Final Report

prepared for the

New Hampshire Commercial & Industrial New Construction Program Baseline Evaluation

for the

NH Monitoring and Evaluation Team

energy & resource solutions

120 Water Street, Suite 350
North Andover, Massachusetts 01845
(978) 521-2550
Fax: (978) 521-4588
www.ers-inc.com

March 2014

Contents

Executive Summary

1

1.1 Introduction

This document presents the results of a “baseline” evaluation for the New Hampshire commercial and industrial new construction program known as nhsaves@Work/New Equipment & Construction, and it was sponsored by the New Hampshire Monitoring and Evaluation Team (M&E Team). The M&E Team is comprised of representatives from the following New Hampshire utilities: Public Service Company of New Hampshire (PSNH), Liberty Utilities, Unitil Energy Systems, Inc., and New Hampshire Electric Cooperative Inc. (NHEC).

This evaluation had four primary components. First, a thorough assessment of the 2013 program measure savings algorithms was conducted. As a part of the assessment the sources for the algorithms were investigated for their accuracy and suitability with respect to the existing baseline parameters. The second component of the study was to review the recent New Hampshire Energy Code that became effective in April 2010 to assess the potential implications of this document on the baseline algorithms. As a subset of the code review, this study also compared the next energy code (IECC 2012) with the currently adopted code and assessed its impact on the current energy efficiency program offerings. The third area of focus of this evaluation was to assess the current practices employed for new construction projects in New Hampshire. The fourth area of focus involved limited primary research into energy efficiency program practices in the northeastern states and a general review of applicable documents to provide a basis for the parameters used in the energy savings algorithms.

Finally, based on these four components of the study, recommendations were developed for revisions to the baseline parameters and calculations that define the minimum qualifying levels of energy efficiency improvements and the corresponding energy savings.

This section (Executive Summary) provides a brief overview of the steps followed for the evaluation process and the resulting findings.

Section 2 presents a review of the existing baseline parameters and algorithms for each Prescriptive and Custom measure (and/or measure category) for the new-construction program as well as a discussion of the origins of these parameters.

Section 3 provides a review of all sections and details of the recent New Hampshire Commercial Energy Code. This section provides a comprehensive comparison of the baseline parameters for the new construction program with the IECC (International Energy Conservation Code) 2009 & 2012 and ASHRAE 90.1 (2007 & 2010) referenced by the new code.

Section 4 details the findings from primary research based on workshops conducted with New Hampshire architects and engineers to assess the current practices incorporated in the new construction industry. This section also presents a comparison of current practices with the program baseline.

Section 5 details the findings from secondary research based on literature review on current practices incorporated in the new construction industry in New Hampshire and nationwide.

Section 6 includes details of the baseline comparison of the New Hampshire programs with the neighboring New England states.

Section 7 summarizes the overall recommendations put forth as a result of synthesizing all of the information established in the previous sections associated with the commercial energy code review, baseline parameters comparisons and current practice research.

1.1 Overview of the Project Process

The evaluation process involved five major tasks. Each of these tasks is described below.

Task 1 – Review of current program baseline parameters: This task involved reviewing the current program's baseline parameters and algorithms for each approved Prescriptive and Custom measure. Additionally, an assessment of the projects conducted under the New Equipment & Construction Program to date was conducted.

Task 2 – Review of new commercial energy code: This task included a comprehensive review of the new commercial energy code, its relationship to the New Equipment & Construction Program and associated baseline parameters. The energy codes were reviewed from the perspective of the New Equipment & Construction Program to determine how the new code relates to the current approved measures. Similar to other states in the region, the recent New Hampshire energy code adopted in 2010 is based on ASHRAE 90.1-2007 and the International Energy Conservation Code (IECC) 2009. The code addresses numerous technical areas applicable to new construction or major renovation of commercial buildings such building envelope, mechanical systems, and lighting systems. As a sub-task, the impact of the future adoption of IECC 2012 on the energy efficiency program was also conducted.

Task 3 – Review of existing information on current practice: This task targeted a comprehensive compilation and review of data describing the current new-construction practices in New Hampshire's commercial sector and the relationship to the utilities' new construction program's baseline parameters. While the new energy code represents one area of consideration for the baseline practices, the actual "typical" practice in New Hampshire is another major consideration. The objective of this task was to gather and organize information to determine what the current practices are and to establish associated recommendations for enhancing the New Equipment & Construction Program baseline assumptions. For this task, ERS evaluated existing program history, reviewed pertinent literature sources, and conducted a limited number of workshops to facilitate discussions with market actors (architects, engineers, contractors, and distributors) involved in new construction in New Hampshire.

Task 4 – Baseline comparison with other states: This task involved a rigorous review of the programmatic baseline assumptions used in neighboring New England states. Tables were developed that compare each of the studied states with the baselines used in New Hampshire, with substantive reasons for discrepancies clearly described.

Task 5 – Synthesis of information and development of recommendations: Upon completion of Tasks 1 through 4 described above, the information obtained was reviewed collectively in relation to one another to provide interrelated insights. The result of this effort was to establish appropriate recommendations for revising designated baseline elements of the new construction program that integrates all elements of the evaluation.

1.2 Review of Electric Prescriptive Measure Baseline Algorithm

The electric Prescriptive program offers rebates for lighting, electronically commutated motors (ECMs), HVAC systems, chillers, and variable frequency drives (VFDs). The projects implementing Prescriptive measures have pre-defined baseline parameters and savings calculations set forth by the program.

1.2.1 Algorithm Observations

There are numerous parameters and specific calculations associated with each of the measure categories under the Prescriptive track of the program. Our observations for each type of technology are discussed briefly in the following paragraphs. The algorithm review for each measure is presented in greater depth in Section 2 of this report.

Lighting

The savings algorithms associated with the Prescriptive measures for lighting systems have been determined by various studies that are ongoing since 1994 that are conducted in collaboration with the Massachusetts utilities. The analysis was categorized by code types (the program incorporates lighting codes to identify technology groupings), and the analysis reviewed the baseline technologies and their relationship to the demand and energy savings calculation algorithms. The baseline algorithms for a number of the lighting technologies were found to be acceptable, however, while in other instances we have recommended specific changes.

Unitary Systems

The base efficiencies for unitary equipment are based on a work done by the Northeastern utility companies in association with Consortium for Energy Efficiency (CEE). The savings algorithms and the associated baseline parameters for unitary systems were reviewed. Based on our investigation, we believe that the energy savings algorithms and the associated energy performance values used in the baseline algorithm are acceptable. We feel that further refinement of the equivalent full load hours (EFLH) for New Hampshire would be beneficial consistent with the methods adopted by the Massachusetts programs, but would require further study investigation. The EFLH hours applied to the hospital facility type in the current calculation spreadsheet were observed to higher when compared with the 2011 and 2012 MA TRM hours for the same facility type. Since the EFLH estimate in the MA TRM document have been developed through indepth study of a variety of building types, we feel that the New Hampshire hours should also be similar to the Massachusetts estimates. Hence, we recommend revising the EFLH applied to the hospital building types to either be consistent with the MA TRM up until New Hampshire decides to revise these estimates specific to their state. In addition to the hospital hours, we recommend reviewing the EFLH hours applied to all facility types and making them consistent with the regional estimates.

Chillers

The NE&C program offers incentives for air-cooled chillers, water-cooled rotary screw and scroll and water-cooled centrifugal chillers. Even though the minimum performance values for air-cooled and water cooled chillers specified in the rebate applications exceed those in the codes, the baseline efficiency values match those specified in the codes. Based on the baseline algorithm, we believe that the values used are consistent with the current technological developments and, hence, are acceptable. Based on discussions with the PMs with the different New Hampshire utilities, we found that different default full load cooling hours are being used when none is offered by the applicant. We recommend reviewing the hours used for the different facility types and making them consistent with the 2012 MA TRM in the short term. In the long term, we recommend determining the full load cooling hours for New Hampshire by conducting a focused study of the chiller installations in the state.

Electronically Commutated Motors

The program currently offers incentives for installing EC motors on fan-powered terminal boxes, fan coil units, HVAC supply fans, refrigeration evaporator fans and small unitary equipment. The savings estimates were derived based on single study conducted by ERS. We recommend adding new applications to the ECM motor application and updating its algorithm and baseline description consistent with the regional programs.

Variable Frequency Drives

The program offers rebates for VFDs installed in HVAC and process applications with rated motor capacities up to 20 hp. The demand and energy savings parameters used by the New Hampshire program are based on a DMI study conducted in 2006 for the Massachusetts utilities. The DMI study utilized actual pre- and post-metered data on a number of projects to determine these factors. We did not have access to these studies, but based on a brief review we believe that these are credible estimates but are conservative or low compared to the latest factors published in the 2012 MA TRM. As a further enhancement, we recommend adding building types as a variable to the VFDs and updating the kWh/HP and kW/HP factors based on building types to further improve the accuracy of the savings estimates.

Air Compressors

The program offers rebates for new air compressors and primary air storage. Rebates are offered for load/unload, VFD and variable displacement type air compressors up to 75 hp. The rebate application also stipulates minimum storage capacity that goes with each compressor type and incentives are only paid for installing primary storage capacity that exceeds the minimum stipulated capacity.

The demand and energy savings parameters used by the New Hampshire programs are based on a focused study conducted by National Grid in Massachusetts. We did not have access to the study report that was used to determine these savings factors. However comparing the current New Hampshire estimates with the latest 2012 MA TRM indicates that the New Hampshire compressed air savings estimates are high and need to be reviewed and revised accordingly.

1.3 Review of Natural Gas Prescriptive Measure Baseline Algorithm

The natural gas Prescriptive program offers rebates for heating equipment, water heating equipment, integrated water heater/condensing boiler, controls equipment, and commercial kitchen equipment. The projects implementing Prescriptive natural gas measures have pre-defined baseline parameters and savings calculations set forth by the program.

1.3.1 Algorithm Observations

There are numerous parameters and specific calculations associated with each of the measure categories under the natural gas Prescriptive track of the program. Our observations for each type of technology are discussed briefly in the following paragraphs. The algorithm review for each measure is presented in greater depth in Section 2 of this report. A global observation was that several measure offerings were not consistent between the two utilities offering natural gas incentives.

Heating Equipment

Measures included under the heating equipment category in the Liberty Utilities incentive program include the installation of high-efficiency furnaces, condensing boilers, and low-intensity infrared heaters. The savings algorithms associated with the Prescriptive heating equipment measures have predetermined deemed savings based on a 2009 study conducted by GDS and other studies conducted by the regional gas utility companies. We were able to trace the studies related to majority of the parameters used in determining the deemed savings but the references for a few studies were not found. Overall, the baseline algorithms for the heating equipment were acceptable. Inconsistencies between program offerings were found.

Water Heating Equipment

Measures included in this category are on-demand tankless water heaters, indirect water heaters, and condensing stand-alone water heaters. Unitil also incentivizes ENERGY STAR-rated free-standing storage water heaters while Liberty Utilities does not. We believe that the deemed savings estimates for the various equipment are well documented and reasonable. Inconsistencies between program offerings were found.

Integrated Water Heater/Condensing Boiler

We believe that the deemed savings estimates for this measure are well documented and reasonable.

Controls Equipment

Measures included in this category are after-market boiler controls, repair/replacement of faulty steam traps, and ENERGY STAR-rated or 7-day programmable thermostats. We believe that the deemed savings estimates for the various equipment are well documented and reasonable. Inconsistencies between program offerings were found.

Commercial Kitchen Equipment

Measures included in this category are high-efficiency fryers, steamers, gas convection ovens, gas combination ovens, gas conveyor ovens, gas rack ovens, and gas griddles. Only Liberty Utilities offers incentives for the installation of low flow pre-rinse spray valves. The deemed savings were

Intentionally Left Blank

Executive Summary

1

1.1 Introduction

This document presents the results of a "baseline" evaluation for the New Hampshire commercial and industrial new construction program known as nhsaves@Work/New Equipment & Construction, and it was sponsored by the New Hampshire Monitoring and Evaluation Team (M&E Team). The M&E Team is comprised of representatives from the following New Hampshire utilities: Public Service Company of New Hampshire (PSNH), Liberty Utilities, Unitil Energy Systems, Inc., and New Hampshire Electric Cooperative Inc. (NHEC).

This evaluation had four primary components. First, a thorough assessment of the 2013 program measure savings algorithms was conducted. As a part of the assessment the sources for the algorithms were investigated for their accuracy and suitability with respect to the existing baseline parameters. The second component of the study was to review the recent New Hampshire Energy Code that became effective in April 2010 to assess the potential implications of this document on the baseline algorithms. As a subset of the code review, this study also compared the next energy code (IECC 2012) with the currently adopted code and assessed its impact on the current energy efficiency program offerings. The third area of focus of this evaluation was to assess the current practices employed for new construction projects in New Hampshire. The fourth area of focus involved limited primary research into energy efficiency program practices in the northeastern states and a general review of applicable documents to provide a basis for the parameters used in the energy savings algorithms.

Finally, based on these four components of the study, recommendations were developed for revisions to the baseline parameters and calculations that define the minimum qualifying levels of energy efficiency improvements and the corresponding energy savings.

This section (Executive Summary) provides a brief overview of the steps followed for the evaluation process and the resulting findings.

Section 2 presents a review of the existing baseline parameters and algorithms for each Prescriptive and Custom measure (and/or measure category) for the new-construction program as well as a discussion of the origins of these parameters.

Section 3 provides a review of all sections and details of the recent New Hampshire Commercial Energy Code. This section provides a comprehensive comparison of the baseline parameters for the new construction program with the IECC (International Energy Conservation Code) 2009 & 2012 and ASHRAE 90.1 (2007 & 2010) referenced by the new code.

Section 4 details the findings from primary research based on workshops conducted with New Hampshire architects and engineers to assess the current practices incorporated in the new construction industry. This section also presents a comparison of current practices with the program baseline.

Section 5 details the findings from secondary research based on literature review on current practices incorporated in the new construction industry in New Hampshire and nationwide.

Section 6 includes details of the baseline comparison of the New Hampshire programs with the neighboring New England states.

Section 7 summarizes the overall recommendations put forth as a result of synthesizing all of the information established in the previous sections associated with the commercial energy code review, baseline parameters comparisons and current practice research.

1.2 Overview of the Project Process

The evaluation process involved five major tasks. Each of these tasks is described below.

Task 1 – Review of current program baseline parameters: This task involved reviewing the current program's baseline parameters and algorithms for each approved Prescriptive and Custom measure. Additionally, an assessment of the projects conducted under the New Equipment & Construction Program to date was conducted.

Task 2 – Review of new commercial energy code: This task included a comprehensive review of the new commercial energy code, its relationship to the New Equipment & Construction Program and associated baseline parameters. The energy codes were reviewed from the perspective of the New Equipment & Construction Program to determine how the new code relates to the current approved measures. Similar to other states in the region, the recent New Hampshire energy code adopted in 2010 is based on ASHRAE 90.1-2007 and the International Energy Conservation Code (IECC) 2009. The code addresses numerous technical areas applicable to new construction or major renovation of commercial buildings such building envelope, mechanical systems, and lighting systems. As a sub-task, the impact of the future adoption of IECC 2012 on the energy efficiency program was also conducted.

Task 3 – Review of existing information on current practice: This task targeted a comprehensive compilation and review of data describing the current new-construction practices in New Hampshire's commercial sector and the relationship to the utilities' new construction program's baseline parameters. While the new energy code represents one area of consideration for the baseline practices, the actual "typical" practice in New Hampshire is another major consideration. The objective of this task was to gather and organize information to determine what the current practices are and to establish associated recommendations for enhancing the New Equipment & Construction Program baseline assumptions. For this task, ERS evaluated existing program history, reviewed pertinent literature sources, and conducted a limited number of workshops to facilitate discussions with market actors (architects, engineers, contractors, and distributors) involved in new construction in New Hampshire.

Task 4 – Baseline comparison with other states: This task involved a rigorous review of the programmatic baseline assumptions used in neighboring New England states. Tables were developed that compare each of the studied states with the baselines used in New Hampshire, with substantive reasons for discrepancies clearly described.

Task 5 – Synthesis of information and development of recommendations: Upon completion of Tasks 1 through 4 described above, the information obtained was reviewed collectively in relation to one another to provide interrelated insights. The result of this effort was to establish appropriate recommendations for revising designated baseline elements of the new construction program that integrates all elements of the evaluation.

1.3 Review of Electric Prescriptive Measure Baseline Algorithm

The electric Prescriptive program offers rebates for lighting, electronically commutated motors (ECMs), HVAC systems, chillers, and variable frequency drives (VFDs). The projects implementing Prescriptive measures have pre-defined baseline parameters and savings calculations set forth by the program.

1.3.1 Algorithm Observations

There are numerous parameters and specific calculations associated with each of the measure categories under the Prescriptive track of the program. Our observations for each type of technology are discussed briefly in the following paragraphs. The algorithm review for each measure is presented in greater depth in Section 2 of this report.

Lighting

The savings algorithms associated with the Prescriptive measures for lighting systems have been determined by various studies that are ongoing since 1994 that are conducted in collaboration with the Massachusetts utilities. The analysis was categorized by code types (the program incorporates lighting codes to identify technology groupings), and the analysis reviewed the baseline technologies and their relationship to the demand and energy savings calculation algorithms. The baseline algorithms for a number of the lighting technologies were found to be acceptable, however, while in other instances we have recommended specific changes.

Unitary Systems

The base efficiencies for unitary equipment are based on a work done by the Northeastern utility companies in association with Consortium for Energy Efficiency (CEE). The savings algorithms and the associated baseline parameters for unitary systems were reviewed. Based on our investigation, we believe that the energy savings algorithms and the associated energy performance values used in the baseline algorithm are acceptable. We feel that further refinement of the equivalent full load hours (EFLH) for New Hampshire would be beneficial consistent with the methods adopted by the Massachusetts programs, but would require further study investigation. The EFLH hours applied to the hospital facility type in the current calculation spreadsheet were observed to higher when compared with the 2011 and 2012 MA TRM hours for the same facility type. Since the EFLH estimate in the MA TRM document have been developed through indepth study of a variety of building types, we feel that the New Hampshire hours should also be similar to the Massachusetts estimates. Hence, we recommend revising the EFLH applied to the hospital building types to either be consistent with the MA TRM up until New Hampshire decides to revise these estimates specific to their state. In addition to the hospital hours, we recommend reviewing the EFLH hours applied to all facility types and making them consistent with the regional estimates.

Chillers

The NE&C program offers incentives for air-cooled chillers, water-cooled rotary screw and scroll and water-cooled centrifugal chillers. Even though the minimum performance values for air-cooled and water cooled chillers specified in the rebate applications exceed those in the codes, the baseline efficiency values match those specified in the codes. Based on the baseline algorithm, we believe that the values used are consistent with the current technological developments and, hence, are acceptable. Based on discussions with the PMs with the different New Hampshire utilities, we found that different default full load cooling hours are being used when none is offered by the applicant. We recommend reviewing the hours used for the different facility types and making them consistent with the 2012 MA TRM in the short term. In the long term, we recommend determining the full load cooling hours for New Hampshire by conducting a focused study of the chiller installations in the state.

Electronically Commutated Motors

The program currently offers incentives for installing EC motors on fan-powered terminal boxes, fan coil units, HVAC supply fans, refrigeration evaporator fans and small unitary equipment. The savings estimates were derived based on single study conducted by ERS. We recommend adding new applications to the ECM motor application and updating its algorithm and baseline description consistent with the regional programs.

Variable Frequency Drives

The program offers rebates for VFDs installed in HVAC and process applications with rated motor capacities up to 20 hp. The demand and energy savings parameters used by the New Hampshire program are based on a DMI study conducted in 2006 for the Massachusetts utilities. The DMI study utilized actual pre- and post-metered data on a number of projects to determine these factors. We did not have access to these studies, but based on a brief review we believe that these are credible estimates but are conservative or low compared to the latest factors published in the 2012 MA TRM. As a further enhancement, we recommend adding building types as a variable to the VFDs and updating the kWh/HP and kW/HP factors based on building types to further improve the accuracy of the savings estimates.

Air Compressors

The program offers rebates for new air compressors and primary air storage. Rebates are offered for load/unload, VFD and variable displacement type air compressors up to 75 hp. The rebate application also stipulates minimum storage capacity that goes with each compressor type and incentives are only paid for installing primary storage capacity that exceeds the minimum stipulated capacity.

The demand and energy savings parameters used by the New Hampshire programs are based on a focused study conducted by National Grid in Massachusetts. We did not have access to the study report that was used to determine these savings factors. However comparing the current New Hampshire estimates with the latest 2012 MA TRM indicates that the New Hampshire compressed air savings estimates are high and need to be reviewed and revised accordingly.

1.4 Review of Natural Gas Prescriptive Measure Baseline Algorithm

The natural gas Prescriptive program offers rebates for heating equipment, water heating equipment, integrated water heater/condensing boiler, controls equipment, and commercial kitchen equipment. The projects implementing Prescriptive natural gas measures have pre-defined baseline parameters and savings calculations set forth by the program.

1.4.1 Algorithm Observations

There are numerous parameters and specific calculations associated with each of the measure categories under the natural gas Prescriptive track of the program. Our observations for each type of technology are discussed briefly in the following paragraphs. The algorithm review for each measure is presented in greater depth in Section 2 of this report. A global observation was that several measure offerings were not consistent between the two utilities offering natural gas incentives.

Heating Equipment

Measures included under the heating equipment category in the Liberty Utilities incentive program include the installation of high-efficiency furnaces, condensing boilers, and low-intensity infrared heaters. The savings algorithms associated with the Prescriptive heating equipment measures have predetermined deemed savings based on a 2009 study conducted by GDS and other studies conducted by the regional gas utility companies. We were able to trace the studies related to majority of the parameters used in determining the deemed savings but the references for a few studies were not found. Overall, the baseline algorithms for the heating equipment were acceptable. Inconsistencies between program offerings were found.

Water Heating Equipment

Measures included in this category are on-demand tankless water heaters, indirect water heaters, and condensing stand-alone water heaters. Unitil also incentivizes ENERGY STAR-rated free-standing storage water heaters while Liberty Utilities does not. We believe that the deemed savings estimates for the various equipment are well documented and reasonable. Inconsistencies between program offerings were found.

Integrated Water Heater/Condensing Boiler

We believe that the deemed savings estimates for this measure are well documented and reasonable.

Controls Equipment

Measures included in this category are after-market boiler controls, repair/replacement of faulty steam traps, and ENERGY STAR-rated or 7-day programmable thermostats. We believe that the deemed savings estimates for the various equipment are well documented and reasonable. Inconsistencies between program offerings were found.

Commercial Kitchen Equipment

Measures included in this category are high-efficiency fryers, steamers, gas convection ovens, gas combination ovens, gas conveyor ovens, gas rack ovens, and gas griddles. Only Liberty Utilities offers incentives for the installation of low flow pre-rinse spray valves. The deemed savings were found to be reasonable with sufficient background information. Some inconsistencies between the program offerings were observed.

1.5 Findings Applicable to Energy Codes and the New Construction Program

This section presents the findings after a comprehensive review of the recent New Hampshire Commercial Energy Code and its relationship to the nhsaves@Work/New Equipment & Construction Program baseline parameters. In April 2010, New Hampshire adopted the IECC 2009 (International Energy Conservation Code.

The new energy code was reviewed from the perspective of the New Equipment & Construction Program with the intention of determining how the new code relates to the existing Prescriptive and Custom measures. In addition to IECC 2009, we reviewed ASHRAE Standard 90.1-2007, which is referenced in the IECC 2009 document. It is also valuable to understand that the new construction program may have broader technology scope than the energy code, particularly when Custom measures are considered.

It should be noted that the IECC 2009 Code Chapter 5 prevails in the majority of instances for new construction projects, and that ASHRAE Standard 90.1-2007 only comes into play when designated criteria specified in IECC 2009 are not satisfied. Although it is difficult to predict definitively, it appears that most new construction projects will fall under the IECC specifications. Subsequently, the baseline algorithm parameters need to reflect the IECC 2009 requirements as a rule, and not ASHRAE Standard 90.1-2007. The nhsaves@Work baseline parameters, as a whole, do exceed the requirements put forth by the IECC 2009 Code.

1.5.1 Electric Prescriptive Measures

The following paragraphs discuss our observations from code review of the electric prescriptive measures.

Lighting

The nhsaves@Work New Equipment & Construction (NE&C) Program specifies lighting fixture types and efficiencies. In contrast, the energy code focuses on LPD, with each space or building type being assigned a maximum allowable lighting power density. The intention of the NE&C program is that if specification of efficient technologies (T8 lamps, electronic ballasts, metal halide fixtures, efficient fixture configurations, etc.) is utilized in typical uniform layouts, code-mandated LPD levels will be met. However, we believe that it is important to consider the integration of LPD calculations into the NE&C program. This could be accomplished by requesting the applicants to include information such as the building type and the square footage information along with the proposed fixture data in the lighting application. This could then be compared with the code specified LPD values.

The program also offers incentives for a variety of occupancy based controls. The energy code requires installation of central timer based controls or local motion based controls. Therefore, strictly based on a code comparison, we did not find any conflicts of the lighting controls with the current code language. However, based on multiple interviews with architects and engineers working the state of New Hampshire, we found that installing local occupancy based controls has become a standard practice, hence we have suggested eliminating certain automatic lighting controls from the NE&C rebate forms.

Unitary Systems

In a new construction project for unitary systems, the efficiency specified by the utility to qualify for rebates is considered as the proposed case and is compared with the baseline efficiency specified by the energy codes. Our review for the HVAC unitary equipment indicates that with the exception of a few unitary AC and split systems and air-to-air heat pumps, efficiency values of all other unitary HVAC units required for rebates under the program are greater than the efficiencies specified by the IECC 2009 energy code. As a general note, our review also found that utility programs were not using efficiency units that were consistent with those specified in the code.

Chillers

The baseline efficiency requirement specified by the New Hampshire utilities for rebate eligibility was compared with IECC 2009. For the air and water-cooled chillers, the current algorithms use Path B chiller efficiency values as the baseline efficiency to estimate the savings. Path B chiller efficiencies are suited for chillers operating in part load for majority of its time, while Path A chiller efficiencies are specified for chillers operating at or close to full load most of the time. The code only requires the chillers to meet the full load and part load efficiencies specified under one path, and not both.

The baseline full load efficiencies in the New Hampshire savings spreadsheet did not include the corresponding part load IPLV data and hence has been recommended for inclusion in the New Hampshire savings spreadsheet for an accurate comparison with the code requirements.

Electronically Commutated Motors

The IECC 2009 does not have a section that addresses minimum energy efficiency for EC motors.

Variable Frequency Drives

The codes, as a whole, require the use of VFDs in the supply and return fan applications for motors above 10 hp. VFDs on exhaust fans are not adequately referenced in the codes. The codes indirectly indicate the requirement to install VFDs on certain hydronic applications and heat rejection devices.

1.5.2 Natural Gas Prescriptive Measures

The following paragraphs discuss our observations from code review of the natural gas prescriptive measures.

Heating Equipment

The baseline efficiencies of the program-specified measures exceeded the efficiency values specified in the code. As a general note, our review also found that utility programs were not using efficiency units that were consistent with those specified in the code.

Water Heating Equipment

The review of baseline efficiencies and code-specified efficiencies indicated that the baseline efficiency of the on-demand tankless water heater needs to be increased slightly to match the code specified value. Our review also found that utility programs were not using efficiency units that were consistent with those specified in the code. For all other measure types, the baseline efficiencies exceeded those specified in the code.

Integrated Water Heater/Condensing Boiler

The baseline efficiencies of the program specified measures exceeded the efficiency values specified in the code.

Controls Equipment

A review of codes suggested that the boiler reset controls measure needs to be limited to boiler systems below 300 MBH, as the current code requires the installation of such controls on boilers with capacities greater than 300 MBH.

The code does not have a section that addresses the steam trap maintenance or replacement requirements. The code requires the installation of programmable thermostats capable of 7-day scheduling. As a result, we have recommended removing the thermostat measure from the programs.

Commercial Kitchen Equipment

The IECC 2009 does not have a section that addresses minimum energy efficiency for commercial kitchen equipment.

1.5.3 Custom Measures

The Custom program is specifically intended for applications that are not covered by the Prescriptive programs. Similar to the Prescriptive programs, the Custom program has qualifying criteria and, in some technologies, specified requirements that must be met by the project.

The observations from our code review and baseline parameter comparison for the Custom measures are as follows:

Lighting

The IECC 2009 and ASHRAE Standard 90.1 2007 do not specify particular types of lighting fixtures for interior lighting but instead specify an allowable lighting power density. The nhsaves@Work Custom program has a somewhat broad specification for interior lighting controls independent of application, while the energy code specifies designated controls for designated applications. For exterior lighting, the energy code and program standard practice used different approaches to achieve the same result. The code incorporates efficacy while the nhsaves@Work Custom program defines fixture technology. Both approaches effectively achieve a similar result for exterior applications.

Mechanical Systems

Based on our comparative review of the various components of the Custom mechanical system descriptions with IECC 2009, our observations are presented below:

Criteria specified for mechanical systems associated with office buildings, fume hoods, and kitchen hood exhaust systems are fully specified in the baseline practices document, but are not addressed as completely in the codes. Additionally, for manufacturing and office areas specified in the baseline practices, the descriptions are not specific enough to suggest inconsistency with the codes.

Unitary HVAC Systems

Baseline efficiencies of most of the unitary HVAC systems are appropriate relative to the code-specified efficiencies.

Chillers

The baseline practice document states certain requirements like cooling tower selection, chiller sequencer controls, heat exchangers for free cooling, etc., that are not addressed by the codes.

Building Control Systems

The baseline practice requirements for building control systems were found to comply with the New Hampshire energy codes.

Boilers

The baseline requirements for boiler support system are not addressed by the codes.

Other Applications

The new energy code does not address many other Custom program applications such as refrigeration, waste water treatment, ice rinks, process-related equipment, plastic injection molding machines, and air compressors.

1.6 Information Related to Current Practices and the New Construction Program

As part of the overall evaluation study process, ERS conducted two workshops to facilitate discussions with the market actors in the design and construction trades in New Hampshire. More than thirty individuals participated in these workshops, representing architects, engineers, distributors, and contractors trades. Valuable insights were gleaned regarding the standard practices at their firms.

In conducting the two workshops, we used an informal process where we used an outline to guide us through a series of focus areas and points of inquiry. The workshops began with a series of information slides on codes and future direction of codes. We then interviewed the participants regarding their design practices and code enforcement experiences. We also discussed high efficiency design practices, such as LEED, and their effects on the end users. We also discussed a variety of different technology areas, requesting information on the types of systems the firm designs or specifies, and the efficiency of those systems. Appendix A provides the PowerPoint presentation that was developed for these workshops.

In general the participants indicated that code does represent an adequate baseline for most installations as most of the projects are designed to meet the minimum code requirements. Participants indicated that they are well aware of the energy efficiency programs but that the program incentives are not large enough to move the decision-makers during critical decision-making points. Market factors emphasizing first-cost concerns have remained a barrier, however, to the penetration of new premium efficiency technologies. These findings are completely discussed in Section 4 of this report.

1.7 Recommendations and Conclusions

Tables 1-1 through 1-4 present a concise overview of our findings from the study for lighting systems, chiller systems, unitary HVAC systems, EC motors, VFDs and compressed air systems.

Table 1-1 (Part 1 of 2)
Recommended Changes to Prescriptive Lighting Applications

Measure Code	Measure Description	Comment	Recommendation
10	Fluorescent fixtures with high performance or reduced wattage (HP/RW) lamp & ballast systems or a T5 lamp and ballast system.	T8s are baseline (Not T12s)	Change factor from 1.3 to 1.18
30A	High efficiency 2 lamp prismatic lensed fluorescent fixtures, 2x2 or 2x4	The proposed savings factor is based on a LPD method	Change savings from 11W/fixture to 35W/fixture
30B	High efficiency 2 lamp parabolic fluorescent fixtures, 2x2 or 2x4	The proposed savings factor is based on a LPD method	Change savings from 11W/fixture to 35W/fixture
30C	High efficiency 2 lamp recessed indirect/direct fluorescent fixtures 2x2 or 2x4	The proposed savings factor is based on a LPD method	Change savings from 11W/fixture to 35W/fixture
31	High efficiency 3 lamp fluorescent fixtures 2x4	Not a typical high volume measure. It can be served by code 10.	Eliminate the code. Can be covered using code 10 ¨
33	High efficiency indirect low glare pendant fluorescent fixtures	The proposed savings factor is based on a LPD method	Change savings from 15W/fixture to 20W/fixture
34	Advanced Recessed Fluorescent Fixtures 1x4 or 2x4	The proposed savings factor is based on a LPD method	Change savings from 17W/fixture to 20W/fixture
41	Industrial/commercial fluorescent fixtures – 4 ft. and 8 ft. fixtures	T8s are baseline (Not T12s)	change factor from 1.46 to 1.1
44	Clean room rated fluorescent fixtures 1x4 or 2x4	Not a typical high volume measure.	Review how many rebates are processed in a typical year and determine whether to keep it.

Table 1-1 (Part 2 of 2)
Recommended Changes to Prescriptive Lighting Applications

Measure Code	Measure Description	Comment	Recommendation
21	Compact fluorescent fixture	Only offered to small C&I customers.	Modify baseline to match EISA 2007 guidelines
23	Dimmable compact fluorescent fixture	Only offered to small C&I customers.	Modify baseline to match EISA 2007 guidelines
56	High intensity fluorescent fixtures (HIF) for low bay applications (≤ 210W)	Becoming a standard practice to install HIF.	Consider elimination of this code type in a year as it is becoming a standard practice
57	High intensity fluorescent fixtures (HIF) for high bay applications (≥ 210W)	Becoming a standard practice to install HIF.	Consider elimination of this code type in a year as it is becoming a standard practice
70	Metal halide specialty lighting fixtures with electronic ballast	LEDs are becoming common.	Consider eliminating as LEDs are becoming more common.
80	LED downlight fixtures hard wired or GU-24 base	The current analysis spreadsheet did not have supporting data	We recommend new savings factors. Please see section 2.2.3.
82A	LED cooler, freezer case or refrigerated shelving fixtures – 3' & 4' fixtures		
82B	LED cooler, freezer case or refrigerated shelving fixtures – 5' & 6' fixtures		
83	LED low bay fixtures - garage fixtures		
84	LED track heads		
61	Remote-mounted occupancy sensor	Currently applying a constant 25% time savings factor	Consider using 2013-2015 MA TRM as reference for the facility hours reference and using custom time savings factor by space/facility type
62	Daylight dimming system (DDS-FL)		
63	Occupancy controlled step-dimming system		
64A	Wall mounted occupancy sensors	Is becoming a standard practice	Eliminate as it is standard practice
64B	Wall mounted vacancy occupancy sensors	Currently applying a constant 25% time savings factor	Consider using 2013-2015 MA TRM as reference for the facility hours reference and using custom time savings factor by space/facility type
65	Photocell sensors (lighting systems on 24/7)	Currently applying a constant 25% time savings factor	Consider removing this measure as energy code require installation of photosensor and time switch control or an astronomical time clock control on all exterior lighting.
68	High bay fluorescent (HIF) occupancy control systems	Currently applying a constant 25% time savings factor	Consider using 2013-2015 MA TRM as reference for the facility hours reference and using custom time savings factor by space/facility type

Table 1-2
Recommended Changes to Prescriptive Chiller Applications

<table>
<tr><th>Unit Size
ARI Net Tons</th><th>Base Efficiency</th><th>Recommendation</th></tr>
<tr><td>Air cooled chillers < 150 tons</td><td>9.562 EER</td><td rowspan="10">1) Add IPLV in the base efficiency term.
2) Review the EFLH hours used for the various building types as they are higher than typical for northeast (reference 2013-2015 MA TRM).
3) Where applicable, consider modifying the chiller application to process Path A/Path B chillers and adjust the energy savings algorithm accordingly.</td></tr>
<tr><td>Air cooled chillers ≥ 150 tons</td><td>9.562 EER</td></tr>
<tr><td>Water cooled chillers (rotary screw or scroll) < 75 tons</td><td>0.800 kW/ton</td></tr>
<tr><td>Water cooled chillers (rotary screw or scroll) ≥ 75 and < 150 tons</td><td>0.890 kW/ton</td></tr>
<tr><td>Water cooled chillers (rotary screw or scroll) ≥ 150 and < 300 tons</td><td>0.718 kW/ton</td></tr>
<tr><td>Water cooled chillers (rotary screw or scroll) ≥ 300 tons</td><td>0.639 kW/ton</td></tr>
<tr><td>Water cooled chillers (centrifugal) < 150 tons</td><td>0.639 kW/ton</td></tr>
<tr><td>Water cooled chillers (centrifugal) ≥ 150 and < 300 tons</td><td>0.639 kW/ton</td></tr>
<tr><td>Water cooled chillers (centrifugal) ≥ 300 and < 600 tons</td><td>0.600 kW/ton</td></tr>
<tr><td>Water cooled chillers (centrifugal) ≥ 600 tons</td><td>0.590 kW/ton</td></tr>
</table>

Table 1-3
Recommended Changes to Prescriptive Unitary HVAC Applications

Size (Btuh)	Base Efficiency (EER)	Recommendation
Unitary AC and Split Systems (new condenser and new coil)		
< 65,000 Split System Packaged System	11.1	Make base efficiency units consistent with code and expand bldg types.
≥ 65,000 to < 135,000	11.2	
≥ 135,000 to < 240,000	10.6	
≥ 240,000 to < 760,000	9.5	
≥ 760,000	9.5	
Air to Air Heat Pump Systems		
< 65,000 Split System Packaged System	11.1	Make base efficiency units consistent with code, add HSPF or COP to the baseline efficiency and expand bldg types.
≥ 65,000 to < 135,000	11.0	
≥ 135,000 to < 240,000	10.6	
≥ 240,000	9.5	
Water Source Heat Pumps		
≤ 135,000	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	
Ground Water - Water Source Heat Pump Equipment (Open Loop)		
≤ 135,000	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	
Ground Water - Water Source Heat Pump Equipment (Closed Loop)		
≤ 135,000	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	
Energy Savings Control Options (when installed with new & qualifying Tier 1 or 2 equipment		
Dual Enthalpy Economizer	Fixed dry-bulb economizer	No change.
Demand Control Ventilation	No-ventilation control.	No change.

Table 1-4
Recommended Changes to Prescriptive Electronically Commutated Motors (ECMs) Applications

Measure Description	Baseline	Box size factor (W/CFM)	Recommendation
EC Motors (< 1000 CFM)	Single speed PSC induction motor	0.32	Consider using the 2013-2015 MA TRM as a reference. Allow other applications such as refrigeration display cases to be included in the forms.
EC Motors (≥ 1000 CFM)	Single speed PSC induction motor	0.21	

Table 1-5
Recommended Changes to Prescriptive VFD Measures

Measure	Recommendation
Supply fan on constant volume supply air handler. [SFA]	1) For the application of VSDs on supply, return and exhaust fans, we recommend revising the savings algorithms based on the building type. 2) For supply and return fans on VAV units, we recommend modifying the minimum requirements to allow incentives only for units with fans below 10 hp. 3) Modify the cooling tower fan VSD requirement to provide incentives only for fans below 7.5 hp 4) In the near term, we recommend adopting the methods and factors stated in the 2013-2015 MA TRM. In the long term, we recommend conducting revising the savings factors based on a separate study targeted towards the buildings in New Hampshire. NH program offerings for VFDs are consistent with the programs in the neighboring states.
Return fan on constant volume return air handler [RFA]	
Supply fan on VAV packaged HVAC unit [SFP]	
Return fan on VAV packaged HVAC unit [RFP]	
Building exhaust fan [BEF]	
Process exhaust fan [PEF]	
Fume hood exhaust fan and makeup air fan [HEF]	
Circulation pump for water source heat pump loop [WWP]	
Process heating & cooling circulation pumps [PHC]	
Boiler feed water pump [FWP]	
Boiler draft fan [BDF]	
Hydraulic pumps [HYP]	
Cooling Tower Fan [CTF]	

Table 1-6
Recommended Changes to Prescriptive Compressed Air Applications

Measure	Compressor/Dryer Type	Base Case Technology	Recommendation
L/NL	Load/No Load Compressor 15-24 hp	Modulating compressor with blow down valve	1) Consider eliminating the incentives for variable displacement compressors as VSD compressors are more commonly adopted. Variable displacement compressors do not offer any significant advantage over the more popular VSD compressors. 2) In the long term, consider revising the baseline from inlet modulation to load/unload. 3) There is opportunity to further enhance the program offering by offering incentives for low pressure drop air filters, low pressure drop piping and no-loss condensate drain traps.
L/NL	Load/No Load Compressor 25-49 hp	Modulating compressor with blow down valve	
L/NL	Load/No Load Compressor 50-75 hp	Modulating compressor with blow down valve	
VD	Variable Displacement Compressor 15-24 hp	Modulating compressor with blow down valve	
VD	Variable Displacement Compressor 25-49 hp	Modulating compressor with blow down valve	
VD	Variable Displacement Compressor 50-75 hp	Modulating compressor with blow down valve	
VSD	VSD Compressor 15-24 hp	Modulating compressor with blow down valve	
VSD	VSD Compressor 25-49 hp	Modulating compressor with blow down valve	
VSD	VSD Compressor 50-75 hp	Modulating compressor with blow down valve	
Dryer	Dryer Category with < 100 CFM cycling	Standard refrigeration dryer	No Change.
Dryer	Dryer Category with 100-199 cycling	Standard refrigeration dryer	
Dryer	Dryer Category with 200-299 CFM cycling	Standard refrigeration dryer	
Dryer	Dryer Category with 300-399 CFM cycling	Standard refrigeration dryer	
Dryer	Dryer Category with => 400 CFM cycling	Standard refrigeration dryer	
Dryer	Dryer Category with < 100 CFM VSD	Standard refrigeration dryer	
Dryer	Dryer Category with 100-199 VSD	Standard refrigeration dryer	
Dryer	Dryer Category with 200-299 CFM VSD	Standard refrigeration dryer	
Dryer	Dryer Category with 300-399 CFM VSD	Standard refrigeration dryer	
Dryer	Dryer Category with => 400 CFM VSD	Standard refrigeration dryer	
Storage	Above minimum required (2 - 4 gallons per CFM) below Max Required (3 - 5 Gallons per CFM)		

Tables 1-7 through 1-10 present a concise overview of our findings from the study for the natural gas measures – heating systems, water heating systems, controls and commercial kitchen equipment.

Table 1-7
Recommended Changes to Prescriptive Natural Gas Measures – Heating Systems

<table>
<tr><th>Measure</th><th>Measure Description</th><th>Recommendations</th></tr>
<tr><td>Furnace ≤ 150 MBH (92% AFUE)</td><td rowspan="4">The installation of high eff natural gas warm air furnace with an ECM for the fan.</td><td rowspan="4">Reconcile the differences between the incentive applications and validate the gross savings estimates with the 2013-2015 MA TRM</td></tr>
<tr><td>Furnace ≤ 150 MBH (94% AFUE)</td></tr>
<tr><td>Furnace ≤ 300 MBH (92% AFUE)</td></tr>
<tr><td>Furnace ≤ 300 MBH (94% AFUE)</td></tr>
<tr><td>Infrared heaters all sizes</td><td>The installation of a gas-fired low intesity infrared heating system in place of unit heater, furnace, or other standard eff equip.</td><td>No change</td></tr>
</table>

Table 1-8
Recommended Changes to Prescriptive Natural Gas Measures – Water Heating Systems

<table>
<tr><th>Measure</th><th>Recommendations</th></tr>
<tr><td>Hydronic boiler ≤ 300 MBH</td><td rowspan="5">Make the program offerings consistent throughout the state. Unitil is offering incentives for this measure.</td></tr>
<tr><td>Hydronic boiler 301 to 499 MBH</td></tr>
<tr><td>Hydronic boiler 500 to 999 MBH</td></tr>
<tr><td>Hydronic boiler 1000 to 1700 MBH</td></tr>
<tr><td>Hydronic boiler ≥ 1701 MBH</td></tr>
<tr><td>Condensing boiler ≤ 300 MBH</td><td rowspan="6">No change</td></tr>
<tr><td>Condensing boiler 301 to 499 MBH</td></tr>
<tr><td>Condensing boiler 500 to 999 MBH</td></tr>
<tr><td>Condensing boiler 1000 to 1700 MBH</td></tr>
<tr><td>Condensing boiler 1701 to 2500 MBH</td></tr>
<tr><td>Condensing ≥ 2500 MBH</td></tr>
</table>

Table 1-9
Recommended Changes to Prescriptive Natural Gas Measures – Controls

Measure	Measure Description	Recommendations
After market boiler reset controls	Boiler reset controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.	Eliminate as they are required by code.
Steam Traps	Repair or replace malfunctioning steam traps.	Eliminate as it is a retrofit measure.
Energy Star or 7-day programmable thermostats	Installation of a 7-day programmable thermostat with the ability to adjust heating or air-conditioning operating times according to a pre-set schedule to meet occupancy needs and minimize redundant HVAC operation.	Eliminate as they are required by code.

Table 1-10
Recommended Changes to Prescriptive Natural Gas Measures – Commercial Kitchen Equipment

<table>
<tr><th>Measure</th><th>Measure Description</th><th>Recommendations</th></tr>
<tr><td>Energy Star Fryer</td><td>The installation of a natural gas-fired fryer that is either ENERGY STAR rated or has a heavy load efficiency of at least 50%.</td><td>No Change</td></tr>
<tr><td>Energy Star Commercial Steamer</td><td>The installation of an ENERGY STAR rated natural gas-fired steamer, either connectionless or steam-generator design, with heavy-load cooking efficiency of at least 38%.</td><td>No Change</td></tr>
<tr><td>Energy Star Commercial Convection Oven</td><td rowspan="4">Installation of high-efficiency gas ovens</td><td rowspan="3">Reconcile the proposed equipment efficiencies between the two programs.</td></tr>
<tr><td>High Efficiency Gas Combination Oven</td></tr>
<tr><td>High Efficiency Gas Conveyor Oven</td></tr>
<tr><td>High Efficiency Gas Rack Oven</td><td>No Change</td></tr>
<tr><td>Energy Star Commercial Griddle</td><td>Installation of a gas griddle with an efficiency of 38%.</td><td>No Change</td></tr>
<tr><td>High Efficiency Pre-Rinse Spray Valve</td><td>Natural gas-fired hot water heaters serving new low-flow pre-rinse spray nozzles with an average flow rate of 1.6 GPM.</td><td>Consider eliminating this measure as EPACT 2005 requires new nozzles to not exceed 1.6 GPM. See Section 6.2.5</td></tr>
</table>

Intentionally Left Blank

Overview of the Current Program and Baseline

2

2.1 Introduction

This section presents the review of the current New Equipment & Construction (NE&C) Program's baseline parameters and algorithms for each approved Prescriptive measure. The approach currently established for each of the Prescriptive measures is discussed and ERS's comments regarding the algorithms are also presented. Additionally, an assessment of the Custom projects conducted under the nhsaves@work New Equipment & Construction program to date by each of the participating utilities is presented. The topics discussed are the types of measures, the types of projects, and how the baseline for Custom projects is assessed.

2.2 Overview of the Prescriptive Program

There are two different tracks that the New Equipment & Construction energy efficiency projects follow under the nhsaves@work program – 1) Prescriptive or 2) Custom. Under the Prescriptive Program, the electric utilities offers incentives for lighting, lighting controls, ECM motors, HVAC systems, chillers, variable frequency drives (VFDs), and compressed-air systems that meet designated efficiency requirements and typically reflect straightforward projects. Under the Prescriptive Program, the natural gas utilities offer incentives for high efficiency heating, water heating, and cooking equipment; boiler reset controls; steam traps, and programmable thermostats. For these projects, baseline parameters and savings calculations are pre-defined and set forth by the program. For projects that do not fall into the Prescriptive project category, a Custom track is followed and individual assessments are conducted to determine the energy savings and incentives are specified on a case-by-case basis.

The nhsaves@work/New Equipment & Construction program was modeled on a similar program developed for the Massachusetts market. We were informed that each year an evaluation team is employed to review the validity of the baseline parameters and savings calculations used for their program. During this review, the team considers the current energy codes and the feedback received from utility clients and consulting firms. This process is implemented so that the baseline parameters and algorithms reflect current practice and energy codes for New Hampshire.

This section reviews the baseline parameters as they have been incorporated for the nhsaves @work/New Equipment & Construction program and how they fit for New Hampshire's new construction market.

2.2.1 Type of Measures

The nhsaves@work New Equipment & Construction program covers the following type of Prescriptive measures:

- Lighting – The measures include fluorescent fixtures with high performance or reduced wattage lamp and ballast systems, compact fluorescent and dimmable compact fluorescent fixtures, metal halide specialty fixtures, high intensity fluorescent fixtures, LED fixtures, and lighting controls for fluorescent and high intensity discharge (HID) systems.
- HVAC equipment and controls – The measures include unitary AC and split, air-to-air heat pump systems, water source heat pumps, dual enthalpy economizers, and demand controlled ventilation.
- Chillers – The measures include air-cooled chillers, and water-cooled rotary screw, scroll, and centrifugal chillers.
- VFDs – The measures include VFDs for fans and pumps installed in HVAC systems: air distribution systems, chilled water distribution pumps, boiler feed water pumps, process heating and cooling circulation pumps, and hydraulic pumps. The motor capacity covered by the VFD program ranges from 5 hp to 20 hp.
- Motors – The measures include electronically commutated motors less than 1 hp only. The motors must be installed on new fan-powered terminal boxes, fan coils, or HVAC supply fans on small unitary equipment.
- Compressed air – The measures include load/no load, variable speed, and variable displacement air compressors with motors rated between 15 hp to 75 hp and receiver tanks.
- Heating equipment – The measures are incentivized for their natural gas impacts; they include furnaces, infrared heaters, hydronic boilers, condensing boilers, and ENERGY STAR-rated condensing unit heaters.
- Water heating equipment – These measures are incentivized for their natural gas impacts and include on-demand tankless water heaters, high-efficiency indirect water heaters, condensing stand-alone water heaters, and ENERGY STAR-rated storage water heaters.
- Integrated water heater/condensing boiler – This measure is incentivized for its natural gas impact, and it is for a single boiler that provides both space heating and hot water.
- Controls equipment – These measures are incentivized for their natural gas impacts, and they include after-market boiler reset controls, steam trap repair/replacement, and ENERGY STAR-rated/7-day programmable thermostats.
- Commercial kitchen equipment – These measures are incentivized for their natural gas impacts, and they include high-efficiency combination, rack, conveyor, and convection ovens. Also included in the commercial kitchen incentive measures are high-efficiency fryers, steamers, griddles, and pre-rinse spray valves.

For all of these measures, the program offers incentives if the proposed equipment is proven to meet the program's specific eligibility criteria. The eligibility criteria are mainly based on the energy efficiency of the proposed equipment, but there are other aspects that are also considered, such as operating hours and size (consumption) of the customer. All of these aspects will be thoroughly discussed in the following sections.

2.2.2 Origin of the Baseline Parameters

There are numerous parameters and specific calculations associated with each of the measure categories under the Prescriptive track of the program. This section discusses the basis for these algorithms for each measure category.

Lighting Systems

The savings algorithms associated with the prescriptive measures for lighting systems have been determined using internal studies conducted by the National Grid evaluation team and inputs from independent consulting firms. In addition, a white paper by NEES for the Prescriptive lighting program of the Massachusetts Electric Company, "Energy Efficient Lighting for Design 2000," was also referenced for analyzing savings based on the use of efficient lighting fixtures. The correction factors used in the algorithms represent either averaged wattage savings for replacing the base technologies with more energy-efficient technologies, or with an average percentage savings. These savings consider the whole spectrum of rated demands under the specific measure code (10, 30, 23, etc.) and compare specific technologies applicable to that code.

HVAC Equipment

The base efficiencies for the unitary equipment are based on the 2009 International Energy Conservation Code, Tables 503.2.3.(1) and 503.2.3.(2). The equivalent full-load hours (EFLH) are based on ASHRAE standard 90.1-2003. Each year, a worksheet evaluation team checks for the validity of the base efficiencies for unitary equipment.

Chillers

Base efficiencies for the chillers are based on 2009 International Energy Conservation Code, Table 503.2.3(7). The EFLH are based on ASHRAE standard 90.1-2003.

VFDs

The demand and annual electric energy savings are calculated by multiplying the deemed savings defined as kW per hp and kWh per hp, respectively, with the VFD rated hp. The kW and kWh per hp factors have been determined by internal studies conducted by National Grid engineers and progressively developed between 1994 and 1996. This study involved measuring power draw for the particular end use before and after the VFD installation. These measurements were mostly taken in the period between 1992 and 1996 and were then used to determine the factors used in the algorithms for the supply fans, return fans, exhaust fans, chilled water pumps, and boiler feed water pumps. These demand savings factors and the annual operating hours used in the energy savings algorithms have been determined through extensive modeling simulation and field measurements. The factors for thirteen out of the seventeen different applications considered for this measure are based on a report dated 2006 by DMI.

Electronically Commutated Motors (ECM) Motors

The savings for this measure are based on savings estimates for a project developed by ERS. It was not based on actual pre- and post-installation measurements.

2.2.3 Savings Algorithms Assessment

ERS has done an analysis of the savings algorithms used for calculating the electric demand and energy and natural gas savings under the Prescriptive programs. We have assessed the baseline efficiencies utilized for different incentivized measures and have investigated if the existing algorithms are reasonably accurate in today's TRM. Our analysis is based on the data discussed above and on our own experience with similar projects. It should be noted that the engineering calculations incorporated for the algorithms are relatively simple and are not intended to represent a statistical assessment.

Lighting Systems

For the lighting systems, we developed the analysis for each measure code (the program incorporates measure codes to identify technology groupings) and looked at the currently used baseline technologies and their relationship to the demand and energy savings calculation algorithms. Each code group is presented separately in Table 2-1, which presents the savings algorithms for the different lighting measure codes. The energy savings are based on actual project estimated hours; if the actual project hours are not available, then hours from a list of more than thirty building types are used.

