NEW HAMPSHIRE
TECHNICAL REFERENCE MANUAL
for Estimating Savings from Energy Efficiency Measures, 2021 Program Year

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Table of Contents

Introduction

This *New Hampshire Technical Reference Manual for Estimating Savings from Energy Efficiency Measures* ("TRM") documents for regulatory agencies, customers, and other stakeholders how the New Hampshire Utilities consistently, reliably, and transparently calculate savings from the installation of efficient equipment, collectively called "measures." This reference manual provides methods, formulas and default assumptions for estimating energy, peak demand and other resource impacts from efficiency measures.

Within this document, efficiency measures are organized by the sector for which the measure is eligible and by the primary energy source associated with the measure. The three sectors are Residential, Income Eligible, and Commercial & Industrial ("C&I"). The primary energy sources addressed in this technical reference document are electricity and natural gas, and savings from delivered fuels such as oil and propane are also addressed where appropriate.

Each measure is presented in its own section as a measure characterization. The measure characterizations provide mathematical equations for determining savings (algorithms), as well as default assumptions and sources, where applicable. In addition, any descriptions of calculation methods or baselines are provided as appropriate. The parameters for calculating savings are listed in the same order for each measure. The measure calculations and assumptions provided in the TRM will match those found in the Benefit Cost Models ("BC Models") created by utilities. There are some measures in the BC models that we do not currently anticipate incentivizing, and therefore have not been reflected in the TRM. If the opportunity arises to offer them in a cost-effective way, we will update the TRM with entries for these measures at that time.

Algorithms are provided for estimating annual energy and peak demand impacts for primary and secondary energy sources if appropriate. In addition, algorithms or calculated results may be provided for other nonenergy impacts (such as water savings or operation and maintenance cost savings). Inputs and assumptions are based on New Hampshire-specific evaluations or data where available Other factors being equal, New Hampshire jurisdiction-specific results will be favoured over results from other jurisdictions in order to account for differences in climate, hours of use, program design and delivery, market conditions, and evaluation frameworks. However, when relevant results exist both from New Hampshire and from other states, it may be necessary to balance the desirable attributes of state-specificity and data reliability. When considering whether to apply results from a study originating in another jurisdiction to New Hampshire programs, the EM&V Working Group (with support from independent evaluation firms as needed), will make the determination based on (1) the similarity of evaluated program/measures to those offered in NH; (2) the similarity of relevant markets and customers base; (3) the recency of the study relative to the recency of any applicable NH results; and (4) the quality of the study's methodology and sample size. In addition to third-party evaluations, inputs may also be based on sources including manufacturer and industry data, data from government agencies such as the U.S. Department of Energy or Environmental Protection Agency, or credible and realistic factors developed using engineering judgment.

This document will be reviewed and updated annually to reflect changes in technology, baselines and evaluation results.

Reference Tables

<u>PROGRAM ABBREVIATIONS</u>

Commercial	
Energy Rewards RFP Program	RFP
Large Business Energy Solutions	LBES
Municipal Energy Solutions	Muni
Small Business Energy Solutions	SBES
Residential	
ENERGY STAR Homes	ES Homes
ENERGY STAR Products	ES Products
Home Energy Assistance	HEA
Home Energy Reports	HER
Home Performance with ENERGY STAR	HPwES

<u>CATEGORIES</u>

Appliances
Building Shell
Compressed Air
Custom
Food Service
Heating Ventilation and Air Conditioning (HVAC)
Hot Water
Lighting
Motors and Drives
Whole Home

Measure Characterization Structure

This section describes the common entries or inputs that make up each measure characterization. A formatted template follows the descriptions of each section of the measure characterization. A single device or behavior is defined as a measure within each program and fuel. The source of each assumption or default parameter value will be referenced in the endnotes section of each measure chapter.

Measure Code	A unique way to identify a measure where the first set of characters indicates the market, the second set of characters indicates the category, and the third set is an abbreviated code for the measure name.
Market	This is the sector for which the measure is applicable and can be Residential, Income Eligible or C&I.
Program Type	The type of baseline used (i.e., retrofit, lost opportunity).
Category	The category of measure type, based on list above.

Description:

This section will include a plain text description of the energy efficiency measure, including the benefit(s) of its installation.

Baseline Efficiency:

This section will include a statement of the assumed equipment/operation efficiency in the absence of program intervention. Multiple baselines will be provided as needed, e.g., for different markets. Baselines may refer to reference tables or may be presented as a table for more complex measures.

High Efficiency:

This section will describe the high efficiency case from which the energy and demand savings are determined. The high efficiency case may be based on specific details of the measure installation, minimum requirements for inclusion in the program, or an energy efficiency case based on historical participation. It may refer to tables within the measure characterization or in the appendices or efficiency standards set by organizations such as ENERGY STAR® and the Consortium for Energy Efficiency.

Algorithms for Calculating Primary Energy Impact:

This section will describe the method for calculating electric savings and electric demand savings in appropriate units.

The savings algorithm will be provided in a form similar to the following:

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

Similarly, the method for calculating electric demand savings will be provided in a form similar to the following:

$$\Delta kW = \left(Watts_{BASE} - Watts_{EE}\right)/1000$$

This section also describes any non-electric (gas, propane, oil) savings in appropriate units, i.e., MMBtu associated with the energy efficiency measure, including all assumptions and the method of calculation.

This section will, as appropriate, summarize electric and non-electric savings in a table that contains the following information:

Measure Name: <Name used in utilities' Benefit-Cost models >
Program: <Defined by utilities, also referred to as Program Name>
Savings: <Measure savings in units of kWh, kW, MMBtu, or other as applicable; this information may be contained in multiple fields>

Measure Life:

This section will provide the measure life for each measure and describe the measure life basis, e.g., effective useful life (EUL) or adjusted measure life (AML). It will note any adjustments made, such as for LED market trends.

BC Measure ID	Measure Name	Program	Measure Life
[Unique ID for measures in the utilities' Benefit-Cost model]	[Measure Name]	[Program Abbreviation from list above]	XX

Other Resource Impacts:

If applicable, this section describes any water or ancillary savings associated with the energy efficiency measure, including all assumptions.

Impact Factors for Calculating Adjusted Gross Savings:

The section includes a table of impact factor values for calculating adjusted gross savings. These include in-service rates, realization rates, and coincidence factors. Further descriptions of the impact factors and the sources on which they are based are described below.

ISR = In-Service Rate
CF_{SP} = Peak Coincidence Factor (summer peak)
CF_{WP} = Peak Coincidence Factor (winter peak)
RR_E = Realization Rate, electric(kWh)
RR_{NE} = Realization Rate, non-electric (MMBtu)
RR_{SP} = Realization Rate for summer peak kW
RR_{WP} = Realization Rate for winter peak kW

Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
[Measure Name]	[Program abbreviation]	X.XX	X.XX	n/a	X.XX	X.XX	X.XX	X.XX

In-Service Rates:

Actual portion of efficient units that are installed. For example, efficient lamps may have an in-service rate less than 1.00 since some lamps are purchased as replacement units and are not immediately installed. The ISR is 1.00 for most measures.

Realization Rates:

Used to adjust the gross savings (as calculated by the savings algorithms) based on impact evaluation studies. The realization rate is equal to the ratio of measure savings developed from an impact evaluation to the estimated measure savings derived from the savings algorithms. The realization rate does not include the effects of any other impact factors, unless explicitly noted. Depending on the impact evaluation study, there may be separate Realization Rates for electric energy (kWh), peak demand (kW), or non-electric energy (MMBtu).

Coincidence Factors:

Adjusts the connected load kW savings derived from the savings algorithm. A coincidence factor represents the fraction of the connected load reduction expected to occur at the same time as a particular system peak period. The coincidence factor includes both coincidence and diversity factors combined into one number, thus there is no need for a separate diversity factor in this TRM.

Energy Load Shape:

The section includes a table or reference with the time-of-use pattern of a typical customer's electrical energy consumption for each segment and end use. Because the value of avoided energy varies throughout the year, load shapes are used to allocate energy savings into specific time periods in order to better reflect its time-dependent value. Load shapes are defined as follows based on ISO-NE definitions:

- Summer On-Peak: 7 am to 11 pm, weekdays, during the months of June through September, except ISO-NE holidays;
- Summer Off-Peak: All other hours during the months of June through September (includes weekends and holidays);
- Winter On-Peak: 7 am to 11 pm, weekdays, during the months of October through May, except ISO-NE holidays; and
- Winter Off-Peak: All other hours during the months of October through May (includes weekends and holidays).

Impact Factors for Calculating Net Savings:

The amount of savings attributable to a program or measure. Net savings differs from "Gross Savings" because it includes adjustments from impact factors, such as free-ridership or spillover. The ratio of net savings to gross savings in known as the Net-to-Gross ratio and is usually expressed as a percent.

This section would only apply to midstream and upstream offerings, which are known to have greater levels of free-ridership than other programs as an inherent part of their program design. For other programs, the utilities will prioritize designing programs and putting mechanisms in place to minimize free-riders, in line with precedent from the 1999 NH EE Working Group report, which stated that "program designs should attempt to minimize free-riders" but "the methodological challenges and associated costs of accurately assessing free-riders no longer justifies the effort required".

Non-Energy Impacts:

As discussed with the NH Benefit/Cost Working Group, and per Commission Order,[1] the NH Utilities are applying non-energy impacts (NEIs) in cost-effectiveness screening as follows:

The **Primary Granite State Test** reflects low-income participant NEIs, based on New Hampshire-specific primary research on the Home Energy Assistance program. Specifically, based on the HEA evaluation,[2] a per-project value of $406 reflecting participant NEIs—including increased comfort, decreased noise, and health-related NEIs—will be applied annually to each weatherization project over its 15-year measure life. These NEIs are reflected in the measure chapters for insulation and air sealing.

The **Secondary Granite State Test** reflects sector-level percentage adders for participant NEIs for the residential (non-low-income) and C&I sectors, based on a review of secondary NEI research from similar jurisdictions, adjusted for New Hampshire-specific economic and other factors and matched to New Hampshire's programs and measures.[3] The test also reflects environmental externality NEIs, based on non-embedded avoided cost values from the AESC. These NEI values are not reflected in the TRM measure chapters. For HEA, the same primary research NEI value is applied in the Secondary Granite State Test as in the Primary Granite State Test.

Both the **Primary and Secondary Granite State Tests** reflect other resource impacts for water and delivered fuels, as reflected in the TRM measure chapters.

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[1] Docket No. DE 17-136, Order Approving Benefit Cost Working Group Recommendations, No. 26,322, December 30, 2019; Order Approving 2020 Update Plan, No. 26,323, December 31, 2019.

[2] Opinion Dynamics. Home Energy Assistance Program Evaluation Report 2016-2017, Final, July 29, 2020. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20200729-NHSaves-HEA-Evaluation-Report-FINAL.pdf

[3] DNV-GL. New Hampshire Non-Energy Impacts Database Methodology Memo, April 2020. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/Final-NH-NEI-Methodology-Memo-20200409.pdf; New Hampshire Non-Energy Impacts Database, July 2020. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20200722-NH-NEI-Draft-Database-NHML-core.xlsm

Impact Factors for Calculating Adjusted Gross and Net Savings

The New Hampshire Utilities use the algorithms in the Measure Characterization sections to calculate the gross savings for energy efficiency measures. Impact factors are then applied to make various adjustments to the gross savings estimates to account for the performance of individual measures or energy efficiency programs as a whole in achieving energy reductions as assessed through evaluation studies. Impact factors address both the technical performance of energy efficiency measures and programs, accounting for the measured energy and demand reductions realized compared to the gross estimated reductions, as well as in certain cases the programs' effect on the market for energy efficient products and services.

This section describes the types of impact factors used to make such adjustments, and how those impacts are applied to gross savings estimates.

Types of Impact Factors

The impact factors used to adjust savings fall into one of two categories:

Impact factors used to adjust gross savings:

- In-Service Rate ("ISR")
- Realization Rate ("RR")
- Summer and Winter Peak Demand Coincidence Factors ("CF")

Impact factors used to calculate net savings:

- Free-Ridership ("FR") and Spillover ("SO") Rates
- Net-to-Gross Ratios ("NTG")

The **in-service rate** is the actual portion of efficient units that are installed. For example, efficient lamps may have an in-service rate less than 1.00 since some lamps are purchased as replacement units and are not immediately installed. The ISR is 1.00 for most measures.

The **realization rate** is used to adjust the gross savings (as calculated by the savings algorithms) based on impact evaluation studies. The realization rate is equal to the ratio of measure savings developed from an impact evaluation to the estimated measure savings derived from the savings algorithms. The realization rate does not include the effects of any other impact factors. Depending on the impact evaluation study, there may be separate Realization Rates for electric energy (kWh), peak demand (kW), or non-electric energy (MMBtu).

A **coincidence factor** adjusts the connected load kW savings derived from the savings algorithm. A coincidence factor represents the fraction of the connected load reduction expected to occur at the same time as a particular system peak period. The coincidence factor includes both coincidence and diversity factors combined into one number, thus there is no need for a separate diversity factor in this TRM. Coincidence Factors are provided for the on-peak period as defined by the ISO New England for the Forward Capacity Market ("FCM"), and are calculated consistently with the FCM methodology. Electric demand reduction during the ISO New England peak periods is defined as follows:

On-Peak Definition (applicable definition for NH):

- Summer On-Peak: average demand reduction from 1:00-5:00 PM on non-holiday weekdays in June July, and August
- Winter On-Peak: average demand reduction from 5:00-7:00 PM on non-holiday weekdays in December and January

Seasonal Peak Definition (not applied in NH):

- Summer Seasonal Peak: demand reduction when the real-time system hourly load is equal to or greater than 90% of the most recent "50/50" system peak forecast for June-August
- Winter Seasonal Peak: demand reduction when the real-time system hourly load is equal to or greater than 90% of the most recent "50/50" system peak load forecast for December-January

The values described as Coincidence Factors in the TRM are not always consistent with the strict definition of a Coincidence Factor (CF). It would be more accurate to define the Coincidence Factor as "the value that is multiplied by the Gross kW value to calculate the average kW reduction coincident with the peak periods." For example, a coincidence factor of 1.00 may be used because the coincidence is already included in the estimate of Gross kW; this is often the case when the "Max kW Reduction" is not calculated and instead the "Gross kW" is estimated using the annual kWh reduction estimate and a loadshape model.

The **net savings** value is the final value of savings that is attributable to a measure or program. Net savings differs from gross savings because it includes the effects of the free-ridership and/or spillover rates. Net savings currently apply to midstream and upstream offerings, which are known to have greater levels of free-ridership than other programs as an inherent part of their program design. For other programs, the utilities will prioritize designing programs and putting mechanisms in place to minimize free-riders, in line with precedent from the 1999 NH EE Working Group report, which stated that "program designs should attempt to minimize free-riders" but "the methodological challenges and associated costs of accurately assessing free-riders no longer justifies the effort required".

A **free-rider** is a customer who participates in an energy efficiency program (and gets an incentive) but who would have installed some or all of the same measure(s) on their own, with no change in timing of the installation, if the program had not been available. The free-ridership rate is the percentage of savings attributable to participants who would have installed the measures in the absence of program intervention.

The **spillover rate** is the percentage of savings attributable to a measure or program, but additional to the gross (tracked) savings of a program. Spillover includes the effects of 1) participants in the program who install additional energy efficient measures outside of the program as a result of participating in the program, and 2) non-participants who install or influence the installation of energy efficient measures as a result of being aware of the program. These two components are the participant spillover (SOP) and nonparticipant spillover (SONP).

The **net-to-gross ratio** is the ratio of net savings to the gross savings adjusted by any impact factors (i.e., the "adjusted" gross savings). Depending on the evaluation study, the NTG ratio may be determined from the free-ridership and spillover rates, if available, or it may be a distinct value with no separate specification of FR and SO values.

1.0 Residential

1.1 Active Demand Response – Residential

Measure Code	[Code]
Market	Residential
Program Type	Custom
Category	Active Demand Response

Description:

Residential Direct Load Control is focused on reducing electrical demand during summer peak load periods by controlling equipment inside a building, such as via wi-fi connected thermostats, communicating domestic hot water heaters and pool pumps, and other controlled energy-using devices.

Residential Storage Daily Dispatch involves customers receiving incentives to decrease demand by discharging energy from storage in response to a signal or communication from the Program Administrators. Residential Storage Daily Dispatch demand response periods may occur during peak hours in summer months.

Summer peak load control periods for both Residential Direct Load Control and Residential Storage Daily Dispatch are three-hour events that may occur between 2:00 p.m. and 7:00 p.m. on non-holiday weekdays between June 1 and September 30.

Baseline Efficiency:

For Direct Load Control, evaluators determined baseline conditions using an experimental design methodology (randomly assigned treatment and control groups), or a within-subject methodology or savings adjustment factor for demand reduction events where experimental design was not possible. For thermostat controls in the Residential Direct Load Control program, vendor-supplied baselines may use one of several baseline methodologies to determine savings. The assumption in this document is that either the ISO-NE[1] or PJM[2] demand response customer baseline operation models are used by the vendor.

The baseline case for Residential Storage Daily Dispatch is an equivalent residential home with onsite energy storage, including any onsite solar PV production, but without peak demand response control.[3]

High Efficiency:

The high efficiency case is a residential building with devices that are equipped to communicate with the utility to reduce demand during curtailment periods. This could include communicating thermostats, residential storage equipment, or other types of residential demand response equipment.

Note that active demand response is not intended to reduce energy use, but rather to reduce power consumption during demand response periods. As a result, little energy savings are available for Residential Direct Load Control. A small amount of energy savings per demand response event is provided in the section below.

For Residential Storage Daily Dispatch, a negative net kWh impact should be assessed to account for round-trip efficiency losses during the charging and discharging periods.

Algorithms for Calculating Primary Energy Impact:

Thermostat control programs are the most widely implemented, and therefore have the most well-supported savings findings.

For vendors that use ISO-NE or PJM baselines to calculate demand savings for central air conditioners controlled by wi-fi connected thermostats, an adjustment to vendor-claimed demand savings based on evaluation results[4] is applied:

$$\Delta kW_{Pre-event} = \left(\Delta kW_{Pre-event,vendor}\right) \times \left(F_{pre-event}\right)$$
$$\Delta kW_{Post-event} = \left(\Delta kW_{Post-event,vendor}\right) \times \left(F_{post-event}\right)$$
$$\Delta kW_{Event} = (\Delta kW_{vendor}) \times (F_{event})$$
$$F_{event} = -3.06 + (0.05 \times Temp_{avg})$$

Where,

Unit	= one dispatched thermostat
$\Delta kW_{Pre-event}$	= demand adjustment for pre-cooling before event
$\Delta kW_{post-event}$	= demand adjustment for recovery cooling after event
$\Delta kW_{pre/post/event,vendor}$	= vendor demand savings in the period of interest (i.e. pre-event, during event, or post-event), typically calculated relative to ISO-NE or PJM baseline
$F_{pre-event}$	= savings adjustment factor in the pre-event period = 0.72
$F_{post-event}$	= savings adjustment factor in the post-event period = 0.68
F_{event}	$= -3.06 + (0.05 \times Temp_{avg})$
$Temp_{avg}$	= average outdoor air temperature during the event period

For demand response events that affect central air conditioners controlled by a wi-fi connected thermostat: a deemed energy savings of 0.67 kWh[4] per event.

For Residential Storage Daily Dispatch, energy savings are measured directly at the device, on a site-by-site basis, as reported by the vendor:

$$\Delta kW_{Event} = \Delta kW_{vendor}$$

More detailed savings algorithms for Residential Storage Daily Dispatch and other types of residential active demand response measures, with pre-, during-, and post-event savings adjustments, may be developed as additional program evaluations are conducted.

Measure Life:

As all residential active demand response measures are based on Program Administrators calling demand reduction events each year, the deemed measure life is 1 year.[4]

BC Measure ID	Measure Name	Program	Measure Life

E21A5a001	Residential Direct Load Control	Residential ADR	1
E21A5a002	Residential Storage Daily Dispatch P4P (savings) Summer	Residential ADR	1
E21A5a003	Residential Storage Daily Dispatch P4P (consumption) Summer	Residential ADR	1

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A5a001	Residential Direct Load Control	Residential ADR	1.00	1.00	1.00	1.00	1.00	1.00	0.00
E21A5a002	Residential Storage Daily Dispatch P4P (savings) Summer	Residential ADR	1.00	1.00	1.00	1.00	1.00	1.00	0.00
E21A5a003	Residential Storage Daily Dispatch P4P (consumption) Summer	Residential ADR	1.00	1.00	1.00	1.00	1.00	1.00	0.00

<u>In-Service Rates:</u>

All installations are assumed to have 100% in-service-rates pending program evaluation. Event opt-outs and attrition during events are captured in the gross impact algorithm above.

<u>Realization Rates:</u>

Savings adjustment factors and deemed energy savings provided in the Algorithms section above represent an evaluation adjustment to vendor-reported reported gross savings.

<u>Coincidence Factors:</u>

Summer coincidence factors are assumed to be 100% reflecting the timing of demand response events. Winter coincidence factors are assumed to be 0%.

Scaling Factors:

A scaling factor is used to account for the fact that the benefits of an active demand response resource depend on how often it performs. The greater the frequency of demand response events, the more that the active demand resource reduces the installed capacity requirement, and therefore the greater its value. For planning the utilities use a scaling factor of 10% for direct load control and 100% for storage, reflecting the AESC 2018 review of sensitivity analyses run by PJM load forecasters.[3] For reporting utilities will use scaling factor values based on the most recent evaluation timing of events that are called in 2021..

Energy Load Shape:

All savings for Active Demand Response take place in the summer on-peak period.

Endnotes:
1: ISO New England (2014). ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources (Manual M-MVDR). Revision 6, June 1, 2014 https://www.iso-ne.com/static-assets/documents/2017/02/mmvdr_measurement-and-verification-demand-reduction_rev6_20140601.pdf

2: Day-Ahead and Real-Time Market Operations (2019). PJM Manual 11: Energy & Ancillary Services Market Operations, Revision 108. Effective Date: December 3, 2019. https://www.pjm.com/~/media/documents/manuals/m11.ashx

3: Navigant Consulting (2020). 2019 Residential Energy Storage Demand Response Demonstration Evaluation, Summer Season. Prepared for National Grid and Unitil. MA. http://ma-eeac.org/wordpress/wp-content/uploads/MA19DR02-E-Storage_Res-Storage-Summer-Eval_wInfographic_2020-02-10-final.pdf

4: Navigant Consulting (2020). 2019 Residential Wi-Fi Thermostat Direct Load Control Offering Evaluation. Prepared for Eversource, National Grid, and Unitil. MA and CT. http://ma-eeac.org/wordpress/wp-content/uploads/2019-Residential-Wi-Fi-Thermostat-DLC-Evaluation-Report-2020-04-01-with-Infographic.pdf

5: The PA program evaluation plan and the measure life for behavioural measures are as published in the 2019-2021 Massachusetts Three-Year Energy Efficiency Plan. http://ma-eeac.org/wordpress/wp-content/uploads/Exh.-1-Final-Plan-10-31-18-With-Appendices-no-bulk.pdf

1.2 Appliances - Advanced Power Strip

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Lost Opportunity
Category	Appliances

Description:

Advanced power strips can automatically eliminate standby power loads of electronic peripheral devices that are not needed (DVD player, computer printer, scanner, etc.) either automatically or when an electronic control device (typically a television or personal computer) is in standby or off mode.

Baseline Efficiency:

The baseline efficiency case is the customers' electronic peripheral devices as they are currently operating.

High Efficiency:

The high efficiency case is the installation of an Advanced Power Strip.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on refenced study results.[1]

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21A3b001	Advanced Power Strip, Tier I	ES Products	117.00	0.011
E21A3b002	Advanced Power Strip, Tier II	ES Products	174.00	0.018

Measure Life:

The measure life is 5 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b001	Advanced Power Strip, Tier I	ES Products	0.86	0.92	n/a	0.92	0.92	0.58	0.86
E21A3b002	Advanced Power Strip, Tier II	ES Products	0.75	0.92	n/a	0.92	0.92	0.58	0.86

<u>In-Service Rates:</u>

In-service rates are based on consumer surveys, as found in the referenced study.[1]

<u>Realization Rates:</u>

Realization rates account for the savings lost due to improper customer set-up/use of devices, as found in the referenced study.[1]

<u>Coincidence Factors:</u>

Programs use a summer coincidence factor of 58% and a winter coincidence factor of 86%.[2]

Energy Load Shape:

See Appendix 1 – "Primary TV and Peripherals".[2]

<u>Endnotes</u>:
1: NMR Group, Inc. (2018). Advanced Power Strip Metering Study. Prepared for Massachusetts Program Administrators and EEAC.
2: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.3 Appliances – Clothes Dryer

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	Appliances

Description:

Clothes dryers exceeding minimum qualifying efficiency standards established as ENERGY STAR® or most efficient.

Baseline Efficiency:

For lost opportunity applications, the baseline efficiency case is a new electric resistance dryer that meets the federal standard as of January 1, 2015 which is a Combined Energy Factor (EF) of 3.73 for a vented standard dryer[1]. Different testing procedures were used in setting the federal standard (DOE Test Procedure Appendix D1) and the Energy Star standard (DOE Test Procedure Appendix D2). To enable comparison a baseline CEF of 3.11 is used. This was derived from ENERGY STAR Version 1.0 Estimated Baseline which multiplies the 2015 federal standard by the average change in electric dryers' assessed CEF between Appendix D1 and Appendix D2: 3.73-(3.73*0.166).
For retrofit applications, the baseline efficiency case is the existing electric resistance dryer.

High Efficiency:

The high efficiency case is a clothes dryer that meets the ENERGY STAR standard as of May 19, 2014. For a new standard vented or ventless electric resistance dryer the minimum CEF is 3.93[2].
For Heat Pump and Hybrid technology clothes dryers, CEFs are based on an average of Northwest Energy Efficiency Alliance qualified product testing as of October 2019. For Heat Pump technology dyers, the average CEF is 6.83. For Hybrid technology clothes dryers, the average CEF is 4.30.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on EPA ENERGY STAR list and Northwest Energy Efficiency Alliance lab testing results. Demand savings are derived from the Navigant Demand Impact Model.[6]

$$\Delta kWh = (lbs/YEAR \div CEF_{Base}) - (lbs/YEAR \div CEF_{EFF})$$

Where:
Lbs/YEAR = Typical pounds of clothing dried per year (based on 8.45 lbs/load and 283 loads/yr)
CEF_{BASE} = Baseline Combined Energy Factor (lbs/kWh)
CEF_{EFF} = Efficient Combined Energy Factor (lbs/kWh)

Unit savings [3,4,5]

BC Measure Id	Measure Name	Program	ΔkWh	ΔkW	ΔGas MMBtu
E21B1a052	Clothes Dryer (Retrofit)	HEA	Calculated	Calculated	n/a
E21A2a055	Clothes Dryer (Retrofit)	HPwES	Calculated	Calculated	n/a
E21A1a027	Clothes Dryer (New Construction)	ES Homes	160.4	0.047	n/a
E21A3b010	Clothes Dryer (ENERGY STAR)	ES Products	160.4	0.047	n/a
E21A3b012	Clothes Dryer (ENERGY STAR + Hybrid technology)	ES Products	213.3	0.063	n/a
E21A3b011	Clothes Dryer (ENERGY STAR + Heat Pump technology)	ES Products	421.1	0.124	n/a

Measure Life:

The measure life is 12 years.[6]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a052	Clothes Dryer (Retrofit)	HEA	1.00	0.91	n/a	0.91	0.91	0.45	0.58
E21A2a055	Clothes Dryer (Retrofit)	HPwES	0.99	0.96	n/a	0.96	1.00	0.45	0.58
E21A1a027	Clothes Dryer (New Construction)	ES Homes	1.00	1.00	n/a	1.00	1.00	0.45	0.58
E21A3b010	Clothes Dryer (ENERGY STAR + Hybrid technology)	ES Products	1.00	1.00	n/a	1.00	1.00	0.45	0.58
E21A3b012	Clothes Dryer (ENERGY STAR + Heat Pump technology)	ES Products	1.00	1.00	n/a	1.00	1.00	0.45	0.58

In-Service Rates:

Installations have 100% in service rate for ES Products unless an evaluation finds otherwise, 100% for HEA[8], and 99% for HPwES[7].

Realization Rates:

Realization rates are 100% for ES Products unless an evaluation finds otherwise, 91% for HEA[8], and 100% for HPwES[7].

Coincidence Factors:

Programs a summer coincidence factor of 45% and a winter coincidence factor of 58%.[9]

Energy Load Shape:

See Appendix 1 – "Clothes Dryer – Electric". [9]

Endnotes:

1: DOE (accessed July 2020). Energy Conservation Program: Energy Conservation Standards for Residential Clothes Dryers. https://www.energy.gov/sites/prod/files/2015/03/f20/Clothes%20Dryer%20Standards_RFI.pdf
2: EnergyStar Energy Efficient Products (accessed July 2020): https://www.energystar.gov/products/appliances/clothes_dryers/key_product_criteria
3: Northwest Energy Efficiency Alliance (2019). Dryers - QPL October 2019.
4: Department of Energy (2015). 10 CFR Part 431 March 27, 2015. Energy Conservation Program: Energy Conservation Standards for Residential Clothes Dryers. Table II.7.
5: Department of Energy (2013). 10 CFR Parts 429 and 430 August 14, 2013. Energy Conservation Program: Test Procedures for Residential Clothes Dryers; Final Rule. Table 11.1.
6: Environmental Protection Agency (2018). Savings Calculator for ENERGY STAR Qualified Appliances. Energy_Star_2018_Consumer_Appliance_Calculator
7: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL, https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/NHSaves-HPwES-Evaluation-Report-Final-20200611.pdf
8: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.
9: Navigant Consulting, 2018. RES1 Demand Impact Model Update. https://ma-eeac.org/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.4 Appliances – Clothes Washer

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	Appliances

Description:

Clothes washers exceeding minimum qualifying efficiency standards established as ENERGY STAR® or Most Efficient. The measure saves electric energy used by the washer itself, as well as heating energy (in the form of electricity or fossil fuel) associated with the heating of the domestic hot water (DHW) consumed during the wash cycles. DHW heating efficiency is assumed to be code-compliant.

