes in place.

4.1 Overview of Maine Commercial & Energy Code

In March 2004 Maine adopted the Maine Model Building Code (MMBC) for both residential and commercial construction. The debate over adopting the MMBC dates as far back as 1979 when the State Office of Energy Resources developed a model energy code and promoted statewide codes as an energy conservation measure. In 1980 the legislature adopted the provisions as a voluntary code. With the 2004 MMBC, municipalities could adopt the updated model code, amending it with stricter provisions if they chose, or they could continue to allow construction with only the mandated life safety codes in place at the time. Although approximately forty municipalities have adopted the voluntary model code, this study and others suggest that energy code provisions are not consistently followed regardless of model code adoption, as knowledge of the code is not widespread and limited resources are focused on life-safety code provisions.

During the legislative session of 2008, provisions were passed to adopt a mandatory statewide building code, which would include the energy provisions of the 2009 International Energy Conservation Code. Adoption of this code brings Maine into compliance with the provisions of ARRA funding for energy efficiency projects and also aligns Maine with the other Northeast states. As this study was being completed, a bill passed the legislature (and currently awaits the Governor's signature) that would exempt municipalities with populations of less than 4,000 residents from mandatory compliance with the code, allowing them to continue with voluntary code compliance.

4.1.1 Study Methodology

Determining new construction practices for completed buildings is not a trivial task. Many elements such as construction materials, equipment, and practices are no longer discernable once the building is completed. Although construction documents (plans and specifications) are often available for review, they may not represent the final "as-built" specifications, and it's not always certain that contractors followed all details as specified.

Because of these uncertainties, this study followed a methodical and comprehensive approach to collecting and verifying as much data as possible in regard to actual design and construction practices. The steps followed are summarized as follows:

- ❑ Contact both building owners and the design team to seek cooperation.
- ❑ Communicate a desire to obtain valuable information regarding the state of commercial construction practices in Maine in order to target future Efficiency Maine efforts.
  - ➢ "Code compliance" was not communicated as a goal, as the Maine code was not mandatory when these buildings were constructed.
- ❑ Offer to provide information about Efficiency Maine programs at the time of the study site visit. This assists in obtaining excellent building owner cooperation rates.
- ❑ Request that all design documents be made available at the time of the study site visit.
- ❑ Schedule the site visit and request that 2-4 hours be made available depending upon the size of the project.
- ❑ Visit the site to perform the following:
  - ➢ Conduct interviews with owner and design team member(s).
  - ➢ Review plan documents and record data on survey forms.
  - ➢ Tour the building and record actual construction practices and any deviations from the plans/specifications.
  - ➢ Note any measures that cannot be field verified and discuss with owner/designer recording results.
- ❑ Review the data collection form and upload it.
- ❑ Enter all data in a custom database.
- ❑ Review each building for design and construction practices in relation to IECC 2009.
- ❑ Rate/score compliance relative to IECC 2009 for each of the following areas:
  - ➢ Building envelope
  - ➢ Mechanical systems
  - ➢ Lighting systems
  - ➢ Lighting controls
  - ➢ Overall performance in relation to code

- ❑ Utilizing billing data, assign an Energy Use Intensity (EUI) to each building.
- ❑ Analyze the data for the following:
  - ➢ Relationship of actual building performance to code compliance in terms of the EUI
  - ➢ Construction practices across building types
  - ➢ Construction practices across geographic regions
  - ➢ Individual measures or groups of measures that were recorded to have high or low rates of compliance
  - ➢ Trends regarding standard practice from 2006-2010
  - ➢ Relationship of standard practice to IECC 2009 across measure categories

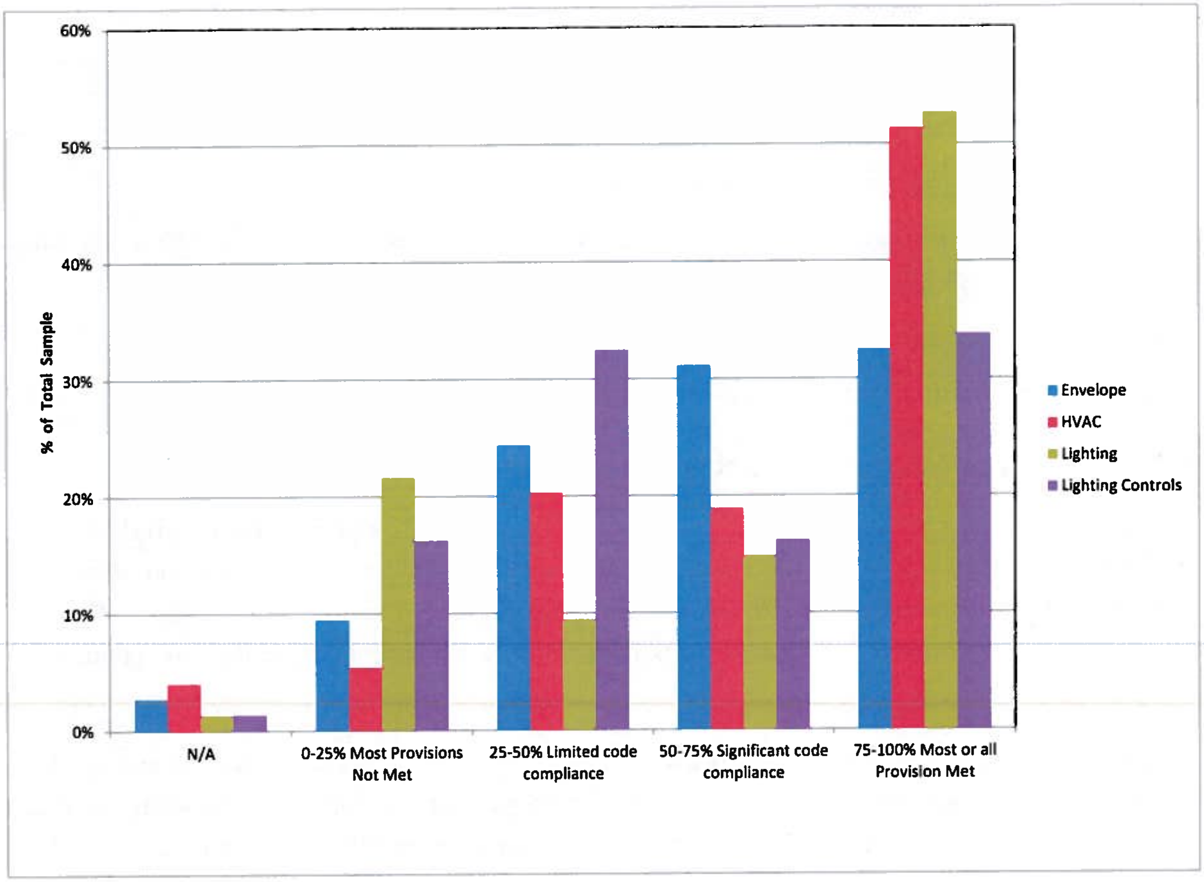
4.2 Summary of Standard Practice in Relation to IECC 2009

With no mandatory state-wide building code in place during the time period that the studied buildings were constructed, Efficiency Maine Trust is very eager to learn how actual commercial construction practices across the state relate to the energy efficiency provisions of IECC 2009 that were adopted as a portion of the state-wide building code that went into effect this past January.

The conclusion reached by this study is that standard construction practice is highly variable in Maine and is, on average, considerably below current energy code levels adopted by the state. This is not to say that the quality of construction is low. Although it was not a focus of the study, we found construction quality to be high. However, as the following sections will detail, many measures that the code addresses need to be substantially improved to bring Maine's recent standard practices up to code-compliant levels.

Of the buildings surveyed approximately 40% were constructed within 75% of the standards established by the current code. About 20% reached 50%-75% of code level, 20% fell within the 25%-50% range, and about 15% met less than 25% of energy code provisions. We were unable to make an accurate determination of 5% of the buildings. See Figure 4-1 for a plot of overall compliance.

Figure 4-1
Overall Compliance



4.3 Building Envelope Practices

The building envelope practices covered by the energy code fall into four categories:

1. Air sealing
2. Above grade opaque assembly insulation levels and techniques
3. Below grade insulation levels and techniques
4. Fenestration performance

Maine's climate and predominant reliance on fuel oil as a heating source make building envelope performance a critical aspect in energy usage and operating expense. Table 4-1 shows that approximately 30% of the buildings surveyed complied with 75% or more of current envelope provisions.

Table 4-1
Building Envelope Compliance

	Bank/ Financial Institute	Grocery Store	Hotel	K-12 School	Office Building	Residential Hall/ Dormitory	Restaurant	Retail Store	Warehouse	Grand Total
0								1	1	2
0-25% Most Provisions Not Met					1		1	2	3	7
25-50% Limited code compliance	2		2	1	5		1	5	2	18
50-75% Significant code compliance	3	3	3	1	5	1	3	3	1	23
75-100% Most or all Provision Met	2	1		6	6	5	1	1	2	24
Grand Total	7	4	5	8	17	6	6	12	9	74

4.3.1 Procedure

Envelope compliance represents greater challenges than the other categories in determining installed practice after construction has been completed. In states with mandatory building codes, the building envelope is inspected during construction in order to observe installed materials and procedures for compliance. This study did not allow that option, so the following procedure was applied:

- Review plans and specifications for envelope provisions, methodically following the survey forms.
- Tour the building verifying that envelope details were in accordance with plans.
  - Measure wall thicknesses and remove electrical box covers.
  - Investigate attic/plenum spaces.
  - Check interior and exterior of foundation surfaces for insulation.
  - Record model numbers and/or NFC #s of windows and doors.
  - Check penetrations for sealing.
- Interview the building owner regarding details that could not be field verified.
- Make a final judgment based on all of the above.

4.3.2 Insulation Levels

Where we were able to accurately determine insulation levels, we found that approximately 40% of the buildings surveyed were constructed with insulation levels that do not meet current code levels. Many insulation levels were made more stringent with the 2009 IECC so a number of those buildings would have met the Maine voluntary code in place at the time of construction. However, it is clear that standard practice in Maine falls below current code levels in terms of insulation levels.

Particular areas of concern include:

- Continuous insulation not installed in addition to cavity insulation in metal-frame construction (critical for thermal break)
- Continuous insulation not installed in addition to cavity insulation in wood-frame construction

- ❑ No below-grade insulation installed
- ❑ Slab edge insulation not protected against UV and physical damage

4.3.3 Air Sealing

Although it was impossible to determine if proper air sealing procedures associated with doors and windows were performed, it was possible to observe other penetrations such as vents, pipes, and electrical entrances. In almost all cases, we found that envelope penetrations had been properly sealed.

4.3.4 Fenestration Performance

It was particularly difficult to ascertain whether or not the windows installed met current code levels for both air leakage and thermal performance. It is now mandated that windows and doors have permanent NFC codes imprinted on the product. However this was not a mandate when these buildings were constructed, and temporary paper labels had been removed following building completion. Where possible, we recorded window and door model numbers and consulted manufacturer catalogue data to determine performance.

In most cases doors installed meet current code values. Approximately 50% of the windows installed meet code thermal performance (U-factor). There is not enough data to determine either infiltration or solar heat gain coefficient (SHGC). It can be argued that SHGC is inconsequential in Maine's heating dominant climate zone.