Table 2-1 (1 of 2)
Savings Algorithms for Prescriptive Lighting Measures

Measure Code	Measure Description	Base Efficiency	Gross kW Savings	Gross kWh Savings
10	Fluorescent Fixtures with High Performance or Reduced Wattage (HP/RW) lamp & ballast systems or a T5 lamp and ballast system.	T12 energy efficient lamps and energy efficient magnetic ballasts	kW = qty * (prop watts * 1.3-prop watts) / 1000	kWh/year = kW * hours/year
30A	High Efficiency 2 lamp Prismatic Lensed Fluorescent Fixtures 2x2 or 2x4	Prismatic lensed fixtures averaging 75% efficient.	kW = qty * (11 watts/fixture) / 1000	kWh/year = kW * hours/year
30B	High Efficiency 2 lamp Parabolic Fluorescent Fixtures 2x2 or 2x4	Parabolic fixtures averaging 68% efficiency	kW = qty * (11 watts/fixture) / 1000	kWh/year = kW * hours/year
30C	High Efficiency 2 lamp Recessed Indirect/Direct Fluorescent Fixtures 2x2 or 2x4	No information available	kW = qty * (11 watts/fixture) / 1000	kWh/year = kW * hours/year
31	High Efficiency 3 lamp Fluorescent Fixtures 2x4	No information available	No information available	kWh/year = kW * hours/year
33	High Efficiency Indirect Low Glare Pendant Fluorescent Fixtures Note: Advanced glare reducing diffuser fixtures are designed to redistribute direct lumens via a refractor (glare reducing lens) to fill the entire volume of space with light without glare or the cave effects of traditional downlights.	No information available	kW = qty * (15 watts/fixture) / 1000	kWh/year = kW * hours/year

Table 2-1 (2 of 2)
Savings Algorithms for Prescriptive Lighting Measures

Measure Code	Measure Description	Base Efficiency	Gross kW Savings	Gross kWh Savings
34	Advanced Recessed Fluorescent Fixtures 1x4 or 2x4	"Paracube" lens type fixtures averaging 50% efficiency	kW = qty * (17 watts/fixture) / 1000	kWh/year = kW * hours/year
41	Industrial/Commercial Fluorescent Fixtures – 4 ft. and 8 ft. Fixtures	Industrial 4' strip type fixture with no hood	kW = qty * (prop watts * 1.46 - prop watts) / 1000	kWh/year = kW * hours/year
44	Clean Room Rated Fluorescent Fixtures 1x4 or 2x4	No information available	No information available	kWh/year = kW * hours/year
21	Compact Fluorescent Fixture	fixtures with incandescent bulbs (average 60 watts)	kW = qty * prop watts * 3.7 / 1000	kWh/year = kW * hours/year
23	Dimmable Compact Fluorescent Fixture	fixtures with incandescent bulbs (average 100 watts)	kW = qty * prop watts * 3.7 / 1000	kWh/year = kW * hours/year
56	High Intensity Fluorescent Fixtures (HIF) for Low Bay Applications (≤ 210W)	Fixture with Standard metal halide lamps and ballast	kW = qty * (prop watts * 1.35 - prop watts) / 1000	kWh/year = kW * hours/year
57	High Intensity Fluorescent Fixtures (HIF) for High Bay Applications (≥ 210W)	Fixture with Standard metal halide lamps and ballast	kW = qty * (prop watts * 1.35 - prop watts) / 1000	kWh/year = kW * hours/year
70	Metal Halide Specialty Lighting Fixtures with Electronic Ballast	No information available	kW = qty * (31 watts/fixture) / 1000	kWh/year = kW * hours/year
80	LED Downlight Fixtures Hard Wired or GU-24 base	No information available	No information available	kWh/year = kW * hours/year
82A	LED Cooler, Freezer Case or Refrigerated Shelving Fixtures – 3' & 4' Fixtures	No information available	No information available	kWh/year = kW * hours/year
82B	LED Cooler, Freezer Case or Refrigerated Shelving Fixtures – 5' & 6' Fixtures	No information available	No information available	kWh/year = kW * hours/year
83	LED Low Bay Fixtures Garage fixtures	No information available	No information available	kWh/year = kW * 8,760 hours/year
84	LED Track Heads	No information available	No information available	kWh/year = kW * hours/year
61	Remote-Mounted Occupancy Sensor	No occupancy sensor control	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction
62	Daylight Dimming System (DDS-FL)	No daylight dimming control ballasts and controls	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction
63	Occupancy Controlled Step-Dimming System	No occupancy sensor control	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction
64A	Wall mounted Occupancy Sensors	No occupancy sensor control	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction
64B	Wall mounted Vacancy Occupancy Sensors	No occupancy sensor control	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction
66	Photocell Sensors (lighting systems on 24/7)	No occupancy sensor control	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction
67	High Bay Fluorescent (HIF) Occupancy Control Systems	No occupancy sensor control	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction

Code 10 ♦ – Fluorescent Fixtures with High Performance or Reduced Wattage (hp/RW) Lamp & Ballast Systems or a T5 Lamp and Ballast System.

The New Hampshire analysis spreadsheet baseline systems for Code 10 ♦ rebates are T12 lamps and energy efficient magnetic ballasts. To receive incentives under this measure code, the fixtures must comply with the following criteria:

- ❑ Each fixture or system must operate a minimum of 1,000 hours per year.

- Each new fixture is composed of one ballast and one, two, three, or four lamps.
- Only one incentive may be counted per fixture.
- Only fixtures with hp/RW 2-foot T8 or 4-foot T5 lamps are eligible. This also applies when hp/RW ballasts are used with non-4-foot lamps (2-foot, 3-foot, U bents, cold apps.).

It is our opinion that the T12 lamps are not representative of the current standard practice and likewise should not be used as a baseline lighting technology for new construction projects. The fluorescent T8 systems have become prevalent and have captured the vast majority of the new construction market share in the last few years.

The demand savings for this measure code are calculated the using the following equation:

$$Demand\ savings\ kW = Qty \times (Proposed\ watts \times 1.3 - Proposed\ watts)/1000$$

It should be noted that in the current method, cooling bonus or heating penalty is not calculated. The New Hampshire algorithms can apply the latest 2013-2015 MA TRM factors to account for these interactive effects associated with lighting projects.

In order to establish the accuracy of the savings algorithms for this code, ERS compared typical systems by analyzing the rated wattages of different baseline systems and code 10 ♦-acceptable systems. The most common fluorescent systems used in commercial and industrial new construction applications are 4-foot T8 systems with two, three, or four lamps. Additionally, 2-foot, 3-foot, and 8-foot T8 systems and T5 systems are also installed, but are not as frequently installed as the 4-foot T8 systems. Our analysis has presumed a one-for-one replacement of the fluorescent T8 baseline fixture with a qualifying fixture. The proposed fixtures are primarily selected on the basis of providing similar light levels at higher lumens per watt for the source (ratio of mean lumens to rated fixture wattage). Based on this approach, we have selected a range of fixtures that are typical for the new construction commercial and industrial applications and developed an average. The assessment is based on rated wattages shown in the nhsaves@work forms. The results are presented in Table 2-2.

Table 2-2 (1 of 2)
Code 10 ♦ Baseline Assessment

Base System Description	Rated Watts	Base Market Share	Proposed System Description	Rated Watts	System Market Share	Saved Watts	Base Watts/ Prop. Watts Ratio	Market Share
1L 4' STD T8	30	3%	1L 4' HPT8 Low Pwr	25	10%	5	1.2	0.30%
1L 4' STD T8	30		1L 4' HPT8	28	70%	2	1.07	1.80%
1L 4' STD T8	30		1L 4' HPT8 ES/Low Pwr	24	15%	6	1.25	0.40%
1L 4' STD T8	30		1L 4' HPT8 High Lmn	39	3%	-9	0.77	0.10%
1L 4' STD T8	30		1L 4' T5	32	2%	-2	0.94	0.10%
2L 4' STD T8	60	1%	1L 4' HPT8	28	20%	32	2.14	0.30%
2L 4' STD T8	60		1L 4' HPT8 High Lmn	39	75%	21	1.54	1.10%
2L 4' STD T8	60		1L 4' T5HO	59	5%	1	1.02	0.10%
Weighted Average	**40.5**	**4%**		**31.1**		**9.4**	**1.3**	**4%**

Table 2-2 (2 of 2)
Code 10 ♦ Baseline Assessment

Base System Description	Rated Watts	Base Market Share	Proposed System Description	Rated Watts	System Market Share	Saved Watts	Base Watts/ Prop. Watts Ratio	Market Share
2L 4' STD T8	60	15%	2L 4' HPT8 Low Pwr	47	15%	13	1.28	2.30%
2L 4' STD T8	60		2L 4' HPT8	53	72%	7	1.13	10.80%
2L 4' STD T8	60		2L 4' HPT8 ES/Low Pwr	44	10%	16	1.36	1.50%
2L 4' STD T8	60		2L 4' HPT8 High Lmn	78	1%	-18	0.77	0.20%
2L 4' STD T8	60		2L 4'T5	63	1%	-3	0.95	0.20%
2L 4' STD T8	60		1L 4'T5HO	59	1%	1	1.02	0.20%
2L 4' STD T8	60	12%	2L 4' HPT8U Low Pwr	47	25%	13	1.28	3.00%
2L 4' STD T8	60		2L 4' HPT8U	53	70%	7	1.13	8.40%
2L 4' STD T8	60		2L 4' HPT8U High Lmn	78	5%	-18	0.77	0.60%
3L 4' STD T8	88	10%	2L 4' HPT8	53	50%	35	1.66	5.00%
3L 4' STD T8	88		2L 4' HPT8 High Lmn	78	40%	10	1.13	4.00%
3L 4' STD T8	88		2L 4'T5	63	8%	25	1.4	0.80%
3L 4' STD T8	88		1L 4'T5HO	59	2%	29	1.49	0.20%
Weighted Average	**67.6**	**37%**		**55.3**		**12.3**	**1.22**	**37%**
3L 4' STD T8	88	45%	3L 4' HPT8 Low Pwr	73	15%	15	1.21	6.80%
3L 4' STD T8	88		3L 4' HPT8	77	72%	11	1.14	32.40%
3L 4' STD T8	88		3L 4' HPT8 ES/Low Pwr	67	10%	21	1.31	4.50%
3L 4' STD T8	88		3L 4' HPT8 High Lmn	112	1%	-24	0.79	0.50%
3L 4' STD T8	88		3L 4'T5	95	1%	-7	0.93	0.50%
3L 4' STD T8	88		1L 4'T5HO	59	1%	29	1.49	0.50%
4L 4' STD T8	112	7%	3L 4' HPT8	77	40%	35	1.45	2.80%
4L 4' STD T8	112		3L 4' HPT8 High Lmn	112	59%	0	1	4.10%
4L 4' STD T8	112		2L 4'T5HO	117	1%	-5	0.96	0.10%
Weighted Average	**91.2**	**52%**		**78.8**		**12.5**	**1.16**	**52%**
4L 4' STD T8	112	6%	4L 4' HPT8 Low Pwr	93	10%	19	1.2	0.60%
4L 4' STD T8	112		4L 4' HPT8	101	83%	11	1.11	5.00%
4L 4' STD T8	112		4L 4' HPT8 ES/Low Pwr	88	5%	24	1.27	0.30%
4L 4' STD T8	112		4L 4' HPT8 High Lmn	156	1%	-44	0.72	0.10%
4L 4' STD T8	112		2L 4'T5HO	117	1%	-5	0.96	0.10%
2L 8' STD T8	109	1%	4L 4' HPT8 Low Pwr	89	10%	20	1.22	0.10%
2L 8' STD T8	109		4L 4' HPT8	101	83%	8	1.08	0.80%
2L 8' STD T8	109		4L 4' HPT8 ES/Low Pwr	88	5%	21	1.24	0.10%
2L 8' STD T8	109		4L 4' HPT8 High Lmn	156	1%	-47	0.7	0.00%
2L 8' STD T8	109		2L 4'T5HO	117	1%	-8	0.93	0.00%
Weighted Average	**111.6**	**7%**		**100.2**		**11.4**	**1.11**	**7%**
Measure Averages	**81.9**	**100%**		**69.7**		**12.2**	**1.18**	**100%**

We believe that, taking into consideration that the majority of the fluorescent systems in new construction commercial and industrial applications are T8 fixtures, the baseline for this measure should be the T8 technology. The savings factor of 1.3 should be revised downwards to reflect this new baseline. The new savings factor estimated by ERS is 1.18, and it reflects an average value for the whole spectrum of lighting systems present in the market.

Code 30A ♦ – High Efficiency Two-Lamp Prismatic Lensed Fluorescent Fixtures, 2×2 or 2×4

The New Hampshire analysis spreadsheet baseline fixtures for Code 30A ♦rebates are prismatic lensed fixtures averaging 75% efficiency with T8 lamps and electronic ballasts. To receive incentives under this measure code, the fixtures must comply with the following criteria:

- Overall fixture efficiency must be at least 83% for 2×4 prismatic lensed fixtures equipped with two T8 or T5 systems and 75% for 2×2 prismatic lensed fixtures equipped with two T8 or T5 systems.

The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW = Qty \times (11\ watts/fixture)/1000$$

In order to establish the accuracy of the savings algorithms for this code, ERS compared application of the approved fixtures under this measure category with the code required lighting power densities (LPD). ERS performed the savings analysis for this measure based on the IECC 2009 LPD requirement of 1.0 watt/ft^2 and 1.2 watts/ ft^2 for offices and classrooms, respectively. The required illumination level of 30 to 50 footcandles was referenced from the IESNA handbook. This exercise was performed for the common space types that would encounter these fixture types. The results of this approach were also recently adopted by Massachusetts in their deemed savings algorithms. Table 2-3 shows the savings analysis details for Code 30A ♦ measure.

Table 2-3
Code 30A ♦ Savings Assessment

	Standards Requirements				Baseline 75% Efficient Luminaire equipped with 3-Lamp T8				Proposed 83% Efficient Luminaire equipped with 2-Lamps HPT8				Savings	
Space Type	IECC 2009 (W/sq.ft.)	IESNA Recommended Horizontal Illumination (FC)	Area (sq.ft.)	Fixtures Spacing	Qty	FC @ workplane	Watts	LPD (W/sq.ft.)	Qty	FC @ workplane	Watts	LPD (W/sq.ft.)	W/sq.ft.	W /Fixt.
Open Office	1.0	30-50	9,600	10' x 10'	109	44.0	9,592	1.0	109	38.5	5,777	0.6	0.4	35
			9,600	8' x 10'	109	44.0	9,592	1.0	109	38.5	5,777	0.6	0.4	35
			9,600	8' x 8'	109	44.0	9,592	1.0	109	38.5	5,777	0.6	0.4	35
Enclosed Office	1.0	30-50	140	-	1	16.2	88	0.6	1	14.2	53	0.4	0.3	35
			140	-	2	32.3	176	1.3	2	28.4	106	0.8	0.5	35
Classroom	1.2	30-50	840	10' x 10'	11	42.7	968	1.2	11	34.0	583	0.7	0.5	35
			840	8' x 10'	11	42.7	968	1.2	11	34.0	583	0.7	0.5	35
			840	8' x 8'	11	42.7	968	1.2	11	34.0	583	0.7	0.5	35

The last column of Table 2-3 was compared with the current savings value of 11 watts/fixture used in the demand savings algorithms for Code 30A ♦. Taking into consideration that majority of the fluorescent systems installed under this measure are shown in the table above, we recommend modifying savings factor for this measure code to the proposed 35 watts/fixture.

Code 30B ♦ – High Efficiency Two-Lamp Parabolic Fluorescent Fixtures 2×2 or 2×4

The New Hampshire analysis spreadsheet baseline fixtures for Code 30B ♦rebates are parabolic fixtures averaging 68% efficiency with T8 lamps and electronic ballasts. To receive incentives under this measure code, the fixtures must comply with the following criteria:

- ❑ Overall fixture efficiency must be at least 80% for 2×4 fixtures with parabolic louver (2″ to 3″ deep cells) equipped with two T8 or T5 systems and for 2×2 fixtures with parabolic louvers (2″ to 3″ deep cells) equipped with two T8 or T5 systems.

The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW\ =\ Qty\ \times\ (11\ W/fixture)/1000$$

ERS performed an analysis that is similar with the one shown in Table 2-3. Based on the analysis, we believe that a 35 W fixture should be considered as the new savings factor for this measure.

Code 30C ♦ – High Efficiency Two-Lamp Recessed Indirect/Direct Fluorescent Fixtures 2×2 or 2×4

The New Hampshire analysis spreadsheet does not provide details on the baseline fixtures for Code 30C ♦. To receive incentives under this measure code, the fixtures must comply with the following criteria:

- ❑ Overall fixture efficiency must be at least 80% for 2×4 fixtures with parabolic louvers (2″ to 3″ deep cells) equipped with two T8 or T5 systems and for 2×2 fixtures with parabolic louvers (2″ to 3″ deep cells) equipped with two T8 or T5 systems.

The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW\ =\ Qty\ \times\ (11\ W/fixture)/1000$$

Based on the analyses ERS performed for measure codes 30A ♦ and 30B ♦, we believe that 35 W/fixture should be considered as the new savings factor for this measure as well.

Code 31 ♦ High Efficiency Three-Lamp Fluorescent Fixtures – 2×4

The New Hampshire analysis spreadsheet did not provide any details about the baseline fixtures for Code 31 ♦. To receive incentives under this measure code, the fixture must comply with the following criteria:

Overall fixture efficiency must be ≥

- ❑ 83% for 2×4 prismatic lensed fixture with three T8 or T-5 lamps;
- ❑ 75% for 2×4 fixture with parabolic louver (2″ to 3″ deep cells) with three T8 or T5 lamps;
- ❑ 70% for 2×4 recessed indirect fixture with three T8 or T5 lamps.

Eligible fixtures are limited to three-lamp fixtures with a low power ballast factor of less than or equal to 0.80.

The New Hampshire analysis spreadsheet did not provide details on the savings algorithm for Code 31 ♦. It is our understanding that this measure code would apply in special situations with four-lamp T8 fixtures constituting the baseline and the three-lamp high efficiency fixtures representing the higher efficiency case. In some cases, a one-for-one scenario could be possible, but in others a sophisticated lighting model would be required to determine the post-case high efficiency scenario. We believe that the fixtures in this measure code are broadly covered by Code 10 fixtures and, hence, suggest elimination of this fixture code.

Code 33 ♦ – High Efficiency Indirect Low-Glare Pendant Fluorescent Fixtures

The program baseline fixture for Code 33 rebates is a paracube lens type averaging 50% efficiency. Each proposed unit shall be a 4-foot section containing no more than two lamps. Each fixture must exceed 80% efficiency. Recessed fixtures are not eligible. To receive incentives under this measure code, the overall fixture efficiency must exceed:

- 80% efficient fixture for an indirect pendant fixture with two T8 or T5 lamps or one T5 HO lamp. Fixtures may have a down-light component of no greater than 45%. Fixtures with a down-light component must incorporate glare limiting louvers or a perforated cover shielding the lamps. Ceiling finish must be white and unobstructed.

The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW = Qty \times (15\ W/fixture)/1000$$

Other Northeast utilities use deemed savings calculated based on an algorithm that accounts for the code allowed lighting power density (LPD) and lighting system's rated watts. ERS performed the savings analysis for this measure based on the IECC 2009 LPD requirement of 1.0 W/ft^2 and IESNA illumination level of 30 to 50 footcandles. ERS estimated the savings associated with installing Code 33-compliant fixtures. Results for a variety of replacements are presented in Table 2-4.

Table 2-4
Code 33 Baseline Assessment

		Baseline Lighting System				Proposed Lighting System						Savings	
Space Type	Area (sq.ft.)	Fixture Type	Qty	Watts per Fixture	Total Watts	Fixture Type	LPD (W/sq.ft.)	FC @ workplane	Qty	Watts per Fixture	Total Watts	Watts	Watts per Fixture
Open Office	9,600	A	109	88	9,592	B	0.7	48.9	131	53	6,943	2,649	20
		A	109	88	9,592	C	0.8	40.5	131	59	7,729	1,863	14
		A	109	88	9,592	D	0.8	40.9	147	53	7,791	1,801	12
		A	109	88	9,592	E	0.7	47.3	131	53	6,943	2,649	20
		A	109	88	9,592	F	0.7	43.4	131	53	6,943	2,649	20
		A	109	88	9,592	G	0.6	36.0	127	47	5,969	3,623	29
		A	109	88	9,592	H	0.8	42.1	127	59	7,493	2,099	17
		A	109	88	9,592	I	0.7	41.7	127	51	6,477	3,115	25
												2,556	**20**

A: 2×4 recessed parabolic 3F32T8 70% efficiency

B: Pendant direct/indirect 60% up/40% down 2F32T8 85.9% efficiency

C: Pendant direct/indirect 99% up/1% down 1F54T5HO 91.4% efficiency

D: Pendant direct/indirect 30% up/70% down 2F32T8 66.3% efficiency

E: Pendant direct/indirect 60% up/40% down 2F32T8 85.6% efficiency

F: Pendant direct/indirect 55% up/45% down 2F32T8 78% efficiency

G: Pendant direct/indirect 87.5% up/12.5% down 2F32T8RW 85.3% efficiency

H: Pendant direct/indirect 60% up/40% down 1F54T5HO 90.1% efficiency

I: Pendant indirect 100% up 2F32T8 86.1% efficiency

The last column of Table 2-4 was compared with the current value of 15 W/fixture used in the demand savings algorithms for Code 33 ♦. We believe that, taking into consideration that the majority of the fluorescent systems in commercial and industrial applications are shown in Table 2-4, 20 W/fixture should be considered as the new savings factor for this measure.

Code 34 ♦ – Advanced Recessed Fluorescent Fixtures

The New Hampshire analysis spreadsheet did not specify the baseline fixtures for Code 34. To receive incentives under this measure code, overall fixture efficiency must exceed:

- ❑ 85% for 2×4 advanced glare-reducing diffuser fixture with one or two T8 or T5 lamps, or one T5HO lamp;
- ❑ 80% for 1×4 advanced glare-reducing diffuser fixture with one or two T8 or T5 lamps, or one T5HO lamp;
- ❑ 80% for 2×2 advanced glare-reducing diffuser fixture with one or two T8 or T5 lamps, or one T5HO lamp.

The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW = Qty \times (17\ W/fixture)/1000$$

Other Northeast utilities use deemed savings calculated based on an algorithm that accounts for the code-allowed LPD and lighting system's rated watts. ERS performed an analysis that is similar with the one shown in Table 2-4. Based on the analysis, we believe that 20 W/fixture should be considered as the new savings factor for this measure.

Codes 41 ♦ – Industrial Fluorescent Fixtures – 4-foot and 8-foot Fixtures

The program baseline fixture for Codes 41 is an industrial strip fixture. To receive incentives under this measure code, the overall fixture efficiency must be:

- ❑ ≥85% for industrial reflector fixture with T8 or T5 lamps;
- ❑ ≥83% for commercial grade wraparound fixture with one or two T8 or T5 lamps.

This measure code applies to fixtures installed less than 16 feet above the floor. It requires up to 20% up-light as an integral fixture feature. Fixtures with T8 or T5 lamps are eligible and each fixture can be composed of one ballast and one, two, three, or four lamps. Only one incentive may be counted per fixture.

Based on the program guidelines, we considered 4-foot and 8-foot T8 lamps/electronic ballast fixtures as the baseline system for Code 41. Results for typical values for the most popular replacements on the market are presented in Table 2-5.

The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW = Qty \times (Proposed\ W\ x\ 1.46 - Proposed\ W)/1000$$

Table 2-5
Code 41 ♦ Baseline Assessment

Base System Description	Rated Watts	Mean Lumens	Lumens/ Watts	Proposed System Description	Rated Watts	Mean Lumens	Lumens/ Watts	Saved Watts	Base Watts/ Prop. Watts
2F32T8 ELIG HIGH LMN	78	6,050	86	2L4' T8EE/ELEE HPF	73	6,770	93	5	1.1
2F32T8 ELIG HIGH LMN	78	6,050	86	2L4' T8EE/ELEE HPF	73	6,770	93	5	1.1
3F32T8 ELIG HIGH LMN	114	8,920	87	3L4' T8EE/ELEE/HPF	109	9,985	92	3	1
2F59T8 ELIG	112	9,030	90	4L4' T8EE/ELEE	107	9,325	87	2	1
4F32T8 ELIG	112	8,870	88	4L4' T8EE/ELEE	107	9,325	87	5	1
4F32T8 ELIG HIGH LMN	155	11,945	85	4L4' T8EE/ELEE HPF	141	14,092	100	15	1.1

Legend: ELIG – Electronic Ballast
Note: Mean lumens are based on Sylvania systems.

The last column of Table 2-5 was compared with the averaged savings ratio of 1.46 used in the current demand savings algorithms for Code 41 ♦. Taking into consideration that the majority of the industrial fluorescent systems are nowadays equipped with T8 systems, the savings factor of 1.46 is high. The savings factor of 1.1 shown in Table 2-5 reflects more accurately the spectrum of different systems present in the market.

Code 44 ♦ – Clean Room-Rated Fluorescent Fixtures, 1×4 or 2×4

The New Hampshire analysis spreadsheet did not provide any details on the baseline fixtures for Code 44 ♦. To receive incentives under this measure code, overall fixture efficiency must be ≥75% for clean room fluorescent fixture up to three T8 or T5 lamps. To be eligible for incentives, fixtures must be installed in a clean room-rated environment.

This is a special application which in most likelihood receives limited activity. As a workaround, this application can be broadly covered by Code 10 fixtures, and as such, ERS recommends reviewing if continuing this highly speacilized fixture code in the list is worth it. The clean room fixtures have higher first costs, and hence, they may not meet the required benefit-to-cost ratio. Therefore, further review of this measure code is also recommended.

Codes 21 & 23 – Compact Fluorescent Fixtures

Codes 21 and 23 are differentiated by the type of ballast; non-dimming ballasts are eligible under Code 21 and dimming ballasts are eligible under Code 23. For both systems, the baseline systems are incandescent bulbs – 60 W and 100 W. Additionally, for Code 23, an incandescent bulb fixture with dimmer switch is considered as the baseline.

To receive incentives under measure Code 21, all fixtures must be hard-wired and have ballasts with <33% THD. Retrofit kits, screw-in adaptors, and exit signs are not eligible. Code 21 only applies to small C&I accounts with facility demand less than 200 kW.

To receive incentives under measure Code 23, all fixtures must be hard-wired and have electronic dimming ballasts with <33% THD. All long-tube CFL or biax fixtures are eligible under this measure category.

The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW = Qty \times Proposed\ W \times 3.7/1000$$

The energy savings are determined using actual hours; if the actual hours are not known, an hours-of-use table is used. The hours-of-use table is comprehensive and covers more than thirty building types.

The Energy Independence and Security Act (EISA) of 2007 requires that incandescent lamps commercialized after January 1, 2012, should meet minimum performance standards; the act also bans the commercialization of 100 W incandescent lamps. The requirements for EISA 2007 are phased in over 2 years, between January 1, 2012, and January 1, 2014. For the same lumen output, the minimum requirements represent a reduction of 25% over the incandescent technology in use in 2007. The regulation is not a product ban, but a performance requirement for wattage, lumen output, and life. Table 2-6 presents the EISA 2007 ruling requirements.

Table 2-6
EISA 2007 Incandescent Lamp Ruling

Current Wattage	Rated Lumens	Max Wattage	Min Lifetime, Hours	Effective Date
100	1,490 - 2,600	72	1,000	1/1/2012
75	1,050 - 1,489	53	1,000	1/1/2013
60	750 - 1,049	43	1,000	1/1/2014
40	310 - 749	29	1,000	1/1/2014

Neighboring northeastern utilities no longer provide incentives for installing CFLs. ERS believes that the current practice in large projects' new construction is represented by the installation of CFLs. Therefore, ERS recommends providing incentives for measure codes 21 and 23 only to facilities with demand less than 200 kW. For CFL measures going forward, we recommend using the EISA time-based guidelines to determine the appropriate incandescent lamp baseline. Accordingly, the savings for these measures would need to be adjusted over time.

ERS performed the savings analysis for this measure. Results for typical values for the most popular replacements on the market are presented in Table 2-7.

Table 2-7
Code 41 ♦ Baseline Assessment with EISA Ruling Requirements

Base System	EISA Approved Rated Watts	Proposed System	Rated Watts	Saved	Base Watts/ Prop. Watts Ratio
Description		Description		Watts	
Incandescent 15 W	15	CFL 4W	5	10	3
Incandescent 40 W	29	CFL 9W	13	16	2.23
Incandescent 60 W	43	CFL 14W	18	25	2.39
Incandescent 75 W	53	CFL 19 W	28	25	1.89
Incandescent 100 W	72	CFL 19 W	32	40	2.25
				Average	**2.35**

As of January 1, 2014, the average savings factor for these code fixtures should be updated from 3.7 to 2.35. In the interim, the savings for incandescent lamps below 75 W can be greater than presented in the above table.

Code 56 ♦ & 57 ♦ – High Intensity Fluorescent Fixtures (HIF)

The program baseline system for measure codes 56 and 57 is standard metal halide lamp and ballast. In order to qualify for incentives under measure code 56 ♦, the fixtures must meet the following criteria:

- ❑ Minimum wattage is 104 W, and maximum wattage is 210 W. T8 systems used for low bay interior fixtures must have HPT8 lamps with high ballast factor ballasts or T5 systems. Fixtures must have a minimum fixture efficiency of 88%, unless the application has a special lens or fixture requirement. Recommended mounting height is greater than 16 feet above the floor. HIF fixtures can incorporate a number of lamp technologies that include T8, T5, T5HO, and compact fluorescent options.

In order to qualify for incentives under measure code 57 ♦, fixtures must meet the following criteria:

- ❑ Minimum wattage is greater than 207 W. T8 systems used for high bay interior fixtures must have HPT8 lamps with high ballast factor ballast or T5 systems. Fixtures must have a minimum fixture efficiency of 88%, unless the application has a special lens or fixture requirement. Recommended mounting height is greater than 20 feet above the floor. HIF fixtures can incorporate a number of lamp technologies that include T8, T5, T5HO and compact fluorescent options.

Although other utilities still provide incentives for measure codes 56 and 57, ERS believes that for new construction projects, the installation of HIF fixtures in high bay applications is becoming a standard practice. Because of those reasons, ERS recommends reviewing this measure code in another year for removal from the list of fixtures incentivized by the NE&C program.

Code 70 – HID Fixtures

The New Hampshire analysis spreadsheet did not provide details on the baseline fixtures for Code 70. In order to qualify for incentives under measure code 70, the fixtures must meet the following criteria:

- Metal halide specialty fixtures may be track, recessed, or surface mounted and used for high-quality display-type lighting. Fixtures range from 20 to 100 W.

The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW\ = Qty \times 31/1000$$

Under measure Code 84 – LED Track Heads, the program provides incentives for fixtures that have the same functionality. In order to promote the newer technologies, and because the standard practice for display lighting is metal halide fixtures installation, ERS recommends the consideration of eliminating measure Code 70 from the Prescriptive program.

Code 80 – LED Downlight Fixtures – Hard-wired or GU-24 base

The New Hampshire analysis spreadsheet did not provide details on the baseline fixtures for Code 80. This incentive only applies to hardwired or GU-24 base LED fixtures on ENERGY STAR's list (www.energystar.gov). ERS has analyzed the energy impact of this measure and summarized the findings in Table 2-8.

Table 2-8
Code 80 – Baseline Assessment

Item	Proposed System					Base System		Market Share	Average Baseline	Base / Prop Watts
	Description	Rated Watts	Device Code	Light Output (lumens)	Efficacy (lumens/ watt)	Description	Rated Watts			
1	Recessed LED Downlight	8	1L008	340	43.9	CFL Downlight	11.9	95%	13.8	1.7
						Incandescent/Halogen DL	49.2	5%		
2	Recessed LED Downlight	10	1L010	419	43.2	CFL Downlight	14.9	95%	17.2	1.7
						Incandescent/Halogen DL	61.5	5%		
3	Recessed LED Downlight	11	1L011	459	43	CFL Downlight	16.4	95%	18.9	1.7
						Incandescent/Halogen DL	67.6	5%		
4	Recessed LED Downlight	12	1L012	499	42.7	CFL Downlight	17.9	95%	20.7	1.7
						Incandescent/Halogen DL	73.8	5%		
5	Recessed LED Downlight	13	1L013	539	42.5	CFL Downlight	19.4	95%	22.4	1.7
						Incandescent/Halogen DL	79.9	5%		
6	Recessed LED Downlight	14	1L014	579	42.3	CFL Downlight	20.8	95%	24.1	1.7
						Incandescent/Halogen DL	86	5%		
7	Recessed LED Downlight	15	1L015	619	42	CFL Downlight	22.3	95%	25.8	1.7
						Incandescent/Halogen DL	92.2	5%		
8	Recessed LED Downlight	16	1L016	659	41.9	CFL Downlight	23.8	95%	27.6	1.7
						Incandescent/Halogen DL	98.3	5%		
9	Recessed LED Downlight	17	1L017	699	41.7	CFL Downlight	25.3	95%	29.3	1.7
						Incandescent/Halogen DL	104.5	5%		
10	Recessed LED Downlight	18	1L018	739	41.5	CFL Downlight	26.8	95%	31	1.7
						Incandescent/Halogen DL	110.6	5%		
11	Recessed LED Downlight	19	1L019	779	41.4	CFL Downlight	28.3	95%	32.7	1.7
						Incandescent/Halogen DL	116.8	5%		
12	Recessed LED Downlight	20	1L020	819	41.2	CFL Downlight	29.8	95%	34.4	1.7
						Incandescent/Halogen DL	122.9	5%		
13	Recessed LED Downlight	21	1L021	859	41.1	CFL Downlight	31.3	95%	36.2	1.7
						Incandescent/Halogen DL	129.1	5%		
14	Recessed LED Downlight	23	1L023	938	40.8	CFL Downlight	34.2	95%	39.6	1.7
						Incandescent/Halogen DL	141.4	5%		
15	Recessed LED Downlight	24	1L024	978	40.7	CFL Downlight	35.7	95%	41.3	1.7
						Incandescent/Halogen DL	147.5	5%		
16	Recessed LED Downlight	25	1L025	1018	40.5	CFL Downlight	37.2	95%	43	1.7
						Incandescent/Halogen DL	153.7	5%		
17	Recessed LED Downlight	28	1L028	1138	40.2	CFL Downlight	41.7	80%	51.8	1.9
						Incandescent/Halogen DL	172.1	5%		
						Metal Halides	65.8	15%		
18	Recessed LED Downlight	30	1L030	1218	40	CFL Downlight	44.7	80%	55.5	1.9
						Incandescent/Halogen DL	184.4	5%		
						Metal Halides	70.4	15%		
19	Recessed LED Downlight	33	1L033	1338	39.7	CFL Downlight	49.1	80%	61.1	1.9
						Incandescent/Halogen DL	202.8	5%		
						Metal Halides	77.5	15%		
20	Recessed LED Downlight	35	1L035	1417	39.6	CFL Downlight	52.1	80%	64.8	1.9
						Incandescent/Halogen DL	215.1	5%		
						Metal Halides	82.2	15%		
21	Recessed LED Downlight	40	1L040	1617	39.2	CFL Downlight	59.6	80%	74	1.9
						Incandescent/Halogen DL	245.8	5%		
						Metal Halides	93.9	15%		
22	Recessed LED Downlight	43	1L043	1737	39	CFL Downlight	64	80%	79.6	1.9
						Incandescent/Halogen DL	264.3	5%		
						Metal Halides	101	15%		
									Avg	**1.8**

ERS recommends the use of the following savings algorithm to calculate the demand savings for this measure:

$$Demand\ savings\ kW\ =\ Qty\ \times\ (Proposed\ W \times 1.8 - Proposed\ W)/1000$$

Codes 82A & 82B – LED Cooler, Freezer Case, or Refrigerated Shelving Fixtures

The New Hampshire analysis spreadsheet did not provide details on the baseline fixtures for fixture codes 82A and 82B. Code 82A applies for 3-foot- and 4-foot-long fixtures, while code 82B applies for 5-foot and 6-foot-long fixtures. Eligible LED cooler and freezer case fixtures are required to be listed on ENERGY STAR or DesignLights Consortium websites (www.energystar.gov and www.designlights.org).

ERS analyzed the energy impact of this measure and summarized its findings in Table 2-9 and Table 2-10. The typical baseline system for the 3-foot fixture case is a one-lamp 3-foot T8HO (1F25SSH) or a one-lamp 3-foot standard T8 (1F25SSM). For the 4-foot case, the typical baseline includes a one-lamp 4-foot T8 fixture with a high power ballast (1F32SSH) or a one-lamp 4-foot T8HO (1F48HSE) fixture. For the 5-foot and 6-foot systems, the typical baseline fixtures are one-lamp 5-foot T8HO (1F60HSE) and one-lamp 6-foot T8HO (1F72HSE) fixtures, respectively.

Table 2-9
Codes 82A & 82B Baseline Assessment – End Fixtures

Item	Proposed System Description	Average Baseline Watts	Baseline / Proposed	Avg Watts Saved	Estimated Annual Hours
1	LED Cooler/Freezer Case Fixture - 3-ft End Fixture	30.3	4.22	22.8	4,500
2	LED Cooler/Freezer Case Fixture - 4-ft End Fixture	47.5	4.27	35.7	4,500
3	LED Cooler/Freezer Case Fixture - 5-ft End Fixture	70	5.96	57.4	4,500
4	LED Cooler/Freezer Case Fixture - 6-ft End Fixture	80	5.83	65	4,500

Table 2-10
Codes 82A & 82B Baseline Assessment – Center Fixtures

Item	Proposed System Description	Average Baseline Watts	Baseline / Proposed	Avg Watts Saved	Estimated Annual Hours
1	LED Cooler/Freezer Case Fixture - 3-ft Center Fixture	30.3	2.1	15.4	4,500
2	LED Cooler/Freezer Case Fixture - 4-ft Center Fixture	47.5	2.29	25.4	4,500
3	LED Cooler/Freezer Case Fixture - 5-ft Center Fixture	70	3.01	45.2	4,500
4	LED Cooler/Freezer Case Fixture - 6-ft Center Fixture	80	2.97	50.7	4,500

ERS recommends the use of the following savings algorithm to calculate the demand savings for this measure:

$$Demand\ savings\ kW\ =\ Qty\ \times\ (Avg\ W\ saved)/1000$$

Where, the value "Avg W saved" is shown in the tables above and it varies with the length of the fixture.

Code 83 – LED Low Bay Fixtures – Garage Fixtures

The New Hampshire analysis spreadsheet did not provide any details on the baseline fixtures for Code 83.

Under this measure, only low bay LED fixtures installed in 8,760 hour applications are eligible for this incentive and must be listed on ENERGY STAR or DesignLights Consortium websites. (www.energystar.gov and www.designlights.org)

The most common baseline light fixtures consist of 4-foot linear fluorescent, high-pressure sodium, and metal halide lights. For each of the three technologies listed above, ERS calculated the average wattage of the baseline light fixture that provided the same light output as the new LED fixture. ERS analyzed the baseline systems, their market share, and the energy impact of this measure. The summarized findings are shown in Table 2-11.

Table 2-11
Code 83 – Baseline Assessment

Proposed System					Base System					
Description	Rated Watts	Light Output (lm)	Efficacy (lms/watt)	Market Share	Description	Rated Watts	Market Share	Average Baseline	Average Savings (kW)	Base-to-Prop Watts Ratio
LED Low Bay Fixt - Garage & Canopy Fixt	49	3,591	72.1	15%	Linear Fluorescent Garage/Canopy Fixt	60.7	35%	79.7	0.031	1.6
					HPS Garage/Canopy Fixt	90.0	65%			
LED Low Bay Fixt - Garage & Canopy Fixt	60	4,356	72.0		Linear Fluorescent Garage/Canopy Fixt	70.3	25%	104.6	0.045	1.7
					HPS Garage/Canopy Fixt	90.0	10%			
					MH Garage/Canopy Fixt	120.0	65%			
LED Low Bay Fixt - Garage & Canopy Fixt	71	5,121	71.8	15%	Linear Fluorescent Garage/Canopy Fixt	108.0	20%	119.1	0.048	1.7
					HPS Garage/Canopy Fixt	130.0	15%			
					MH Garage/Canopy Fixt	120.0	65%			
LED Low Bay Fixt - Garage & Canopy Fixt	116	8,250	71.3		Linear Fluorescent Garage/Canopy Fixt	205.5	20%	188.6	0.073	1.6
					HPS Garage/Canopy Fixt	160.0	15%			
					MH Garage/Canopy Fixt	190.0	65%			
LED Low Bay Fixt - Garage & Canopy Fixt	139	9,849	71.1	20%	Linear Fluorescent Garage/Canopy Fixt		0%	196.4	0.057	1.4
					HPS Garage/Canopy Fixt	190.0	15%			
					MH Garage/Canopy Fixt	197.5	85%			
LED Low Bay Fixt - Garage & Canopy Fixt	164	11,587	70.8		Linear Fluorescent Garage/Canopy Fixt		0%	253.5	0.090	1.5
					HPS Garage/Canopy Fixt	190.0	15%			
					MH Garage/Canopy Fixt	250.0	90%			
LED Low Bay Fixt - Garage & Canopy Fixt	186	13,117	70.6	25%	Linear Fluorescent Garage/Canopy Fixt		0%	246.5	0.061	1.3
					HPS Garage/Canopy Fixt	215.0	10%			
					MH Garage/Canopy Fixt	250.0	90%			
LED Low Bay Fixt - Garage & Canopy Fixt	211	14,855	70.3		Linear Fluorescent Garage/Canopy Fixt		0%	292.3	0.081	1.4
					HPS Garage/Canopy Fixt	240.0	5%			
					MH Garage/Canopy Fixt	295.0	95%			
LED Low Bay Fixt - Garage & Canopy Fixt	233	16,384	70.1	15%	Linear Fluorescent Garage/Canopy Fixt		0%	293.6	0.061	1.3
					HPS Garage/Canopy Fixt	267.5	5%			
					MH Garage/Canopy Fixt	295.0	95%			
LED Low Bay Fixt - Garage & Canopy Fixt	256	17,983	69.8		Linear Fluorescent Garage/Canopy Fixt		0%	295.0	0.039	1.2
					HPS Garage/Canopy Fixt	295.0	5%			
					MH Garage/Canopy Fixt	295.0	95%			
LED Low Bay Fixt - Garage & Canopy Fixt	279	19,582	69.6	10%	Linear Fluorescent Garage/Canopy Fixt		0%	455.0	0.176	1.6
					HPS Garage/Canopy Fixt		0%			
					MH Garage/Canopy Fixt	455.0	100%			
	155.2			**100%**				**220.3**	**0.065**	**1.4**

ERS recommends the use of the following savings algorithm, which calculates the demand savings using the following equation:

$$Demand\ savings\ kW\ =\ Qty\ \times\ (Proposed\ W\ \times\ 1.4 - Proposed\ W)/1000$$

Code 84 – LED Track Heads

The New Hampshire analysis spreadsheet did not provide details on the baseline fixtures for Code 84.

This measure allows incentives for hardwired LED track heads fixtures only, replacement lamps are not eligible. Eligible fixtures are required to be listed Energy Star or DesignLights Consortium websites. (www.energystar.gov and www.designlights.org)

ERS analyzed the baseline systems, their market share, and the energy impact of this measure. The baseline systems for this measure are: incandescent track heads, halogen track heads, CFL tack heads, and ceramic MH track heads. ERS calculated the baseline system rated wattage based on the systems rated wattage and their market share. ERS split the measure into three categories. This measure is mostly installed in retail applications that have a typical annual operation of 4,800 hours. The summarized findings are shown in Table 2-12.

Table 2-12
Code 84 Baseline Assessment

Item	Proposed System Description	Average Baseline Watts	Baseline / Proposed	Estimated Annual Hours
1	LED Track Heads < 25	55.4	3.4	4,800
2	LED Track Heads between 25 and 31	36.8	1.3	4,800
3	LED Track Heads > 31	38.8	1.1	4,800

ERS recommends the use of the following savings algorithm, which calculates the demand savings using the equation:

$$Demand\ savings\ kW\ =\ Qty\ \times\ (Proposed\ W \times\ Baseline/Proposed - Proposed\ W)/1000$$

Where, the Baseline/Proposed factor will vary based on the number of track heads in the fixture.

For all the above measure codes, the electric energy savings are calculated using the following formula:

$$kWh = kW\ \times\ Hours$$

Lighting Controls – Codes 61 through 68

The New Hampshire analysis spreadsheet baseline for all lighting control codes is manual switching. The key features of the controls measures are summarized here:

- Code 61 – Remote-mounted occupancy sensor. In order to be eligible for incentives, the sensors must comply with the following criteria: Ceiling-mounted control with no manual-on overrides. Must comply with manufacturer's coverage recommendations.

- Code 62 – Daylight dimming system (DDS-FL). In order to be eligible for incentives, the sensors must comply with the following criteria: Must have continuous dimming or adjust to a minimum of four levels. Typical lamping is either a 30 W or 32 W T8 lamp or a T5 system.
- Code 63 – Occupancy-controlled step-dimming system. In order to be eligible for incentives, the sensors must comply with the following criteria: ballast must be automatically controlled based on occupancy. Power consumption in low mode must not exceed 60%.
- Code 64A – Wall-mounted occupancy sensors. In order to be eligible for incentives, the sensors must comply with the following criteria: Occupancy sensors must operate as automatic on and off. Sensors are wall-mounted devices only. Not eligible if installed in restrooms, locker rooms, stairwells, or rooms of greater than 250 square feet.
- Code 64B – Wall-mounted vacancy occupancy sensors. In order to be eligible for incentives, the sensors must comply with the following criteria: Vacancy sensors must operate as manual on, automatic off. Sensors are wall-mounted devices only. Not eligible if installed in restrooms, locker rooms, stairwells, or rooms of greater than 250 square feet.
- Code 65 – Photocell sensors. In order to be eligible for incentives, the sensors must comply with the following criteria: Photocell control for lighting systems that operate on 24 hours a day, 7 days a week (8,760 hours annually)
- Code 68 – High intensity fluorescent (HIF) Occupancy Control Systems. In order to be eligible for incentives, the sensors must comply with the following criteria: ballasts must be automatically controlled based on occupancy. Systems with manual on or override switches are not eligible. Sensors to be mounted on individual fixtures only.

The prescriptive measure algorithms for the lighting controls measure codes 61 through 68 are identical. Basically, the algorithms consider demand savings of 25% of the controlled watts, and the energy savings are based on the reduced annual hours of operation. The savings algorithm calculates the demand savings using the following equation:

$$Demand\ savings\ kW\ =\ Qty\ of\ fixtures\ controlled\ \times\ Fixture\ W\ \times\ 0.25/1000$$

The savings algorithm calculates the energy savings using the following equation:

$$Annual\ kWh\ =\ Qty\ of\ fixtures\ controlled\ \times Fixture\ W \times\ Annual\ hours\ reduction/1000$$

ERS analyzed these algorithms, and our observations are presented in the discussion below:

- The savings are currently calculated using the same algorithm, regardless of the type of lighting control system. However, the demand savings are highly dependent on the type of control system. Daylight dimming and photocell sensors do not perform the same way as occupancy sensors; hence, the savings associated with these systems should be different.
- The demand savings depend on the complexity of the application and the number of spaces controlled by discreet devices. As the number of controlled spaces increases, greater demand savings can be achieved, as the probability of lights being off at the same time also increases.

Based on the review, our conclusions are presented below:

- The demand savings are different for occupancy-based sensors as compared to daylight-based and photocell sensors. We recommend developing separate demand savings factors based on the control and space type.
- In new construction projects, automatic controls that qualify for incentives under measure codes 64A and 65 have become standard practice over the last few years due to changes in the code requirements and reduction in costs for these types of devices. ERS recommends eliminating measure Codes 64A and 65 from the prescriptive program.

HVAC Unitary Equipment

The savings algorithms for these systems are based on the efficiency differences between a base design and the proposed design. Table 2-13 presents the savings algorithms used for calculating the demand and energy savings for unitary HVAC equipment measures.

Table 2-13
Savings Algorithms for Prescriptive Unitary HVAC Measures

Size (Btuh)	Tier 1 Minimum Efficiency	Tier 2 Minimum Efficiency	Base Efficiency (EER)	Gross kW Savings	Gross kWh Savings	Hours
Unitary AC and Split Systems (new condenser and new coil)						
< 65,000			11.1	See equation (a)	See equation (b)	Hospital: 2,330
Split System	14.0 SEER, 12.0 EER	15.0 SEER, 12.5 EER				Office (Sm, Med, Lg): 970
Packaged System	14.0 SEER, 11.6 EER	15.0 SEER, 12.0 EER				Retail Store: 1,380
≥ 65,000 to < 135,000	11.5 EER	12.0 EER	11.2	See equation (a)	See equation (b)	Schools: 510
≥ 135,000 to < 240,000	11.5 EER	12.0 EER	10.6	See equation (a)	See equation (b)	
≥ 240,000 to < 760,000	10.5 EER & 9.9 IPLV	10.8 EER & 10.1 IPLV	9.5	See equation (a)	See equation (b)	
≥ 760,000	10.2 EER & 9.5 IPLV	10.4 EER & 9.7 IPLV	9.5	See equation (a)	See equation (b)	
Air to Air Heat Pump Systems						
< 65,000			11.1	See equation (a)	See equation (b)	Hospital: 3,010
Split System	14.0 SEER & 8.5 HSPF	15.0 SEER & 9.0 HSPF				Office (Sm, Med, Lg): 1,970
Packaged System	14.0 SEER & 8.0 HSPF	15.0 SEER & 8.5 HSPF				Retail Store: 2,250
≥ 65,000 to < 135,000	11.5 EER & 3.4 COP	12.0 EER & 3.4 COP	11	See equation (a)	See equation (b)	Schools: 1,030
≥ 135,000 to < 240,000	11.5 EER & 3.2 COP	12.0 EER & 3.2 COP	10.6	See equation (a)	See equation (b)	
≥ 240,000	10.7 EER & 3.2 COP	10.9 EER & 3.2 COP	9.5	See equation (a)	See equation (b)	
Water Source Heat Pumps						
≤ 135,000	14.0 EER & 4.6 COP	N.A.	11.2 (<16,800)	See equation (a)	See equation (b)	
			12.0 (≥16,800 to < 135,000)			
Ground Water - Water Source Heat Pump Equipment (Open Loop)						
≤ 135,000	18.0 EER & 4.0 COP	N.A.	11.2 (<16,800)	See equation (a)	See equation (b)	
			12.0 (≥16,800 to < 135,000)			
Ground Water - Water Source Heat Pump Equipment (Closed Loop)						
≤ 135,000	15.0 EER & 3.2 COP	N.A.	11.2 (<16,800)	See equation (a)	See equation (b)	
			12.0 (≥16,800 to < 135,000)			
Energy Savings Control Options (when installed with new & qualifying Tier 1 or 2 equipment						
Dual Enthalpy Economizer	Outside air economizer utilizing two enthalpy sensors (1 for outdoor & 1 for return air)		Fixed dry-bulb economizer	0	annual kWh = Ton * 276	N.A.
Demand Control Ventilation	Outside air intake controlled based on CO2 sensor in space or return air		No-ventilation control.	0	annual kWh = Ton * 200	

Equation A: $kW = Qty \times Tons\ per\ unit \times 12\ x\ (\frac{1}{EER_{base}} - \frac{1}{EER_{prop}})$

Equation B: $Annual\ kWh = kW \times Hour$

The baseline efficiency values shown in the table are based on IECC 2009, while the equivalent full-load operating hours are derived from the ASHRAE standard 90.1-2003.

ERS analyzed these algorithms and our observations are presented in the discussion below:

The prescriptive EFLHs for each of the four listed building types are different from the hours presented in the 2011 Massachusetts TRM (2011 MA TRM) for the same building types as depicted in Table 2-14. The latest 2013-2015 MA TRM did not publish these values hence the values from the previous version of the MA TRM were used here to express the differences. We recommend reconciling the cooling EFLH hours with the 2011 and or 2013-2015 MA TRM and in the long term conduct a focused study specific to understanding the load curves for chiller installations in New Hampshire.

Table 2-14
Cooling and Heating EFLH by Building Type

	2011 MA TRM Cooling EFLH	NH Values Cooling EFLH	2011 MA TRM Heating EFLH	NH Values Heating EFLH
Hospital	1,307	2,330	270	680
Office	797	970	1,248	1,000
Retail store	837	1,380	1,171	870
School	594	510	1,637	520

When compared with the 2013-2015 MA TRM values, the New Hampshire programs deemed savings for the dual enthalpy economizer measure are smaller, while the ones for demand controlled ventilation measure are higher. We recommend reconciling the deemed savings values for these two measures because over the years, the New Hampshire and Massachusetts program designs and algorithms have mostly been similar. Please note that the EM&V forum also conducted a recent study on the EFLH associated with unitary HVAC systems, which could also be used as a credible reference.

Chillers

The New Equipment & Construction Prescriptive Program covers air-cooled and water-cooled chillers. The equipment efficiencies are based on applicable ARI Standards. Chillers must meet both full- and part-load efficiency ratings.

The savings algorithms for these systems are based on efficiency differences between a base-case design and the proposed design. For energy savings, different EFLH have been used, depending on the building they serve. As discussed earlier in this section, the EFLH values are based on ASHRAE standard 90.1-2003. Table 2-15 presents the savings algorithms used for calculating the demand and electric energy savings for the chiller systems measures.