Baseline Efficiency:

For lost opportunity baseline, the base efficiency case is a residential clothes washer that meets the federal standard for front-loading washers effective 3/7/2015 which requires an IMEF (Integrated Modified Energy Factor) no less than 1.84 and an IWF (Integrated Water Factor) no greater than 4.7, and for top-loading washers effective 1/1/18 which requires an IMEF no less than 1.57 and an IWF no greater than 6.5. For retrofit baseline, the base efficiency case is the existing residential clothes washer.

High Efficiency:

The high efficiency case is a residential clothes washer that meets the ENERGY STAR standard as of February 5, 2018. For a new front-loading clothes washer the minimum IMEF is 2.76 and the maximum IWF is 3.2. For a new top-loading clothes washer the minimum IMEF is 2.06 and the maximum IWF is 4.3.

Algorithms for Calculating Primary Energy Impact:

Unit electric savings are based on weighted averages by efficiency class presented in the 2018 Efficiency Vermont TRM[1]. Demand savings are derived from the Navigant Demand Impact Model[5]. Fossil fuel DHW savings are based on NH-specific water heating fuel types.

Measure ID	**Measure Name**	**Program**	**ΔkWh**	**ΔkW**	**ΔGas MMBtu**	**ΔOil MMBtu**	**ΔPropane MMBtu**
E21B1a051	Clothes Washer (Retrofit)	HEA	Calculated	Calculated	Calculated	Calculated	Calculated
E21A2a054	Clothes Washer (Retrofit)	HPwES	Calculated	Calculated	Calculated	Calculated	Calculated
E21A1a026	Clothes Washer (New Construction)	ES Homes	89.9	0.279	0.000	0.000	0.050

G21A1a009	Clothes Washer (New Construction) – Gas	ES Homes	24.1	0.0.075	0.290	0.00	0.000
E21A3b017	Clothes Washer (ENERGY STAR)	ES Products	89.9	0.279	0.024	0.042	0.003
E21A3b018	Clothes Washer (ENERGY STAR Most Efficient)	ES Products	138.9	0.431	0.166	0.291	0.023

Measure Life:

The measure life is 11 years. [1, 2]

Other Resource Impacts:

Annual water savings are deemed.

Measure Name	Program	Annual Water Savings (gallons)
Clothes Washer (Retrofit)	HEA/HPwES	Calculated
Clothes Washer (New Construction)	ES Homes	2,244
Clothes Washer (ENERGY STAR)	ES Products	2,244
Clothes Washer (ENERGY STAR Most Efficient)	ES Products	3,940

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a051	Clothes Washer (Retrofit)	HEA	1.00	0.91	0.91	0.91	0.91	0.49	0.52
E21A2a054	Clothes Washer (Retrofit)	HPwES	0.99	0.96	0.96	0.96	0.96	0.49	0.52
E21A1a026	Clothes Washer (New Construction)	ES Homes	1.00	1.00	1.00	1.00	1.00	0.49	0.52
G21A1a009	Clothes Washer (New Construction) – Gas	ES Homes	1.00	1.00	1.00	1.00	1.00	0.49	0.52
E21A3b017	Clothes Washer (ENERGY STAR)	ES Products	1.00	1.00	1.00	1.00	1.00	0.49	0.52
E21A3b018	Clothes Washer (ENERGY STAR Most Efficient)	ES Products	1.00	1.00	1.00	1.00	1.00	0.49	0.52

<u>In-Service Rates:</u>

Installations have 100% in service rate for ES Products unless an evaluation finds otherwise, 100% for HEA[4], and 99% for HPwES[3].

<u>Realization Rates:</u>

Realization rates are 100% for ES Products unless an evaluation finds otherwise, 91% for HEA[4], and 100% for HPwES[3].

<u>Coincidence Factors:</u>

All electric programs use a summer coincidence factor of 49% and a winter coincidence factor of 52%.[5]

Energy Load Shape:

See Appendix 1 – "Clothes Washer".[5]

<u>Endnotes</u>:
1: Energy Efficiency Vermont (2018) Technical Reference User Manual. Efficient Clothes Washers.
2: Appliance Magazine. U.S. Appliance Industry: Market Share, Life Expectancy & Replacement Market, and Saturation Levels. Jan. 2010. p. 10

3: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
4: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.
5: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.5 Appliances – Dehumidifier

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	Appliances

Description:

Dehumidifiers exceeding minimum qualifying efficiency standards established as ENERGY STAR.

Baseline Efficiency:

The lost opportunity baseline efficiency case is a dehumidifier that meets the federal standard effective June 13, 2019. Specific baseline Energy Factors (EFs) by product capacity found in the Code of Federal Regulations, 10 CFR 430.32(v)(2). The retrofit baseline efficiency case is the existing dehumidifier.

High Efficiency:

The high efficiency case is a dehumidifier that meets the ENERGY STAR standard as of October 31, 2019[1]. For a new dehumidifier with a capacity less than 25 pints/day the minimum EF is 1.57 liters/kWh. For a new dehumidifier with a capacity between 25.01 and 50 pints/day the minimum EF is 1.8 liters/kWh. For a new dehumidifier with a capacity greater than or equal to 50 pints/day the minimum EF is 3.3 liters/kWh.

Capacity (pints)	Energy Factor (2019 Federal Standard)	Energy Factor (ENERGY STAR)
≤ 25	1.30	1.57
25.01-50	1.60	1.80
≥ 50	2.80	3.30

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated as below. Demand savings are derived from the Navigant Demand Impact Model.[1]

$$\Delta kWh = Load \times [(1 \div Eff_{BASE}) - (1 \div Eff_{ES})] \times Hours$$

Where:
Load = Typical dehumidification load, 1520 Liters/year[1]
Eff_{BASE} = Average efficiency of model meeting the federal standard, in Liters/kWh
Eff_{ES} = Efficiency of ENERGY STAR® model, in Liters/kWh
Hours = Dehumidifier annual operating hours, site-specific if available, or deemed 2,851 hour/year[2]

Table: Measure Energy Impact[3]

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21B1a053	Dehumidifier (Retrofit)	HEA	407.1	0.10
E21A2a056	Dehumidifier (Retrofit)	HPwES	407.1	0.10
E21A3b019	Dehumidifier (ENERGY STAR)	Products	82.3	0.02

Measure Life:

The measure life is 12 years.[3]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a053	Dehumidifier (Retrofit)	HEA	1.00	0.91	n/a	0.91	0.91	0.82	0.17
E21A2a056	Dehumidifier (Retrofit)	HPwES	0.99	0.96	n/a	0.96	1. 0.96	0.82	0.17
E21A3b019	Dehumidifier (ENERGY STAR)	ES Products	1.00	1.00	n/a	1.00	1.00	0.82	0.17

<u>In-Service Rates:</u>

Installations have 100% in service rate for ES Products unless an evaluation finds otherwise, 100% for HEA[5], and 99% for HPwES[4].

<u>Realization Rates:</u>

Realization rates are 100% for ES Products unless an evaluation finds otherwise, 91% for HEA[5], and 100% for HPwES[4].

<u>Coincidence Factors:</u>

All programs use a summer coincidence factor of 82% and a winter coincidence factor of 17%.[1]

Energy Load Shape:

See Appendix 1 – “Dehumidifier”.[1]

<u>Endnotes</u>:

1: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

2: Environmental Protection Agency (2019). Dehumidifier Key Efficiency Criteria.
https://www.energystar.gov/products/appliances/dehumidifiers/key_efficiency_criteria
3: Environmental Protection Agency (2014). Savings Calculator for Energy Star Qualified Appliances. ENERGY_STAR_2015_Appliance_Calculator
4: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
5: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.6 Appliances – Dishwasher

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Lost Opportunity
Category	Appliances

Description:

The installation of a high efficiency ENERGY STAR residential dishwasher.

Baseline Efficiency:

The baseline efficiency case is a dishwasher that meets the federal standard effective May 30, 2013. Standard size dishwashers shall not exceed 307 kwh/year and 5.0 gallons per cycle.

High Efficiency:

The high efficiency case is a dishwasher that meets the ENERGY STAR standard as of January 29, 2016. Standard size dishwashers shall not exceed 270 kwh/year and 3.5 gallons per cycle.

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated based on the EPA ENERGY STAR appliance calculator. Demand savings are derived from the Navigant Demand Impact Model.

$\Delta kWh = kWh_{BASE} - kWh_{ES}$

Where:
kWh_{BASE} = Average usage of a baseline dishwasher
kWh_{ES} = Average usage of a new dishwasher meeting ENERGY STAR® standards

Table: Measure Energy Impact[1]

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21A3b020	ES Dishwasher	ES Products	37.0	0.011

Measure Life:

The measure life is 10 years.[1]

Other Resource Impacts:

There are annual water savings of 161 gallons associated with this measure.[1]

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b020	ES Dishwasher	ES Products	1.00	1.00	n/a	1.00	1.00	0.28	0.48

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Programs use a summer coincidence factor of 28% and a winter coincidence factor of 48%.[2]

Energy Load Shape:

See Appendix 1 – “Dishwasher”.[2]

<u>Endnotes</u>:

1: Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances.
2: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.7 Appliances – Freezer

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	Appliances

Description:

Freezers exceeding minimum qualifying efficiency standards established as ENERGY STAR®.

Baseline Efficiency:

For lost-opportunity, the baseline efficiency case is a freezer that meets the Federal standard effective September 15, 2014. Specific baseline coefficients and constants by product class found in the Code of Federal Regulations, 10 CFR 430.32(a). For retrofit, the baseline efficiency case is the existing freezer.

High Efficiency:

The high efficiency case is a freezer that meets the ENERGY STAR standard as of September 15, 2014. For a new freezer the measured energy use must be 10% less than the minimum federal efficiency standards.

Algorithms for Calculating Primary Energy Impact:

Retrofit unit energy and demand savings are based on project-specific calculations. Lost-opportunity unit energy and demand savings are based on calculations from the 2018 Vermont TRM[2].

$\Delta kWh = kWh_{BASE} - kWh_{ES}$

Where:
kWh_{BASE} = Average usage of a baseline freezer
kWh_{ES} = Average usage of a new freezer meeting ENERGY STAR® standards

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21B1a050	Freezer (Retrofit)	HEA	Calculated	Calculated
E21A2a053	Freezer (Retrofit)	HPwES	Calculated	Calculated
E21A3b021	Freezer (ENERGY STAR®)	ES Products	31.2	0.004

Measure Life:

The measure life is 12 years.[6]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a050	Freezer (Retrofit)	HEA	1.00	0.91	n/a	0.91	0.91	0.91	0.68
E21A2a053	Freezer (Retrofit)	HPwES	0.99	0.96	n/a	0.96	0.96	0.91	0.68
E21A3b021	Freezer (ENERGY STAR®)	ES Products	1.00	1.00	n/a	1.00	1.00	0.91	0.68

In-Service Rates:

Installations have 100% in service rate for ES Products unless an evaluation finds otherwise, 100% for HEA[4], and 99% for HPwES[3].

Realization Rates:

Realization rates are 100% for ES Products unless an evaluation finds otherwise, 91% for HEA[4], and 100% for HPwES[3].

Coincidence Factors:

Summer and winter coincidence factors are estimated using the demand allocation methodology described in the referenced study.[5]

Energy Load Shape:

See Appendix 1 – "Freezer".[5]

Endnotes:
2: Vermont TRM (2018): ENERGY STAR Retail Products Platform, page 178 of 313.
3: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
4: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.
5: Navigant Consulting,2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
6: Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances.

1.8 Appliances – Refrigerator

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	Appliances

Description:

Refrigerators exceeding minimum qualifying efficiency standards established as ENERGY STAR®.

Baseline Efficiency:

The new product baseline efficiency case is a refrigerator that meets the Federal standard effective September 15, 2014. Specific baseline coefficients and constants by product class found in the Code of Federal Regulations, 10 CFR 430.32(a).

The retrofit baseline efficiency case is an existing refrigerator. It is assumed that income eligible customers would otherwise replace their refrigerators with a used inefficient unit.

High Efficiency:

The high efficiency case is a refrigerator that meets the ENERGY STAR standard as of September 15, 2014. For a new refrigerator the measured energy use must be 10% less than the minimum federal efficiency standards.

Algorithms for Calculating Primary Energy Impact:

Unit energy savings are based on consumption values from New Hampshire evaluation results.[1] Demand savings are derived from the Navigant Demand Impact Model[2].

$\Delta kWh = (kWh_{BASE} - kWh_{ES}) \times SLF$

Where:
kWh_{BASE} = Average baseline usage: a new refrigerator meeting federal standards, average energy consumption assumed to be 502 kWh for lost-opportunity, site-specific for retrofit
kWh_{ES} = Average usage of a new refrigerator meeting ENERGY STAR® standards with an average energy consumption of 452 kWh for ENERGY STAR refrigerators, or 393 kWh for Most Efficient refrigerator
SLF = Site/Lab adjustment factor (an adjustment for real-world performance (site) versus testing (lab)) = 0.881[3]

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21B1a049	Refrigerator (Retrofit)	HEA	Calculated	Calculated
E21A2a049	Refrigerator (Retrofit)	HPwES	Calculated	Calculated

E21A1a025	Refrigerator (New Construction)	ES Homes	44.2	0.01
E21A3b022	Refrigerator (ENERGY STAR®)	ES Products	44.2	0.01
E21A3b023	Refrigerator (Most Efficient)	ES Products	96.4	0.02

Measure Life:

The measure life is 12 years.[4]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a049	Refrigerator (Retrofit)	HEA	1.00	0.91	n/a	.91	0.91	0.79	0.65
E21A2a049	Refrigerator (Retrofit)	HPwES	0.99	0.96	n/a	0.96	0.96	0.79	0.65
E21A1a025	Refrigerator (New Construction)	ES Homes	1.00	1.00	n/a	1.00	1.00	0.79	0.65
E21A3b022	Refrigerator (ENERGY STAR®)	ES Products	1.00	1.00	n/a	1.00	1.00	0.79	0.65
E21A3b023	Refrigerator (Most Efficient)	ES Products	1.00	1.00	n/a	1.00	1.00	0.79	0.65

<u>In-Service Rates:</u>

Installations have 100% in service rate for ES Products unless an evaluation finds otherwise, 100% for HEA[5], and 99% for HPwES[1].

<u>Realization Rates:</u>

Realization rates are 100% for ES Products unless an evaluation finds otherwise, 91% for HEA[5], and 100% for HPwES[1].

<u>Coincidence Factors:</u>

A summer coincidence factor of 79% and a winter coincidence factor of 65% are based on the Navigant Demand Impact Model.[2]

Energy Load Shape:

See Appendix 1 – "Primary Refrigerator".[2]

<u>Endnotes</u>:

1: Opinion Dynamics (2019). Home Performance with Energy Star Program Evaluation Report 2016-2017. Prepared for NH Utilities. ES standard energy consumption values and savings methodology extracted from supporting analysis.
2: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf.
3: Connecticut Program Savings Document (PSD) (2019).
4: Environmental Protection Agency (2018). Savings Calculator for Energy Star Qualified Appliances.
5: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.9 Appliances – Recycling

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit
Category	Appliances

Description:

The retirement of old, inefficient refrigerators, freezers and room air conditioners. In cases when these appliances are replaced by a homeowner, the existing unit is retained, sold or donated for use elsewhere, representing additional load on the grid. This measure covers recycling of the existing, functional equipment, thereby eliminating the consumption associated with that equipment. Appliance recycling programs receive energy savings credit for permanently removing inefficient, functional equipment from the electric grid.

Baseline Efficiency:

The baseline efficiency case is an old, inefficient working refrigerator, freezer or room air conditioner.

High Efficiency:

The high efficiency case assumes no replacement of the recycled unit.

Algorithms for Calculating Primary Energy Impact:

Unit energy and demand savings are deemed based on MA study results.[1, 4]

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21A3b027 E21A3b028	Refrigerator Recycling	ES Products	1,027	0.18
E21A3b029	Freezer Recycling	ES Products	769	0.14
E21A3b030	Room Air Conditioner Recycling	ES Products	113	0.18

Measure Life:

The measure life is 5 years for refrigerators, 4 years for freezers and 3 years for room air conditioners.[3]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings[2]:

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b027	Refrigerator Recycling	ES Products	1.00	1.00	n/a	1.00	1.00	0.79	0.65
E21A3b028	Secondary Refrigerator Recycling	ES Products	1.00	1.00	n/a	1.00	1.00	0.86	0.52
E21A3b029	Freezer Recycling	ES Products	1.00	1.00	n/a	1.00	1.00	0.91	0.68
E21A3b030	Room Air Conditioner Recycling	ES Products	1.00	1.00	n/a	1.00	1.00	0.46	0.00

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Coincidence factors are based on the Navigant Demand Impact Model.[2]

Energy Load Shape:

See Appendix 1 – "Primary Refrigerator" for primary refrigerator recycling, "Secondary Refrigerator" for secondary refrigerator recycling, "Freezer" for secondary freezer recycling, "Room or Window Air Conditioner" for room air conditioner recycling.[2]

<u>Endnotes</u>:

1: NMR Group, Inc. (2019). Appliance Recycling Report. Prepared for MA Joint Utilities. https://ma-eeac.org/wp-content/uploads/MA19R01-E-ApplianceRecycleReport-Final-2019.03.26.pdf

2: Navigant Consulting, 2018. RES1 Demand Impact Model Update 3**:** California Public Utilities Commission, 2014 Database for Energy-Efficient Resources, Feb. 4, 2014. Available at: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

4: Room air conditioning recycling savings are based on the early replacement savings value found in The Cadmus Group, Inc. (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Multifamily-Impact-Evaluation4.pdf

1.10 Appliances – Room Air Purifier

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Lost Opportunity
Category	Appliances

Description:

Room air purifiers exceeding minimum qualifying efficiency standards established as ENERGY STAR®.

Baseline Efficiency:

The baseline efficiency case is a room air purifier that does not meet ENERGY STAR® efficiency requirements.

High Efficiency:

The high efficiency case is a room air purifier that meets the ENERGY STAR® standard as of July 1, 2004. A new room air purifier must produce a minimum Clean Air Delivery Rate (CADR)[1] of 50, and minimum performance of 3.0 CADR per watt.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on averaged inputs from the EPA EnergyStar calculator.[2]

Measure Name	kWh	kW
Room Air Cleaner	391	0.04

Demand savings are calculated using the following formula:

$$\Delta kW = \frac{\Delta kWh}{Hours}$$

Where:
$Hours$ = Assumed annual operating hours, 8,760 hours per year

Measure Life:

The measure life is 9 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b025	Room Air Purifier	ES Products	0.97	1.00	n/a	1.00	1.00	1.00	1.00

<u>In-Service Rates:</u>

In-service rate is based on evaluation results.[3]

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Coincidence factors are 100% for both summer and winter peaks, since the air purifiers are expected to operate continuously during peak hours.

Energy Load Shape:

See Appendix 1 – "24 hour operation".[4]

<u>Endnotes</u>:

1: The Clean Air Delivery Rate is voluntary standard made available for comparing the performance of portable air filters in a room at steady-state conditions during a controlled laboratory test: ANSI/AHAM AC-1-2015 (AHAM 2015). It was developed by the Association of Home Appliance Manufacturers (AHAM), a private voluntary standard-setting trade association, and is recognized by the American National Standards Institute (ANSI).

2: Energy Star (2018). Savings Calculator for Energy Star Appliances. https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/5ee4886e6996f260b17df793/view?authToken=76a386554f80c635695670ab6c5f42d3a2689e84fed3c5c17ba875a72d1de97d358af4b53cf387bb4d6fe50367f9f9a7099bca84678c31644b474ab83eb99be06c5e49983ae488
https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

3: NMR Group, Inc. (2018). Products Impact Evaluation of In-Service and Short Term Retention Rates Study.

4: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf.

1.11 Motors- ECM Circulator Pump

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Lost Opportunity
Category	Motors and Drives

Description:

Installation of high efficiency residential boiler circulator pumps, equipped with variable speed electronically commutated motors (ECMs).

Baseline Efficiency:

The baseline efficiency case is the installation of a standard circulator pump.

High Efficiency:

The high efficiency case is the installation of an ECM circulator pump.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results[1].

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21A3b013	ECM Motor for FWH Circulating Pump	ES Products	68.0	0.024

Measure Life:

The measure life is 15 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b013	ECM Motor for FWH Circulating Pump	ES Products	1.00	1.00	n/a	1.00	1.00	0.00	1.00

<u>In-Service Rates:</u>

All installations have a 100% in-service-rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Programs use a summer coincidence factor of 0% and a winter coincidence factor of 100%, because the deemed value of 0.024 kW cited above represents coincident winter peak demand reduction .[1]

Energy Load Shape:

See Appendix 1 – “Boiler Distribution”.[2]

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):

For ECM motors delivered through midstream channels, the following factors apply.

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21A3b013	ECM Motor for FWH Circulating Pump	ES Products	0.40	0.09	0.00	0.69

Endnotes:
1: West Hill Energy and Computing, 2018. CT HVAC and Water Heater Process and Impact Evaluation and CT Heat Pump Water Heater Impact Evaluation.
2: Assumed to be consistent with C&I Electric Motors & Drives – Energy & Resources Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1. ERS_2005_Measure_Life_Study

1.12 Motors - Pool Pump

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Lost Opportunity
Category	Motors and Drives

Description:

The installation of a variable-speed drive pool pump. Operating a pool pump for a longer period at a lower wattage can move the same amount of water, using significantly less energy.

Baseline Efficiency:

The baseline efficiency case is a single speed 1.5 horsepower pump that pumps 97 gallons per minute (gpm) and runs 5.7 hours per day for 122 days a year. It has an Energy Factor (EF) of 2.0 . The pool size is assumed to be 22,000 gallons.[1]

High Efficiency:

The high efficiency case is a variable-speed pump rated at 77 gpm at high speed and 31 gpm at low speed. It has a 2.9 EF at high speed, a 10.5 EF at low speed and runs 2 hr/day at high speed for filter and cleaning and 15.7 hr/ day for filtering alone. The pool size is assumed to be 22,000 gallons. [1]

Algorithms for Calculating Primary Energy Impact[1]:

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21A3b024	Pool Pump (Variable Speed)	ES Products	1,284	1.35

Measure Life:

The measure life is 10 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b024	Pool Pump (Variable Speed)	ES Products	1.00	1.00	n/a	1.00	1.00	0.55	0.00

In-Service Rates:

All installations have a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Programs use a summer coincidence factor of 55% and a winter coincidence factor of 0% which are estimated using demand allocation methodology described in the Demand Impact Model.[3]

Energy Load Shape:

See Appendix 1 – "Pool Pump".[3]

Endnotes:

1. DOE, December 2016. Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment; Dedicated – Purpose Pool Pumps. https://www.regulations.gov/document?D=EERE-2015-BT-STD-0008-0105

2. Davis_Energy_Group_2008_Proposal_Info_Template_for_Residential_Pool_Pump_Measure_Revisions https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/5ee4886d6996f219ce7df78e/view?authToken=3b71e1346320906c2aa98b46f0bc51366572ba635fb746acadde94699187bcb6ff5af967900e9bb3a8ba4ef6c9998da9c7213c8b2be31b4420695f20c39232a5c3f169b40bb1c9

3: Navigant, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.13 Building Shell – Air Sealing

Measure Code	[To Be Defined in ANB system],
Market	Residential
Program Type	Retrofit, Single Family
Category	Building Shell

Description:

The reduction of a home's conditioned air loss (leakage) resulting from the sealing of a home's cracks and air gaps. Home air leakage is measured in air loss in Cubic Feet per Minute (CFM), measured at 50 pascals.

Baseline Efficiency:

The baseline efficiency case is an existing home before it is air sealed.

High Efficiency:

The high efficiency case is an existing home after it has been air sealed.

Algorithms for Calculating Primary Energy Impact:

The programs use vendor-calculated energy savings for air sealing measures in the Residential Home Performance with ENERGY STAR and Home Energy Assistance programs. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The software's building model is based on thermal transfer, building gains, and a variable-based heating and cooling degree day (or hour) climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Infiltration savings use site-specific seasonal N-factors to convert measured leakage to seasonal energy impacts. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 as their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to incorrectly "adding" individual measure results.

Should the vendor software be unavailable or unable to estimate a home's energy savings from air sealing, the following savings algorithm should be used.

$\Delta MMBtu = \Delta CFM * (MMBtu/CFM_{heating} + CFM_{cooling})$

Where:

ΔCFM = Reduced air loss, in Cubic Feet per Minute (CFM) in a treated home.

MMBtu/CFM = Deemed savings per reduced CFM of 0.012934 MMBtu per CFM. This represents a blended savings value, applicable for all heating fuel types and cooling equipment scenarios in HPwES, based on evaluation results.[1]

In addition to heating fuel savings, the following deemed values are applied to reflect ancillary electric savings for heating load reductions, depending on the home heating equipment. The values are based on evaluation results for weatherized homes, and are applied once per home for homes receiving air sealing and/or insulation (rather than separately applying for air sealing and insulation):[5]

Equipment	kWh Savings	Description of Impact
Furnace fan	86.0	Per home value reflecting reduced fan operation based on heating load reduction from weatherization measures
HW boiler circulation pump(s)	9.0	Per circulator pump value reflecting reduced pump operation based on heating load reduction from weatherization measures

Measure Life:

The effective useful life (EUL) for air sealing, which assumes retrofit installation, is 15 years.[2] Other Resource Impacts:
There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[1 3]

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a001	Air Sealing	Cord Wood	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a001	Air Sealing	Cord Wood	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1a002	Air Sealing	Electric	HEA	1.00	0.91	n/a	0.91	0.91	0.00	0.43
E21A2a002	Air Sealing	Electric	HPwES	0.99	0.96	n/a	0.96	0.96	0.00	0.43
E21B1a003 G21B1a001	Air Sealing	Gas	HEA	1.00	n/a	1.04	n/a	n/a	n/a	n/a
E21A2a003 G21A2a001	Air Sealing	Gas	HPwES	0.99	n/a	1.04	n/a	n/a	n/a	n/a
E21B1a004	Air Sealing	Kerosene	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a004	Air Sealing	Kerosene	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1a005	Air Sealing	Oil	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a005	Air Sealing	Oil	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1a006	Air Sealing	Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a006	Air Sealing	Propane	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1a007	Air Sealing	Wood Pellets	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a007	Air Sealing	Wood Pellets	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

In-service rates for HPwES programs are 99% and are 100% HEA programs based on evaluation results[1,3].

<u>Realization Rates:</u>

Realization rate for HPwES programs are 100% and are 91% for HEA programs based on evaluation results.[1,3]

<u>Coincidence Factors:</u>

A winter coincidence factor of 43% is utilized for primary and ancillary electric heating savings.[4]

Energy Load Shape:

See Appendix 1. – “Hardwired Electric Heat”

Non-Energy Impacts:

For HEA programs, a per-project value of $406 reflecting participant NEIs—including increased comfort, decreased noise, and health-related NEIs—will be applied annually to each weatherization project over its 15-year measure life[3].

Endnotes:
1: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
2: Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf
3: Opinion Dynamics. Home Energy Assistance Program Evaluation Report 2016-2017, Final, July 29, 2020. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20200729-NHSaves-HEA-Evaluation-Report-FINAL.pdf
4: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
5: Cadmus, April 5, 2013, New Hampshire HVAC Load and Savings Research, Final Report, table 19.

1.14 Building Shell – Insulation

Measure Code	[To Be Defined in ANB system],
Market	Residential
Program Type	Retrofit
Category	Building Shell

Description:

The installation of high efficiency insulation in an existing home.

Baseline Efficiency:

The baseline efficiency case is the pre-installation average R-value for an insulation type in an existing home before installation of new insulation.

High Efficiency:

The high efficiency case is the post-installation average R-value for an insulation type in an existing home.

Algorithms for Calculating Primary Energy Impact:

The programs currently use vendor calculated energy savings for these measures in the Residential Home Performance with ENERGY STAR and Home Energy Assistance programs. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates building heating and cooling loads and other key parameters. The proprietary building model is based on thermal transfer, building gains, and a variable-based heating/cooling degree day/hour climate model. This provides an initial estimate of energy use that may be compared with actual billing data to adjust as needed for existing conditions. Then, specific recommendations for improvements are added and savings are calculated using measure-specific heat transfer algorithms.

Rather than using a fixed degree day approach, the building model estimates both heating degree days and cooling degree hours based on the actual characteristics and location of the house to determine the heating and cooling balance point temperatures. Savings from shell measures use standard U-value, area, and degree day algorithms. HVAC savings are estimated based on changes in system and/or distribution efficiency improvements, using ASHRAE 152 as their basis. Interactivity between architectural and mechanical measures is always included, to avoid overestimating savings due to incorrectly “adding” individual measure results. Should the vendor software be unavailable or unable to estimate a home’s energy savings from insulation, the following savings algorithm should be used.[1]

$\Delta MMBtu = HSqFt * (MMBtu_{heating} + MMBtu_{cooling})$

Where:
HSqFt = Hundred square feet of installed insulation in a treated home (represented by installed sq ft / 100 sq ft).