4.3.5 Opportunities for Training

Clearly the Maine construction industry would benefit from outreach and training regarding building envelope measures. Solid building science has formed the basis of the current code provisions regarding envelope performance, and proper techniques not only ensure good energy performance, but also building longevity. Opportunities include:

- ❑ Building science training on how air, moisture, and heat travel through buildings, materials, and assemblies. As codes mandate higher levels of insulation and air sealing, it is critical that designers and builders have a background in basic building science.
- ❑ Informational outreach and training on the NFC rating system. It is equally important that this training be delivered to distributors of windows and doors as well as to design professionals and contractors.
- ❑ Training on the use of current insulating materials, especially as they are utilized for below-grade insulation and for continuous insulation to provide thermal breaks.

4.4 Building Mechanical System Practices

Building mechanical systems covered by the energy code include heating, ventilation, and air conditioning systems (HVAC). Other mechanical systems such as commercial refrigeration or motor-driven process systems are not covered by the energy code, but in some cases are included in federal standards. Table 4-2 shows the breakdown of code compliance by building type. Key elements covered by the code include:

- ❑ Sizing of HVAC systems
- ❑ Equipment efficiency levels
- ❑ Controls for simple and complex systems
- ❑ Demand and variable control of ventilation
- ❑ Heat/energy recovery
- ❑ Insulation and sealing of distribution systems

Table 4-2
HVAC Compliance

	Bank/ Financial Institute	Grocery Store	Hotel	K-12 School	Office Building	Residential Hall/ Dormitory	Restaurant	Retail Store	Warehouse	Grand Total
0					1			1	1	3
0-25% Most Provisions Not Met		1			2				1	4
25-50% Limited code compliance			3		2	1	2	5	2	15
50-75% Significant code compliance	2		1		3	1	2	2	3	14
75-100% Most or all Provision Met	5	3	1	8	9	4	2	4	2	38
Grand Total	7	4	5	8	17	6	6	12	9	74

4.4.1 Procedure

Because much of mechanical systems remain visible following the completion of construction, it is much easier to gauge efficiency levels and the state of standard practice in relation to current code levels. As with envelope measures we started with a review of the plans and specifications in order to record equipment model numbers and efficiency levels, identify controls, and look for specifications/documentation for ventilations rates, system sizing, distribution insulation, etc. This was followed by a physical inspection of the systems, verifying that they were installed according to plan and noting any discrepancies. An interview with the owner and/or design team provided any discrepancies or items that could not be otherwise determined.

The results of the site visit were uploaded to the database, and all measures were evaluated in comparison with current code provisions.

4.4.2 HVAC System Sizing

The code stipulates that HVAC systems must be sized according to ASHRAE accepted practice and cannot be oversized. Because most system sizing is done with the assistance of computer software, it was beyond the scope of this study to review sizing procedures. However, given the range of system sizes in comparison to building types/sizes it is fair to say that a fair percentage of systems are sized by "rules of thumb" and are then somewhat oversized to compensate for any unforeseen circumstances and to avoid callbacks due to inadequate heating or cooling. This is also common outside of Maine, especially with smaller commercial buildings that are rarely modeled.

4.4.3 System Efficiency Levels

Model numbers and efficiency levels were recorded for all relevant mechanical systems. Efficiency levels were at or above current code levels for most mechanical equipment. In fact, nearly all boilers and furnaces met the current efficiency levels. Approximately 80% of air conditioning and heat pump units met current code levels, and 93% of service water heaters met the current efficiency levels.

The high levels of compliance with current code efficiency levels can be attributed to several factors:

- The Efficiency Maine Business Program successfully promotes high efficiency equipment.
- Manufacturers supply equipment nationwide and are compelled to meet national model codes.
- Distributors that stock equipment for the region and New York, Massachusetts, and Connecticut have enforced energy codes for over a decade.
- Mechanical system designers and market actors promote efficient equipment especially for space heating.
- Mechanical system manufactures have lobbied hard to keep ASHRAE standard-based codes at efficiency levels that all manufacturers are able to meet with standard equipment lines. In many equipment categories, equipment significantly more efficient than code levels dictate is readily available.

4.4.4 HVAC Controls and Heat/Energy Recovery

HVAC controls installed do not meet the same high levels of compliance as equipment efficiency levels and range from 18% to 80% depending on the control type (see Table 4-3).

Table 4-3
HVAC Compliance Rates

Control	Compliance Rate*
Programmable electronic thermostats	80%
Heat pump electric heat lockout	60%
Air side economizing	57%
Simultaneous heating and cooling lockout	76%
Balancing valves/terminals	75%
VFD fan motor control	38%
Pumping system temperature reset	50%
VFD control of heat rejection fans	38%
Heat/energy recovery for outside air supply	73%
Condenser heat recovery for service DHW	18%

* Note that the requirements listed vary based on building/system size and usage. The compliance percentage applies only to those applications.

4.4.5 Duct and Delivery Piping Insulation and Sealing

Our surveyors found that there was a high degree of compliance with the current requirements of delivery system insulation. Proper duct sealing was performed in over 90% of the buildings. Likewise, 88% of ducts, 79% of circulation piping, and 72% of service hot water piping was insulated.

4.4.6 Opportunities for Training Regarding Mechanical System Performance

A clear opportunity for training exists in two areas related to mechanical systems:

1. **System Sizing/Design** – It is understandable that oversized HVAC systems are selected when there is any doubt as to what size system is needed to handle a particular building. Learning the tools, techniques, and resources involved in properly sizing systems would reap significant benefits.

2. **System Controls** – There is a stark contrast between the practice of selecting high efficiency equipment and installing proper controls to make the most of that equipment. Controls training and outreach would result in large savings through improved control systems.

4.5 Lighting Systems

For the analysis and reporting of our findings, we have decided to divide lighting and lighting controls into two distinct categories. This section will cover lighting systems only, and the next section will cover controls. We have done this because there is a large difference between compliance rates and because the code takes two different approaches to these provisions.

Lighting system provisions are not technology based. For the most part, one can comply with the code by incorporating any lighting technology available in today's marketplace. Instead, lighting provisions are performance based. Lighting power density (LPD) is the predominant factor in determining lighting system compliance. LPD is simply the amount of power, in watts, dedicated to space lighting, per square feet of building area. The maximum LPD allowed by code is termed the lighting power allowance (LPA). In most cases, the code is blind to lamp and ballast technologies.

In general we found lighting power density levels to be at or better than code levels in more than half of the buildings, or 66% (see Table 4-4).

Table 4-4
Lighting Compliance

	Bank/ Financial Institute	Grocery Store	Hotel	K-12 School	Office Building	Residential Hall/ Dormitory	Restaurant	Retail Store	Warehouse	Grand Total
0					1					1
0-25% Most Provisions Not Met	2			1	5		2	3	3	16
25-50% Limited code compliance	1		1		2			2	1	7
50-75% Significant code compliance	2	1	2		1		4	1		11
75-100% Most or all Provision Met	2	3	2	7	8	6		6	5	39
Grand Total	7	4	5	8	17	6	6	12	9	74

4.5.1 Procedure

LPD is often calculated incorrectly. This is the result of a misunderstanding regarding the difference between nominal wattage and rated wattage, as light fixtures typically consume less or more than the nominal wattage of their lamps indicates. In addition, lamp and ballast wattage are often mistakenly added together, when the true wattage is the rated wattage of the ballast with the installed lamp configuration.

For this reason, we did not base our LPD calculations on the fixture wattages listed on the project plans. Instead we adhered to the following procedure:

- ❑ Identify at least two areas - or include the entire building - for LPD calculations.
- ❑ Record the space types.
- ❑ Identify the rated wattage of the fixtures based on installed lamps/ballasts.
- ❑ Record the square footage of the spaces and the installed wattage.
- ❑ Upload to a database.
- ❑ Calculate LPD and compare with code LPA for the appropriate space type.

4.5.2 Lighting System Performance

With no mandatory code in place, 66% of the buildings surveyed had LPDs at or lower than those allowed by the current code. This can be seen as a fairly positive result and is associated with two intersecting factors: energy code LPAs and lighting technologies.

- **Energy Code LPAs** – The LPAs allow lighting designers to meet recommended lighting levels by utilizing modern efficient lighting technologies in standard practice layouts for the space type. Therefore, in most commercial spaces, if efficient fixtures with T8 lamps and electronic ballasts are installed in standard spacing patterns, code LPDs are met. If those fixtures are less efficient, thereby requiring more lamps (four-lamp fixtures instead of three-lamp fixtures for example), code level LPDs would not be met.
- **Lighting Technologies** - The lighting programs of the Efficiency Maine Business Programs have been aggressive over the past several years. Efficiency Maine was the first program in the Northeast to eliminate incentives for standard T8 systems, promoting only the higher efficiency (HPT8) lamp and ballast systems. This helped to transform stocking practices amongst the lighting distributors in the state, providing a significant spillover (free ridership) effect.

4.5.3 Lighting Opportunities

Lighting technology is advancing faster than any other area that is touched by energy codes. Fluorescent systems keep advancing with high efficacy (lumens per watt) T8 and T5 systems being introduced nearly every year. In addition, solid state lighting such as LED lighting is advancing at an alarming rate, prices are coming down, quality is improving, and the variety of fixture styles and applications is growing. For the foreseeable future there are opportunities to encourage market actors, designers, and building owners to adopt advancing strategies to lower LPDs in commercial buildings.

4.6 Lighting Controls

Unfortunately, there is no free ridership to be had with lighting controls, as there is no functional need to have any more lighting control than the ability to turn the lights on and off. The code handles lighting controls in the following ways:

- Individual enclosed areas must have at least a manual on/off switch.
- Any areas that are required to have a manual on/off switch must also have bi-level switching, occupancy sensing, daylight dimming, or timer control of the lighting.
- Most outdoor lighting must be controlled by either a timer system or photo-sensing daylight dusk/dawn control.
- Buildings over 5,000 ft^2 in area must have an automatic control to turn off all non-emergency lighting after normal business hours.
- A new provision of the code calls for separate control of day lit zones.

Table 4-5 shows the levels of lighting controls compliance by building type.

Table 4-5
Lighting Controls Compliance

	Bank/ Financial Institute	Grocery Store	Hotel	K-12 School	Office Building	Residential Hall/ Dormitory	Restaurant	Retail Store	Warehouse	Grand Total
0									1	1
0-25% Most Provisions Not Met	1	1	1	1	1	1	1	2	3	12
25-50% Limited code compliance	4		1	1	5	2	3	6	2	24
50-75% Significant code compliance		1	2	2	4		1	1	1	12
75-100% Most or all Provision Met	2	2	1	4	7	3	1	3	2	25
Grand Total	7	4	5	8	17	6	6	12	9	74

4.6.1 Procedure

From the lighting schedule, or electrical control schedule, we recorded the controls that were intended for installation. During the tour of the building, we noted the controls that were actually installed. If discrepancies were found, we interviewed the owner to determine if changes had been made after construction was completed.

4.6.2 Lighting Controls Performance

Ninety-six percent of the buildings surveyed met the basic requirement that a manual switch be installed in each enclosed area, and 93% had controls on the exterior lighting. Outside of those two measures, lighting control provisions were met in less than half of the buildings:

- Thirty-seven percent of buildings over 5,000 ft^2 had automatic control of lighting systems.
- Twenty-two percent had bi-level switching in enclosed offices.
- No buildings had separated control of day-lit zones.
- Nine percent of the buildings incorporated daylight dimming in some areas.
- Forty-one percent of the buildings had occupancy sensing controls in some areas.
- Thirty-four percent of the buildings had timers installed in some areas (this provision was found in many of the same buildings as occupancy sensing, but incorporated in different areas).