Table 2-15
Savings Algorithms for Prescriptive Chiller Measures

Unit Size ARI Net Tons	Minimum Performance Requirements, FL or IPLV	Base Efficiency	Gross kW savings	Gross kWh savings
Air Cooled Chillers < 150 tons	EER: FL: 10.6 IPLV: 13.9	9.562 EER	See equation (a)	See equation (b)
Air Cooled Chillers ≥ 150 tons	EER: FL: 10.6 IPLV: 14.1	9.562 EER	See equation (a)	See equation (b)
Water Cooled Chillers (rotary screw or scroll) < 75 tons	kW/ton: FL: 0.702 IPLV: 0.540	0.800 kW/ton	See equation (a)	See equation (c)
Water Cooled Chillers (rotary screw or scroll) ≥ 75 and < 150 tons	kW/ton: FL: 0.697 IPLV: 0.527	0.890 kW/ton	See equation (a)	See equation (c)
Water Cooled Chillers (rotary screw or scroll) ≥ 150 and < 300 tons	kW/ton: FL: 0.612 IPLV: 0.486	0.718 kW/ton	See equation (a)	See equation (c)
Water Cooled Chillers (rotary screw or scroll) ≥ 300 tons	kW/ton: FL: 0.558 IPLV: 0.441	0.639 kW/ton	See equation (a)	See equation (c)
Water Cooled Chillers (centrifugal) < 150 tons	kW/ton: FL: 0.570 IPLV: 0.405	0.639 kW/ton	See equation (a)	See equation (c)
Water Cooled Chillers (centrifugal) ≥ 150 and < 300 tons	kW/ton: FL: 0.570 IPLV: 0.405	0.639 kW/ton	See equation (a)	See equation (c)
Water Cooled Chillers (centrifugal) ≥ 300 and < 600 tons	kW/ton: FL: 0.518 IPLV: 0.360	0.600 kW/ton	See equation (a)	See equation (c)
Water Cooled Chillers (centrifugal) ≥ 600 tons	kW/ton: FL: 0.513 IPLV: 0.360	0.590 kW/ton	See equation (a)	See equation (c)

Equation A: $kW = Qty \times Tons\ per\ unit \times (Base\ kW\ per\ ton - Proposed\ kW\ per\ ton)$

Equation B: $Annual\ kWh = kW \times Hours$

Equation C: $Annual\ kWh = kW \times 970$

ERS analyzed these algorithms and our observations are presented in the discussion below:

- We recommend incorporating the chiller IPLV in baseline efficiency characterization. We also recommend incorporating the chiller IPLV in the demand savings algorithm because it would accurately capture the chiller performance compared to the current method of using the chiller efficiency at full load.
- The deemed savings for water-cooled chillers are based on a constant 970 EFLH, irrespective of the application. We recommend varying the EFLH value based on the building type. The 2013-2015 MA TRM already incorporates this method in estimating energy savings for their chiller projects.
- The EFLH values assigned for the various building types for the air-cooled chillers also seem to be significantly higher than what is normal for the region when compared to the 2013-2015 MA TRM.

Electronically Commutated Motors (ECMs)

The New Equipment & Construction Prescriptive Program provides incentives for the installation of electronically commutated motors (ECM). EC motors must operate at least 2,000 hours per year in order to be eligible for incentives. Only ECMs on new fan-powered terminal boxes, fan coils, and HVAC supply fans on small unitary equipment are eligible.

The New Hampshire TRM savings algorithm uses deemed savings of 0.075 kW and 633 kWh per motor per year. We were not supplied with the details supporting the development of the above factors. Hence, as a reference, we recommend using the 2013-2015 MA TRM algorithm and baseline description details for the ECM motors in Table 2-16.

Table 2-16
Savings Algorithms for Prescriptive ECM Measure (2013-2015 MA TRM)

Measure Description	Baseline	Box size factor (W/CFM)	Gross summer kW savings	Gross winter kW savings	Gross annual kWh savings
EC Motors (< 1000 CFM)	Single speed PSC induction motor	0.32	See equation (a)	See equation (b)	See equation (c)
EC Motors (≥ 1000 CFM)	Single speed PSC induction motor	0.21	See equation (a)	See equation (b)	See equation (c)

Equation A: $kW = Qty \times CFM \times Box\ size\ factor \times .60/1000$

Equation B: $kW = Qty \times CFM \times Box\ size\ factor \times .33/1000$

Equation C: $Annual\ kWh = Qty \times CFM \times Box\ size\ factor \times .52/1000 \times Hours$

In the longer term, we advise conducting separate research or a study to evaluate the savings associated with this measure in New Hampshire and adding other common applications such as refrigeration display cases in the list of approved end uses.

VFDs

The New Equipment & Construction Prescriptive Program offers incentives for VFDs installed in HVAC systems with rated capacities between 5 hp and 20 hp. The applicants must demonstrate that the systems operate a minimum of 2,000 hours per year. HVAC circulation pumps are not eligible for incentives. The baseline system's energy use is shown as kWh per hp for each application impacted by this measure. The energy and demand savings are calculated by multiplying the savings factors with the VFD-rated horsepower. Table 2-17 presents the savings factors for the VFD measures.

Table 2-17
Savings Factors for Prescriptive VFD Measures

Measure	Hours	Baseline Energy Use (kWh/HP)	Gross Energy Savings (kWh/HP)	Gross Summer Demand Savings (kW/HP)	Gross Winter Demand Savings (kW/HP)
Supply fan on constant volume supply air handler. Application Code [SFA]	3,955	2,413.1	898.7	0.1	0.4
Supply fan on VAV packaged HVAC unit [SFP] (forward curved fans with inlet vanes are not eligible)	3,955	1,934.7	923.8	0.1	0.3
Return fan on constant volume return air handler [RFA]	3,955	2,413.1	900.0	0.1	0.4
Return fan on VAV packaged HVAC unit [RFP] (forward curved fans with inlet vanes are not eligible)	3,955	1,646.0	719.0	0.0	0.3
Building exhaust fan (04) [BEF]	3,801	2,286.8	816.5	0.1	0.4
Process exhaust fan (04) [PEF]	6,048	2,463.5	152.3	0.0	0.0
Fume hood exhaust fan and makeup air fan (04) [HEF]	8,760	5,476.2	2,164.4	(0.0)	(0.0)
Chilled water pump	2,150	1,066.1	298.8	0.1	0.0
Heating hot water pump	3,996	1,695.2	913.4	0.0	0.2
Circulation pump for water source heat pump loop (05) [WWP]	8,760	3,522.8	1,617.3	0.0	0.2
Process heating & cooling circulation pumps [PHC]	3,810	2,038.9	368.0	0.1	0.1
Boiler feed water pump [FWP]	8,022	3,418.2	1,555.7	0.2	0.2
Boiler draft fan (04) [BDF]	8,022	4,318.8	2,469.9	0.3	0.3
Water supply or wastewater treatment pump	8,760	4,687.7	789.1	0.1	0.1
RAS pump in wastewater treatment plant	4,380	2,520.6	847.2	0.1	0.1
Hydraulic pumps (04) [HYP]	7,404	4,179.5	1,210.0	0.2	0.2
Cooling Tower Fan (05) [CTF]		543.5	338.0	0.1	0.0

The demand savings algorithms are based on savings factors that are different for each type of system served. ERS would like to emphasize that most of the VFD systems installed may not yield demand savings. Furthermore, the VFD introduces energy losses of up to 5% when the motor operates at full load.

We believe that the study on which the algorithms are based should be updated to reflect the technology changes that have transpired over the 6 years since the study's completion. The current VFD application does not associate hours of operation with a particular building type. In order to accurately characterize the energy savings associated with an end use, we suggest that as a part of the new study, some building types also be associated with the end uses like (hospitals, offices, schools, retail, and industrial).

Heating Equipment

Table 2-18 summarizes both the Liberty Utilities and Unitil heating equipment prescriptive incentive programs and the reviewers' findings regarding baseline requirements and deemed savings algorithms. The deemed savings values and information about the baseline and proposed equipment for all measures are referenced from the 2012 Massachusetts TRM.

Table 2-18 (1 of 2)
Natural Gas Heating Equipment Measures

Measure	Measure Description	Base Efficiency	Proposed Efficiency	Gross Savings (MMBtu/yr)
Furnace ≤ 150 MBH	The installation of high efficiency natural gas warm air furnace with an ECM for the fan.	78% AFUE, 80% Thermal efficiency (Warm Air Duct Furnace, all capacities 80% Combustion efficiency)	92% AFUE or greater w/ECM	18
Furnace ≤ 150 MBH		78% AFUE, 80% Thermal efficiency (Warm Air Duct Furnace, all capacities 80% Combustion efficiency)	94% AFUE or greater w/ECM	20.7
Furnace ≤ 300 MBH		80% Thermal efficiency (≥ 225 MBH) (Warm Air Duct Furnace, all capacities 80% Combustion efficiency)	92% AFUE or greater w/ECM	18
Furnace ≤ 300 MBH		80% Thermal efficiency (≥ 225 MBH) (Warm Air Duct Furnace, all capacities 80% Combustion efficiency)	94% AFUE or greater w/ECM	20.7
Infrared heaters all sizes	The installation of a gas-fired low intensity infrared heating system in place of unit heater, furnace, or other standard efficiency equip. Infrared heating uses radiant heat as opposed to warm air to heat buildings. In commercial environments with high air exchange rates, heat loss is minimal because the space's heat comes from surfaces rather than air.	Standard efficiency gas-fired unit heater (80% Combustion efficiency)	Low Intensity	74.4

Both Liberty Utilities and Unitil offer prescriptive incentives for the installation of high-efficiency heating equipment. Measures included under the heating equipment category in the Liberty Utilities incentive program include the installation of high-efficiency furnaces, condensing boilers, and low intensity infrared heaters. In addition to the heating equipment mentioned above, Unitil also incentivizes condensing unit heaters with capacities ranging up to 300 MBH. While Liberty Utilities only incentivizes high-efficiency furnaces up to 150 MBH, Unitil offer incentives for units sized up to 300 MBH.

Table 2-18 (2 of 2)
Natural Gas Heating Equipment Measures

Measure	Measure Description	Base Efficiency	Proposed Efficiency	Gross Savings (MMBtu/yr)
Condensing boiler ≤ 300 MBH	The installation of a high efficiency natural gas-fired condensing hot water boiler. High efficiency condensing boilers can take advantage of improved design, sealed combustion and condensing flue gases in a second heat exchanger to achieve improved efficiency.	80% AFUE	90% AFUE or greater	22.1
Condensing boiler 301 to 499 MBH		75% Thermal efficiency, 80% Combustion efficiency	90% Thermal efficiency	42.3
Condensing boiler 500 to 999 MBH		75% Thermal efficiency, 80% Combustion efficiency	90% Thermal efficiency	77.1
Condensing boiler 1000 to 1700 MBH		75% Thermal efficiency, 80% Combustion efficiency	90% Thermal efficiency	142.6
Condensing boiler 1701 to 2500 MBH		75% Thermal efficiency, 80% Combustion efficiency	90% Thermal efficiency	249
Condensing ≥ 2500 MBH		80% Combustion efficiency	90% Thermal efficiency	25.2
Condensing Unit Heaters up to 300 MBH	Installation of a condensing gas-fired unit heater for space heating with capacity up to 300 MBH and minimum combustion efficiency of 90%.	Standard efficiency gas fired unit heater with minimum combustion efficiency of 80%, interrupted or intermittent ignition device (IID), and either power venting or an automatic flue damper	≥ 90% Thermal efficiency	40.9

Based on a review of the above measures, following observations were made:

- **Furnaces** – As mentioned earlier, the reviewers noticed that Liberty Utilities incentivizes furnaces up to 150 MBH, while Unitil incentivizes furnaces up to 300 MBH. Both utilities have a two-tier incentive for furnaces. According to the prescriptive application form for both utilities, the first tier of high-efficiency furnaces is rated at 92% AFUE and the second tier is rated at 94% AFUE. However, the gross savings values presented in Table 2-18 for the furnace measure correspond to efficiencies of 95% and 96% AFUE for tier-one and tier-two furnaces, respectively. These gross savings values were referenced from Table 40 of the Massachusetts 2012 Technical Reference Manual (MA 2012 TRM).

- The gross savings found in the 2013-2015 MA TRM were based on the findings of a 2009 study "Natural Gas Energy Efficiency Potential in Massachusetts" by GDS. Table B-2b in Appendix B-2 of the GDS report projects a 15.2% savings factor and an annual savings of 40.46 MMBtu for a 300 MBH unit with 92% AFUE and a baseline efficiency of 78% AFUE. The 2013-2015 MA TRM gross savings values of 18.0 MMBtu and 20.7 MMBtu for tier-one and tier-two units, respectively, were determined by applying an adjustment factor to the GDS reported annual savings value. The adjustment factor was determined based on the results of a 2010 evaluation conducted by Nexus Market Research and the Cadmus Group entitled "HEHE Process and Impact Evaluation." Reviewers were unable to determine the specific algorithms used to determine the gross deemed savings value or the adjustment factor.
- The baseline efficiencies for the furnace measures were found in Table 41 of the 2013-2015 MA TRM and were centered on a capacity of 225 MBH. The efficiency values were adopted from the 2009 International Energy Conservation Code; Table 503.2.3(4).
- **Low-intensity infrared heaters** – Both utilities incentivize the installation of low-intensity infrared heaters under their prescriptive program. The baseline case considered for these measures is outlined in the 2013-2015 MA TRM and is reported as a standard efficiency unit heater with a combustion efficiency of 80%. No mention of the source of this baseline efficiency value was found in the TRM. The gross savings value of 74.4 MMBtu per year was based on modeled data from sixty-two low-intensity infrared heaters installed by Columbia Gas of MA through their custom C/I energy efficiency program. The reviewers were not able to obtain a copy of the spreadsheet summarizing the findings of the study. A recent evaluation of the MA large C&I programs indicated that the IR heaters result in an average savings of 7.2 MMBtu per year. Hence we recommend a review of the savings claimed for this measure.
- **Condensing boilers** – Both utilities incentivize the installation of high-efficiency natural gas-fired condensing boilers. The baseline and deemed savings for these measures were determined through review of the MA 2012 TRM. Table 37 and Table 38 in the 2013-2015 MA TRM outline the deemed savings and baseline parameters associated with each boiler size range, respectively. The baseline parameters were adopted from the 2009 IECC Table 503.2.3(5). The deemed savings values were referenced from a 2011 KEMA evaluation entitled "Prescriptive Boiler Impact Evaluation, Project 5 Prescriptive Gas."

Reviewers were able to access this paper and find the deemed savings algorithm employed to determine the values shown in the MA 2012 TRM. The following algorithm was used to determine the draft MA TRM savings value:

$$Savings = \left(\frac{TE_E - TE_B}{TE_E}\right) \times Capacity \times EFLH$$

where,

TE_E = Thermal efficiency of the replacement unit (.92)

TE_B = Assumed baseline thermal efficiency (.8)

$Capacity$ = Size bin midpoint (165 MBH for the smallest, 1,700 MBH for the largest, and the rest are midpoints of the size range)

$EFLH$ = Equivalent full-load hours for the replacement unit (1,500)

In addition to calculating the TRM savings, KEMA also developed estimates of unit savings at three subsequent levels: nameplate, telephone survey, and on-site survey. The four levels of savings were combined using a ratio estimator method typical for sample-based, engineering impact analysis. The nameplate savings and TRM savings were compared to determine a nameplate/TRM ratio while the telephone and on-site interview savings were compared to the nameplate savings to determine an overall on-site/telephone/nameplate ratio. Table 2-19 is referenced from the KEMA study (Table 1-2) and displays the results of this realization rate analysis:

Table 2-19
Condensing Boilers – Realization Rates

TRM Size Category (MBH)	Nameplate/ TRM Ratio	Overall On-Site/ Telephone/Nameplate Ratio	TRM Realization Rate
Capacity ≤ 300	1.27	0.54	0.68
300 < & < 500	1.00		0.54
500 ≤ & <1,000	0.98		0.53
1,000 ≤ & ≤ 1,700	1.00		0.54
>1,700	1.39		0.75
Overall	1.14		0.61

The TRM Realization Rate was then applied to the savings determined through the use of the aforementioned algorithm to generate the deemed savings values presented in the MA 2012 TRM.

- Unitil provides incentives for condensing unit heaters sized up to 300 MBH with 90% thermal efficiency or greater. The baseline parameters were referenced from page 308 of the 2013-2015 MA TRM which references the 2009 International Energy Conservation Code. Deemed savings were determined from the NYSERDA Deemed Savings Database (Rev 11). The database claims savings of 204.6 MMBtu per MMBtu/h of heater input capacity. An average unit size of 200,000 Btu was considered to determine the deemed savings.
- With the exception of the deemed savings for the furnace measure, the reviewers believe that the deemed savings algorithms and values for all other measures are reasonable and well supported.

The following is a list of our recommendations for the above mentioned measures:

- The reviewers recommend that both Liberty Utilities and Unitil reconcile the differences between their incentive applications.
- The reviewers also recommend confirming that appropriate gross savings values are referenced from the supporting documentation indicated in the MA 2012 TRM.

Water Heating Equipment

Both Liberty Utilities and Unitil incentivize water heating equipment. They provide the same monetary assistance for the installation of on-demand tankless water heaters, indirect water heaters, and condensing stand-alone water heaters. Both utilities have the same sizing, baseline, and proposed efficiency level requirements for incentive-eligible equipment. Unitil also incentivizes ENERGY STAR-rated, free-standing storage water heaters while Liberty Utilities does not. Unitil considers the installation of an integrated water heater/condensing boiler unit as a part of its water heating equipment measures, but Liberty Utilities has created a specific subsection for these types of projects. The 2013-2015 MA TRM considers the first three measures in a single section and has a separate section dedicated to integrated water heater/condensing boiler units. For the purposes of this report, the reviewers will consider this measure separately. Table 2-20 summarizes both the Liberty Utilities and Unitil heating equipment prescriptive incentive programs and the reviewers' findings regarding baseline requirements and deemed savings algorithms.

Table 2-20
Water Heating Equipment Measures

Measure	Measure Description	Base Efficiency	Proposed Efficiency	Gross Savings (MMBtu/yr)
On demand tankless water heater with electronic ignition	Installation of a high-efficiency gas-fired water heater.	Storage tank water heater = 0.59 EF	Energy Factor (EF) ≥0.82	7.1
High-efficiency indirect water heater	*Indirect water heaters* use a storage tank that is heated by the main boiler.	Storage tank water heater = 0.59 EF	combined appliance efficiency rating ≥ 85% or EF ≥ 0.82	30.4
Condensing standalone 75 to 300 MBH		Standalone tank water heater w/ 80% thermal efficiency	Thermal Efficiency ≥95%	25
Energy Star Storage Water Heater (≤ 75,000 Btu)	*Tankless water heaters* circulate water through a heat exchanger to be heated for immediate use, eliminating the standby heat loss associated with a storage tank.	Storage tank water heater with 0.59 EF	≥ 0.67 EF	3

The list of our comments based on a review of the algorithms for the above measures is presented here:

- **On-demand tankless water heater** – Both utilities have the same requirements for the installation of on-demand tankless water heaters, and they incentivize such measures similarly. The 2013-2015 MA TRM baseline was adopted from the 2009 International Energy Conservation Code Table 504.2.

The TRM also references a study completed by GDS Associates, Inc., in 2009 entitled "Natural Gas Energy Efficiency Potential in Massachusetts." This study claims that its baseline and deemed savings source is the U.S. DOE – Federal Energy Management Program (FEMP): Energy Cost Calculator for Gas Water Heaters. The reviewers were able to determine that the base model considered in the FEMP calculator meets the 2009 IECC. The savings were based on an average daily usage of 64 gallons per day.

- **Indirect water heaters** – Both utilities have the same requirements for the installation of indirect water heaters and incentivize such measures similarly. The 2013-2015 MA TRM references the 2009 IECC Table 504.2 as the source of the baseline efficiency requirement.

  The 2013-2015 MA TRM also references a study completed by GDS Associates, Inc. in 2009 entitled "Natural Gas Energy Efficiency Potential in Massachusetts." The GDS study references the US DOE FEMP Energy Cost Calculator for Gas Water Heaters as the source of its baseline requirements. To determine the deemed savings for this measure, GDS used the gas-fired water heater screening tool developed by ESource in 2007.

- **Condensing stand-alone water heaters** – Both utilities have the same requirements for the installation of condensing stand-alone water heaters, and they incentivize such measures similarly. The incentive is applied to units sized between 75 MBH and 300 MBH. The 2013-2015 MA TRM references the 2009 IECC Table 504.2 as the source of the baseline efficiency requirement.

  The TRM references the GDS 2009 paper as the source of it deemed savings values. The GDS paper, in turn, adopted the deemed savings from the ESource 2007 screening tool. Using an average daily draw of 250 gallons, a baseline efficiency of 80%, and proposed efficiency of 96%, the reviewers were able to recreate the reported deemed savings values.

- **Water storage heaters** – Unitil incentivizes free-standing water heaters with a maximum capacity of 75,000 Btu/h. The 2013-2015 MA TRM references the 2009 IECC as the source of its baseline efficiency. The deemed savings are adopted from the GDS 2009 paper that references the FEMP energy cost calculator for gas water heaters. The reviewers were able to replicate the deemed savings calculations using the FEMP calculator.

Overall, the reviewed documentation suggests that deemed savings algorithms and values are reasonable and well supported.

For the above-mentioned measures, we recommend making the program offerings consistent. Liberty Utilities does not offer incentive for the storage water heater or the condensing unit heater measure.

Integrated Water Heater/Condensing Boiler

Both utilities incentivize the installation of integrated water heater/condensing boiler units. The 2013-2015 MA TRM references a 2009 GDS Associates, Inc., paper entitled "Natural Gas Energy Efficiency Potential in Massachusetts" as the source of its baseline and deemed savings values. The GDS paper adopted its baseline parameters from Federal Code: FR66/11/Jan 17, 2001, page 4497. The baseline is based on a 40-gallon gas storage water heater. It seems as though the federal code has since been updated as of November 19, 2007. The deemed savings were referenced from an unidentifiable spreadsheet and are referenced in the GDS paper solely as "SB calc; SB SH HVAC Analysis Tab, and SB DHW Analysis Tab." Table 2-21 summarizes the reviewers' findings for the integrated water heater/condensing boiler measure.

Table 2-21
Integrated Water Heater/Condensing Boiler Equipment Measures

Measure	Measure Description	Base Efficiency	Proposed Efficiency	Gross Savings (MMBtu/yr)
Integrated water heater/Condensing boiler	This measure promotes the installation of a combined high-efficiency boiler and water heating unit. Combined boiler and water heating units are more efficient than separate systems because they eliminate the standby heat loss of an additional tank.	Standard efficiency gas-fired storage tank hot water heater with a separate standard efficiency boiler for space heating, 80% AFUE boiler and 0.594 EF water heater	0.9 EF or 90% AFUE	24.6

Controls Equipment

Both Unitil and Liberty Utilities offer similar incentives for the implementation of controls measures that help reduce the consumption of natural gas. Incentivized measures include: the installation of after-market boiler controls, the repair/replacement of faulty steam traps, and the installation of ENERGY STAR-rated or 7-day programmable thermostats. Table 2-22 presents the reviewers' findings for prescriptive controls measures.

Table 2-22
Controls Equipment Measures

Measure	Measure Description	Base Efficiency	Proposed Efficiency	Gross Savings (MMBtu/yr)
After-market boiler reset controls	Boiler reset controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.	Boiler without reset controls	Boiler with reset controls	35.5
Steam traps	Repair or replace malfunctioning steam traps.	Failed steam trap	Repaired or replaced steam trap	25.7

Measure	Measure Description	Base Efficiency	Proposed Efficiency	Gross Savings (MMBtu/yr)
ENERGY STAR or 7-day programmable thermostats	Installation of a 7-day programmable thermostat with the ability to adjust heating or air-conditioning operating times according to a pre-set schedule to meet occupancy needs and minimize redundant HVAC operation.	HVAC system using natural gas to provide space heating without a programmable thermostat	HVAC system using natural gas for space heating with a 7-day programmable thermostat	7.57

The list of our comments based on a review of the algorithms for the above measures is presented here:

- The 2013-2015 MA TRM states that the baseline system used to determine the deemed savings for the after-market boiler reset controls measure is a boiler with no reset control capability. The deemed savings were referenced from the 2009 GDS study. The GDS paper mentions that the prescribed baseline is "business as usual." The baseline annual energy use was calculated by GDS and determined to be 710.46. The 5% savings factor was adopted from www.energysolutionscenter.org, but the specific page is no longer accessible. The application of the 5% savings factor provides the GDS reported deemed savings of 35.5 MMBtu.
- The 2013-2015 MA TRM states that the base case for the repair/replacement of steam traps is a faulty steam trap in need of repair/replacement. The TRM cites research conducted in 2008 by National Grid on historical steam trap surveys as the basis for its deemed saving value of 25.7 MMBtu per year per trap. Steam losses were calculated for all trap sizes between 1/32″ to 1/4″, for both low pressures (between 5 and 10 psig) and high pressures (between 50 and 100 psig). Traps were assumed to be failing for 540 hours per year. Using this method the energy loss was determined to be 385 Btus per trap per year. Fifty percent of the traps were assumed to fail in the open position. The savings are calculated by multiplying by the inverse of the boiler efficiency, which in this case was cited as 75%. Hence the annual natural gas saving s of 25.7 MMBtu.
- Deemed savings for the installation of ENERGY STAR-rated or 7-day programmable thermostats were calculated based on the assumption that the baseline natural gas-supplied HVAC system was not controlled by such a device. The 2013-2015 MA TRM references a 2007 study completed by RLW Analytics entitled, "Validating the Impact of Programmable Thermostats." The reviewers were able to access this paper and verify the deemed savings value of 7.7 MMBtu per year.
- Overall, the reviewed documentation suggests that deemed savings algorithms and values are reasonable and well supported.

Commercial Kitchen Equipment

Both utilities incentivize the installation of high-efficiency commercial kitchen equipment. Equipment that is incentivized under both Liberty Utilities and Unitil prescriptive programs includes high-efficiency fryers, steamers, gas convection ovens, gas combination ovens, gas conveyor ovens, gas rack ovens, and gas griddles. In addition to the equipment mentioned, Liberty Utilities also incentivizes the installation of high-efficiency pre-rinse spray valves. Table 2-23 presents the reviewers' findings for prescriptive commercial kitchen measures.

Table 2-23
Incentivized Controls Equipment Measures

Measure	Measure Description	Base Efficiency	Proposed Efficiency	Gross Savings (MMBtu/yr)
Energy Star fryer	The installation of a natural gas-fired fryer that is either ENERGY STAR rated or has a heavy load efficiency of at least 50%. Qualified fryers use advanced burner and heat exchanger designs to use fuel more efficiently, as well as increased insulation to reduce standby heat loss	35% cooking efficiency, 16,000 Btu preheat energy, 14,000 Btuh Idle Energy Rate, 60 lbs/hr production capacity	High efficiency and Idle Energy Rate are site specific and can be determined on a case-by-case basis. To simplify the savings algorithm, typical values for food load (150 lbs/day) and preheat energy (15.5 Btu) are assumed.	58.6
Energy Star commercial steamer	The installation of an ENERGY STAR rated natural gas-fired steamer, either connectionless or steam-generator design, with heavy-load cooking efficiency of at least 38%. Qualified steamers reduce heat loss due to better insulation, improved heat exchange, and more efficient steam delivery systems.	Typical boiler-based steamer w/ the following operating parameters: Preheat Energy Rate = 72,000 Btu/hr, Idle Energy Rate = 18,000 Btu/hr, Heavy Load Efficiency = 18.0%, Production Capacity = 23.3 lbs/hr/pan, Average Water Consumption Rate = 40 gal/hr, and Percentage of Time in Constant Steam Mode = 40%	Energy Star qualified gas-fired steamer with the following operating parameters for a 6 pan steamer: Preheat Energy Rate = 36,000 Btuh, Idle Energy Rate = 12,500 Btuh, Heavy Load Efficiency = 38.0%, Production Capacity = 20.0 lbs/hr/pan, Average Water Consumption Rate = 3.0 gal/hr, and Percentage of Time in Constant Steam Mode = 40%	106.6
Energy Star commercial convection oven	Installation of high-efficiency gas ovens	0.3	≥ 44%	24.8
High efficiency gas combination oven		0.35	≥ 44%	110.3
High efficiency gas conveyor oven		20% Heavy Load	≥ 44%	84.5
High efficiency gas rack oven		0.3	≥ 50%	211.3
Energy Star commercial griddle	Installation of a gas griddle with an efficiency of 38%.	30%	38%	18.5
High efficiency pre-rinse spray valve	Retrofitting existing standard spray nozzles in locations where service water is supplied by natural gas-fired hot water heaters with new low-flow pre-rinse spray nozzles with an average flow rate of 1.6 GPM.	Standard efficiency spray valve, Laboratory determined flow rate of 3.34 GPM	Low-flow pre-rinse spray valve w/average flow rate of 1.6 GPM	33.6

The list of our comments based on a review of the algorithms for the above measures is presented here:

- **Fryer** – The 2013-2015 MA TRM states that to be eligible for incentive, a commercial fryer must be either ENERGY STAR rated or have a heavy-load cooking efficiency of at least 50%. The baseline efficiency case, as described in the TRM, is a typical low-efficiency gas-fired fryer with a 35% cooking efficiency, 16,000 Btu preheat energy, 14,000 Btu/h idle energy rate, and 60 lbs/hour of production. These baseline parameters were defined by the gas fryer life-cycle cost calculator developed by Food Service Technology Center in 2010.

The deemed energy savings of 58.6 MMBtu, reported for this measure are referenced from the life cycle cost estimate for ENERGY STAR gas fryers developed by the EPA in 2009. The following algorithm and assumptions were used to determine the savings associated with this measure:

$$\Delta MMBtu = \left[\left(\frac{A_{Base}}{\eta_{Base}} + (B_{Base} \times IDLE_{Base}) + C_{Base} - \left(\frac{A_{EE}}{\eta_{EE}} + (B_{EE} \times IDLE_{EE}) + C_{EE} \right) \right] \left(\frac{365}{1{,}000{,}000} \right)$$

where,

Unit = Installed high efficiency gas commercial fryer

ΔMMBtu = Gross annual average MMBtu saving per unit: 58.6

A_{Base} = Baseline equipment daily cooking energy (Btu/day). Default: 85,500 Btu.

η_{Base} = Baseline equipment heavy-load cooking efficiency. Default: 35%.

B_{Base} = Baseline equipment daily fryer idle time (hours). Default 13.25 hrs.

$IDLE_{Base}$ = Baseline equipment idle energy rate (Btu/h). Default: 14,000 Btu/h

C_{Base} = Baseline equipment total daily preheat energy (Btu). Default: 16,000 Btu

A_{EE} = Efficient equipment daily cooking energy (Btu/day). Default: 85,500 Btu.

η_{EE} = Efficient equipment heavy-load cooking efficiency. Default: 55%.

B_{EE} = Efficient equipment daily fryer idle time (hours). Default: 13.44 hrs.

$IDLE_{EE}$ = Efficient equipment idle energy rate (Btu/h). Default: 8,500 Btu/h

C_{EE} = Efficient equipment total daily preheat energy (Btu). Default: 15,500 Btu

365 = Days per year

1,000,000= Btu per MMBtu

The high-efficiency cooking efficiency and idle energy rate are site-specific parameters and are determined on a case-by-case basis. The values mentioned above for these parameters were used to simplify the savings algorithm.

- **Commercial steamers** – The baseline efficiency case for commercial steamers, as described in the MA 2012 TRM, is a typical boiler-based steamer. The following operating parameters, which were referenced from the 2011 EPA life cycle cost estimate for ENERGY STAR gas steamers, characterize the baseline system:
  - Preheat energy rate = 72,000 Btu/h
  - Idle energy rate = 18,000 Btu/h
  - Heavy load efficiency = 18%
  - Production capacity = 23.3 lbs/hour/pan
  - Average water consumption rate = 40 gal/hr
  - % of time in constant steam mode = 40%

The 2013-2015 MA TRM states that to be eligible for this incentive, a commercial steamer must have a heavy-load cooking efficiency of at least 38%. The high efficiency case as described in the 2013-2015 MA TRM has the following parameters:

- Preheat energy rate = 36,000 Btu/h
- Idle energy rate = 12,500 Btu/h
- Heavy-load efficiency = 38%
- Production capacity = 20 lbs/hr/pan
- Average water consumption rate= 3 gal/hr
- % of time in constant steam mode= 40%

The deemed savings calculations are carried out assuming that the steamers operate for 12 hours per day for 365 days per year, for a total of 4,380 hours per year. The source of the high-efficiency system and operating hours is also the EPA Life Cycle Cost Estimate spreadsheet.

- **Convection, combination, conveyor, and rack ovens** – Both Unitil and Liberty Utilities incentivize the installation of high-efficiency convection, combination, conveyor, and rack ovens. The baseline and high-efficiency levels are provided in Table 2-22 along with the deemed savings for each type of measure.

  The 2013-2015 MA TRM for convection ovens cites a 2008 paper written by the Consortium for Energy Efficiency entitled "Technology Opportunity Assessment: Convention Ovens" as the source of the deemed energy savings values. Page 4 of the CEE paper provides, in tabular form, the baseline and high-efficiency system parameters considered in the savings calculations. The baseline parameters are as follows:

  - Cooking energy efficiency = 30%
  - Preheat energy = 19,000 Btu
  - Idle energy rate = 18,000 Btu/h
  - Production capacity = 70 lbs/hr

The high-efficiency system parameters are as follows:

- Cooking energy efficiency = 44%
- Preheat energy = 19,000 Btu
- Idle energy rate = 14,000 Btu/h
- Production capacity = 70 lbs/hr

The next-to-last page of the CEE paper, page 5, provides a summary of the savings associated with the installation of a high-efficiency convection oven. The baseline system consumed 1,052 therms while the high-efficiency system consumed 804 therms for a savings of 248 therms or 24.8 MMBtu.

The baseline and deemed savings calculations for the combination, conveyor, and rack ovens are displayed in Table 44 of the MA 2012 TRM. The TRM references the same 2010 Food Service Technology Center spreadsheet as the source of the baseline parameters, proposed parameters, and deemed savings for each of the measures. The reviewers were not able to access this spreadsheet to verify the parameters. However, reviewers have found their approach sound and reasonable.

- **Commercial griddles** – Both utilities offer incentives for the installation of high-efficiency commercial griddles. The 2013-2015 MA TRM references the Food Service Technology Center's 2010 study entitled "Gas Griddle Life-Cycle Cost Calculator" as the source of its deemed savings value. The reviewers were not able to access the spreadsheet and were therefore unable to verify the parameters used.
- **High-efficiency pre-rinse spray valves** – Only Liberty Utilities provides incentives for the installation of high-efficiency pre-rinse spray valves. The 2013-2015 MA TRM references a 2004 study completed by SBW Consulting, Inc., entitled, "Evaluation, Measurement & Verification Report" for the CUWCC Pre-Rinse Spray Head Distribution Program as the source of baseline efficiency and deemed savings value. The reviewers were unable to verify the source of the proposed high-efficiency flow rate of 1.6 GPM. It should be noted that the EPACT 2005 set forth new guidelines that require all nozzles to be better than or equal to 1.6 GPM.

  Using data collected from nineteen metered sites, the SBW Consulting team determined an average pre-flow rate of 3.34 gpm at 60 psig with average on-time of 1.27 hours/day. Based on these parameters, SBW was able to generate a .92 therms/day/head savings for this a natural gas supplied high-efficiency pre-rinse spray valve. This totals in a total annual energy savings of .92 therms/day/head × 365 days/year or 336 therms/year/head.

Our recommendations for the above-mentioned measures are as follows. We recommend making the program offerings consistent throughout the state. Unitil does not offer incentives for the high-efficiency pre-rinse spray valves measure. Unitil requires cooking efficiency of 40% while NGRID requires 44% for the same equipment – convection ovens, combination ovens, and conveyor ovens.

2.3 Overview of the Custom Program

As discussed earlier in this section, there are two different tracks that energy efficiency projects follow under the nhsaves@work/New Equipment & Construction – Prescriptive and Custom. The Prescriptive program has been discussed above in detail. For projects that do not fall into the Prescriptive project category, a Custom track is followed. Assessments are conducted to determine the energy savings and incentives specifically for the application at hand and are addressed on a case-by-case basis.

When a new technology is added to the programs, it is typically added first to the Custom program. If that technology were later determined to fit the Prescriptive program approach, the Custom program would still retain that technology as a potential incentive option.

The baseline parameters for the Custom program are put forth in a summary document that addresses technology categories. The baseline systems for these designated measure categories are decided based on utility project experience, current practices of market actors, and consulting assessments. In addition to these sources, the energy codes are also considered while deciding the baseline parameters.

2.3.1 Type of Measures

The nhsaves@work/New Equipment & Construction Program covers a wide variety of Custom measures. The Custom project track is used for approval of qualified projects that are not covered by Prescriptive rebates. All projects require a detailed engineering analysis to determine project savings. The incentives for Custom applications will buy down the project to a 1-year payback period, or pay 75% of the incremental cost of the project, whichever is less.

The baseline for the Custom project categories reflects current or standard practice for the different type of systems considered by the program.

A condensed list of measures covered under the Custom Program is presented below:

- Interior lighting – Install highly efficient lighting systems providing similar light levels.
- Exterior lighting – Install automatic controls.
- Lighting controls – Install complex lighting control systems.
- Windows and skylight glazing – Install high efficiency windows and skylights.
- Office building HVAC systems – Install high efficiency control equipment, as VFD controls, DDC controls, central plant optimization systems, and other controls.
- Manufacturing or classroom buildings – Install high efficiency air distribution systems and VFDs on water loops.
- Exhaust systems – Install high efficiency equipment on fume hoods and kitchen hoods.
- HVAC unitary equipment and split systems – Install high efficiency equipment, such as evaporative condensers, enthalpy/heat exchangers, and VFDs.
- Water source heat pumps – Install high efficiency equipment, such as VFDs on water loops, and induced draft cooling towers.
- New chilled water plants – Install higher efficiency chillers and other energy efficiency measures as VFDs, DDC controls, sequencing controls, and thermal storage.
- Building control systems – Install complex EMS with features, such as static pressure reset based on HVAC system demand, CO_2 and VOC sensors, and enthalpy control.
- Boiler equipment – Install VFDs on feed water pumps and on draft fans.
- Commercial refrigeration – Install high efficiency equipment, such as VFDs, high efficiency compressors, electronic controls, and heaterless doors.
- Industrial refrigeration – Install high efficiency equipment, such as VFDs, high efficiency compressors, multi-stage compressor systems, electronic controls, and high-speed freezer doors.

- Process-related equipment – Install VFDs, electronically operated and controlled equipment, and other specific energy efficient equipment.
- Air compressed systems - Install high efficiency equipment, such as VFDs, multi-stage compressors, sequencing controls, cycling refrigerated dryers, and low-pressure blower systems.
- Waste water treatment and fresh water plants – Install VFDs and other specific energy efficient equipment.
- Plastic injection molding machines – Install high efficiency equipment, such as VFDs or other hydraulic enhancements.
- Ice rinks – Install high efficiency equipment, such as infrared ice-surface temperature sensors, hot gas heat recovery, and desiccant dehumidification.

2.3.2 Type of Projects to Date

ERS has asked all of the participating utilities in New Hampshire to provide information about the Custom projects for which incentives have been offered under the nhsaves@work/New Equipment & Construction program. We received information from Public Service of New Hampshire, Liberty Utilities, and New Hampshire Electric Coop. Unitil did not implement any projects to date under the Custom program. A short description of the projects received is presented in Tables 2-24 through 2-26.

Table 2-24
Custom Projects List – Liberty Utilities

Measure	Baseline	As-Built
Wall insulation	18213 sq ft of R-15 wall insulation from RS Means	18213 sq ft of R-24 wall insulation
Windows	Using RS means cost for 2,391 sqft of double hung vinyl windows	Installing 2,391 sqft of energy efficient double hung windows
Roof Insulation	8761 sq ft of R-38 roof insulation from RS Means	8761 sq ft of R-60 new roof
Energy recovery	Old ventilation system	Add (3) Energy Recovery Ventilators
Water heater		(2) 1,444 MBH space heating boilers with 109 gallon storage tank each
Ventilation Heat Recovery	Building is new construction. The base case is assumed to be energy code.	Install three (3) ERV's supplying 4,500, 6,000, and 35,000 CFM.
Refrigeration heat recovery	Evaporative condensers rejecting heat to the atmosphere	Evaporative condensers equipped with heat exchangers to recover waste heat which will be supplied to each RTU
Energy recovery	Only 5,000 CFM ERV is over code so needs base case cost	(5) Greenheck ERVs installed
Condensing boilers	(3) 765 MBH boilers and 50,045 CFM worth of Air Handling Units	(3) Lochnivar XL KBN801 752 MBH output boilers, 20 FHP heatpumps and 5/8 radiant pipe heating for lobby
HVAC		
VFD air compressor	add a 3rd 75 hp inlet modulation air compressor to serve expanded load	add a new 100 hp vfd compressor, vfd dryer, low pressure drop filters, no-loss drains and storage
High efficiency heat pumps, ERVs, CO2 ventilation control	Standard efficiency air-to-air heat pumps, no energy recovery, constant volume ventilation	High efficiency heat pumps, ERVs, CO2 ventilation control
Refrigerated case covers	Refrigerated case without covers	Refrigerated case with covers

Table 2-25
Custom Projects List – Public Services of New Hampshire

Measure	Baseline	As-Built
EMS	RTU fans and AC running longers	Reduced RTU fan and AC runtime.
Snow guns	Ratnik snow guns	Pole Cat snow guns
Install new LED lighting system with controls	High pressure sodium and T5 fluorescent	LED
Injection molding machines	Standard efficiency injection molding machine	High efficiency injection molding machine

Table 2-26
Custom Projects List – Unitil

Measure	Baseline	As-Built
New Heating System	Oil-fired Kewanee boiler	2 Lochinvar model KBN 601 boilers, piping, pumps, flue venting, gas piping, 1" fiberglass insulation, and electrical
Hydraulic motor servo controllers	Less efficient hydraulic motors and controls	hydraulic moter servo controllers

From the tables above, it can be noticed that a variety of projects have been covered under the nhsaves@work/New Equipment & Construction Custom program. It is apparent from the data presented in the table that the most commonly encountered measures involve some sort of energy recovery.

2.3.3 Approach for Baseline Development and Project Analysis of Custom Measures

As stated above, all custom projects require a detailed engineering analysis to determine project savings. This analysis should establish application-specific parameters and quantitative assessments for the given project. Detailed description of the measures and energy savings calculations should be provided along with the application.

The baseline description/energy saving opportunities list does not offer detailed information about the energy efficiency of the baseline systems, with the exception of HVAC unitary systems and chillers. For these systems, the list offers a guide for the baseline systems and for the energy efficiency measures.

However, for measures like lighting, mechanical systems, motors, and VFDs that have complex applications that are not covered under the Prescriptive criteria, separate baseline practices are specified for custom projects.

The demand and energy savings to a greater extent depend on the expertise and qualifications of the personnel that prepare the custom application. The baseline assumptions for parameters like operating hours, loads, and base case demand are very important and the experience of the applicant has a key role in correctly evaluating the savings associated with the proposed measure(s).

Energy Code Review

3

3.1 Introduction

This section presents a comprehensive review of the recent New Hampshire Commercial Energy Code and its relationship to the nhsaves@work New Construction Program baseline parameters. The current energy code (IECC 2009/ASHRAE 90.1-2007) was reviewed from the perspective of the New Construction Program with the intention of determining how the code relates to the existing prescriptive and custom measures. This review, however, was not intended to be a code compliance study.

As an additional step, we also compared the current baseline parameters with IECC 2012 or ASHRAE 90.1-2010 to provide some insights on the impending changes in the near future.

Review of the new energy code involved several sub-tasks including an overall review of the approach taken by the new code, an assessment of the relationship to the prescriptive measures, and an assessment of the relationship to the custom measures.

This section ends with a comparison of IECC 2009 and IECC 2012)

3.2 Overview of the NH New Commercial and industrial Energy Code

Effective, April 1, 2010, New Hampshire adopted the IECC 2009 (International Energy Conservation Code). This decision by New Hampshire follows recent adoption of similar energy codes by other states in the region. The various states' codes are more similar than dissimilar, and they are primarily based on the IECC and on ASHRAE Standard 90.1 (2007). The IECC 2009 code for commercial buildings addresses numerous technical areas applicable to new construction or major renovation of commercial buildings.

By their nature, energy codes establish an important baseline for minimum acceptable "legal" practice for new construction projects. Nevertheless, evidence shows that many new buildings do not comply with codes, and some are considerably below the basic equipment and design requirements required by the code. Other buildings choose designs and equipment that are considerably better than the code, even when they are not incentivized through efficiency programs. It is valuable to understand that the New Construction program may have broader technology scope than the energy code, particularly when custom measures are considered.

It should be noted that the IECC 2009 code references ASHRAE standards 90.1 2007 in association with Commercial Building Design; however, not all buildings have to meet the more stringent requirements of the ASHRAE standard. Chapter 5 of the IECC, Commercial Energy Efficiency, specifically outlines criteria for which buildings, or sections of buildings, can meet and fall under the specifications of the IECC. In cases where these criteria are not met, references to alternate approaches in the ASHRAE Standard are put forth. Through interviews of multiple architects and engineers practicing in the state of New Hampshire, and through our own work in this field, it is our perspective that the majority of new construction projects in New Hampshire reflect the IECC 2009 Chapter 5 specifications.

A brief overview of the International Energy Conservation Code (IECC) 2009 and ASHRAE Standard 90.1-2007 are presented in following sections.

3.2.1 International Energy Conservation Code 2009

The International Energy Conservation Code 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 will impact a building's operation and energy consumption. This comprehensive code establishes minimum regulations for energy-efficient buildings using prescriptive and performance-related provisions. The principles utilized in the development of this code were based on the intent to establish an energy conservation code that adequately conserves energy; does not unnecessarily increase construction costs; does not restrict the use of new material, products, or methods of construction; and does not give preferential treatment to particular industries or types or classes of materials, products, or methods of construction.

The IECC 2009 Code prevails in the majority of instances, and it is only the exceptions that do not have to meet the specified criteria in IECC 2009. The exceptions are addressed via ASHRAE Standard 90.1-2007. Although it is difficult to definitively predict, it appears that most new construction projects fall exclusively under the IECC specifications. Subsequently, the baseline algorithm parameters should give primary importance to the IECC 2009 requirements, as a rule. The New Hampshire baseline parameters, as a whole, do exceed these requirements put forth by the IECC 2009 Code.

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. The following paragraphs briefly discuss the topics related to the scope of this study.

- Building envelope requirements – This section of the code addresses building envelope design and construction, and considers: insulation levels or U-values for walls, roofs, windows, and other shell elements; foundation and slab requirements; and air leakage requirements pertaining to windows, doors, curtain wall assemblies, and openings/penetrations into the building.
- Mechanical (HVAC) systems – This section of the code addresses the design and construction of mechanical systems. It states requirements for load calculation methodology and associated equipment sizing. Minimum equipment efficiency for unitary air conditioners, heat pumps, packaged terminal air conditioning (PTAC) and packaged terminal heat pump (PTHP) systems, warm air furnaces, boilers, and other systems are stipulated. Other requirements address air economizing, duct and plenum sealing and insulation, controls for space temperature and fan systems, etc.

- Lighting and lighting controls – This section of the code addresses lighting controls and lighting power density (LPD) allowances. It states where lighting controls are required and how they must be implemented. For LPD requirements, it states the maximum power density allowance (watts per square foot) for different building or space types. Other requirements address issues such as tandem wiring, multi-level switching, and exterior lighting.

3.2.2 ASHRAE/IESNA 90.1-2007

The scope of ASHRAE/IESNA Standard 90.1-2007 includes specification of minimum energy-efficient requirements for the design and construction of new buildings – or portions of buildings – and their systems, for specification of new systems and equipment in existing buildings, and to provide criteria for determining compliance with these requirements. The scope of this standard does not cover low-rise residential buildings. As indicated above, the IECC 2009 Code prevails in the majority of instances, and it is only the exceptions that do not meet specified criteria in IECC 2009 that are addressed via ASHRAE Standard 90.1-2007.

The provisions of this standard apply to the envelope of buildings conditioned by a heating system having output capacity greater than or equal to 3.4 Btu/h-ft^2 or by a cooling system whose sensible output capacity is greater than or equal to 5 Btu/h-ft^2. The provisions also apply to systems and equipment used in conjunction with buildings such as heating, ventilating and air conditioning, service water heating, electric power distribution and metering provisions, electric motor and belt drives, and lighting. The provisions do not apply to single-family homes or multi-family structures, buildings that do not use electricity or fossil fuel, and equipment or portions of a building that use energy primarily to provide for industrial, manufacturing, or commercial processes.

The scope of this section of the report focuses on the technical areas applicable to new construction or major renovation of commercial and industrial buildings, which include building envelopes, mechanical systems, and lighting systems.

3.2.3 Rules

In addition to the explicit energy code itself, there are "rules" and regulations put forth by the New Hampshire Public Utilities Commission that are also relevant. The "PUC 1800 – New Hampshire Code for Energy Conservation in New Building Construction" and "RSA 155-D – Energy Conservation in New Building Construction" provide further definition on the nature of the code document.

The topics covered by PUC 1800 include application of the rules, methods of compliance regarding design, the application process, evidence of compliance of the completed building, and amendments to ASHRAE standards 90.1 (non-residential buildings).

RSA 155-D provides information pertaining to construction standards, administration, unlawful acts, penalties, injunctions, exemptions, changes of occupancy, training, and rule making.

The rules are under constant review and are updated as and when required.

3.3 Prescriptive Program Code Applicability

ERS reviewed the recent New Hampshire Energy Code (IECC 2009) to determine the relationship to the prescriptive and custom measures of the nhsaves@work/New Construction program. The tasks involved in the review process are briefly described below.

- Code review and outline – For this task, ERS reviewed all sections and details of the new commercial energy code. We tabulated any specific requirements of the code that have applicability to any of the approved prescriptive measures of the nhsaves@work/New Construction program. Based on our review of the energy code, we prepared a comprehensive table of energy code-based performance parameters for comparison to the existing prescriptive measure baseline details.
- Comparison with existing baseline parameters – The comparison between the existing baseline parameters used by the program and the parameters resulting from our code review yielded minor differences in a small listing of program offerings.
- Development of code-based baseline parameters & observations – Following the comparison, we have enlisted our observations to be used for the development of focused recommendations for the enhancement of individual measure baselines. Sections of the new code contain explicit design approaches and equipment efficiency rules for HVAC systems, lighting technologies, and building envelope characteristics. All of these parameters have been reviewed for the purpose of developing recommendations.

3.3.1 Lighting Systems

The IECC 2009 addresses lighting systems in Section 505. Also, ASHRAE 90.1-2007 addresses lighting controls and LPD allowances in Chapter 9. Both documents state criteria for which lighting controls are required and how they must be implemented. According to IECC 2009 section 505.2.2.1, the code requires the use of bi-level manual switching for areas that are required to have manual control but do not have occupancy controls and have more than one lighting fixture. According to the IECC 2009, section 505.2.2.2, for buildings having an area > 5,000 sq. ft., automatic lighting shutoff is required for most spaces.

For LPD requirements, the IECC 2009 code and ASHRAE 90.1-2007 state the maximum power density allowance (W/ft^2) for different building or space types. Other requirements address issues such as tandem wiring, multi-level switching, and exterior lighting.

There are no references to the energy efficiency of the lighting system components, with the exception of Section 9.4.4 of ASHRAE 90.1-2007 and Section 505.6.1 of IECC 2009, where minimum efficacy for lamps used in exterior building grounds luminaries are offered. There are no other references to minimum acceptable lamps' efficacies or to luminaries' efficiencies.

Table 3-1 presents our comments on the findings for lighting and lighting controls in relationship with the New Hampshire New Construction Program. Based on our observations, we conclude that the allowable LPD requirements of the Energy Code could have a significant impact on the New Construction Program. The prescriptive incentives are based on lighting fixture and/or component performance, while the energy code is based on building/space performance. Certainly the proper utilization of the rebate-eligible lighting measures will help to meet energy code requirements, but there is no direct connection. It is likely that the use of technologies that qualify for incentives leads to projects that can be considered more efficient than code. It is also entirely possible that projects that meet the requirements of the New Construction Program may not meet the minimum requirements of the code. Refer to Section 6 for further discussions on LPD.

Table 3-1 (Part 1 of 3)
Comparison of Prescriptive Lighting Measures with IECC 2009 Code and ASHRAE Standards 90.1-2007

Code	Measure Description	Measure Eligibility Requirements	IECC 2009	ASHRAE 90.1-07 - Chapter 9. Lighting
10	High efficiency fluorescent lamps and ballasts	Each unit is composed of a ballast and 1,2,3, or 4 lamps. Only one unit may be counted per fixture. Two fixtures tandem-wired are only eligible for one rebate. These customers are eligible for eight foot T8 ballast rebates.	There are no specific energy efficiency requirements. Only limits on the lighting power density (LPD) are imposed based on the occupancy type in the codes.	There are no specific energy efficiency requirements. Only limits on the lighting power density (LPD) are imposed based on the occupancy type in the codes.
30A	High efficiency recessed Fluorescent Fixtures	High efficiency new prismatic lensed fixture. Overall efficiency must exceed 83% for 2x4 fixtures and 75% for 2x2 fixtures. Eligible fixtures are limited to two T8 or T5 lamps. Biax lamps are not eligible.		
30B	High efficiency recessed fluorescent fixtures	High efficiency new parabolic fixture. Overall efficiency must exceed 80%. Eligible fixtures are limited to two T8 or T5 lamps. Biax lamps are not eligible.		
30C	High efficiency recessed fluorescent fixtures	High efficiency two-lamp recessed Indirect/Direct fixture. Overall efficiency must exceed 75% for 2x4 and 2x2 I/D fixtures, 80% for 2x2 reduced glare reducing fixtures. T8, T5 and T5HO lamps are eligible in 2x2 fixtures. T8 and T5 lamps are eligible in 2x4 fixtures. Biax lamps are not eligible. Eligible fixtures are limited to two T8 or T5 lamps. Biax lamps are not eligible.		
31	High efficiency 3 lamp fluorescent fixtures	High efficiency new fluorescent lensed fixture. Overall efficiency must exceed 83% for 2x4 Prismatic lensed fixtures, 75% for parabolic2x4 fixtures and 70% for 2x4 recessed indirect fixtures. Eligible fixtures are limited to 3 T8 or T5 lamps and a low power (less than 0.08) ballast.		
33	Low glare indirect fluorescent fixtures	Each unit must exceed 80% efficiency. Each fixture is limited to two T8 or T5 lamps or one T5HO lamp. Fixtures with a down light component must incorporate glare reducing louvers or perforated covers. Down light component must not exceed 45%. The ceiling must be white and unobstructed.	There are no specific energy efficiency requirements. Only limits on the lighting power density (LPD) are imposed based on the occupancy type in the codes.	There are no specific energy efficiency requirements. Only limits on the lighting power density (LPD) are imposed based on the occupancy type in the codes.
34	Advance recessed fluorescent fixtures	High efficiency new fluorescent fixture. Overall efficiency must exceed 83% for 2x4 fixtures, 80% for 1x4 fixtures and 80% for 2x2 fixtures. Eligible fixtures are limited to one or two T8 or T5 lamps or one T5 lamp.		
41	Fluorescent fixtures with high efficiency reflectors - 4'	Each unit must include a new custom reflector with a minimum reflectivity of 85% for industrial reflector fixture and 83% for commercial grade wraparound fixture with T8 or T5 lamps. Eight foot fixtures must use T8 lamps. Reflectors shall have no uplighting features. High efficiency white reflective surfaces have a $10 limit.		
42	Fluorescent fixtures with high efficiency reflectors - 8'			
44	Clean room rated fluorescent fixtures	Each unit must include a new clean room fluorescent fixture. Over all efficiency must exceed 75% and contain no more than three T8 or T5 lamps.		