MMBtu*heating* = Deemed savings per square foot of installed insulation, using appropriate value for basements, walls, or attics in the tables developed by Opinion Dynamics and program implementers.[1]
MMBtu*cooling* = If cooling is present in treated home, use appropriate value for basements, walls, or attics the table developed by Opinion Dynamics and program implementers. Otherwise set to 0.[1]

In addition to heating fuel savings, the following deemed values are applied to reflect ancillary electric savings for heating load reductions, depending on the home heating equipment. The values are based on evaluation results for weatherized homes, and are applied once per home for homes receiving air sealing and/or insulation (rather than separately applying for air sealing and insulation):[1]

Equipment	kWh Savings	Description of Impact
Furnace fan	86.0	Per home value reflecting reduced fan operation based on heating load reduction from weatherization measures
HW boiler circulation pump(s)	9.0	Per circulator pump value reflecting reduced pump operation based on heating load reduction from weatherization measures

Measure Life:

The effective useful life (EUL) for insulation, which assumes retrofit installation, is 25 years.[2] Other Resource Impacts:
There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[1,3]

BC Measure ID	Measure Name	Fuel	ISR	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a022	Insulation	Cord Wood	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a022	Insulation	Cord Wood	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1a023	Insulation	Electric	HEA	1.00	0.91	n/a	0.91	0.91	0.00	0.43
E21A2a023	Insulation	Electric	HPwES	0.99	0.96	n/a	0.96	0.96	0.00	0.43
E21B1a024 G21B1a004	Insulation	Gas	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a024 G21A2a004	Insulation	Gas	HPwES	0.99	n/a	1.04	n/a	n/a	n/a	n/a
E21B1a025	Insulation	Kerosene	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a025	Insulation	Kerosene	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1a026	Insulation	Oil	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a026	Insulation	Oil	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1a027	Insulation	Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a027	Insulation	Propane	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1a028	Insulation	Wood Pellets	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a028	Insulation	Wood Pellets	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

In-service rates are 99% for HPwES programs and are 100% HEA programs based on evaluation results.[1,3]

<u>Realization Rates:</u>

Realization rate for HPwES programs are 100% and are 91% for HEA programs based on evaluation results.[1,3]

<u>Coincidence Factors:</u>

A winter coincidence factor of 43% is utilized for primary and ancillary electric heating savings.[4]

Energy Load Shape:

See Appendix 1. – “Hardwired Electric Heat”

Non-Energy Impact:

For HEA programs, a per-project value of $406 reflecting participant NEIs—including increased comfort, decreased noise, and health-related NEIs—will be applied annually to each weatherization project over its 15-year measure life.

Endnotes:
1: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL. Excel file associated with report with calculations, "2019 NHSaves HPwES Deemed Savings_2020-02-25_FM adjustments".
2: Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf
3: Opinion Dynamics. Home Energy Assistance Program Evaluation Report 2016-2017, Final, July 29, 2020. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/20200729-NHSaves-HEA-Evaluation-Report-FINAL.pdf
4: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.15 Hot Water – Faucet Aerator

Measure Code	
Market	Residential
Program Type	Retrofit
Category	Hot Water

Description:

Installation of aerators meeting the EPA WaterSense specification to replace Federal Standard or higher flow faucet aerators.

Baseline Efficiency:

The baseline efficiency case is the existing faucet aerators with Federal Standard[1] flow rate of 2.2 gallons per minute (GPM) or higher.

High Efficiency:

The high efficiency case is a low flow faucet aerator with EPA WaterSense[2] specified maximum flow rate of 1.5 GPM.

Algorithms for Calculating Primary Energy Impact:

The programs use vendor calculated energy savings for measures in the Residential Home Performance with ENERGY STAR and Home Energy Assistance programs. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates domestic hot water loads and other key parameters. Should the vendor software be unavailable or unable to estimate a home's energy savings from faucet aerators, the following deemed savings should be used, based on evaluation results.[3, 4]

BC Measure ID	Measure Name	Fuel Type	Program	ΔkWh	ΔkW[4]	ΔMMBtu
E21B1a009	Faucet Aerator	Electric	HEA	46.863	0.011	
E21B1a010 G21B1a002	Faucet Aerator	Gas	HEA			0.156
E21B1a011	Faucet Aerator	Kerosene	HEA			0.156
E21B1a012	Faucet Aerator	Oil	HEA			0.156
E21B1a013	Faucet Aerator	Propane	HEA			0.156
E21A2a009	Faucet Aerator	Electric	HPwES	46.863	0.011	
E21A2a010	Faucet Aerator	Gas	HPwES			0.156

G21A2a002						
E21A2a011	Faucet Aerator	Kerosene	HPwES			0.156
E21A2a012	Faucet Aerator	Oil	HPwES			0.156
E21A2a013	Faucet Aerator	Propane	HPwES			0.156

Measure Life:

The measure life is 7 years.[5]

Other Resource Impacts:

Residential annual water savings for faucet aerators is 586 gallons per unit.[3]

Impact Factors for Calculating Adjusted Gross Savings: [3] [6]

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a009	Faucet Aerator	Electric	HEA	1.00	0.91	n/a	0.91	0.91	0.31	0.81
E21B1a010 G21B1a002	Faucet Aerator	Gas	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1a011	Faucet Aerator	Kerosene	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1a012	Faucet Aerator	Oil	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1a013	Faucet Aerator	Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a009	Faucet Aerator	Electric	HPwES	0.99	0.96	n/a	0.96	0.96	0.31	0.81
E21A2a010 G21A2a002	Faucet Aerator	Gas	HPwES	0.99	n/a	1.04	n/a	n/a	n/a	n/a
E21A2a011	Faucet Aerator	Kerosene	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21A2a012	Faucet Aerator	Oil	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21A2a013	Faucet Aerator	Propane	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

In-service rates are 99% for HPwES programs and are 100% HEA programs based on evaluation

results.[3, 6]Realization Rates:

All PAs use a realization rate of 100% for HPwES program and a realization rate of 91% for HEA program.[3 6]

Coincidence Factors:

A summer coincidence factor of 31% and a winter coincidence factor of 81% are utilized for faucet aerators with electric fuel type.[4]

Energy Load Shape:

See Appendix 1 "Water Heater – Electric".[4]

Endnotes:

1: In 1998, the Department of Energy adopted a maximum flow rate standard of 2.2 gpm at 60 psi for all faucets: 63 Federal Register 13307; March 18, 1998. https://www.epa.gov/sites/production/files/2017-02/documents/ws-specification-home-final-suppstatement-v1.0.pdf
2: WaterSense: Bathroom Faucets. https://www.epa.gov/watersense/bathroom-faucets
3: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
4: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
5: Faucet aerator is an add on measure. Measure life assumes 1/3 the life of the host equipment (faucet).
6: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.16 Hot Water – Heat Pump Water Heater

Measure Code	
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	Hot Water

Description:

Installation of an Energy Star ® certified heat pump storage water heater, either through direct installation programs to replace an electric resistance storage water heater, or as a lost opportunity retail offering.

Baseline Efficiency:

The direct install baseline efficiency case is a standard efficiency electric resistance storage hot water heater. The lost opportunity baseline is a blended mix of electric and fossil fuel water heating based on study results, used for retail offerings where customer-specific baselines are unknown.[1]

High Efficiency:

The high efficiency case is a high efficiency Energy Star ® certified heat pump storage water heater.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

BC Measure ID	Measure Name	Program	ΔkWh	Summer kW	Winter kW	ΔMMBtu
E21B1a043	Heat Pump Water Heater	HEA	1,818	0.296	0.234	
E21A2a043	Heat Pump Water Heater	HPwES	1,818	0.296	0.234	
E21A3b007	Heat Pump Water Heater, 50-gallon, Energy Star, EF	ES Products	1,818 kWh for retrofit 961 kWh for lost opportunity	0.296 for retrofit 0.175 for lost opportunity	0.234 for retrofit 0.134 for lost opportunity	2.149 for lost opportunity
E21A3b008	Heat Pump Water Heater, 80-gallon, Energy Star, EF	ES Products	1,258 kWh for retrofit 565 kWh for lost opportunity	0.113 for retrofit 0.040 for lost opportunity	0.101 for retrofit 0.035 for lost opportunity	2.149 for lost opportunity

Measure Life:

The measure life is 13 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[3 4 5]

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a043	Heat Pump Water Heater (Retrofit)	HEA	1.00	0.91	n/a	0.91	0.91	1.00	1.00
E21A2a043	Heat Pump Water Heater (Retrofit)	HPwES	0.99	0.96	n/a	0.96	0.96	1.00	1.00
E21A3b007	Heat Pump Water Heater, 50-gallon, Energy Star, EF	ES Products	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21A3b008	Heat Pump Water Heater, 80-gallon, Energy Star, EF	ES Products	1.00	1.00	n/a	1.00	1.00	1.00	1.00

<u>In-Service Rates:</u>

Installations have 100% in service rate for ES Products unless an evaluation finds otherwise, 100% for HEA, and 99% for HPwES[3, 4].
.

<u>Realization Rates:</u>

All PAs use a realization rate of 100% for HPwES program and a realization rate of 91% for HEA program.[3 4] The ES Homes and ES Products programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Programs use coincidence factors of 100% because the deemed summer and winter kW values represent coincident peak demand reductions.[1]

Energy Load Shape:

See Appendix 1 – “Water Heater – Heat Pump”.[5]

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):[6]

For HPWH delivered through midstream channels, the following factors apply.

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21A3b007	Heat Pump Water Heater, 50-gallon, Energy Star, EF	ES Products	0.23	0.00	0.00	0.77
E21A3b008	Heat Pump Water Heater, 80-gallon, Energy Star, EF	ES Products	0.23	0.00	0.00	0.77

Endnotes:
1: R1614/R1613 CT HVAC and Water Heater Process and Impact Evaluation, West Hill Energy and Computing, EMI Consulting & Lexicon Energy Consulting, Jul. 19, 2018. pp. 8.6-8.8. https://www.energizect.com/connecticut-energy-efficiency-board/evaluation-reports; also see 2020 CT Program Savings Document, chapter 4.5.4 for savings for 80-gallon water heaters.
2: Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task 7: Residential Water Heater Analysis Memo. http://ma-eeac.org/wordpress/wp-content/uploads/RES19_Assembled_Report_2018-09-27.pdf
3: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
4: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.
5: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
6: Michael's Energy, June 26, 2020. Efficiency Maine HPWH Free-ridership and Baseline Assessment Results Memo. https://www.efficiencymaine.com/docs/Heat-Pump-Water-Heater-Free-ridership-and-Baseline-Assessment.pdf

1.17 Hot Water – Pipe Insulation

Measure Code	
Market	Residential
Program Type	Retrofit
Category	Hot Water

Description:

Installation of insulation on domestic hot water pipes.

Baseline Efficiency:

The baseline efficiency case is the existing uninsulated domestic hot water piping system located in non-conditioned spaces.

High Efficiency:

The high efficiency case is the domestic hot water piping system in unconditioned spaces with insulation installed.

Algorithms for Calculating Primary Energy Impact:

The programs use vendor calculated energy savings for these measures in the Residential Home Performance with ENERGY STAR and Home Energy Assistance programs. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates domestic hot water loads and other key parameters. Should the vendor software be unavailable or unable to estimate a home's energy savings from pipe insulation, the following savings algorithm should be used. Unit savings are deemed based on study results.[1] [2]

$$\Delta kW_{total} = Linear\ feet \times \Delta kW$$

$$\Delta kWh_{total} = Linear\ feet \times \Delta kWh$$

$$\Delta MMBtu_{total} = Linear\ feet \times \Delta MMBtu$$

Where:
Linear feet = Total length of pipe insulation (in feet)
ΔkWh, ΔkW, and ΔMMBtu per linear foot are as follows:

BC Measure ID	Measure Name	Fuel Type	Program	ΔkWh	ΔkW	ΔMMBtu
E21B1a037 E21A2a037	Pipe Insulation <3/4” Pipe Pipe Insulation >3/4” Pipe	Electric	HEA/HPwES	14.100 20.500	0.010	
E21B1a038	Pipe Insulation <3/4” Pipe Pipe Insulation >3/4” Pipe	Gas	HEA/HPwES			0.078 0.114

G21B1a011 E21A2a038 G21A2a011						
E21B1a039 E21A2a039	Pipe Insulation <3/4” Pipe Pipe Insulation >3/4” Pipe	Kerosene	HEA/HPwES			0.075 0.110
E21B1a040 E21A2a040	Pipe Insulation <3/4” Pipe Pipe Insulation >3/4” Pipe	Oil	HEA/HPwES			0.087 0.126
E21B1a041 E21A2a041	Pipe Insulation <3/4” Pipe Pipe Insulation >3/4” Pipe	Propane	HEA/HPwES			0.075 0.110

Measure Life:

The measure life is 15 years.[3]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[1,4]

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a037	Pipe Insulation	Electric	HEA	1.00	0.91	n/a	0.91	0.91	0.31	0.81
E21B1a038 G21B1a011	Pipe Insulation	Gas	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1a039	Pipe Insulation	Kerosene	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1a040	Pipe Insulation	Oil	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1a041	Pipe Insulation	Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a037	Pipe Insulation	Electric	HPwES	0.99	0.96	n/a	0.96	0.96	0.31	0.81
E21A2a038 G21A2a011	Pipe Insulation	Gas	HPwES	0.99	n/a	1.04	n/a	n/a	n/a	n/a
E21A2a039	Pipe Insulation	Kerosene	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21A2a040	Pipe Insulation	Oil	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21A2a041	Pipe Insulation	Propane	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

In-service rates are 99% for HPwES programs and are 100% for HEA programs based on evaluation results.[1,4].

<u>Realization Rates:</u>

All PAs use a realization rate of 100% for HPwES program and a realization rate of 91% for HEA program.[1,4]

<u>Coincidence Factors:</u>

A summer coincidence factor of 31% and a winter coincidence factor of 81% are utilized for pipe insulation with electric fuel type.[2]

Energy Load Shape:

See Appendix 1 – “Water Heater - Electric”

<u>Endnotes</u>:

1: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL
2: Navigant Consulting,2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
3: Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf
https://energy.mo.gov/sites/energy/files/measure-life-report-2007.pdf
4: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.18 Hot Water – Setback

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit
Category	Hot Water

Description:

Manual setback of the thermostat on a water heating device to reduce energy consumption.

Baseline Efficiency:

The baseline efficiency case is a water heater with a standard water temperature of 140°F.

High Efficiency:

The high efficiency case is a water heater with an adjusted water temperature of 125°F.

Algorithms for Calculating Primary Energy Impact:

The programs use vendor calculated energy savings for measures in the Residential Home Performance with ENERGY STAR and Home Energy Assistance programs. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates domestic hot water loads and other key parameters. Should the vendor software be unavailable or unable to estimate a home's energy savings from hot water setback, the following deemed savings should be used, based on evaluation results.[1] Note: Savings are due to reduced standby losses, which are assumed to be constant over the year, so ΔkW = ΔkWh / 8760 hours.

Measure Name	Program	Fuel Type	ΔkWh/unit	ΔkW	ΔMMBtu/unit
Hot Water Setback (both dishwasher and clothes washer configuration)	HPwES HEA	Electricity	51.0	0.006	n/a
Hot Water Setback (clothes washer only)	HPwES HEA	Electricity	78.6	0.009	n/a
Hot Water Setback (clothes washer only)	HPwES HEA	Propane	n/a	n/a	0.411
Hot Water Setback (clothes washer only)	HPwES HEA	Gas	n/a	n/a	0.411
Hot Water Setback (clothes washer only)	HPwES HEA	Oil	n/a	n/a	0.411

Measure Life:

The table below includes the measure life for existing units and new equipment.[2]

BC Measure ID	Measure Name	Fuel Type	Program	Measure Life
	Hot Water Setback	All	HPwES HEA	2

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[1]

BC Measure ID	Measure Name	Program	Fuel	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
	Hot Water Setback	HEA	Electricity	1.00	0.91	n/a	0.91	0.91	1.00	1.00
	Hot Water Setback	HEA	Propane	1.00	n/a	0.91	n/a	n/a	n/a	n/a
	Hot Water Setback	HEA	Oil	1.00	n/a	0.91	n/a	n/a	n/a	n/a
	Hot Water Setback	HEA	Gas	1.00	n/a	0.91	n/a	n/a	n/a	n/a
	Hot Water Setback	HPwES	Electricity	0.99	0.96	n/a	0.96	0.96	1.00	1.00
	Hot Water Setback	HPwES	Propane	0.99	n/a	1.14	n/a	n/a	n/a	n/a
	Hot Water Setback	HPwES	Oil	0.99	n/a	1.14	n/a	n/a	n/a	n/a
	Hot Water Setback	HPwES	Gas	0.99	n/a	1.04	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

In-service rates are 99% for HPwES programs and are 100% for HEA programs based on evaluation results.[1, 4]

<u>Realization Rates:</u>

All PAs use a realization rate of 100% for the HPwES program and a realization rate of 91% for the HEA program.[1, 4]

<u>Coincidence Factors:</u>

Coincidence factors for electric hot water are assumed to be 100% because savings are from reduced standby losses, which are assumed to be constant over the year.

Energy Load Shape:

See Appendix 1 – "24 Hour Operation"[3]

Endnotes:

1: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.

2: Illinois TRM Version 9.0, measure 5.4.6 water heater temperature setback. https://www.ilsag.info/technical-reference-manual/il-trm-version-9/

3: Savings are from reduced standby losses, which are assumed to be constant over the year.

4: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.19 Hot Water – Showerhead

Measure Code	
Market	Residential
Program Type	Retrofit
Category	Hot Water

Description:

An existing shower head with high flow rate is replaced with a new low flow shower head.

Baseline Efficiency:

The baseline efficiency case is the existing showerhead with a baseline flow rate of 2.5 gallons per minute (GPM).

High Efficiency:

The high efficiency case is a low flow shower head having a maximum flow rate of 2.0 GPM or less.

Algorithms for Calculating Primary Energy Impact:

The programs use vendor calculated energy savings for measures in the Residential Home Performance with ENERGY STAR and Home Energy Assistance programs. These savings values are calculated using vendor proprietary software where the user inputs a minimum set of technical data about the house and the software calculates domestic hot water loads and other key parameters. Should the vendor software be unavailable or unable to estimate a home's energy savings from low flow showerheads, the following deemed savings should be used, based on evaluation results.[1] kW savings are calculated using the demand impact model.[2]

BC Measure ID	Measure Name	Hot Water Fuel Type	Program	ΔkWh	ΔkW	ΔMMBtu

E21B1a016	Handheld Showerhead	Electric	HEA	145.226	0.050	
E21B1a017 G21B1a003	Handheld Showerhead	Gas	HEA			0.633
E21B1a018	Handheld Showerhead	Kerosene	HEA			0.633
E21B1a019	Handheld Showerhead	Oil	HEA			
E21B1a020	Handheld Showerhead	Propane	HEA			0.633
E21A2a016	Handheld Showerhead	Electric	HPwES	145.226	0.050	
E21A2a017 G21A2a003	Handheld Showerhead	Gas	HPwES			0.633
E21A2a018	Handheld Showerhead	Kerosene	HPwES			0.633
E21A2a019	Handheld Showerhead	Oil	HPwES			
E21A2a020	Handheld Showerhead	Propane	HPwES			0.633
E21B1a030	Low flow Showerhead	Electric	HEA	145.226	0.050	
E21B1a031 G21B1a010	Low flow Showerhead	Gas	HEA			0.633
E21B1a032	Low flow Showerhead	Kerosene	HEA			0.633
E21B1a033	Low flow Showerhead	Oil	HEA			
E21B1a034	Low flow Showerhead	Propane	HEA			0.633
E21A2a030	Low flow Showerhead	Electric	HPwES	145.226	0.050	
E21A2a031 G21A2a010	Low flow Showerhead	Gas	HPwES			0.633
E21A2a032	Low flow Showerhead	Kerosene	HPwES			0.633
E21A2a033	Low flow Showerhead	Oil	HPwES			
E21A2a034	Low flow Showerhead	Propane	HPwES			0.633

Measure Life:

The measure life is 15 years.[3]

Other Resource Impacts:

Annual water savings are 1,246 gallons per unit.[1]

Impact Factors for Calculating Adjusted Gross Savings:[1,4]

BC Measure ID	Measure Name	Hot Water Fuel Type	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1a016	Handheld showerhead	Electric	HEA	1.00	0.91	n/a	0.91	0.91	0.31	0.81
E21B1a017 G21B1a003 E21B1a018 E21B1a019 E21B1a020	Handheld showerhead	Gas Kerosene Oil Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a016	Handheld showerhead	Electric	HPwES	0.99	1.00	n/a	1.00	1.00	0.31	0.81
E21A2a017 G21A2a003 E21A2a018 E21A2a019 E21A2a020	Handheld showerhead	Gas Kerosene Oil Propane	HPwES	0.99	n/a	1.00	n/a	n/a	n/a	n/a
E21B1a030	Low flow Showerhead	Electric	HEA	1.00	0.91	n/a	0.91	0.91	0.31	0.81
E21B1a031 G21B1a010 E21B1a032 E21B1a033 E21B1a034	Low flow Showerhead	Gas Kerosene Oil Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2a030	Low flow Showerhead	Electric	HPwES	0.99	1.00	n/a	1.00	1.00	0.31	0.81
E21A2a031 G21A2a010 E21A2a032 E21A2a033 E21A2a034	Low flow Showerhead	Gas Kerosene Oil Propane	HPwES	0.99	n/a	1.00	n/a	n/a	n/a	n/a

In-Service Rates:

In-service rates are 99% for HPwES and are 100% for HEA based on evaluation results.[1,4]

Realization Rates:

All PAs use a realization rate of 100% for HPwES and a realization rate of 91% for HEA.[1,4]

Coincidence Factors:

A summer coincidence factor of 31% and a winter coincidence factor of 81% are utilized.[2]

Energy Load Shape:

See Appendix 1 “Water Heater – Electric”.

Endnotes:
1: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL. kWh were estimated using the input values and methodology described in 'Table C-7. Algorithms and Inputs for Efficient Showerheads'.
2: Navigant Consulting,2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
3: Guidehouse, inc (2020). Massachusetts Comprehensive TRM Review - MA19R17-B-TRM. Prepared for the electric and gas program administrators of Massachusetts part of the residential evaluation program area.
4: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.20 Hot Water – Gas Water Heater

Measure Code	[Code]
Market	Residential
Program Type	Retrofit/ Lost Opportunity
Category	Hot Water

Description:

Installation of a new high-efficiency natural gas tankless and storage water heaters.

Baseline Efficiency:

For indirect water heaters, the baseline efficiency case is the existing indirect water heater with EF of 0.6.[1]

For water heaters integrated with condensing boiler, the baseline efficiency case is an 85% AFUE rated boiler (79.3% AFUE actual) with a 0.6 EF water heater.[1] The ER baseline is an 80% AFUE rated boiler (77.4% AFUE actual) with either an indirect water heater or with a 0.55 EF water heater.

For tankless water heaters, the baseline efficiency case is a stand-alone tank water heater with a UEF of 0.63. For the early retirement portion, the baseline efficiency is an existing 0.58 UEF standalone water heater.

For standalone storage tank water heater, the baseline efficiency case is a stand-alone tank water heater with a UEF of 0.63. For the early retirement portion, the baseline efficiency is an existing 0.58 UEF standalone water heater.

High Efficiency:

The high efficiency case for indirect water heaters is an indirect water heater attached to an ENERGY STAR® rated forced hot water boiler.

For water heaters integrated with condensing boilers, the high efficiency case is an integrated water heater/boiler unit with a 90% AFUE condensing boiler and a 0.9 EF water heater or a 95% AFUE condensing boiler and a 0.95 EF water heater.

For tankless water heaters, the high efficiency case is a tankless water heater with UEF of 0.94.

For standalone storage tank water heater, the baseline efficiency case is a stand-alone water heater with EF $\geq$ 0.66.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[2 3] Savings have been adjusted to reflect the mix of replace and failure and early retirement based on study results. There is an electric penalty associated with the gas on-demand tankless water heater to account for additional electrical consumption for power venting and electronic pilot ignition.

BC Measure ID	Measure Name	Fuel Type	Program	∆kWh	∆kW	∆MMBtu
G21A3b012	Water Heater - Indirect (attached to ES FHW Boiler; Combined eff rating >=85% (EF=.82)	Gas	ES Products			4.0
G21A3b013	Water Heater - Integrated with Condensing Boiler >= 90% AFUE	Gas	ES Products			8.4
G21A3b014	Water Heater - Integrated with Condensing Boiler >= 95% AFUE	Gas	ES Products			12.8
G21A3b015	Condensing Water Heater (EF 0.95)	Gas	ES Products	-43.0	-0.010	7.0
G21A3b016	Stand Alone Storage Tank Water Heater (EF 0.67)	Gas	ES Products	-43.0	-0.010	3.0
G21A3b018	Water Heater - Tankless, On-Demand UEF >=. 87	Gas	ES Products	-43.0	-0.010	7.3

Measure Life:

The table shows the measure life for each measure.[4 5 6 7]

BC Measure ID	Measure Name	Program	Measure Life
G21A3b012	Water Heater - Indirect (attached to ES FHW Boiler; Combined eff rating >=85% (EF=.82) (Retrofit)	ES Products	20
G21A3b013	Water Heater - Integrated with Condensing Boiler >= 90% AFUE (Retrofit)	ES Products	19
G21A3b014	Water Heater - Integrated with Condensing Boiler >= 95% AFUE (Retrofit)	ES Products	19

G21A3b015	Condensing Water Heater (EF 0.95)	ES Products	15
G21A3b016	Stand Alone Storage Tank Water Heater (EF 0.67)	ES Products	10
G21A3b018	Water Heater - Tankless, On-Demand >=.87	ES Products	19

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21A3b012	Water Heater - Indirect (attached to ES FHW Boiler; Combined eff rating >=85% (EF=.82) (Retrofit)	ES Products	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21A3b013	Water Heater - Integrated with Condensing Boiler >= 90% AFUE (Retrofit)	ES Products	1.00	n/a	n/a	n/a	n/a	n/a	n/a
G21A3b014	Water Heater - Integrated with Condensing Boiler >= 95% AFUE (Retrofit)	ES Products	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21A3b015	Condensing Water Heater (EF 0.95)	ES Products	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21A3b016	Stand Alone Storage Tank Water Heater (EF 0.67)	ES Products	1.00	1.00	1.00	n/a	n/a	0.21	0.40
G21A3b018	Water Heater - Tankless, On-Demand >=.94 (New Construction)	ES Products	1.00	1.00	1.00	n/a	n/a	0.21	0.40

<u>In-Service Rates:</u>

All installations have a 100% in-service-rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

A summer coincidence factor of 21% and a winter coincidence factor of 40% are claimed for tankless and stand-alone storage water heaters.[8]

Energy Load Shape:

See Appendix 1 – "Water Heater - Natural Gas/Fuel Oil".

Endnotes:

1: The 85% AFUE baseline represents value negotiated in MA for new boilers, which is applied to water heaters in this case.

2: Massachusetts Program Administrators (2018). 2019-2021 Gas HVAC and Water Heating Calculations Workbook. Workbook can be downloaded here: https://etrm.anbetrack.com/#/workarea/trm/MADPU/RES-WH-ODTWH/2020%20Report%20DRAFT%20WORKING%20TRM/version/4?measureName=Hot%20Water%20-%20On%20Demand%2FTankless%20Water%20Heater

3: Navigant (2018). Home Energy Service Impact Evaluation. Prepared for program administrators in Massachusetts. http://ma-eeac.org/wordpress/wp-content/uploads/RES34_HES-Impact-Evaluation-Report-with-ES_FINAL_29AUG2018.pdf

4: GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

5: Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Qualified Boiler. https://www.energystar.gov/sites/default/files/asset/document/Savings_and_Cost_Estimate_Summary.pdf

6: DOE (2008). Energy Star Residential Water Heaters: Final Criteria Analysis and The Cadmus Group (2013). 2012 Residential Heating, Water Heating, and Cooling Equipment Evaluation: Net-to-Gross, Market Effects, and Equipment Replacement Timing.

7: Guidehouse, inc (2020). Massachusetts Comprehensive TRM Review - MA19R17-B-TRM. Prepared for the electric and gas program administrators of Massachusetts part of the residential evaluation program area.

8: Navigant Consulting (2018). Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.21 HVAC – Boiler

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	HVAC

Description:

Installation of a new high efficiency forced hot water boiler for space heating.

Baseline Efficiency:

For Home Energy Assistance (HEA), the baseline efficiency is the existing system, consistent with the TREAT model used by the state Weatherization Assistance Program. For Home Performance with Energy STAR (HPwES) and Energy Star Products, the baseline reflects a bended value ~~based on past baseline research~~. The blended value uses an ~~80~~ 84% AFUE rated boiler ~~(77.4% AFUE actual)~~ for early replacement and an 85% AFUE boiler ~~(79.3% AFUE actual)~~ for lost opportunity.[1]

High Efficiency:

The high efficiency case is a boiler with an AFUE rating of 90% or greater (i.e. a condensing boiler). Based on evaluation results the actual AFUE is 87.2% for a 90% AFUE rated boiler and 89.4% for a 95% AFUE rated boiler.

Algorithms for Calculating Primary Energy Impact:

Currently, HPwES uses deemed savings, while HEA uses modeled savings based on the TREAT model. Starting in mid-2021, HPwES will begin using modeled savings as well, based on a modified version of the TREAT model.