4.6.3 Lighting Controls Opportunities

It is clear that there is a major opportunity for lighting control upgrades in new construction. Unfortunately lighting controls are often the first item eliminated when trimming the budget for new construction. With less than half the newly constructed buildings incorporating automatic lighting controls, the new-construction community would benefit from training and technical assistance in this area.

With the IECC 2009 code, individual control of day-lit areas is included for the first time. This coincides with improved window performance and a desire to bring more natural light into workspaces. Daylighting is a major training opportunity.

Commissioning of lighting controls will be an area of great concern as controls become more widespread. In other areas of the Northeast where codes have required automatic controls, a lack of proper commissioning has led to disappointing savings and many cases of disabled or removed controls. Assistance for market actors to assure properly adjusted controls will be critical.

4.7 Other Code Provisions

In addition to the technology-related provisions, IECC 2009 includes some provisions that cover design document procedures, communication with owners, and simple system commissioning.

4.7.1 Design Document Provisions

Design documents must be provided to owners and code officials that provide enough detail to determine if code provisions are being met. Although we found that design documents had been provided to owners in 80% of cases, approximately 50% of the time such documents did not have enough detail to determine code compliance. Basic energy code courses, if and when funding is available, should stress the importance of documenting code provisions.

4.7.2 Communication with Building Owners

The code requires that design teams communicate system operation details and provide simple training and owner manuals for major building systems. It is very difficult to determine compliance with these provisions, but in most cases owners received operations manuals but did not receive training in the operation of systems.

4.7.3 Simple Commissioning

This is a new provision incorporated in the IECC 2009. It requires simple operational testing of systems and intersects with the above provision for communication with the owners. Future versions of the code are likely to include more extensive commissioning of systems. Determining the state of commissioning was not possible for this study, but surveyors often heard that call backs were needed to correct operational difficulties. Commissioning of systems is a focus of the Efficiency Maine CNC program, and as more funding becomes available efforts in this area should be increased.

4.8 Regional Baseline/Code Consideration

Compliance with code provisions is fairly constant across the State's regions with the exception of the Northern Region.

4.8.1 Northern Maine

Compliance with envelope energy code provisions is the worst in Northern Maine, which is especially unfortunate as it is the area with the most severe climate. However, this is somewhat offset by the fact that lighting and lighting controls had a higher compliance rate that other regions.

It should be noted that with the state of the economy in Northern Maine over the past several years, there has been little commercial new construction and therefore our sample of buildings was very limited.

- **Envelope** – Of the buildings surveyed, 75% were found to comply with current envelope provisions in the range of 25%-50% compliance. We could not determine the compliance of the other 25% of the buildings, as there was not have enough information on the plans and site verification was not possible.
- **Mechanical** – There is only a small variation amongst regions when it comes to the mechanical provision. This can be attributed to the fact that equipment stocking decisions are made on a regional basis.
- **Lighting** – Although the sample is limited to four buildings, three of them met, or nearly met, the provisions for LPD.
- **Lighting Controls** – Half of the buildings surveyed met most of the lighting control provisions. Though this was much better than the rest of the state, the sample was small.

The following figures show regional code compliance plots for building envelope, HVAC, lighting, and lighting controls.

Figure 4-2
Envelope Compliance by Region

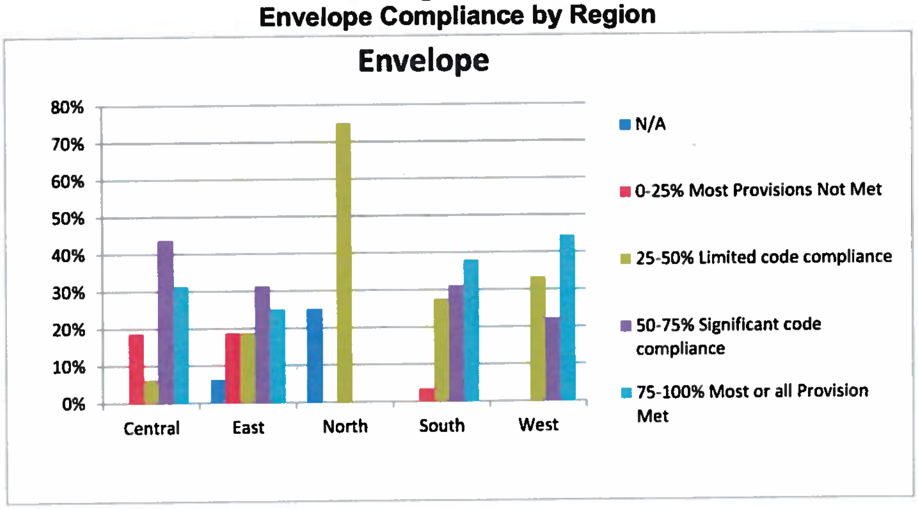


Figure 4-3
HVAC Compliance by Region

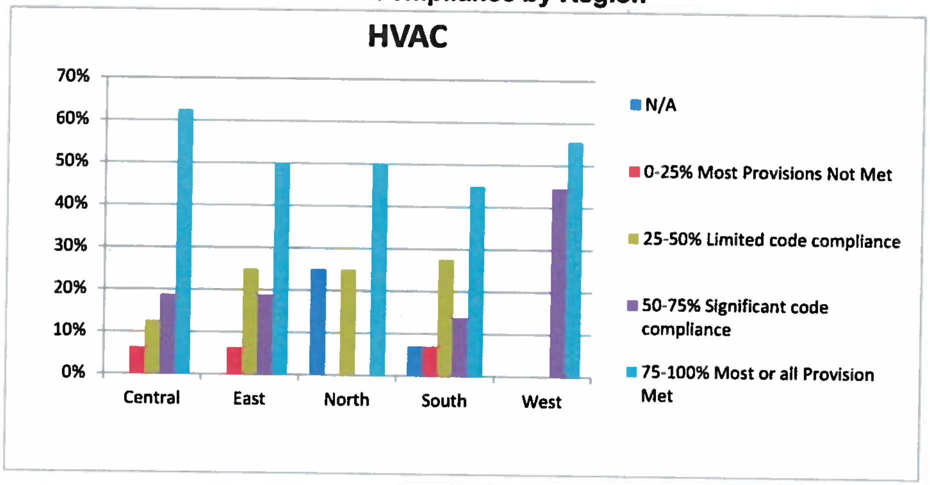


Figure 4-4
Lighting Compliance by Region

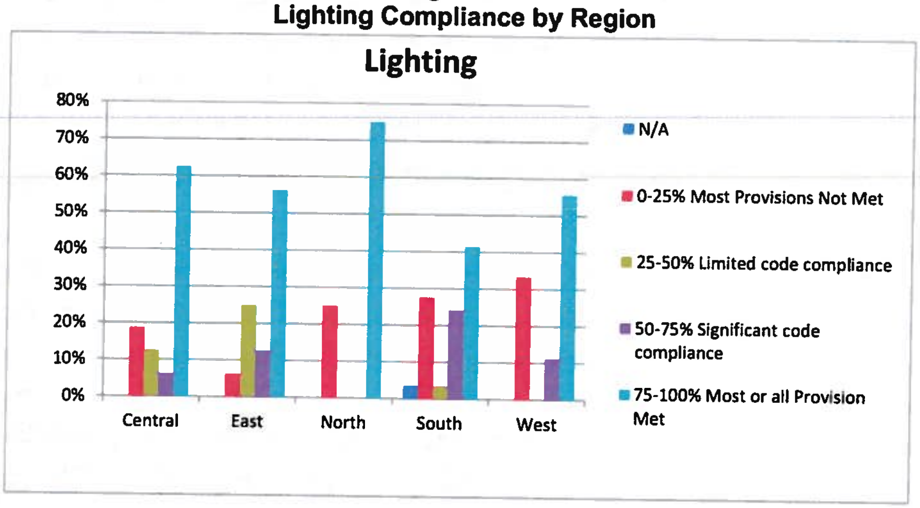
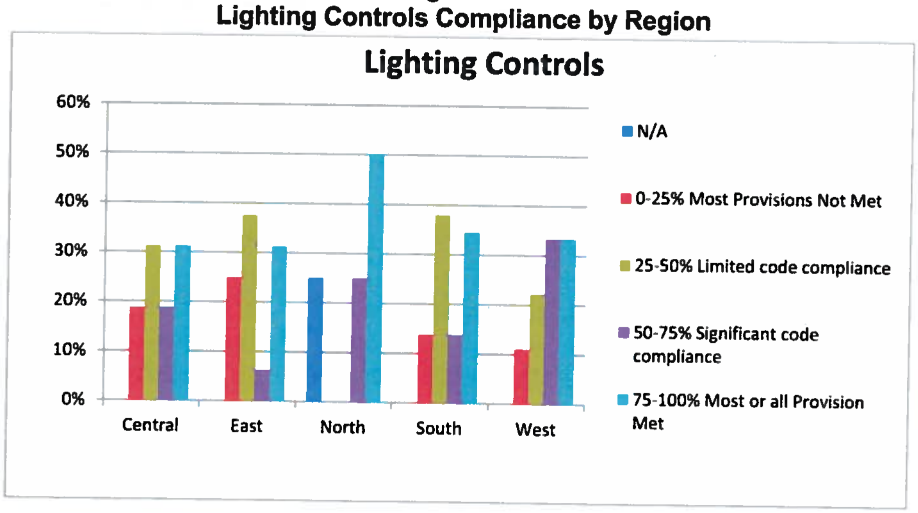


Figure 4-5
Lighting Controls Compliance by Region



4.9 Baseline/Code Provisions by Building Type

Across most of the building types there is little variation in the rate of compliance with current code provisions. There are, however, two exceptions: grocery stores and K-12 schools.

4.9.1 Grocery Stores

Grocery stores had higher compliance rates than all other categories except schools, with three of the four stores surveyed demonstrating compliance with most code provisions. Discussions with owners and designers revealed that this is largely because the regional grocery chains have made a concerted effort to build efficient stores, and the chain's regions included several states that have mandatory codes.

4.9.2 K-12 Schools

Likewise the schools surveyed demonstrated higher rates of compliance, with seven of the eight complying with most energy code provisions except the automatic lighting control provisions. This could only be attributed to the fact that Maine has maintained an aggressive High Performance Schools Construction Program for years that has been operated by the Department of Education with assistance from Efficiency Maine. This school program has been aligned with the new construction practices promoted by the "reach code" program Core Performance and its predecessor Benchmark, both of which are programs developed by New Buildings Institute and adopted/sponsored by Efficiency Maine.

The International Energy Conservation Code 2003 addresses the design of energy efficient building envelopes and the installation of energy efficient mechanical, lighting, and power systems. The code dictates certain material and equipment performance characteristics that impact building operation and energy consumption. This comprehensive code establishes minimum regulations for energy efficient buildings using prescriptive and performance-related provisions. The principles used in the development of this code were intended to establish an energy conservation code that adequately conserves energy, without unnecessarily increasing construction costs, restricting the use of new materials, products, or methods of construction, or giving preferential treatment to particular types of materials, products, or methods of construction.

The International Energy Conservation Code is kept up to date through the review of proposed changes submitted by code enforcement officials, industry representatives, design professionals, and other interested parties. Proposed changes are carefully considered through an open code development process in which all interested and affected parties may participate.