Table 3-1 (Part 2 of 3)
Comparison of Prescriptive Lighting Measures with IECC 2009 and ASHRAE Standards 90.1-2007

Code	Measure Description	Measure Eligibility Requirements	IECC 2009	ASHRAE 90.1-07 - Chapter 9. Lighting
21	1 lamp compact fluorescent hardwired fixture	Rebates are for new hardwired, permanently mounted, fixtures with fluorescent lamps and a ballast (THD<33%). Retrofit kits, screw-in adaptors and exit signs are not eligible.	There are no specific energy efficiency requirements. Only limits on the lighting power density (LPD) are imposed based on the occupancy type in the codes.	There are no specific energy efficiency requirements. Only limits on the lighting power density (LPD) are imposed based on the occupancy type in the codes.
23	Compact fluorescent fixtures with dimming ballasts	Rebates are for new hardwired, permanently mounted, fixtures with fluorescent lamps and a ballast (THD<33%). Retrofit kits, screw-in adaptors and exit signs are not eligible. All long tube CFL and biax fixtures are eligible.		
56	Low bay fluorescent fixtures <= 210 Watt	Minimum wattage is 104, maximum is 210 watts. Systems used for low bay (recommended >=16 ft) must have fixture efficiency of 88% and contain T8 lamps with a >88% ballast factor ballast or T5 lamp and ballast. T5 and CFL systems are eligible.		
57	High bay fluorescent fixtures >= 210 Watt	Minimum wattage is 207 watts. Systems used for Hi bay (recommended >=20 ft) must have fixture efficiency of 88% and contain T8 lamps with a >88% ballast factor ballast or T5 lamp and ballast. T5 and CFL systems are eligible.		
70	Metal halide specialty fixtures with electronic ballast	Each unit must be a new fixture between 20 and 100 watts. The fixtures maybe track, recessed or surface mounted.		
61	Remote-mounted occupancy sensor	Sensors must be ceiling or wall mounted. Must comply with manufacturer's coverage recommendations. Must control a minimum of 110 watts. Switch plate mounted units are not eligible. No manual "ON" overrides.	The codes require the use of bi-level manual switching for areas that do not have occupancy controls under most commonly found conditions. (Section 505.2.2.1)	For buildings having area > 5,000 sq. ft, automatic lighting shutoff is required for most spaces. Measures 61, 63 and 64 will meet this requirement as will certain automatic time clocks. (Section 9.4.1.1)
62	Daylight dimming system	Install dimming ballasts, photo sensor and associated control wiring where perimeter or skylight daylight is available. Must have continuous dimming or adjust to at least 4 levels. No on/off. Must control a minimum of 53 watts per fixture.	The codes require individual controls independent from the general area lighting.	
63	Occupancy controlled step dimming	Ballasts must be automatically controlled based on occupancy. Systems with manual on or override switches are not eligible. Power consumption in low mode must not exceed 60%. Controlled watts must exceed minimum watts listed. Must control a minimum of 53 watts per fixture.	For buildings having area > 5,000 sq. ft, automatic lighting shutoff is required for most spaces. Measures 61, 63 and 64 will meet this requirement as will certain automatic time clocks. (Section 505.2.2.2)	
64A	Wall mounted occupancy sensors	Install wall switch type occupancy sensor/controller. Must operate as auto on and auto off. Not Eligible if installed in restrooms, locker rooms, stairwells or rooms of greater than 250 square feet. Must control a minimum of 51 watts per fixture.		

Table 3-1 (Part 3 of 3)
Comparison of Prescriptive Lighting Measures with IECC 2009 and ASHRAE Standards 90.1-2007

Code	Measure Description	Measure Eligibility Requirements	IECC 2009	ASHRAE 90.1-07 - Chapter 9. Lighting
64B	Wall mounted vacancy occupancy sensors	Install wall switch type occupancy sensor/controller. Must operate as manual on and auto off. Not Eligible if installed in restrooms, locker rooms, stairwells or rooms of greater than 250 square feet. Must control a minimum of 51 watts per fixture.	For buildings having area > 5,000 sq. ft, automatic lighting shutoff is required for most spaces. Measures 61, 63 and 64 help meet the code requirement (Section 505.2.2.2)	For buildings having area > 5,000 sq. ft, automatic lighting shutoff is required for most spaces. Measures 61, 63 and 64 help meet the code requirement. (Section 9.4.1.1)
65	Photocell sensors	Photo cell control for lighting system operating 8760 hours per year controlling more than 70 watts.	Codes call for either a astronomical time clock or photosensor control	Codes call for either a astronomical time clock or photosensor control
68	High bay (HIF) fluorescent occupancy controls	Ballasts must be automatically controlled based on occupancy. Systems with manual on or override switches are not eligible. Sensor's to be mounted on individual fixtures only.	N/A	N/A
80	LED downlight fixtures	Fixture must be hard wired or GU-24 based and Energy Star listed.	There are no specific energy efficiency requirements. Only limits on the lighting power density (LPD) are imposed based on the occupancy type in the codes.	There are no specific energy efficiency requirements. Only limits on the lighting power density (LPD) are imposed based on the occupancy type in the codes.
82A	LED cooler, freezer case or refrigerated shelving fixtures	3' and 4' LED cooler and freezer case lights. Must be Energy Star listed.		
82B		5' and 6' LED cooler and freezer case lights. Must be Energy Star listed.		
83	LED low bay fixtures	Only LED low bay fixtures installed in 8760 hour applications are eligible. Fixtures must be Energy Star or Design Lights Consortium listed.		
84	LED track lights	Only hard wired fixtures are eligible. Fixtures must be Energy Star or Design Lights Consortium listed. Replacement lamps are not eligible.		

3.3.2 Unitary HVAC Equipment

Both the IECC 2009 and ASHRAE Standard 90.1 2007 address the design and construction of mechanical systems. They state requirements for load calculation methodology and associated equipment sizing. Minimum equipment efficiencies for unitary air conditioners, heat pumps, PTAC and PTHP systems, warm air furnaces, boilers, and other systems are stipulated. Other requirements address air economizing, duct and plenum sealing and insulation, and controls for space temperature and fan systems.

Chapter 5 in the IECC 2009 addresses the Acceptable Practice for Commercial Buildings and only designated exceptions to the IECC 2009 must meet ASHRAE 90.1 2007 requirements. The efficiencies pertinent to the New Hampshire New Construction Programs are presented in Table 3-2 and are predominately associated with IECC 2009.

Table 3-2 (Part 1 of 2)
Comparison of Prescriptive Unitary HVAC Equipment Efficiencies with IECC 2009 and ASHRAE Standard 90.1-2007

Unitary Equipment	Base Efficiency (EER)	IECC 2009	ASHRAE 90.1-2007	Recommendations
Unitary AC and split systems <65,000 Btuh (Tier 1)	11.1	13.0 SEER	13.0 SEER	Align unit size breakdown with code tables and make efficiency units (EER, SEER, IEER, COP, HSPF, IPLV) consistent with the code tables.
(Tier 2)	11.1			
Unitary AC and split systems >65,000 Btuh to 135,000 Btuh (Tier 1)	11.2	11.2 EER	11.2 EER (for electrical resistance), otherwise 11.0 EER	No change.
(Tier 2)	11.2			
Unitary AC and split systems >135,000 Btuh to 240,000 Btuh (Tier 1)	10.6	11.0 EER	11.0 EER (for electrical resistance), otherwise 10.8 EER	Increase the baseline efficiency requirement to be satisfactorily greater than the IECC 2009 requirement.
(Tier 2)	10.6			
Unitary AC and split systems >240,000 Btuh to 760,000 Btuh (Tier 1)	9.5	10.0 EER / 9.7 IPLV	10.0 EER/9.7 IPLV (for electrical resistance), otherwise 9.8 EER/9.5 IPLV	Increase the baseline efficiency requirement to be satisfactorily greater than the IECC 2009 requirement and add IPLV to the baseline specification.
(Tier 2)	9.5			
Unitary AC and split systems >760,000 Btuh (Tier 1)	9.5	9.7 EER / 9.4 IPLV	9.7 EER/9.4 IPLV (for electrical resistance), otherwise 9.5 EER/9.2 IPLV	
(Tier 2)	9.5			
Air to air heat pumps < 65,000 Btuh (Tier 1)	11.1	13.0 SEER & 7.7 HSPF	13.0 EER/7.7 HSPF	Include HSPF in baseline efficiency and make units consistent with code tables.
(Tier 2)	11.1			
Air to air heat pumps > 65,000 Btuh to 135,000 Btuh (Tier 1)	11	11.0 EER & 3.3 COP	11.0 EER (for electrical resistance), otherwise 10.8 EER & 3.3/2.2 COP	Include COP in the baseline efficiency.
(Tier 2)	11			
Air to air heat pumps > 135,000 Btuh to 240,000 Btuh (Tier 1)	10.6	10.6 EER & 3.2 COP	10.6 EER (for electrical resistance), otherwise 10.4 EER & 3.2/2.0 COP	Increase the baseline efficiency requirement to be satisfactorily greater than the IECC 2009 requirement and add COP to the baseline specification.
(Tier 2)	10.6			

Table 3-2 (Part 2 of 2)
Comparison of Prescriptive Unitary HVAC Equipment Efficiencies with IECC 2009 and ASHRAE Standard 90.1-2007

Unitary Equipment	Base Efficiency (EER)/ Description	IECC 2009	ASHRAE 90.1-2007	Recommendations
Water source heat pumps ≤ 135,000 Btuh (Tier 1)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	11.2 EER < 17,000 Btuh 12.0 EER ≥ 17,000 & <135,000 Btuh 4.2 COP	11.2 EER for < 17,000 Btu/h, 12.0 EER for ≥ 17,000 Btu/h and <135,000 Btu/h	Include COP in the baseline efficiency
(Tier 2)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	No data	No data	No change
Ground water - water source heat pump equipment (open loop) ≤ 135,000 Btuh (Tier 1)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	16.2 EER & 3.6 COP	16.2 EER & 3.6 COP	Increase the baseline efficiency requirement to be satisfactorily greater than the IECC 2009 requirement and add COP to the baseline specification.
(Tier 2)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	No data	No data	No change
Ground water - water source heat pump equipment (closed loop) ≤ 135,000 Btuh (Tier 1)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	13.4 EER & 3.1 COP	13.4 EER & 3.1 COP	Increase the baseline efficiency requirement to be satisfactorily greater than the IECC 2009 requirement and add COP to the baseline specification.
(Tier 2)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	No data	No data	No change
Dual enthalpy economizer	Fixed dry-bulb economizer	Economizers on all cooling systems >=54,000 Btuh	Economizers on all cooling systems >=135,000 Btuh	No change
Demand control ventilation	No-ventilation control.	DCV is required for spaces larger than 500 sq ft and with an avg. occupant load of 40 people per 1000 sq ft.	DCV is required for spaces larger than 500 sq ft and with an avg. occupant load of 40 people per 1000 sq ft.	Verify that the code required spaces are not included in the incentive application.

Our observations from the comparison of the baseline parameters and energy code are discussed here:

- For all equipment types the requirements in the IECC 2009 was either equal to or slightly greater than those shown in ASHRAE 90.1 2007, which makes the IECC 2009 the more stringent document. All comparisons made in the following bullets are made from the rebate program against the IECC 2009.
- For unitary AC and split systems ≤ 65,000 Btu/h (Tier 1 and 2), the minimum SEER required for a rebate exceeds the values presented by IECC 2009 energy code and ASHRAE Standard 90.1 2007.
- For unitary AC and split systems > 65,000 Btu/h and ≤ 135,000 Btu/h, the minimum efficiency for Tier 1 required for rebate is not substantively greater than the efficiency specified by the IECC 2009.

- The following measures stipulate minimum EER, SEER, HSPF, IPLV, and/or COP ratings that are slightly greater than the IECC 2009/ASHRAE 90.1-2007 values; hence, no change is recommended.
  - Unitary AC and split systems >65,000 Btu/h to 135,000 Btu/h (Tier 1)
  - Unitary AC and split systems >240,000 Btu/h to 760,000 Btu/h (Tier 1 & 2)
  - Unitary AC and split systems >760,000 Btu/h (Tier 1 & 2)
  - Air-to-air heat pumps > 65,000 Btu/h to 135,000 Btu/h (Tier 1 & 2)
  - Air-to-air heat pumps > 135,000 Btu/h to 240,000 Btu/h (Tier 1 & 2)
  - Ground water – water source heat pump (open loop) ≤ 135,000 Btu/h (Tier 1)
  - Ground water – water source heat pump (closed loop) ≤ 135,000 Btu/h (Tier 1)

Our general observation for the HVAC unitary equipment is that a majority of the efficiency values required for rebate are equal to or minimally greater than the efficiencies specified by the IECC 2009 energy code. Specific instances have been noted above. The measures not mentioned are satisfactorily greater than both code manuals.

3.3.3 Chillers

The requirements in the IECC 2009 in Table 503.3.2(7) and ASHRAE standard 90.1-2007 in Table 6.8.1C present the minimum efficiency requirements for chillers. These efficiencies are compared in Table 3-3 with the minimum efficiencies for rebates under the nhsaves@work/New Construction and Equipment Program and the baseline efficiencies used in the energy savings algorithms.

Table 3-3
Comparison of Prescriptive Chiller Efficiencies with IECC 2009 and ASHRAE Standard 90.1-2007

Measure	Baseline Efficiency	IECC 2009	IECC 2012	Impact of IECC 2009 vs 2012
Air Cooled Chiller				
≤ 150 tons	9.562 EER	≥ 9.562 EER (full load), ≥ 12.50 EER (IPLV)	≥ 9.562 EER (full load), ≥ 12.50 EER (IPLV),	No change
≥ 150 tons	9.562 EER	≥ 9.562 EER (full load), ≥ 12.50 EER (IPLV)	≥ 9.562 EER (full load), ≥ 12.75 EER (IPLV),	No change
Water Cooled Chillers - Rotary Screw & Scroll				
< 75 tons	0.800 kW/ton	≤ 0.780 kW/ton (full load), ≤ 0.630 kW/ton (IPLV)	≤ 0.780 kW/ton (full load), ≤ 0.630 kW/ton (IPLV)	No change compared to IECC 2009. The current program baseline efficiency values meet Path B requirements.
≥ 75 and < 150 tons	0.890 kW/ton	≤ 0.775 kW/ton (full load), ≤ 0.615 kW/ton (IPLV)	≤ 0.775 kW/ton (full load), ≤ 0.615 kW/ton (IPLV)	
≥ 150 and < 300 tons	0.718 kW/ton	≤ 0.680 kW/ton (full load), ≤ 0.586 kW/ton (IPLV)	≤ 0.680 kW/ton (full load), ≤ 0.580 kW/ton (IPLV)	
≥ 300 tons	0.639 kW/ton	≤ 0.620 kW/ton (full load), ≤ 0.540 kW/ton (IPLV)	≤ 0.620 kW/ton (full load), ≤ 0.540 kW/ton (IPLV)	
Water Cooled Chillers - Centrifugal				
< 150 tons	0.639 kW/ton	≤ 0.634 kW/ton (full load), ≤ 0.596 kW/ton (IPLV)	≤ 0.634 kW/ton (full load), ≤ 0.596 kW/ton (IPLV)	No change compared to IECC 2009. The current program baseline efficiency values meet Path B requirements.
≥ 150 and < 300 tons	0.639 kW/ton	≤ 0.634 kW/ton (full load), ≤ 0.596 kW/ton (IPLV)	≤ 0.634 kW/ton (full load), ≤ 0.596 kW/ton (IPLV)	
≥ 300 and < 600 tons	0.600 kW/ton	≤ 0.576 kW/ton (full load), ≤ 0.549 kW/ton (IPLV)	≤ 0.576 kW/ton (full load), ≤ 0.549 kW/ton (IPLV)	
≥ 600 tons	0.590 kW/ton	≤ 0.570 kW/ton (full load), ≤ 0.539 kW/ton (IPLV)	≤ 0.570 kW/ton (full load), ≤ 0.539 kW/ton (IPLV)	

The IECC 2009 presents efficiencies for Path A and Path B. Compliance is only required with Path A or Path B. The efficiency requirements shown in Table 3-3 for IECC 2009 are for path A, which by comparison to path B was more stringent. To determine which of the two paths was more stringent, the lower of the IPLV values (kW/ton) was compared because it is a more accurate representation of chiller performance than EER. Code compliance is only required with one of the paths; however, both the full- and part-load values must be met.

Based on our observations from the table above, the minimum efficiency required to be eligible for incentives for all air-cooled and water-cooled chillers is greater than the efficiencies specified by the IECC 2009 and ASHRAE standard 90.1 2007.

However, the baseline efficiencies in the following instances were observed to be below the code-specified values that we recommend for modifying the baseline efficiency values.

- ❑ Water-cooled chillers – rotary screw & scroll (all chillers more than 75 tons)
- ❑ All water-cooled centrifugal chillers

3.3.4 Motors (ECMs)

Since the adoption of the Independence and Security Act of 2007 (EISA), all electric motors manufactured after December 19, 2010, with a power rating of at least 1 hp but not greater than 200 hp, are now required to have a nominal full-load efficiency that is not less than as defined in NEMA MG– 1 (2006) Table 12-12 (a.k.a. NEMA Premium® efficiency levels). This has rendered all well-established energy efficiency programs to stop providing incentives for the installation of NEMA Premium efficiency motors. Hence, no research or discussion on the standard electric motors was conducted as a part of this study. Instead, incentives for a new motor category, electronically commutated motors (ECM), are currently being supported by the NH energy efficiency programs.

The nhsaves@work/New Construction program is currently offering incentives for the installation of electronically commutated motors (ECMs) on fan-powered terminal boxes, fan coils, or HVAC supply fans on small unitary equipment. Both the IECC 2009 and ASHRAE Standard 90.1-2007 do not specify baseline requirements for ECMs.

3.3.5 Variable Frequency Drives (VFDs)

The current prescriptive program provides rebates for the installation of VFDs on motor sizes between 5 hp and 20 hp on a variety of applications. Table 3-4 presents a comparative analysis of the existing VFD measures under the Prescriptive Program with the IECC 2009 energy code and the ASHRAE standard 90.1-2007. IECC 2009 addresses the use of VFDs for various applications in chapter 5, section 503 (Design by Acceptable Practice for Commercial Buildings) and ASHRAE 90.1-2007 addresses the use of VFDs in Chapter 6 (Heating, Ventilating, and Air Conditioning).

Table 3-4
Comparison of Prescriptive VFD Measures with IECC 2009 and ASHRAE Standard 90.1-2007

<table>
<tr><th colspan="2">VFD Measures for Sizes (hp): 5, 7.5, 10, 15, and 20</th><th>IECC 2009</th><th>ASHRAE 90.1-2007</th><th>Recommendation</th></tr>
<tr><td>Code</td><td>Application</td><td rowspan="14">For VAV systems with motors ≥ 10 hp (7.5 kW) shall be driven by mechanical or electrical variable speed drives; that provides no more than 30% of design wattage at 50% of design airflow. (Section 503.4.2)

Hydronic systems with capacities ≥ 300,000 Btuh output supplying heated or chilled water shall either reset loop temperature or reduce pump flow rate by at least 50% of design flow rate using adjustable speed drive or multi stage pumps where at least one-half of the total horsepower is capable of being automatically turned off or control valves designed to modulate as a function of load. (Section 503.4.3.4)

Fans powered by >=7.5 hp on heat rejection equipment shall have the capability to operate that fan at 2/3rd of full speed or less.</td><td rowspan="14">For VAV systems with motors ≥ 10 hp (7.5 kW) shall be driven by mechanical or electrical variable speed drives; that provides no more than 30% of design wattage at 50% of design airflow. (Section 6.5.3.2)

HVAC pumping systems that include control valves to modulate as a function of load shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to 50% or less of design. Individual pumps serving variable flow systems with heads exceeding 100 ft and motor exceeding 50 hp shall have controls that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow. (Section 6.5.4.1)

Each fan powered by a motor of 7.5 hp or larger on a heat rejection device shall have the capability to operate that fan at 2/3rd of full speed.

Fume hoods with total exhaust greater than 15,000 cfm shall include VAV hood exhaust and room supply systems capable of reducing exhaust and make up air volume to 50% or less of design.</td><td rowspan="14">No longer provide rebates/incentives for new construction VFDs on supply and return fans equal to and greater than 10 hp in size. In IECC 2009, these sizes are required to have a VFD installed.</td></tr>
<tr><td>SFA</td><td>Supply fan on supply air handler</td></tr>
<tr><td>SFP</td><td>Supply fan on VAV packaged HVAC unit</td></tr>
<tr><td>RFA</td><td>Return fan on return air handler</td></tr>
<tr><td>RFP</td><td>Return fan on VAV packaged HVAC unit</td></tr>
<tr><td>BEF</td><td>Building exhaust fan</td></tr>
<tr><td>PEF</td><td>Process exhaust fan</td></tr>
<tr><td>HEF</td><td>Fume hood exhaust fan & makeup air fan</td></tr>
<tr><td>FWP</td><td>Boiler feed water pump</td></tr>
<tr><td>WWP</td><td>Circulation pump for water source heat pump loop</td></tr>
<tr><td>BDF</td><td>Boiler draft fan</td></tr>
<tr><td>PHC</td><td>Process heating & cooling circulation pumps</td></tr>
<tr><td>HYP</td><td>Hydraulic pumps</td></tr>
<tr><td>CTF</td><td>Cooling tower fan</td></tr>
</table>

The key code requirements affecting the program design are listed here:

- According to IECC 2009 section 503.4.2, variable air volume (VAV) systems with motors ≥ 10 hp (7.5 kW) shall be driven by mechanical or electrical variable speed drives (VSDs) that provide no more than 30% of design wattage at 50% of design airflow when the static pressure setpoint equals one-third of the total design static pressure.
- IECC 2009 section 503.4.3.4 states that for hydronic systems with capacities ≥ 300,000 Btu/h output supplying heated or chilled water shall either have the capability to reset loop temperatures with outside air conditions and loads or have the ability to reduce system pump flow by at least 50 percent of design flow rate using VFDs.
- IECC 2009 section 503.4.4 for fans on heat rejection devices states that each fan powered by a motor of 7.5 hp or larger shall have the capability to operate the fan at two-thirds of full speed or less and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing pressure/temperature.
- The codes did not prescribe any requirements for the following measure codes – BEF, PEF, BDF, PHC, and HYP. Hence, there are no code-specific recommendations pertaining to these measure codes in this discussion.

- The ASHRAE requirements mostly matched those specified in IECC 2009 with two exceptions. The first exception, according to the ASHRAE standard, requires HVAC pumps with variable loads and with motors greater than or equal to 50 hp to have VFDs. The second exception requires the installation of flow control devices on fume hood exhaust systems with flow rates exceeding 15,000 cfm. For the most part, it is our understanding that the IECC 2009 requirements precede the ASHRAE standard 90.1-2007 requirements; hence, our recommendations for the VFDs are based on the comparison of the current program practices with that stipulated in IECC 2009.

Based on our review, we recommend eliminating the incentives for VFDs on supply and return fans in VAV applications greater than 10 hp, as they are required by code.

We also recommend limiting the incentives for the installation of VFDs on HVAC circulation pumps to less than or equal to 50 hp. The VFD applications for HVAC pumps greater than 20 hp are currently processed as custom measures, as the prescriptive program only covers motor sizes up to 20 hp.

3.3.6 Air Compressors

The nhsaves@work/New Construction program offers incentives for air compressors; however, the IECC 2009 or ASHRAE 90.1-2007 standards do not address air compressors.

3.3.7 Natural Gas Equipment

The IECC 2009 and ASHRAE Standard 90.1-2007 address the minimum efficiencies for a variety of gas-fired equipment. The efficiencies pertinent to the New Hampshire New Construction Programs are presented in Table 3-5 and have been compared to the IECC 2009 and ASHRAE Standard 90.1 2007.

Table 3-5 (Part 1 of 3)
Comparison of Prescriptive Gas-Fired Equipment Measures with IECC 2009 and ASHRAE Standard 90.1-2007

Natural Gas Equipment	Minimum Equipment Efficiency Criteria	Baseline Efficiency	IECC 2009	ASHRAE 90.1-2007	Recommendations
Furnaces					
≤ 300,000 Btu/h (Unitil) and ≤ 150,000 Btu/h (National Grid)	92% AFUE or greater w/ECM	78% AFUE, 80% thermal efficiency (Et)	80% combustion efficiency (Ec)	80% Ec	Make units consistent with code. Make program offerings consistent. Unitil pays incentives for units up to 300 MBH while National Grid supports incentives for units up to 150 MBH.
≤ 300,000 Btu/h (Unitil) and ≤ 150,000 Btu/h (National Grid)	94% AFUE or greater w/ECM	78% AFUE, 80% Et	80% Ec	80%Ec	
Infrared Heaters					
All Sizes	Low Intensity	80% Ec	NA	NA	Not enough information to suggest any change.
Hydronic Boilers					
≤ 300,000 Btu/h	85% AFUE	80% AFUE	80% AFUE for hot water, 75% AFUE for steam	80% AFUE	No change
> 300,000 Btu/h to ≤ 499,000 Btu/h	85% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et	No change
≥ 500,000 Btu/h to ≤ 999,000 Btu/h	85% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et	No change
≥ 1,000,000 Btu/h to ≤ 1,700,000 Btu/h	85% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et	No change
> 1,700,000 Btu/h	85% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	82% Ec (≥ 2,500,000 Btu/h)	No change
Condensing Boilers					
≤ 300,000 Btu/h	90% AFUE	80% AFUE	80% AFUE for hot water, 75% AFUE for steam	80% AFUE for hot water, 75% AFUE for steam	No change
> 300,000 Btu/h to ≤ 499,000 Btu/h	90% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et and 79% Ec	No change
≥ 500,000 Btu/h to ≤ 999,000 Btu/h	90% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et and 79% Ec	No change
≥ 1,000,000 Btu/h to ≤ 1,700,000 Btu/h	90% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et and 79% Ec	No change
> 1,700,000 Btu/h	90% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et for hot water (82% Et for input > 2,500,000 Btu/h) and 79% Et for steam	No change
Water Heating Equipment					
On demand, Tankless Water Heater	0.82 Energy Factor (EF) or greater	Storage tank water heater = 0.59 EF	Smaller instantaneous water heater (IWH) and storage water (SWH) units (≤200 MBH for IWH and ≤75 MBH SWH) require EF of 0.62-0.0019V. Larger units require 80% Et (≥200 MBH for IWH and ≥75 MBH SWH).	Smaller instantaneous water heater (IWH) and storage water (SWH) units (≤200 MBH for IWH and ≤75 MBH SWH) require EF of 0.62-0.0019V. Larger units require 80% Et (≥200 MBH for IWH and ≥75 MBH SWH).	The baseline efficiencies need to be increased slightly to match with the IECC 2009 requirements.
Indirect Water Heater	Combined appliance efficiency (CAE) ≥ 85% or EF ≥ 82	Storage tank water heater = 0.59 EF	R-12.5	R-12.5	The codes do not stipulate CAE hence no direct method available to compare the current practices.

Table 3-5 (Part 2 of 3)
Comparison of Prescriptive Gas-Fired Equipment Measures with IECC 2009 and ASHRAE Standard 90.1-2007

Natural Gas Equipment	Minimum Equipment Efficiency Criteria	Baseline Efficiency	IECC 2009	ASHRAE 90.1-2007	Recommendations
Water Heating Equipment					
Condensing Stand Alone 75 to 300 MBH	≥ 95% Et	Stand along tank water heater with Et of 80%.	80% Et	80% Et	No change.
Integrated water heater/condensing boiler	0.90 EF or 90% AFUE	Storage tank hot water heater with a separate standard efficiency boiler for space heating. 80% AFUE boiler and 0.59 EF water heater.	80% Et	80% Et	No change.
Storage Water Heater	≥ 0.67 EF	Storage tank water heater = 0.59 EF	Smaller storage water (SWH) units (≤75 MBH SWH) require EF of 0.62-0.0019V. Larger units require 80% Et (≥75 MBH SWH).	Smaller storage water (SWH) units (≤75 MBH SWH) require EF of 0.62-0.0019V. Larger units require 80% Et (≥75 MBH SWH).	National grid does not offer incentive for this measure. The baseline efficiencies need to be increased slightly to match with the IECC 2009 requirements.
Condensing Unit Heater up to 300 MBH	≥ 90% Et	80% Ec	80% Ec	80% Ec	National grid does not offer incentive for this measure. Make units consistent with code and program documents.
Cooking Equipment					
Fryers	Energy Star or cooking efficiency (CE) ≥ 50%	35% CE	NA	NA	No change
High Efficiency Gas Steamer	Energy Star or CE ≥ 38%	18% CE	NA	NA	No change
High Efficiency Gas Convection Oven	CE ≥ 44% (National Grid) & CE ≥ 40% (Unitil)	30% CE	NA	NA	Make program requirements consistent. Unitil requires CE of 40% while NGRID requires 44%.
High Efficiency Gas Combination Oven		35% CE	NA	NA	
High Efficiency Gas Conveyor Oven		20% CE	NA	NA	
High Efficiency Gas Rack Oven	CE ≥ 50%	30% CE	NA	NA	No change
High Efficiency Gas Griddle	Energy Star or CE ≥ 38%	30% CE	NA	NA	No change
High Efficiency Pre-Rinse Spray Valve	Flow rate of 1.6 GPM	Flow rate of 3.34 GPM	NA	NA	Unitil does not offer incentive for this measure.

Table 3-5 (Part 3 of 3)
Comparison of Prescriptive Gas-Fired Equipment Measures with IECC 2009 and ASHRAE Standard 90.1-2007

Natural Gas Equipment	Minimum Equipment Efficiency Criteria	Baseline Efficiency	IECC 2009	ASHRAE 90.1-2007	Recommendations
Controls					
After market boiler reset controls	Boiler with outside air or return water temperature based reset controls.	Boiler without reset controls	Hydronic heating systems with capacities ≥ 300 MBH output shall either reset loop temperature or reduce pump flow rate by at least 50% of design flow rate.	Hydronic heating systems with capacities > 300 MBH shall include controls that automatically reset supply water temperature (Section 6.5.4.3)	Limit the incentive to boiler systems < 300 MBH.
Steam traps	Repaired or replaced steam trap.	Failed steam trap	NA	NA	No change
7-day programmable thermostats	Programmable thermostat	No programmable thermostat	Each zone shall be provided with thermostatic setback controls that are controlled by either an automatic time clock or programmable control system (Section 503.2.4.3)	HVAC systems shall be equipped with controls that start and stop the system under different time schedules for 7 different day-types per week. (Section 6.4.3.3.1)	Remove the 7-day programmable thermostat incentive from the New Construction program offering.

When comparing the current minimum rebate efficiency requirements for natural gas equipment with the efficiencies specified by the IECC 2009 and ASHRAE standard 90.1 2007, we observed that the minimum efficiency values and the baseline efficiency values required for rebates were satisfactorily greater than the IECC 2009 and ASHRAE Standard 90.1 2007.

3.4 Custom Program Code Applicability

The Custom Program is specifically intended for applications that are not covered by the prescriptive programs. Similar to the Prescriptive programs, the Custom programs have qualifying criteria. In the Custom Program a rebate is based on the total project cost and the potential energy savings. The prescriptive program has a fixed rebate based on technology type.

ERS reviewed the recent New Hampshire Energy Code to determine the relationship to the custom measures of the nhsaves@work/New Construction program. The tasks involved in the review process were similar to those for the prescriptive measures – code review and outline, comparison with existing baseline parameters, and development of code-based recommendations.

Each area of the code review conducted is presented in the sections below.

3.4.1 Building Envelope

The IECC 2009 and ASHRAE Standard 90.1-2007 address the code requirements for building envelopes in Section 502 and Chapter 5, respectively. No specific provisions are made by the custom program for building envelope requirements.

For information purposes, Table 3-6 lists some of the requirements for opaque building envelope assemblies. Also presented are specifications on maximum solar heat gain coefficients (SHGC), thermal transmittance (U-factor), thermal conductance (C-factor), and slab perimeter heat loss factor (F-factor) of structure types and assemblies located in the building envelope.

Table 3-6
Comparison of Building Envelope Requirements – IECC 2009 and ASHRAE Standard 90.1-2007

<table>
<tr><th>Category</th><th>IECC 2009</th><th>ASHRAE 90.1-2007</th></tr>
<tr><td colspan="2">Roofs</td><td rowspan="18">ASHRAE 90.1 2007 is dissimilar to IECC 2009 in that it doesn't provide minimum guidelines each structure type, but rather provides values to use depending on the final design. For example, R-19 roof insulation above deck can be translated to a U-value of U-0.051 for the entire assembly.</td></tr>
<tr><td>Insulation above deck</td><td>U-0.048/U-0.048</td></tr>
<tr><td>Metal buildings</td><td>U-0.055/U-0.055</td></tr>
<tr><td>Attic and other</td><td>U-0.027/U-0.027</td></tr>
<tr><td colspan="2">Walls, Above Grade</td></tr>
<tr><td>Mass</td><td>U-0.090/U-0.080</td></tr>
<tr><td>Metal buildings</td><td>U-0.069/U-0.069</td></tr>
<tr><td>Metal framed</td><td>U-0.064/U-0.064</td></tr>
<tr><td>Wood framed and other</td><td>U-0.064/U-0.051</td></tr>
<tr><td colspan="2">Walls, Below Grade</td></tr>
<tr><td>Below-grade wall</td><td>C-0.119/C-0.119</td></tr>
<tr><td colspan="2">Floors</td></tr>
<tr><td>Mass</td><td>U-0.074/U-0.064</td></tr>
<tr><td>Joist/Framing</td><td>U-0.033/U-0.033</td></tr>
<tr><td colspan="2">Slab-on-Grade Floors</td></tr>
<tr><td>Unheated slabs</td><td>F-0.730/F-0.540</td></tr>
<tr><td>Heated slabs</td><td>F-0.860/F-0.860</td></tr>
</table>

3.4.2 Lighting Systems

We reviewed the New Hampshire baseline requirements for the Custom component of the nhsaves@work/New Construction program, and our observations are discussed in this section. ASHRAE Standard 90.1-2007 addresses lighting systems in Chapter 9 and IECC 2009 addresses lighting systems in Section 505.

Table 3-7 provides a brief comparison of the current standard practices for custom lighting projects followed by the New Hampshire utilities with the ASHRAE Standard 90.1-2007 standards and IECC 2009. Based on this review, we did not find any specific changes that could be proposed to the measure baselines.

Table 3-7
Comparison of Custom Lighting Practices with IECC 2000 and ASHRAE Standard 90.1-2007

Category	Program Assumed Standard Practice	IECC 2009	ASHRAE 90.1-2007
Interior lighting	**High Intensity Discharge - (typical where ceilings exceed 50 feet)**		
	Metal halide (MH) fixtures	There are no specific energy requirements. The only parameter imposed is the lighting power density (Section 505.5)	There are no specific energy requirements. The only parameter imposed is the lighting power density (Section 9.5)
	Fluorescent - (typically where ceilings are below 50 feet)		
	High intensity fluorescent (HIF)	There are no specific energy requirements. The only parameter imposed is the lighting power density (Section 505.5)	There are no specific energy requirements. The only parameter imposed is the lighting power density (Section 9.5)
Exterior lighting	HPS or MH with time clock and/or photocell control	The code specifies for lamps > 100 Watt, minimum efficacy of 60 lumens per watt. As an alternate it also provides lighting power allowances. For lighting not designated for dusk-to-dawn operation shall be controlled by ether a combination of a photosensor and a time switch or an astronomical time switch. (Section 505.2.4 and 505.6.2)	The code specifies for lamps > 100 Watt, minimum efficacy of 60 lumens per watt. As an alternate it also provides lighting power allowances. For lighting not designated for dusk-to-dawn operation shall be controlled by ether a combination of a photosensor and a time switch or an astronomical time switch. (Section 9.4.5)
Lighting controls	Time clock or manual on/off control based on general occupancy schedules	The code requires manual + dual switching in interior spaces. Additionally, buildings larger than 5,000 square feet are required to have automatic controls to shut off lighting in those areas. Daylight zones require separate switching.	The code requires manual + dual switching in interior spaces. Additionally, buildings larger than 5,000 square feet are required to have automatic controls to shut off lighting in those areas. Daylight zones require separate switching.

The comparisons made in the table above are discussed below in detail:

- Until recently, the interior lighting standard for medium to high bay applications was HID lighting. The current practice now is mostly reflective of the heavy use of various fluorescent lighting technologies in interior lighting applications. We left the use of HID fixtures in very high ceiling applications, but even that may change in the near future. ASHRAE Standard 90.1-2007 and IECC 2009 do not specify certain types of lighting fixtures or fixture efficiencies. Instead, the provisions provide guidelines based on LPD. The standard practice and baseline parameters for the New Hampshire Programs do not consider LPD.
- The standard practice baseline for exterior lighting is high-pressure sodium vapor lighting fixtures or metal halide lighting fixtures with time clock and/or photocell control. Both types of lighting fixtures have efficacies greater than 60 lumens per watt, which meets the requirement specified in ASHRAE Standard 90.1-2007 and in IECC 2009. In addition, ASHRAE Standard 90.1-2007 section 9.4.1.3 and IECC 2009 section 505.2.4 states that all exterior lighting not designated for dusk-to-dawn operation shall be controlled by either a photo sensor/time switch combo or an astronomical time switch. Thus, it can be concluded that the program minimum requirement satisfies both IECC 2009 and ASHRAE Standard 90.1-2007.
- The base requirement for lighting controls for New Hampshire programs is the time clock or manual on/off control based on occupancy. The IECC 2009 section 505.2 and ASHRAE standard 90.1-2007 require manual lighting control and dual switching for each area enclosed by walls. Additionally, the code and standard requires that the interior lighting in areas larger

than 5,000 square feet should be controlled by an automatic control device. The device should either turn off the lighting within 30 minutes of inactivity or operate on programmed time schedules or should be occupant-intervened.

ASHRAE Standard 90.1-2007 and IECC 2009 specified lighting power densities are presented in Appendix B.

3.4.3 Mechanical Systems

The differences between the current prescriptive program, IECC 2009, and ASHRAE 90.1 2007 have been already described in the prescriptive program section. Brief comparisons of standard conditions required for the Custom New Construction program are performed in Table 3-8. Tables 6.8.1A, 6.8.1B and 6.8.1C from ASHRAE 90.1-2007, and Tables 503.2.3(1), 503.2.3(2) and 503.2.3(7) from IECC 2009 standards are presented in Appendix B for reference.

Table 3-8 presents a comment summary based on comparison of the New Construction Program Standard Practice to the IECC 2009 and ASHRAE Standard 90.1-2007. A discussion of the comparison follows the table.

Table 3-8 (Part 1 of 4)
Comparison of Custom Mechanical Systems Practices with IECC 2009 and ASHRAE Standard 90.1-2007

Category	Program Assumed Standard Practice	IECC 2009 Section 503	ASHRAE 90.1-2007 Chapter 6
Office buildings under 40,000 sq. ft.	Constant volume fans (supply, return, exhaust)	Not specified	Not specified
Office buildings over 40,000 sq. ft.	VAV on supply, return, and exhaust fans over 20 HP (w/ VFD control)	Not specified	Not specified
	Standard distribution system	Not specified	Not specified
	Electronic controls on main HVAC equipment	Not specified	Not specified
Manufacturing or classroom building	Constant volume distributed HVAC systems (fancoils or unit ventilators)	Not specified	Not specified
Fume hood exhaust systems	Constant volume exhaust system with VSD on VAV supply fan	Energy recovery ventilation system not required in laboratory fume hood systems that include capabilities of reducing exhaust and makeup air volume to 50% or less of design values; or, aux. supply air equal to at least 75% of the exhaust rate, or heat recovery system to precondition makeup air. VSD required on fans with motors 10 hp or greater. (section 503.2.6 and 503.4.2)	Fume hood exhaust systems greater than 15,000 cfm shall have one of: the capability to reduce air volume by 50% or less of design, aux. supply air equal to at least 75% of the exhaust rate, or heat recovery system to precondition makeup air. VSD required on fans with motors 10 hp or greater. (Section 6.5.7.2)
Kitchen hood exhaust systems	Constant volume exhaust with manual on/off control	Not specified	Not Specified
Unitary equipment and split systems	Air cooled packaged/split units: <5 Ton, 14 SEER 5-11 Ton, 11.5 EER >11 Ton, 11.5 EER	The efficiencies meet or exceed the baseline efficiencies. (Table 503.2.3(1))	The efficiencies meet or exceed the baseline efficiencies. (Table 6.8.1A)
	Air cooled packaged/split systems over 30 tons (baselines dependent on system size)	Code specifies EERs in the range of 9.2 to 9.5	Code specifies EERs in the range of 9.2 to 9.5
Air source heat pumps	Air source heat pump with fossil fuel heat source	Does not include specifications for use of fossil fuel use (Table 503.2.3(2))	Does not include specifications for use of fossil fuel use (Table 6.8.1B)
Water source heat pump systems	Constant flow water loop	Systems with total pump system power exceeding 10 hp shall have two-position valve.	Not specified
	Forced draft cooling tower with centrifugal fan	Not specified	
Packaged reciprocating chillers	Air cooled chillers <150 tons at 9.56 EER >150 tons at 9.56 EER	Code specifies air cooled chillers (w/ condenser) <150 tons: ≥ 9.562 EER & ≥ 12.5 IPLV ≥ 150 tons: ≥ 9.562 EER, ≥ 12.5 IPLV Air cooled chillers (without condenser): must be rated with matching condensers and comply with air-cooled chiller efficiencies (Table 503.2.3(7))	Code specifies air cooled chillers (w/ condenser): 2.8 COP & 3.05 IPLV Air cooled chillers (without condenser) 3.1 COP& 3.45 IPLV (Table 6.8.1C)

Table 3-8 (Part 2 of 4)
Comparison of Custom Mechanical Systems Practices with IECC 2009 and ASHRAE Standard 90.1-2007

Category	Program Assumed Standard Practice	IECC 2009 Section 503	ASHRAE 90.1-2007 Chapter 6
New chilled water plants	Water cooled centrifugal chillers: <150 tons = 0.89 kW/ton 150 to <300 tons = 0.718 kW/ton 300 to 1000 tons = 0.639 kW/ton	Water-cooled centrifugal chiller minimum efficiencies: <300 tons: 0.634 kW/ton & 0.596 IPLV ≥ 300 tons & <600 tons: 0.576 kW/ton & 0.549 IPLV ≥ 600 tons: 0.570 kW/ton & 0.539 IPLV (Table 503.2.3 (7))	Water-cooled centrifugal chiller minimum efficiencies: < 150 tons: 5.00 COP & 5.25 IPLV ≥ 150 tons & < 300 tons: 5.55 COP & 5.90 IPLV ≥ 300 tons: 6.10 COP & 6.40 IPLV (Table 6.8.1C)
	Water-cooled, electrically operated, positive displacement (reciprocating)	< 75 tons: 0.780 kW/ton, 0.630 IPLV ≥ 75 tons & < 150 tons: 0.775 kW/ton, 0.615 IPLV ≥ 150 tons & < 300 tons: 0.680 kW/ton, 0.580 IPLV	4.20 COP & 5.05 IPLV (all capacities)
	Water cooled, electrically operated, positive displacement (rotary screw and scroll)	Water-cooled positive displacement chiller minimum efficiencies: < 75 tons: ≤ 0.780 kW/ton & ≤ 0.630 IPLV ≥ 75 tons & < 150 tons: ≤ 0.775 kW/ton & ≤ 0.615 IPLV ≥ 150 tons & < 300 tons: ≤ 0.680 kW/ton & ≤ 0.580 IPLV ≥ 300 tons: ≤ 0.620 kW/ton & ≤ 0.540 IPLV (Table 503.2.3(7))	Water-cooled centrifugal chiller minimum efficiencies: < 150 tons: 4.45 COP & 5.20 IPLV ≥ 150 tons & < 300 tons: 4.90 COP & 5.60 IPLV ≥ 300 tons: 5.50 COP & 6.15 IPLV (Table 6.8.1C)
	Chiller (over 1000 tons) efficiency depends on refrigerant/size	Not specified	Not specified
	Chilled water temperature reset based on return water temp based on OAT	The baseline requirements for hydronic systems are in agreement with the code requirements for systems ≥ 500,000 Btuh (Section 503.4.3)	The baseline requirements for hydronic systems are in agreement with the code requirements for systems ≥ 300,000 Btuh (Section 6.5.4.3)
	Primary / Secondary pumping with VSD on secondary pump	The baseline requirements are in agreement with code. Section 503.4.3.4	The baseline requirements for hydronic systems are in agreement with the code requirements for pumps above 50 HP (Section 6.5.4)
	Standard selection size cooling tower	Not specified	Not specified
	Cooling towers with multiple fans or dual speed fans	The baseline requirement for heat rejection equipment satisfies the code requirements for motors ≥ 7.5 HP (Section 503.4.4)	The baseline requirement for heat rejection equipment satisfies the code requirements for motors ≥ 7.5 HP (Section 6.5.5.2)
	Constant flow condenser water pump system	Not specified	Not specified
	Chiller sequencing controls based on load	Not specified	Not specified
	Plate and frame heat-X-changers (free cooling)	Not specified	Not specified
	No thermal storage	Not specified	Not specified

Table 3-8 (Part 3 of 4)
Comparison of Custom Mechanical Systems Practices with IECC 2009 and ASHRAE Standard 90.1-2007

Category	Program Assumed Standard Practice	IECC 2009 Section 503	ASHRAE 90.1-2007 Chapter 6
Building control systems	7 day time scheduling	The two baseline parameters satisfy the code requirements (Section 503.2.4.3.2)	The baseline parameter satisfies the code (Section 6.4.3.3.1)
	Optimized start/stop	Not specified	The baseline parameter satisfies the code (Section 6.4.3.3.3)
	DDC control of air handlers	The baseline parameter satisfies the code (Section 503.2.5.1)	The baseline parameter satisfies the code (Section 6.4.3.3.4)
	Chilled water reset	The baseline requirements for hydronic systems are in agreement with the code requirements for systems ≥ 300,000 Btuh (Section 503.3.2)	The baseline requirements for hydronic systems are in agreement with the code requirements for systems ≥ 300,000 Btuh (Section 6.5.4.3)
	Dry bulb economizer control	The standard requirement meets the code requirement (Section 503.3.2)	The baseline parameter satisfies the code (Section 6.5.1.3)
Boiler equipment	Constant speed feed water pumps	Not specified	Not specified
	Constant speed forced draft fans		
Computer room packaged HVAC with humidifiers	Electric resistance steam generators & DX compressor/coil	Not specified	Not specified
Commercial refrigeration	Multiplexed refrigeration racks VSD on lead compressors Plate and frame sub-coolers Floating head pressure controls Demand defrost controls T8s for case lighting	Not specified	Not specified
	Air cooled condensers		
	Screw compressors		
	Case doors with anti-sweat heat controls		
	Case lighting T12 lamps and EE magnetic ballasts		
	Motorized freezer doors		
	Humidity controls with reheat		
	Refrigeration heat recovery for DHW		
	Self contained TEV (thermal expansion valves)		
	Rack type refrigeration compressors		
Industrial refrigeration (systems serving facilities over 50,000 sq. ft. or 250 tons)	Evaporative cooled condensers	Not specified	Not specified
	Standard size evaporator coils and controls		
	Single-stage compressor system		
	Floating head pressure controls, Electric defrost control, and Subcoolers		
	Standard design cooling equipment and controls sequences		
	Motorized freezer doors		

Table 3-8 (Part 4 of 4)
Comparison of Custom Mechanical Systems Practices with IECC 2009 and ASHRAE Standard 90.1-2007

Category	Program Assumed Standard Practice	IECC 2009 Section 503	ASHRAE 90.1-2007 Chapter 6
Waste water treatment and fresh water plants	Fine bubble aeration with VSD and positive displacement blower	Not specified	Not specified
	VSDs on all pumps 25 HP and larger		
	VSDs on ID fans and fume control systems		
New ice rinks	Low E ceilings	Not specified	Not specified
	Water-cooled chiller		
	Floor mounted ice temperature sensors		
	Multi-speed brine pump (Smart Drive)		
	Floating head pressure controls down to 75 def F.		
	Dehumidification		
Process related equipment	Constant speed fans, process pumps or blowers with variable loads	Not specified	Not specified
	VSDs on motors requiring variable speed		
	Solid state motor-generator sets making off-frequency (i.e. not 60 Hz) power		
Plastic injection molding machines	Hydraulic operated operation	Not specified	Not specified
Air compressors (under 130 PSI)	Single stage rotary screw compressors with modulating control via inlet valve control and unloading point below 50% of rated CFM	Not specified	Not specified
Air compressors (130 PSI and over)	2 stage rotary screw compressors with cycling dryer and same baseline for <130 PSI		
Compressed air auxiliary equipment	Standard pressure drop filters Refrigerated dryers		
	Standard design distribution and end use requirements		

The comparisons made in Table 3-8 are explained here:

- Fume hood exhaust systems – The standard condition required for fume hood exhaust systems is constant volume exhaust system with a VFD on a VAV supply fan. According to ASHRAE Standard 90.1-2007 section 6.5.7.2, building fume hood systems having total exhaust rates of greater than 15,000 cfm require VAV hood exhaust and room supply systems capable of reducing exhaust and make-up air volume to 50% or less of design values. IECC 2009 sections 503.2.6 and 503.4.2 have similar requirements. The standard practices conform to energy code.
- Kitchen hood exhaust systems – For these systems, the standard practice specified is a constant volume exhaust with manual on/off controls. ASHRAE Standard 90.1-2007 section 6.5.7.1 specifies extra requirements for exhaust hoods larger than 5,000 cfm to be provided with make-up air sized for at least 50% of exhaust air volume that is cooled or uncooled without

mechanical cooling and heated or unheated to no more than 60°F. IECC 2009 code does not address kitchen hood exhaust systems.

- Unitary equipment and split systems – The New Hampshire New Construction prescriptive program specifies efficiency requirements for unitary equipment and split systems based on the tonnage of the units. The differences between the prescriptive program, IECC 2009, and ASHRAE Standard 90.1 2007 have been addressed in Section 3.3.2. The impact analysis of adopting the IECC 2012 is addressed in section 3.5.
- Water source heat pump systems – Currently the minimum requirement for the rebate program is a constant flow water loop and a forced-draft cooling tower with centrifugal fan. ASHRAE Standard 90.1 2007 states that all heat pumps must have a two-position interlock valve to shut off water flow when the compressor is off. There is no further information regarding forced-draft cooling tower configurations. The IECC 2009 section 503.4.3.3 requires controls capable of operating the central loop with a temperature dead band of at least 20°F between initiation of heat rejection and heat addition by the central devices. An exception is granted where a system loop temperature optimization controller is installed and can determine the most efficient operating temperature based on real-time conditions. Also, the code requires installation of a separate heat exchanger that can isolate the cooling tower from the heat pump loop with automatic control valves to stop flow of fluid in the cooling tower loop. Additionally, for heat pump systems with pump power exceeding 10 HP, the code requires the installation of a two-position valve.
- Packaged reciprocating chillers – The differences between the prescriptive program, IECC 2009, and ASHRAE Standard 90.1 2007 have been addressed in Section 3.3.3. The impact analysis of adopting the IECC 2012 is addressed in section 3.5.
- Building control systems – ASHRAE Standard 90.1 2007 sections 6.4.3.3.1 through 6.2.3.2.4, 6.5.4.3, and 6.5.1.3 provide guidelines for controls in the building. According to these sections, the HVAC systems shall require: control that can start and stop the system under different time schedules for seven different day-types per week; optimized start controls; motorized dampers that will automatically shut when the systems or spaces served are not in use; controls that automatically reset supply water temperatures by representative building loads or by outside air temperature; and integrated economizer systems. There is no area limitation specified for such systems. IECC 2009 code addresses similar requirements in sections 503.2.4.3.2, 503.2.5.1, and 503.3.2. Current standard practice meets these requirements.
- Boiler equipment – Both ASHRAE Standard 90.1 1999 and IECC 2000 do not specifically address the feed water pump and draft fan application descriptions for boiler systems to make any conclusions.

3.4.4 Electronically Commutated Motors (ECMs)

The nhsaves@work/New Construction program offers incentives for the installation of ECMs on fan-powered terminal boxes, fan coils, or HVAC supply fans on small unitary equipment. All other ECM applications, such as refrigerated cases, may be eligible through the New Construction custom program. Neither IECC 2009 nor ASHRAE Standard 90.1-2007 has baseline efficiency requirements for ECMs.