For Energy Star Products, unit savings are calculated based on deemed inputs and have been adjusted to reflect the mix of replace on failure and early replacement. [1]

BC Measure ID	Measure Name	Fuel Type	Program	ΔMMBtu/unit
E21B1b001 G21B1b001	Boiler Replacement, Forced Hot Water	Gas	HEA	Calculated
E21A2b001 G21A2b001	Boiler Replacement, Forced Hot Water	Gas	HPwES	12.1
E21B1b003	Boiler Replacement, Forced Hot Water	Oil	HEA	Calculated
E21A2b003	Boiler Replacement, Forced Hot Water	Oil	HPwES	2.7 currently, to be calculated once new model in place

E21B1b004 E21B1b002	Boiler Replacement, Forced Hot Water	Propane	HEA	Calculated
E21A2b004 E21A2b002	Boiler Replacement, Forced Hot Water	Propane	HPwES	16.7 currently, to be calculated once new model in place
G21A3b006	Condensing Boiler >=90% AFUE (Up to 300 MBh)	Gas	ES Products	12.1
G21A3b007	Condensing Boiler >=95% AFUE (Up to 300 MBh)	Gas	ES Products	14.8

Measure Life:

The measure life for all boilers is 19 years. [1]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1b001 G21B1b001	Boiler Replacement, Forced Hot Water	Gas	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b001 G21A2b001	Boiler Replacement, Forced Hot Water	Gas	HPwES	0.99	n/a	1.00	n/a	n/a	n/a	n/a
E21B1b003	Boiler Replacement, Forced Hot Water	Oil	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b003	Boiler Replacement, Forced Hot Water	Oil	HPwES	0.99	n/a	1.00	n/a	n/a	n/a	n/a
E21B1b004 E21B1b002	Boiler Replacement, Forced Hot Water	Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b004 E21A2b002	Boiler Replacement, Forced Hot Water	Propane	HPwES	0.99	n/a	1.00	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

ES Products uses a 100% in-service rate unless an evaluation finds otherwise. In-service rates are 99% for HPwES and are 100% for HEA based on evaluation results.[2, 3]

<u>Realization Rates:</u>

ES Products uses a 100% realization rate unless an evaluation finds otherwise. All PAs use a realization rate of 100% for HPwES and a realization rate of 91% for HEA.[2, 3]

Coincidence Factors:

No electric impacts are claimed.

Energy Load Shape:

No electric impacts are claimed.

Endnotes:
1: The 84% AFUE baseline is based on the New Hampshire Potential Study Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023, Volume III: Residential Market Baseline Study, June 11, 2020, p. 3-17. The 85% AFUE baseline represents value negotiated in MA for new boilers.
2: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
3: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.22 HVAC – Boiler Reset Control

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit
Category	HVAC

Description:

Installation of reset controls to automatically control boiler water temperature based on outdoor temperature or return water temperature in case of condensing boilers.

Baseline Efficiency:

The baseline efficiency case is a boiler without reset controls.

High Efficiency:

The high efficiency case is a boiler with reset controls.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

BC Measure ID	Measure Name	Fuel Type	Program	ΔMMBtu/unit
G21A3b005	Boiler Reset Control	Gas	ES Products	5.1

Measure Life:

The measure life of reset controls installed on a new boiler is 15 years.[2]

BC Measure ID	Measure Name	Fuel	Program	EUL
G21A3b005	Boiler Reset Control	All	All	15

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21A3b005	Boiler Reset Control	Gas	ES Products	1.00	n/a	1.00	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100% in-service-rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

Energy Load Shape:

See Appendix 1 “Non-Electric Measures”.

Endnotes:
1: Navigant Consulting, August 2018. Home Energy Services (HES) Impact Evaluation for Massachusetts. http://ma-eeac.org/wordpress/wp-content/uploads/RES34_HES-Impact-Evaluation-Report-with-ES_FINAL_29AUG2018.pdf
2: ACEEE, 2006. Emerging Technologies Report: Advanced Boiler Controls. Prepared for ACEEE.

1.23 HVAC – ENERGY STAR Central Air Conditioning

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	HVAC

Description:

The installation of a high efficiency ENERGY STAR central air conditioning (AC) system.

Baseline Efficiency:

For lost opportunity and replace on failure retrofit, the baseline efficiency case is a Seasonal Energy Efficiency Ratio (SEER) 12.4 central air-conditioning unit.[1] For early retirement, if values are known, then baseline is the existing air-conditioning unit SEER over its remaining life, and a SEER 12.4 central air-conditioning unit for the remaining life of the new unit. If baseline values are unknown, the baseline case over its remaining life should be the average efficiency levels of units replaced in the previous calendar year.

High Efficiency:

The high efficiency case is a program qualified ENERGY STAR central air-conditioning unit. The minimum ENERGY STAR Seasonal Energy Efficiency Ratio (SEER) requirement for the program is 15.

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh = Tons \times 12\ kBtu/hr\ /\ Ton \times (1/SEER_{BASE} - 1/SEER_{EE}) \times Hours$
$\Delta kW = \Delta kWh \times \text{Annual Maximum Demand Factor}$
Where:
Tons = Cooling capacity of the central AC equipment in tons. Use actual rebated tons or if unknown assume previous year average program rebated tonnage (for 2019, was 2.85 tons).[2]
SEERBASE = Seasonal Energy Efficiency Ratio (SEER).

- For lost opportunity and replace on failure retrofit installation, baseline AC equipment should be SEER 12.4 equipment.
- For early replacement retrofit, baseline AC equipment is divided into two components:
    - For the remaining useful life of the replaced AC equipment:
        - if known, use the replaced (old) AC SEER value.
        - if unknown, assume previous calendar year average of the replaced (old) AC SEER value (for 2019 was SEER 10).
    - For the remaining useful life of the new AC equipment: baseline AC equipment should be 12.4 SEER

$SEER_{EE}$ = Seasonal Energy Efficiency Ratio (SEER) of new efficient AC equipment. Use actual rebated SEER, or if unknown, assume previous calendar year average (for 2019 was 17.1 SEER). [3]
Hours = Equivalent Full Load Hours (EFLH). Assume 385 for New Hampshire based on the ENERGY STAR calculator.[4]

Savings Assumptions for Calculating Residential Central Air Conditioners:

BC Measure ID	Measure Name	Program	Tons	$SEER_{BASE}$	$SEER_{EE}$	Hours	Annual Max Demand Factor[9]
E21A3b015	ENERGY STAR Central AC	ENERGY STAR Products	Use actual, if unknown use 2.85	12.4	Use actual, if unknown use 17.1	385	0.001594
	ENERGY STAR Central AC, Early Retirement	HPwES/HEA	Use actual, if unknown use 2.85	Use actual, if unknown use 10 for remaining useful life of replaced AC, 12.4 for remaining useful life of new AC	Use actual, if unknown use 17.1	385	0.001594

Measure Life:

The table below includes the effective useful life (EUL) for central air-conditioning units which assumes a lost opportunity installation. Retrofit installations that meet early retirement criteria should receive a remaining useful life of 6 years for a total of 18-year life[5, 6]. To calculate lifetime savings for lost opportunity and replace on failure retrofit installations, use the full EUL of 18 years with the first row of savings assumptions (ENERGY STAR Central AC) above. For retrofit installations that meet early retirement criteria, lifetime savings are based on the sum of two components: 6 years with savings from the second row of savings assumptions above (ENERGY STAR Central AC, Early Retirement) and the remaining 12 years using the lost opportunity savings assumptions (ENERGY STAR Central AC).

BC Measure ID	Measure Name	Program	Measure Life (EUL)	Measure Life (RUL)
E21A3b015	ENERGY STAR Central AC	ES Products	18	n/a
	ENERGY STAR Central AC, Early Retirement	HPwES/HEA	18	6

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b015	ENERGY STAR Central AC	ES Products	1.00	1.00	n/a	1.00	1.00	0.35	0.00
	ENERGY STAR Central AC, Early Retirement	HEA	1.00	0.91	n/a	0.91	0.91	0.35	0.00
	ENERGY STAR Central AC, Early Retirement	HPwES	0.99	0.96	n/a	0.96	0.96	0.35	0.00

<u>In-Service Rates:</u>

In-service rates are 100% for ES Products unless an evaluation finds otherwise, 100% for HEA[8], and 99%% for HPwES[7].

<u>Realization Rates:</u>

Realization rates are 100% for ES Products, 91% for HEA[8], and 100% for HPwES[7].

<u>Coincidence Factors:</u>

Summer coincidence factors are estimated using the RES1 Demand Impact Model Update.[9] The winter coincidence factor is assumed to be zero.

Energy Load Shape:

See Appendix 1 – "Central Air Conditioner/Heat Pump (Cooling)".

<u>Endnotes</u>:
1: Itron 2020. New Hampshire Residential Baseline Study. Prepared for New Hampshire Evaluation, Measurement and Verification Working Group.
2: Average tonnage for Eversource 2019 rebated ENERGY STAR central AC according to tracking database summary report. Pulled February 10, 2020.
3: Average SEER for Eversource 2019 rebated ENERGY STAR central AC according to tracking database summary report. Pulled February 10, 2020.
4: ENERGY STAR Central AC calculator. Assumptions worksheet. Usage: Full Load Cooling Hours. Concord NH location. Based on 2002 EPA study.
https://www.energystar.gov/sites/default/uploads/buildings/old/files/CentralAC_Calculator.xls
EFLH Calculator tab in the EVT_CCHP MOP and Retrofit_2018_.xlsx.). Previous VT TRM was 375. Cadmus study showed much lower for heat pumps:
https://publicservice.vermont.gov/sites/dps/files/documents/2017%20Evaluation%20of%20Cold%20Climate%20Heat%20Pumps%20in%20Vermont.pdf
5: Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf
6: RUL is based on the 2019 MA TRM, Illinois TRM version 9.0, and NEEP TRM version 9.0, which all assume an RUL of one-third the EUL, or six years.
7: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.

8: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.
9: Navigant Consulting, 2018. RES1 Demand Impact Model Update. https://ma-eeac.org/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.24 HVAC – ENERGY STAR Room Air Conditioning

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Lost Opportunity/Retrofit
Category	HVAC

Description:

The installation of a high efficiency room air conditioning (AC) unit.

Baseline Efficiency:

The lost opportunity baseline efficiency case is a room AC unit meeting current federal standard, and the early replacement baseline is the existing inefficient unit.

High Efficiency:

The high efficiency case is a program-qualified ENERGY STAR room AC unit.

Algorithms for Calculating Primary Energy Impact:

Electric energy savings for a program-qualified ENERGY STAR room air-conditioning unit are deemed at 33 kWh per unit for lost opportunity. Unit savings are based on the Massachusetts eTRM value (36 kWh) adjusted to account for the cooling load differential between Massachusetts and New Hampshire.[1] Early replacement savings for HEA and HPwES are vendor calculated using proprietary software where the user inputs a minimum set of home-specific technical data. As an alternative, the deemed savings below should be used, based on evaluation results.[2]

Savings Assumptions for Calculating Residential ENERGY STAR Room Air Conditioners:

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW[3]
E21A3b016	ENERGY STAR Room AC	ES Products	33	0.06
E21B1a054	ENERGY STAR Room AC	HEA	113	0.18
E21A2a057	ENERGY STAR Room AC	HPwES	113	0.18

Measure Life:

The table below includes the effective useful life (EUL) for room air-conditioning units which assumes lost opportunity installation. The 3 year remaining useful life (RUL) for early replacement units is multiplied by the early replacement annual savings value above, and the remaining 6 years of the EUL for those units is multiplied by the lost opportunity savings value above.

BC Measure ID	Measure Name	Program	Measure Life (EUL) [7]	Measure Life (RUL)[4]
E21A3b016	ENERGY STAR Room AC	ES Products	9	n/a
E21B1a054	ENERGY STAR Room AC	HEA	9	3
E21A2a057	ENERGY STAR Room AC	HPwES	9	3

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b016	ENERGY STAR Room AC	ES Products	1.00	1.00	n/a	1.00	1.00	0.33	0.00
E21B1a054	ENERGY STAR Room AC	HEA	1.00	0.91	n/a	0.91	0.91	0.33	0.00
E21A2a057	ENERGY STAR Room AC	HPwES	0.99	0.96	n/a	0.96	0.96	0.33	0.00

<u>In-Service Rates:</u>

In-service rates are 100% for ES Products unless an evaluation finds otherwise, 100% for HEA[6], and 99%% for HPwES[5]

<u>Realization Rates:</u>

Realization rates are 100% for ES Product program until the measure is evaluated. Realization rates for all HEA programs are 91%[6] and for all HPwES programs are 100%[5] per evaluation results.

<u>Coincidence Factors:</u>

Summer coincidence factors is estimated using the RES1 Demand Impact Model Update.[3] The winter coincidence factor is assumed to be zero.

Energy Load Shape:

See Appendix 1 – “Room or Window Air Conditioner”.

<u>Endnotes</u>:
1: Connecticut’s 2019 Program Savings Document, March 1, 2019.
https://www.energizect.com/sites/default/files/2019%20PSD%20%283-1-19%29.pdf
Common cooling savings algorithms used in the Connecticut PSD show a directly proportional relationship between savings and cooling operational hours. We assume a similar directly proportional relationship between cooling operational hours (EFLH), cooling savings, and cooling degree days. The

New Hampshire CDD of 518 is based on the HPwES evaluation and the MA CDD is assumed to be the average of New Hampshire and Connecticut (603).
2: The Cadmus Group, Inc. (2015). Massachusetts Low-Income Multifamily Initiative Impact Evaluation. http://ma-eeac.org/wordpress/wp-content/uploads/Low-Income-Multifamily-Impact-Evaluation4.pdf
3: Navigant Consulting, 2018. RES1 Demand Impact Model Update. https://ma-eeac.org/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf.
4: California Public Utilities Commission, 2014 Database for Energy-Efficient Resources, Feb. 4, 2014. Available at: http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx last accessed Sep 3, 2020.
5: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
6: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.
7: Environmental Protection Agency (2009). Life Cycle Cost Estimate for ENERGY STAR Room Air Conditioner. EPA_2009_Lifecycle_Cost_Estimate_for_ENERGY_STAR_Room_Air_Conditione

1.25 HVAC – Furnace

Measure Code	
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	HVAC

Description:

Installation of a new high efficiency space heating furnace with an electronically commutated motor (ECM) for the fan.

Baseline Efficiency:

For Home Energy Assistance (HEA), the baseline efficiency is the existing system, consistent with the TREAT model used by the state Weatherization Assistance Program. For Home Performance with Energy STAR (HPwES) and Energy Star Products, the baseline reflects a bended value ~~based on past baseline research, specifically a 83.2% AFUE furnace~~. The blended value uses an 83% AFUE rated furnace for early replacement and an 85% AFUE furnace for lost opportunity.[1]

High Efficiency:

The high efficiency case is a new furnace with AFUE ≥ 95%.

Algorithms for Calculating Primary Energy Impact:

Currently, HPwES uses deemed savings, while HEA uses modeled savings based on the TREAT model. Starting in mid-2021, HPwES will begin using modeled savings as well, based on a modified version of the TREAT model.

For Energy Star Products, unit savings are calculated based on deemed inputs based on a blended Early Retirement/Replace on Failure baseline that reflects the historical project mix.

Unit savings for Furnace ancillary savings measure are based on the 2020 HPwES study results.[2] Ancillary electric savings for furnace replacement measure are based on the 2018 ES Products evaluation study.[4]

BC Measure ID	Measure Name	Fuel	Program	ΔkWh	ΔkW	ΔMMBtu
E21B1b005 G21B1b002 E21A2b005 G21A2b002	Furnace Replacement	Gas	HEA HPwES	130.6 168	0.064	Calculated
E21B1b006 E21A2b006	Furnace Replacement	Kerosene	HEA HPwES	87.6 168	0.064	Calculated

E21B1b008 E21A2b008	Furnace Replacement	Propane	HEA HPwES	130.6 168	0.064	Calculated for HEA 6.3 for HPwES for now, will be calculated later
E21B1b007 E21A2b007	Furnace Replacement	Oil	HEA HPwES	6.700 168	0.064	Calculated for HEA 4.6 for HPwES for now, will be calculated later
G21A3b008	Furnace 95+ AFUE (<150) w/ECM Motor	Gas	ES Products	104.2	0.07	9.8
G21A3b009	Furnace 97+ AFUE (<150) w/ECM Motor	Gas	ES Products	104.2	0.07	10.3

Measure Life:

Measure life is 17 years based on MA study results.[4]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings: [2, 5]

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1b005 G21B1b002	Furnace Replacement	Gas	HEA	1.00	n/a	0.91	0.91	0.91	0.00	0.45
E21A2b005 G21A2b002	Furnace Replacement	Gas	HPwES	0.99	n/a	1.00	1.00	1.00	0.00	0.45
E21B1b006	Furnace Replacement	Kerosene	HEA	1.00	n/a	0.91	0.91	0.91	0.00	0.45
E21A2b006	Furnace Replacement	Kerosene	HPwES	0.99	n/a	1.00	1.00	1.00	0.00	0.45
E21B1b008	Furnace Replacement	Propane	HEA	1.00	n/a	0.91	0.91	0.91	0.00	0.45
E21A2b008	Furnace Replacement	Propane	HPwES	0.99	n/a	1.00	1.00	1.00	0.00	0.45
E21B1b007	Furnace Replacement	Oil	HEA	1.00	n/a	0.91	0.91	0.91	0.00	0.45

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A2b007	Furnace Replacement	Oil	HPwES	0.99	n/a	1.00	1.00	1.00	0.00	0.45

In-Service Rates:

ES Products installations have a 100% in-service-rate unless an evaluation finds otherwise. In-service rates are 99% for HPwES and are 100% for HEA based on evaluation results.[2,5]

Realization Rates:

All PAs use a realization rate of 100% for HPwES program and a realization rate of 91% for HEA program.[2,5] ES Products installations have a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

The summer coincidence factor for ancillary electric savings is 0.00 and winter coincidence factor is 0.45.[6]

Energy Load Shape:

See Appendix 1 “Furnace Fan”.

Endnotes:

1: ~~Itron 2020. New Hampshire Residential Baseline Study. Prepared for New Hampshire Evaluation, Measurement and Verification Working Group.~~ The 83% AFUE baseline is based on the New Hampshire Potential Study Statewide Assessment of Energy Efficiency and Active Demand Opportunities, 2021-2023, Volume III: Residential Market Baseline Study, June 11, 2020, p. 3-14. The 85% AFUE baseline represents value negotiated in MA for new boilers, which is applied to furnaces in this case.

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2: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.

3: New Hampshire ENERGY STAR® Products Program 2016 Evaluation Report (2018).

4: Guidehouse, Inc (2020). Massachusetts Comprehensive TRM Review - MA19R17-B-TRM. Prepared for the electric and gas program administrators of Massachusetts part of the residential evaluation program area.

5:Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

6: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.26 HVAC – Central Air-source Heat Pump

Measure Code	[Code]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	HVAC

Description:

This measure includes the installation of a high-efficiency, central air-source heat pump unit (ASHP) to serve the heating and cooling loads of a residential unit. The electric savings for this measure are realized through the increased nameplate efficiency between the baseline and installed equipment. If a fossil-fuel based heating system is being partially or completely displaced by the new heat pump unit, fossil fuel savings and increased electric consumption will be realized.

Baseline Efficiency:

The baseline efficiency varies as a function of replacement scenario.

For lost opportunity or replace on failure, the baseline is a code-compliant 2.8-ton, SEER 14, HSPF 8.2 heat pump unit. [3]

For retrofit installations in homes with electric resistance heating, the baseline is an electric heating system with COP = 1, which converts to an HSPF value of 3.412 Btu/w-h.[4] The cooling baseline is project-specific based on the existing equipment.

For retrofit installations in oil or propane-heated homes, the utilities are proposing a limited pilot offering starting in 2021. The heating and cooling baselines are project-specific. Estimated savings have been developed based on secondary research,[10] and will be updated with primary research on pilot participants, pending pilot approval.

High Efficiency:

The high efficiency (or energy efficient) case is the site-specific air-source heat pump unit. For full displacement, the heat pump must meet cold-climate heat pump standards, such as those on the NHSaves qualified product list.

Algorithms for Calculating Primary Energy Impact:

The savings for this measure are attributable to the increase in nameplate efficiency between the baseline and installed units. The savings are based on the energy efficient heat pump serving both the cooling and heating loads of the house.

The algorithm for calculating electric demand savings is:

$$\Delta kW = \max\left(\Delta kW_{cool}\ or\ \Delta kW_{heat}\right)$$

$$\Delta kW_{cool} = Cap_{cool} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

For retrofit applications where cooling is absent in the preexisting case, the term ($1/EER_{BASE}$) = 0

$$\Delta kW_{heat} = Cap_{heat} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right)$$

$Cap_{heat} = Cap_{cool} \times 1.0$ if unit is a cold climate air-source heat pump
$Cap_{heat} = Cap_{cool} \times 0.9$ for all other air-source heat pump

Where:
ΔkW_{cool} = Gross annual cooling demand savings for air-source heat pump unit
ΔkW_{heat} = Gross annual heating demand savings for air-source heat pump unit
Cap_{cool} = Cooling capacity (in kBtu/h) of the energy efficient air-source heat pump unit, from equipment specifications
Cap_{heat} = Heating capacity (in kBtu/h) of the energy efficient air-source pump unit, from equipment specifications. Use equation to convert from cooling capacity value if standard equipment literature does not provide this value.
EER_{BASE} = Energy Efficiency Ratio of the baseline cooling equipment
EER_{EE} = Energy Efficiency Ratio of the energy efficient air-source heat pump unit, from equipment specifications
$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline heat pump equipment
$HSPF_{EE}$ = Heating Seasonal Performance Factor of energy efficient air-source heat pump unit, from equipment specifications

The algorithm for calculating annual electric energy savings is:

$$\Delta kWh_{cool} = Cap_{cool} \times \left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right) \times EFLH_{cool}$$

For retrofit applications where cooling is absent in the preexisting case, the term ($1/SEER_{BASE}$) = 0

$$\Delta kWh_{heat} = Cap_{heat} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right) \times EFLH_{heat}$$

If fossil fuel heating baseline, the term ($1/HSPF_{BASE}$) = 0 and the fossil fuel savings are:

$$\Delta MMBtu_{heat} = \frac{Cap_{heat}}{AFUE} \times EFLH_{heat} \times 10^{-3}$$

$Cap_{heat} = Cap_{cool} \times 1.0$ if unit is a cold climate air-source heat pump
$Cap_{heat} = Cap_{cool} \times 0.9$ for all other air-source heat pump

Where:
ΔkWh_{cool} = Gross annual cooling savings for air-source heat pump unit
ΔkWh_{heat} = Gross annual heating savings for air-source heat pump unit

$\Delta MMBtu_{heat}$ = Gross annual heating savings resulting from the decrease in fuel consumption due to the partial or complete displacement of the heating load by the energy efficient air-source heat pump unit.
Cap_{cool} = Cooling capacity (in kBtu/h) of the energy efficient air-source heat pump unit, from equipment specifications
Cap_{heat} = Heating capacity (in kBtu/h) of the energy efficient air-source pump unit, from equipment specifications. Use equation to convert from cooling capacity value if standard equipment literature does not provide this value.
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline cooling equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of energy efficient air-source heat pump unit, from equipment specifications
$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline heat pump equipment
$HSPF_{EE}$ = Heating Seasonal Performance Factor of energy efficient air-source heat pump unit, from equipment specifications
$EFLH_{cool}$ = Equivalent Full Load Hours for cooling
$EFLH_{heat}$ = Equivalent Full Load Hours for heating
AFUE = Annual fuel utilization efficiency of replaced fossil fuel heating system
0.9 = Conversion factor[1] to convert cooling capacity to heating capacity for non-cold climate, air-source heat pump units not meeting standards similar to NEEP's cold climate air source heat pump (ccASHP) product list. The conversion factor for ccASHP meeting standards similar to NEEP's is 1.0.
10^{-3} = Conversion factor from kBtu to MMBtu

Heat Pump Type	Cooling Capacity Range	Parameter	Value			Units
			1. Lost Opportunity	2. Retrofit - Resistance	3. Retrofit – Fossil Fuel	
Air-source Heat Pump	All sizes	EER_{BASE}	12.72[2]	-	-	Btu/W-h
		$SEER_{BASE}$	14.00[3]	-	-	Btu/W-h
		$HSPF_{BASE}$	8.20[3]	3.412[4]	-	Btu/W-h
		AFUE	N/A	N/A	75%[5]	
		$EFLH_{cool}$	280[6]			Hours
		$EFLH_{heat}$	1020[7]			Hours

Measure Life:

The measure life of a new heat pump unit is 18 years. [8]

BC Measure ID	Measure Name	Program	Measure Life
E21A3b003	Air-source Heat Pump – Lost Opportunity (Cooling)	ES Products	18

E21A3b004	Air-source Heat Pump – Lost Opportunity (Heating)	ES Products	18
E21A3b034	Air-source Heat Pump – Retrofit Resistance	ES Products	18

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b003	Air-source Heat Pump – Lost Opportunity (Cooling)	ES Products	1.00	1.00	1.00	1.00	1.00	0.346	0.00
E21A3b004	Air-source Heat Pump –Lost Opportunity (Heating)	ES Products	1.00	1.00	1.00	1.00	1.00	0.00	0.620
E21A3b034	Air-source Heat Pump – Retrofit Resistance	ES Products	1.00	1.00	1.00	1.00	1.00	0.346	0.620

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

A coincidence factor of 34.60% during cooling season and a coincidence factor of 62.0% for the heating season should be applied. [9]

Energy Load Shape:

See Appendix 1 – "Central Heat Pump"

<u>Endnotes</u>:

1: Conversion factor is based on internal ERS analysis of Mass Save and NEEP ccASHP product data.
2: Since IECC does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.
3: International Energy Conservation Code 2015, table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps
4: Electric heating system has COP = 1, which converts to an HSPF value of 3.412 Btu/w-h

5: MA TRM DMSHP measure. This value in the MA TRM has been agreed upon by EEAC consultants and represents actual fossil fuel heating equipment efficiencies which include efficiency degradation over the age of the equipment. MA TRM DMSHP.
6: Cooling hours from NY TRM v7 Appendix G for Single family homes. The average of cooling hour values for the cities of Albany and Massena are assumed to be representative of NH, because they lie roughly along the same latitudes as endpoints of NH.
7: Heating hours from NY TRM v7 Appendix G for Single family homes. The average of heating hour values for the cities of Albany and Massena are assumed to be representative of NH, because they lie roughly along the same latitudes as the endpoints of NH.
8: GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
9: Coincidence Factors obtained from Navigant Consulting (2018), Demand Impact Model Update (for Central Air Conditioner/Heat Pump (Cooling) and Ductless Mini Split Heat Pumps (Heating)). The calculation of Coincidence Factors can be found in MA PAs' 2019-2021 Plan Electric Heating and Cooling Savings Workbook (2018)
10: Navigant, Energy Optimization. Sep. 12, 2019. See https://puc.nh.gov/Regulatory/Docketbk/2017/17-136/LETTERS-MEMOSTARIFFS/17-136_2019-10-31_STAFF_NH_ENERGY_OPTIMIZATION_STUDY.PDF and https://puc.nh.gov/Electric/Reports/20190805-PUCElectric-NH-Energy-Optimization-Model.xlsx.

1.27 HVAC – Ductless Mini-Split Heat Pump

Measure Code	[Code]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	HVAC

Description:

This measure includes the installation of a high-efficiency, ductless, mini-split heat pump unit (DMSHP) to serve the heating and cooling loads of a residential unit. The savings for this measure are realized through the increased nameplate efficiency between the baseline and installed equipment. If a fossil-fuel based heating system is being partially or completely displaced by the new heat pump unit, fossil fuel savings and electric consumption increases will be realized.

Baseline Efficiency:

The baseline efficiency varies as a function of replacement scenario.

For lost opportunity or replace on failure, the baseline is a code-compliant 2.2-ton, SEER 14, HSPF 8.2 heat pump unit. [3]

For retrofit installations in homes with electric resistance heating, the baseline is an electric heating system with COP = 1, which converts to an HSPF value of 3.412 Btu/w-h.[4] The cooling baseline is project-specific based on the existing equipment.

For retrofit installations in oil or propane-heated homes, the utilities are proposing a limited pilot offering starting in 2021. The heating and cooling baselines are project-specific. Estimated savings have been developed based on secondary research,[10] and will be updated with primary research on pilot participants, pending pilot approval.

High Efficiency:

The high efficiency (or energy efficient) case is the site-specific ductless, mini-split heat pump unit. For full displacement, the heat pump must meet cold-climate heat pump standards, such as those on the NHSaves qualified product list.

Algorithms for Calculating Primary Energy Impact:

The savings for this measure are attributable to the increase in nameplate efficiency between the baseline and installed units. The savings are based on the energy efficient heat pump serving both the cooling and heating loads of the house.