4.10 Energy Use Intensity (EUI) Comparison

As part of the building data collection for the development of the Efficiency Maine Trust Commercial Baseline Study the onsite data collection staff was asked to collect full utility data from each location. Of the seventy-four buildings in the study thirty-nine participants provided adequate utility data to develop complete EUIs for each building type. An additional ten participants provided electric data only, so we developed electricity EUIs for forty-nine buildings.

The challenge of collecting utility data from the study participant as opposed to directly from the utilities is evident by the percentage of full and partial data the surveyors were able to collect. In some cases where partial data was provided the analyst was able to extrapolate the data to fill any voids in the data set.

The EUIs developed from this study were compared to the data found in the 2003 Commercial Buildings Energy Consumption Survey (CBECS). The CBECS is a national sample survey that collects information on the stock of U.S. commercial buildings, their energy-related building characteristics, and their energy consumption and expenditures. Commercial buildings include all buildings in which at least half of the floor space is used for a purpose that is not residential, industrial, or agricultural, so they include building types that might not traditionally be considered "commercial," such as schools, correctional institutions, and buildings used for religious worship. The CBECS was first conducted in 1979; the eighth, and most recent survey, was conducted in 2003. CBECS is currently conducted on a quadrennial basis. The CBECS is a member of a suite of surveys (along with the Residential Energy Consumption Survey, or RECS, and the Manufacturing Energy Consumption Survey, or MECS) conducted by the Energy Consumption Division within the Energy Information Administration (EIA) to measure energy consumption in the United States.1

4.10.1 EUI Definition and Comparison

Energy use index (EUI) is a unit of measurement that describes a building's energy use. EUI represents the energy consumed by a building relative to its size. A building's EUI is calculated by taking the total energy consumed in one year (measured in kBtu) and dividing it by the total floor space of the building. For example, if a 50,000 ft2 school consumed 7,500,000 kBtu of energy last year, its EUI would be 150. A similarly sized school that consumed 9,000,000 kBtu of energy last year would have a higher EUI (180) to reflect its higher energy use. Generally, a low EUI indicates good energy performance. Certain building types will always use more energy than others. For example, an elementary school uses relatively little energy compared to a hospital. Similarly, a small office building that supports eighty workers will use less energy than a skyscraper that supports thousands.

4.10.2 Building Types

Buildings that were selected for the baseline study were grouped into common uses and identified by the Trust in order to compare their characteristics and EUI on a consistent basis. With the identification of nine separate business types, anomalies within each type can skew the results and affect the comparison to the CBECS data. The nine business types are:

1. Bank/Financial Institute

1 U.S. Energy Information Administration, via website: http://www.eia.gov/emeu/cbecs/

2. Grocery Store
3. Hotel and Motel
4. K-12 School
5. Office Building
6. Residential Hall/ Dormitory
7. Restaurant
8. Retail Store
9. Warehouse

Table 4-6 shows the distribution of buildings included in the 2011 Commercial Baseline Study and those with adequate utility data to develop complete EUIs. The difficulty in securing utility data from the participants verses the utilities is evident by the small EUI sample size for some of the categories.

Table 4-6
Distribution of Buildings

Building Type	Buildings Included in the 2011 Baseline Study	Buildings Included in the 2011 EUI Study
Bank/financial institution	8	3
Grocery store	6	6
Hotel and motel	5	4
K-12 school	6	5
Office building	14	7
Residence hall/dormitory	7	4
Restaurant	5	2
Retail store	12	4
Warehouse	11	3
Total	74	38

4.10.3 Summary

The EUI summaries in Tables 4-7 and 4-8 were based on the information collected during the 2011 baseline study. As detailed in the tables, the EUI varies dramatically depending on the building type. In some cases variations are easily explained based on the use of the building. Restaurant and grocery store EUIs are historically higher because of their refrigeration and cooking loads verses office buildings and retail stores with a majority of their loads being lighting and heating.

One caveat to consider is the EUI data is a snapshot of the buildings performance based one full year of data. In some cases there was an adequate amount of incomplete data from which we were able to extrapolate to fill the voids. Also, it is important to understand the data in some instances is the first full year of building occupancy, which can change over time. The the data derived from the EUI study provides a benchmark for the buildings that were built between 2006 and 2010.

Table 4-7
Baseline Study EUI Summaries

Building Type	Average	CBECS* Standards	Percent Relationship to the CBECS Standards	Number of Buildings
Bank/financial institution	85.7	100.8	55%	3
Grocery store	214.5	199.7	107%	6
Hotel and motel	64.2	126.7	51%	4
K-12 school	46.2	87.7	53%	5
Office building	82.2	120.1	68%	7
Residence hall/dormitory	64.3	126.7	51%	4
Restaurant	714.3	276.6	258%	2
Retail store	72.7	108.4	67%	4
Warehouse	30.2	30.2	100%	3
Total				38

* Commercial Building Energy Consumption Survey 2003: New England, Northeast, National - in that order when available.

Table 4-8
Baseline Study Electric EUI Summaries

Building Type	Average	CBECS* Standards	Percent Relationship to the CBECS Standards	Number of Buildings
Bank/financial institution	16.3	6.9	236%	5
Grocery store	40.3	49.4	82%	6
Hotel and motel	9.6	13.5	71%	4
K-12 school	4.3	11	39%	6
Office building	7.4	17.3	43%	8
Residence hall/dormitory	8.4	13.5	62%	4
Restaurant	143.4	38.4	373%	2
Retail store	10.1	14.3	71%	6
Warehouse	5.6	7.6	74%	6
Total				48

* Commercial Building Energy Consumption Survey 2003: New England, Northeast, National - in that order when available.

4.10.4 Findings

Tables 4-7 and 4-8 indicate a majority of the building types in the baseline study are at, just above, or below the standards listed in the CBECS 2003 data. The exception is the restaurant sector, which will be addressed.

It is evident that energy programs in Maine targeting electrical equipment have had an impact on the electrical EUIs listed in Table 4-8. Efficiency Maine, a state-wide electrical energy efficiency program, was introduced in April 2003. The program provides incentives to businesses that install energy efficient electrical equipment. A majority of the incentives provided by Efficiency Maine are for lighting improvements. Though this baseline study is only addressing new construction, Table 4-9 provides a statistical snapshot of the incentives provided to retrofit and new construction projects for each sector tracked by Efficiency Maine.

Table 4-9
Summary of Processed Incentives by Facility Type 2003-2011[2]

Program Type	# of Participants	# of Projects	Total Incentive Paid	% of Total Incentives Paid	kWh Savings	% of Total kWh Savings	kW Savings	Participant Costs
Agriculture	178	313	$411,263.22	2%	6,896,409.03	3%	1,772.09	$1,039,730.09
College	25	148	$634,994.02	2%	5,267,311.69	3%	1,201.14	$1,613,919.30
Convenience stores	111	178	$200,848.42	1%	1,347,451.23	1%	217.35	$528,008.58
Elementary/secondary school	216	805	$3,002,840.80	12%	16,707,428.27	8%	6,020.58	$7,882,619.76
Garage/repair	29	34	$18,913.00	0%	152,244.80	0%	50.38	$62,046.00
Grocery store	107	224	$1,113,487.09	4%	7,122,825.44	3%	1,192.26	$2,162,129.27
Health	153	191	$714,661.21	3%	3,913,013.10	2%	924.59	$1,707,547.51
Hospital	33	96	$806,322.62	3%	4,227,537.69	2%	741.47	$2,339,371.63
Lodging	138	215	$264,728.64	1%	4,160,323.47	2%	1,037.04	$794,014.13
Manufacturing	475	882	$7,618,708.14	30%	76,086,790.42	36%	10,527.06	$21,451,405.68
Office	686	1088	$2,312,880.22	9%	12,792,505.47	6%	3,454.77	$5,915,971.90
Other	1122	1655	$4,443,612.86	17%	30,555,084.00	15%	11,905.85	$13,125,134.95
Restaurant	131	156	$126,004.37	0%	885,803.66	0%	233.72	$312,303.51
Retail	534	853	$1,995,663.37	8%	20,757,363.00	10%	5,066.73	$5,476,764.05
Warehouse	399	518	$1,781,599.75	7%	19,242,175.84	9%	3,959.07	$6,358,899.34
Totals:	**3778**	**7356**	**$25,446,527.73**		**210,114,267.10**		**48,304.10**	**$70,769,865.69**

Different factors within each building type will affect and limit the validity of the EUIs. For example the restaurant sector is 258% above the full EUI and 373% above the electric only EUI. But the two buildings in the sector with complete utility data were small, 3,000 to 3,400 ft^2 chain restaurants. The relationship between energy intense food preparation areas, typically 50%-75% of the building square footage and the dining areas or in some cases lack thereof increases the EUI per square foot dramatically.

The EUI data also points to many positive results. For example the High Performance Schools (HPS) Program offered incentives that helped twenty-nine school systems statewide save both electricity and fossil fuel by building more energy efficient schools between 2004 and 2010. It was a

[2] Data from the Efficiency Maine effRT database.

highly successful combined effort of the State of Maine Bureau of General Services, Department of Education, Maine School Management Association, Efficiency Maine, and Rebuild America. The K-12 schools sector EUI was 53% of the CBECS standard set in 2003. The drop in EUIs shows a direct relationship between lack of new school construction before 2003 and the proliferation of it after. Efficiency Maine also offered a special 25% increase in incentives for schools during this time period, which further helped to reduce the overall EUIs for this sector.

Another good example is the reduction in electric EUIs during this time period is in office buildings, hotels and motels, K-12 schools, and retail stores. The electric EUIs for all four of these sectors fall in the 39% to 71% range of the CBECS standard set in 2003. As indicated earlier, a majority of Efficiency Maine's incentives are for lighting. These four sectors are heavily weighted toward lighting loads; thus the option of purchasing and receiving an incentive for energy efficient lighting has a direct relationship to this EUI reduction. Aside from the anomaly presented in the restaurant sector, which is a function of a small sample size and energy intense small buildings, the EUIs for the baseline study sample group is good but has plenty of room for improvement. Data from the review of the code compliance and the EUI section of this report can be used as a benchmark to develop new training programs for the new construction sector.

4.11 Residential Baseline Summary

Residential new construction starts remained low between 2006 and 2011 with construction practices remaining the same since the 2008 baseline study was completed. Included in section 4.1.1.3 of this report is the highlight of that study, which takes those original findings and compares construction practices to the IECC 2009 energy code.

4.11.1 Approach

In the fall of 2007 and early winter 2008, four accredited Maine Home Energy Rating System (HERS) providers sent five certified Energy Raters to visit eighty homes that had been built and occupied since January 1, 2005. Seventy-eight energy ratings were finally used along with seventy-six homes from the supplemental database completed on each of these homes. A cluster sample approach was used to determine representative communities from which to recruit participating homeowners.

Our team telephoned and enlisted participants with the aid of a $100 token of our appreciation for the 3- to 5-hour visit per home. Complete HERS energy ratings, including blower-door and duct leakage testing (where appropriate), and an extensive additional list of questions and observations were gathered. Additionally, the Raters were encouraged to report their field observations on energy features, issues, deficiencies, and opportunities. Using these professional, experienced eyes provided an additional level of insight that helped solidify a comprehensive picture of typical new homes in Maine. For the builder/architect surveys, willing participants were selected through a number of different means including personal referrals, suggestions from the home builders associations, and word of mouth.