3.4.5 Variable Frequency Drives (VFDs)

The recommendations and observations made in the prescriptive section apply to this section.

3.5 Comparison of IECC 2009 with IECC 2012

The International Code Council (ICC) recently released its IECC 2012 code. With new code releases every three years, New Hampshire in the recent times has stayed current with its codes. Along those lines, the New Hampshire code authorities are exploring the adoption of the latest code and likewise the utility companies are interested in the impact the latest code would have on their programs and the baselines used in the prescriptive programs. This section presents a high-level comparison of the IECC 2009 and IECC 2012 codes as they relate with the energy efficiency programs.

Section 3.3 lists the different measure categories that are affected by the codes. Potential impacts from the adoption of the IECC 2012 are discussed.

3.5.1 Lighting Systems

The impact of adopting the IECC 2012 Section C405 would be minimal. The LPD requirements between the IECC 2009 and 2012 codes are similar and hence no changes would be required to be made to the lighting fixtures offerings. Interior space lighting lower density (LPD) allowances for the whole building method remain similar with one new building category being added (fire station), twenty eight categories remain the same, one increasing (post office) and three decreasing slightly (museum, retail, and warehouse). Exterior LPD allowances remained the same.

Changes in the requirements for occupancy sensors in all spaces 300 square feet or less rather than in buildings greater than 5,000 square feet will have a minor impact to construction and design costs. This impact has already been captured by our recommendation to eliminate providing incentives for wall mounted occupancy sensors.

In daylight designated zones, IECC 2012 requires either continuous dimming down to less than 35% or a minimum of two-step dimming with at least one control step between 50% and 70% and another less than 35%. Adoption of the IECC 2012 code would hence require the elimination of rebates for automatic daylight sensors.

3.5.2 Unitary HVAC Equipment

Table 3-9 shows a list of the current prescriptive rebate measures and how they compare to both the IECC 2009 and 2012 versions. The “Impact” column lists and changes.

Table 3-9 (1 of 2)
Unitary HVAC Equipment - Comparison of the IECC 2009 and 2012 Codes

Unitary Equipment	Base Efficiency (EER)	IECC 2009	IECC 2012	Impact of IECC 2009 vs IECC 2012
Unitary AC and split systems <65,000 Btuh (Tier 1)	11.1	13.0 SEER	13.0 SEER	No change
(Tier 2)	11.1			
Unitary AC and split systems >65,000 Btuh to 135,000 Btuh (Tier 1)	11.2	11.2 EER	11.2 EER/11.4 IEER (for electrical resistance), otherwise 11.0 EER/11.2 IEER	No change
(Tier 2)	11.2			
Unitary AC and split systems >135,000 Btuh to 240,000 Btuh (Tier 1)	10.6	11.0 EER	11.0 EER/11.2 IEER (for electrical resistance), otherwise 10.8 EER/11.0 IEER	No change
(Tier 2)	10.6			
Unitary AC and split systems >240,000 Btuh to 760,000 Btuh (Tier 1)	9.5	10.0 EER / 9.7 IPLV	10.0 EER/10.1 IEER (for electrical resistance), otherwise 9.8 EER/9.9 IEER	Slight increase in IPLV/IEER criteria. The current minimum requirements do not meet this requirement.
(Tier 2)	9.5			
Unitary AC and split systems >760,000 Btuh (Tier 1)	9.5	9.7 EER / 9.4 IPLV	9.7 EER/9.8 IEER (for electrical resistance), otherwise 9.5 EER/9.6 IEER	Slight increase in IPLV/IEER criteria. The current minimum requirements do not meet this requirement.
(Tier 2)	9.5			
Air to air heat pumps < 65,000 Btuh (Tier 1)	11.1	13.0 SEER & 7.7 HSPF	13 SEER & 7.7 HSPF	No change
(Tier 2)	11.1			
Air to air heat pumps > 65,000 Btuh to 135,000 Btuh (Tier 1)	11	11.0 EER & 3.3 COP	11 EER/11.2 IEER (for electrical resistance), otherwise 10.8 EER/11 IEER & 3.3/2.25 COP	No change
(Tier 2)	11			
Air to air heat pumps > 135,000 Btuh to 240,000 Btuh (Tier 1)	10.6	10.6 EER & 3.2 COP	10.6 EER/10.7 IEER (for electrical resistance), otherwise 10.4 EER/10.5 IEER 3.2/2.05 COP	Units changed from EER/COP to EER/IEER/COP. The current rebate program would need to update its units and requirements accordingly. No change in efficiency requirements.
(Tier 2)	10.6			
Water source heat pumps ≤ 135,000 Btuh (Tier 1)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	11.2 EER < 17,000 Btuh 12.0 EER ≥ 17,000 & <135,000 Btuh 4.2 COP	11.2 EER for < 17,000 Btu/h, 12.0 EER for ≥ 17,000 Btu/h and <135,000 Btu/h 4.2 COP	No change
(Tier 2)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	No data	NA	NA

Table 3-9 (2 of 2)
Unitary HVAC Equipment - Comparison of the IECC 2009 and 2012 Codes

Unitary Equipment		IECC 2009	IECC 2012	Impact of IECC 2009 vs 2012
Ground water - water source heat pump equipment (open loop) ≤ 135,000 Btuh (Tier 1)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	16.2 EER & 3.6 COP	16.2 EER & 3.6 COP	No change
(Tier 2)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	No data	NA	NA
Ground water - water source heat pump equipment (closed loop) ≤ 135,000 Btuh (Tier 1)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	13.4 EER & 3.1 COP	13.4 EER & 3.1 COP	No change
(Tier 2)	11.2 (<16,800) 12.0 (≥16,800 to < 135,000)	No data	NA	NA
Dual enthalpy economizer	Fixed dry-bulb economizer	Economizers on all cooling systems >=54,000 Btuh	Economizers on all cooling systems >=54,000 Btuh	No change
Demand control ventilation	No-ventilation control.	DCV is required for spaces larger than 500 sq ft and with an avg. occupant load of 40 people per 1000 sq ft.	DCV is required for spaces larger than 500 sq ft and with an avg. occupant load of 40 people per 1000 sq ft.	No change

As noted in Table 3-9, there need to be changes made to the minimum efficiency requirements for certain measures if the IECC 2012 were to be adopted. The majority of the impacts minor and could be adjusted without conducting in-depth studies.

3.5.3 Chillers

As shown in Table 3-10, there is no change in the code required chiller efficiency values from the IECC 2009 to 2012. The baseline efficient update was also identified in earlier chiller section. Therefore, would be no impact to the chiller prescriptive rebate program if the IECC 2012 were to be adopted.

Table 3-10
Chillers - Comparison of the IECC 2009 and 2012 Codes

Measure	Baseline Efficiency	IECC 2009	IECC 2012	Impact of 2009 vs 2012
Air Cooled Chiller				
≤ 150 tons	9.562 EER	≥ 9.562 EER (full load), ≥ 12.50 EER (IPLV)	≥ 9.562 EER (full load), ≥ 12.50 EER (IPLV),	No change
≥ 150 tons	9.562 EER	≥ 9.562 EER (full load), ≥ 12.50 EER (IPLV)	≥ 9.562 EER (full load), ≥ 12.75 EER (IPLV),	No change
Water Cooled Chillers - Rotary Screw & Scroll				
< 75 tons	0.800 kW/ton	≤ 0.780 kW/ton (full load), ≤ 0.630 kW/ton (IPLV)	≤ 0.780 kW/ton (full load), ≤ 0.630 kW/ton (IPLV)	No change compared to IECC 2009. The current program baseline efficiency values meet Path B requirements.
≥ 75 and < 150 tons	0.890 kW/ton	≤ 0.775 kW/ton (full load), ≤ 0.615 kW/ton (IPLV)	≤ 0.775 kW/ton (full load), ≤ 0.615 kW/ton (IPLV)	
≥ 150 and < 300 tons	0.718 kW/ton	≤ 0.680 kW/ton (full load), ≤ 0.586 kW/ton (IPLV)	≤ 0.680 kW/ton (full load), ≤ 0.580 kW/ton (IPLV)	
≥ 300 tons	0.639 kW/ton	≤ 0.620 kW/ton (full load), ≤ 0.540 kW/ton (IPLV)	≤ 0.620 kW/ton (full load), ≤ 0.540 kW/ton (IPLV)	
Water Cooled Chillers - Centrifugal				
< 150 tons	0.639 kW/ton	≤ 0.634 kW/ton (full load), ≤ 0.596 kW/ton (IPLV)	≤ 0.634 kW/ton (full load), ≤ 0.596 kW/ton (IPLV)	No change compared to IECC 2009. The current program baseline efficiency values meet Path B requirements.
≥ 150 and < 300 tons	0.639 kW/ton	≤ 0.634 kW/ton (full load), ≤ 0.596 kW/ton (IPLV)	≤ 0.634 kW/ton (full load), ≤ 0.596 kW/ton (IPLV)	
≥ 300 and < 600 tons	0.600 kW/ton	≤ 0.576 kW/ton (full load), ≤ 0.549 kW/ton (IPLV)	≤ 0.576 kW/ton (full load), ≤ 0.549 kW/ton (IPLV)	
≥ 600 tons	0.590 kW/ton	≤ 0.570 kW/ton (full load), ≤ 0.539 kW/ton (IPLV)	≤ 0.570 kW/ton (full load), ≤ 0.539 kW/ton (IPLV)	

3.5.4 Electronically Commutated Motors

The codes do not specify efficiencies for ECM motors hence ECM motors are not discussed in this section.

3.5.5 Variable Frequency Drives (VFDs)

Table 3-11 shows a list of the current VFD measures and how they compare to both the IECC 2009 and 2012 codes. The "Impact" column lists changes observed between the two codes and its impact on the energy efficiency program offerings.

Table 3-11
VFDs - Comparison of the IECC 2009 and 2012 Codes

<table>
<tr><th colspan="2">VFD Measures for Sizes (hp): 5, 7.5, 10, 15, and 20</th><th>IECC 2009</th><th>IECC 2012</th><th>Impact of IECC 2009 vs 2012</th></tr>
<tr><td>Code</td><td>Application</td><td rowspan="15">For VAV systems with motors ≥ 10 hp (7.5 kW) shall be driven by mechanical or electrical variable speed drives; that provides no more than 30% of design wattage at 50% of design airflow. (Section 503.4.2)

Hydronic systems with capacities ≥ 300,000 Btuh output supplying heated or chilled water shall either reset loop temperature or reduce pump flow rate by at least 50% of design flow rate using adjustable speed drive or multi stage pumps where at least one-half of the total horsepower is capable of being automatically turned off or control valves designed to modulate as a function of load. (Section 503.4.3.4)

Fans powered by >=7.5 hp on heat rejection equipment shall have the capability to operate that fan at 2/3rd of full speed or less.</td><td rowspan="15">For VAV systems with motors ≥ 7.5 hp (5.6 kW) shall be driven by mechanical or electrical variable speed drives and a vane-axial fan with variable-pitch blades; that provide no more than 30% of design wattage at 50% of design airflow.
(Section C403.4.2)

Hydronic heating systems comprised of a single boiler having a capacity ≥ 500,000 Btuh shall include either a multistaged or modulating burner. (Section C403.4.3)</td><td rowspan="15">Minimum motor size required to have a variable speed drive has decreased from 10 hp to 7.5 hp. Adopting the IECC 2012 version will require changes to the prescriptive rebate requirements.

No change associated with hydronic heating systems.</td></tr>
<tr><td>SFA</td><td>Supply fan on supply air handler</td></tr>
<tr><td>SFP</td><td>Supply fan on VAV packaged HVAC unit</td></tr>
<tr><td>RFA</td><td>Return fan on return air handler</td></tr>
<tr><td>RFP</td><td>Return fan on VAV packaged HVAC unit</td></tr>
<tr><td>BEF</td><td>Building exhaust fan</td></tr>
<tr><td>PEF</td><td>Process exhaust fan</td></tr>
<tr><td>HEF</td><td>Fume hood exhaust fan & makeup air fan</td></tr>
<tr><td>FWP</td><td>Boiler feed water pump</td></tr>
<tr><td>WWP</td><td>Circulation pump for water source heat pump loop</td></tr>
<tr><td>BDF</td><td>Boiler draft fan</td></tr>
<tr><td>PHC</td><td>Process heating & cooling circulation pumps</td></tr>
<tr><td>HYP</td><td>Hydraulic pumps</td></tr>
<tr><td>CTF</td><td>Cooling tower fan</td></tr>
</table>

Adopting the IECC 2012 code would require a minor change to the current VFD program offering. The IECC 2012 code drops the minimum motor size requiring a VFD on VAV units from 10 HP to 7.5 HP. In section 3, we recommended allowing incentives for supply and return fans in VAV systems below 10 HP as specified by the IECC 2009 code. If the IECC 2012 code were to be adopted it would require a further refinement in the program literature to allow incentives for supply and return fans below 7.5 HP.

3.5.6 Air Compressors

The codes do not specify efficiencies for air compressors hence air compressor based measures are not discussed in this section.

3.5.7 Natural Gas Equipment

Table 3-12 shows a list of the current natural gas heating equipment measures and how they compare to both the IECC 2009 and 2012 codes. The "Impact" column lists and changes.

Table 3-12
Natural Gas Equipment - Comparison of the IECC 2009 and 2012 Code

Natural Gas Equipment	Minimum Equipment Efficiency Criteria	Baseline Efficiency	IECC 2009	IECC 2012	Impact of IECC 2012 vs IECC 2009
Furnaces					
≤ 300,000 Btu/h (Unitil) and ≤ 150,000 Btu/h (National Grid)	92% AFUE or greater w/ECM	78% AFUE, 80% thermal efficiency (Et)	80% combustion efficiency (Ec)	80% Ec	No change
≤ 300,000 Btu/h (Unitil) and ≤ 150,000 Btu/h (National Grid)	94% AFUE or greater w/ECM	78% AFUE, 80% Et	80% Ec	80% Ec	
Infrared Heaters					
All Sizes	Low Intensity	80% Ec	NA	NA	No change
Hydronic Boilers					
≤ 300,000 Btu/h	85% AFUE	80% AFUE	80% AFUE for hot water, 75% AFUE for steam	80% AFUE	No change
> 300,000 Btu/h to ≤ 499,000 Btu/h	85% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et	
≥ 500,000 Btu/h to ≤ 999,000 Btu/h	85% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et	
≥ 1,000,000 Btu/h to ≤ 1,700,000 Btu/h	85% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et	
> 1,700,000 Btu/h	85% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	82% Ec (≥ 2,500,000 Btu/h)	
Condensing Boilers					
≤ 300,000 Btu/h	90% AFUE	80% AFUE	80% AFUE for hot water, 75% AFUE for steam	80% AFUE for hot water, 75% AFUE for steam	No change
> 300,000 Btu/h to ≤ 499,000 Btu/h	90% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et and 79% Ec	Thermal efficiency requirement has increased, change in the baseline efficiency would need to be made.
≥ 500,000 Btu/h to ≤ 999,000 Btu/h	90% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et and 79% Ec	
≥ 1,000,000 Btu/h to ≤ 1,700,000 Btu/h	90% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et and 79% Ec	
> 1,700,000 Btu/h	90% AFUE	75% Et, 80% Ec	75% Et and 80% Ec	80% Et for hot water (82% > 2,500,000 Btuh) and 79% Et for steam	
Water Heating Equipment					
On demand, Tankless Water Heater	0.82 Energy Factor (EF) or greater	Storage tank water heater = 0.59 EF	Smaller instantaneous water heater (IWH) and storage water (SWH) units (≤200 MBH for IWH and ≤75 MBH SWH) require EF of 0.62-0.0019V. Larger units require 80% Et (≥200 MBH for IWH and ≥75 MBH SWH).	Dependant on size. Smaller units require 0.62-0.0019V min. Energy Factor. Larger units require ~80% min. Et.	No change
Indirect Water Heater	Combined appliance efficiency (CAE) ≥ 85% or EF ≥ 82	Storage tank water heater = 0.59 EF	R-12.5	NA	NA

The other natural gas measures not listed in the table above have no change or are not covered by the codes and hence were not listed.

In summary, adopting the IECC 2012 would require modifying the minimum thermal efficiency for natural gas boilers greater than 300,000 Btu/h in input size. This change would have no effect on the prescriptive rebate program as the minimum efficiency is satisfactorily greater at 90%, however the claimed savings would need to be adjusted downwards based on the code requirements.

Current Practice – Primary Research

4

4.1 Introduction

This section presents a discussion of the primary research conducted during this evaluation to assess the current practices employed for new construction in New Hampshire. The goal of the limited research effort was to capture the perspectives and behaviors of market actors and utility participants pertaining to current practice. This work was not intended to be either exhaustive or statistically based. Face-to-face interactive sessions with market actors involved in New Hampshire's new-construction industry were conducted. Additionally, utility personnel were interviewed for their perspectives and to obtain information about projects completed under the program to date.

Our primary research with market actors is presented in Section 4.2 titled "Review of A&E Current Practice Findings." That section presents the approach taken by ERS for conducting a limited amount of new primary research though group discussion sessions with New Hampshire architects, engineers, distributors, and contractors involved in commercial and industrial new construction. Descriptions of the sessions and a summarization of those discussions are presented.

Next, the "Review of Custom Projects" section discusses results of all the Custom projects conducted by the New Hampshire utilities to date. Information presented in this section is based on results of Custom studies provided by the New Hampshire utilities: Public Service Company of New Hampshire (PSNH), Liberty Utilities, Unitil Energy Systems, Inc., and New Hampshire Electric Cooperative Inc. (NHEC). This section provides further information regarding the current practices in New Hampshire's new construction market.

The final segment of Section 4 presents observations on current practices based on Utility participants' and ERS's involvement in numerous new construction projects. The perspectives of utility staff obtained via meetings and phone interviews regarding the existing Prescriptive and Custom measures are presented. Additionally, samples of Custom project analyses are provided that discuss the approach adopted by ERS in defining system baselines and assessment of energy savings for several technology types. Brief discussions on comparison of New Hampshire current practices with other states like Massachusetts, Connecticut, and New York are also put forth in this Section 6 of this report.

4.2 Review of A&E Current Practice Findings

As part of the overall evaluation study process, ERS conducted two workshops with the architects, engineers, and contractors working on New Hampshire commercial and industrial projects in June 2012. The first workshop was held on June 11 at the PSNH headquarters in Manchester, and the second workshop was held on June 13 at the New Hampshire Public Utilities Commission (NH PUC) building in Concord. A total of thirty-three architects, engineers, utility members, and contractors attended the two sessions. Each session was more than 2 hours in duration and was designed to facilitate discussions to gather data on the current design practices being implemented by the participants in their C&I projects. Appendix A includes a copy of the PowerPoint presentation slides that were used during these workshops. These discussions also covered the current and future direction of energy codes, code compliance issues, and the perception of the participants regarding the application of energy codes and code compliance in their projects. Below are key points of the discussions that resulted from the sessions.

4.2.1 Code Related Summary

- All participating architects and engineers indicated that the baseline design is one that meets the code. There was clear acknowledgement that code establishes the minimum building performance level for the design process.
- The participants also indicated that due to limited budgets and "value engineering," higher efficiency designs often get downgraded to the minimum code design.
- Some architects indicated challenges in keeping track of the various versions of the code adopted throughout the state. New standards/codes are released by ASHRAE/IECC every 3 years but are adopted by the states, cities, or towns at a timeframe of their choosing. Some cities/towns adopt stricter codes, such as the Town of Durham's adoption of the IECC 2012 in January 2012 while the rest of state has adopted IECC 2009.
- Some participants also indicated that A&E firms get used to a certain way of designing buildings, and as new codes are adopted they add a level of difficulty and extra burden to keep up with the changes.
- It was recognized that the introduction of new construction materials allows the advancement of codes, and that in some cases design teams and construction crews have to learn quickly how to properly utilize these materials.
- Participants also indicated an interest in having the entire state adopt the same format of the code instead of the individual towns/cities adopting variations of the general code. This would simplify the adoption of the codes in their opinion.
- More than half the area in the state is not covered by dedicated code officials. According to the participants, in cities and towns without code officials, the buildings are still being built to the minimum required code standards. In the areas without code officials, the A&E firms submit project documents to the appropriate town office stating that their projects meet code. No enforcement activities are conducted in such towns.

- In cities and towns with code officials, the perception was that the focus of the code compliance officials is typically on verifying the integrity of the structural elements for occupant safety, followed by inspecting one or two key energy code compliance tasks such as verifying windows or appliance efficiencies. A comprehensive review of the energy aspects of the code is not performed.
- Many participants indicated that having higher efficiency requirements in the code helps selling the end user (owner) on the need to install such equipment, as value engineering inevitably results in the installation of the equipment with the lowest possible code-compliant efficiency.
- Participants also indicated that projects are getting expensive to implement, due to the higher standards required by the code.
- A few participants indicated that it is a challenge to keep up to date with the applicable codes and track the impact on inspections performed by the code officials. The applicable code for a given project depends on the date the approved permits are received. While the actual building construction may happen over a period of time after the permit is received, there is a chance that during that time the prior code will be replaced by a new one. Therefore, it is up to the building designers to keep a track of these documents so as to avoid confusion during inspection.
- Participants acknowledged that codes are getting stricter, as are the minimum standards to which the majority of the buildings are designed.

4.2.2 Outcome-Based Code Discussion Summary

Outcome-based codes allow design flexibility to meet a target energy intensity level for the size and type of building. Post-construction monitoring confirms the performance. Outcome-based codes are being discussed as an alternative compliance methodology for future versions of the IECC, and they may be piloted in the Massachusetts Stretch Code.

- None of the participants indicated that they had heard about the outcome-based code model.
- After explaining the key features of the outcome-based code, participants listed several concerns with regards to adopting the outcome-based code as listed below :
  - Participants felt that it is too open-ended and would result in increased liability and litigation.
  - The participants questioned what would happen if the use of the building changes after occupancy.
  - This code would work ideally in a scenario where the before (modeled) and after (actual) use of the designed building is identical.
  - Participants indicated that the cost of such projects would have to be increased dramatically to cover the cost of administering the alternative approach.
  - A few participants indicated that it would be better if the requirements for meeting the after-occupancy code are relegated to the building owners.
  - A manufacturer's representative indicated that they would gladly support an operations-based code, as it would help drive their business.

4.2.3 Other Summary

- Participants indicated that some large institutional facility design teams may entertain life cycle cost analysis to justify higher efficiency designs; however, most customers base their decisions on the initial cost. This typically results in buildings that only meet the minimum code requirements and do not exceed them. Municipal buildings fall into the category with decisions predominantly driven by first cost.
- Participants identified as the least efficient the leased commercial space mostly in the non-urban areas. Since the operating costs are transferred to the tenants, participants indicated that the owners have little incentive to invest in owning a higher efficiency/higher first-cost building. However, participants indicated that an exception to this would be commercial buildings in urban areas that typically deal with tenants who desire working in energy efficient buildings that feature a smaller energy footprint compared to other similar comparable options in the area.
- It was also indicated that paying attention to small details during design and construction (particularly with shell details) is a key element that can result in efficient buildings and may not necessarily result in higher design or construction costs.
- Participants indicated that public schools and municipal facilities do not spend the required time and resources on maintaining the use of new automated building and lighting controls required by code. Over time, the energy use of these buildings goes up because the staff members who were trained at the start of the occupancy have been replaced by new staff members who do not have the required training, and, hence, controls often get bypassed.
- Participants indicated that higher energy costs help in pushing higher efficiency design to their customers.
- Regarding benchmarking, a code official indicated that the residential market is well served by the HERS rating system but very little data is available regarding benchmarking of commercial buildings in New Hampshire.
- Participants suggested a need for commissioning and continuous commissioning services to further augment the energy efficiency program offerings.
- One participant indicated that building environment is increasingly reliant on automated technology for which simple solutions are no longer available when such building systems malfunction. As an example, the participant suggested that if an air handling system went down in the past, occupants could simply open their windows.

LEED and Other High Performance Buildings Summary

- According to the participants, the majority of the customers interested in a LEED design want a building designed to LEED standards without wanting to pay for the effort to complete the documentation and obtain the LEED certification.
- Only large corporations and institutions typically go ahead with the intensive LEED certification process.

- One participant indicated that new ENERGY STAR certification requirements are making the process expensive and thus less attractive to pursue.
- One participant indicated that LEED is slowly losing its appeal, as other similar standards are equally appealing.

4.2.4 Energy Efficiency Programs Summary

- Participants indicated that they routinely interact with the energy efficiency programs and are aware of their offerings.
- One participant suggested that it would be ideal to receive the incentives for adopting higher efficiency designs early in the project design phase, as it would protect the high efficiency equipment from being eliminated through the value engineering process.
- A few participants also indicated that the new construction project incentive amounts are typically very small compared to the overall cost of the project. Therefore, the building owners typically decide to go ahead with designs that have no influence from the energy efficiency programs. This typically results in the installation of the minimum code-compliant equipment and is an opportunity for future program improvements.

4.2.5 Building Envelope Discussion Summary

- Some participants indicated that their projects involve designs with slightly greater R-value than the minimum code-required value.
- Multiple participants indicated challenge in designing and constructing commercial buildings with metal studs, as the code requires continuous insulation in such installations. They indicated that this code requirement was ahead of its time. It would have been preferred if working examples were provided on implementing continuous insulation in such installations.
- Participants indicated no challenges or issues with meeting the code requirements for windows. However, they indicated that window designs haven’t changed much over time, with window frames still representing the weakest link in a window system.
- One participant also suggested eliminating the use of the visual check list for confirming compliance of building fenestration. In its place, the participant suggested use of the blower door test to quantify the air leakage rate.

4.2.6 Lighting Discussion Summary

- Participants indicated that LED lighting is becoming increasingly popular in their projects.
- Institutional buildings typically adopt automated occupancy and daylighting controls in greater quantities.
- Participants indicated that at a minimum all projects involve dual occupancy sensors.
- As mentioned earlier, a participant indicated that since the incentives arrive towards the end of the project, they do not seem to have a bigger impact on the decision making process.

- The lighting design and lighting power density calculations are typically performed by the contracted lighting designer or electrical contractor. Lighting projects are mostly submitted to the utilities for incentives.

4.3 Review of Custom Projects

This section provides a summary of the Custom measure projects conducted under the current nhsaves@work New Equipment & Construction program to date. ERS requested information on completed Custom projects from all the New Hampshire utilities. We received Custom projects-related files from Public Service Company of New Hampshire (PSNH), Unitil Energy Systems, Inc., and Liberty Utilities. Table 4-1 presents information on the number of Custom studies provided to ERS by the utilities. It should be noted that some utilities have not completed any Custom projects to date and some have not supplied data for their Custom projects.

Table 4-1
Number of Custom Studies Completed by New Hampshire Utilities

Utility	Number of Custom Projects
PSNH	4
Unitil	2
NGrid	7

Tables 4-2 through 4-4 provide brief information on the Custom projects provided by the New Hampshire utilities.

Table 4-2
Summary of Custom Projects – PSNH

Measure	Baseline	As-Built
EMS	RTU fans and AC running longers	Reduced RTU fan and AC runtime.
Snow guns	Ratnik snow guns	Pole Cat snow guns
Install new LED lighting system with controls	High pressure sodium and T5 fluorescent	LED
Injection molding machines	Standard efficiency injection molding machine	High efficiency injection molding machine

Table 4-3
Summary of Custom Projects – Unitil

Measure	Baseline	As-Built
New Heating System	Oil-fired Kewanee boiler	2 Lochinvar model KBN 601 boilers, piping, pumps, flue venting, gas piping, 1" fiberglass insulation, and electrical
Hydraulic motor servo controllers	Less efficient hydraulic motors and controls	hydraulic moter servo controllers

Table 4-4
Summary of Custom Projects – Liberty Utilities

Measure	Baseline	As-Built
Wall insulation	18213 sq ft of R-15 wall insulation from RS Means	18213 sq ft of R-24 wall insulation
Windows	Using RS means cost for 2,391 sqft of double hung vinyl windows	Installing 2,391 sqft of energy efficient double hung windows
Roof Insulation	8761 sq ft of R-38 roof insulation from RS Means	8761 sq ft of R-60 new roof
Energy recovery ventilator	Old ventilation system	Add (3) Energy Recovery Ventilators
Water heater		(2) 1,444 MBH space heating boilers with 109 gallon storage tank each
Ventilation Heat Recovery	Building is new construction. The base case is assumed to be energy code.	Install three (3) ERV's supplying 4,500, 6,000, and 35,000 CFM.
Refrigeration heat recovery	Evaporative condensers rejecting heat to the atmosphere	Evaporative condensers equipped with heat exchangers to recover waste heat which will be supplied to each RTU
Energy recovery ventilator	Only 5,000 CFM ERV is over code so needs base case cost	(5) Greenheck ERVs installed
Condensing boilers	(3) 765 MBH boilers and 50,045 CFM worth of Air Handling Units	(3) Lochnivar XL KBN801 752 MBH output boilers, 20 FHP heatpumps and 5/8 radiant pipe heating for lobby
HVAC equipment/systems		
VFD air compressor	add a 3rd 75 hp inlet modulation air compressor to serve expanded load	add a new 100 hp vfd compressor, vfd dryer, low pressure drop filters, no-loss drains and storage
High efficiency heat pumps, ERVs, CO2 ventilation control	Standard efficiency air-to-air heat pumps, no energy recovery, constant volume ventilation	High efficiency heat pumps, ERVs, CO2 ventilation control
Refrigerated case covers	Refrigerated case without covers	Refrigerated case with covers

The data provided by the various utilities for the completed custom projects is compared with the typical custom baseline measures descriptions. Table 4-5 presents typical scenarios encountered in custom projects and their instances that were found in the supplied New Hampshire Custom projects. Based on the information presented in the tables above, it is interesting to note that the most commonly implemented Custom measures involve some sort of energy recovery.

Table 4-5 (Part 1 of 4)
Results Based on Completed Custom Project Categories

Category	Standard Practice	Possible Energy Saving Improvements:	Comments Based on Available Custom Projects
Interior lighting	**High Intensity Discharge - (typical where ceilings exceed 50 feet)**		
	Metal Halide (MH) Fixtures/High Pressure Sodium (HPS)	- Higher efficiency fixtures or system designs providing similar light levels*	Existing baseline is appropriate - one project implemented
	Fluorescent - (typically where ceilings are below 50 feet)		
	High Intensity Fluorescent (HIF)	None	No projects implemented
Exterior lighting	HPS or MH with time clock and/or photocell control	Automatic high/low controls (for loading docks or areas with variable occupancy) (should not have manual override Aon ~ option)	No projects implemented
Lighting controls	Time clock or manual on/off control based on general occupancy schedules	-Microprocessor based control systems with central operator station, individual zone control and occupancy schedules, with central and local schedule adjustment capabilities.	No projects implemented
		Automatic high/low controls	No projects implemented
		Skylight/daylight dimming controls	No projects implemented
Window and skylight glazing	**Glass with Shading Coefficient of:**	**Glass with Shading Coefficient of:**	
	0.78 for windows 10% or less of total wall area.	0.51 for windows 10% or less of total wall area.	No projects implemented
	0.59 for windows between 10% and 30% of total wall area.	0.44 for windows between 10% and 30% of total wall area.	No projects implemented
	0.52 for windows greater than 30% of total wall area.	0.41 for windows greater than 30% of total wall area.	No projects implemented
	0.46 in curtain walls, atrium and skylights.	0.35 in curtain walls, atrium and skylights.	No projects implemented
Office buildings under 40,000 sq. ft	Constant Volume fans (supply, return, exhaust)	VAV HVAC systems with VFD on fans	No projects implemented
Office buildings over 40,000 sq. ft.	VAV on supply, return, and exhaust fans over 20 HP (w/VFD control)	- VFDs on motors <20HP with automatic control	No projects implemented
	Standard distribution system sizing	Low pressure drop system designs with low temperature air distribution	No projects implemented
	Electronic controls on main HVAC equipment	Full building DDC controls with static pressure reset based on terminal unit loads, discharge air temperature reset, outside air intake monitoring and control, central plant optimization, VFD pump controls, etc.	No projects implemented
Manufacturing or classroom bldg.	Constant volume distributed HVAC systems (fancoils or unit ventilators)	VAV Distribution and control systems	No projects implemented
		Primary/secondary pumping w/VFD control	No projects implemented
Fume hood exhaust systems	Constant volume exhaust system with VSD on VAV supply fan	Occupancy sensor on fume hood, Static pressure reset and Automated sash operation	No projects implemented
		Heat/AC recovery systems	Existing baseline is appropriate - one project implemented
Kitchen hood exhaust systems	Constant volume exhaust with manual on/off control	VFD for variable volume exhaust and intergrated make-up air system and controls	No projects implemented

Table 4-5 (Part 2 of 4)
Results Based on Completed Custom Project Categories

Category	Standard Practice	Possible Energy Saving Improvements:	Comments Based on Available Custom Projects
Unitary equipment and split systems	Air cooled Package /Split units: < 5 Ton, 10.0 SEER 5-11 Ton, 8.9 EER >11-30 Ton, 8.6 EER	Evaporative condensers Enthalpy/heat exchangers	No projects implemented
	Air cooled Package /Split systems over 30 tons (baselines dependent on system size)	- Higher efficiency packaged systems with optimized control systems	No projects implemented
		- Custom units with oversized coils	No projects implemented
		- Evaporative condensers	No projects implemented
		- Enthalpy/heat exchangers	No projects implemented
		- Water cooled systems	No projects implemented
Air source heat pumps	Air source heat pump with fossil fuel heat source, Standard efficiency air-to-air heat pump with no energy recovery and constant volume ventilation	High efficiency heat pump, energy recovery, CO_2 control	Existing baseline is appropriate - one project implemented
Water source heat pump systems	Constant flow water loop	Variable flow water loop with VSD	No projects implemented
Cooling tower systems	Forced draft cooling tower with centrifugal fan	Induced Draft cooling tower with axial fan	No projects implemented
Packaged reciprocating chillers	Air cooled chillers <150 tons at 9.8 EER >150 TONS AT 9.6 EER	Evaporative condensers / Multistage compressors	Existing Baseline is appropriate - one project implemented
Existing chilled water plants (Renovation, expansions, replacements)	Lead / lag chiller control; no CHWT reset	Chiller sequencing /optimization/ CHWT reset	No projects implemented
	Primary chilled water system	Primary/secondary with VSD pumping on secondary	No projects implemented
	Constant flow chilled water pumps	VSDs on primary chilled water pumps	No projects implemented
	2 speed cooling tower fans	VSD on cooling tower fans	No projects implemented
	Evaporative Induced Draft Cooling Tower	Plate and frame heat exchanger (also called water side economizer) for free winter cooling	Existing Baseline is appropriate - one project implemented
	Fixed condenser supply temp with mixing valve and tower fan control.	Condenser controls with condenser water temperature reset	No projects implemented
		VSD on condenser pump	No projects implemented
New chilled water plants	Water cooled centrifugal chillers: < 150 tons = 0.651 kW/ton 150 to < 300 tons = 0.633 kW/ton, 0.577 kW/ton IPLV 300 to 1000 tons = .620 kW/ton peak, .570 kW/ton IPLV	Higher Efficiency Chillers	No projects implemented
	Chiller (over 1000 tons) efficiency depends on refrigerant/size	Higher Efficiency Chillers	No projects implemented
	Chilled water temperature reset based on return water temp based on OAT	Chilled water reset based on building HVAC loads and discharge air temps w/ full DDC controls including terminal units	No projects implemented
	Primary/Secondary pumping with VSD on secondary pump	Multiple sequenced high efficiency pumps on secondary distribution system	No projects implemented
	Standard selection size cooling tower	Oversized cooling towers with reduced Fan HP	No projects implemented
	Cooling towers with multiple fans or dual speed fans	VSD(s) on cooling tower fans	No projects implemented
	Constant flow condenser water pump system	VSD on cond. water pump	No projects implemented
	Chiller sequencing controls based on load	Optimized chiller sequencing controls based on load and overall operating kW/ton	No projects implemented
	Plate and frame heat-X- changers (free cooling)		No projects implemented
	No thermal storage	Thermal storage to reduce plant kW demand	No projects implemented

Table 4-5 (Part 3 of 4)
Results Based on Completed Custom Project Categories

Category	Standard Practice	Possible Energy Saving Improvements:	Comments Based on Available Custom Projects
Building control systems (EMS) (over 40,000 sq ft)	7 day time scheduling	Static pressure reset based HVAC system demand.	No projects implemented
	Optimized start/stop	Outside air intake control based on carbon dioxide sensors, VOC sensors or other indicator of ventilation requirements.	No projects implemented
	HVAC system without controls	HVAC system with EMS controls implemented	Existing baseline is appropriate - one project implemented
	DDC control of air handlers	Discharge air temperature reset	No projects implemented
	Chilled water reset	Enthalpy control	No projects implemented
	DB Economizer control		No projects implemented
Boiler equipment	Constant speed feed water pumps	VSD on feedwater pumps >20 HP with automatic pressure controls	No projects implemented
	Standard efficiency boilers	High effciency condensing boilers	Existing baseline is appropriate - three projects implemented
	Constant speed forced draft fans	VSD on draft fans with automatic pressure controls	No projects implemented
Computer room packaged HVAC with humidifiers	Electric resistance steam generators	Ultrasonic/evaporative humidifiers	No projects implemented
	DX compressor/coil	Water Side Economizer	No projects implemented
		Chilled Water cooling	No projects implemented
Commercial refrigeration	Multiplexed refrigeration racks VSD on lead compressors Plate and frame sub-coolers Floating head pressure controls Demand defrost controls T8s for case lights	Hot gas defrost and controls	No projects implemented
	Air cooled condensers	Evaporative condensers	No projects implemented
		VSD on condenser fans	No projects implemented
	Screw compressors	Scroll compressors	No projects implemented
	Refrigerated case without covers	Refrigerated case covers	Existing baseline is appropriate - one project implemented
	Case doors with anti-sweat heat controls	Heater less doors (triple pane)	No projects implemented
	Case lighting T12 lamps and EEmag ballasts	T8/T5 lamps with electronic ballasts	No projects implemented
		Remote mounted ballasts *(out of refrig. case)*	No projects implemented
	Motorized freezer doors	High speed operated freezer doors	No projects implemented
	Humidity controls with reheat	Heat pipe on HVAC unit with coil bypass	No projects implemented
		Low temperature air distribution	No projects implemented
	Refrigeration heat recovery - Evaporative condensers rejecting heat to the atmosphere	Evaprative condensers equipped with heat exchangers to recover waste heat which will be supplied to each RTU	Existing baseline is appropriate - one project implemented
	self contained TEV (thermal expansion valves)	Electronic controlled TEV (thermal expansion valves)	No projects implemented
	Rack type refrigeration compressors	Distributed refrigeration systems (no pumps, smaller diameter pipes)	No projects implemented
Industrial refrigeration systems (serving facilities over 50,000 sq. ft. or 250 tons)	Evaporative cooled condensers	Oversized evaporative condensers	No projects implemented
		VSD on evaporative condenser fans	No projects implemented
	Standard size evaporator coils and controls	Oversized/lower fan HP evaporator coils	No projects implemented
		Evaporator fans on/off control	No projects implemented
	single-stage compressor systems	Multi-stage compressor systems	No projects implemented
	Floating head pressure controls, Electric defrost control, and Subcoolers	Hot gas defrost and controls	No projects implemented
	Standard design cooling equipment and controls sequences	Oversized cooling equipment with thermal shifting capability	No projects implemented
	Motorized freezer doors	High speed operated freezer doors	No projects implemented
Waste water treatment and fresh water plants	Fine bubble aeration with VSD and positive displacement blower	Centrifugal blower and dissolved oxygen (DO) controller	No projects implemented
	VSDs on all pumps 25 HP and larger	VSDs on pumps <25 HP	No projects implemented
	VSD's on ID fans and fume control systems		No projects implemented
New ice rinks	Low E ceilings		No projects implemented
	Water cooled chiller		No projects implemented
	Floor mounted ice temperature sensors	Infrared ice surface temperature sensors and controls	No projects implemented
	Multi-speed brine pump (Smart Drive)		No projects implemented
	Floating head pressure controls down to 75 deg F.	Ice temperature reset based on occupancy/use	No projects implemented
	Dehumidification	Desiccant dehumidification	No projects implemented
		Heat Recovery	No projects implemented

Table 4-5 (Part 4 of 4)
Results Based on Completed Custom Project Categories

Category	Standard Practice	Possible Energy Saving Improvements:	Comments Based on Available Custom Projects
Process related equipment	Constant speed fans, process pumps or blowers with variable loads	VSDs on pumps, fans or blowers with automatic controls	Existing Baseline is appropriate - one project implemented
	VSD on motors requiring variable speed	None	No projects implemented
	Solid state Motor-Generator sets making off-frequency (i.e. not 60 Hz) power	None	No projects implemented
Plastic injection molding machines	Hydraulic operated operation	VSD or other hydraulic enhancements	No projects implemented
		Electrically operated and controlled equipment	Existing baseline is appropriate - one project implemented
Air compressors (under 130 PSI)	Single stage rotary screw compressors with modulating control via inlet valve control and unloading point below 50% of rated CFM	-Single stage rotary screw compressors with load/no load control and storage	No projects implemented
		- Geometry type flow controls	No projects implemented
		- VFD controlled compressor	Existing baseline needs to be reconsidered - one project implemented
		- Scroll type compressors	No projects implemented
		-2 stage rotary screw compressors with load/no load control and storage	No projects implemented
		-2 stage double acting reciprocating compressors	No projects implemented
		-3 stage centrifugal compressors	No projects implemented
Air compressors (130 PSI and over)	2 stage rotary screw compressors with cycling dryer and same baseline for <130 PSI	3 stage centrifugal compressors	No projects implemented
		2 stage double acting reciprocating compressors	No projects implemented
Compressed air auxiliary equipment	Standard pressure drop filters	Low pressure drop filters (<1 PSI)	Existing Baseline is appropriate - two projects implemented
	Refrigerated Dryers	Cycling refrigerated dryers	No projects implemented
		VFD controlled dryers	Existing baseline is appropriate - one project implemented
		Heat of compression dryer	No projects implemented
	Standard design distribution and end use requirements	Distribution system improvements (multiple pressure/compressor systems, pressure booster compressors,	No projects implemented
		End use equipment reduced pressure requirements	No projects implemented
		Sequencing Controls	No projects implemented
		Intermediate Pressure Controllers	No projects implemented
		Low pressure (<40psi) blower systems	No projects implemented
Snow making equipment	Standard efficiency snow making guns	High efficiency snow making guns	Existing baseline is appropriate - one project implemented
Envelope	Wall insulation (R-15)	R-24	Existing baseline is appropriate - one project implemented
	Windows (double hung vinyl windows)	Energy efficient double hung windows	Existing baseline is appropriate - one project implemented
	Roof insulation (R-38)	R-60	Existing baseline is appropriate - one project implemented
Water heaters	(2) 1,275 MBH gas fired water heaters	(2) 1,444 MBH space heating boilers with 109 gallon storage tank each	Existing baseline is appropriate - one project implemented

4.4 Additional Expert Considerations

In this section some representative custom projects, completed by ERS over the past year, will be discussed.

4.4.1 Sample ERS Projects

This section presents information on designated technical assessments conducted by ERS in the last 12-month period for some of the Northeast-based utilities. ERS was asked to provide technical assistance to establish the baseline and proposed system energy consumptions. The assessments presented below provide detail on the baseline and proposed case descriptions that were utilized for designated custom measures that were not represented in Table 4-5. These measures have not necessarily been implemented or submitted under the program for incentives by the utility companies, but they present samples of custom measure analysis approaches in quantifying project characteristics and savings.

Cooler/Freezer Area Lighting

The following is a description of a completed project assessment and presents the approach ERS utilized for assessing the replacement of high intensity fluorescent (HIF) and metal-halide fixtures in the cooler and freezer sections of a warehouse, respectively. The baseline interior lighting technology in the cooler area was four-lamp, high-output T5 fixtures. The light level at various locations in the cooler area was measured to be around 20 footcandles. The baseline lighting in the freezer spaces was comprised of 400 W metal-halide fixtures. The existing fixtures in both the coolers and freezers were replaced by LED fixtures. Figures 4-1, 4-2, and 4-3 demonstrate the existing cooler, proposed cooler, and proposed freezer lighting configurations, respectively.

Figure 4-1
Existing Cooler Lighting Configuration

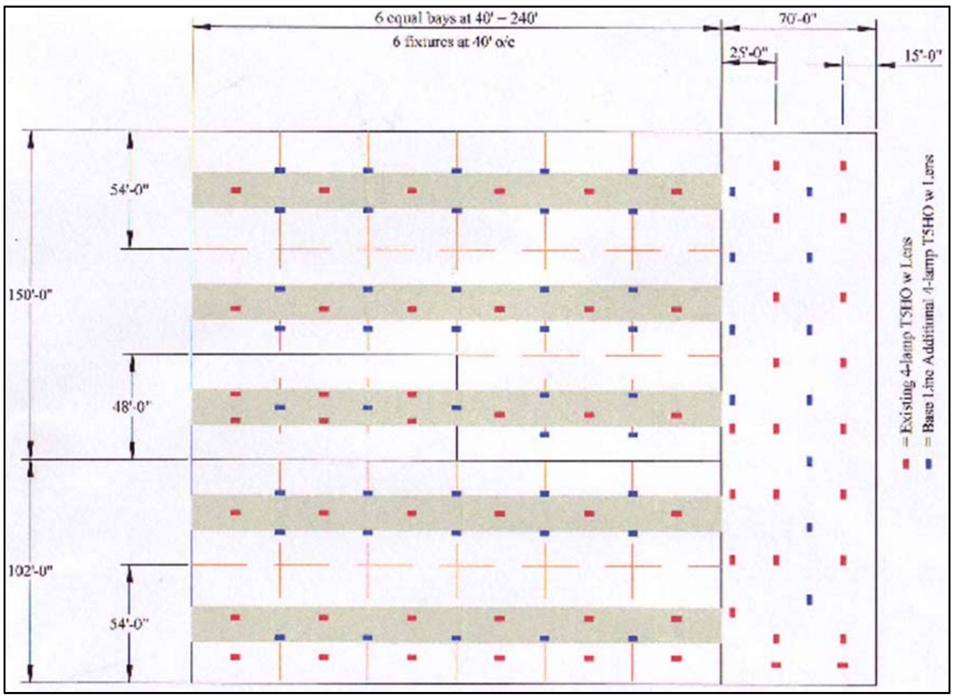


Figure 4-2
Proposed Cooler Lighting Configuration

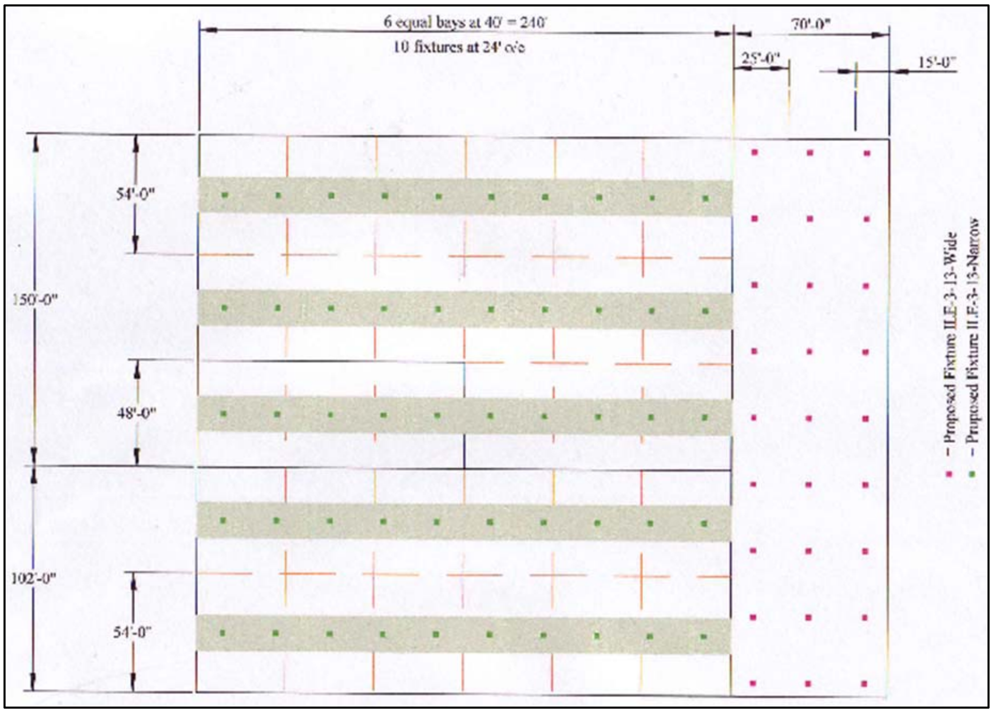
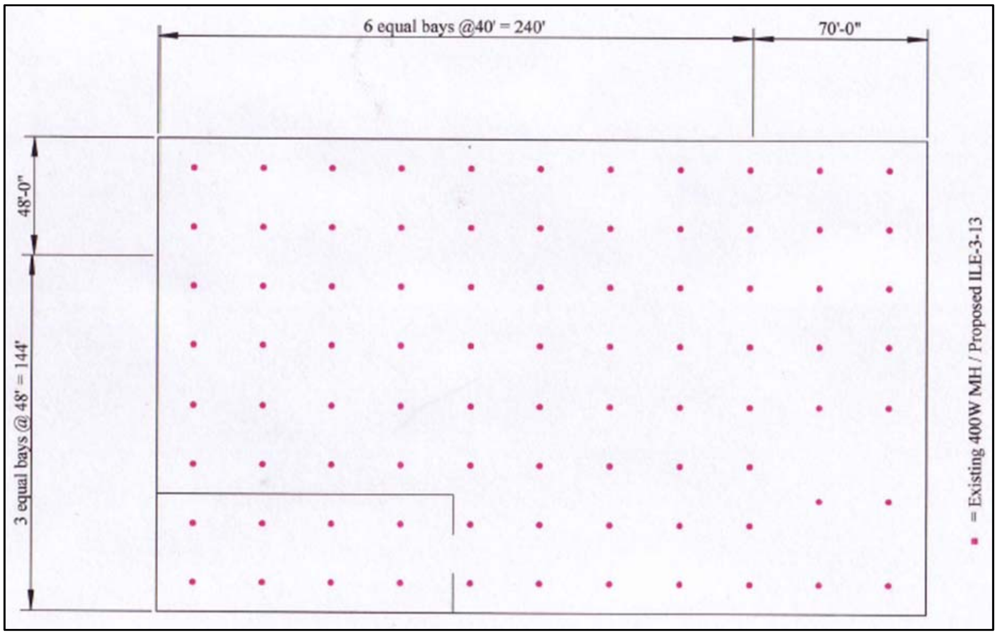


Figure 4-3
Proposed Freezer Lighting Configuration



ERS analyzed replacing the existing HIF and 400 W metal halide fixtures with LED equivalents equipped with occupancy controls. The reduction in operating hours due to the implementation of occupancy controls increased the proposed savings associated with this project. The proposed energy and demand savings were calculated using the following formulas:

$$kWh_{saved} = QTY_{exist} \times Hours_{exist} \times kW_{exist} - QTY_{as-built} \times Hours_{as-built} \times kW_{as-built}$$

$$kW_{saved} = QTY_{exist} \times kW_{exist} - QTY_{as-built} \times kW_{as-built}$$

The existing cooler lighting consisted of sixty-one four-lamp, high output T5 fixtures. In this configuration the average light level at the warehouse floor was approximately 10 footcandles. Through discussions with facility staff, ERS learned that higher illumination levels were desired. Therefore ERS generated a proposed baseline scenario which required the addition of fifty-three HIF fixtures to meet the desired illumination levels. This was done so that an apples-to-apples comparison could be made to the proposed lighting system, which was designed to achieve a light level of 20 footcandles. Figure 4-1 displays the proposed cooler baseline scenario developed by ERS for this project. A summary of results is presented in Table 4-6.

Table 4-6
Summary of Lighting Analysis (Option 1)

Summary - Cooler/Freezer Area Lighting Project	
Total proposed number of fixtures retrofitted	114
Total proposed number of controls installed	77
Existing demand (kW)	26.7
Proposed demand (kW)	20.1
Demand savings (kW)	6.5
Existing annual use (kWh)	161,345
Proposed annual use (kWh)	43,074
Annual energy savings (kWh)	118,271
Cost of improved system with incentives	$130,575.00
Annual cost savings	$39,493.00
Payback period	3.3

Conclusion

Based on our experience, the base case descriptions presented in the analysis above are in agreement with the descriptions provided in the Custom measures table for interior HIF lighting. Based on our work with the New Hampshire utilities, we have mostly observed the use of metal halide, high-pressure sodium vapor, and HIF lamp fixtures in industrial environments. Based on our experience of designing efficient lighting systems, we believe that the existing baseline and proposed measure descriptions for the HIF fixtures in interior spaces are adequate.

Supermarket Refrigeration

The following discussion presents information utilized for assessing energy saving opportunities for refrigerated display cases, coolers, and freezers at a supermarket. Measures implemented at the store to create an efficient refrigeration system included: lowering humidification levels in refrigerated areas, anti-fog coating on refrigerated case doors, electronic expansion valves, oversized condensers, ECM motors, and LED case lighting.

The supermarket was a new construction project. The owners of the store made the decision to install high efficiency versus standard efficiency refrigeration equipment. The new cases will be used for merchandising and maintaining product quality. Finally, rebate information was calculated for the recommended energy saving measures.

Base Case Definitions and Comparison with Efficient Equipment

This section describes the approach used to evaluate the proposed refrigeration display cases with the energy efficient display cases. Display-type refrigeration cases are made up of the following components: the compressor (self-contained models), the condenser (self-contained models), the evaporator, evaporator fans, display glass doors (optional), defrost mechanism, and anti-sweat mechanism (optional). There is no existing federal standard for minimum efficiency of commercial refrigeration units. Furthermore, there are no industry standards or state codes that put forth standardized baseline information for this type of application (for example, ASHRAE 90.1 and similar standards do not give any guidelines for this type of equipment). The base cases for these measures were determined using standard efficiency equipment that is commonly found in these applications. Table 4-7 presents a summary of the standard efficiency cases for the refrigeration measures implemented at the store.