The algorithm for calculating electric demand savings is:

$$\Delta kW = \max\left(\Delta kW_{cool} \text{ or } \Delta kW_{heat}\right)$$

$$\Delta kW_{cool} = Cap_{cool} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

For retrofit applications where cooling is absent in the preexisting case, the term ($1/EER_{BASE}$) = 0

$$\Delta kW_{heat} = Cap_{heat} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right)$$

$Cap_{heat} = Cap_{cool} \times 1.0$ if unit is a cold climate ductless mini split heat pump
$Cap_{heat} = Cap_{cool} \times 0.9$ for all other ductless mini split heat pump

Where:
ΔkW_{cool} = Gross annual cooling demand savings for ductless, mini-split heat pump unit
ΔkW_{heat} = Gross annual heating demand savings for ductless, mini-split heat pump unit
Cap_{cool} = Cooling capacity (in kBtu/h) of the energy efficient ductless, mini-split heat pump unit, from equipment specifications
Cap_{heat} = Heating capacity (in kBtu/h) of the energy efficient ductless, mini-split pump unit, from equipment specifications. Use equation to convert from cooling capacity value if standard equipment literature does not provide this value.
EER_{BASE} = Energy Efficiency Ratio of the baseline cooling equipment
EER_{EE} = Energy Efficiency Ratio of the energy efficient ductless, mini-split heat pump unit, from equipment specifications
$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline heat pump equipment
$HSPF_{EE}$ = Heating Seasonal Performance Factor of energy efficient ductless, mini-split heat pump unit, from equipment specifications

The algorithms for calculating annual cooling and heating electric energy savings are as follows:

$$\Delta kWh_{cool} = Cap_{cool} \times \left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right) \times EFLH_{cool}$$

For retrofit applications where cooling is absent in the preexisting case, the term ($1/SEER_{BASE}$) = 0

$$\Delta kWh_{heat} = Cap_{heat} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right) \times EFLH_{heat}$$

If fossil fuel heating baseline, the factor ($1/HSPF_{BASE}$) = 0 and the fossil fuel savings are:

$$\Delta MMBtu_{heat} = \frac{Cap_{heat}}{AFUE} \times EFLH_{heat} \times 10^{-3}$$

$Cap_{heat} = Cap_{cool} \times 1.0$ if unit is a cold climate ductless mini split heat pump
$Cap_{heat} = Cap_{cool} \times 0.9$ for all other ductless mini split heat pump

Where:
ΔkWh_{cool} = Gross annual cooling savings for ductless, mini-split heat pump unit
ΔkWh_{heat} = Gross annual heating savings for ductless, mini-split heat pump unit

$\Delta MMBtu_{heat}$ = Gross annual heating savings resulting from the decrease in fuel consumption due to the partial or complete displacement of the heating load by the energy efficient ductless, mini-split heat pump unit.
Cap_{cool} = Cooling capacity (in kBtu/h) of the energy efficient ductless, mini-split heat pump unit, from equipment specifications

Cap_{heat} = Heating capacity (in kBtu/h) of the energy efficient ductless, mini-split pump unit, from equipment specifications. Use equation to convert from cooling capacity value if standard equipment literature does not provide this value.
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline cooling equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of energy efficient ductless, mini-split heat pump unit, from equipment specifications
$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline heat pump equipment
$HSPF_{EE}$ = Heating Seasonal Performance Factor of energy efficient ductless, mini-split heat pump unit, from equipment specifications
$EFLH_{cool}$ = Equivalent Full Load Hours for cooling
$EFLH_{heat}$ = Equivalent Full Load Hours for heating (Note: The algorithm assumes higher heating hours for full displacement scenarios, where heat pump meets over 90 percent of annual space heating needs and meets cold climate heat pump standards).
$AFUE$ = Annual fuel utilization efficiency of replaced fossil fuel heating system
0.9 = Conversion factor[1] to convert cooling capacity to heating capacity for non-cold climate, ductless heat pump units not meeting standards similar to NEEP's cold climate air source heat pump (ccASHP) product list. The conversion factor for ccASHP meeting standards similar to NEEP's is 1.0.
10^{-3} = Conversion factor from kBtu to MMBtu

Heat Pump Type	**Cooling Capacity Range**	**Parameter**	**Value**			**Units**
			1. Lost Opportunity	**2. Retrofit - Resistance**	**3. Retrofit – Fossil Fuel**	**Units**
Ductless Mini Split	All sizes	EER_{BASE}	12.72[2]	-	-	Btu/W-h
		$SEER_{BASE}$	14.00[3]	-	-	Btu/W-h
		$HSPF_{BASE}$	8.20[3]	3.412[4]	-	Btu/W-h
		AFUE	N/A	N/A	75%[5]	
		$EFLH_{cool}$	218[6]			Hours
		$EFLH_{heat, partial}$	535[7]			Hours
		$EFLH_{heat, full}$	1,117[7]			Hours

Measure Life:

The table below lists the measure life of the ductless mini-split heat pump equipment. [8]

BC Measure ID	Measure Name	Program	Measure Life
E21A3b005	Ductless Mini-split Heat Pump (cooling) - Lost Opportunity	ES Products	18
E21A3b006	Ductless Mini-split Heat Pump (heating) - Lost Opportunity	ES Products	18
E21A3b031	Ductless Mini-split Heat Pump - Retrofit Resistance	ES Products	18

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b005	Ductless Mini-split Heat Pump (cooling) - Lost Opportunity	ES Products	1.00	1.00	1.00	1.00	1.00	0.29	0.00
E21A3b006	Ductless Mini-split Heat Pump (heating) - Lost Opportunity	ES Products	1.00	1.00	1.00	1.00	1.00	0.00	0.62
E21A3b031	Ductless Mini-split Heat Pump - Retrofit Resistance	ES Products	1.00	1.00	1.00	1.00	1.00	0.29	0.62

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Coincidence factor of 29% during cooling season and a coincidence factor of 62% for the heating season should be applied. [9]

Energy Load Shape:

For cooling, see Appendix 1 – Mini-Split Air Conditioner/Heat Pump (Cooling)
For heating, see Appendix 1 – Mini-Split Heat Pump (Heating)

<u>Endnotes</u>:

1: Conversion factor is based on internal ERS analysis of Mass Save and NEEP ccASHP product data.
2: Since IECC does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.
3: International Energy Conservation Code 2015, table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps
4: Electric heating system has COP = 1, which converts to an HSPF value of 3.412 Btu/w-h
5: MA TRM DMSHP measure. This value in the MA TRM has been agreed upon by EEAC consultants and represents actual fossil fuel heating equipment efficiencies which include efficiency degradation over the age of the equipment. MA TRM DMSHP.
6: Cooling hours from Cadmus Group (2016), Ductless Mini-Split Heat Pump Impact Evaluation, December 30, 2016. Cadmus_2016_DMSHP_Impact_Evaluation
7: Heating hours from Navigant Consulting (2018), Quick Hit Study: Ductless Mini-Split Heat Pump Survey (RES 29), March 30, 2018. Assumes higher heating hours for displacement of electric heat based on top 25% EFLH (heating) reported in Cadmus Group (2016), Ductless Mini-Split Heat Pump Impact Evaluation, December 30, 2016. Navigant_2018_DMSHP_Survey.
8: GDS Associates, Inc. (2007). Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures. Prepared for The New England State Program Working Group; Page 1-3, Table 1.
9: Coincidence factors come from the Navigant Demand Impact model analysis spreadsheet – MA, Aug 2018.
10: Navigant, Energy Optimization. Sep. 12, 2019. See https://puc.nh.gov/Regulatory/Docketbk/2017/17-136/LETTERS-MEMOSTARIFFS/17-136_2019-10-31_STAFF_NH_ENERGY_OPTIMIZATION_STUDY.PDF and https://puc.nh.gov/Electric/Reports/20190805-PUCElectric-NH-Energy-Optimization-Model.xlsx.

1.28 HVAC – Heat Recovery Ventilator

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Lost Opportunity
Category	HVAC

Description:

Heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs) can help make mechanical ventilation more cost effective by reclaiming energy from exhaust airflows.

Baseline Efficiency:

The baseline efficiency case is an ASHRAE 62.2-compliant exhaust fan system with no heat recovery.

High Efficiency:

The high efficiency case is an exhaust fan system with heat recovery.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

BC Measure ID	Measure Name	Program	Δmmbtu
G21A3b010	Heat Recovery Ventilator	ES Products	7.7

Measure Life:

The measure life is 20 years[1].

Other Resource Impacts:

An electric penalty results due to the electricity consumed by the system fans[1].

BC Measure ID	Measure Name	Fuel Type	Program	ΔkWh/Unit	ΔkW/Unit
G21A3b010	Heat Recovery Ventilator	Electric	ES Products	-133	-0.10

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21A3b010	Heat Recovery Ventilator	ES Products	1.00	1.00	1.00	1.00	1.00	0.34	0.21
	Energy Recovery Ventilator	ES Products	1.00	1.00	1.00	1.00	1.00	0.00	1.00

In-Service Rates:

All installations have a 100% in-service-rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described by the Cadmus Demand Impact Model (2012) prepared for MA Program Administrators.

Energy Load Shape:

See Appendix 1.

Endnotes:

1: Guidehouse, August 2020. Comprehensive TRM Review MA19R17-B-TRM. Prepared for The Electric and Gas Program Administrators of Massachusetts.

1.29 HVAC- Swimming Pool Heater

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Lost Opportunity
Category	Custom

Description:

The installation of a high efficiency heat pump or gas swimming pool heater.

Baseline Efficiency:

The base case is a new, standard efficiency electric resistance hot water heater.

High Efficiency:

The high efficiency case is a heat pump or gas-fired water heater.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[1]

Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21A3b009	Heat Pump Swimming Pool Heater, <55 gallon, Energy Star, UEF 2.00	ES Products	1592	0.100
E21A3b009	Heat Pump Swimming Pool Heater, >55 gallon, UEF 2.70	ES Products	197	0.018

Measure Life:

The measure life is 13 years[1].

Other Resource Impacts:

The Gas Swimming Pool Heater measure increases gas consumption by 20.1 MMBtu/year.[1]

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3b009	Heat Pump Swimming Pool Heater	ES Products	1.00	1.00	n/a	1.00	0.00	0.00	0.00
G21A3b016	Gas Swimming Pool Heater	ES Products	1.00	n/a	1.00	1.00	0.00	0.00	0.00

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

The programs assume no summer or winter peak savings because it is assumed heaters are not used during summer peak periods and do not operate during the winter.

Energy Load Shape:

See Appendix 1.

Endnotes:

1: Navigant Consulting, 2018. Water Heating, Boiler, and Furnace Cost Study (RES 19) Appendix E, Add-On Task 7: Residential Water Heater Analysis Memo. 2018_Navigant_Water_Heater_Analysis_Memo http://ma-eeac.org/wordpress/wp-content/uploads/RES19_Assembled_Report_2018-09-27.pdf

1.30 Lighting - Fixture

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	Lighting

Description:

The installation of Light-Emitting Diode (LED) fixtures, which offer comparable luminosity to incandescent and halogen fixtures at significantly less wattage and significantly longer lifetimes.

Baseline Efficiency:

The baseline efficiency case for a lost opportunity LED fixture is a combination of an incandescent fixture, halogen fixture, and a compact fluorescent fixture. The baseline efficiency case for a retrofit LED fixture is a combination of an incandescent fixture and halogen fixture.

High Efficiency:

The high efficiency case is an ENERGY STAR ® rated LED fixture.

Algorithms for Calculating Primary Energy Impact:

Unit savings are based on the algorithm below. Demand savings are derived from the Navigant Demand Impact Model.

Vendor calculated unit savings are calculated using the following algorithms and assumptions:

$\Delta kWh = ((Watts\_Ineff - Watts\_EE) \times HOU)))/1000 \times Qty\_Bulbs \times 365$

$\Delta kW = \Delta kWh \times kW/kWh$

kW/kWh = Average kW reduction per kWh reduction: 0.00025 kW/kWh

Watts_Ineff = Rated watts of inefficient bulbs (either removed, through retrofit, or assumed to have been installed, through lost opportunity)

Watts_EE = Rated watts of efficient bulbs installed

Qty_Bulbs = Number of bulbs per fixture

365 = Days per year

HOU = Daily hours of use. The hours of use are largely based on recent NH evaluation studies for the ENERGY STAR Products Program and the Home Performance with ENERGY STAR Program, as well as increased hours of operation for ENERGY STAR Products to account for cross-sector sales at retailers (i.e., businesses purchasing program incented fixtures). The direct installation delivery strategies (HPwES) are based on residential hours only but reflect higher hours of use since the programs direct contractors to only replace fixtures that are used for at least three hours per day. The following summarizes the key assumptions for daily hours of use:[1]

- Lost opportunity LEDs installed in residential applications: 1.75 hours/day
- Lost opportunity LEDs installed in commercial applications (7% of all lost opportunity fixtures): 7 hours/day
- Retrofit HPwES LEDs (all installed in residential applications): 3.0 hours/day
- Retrofit HEA LEDs: (all installed in residential applications): 3.0 hours/day

Delta watts (WattsINEFF – WattsEE) are broken out by delivery strategy, and reflect a mix of program fixture wattages (for the efficient wattage), removed fixtures (for retrofit inefficient fixtures), and a blended mix of incandescents, halogens, and CFLs that would have been purchased in absence of the program measure.[2]

BC Measure ID	Measure Name	Program	Delta Watts per Fixture	Daily HOU	Number of Bulbs	ΔkWh	ΔkW
E21A3a009	LED Fixture	ES Products	34.2	2.1	1	26.4	0.007
E21A2a048	LED Fixture	HPwES	34.2	3	1	37.4	0.010
E21B1a048	LED Fixture	HEA	Vendor Calculated				
E21A3a010	LED Fixture (Hard to Reach)	ES Products	34.2	2.1	1	26.4	0.007
E21A1a024	LED Fixture	ES Homes	8.55	1.75	1	5.5	0.001

Measure Life:

The table below summarizes the measure lives for each of the measures listed above. Note these measure lives have been adjusted to account for the differential in measure life between the inefficient fixtures and LED fixtures (as well as the remaining useful life in the retrofit cases), and the potential for future lighting standards to lead the same sockets reached through the program to have been occupied by an LED in a period shorter than the technical life of the LED.[3]

BC Measure ID	Measure Name	Program	Adjusted Measure Life
E21A3a009	LED Fixture	ES Products	3
E21A2a048 E21B1a048	LED Fixture	HPwES/HEA	2
E21A3a010	LED Fixture (Hard to Reach)	ES Products	3
E21A1a024	LED Fixture	ES Homes	3

Other Resource Impacts:

Based on the 2018 NH Energy Star Products Program Evaluation report, fossil fuel interactive penalties for residential lighting programs are -2,272 Btu/kWh saved.[8]

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3a009	LED Fixture	ES Products	1.00	1.00	n/a	1.00	1.00	0.55	0.85
E21A2a048	LED Fixture	HPwES	0.99	0.96	n/a	0.96	0.96	0.55	0.85
E21B1a048	LED Fixture	HEA	1.00	0.91	n/a	0.91	0.91	0.55	0.85
E21A3a010	LED Fixture (Hard to Reach)	ES Products	1.00	1.00	n/a	1.00	1.00	0.55	0.85
E21A1a024	LED Fixture	ES Homes	1.00	1.00	n/a	1.00	1.00	0.55	0.85

<u>In-Service Rates:</u>

All HEA installations use an in-service rate of 100% because HEA realization rates account for uninstalled measures. All HPwES installations use in-service rate of 99% based on evaluation results. [5] [9] All other installations have a 100% in-service rate unless an evaluation finds otherwise.[4]

<u>Realization Rates:</u>

Based on evaluation results, all HEA installations use a realization rate of 91% and all HPwES installations use a realization rate of 100% because gross savings assumptions are adjusted to reflect evaluated results. [5] [9] All other installations have a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Coincidence factors are based on prescriptive loadshapes from the updated Navigant Massachusetts Demand Impact Model.[6]

Energy Load Shape:

See Appendix 1 – “Lighting”.[6]

Impact Factors for Calculating Net Savings:[7]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21A3a009	LED Fixture	ES Products	67%	n/a	n/a	33%
E21A3a010	LED Fixture (Hard to Reach)	ES Products	47%	n/a	n/a	53%

<u>Endnotes</u>:

1: Hours of use (residential) for the ES Products and HTR channel are based off of “New Hampshire ENERGY STAR® Products Program”, prepared by Cadmus for the New Hampshire ENERGY STAR Products New Hampshire Evaluation Measurement & Verification Working Group, October 17, 2018. The values reflect the daily weighted average LED hours of use. Cross-sector sales are based upon MA

RLPNC Cross-Sector Sale HOU Update", Prepared by the NMR Group for the Massachusetts Program Administrators (PAs), August 2, 2018. The 2.1 hours per day for ES Products and HTR are calculated as the weighted combination of residential and commercial hours of use: (residential HOU*residential %)+(commercial HOU*commercial %) = (1.75*0.93)+(7.0*0.07). HOU for ES Homes reflects the residential HOU only. Hours of use for the HPwES and HEA are based on program requirements for contractors to only replace fixtures that are used for at least three hours per day.

2: The delta watts are based off of the "MA PAs (2018). 2019-2021 Lighting Worksheet" (https://etrm.anbetrack.com/etrm/api/v1/etrm/documents/5bd06d1d6c50367b3deba017/view?authToken=fe238b4571e888c7558f844a02040d1941948e021564ac20156f12ece790e6a86c8a6c488b1d838694b8d9). Note the delta watts for ES Homes is reduced by 75% to reflect the requirement that 75% of lamps be high-efficacy lamps for new construction (https://www.energycodes.gov/sites/default/files/becu/2015_IECC_residential_requirements.pdf).

3: The direct installation measure life values come from RLPNC 18-5 Home Energy Assessment LED Net-to-Gross Consensus, Prepared by NMR Group, Inc. for the 2019—21 Planning Assumptions: Lighting Hours-of-Use and In-Service Rate, Prepared by NMR Group, Inc. for the Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) Consultants, July 23, 2018 (http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_185_HEALEDNTG_REPORT_23July2018_Final.pdf). These values reflect early replacement baselines, and assume that the replaced bulb, when it burnt out, would have been replaced by an LED at that time. Lighting measures with lost opportunity baselines (e.g., ES Products) add a year to measure life to reflect the different baseline as well as significantly lower hours of use.

4: In-service rates for ES Products and HTR channel, as well as ES Homes, are based on MA assumptions of 100% ISR for fixtures. In-service rates for HPwES and HEA are based on the NH study "Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL," Prepared by Opinion Dynamics Corporation, June 11, 2020. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/NHSaves-HPwES-Evaluation-Report-Final-20200611.pdf

5: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.

6: Navigant, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

7: "R1615 Light Emitting Diode (LED) Net-to- Gross Evaluation," Prepared by the NMR Group, Inc. for the Connecticut EEB, August 7, 2017. The 2020 Connecticut net-to-gross values are applied to New Hampshire for 2021 to account for the relatively slower pace of market transformation, due in part to fewer program bulbs per home in New Hampshire (2.5 bulbs per home in 2019) compared to Connecticut (4 bulbs per home in 2019).

8: Table 22. PY2016 Residential Lighting Energy Savings by Utility. Shows evaluated annual net electric energy savings, and evaluated penalties for gas, oil, and propane. Using the values for Eversource, a total calculated heating energy penalty of 341,757,000,000 Btu was assessed on the 150,403,000 kWh of electrical energy savings. **"**New Hampshire ENERGY STAR® Products Program 2016 Evaluation Report", prepared by Cadmus for the New Hampshire ENERGY STAR Products New Hampshire Evaluation Measurement & Verification Working Group, October 17, 2018.

9: Opinion Dynamics, July 29 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.31 Lighting – LED Lamp

Measure Code	[To Be Defined in ANB system]
Market	Residential
Program Type	Retrofit/Lost Opportunity
Category	Lighting

Description:

The installation of Light-Emitting Diode (LED) screw-in lamps and linear LEDs. LEDs offer comparable luminosity to incandescent and halogen lamps at significantly less wattage and significantly longer lamp lifetimes.

Baseline Efficiency:

The baseline efficiency case lost opportunity is a combination of an incandescent lamp, halogen lamp, and a compact fluorescent lamp. The baseline efficiency case for retrofit LED lamps is a combination of an incandescent lamp and halogen lamp.

High Efficiency:

The high efficiency case is an ENERGY STAR ® rated LED lamp.

Algorithms for Calculating Primary Energy Impact:

Unit savings are based on the algorithm below. Demand savings are derived from the Navigant Demand Impact Model.

Vendor calculated unit savings are calculated using the following algorithms and assumptions:[1]

ΔkWh = ((Watts_Ineff-Watts_EE) × HOU)/1000 × 365

ΔkW = ΔkWh × kW/kWh

kW/kWh = Average kW reduction per kWh reduction: 0.00025 kW/kWh

Watts_Ineff = Rated watts of inefficient lamps (either removed, through retrofit, or assumed to have been installed in lieu of the program lamps, through lost opportunity)

Watts_EE = Rated watts of efficient lamps installed

365 = Days per year

HOU = Daily hours of use. The hours of use are largely based on recent NH evaluation studies for the ENERGY STAR Products Program and the Home Performance with ENERGY STAR Program, as well as increased hours of operation for ENERGY STAR Products to account for cross-sector sales at retailers (i.e., businesses purchasing program incented lamps). The direct installation delivery strategies (HPwES, HEA) are based on residential hours only but reflect higher hours of use since the programs direct contractors to only replace lamps that are used for at least three hours per day. The following summarizes the key assumptions for daily hours of use:[2]

- Lost opportunity LEDs installed in residential applications: 1.75 hours/day
- Lost opportunity LEDs installed in commercial applications (7% of all lost opportunity lamps): 7 hours/day
- Retrofit HPwES LEDs (all installed in residential applications): 3.0 hours/day
- Retrofit HEA LEDs: (all installed in residential applications): 3.0 hours/day

Delta watts (Watts_Ineff – Watts_EE) are broken out by lamp style and delivery strategy, and reflect a mix of program lamp wattages (for the efficient wattage), removed lamps (for retrofit inefficient lamps), and a blended mix of incandescents, halogens, and CFLs that would have been purchased in absence of the program measure (for lost opportunity inefficient lamps).[3, 11]

Note that the ENERGY STAR Homes values represent a weighted average (based on the distribution of LEDs in NH homes as identified as part of a recent saturation study) of general service lamps, reflectors, and other specialty values.[4] The linear lamp values are based off of a separate research project in MA that specifically examined the characteristics (e.g., incented technologies, rooms with linear lamps) of linear LEDs.[5]

BC Measure ID	Measure Name	Program	Delta Watts	Daily HOU	ΔkWh	ΔkW
E21A3a001	General Service Lamps	ES Products	40	2.1	30.7	0.008
E21A3a004	Reflector	ES Products	43	2.1	33.0	0.008
E21A3a003	Other Specialty	ES Products	35	2.1	26.8	0.007
E21A3a002	Linear	ES Products	17.9	1.6	10.5	0.003
E21A2a044	General Service Lamps	HPwES	32.2	3.0	35.3	0.009
E21A2a047	Reflector	HPwES	46.2	3.0	50.6	0.013
E21A2a046	Other Specialty	HPwES	46.2	3.0	50.6	0.013
E21A2a045	Linear	HPwES	17.9	3.0	19.6	0.005
E21B1a044	General Service Lamps	HEA	Vendor Calculated			
E21B1a047	Reflector	HEA	Vendor Calculated			
E21B1a046	Other Specialty	HEA	Vendor Calculated			
E21B1a045	Linear	HEA	Vendor Calculated			
E21A3a005	General Service Lamps (Hard to Reach)	ES Products	40	2.1	30.7	0.008
E21A3a008	Reflector (Hard to Reach)	ES Products	43	2.1	33.0	0.008
E21A3a007	Other Specialty (Hard to Reach)	ES Products	35	2.1	26.8	0.007
E21A3a006	Linear (Hard to Reach)	ES Products	17.9	1.6	10.5	0.003
E21A1a023	ES Homes Lighting	ES Homes	10.2	1.75	6.5	0.002

	General Service Lamps	Drop Ship	40	1.75	25.6	0.007
	Reflector	Drop Ship	43	1.75	27.5	0.007
	Other Specialty	Drop Ship	35	1.75	22.4	0.006

Measure Life:

The table below summarizes the measure lives for each of the measures listed above. Note these measure lives have been adjusted to account for the differential in measure life between the inefficient lamps and LEDs (as well as the remaining useful life in the retrofit cases), and the potential for future lighting standards to lead the same sockets reached through the program to have been occupied by an LED in a period shorter than the technical life of the LED.[6]

BC Measure ID	Measure Name	Program	Adjusted Measure Life
E21A3a001	General Service Lamps	ES Products/Drop Ship	3
E21A3a004	Reflector	ES Products/Drop Ship	2
E21A3a003	Other Specialty	ES Products/Drop Ship	3
E21A3a002	Linear	ES Products	10
E21A2a044 E21B1a044	General Service Lamps	HPwES/HEA	2
E21A2a047 E21B1a047	Reflector	HPwES/HEA	2
E21A2a046 E21B1a046	Other Specialty	HPwES/HEA	2
E21A2a045 E21B1a045	Linear	HPwES/HEA	10
E21A3a005	General Service Lamps (Hard to Reach)	ES Products	3
E21A3a008	Reflector (Hard to Reach)	ES Products	2
E21A3a007	Other Specialty (Hard to Reach)	ES Products	3
E21A3a006	Linear (Hard to Reach)	ES Products	10
E21A1a023	ES Homes Lighting	ES Homes	3

Other Resource Impacts:

Based on the 2018 NH Energy Star Products Program Evaluation report, fossil fuel interactive penalties for residential lighting programs are -2,272 Btu/kWh saved.[10]

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3a001	General Service Lamps	ES Products	0.86	1.00	n/a	1.00	1.00	0.55	0.85
E21A3a004	Reflector	ES Products	0.89	1.00	n/a	1.00	1.00	0.55	0.85
E21A3a003	Other Specialty	ES Products	0.89	1.00	n/a	1.00	1.00	0.55	0.85
E21A3a002	Linear	ES Products	0.89	1.00	n/a	1.00	1.00	0.55	0.85
E21B1a044	General Service Lamps	HEA	1.00	0.91	n/a	0.91	0.91	0.55	0.85
E21A2a044	General Service Lamps	HPwES	0.99	1.00	n/a	1.00	1.00	0.55	0.85
E21B1a047	Reflector	HEA	1.00	0.91	n/a	0.91	0.91	0.55	0.85
E21A2a047	Reflector	HPwES	0.99	1.00	n/a	1.00	1.00	0.55	0.85
E21B1a046	Other Specialty	HEA	1.00	0.91	n/a	0.91	0.91	0.55	0.85
E21A2a046	Other Specialty	HPwES	0.99	0.96	n/a	0.96	0.96	0.55	0.85
E21B1a045	Linear	HEA	1.00	0.91	n/a	0.91	0.91	0.55	0.85
E21A2a045 E21B1a045	Linear	HPwES	0.99	0.96	n/a	0.96	0.96	0.55	0.85

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A3a005	General Service Lamps (Hard to Reach)	ES Products	0.86	1.00	n/a	1.00	1.00	0.55	0.85
E21A3a008	Reflector (Hard to Reach)	ES Products	0.89	1.00	n/a	1.00	1.00	0.55	0.85
E21A3a007	Other Specialty (Hard to Reach)	ES Products	0.89	1.00	n/a	1.00	1.00	0.55	0.85
E21A3a006	Linear (Hard to Reach)	ES Products	0.89	1.00	n/a	1.00	1.00	0.55	0.85
E21A1a023	ES Homes Lighting	ES Homes	1.00	1.00	n/a	1.00	1.00	0.55	0.85
	General Service Lamps	Drop Ship	.50	1.00	n/a	1.00	1.00	0.55	0.85
	Reflector	Drop Ship	.50	1.00	n/a	1.00	1.00	0.55	0.85
	Other Specialty	Drop Ship	.50	1.00	n/a	1.00	1.00	0.55	0.85

<u>In-Service Rates:</u>

All HEA installations use an in-service rate of 100% because HEA realization rates account for uninstalled measures[12]. All HPwES installations use an in-service rate of 99%.[4] In-service for all other installations are based on MA evaluations.[7]

<u>Realization Rates:</u>

Based on evaluation results, all HEA installations use a realization rate of 91%.[12] All HPwES installations use a realization rate of 100% because gross savings assumptions are adjusted to reflect evaluated results.[4] All other installations have a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Coincidence factors are based on prescriptive loadshapes from the updated Navigant Massachusetts Demand Impact Model.[8]

Energy Load Shape:

See Appendix 1 – “Lighting”.[8]

Impact Factors for Calculating Net Savings:[9]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21A3a001	General Service Lamps	ES Products	67%	n/a	n/a	33%
E21A3a004	Reflector	ES Products	67%	n/a	n/a	33%
E21A3a003	Other Specialty	ES Products	67%	n/a	n/a	33%
E21A3a002	Linear	ES Products	67%	n/a	n/a	33%
E21A3a005	General Service Lamps (Hard to Reach)	ES Products	47%	n/a	n/a	53%
E21A3a008	Reflector (Hard to Reach)	ES Products	47%	n/a	n/a	53%
E21A3a007	Other Specialty (Hard to Reach)	ES Products	47%	n/a	n/a	53%
E21A3a006	Linear (Hard to Reach)	ES Products	47%	n/a	n/a	53%

Endnotes:
1: Note that interactive effects require modeling HVAC end-use consumption based on home characteristics and equipment (e.g., cooling, heating fuel) saturation assumptions. The data and models were not available for New Hampshire, so are not included in the TRM.
2: Hours of use (residential) for the ES Products and HTR channel are based off of "New Hampshire ENERGY STAR® Products Program", prepared by Cadmus for the New Hampshire ENERGY STAR Products New Hampshire Evaluation Measurement & Verification Working Group, October 17, 2018. The values reflect the daily weighted average LED hours of use. Cross-sector sales are based upon MA RLPNC Cross-Sector Sale HOU Update", Prepared by the NMR Group for the Massachusetts Program Administrators (PAs), August 2, 2018. The 2.1 hours per day for ES Products and HTR channel are calculated as the weighted combination of residential and commercial hours of use: (residential HOU*residential %)+(commercial HOU*commercial %) = (1.75*0.93)+(7.0*0.07). HOU for ES Homes reflects the residential HOU only. Hours of use for the HPwES and HEA are based on program requirements for contractors to only replace fixtures that are used for at least three hours per day.
3: NMR, 2020. Delta Watt Update (MA19R09-E). Delta watts for ES Products and HTR are based on both historical lamps sales in Massachusetts and the most recently available market adoption model (for PY2021). Note that Massachusetts data were used because the New Hampshire ENERGY STAR Product evaluation had not stratified the program data or forecasted baseline wattage by style at the time of this TRM. The delta watts for ES Homes is reduced by 75% to reflect the requirement that 75% of lamps be high-efficacy lamps for new construction (https://www.energycodes.gov/sites/default/files/becu/2015_IECC_residential_requirements.pdf).
4: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.
5: RLPNC 18-7: TLED Product Impact Factor Estimation, Memo from NMR Group, Inc. to the Massachusetts Program Administrators, August 3, 2018.
6: The direct installation measure life values come from RLPNC 18-5 Home Energy Assessment LED Net-to-Gross Consensus, Prepared by NMR Group, Inc. for the 2019—21 Planning Assumptions: Lighting Hours-of-Use and In-Service Rate, Prepared by NMR Group, Inc. for the Massachusetts Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) Consultants, July 23,

2018 (http://ma-eeac.org/wordpress/wp-content/uploads/RLPNC_185_HEALEDNTG_REPORT_23July2018_Final.pdf). These values reflect early replacement baselines, and assume that the replaced bulb, when it burnt out, would have been replaced by an LED at that time. Lighting measures with lost opportunity baselines (e.g., ES Products) add a year to measure life to reflect the different baseline as well as significantly lower hours of use.
7: In-service rates for ES Products and HTR channel are based on the MA study "RLPNC 179: 2019—21 Planning Assumptions: Lighting Hours-of-Use and In-Service Rate," Prepared by the NMR Group, Inc. for the Massachusetts Program Administrators, July 13, 2018. Note the ISR is adjusted downward for lamps that are assumed to never be installed but does account (through discounted values) for lamps that are not immediately installed but are likely to be installed in the future. The ISR for Drop Ship is estimated based on program experience with lighting kits and will be evaluated.
8: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
9: "R1615 Light Emitting Diode (LED) Net-to- Gross Evaluation," Prepared by the NMR Group, Inc. for the Connecticut EEB, August 7, 2017. The 2020 Connecticut net-to-gross values are applied to New Hampshire for 2021 to account for the relatively slower pace of market transformation, due in part to fewer program bulbs per home in New Hampshire (2.5 bulbs per home in 2019) compared to Connecticut (4 bulbs per home in 2019).
10: Table 22. PY2016 Residential Lighting Energy Savings by Utility. Shows evaluated annual net electric energy savings, and evaluated penalties for gas, oil, and propane. Using the values for Eversource, a total calculated heating energy penalty of 341,757,000,000 Btu was assessed on the 150,403,000 kWh of electrical energy savings. **"**New Hampshire ENERGY STAR® Products Program 2016 Evaluation Report", prepared by Cadmus for the New Hampshire ENERGY STAR Products New Hampshire Evaluation Measurement & Verification Working Group, October 17, 2018.
11: Delta watts for HPwES are based on NH study "Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL," Prepared by Opinion Dynamics Corporation, June 11, 2020. https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/NHSaves-HPwES-Evaluation-Report-Final-20200611.pdf
12: Opinion Dynamics, July 29, 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.