4.11.2 KEY FINDINGS

Overall, we found that while Maine builders generally produce a reasonable home in terms of energy consumption, there are numerous opportunities for energy improvements. Most homes don't even meet Maine's Model Energy Code, due in large part to uninsulated basements and low effective R-values of ceiling insulation caused by many uninsulated areas and poor quality installation. There were also many opportunities for more efficient lighting.

On the positive side, air leakage rates were in line with national standards, windows were predominantly energy efficient low e, most above-grade walls were framed with 2x6s to allow for more insulation, heating equipment efficiencies (AFUEs) were relatively high, numerous efficient indirect-fired storage tanks were used to heat domestic hot water off the boiler, and many of the major appliances were ENERGY STAR labeled.

Our research clearly indicates that there are significant, cost-effective, opportunities to improve the efficiency of residential new construction in Maine. This is not unusual, as virtually all residential new construction markets nationwide show substantial room for potential improvement through the promotion of cost-effective, market-transformation-oriented, energy efficiency programs. However, due to the lack of an existing residential new construction program, this study finds that the opportunities in Maine are greater than in other parts of the Northeast region. There are differences in energy efficiency features in these Maine homes as compared to homes in other states in the Northeast that have had ENERGY STAR Homes programs in place.

Table 4-10 shows a summary of the key findings from this study. While there are certainly some positive energy features, there are quite a few opportunities for improvement.

Table 4-10
Summary Average Characteristics of New Maine Home

Feature	Characteristic	Units	Notes
General Information			
Conditioned area	2,057	Square feet	
Bedrooms	3.1		
Building Shell Features			
Ceiling flat	30.8	Nominal R-value	
Vaulted ceiling	31.3	Nominal R-value	
Above-grade walls	17.5	Nominal R-value	
2x4 wall framing	14%	Present	
2x6 wall framing	83%	Present	
Other	2%	Present	ICF; 2x8
Exposed floor (all)	15.3	Nominal R-value	
Foundation Wall Insulation			
No insulation present	66%		For only walls exposed to ambient conditions
Foundation walls	3.4	Nominal R-value	
Slab on Grade Insulation			
Combined	57%	Present	Insulation present under slab OR on perimeter
Windows			
Average U-value	0.37	U value	
Air Leakage (Infiltration)			
Blower-door tested	2,037	Cfm 50	
Air changes per hour at 50 Pa	5.4	ACH 50	ENERGY STAR Homes std. is <5
Air changes per hour natural	0.3	ACH natural	
Mechanical Systems Features			
Heating Distribution System			
Ducted	14%	Present	
Hydronic	81%	Present	
Other (baseboard/unit heaters)	5%	Present	
Heating Fuel Type			
Natural gas	4%	Present	
Propane	15%	Present	
Fuel oil	75%	Present	
Electric	5%	Present	
Heating Efficiency			
Furnaces	87.7%	%AFUE	
Boilers	85.3%	%AFUE	
Cooling System Type			
Central air conditioning system	12%	Present	
Room air conditioner	34%	Present	
Cooling System Efficiency			
Central air conditioning system	12.85	SEER	
Room air conditioner	10.42	EER	
Duct Leakage			
Leakage to outside	269	Cfm 25 to outside	
Leakage per 100 sq ft	10.0	Cfm 25 per 100 sq ft	ENERGY STAR Homes std. is <6
Ventilation System			
None	82%		Don't meet Maine Ventilation Code
Domestic Hot Water Type			
Conventional	13%	Present	
Instantaneous	5%	Present	
Integrated (indirect-fired storage tank)	63%	Present	
Combination tank	3%	Present	
Tankless coil	17%	Present	
Lighting			
Total fluorescent fixtures	15%	Present	
Total incandescent fixtures	85%	Present	
Light sockets count	70	Per home	
Appliances			
Refrigerator	65%	ENERGY STAR qualified	13% Don't know or NA
Dishwasher	68%	ENERGY STAR qualified	15% Don't know or NA
Clothes washer	60%	ENERGY STAR qualified	16% Don't know or NA
Clothes dryer fuel type	91%	Electric	

Below are some of the highlights from the study:

- ❑ Eighty-three percent (83%) of homes would not pass the Maine Model Building Energy Code (IECC-2003 using consumption compliance path).
- ❑ Eighty-one percent (81%) of homes would not pass the Maine Ventilation Code.
- ❑ No homes were found to be already ENERGY STAR labeled.
- ❑ Maine homes scored an average of 86 on the national Home Energy Rating System Index (with 100 as "national code" and 0 as a "zero energy home"; lower is better)
- ❑ Oil is the predominant fuel for space heating (75%) and water heating (71%), with 63% utilizing a very efficient indirect-fired storage tank as a zone off the boiler.
- ❑ Boilers with efficient hydronic (baseboard) distribution systems are found in 86% of new homes.
- ❑ Twelve percent (12%) of new homes have a central air conditioning system.
- ❑ Most homes (83%) are framed with 2x6 walls.
- ❑ Ceiling insulation effectiveness was compromised and resulted in low effective R-values due to poor quality installation and areas of missing insulation (such as attic hatches, among other locations)
- ❑ Sixty-six percent (66%) of foundation walls were uninsulated; this is one of the primary reasons homes don't pass code.
- ❑ Energy-efficient low-e windows (Uo<= 0.36) were found to be predominant.
- ❑ Air leakage (infiltration) rates (5.4 air-changes per hour at 50 Pa) were in line with national ENERGY STAR Homes standard.
- ❑ Heating system efficiencies were relatively high (85%+ AFUE).
- ❑ The overwhelming majority of light fixtures (85%) are still incandescent with opportunities for over fifty-five sockets (hard wired and plug in) per home to be fitted with efficient fluorescent CFLs.
- ❑ Despite the fact that heating system efficiencies are generally pretty good, low-e windows are predominantly installed and air leakage rates are in line with ENERGY STAR standards, there are numerous opportunities to improve the energy efficiency of new Maine homes.

4.11.3 Code Comparison

Table 4-11 compares the summarized average thermal characteristics for windows, walls, and insulation from Efficiency Maine's 2007 Residential Baseline Study verses the 2009 International Energy Conservation Code (IECC). Based on the findings from the original study and the 2009 IECC standards, there are numerous opportunities to increase the thermal energy efficiency of new homes built in Maine.

Low insulation levels in the walls, ceilings, and framed floors are easily addressed with high density R-20 insulation in the walls, R-30 batt insulation in the floor, and 18 to 20 inches of blown-in insulation in the ceiling. Foundation insulation - both interior and exterior - is typically overlooked in the construction process due to the cost of adding insulation to either surface, protection of the exterior insulation, and the overall look of interior insulation.

Opportunities to educate the building community on the buildings thermal characteristics based on the current 2009 IECC code should focus on increased insulation levels and quality of the installation. It should also focus on the quality and quantity of insulation on the interior or exterior foundation.

Table 4-11
Summary Average 2007 Baseline Study vs. 2009 IECC Standards

Thermal Envelope Characteristics			
Feature	**Units**	**2007 Baseline Study Average Values**	**2009 IECC Standards**
Windows			
Thermal properties	U-value	0.37	0.35
Shading properties	Solar heat gain coefficient	0.45	0.40
Glazing percentage	% window-to-wall ratio	15%	15%
Walls	R-value	17.5	20
Frame floors	R-value	15.3	30
Foundation walls	R-value	3.4	15/19*
Ceiling	R-value	31	49

*R-15 continuous insulated sheathing on the interior or exterior of the home or R-19 cavity insulation a the interior of the basement wall. "15/19"

4.11.4 RECOMMENDATIONS

The findings of this study recommended a number of number of strategies, including technical assistance, direct incentives, marketing, and consumer education. The program should work closely with builders and other important stakeholders to encourage energy efficient homes that are also high performance buildings. Based on the research conducted for this study, including field testing and observations, discussions with homeowners, and data analysis, we make the following recommendations to help improve program performance and maximize market impacts:

1. **Code Adoption and Enforcement** – Given the fact that 83% of new homes do not meet code in Maine, there are some real opportunities for improving energy efficiency and the performance of new homes. Many political and implementation issues associated with an energy code would need to be resolved moving forward, but a lot of energy could be saved if all new homes were constructed to the code levels that Maine has already adopted. If a robust Home Energy Rating System (HERS) Program were developed through this residential new construction initiative, the Raters could serve as a code support network. If builders were required to build to code and could demonstrate such through a home energy rating, the costs of compliance could be rolled into the home costs so that buyers who benefit from lower energy costs would pay for these upgrades and services. Using HERS Raters for code support would relieve municipalities from any new mandates, would stimulate Maine "green collar" jobs, and would introduce builders to energy professionals that could lead them to higher tiers of the new homes program for greater energy savings.

2. **Builder Training** – Maine builders have a lot to learn about building performance and energy efficient construction. Comment after comment from the Energy Raters pointed out building shortcomings and deficiencies. A comprehensive series of trainings targeted at builders with some inducements to get them to attend would go a long way toward improving the performance of the homes they build. Opportunities to educate the building community on the buildings thermal characteristics based on the current 2009 IECC code should focus on increased insulation levels and quality of installation. It should also focus on the quality and quantity of insulation on the interior or exterior foundation.

   Incorporating building science curricula at trade schools would start the process for the next generation of builders. Builder training is a long-term effort that needs to begin as a new homes program rolls out so that trainers and builders can work together to drive demand and supply of energy efficient homes and ensure real market transformation of the new homes industry into the future.

3. **Tiered Approach** – While many of the homes examined don't meet the energy code, there are some that are already doing pretty well in terms of energy performance. As the architect and builder surveys revealed, some of these people and businesses are building efficient homes without a program. What this demonstrates is that a program in Maine with "one size fits all" will likely not work because it won't meet the needs of all new-home customers. Adopting a program with multiple tiers that can allow entry into the program at multiple levels and drive them to higher steps of performance would be the most effective approach.

4. **Manufactured Homes** – About a quarter of the new homes constructed each year in Maine are built in a factory. A concerted focus on improving the energy efficiency of manufactured homes could yield lasting results as once certain approaches are changed in the factory situation, there is a high likelihood that those changes will stick and be applied to all future homes.

5. **Electricity Focus** – There were a number of opportunities for electrical savings identified in the homes in the survey. These areas should be a focus of the new homes program in order to reduce electrical use.
   - Electric heat
   - Cooling systems
   - Lighting
   - Appliances
   - Clothes dryers
6. **Technical Features** – Homes in the survey had quite a few energy and building science-related shortcomings. These resulted in a wide range of HERS scores and a high percentage of code underachievement. Some of these areas include:
   - Building science
   - Insulation
   - Seal ducts
   - Reduce infiltration
   - HVAC oversizing
   - Mechanical ventilation

4.12 Conclusions and Recommendations

The conclusion reached by this study is that standard construction practice is highly variable in Maine and is on average considerably below current energy code levels adopted by the state. This is not to say that the quality of construction is low. Although it was not a focus of the study, we found construction quality to be generally high. It is clear that where there are efficiency programs and initiatives in place such as the High Performance Schools Program, code compliance and proper energy-related construction techniques and materials are utilized at a much higher rate. Where the building community is not assisted by either a program or some form of mandatory code, energy efficiency is not an area of focus. The EUI comparisons also demonstrate in many cases a higher energy use per square foot of conditioned space for the Maine commercial building stock. The following outlines the general areas for training opportunities to help ensure code compliance moving forward.