Table 4-7
Results of Baseline Survey

Measure Description	Baseline System	Installed System
Dessicant dehumidification	Energy use of refrigerated cases under standard store conditions	Energy use of refrigerated cases in a dehumidified area
High-efficiency case doors	Constant operation of anti-sweat heaters on refrigerated case doors	Reduced operation of anti-sweat heaters on refrigerated case doors due to anti-fog film application
Electronic expansion valve case controls	Thermostatic expansion valves on condensers	Electronic expansion valves on condensers
Oversized condensers	Standard sized condensers	Oversized condensers
ECM case motors	Standard motors in refrigerated cases	ECM motors in refrigerated cases
LED case lighting	Standard lighting in refrigerated cases	LED lighting in refrigerated cases

After reviewing the project documentation, ERS learned that the dehumidification of the refrigerated case areas and anti-fog coating measures were not considered in the incentive calculations for this project. The post-installation contractor determined through discussions with the store's refrigeration expert regarding the operation of the dehumidification system that savings would be difficult to achieve in the in Northern climates. The post-installation contractor also noted that humidity from other, less controlled, sections of the store would affect the refrigerated sections regardless of the dehumidification controls placed in those sections. The anti-fog coating was not incentivized because the cases are already equipped with door-defrost units. To obtain an incentive for this measure, the post-installation contractor determined that the door-defrost units would have to be removed or permanently disconnected.

The savings estimates for this project were calculated through the use of the technical assistant's own spreadsheet tools. Interactive effects of measures were taken into account through an eQuest model. The proposed case model considers the implementation of all the measures listed in Table 4-7, while the baseline model was generated based on the non-implementation of the measures. Table 4-8 is a summary of the analysis of this project; the dehumidification and case doors measures have been left out of the summary table.

Table 4-8
Savings Summary

Summary - Supermarket Refrigeration Project	
Demand savings (kW)	45.8
Energy savings (kWh)	326,797
Cost savings	$34,411
Proposed cost	$158,919
Incentive	$77,719
Customer cost	$81,200
Payback w/o incentive	4.6
Payback w/ incentive	2.4

Conclusion

Based on our experience, the base case descriptions presented in Table 4-7 seem to be reasonable. Refrigeration systems typically comprise 30%–50% of the total electrical consumption of supermarkets. Even though built-up refrigeration systems represent a sizable energy end use, they are not represented in the codes because of the complex system designs. Therefore, we believe that such systems can only be accurately characterized using the Custom measure approach.

In addition, we also feel that there is a need for addressing the requirements of defining base case descriptions for refrigeration systems in the state codes and federal energy standards.

Condensing Boilers

The following discussion presents information ERS utilized for reviewing energy savings for a central boiler plant consisting of high efficiency condensing boilers at a new high school. The high school is still in the design phase, and therefore the condensing boiler measure was assessed as a new construction project. The baseline considered in the proposed savings analysis for this measure was standard efficiency boilers, as required by code. The savings calculations for this measure were determined through the use of eQuest modeling software. Table 4-9 displays the details of the baseline and proposed systems.

Table 4-9
Results of Baseline Survey

Measure Description	Baseline System	Installed System
Condensing boilers	Four 2,500 MBH standard efficiency gas-fired boilers (central heating plant). Code compliant boilers: 80% thermal efficiency	Four 2,500 MBH high efficiency gas-fired condensing boilers (central heating plant)
Condensing boilers	Two 450 MBH standard efficiency gas-fired boilers (gym heating plant). High efficiency condensing boilers: 90% thermal efficiency	Two 450 MBH high efficiency gas-fired condensing boilers (gym heating plant)

Table 4-10 is a summary of the measure savings and paybacks.

Table 4-10
Summary Table

Summary - Cooler/Freezer Area Lighting Project	
Existing gas use (Mbtu)	7,256
Proposed gas use (MBtu)	6,610
Gas use savings (MBtu)	646
Existing annual use (kWh)	1,638,903
Proposed annual use (kWh)	1,644,348
Annual energy savings (kWh)	(5,445)
Incremental cost of improved system	$100,000
Incentive	$9,692
Customer cost	$90,308
Payback period	1.1

Conclusion

Based on our experience, the base case description utilized in the discussion above is adequate. We also believe that such systems can be most accurately characterized using the custom measure approach.

Intentionally Left Blank

Current Practice – Literature Review

5

5.1 Introduction

This section presents a discussion of pertinent secondary research that is related to current practices in New Hampshire and nearby locales. A review of the literature to determine and assess secondary sources of information was conducted. It is worthwhile to note that there has been no comparable update to the 2000 Survey of Commercial New Construction Activities in New Hampshire that was found to be a relevant source in the literature review by ERS in 2003. Instead, two very recent studies for commercial new construction activities in Maine and Vermont are reviewed closely. These were supplemented by new interviews with New Hampshire architects and engineers, as well as several reports on overall New Hampshire commercial new construction characteristics and code officials' perspectives.

Commercial and industrial building characteristics across the nation were reviewed to develop the profile of a typical commercial building. Information on significant parameters that distinguish nonresidential buildings from residential buildings is introduced. Specifically, data on the national breakdown of commercial building types, their end-use intensities, and their end-use energy use intensities (EUIs) are presented.

The Buildings Characterization section is followed by a Review of Existing Sources that discusses existing literature sources for commercial and industrial new construction current practices. These sources were reviewed for their relevance with respect to the new construction practices for commercial and industrial buildings in New Hampshire as well as other states in the U.S. As a part of this section, pertinent information regarding design practices adopted by architects and engineers, building envelope practices, lighting system practices, mechanical systems practices, and energy management system practices in New Hampshire and nationwide were reviewed.

Discussions for the current practices of various technologies identified above begin with the presentation of the data applicable to the states of Maine and Vermont, followed by the practices adopted on a nationwide basis where available. Several tables and figures have been used from the referenced reports to present the information on new construction practices.

Tables 5-1 through 5-3 briefly summarize the findings from various studies/sources that we reviewed. Please note that a study was conducted by DNV KEMA after the results of this study were presented regarding the Massachusetts C&I code compliance and hence the results of that study are not presented in the table below.

Table 5-1
Brief Summary of Findings for Building Envelope from Literature Review

Study/Source	Findings	Comments
Maine Commercial Study Baseline Report (2011)	Insulation: Where measurements were possible, 40% of buildings did not meet code.	A higher percentage of the buildings in the northern part of the state did not pass insulation code.
	IECC 2009 code revisions are more stringent, and many buildings that did not pass before do not pass anymore.	–
	50% of windows did not pass code.	–
	Much room for efficiency improvements in building envelopes, which is especially applicable since Maine is in climate zone 6 &7.	–
Vermont Business Sector Market Assessment and Baseline Study (2009)	Above-ground insulation values averaged U=0.045, which is significantly better than code U=0.064 for most buildings .	Only 10% of buildings did not pass code for insulation values.
	78% of fenestration was double glazed and 37% were low emissivity.	–
Survey of Architects and Engineers by ERS (2012)	Code defines the standard practice	-
	Code enforcement is limited and is focused on structural elements	

Table 5-2
Brief Summary of Findings for Lighting Systems from Literature Review

Study/Source	Findings	Comments
Maine Commercial Study Baseline Report (2011)	Efficiency: 66% of buildings surveyed passed energy code, which is based on lighting power density (LPD).	This is attributed to energy code lighting power allowances (LPAs) and the aggressive evolution of lighting technology.
	Controls: 96% of enclosed areas and 93% of outdoor fixtures met basic control requirement.	Compliance far worse outside of these two basic measures.
Vermont Business Sector Market Assessment and Baseline Study (2009)	Efficiency: The mean LPD from survey is .88 plus or minus 0.20 – significantly lower than the weighted average maximums of 1.21.	–
	The LPDs in new construction are not significantly different from existing.	–
	T12 fixtures are almost non-existent in new construction.	Close to 90% of commercial new construction served by some type of linear fluorescent.
	The majority of installed linear fluorescents are standard T8 fixtures	Significant opportunity for retrofits.
	High bay HID: There has been a decrease in HID fixtures and an increase in T5 fixtures. This is attributed to T5s being recommended in place of HIDs.	–
	Outdoor: More than 75% of outdoor lighting is metal halide technology, with the significant remainder served by incandescent and quartz.	–
Buildings Energy Data Book (2011)	Total energy consumed by lighting has decreased by 0.7 quadrillion Btu in the last 8 years.	Attributed to efficiency increases in linear fluorescents or other undeterminable characteristics.
	Almost 75 percent of commercial lighting energy consumption is by linear fluorescents.	This is about 37% of total lighting energy consumption in the U.S. without industry and residential contributions.
	Large decreases in overall consumptions by T12 fixtures and incandescents. Increases by T8s, T5s MH, HPS, and CFLs.	T12s still make up 31% of commercial lighting energy consumption but T8s are now 35%.
US Lighting Market Characterization (2010)	Average installed efficacy increased from 45 lumens per watt in 2001 to 58 lumens per watt in 2010.	Attributed largely to a shift in incandescents to CFLs in the residential sector and T12s to T8s and T5s in commercial
	Lighting electricity consumption: Linear fluorescents are 42%, HID are 26%, and incandescent are 22%	–
	LED lighting is still mostly applicable to niche lighting and will need development to bring costs down and realize full potential.	–
Survey of Architects and Engineers by ERS (2012)	T8s are standard practice	-
	Wall mounted occupancy sensors are standard practice	
	HIFs are standard practice	

Table 5-3
Brief Summary of Findings for Mechanical Systems from Literature Review

Study/Source	Findings	Comments
Maine Commercial Study Baseline Report (2011)	Approximately 80% of HVAC equipment and heat pump units met code requirements.	Mechanical equipment suppliers have been dealing with energy code enforcement for over a decade, and this is one of the most transparent consumers of electricity.
	93% of service water heaters met code efficiency levels.	–
	HVAC controls had a broad variety of compliance; see Table 5-19.	Compliance ranges from 18% to 80%.
	High levels of compliance with delivery system insulation levels were noted at 88% of ducts, 79% of circulation piping, and 72% of service hot water piping. Also, proper duct sealing was noted in 90% of systems.	–
Vermont Business Sector Market Assessment and Baseline Study (2009)	Large opportunities for improvements in cooling equipment controls (at least 43% of space).	–
	Opportunity for more efficient motors and controls with heating and cooling systems.	–
	Insulation levels were found to be very good for the most part.	Insulation is fairly straightforward to implement.
Survey of Architects and Engineers by ERS (2012)	Code represents the baseline for all projects.	-

5.2 Commercial and Industrial Buildings Characterization

In the process of defining current practice for new construction, we felt that it would be helpful to first obtain an understanding of the types of buildings that are present as well as the related end-uses and energy consumption associated with the building stock. The information presented below depicts various statistics about building types, building end-uses, and energy intensities. Additionally, key building parameters that impact energy consumption are briefly discussed in terms of how designers' choices make a difference in energy usage.

To characterize commercial and industrial buildings energy use, relevant information from the U.S. Department of Energy Buildings Energy Data Book was gathered. The Buildings Energy Data Book is a regularly updated source for statistics on energy consumption and a wide variety of other information related thereof.

5.2.1 Key Building Parameters

The key parameters that differentiate the energy usage in non-residential buildings include:

- ❑ Hours and days of operation
- ❑ Climate
- ❑ Occupant density
- ❑ Occupant activities
- ❑ Lighting system type and efficiency
- ❑ HVAC system type and efficiency
- ❑ Insulation and glazing
- ❑ Orientation and configuration

- ❑ Other energy using systems (refrigeration, elevators, process loads, plug loads, etc.)

The first four of the preceding parameters – hours of operation, climate, occupant density, and occupant activities – are generally beyond the control of building designers. The remaining five parameters – lighting systems, HVAC systems, insulation and glazing, orientation, and internal systems – can be manipulated through good design and the use of energy efficient technologies to improve the overall efficiency of the building.

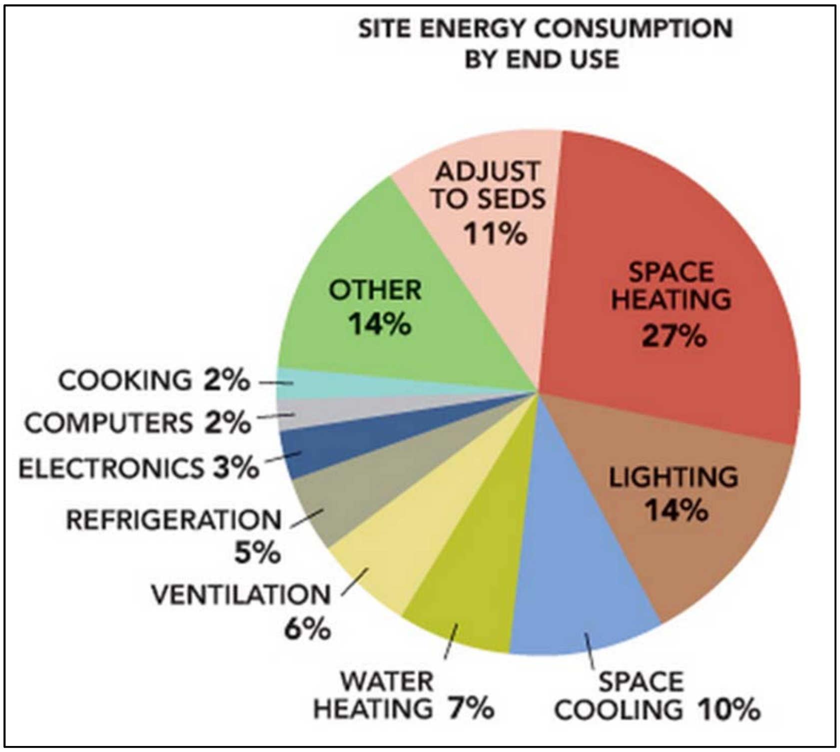
It is helpful to present information on the breakdown of building type to identify the significant trends and relevant characteristics. The 2011 Buildings Energy Data Book by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy contains current and accurate set of comprehensive nationwide buildings-related data. The Data Book is a dynamic reference that is constantly updated with new data as it becomes available. Based on information available in the 2011 Buildings Energy Data Book, Table 5-4 presents the principal building types by percent of total floor space. The data shows that a majority (61%) of the commercial building space is occupied by office, retail, warehouse, and educational facilities. Note that the data presented in the 2011 study relates to the status of the buildings in 2003.

Table 5-4
Building Types by Percent Floor Space

Building Type	% Space of Total
Office	17%
Mercantile	16%
Education	14%
Warehouse and storage	14%
Lodging	7%
Service	6%
Public assembly	5%
Religious worship	5%
Health care	4%
Food sales	2%
Food service	2%
Public order and safety	2%
Other	2%
Vacant	4%
Total	**100%**

Figure 5-1 presents a breakdown of information on the related commercial building energy end uses in the U.S. It is clear that space heating (27%) is the largest commercial consumer of energy, followed by lighting (14%) and space cooling (10%). The new data represents an increase in the space heating-related energy by 8% when compared to the 2000 data and a decrease in the relative lighting consumption of 10%. This figure references a total energy consumption of 18.26 quadrillion Btu, including generation and transmission losses.

Figure 5-1
Commercial and Industrial Buildings Energy End-Use Splits, 2010 (US DOE, 2012)



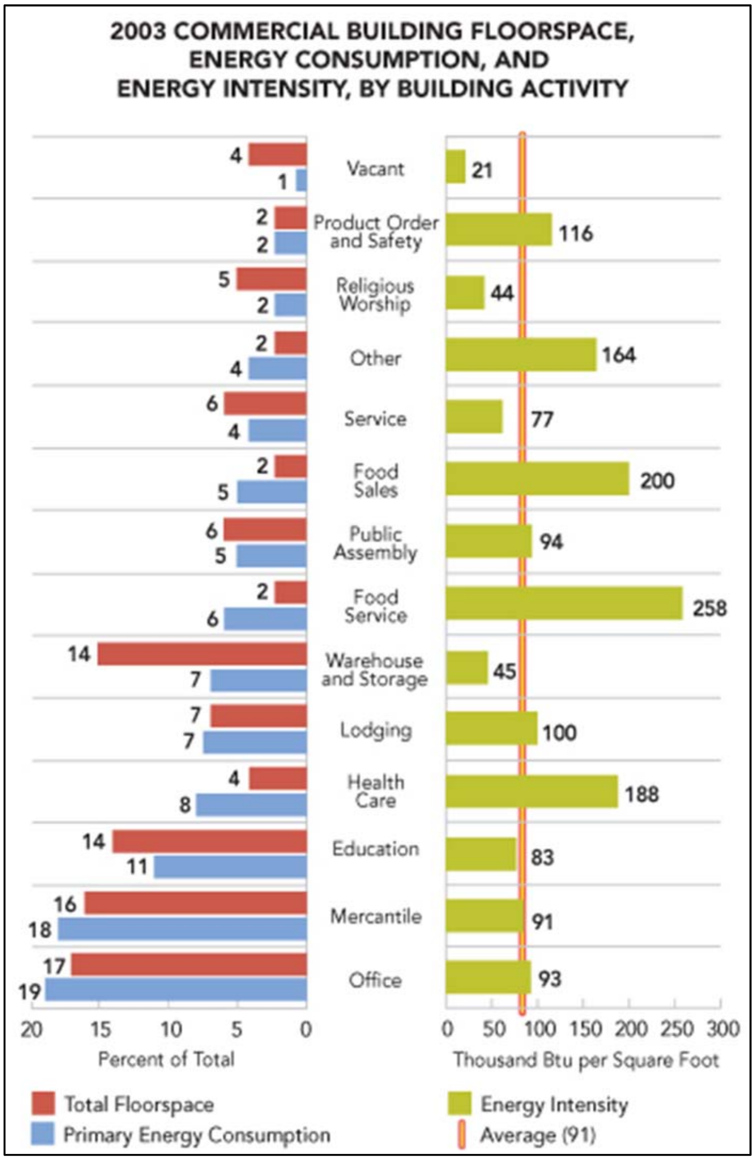
To reflect on this data from a different perspective and with more detail, the Buildings Energy Data Book has also compiled energy use intensities (EUIs) by building type and energy end uses; this information is presented in Table 5-5. This table upholds the findings in Figure 5-1, that space heating and lighting are the biggest energy consumers. It is also noticeable that health care and public-assembly/public-order type spaces are the most energy intensive sectors in the commercial buildings landscape.

Table 5-5
Commercial Building Energy Use Intensities (EUIs) By Building Type and Energy End Use

End Use	Education	Food Sales	Food Service	Health Care	Inpatient	Outpatient	Lodging
Space heating	39.4	28.9	43.1	70.4	91.8	38.1	22.2
Cooling	8.0	9.8	17.4	14.1	18.6	7.2	4.9
Ventilation	8.4	5.9	14.8	13.3	20.0	3.3	2.7
Water heating	5.8	2.9	40.4	30.2	48.4	2.5	31.4
Lighting	11.5	36.7	25.4	33.1	40.1	22.6	24.3
Cooking	0.8	8.6	63.5	3.5	5.6	N.A.	3.2
Refrigeration	1.6	94.8	42.1	2.6	2.0	3.5	2.3
Office equipment	0.4	1.6	1.0	1.2	1.1	1.3	N.A.
Computers	3.4	1.9	1.4	3.4	3.9	2.6	1.3
Other	4.0	9.1	9.5	16.1	18.1	13.2	7.0
Total	**83.1**	**199.7**	**258.3**	**187.7**	**249.2**	**94.6**	**100.0**
End Use	**Mercantile**	**Service**	**Retail (No Mall)**	**Enclosed and Strip Malls**	**Office**	**Public Assembly**	**Public Order and Safety**
Space heating	24.0	35.9	24.8	23.6	32.8	49.7	49.9
Cooling	9.9	3.8	5.9	12.4	8.9	9.6	8.9
Ventilation	6.0	6.0	3.7	7.5	5.2	15.9	9.5
Water heating	5.1	1.0	1.1	7.7	2.0	1.0	14.0
Lighting	27.5	15.6	25.7	28.6	23.1	7.0	16.5
Cooking	2.3	N.A.	0.6	3.4	0.3	0.8	1.3
Refrigeration	4.4	2.1	5.0	4.0	2.9	2.2	2.9
Office equipment	0.7	0.3	0.6	0.8	2.6	N.A.	0.6
Computers	1.1	1.0	1.0	1.1	6.1	N.A.	1.6
Other	10.3	11.4	5.6	13.2	9.0	6.5	10.6
Total	**91.3**	**77.0**	**73.9**	**102.2**	**92.9**	**93.9**	**115.8**
End Use	**Religious Worship**	**Warehouse and Storage**	**Other**	**Vacant**			
Space heating	26.2	19.3	79.4	14.4			
Cooling	2.9	1.3	10.5	0.6			
Ventilation	1.4	2.0	6.1	0.4			
Water heating	0.8	0.6	2.1	0.1			
Lighting	4.4	13.1	34.1	1.7			
Cooking	0.8	N.A.	N.A.	N.A.			
Refrigeration	1.7	3.5	6.0	N.A.			
Office equipment	0.1	0.2	N.A.	N.A.			
Computers	0.3	0.6	3.0	N.A.			
Other	4.9	4.8	18.9	3.1			
Total	**43.5**	**45.2**	**164.4**	**20.9**			

Figure 5-2 shows the primary energy consumption in conjunction with floor space and EUI. It illustrates that the markets with energy intensive requirements such as health care, food service, and sales make up 19% of the primary energy consumption even though they only comprise 8% of the commercial floor space. This is overshadowed by the consumption of retail and office space, which are 33% of floor space and 37% of overall energy use. The spaces with the lowest energy consumption rates are warehouses, places of religious worship, service buildings, and educational institutions. This makes sense in terms of usages as well; a church has much fewer occupied hours than a retail store.

Figure 5-2
2003 Commercial Building Floor Space Energy Consumption



5.3 Review of Existing Sources

A review of literature for the New England region was performed in reference to commercial baseline activities. The sources included in the final review assess baseline information in New Hampshire and a few other states, including Vermont and Maine. All sources were carefully scrutinized for relevance and credibility. The following studies were determined to have these qualifications and were included in this report.

- ERS – Harrington, B., McCowan, B., Clark, T., & Fratto, B. (2011). *Commercial Baseline Study Final Report.* Efficiency Maine Trust.
- GDS Associates, Inc. (2010). *2010 NH Energy Code Survey of Statewide Code Officials.*

- GDS Associates, Inc. (2011). *New Hampshire Baseline Residential and Commercial Construction Activity and Associated Market Actors Characterization*. NH Office of Energy and Planning.
- KEMA. (2009). *Business Sector Market Assessment and Baseline Study: Commercial New Construction Vol. 1*. Madison, Wisconsin: Vermont Department of Public Service.
- US DOE. (2012, March). *Chapter 3:Commercial Sector*. Retrieved from Buildings Energy Data Book: http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx
- GDS Associates, Inc (2009). *Additional Opportunities for Energy Efficiency in New Hampshire*

The following paragraphs present brief overviews of the literature sources cited above.

ERS – Harrington, B., McCowan, B., Clark, T., & Fratto, B. (2011). Commercial Baseline Study Final Report. Efficiency Maine Trust.

Energy and Resource Solutions (ERS) performed an assessment of commercial new construction activities to evaluate code compliance and overall energy efficiency in Maine. To accomplish this, ERS surveyed 57 sites from a population of 381 new projects between the years of 2006 and 2010. The sites were sorted by region and then randomly chosen from a wide range of facility types with review afterwards to insure a broad geographic distribution. The building types included grocery, office, retail, warehouse, hotel, financial, educational, and dormitory. Site surveys were conducted by qualified individuals who scored compliance with the IECC 2009 code in the following areas: building envelope, mechanical systems, lighting systems, lighting controls, and overall performance. Results were summarized by region and compared by type. This report also includes some information on residential baselines that was not included in this literature review.

GDS Associates, Inc. (2010). 2010 NH Energy Code Survey of Statewide Code Officials.

This report was a presentation on surveys conducted with New Hampshire energy code officials during the 2010 year. GDS tabulated general compliance practices for new construction and renovation projects based on information provided by 111 code officials with reference to the IECC 2009 code. This includes data on frequency of inspections, plan reviews, and general perception. This survey is an appendix of the larger 2012 Code Compliance Roadmap report.

GDS Associates, Inc. (2011) – New Hampshire Baseline Residential and Commercial Construction Activity and Associated Market Actors Characterization. NH Office of Energy and Planning.

GDS performed research with support from the Department of Energy in assessment of both residential and commercial construction baseline activity. A broad range of sources were considered in respect to the factors of total construction costs, value, number, distribution, and energy intensity of recent new construction endeavors. This is an appendix of the larger 2012 Code Compliance Roadmap report.

KEMA (2009) – Business Sector Market Assessment and Baseline Study: Commercial New Construction Vol. 1. Madison, Wisconsin: Vermont Department of Public Service.

This study is the second of three commissioned by the Vermont Department of Public Service to characterize baselines in the interest of revealing opportunities and guiding energy efficiency program improvements. For this effort, twenty-seven sites were surveyed with respect to lighting, building envelope, and mechanical equipment. Sites were chosen from retail, office, education, health, and lodging building types. Comparisons were not made to IECC code, but were instead reviewed for general population trends and practices.

US DOE (2012, March) – Chapter 3: Commercial Sector. Retrieved from Buildings Energy Data Book: http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx

The U.S. Department of Energy (specifically the office of Energy Efficiency & Renewable Energy) keeps statistics on residential and commercial building energy consumption. Of course, for this report only the commercial data is relevant, and the data book also has information related to building types and overall fuel usages.

5.3.1 Design Practice: Architects', Engineers' and Code Officials' Perspective

New construction projects begin long before the first piece of earth is moved at the site and often start years prior to breaking ground. The design process for large commercial and industrial facilities typically starts with the architectural and engineering communities. The standard design practices of these disciplines impact the resulting energy consumption levels in the completed facilities in a significant way. To better understand the nature of current practices in the community of design professionals, ERS conducted both primary and secondary research as mentioned above. The section presents pertinent information found from secondary research sources.

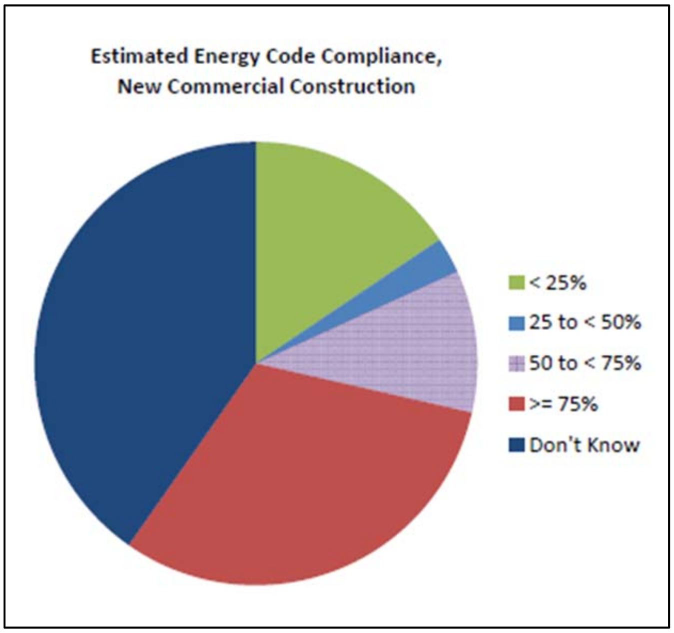
Code Officials Perspective on Compliance

Energy codes play a crucial role in raising energy efficiency in the nonresidential new construction (NRNC) market. They operate in two distinct ways to do so:

- Code Enforcement – Limits the number of buildings falling below the current energy code.
- Code Revision – Gradually increases the requirements that all buildings must meet.

Information on code compliance from the perspective of energy code officials in New Hampshire was furnished by aforementioned GDS survey, which supplied Figures 5-3, 5-4, and 5-5. Figure 5-3 describes the opinion of officials on percentage of code compliance in projects.

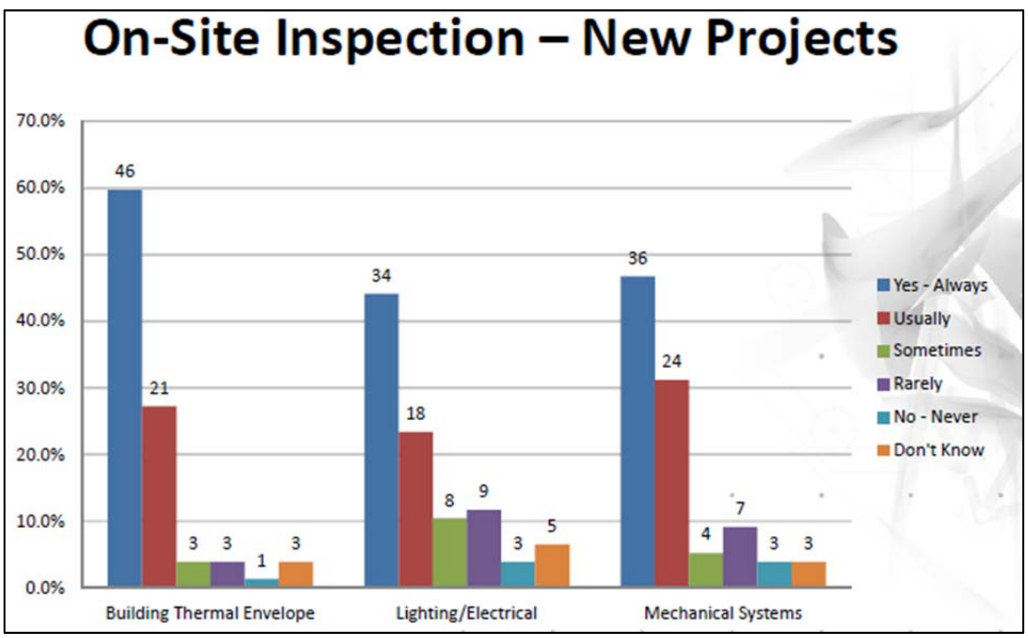
Figure 5-3
Code Officials' Perceptions of Energy Code Compliance for New Construction



This figure shows that the majority of code officials do not know if commercial new construction projects are in compliance with the 2009 IECC code. It seems that of the officials who do know, the majority believe that more than 75% of current new constructions projects are in compliance.

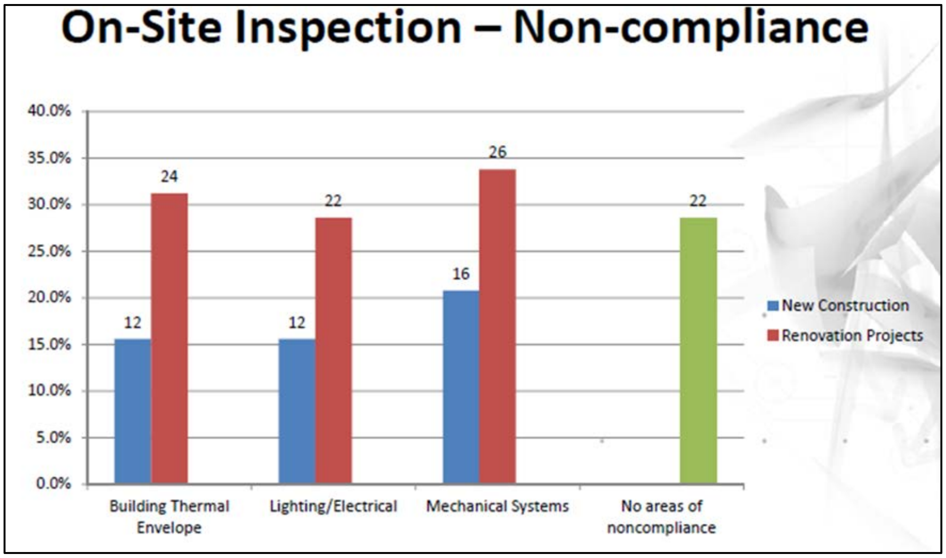
Those same code officials were asked how often they looked at building envelope, lighting/electrical, and mechanical systems specifications when on-site inspections. About 60% of the code officials are inspecting the relevant systems during inspections. This finding is reported in Figure 5-4.

Figure 5-4
Frequency of Areas Evaluated During Inspections



In follow-up to Figure 5-4, areas of typical non-compliance and the numbers of officials who found them so are shown in Figure 5-5.

Figure 5-5
Areas Typically Non-Compliant with Energy Code during On-Site Inspections



Some comments from code officials about NRNC code compliance showing the overall lack of communication and referenced from the GDS survey are as follows.

- "Under 10 new buildings built since 2007. These would be the only ones we would have compliance records of."
- "Some renovations simply are making improvements, but may not comply to the letter of the code. The efforts are limited by cost, especially on municipal buildings."
- "Very little quantifiable information on which to form an opinion."
- "Very few projects, none under new code, and old buildings are usually not in compliance."

Some of the findings about the impediments to widespread code compliance are listed below. It seems, in order for an energy code to be most effective it should be enforced in a simple, clear way and combined with education and outreach to follow up.

The following factors are common barriers to code compliance:

- Performance uncertainties
- Lack of education/foresight
- Organizational practices
- Misplaced or split incentives
- Hidden costs

Engineers also mentioned the following as primary barriers to energy efficiency:

- Access to financing
- Architectural and aesthetic features
- Contractors changing engineering specs
- Hassle and transaction costs
- Inseparability of product features
- Bounded rationality on the part of building owners

To overcome the barriers to energy efficiency, engineers suggest:

- Educating architects and building owners
- Lucrative incentive programs
- Increasing the cost of energy
- Providing state funding to increase construction budgets on public sector projects

5.3.2 Building Envelope Current Practice

In the nonresidential sector, the building envelope is determined as much by the nature of the building and its end use as it is by code, standards, and all other factors. Clearly, a building designed as an office space will have much more glass and carefully detailed exteriors than a building designed to be a warehouse or a manufacturing facility. The IECC code has performance requirements for four categories: air sealing, above-grade opaque insulation, below-grade insulation, and fenestration.

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. In instances where this is not an option, the building plans can be reviewed in addition to a building inspection and owner interview. This was the case for the Commercial Baseline Study performed by ERS in Maine.

Based on the ERS study of commercial new construction and the KEMA study of the same nature, the following conclusions can be drawn about current building envelope practices in Vermont and Maine.

Maine

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 5-6 shows that approximately 30% of the buildings surveyed complied with 75% or more of current envelope provisions.

Table 5-6
Building Envelope Compliance in Maine

	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

Insulation

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. The following areas of concern were identified:

- ❑ Continuous insulation not installed in addition to cavity insulation in metal or wood frame construction (critical for thermal break)
- ❑ No below-grade insulation installed
- ❑ Slab edge insulation not protected against UV and physical damage

Air Sealing

It not always possible to determine air sealing construction practices around doors and windows, but a large level of compliance was noted where possible around vents, pipes, and electrical entrances.

Fenestration

At the time of the study 2006 to 2009 it was not required to have permanent National Fenestration Rating Council codes imprinted on windows, so window performance measurement was not possible in much of the sample. Where possible model numbers were taken and performance was measured. Fifty percent of compared windows met code thermal performance.

Vermont

Like Maine, Vermont uses primarily propane and fuel oil for heating and is entirely in climate zone 6, making building envelope procedures an important part of overall building operating costs.

Insulation

Above-ground insulation values averaged at U=.045, which is significantly better than code, and less than 10% of surveyed buildings were found to have insulation values less than code. Insulation values were not attainable for about one-quarter of surveyed facilities.

Air Sealing

Considering the difficulty of measuring the extent of this parameter, this report did not try to investigate such measures.

Fenestration

78% of buildings surveyed were double-glazed windows, 37% were low emissivity, and 33% were clear.

5.3.3 Lighting Systems Current Practice

Overall lighting market figures were collected from the 2010 "U.S. Lighting Market Characterization" report by Navigant Consulting, Inc. Energy consumption for all lighting in the U.S. is estimated to be 7.5 quadrillion Btu, which is 0.7 quadrillion Btu less than it was estimated to be in 2002. The decrease is attributed to an overall shift to more efficient lighting as well as an overall decrease in the number of lamps used, especially in industrial sites, where there has been a decrease of 54% in lamp inventory over the last 10 years. Lighting is the area of fastest evolution in the energy code, and new technologies are introduced each year.

A key contribution to this would be in the area of linear fluorescent lighting. In 2001, T8 lamps made up 13% of the installed base commercial lighting energy consumption; in 2010 that number had grown to 35%. T12 fixtures have dropped from 40% to 31%, and T5s have increased from 0% to 5%. This represents a huge shift in the lighting baseline efficiencies because linear fluorescent lighting is almost 75% of the commercial lighting consumption, which is about 50% of the total lighting energy use in the U.S. This is 37.5% of the total lighting energy consumption in the U.S., which does not include small contributions from industrial and residential sectors. Although fluorescents have improved drastically from 10 years ago, LED lighting is establishing itself as the future of high efficiency lighting. Although it will be a while before LEDs compete cost-wise with current fluorescents, it is notable that recently, the first linear LED T8 replacement lamp was approved for the Design Lights Consortium Qualified Products list.

Breakdowns from the 2010 Buildings Energy Data Book on the total lighting electricity consumption by technology and lighting energy intensities by commercial building types are provided in Table 5-7 and Table 5-8.

Table 5-7
Total Lighting Technology Electricity Consumption

Building Type	Percent of Total Lighted Floor Space	Total Annual Lighting Energy (Billion KWh)		Lighting Energy Intensity (kWh/sq. ft)
Education	14%	33.1	8.4%	3.4
Food sales	2%	13.5	3.4%	10.8
Food service	2%	12.3	3.1%	7.4
Health care	5%	30.8	7.8%	9.7
Inpatient	3%	22.3	5.7%	11.8
Outpatient	2%	8.2	2.1%	6.6
Lodging	7%	36.3	9.3%	7.1
Mercantile	16%	90.3	23.0%	8.1
Retail (other than mall)	6%	32.5	8.3%	7.5
Enclosed and strip malls	10%	57.7	14.7%	8.4
Office	18%	82.4	21.0%	6.8
Public assembly	6%	7.9	2.0%	2.1
Public order and safety	2%	5.3	1.3%	4.8
Religious worship	5%	5.0	1.3%	1.3
Service	6%	18.5	4.7%	4.6
Warehouse and storage	13%	38.7	9.9%	3.8
Other	2%	17.3	4.4%	10.0
Vacant	1%	1.2	0.3%	0.5
Total		**392.4**	**100%**	

Table 5-8
Breakdown of Lighting Energy Electricity Consumption

	Residential		Commercial		Industrial		Other (2)		Total	
Fixture Type	**TWh/yr**	**%**	**TWh/yr**	**%**	**TWh/yr**	**%**	**TWh/yr**	**%**	**TWh/yr**	**%**
Incandescent	**136**	**78%**	**15**	**4%**	**0**	**0%**	**4**	**4%**	**156**	**22%**
General (A-type, decorative)	112	64%	9	3%	0	0%	-	-	122	17%
Reflector	19	11%	5	2%	0	0%	-	-	24	3%
Miscellaneous	5	3%	0	0%	0	0%	4	4%	9	1%
Halogen	**12**	**7%**	**15**	**4%**	**0**	**0%**	**1**	**1%**	**28**	**4%**
General	1	1%	0	0%	0	0%	-	-	1	0%
Reflector	8	5%	7	2%	0	0%	-	-	15	2%
Low-voltage display	1	0%	7	2%	-	-	-	-	8	1%
Miscellaneous	2	1%	1	0%	0	0%	1	1%	4	1%
Compact Fluorescent	**15**	**9%**	**16**	**5%**	**0**	**0%**	**1**	**1%**	**32**	**5%**
General (screw, pin)	13	7%	13	4%	0	0%	-	-	26	4%
Reflector	1	1%	3	1%	0	0%	-	-	4	1%
Miscellaneous	1	1%	-	-	0	0%	1	1%	2	0%
Linear Fluorescent	**10**	**6%**	**250**	**72%**	**23**	**40%**	**10**	**9%**	**294**	**42%**
T5	0	0%	16	5%	2	4%	-	-	19	3%
T8	1	1%	124	35%	12	21%	-	-	137	20%
T12	7	4%	109	31%	9	15%	-	-	124	18%
Miscellaneous	2	1%	2	0%	0	0%	10	9%	14	2%
High Intensity Discharge	**0**	**0%**	**49**	**14%**	**35**	**60%**	**98**	**83%**	**183**	**26%**
Mercury vapor	0	0%	1	0%	4	7%	4	3%	9	1%
Metal halide	0	0%	43	12%	25	42%	29	25%	97	14%
High pressure sodium	0	0%	5	1%	6	11%	65	55%	76	11%
Low pressure sodium	0	0%	0	0%	0	0%	1	1%	1	0%
Other	**1**	**1%**	**3**	**1%**	**0**	**0%**	**3**	**3%**	**8**	**1%**
LED	0	0%	3	1%	0	0%	2	1%	5	1%
Miscellaneous	1	1%	0	0%	-	-	1	1%	3	0%
Total	**175**	**100%**	**349**	**100%**	**58**	**100%**	**118**	**100%**	**700**	**100%**

The fact that T8 lamps have become the new standard in linear fluorescent lighting is further confirmed by the KEMA report of Vermont practice. To quote: "At this stage, T-12 fixtures have virtually disappeared from new construction. The field engineers identified T-12 fixtures in only 3 percent of the floor space of the new construction sample, versus 49 percent of the floor space in the existing facility sample."

Table 5-9 shows fixture types and average wattages for installed types in different sectors with their associated usage times, once again from the most recent Buildings Energy Data Book.

Table 5-9
2010 Lamp Wattage, Quantity, and Hours of Usage

Lamp Type	Lamp Wattage (Watts per lamp)				No. of Lamps per Building			Hours of Usage per Day			
	Resid.	Commer.	Indust.	Other	Resid.	Commer.	Indust.	Resid.	Commer.	Indust.	Other
Incandescent	56	53	46	68	32	14	1	2	10	13	9
General (A-type, decorative)	58	58	46	N/A	27	8	1	2	10	13	N/A
Reflector	69	79	65	N/A	4	4	0	2	10	12	N/A
Miscellaneous	45	7	0	68	1	3	N/A	2	11	0	9
Halogen	65	68	68	149	2	9	0	2	12	12	11
General	50	46	36	N/A	0	0	0	2	12	12	N/A
Reflector	68	78	64	N/A	1	4	0	2	12	12	N/A
Low-voltage display	44	60	0	N/A	0	5	N/A	2	13	0	N/A
Miscellaneous	82	99	145	149	0	0	0	2	10	12	11
Compact fluorescent	16	19	31	22	12	39	1	2	10	13	9
General (screw, pin)	17	19	36	N/A	10	32	1	2	10	13	N/A
Reflector	17	20	16	N/A	1	7	0	2	10	13	N/A
Miscellaneous	18	0	0	22	1	N/A	N/A	2	0	0	9
Linear fluorescent	24	37	39	63	5	301	283	2	11	13	14
T5	19	36	58	N/A	0	20	20	2	12	13	N/A
T8	26	31	32	N/A	1	181	182	2	11	13	N/A
T12	28	50	53	N/A	3	98	79	2	11	12	N/A
Miscellaneous	16	31	42	63	1	2	1	2	11	12	14
High intensity discharge	126	350	403	240	0	6	31	2	11	17	12
Mercury vapor	193	362	451	219	0	0	3	2	11	17	11
Metal halide	79	349	434	247	0	6	21	2	11	17	12
High pressure sodium	150	356	295	241	0	1	7	2	11	18	13
Low pressure sodium	0	185	0	107	N/A	0	N/A	0	11	0	11
Other	47	12	11	30	0	7	1	2	21	22	10
LED	11	12	11	20	0	7	1	2	21	22	9
Miscellaneous	54	11	0	93	0	0	N/A	1	15	0	13
Total	**46**	**42**	**75**	**151**	**51**	**376**	**317**	**2**	**11**	**13**	**12**

Notes: 1) Accounts for the remainder of lamps not installed inside buildings, including parking lot, stadium, stationary aviation, billboard, and traffic and street lighting.
2) Values for general incandescent, general compact fluorescent, T5 fluorescent, T8 fluorescent, and T12 fluorescent lamps are weighted-averages calculated using the estimated inventory of different lamps that fit within that category.
3) A value of zero indicates less than 0.5.
Source(s): DOE/EERE, 2010 U.S. Lighting Market Characterization, Jan. 2012, Tables 4-1, 4-3, 4-5, 4-7, p. 22, 26, 29, 32.

Maine

The ERS Maine Commercial Baseline study broke lighting compliance into two parts, lighting and lighting controls.

Lighting

The Maine Commercial Baseline did not look at specifically chosen lamps and ballasts. This study calculated sample lighting power densities for each site to compare with the energy code. In general, high levels of compliance were noted, as shown in Table 5-10, with 67% of surveyed buildings featuring lighting power densities (LPDs) at or below code.

Table 5-10
Lighting Compliance – Maine

	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

The rates of compliance are attributed to energy code LPAs, which are essentially lighting design recommendations for specific room types that pass code by utilizing efficient fixtures. As long as a designer chooses the right product, the room should pass energy code. In addition, the aggressive evolution of the Efficiency Maine program has helped push standard practice to higher efficiency. Efficiency Maine was one of the first such programs to stop incentives for standard T8 lamps and ballasts.

<u>**Lighting Controls**</u>

The IECC 2009 code also has provisions for lighting controls, as listed here:

- 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 larger than 5,000 square feet in area must have an automatic control to turn off all nonemergency lighting after normal business hours.
- A new provision of the code calls for separate control of day-lit zones.

It is of note that this is the first year that day-lighting control measures have been included in the code. The Maine survey implemented by ERS found that while 96% of buildings had the basic measure of a manual switch in each enclosed area, far less compliance was met in all of the other provisions. This is thought to be a consequence of the fact that lighting controls are often the first to go during budget cuts and, indirectly, a lack of commissioning can lead to poor performance.

Vermont

As shown in Table 5-11, in Vermont, linear fluorescents are by far the majority in commercial lighting and as mentioned in new construction projects, T8 fixtures have become the standard. Continuing this move towards more efficient linear lighting, high performance T8 fixtures are being widely used for retrofits and new construction projects. A quote from the Business Sector Market Assessment and Baseline Study: Existing Commercial Buildings, Vol. 1, pages 8-12, "In general contractors agreed that higher efficiency lighting is becoming the standard in new construction." Vermont's study found 20% of floor space in new construction had high performance T8s compared to 6% for existing facilities.

The KEMA report for Vermont tabulated the following results from their survey for the type of lighting installed by percent of floor space. Table 5-11 columns total greater than 100% because some spaces utilize several types of lighting for the same floor area.

Table 5-11
Percent of Floor Space Served by Lighting Equipment
Weighted by Square Foot – Vermont

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

Another noticeable trend in Table 5-11 is the move from high intensity discharge fixtures to high output fluorescents. This switch results in large energy savings, with the T5HO fixtures providing better quality light without the drawback of slow warm-up times.

The KEMA report also performed LPD calculations and found that the mean for their sample population was 0.88 W/ft^2 for new construction and 0.85 W/ft^2 for existing premises. IECC 2009 code allowable LPDs for most facilities are 1 or greater; some examples include hotels=1, museums=1.1, post offices=1.1, family dining areas=1.6, and offices=0.8.

5.3.4 Mechanical Systems Current Practice

Table 5-12 presents information on the application of heating and cooling equipment in commercial buildings by percent floor space; this information is available in the 2010 Buildings Energy Data Book. For the most part, the cooling equipment use by technology has remained consistent over the reporting period of 1995 through 2003. On the other hand, for heating systems, the use of individual space heaters and district heating has declined over time, while the use of furnaces has increased.

Table 5-12
Commercial Use of Heating and Cooling Equipment by Floor Space

Heating Equipment	1995	1999	2003 (2)
Packaged heating units	29%	38%	28%
Boilers	29%	29%	32%
Individual space heaters	29%	26%	19%
Furnaces	25%	21%	30%
Heat pumps	10%	13%	14%
District heat	10%	8%	8%
Other	11%	6%	5%
Cooling Equipment	**1995**	**1999**	**2003 (2)**
Packaged air conditioning units	45%	54%	46%
Individual air conditioners	21%	21%	19%
Central chillers	19%	19%	18%
Residential central air conditioners	16%	12%	17%
Heat pumps	12%	14%	14%
District chilled water	4%	4%	4%
Swamp coolers	4%	3%	2%
Other	2%	2%	2%

Notes: 1) Heating and cooling equipment percentages of floorspace total more than 100% since equipment shares floorspace.

2) Malls are no longer included in most CBECs tables; therefore, some data is not directly comparable to past CBECs.

Sources: 'EIA, Commercial Building Characteristics 1995, Oct. 1998, Tables B34 and B36 for 1995, and EIA, Commercial Building Characteristics 1999, Aug. 2002,
Tables B33 and B34 for 1999; and EIA, 2003 Commercial Buildings Energy Consumption and Expenditures: Consumption and Expenditures Tables, June 2006, Tables B39 and B41 for 2003.

Ideally, information on the commercial energy use by type of equipment would be provided, but this data has not been updated in the Energy Data Book since 1995 and is therefore deemed irrelevant. To supplement floor space numbers, stock efficiencies, average efficiencies, and best available efficiencies are presented in Table 5-13.

Table 5-13
Commercial Equipment Efficiencies

Equipment Type	Efficiency Parameter	2007 Stock Efficiency	2010 U.S. Average New Efficiency	2010 Best-Available New Efficiency
Chiller				
Screw	COP (full-load / IPLV)	2.80 / 3.05	2.80 / 3.05	3.02 / 4.45
Scroll	COP	2.80 / 3.06	2.96 / 4.40	N.A.
Reciprocating	COP (full-load / IPLV)	2.80 / 3.05	2.80 / 3.05	3.52 / 4.40
Centrifugal	COP (full-load / IPLV)	5.0 / 5.2	6.1 / 6.4	7.3 / 9.0
Gas-fired absorption	COP	1.0	1.1	N.A.
Gas-fired engine driven	COP	1.5	1.8	N.A.
Rooftop A/C	EER	10.1	11.2	13.9
Rooftop heat pump	EER (cooling)	9.8	11.0	12.0
	COP (heating)	3.2	3.3	3.4
Boilers				
Gas-fired	Combustion efficiency	77	80	98
Oil-fired	Thermal efficiency	80	84	98
Electric	Thermal efficiency	98	98	98
Furnace	AFUE	77	80	82
Water Heater				
Gas-fired	Thermal efficiency	78	80	96
Oil-fired	Thermal efficiency	79	80	85
Electric resistance	Thermal efficiency	98	98	98
Gas-fired instantaneous	Thermal efficiency			77

Due to the nature of mechanical equipment requiring accessibility, the types and efficiencies used are fairly transparent. This allows compliance measurement with almost no uncertainty. The IECC 2009 code judges HVAC equipment on the following qualities:

- ❑ 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

Maine

ERS inspection protocol for Efficiency Maine entailed reviewing the building plans and then on site verification of proposed equipment. Efficiency numbers were verified as well as control measures but unfortunately system sizing was beyond the scope of that project. Computer programs are often used for sizing larger systems but on smaller buildings as is often the case in rural Maine, a rule of thumb is often used. The rule of thumb method would of course include an element of oversizing to account for unforeseen spikes in demand. This practice is also common outside of Maine. ERS found very high levels of efficiency compliance in HVAC equipment. To quote the Maine Commercial Baseline Study Report "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". Compliance rates for Maine are shown in Table 5-14.

Table 5-14
Compliance Rates for HVAC Equipment – Maine

	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

The high levels of compliance are believed to be for the following reasons:

- Successful implementation of the Efficiency Maine business program.
- Suppliers in New England have been dealing with enforced energy codes on mechanical equipment for more than a decade.
- One of the most transparent consumers of energy and therefore targets for designers to improve building efficiency.
- Manufacturers have lobbied to keep codes within reach of standard equipment lines.

Although unit efficiency compliance rates were very high, HVAC controls and energy recovery measures did offer the same high rate of compliance. These rates ranged from 18% to 80% and are shown in Table 5-15.

Table 5-15
HVAC Controls and Energy Recovery Compliance – Maine

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%

Vermont

Vermont compliance with respect to mechanical systems has been reviewed on cooling and heating equipment.

Cooling

Table 5-16 displays the distribution of cooling equipment by type in new construction projects and existing premises. Chiller systems and split systems seem to be dominant in the Vermont new construction projects.

Table 5-16
Percent of Overall Tons of Cooling by Equipment Type – Vermont

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

Similarly to the Maine Commercial Baseline Report, the Vermont New Construction Report also found that cooling systems were often sized according to rule of thumb. Therefore, this leads the authors to suggest that there is opportunity for further improvements in energy efficiency program delivery by using appropriate procedures to correctly size HVAC equipment.

Space Heating

Table 5-17 shows the distribution of space heating equipment by weighted square foot served. It was found that roughly 33% of building spaces were served by more than one type of equipment, which is much less than the 60% for existing facilities. Hot water boilers are by far the most commonly used method of space heating, followed by furnaces, which have decreased in installation significantly from existing facilities.

Table 5-17
Weighted Square Footage of Heating Equipment Installations

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

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

Table 5-18 presents the fuel sources used weighted by square footage. There is an increase in the use of electricity for space heating in new construction project when compared to the existing buildings, which can probably be attributed to the increased occurrence of heat pumps. There is also a notable decrease in the use of natural gas and an increase in usage of liquefied petroleum gas.

Table 5-18
Weighted Square Footage of Heating Fuel Used

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

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

Table 5-19 shows the saturation of heating controls used. There has been a great increase in the use of energy management systems (EMS), to the point where they are now the most common in new construction. Use of manual thermostats has decreased from 38% to 19%.

Table 5-19
Thermostat Controls by Weighted Use

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

5.4 Summary

Standard practice in New Hampshire, Maine, and Vermont was reported through available literature in this review with supplements from the *2010 Buildings Energy Data Book* and *2010 U.S. Lighting Market Characterization*, where applicable. Information from the two workshops and interviews with architects and engineers was used with additional information from the presentation by GDS, "2010 NH Energy Code Survey of Statewide Code Officials."