1.32 Thermostat – Wi-Fi Communicating

Measure Code	TBD
Market	Residential
Program Type	Retrofit
Category	HVAC

Description:

A communicating Wi-Fi enabled thermostat which allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling systems.

Baseline Efficiency:

The baseline efficiency case is an HVAC system with either a manual or a programmable thermostat.

High Efficiency:

The high efficiency case is an HVAC system that has a Wi-Fi thermostat installed.

Algorithms for Calculating Primary Energy Impact: [4]

Unit savings are deemed based primarily on impact evaluation results.[4] ES Products savings are deemed based on statewide data on saturation of residential cooling equipment and heating fuel types.[3] For fuels that were not included in the impact evaluation (i.e. kerosene and wood pellets), unit savings are instead based on secondary research recommendations.[1]
Direct install thermostats that control both heating and cooling systems should claim savings using the Cooling measure in the last line of the table below in addition to the relevant heating savings measure line.

The utilities are not claiming any peak kW demand reductions until impact evaluation results are available, as savings are driven by runtime reductions rather than demand reductions.

BC Measure ID	Measure Name	Energy Type	Program	ΔkWh	ΔkW	ΔMMbtu
E21B1b015 E21A2b015	Wi-Fi Thermostat, Electric Heating	Electricity	HEA HPwES	419.0	0	n/a
E21B1b016 G21B1b004 E21A2b016 G21A2b004	Wi-Fi Thermostat, Gas	NG - Res Heating	HEA HPwES	46.0	n/a	5.80
E21B1b017 E21A2b017	Wi-Fi Thermostat, Kerosene	Kerosene	HEA HPwES	n/a	n/a	3.10

E21B1b018 E21A2b018	Wi-Fi Thermostat, Oil	Fuel Oil - Residential Distillate	HEA HPwES	n/a	n/a	5.90
E21B1b019 E21A2b019	Wi-Fi Thermostat, Propane	Propane	HEA HPwES	n/a	n/a	5.80
E21B1b020 E21A2b020	Wi-Fi Thermostat, Wood Pellets	Pellet Wood	HEA HPwES	n/a	n/a	3.10
E21A3b026	Wi-Fi Thermostat (Heating & Cooling)	Fuel Blind	ES Products	46.00	n/a	4.92
G21A3b019	WiFi Thermostat (Heating Only)	NG - Res Heating	ES Products	n/a	n/a	5.80
G21A3b020	Wi-Fi Thermostat (Heating & Cooling)	NG - Res Heating	ES Products	46.0	n/a	5.80

Measure Life:

The measure life is 15 years.[2]

Other Resource Impacts:

No other impacts are reported.

Impact Factors for Calculating Adjusted Gross Savings: [1,3,4]

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1b015	Wi-Fi Thermostat, Electric	Electricity	HEA	1.00	0.91	n/a	0.91	0.91	n/a	n/a
E21A2b015	Wi-Fi Thermostat, Electric	Electricity	HPwES	0.99	0.96	n/a	0.96	0.96	n/a	n/a

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1b016 G21B1b004	Wi-Fi Thermostat, Gas	NG - Res Heating	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b016 G21A2b004	Wi-Fi Thermostat, Gas	NG - Res Heating	HPwES	0.99	n/a	1.04	n/a	n/a	n/a	n/a
E21B1b017	Wi-Fi Thermostat, Kerosene	Kerosene	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b017	Wi-Fi Thermostat, Kerosene	Kerosene	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1b018	Wi-Fi Thermostat, Oil	Fuel Oil - Residential Distillate	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b018	Wi-Fi Thermostat, Oil	Fuel Oil - Residential Distillate	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1b019	Wi-Fi Thermostat, Propane	Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b019	Wi-Fi Thermostat, Propane	Propane	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21B1b020	Wi-Fi Thermostat, Wood Pellets	Pellet Wood	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b020	Wi-Fi Thermostat, Wood Pellets	Pellet Wood	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21A3b026 G21A3b019 G21A3b020	Wi-Fi Thermostat (Heating Only; Cooling Only; Heating & Cooling)	NG- Res Heating; Fuel Blind	ES Products	1.00	1.00	1.04	n/a	n/a	n/a	n/a

In-Service Rates:

All HEA installations have a 100% in-service-rate and all HPwES installations have a 99% in-service rate based on evaluation results.[5,6] All ES Products installations use a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All HEA installations have a 91% realization rate and all HPwES installations have a 100% realization rate based on evaluation results.[5,6] All ES Products installations use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

The utilities are not claiming any peak kW demand reductions until impact evaluation results are available, as savings are driven by runtime reductions rather than demand reductions.

Energy Load Shape:

See Appendix 1 "Weighted HVAC- All Homes"

Endnotes:

1: Navigant Consulting, September 2018. Wi-Fi Thermostat Impact Evaluation--Secondary Research Study Memo. http://ma-eeac.org/wordpress/wp-content/uploads/Wi-Fi-Thermostat-Impact-Evaluation-Secondary-Literature-Study_FINAL.pdf
2: Environmental Protection Agency, 2010. Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat. Assumed to have the same lifetime as a regular programmable thermostat
3: Itron 2020. New Hampshire Residential Baseline Study. Prepared for New Hampshire Evaluation, Measurement and Verification Working Group. Worksheet based on this analysis embedded here:

WiFi tStat Worksheet, 2021.xlsx

4: Navigant Consulting, August 2018. Home Energy Services (HES) Impact Evaluation, Table 5-13. https://ma-eeac.org/wp-content/uploads/RES34_HES-Impact-Evaluation-Report-with-ES_FINAL_29AUG2018.pdf
5: Opinion Dynamics, July 29, 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.
6: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.

1.33 Thermostat – Programmable

Measure Code	
Market	Residential
Program Type	Retrofit
Category	HVAC

Description:

Installation of a programmable thermostat, which gives the ability to adjust heating or air-conditioning operating times according to a pre-set schedule.

Baseline Efficiency:

The baseline efficiency case is an HVAC system without a programmable thermostat: either a manual thermostat or no thermostat.

High Efficiency:

The high efficiency case is an HVAC system that has a programmable thermostat installed.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on evaluation results.[1]

BC Measure ID	Measure Name	Energy Type	Program	ΔkWh	ΔkW	ΔMMbtu
E21B1b009	Programmable Thermostat, Electric Heat	Electricity	HEA	251.0	n/a	n/a
E21B1b010 G21B1b003	Programmable Thermostat, Gas	NG - Res Heating	HEA	27	0.04	3.50
E21B1b011	Programmable Thermostat, Kerosene	Kerosene	HEA	n/a	n/a	3.50
E21B1b012	Programmable Thermostat, Oil	Fuel Oil - Residential Distillate	HEA	n/a	n/a	3.50
E21B1b013	Programmable Thermostat, Propane	Propane	HEA	n/a	n/a	3.50
E21B1b014	Programmable Thermostat, Wood Pellets	Pellet Wood	HEA	n/a	n/a	3.50

E21A2b009	Programmable Thermostat, Electric	Electricity	HPwES	251.0	n/a	n/a
E21A2b010 G21A2b003	Programmable Thermostat, Gas	NG - Res Heating	HPwES	n/a	n/a	3.50
E21A2b011	Programmable Thermostat, Kerosene	Kerosene	HPwES	n/a	n/a	3.50
E21A2b012	Programmable Thermostat, Oil	Fuel Oil - Residential Distillate	HPwES	n/a	n/a	3.50
E21A2b013	Programmable Thermostat, Propane	Propane	HPwES	n/a	n/a	3.50
E21A2b014	Programmable Thermostat, Wood Pellets	Pellet Wood	HPwES	n/a	n/a	3.50
TBD	Programmable Thermostat, AC only	Electricity	TBD	27.0	n/a	n/a
G21A3b011	Programmable Thermostat, Gas	Gas	ES Products	27.0	0.04	3.5

Thermostats that control both heating and central cooling may claim savings for both cooling (27.0 kWh/yr) and heating impacts (by fuel).

Measure Life:

The measure life is 15 years.[2]

Other Resource Impacts:

No other resource impacts are included.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21B1b009	Programmable Thermostat, Electric	Electricity	HEA	1.00	0.91	0.00	0.91	0.91	0.00	1.00

E21B1b010 G21B1b003	Programmable Thermostat, Gas	NG - Res Heating	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1b011	Programmable Thermostat, Kerosene	Kerosene	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1b012	Programmable Thermostat, Oil	Fuel Oil - Residential Distillate	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1b013	Programmable Thermostat, Propane	Propane	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21B1b014	Programmable Thermostat, Wood Pellets	Pellet Wood	HEA	1.00	n/a	0.91	n/a	n/a	n/a	n/a
E21A2b009	Programmable Thermostat, Electric	Electricity	HPwES	0.99	0.96	n/a	0.96	0.96	0.00	1.00
E21A2b010	Programmable Thermostat, Gas	NG - Res Heating	HPwES	0.99	n/a	1.04	n/a	n/a	n/a	n/a
E21A2b011	Programmable Thermostat, Kerosene	Kerosene	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21A2b012	Programmable Thermostat, Oil	Fuel Oil - Residential Distillate	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21A2b013	Programmable Thermostat, Propane	Propane	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
E21A2b014	Programmable Thermostat, Wood Pellets	Pellet Wood	HPwES	0.99	n/a	1.14	n/a	n/a	n/a	n/a
TBD	Programmable Thermostat, AC only	Electricity	TBD	1.00	1.00	1.14	1.00	1.00	1.00	0.00

Programmable thermostats that control both cooling and heating equipment should claim both the 27 kWh of electric energy savings associated with the cooling equipment at the impact factors listed above and any heating savings.

<u>In-Service Rates:</u>

All HEA installations have a 100% in-service rate and all HPwES installations have a 99% in-service rate based on evaluation results.[4] [5]

Realization Rates:

All HEA installations have a 91% realization rate and all HPwES installations have a 100% realization rate based on evaluation results.[4,5]

Coincidence Factors:

Summer and winter coincidence factors are estimated using demand allocation methodology described the Navigant Demand Impact Model prepared for MA Program Administrators.[3]

Energy Load Shape:

See Appendix 1 “Weighted HVAC- All Homes”

Endnotes:

1: Navigant Consulting, August 2018. Home Energy Services (HES) Impact Evaluation. https://ma-eeac.org/wp-content/uploads/RES34_HES-Impact-Evaluation-Report-with-ES_FINAL_29AUG2018.pdf**2:** Environmental Protection Agency, 2010. Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat.
3: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
4: Opinion Dynamics, July 29, 2020, New Hampshire Utilities, Home Energy Assistance Program Evaluation Report, 2016-2017 – FINAL.
5: Opinion Dynamics, June 11, 2020, Home Performance with Energy Star Program Evaluation Report 2016-2017 – FINAL.

1.34 Whole Home – New Construction

Measure Code	RES-WH-NEW
Market	Residential
Program Type	Lost Opportunity
Category	Whole Home

Description:

The Program Administrators currently use vendor calculated energy savings using a RESNET accredited Rating Software Tool (REM/Rate) where a user inputs a detailed set of technical data about a project, comparing as-built projected energy consumption to that of a Baseline Home. This process is used to calculate electric and fossil fuel energy savings due to heating, cooling, and water heating for all homes.[1]

Baseline Efficiency:

The Baseline Home is based on a User Defined Reference Home (UDRH), which was updated in 2019 to reflect the IECC 2015 code, with amendments as adopted by the state of NH.[2, 3] UDRH heating system efficiencies and air infiltration rates remain more stringent than code to reflect the results of the 2017 NH Energy Star Homes evaluation.[4]

High Efficiency:

The high-efficiency case is represented by the specific energy characteristics of each "as-built" home completed through the program.

Algorithms for Calculating Primary Energy Impact:

Unit savings are custom calculated for each home for heating, cooling, and water heating end uses. Demand savings are derived from the Navigant Demand Impact Model. As noted below, because the values are custom generated on a site-by-site basis, they are not shown in the table below.

BC Measure ID	Measure Name	Program
E21A1a001 E21A1a012 G21A1a001 G21A1a002	Cooling, Electric Cooling, Electric SF Cooling, Electric, MF	ES Homes
E21A1a002 E21A1a013	Heating, Electric	ES Homes
E21A1a003 E21A1a014 G21A1a002	Heating, Gas Heating, Gas,SF Heating, Gas, MF	ES Homes

G21A1a005		
E21A1a004 E21A1a015	Heating, Oil	ES Homes
E21A1a005 E21A1a016	Heating, Propane	ES Homes
E21A1a006 E21A1a017	Heating, Wood Pellets	ES Homes
E21A1a007 E21A1a018	Hot Water, Electric	ES Homes
E21A1a008 E21A1a019 G21A1a003 G21A1a006	Hot Water, Gas Hot Water, Gas, SF Hot Water, Gas,MF	ES Homes
E21A1a009 E21A1a020	Hot Water, Oil	ES Homes
E21A1a010 E21A1a021	Hot Water, Propane	ES Homes
E21A1a011 E21A1a022	Hot Water, Wood Pellets	ES Homes

Measure Life:

The measure life is shown below and varies by end use.[5]

BC Measure ID	Measure Name	Program	EUL
E21A1a002 E21A1a013 E21A1a003 E21A1a014 E21A1a004 E21A1a015 E21A1a005 E21A1a016 E21A1a006 E21A1a017	Heating	ES Homes	25
E21A1a001 E21A1a012	Cooling	ES Homes	25
E21A1a007 E21A1a018 E21A1a008 E21A1a019 E21A1a009 E21A1a020 E21A1a010 E21A1a021 E21A1a011 E21A1a022	Water Heating	ES Homes	15

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A1a001 E21A1a012	Cooling, Electric	ES Homes	1.00	1.00	1.00	1.00	1.00	0.35	0.00
E21A1a002 E21A1a013	Heating, Electric	ES Homes	1.00	1.00	1.00	1.00	1.00	0.00	0.43
E21A1a003 E21A1a014	Heating, Gas	ES Homes	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E21A1a004 E21A1a015	Heating, Oil	ES Homes	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E21A1a005 E21A1a016	Heating, Propane	ES Homes	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E21A1a006 E21A1a017	Heating, Wood Pellets	ES Homes	1.00	1.00	1.00	1.00	1.00	1.00	1.00

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A1a007 E21A1a018	Hot Water, Electric	ES Homes	1.00	1.00	1.00	1.00	1.00	0.31	0.81
E21A1a008 E21A1a019	Hot Water, Gas	ES Homes	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E21A1a009 E21A1a020	Hot Water, Oil	ES Homes	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E21A1a010 E21A1a021	Hot Water, Propane	ES Homes	1.00	1.00	1.00	1.00	1.00	1.00	1.00
E21A1a011 E21A1a022	Hot Water, Wood Pellets	ES Homes	1.00	1.00	1.00	1.00	1.00	1.00	1.00

In-Service Rates:

All installations have 100% in service rate unless an evaluation finds otherwise.

Realization Rates:

All energy realization rates are 100% because energy and demand savings are custom calculated based on project specific details.

Coincidence Factors:

Coincidence factors for electric end uses are based on prescriptive load shapes from the updated Navigant Demand Impact Model for Massachusetts.[6]
Coincidence factors for non-electric end uses are set to 100% as no electrical energy impacts are expected.

Energy Load Shape

See Appendix 1.

Endnotes:

1: Note that there are also prescriptive rebates for appliances, including clothes washers, clothes dryers, and refrigerators, as well as lighting, which are covered in other sections of the TRM.
2: See "ESHOME UDRH update 02-23-2018, Revised 5-17-2019.docx"
3: Note the UDRH represents both single family and multifamily homes, and all measures (cooling heating, and hot water) are present in both single family and multifamily homes.
4: Energy and Resource Solutions, December 7, 2018. New Hampshire ENERGY STAR Homes Program Impact Evaluation. Prepared for the NH Program Administrators.
https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/NH_ESHomes_Report_Final_v4-2017.pdf
5: MA Technical Reference Manual 2019 Plan-Year Report Version, Page 244, "Chapter 1.60: Whole Home New Construction" section, accessed on February 14, 2020, and GDS Associates Inc. Measure Life Report, Residential and Commercial Industrial Lighting and HVAC Measures, Jun. 2007.
6: Navigant Consulting, 2018. RES 1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

1.35 Whole Home – Energy Report

Measure Code	
Market	Residential
Program Type	Custom
Category	Behavioral

Description:

Residential home energy report ("HER") programs levereage behavior science to influence customers' energy use practices. The program strategy involves sending customer-specific energy use reports to a sample of electric and / or natural gas customers. The implementation vendor calculates savings results based on statistical analysis of the differences in energy usage for the treatment group when compared to the energy usage of a control group.

Baseline Efficiency:

The baseline efficiency case is a control-group customer who does not receive home energy reports.

High Efficiency:

The high efficiency case is a customer who receives periodic mailed and/or emails home energy reports tailored and has access to a web-based dashboard that includes tailored messaging regarding ways of reducing energy use.

Algorithms for Calculating Primary Energy Impact:

Unit savings for Home Energy Reports are based on calculations from vendor results.

A lagged-dependent variable (LDV) model (sometimes also referred to as a post-period regression with pre-period controls) utilizes a panel data set (a cross-sectional time-series) to estimate energy savings from a randomized control trial (RCT) using pre-treatment (lagged) energy consumption value(s) as an independent control.

$$ADU_{k,t} = \alpha + \beta_1 treatment_k + \sum_j \beta_{2j} Month_t + \sum_i \beta_{3i} ADUlag_{k,t,i} + \varepsilon_{k,t}$$

Where:

- $ADU_{k,t}$ is average daily consumption of kWh by household *k* in month *t*,
- α is the model intercept,
- $treatment_k$ is a binary variable with a value of 0 if household *k* is assigned to the control group and 1 if assigned to the treatment group,
- $Month_j$ is a binary variable with a value of 1 when *t*=*j*, and is 0 otherwise,
- $ADUlag_{k,t,i}$ is a vector of *i* baseline usage control variables. An evaluator may choose the form of these control values, as pre-treatment data availability may allow. A suggested formulation for this vector is the following three (*i*=3) LDV terms:

- *avg_preusage*$_k$ is the average daily usage across household k's available pre-treatment meter reads for the year prior to the start of treatment,
- *avg_preusage_winter*$_k$ is the average daily usage over the months of December through March across household k's available pre-treatment meter reads for the year prior to the start of treatment and,
- *avg_preusage_winter*$_k$ is the average daily usage over the months of June through September across household k's available pre-treatment meter reads for the year prior to the start of treatment.

A simpler, alternative, formulation of this $ADUlag_{k,t,i}$ term can be a single (i=1) LDV representing household k's average daily energy use in the same calendar month as t in year immediately preceding the program.

- $\varepsilon_{k,t}$ is the cluster-robust idiosyncratic error term for household k in month t.

The coefficient β_1 is the coefficient of interest; it is the estimate of average daily energy savings for a household in the treatment group.

Measure Life:

The measure life for Home Energy Reports is 1 year[1]. As a behavioral measure, the intervention of regularly receiving a Home Energy Report is required to claim savings.

BC Measure ID	Measure Name	Program	Measure Life
E21A4a001 G21A4a001	Residential Whole Home Energy Report	[Abbr]	1

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21A4a001	Residential Whole Home Energy Report	Residential Behavior	1.00	1.00	NA	1.00	1.00	0.547	0.848
G21A4a001	Residential Whole Home Energy Report	Residential Behavior	1.00	NA	1.00	NA	NA	NA	NA

<u>In-Service Rates:</u>

All installations have 100% in-service-rates since reports are sent out regularly to participants.[1]

<u>Realization Rates:</u>

Realization rates from Navigant's 2016 evaluation of Eversource New Hampshire Home Energy Report pilot program found that the realization rate for the normative behavior program design was 99.9%.[1]

Coincidence Factors:

Summer and winter coincidence factors are based on a residential lighting loadshape.[2]

Energy Load Shape:

See Appendix 1.

Endnotes:

1: Navigant Consulting (2016). Home Energy Report Pilot Program Evaluation Final Report, Feb 2014-Feb 2015. Prepared for Eversource New Hampshire.
2: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
2018_Navigant_Baseline_Loadshape_Comprehensive_Report

2. Commercial

2.1

2.1 C&I Active Demand Response

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Custom
Category	Active Demand Response

Description:

Active Demand Reduction includes C&I Load Curtailment Targeted Dispatch and Storage Daily Dispatch Performance.

The Load Curtailment offering is technology agnostic and provides an incentive for verifiable shedding of load in response to a signal or communication from the Program Administrators coinciding with system peak conditions. Large C&I customers that are subject to demand charges and/or direct capacity charges (determined by ICAP tags) with the ability to control lighting, HVAC, and/or process loads, can use this demand reduction performance offering to generate revenue by altering their operations a few times per year. The offering focuses on reducing demand during summer peak events typically targeting fewer than twenty hours per summer.

The C&I Storage Performance offering provides performance incentives for C&I storage performance. Since storage does not impact customer comfort or operations, storage resources are expected to be available for daily dispatch to maximize their value.

Baseline Efficiency:

Baseline conditions will be determined based on technology.

For Load Curtailment, baseline conditions are based on an adjustment settlement baseline with symmetric, additive adjustment. The symmetrically adjusted settlement baseline is developed based on a pool of the most recent 10 non-holiday weekdays. The baseline shape consists of average load per interval across the eligible days. The baseline is adjusted based on the difference between baseline and facility load in the second hour prior to the event (the baseline adjustment period), and the adjustment can be either to increase or decrease the estimated load reduction (i.e., symmetric adjustment). This adjustment accounts for weather-related and other differences of load magnitude.[1]

For Storage, demand reduction is calculated based on battery load. A baseline value is not directly calculated for storage, instead, the counterfactual is the actual facility load without the battery, which is derived based on the facility load with the battery and the battery load.[2]

High Efficiency:

Active Demand Reduction does not directly increase efficiency. Load curtailment does reduce power consumption by curtailing use, but does not inherently reduce energy consumption.

Storage increases energy consumption due to round trip efficiency losses. Battery round trip efficiency losses are calculated on a per-project basis. For reference, evaluation results for daily dispatch storage reflect an impact of 240 kWh per year per kW of nameplate battery discharge capacity.[2]

Algorithms for Calculating Primary Energy Impact:

The Active Demand Reduction measure generates site-specific vendor-reported demand savings, which are validated by evaluation. Savings estimates for these projects are calculated using engineering analysis with project-specific details.

Measure Life:

As all C&I active demand response measures are based on Program Administrators calling demand reduction events each year, the deemed measure life is one year.

BC Measure ID	Measure Name	Program	Measure Life
E21C5a001	Load Curtailment Targeted Dispatch P4P Summer	C&I Active Demand Response	1
E21C5a002	Storage Daily Dispatch P4P (savings) Summer	C&I Active Demand Response	1
E21C5a003	Storage Daily Dispatch P4P (consumption) Summer	C&I Active Demand Response	1

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C5a001	Load Curtailment Targeted Dispatch P4P Summer	C&I Active Demand Response	1.00	0.981	1.00	0.981	1.00	1.00	0.00
E21C5a002	Storage Daily Dispatch P4P (savings) Summer	C&I Active Demand Response	1.00	1.04	1.00	1.04	1.00	1.00	0.00
E21C5a003	Storage Daily Dispatch P4P (consumption) Summer	C&I Active Demand Response	1.00	1.04	1.00	1.04	1.00	1.00	0.00

<u>In-Service Rates:</u>

In-service rates for commercial and industrial active demand response are assumed to be 100% by default, as measured performance in the ADR program is required to claim savings.

Realization Rates:

Electrical energy realization rates for this measure are assumed to be equal to summer peak demand realization rates.
Summer peak realization rates for interruptible load are based on a program evaluation of the 2019 summer demand reduction period for New Hampshire.[1] These realization rates are based on the overall program savings, rather than individual measure savings, and represent the retrospective realization rate (i.e. the evaluated symmetric savings estimate divided by the reported asymmetric savings estimate).
For daily and targeted storage dispatch programs, summer peak realization rates are based on an evaluation of Eversource battery storage demonstration projects.[2]

Coincidence Factors:

Coincidence factors for this measure are assumed to be 100%, as the scaling factor accounts for the coincidence of program events with the system peak. The programs are not claiming winter peak impacts due to the fact that the ISO-NE system is summer peaking.

Scaling Factors:

A scaling factor is used to account for the fact that the benefits of an active demand response resource depend on how often it performs. The greater the frequency of demand response events, the more that the active demand resource reduces the installed capacity requirement, and therefore the greater its value. For planning the utilities use a scaling factor of 10% for load curtailment measures and 100% for daily dispatch measures, reflecting the AESC 2018 review of sensitivity analyses run by PJM load forecasters. [3] For reporting utilities will use scaling factor values based on the most recent evaluation timing of events that are called in 2021.

Energy Load Shape:

As commercial active demand response events are called on the day preceding the event, the most appropriate load shape to use is a symmetric load based on the 10 baseline day load shape at the same facility.[1]

Endnotes:
1: ERS (2020). Cross-State C&I Active Demand Reduction Initiative Summer 2019 Evaluation Report. Prepared for Eversource, National Grid, and Unitil (MA, CT, and NH). https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/Cross-State-CI-DR-S19-Evaluation-Report_04-15-2020.pdf

2: ERS (2020). Daily Dispatch Battery Project Evaluation Report. Prepared for Eversource. https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/5ee488776996f264267df7b6/view?authToken=8a34f8598773992325038987ea62e83319d208f835e892092c491823f78722e7a92604e473dc75021eb90f821f219b8cbc0ddafaae207ed1924f97faecb70d5eaf3e5372d04fb6

3: Avoided Energy Supply Components in New England: 2018 Report, page 105. https://www.synapse-energy.com/sites/default/files/AESC-2018-17-080-Oct-ReRelease.pdf

2.2 Building Envelope – Air Sealing and Insulation

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	**Building Shell**

Description:

Air Sealing: Air sealing will decrease the infiltration of outside air through cracks and leaks in the building.

Insulation: The installation of high efficiency insulation in an existing structure.

Air sealing and insulation are offered through the Municipal Energy Solutions program, and apply to municipal buildings.

Baseline Efficiency: :

Air Sealing: The baseline efficiency case is the existing building before the air sealing measure is implemented. The baseline building is characterized by the existing air changes per hour (ACHPRE) for multi-family facilities, which is measured prior to the implementation of the air sealing measure. This will typically be a default value of a baseline/pre-retrofit ACH =0.5.

Insulation: The baseline efficiency case is characterized by the total R-value of the existing attic, basement, or sidewall (Rexist). This is calculated as the R-value of the existing insulation, estimated by the program contractor, plus the R-value of the ceiling, floor, or wall (for all projects: RCEILING = 3.36; RFLOOR = 6.16; RWALL = 6.65).

High Efficiency:

Air Sealing: The baseline efficiency case is the existing building after the air sealing measure is implemented. The high efficiency building is characterized by the new air changes per hour (ACHPOST) for multi-family facilities, which is measured after the air sealing measure is implemented. This will typically be a default value of a baseline/pre-retrofit ACH =0.4.

Insulation: The high efficiency case is characterized by the total R-value of the attic after the installation of additional attic, basement, or sidewall insulation. This is calculated as the sum of the existing R-value (Rexisit) plus the R-value of the added insulation.