4.12.1 Envelope – Residential and Commercial

- ❑ **Building Science Training**- Focus on how air, moisture, and heat travel through buildings, materials, and assemblies. As codes mandate higher levels of insulation and air sealing, it is critical that designers and builders have a background in basic building science. Without such training they avoid making tight buildings or are likely to make air and vapor barrier mistakes that lead to lower performance and materials deterioration.

- **Informational Outreach and Training on the NFC Rating System** - It is important that this training be delivered to distributors of windows and doors as well as to design professionals and contractors.
- **Training on the Use of Insulating Materials** – Focus on how materials are utilized for below-grade insulation and for continuous insulation to provide thermal breaks. Also, how two-part foams can be utilized to reach the high R-values mandated by code.

4.12.2 Mechanical Systems – Primarily Commercial

- **System Sizing/Design** – It is understandable that oversized HVAC systems are selected when there is any doubt as to what size system is needed to handle a particular building. Learning the tools, techniques, and resources involved in properly sizing systems would reap significant benefits. Learning the tools, techniques, and resources involved in properly sizing systems would reap significant benefits.
- **System Controls** – There is a stark contrast between the practice of selecting high efficiency equipment and installing proper controls to make the most of that same equipment. Controls training and outreach would result in large savings through improved control systems. The newly adopted code requires VFDs for some HVAC equipment. Without proper training, many of those VFD installations will be controlled improperly leaving large savings potentials unrealized.

4.12.3 Lighting – Commercial/Industrial

- **Fluorescent Lighting** - Remarkable efficiency improvements have been made to fluorescents in recent years. The higher efficacy lamps and ballasts allow fewer fixtures, or fewer lamps per fixture to be installed. Yet without guidance, electrical contractors often specify lighting by outdated rules of thumb, leading to the higher LPDs identified in this study.
- **Solid State Lighting (LED)** – LEDs are advancing at an high rate: prices are coming down, quality is improving, and the variety of fixture styles and applications is growing. For the foreseeable future there are opportunities to encourage market actors, designers, and building owners to adopt advancing strategies to lower LPDs in commercial buildings.

4.12.4 Lighting Controls

It is clear that there is a major opportunity for lighting control upgrades in new construction. Unfortunately lighting controls are often the first item eliminated when trimming the construction budget. With less than half the newly constructed buildings incorporating automatic lighting controls, the new construction community will benefit from training and technical assistance in this area.

4.12.5 Policy

It now appears that the adopted energy code will not be deployed statewide. It will be difficult for designers, developers, and contractors to work in an environment where mandates differ across town lines. It will also be nearly impossible for supply houses to stock the range of materials that will be in demand. As a result, the overall energy performance of buildings will be degraded and costs associated with special order equipment will be driven up.

The results of this study suggest that the Trust should continue to support the adoption of a state-wide energy efficiency code, and that educational efforts in support of IECC 2009 will harvest significant energy savings.

Appendix A

Commercial Building Data Collection Checklist

Commercial Building Data Collection Checklist

2011 Commercial Baseline Study

Building ID:_____ Climate Zone: ___

Date:____________ Name of Evaluator(s): ______________________________

Building Contact: Name:______________________ Phone:__________ Email:______________

Building Name & Address:______________________________________ Conditioned Floor Area:__________ft²

State:____________ County:__________________

Building Use: ☐ Office Building ☐ Retail Store ☐ Warehouse ☐ K-12 School ☐ Hotel

☐ Restaurant ☐ Grocery Store ☐ Banking/Financial Institute ☐ Residential Hall/Dormitory

Building Ownership: ☐ State-owned ☐ Local government-owned ☐ National account ☐ Speculative ☐ Private ☐ Other

2009 IECC Section #	Plan Review	Y	N	N/A	Comments/Assumptions
103.2 [PR1][1]	Plans available: Envelope HVAC Electrical	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	
103.2 [PR2][1]	Plans, & specifications enough detail for determining Energy Performance: Envelope HVAC Electrical	☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	

Additional Comments/Assumptions:

Commercial Building Data Collection Checklist

2011 Commercial Baseline Study

efficiency MAINE — Leading the Way to a Brighter Future

Envelope

2009 IECC Section #	Footing / Foundation Inspection	Verified Value	Y	N	N/A	Comments/Assumptions
502.2.4 [FO1][2]	Below-grade wall insulation R-value.	R-______	☐	☐	☐	
502.2.6 [FO3][2]	Slab edge insulation R-value.	R-______ ☐ Radiant Floor	☐	☐	☐	
502.2.6 [FO5][2]	Slab edge insulation depth below grade	______ ft	☐	☐	☐	
303.2.1 FO6][1]	Exterior insulation protected against damage (trowel/spay-on or rigid covering)		☐	☐	☐	
503.2.7 FO8][1]	Piping, ducts and plenum are insulated and sealed when installed in or under a slab.	R-______	☐	☐	☐	

2009 IECC Section #	Wall & Floor Systems	Verified Value	Y	N	N/A	Comments/Assumptions
502.3.2	Fenestration Labels Present? Or; Performance Levels on Plans?	______ cfm/ ft²	☐	☐	☐	
502.4.1, 502.4.2 [FR2][3]	Doors labeled for air leakage	______ cfm/ ft²	☐	☐	☐	
502.4.1, 502.4.2 [FR3][3]	Windows labeled for air leakage.	______ cfm/ ft²	☐	☐	☐	
502.3.2 [FR9][1]	Windows	U factor _____ SHGC ______	☐	☐	☐	Describe:
502.3.2 [FR10][1]	Doors	U factor _____ SHGC ______	☐	☐	☐	Describe:
502.4.7 [FR4][3]	Vestibule at main entrance? Revolving Door? Self-Closing Door?		☐ ☐ ☐	☐ ☐ ☐	☐ ☐ ☐	
502.2.3	Above-grade wall insulation R-value.	R-______ **Structure type** ☐ Mass ☐ Metal ☐ Steel ☐ Wood	☐	☐	☐	
303.2 [IN7][1]	Above-grade wall insulation properly installed.		☐	☐	☐	

Envelope Cont.

2009 IECC Section #	Wall & Floor Systems	Verified Value	Y	N	N/A	Comments/Assumptions
	Metal framing – continuous rigid insulation for thermal break	R-______	☐	☐	☐	
502.2.5 [IN8][2]	Floor insulation R-value.	R-______ **Structure type** ☐ Mass ☐ Steel ☐ Wood	☐	☐	☐	
303.2 [IN9][2]	Floor insulation properly installed		☐	☐	☐	
303.1.1, 303.1.1.1 [IN10][2]	Insulation is labeled with R-value or insulation certificate providing R-value and other relevant data.		☐	☐	☐	

Additional Comments/Assumptions:

2009 IECC Section #	Roof Systems	Verified Value	Y	N	N/A	Comments/Assumptions
502.4.1, 502.4.2 [FR1][3]	Roof penetrations sealed?		☐	☐	☐	
502.2.1 [IN17][3]	Insulation intended to meet the roof insulation requirements not installed on top of a suspended ceiling.		☐	☐	☐	
502.2.1 [FR5][1]	Roof insulation R-value.	R-______ ☐ Above deck ☐ Metal ☐ Attic	☐	☐	☐	
	Metal frame - Continuous rigid insulation for thermal break		☐	☐	☐	
502.3.2 [FR11][1]	Skylights	U factor _____ SHGC ______	☐	☐	☐	Describe:

Additional Comments/Assumptions:

Mechanical Systems

2009 IECC Section #	Mechanical - HVAC	Verified Value	Y	N	N/A	Comments/Assumptions
503.2.3	1) HVAC equipment. Type: ☐ Small to Medium Unitary ☐ Packaged Terminal AC & Heat Pumps ☐ Warm Air Furnace ☐ Boilers (Circle 1 Oil or Gas) ☐ Condensing Units ☐ Chillers Manufacturer:________ Model Number:________ Capacity Output BTUH:________ kW:____ Tons:____ HP:____ Efficiency:____ 2) HVAC equipment. Type: ☐ Small to Medium Unitary ☐ Packaged Terminal AC & Heat Pumps ☐ Warm Air Furnace ☐ Boilers (Circle 1 Oil or Gas) ☐ Condensing Units ☐ Chillers Manufacturer:________ Model Number:________ Capacity Output BTUH:________ kW:____ Tons:____ HP:____ Efficiency:____					
503.2.4.1 [FI2] [2]	Heating and cooling to each zone is controlled by an electronic thermostat with setback/ set forward control. (EMS)	☐	☐	☐	☐	
503.2.4.1.1 [FI5] [3]	Heat pump controls prevent supplemental electric resistance heat from coming on when not needed. (Model #)	☐	☐	☐	☐	
503.2.7 [ME8] [2]	HVAC ducts and plenums insulated.	R-____	☐	☐	☐	
503.2.8 [ME9] [2]	HVAC piping insulation thickness.	____ in.	☐	☐	☐	
503.2.7.1 [ME10] [2]	Ducts and plenums sealed – mastic or approved tape		☐	☐	☐	
503.3.1, 503.4.1 [ME12] [1]	Air economizers installed		☐	☐	☐	
503.4.5 [ME17] [1]	Zone controls can limit simultaneous heating and cooling and sequence heating and cooling to each zone.		☐	☐	☐	

Commercial Building Data Collection Checklist
2011 Commercial Baseline Study

Mechanical Systems Cont.

2009 IECC Section #	Mechanical - HVAC	Verified Value	Y	N	N/A	Comments/Assumptions
503.2.9.1 [ME41iecc][3]	Air outlets and zone terminal devices have means for air balancing.		☐	☐	☐	
503.2.9.2 [ME42iecc][3]	HVAC hydronic heating and cooling coils have means to balance and have pressure test connections.		☐	☐	☐	
503.2.11 [ME34][3]	Efficiency level of Service water heating equipment	_______%	☐	☐	☐	
504.5 [PL1][2]	Piping for recirculating and non-recirculating service hot-water systems insulated.	☐	☐	☐		

Additional Comments/Assumptions:

Complex HVAC Systems

503.4.2 [ME22] [2]C	VAV fan motors ≥10 hp controlled VFD or Vane Axial Fan 	☐ VSD ☐ Vane axial fan ☐ Other	☐	☐	☐	
503.4.3.4 [ME27] [3]C	Pumping systems >10 hp for chiller and boiler systems > 300,000 Btu/h; temperature reset based on load		☐	☐	☐	
503.4.3.3.3 [ME28] [3] C	Two-position automatic valve interlocked to shut off water flow when hydronic heat pump with pumping system >10 hp is off.		☐	☐	☐	
503.4.4 [ME29] [3]C	Heat rejection Fan systems with motors ≥7.5 hp controlled by VFD.		☐	☐	☐	
503.2.6 [ME30][1]	Energy recovery *(ERV or HRV)* on systems ≥ 5,000 cfm and 70% outside supply air.		☐	☐	☐	
503.4.6 [ME31] [3]C	Condenser heat recovery system for preheating of service hot water in 24/7 facilities with loads >6 MMBtu *(Hospital, etc.)*		☐	☐	☐	

Additional Comments/Assumptions:

Commercial Building Data Collection Checklist
2011 Commercial Baseline Study

Lighting/Electrical

2009 IECC Section #	Lighting Controls	Y	N	N/A	Comments/Assumptions
505.2.2.2 [EL1][2]	Buildings >5,000 ft². Automatic lighting control to shut off all non-emergency building lighting after hours (timer or occupancy)	☐	☐	☐	
505.2.1 [EL2][2]	Each enclosed space includes at least a manual light switch	☐	☐	☐	
505.2.2.1 [EL10iecc][1]	Bi-Level switching in offices	☐	☐	☐	
	Are any daylit zones controlled separately? (manual or auto)	☐	☐	☐	
505.2.3 [EL4][1]	Verify separate lighting control devices for specific uses installed Occupancy/Vacancy Sensors Timers Daylight dimming	 ☐ ☐ ☐	 ☐ ☐ ☐	 ☐ ☐ ☐	
505.4 [EL6][1]	LED or self-illuminating exit signs	☐	☐	☐	
505.2.4 [EL3][2]	Automatic lighting controls for exterior lighting installed. Photocell Astronomical timer	 ☐ ☐	 ☐ ☐	 ☐ ☐	
505.6.1 [EL7][1]	Exterior lighting over 100 W is fluorescent, HID or LED	☐	☐	☐	

Additional Comments/Assumptions:

Commercial Building Data Collection Checklist

2011 Commercial Baseline Study

Lighting Cont.