Commercial and industrial buildings were characterized with information from the *2010 Buildings Energy Data Book*. This information was given in terms of percent energy consumption by use and then in a breakdown of energy-use intensities by building type and end use.

Findings from interviews were presented and supplemented by the referenced surveys with code officials.

Standard practices were reviewed for building envelope, lighting systems, and mechanical equipment. Varying levels of compliance were found with envelope procedures, and in many instances, the only way to fully verify amenability is by inspection during construction. Because this was not the case for the vast majority of the cases, certain measures such as air sealing were not judged. In our literature review, higher levels of compliance with insulation code were found in Vermont than in Maine.

Lighting technology is evolving at a dramatic pace, and this is evident by an overall decrease in lighting energy consumption. It appears T12s have very much been replaced by standard T8s as the baseline in new construction. The percentage of overall energy consumed by incandescents and halogens has dropped from 38% to 26% over the last 10 years, and HID fixtures consumption has increased by 10%.

Mechanical equipment is hard to evaluate as standard practice because of the individual nature of most projects, but distribution patterns are given.

The following is a short summary of findings in the areas of inspection. Note that similar data was not available for New Hampshire, so this information is presented here for informational purposes.

Building Envelope

Maine – 30% of the buildings were found to meet compliance in at least 75% of inspected areas.

Vermont – High levels of compliance were found with greater than 90% of buildings meeting insulation requirements.

Lighting

Maine – 79% of buildings were in compliance with code LPD values.

Vermont – The mean LPD found from the survey is 0.88 W/ft^2 and the weighted average of maximum allowable LPDs in the Vermont guidelines is 1.21.

Mechanical Systems

Maine – 80% of air conditioning and heat pump units and 93% of service water heaters met the current efficiency levels. There is opportunity for improvement of controls in the majority of the inspected systems.

Vermont – There is opportunity for improvement of controls in the many of the inspected systems. High levels of compliance were found with insulation levels, but equipment efficiencies were not measured.

Baseline Comparison with Other States

6

6.1 Introduction

The market for most of the mechanical and electrical equipment installed in new buildings is certainly regional, if not broader to all of New England and the Northeast. Each of the states bordering New Hampshire offers rebate programs for high efficiency equipment, and has similar energy codes referring to IECC-2009, for new construction. In order to maximize the market penetration of high efficiency equipment and the success of energy conservation efforts, it is useful to consider how New Hampshire's programs relate to those of its neighbors.

Across this region, the difference in baseline efficiencies is variable by technology. For some such as air conditioning there is more commonality, while for lighting, there is less. In part, these differences are a function of time as programs are updated state by state. This section provides a practical comparison of baseline efficiencies for technologies in various new construction programs.

6.2 Comparison with Other States' Programs

The following sections present a comparison of baselines for new construction prescriptive programs among the states of New Hampshire, Massachusetts, Maine, and Vermont.

6.2.1 Lighting and Lighting Controls

All four of these states have adopted energy codes that use lighting power density to determine compliance. Baselines defined accordingly, i.e., watts per square foot, will not meaningfully correspond to program baselines defined by fixture type or technology. Such is the case with the current prescriptive new construction baselines for lighting in New Hampshire. However, in two states there are some exceptions to baselines relying on the energy codes. Maine has recently removed the state requirement that the energy code be enforced in communities with a population under 4,000. In Vermont, new buildings (and major renovations) smaller than 10,000 square feet are eligible to participate in the prescriptive equipment replacement program.

- Because the other three states' programs operate in the power density mode, listing the many fixture types identified by the New Hampshire new construction program are eliminated in Massachusetts, Maine, and Vermont. Nonetheless, Table 6-1 does provide some view of the current differences between these states. We recommend that New Hampshire adopt power density lighting baselines to be consistent with surrounding states and its own energy code. See Section 6.2.2 for a discussion of this recommendation, relevant market forces, and current new construction practices.

Table 6-1
Lighting Baseline Comparisons

<table>
<tr><th rowspan="2">Lighting Measure Description</th><th colspan="4">Baseline Fixture or Control</th></tr>
<tr><th>New Hampshire</th><th>Massachusetts</th><th>Maine</th><th>Vermont</th></tr>
<tr><td>High performance or Reduced wattage (HP/RW) lamp & ballast systems or a T5 lamp and ballast system.</td><td>T12 lamps and magnetic ballasts</td><td rowspan="6">Comparable code- compliant fixture and associated wattage</td><td>T8 lamps with electronic ballast(s)</td><td>T8 lamps with electronic ballast(s)</td></tr>
<tr><td>High efficiency two-lamp prismatic lensed fluorescent fixtures, 2×2 or 2×4</td><td>Prismatic lensed fixtures, avg. 75% efficient.</td><td>No data</td><td></td></tr>
<tr><td>High efficiency two-lamp parabolic fluorescent fixtures, 2×2 or 2×4</td><td>Parabolic fixtures avg. 68% efficiency</td><td>No data</td><td></td></tr>
<tr><td>Advanced recessed fluorescent fixtures 1×4 or 2×4</td><td>"Paracube" lens fixtures avg. 50% efficiency</td><td>No data</td><td></td></tr>
<tr><td>Compact fluorescent fixture</td><td>Fixtures with incandescent bulbs (avg. 60 watts)</td><td rowspan="2">Incandescent lamp with similar lumen output</td><td rowspan="2">Incandescent /halogen, date-dependent baseline adjustment factor to reflect EISA-2007 phase-out for incandescent lamps.</td></tr>
<tr><td>Dimmable compact fluorescent fixture</td><td>Fixtures with incandescent bulbs (average 100 watts)</td></tr>
<tr><td>LED cooler, freezer case or refrigerated shelving fixtures – 3´ & 4´ fixtures</td><td>No data</td><td rowspan="2">Existing freezer or cooler case lighting</td><td rowspan="2">T8 or T5 linear fixture</td><td></td></tr>
<tr><td>LED cooler, freezer case, or refrigerated shelving fixtures – 5´ & 6´ fixtures</td><td>No data</td><td></td></tr>
<tr><td>LED low bay fixtures/ Garage fixtures</td><td>No data</td><td rowspan="2">Comparable code-compliant fixture and associated wattage</td><td>No data</td><td></td></tr>
<tr><td>LED track heads</td><td>No data</td><td>No data</td><td></td></tr>
</table>

Table 6-2 presents the comparative details of the lighting controls baselines used in the neighboring northeastern states.

Table 6-2
Lighting Controls Baseline Comparisons

Lighting Measure Description	Baseline Control			
	New Hampshire	Massachusetts	Maine	Vermont
Remote-mounted occupancy sensor	No occupancy sensor control	Code-compliant controls (IECC-2009 or ASHREA 90.1-2007) for new construction	No occupancy sensor control	No data
Daylight dimming system (DDS-FL)	No daylight dimming controls		No daylight sensor control	No data
Occupancy controlled step-dimming system	No occupancy sensor control		No occupancy sensor control	No data
Wall-mounted vacancy occupancy sensors	No occupancy sensor control		No occupancy sensor control	No data

6.2.2 Unitary HVAC Equipment

Variations between the northern New England states exist. Where New Hampshire and Maine offer prescriptive rebates for air-cooled unitary and split systems that cover units up to and greater than 760,000 Btu/h, Massachusetts and Vermont stop at 375,000 Btu/h for these as well as for air source heat pumps. New Hampshire and Massachusetts provide incentives specifically for ground source heat pumps, while Maine and Vermont do not. New Hampshire and Massachusetts are unique in designating incentives for small (less than 16,800 Btu/h), water source heat pump.

As to the minimum efficiency values, New Hampshire, Maine, and Massachusetts codes refer to the IECC 2009. In some instances, Vermont relies upon the Consortium for Energy Efficiency's (CEE) annually updated levels. The New Hampshire baseline efficiencies are specified in the units of EER, while those in the other state programs and in the code are in SEER. The listed EER values convert to higher SEER values, which would closely match those stipulated in Massachusetts and Vermont. We do not have a specific recommendation to modify the efficiency standards or values at this time. However, it would be ideal to use standardized efficiency units that are consistent with the code and consistent with units being used by the other northeastern states.

Table 6-3 presents baseline levels for unitary systems in the four New England states.

Table 6-3
Baseline Efficiency Levels for Prescriptive Rebates in Four New England States

Btu/h	New Hampshire Baseline Efficiency	Massachusetts Baseline Efficiency	Maine Baseline Efficiency	Vermont Baseline Efficiency
Air-Cooled Unitary and Split Systems (New condenser and new coil)				
≤ 65,000 split system	11.1 EER	13.0 SEER	10.0 SEER	13.0 SEER
≤ 65,000 packaged system	11.1 EER	13.0 SEER	9.7 SEER	13.0 SEER
65,001 to 135,000	11.2 EER	11.2 EER	10.3 EER	10.3 EER
135,001 to 240,000	10.6 EER	11.0 EER	9.7 EER	9.7 EER
240,001 to 760,000	9.5 EER	10.0 EER	9.5 EER	9.5 EER
Air-to-Air Heat Pumps				
≤ 65,000 split system	11.1 EER	13.0 SEER & 7.7 HSPF	10.0 SEER	13.0 SEER
≤ 65,000 packaged system	11.1 EER	13.0 SEER & 7.7 HSPF	9.7 SEER	13.0 SEER
65,001 to 135,000	11.0 EER	11.0 EER & 3.3 COP	10.1 EER	10.1 EER
135,001 to 240,000	10.6 EER	10.6 EER & 3.2 COP	9.3 EER	9.3 EER
>240,000	9.5 EER	9.5 EER & 3.2 COP	9.0 EER	9.0 EER
Water Source Heat Pumps				
<17,000	11.2 EER & 4.2 COP	11.2 EER & 4.2 COP		
17,000 to 135,000	12.0 EER & 4.2 COP	12.0 EER & 4.2 COP	12.0 EER	12.0 EER
Ground Water – Water Source Heat Pumps (Open loop)				
<135,000	16.2 EER & 3.6 COP	16.2 EER & 3.6 COP	---	16.2 EER
Ground Water – Water Source Heat Pumps (Closed loop)				
<135,000	13.4 EER & 3.1 COP	13.4 EER & 3.1 COP	---	16.2 EER
Dual Enthalpy Economizers				
	Deemed savings, no baseline specified	Dry-bulb economizer	Dry-bulb economizer for units ≥ 5.4 tons	Dry-bulb economizer for units ≥ 5.4 tons

6.2.3 Chillers

New Hampshire building code cites the International Energy Conservation Code (IECC) 2009 as the basis for establishing minimum efficiencies for mechanical equipment in new construction. This is also the case for Maine and Massachusetts. Vermont currently utilizes its own Commercial Building Energy Standards – 2005, which is now under revision to reflect the IECC 2009 minimum efficiency levels. As presented in the Table 6-4, the full load chiller efficiency values in New Hampshire are slightly greater than the Massachusetts specified values and lower than the values used in Vermont. We recommend reconciling the New Hampshire energy efficiency programs chiller efficiency values to be consistent with the newly adopted IECC 2009.

Table 6-4
Minimum Baseline Chiller Efficiencies (kW/ton)

Tons	New Hampshire		Massachusetts		Maine		Vermont	
	Full Load	IPLV	Full Load	IPLV	Full Load	IPLV	Full Load	IPLV
Water-Cooled Reciprocating and Rotary Chillers								
<75	0.800		0.780	0.630			0.837	0.756
>75 and <150	0.890		0.775	0.615			0.837	0.756
>150 and <300	0.718		0.680	0.580			0.837	0.756
>300	0.639		0.620	0.540			0.837	0.756
Water-Cooled Centrifugal Chillers								
<150	0.639		0.634	0.596			0.703	0.703
≥150 and <300	0.639		0.634	0.596			0.634	0.634
≥300 and <600	0.600		0.576	0.549			0.576	0.576
≥600	0.590		0.570	0.539			0.576	0.576

6.2.4 Variable Frequency Drives

While the baseline of a full-speed motor with valves or dampers to control output is common, each of these four states deals with this technology differently. To determine savings, New Hampshire uses a list of specific applications (referred to as equipment types in the Table 6-5), that includes typical operating hours to arrive at kW and kWh per horsepower savings factors. In Massachusetts, in addition to the factors used in the New Hampshire programs, building type is incorporated to adjust the savings. The program in Maine limits prescriptive rebates to HVAC supply, return, and exhaust fans, and chilled or hot water circulation pumps of certain size. There is no prescriptive program for variable frequency drives (VFDs) in Vermont. We have no recommendations for changes to New Hampshire's program for VFDs at this time when compared with the practices in the neighboring states. It should however be noted that we have recommended a change to not provide incentives for new construction VFDs on supply/return fan motors greater than 10 hp based on the current IECC 2009 requirements. A summary of VFD programs is presented in Table 6-5.

Table 6-5
Prescriptive Programs for VFDs

Variable Frequency Drives – Basis for Savings			
New Hampshire	**Massachusetts**	**Maine**	**Vermont**
Savings calculated using "savings factors" specific to fan or pump type.	Savings determined by tabulated data specific to building and equipment types.	Savings determined by tabulated data specific to equipment type. Limited from 5 to 30 hp motors.	Savings based on site-specific data; all applications are custom.

6.2.5 Natural Gas Measures

The following section describes the results of comparing the natural gas measures offered by New Hampshire with those offered by other utility companies in the Northeast region.

Heating & DHW

Several natural gas-fired space heating and domestic hot water (DHW) devices are part of the prescriptive programs in New Hampshire, Maine, and Massachusetts, whereas in Vermont units larger than 300 MBH are handled on a custom basis. New Hampshire gas utilities rely on the Massachusetts baseline values and are therefore identical for measures offered in both states.

Table 6-6
Space and Water Heating Baseline Efficiencies

Size	New Hampshire	Massachusetts	Maine	Vermont
Gas-Fired Furnaces				
≤300 MBH	78% AFUE or 80% thermal efficiency	78% AFUE or 80% thermal efficiency	AFUE = 78%	
Gas-Fired Water Heating Equipment				
On-demand tankless water heater	Energy factor ≥ .59	Energy factor ≥ 0.59		Energy factor ≥ 0.82
Condensing stand-alone 75–300 MBH	Thermal efficiency= 80%	Thermal efficiency= 80%		
Integrated with condensing boiler	Thermal efficiency= 80%	Thermal efficiency= 80%		
Other				
Infrared heaters	Combustion eff. (CE) = 80%	CE = 80%	CE = 80%	
Low-flow shower heads	2.5 gpm	2.5 gpm		2.65 gpm
Faucet aerators	2.2 gpm	2.2 gpm		2.35 gpm
Steam traps	Failed state	Failed state		

Commercial Kitchen Equipment

Prescriptive rebates are offered in all four states for many commercial kitchen devices with an ENERGY STAR rating. Savings for those units are deemed, and baseline data is not included here for them. Unlike most of the equipment discussed above, the performance ratings for commercial kitchen equipment including fryers, ovens, griddles, steamers, and pre-rinse spray nozzles are not sufficiently useful in determining energy use. Real world comparisons rely on test data. The Food Service Technology Center has done extensive testing in this area, and it produced nearly all of the widely accepted energy consumption data for the various models and vintages of this equipment. Their results have been incorporated into ENERGY STAR ratings, which are the basis for deemed savings used throughout New England. However, that data is not uniformly used in all states. For comparison purposes, the New Hampshire programs are consistent with the regional states with regards to the commercial kitchen equipment measures. The incentive for pre-rinse nozzles that use no more than 1.6 gpm of hot water has been made redundant by the Energy Policy Act of 2005, which establishes 1.6 gpm as an upper limit for new nozzles. We recommend that pre-rinse nozzles be eliminated as a measure.

Table 6-7
Commercial Kitchen Gas Saving Baselines

Commercial Kitchen Equipment				
Models Used to Determine Baseline Gas Usage				
Equipment	**New Hampshire**	**Massachusetts**	**Maine**	**Vermont**
Fryers	Deemed savings based on ENERGY STAR data, including average operating hours and throughput.			Savings basis dependent on: 1) ENERGY STAR data 2) Site-specific operating hours 3) Site-specific throughput
Steamers				
Convection ovens				
Combination ovens				
Conveyer ovens				
Rack ovens				
Griddles				
Pre-rinse nozzles	3.34 gpm	3.34 gpm		EPACT 2005 limits flow to 1.6 gpm

Intentionally Left Blank

Conclusions and Recommendations

7

7.1 Introduction

This section presents the final compilation of recommendations for the nhsaves@work/New Equipment & Construction Prescriptive and Custom measures based on our review of the baseline algorithms, and blending our observations and comments presented in Sections 2, 3, 4, and 5. The previous sections of this report have concentrated on: presenting discrete pieces of information on the investigation of the validity of existing algorithms used by the program; comparing the existing baseline with the New Hampshire state energy code (IECC 2009) and ASHRAE 90.1-2007; and comparing the current commercial and industrial new construction practices with the baseline document.

Section 2 presented the review of the current program's baseline parameters and algorithms for each approved Prescriptive measure. The approach currently established for each of the Prescriptive measures was discussed and ERS's comments regarding the algorithms are also presented. Additionally, an assessment of the Custom projects conducted under the New Construction program to date by each of the participating utilities is also presented.

Section 3 presented a comprehensive review of the recent New Hampshire Commercial Energy Code and its relationship to the nhsaves@work/New Equipment & Construction program baseline parameters. The current energy code (IECC 2009) was reviewed from the perspective of the New Construction program with the intention of determining how the new code relates to the existing Prescriptive and Custom measures.

Section 4 presented discussions and related information of primary research that was related to the current practices in New Hampshire. The primary research was performed by conducting two workshops with market actors involved in New Hampshire's new construction industry. Finally, this section presents case studies of relevant ERS Custom projects associated with new construction in New Hampshire.

Section 5 presented discussions and information of pertinent secondary research that was related to the current practices in New Hampshire and across the nation. Secondary research involved reviewing existing literature sources for commercial and industrial new construction current practices. Literature sources that were reviewed were checked for their validity with respect to the new construction practices for commercial and industrial buildings in New Hampshire, and other states in the U.S.

Section 6 presented information related to the comparison of the baseline parameters with the baseline parameters used in regional energy efficiency programs.

In the effort to provide information to create an effective New Hampshire baseline document, a comparative analysis of the information presented in Sections 2, 3, 4, 5, and 6 was performed. The resulting recommendations are presented in tabular form (where applicable) and through discussion of alternative solutions.

7.2 Conclusions and Recommendations for the Prescriptive Programs

This section presents recommendations for the Prescriptive programs based on the comparative analysis of the information presented in sections 2, 3, 4, 5, and 6. The nhsaves@work New Equipment & Construction program offers rebates if the proposed equipment for the technologies presented below is proven to meet the program-specific eligibility criteria under the Prescriptive measures.

- Lighting – The measures include fluorescent fixtures, compact fluorescent fixtures, , HID fixtures, high intensity fluorescent fixtures, lighting controls for fluorescent and HID systems, and LED lighting fixtures.
- HVAC equipment – The measures include unitary AC and split systems with capacities up to 63 tons, air-to-air heat pump systems with capacities up to 20 tons, and water-source heat pumps with capacities up to 11 tons.
- Chillers – The measures include air-cooled chillers with capacities up to 150 tons, and water-cooled chillers with capacities up to 600 tons.
- Variable frequency drives (VFDs) – The measures include VFDs for fans and pumps installed in HVAC systems, air distribution equipment, and boiler feed water pumps. The motor capacities covered by the VFD program are between 5 and 20 hp.
- Electronically commutated motors (ECMs) – Measures include EC motors less than 1 hp.
- Compressed air – The measures include load/no load, variable speed, and variable displacement air compressors with motors rated between 15 hp to 75 hp , receiver tanks, and efficient dryers.
- Heating equipment – The measures are incentivized for their natural gas impacts and include furnaces, infrared heaters, hydronic boilers, condensing boilers, and ENERGY STAR-rated condensing unit heaters.
- Water heating equipment – These measures are incentivized for their natural gas impacts, and they include on-demand tankless water heaters, high-efficiency indirect water heaters, condensing stand-alone water heaters, and ENERGY STAR-rated storage water heaters.
- Integrated water heater/condensing boiler – This measure is incentivized for its natural gas impact and is for a single boiler that provides both space heating and hot water.
- Controls equipment - These measures are incentivized for their natural gas impacts and include after-market boiler reset controls, steam trap repair/replacement, and ENERGY STAR-rated/7-day programmable thermostats.
- Commercial kitchen equipment – These measures are incentivized for their natural gas impacts, and they include high-efficiency combination, rack, conveyor, and convection ovens.

Also included in the commercial kitchen incentive measures are high-efficiency fryers, steamers, griddles, and pre-rinse spray valves.

The eligibility criteria are primarily based on the energy efficiency of the proposed equipment; however, there are other aspects that are also considered, such as the applicable baseline, incremental measure cost, and operating hours. All of these aspects have been investigated during the review process for applicable changes. Results of the analyses for the related technology types mentioned are presented below.

7.2.1 General Comments

This section presents several general comments that have been developed based on our efforts through this baseline evaluation project, but are not specific to any program measure. Further, some of these are just general programmatic recommendations that are not necessarily associated with elements of the baseline assumptions or analysis methodologies.

Comment on Program Budgets

Historically, the New Construction programs funded through the Systems Benefits Charge (SBC) are approved by the Public Utilities Commission on a 2-year basis. The recent increase in interest in the energy efficiency programs has resulted in a trend that is unique to New Hampshire wherein the energy efficiency programs tend to run out of money in the middle of the program-year cycle. This can adversely affect customers and result in lost opportunities as the utilities may curtail their offerings or request customers to postpone their purchases. This could be remedied by increasing the program budgets or realigning budgets to programs that offer significantly higher benefits to costs in their operations.

General Comment on the Use of Energy Code as Baseline

Due to the various versions of the code adopted by the cities and towns at different times, the architectural and engineering community indicated challenges in keeping track of the current code. There is also general belief that there is limited code enforcement.

With consideration of this and the general trend towards value engineering and low first cost, we believe that the energy code is a reasonable representation for the new construction baseline. However, we would like to point that there are instance where the current practice is frequently far less efficient than the energy code.

Training Programs for Buildings Community

In the process of conducting the current practice workshops, it became apparent that some in the design and construction community in New Hampshire are not fully versed in some of the advances in buildings systems, energy codes, and technologies. We believe that mechanisms to increase the awareness of the technical details and economic advantages of energy efficient systems will increase program participation, progressively increase the current practice baseline, and benefit New Hampshire, in general. An important step would be to develop wide-reaching training programs for owners, developers, architects, engineers, vendors, contractors, and building operators. Such trainings would increase receptiveness to premium energy efficiency technologies, promote a better understanding of energy code requirements, and result in enhanced penetration of energy efficient designs and construction.

Comments on LEED and Commissioning Programs

Another outcome of the two workshops was the finding that many highly motivated end users design their buildings to LEED standard without pursuing the certification indicating that they are interested in the concepts, but are not interested in the burden of the documentation or complexities of the process.

New Hampshire new-construction participants also indicated a lack of rigor in commissioning and continuous commissioning in their projects. This is an opportunity that could be well served by developing new program offerings that can help the design and engineering community provide projects that can sustain higher level of building performance over a long period of time.

Consider Adding a New Program Offering for Standard Refrigeration Measures

Though standard prescriptive rebates are not offered under the New Construction program in the the northeast, California offers prescriptive rebates for upgrades typically geared towards the supermarkets. They include incentives for installing anti-sweat heater controls, efficient evaportator motors, evaporator fan controllers in walk-in units, high efficiency display cases, night covers, strip curtains, etc. Depending on the level of activity anticipated over the coming years, adding refrigeration to the program offerings would be beneficial.

7.2.2 Lighting

The following recommendations for characterizing the lighting baseline technology are based on the review of existing baseline algorithm parameters, comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents, and other current-practice research documents. Table 7-1 presents information on quantitative changes recommended by ERS to the algorithms that are currently used in assessing the lighting projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, and 5. It has also been cited in the tables for easy referencing and is also discussed immediately following the table. Qualitative recommendations regarding program changes are discussed following Table 7-1.

Table 7-1 (Part 1 of 2)
Lighting Recommendation

Measure Code	Measure Description	Gross kW Savings	Gross kWh Savings	Recommendation	Comment
10	Fluorescent fixtures with high performance or reduced wattage (HP/RW) lamp & ballast systems or a T5 lamp and ballast system.	kW = qty * (prop watts * 1.3- prop watts) / 1000	kWh/year = kW * hours/year	Change factor from 1.3 to 1.18	see section 2.2.3
30A	High efficiency 2 lamp prismatic lensed fluorescent fixtures, 2x2 or 2x4	kW = qty * (11 watts/fixture) / 1000	kWh/year = kW * hours/year	Change savings from 11W/fixture to 35W/fixture	see section 2.2.3
30B	High efficiency 2 lamp parabolic fluorescent fixtures, 2x2 or 2x4	kW = qty * (11 watts/fixture) / 1000	kWh/year = kW * hours/year	Change savings from 11W/fixture to 35W/fixture	see section 2.2.3
30C	High efficiency 2 lamp recessed indirect/direct fluorescent fixtures 2x2 or 2x4	kW = qty * (11 watts/fixture) / 1000	kWh/year = kW * hours/year	Change savings from 11W/fixture to 35W/fixture	see section 2.2.3
31	High efficiency 3 lamp fluorescent fixtures 2x4	No information available	kWh/year = kW * hours/year	Eliminate the code. Can be covered using code 10.	see section 2.2.3
33	High efficiency indirect low glare pendant fluorescent fixtures	kW = qty * (15 watts/fixture) / 1000	kWh/year = kW * hours/year	Change savings from 15W/fixture to 20W/fixture	see section 2.2.3
34	Advanced Recessed Fluorescent Fixtures 1x4 or 2x4	kW = qty * (17 watts/fixture) / 1000	kWh/year = kW * hours/year	Change savings from 17W/fixture to 20W/fixture	see section 2.2.3
41	Industrial/commercial fluorescent fixtures – 4 ft. and 8 ft. fixtures	kW = qty * (prop watts * 1.46 - prop watts) / 1000	kWh/year = kW * hours/year	change factor from 1.46 to 1.1	see section 2.2.3
44	Clean room rated fluorescent fixtures 1x4 or 2x4	No information available	kWh/year = kW * hours/year	Consider removing based on the number of applications processed in a year	see section 2.2.3
21	Compact fluorescent fixture	kW = qty * prop watts * 3.7 / 1000	kWh/year = kW * hours/year	Modify baseline to match EISA 2007 guidelines	see section 2.2.3
23	Dimmable compact fluorescent fixture	kW = qty * prop watts * 3.7 / 1000	kWh/year = kW * hours/year	Modify baseline to match EISA 2007 guidelines	see section 2.2.3
56	High intensity fluorescent fixtures (HIF) for low bay applications (≤ 210W)	kW = qty * (prop watts * 1.35 - prop watts) / 1000	kWh/year = kW * hours/year	Consider elimination of this fixture code in a year as it is becoming a standard practice.	see section 2.2.3
57	High intensity fluorescent fixtures (HIF) for high bay applications (≥ 210W)	kW = qty * (prop watts * 1.35 - prop watts) / 1000	kWh/year = kW * hours/year	Consider elimination of this fixture code in a year as it is becoming a standard practice.	see section 2.2.3
70	Metal halide specialty lighting fixtures with electronic ballast	kW = qty * (31 watts/fixture) / 1000	kWh/year = kW * hours/year	Consider eliminating as LEDs are becoming more common.	see section 2.2.3
80	LED downlight fixtures hard wired or GU-24 base	No information available	kWh/year = kW * hours/year	We recommend a new savings equation. See section below.	see section 2.2.3
82A	LED cooler, freezer case or refrigerated shelving fixtures – 3' & 4' fixtures	No information available	kWh/year = kW * hours/year	We recommend a new savings equation. See section below.	see section 2.2.3
82B	LED cooler, freezer case or refrigerated shelving fixtures – 5' & 6' fixtures	No information available	kWh/year = kW * hours/year	We recommend a new savings equation. See section below.	see section 2.2.3
83	LED low bay fixtures - garage fixtures	No information available	kWh/year = kW * 8,760 hours/year	We recommend a new savings equation. See section below.	see section 2.2.3
84	LED track heads	No information available	kWh/year = kW * hours/year	We recommend a new savings equation. See section below.	see section 2.2.3

Table 7-1 (Part 2 of 2)
Lighting Recommendation

Measure Code	Measure Description	Gross kW Savings	Gross kWh Savings	Recommendation	Comment
61	Remote-mounted occupancy sensor	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction	Consider using the 2013-2015 MA TRM facility hours as a reference. Develop custom time savings factors by space/facility type.	see section 2.2.3
62	Daylight dimming system (DDS-FL)				see section 2.2.3
63	Occupancy controlled step-dimming system				see section 2.2.3
64A	Wall mounted occupancy sensors	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction	Eliminate as it is standard practice	see section 2.2.3
64B	Wall mounted vacancy occupancy sensors	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction	Consider using the 2013-2015 MA TRM facility hours as a reference. Develop custom time savings factors by space/facility type.	see section 2.2.3
65	Photocell sensors (lighting systems on 24/7)	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction	Consider removing this measure code as energy codes require installation of photcell and time switch control or an astronomical time clock control on all exterior lighting.	see section 2.2.3
68	High bay fluorescent (HIF) occupancy control systems	kW = (qty fixtures controlled * fixture wattage) / 1000 * 0.25	kWh = (qty fixtures controlled * fixture wattage) / 1000 * annual hours of reduction	Consider using the 2013-2015 MA TRM facility hours as a reference. Develop custom time savings factors by space/facility type.	see section 2.2.3

Our recommendations for the various elements of lighting systems are described below. These conclusions are based on a synthesis of information associated with our discussions with various utility representatives, our experience in dealing with the Prescriptive programs in New Hampshire and of other utility programs in the region and the research and assessments conducted under this study.

Lighting Recommendations and Comments

This subsection provides supporting information for recommendations presented in Table 7-1. Based on information presented on lighting codes in Section 3, no specific lighting technology efficiency requirements are identified. Only limits on lighting power density (W/ft^2) are set for different building or space types, which do not directly impact the existing baseline algorithms.

Energy Code Based Lighting Power Density Requirements – With Prescriptive technology-based incentives, it is often difficult to determine whether or not net energy savings are realized. Programs designed for the retrofit of existing facilities offer opportunities to easily identify energy savings. New or renovated facilities, however, can be designed with very efficient fixtures, but if the quantity of the fixtures is too great, with smaller than necessary fixture spacing, the energy used to illuminate the space can be much higher than standard practice would predict. The new energy code allows a convenient and consistent test for "space" efficiency. Lighting power density is the main focus of the energy code in regards to lighting, with each space or building type being assigned a maximum allowable lighting power density.

Utility programs are not designed to be enforcement vehicles for energy efficiency, or other codes. However, energy codes offer an opportunity for the coordination of efforts that are struggling to meet related goals. Much work has been done in developing lighting power density (LPD) thresholds that allow readily available, yet efficient, technologies to be utilized in such a manner as to provide lighting levels consistent with Illuminating Engineering Society of North America (IESNA) recommended illumination levels.

The work that the IESNA has performed in developing ASHRAE Standard-based LPD levels can also be related to fixture type and configurations. Basically, if efficient technologies (hp T8 lamps, electronic ballasts, T5 lamps, metal halide fixtures, efficient fixture configurations, etc.) are utilized in typical uniform layouts, code-mandated LPD levels will be met.

From the above, it can be safely assumed that code-mandated LPD levels will be met through the installation of lighting technologies that qualify for utility company incentives a majority of the time. However, many projects proceed with atypical fixture layouts that supply much more light than is needed or even desired.

Again, it is clear that utility companies are not the enforcement agency responsible for the energy code. However, states are relying on the design community to enforce the code, and the utility companies, through the promotion of their efficiency programs, have become integral parts of the design community.

Recommendation

Consider requiring a calculation demonstrating a lighting power density of at least 20% lower than the code in order to receive any incentives for the Prescriptive lighting measure codes. A table on the form could facilitate the process, prompting the relevant information and demonstrating the calculation. Alternately, the incentive application forms could be restructured to add information about the space layout and the number of fixtures in that space, building type which could then be easily used to develop the LPD estimate.

LED Measure Life

Currently the New Hampshire New Equipment & Construction program utilizes 15-year measure life for all lighting fixture based measure codes and 10-year measure life for lighting controls. The measure life for any equipment depends on its hours of use and the rate at which market innovation provides economically feasible replacement alternatives (persistence rates). With LED technologies offering lamp life of 50,000 hours or greater, it is possible to have LED fixtures with measure life exceeding 20 years for single-shift or office-type applications. Due to the relatively recent adoption of LED technologies, there is limited public information on the measure life of LED lamps. The only exception to this rule is the LED exit signs, which have been found to measure life exceeding 20 years. We recommend a further review of the measure life data used for screening LED technologies.

Individual Measure Recommendations

Code 10 ♦– Fluorescent fixtures with high performance or reduced wattage (hp /RW) lamp & ballast systems or a T5 lamp and ballast system

According to our research efforts, T12 lamps are not used anymore in new construction projects. T8 systems have become standard practice and have reached almost 98% market penetration, while T5 systems have reached around 2% market penetration. We believe that the baseline should be standard T8 systems and the new savings factor should be 1.18.

Code 30 ♦, 30 B ♦, 30 C ♦ – High efficiency two-lamp prismatic lensed, parabolic, and high efficiency two-lamp recessed indirect/direct fluorescent fixtures 2×2 or 2×4

ERS recommends using an algorithm based on the lighting power density (LPD) to calculate the deemed savings for the Code 30 fixtures. The LPD algorithm provides a more accurate description of the measure impact on the light output and quality and energy use.

Based on the ERS analysis in Section 2 we recommend adjusting the average savings value of 11 W/fixture in the baseline algorithm to 35 W/fixture.

Code 31 ♦ High efficiency three-lamp fluorescent fixtures – 2×4

The New Hampshire analysis spreadsheet did not have information supporting the baseline and the algorithm to estimate the savings for this measure code's fixtures. Therefore, ERS did not have access to enough details to make a recommendations based on the currently used baseline and algorithm for this measure. It is our understanding that this measure code would apply in special situations with four-lamp T8 fixtures constituting the baseline and the three-lamp high efficiency fixture representing the higher efficiency case. In some cases, a one-for-one scenario could be possible, but in others a sophisticated lighting model would be required to determine the post-case high efficiency scenario. We believe that the fixtures in this measure code are already broadly covered by Code 10 fixtures, and therefore we suggest simplifying the program offerings and eliminating this fixture code.

Code 33 ♦ High efficiency indirect low-glare pendant fluorescent fixtures

ERS recommends using an algorithm based on the lighting power density (LPD) to calculate the deemed savings for this measure. The LPD algorithm provides a more accurate description of the measure impact on the light output and quality and energy use.

Based on the ERS analysis in Section 2 we consider that the average value of 17 W/fixture in the baseline algorithm should be updated to 20 W/fixture.

Code 33- Low-glare advanced recessed fluorescent fixtures

ERS recommends using an algorithm based on the lighting power density (LPD) to calculate the deemed savings for this measure. The LPD algorithm discussed in Section 2 provides a more accurate description of the measure impact on the light output and quality and energy use.

Based on the ERS analysis in Section 2, we consider that the average value of 17 W/fixture in the baseline algorithm should be updated to 20 W/fixture.

Code 41 ♦ – Industrial fluorescent fixtures – (4-foot and 8-foot)

For this measure, T12 lamps are not used anymore in new construction projects. T8 systems have become standard practice and have reached almost 99% market penetration, while T5 systems reached around 1% market penetration. We believe that the baseline should be standard T8 systems and the new savings factor should be 1.18.

Code 44 ♦ – Clean room-rated fluorescent Fixtures 1×4 or 2×4

These are specialty fixtures with the same requirements as Code 10 fixtures. This is a special application which in most likelihood receives limited program participation. As a workaround, this application can be broadly covered by Code 10 fixtures, and as such, ERS recommends eliminating this measure code.

Codes 21 & 23 – Compact fluorescent fixtures

Codes 21 and 23 are differentiated by the type of ballast – non-dimming ballasts are eligible under code 21 and dimming ballasts are eligible under code 23. Even though CFL fixtures have become fairly common in new construction projects, program administrators informed us that that a large number of the small commercial and industrial customers still rely on the program to purchase these lamps in bulk. However, since the EISA 2007 requires higher incandescent lamp efficiency starting from 2012, ERS recommends adjusting the baseline efficiencies consistent with the EISA 2007 requirements and the energy savings algorithms accordingly. Section 2 provides more details regarding the new savings factors.

Code 56 ♦ & 57 ♦ – High intensity fluorescent fixtures (HIF)

Although other Northeastern utilities still provide incentives for measure Codes 56 and 57, ERS believes that for new construction projects, the installation of fluorescent fixtures has become standard practice. Therefore, ERS recommends eliminating both measure codes 56 and 57 from the Prescriptive program. As a replacement alternative to the current HIF technology, new high bay LED technologies are becoming available and could be offered under a new measure code. As an example, the Design Lighs Consortium has a list of approved high bay LED fixtures provide by a number of manufacturers such as Acuity Brands Lighting (supplied by Lithonia Lighting), Albeo Technologies (C and H series) and Digital Lumens.

Code 70 – HID fixtures

Under measure Code 84 (LED track heads), the program provides incentives for new LED fixtures that have the same functionalities with better performance than the HID fixtures. For that reason, and since the standard practice for display lighting is metal halide fixtures, ERS recommends eliminating measure Code 70 from the prescriptive program.

Code 80 – LED downlight fixtures, hard-wired or GU-24 base

The New Hampshire analysis spreadsheet provided no supporting data on the algorithms being used for this measure code. ERS therefore conducted a limited analysis using a combination of CFL, incandescent, and metal halide lamps as baseline fixture types and developed the savings factor for this measure code. Based on our analysis in Section 2, we recommend using the savings factor of 1.8 W/fixture for this measure code using the following algorithm:

$$Demand\ savings\ kW = Qty \times (Proposed\ W \times 1.8 - Proposed\ W)/1000$$

Code 82A & 82B – LED cooler, freezer case, or refrigerated shelving fixtures

The New Hampshire analysis spreadsheet provided no supporting data on the algorithms being used for this measure code. ERS therefore conducted a limited analysis assuming T8 lamps as the baseline. Based on our analysis in Section 2, we recommend using a savings per fixture factor based on the location (center and end) and length (3″, 4″, 5″, and 6″) of the lamp. The recommended savings algorithm is:

$$Demand\ savings\ kW = Qty \times (Avg\ W\ saved)/1000$$

Code 83 – LED low bay fixtures, garage fixtures

The New Hampshire analysis spreadsheet provided no supporting data on the algorithms being used for this measure code. ERS therefore conducted a limited analysis assuming linear fluorescent, high-pressure sodium (HPS), and metal halide lamps as baseline. Based on our analysis in Section 2, we recommend using a savings factor of 1.4 W/fixture using the following algorithm:

$$Demand\ savings\ kW = Qty \times (Proposed\ W \times 1.4 - Proposed\ W)/1000$$

Code 84 – LED track heads

The New Hampshire analysis spreadsheet provided no supporting data on the algorithms being used for this measure code. ERS therefore conducted a limited analysis using incandescent, halogen, CFL, and ceramic metal halide track heads. Based on our analysis in Section 2, we recommend using an average savings factor per fixture that is based on the rated LED fixture watts using the following algorithm:

$$Demand\ savings\ kW = Qty \times (Proposed\ W \times Baseline/proposed - Proposed\ W)/1000$$

Codes 61 through 68 – Lighting controls

The Prescriptive measure algorithms for all of the lighting controls codes 61 through 68 are identical. Basically, the algorithms consider demand savings of 25% of the total installed W and energy savings based on reduced weekly hours of operation.

The savings factor remains constant regardless of the type of lighting-control system. The demand savings depends greatly on the type of control system. Daylight dimming sensors do not perform the same way as occupancy sensors; hence, the savings associated with these systems will differ. To add to this, the fluorescent systems have a very different potential for savings than the HID systems.

Based on our review of existing lighting control algorithms, recommendations related to Code 61 through 68 for lighting controls are presented here:

- ❑ The demand savings are different for occupancy-based sensors as compared to daylight-based and photocell sensors. We recommend developing separate demand savings factors based on the control and space type.
- ❑ In new construction projects, automatic controls that qualify for incentives under measure code 64A (wall-mounted occupancy sensors) have become standard practice over the last few years due to changes in the code requirements and reduction in costs for these types of devices. ERS recommends eliminating measure Codes 64A from the prescriptive program.
- ❑ For Code 65, we recommend specifying that this measure is eligible for wall packs and garage lights as the application of this control in other locations is required by code.

7.2.3 Unitary HVAC Equipment

The following recommendations for characterizing the unitary HVAC equipment systems are based on the review of existing baseline algorithm parameters and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-2 presents our findings associated with the algorithms that are currently used in assessing the unitary HVAC equipment projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing. Discussion of these tabulated recommendations for program baseline changes are presented following Table 7-2.

Table 7-2
Unitary HVAC Equipment Recommendations

Size (Btuh)	Gross kW savings	Gross kWh Savings	Hours	Recommendation
Unitary AC and Split Systems (new condenser and new coil)				
< 65,000 Split System Packaged System	See equation (a)	See equation (b)	Hospital: 2,330 Office (Sm, Med, Lg): 970 Retail Store: 1,380 Schools: 510	Make base efficiency units consistent with code and expand bldg types.
≥ 65,000 to < 135,000	See equation (a)	See equation (b)		
≥ 135,000 to < 240,000	See equation (a)	See equation (b)		
≥ 240,000 to < 760,000	See equation (a)	See equation (b)		
≥ 760,000	See equation (a)	See equation (b)		
Air to Air Heat Pump Systems				
< 65,000 Split System Packaged System	See equation (a)	See equation (b)	Hospital: 3,010 Office (Sm, Med, Lg): 1,970 Retail Store: 2,250 Schools: 1,030	Make base efficiency units consistent with code, add HSPF or COP to the baseline efficiency and expand bldg types.
≥ 65,000 to < 135,000	See equation (a)	See equation (b)		
≥ 135,000 to < 240,000	See equation (a)	See equation (b)		
≥ 240,000	See equation (a)	See equation (b)		
Water Source Heat Pumps				
≤ 135,000	See equation (a)	See equation (b)		
Ground Water - Water Source Heat Pump Equipment (Open Loop)				
≤ 135,000	See equation (a)	See equation (b)		
Ground Water - Water Source Heat Pump Equipment (Closed Loop)				
≤ 135,000	See equation (a)	See equation (b)		
Energy Savings Control Options (when installed with new & qualifying Tier 1 or 2 equipment				
Dual Enthalpy Economizer	0	annual kWh = Ton * 276	Not applicable	No change.
Demand Control Ventilation	0	annual kWh = Ton * 200		No change.
Equation (a): kW = qty * Tons per Unit * (12/ EER base - 12/ EER proposed) **Equation (b): annual kWh = kW * Hours**				

Our recommendations for unitary HVAC systems are described below:

Effective Full Load Hours (EFLH)

This subsection provides supporting information for recommendations presented in Table 7-2. The critical parameters used for determining unitary HVAC system savings are the base case and proposed case efficiencies and the EFLH. The base case efficiency values are predicated on a study conducted by NEEP and should be updated to reflect IECC 2009. For the most part, they meet or slightly exceed the minimum code-required efficiency values.

The existing building type list based on which the cooling equipment EFLH is determined should be expanded. The existing EFLH values are also higher than typical equivalent hours of the cooling season in New Hampshire. The heating season EFLH values seem low if we consider the outdoor conditions in New Hampshire. The EM&V forum also conducted a study of unitary HVAC EFLH which could be brought in as a reference regarding these updates.

The unit sizes also do not always align with the breakdown presented in the IECC 2009 code. For the convenience of future code comparisons, we recommend aligning the unit sizes with the code tables.

ERS recommends that a study be conducted to specifically assess the New Hampshire unitary HVAC market Equivalent Full Load Hours (EFLH) for different types of unitary systems based on a larger selection of building types on which they are installed.

Comments on Efficiency

Our observations from the comparison of the baseline parameters and energy code are discussed below:

- For all equipment types, the requirements in the IECC 2009 were either equal to or slightly greater than those shown in ASHRAE 90.1 2007, while the IECC 2012 specified efficiency values were found to be more stringent. Conclusions made below are made from comparing the program efficiencies against the IECC 2009 code.
- For unitary AC and split systems ≤ 65,000 Btu/h (Tier 1 and 2), the minimum SEER required for a rebate satisfactorily exceeds the values presented by IECC 2009 energy code and ASHRAE Standard 90.1 2007.
- The following measures require EER, SEER, HSPF, IPLV, and/or COP ratings that are slightly greater than the IECC 2009/ASHRAE 90.1-2007 values:
    - Unitary AC and split systems >65,000 Btu/h to 135,000 Btu/h (Tier 1)
    - Unitary AC and split systems >240,000 Btu/h to 760,000 Btu/h (Tier 1 & 2)
    - Unitary AC and split systems >760,000 Btu/h (Tier 1 & 2)
    - Air-to-air heat pumps > 65,000 Btu/h to 135,000 Btu/h (Tier 1 & 2)
    - Air-to-air heat pumps > 135,000 Btu/h to 240,000 Btu/h (Tier 1 & 2)
    - Ground water – water source heat pump (Open Loop) ≤ 135,000 Btu/h (Tier 1)
    - Ground water – water source heat pump (Closed Loop) ≤ 135,000 Btu/h (Tier 1)

- The future energy codes have started to specify part load performance of unitary HVAC units using IEER (integrated energy efficiency ratio) ratings. The ratings have been in effect since 2010 and we will soon start seeing increasing adoption of this unit by programs throughout the country. We therefore recommend updating the minimum required equipment efficiency ratings to the IEER within the next 2 years.

Our general observation for the HVAC unitary equipment is that a majority of the efficiency values required for rebate are equal to or not substantively greater than the efficiencies specified by the IECC 2009 energy code. Specific instances have been noted above. The measures not mentioned are satisfactorily greater than both code manuals. As a general note, we recommend matching the program efficiency units (COP, HSPF, EER, and SEER) with the code-specified values.

Future New Measure Categories

Recently there has been a tremendous interest in the new construction community regarding the installation of multisplit systems featuring variable refrigerant flow. These systems offer significant efficiency improvement compared to the traditional air-cooled DX technology. They are more expensive compared to the traditional options but the incremental costs are defrayed by lower operating costs. The Consortium for Energy Efficiency (CEE) has developed guidelines that support the required information required to include these measures in the energy efficiency program lineup. We suggest adding the following two new measure categories under the unitary HVAC section:

1. Variable Refrigerant Flow Multisplit Air Conditioner
2. Variable Refrigerant Flow Multisplit Heat Pump

7.2.4 Chillers

The following recommendations for characterizing the chillers are based on the review of existing baseline algorithm parameters, comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-3 presents our findings associated with the algorithms that are currently used in assessing chiller projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing. Qualitative discussions of the tabulated recommendations for program baseline changes are presented following Table 7-3.

Table 7-3
Chiller Recommendations

Unit Size ARI Net Tons	Gross kW savings	Gross kWh savings	Recommendation
Air cooled chillers < 150 tons	See equation (a)	See equation (b)	1) Add IPLV in the base efficiency term. 2) Review the EFLH hours used for the various building types as they are higher than typical for northeast. 3) Where applicable, consider modifying the chiller application to process Path A/Path B chillers and adjust the energy savings algorithm accordingly.
Air cooled chillers ≥ 150 tons	See equation (a)	See equation (b)	
Water cooled chillers (rotary screw or scroll) < 75 tons	See equation (a)	See equation (c)	
Water cooled chillers (rotary screw or scroll) ≥ 75 and < 150 tons	See equation (a)	See equation (c)	
Water cooled chillers (rotary screw or scroll) ≥ 150 and < 300 tons	See equation (a)	See equation (c)	
Water cooled chillers (rotary screw or scroll) ≥ 300 tons	See equation (a)	See equation (c)	
Water cooled chillers (centrifugal) < 150 tons	See equation (a)	See equation (c)	
Water cooled chillers (centrifugal) ≥ 150 and < 300 tons	See equation (a)	See equation (c)	
Water cooled chillers (centrifugal) ≥ 300 and < 600 tons	See equation (a)	See equation (c)	
Water cooled chillers (centrifugal) ≥ 600 tons	See equation (a)	See equation (c)	
Equation (a): kW = qty * Tons per Unit * (Base kW/ton - Proposed kW/ton) **Equation (b): annual kWh = kW * Hours** **Equation (c): annual kWh = kW * 970**			

Our recommendations for chiller systems are described in the following section.

Other Chiller System Recommendations and Comments

This subsection provides supporting information for recommendations presented in Table 7-3. The critical parameters used for characterizing chiller systems are the base case and proposed case efficiencies, and the EFLH. Based on conversations with the program staff, the existing algorithm parameters have been updated annually by their team, indicating that the existing algorithm values are consistent with the current technological development of chiller systems.

The energy savings algorithm should be based on chillers IPLV values. The savings for water-cooled chillers is a constant 970 EFLH, irrespective of the application or building type. The EFLH value should be specific to the building type served by the new chiller, similar to the unitary HVAC algorithm.

Based on our review, we found that the minimum efficiency required to obtain rebates for all chillers of all capacities is greater than the efficiencies specified by the IECC 2009 and ASHRAE standard 90.1 2007.

ERS recommends that, for consistency, the units used to calculate the baseline efficiency be updated to reflect those used in the IECC 2009 and ASHRAE 90.1-2007. This is applicable to all chiller types shown in Table 7-3.

7.2.5 Electronically Commutated Motors (ECM)

The following recommendations for characterizing the EC motor systems are based on the review of existing baseline algorithm parameters and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-4 presents information on quantitative changes recommended by ERS to the algorithms that are currently used in assessing the EC motor projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing.

Table 7-4
ECM Recommendations

Measure Description	Baseline	Box size factor (W/CFM)	Gross summer kW savings	Gross winter kW savings	Gross kWh savings	Recommendation
EC Motors (< 1000 CFM)	Single speed PSC induction motor	0.32	See equation (a)	See equation (b)	See equation (c)	Consider using the 2013-2015 MA TRM as a reference.
EC Motors (≥ 1000 CFM)	Single speed PSC induction motor	0.21	See equation (a)	See equation (b)	See equation (c)	
Equation (a): kW = qty * CFM * Box size factor * 0.63 / 1000						
Equation (b): kW = qty * CFM * Box size factor * 0.33 / 1000						
Equation (c): annual kWh = qty * CFM * Box size factor * 0.52 / 1000 * Hours						

In the longer term, we advise conducting separate research or a study to evaluate the savings associated with this measure in New Hampshire and adding other common applications such as refrigeration display cases in the list of approved end uses.

7.2.6 Variable Frequency Drives (VFDs)

The following recommendations for characterizing the VFDs are based on the review of existing baseline algorithm parameters and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-5 presents information associated with the algorithms that are currently used in assessing the VFD projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing. Discussion of these tabulated recommendations for program baseline changes are presented following Table 7-5.

Table 7-5
VFD Systems Recommendations

Measure	kW Savings	kWh Savings	Recommendation
Supply fan on constant volume supply air handler. [SFA]	See equation (a)	See equation (b)	1) For the application of VSDs on supply, return and exhaust fans, we recommend revising the savings algorithms based on the building type. 2) For supply and return fans on VAV units, we recommend modifying the minimum requirements to allow incentives only for units with fans below 10 hp. 3) Modify the cooling tower fan VSD requirement to provide incentives only for fans below 7.5 hp 4) In the near term, we recommend adopting the methods and factors stated in the 2013-2015 MA TRM. In the long term, we recommend conducting revising the savings factors based on a separate study targeted towards the buildings in New Hampshire. NH program offerings for VFDs are consistent with the programs in the neighboring states.
Return fan on constant volume return air handler [RFA]	See equation (a)	See equation (b)	
Supply fan on VAV packaged HVAC unit [SFP]	See equation (a)	See equation (b)	
Return fan on VAV packaged HVAC unit [RFP]	See equation (a)	See equation (b)	
Building exhaust fan [BEF]	See equation (a)	See equation (b)	
Process exhaust fan [PEF]	See equation (a)	See equation (b)	
Fume hood exhaust fan and makeup air fan [HEF]	See equation (a)	See equation (b)	
Circulation pump for water source heat pump loop [WWP]	See equation (a)	See equation (b)	
Process heating & cooling circulation pumps [PHC]	See equation (a)	See equation (b)	
Boiler feed water pump [FWP]	See equation (a)	See equation (b)	
Boiler draft fan [BDF]	See equation (a)	See equation (b)	
Hydraulic pumps [HYP]	See equation (a)	See equation (b)	
Cooling Tower Fan [CTF]	See equation (a)	See equation (b)	
Equation (a): kW Savings = qty * HP * kW/HP			
Equation (b): kWh Savings = HP x QTY x kWh/HP-yr			

Our recommendations for VFDs are described below.

This subsection provides supporting information for recommendations presented in Table 7-5. The critical parameters used for characterizing a VFD are the kW savings factor, which are different for each type of system served, and operating hours. We would like to emphasize that many of the VFD systems installed may not yield demand savings. Furthermore, the VFD introduces energy losses of up to 5% when motor operates at full load.

We believe that the study on which the algorithms are based should be updated to reflect the technology changes and better understanding of system operating characteristics. The current VFD application does not associate hours of operation to a particular building type. Therefore, in order to accurately characterize the energy savings associated with an end use, we suggest that any future study associated with these parameters develop building-sector specific (hospitals, offices, schools, retail, and industrial) operating hour parameters.

According to IECC 2009 section 503.4.2, variable air volume (VAV) systems with motors ≥ 10 hp (7.5 kW) shall be driven by mechanical or electrical VFDs that provide no more than 30% of design wattage at 50% of design airflow when static pressure setpoint equals one-third of the total design static pressure.

According to ASHRAE 90.1-2007 section 6.5.3.2, VAV fans with motors ≥10 hp (7.5 kW) shall be driven by mechanical or electrical VFDs that provide no more than 30% of design wattage at 50% of design air volume when static pressure setpoint equals one third of the total design static pressure.