Algorithms for Calculating Primary Energy Impact:

Air Sealing:

Unit savings are calculated using the following algorithms and assumptions:

kWh = (Vol x ACH x 0.018 x HDD x 24/ ηheating) / 3,413
MMBtu = (Vol x ACH x 0.018 x HDD x 24/ ηheating) / 1,000,000
kW = kWh x kW/kWh

Where:
Vol = [ft^3] This is the air volume of the treated space, calculated from the dimensions of the space, which could include the number of floors, the floor area per floor, and the floor-to-ceiling height, or the dwelling floor area and number of dwellings. The treated space can be the entire building including the common areas, or just the individual dwelling units. (Auditor Input)
Δ ACH = [ºF-day] Infiltration reduction in Air Changes per Hour, natural infiltration basis. This will typically be a default value, but the source of the assumption should be transparent and traceable, or it could come from a blower door test. (Stipulated Value or Blower Door Test)
HDD60 = Heating degree-days with temperature base of 60 degrees. [1]
ηheating = [AFUE, COP, thermal efficiency (%)] Efficiency of the heating system, as determined on site (Auditor Input)
24 = Conversion factor: 24 hours per day
0.018 = [Btu / ft^3- ºF] Air heat capacity: The specific heat of air (0.24 Btu / ºF.lb) times the density of air (0.075 lb / ft_3)
1,000,000 = Conversion factor: 1,000,000 Btu per MMBtu
3,413 = Conversion factor: 3,413 Btu / kWh
kW / kWh = Average kW reduction per kWh reduction: 0.00073 kW / kWh [2]

Insulation:
Unit savings are calculated using the following algorithms and assumptions:
$MMBtu_{annual} = ((1/R_{exist} - 1/R_{new}) * HDD * 24 * Area)/1000000 * \eta_{heat}$
$kWh_{annual} = MMBtu_{annual} * 293.1$
$kW = kWh_{annual} * kW/kWh_{heating}$

Where,
R_{exist} = Existing effective R-value (R-ExistingInsulation + R-Assembly),ft2-°F/Btuh
R_{new} = New total effective R-value (R-ProposedMeasure + R-ExistingInsulation+ R-Assembly), ft2-°F/Btuh
Area = Square footage of insulated area
η_{heat} = Efficiency of the heating system (AFUE or COP) 293.1 = Conversion constant (1MMBtu = 293.1 kWh)
24 = Conversion for hours per day
HDD = Heating Degree Days; dependent on location
1,000,000 = Conversion from Btu to MMBtu kW/kWh heating = Average annual kW reduction per kWh reduction [2]

Measure	kW/kWh Factor
Insulation (Electric)	0.00073
Insulation (Gas, Oil, Other FF)	0.00076
Insulation, Central AC in Electrically Heated Unit	0.00059

Measure Life:

The measure life is shown in the table below.[3]

BC Measure ID	Measure Name	Program	Measure Life
E21C3a015 E21C3a016 E21C3a017 E21C3a018 E21C3d017 E21C3d018 E21C3d019 E21C3d020	Air Sealing	Municipal Retrofit Municipal Direct Install	15
E21C3a051 E21C3a052 E21C3a053 E21C3a054 E21C3d051 E21C3d052 E21C3d053 E21C3d054	Insulation	Municipal Retrofit Municipal Direct Install	25
G21C1a017 G21C2a017	Air Sealing	Large C&I Retrofit Small C&I Retrofit	15
G21C1a018 G21C2a018	Insulation	Large C&I Retrofit Small C&I Retrofit	25

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[2]

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C3a015 E21C3d017	Air Sealing	Electric	Muni Retro Muni DI	1.00	1.00	n/a	n/a	n/a	0.00	0.43
E21C3a016 E21C3d018	Air Sealing	Gas	Muni Retro Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3a017 E21C3d019	Air Sealing	Oil	Muni Retro Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3a018 E21C3d020	Air Sealing	Propane	Muni Retro Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C3a051 E21C3d051	Insulation	Electric	Muni Retro Muni DI	1.00	1.00	n/a	n/a	n/a	0.34	0.17
E21C3a052 E21C3d052	Insulation	Gas	Muni Retro Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3a053 E21C3d053	Insulation	Oil	Muni Retro Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3a054 E21C3d054	Insulation	Propane	Muni Retro Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1a017 G21C2a017	Air Sealing	Gas	Large C&I Retrofit Small C&I Retrofit	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1a018 G21C2a018	Insulation	Gas	Large C&I Retrofit Small C&I Retrofit	1.00	n/a	1.00	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Summer and winter coincidence factors for insulation are estimated using demand allocation methodology described in the Demand Impact Model.
A winter coincidence factor of 43% is utilized for air sealing.[2]

Energy Load Shape:

For electric air sealing and insulation, see Appendix 1 C&I Load Shapes "Hardwired Electric Heat"
For non-electric air sealing, see Appendix 1 C&I Load Shapes "Non-Electric Measures"
For non- electric insulation, see Appendix 1 C&I Load Shapes "Central Air Conditioner/ Heat Pump (Cooling)

Endnotes:
1: The HDD should be calculated based on the TMY3 weather data of the nearest weather station. https://www7.ncdc.noaa.gov/CDO/cdoselect.cmd?datasetabbv=GSOD&countryabbv=&georegionabbv
2: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

3: Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf

2.3 Compressed Air – Air Compressor

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Compressed Air

Description:

Covers the installation of oil flooded, rotary screw compressors with Variable Speed Drive or Variable Displacement capacity control with properly sized air receiver. Efficient air compressors use various control schemes to improve compression efficiencies at partial loads.

Baseline Efficiency:

The baseline efficiency case is a typical load/unload compressor.

High Efficiency:

The high efficiency case is an oil-flooded, rotary screw compressor with Variable Speed Drive or Variable Displacement capacity control with a properly sized air receiver. Air receivers are designed to provide a supply buffer to meet short-term demand spikes which can exceed the compressor capacity. Installing a larger receiver tank to meet occasional peak demands can allow for the use of a smaller compressor.

Algorithms for Calculating Primary Energy Impact:

Δ kWh = (HP COMPRESSOR) x (Save) x (Hours)
Δ kW = (HP COMPRESSOR) x (Save)
Where:
HP COMPRESSOR = Nominal rated horsepower of high efficiency air compressor
Save = Air compressor kW reduction per HP: 0.189[1]
Hours = Annual operating hours of the air compressor

Measure Life:

The measure life is 15 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b016	Air Compressor	LBES New	1.00	.99	.n/a	1.00	1.00	1.17	0.98
E21C2b016 E21C3b016	Air Compressor	SBES New Muni New	1.00	1.00	n/a	1.00	1.00	1.17	0.98

In-Service Rates:

All installations have a 100% in service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [3]

Coincidence Factors:

CFs from the prospective results of the 2015 study of prescriptive compressed air.[1]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Compressed Air – VFD Compressor"

Endnotes:

1: DNV GL, October 2015. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for the MA PAs and EEAC. Result for VSD 25-75 HP used since "All" result includes savings from load/unload compressors, which are now baseline. http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf

2: ERS, November 2005. Measure Life Study. Prepared for MA Joint Utilities. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf

3: DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities.
https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

2.4 Compressed Air – Air Nozzle

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity/ Retrofit
Category	Compressed Air

Description:

Covers the installation of engineered air nozzles which provide effective air nozzle action while reducing compressed air system air flow.

Baseline Efficiency:

The baseline efficiency case is a a standard nozzle on a compressed air system.

High Efficiency:

The high efficiency case is an engineered nozzle on the same compressed air system.

Algorithms for Calculating Primary Energy Impact:

Savings are calculated in a spreadsheet tool per the following:

$$\Delta kW = (FLOW_{BASE} - FLOW_{EE}) \times \frac{kW}{cfm}$$

$$\Delta kWh = \Delta kW \times hr$$

Where:

$FLOW_{BASE}$ = base case nozzle flow in cfm, at site specific pressure if available, or else at 100 psig
$FLOW_{EE}$ = energy efficient nozzle flow in cfm, at site specific pressure if available, or else at 100 psig
$\frac{kW}{cfm}$ = site specific compressor efficiency, default value of 0.29 if unavailable

Measure Life:

The measure life is 13 years.

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b017	Air Nozzle	LBES New	1.00	.99	n/a	1.00	1.00	0.80	0.54
E21C2b017 E21C3b017	Air Nozzle	SBES New Muni New	1.00	1.00	n/a	1.00	1.00	0.80	0.54

<u>In-Service Rates:</u>

All installations have a 100% in service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [2]

<u>Coincidence Factors:</u>

CFs from the prospective results of the 2015 study of prescriptive compressed air.[1]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Compressed Air – VFD Compressor".

<u>Endnotes</u>:

1: DNV GL, October 2015. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for Massachusetts Program Administrators and Massachusetts Energy Efficiency Advisory Council. http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf

2:DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities.
https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

2.5 Compressed Air – Adding Compressor Capacity and/or Storage

Measure Code	[Code]
Market	Commercial
Program Type	Retrofit
Category	Compressed Air

Description:

Adding storage capacity to compressed air systems with previously insufficient storage results in less system pressure fluctuations and allows lower average system pressures, leading to air compressor energy savings when operated at lower system pressures. It also reduces cycling losses in compressor systems that use a compressor with load-unload controls for part-load modulation.

Baseline Efficiency:

The baseline is the site-specific air compressor energy consumption operating at the higher average system pressure with insufficient compressed air storage.

High Efficiency:

The high efficiency case is the site-specific air compressor energy consumption operating at the lower average system pressure after the added compressed air storage, and with reduced cycling losses for load/unload compressors.

Algorithms for Calculating Primary Energy Impact:

The energy savings are based on air compressor energy efficiency improvements resulting from two components: the lower average pressure after air storage capacity is added, and reduced cycling losses. The measure may realize one or both savings components, depending on baseline conditions.

The algorithm for calculating electric demand savings from the system pressure reduction is:

$$\Delta kW_{PR} = kW_{BASE} \times (psi_{BASE} - psi_{EE}) \times 0.4\%$$

Where:
ΔkW_{PR} = Average kW savings from the system pressure reduction
kW_{BASE} = Baseline air compressor system average input kW
psi_{BASE} = Baseline average system pressure, in psi
psi_{EE} = Energy efficient average system pressure with added storage, in psi
0.4%/psi = Compressor kW reduction factor[1]

The algorithm for calculating annual electric energy savings from the system pressure reduction is:

$$\Delta kWh_{PR} = \Delta kW_{PR} \times \frac{hr}{yr}$$

Where:

ΔkWh_{PR} = Gross annual kWh savings from system pressure reduction
ΔkW_{PR} = Average kW savings from the system pressure reduction
$\frac{hr}{yr}$ = Annual compressed air system pressurization hours

The algorithm for calculating savings from the reduction in cycling losses is:

$$\Delta kW_{CL} = kW_{BASE,MOD} \times (\%kW_{BASE} - \%kW_{EE})$$

Where:
ΔkW_{CL} = Average kW savings from the reduction in cycling losses for load/unload compressors
$kW_{BASE,MOD}$ = Baseline air compressor input kW for the load-unload compressor that is the modulating or topping compressor
$\%kW_{BASE}$ = Percentage kW input in the base case (refer to %kW table, interpolate as needed)
$\%kW_{EE}$ = Percentage kW input in the energy efficient case after added storage (refer to % kW table, interpolate as needed)

Average Percent Capacity	**Tank Plus Distribution System Storage per Compressor Capacity** *(use the modulating compressor capacity only)*	**% kW**[2]
25%	1 gal/cfm	70%
	3 gal/cfm	55%
	5 gal/cfm	50%
	10 gal/cfm	48%
50%	1 gal/cfm	88%
	3 gal/cfm	76%
	5 gal/cfm	71%
	10 gal/cfm	68%
75%	1 gal/cfm	96%
	3 gal/cfm	92%
	5 gal/cfm	89%
	10 gal/cfm	86%

The algorithm for calculating annual electric energy savings from the cycling losses is:

$$\Delta kWh_{CL} = \Delta kW_{CL} \times \frac{hr}{yr}$$

Where:
ΔkWh_{CL} = Gross annual kWh savings from the reduction in cycling losses for load/unload compressors
ΔkW_{CL} = Average kW savings from the reduction in cycling losses for load/unload compressors
$\frac{hr}{yr}$ = Annual operating hours of the load/unload topping compressor

Measure Life:

The measure life is 17 years for non-mechanical infrastructure[3]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b020	Compressed air – compressor storage	LBES	1.00	.99	n/a	1.00	1.00	1.17	0.98
E21C2b020	Compressed air – compressor storage	SBES	1.00	1.00	n/a	1.00	1.00	1.17	0.98
E21C3b032	Compressed air – compressor storage	Muni	1.00	1.00		1.00	1.00	1.17	0.98

<u>In-Service Rates:</u>

All installations have 100% a in-service-rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [4]

<u>Coincidence Factors:</u>

A summer coincidence factor of 117% and a winter coincidence factor of 98% is utilized.[4]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Compressed Air- VFD Compressor".

<u>Endnotes</u>:
1: Estimate based on ERS data of CAGI Compressor Data Sheets of 40 operating points of 10 compressors from 4 manufacturers, downloaded 5/21/20.
2: Department of Energy Compressed Air Challenge. Improving Compressed Air System Performance A Sourcebook for Industry, Third Edition, DOE/EE-1340, (approx. 2015) p. 40.
3: Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf Measure life value represents the median MA Measure Life for 15-75 HP Effissient Compressors in the Compressed Air Category shown in Table 3-9 of the study.
4: DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for The Massachusetts Joint Utilities.
DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

2.6 Compressed Air – Low Pressure Drop Filter

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit/Lost Opportunity
Category	Compressed Air

Description:

Filters remove solids and aerosols from compressed air systems. Low pressure drop filters have longer lives and lower pressure drops than traditional coalescing filters, resulting in low air compressor energy use.

Baseline Efficiency:

The baseline efficiency case is a standard coalescing filter with initial drop of between 1 and 2 pounds per sq inch (psi) with an end of life drop of 10 psi.

High Efficiency:

The high efficiency case is a low pressure drop filter with initial drop not exceeding 1 psi over life and 3 psi at element change. Filters must be deep-bed, “mist eliminator” style and installed on a single operating compressor rated 15 - 75 HP.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kW = kW_{BASE} \times (psi_{BASE} - psi_{EE}) \times 0.4\%$$
$$\Delta kWh = \Delta kW \times \frac{hr}{yr}$$

Where:
ΔkW = Average kW savings
ΔkWh = Gross annual kWh savings
kW_{BASE} = Air compressor system average input kW, site specific
psi_{BASE} = Baseline standard filter pressure drop, in psi
psi_{EE} = Energy efficient filter pressure drop, in psi
0.4%/psi = Compressor kW reduction factor[1]
$\frac{hr}{yr}$ = Annual compressed air system pressurization hours

Measure Life:

The measure life is 5 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a032	Low Pressure Drop Filter	LBES Retro	1.00	.99	n/a	1.00	1.00	0.80	0.54
E21C1b043	Low Pressure Drop Filter	LBES New	1.00	.99	n/a	1.00	1.00	0.80	0.54
E21C1d032	Low Pressure Drop Filter	LBES DI	1.00	.99	n/a	1.00	1.00	0.80	0.54
E21C2a032	Low Pressure Drop Filter	SBES Retro	1.00	1.00	n/a	1.00	1.00	0.80	0.54
E21C2b043	Low Pressure Drop Filter	SBES New	1.00	1.00	n/a	1.00	1.00	0.80	0.54
E21C2d032	Low Pressure Drop Filter	SBES DI	1.00	1.00	n/a	1.00	1.00	0.80	0.54
E21C3a055	Low Pressure Drop Filter	Muni Retro	1.00	1.00	n/a	1.00	1.00	0.80	0.54
E21C3b065	Low Pressure Drop Filter	Muni New	1.00	1.00	n/a	1.00	1.00	0.80	0.54
E21C3d055	Low Pressure Drop Filter	Muni DI	1.00	1.00	n/a	1.00	1.00	0.80	0.54

In-Service Rates:

All installations have a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Realization rates are based on impact evaluation of PY 2004 compressed air installations.[3]
Realization rates are based on impact evaluation of NSTAR 2006 compressed air installations.[4] The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [5]

Coincidence Factors:

Summer and winter coincidence factors are CFs based on impact evaluation of PY 2004 compressed air installations.[3]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Compressed Air – VFD Compressor".

Endnotes: :
1: Estimate based on ERS data of CAGI Compressor Data Sheets of 40 operating points of 10 compressors from 4 manufacturers, downloaded 5/21/20.
2: ERS, November 2005. Measure Life Study. Prepared for MA Joint Utilities. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf
3: DMI, 2006. Impact Evaluation of 2004 Compressed Air Prescriptive Rebates. Results analyzed in RLW Analytics, 2006. Sample Design and Impact Evaluation Analysis for Prescriptive Compressed Air Measures in Energy Initiative and Design 2000 Programs.
4: LW Analytics, 2008. Business & Construction Solutions (BS/BC) Programs Measurement & Verification - 2006 Final Report.

DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for The Massachusetts Joint Utilities.

DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

2.7 Compressed Air – Refrigerated Air Dryer

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Compressed Air

Description:

The installation of cycling or variable frequency drive (VFD)-equipped refrigerated compressed air dryers. Refrigerated air dryers remove the moisture from a compressed air system to enhance overall system performance. An efficient refrigerated dryer cycles on and off or uses a variable speed drive as required by the demand for compressed air instead of running continuously. Only properly sized refrigerated air dryers used in a single-compressor system are eligible.

Baseline Efficiency:

The baseline efficiency case is a non-cycling refrigerated air dryer.

High Efficiency:

The high efficiency case is a cycling refrigerated dryer or a refrigerated dryer equipped with a VFD.

Algorithms for Calculating Primary Energy Impact:

Δ kWh = (CFM DRYER) x (Save) x (HRS)
Δ kW = (CFM DRYER) x (Save)
Where:
CFM DRYER = Full flow rated capacity of the refrigerated air dryer in cubic feet per minute (CFM) obtained from equipment's Compressed Air Gas Institute Datasheet.
Save = Refrigerated air dryer kW reduction per dryer full flow rated CFM: 0.00554[1]
HRS = Annual operating hours of the refrigerated air dryer

Measure Life:

The measure life is 15 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b047	Refrigerated Air Dryer	LBES New	1.00	1.56	n/a	1.00	1.00	1.17	0.98

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C2b047	Refrigerated Air Dryer	SBES New	1.00	1.56	n/a	1.00	1.00	1.17	0.98
E21C3b078	Refrigerated Air Dryer	Muni New	1.00	1.56	n/a	1.00	1.00	1.17	0.98

<u>In-Service Rates:</u>

All installations have a 100% in-service rates unless an evaluation finds otherwise.

<u>Realization Rates:</u>

Realization rates are from the prospective results of the 2015 study of prescriptive compressed air.[1]

<u>Coincidence Factors:</u>

Summer and winter coincidence factors are from the prospective results of the 2015 study of prescriptive compressed air. [1]

<u>Energy Load Shape:</u>

See Appendix 1, C&I Load Shapes Table "C&I Compressed Air – Air Dryer"

<u>Endnotes</u>:

1 DNV GL, October 2015. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for MA Joint Utilities and MA EEAC. http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf

2: ERS, November 2005. Measure Life Study. Prepared for MA Joint Utilities. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf

2.8 Compressed Air – Zero Loss Condensate Drain

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit/Lost Opportunity
Category	Compressed Air

Description:

Drains remove water from a compressed air system. Zero loss condensate drains remove water from a compressed air system without venting any air, resulting in less air demand and consequently less air compressor energy use.

Baseline Efficiency:

The baseline efficiency case a standard condensate drain on a compressor system.

High Efficiency:

The high efficiency case is installation of a zero loss condensate drain on a single operating compressor rated ≤ 75 HP.

Algorithms for Calculating Primary Energy Impact:

ΔkWh = (CFMpipe) x (CFMsave) x (Save) x (Hours)
ΔkW = (CFMpipe) x (CFMsave) x (Save)
Where:
ΔkWh = Energy Savings
ΔkW = Demand savings
CFMpipe = CFM capacity of piping that is served by the condensate drain, site specific
CFMsaved = Average CFM saved per CFM of piping capacity: 0.049[1]
Save = Average savings per CFM, site specific if available, default value of 0.21 kW/CFM[1]
Hours = Annual operating hours of the zero loss condensate drain.

Measure Life:

The measure life is 15 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a046	Zero Loss Condensate Drains	LBES Retro	1.00	.99	1.00	1.00	1.00	0.80	0.54
E21C1b051	Zero Loss Condensate Drains	LBES New	1.00	.99	1.00	1.00	1.00	0.80	0.54
E21C1d046	Zero Loss Condensate Drains	LBES DI	1.00	.99	1.00	1.00	1.00	0.80	0.54
E21C2a046	Zero Loss Condensate Drains	SBES Retro	1.00	1.00	1.00	1.00	1.00	0.80	0.54
E21C2b051	Zero Loss Condensate Drains	SBES New	1.00	1.00	1.00	1.00	1.00	0.80	0.54
E21C2d046	Zero Loss Condensate Drains	SBES DI	1.00	1.00	1.00	1.00	1.00	0.80	0.54
E21C3a090	Zero Loss Condensate Drains	Muni Retro	1.00	1.00	1.00	1.00	1.00	0.80	0.54
E21C3b082	Zero Loss Condensate Drains	Muni New	1.00	1.00	1.00	1.00	1.00	0.80	0.54
E21C3d090	Zero Loss Condensate Drains	Muni DI	1.00	1.00	1.00	1.00	1.00	0.80	0.54

In-Service Rates:

All installations have a 100% in-service rate since unless an evaluation finds otherwise.

Realization Rates:

All program use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [3]

Coincidence Factors:

Summer and winter coincidence factors are based on Massachusetts TRM values. Latest 2015 evaluation study did not yield a statistically significant sample size for updating CF values.

Energy Load Shape:

See Appendix 1, C&I Load Shapes Table "C&I Compressed Air – VFD Compressor"

Endnotes:

1: Prescriptive_CAIR_ZLD_LPDF_Tool.xlsx referenced by the Massachusetts TRM.

2: Energy & Resource Solutions, November 2005. Measure Life Study. Prepared for Massachusetts Joint Utilities. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf

3: DNV GL (2015). Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for The Massachusetts Joint Utilities.

DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

2.9 Custom Measures

Measure Code	[Code]
Market	Commercial
Program Type	Retrofit/Lost Opportunity
Category	Custom

Description:

The Custom project track is offered for electric and natural gas energy efficiency projects involving complex site-specific applications that require detailed engineering analysis and/or projects which do not qualify for incentives under any of the prescriptive rebate offering.

Baseline Efficiency:

Retrofit projects will use the existing system or performance as the baseline for all single baseline projects. Lost opportunity projects will generally refer to code, until such time as the EM&V working group selects appropriate ISP values from relevant research. Other factors being equal, New Hampshire jurisdiction-specific results will be favored over results from other jurisdictions, however when relevant results exist from both New Hampshire and from other states, it may be necessary to balance the desirable attributes of state-specificity and data reliability. When considering whether to apply results from a study originating in another jurisdiction to New Hampshire programs, the EM&V working group (with support from independent evaluation firms as needed), will make the determination based on 1) the similarity of evaluated program/measures to those offered in NH; 2) the similarity of relevant markets and customer base, 3) the recency of the study relative to the recency of any applicable NH results, and 4) the quality of the study's methodology and sample size. If a relevant ISP has been established, lost opportunity projects should refer to that ISP if applicable. If code does not apply and an ISP is not available, engineering judgement should be used to determine a project baseline.High Efficiency:

The high efficiency scenario is specific to the custom project and may include one or more energy efficiency measures. Energy and demand savings calculations are based on projected or measured changes in equipment efficiencies and operating characteristics and are determined on a case-by-case basis.

Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings estimates for custom projects are calculated using engineering analysis with project-specific details. Custom analyses typically include a weather dependent load bin analysis, whole building energy model simulation, end-use metering or other engineering analysis and include estimates of savings, costs, and an evaluation of the projects' cost-effectiveness.

Measure Life:

For both lost-opportunity and retrofit custom applications, the measure life is determined on a case-by-case basis.[2]

Other Resource Impacts:

Other resource impacts should be determined on a case by case basis for custom projects.

Impact Factors for Calculating Adjusted Gross Savings:[1]

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b001	Custom Large Compressed Air New	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1a001	Custom Large Compressed Air Retro	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1d001	Custom Large Compressed Air Direct Install	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1b002	Custom Large Hot Water New	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1a002	Custom Large Hot Water Retro	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1d002	Custom Large Hot Water Direct Install	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1b003	Custom Large HVAC New	LBES	1.000	0.900	0.87	1.000	1.000	1.00	0.385
E21C1a003	Custom Large HVAC Retro	LBES	1.000	0.900	0.87	1.000	1.000	0.70	0.85
E21C1d003	Custom Large HVAC Direct Install	LBES	1.000	0.900	0.87	1.000	1.000	0.70	0.85
E21C1b004	Custom Large Lighting New – Interior	LBES	1.000	0.990	n/a	1.000	1.000	0.80	0.61
E21C1b054	Custom Large Lighting New – Exterior	LBES	1.000	0.990	n/a	1.000	1.000	0.00	1.00
E21C1b055	Custom Large Lighting New – Controls	LBES	1.000	0.990	n/a	1.000	1.000	0.15	0.13
E21C1a004	Custom Large Lighting Retro – Interior	LBES	1.000	0.990	n/a	1.000	1.000	0.80	0.61
E21C1a047	Custom Large Lighting Retro – Exterior	LBES	1.000	0.990	n/a	1.000	1.000	0.00	1.00
E21C1a048	Custom Large Lighting Retro – Controls	LBES	1.000	0.990	n/a	1.000	1.000	0.15	0.13
E21C1d004	Custom Large Lighting Direct Install – Interior	LBES	1.000	0.990	n/a	1.000	1.000	0.80	0.61
E21C1d005	Custom Large Lighting Direct Install – Exterior	LBES	1.000	0.990	n/a	1.000	1.000	0.00	1.00
E21C1d006	Custom Large Lighting Direct Install – Controls	LBES	1.000	0.990	n/a	1.000	1.000	0.15	0.13

E21C1b005	Custom Large Motors New	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1a005	Custom Large Motors Retro	LBES	1.000	0.900	0.87	1.000	1.000	0.92	0.90
E21C1d007	Custom Large Motors Direct Install	LBES	1.000	0.900	0.87	1.000	1.000	0.92	0.90
E21C1b008	Custom Large Other New	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1a008	Custom Large Other Retro	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1a010	Custom Large Other Direct Install	LBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C1b006	Custom Large Process New	LBES	1.000	0.900	0.87	1.000	1.000	0.95	0.45
E21C1a006	Custom Large Process Retro	LBES	1.000	0.900	0.87	1.000	1.000	0.95	0.90
E21C1d008	Custom Large Process Direct Install	LBES	1.000	0.900	0.87	1.000	1.000	0.95	0.90
E21C1b007	Custom Large Refrigeration New	LBES	1.000	0.900	n/a	1.000	1.000	0.00	0.00
E21C1a007	Custom Large Refrigeration Retro	LBES	1.000	0.900	n/a	1.000	1.000	0.00	0.00
E21C1d009	Custom Large Refrigeration Direct Install	LBES	1.000	0.900	n/a	1.000	1.000	0.00	0.00
E21C1b056	Custom Large Comprehensive Design	LBES	1.000	0.900	n/a	1.000	1.000	0.00	0.00
E21C3b001	Custom Muni Compressed Air New	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3a001	Custom Muni Compressed Air Retro	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3d001	Custom Muni Compressed Air Direct Install	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3b002	Custom Muni Hot Water New	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3a002	Custom Muni Hot Water Retro	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3d002	Custom Muni Hot Water Direct Install	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3b003	Custom Muni HVAC New	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3a003	Custom Muni HVAC Retro	MES	1.000	0.900	0.87	1.000	1.000	0.70	0.85
E21C3d003	Custom Muni HVAC Direct Install	MES	1.000	0.900	0.87	1.000	1.000	0.70	0.85
E21C3b004	Custom Muni Lighting New – Interior	MES	1.000	1.066	n/a	1.000	1.000	0.00	0.00
E21C3b085	Custom Muni Lighting New – Exterior	MES	1.000	1.027	n/a	1.000	1.000	0.00	0.00
E21C3b086	Custom Muni Lighting New – Controls	MES	1.000	1.00	n/a	1.000	1.000	0.00	0.00
E21C3a004	Custom Muni Lighting Retro – Interior	MES	1.000	1.066	n/a	1.000	1.000	0.80	0.61
E21C3a091	Custom Muni Lighting Retro – Exterior	MES	1.000	1.027	n/a	1.000	1.000	0.00	1.00
E21C3a092	Custom Muni Lighting Retro – Controls	MES	1.000	1.00	n/a	1.000	1.000	0.15	0.13

E21C3d004	Custom Muni Lighting Direct Install – Interior	MES	1.000	1.066	n/a	1.000	1.000	0.80	0.61
E21C3d005	Custom Muni Lighting Direct Install – Exterior	MES	1.000	1.027	n/a	1.000	1.000	0.00	1.00
E21C3d006	Custom Muni Lighting Direct Install – Controls	MES	1.000	1.00	n/a	1.000	1.000	0.15	0.13
E21C3b005	Custom Muni Motors New	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3a005	Custom Muni Motors Retro	MES	1.000	0.900	0.87	1.000	1.000	0.92	0.90
E21C3d007	Custom Muni Motors Direct Install	MES	1.000	0.900	0.87	1.000	1.000	0.92	0.90
E21C3b008	Custom Muni Other New	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3a008	Custom Muni Other Retro	MES	1.000	0.900	0.87	1.000	1.000	0.476	0.428
E21C3d010	Custom Muni Other Direct Install	MES	1.000	0.900	0.87	1.000	1.000	0.476	0.428
E21C3b006	Custom Muni Process New	MES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C3a006	Custom Muni Process Retro	MES	1.000	0.900	0.87	1.000	1.000	0.95	0.90
E21C3d008	Custom Muni Process Direct Install	MES	1.000	0.900	0.87	1.000	1.000	0.95	0.90
E21C3b007	Custom Muni Refrigeration New	MES	1.000	0.900	n/a	1.000	1.000	0.00	0.00
E21C3a007	Custom Muni Refrigeration Retro	MES	1.000	0.900	n/a	1.000	1.000	0.00	0.00
E21C3d009	Custom Muni Refrigeration Direct Install	MES	1.000	0.900	n/a	1.000	1.000	0.00	0.00
E21C2b001	Custom Small Compressed Air New	SBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C2a001	Custom Small Compressed Air Retro	SBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C2d001	Custom Small Compressed Air Direct Install	SBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C2b002	Custom Small Hot Water New	SBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C2a002	Custom Small Hot Water Retro	SBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C2d002	Custom Small Hot Water Direct Install	SBES	1.000	0.900	0.87	1.000	1.000	0.00	0.00
E21C2b003	Custom Small HVAC New	SBES	1.000	0.900	0.87	1.000	1.000	1.00	0.385
E21C2a003	Custom Small HVAC Retro	SBES	1.000	0.900	0.87	1.000	1.000	0.70	0.85
E21C2d003	Custom Small HVAC Direct Install	SBES	1.000	0.900	0.87	1.000	1.000	0.70	0.85
E21C2b004	Custom Small Lighting New - Interior	SBES	1.000	1.066	n/a	1.000	1.000	0.80	0.61
E21C2b054	Custom Small Lighting New - Exterior	SBES	1.000	1.027	n/a	1.000	1.000	0.00	1.00
E21C2b055	Custom Small Lighting New - Controls	SBES	1.000	1.00	n/a	1.000	1.000	0.15	0.13