2009 IECC Section #	Lighting Power Density Allowance	Y	N	N/A	Comments/Assumptions
	Collect LPD data for the entire building or 2 representative spaces				Describe Fixtures
	Space Type ______________________ Length ________________ Width ________________ Fixture: 2L4'T8 __________Watts 3L4'T8 __________Watts 4L4'T8 __________Watts 2 U T8 __________Watts 8' T8 __________Watts CFL __________Watts Inc. __________ Socket rated Watts HIF __________Watts HID __________Watts Other __________Watts	☐	☐	☐	
	Area 2 **Space Type** ______________________ Length ________________ Width ________________ Fixture: 2L4'T8 __________Watts 3L4'T8 __________Watts 4L4'T8 __________Watts 2 U T8 __________Watts 8' T8 __________Watts CFL __________Watts Inc. __________ Socket rated Watts HIF __________Watts HID __________Watts Other __________Watts	☐	☐	☐	

Make additional Copies of this page as needed.

Additional Comments/Assumptions:

Commercial Building Data Collection Checklist

2011 Commercial Baseline Study

Other

2009 IECC Section #	Other	Complies Y	N	N/A	Comments/Assumptions
502.4.6 [FI1] [1]	Weather seals installed on all loading dock cargo doors	☐	☐	☐	
504.7.1 [FI13] [3]C	Pool heaters are equipped with on/off switch and no continuous burning pilot light.	☐	☐	☐	
504.7.3 [FI4] [2]C	Pool covers are provided for heated pools and pools heated to >90°F have a cover ≥R-12.	☐	☐	☐	
504.7.2 [FI15] [3]C	Time switches are installed on all pool heaters and pumps.	☐	☐	☐	
503.2.9.3 [FI17] [3]	Contractors furnished O&M instructions for systems and equipment to the building owner	☐	☐	☐	

Additional Comments/Assumptions:

Appendix B

All Sites Code Compliance – Data Analysis
(Available in Electronic Version Only)

All Sites Code Compliance - Data Analysis

(Available in Electronic Version Only)

Appendix C

Energy Usage Intensity Spreadsheet

Some data (yellow)
No data (green)

ID	SQFT	Units	11-Mar	11-Feb	11-Jan	10-Dec	10-Nov	10-Oct	10-Sep	10-Aug	10-Jul	10-Jun	10-May	10-Apr	Btu Conversion	Total Btu	Energy Intensity (kBtu/SQFT) per year	Building Type
1	2500	kWh					45000						22500		230310000	413604000	165.4416	Banks/Financial Institution
		Gallons						2000							183294000			
9	3700	kWh	4930	5755	5544	5650	5522	4635	5061	5370	5211	4905	4211	5097	211172092	380535748	102.8474995	Banks/Financial Institution
		Gallons						1848							169363656			
13	36000	kWh	146720	134080	137920	142960	136400	152960	176800	163440	178960	144080	139920	142960	6132046400	7017264773	194.9240215	Grocery Store
		Gallons	2335		2369		1782			1398			1775		885218373			
17	2400	kWh	584	642	655	683	753	761	467	488	262	471	682	583	23989772	82139793.5	34.22491396	K-12 School
		Gallons						634.5							58150021.5			
24	38000	kWh	1570	16560	17520	17880	16440	18960	19920	17760	20280	12240	14500	1500	597543560	2438456849	64.16991708	K-12 School
		Gallons						20087							1840913289			
31	3000	kWh	519	475	450	476	479	460	669	741	876	582	511	648	23495032	23495032	7.831677333	Office Building
		Gallons													0			
32	6500	kWh	4716	4259	4123	4408	5497	4141	4884	5265	4712	5115	4137	4620	190652324	247210437.1	38.03237494	Office Building
		Gallons		218.5				228.25				170.38			56558113.11			
38	50000	kWh														0	0	Office Building
		Gallons																
41	6000	kWh						38511							131399532	268870032	44.811672	Residence Hall/Dormitory
		Gallons						1500							137470500			
44	55000	Btu	325000	425000	310000	180000	120000	80000			1216855.476				9065190886	9396425986	170.8441088	Residence Hall/Dormitory
		CCF	233	173	222	201	362	533	235	246	243	409	167	195	331235100			
57	13200	kWh														0	0	Restaurant
		Gallons																
60	4792	kWh	11624	11204	11746	14430	13120	15656	18941	17306	18050	14254	13831	12500	589122744	589122744	122.938803	Retail Store
		Gallons						No fossil fuel used all electric										
65	7000	kWh														0	0	Retail Store
		Gallons																
74	15300	kWh	10,102	10,471	9,979	11,103	10,739	11,395	10,988	10,988	19,614	13,993	11,671	11,073	484,899,792	844,889,208	55.22151686	Retail Store
		Gallons						3928							359989416			
83	22028	kWh	22320	19320	20520	20280	22080	23040	28680	26040	27600	23760	20640	15600	920,830,560	2316403582	105.1572354	Office Building
		Gallons						15227.7							1395573022			
84	17000	kWh	6559	7523	6721	6705	5143	4364	4872	4935	4892	2354	3740	4211	211608828	211608828	12.44757812	Warehouse
		Gallons													0			
92	2400	kWh						31951							109,016,812	205796044	85.74835167	Banks/Financial Institution
		Gallons						1056							96779232			
96	24800	kWh	79440	94320	80400	86400	97200	91560	97080	94080	94680	86040	78360	85080	3,632,551,680	3896522534	157.1178441	Grocery Store
		Gallons						2880.3							263970854.1			
98	72000	kWh	58320	82960	88560	85120	72480	61920	64560	40160	57360	71280	59840	58480	2733148480	5324009170	73.94457181	Hotels and Motels
		Gallons						28270							2590860690			
100	41034	kWh	17600	19160	18480	21760	18040	19280	21000	22760	18480	21760	17600	19080	801820000	2138674789	52.11957862	K-12 School
		Gallons						14587							1336854789			
101	3000	kWh														0	0	Office Building
		Gallons																
105	21198	kWh	40648	39096	37398	36459	35004	33472	32329	31494	30653	29967	28861	27939	1376127840	1376127840	64.91781489	Residence Hall/Dormitory
		Gallons																
106	29920	kWh													0	714938247	23.89499489	Residence Hall/Dormitory
		Gallons						7801							714938247			
111	3192	kWh	20000	21200	20080	21600	23720	26120	28960	33400	34240	30400	24480	25480	886164640	2322823012	727.7014449	Restaurant
		Gallons	1159	2529	2692	2445	2140	1177	462	636	568	500	500	868	1436658372			
119	6040	kWh						270000							921240000	1879501032	311.1756675	Retail Store
		Gallons						10456							958261032			
123	15584	kWh						65716							224222992	224222992	14.38802567	Retail Store
		Gallons																
125	12000	kWh	8832	9131	7155	9917	8834	8775	9040	12097	13427	14387	10714	9309	414960616	680736916	56.72807633	Retail Store
		Gallons	375	533	560	912	293	70	0	0	0	0	13	144	265776300			
132	28000	kWh														0	0	Retail Store
		Gallons																
137	9375	kWh						24192							82543104	170799165	18.2185776	Warehouse
		Gallons						963							88256061			
138	6500	kWh														0	0	Warehouse
		Gallons																
139	7200	kWh						25023							85378476	216891921	30.12387792	Warehouse
		Gallons						1435							131513445			
145	5100	kWh														0	0	Warehouse
		Gallons																
146	2932	kWh						31340							106932080	200870255	68.50963677	Banks/Financial Institution
		Gallons						1025							93938175			
147	58445	kWh						684960							2337083520	4629908166	79.21820799	Hotels and Motels
		Gallons						25018							2292824646			
148	10286	kWh						57816							197268192	497228823	48.34034834	Office Building
		Gallons						3273							299960631			
152	1400	kWh						6666							22744392	22744392	16.24599429	Warehouse
		Gallons																
158	2900	kWh	3761	3916	4821	4349	3626									0	0	Banks/Financial Institution
		Gallons	136.9	165.6	217.8	182.5	144	117.2	403.9									

Some data (yellow)
No data (green)