According to ASHRAE 90.1-2007 section 6.5.4.1, for HVAC hydronic systems that have a total pump system power exceeding 10 hp shall be capable of reducing pump flow rates to 50% or less of the design flow rate. Individual pumps serving variable flow systems having a pump head > 100 feet and motor >50 hp shall have controls and or devices such as variable speed controls to control the flow that will result in a pump motor demand of less than 30% of design wattage at 50% of design water flow.

The current prescriptive program provides rebates for VFDs on motor sizes between 5 hp and 20 hp. Based on the requirements of the IECC 2009, it is recommended that rebates not be provided for new construction VFDs on supply and return fan VFDs for sizes greater than and equal to 10 hp as they are required by code.

7.2.7 Compressed Air Measures

The following recommendations for characterizing the compressed air measures are based on the review of existing baseline algorithm parameters and other current practice research documents. Table 7-6 presents information associated with the algorithms that are currently used in assessing the compressed air projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, and 5 and has been cited in the tables for easy referencing.

Table 7-6
Compressed Air Systems Recommendations

Measure	Compressor/Dryer Type	Gross kW Savings	Gross kWh Savings	Recommendation
L/NL	Load/No Load Compressor 15-24 hp	See equation (a)	See equation (c)	1) Consider eliminating the incentives for variable displacement compressors as VSD compressors are more commonly adopted. Variable displacement compressors do not offer any significant advantage over the more popular VSD compressors. 2) In the long term, consider revising the baseline from inlet modulation to load/unload. 3) There is opportunity to further enhance the program offering by offering incentives for low pressure drop air filters, low pressure drop piping and no-loss condensate drain traps.
L/NL	Load/No Load Compressor 25-49 hp	See equation (a)	See equation (c)	
L/NL	Load/No Load Compressor 50-75 hp	See equation (a)	See equation (c)	
VD	Variable Displacement Compressor 15-24 hp	See equation (a)	See equation (c)	
VD	Variable Displacement Compressor 25-49 hp	See equation (a)	See equation (c)	
VD	Variable Displacement Compressor 50-75 hp	See equation (a)	See equation (c)	
VSD	VSD Compressor 15-24 hp	See equation (a)	See equation (c)	
VSD	VSD Compressor 25-49 hp	See equation (a)	See equation (c)	
VSD	VSD Compressor 50-75 hp	See equation (a)	See equation (c)	
Dryer	Dryer Category with < 100 CFM cycling	See equation (b)	See equation (c)	No Change.
Dryer	Dryer Category with 100-199 cycling	See equation (b)	See equation (c)	
Dryer	Dryer Category with 200-299 CFM cycling	See equation (b)	See equation (c)	
Dryer	Dryer Category with 300-399 CFM cycling	See equation (b)	See equation (c)	
Dryer	Dryer Category with => 400 CFM cycling	See equation (b)	See equation (c)	
Dryer	Dryer Category with < 100 CFM VSD	See equation (b)	See equation (c)	
Dryer	Dryer Category with 100-199 VSD	See equation (b)	See equation (c)	
Dryer	Dryer Category with 200-299 CFM VSD	See equation (b)	See equation (c)	
Dryer	Dryer Category with 300-399 CFM VSD	See equation (b)	See equation (c)	
Dryer	Dryer Category with => 400 CFM VSD	See equation (b)	See equation (c)	
Storage	Above minimum required (2 - 4 gallons per CFM) below Max Required (3 - 5 Gallons per CFM)			
Equation (a): kW = qty * HP per Unit * Savings Factor				
Equation (b): kW = qty * CFM per Unit * Savings Factor				
Equation (c): annual kWh = kW * Hours				

7.2.8 Heating Equipment

The following recommendations for characterizing the heating equipment under the natural gas program offerings are based on the review of existing baseline algorithm parameters, comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-7 presents information associated with the algorithms that are currently used in assessing the heating system projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing.

Table 7-7
Heating Equipment Recommendations

Measure	Measure Description	Recommendations
Furnace ≤ 150 MBH (92% AFUE)	The installation of high eff natural gas warm air furnace with an ECM for the fan.	Reconcile the differences between the incentive applications and validate the gross savings with the MA 2012 TRM
Furnace ≤ 150 MBH (94% AFUE)		
Furnace ≤ 300 MBH (92% AFUE)		
Furnace ≤ 300 MBH (94% AFUE)		
Infrared heaters all sizes	The installation of a gas-fired low intesity infrared heating system in place of unit heater, furnace, or other standard eff equip.	No change

7.2.9 Water Heating Equipment

The following recommendations for characterizing the water heating equipment under the natural gas program offerings are based on the review of existing baseline algorithm parameters and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-8 presents information associated with the algorithms that are currently used in assessing the water heating system projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing.

Table 7-8
Water Heating Equipment Recommendations

Measure	Recommendations
Hydronic boiler ≤ 300 MBH	Make the program offerings consistent throughout the state. Unitil is offering incentives for this measure.
Hydronic boiler 301 to 499 MBH	
Hydronic boiler 500 to 999 MBH	
Hydronic boiler 1000 to 1700 MBH	
Hydronic boiler ≥ 1701 MBH	
Condensing boiler ≤ 300 MBH	No change
Condensing boiler 301 to 499 MBH	
Condensing boiler 500 to 999 MBH	
Condensing boiler 1000 to 1700 MBH	
Condensing boiler 1701 to 2500 MBH	
Condensing ≥ 2500 MBH	

7.2.10 Integrated Water Heater/Condensing Boiler Equipment

The following recommendations for characterizing the integrated water heater/condensing boiler projects under the natural gas program offerings are based on the review of existing baseline algorithm parameters and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-9 presents information associated with the algorithms that are currently used in assessing the integrated water heater/condensing boiler projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing.

Table 7-9
Integrated Water Heater/Condensing Boiler Equipment Recommendations

Measure	Measure Description	Recommendations
Integrated water heater/Condensing boiler	This measure promotes the installation of a combined high-eff boiler and water heating unit.	No change

7.2.11 Controls Equipment

The following recommendations for characterizing the controls projects under the natural gas program offerings are based on the review of existing baseline algorithm parameters and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-10 presents information associated with the algorithms that are currently used in assessing the controls projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing.

Table 7-10
Controls Equipment Recommendations

Measure	Measure Description	Recommendations
After market boiler reset controls	Boiler reset controls are devices that automatically control boiler water temperature based on outdoor or return water temperature using a software program.	Eliminate as they are required by code.
Steam Traps	Repair or replace malfunctioning steam traps.	Eliminate as it is a retrofit measure.
Energy Star or 7-day programmable thermostats	Installation of a 7-day programmable thermostat with the ability to adjust heating or air-conditioning operating times according to a pre-set schedule to meet occupancy needs and minimize redundant HVAC operation.	Eliminate as they are required by code.

7.2.12 Commercial Kitchen Equipment

The following recommendations for characterizing the commercial kitchen equipment projects under the natural gas program offerings are based on the review of existing baseline algorithm parameters and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-11 presents information associated with the algorithms that are currently used in assessing the commercial kitchen equipment projects. Supporting information for the recommended changes has been presented in Sections 2, 3, 4, 5, and 6 and has been cited in the tables for easy referencing.

Table 7-11
Commercial Kitchen Equipment Recommendations

Measure	Measure Description	Recommendations
Energy Star Fryer	The installation of a natural gas-fired fryer that is either ENERGY STAR rated or has a heavy load efficiency of at least 50%.	No Change
Energy Star Commercial Steamer	The installation of an ENERGY STAR rated natural gas-fired steamer, either connectionless or steam-generator design, with heavy-load cooking efficiency of at least 38%.	No Change
Energy Star Commercial Convection Oven	Installation of high-efficiency gas ovens	Reconcile the proposed equipment efficiencies between the two programs.
High Efficiency Gas Combination Oven		
High Efficiency Gas Conveyor Oven		
High Efficiency Gas Rack Oven		No Change
Energy Star Commercial Griddle	Installation of a gas griddle with an efficiency of 38%.	No Change
High Efficiency Pre-Rinse Spray Valve	Natural gas-fired hot water heaters serving new low-flow pre-rinse spray nozzles with an average flow rate of 1.6 GPM.	Consider eliminating this measure as EPACT 2005 requires new nozzles to not exceed 1.6 GPM. See Section 6.2.5

7.3 Conclusions and Recommendations for the Custom Programs

This section presents recommendations for the nhsaves@work/New Equipment & Construction program Custom projects based on the comparative analysis of the information presented in Sections 2, 3, 4, 5, and 6. The program offers rebates for Custom measures that do not fall into the Prescriptive project category. Assessments are conducted to determine the energy savings and incentives specifically for the application at hand and are addressed on a case-by-case basis. The rebates for Custom applications will buy down the project to a 1.5-year payback period or pay 75% of the incremental cost of the project, whichever is less.

The baseline for the Custom project categories reflects current or standard practice for the different type of systems considered by the program. The baseline description/energy saving opportunities list does not offer detailed information about the energy efficiency of the baseline systems, with the exception of HVAC unitary systems and chillers. For these systems, the list offers a guide for the baseline systems and for the energy efficiency measures. Where possible, based on available completed Custom studies and our experience, the Custom measures were investigated for making modifications and the results are presented in the tables that follow.

7.3.1 Custom Lighting

The following recommendations for characterizing the lighting baseline technology are based on the review of existing Custom lighting baseline descriptions and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-12 presents information the baseline that is currently used in assessing the Custom lighting projects. As can be seen from Table 7-12, the existing baseline descriptions for the Custom lighting projects are reasonable and there are no recommendations put forth for changes at this time.

Table 7-12
Custom Lighting Measure Recommendation

Category	Standard Practice	Recommendation
Interior lighting	**High Intensity Discharge - (typical where ceilings exceed 50 feet)**	
	Metal Halide (MH) Fixtures	No changes recommended
	Fluorescent - (typically where ceilings are below 50 feet)	
	High Intensity Fluorescent (HIF)	No changes recommended
Exterior lighting	HPS or MH with time clock and/or photocell control	No changes recommended
Lighting controls	wall mounted occupancy sensors	No changes recommended

The following comments are based on a comparison of the Custom lighting measure descriptions with the building codes.

- The interior lighting standard requirements for the New Hampshire New Construction Program depend on the ceiling height. For high ceilings (higher than 50 feet), high intensity discharge (HID) lighting is the standard practice. ASHRAE Standard 90.1-2007 and IECC 2009 do not specify certain types of lighting fixtures or fixture efficiencies along with the ceiling height specifics. Instead, the provisions provide guidelines based on lighting power densities (LPD). The standard practice and baseline parameters for the New Hampshire Programs do not consider LPD. Subsequently, the minimum requirements for ASHRAE Standard 90.1 2007 and IECC 2009 do not impact by the program.
- The minimum requirement for exterior lighting is HPS or metal halide lighting fixtures with time clock and/or photocell control. Both types of lighting fixtures have efficacies greater than 60 lumens per watt. ASHRAE Standard 90.1 2007 requires a minimum lamp efficacy of 60 lumens per watt for exterior fixtures operating at greater than 100 W. In addition, ASHRAE Standard 90.1 2007 states that the exterior lighting fixtures shall be controlled by either a photo-sensor or an astronomical time switch. The minimum lamp efficacy specified by IECC 2009 is 45 lumens per watt and the type of control required to control the exterior lighting fixture is photocell or automatic time switch. Thus, it can be concluded that the program minimum requirement satisfies both IECC 2009 and ASHRAE Standard 90.1 2007.
- The base requirement for lighting controls for the New Hampshire program is the time clock or manual on/off control based on occupancy. The IECC 2009 requires a manual lighting control for each area enclosed by walls with the option of bi-level light controls. According to ASHRAE Standard 90.1-2007 section 9.2.1, interior lighting for areas greater than 5,000 square feet should be controlled by an automatic control device. The device should either turn

off the lighting within 30 minutes of inactivity or operate on pre-programmed time schedules or should be occupant intervened. However, the program standard practices for lighting controls do not mention space type or minimum area controlled. However, we've found out through discussions with market actors that the installation of wall-mounted occupancy sensors has become a standard practice as it is much easier to install and meet the required code compared to the option of install time clock controls.

Based on the comparative review of the existing Custom lighting baseline practices and the building codes, we believe that the baseline practices are consistent with energy code requirements. Both interior and exterior lighting technologies specified by the Custom program are suitable in relation to code requirements.

7.3.2 Custom Building Envelope

The following information characterizing the building envelope measures are based on the review of existing Custom building envelope descriptions and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Based on the review of utility sponsored Custom projects, no Custom building envelope measures were conducted. Based on our research, the existing baseline descriptions for the Custom building envelope projects are reasonable and there are no recommendations to change the descriptions.

Based on our review of the new energy code, the baseline requirements set forth in the document are not addressed in the codes. The new construction Custom program baseline requirements do not address building envelope considerations with the exception of glazing. It may be beneficial to consider other elements of building envelope such as wall insulation levels, window insulation levels, and roof insulation levels for inclusion in an overall blend of available measures.

Table 7-13
Custom Building Envelope Measure Recommendations

Category	Standard Practice	Recommendation
Window and skylight glazing	Glass with shading coefficient of:	No change
	0.78 for windows 10% or less of total wall area	
	0.59 for windows between 10% and 30% of total wall area	
	0.52 for windows greater than 30% of total wall area	
	0.46 in curtain walls, atrium and skylights	

7.3.3 Custom Mechanical Systems

The following information characterizing the mechanical systems measures are based on the review of existing Custom mechanical systems baseline descriptions and comparison with the New Hampshire energy code (IECC 2009 and ASHRAE 90.1-2007) documents and other current practice research documents. Table 7-14 below presents information on the baseline that is currently used in assessing the Custom mechanical systems projects. Based on the review of utility-sponsored Custom projects, heat recovery measures are the most commonly encountered measures. Based on our research, the existing baseline descriptions for the Custom mechanical system projects are reasonable and there are no recommendations to change the descriptions.

Table 7-14 (Part 1 of 4)
Custom Mechanical Systems Measure Recommendations

Category	Standard Practice	Recommendation
Office buildings under 40,000 sq. ft	Constant volume fans (supply, return, exhaust)	No change
Office buildings over 40,000 sq. ft.	VAV on supply, return, and exhaust fans over 10 HP (w/VFD control)	
	Standard distribution system sizing	
	Electronic controls on main HVAC equipment	
Manufacturing or classroom bldg.	Constant volume distributed HVAC systems (fancoils or unit ventilators)	
Fume hood exhaust systems	Constant volume exhaust system with VSD on VAV supply fan	
Kitchen hood exhaust systems	Constant volume exhaust with manual on/off control	
Unitary equipment and split systems	Air cooled package/split units: < 5 Ton, 13.0 SEER 5-11 Ton, 10.3 EER >11-30 Ton, 11 EER	
	Air cooled package/split systems over 30 tons (baselines dependent on system size)	

Table 7-14 (Part 2 of 4)
Custom Mechanical Systems Measure Recommendations

Category	Standard Practice	Recommendation
Air source heat pumps	Air source heat pump with fossil fuel heat source	No change
Water source heat pump systems	Constant flow water loop	
Cooling tower systems	Forced draft cooling tower with centrifugal fan	
Packaged reciprocating chillers	Air cooled chillers <150 tons at 9.8 EER >150 TONS AT 9.6 EER	
Existing chilled water plants (Renovation, expansions, replacements)	Lead / lag chiller control; no CHWT reset	
	Primary chilled water system	
	Constant flow chilled water pumps	
	2 speed cooling tower fans	
	Evaporative Induced Draft Cooling Tower	
	Fixed condenser supply temp with mixing valve and tower fan control.	
New Chilled Water Plants	Water cooled centrifugal chillers: < 150 tons = 0.651 kW/ton 150 to < 300 tons = 0.633 kW/ton, 0.577 kW/ton IPLV 300 to 1000 tons = .620 kW/ton peak, .570 kW/ton IPLV	
	Chiller (over 1000 tons) efficiency depends on refrigerant/size	
	Chilled water temperature reset based on return water temp based on OAT	
	Primary/Secondary pumping with VSD on secondary pump	
	Standard selection size cooling tower	
	Cooling towers with multiple fans or dual speed fans	
	Constant flow condenser water pump system	
	Chiller sequencing controls based on load	
	Plate and frame heat-X- changers (free cooling)	
	No thermal storage	

Table 7-14 (Part 3 of 4)
Custom Mechanical Systems Measure Recommendations

Category	Standard Practice	Recommendation
Building Control Systems (EMS) (over 40,000 sq ft)	7 day time scheduling	No change
	Optimized start/stop	
	DDC control of air handlers	
	Chilled water reset	
	DB Economizer control	
Boiler Equipment	Constant speed feed water pumps	
	Constant speed forced draft fans	
Computer room packaged HVAC with humidifiers	Electric resistance steam generators	
	DX compressor/coil	
Commercial refrigeration	Multiplexed refrigeration racks VSD on lead compressors Plate and frame sub-coolers Floating head pressure controls Demand defrost controls T8s for case lights	
	Air cooled condensers	
	Screw compressors	
	Case doors with anti-sweat heat controls	
	Case lighting T12 lamps and EEmag ballasts	
	Motorized freezer doors	
	Humidity controls with reheat	
	Refrigeration heat recovery for DHW	
	self contained TEV (thermal expansion valves)	
	Rack type refrigeration compressors	
Industrial refrigeration systems serving facilities over 50,000 sq. ft. or 250 tons	Evaporative cooled condensers	
	Standard size evaporator coils and controls	
	single-stage compressor systems	
	Floating head pressure controls, Electric defrost control, and Subcoolers	
	Standard design cooling equipment and controls sequences	
	Motorized freezer doors	
Waste water treatment and fresh water plants	Fine bubble aeration with VSD and positive displacement blower	
	VSDs on all pumps 25 HP and larger	
	VSD's on ID fans and fume control systems	

Table 7-14 (Part 4 of 4)
Custom Mechanical Systems Measure Recommendations

Category	Standard Practice	Recommendation
New ice rinks	Low E ceilings	No change
	Water cooled chiller	
	Floor mounted ice temperature sensors	
	Multi-speed brine pump (Smart Drive)	
	Floating head pressure controls down to 75 F.	
	Dehumidification	
Process related equipment	Constant speed fans, process pumps or blowers with variable loads	
	VSD on motors requiring variable speed	
	Solid state Motor-Generator sets making off-frequency (i.e. not 60 Hz) power	
Plastic injection molding machines	Hydraulic operated operation	
Air compressors (under 130 PSI)	Single stage rotary screw compressors with modulating control via inlet valve control and unloading point below 50% of rated CFM	
Air compressors (130 PSI and over)	2 stage rotary screw compressors with cycling dryer and same baseline for <130 PSI	
Compressed air auxiliary equipment	Standard pressure drop filters	
	Refrigerated dryers	
	Standard design distribution and end use requirements	

The following comments are based on a comparison of the Custom mechanical measure descriptions listed in the table above with the New Hampshire Energy Code:

- **Office buildings** – From the code review and comparisons, we conclude that the standard practices for buildings over 40,000 square feet satisfy the IECC 2009 energy code and ASHRAE Standard 90.1 2007. However, the code does not address the distribution system.
- **Manufacturing or classroom building** – From the code review and comparisons, we conclude that the information presented in the baseline description is ambiguous and therefore, it is difficult to determine if there is conformity with the minimum requirements stated by IECC 2009 and ASHRAE Standard 90.1 2007.
- **Fume hood exhaust systems** – From the code review and comparisons, we conclude that the standard practices conform to energy code.
- **Kitchen hood exhaust systems –** Based on the code review, IECC 2009 code does not address kitchen hood exhaust systems.
- **Unitary equipment & split systems** – From the code review and comparisons, we conclude that the standard practices conform to energy code.

- **Air source heat pump** – Based on the code review, both ASHRAE Standard 90.1- 2007 and IECC 2009 do not address requirements set forth in the Custom baseline description document.
- **Water source heat pump systems** – Currently, the minimum requirement for the rebate program is a constant flow water loop and a forced-draft cooling tower with centrifugal fan. ASHRAE Standard 90.1 2007 does not specifically address the water loop system and cooling tower fans for water source heat pumps. However, according to IECC 2009 energy code the pump system should be able to reduce the system flow with the use of adjustable speed drive (ASD) on related pumps. Therefore, slight non-conformity in the baseline systems is observed.
- **Packaged reciprocating chillers** – Based on the code review, our observations indicate that the standard baseline efficiencies specified by the New Hampshire new construction program exceed the efficiencies specified by code for air-cooled chillers and water-cooled chillers.
- **Building control systems** – ASHRAE Standard 90.1 2007 does not specifically address building control systems as a whole. The ASHRAE Standard does not specify the area limitation for such systems. IECC 2009 energy code does not address damper control and chilled water reset for buildings. However, the code does address 7-day scheduling, optimized start controls, and economizers for HVAC systems. In lieu of generalized information presented in the codes, based on review we believe that the existing baseline is accurate.
- **Boiler equipment** – The standard condition for boiler equipment required by New Hampshire New Construction Program is a constant-speed feed-water pump and constant-speed forced draft fan. ASHRAE Standard 90.1 2007 and IECC 2009 code do not specifically address fan system for boiler equipment.

The New Hampshire Energy Code does not provide any information for applications such as refrigeration, waste water treatment, ice rinks, process-related equipment, plastic injection molding machines, and air compressors.

appendix a

A

WORKSHOP PRESENTATION SLIDES

New Hampshire New Construction

Discussion on Energy Codes and Standard Practices

June 11 and 13, 2012

Sponsored By

PSNH
Unitil
NHEC
National Grid

Discussion Objectives

- Gain an understanding of new construction standard practice
  - Building envelope
  - Lighting and electrical
  - Mechanical systems
- Drivers of standard practice
- Impacts of energy codes
- Impacts of energy efficiency programs
- Impacts of green initiatives

History of NH Codes

1979 – NH adopted an energy code (ASHRAE/IES Standard 90-75)

1993 – Revised standards to comply with ASHRAE/IESNA 90.1-1989

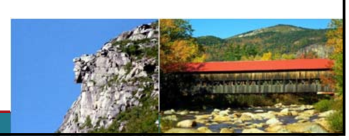
1998 – Adopted MEC 95

2002 – Adopted IECC 2000

2007 – Adopted IECC 2006

2009 – Adopted IECC 2009, effective since April 1, 2010

On January 24, 2011, the Town of Durham adopted IECC 2012.



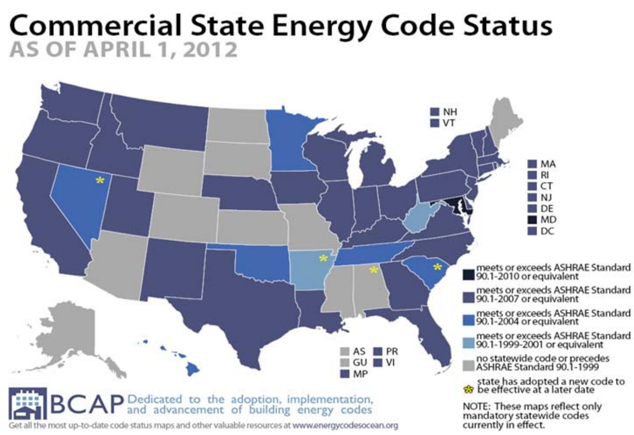
NH Code Compliance Study Results

Cities with Full-Time or Part-Time Code Officials

Public Service of New Hampshire | Unitil | New Hampshire Electric Co-op | nationalgrid THE POWER OF ACTION

ers energy & resource solutions

Nationwide Code Adoption Status



Public Service of New Hampshire | Unitil | New Hampshire Electric Co-op | nationalgrid THE POWER OF ACTION

ers energy & resource solutions

NH Code Compliance Study Results

Top code compliance barriers according to legislative, policy, and regulatory stakeholders

- Lack of resources and support for policy implementation
- Limited knowledge
- Lack of policy enforcement

Top code compliance barriers according to code officials

- Insufficient funding
- Lack of resources and training
- Competing priorities

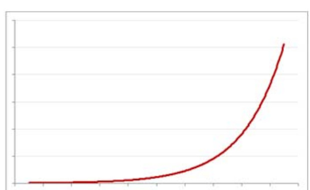
Top code compliance barriers according to builders/contractors, architects, engineers

- Limited knowledge/awareness
- Lack of resources and training
- Customer driven

ers energy & resource solutions | Public Service of New Hampshire | Unitil | New Hampshire Electric Co-op | nationalgrid THE POWER OF ACTION

Advancing Codes

- Getting stricter at a more aggressive rate



- Outcome-based code?
- Potential future codes to include operational elements after occupancy

ers energy & resource solutions | Public Service of New Hampshire | Unitil | New Hampshire Electric Co-op | nationalgrid THE POWER OF ACTION

IECC 2009 Primer

1. Major
   - Mandates daylighting controls in areas with skylights and vertical fenestration
   - Minimum efficiency for unitary AC units raised from 10 SEER (IECC 2006) to 13 SEER
   - Lighting zone-based power allowances are specified for exterior lighting
   - More stringent efficiency requirements for envelope and HVAC equipment
   - Demand control ventilation for high occupancy areas
2. Minor
   - Provisions applicable to large buildings now applicable to small buildings
   - Two options for fan horsepower requirements
   - Metal building insulation requirements are more stringent
   - All skylights to meet stringent U-factor and SHGC
   - Economizers are required when cooling capacity exceeds 54 kBtu/h

> Commercial buildings designed with IECC 2009 save 4.4% to 9.5% site energy when compared to buildings designed with IECC 2006.

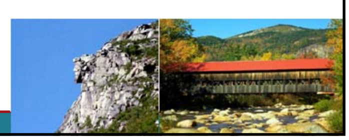
ers energy & resource solutions — Public Service of New Hampshire — Unitil — New Hampshire Electric Co-op — nationalgrid THE POWER OF ACTION

IECC 2012 Primer

1. Major
   - Any conditioned space that is altered has to meet code requirements.
   - In addition to the standard prescriptive requirements, need to meet one additional requirement (efficient HVAC or efficient lighting or on-site renewable energy).
   - Total building performance method energy costs ≤85% of prescriptive method costs.
   - Stringent requirements throughout for envelope measures (changes range from 12% to 30% of the amounts specified in IECC 2009).
   - Requires automated lighting controls in spaces less than 300 sq ft.
2. Minor
   - Higher allowance for skylight and vertical fenestration area if daylighting controls are used
   - Air barrier to be verified by inspection or testing
   - More HVAC and lighting controls requirements

> IECC 2012 is roughly 30% more efficient than IECC 2009

ers energy & resource solutions — Public Service of New Hampshire — Unitil — New Hampshire Electric Co-op — nationalgrid THE POWER OF ACTION



Energy Code Impacts on New Construction Practice

- How do energy codes drive new construction practice?
- Do energy code requirements establish design basis?
- Is code compliance difficult to achieve?
- Comments on code enforcement
- Support for more aggressive codes
  - IECC 2012
  - Other advanced codes

Discussion of Standard Practices in New Construction Projects

- Building envelope
  - Insulation
  - Fenestration
- Lighting
  - Lighting power density
  - Controls
- HVAC systems
  - Unitary systems
  - Chillers
  - Boilers
  - Controls

Energy Efficiency Programs and New Construction Practices

- Do NH energy efficiency programs drive new construction practice?
- Do your firms participate in EE programs?
- Do program requirements represent an aggressive step beyond standard practice?
- Do programs motivate performance beyond energy code requirements or beyond standard practice?

High Performance Programs on New Construction Practices

- Have high performance new construction programs impacted standard practice?
  - LEED
  - Core Performance
- Status of high performance programs in state
- Examples and discussion

Other Factors That Impact New Construction Practices

- Push toward sustainability
- Corporate marketing
- Green washing
- Other drivers

Continued Discussion

- Open discussion on topics of interest

CODE REQUIREMENT TABLES

IECC 2009

TABLE 505.5.2
INTERIOR LIGHTING POWER ALLOWANCES

LIGHTING POWER DENSITY	
Building Area Type[a]	**(W/ft^2)**
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Gymnasium	1.1
Healthcare—clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theater	1.2
Multifamily	0.7
Museum	1.1
Office	1.0
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theater	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3
Retail[b]	1.5
School/University	1.2
Sports Arena	1.1
Town Hall	1.1

TABLE 505.5.2—continued
INTERIOR LIGHTING POWER ALLOWANCES

LIGHTING POWER DENSITY	
Building Area Type[a]	(W/ft^2)
Transportation	1.0
Warehouse	0.8
Workshop	1.4

For SI: 1 foot = 304.8 mm, 1 watt per square foot = $W/0.0929 m^2$.

a. In cases where both a general building area type and a more specific building area type are listed, the more specific building area type shall apply.

b. Where lighting equipment is specified to be installed to highlight specific merchandise in addition to lighting equipment specified for general lighting and is switched or dimmed on circuits different from the circuits for general lighting, the smaller of the actual wattage of the lighting equipment installed specifically for merchandise, or additional lighting power as determined below shall be added to the interior lighting power determined in accordance with this line item.

Calculate the additional lighting power as follows:

Additional Interior Lighting Power Allowance = 1000 watts + (Retail Area 1 × $0.6 W/ft^2$) + (Retail Area 2 × $0.6W/ft^2$) + (Retail Area 3 × $1.4 W/ft^2$) + (Retail Area 4 × $2.5 W/ft^2$).

where:

Retail Area 1 = The floor area for all products not listed in Retail Area 2, 3 or 4.

Retail Area 2 = The floor area used for the sale of vehicles, sporting goods and small electronics.

Retail Area 3 = The floor area used for the sale of furniture, clothing, cosmetics and artwork.

Retail Area 4 = The floor area used for the sale of jewelry, crystal and china.

Exception: Other merchandise categories are permitted to be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is *approved* by the authority having jurisdiction.

IECC 2009

TABLE 503.2.3(1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Air conditioners, Air cooled	< 65,000 Btu/h[d]	Split system	13.0 SEER	AHRI 210/240
		Single package	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	10.3 EER[c] (before Jan 1, 2010) 11.2 EER[c] (as of Jan 1, 2010)	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.7 EER[c] (before Jan 1, 2010) 11.0 EER[c] (as of Jan 1, 2010)	AHRI 340/360
	≥ 240,000 Btu/h and < 760,000 Btu/h	Split system and single package	9.5 EER[c] 9.7 IPLV[c] (before Jan 1, 2010) 10.0 EER[c] 9.7 IPLV[g] (as of Jan 1, 2010)	
	≥ 760,000 Btu/h	Split system and single package	9.2 EER[c] 9.4 IPLV[c] (before Jan 1, 2010) 9.7 EER[c] 9.4 IPLV[c] (as of Jan 1, 2010)	
Through-the-wall, Air cooled	< 30,000 Btu/h[d]	Split system	10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	AHRI 210/240
		Single package	10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	
Air conditioners, Water and evaporatively cooled	< 65,000 Btu/h	Split system and single package	12.1 EER	AHRI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	11.5 EER[c]	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	11.0 EER[c]	AHRI 340/360
	≥ 240,000 Btu/h	Split system and single package	11.5 EER[c]	

For SI: 1 British thermal unit per hour = 0.2931 W.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. IPLVs are only applicable to equipment with capacity modulation.

c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

d. Single-phase air-cooled air conditioners < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA); SEER values are those set by NAECA.

IECC 2009

TABLE 503.2.3(2)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Air cooled, (Cooling mode)	< 65,000 Btu/h[d]	Split system	13.0 SEER	AHRI 210/240
		Single package	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	10.1 EER[c] (before Jan 1, 2010) 11.0 EER[c] (as of Jan 1, 2010)	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.3 EER[c] (before Jan 1, 2010) 10.6 EER[c] (as of Jan 1, 2010)	AHRI 340/360
	≥ 240,000 Btu/h	Split system and single package	9.0 EER[c] 9.2 IPLV[c] (before Jan 1, 2010) 9.5 EER[c] 9.2 IPLV[c] (as of Jan 1, 2010)	
Through-the-Wall (Air cooled, cooling mode)	< 30,000 Btu/h[d]	Split system	10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	AHRI 210/240
		Single package	10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	
Water Source (Cooling mode)	< 17,000 Btu/h	86°F entering water	11.2 EER	AHRI/ASHRAE 13256-1
	≥ 17,000 Btu/h and < 135,000 Btu/h	86°F entering water	12.0 EER	AHRIASHRAE 13256-1
Groundwater Source (Cooling mode)	< 135,000 Btu/h	59°F entering water	16.2 EER	AHRI/ASHRAE 13256-1
Ground source (Cooling mode)	< 135,000 Btu/h	77°F entering water	13.4 EER	AHRI/ASHRAE 13256-1
Air cooled (Heating mode)	< 65,000 Btu/h[d] (Cooling capacity)	Split system	7.7 HSPF	AHRI 210/240
		Single package	7.7 HSPF	
	≥ 65,000 Btu/h and < 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb Outdoor air	3.2 COP (before Jan 1, 2010) 3.3 COP (as of Jan 1, 2010)	
	≥ 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb Outdoor air	3.1 COP (before Jan 1, 2010) 3.2 COP (as of Jan 1, 2010)	AHRI 340/360

(continued)

IECC 2009

TABLE 503.2.3(2)—continued
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Through-the-wall (Air cooled, heating mode)	< 30,000 Btu/h	Split System	7.1 HSPE (before Jan 23, 2010) 7.4 HSPF (as of Jan 23, 2010)	AHRI 210/240
		Single package	7.0 HSPF (before Jan 23, 2010) 7.4 HSPF (as of Jan 23, 2010)	
Water source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	68°F entering water	4.2 COP	AHRI/ASHRAE 13256-1
Groundwater source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	50°F entering water	3.6 COP	AHRI/ASHRAE 13256-1
Ground source (Heating mode)	< 135,000 Btu/h (Cooling capacity)	32°F entering water	3.1 COP	AHRI/ASHRAE 13256-1

For SI: °C = [(°F) - 32]/1.8, 1 British thermal unit per hour = 0.2931 W.

db = dry-bulb temperature, °F; wb = wet-bulb temperature, °F.

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.

c. Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.

d. Single-phase air-cooled heat pumps < 65,000 Btu/h are regulated by the National Appliance Energy Conservation Act of 1987 (NAECA), SEER and HSPF values are those set by NAECA.

IECC 2009

TABLE 503.2.3(7)
WATER CHILLING PACKAGES, EFFICIENCY REQUIREMENTS[a]

EQUIPMENT TYPE	SIZE CATEGORY	UNITS	BEFORE 1/1/2010 FULL LOAD	BEFORE 1/1/2010 IPLV	AS OF 1/1/2010[c] PATH A FULL LOAD	AS OF 1/1/2010[c] PATH A IPLV	AS OF 1/1/2010[c] PATH B FULL LOAD	AS OF 1/1/2010[c] PATH B IPLV	TEST PROCEDURE[b]
Air-cooled chillers	< 150 tons	EER	≥ 9.562	≥ 10.416	≥ 9.562	≥ 12.500	NA[d]	NA[d]	AHRI 550/590
	≥ 150 tons	EER			≥ 9.562	≥ 12.750	NA[d]	NA[d]	
Air cooled without condenser, electrical operated	All capacities	EER	≥ 10.586	≥ 11.782	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water cooled, electrically operated, reciprocating	All capacities	kW/ton	≤ 0.837	≤ 0.696	Reciprocating units must comply with water cooled positive displacement efficiency requirements				
Water cooled, electrically operated, positive displacement	< 75 tons	kW/ton	≤ 0.790	≤ 0.676	≤ 0.780	≤ 0.630	≤ 0.800	≤ 0.600	
	≥ 75 tons and < 150 tons	kW/ton			≤ 0.775	≤ 0.615	≤ 0.790	≤ 0.586	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.717	≤ 0.627	≤ 0.680	≤ 0.580	≤ 0.718	≤ 0.540	
	≥ 300 tons	kW/ton	≤ 0.639	≤ 0.571	≤ 0.620	≤ 0.540	≤ 0.639	≤ 0.490	
Water cooled, electrically operated, centrifugal	< 150 tons	kW/ton	≤ 0.703	≤ 0.669	≤ 0.634	≤ 0.596	≤ 0.639	≤ 0.450	
	≥ 150 tons and < 300 tons	kW/ton	≤ 0.634	≤ 0.596					
	≥ 300 tons and < 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.576	≤ 0.549	≤ 0.600	≤ 0.400	
	≥ 600 tons	kW/ton	≤ 0.576	≤ 0.549	≤ 0.570	≤ 0.539	≤ 0.590	≤ 0.400	
Air cooled, absorption single effect	All capacities	COP	≥ 0.600	NR[e]	≥ 0.600	NR[e]	NA[d]	NA[d]	AHRI 560
Water-cooled, absorption single effect	All capacities	COP	≥ 0.700	NR[e]	≥ 0.700	NR[e]	NA[d]	NA[d]	
Absorption double effect, indirect-fired	All capacities	COP	≥ 1.000	≥ 1.050	≥ 1.000	≥ 1.050	NA[d]	NA[d]	
Absorption double effect, direct fired	All capacities	COP	≥ 1.000	≥ 1.000	≥ 1.000	≥ 1.000	NA[d]	NA[d]	

For SI: 1 ton = 3517 W, 1 British thermal unit per hour = 0.2931 W.

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is < 40°F.

b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or B.

d. NA means that this requirement is not applicable and cannot be used for compliance.

e. NR means that there are no minimum requirements for this category.

ASHRAE 90.1 – 2007

TABLE 9.5.1 Lighting Power Densities Using the Building Area Method

Building Area Type[a]	*LPD* (W/ft^2)
Automotive facility	0.9
Convention center	1.2
Courthouse	1.2
Dining: bar lounge/leisure	1.3
Dining: cafeteria/fast food	1.4
Dining: family	1.6
Dormitory	1.0
Exercise center	1.0
Gymnasium	1.1
Health-care clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing facility	1.3
Motel	1.0
Motion picture theater	1.2
Multifamily	0.7
Museum	1.1
Office	1.0
Parking garage	0.3
Penitentiary	1.0
Performing arts theater	1.6
Police/fire station	1.0
Post office	1.1
Religious building	1.3
Retail	1.5
School/university	1.2
Sports arena	1.1
Town hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

[a] In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply.

ASHRAE 90.1 – 2007

TABLE 6.8.1A Electronically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air conditioners, air cooled	<65,000 Btu/h[c]	All	Split system	10.0 SEER (before 1/23/2006) 13.0 SEER (as of 1/23/2006)	ARI 210/240
			Single package	9.7 SEER (before 1/23/2006) 13.0 SEER (as of 1/23/2006)	
Through-the-wall, air cooled	≤30,000 Btu/h[c]	All	Split system	10.0 SEER (before 1/23/2006) 10.9 SEER(as of 1/23/2006) 12 SEER(as of 1/23/2010)	
			Single package	9.7 SEER (before 1/23/2006) 10.6 SEER(as of 1/23/2006) 12.0 SEER(as of 1/23/2010)	
Air conditioners, air cooled	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	Split system and single package	10.3 EER (before 1/1/2010) 11.2 EER (as of 1/1/2010)	ARI 340/360
		All other	Split system and single package	10.1 EER (before 1/1/2010) 11.0 EER (as of 1/1/2010)	
	≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	Split system and single package	9.7 EER (before 1/1/2010) 11.0 EER (as of 1/1/2010)	
		All other	Split system and single package	9.5 EER (before 1/1/2010) 10.8 EER (as of 1/1/2010)	
	≥240,000 Btu/h and <760,000 Btu/h	Electric resistance (or none)	Split system and single package	9.5 EER (before 1/1/2010) 10.0 EER (as of 1/1/2010) 9.7 IPLV	
		All other	Split system and single package	9.3 EER (before 1/1/2010) 9.8 EER (as of 1/1/2010) 9.5 IPLV	
	≥760,000 Btu/h	Electric resistance (or none)	Split system and single package	9.2 EER (before 1/1/2010) 9.7 EER (as of 1/1/2010) 9.4 IPLV	
		All other	Split system and single package	9.0 EER (as of 1/1/2010) 9.5 EER (as of 1/1/2010) 9.2 IPLV	

ASHRAE 90.1 – 2007

TABLE 6.8.1A Electronically Operated Unitary Air Conditioners and Condensing Units— Minimum Efficiency Requirements *(continued)*

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air conditioners, water and evaporatively cooled	<65,000 Btu/h	All	Split system and single package	12.1 EER	ARI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	Split system and single package	11.5 EER	ARI 340/360
		All other	Split system and single package	11.3 EER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	Split system and single package	11.0 EER	
		All other	Split system and single package	10.8 EER	
	≥240,000 Btu/h	Electric resistance (or none)	Split system and single package	11.0 EER 10.3 IPLV	
		All other	Split system and single package	10.8 EER 10.1 IPLV	
Condensing units, air cooled	≥135,000 Btu/h	–		10.1 EER 11.2 IPLV	ARI 365
Condensing units, water or evaporatively cooled	≥135,000 Btu/h	–		13.1 EER 13.1 IPLV	

[a] IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
[b] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[c] Single-phase, air-cooled air conditioners <65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

ASHRAE 90.1 – 2007

TABLE 6.8.1B Electrically Operated Unitary and Applied Heat Pumps—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air cooled (cooling mode)	<65,000 Btu/h[c]	All	Split system	10.0 SEER (before 1/23/2006) 13.0 SEER (as of 1/23/2006)	ARI 210/240
			Single package	9.7 SEER (before 1/23/2006) 13.0 SEER (as of 1/23/2006)	
Through-the-wall (air cooled, cooling mode)	≤30,000 Btu/h[c]	All	Split system	10.0 SEER (before 1/23/2006) 10.9 SEER (as of 1/23/2006) 12 SEER (as of 1/23/2010)	
			Single package	9.7 SEER (before 1/23/2006) 10.6 SEER (as of 1/23/2006) 12.0 SEER (as of 1/23/2010)	
Air cooled (cooling mode)	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	Split system and single package	10.1 EER (before 1/1/2010) 11.0 EER (as of 1/1/2010)	ARI 340/360
		All other	Split system and single package	9.9 EER (before 1/1/2010) 10.8 EER (as of 1/1/2010)	
	≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	Split system and single package	9.3 EER (before 1/1/2010) 10.6 EER (as of 1/1/2010)	
		All other	Split system and single package	9.1 EER (before 1/1/2010) 10.4 EER (as of 1/1/2010)	
	≥240,000 Btu/h	Electric resistance (or none)	Split system and single package	9.0 EER (before 1/1/2010) 9.5 EER (as of 1/1/2010) 9.2 IPLV	
		All other	Split system and single package	8.8 EER (before 1/1/2010) 9.3 EER (as of 1/1/2010) 9.0 IPLV	
Water source (cooling mode)	<17,000 Btu/h	All	86°F entering water	11.2 EER	ISO-13256-1
	≥17,000 Btu/h and <65,000 Btu/h	All	86°F entering water	12.0 EER	ISO-13256-1
	≥65,000 Btu/h and <135,000 Btu/h	All	86°F entering water	12.0 EER	ISO-13256-1
Groundwater source (cooling mode)	<135,000 Btu/h	All	59°F entering water	16.2 EER	ISO-13256-1
Ground source (cooling mode)	<135,000 Btu/h	All	77°F entering water	13.4 EER	ISO-13256-1
Air cooled (heating mode)	<65,000 Btu/h[c] (cooling capacity)	—	Split system	6.8 HSPF (before 1/23/2006) 7.7 HSPF (as of 1/23/2006)	ARI 210/240
			Single package	6.6 HSPF (before 1/23/2006) 7.7 HSPF (as of 1/23/2006)	
Through-the-wall, (air cooled, heating mode)	≤30,000 Btu/h[c] (cooling capacity)	—	Split system	6.8 HSPF (before 1/23/2006) 7.1 HSPF (as of 1/23/2006) 7.4 HSPF (as of 1/23/2010)	
			Single package	6.6 HSPF (before 1/23/2006) 7.0 HSPF (as of 1/23/2006) 7.4 HSPF (as of 1/23/2010)	

ASHRAE 90.1 – 2007

TABLE 6.8.1B Electrically Operated Unitary and Applied Heat Pumps— Minimum Efficiency Requirements *(continued)*

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air cooled (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.2 COP (before 1/1/2010) 3.3 COP (as of 1/1/2010)	ARI 340/360
			17°F db/15°F wb outdoor air	2.2 COP	
	≥135,000 Btu/h (cooling capacity)	—	47°F db/43°F wb outdoor air	3.1 COP (before 1/1/2010) 3.2 COP (as of 1/1/2010)	
			17°F db/15°F wb outdoor air	2.0 COP	
Water source (heating mode)	<135,000 Btu/h (cooling capacity)	—	68°F entering water	4.2 COP	ISO-13256-1
Groundwater source (heating mode)	<135,000 Btu/h (cooling capacity)	—	50°F entering water	3.6 COP	ISO-13256-1
Ground source (heating mode)	<135,000 Btu/h (cooling capacity)	—	32°F entering water	3.1 COP	ISO-13256-1

[a] IPLVs and part-load rating conditions are only applicable to equipment with capacity modulation.
[b] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[c] Single-phase, air-cooled heat pumps <65,000 Btu/h are regulated by NAECA. SEER and HSPF values are those set by NAECA

ASHRAE 90.1 – 2007

TABLE 6.8.1C Water Chilling Packages–Minimum Efficiency Requirements

Equipment Type	Size Category	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air cooled, with condenser, electrically operated	All capacities	—	2.80 COP 3.05 IPLV	ARI 550/590
Air cooled, without condenser, electrically operated	All capacities	—	3.10 COP 3.45 IPLV	
Water cooled, electrically operated, positive displacement (reciprocating)	All capacities	—	4.20 COP 5.05 IPLV	ARI 550/590
Water cooled, electrically operated, positive displacement (rotary screw and scroll)	<150 tons	—	4.45 COP 5.20 IPLV	ARI 550/590
	≥150 tons and <300 tons	—	4.90 COP 5.60 IPLV	
	≥300 tons	—	5.50 COP 6.15 IPLV	
Water cooled, electrically operated, centrifugal	<150 tons	—	5.00 COP 5.25 IPLV	ARI 550/590
	≥150 tons and <300 tons	—	5.55 COP 5.90 IPLV	
	≥300 tons	—	6.10 COP 6.40 IPLV	
Air-cooled absorption single effect	All capacities	—	0.60 COP	ARI 560
Water-cooled absorption single effect	All capacities	—	0.70 COP	
Absorption double effect, indirect-fired	All capacities	—	1.00 COP 1.05 IPLV	
Absorption double effect, direct-fired	All capacities	—	1.00 COP 1.00 IPLV	

[a] The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is <40°F.
[b] Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

ASHRAE 90.1 – 2007 Supplement 2008

TABLE 6.8.1A Electrically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air Conditioners, Air Cooled	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.3 EER (before 1/1/2010) 11.2 EER (as of 1/1/2010) 11.4 IEER (as of 1/1/2010)	ARI 340/360
		All other	Split System and Single Package	10.1 EER (before 1/1/2010) 11.0 EER (as of 1/1/2010) 11.2 IEER (as of 1/1/2010)	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.7 EER (before 1/1/2010) 11.0 EER (as of 1/1/2010) 11.2 IEER (as of 1/1/2010)	
		All other	Split System and Single Package	9.5 EER (before 1/1/2010) 10.8 EER (as of 1/1/2010) 11.0 IEER (as of 1/1/2010)	
	≥240,000 Btu/h and <760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.5 EER (before 1/1/2010) 10.0 EER (as of 1/1/2010) 9.7 IPLV (before 1/1/2010) 10.1 IEER (as of 1/1/2010)	
		All other	Split System and Single Package	9.3 EER (before 1/1/2010) 9.8 EER (as of 1/1/2010) 9.5 IPLV (before 1/1/2010) 9.9 IEER (as of 1/1/2010)	
	≥760,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.2 EER (before 1/1/2010) 9.7 EER (as of 1/1/2010) 9.4 IPLV (before 1/1/2010) 9.8 IEER (as of 1/1/2010)	
		All other	Split System and Single Package	9.0 EER (before 1/1/2010) 9.5 EER (as of 1/1/2010) 9.2 IPLV (before 1/1/2010) 9.6 IEER (as of 1/1/2010)	
Air Conditioners, Water and Evaporatively Cooled	<65,000 Btu/h	All	Split System and Single Package	12.1 EER 12.3 IEER (as of 1/1/2010)	ARI 210/240
	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.5 EER 11.7 IEER (as of 1/1/2010)	ARI 340/360
		All other	Split System and Single Package	11.3 EER 11.5 IEER (as of 1/1/2010)	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 11.2 IEER (as of 1/1/2010)	
		All other	Split System and Single Package	10.8 EER 11.0 IEER (as of 1/1/2010)	
	≥240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	11.0 EER 10.3 IPLV (before 1/1/2010) 11.1 IEER (as of 1/1/2010)	
		All other	Split System and Single Package	10.8 EER 10.1 IPLV (before 1/1/2010) 10.9 IEER (as of 1/1/2010)	

The remainder of the table is left unchanged.

ASHRAE 90.1 – 2007 Supplement 2008

TABLE 6.8.1B Electrically Operated Unitary and Applied Heat Pumps— Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air Cooled (Cooling Mode)	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	10.1 EER (before 1/1/2010) 11.0 EER (as of 1/1/2010) 11.2 IEER (as of 1/1/2010)	ARI 340/360
		All other	Split System and Single Package	9.9 EER (before 1/1/2010) 10.8 EER (as of 1/1/2010) 11.0 IEER (as of 1/1/2010)	
	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.3 EER (before 1/1/2010) 10.6 EER (as of 1/1/2010) 10.7 IEER (as of 1/1/2010)	
		All other	Split System and Single Package	9.1 EER (before 1/1/2010) 10.4 EER (as of 1/1/2010) 10.5 IEER (as of 1/1/2010)	
	≥240,000 Btu/h	Electric Resistance (or None)	Split System and Single Package	9.0 EER (before 1/1/2010) 9.5 EER (as of 1/1/2010) 9.2 IPLV (before 1/1/2010) 9.6 IEER (as of 1/1/2010)	
		All other	Split System and Single Package	8.8 EER (before 1/1/2010) 9.3 EER (as of 1/1/2010) 9.0 IPLV (before 1/1/2010) 9.4 IEER (as of 1/1/2010)	
Air Cooled (Heating Mode)	≥65,000 Btu/h and <135,000 Btu/h (Cooling Capacity)	–	47°F db/43°F wb Outdoor Air	3.2 COP (before 1/1/2010) 3.3 COP (as of 1/1/2010)	ARI 340/360
			17°F db/15°F wb Outdoor Air	2.2 COP (before 1/1/2010) 2.25 COP (as of 1/1/2010)	
	≥135,000 Btu/h (Cooling Capacity)	–	47°F db/43°F wb Outdoor Air	3.1 COP (before 1/1/2010) 3.2 COP (as of 1/1/2010)	
			17°F db/15°F wb Outdoor Air	2.0 COP (before 1/1/2010) 2.05 COP (as of 1/1/2010)	

The remainder of the table is left unchanged.

ASHRAE 90.1 – 2007 Supplement 2008

TABLE 6.8.1C Water Chilling Packages—Efficiency Requirements[a]

Equipment Type	Size Category	Units	Before 1/1/2010		As of 1/1/2010[c]				Test Procedure[b]
					Path A		Path B		
			Full Load	IPLV	Full Load	IPLV	Full Load	IPLV	
Air-Cooled Chillers	≤150 tons	EER	≥9.562	≥10.416	≥9.562	≥12.500	NA[d]	NA[d]	ARI 550/590
	≥150 tons	EER			≥9.562	≥12.750	NA[d]	NA[d]	
Air-Cooled without Condenser, Electrical Operated	All Capacities	EER	≥10.586	≥11.782	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements				
Water Cooled, Electrically Operated, Reciprocating	All Capacities	kW/ton	≤0.837	≤0.696	Reciprocating units must comply with water cooled positive displacement efficiency requirements				
Water Cooled, Electrically Operated, Positive Displacement	≤75 tons	kW/ton	≤0.790	≤0.676	≤0.780	≤0.630	≤0.800	≤0.600	
	≥75 tons and < 150 tons	kW/ton	≤0.790	≤0.676	≤0.775	≤0.615	≤0.790	≤0.586	
	≥150 tons and < 300 tons	kW/ton	≤0.717	≤0.627	≤0.680	≤0.580	≤0.718	≤0.540	
	≥300 tons	kW/ton	≤0.639	≤0.571	≤0.620	≤0.540	≤0.639	≤0.490	
Water Cooled, Electrically Operated, Centrifugal	≤150 tons	kW/ton	≤0.703	≤0.669	≤0.634	≤0.596	≤0.639	≤0.450	
	≥150 tons and < 300 tons	kW/ton	≤0.634	≤0.596	≤0.634	≤0.596	≤0.639	≤0.450	
	≥300 tons and < 600 tons	kW/ton	≤0.576	≤0.549	≤0.576	≤0.549	≤0.600	≤0.400	
	≥600 tons	kW/ton	≤0.576	≤0.549	≤0.570	≤0.539	≤0.590	≤0.400	
Air Cooled Absorption Single Effect	All Capacities	COP	≥0.600	NR[e]	≥0.600	NR[e]	NA[d]	NA[d]	ARI 560
Water-Cooled Absorption Single Effect	All Capacities	COP	≥0.700	NR[e]	≥0.700	NR[e]	NA[d]	NA[d]	
Absorption Double Effect Indirect-Fired	All Capacities	COP	≥1.000	≥1.050	≥1.000	≥1.050	NA[d]	NA[d]	
Absorption Double Effect Direct-Fired	All Capacities	COP	≥1.000	≥1.000	≥1.000	≥1.000	NA[d]	NA[d]	

a. The chiller equipment requirements do not apply for chillers used in low-temperature applications where the design leaving fluid temperature is <40°F.
b. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
c. Compliance with this standard can be obtained by meeting the minimum requirements of Path A or Path B. However, both the full load and IPLV must be met to fulfill the requirements of Path A or Path B.
d. *NA* means that this requirement is not applicable and cannot be used for compliance.
e. *NR* means that there are no minimum requirements for this category.