ID	SQFT	Units	11-Mar	11-Feb	11-Jan	10-Dec	10-Nov	10-Oct	10-Sep	10-Aug	10-Jul	10-Jun	10-May	10-Apr	Btu Conversion	Total Btu	Energy Intensity (kBtu/SQFT) per year	Building Type
167	3900	kWh	6618	6729	7753	7897	7265	6681	6462	7182	6796	5901	7527	7000	285963132	285963132	73.32388	Banks/Financial Institution
		Gallons													0			
175	7000	kWh	7200	6900	6600	6600	6981	5814	8333	10076	9019	8189	7179	7422	308147956	308147956	44.02113657	Banks/Financial Institution
		Gallons										810	342	273				
178	36129	kWh	125160	112560	102240	115560	131040	125040	133080	173520	150240	162480	130680	133200	5441457600	8400830877	232.5232051	Grocery Store
		Gallons	3050	5728	4709	5426	3023	2804	2708	0	0	2479	0	2364	2959373277			
187	56000	kWh	1914	2236	1950	2100	1768	1748	1853	2036	2121	1500	1807	1452	76718820	2744562990	49.01005339	Hotels and Motels
		Gallons	3820	5010	4950	3860	2700	1260	1160	1300	1150	950	810	2140	2667844170			
191	12600	kWh														0	0	K-12 School
		Gallons																
192	27000	kWh	10000	10720	9360	9760	12960	10560	11840	15280	14960	12880	10640	10560	476042240	1762857767	65.29102841	K-12 School
		Gallons	2043	2348	269	4327	1180	2476						1398	1286815527			
198	25800	kWh	22102	19210	18177	18590	23134	21482	24787	17144	16111	10741	10534	10328	724504080	1986849858	77.00968442	Office Building
		Gallons	2432	2084	2272	2084	2187	0	0	0	222	0	803	1690	1262345778			
210	4100	kWh	370	1156												0	0	Office Building
		CCF	274	187														
212	259000	kWh	59800	59600	71200	63600	54000	57400	88400	81400	75400	67200	66600	57200	2735741600	9561335219	36.9163522	Office Building
		Gallons	7634	9612	11852	7698	5842	5004	4508	3250	4500	4221	5126	5230	6825593619			
214	5400	kWh														0	0	Office Building
		Gallons																
235	20000	kWh	3700	3700	3700	3700	3700	3778	3234	4194	3631	3375	3227	3944	149728796	312104996	15.6052498	Office Building
		CCF	229	335	429	212	126	27	5	1	2	7	70	135	162376200			
240	54000	kWh	53400	53250	51240	61560	58320	65760	75480	92880	89880	80040	73440	74760	2831994120	4715784420	87.32934111	Office Building
		CCF	2573	3515	3286	2394	1366	699	370	335	405	463	1096	1805	1883790300			
255	17500	kWh														0	0	Residence Hall/Dormitory
		Gallons																
258	61000	kWh	42480	42840	35040	45840	42240	56400	39960	32640	33480	30600	46440	40680	1667239680	3440609130	56.40342836	Residence Hall/Dormitory
		Gallons	2760	3230	3250	1870	1770	940	560	310	380	370	1480	2430	1773369450			
265	3497	kWh							337120						1150253440	2451223995	700.9505276	Restaurant
		Therms							13001 (P105 coverted Therms to Btuh)						1300970555			
272	4000	kWh														0	0	Restaurant
		Gallons																
284	7000	kWh														0	0	Restaurant
		Gallons																
288	34400	kWh	71835	72999	82789	76749	72000	83070	102828	98069	113361	87929	80895	71021	3458215540	6647601040	193.2442163	Restaurant
		CCF	3290	3786	3620	4390	2610	1989	1936	1609	1645	1794	1733	2593	3189385500			
297	2400	kWh	1339	491	1054	1074	922	921	1188	1006	898	917	1094	1035	40735868	40735868	16.97327833	Retail Store
		Gallons																
299	4748	kWh	12563	12760	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000	495842076	940238379	198.0283022	Retail Store
		Gallons	400	389	460	400	400	400	400	400	400	400	400	400	444396303			
310	10000	kWh														0	0	Retail Store
		Gallons																
312	11500	kWh														0	0	Retail Store
		Gallons																
313	13000	kWh	26640	32160	29280	22320	17520	22800	28800	28320	23760	18720	19440	17040	978561600	978561600	75.27396923	Retail Store
		Gallons																
326	16000	kWh	10760	10360	14160	15320	12520	13440	16000	16120	14080	11360	9160	11460	527972880	896972280	56.0607675	Retail Store
		CCF							3586						368999400			
338	1312	kWh							10791						36818892	36818892	28.06317988	Warehouse
		Gallons																
341	2200	kWh														0	0	Warehouse
		Gallons																
346	6400	kWh	1679	1979	2067	2095	1926	2177	2344	2810	2399	1851	2078	1877	86262184	270144484	42.21007563	Warehouse
		CCF	275	381	505	175	108	23	2	0	5	26	76	211	183882300			
357	30000	kWh														0	0	Warehouse
		Gallons																
359	2900	kWh	5757	5151	5645	5034	4978	5435	5879	6554	5242	4888	5640	4888	222090492	222090492	76.58292828	Banks/Financial Institution
		Gallons																
362	44000	kWh	91920	82680	85320	67320	46200	41760	39840	44400	36480	33840	43920	51240	2268707040	2403912618	54.63437768	Hotels and Motels
		Gallons	1233	1593	1117	763				1475.23511					135205578.1			
364	26800	kWh	3440	3666	3812	3320	3478	3780	7879	2578	5843	0	0	3444	140710880	965533880	36.02738358	K-12 School
		Gallons							9000						824823000			
366	59549	kWh							357600						1220131200	2661371922	44.69213458	K-12 School
		Gallons							15726						1441240722			
368	2100	kWh														0	0	Office Building
		Gallons																
370	4200	kWh							21158						72191096	328802696	78.28635619	Office Building
		Gallons							2800						256611600			
374	46900	kWh	13382	13382	12811	14688	13056	14198	12077	10282	12240	12300	12566	12566	45659384	846287576	18.04451122	Residence Hall/Dormitory
		Gallons							8736						800628192			
376	14700	kWh														0	0	Retail Store
		Gallons																
380	11000	kWh	13000	13000	13000	13000	13000	13000	15000	0	0	0	8000	13000	388968000	388968000	35.36072727	Warehouse
		Gallons													0			

ID	SQFT	Total Btu	Energy Intensity (kBtu/SQFT) per year	Building Type	Average Energy Intensity (kBtu/SQFT) per year ≤ 25,000 Sq Ft Building	Averages > 25,000 Sq Ft Building			Average Energy Intensity (kBtu/SQFT) per year > 25,000 Sq Ft Building	Average Energy Intensity (kBtu/SQFT) per year all Buildings	Averages > 25,000 Sq Ft Building			2003 Commercial Buildings Energy Consumption Survey Categories
						National	Northeast	New England			National	Northeast	New England	
92	2400	205796044	85.7	Banks/Financial Institution										
146	2932	200870255	68.5	Banks/Financial Institution										
9	3700	380535748	102.8	Banks/Financial Institution	85.7	77	80	100.8		85.7	77	80	100.8	Service
299	4748	940238379	198.0	Convenience Store										
119	6040	1879501032	311.2	Convenience Store										
96	24800	3896522534	157.1	Grocery Store										
288	34400	6647601040	193.2	Travel Plaza										
13	36000	7017264773	194.9	Grocery Store										
178	36129	8400830877	232.5	Grocery Store	222.1	199.7	Q††	Q††	206.9	214.5	199.7	Q††	Q††	Food Sales
362	44000	2403912618	54.6	Hotels and Motels										
187	56000	2744562990	49.0	Hotels and Motels										
147	58445	4629908166	79.2	Hotels and Motels										
98	72000	5324009170	73.9	Hotels and Motels		100	103.7	126.7	64.2	64.2	100	103.7	126.7	Lodging
17	2400	82139793.5	34.2	K-12 School										
364	26800	965533880	36.0	K-12 School										
24	38000	2438456849	64.2	K-12 School										
100	41034	2138674789	52.1	K-12 School										
366	59549	2661371922	44.7	K-12 School	34.2	83.1	77.6	87.7	49.3	46.2	83.1	77.6	87.7	Education
370	4200	328802696	78.3	Office Building										
32	6500	247210437.1	38.0	Office Building										
148	10286	497228823	48.3	Office Building										
235	20000	312104996	15.6	Office Building										
83	22028	2316403582	105.2	Office Building										
198	25800	1986849858	77.0	Office Building										
240	54000	4715784420	87.3	Office Building	57.1	92.9	72.1	120.1	3000.0	64.3	92.9	72.1	120.1	Office
41	6000	268870032	44.8	Residence Hall/Dormitory										
374	46900	846287576	18.0	Residence Hall/Dormitory										
44	55000	9396425986	170.8	Residence Hall/Dormitory										
258	61000	3440609130	56.4	Residence Hall/Dormitory	44.8	100	103.7	126.7	81.8	72.5	100	103.7	126.7	Lodging
111	3192	2322823012	727.7	Restaurant										
265	3497	2451223995	701.0	Restaurant	714.3	258.3	243.8	276.6		714.3	258.3	243.8	276.6	Food Servivce
60	4792	589122744	122.9	Retail Store										
125	12000	680736916	56.7	Retail Store										
74	15300	844889208	55.2	Retail Store										
326	16000	896972280	56.1	Retail Store	72.7	73.9	63.2	108.4		72.7	73.9	63.2	108.4	Retail other than mall
346	6400	270144484	42.2	Warehouse										
139	7200	216891921	30.1	Warehouse										
137	9375	170799165	18.2	Warehouse	30.2	45.2	39	86.4		30.2	45.2	39	86.4	Warehouse

Notte: Q†† data set too small

ID	SQFT	Total Btu	Energy Intensity KWh/SQFT) per year	Building Type	Average Electric Energy Intensity (kWh/SQFT) per year ≤ 25,000 Sq Ft Building	Average Electric Energy Intensity (kWh/SQFT) per year > 25,000 Sq Ft Building	Average Electric Energy Intensity (kWh/SQFT) per year all Buildings	Averages > 25,000 Sq Ft Building: National	Averages > 25,000 Sq Ft Building: Northeast	Averages > 25,000 Sq Ft Building: New England	2003 Commercial Buildings Energy Consumption Survey Categories
359	2900	222090492	22.4	Banks/Financial Institution							
146	2932	106932080	10.7	Banks/Financial Institution							
9	3700	211172092	16.7	Banks/Financial Institution							
92	2400	109016812	13.3	Banks/Financial Institution							
167	3900	285963132	21.5	Banks/Financial Institution	16.3		16.3	11	6.9	Q††	Service
175	7000	308147956	12.9	Banks/Financial Institution							
299	4748	495842076	30.6	Convenience Store							
119	6040	921240000	44.7	Convenience Store							
96	24800	3632551680	42.9	Grocery Store							
288	34400	3458215540	29.5	Travel Plaza							
178	36129	5441457600	44.1	Grocery Store	30.6	41.2	40.3	49.4	Q††	Q††	Food Sales
13	36000	6132046400	49.9	Grocery Store							
362	44000	2268707040	15.1	Hotels and Motels							
98	72000	2733148480	11.1	Hotels and Motels							
187	56000	76718820	0.4	Hotels and Motels		9.6	9.6	13.5	Q††	Q††	Lodging
147	58445	2337083520	11.7	Hotels and Motels							
17	2400	23989772	2.9	K-12 School							
364	26800	140710880	1.5	K-12 School							
192	27000	476042240	5.2	K-12 School							
24	38000	597543560	4.6	K-12 School							
100	41034	801820000	5.7	K-12 School	2.9	4.6	4.3	11	7.8	Q††	Education
366	59549	1220131200	6.0	K-12 School							
31	3000	23495032	2.3	Office Building							
370	4200	72191096	5.0	Office Building							
32	6500	190652324	8.6	Office Building							
148	10286	197268192	5.6	Office Building							
83	22028	920830560	12.3	Office Building							
198	25800	724504080	8.2	Office Building							
235	20000	149728796	2.2	Office Building							
240	54000	2831994120	15.4	Office Building	6.3	15.4	7.4	17.3	16.5	16.3	Office
41	6000	131399532	6.4	Residence Hall/Dormitory							
105	21198	1376127840	19.0	Residence Hall/Dormitory							
374	46900	45659384	0.3	Residence Hall/Dormitory	12.7	4.1	8.4	13.5	Q††	Q††	Lodging
258	61000	1667239680	8.0	Residence Hall/Dormitory							
111	3192	886164640	81.4	Restaurant							Food Service
265	3497	2451223995	205.4	Restaurant	143.4		143.4	38.4	Q††	Q††	
297	2400	40735868	5.0	Retail Store							
123	15584	224222992	4.2	Retail Store							
125	12000	414960616	10.1	Retail Store							
313	13000	978561600	22.1	Retail Store							
74	15300	484899792	9.3	Retail Store							
326	16000	527972880	9.7	Retail Store	10.1		10.1	14.3	8.8	Q††	Retail other than mall
338	1312	36818892	8.2	Warehouse							
152	1400	22744392	4.8	Warehouse							
137	9375	82543104	2.6	Warehouse							
346	6400	86262184	4.0	Warehouse							
139	7200	85378476	3.5	Warehouse							
380	11000	388968000	10.4	Warehouse	5.6		5.6	7.6	5.9	Q††	Warehouse