E21C2a004	Custom Small Lighting Retro - Interior	SBES	1.000	1.066	n/a	1.000	1.000	0.70	0.85
E21C2a047	Custom Small Lighting Retro- Exterior	SBES	1.000	1.027	n/a	1.000	1.000	0.80	0.61
E21C2a048	Custom Small Lighting Retro - Controls	SBES	1.000	1.00	n/a	1.000	1.000	0.15	0.13
E21C2d004	Custom Small Lighting Direct Install - Interior	SBES	1.000	1.066	n/a	1.000	1.000	0.70	0.85
E21C2d005	Custom Small Lighting Direct Install - Exterior	SBES	1.000	1.027	n/a	1.000	1.000	0.80	0.61
E21C2d006	Custom Small Lighting Direct Install - Controls	SBES	1.000	1.00	n/a	1.000	1.000	0.15	0.13
E21C2b005	Custom Small Motors New	SBES	1.000	0.900	0.87	1.000	1.000	0.95	0.80
E21C2a005	Custom Small Motors Retro	SBES	1.000	0.900	0.87	1.000	1.000	0.92	0.90
E21C2d007	Custom Small Motors Direct Install	SBES	1.000	0.900	0.87	1.000	1.000	0.92	0.90
E21C2b008	Custom Small Other New	SBES	1.000	0.900	0.87	1.000	1.000	0.476	0.428
E21C2a008	Custom Small Other Retro	SBES	1.000	0.900	0.87	1.000	1.000	0.45	0.52
E21C2d010	Custom Small Other Direct Install	SBES	1.000	0.900	0.87	1.000	1.000	0.45	0.52
E21C2b006	Custom Small Process New	SBES	1.000	0.900	0.87	1.000	1.000	0.95	0.45
E21C2a006	Custom Small Process Retro	SBES	1.000	0.900	0.87	1.000	1.000	0.95	0.90
E21C2d008	Custom Small Process Direct Install	SBES	1.000	0.900	0.87	1.000	1.000	0.95	0.90
E21C2b007	Custom Small Refrigeration New	SBES	1.000	0.900	n/a	1.000	1.000	0.80	0.80
E21C2a007	Custom Small Refrigeration Retro	SBES	1.000	0.900	n/a	1.000	1.000	0.90	0.99
E21C2d009	Custom Small Refrigeration Direct Install	SBES	1.000	0.900	n/a	1.000	1.000	0.90	0.99
E21C2b056	Custom Small Comprehensive Design	SBES	1.000	0.900	n/a	1.000	1.000	0.90	0.99
G21C1a001	Custom Large Hot Water Retro	LBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C1a002	Custom Large HVAC Retro	LBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C1a003	Custom Large Other Retro	LBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C1a004	Custom Large Process Retro	LBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C1b001	Custom Large Hot Water New	LBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C1b002	Custom Large HVAC New	LBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C1b003	Custom Large Other New	LBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C1b004	Custom Large Process New	LBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a

G21C2a001	Custom Small Hot Water Retro	SBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C2a002	Custom Small HVAC Retro	SBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C2a003	Custom Small Other Retro	SBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C2a004	Custom Small Process Retro	SBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C2b001	Custom Small Hot Water New	SBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C2b002	Custom Small HVAC New	SBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C2b003	Custom Small Other New	SBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a
G21C2b004	Custom Small Process New	SBES	1.000	n/a	0.87	n/a	n/a	n/a	n/a

Impact Factors for Calculating Net Savings:

Free-ridership and spillover for custom lighting are based on study results from CT the nearby jurisdiction with programs and markets most similar to those in NH.[4]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C2b004	Custom Small Lighting New - Interior	SBES	11%	5%	0%	94%
E21C2b054	Custom Small Lighting New - Exterior	SBES	11%	5%	0%	94%
E21C2b055	Custom Small Lighting New - Controls	SBES	11%	5%	0%	94%
E21C2a004	Custom Small Lighting Retro - Interior	SBES	11%	5%	0%	94%
E21C2a047	Custom Small Lighting Retro- Exterior	SBES	11%	5%	0%	94%
E21C2a048	Custom Small Lighting Retro - Controls	SBES	11%	5%	0%	94%
E21C2d004	Custom Small Lighting Direct Install - Interior	SBES	11%	5%	0%	94%
E21C2d005	Custom Small Lighting Direct Install - Exterior	SBES	11%	5%	0%	94%
E21C2d006	Custom Small Lighting Direct Install - Controls	SBES	11%	5%	0%	94%
E21C3b004	Custom Muni Lighting New – Interior	MES	11%	5%	0%	94%
E21C3b085	Custom Muni Lighting New – Exterior	MES	11%	5%	0%	94%
E21C3b086	Custom Muni Lighting New – Controls	MES	11%	5%	0%	94%
E21C3a004	Custom Muni Lighting Retro – Interior	MES	11%	5%	0%	94%

E21C3a091	Custom Muni Lighting Retro – Exterior	MES	11%	5%	0%	94%
E21C3a092	Custom Muni Lighting Retro – Controls	MES	11%	5%	0%	94%
E21C3d004	Custom Muni Lighting Direct Install – Interior	MES	11%	5%	0%	94%
E21C3d005	Custom Muni Lighting Direct Install – Exterior	MES	11%	5%	0%	94%
E21C3d006	Custom Muni Lighting Direct Install – Controls	MES	11%	5%	0%	94%
E21C1b004	Custom Large Lighting New – Interior	LBES	11%	5%	0%	94%
E21C1b054	Custom Large Lighting New – Exterior	LBES	11%	5%	0%	94%
E21C1b055	Custom Large Lighting New – Controls	LBES	11%	5%	0%	94%
E21C1a004	Custom Large Lighting Retro – Interior	LBES	11%	5%	0%	94%
E21C1a047	Custom Large Lighting Retro – Exterior	LBES	11%	5%	0%	94%
E21C1a048	Custom Large Lighting Retro – Controls	LBES	11%	5%	0%	94%
E21C1d004	Custom Large Lighting Direct Install – Interior	LBES	11%	5%	0%	94%
E21C1d005	Custom Large Lighting Direct Install – Exterior	LBES	11%	5%	0%	94%
E21C1d006	Custom Large Lighting Direct Install – Controls	LBES	11%	5%	0%	94%

Energy Load Shape:

See Appendix 1, C&I Load Shapes Table

- "C&I Interior Lighting – Prescriptive"
- "C&I Exterior Lighting"
- "C&I Lighting Controls"
- "C&I- Refrigeration"

Endnotes:

1: Realization rates for custom non lighting measures are based on a weighted average of realization rates from jurisdictions within New England, with a 50% weight for New Hampshire. To be updated once the Large C&I Custom Impact Evaluation is complete in 2021/2022.

Realization rates for custom lighting measures are based on DNV GL, September 2015. New Hampshire Utilities Large Commercial and Industrial (C&I) Retrofit And New Equipment & Construction Program Impact Evaluation. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

2: Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-2. ERS_2005_Measure_Life_Study

3: Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo. 2018_DNVGL_ERS_Portfolio_Model_Companion_Sheet
4: EMI, September 25, 2019 . C1644 EO Net-to-Gross Study, Final Report. https://www.energizect.com/sites/default/files/C1644%20-%20EO%20NTG%20Final%20Report_9.25.19.pdf
Downstream NTG values are based on Energy Opportunities NTG Study Results for Lighting shown in Table ES-1-1 on p. ES-3.

2.10 Food Service – Dishwasher

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Food Service

Description:

Dishwasher High Temperature: Installation of a qualified ENERGY STAR® high temperature commercial dishwasher in a building with gas domestic hot water. High temperature dishwashers use a booster heater to raise the rinse water temperature to 180 F – hot enough to sterilize dishes and assist in drying. Electric savings are achieved through savings to the electric booster.

Dishwasher Low Temperature: Installation of a qualified ENERGY STAR® low temperature commercial dishwasher in a facility with electric hot water heating. Low temperature dishwashers use the hot water supplied by the kitchen's existing water heater and use a chemical sanitizing agent in the final rinse cycle and sometimes a drying agent.

Baseline Efficiency:

Dishwasher High Temp: The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows[1]:

Dishwasher Type	Idle Energy Rate (kW)	Water Consumption (gal/rack)
High Temp Under Counter Dishwasher	0.76	1.09
High Temp Door Type Dishwasher	0.87	1.29
High Temp Single Tank Conveyer Dishwasher	1.93	0.87
High Temp Multi Tank Conveyer Dishwasher	2.59	0.97
High Temp Pots & Pans Dishwasher	1.20	0.70

Dishwasher Low Temp: The baseline efficiency case is a commercial dishwasher with idle energy rates and water consumption as follows[1]:

Dishwasher Type	Idle Energy Rate (kW)	Water Consumption (gal/rack)
Low Temp Under Counter Dishwasher	0.50	1.73
Low Temp Door Type Dishwasher	0.60	2.10
Low Temp Single Tank Conveyor Dishwasher	1.60	1.31

Low Temp Multi Tank Conveyor Dishwasher	2.00	1.04

High Efficiency:

Dishwasher High Temp: The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR® Efficiency Requirements[2] as follows:

Dishwasher Type	Idle Energy Rate (kW)	Water Consumption (gal/rack)
High Temp Under Counter Dishwasher	0.50	0.86
High Temp Door Type Dishwasher	0.70	0.89
High Temp Single Tank Conveyer Dishwasher	1.50	0.70
High Temp Multi Tank Conveyer Dishwasher	2.25	0.54
High Temp Pots & Pans Dishwasher	1.20	0.58

Dishwasher Low Temp: The high efficiency case is a commercial dishwasher with idle energy rates and water consumption following ENERGY STAR® Efficiency Requirements[2] as follows:

Dishwasher Type	Idle Energy Rate (kW)	Water Consumption (gal/rack)
Low Temp Under Counter Dishwasher	0.50	1.19
Low Temp Door Type Dishwasher	0.60	1.18
Low Temp Single Tank Conveyor Dishwasher	1.60	0.79
Low Temp Multi Tank Conveyor Dishwasher	2.00	0.54

Algorithms for Calculating Primary Energy Impact:

Dishwasher High Temp: Unit savings are deemed based on the Energy Star Commercial Kitchen Equipment Savings Calculator[1]:
kWh = kWh
kW = kWh / hours
MMBtu = MMBtu

Where:
kWh = gross annual kWh savings from the measure. See table below.
kW = gross average kW savings from the measure. See table below.
MMBtu = gross average natural gas MMBtu savings from the measure. See table below.

Hours = Average annual equipment operating hours is 18 hours/ day, 6,570 hours/year.

BC Measure ID	Measure	Program	ΔkW	ΔkWh	ΔMMBtu
E21C1b026 E21C2b026 E21C3b040 E21C1c024 E21C2c024	High Temp Under Counter Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	0.32	1,791	n/a
E21C1b022 E21C2b022 E21C3b036 E21C1c020 E21C2c020	High Temp Door Type Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	0.74	4,151	n/a
E21C1b025 E21C2b025 E21C3b039 E21C1c023 E21C2c023	High Temp Single Tank Conveyer Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	0.75	4,243	n/a
E21C1b023 E21C2b023 E21C3b037 E21C1c021 E21C2c021	High Temp Multi Tank Conveyer Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	1.71	9,630	n/a
E21C1b024 E21C2b024 E21C3b038 E21C1c022 E21C2c022	High Temp Pots & Pans Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	0.18	1,032	n/a
E21C1b030 E21C2b030 E21C3b044 E21C1c028 E21C2c028	Low Temp Under Counter Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	0.39	2,178	n/a
E21C1b027 E21C2b027 E21C3b041 E21C1c025 E21C2c025	Low Temp Door Type Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	2.46	13,851	n/a
E21C1b029 E21C2b029 E21C3b043 E21C1c027 E21C2c027	Low Temp Single Tank Conveyor Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	2.07	11,685	n/a

E21C1b028 E21C2b028 E21C3b042 E21C1c026 E21C2c026	Low Temp Multi Tank Conveyor Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	2.86	16,131	n/a

Measure Life:

The measure life for a new high temperature dishwasher is given by type below [3]:

BC Measure ID	Measure Name	Program	Measure Life
E21C1b026 E21C2b026 E21C3b040 E21C1c024 E21C2c024	High Temp Under Counter Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	10
E21C1b022 E21C2b022 E21C3b036 E21C1c020 E21C2c020	High Temp Door Type Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	15
E21C1b025 E21C2b025 E21C3b039 E21C1c023 E21C2c023	High Temp Single Tank Conveyer Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	20
E21C1b023 E21C2b023 E21C3b037 E21C1c021 E21C2c021	High Temp Multi Tank Conveyer Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	20
E21C1b024 E21C2b024 E21C3b038 E21C1c022 E21C2c022	High Temp Pots & Pans Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	10
E21C1b030 E21C2b030 E21C3b044 E21C1c028 E21C2c028	Low Temp Under Counter Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	10

E21C1b027 E21C2b027 E21C3b041 E21C1c025 E21C2c025	Low Temp Door Type Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	15
E21C1b029 E21C2b029 E21C3b043 E21C1c027 E21C2c027	Low Temp Single Tank Conveyor Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	20
E21C1b028 E21C2b028 E21C3b042 E21C1c026 E21C2c026	Low Temp Multi Tank Conveyor Dishwasher	LBES New SBES New Muni New LBES Mid SBES Mid	20

Other Resource Impacts:

Dishwasher high temp: There are water savings associated with this measure. [1]

Dishwasher Type	Annual water savings (gal/unit)
High Temp Under Counter Dishwasher	5,399
High Temp Door Type Dishwasher	35,056
High Temp Single Tank Conveyer Dishwasher	21,284
High Temp Multi Tank Conveyer Dishwasher	80,754
High Temp Pots & Pans Dishwasher	10,517

Dishwasher low temp: There are water savings associated with this measure. [1]

Dishwasher Type	Annual water savings (gal/unit)
Low Temp Under Counter Dishwasher	12,677
Low Temp Door Type Dishwasher	80,629
Low Temp Single Tank Conveyor Dishwasher	65,104
Low Temp Multi Tank Conveyor Dishwasher	93,900

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b026 E21C2b026 E21C3b040 E21C1c024 E21C2c024	High Temp Under Counter Dishwasher	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b022 E21C2b022 E21C3b036 E21C1c020 E21C2c020	High Temp Door Type Dishwasher	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b025 E21C2b025 E21C3b039 E21C1c023 E21C2c023	High Temp Single Tank Conveyer Dishwasher	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b023 E21C2b023 E21C3b037 E21C1c021 E21C2c021	High Temp Multi Tank Conveyer Dishwasher	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b024 E21C2b024 E21C3b038 E21C1c022 E21C2c022	High Temp Pots & Pans Dishwasher	SBES New LBES Mid SBES Mid Muni New	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b030 E21C2b030 E21C3b044 E21C1c028 E21C2c028	Low Temp Under Counter Dishwasher	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b027 E21C2b027 E21C3b041 E21C1c025 E21C2c025	Low Temp Door Type Dishwasher	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b029 E21C2b029 E21C3b043 E21C1c027 E21C2c027	Low Temp Single Tank Conveyor Dishwasher	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b028 E21C2b028	Low Temp Multi Tank Conveyor Dishwasher	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C3b042 E21C1c026 E21C2c026									
E21C1b026 E21C2b026 E21C3b040	High Temp Under Counter Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b022 E21C2b022 E21C3b036	High Temp Door Type Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b025 E21C2b025 E21C3b039	High Temp Single Tank Conveyer Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b023 E21C2b023 E21C3b037	High Temp Multi Tank Conveyer Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b024 E21C2b024 E21C3b038	High Temp Pots & Pans Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b030 E21C2b030 E21C3b044	Low Temp Under Counter Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b027 E21C2b027 E21C3b041	Low Temp Door Type Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b029 E21C2b029 E21C3b043	Low Temp Single Tank Conveyor Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b028 E21C2b028 E21C3b042	Low Temp Multi Tank Conveyor Dishwasher	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90

In-Service Rates:

In-service rates are assumed to be 100% until an evaluation finds otherwise.

Realization Rates:

Realization rates are assumed to be 100% until an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [4]

Coincidence Factors:

Coincidence Factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[5]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c024 E21C2c024	High Temp Under Counter Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86
E21C1c020 E21C2c020	High Temp Door Type Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86
E21C1c023 E21C2c023	High Temp Single Tank Conveyer Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86
E21C1c021 E21C2c021	High Temp Multi Tank Conveyer Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86
E21C1c022 E21C2c022	High Temp Pots & Pans Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86
E21C1c028 E21C2c028	Low Temp Under Counter Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86
E21C1c025 E21C2c025	Low Temp Door Type Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86
E21C1c027 E21C2c027	Low Temp Single Tank Conveyor Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86
E21C1c026 E21C2c026	Low Temp Multi Tank Conveyor Dishwasher	LBES Mid SBES Mid	0.225	0.085	0.0	0.86

Energy Load Shape:

See Appendix 1, C&I Load Shapes Table- “C&I Food Services”

Endnotes:

1. ENERGY STAR Commercial Kitchen Equipment Calculator. Updated October 2016.
   Note: High temperature units are assumed to have natural gas hot water and electric temperature boosters. Low temperature units are assumed to have electric hot water. ENERGY STAR notes that a new version of the calculator will be available in fall 2020.
2. ENERGY STAR Commercial Dishwashers Key Product Criteria, version 2.0. Effective Feb 1, 2013.
   Note: ENERGY STAR Commercial Dishwashers product specification version 3.0 is in its final form as of October 27, 2020 and will go into effect July 27, 2021.
3. FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators/
4. DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities.
   https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

5. NMR, DNV-GL, and Tetra-Tech, Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study, Aug. 14, 2018 (Table 48, Table 52)

2.11 Food Service – Fryer

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Food Service

Description:

Electric Fryer: Installation of a qualified ENERGY STAR standard or large vat commercial fryer. ENERGY STAR commercial fryers save energy during cooking and idle times due to improved cooking efficiency and idle energy rates.

Gas Fryer: The installation of a natural-gas fired fryer that is either ENERGY STAR rated or has a heavy-load cooking 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.

Baseline Efficiency:

Electric Fryer: The baseline efficiency case for both, standard sized fryers and large capacity fryers is an electric deep-fat fryer of the same size with a cooking energy efficiency, shortening capacity, and idle energy rate as defined by any relevant U.S. federal requirements.

Gas Fryer: The baseline efficiency case is a gas deep-fat fryer of the same size with a cooking energy efficiency, shortening capacity, and idle energy rate as defined by any relevant U.S. federal requirements.

High Efficiency:

Electric Fryer: The high efficiency case for both, standard sized fryer and large capacity fryers is an electric deep-fat fryer with a cooking energy efficiency, shortening capacity, and idle energy rate in line with ENERGY STAR requirements.

Gas Fryer: The high efficiency case is an fryers is a deep-fat gas fryer with a cooking energy efficiency, shortening capacity, and idle energy rate in line with ENERGY STAR requirements.

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh = \Delta kWh$
$\Delta kW = \Delta kWh / Hours$
Where:
ΔkWh = gross annual kWh savings from the measure per table below
ΔkW = gross average kW savings from the measure per table below
Hours = Annual hours of operation

$\Delta MMBtu = \Delta MMBtu$
Where:
$\Delta MMBtu$ = gross annual MMBtu gas savings from the measure per table below

Energy Savings for Commercial Fryer:

BC Measure ID	Measure Name	Program	ΔkW	ΔkWh	ΔMMBtu
E21C1b033 E21C2b033 E21C3b050 E21C1c032 E21C2c032	Electric Fryer, Standard Vat	LBES New SBES New Muni LBES Mid SBES Mid	0.50	2,976	n/a
E21C1b032 E21C2b032 E21C3b049 E21C1c031 E21C2c031	Electric Fryer, Large Vat	LBES New SBES New Muni LBES Mid SBES Mid	0.50	2,841	n/a
G21C1b024 G21C2b024 G21C1c004 G21C2c004	Gas Fryer	LBES New SBES New LBES Mid SBES Mid	n/a	n/a	78.3

Measure Life:

The measure life for a new commercial fryer is 12 years.[1]

Other Resource Impacts:

There are no other resource impacts for these measures.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b033	Electric Fryer, Standard Vat	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
E21C1b032	Electric Fryer, Large Vat	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
G21C1b024	Gas Fryer	LBES New	1.00	n/a	1.00	1.00	1.00	n/a	n/a
E21C1b033 E21C2b033 E21C3b050 E21C1c032 E21C2c032	Electric Fryer, Standard Vat	SBES New Muni LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b032 E21C2b032 E21C3b049 E21C1c031 E21C2c031	Electric Fryer, Large Vat	SBES New Muni LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1b024 G21C2b024 G21C1c004 G21C2c004	Gas Fryer	SBES New LBES Mid SBES Mid	1.00	n/a	1.00	1.00	1.00	n/a	n/a

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [2]

<u>Coincidence Factors:</u>

Coincidence Factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[3]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c032 E21C2c032	Electric Fryer, Standard Vat	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c031 E21C2c031	Electric Fryer, Large Vat	LBES Mid SBES Mid	0.225	0.085	0	0.86
G21C1c004 G21C2c004	Gas Fryer	LBES Mid SBES Mid	0.237	0.07	0	0.83

Energy Load Shape:

See Appendix 1 C&I Load Shapes, "C&I Food Services"

Endnotes:

1: SupportTable_EUL.csv, from DEER Database for Energy-Efficient Resources; Version 2016, READI v.2.4.3 (Current Ex Ante data) found at http://www.deeresources.com/

2: DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

3: NMR, DNV-GL, and Tetra-Tech, Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study, Aug. 14, 2018 (Table 48, Table 52)

2.12 Food Service – Griddle

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Food Service

Description:

Electric Griddle: Installation of a qualified ENERGY STAR electric griddle.

Gas Griddle: Installation of a qualified ENERGY STAR gas griddle.

ENERGY STAR griddles save energy cooking and idle times due to improved cooking efficiency and idle energy rates.

Baseline Efficiency:

Electric Griddle: The baseline efficiency case is a typically sized, (6 sq. ft.) electric, commercial griddle with a cooking energy efficiency, production capacity, and idle energy rate as defined by any applicable U.S. federal requirements.

Gas Griddle: The baseline efficiency case is a typically sized, (6 sq. ft.) gas, commercial griddle with a cooking energy efficiency, production capacity, and idle energy rate as defined by any applicable U.S. federal requirements.

High Efficiency:

Electric Griddle: The high efficiency case is a typically sized (6 sq. ft.), electric, commercial griddle with a cooking energy efficiency, production capacity, and idle energy rate meeting the minimum ENERGY STAR requirements.

Gas Griddle: The high efficiency case is a typically sized (6 sq. ft.), gas, commercial griddle with a cooking energy efficiency, production capacity, and idle energy rate meeting the minimum ENERGY STAR requirements.

Algorithms for Calculating Primary Energy Impact:

BC Measure ID	Measure Name	Program	ΔkW	ΔkWh	ΔMMBtu
E21C1b034 E21C2b034 E21C3b055 E21C1c033 E21C2c033	Commercial Electric Griddle	LBES New SBES New Muni LBES Mid SBES Mid	0.90	3,965	n/a

G21C1b025 G21C2b025 G21C1c005 G21C2c005	Commercial Gas Griddle	LBES New SBES New LBES Mid SBES Mid	n/a	n/a	37.9

For electric Griddle:
ΔkWh = ΔkWh
ΔkW = ΔkWh / Hours

Where:
ΔkWh = gross annual kWh savings from the measure per table above
ΔkW = gross average kW savings from the measure per table above
Hours = annual operating hours

For Gas Griddle:
ΔMMBtu = MMBtu

Where:
ΔMMBtu = gross annual MMBtu gas savings from the measure per table above.

Measure Life:

The measure life for a new commercial griddle is 12 years.[1]

Other Resource Impacts:

There are no other resource impacts for these measures.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b03	Electric Griddle	LBES New	1.00	.99	n/a	1.00	1.00	0.90	0.90
G21C1b025	Gas Griddle	LBES New	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C1b034 E21C2b034 E21C3b055 E21C1c033 E21C2c033	Electric Griddle	SBES New Muni LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
G21C1b025 G21C2b025 G21C1c005 G21C2c005	Gas Griddle	SBES New LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [2]

Coincidence Factors:

Coincidence Factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[3]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c033 E21C2c033	Electric Griddle	LBES Mid SBES Mid	0.225	0.085	0	0.86
G21C1c005 G21C2c005	Gas Griddle	LBES Mid SBES Mid	0.237	0.07	0	0.83

Energy Load Shape:

See Appendix 1 C&I Load Shapes, "C&I Food Services".

Endnotes:
1: SupportTable_EUL.csv, from DEER Database for Energy-Efficient Resources; Version 2016, READI v.2.4.3 (Current Ex Ante data) found at http://www.deeresources.com/
2: DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities.
https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf
3: NMR, DNV-GL, and Tetra-Tech, Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study, Aug. 14, 2018 (Table 48, Table 52)

2.13 Food Service – Holding Cabinet

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Food Service

Description:

Installation of a qualified ENERGY STAR hot food holding cabinet (HFHC). ENERGY STAR hot food holding cabinets are 70 percent more energy efficient than standard models. Models that meet this requirement incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door gaskets, auto-door closures, or Dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. Offering full size, 3/4 size, and 1/2 size HFHC.

Baseline Efficiency:

The baseline efficiency idle energy rate for a HFHC is a unit meeting any applicable federal energy efficiency standards.

High Efficiency:

The high efficiency idle energy rate for HFHC is based on the product interior volume in cubic feet (V) as shown below. [1]

Size Category	Product Interior Volume, V (ft^3)	Product Idle Energy Consumption Rate (W)
Half size	$0 < V < 13$	$\leq 21.5\ V$
3/4 size	$13 \leq V < 28$	$\leq 2.0\ V + 254.0$
Full size	$28 \leq V$	$\leq 3.8\ V + 203.5$

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed:

kWh = kWh
kW = kWh / Hours
Where:
kWh = gross annual kWh savings from the measure: See table below.
kW = gross average kW savings from the measure: See table below.
Hours = annual operating hours

Energy Savings for Commercial Hot Food Holding Cabinets

BC Measure ID	Measure Name	Program	ΔkW	ΔkWh
E21C1b037 E21C2b037 E21C3b058 E21C1c035 E21C2c035	Full Size	LBES New SBES New Muni LBES Mid SBES Mid	0.50	2,737
E21C1b036 E21C2b036 E21C3b057 E21C1c034 E21C2c034	3/4 Size	LBES New SBES New Muni LBES Mid SBES Mid	0.20	1,095
E21C1b038 E21C2b038 E21C3b059 E21C1c036 E21C2c036	1/2 Size	LBES New SBES New Muni LBES Mid SBES Mid	0.20	1,095

Measure Life:

The measure life for a new commercial HFHC is 12 years. [2]

Other Resource Impacts:

There are no other resource impacts for these measures.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b037	Hot Food Holding Cabinet Full Size	LBES New	1.00	0.99	n/a	1.00	1.00	0.90	0.90
E21C1b036	Hot Food Holding Cabinet 3/4 Size	LBES New	1.00	0.99	n/a	1.00	1.00	0.90	0.90
E21C1b038	Hot Food Holding Cabinet Half Size	LBES New	1.00	0.99	n/a	1.00	1.00	0.90	0.90
E21C2b037 E21C3b058 E21C1c035 E21C2c035	Hot Food Holding Cabinet Full Size	SBES New Muni LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C2b036 E21C3b057 E21C1c034 E21C2c034	Hot Food Holding Cabinet 3/4 Size	SBES New Muni LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C2b038 E21C3b059 E21C1c036 E21C2c036	Hot Food Holding Cabinet Half Size	SBES New Muni LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90

In-Service Rates:

All installations have a 100% in-service rate since programs include verification of equipment installations.

Realization Rates:

100% Realization Rates are assumed because savings are based on researched assumptions by ENERGY STAR. . The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [3]

Coincidence Factors:

Coincidence Factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[4]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c035 E21C2c035	Hot Food Holding Cabinet Full Size	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c034 E21C2c034	Hot Food Holding Cabinet 3/4 Size	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c036 E21C2c036	Hot Food Holding Cabinet Half Size	LBES Mid SBES Mid	0.225	0.085	0	0.86

Energy Load Shape:

See Appendix 1 C&I Load Shapes, "C&I Food Services".

Endnotes:

1: ENERGY STAR Program Requirements Product Specification for Commercial Hot Food Holding Cabinets, Version 2.0. Effective October 1, 2011. https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/hfhc/Final_V2.0_HFHC_Program_Requirements.pdf?b187-e770
2: FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators/

3: DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities.
https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf
4: NMR, DNV-GL, and Tetra-Tech, Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study, Aug. 14, 2018 (Table 48, Table 52)

2.14 Food Service – Ice Machine

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Food Service

Description:

Installation of a qualified ENERGY STAR commercial ice machine. Commercial ice machines meeting the ENERGY STAR specifications are on average 15 percent more energy efficient and 10 percent more water-efficient than standard models. ENERGY STAR qualified equipment includes ice-making head (IMH), self-contained (SCU), and remote condensing units (RCU).

Baseline Efficiency:

The baseline efficiency case is a non-ENERGY STAR commercial ice machine, which must be compliant with the applicable federal standard.[1]

High Efficiency:

The high efficiency case is a commercial ice machine meeting the ENERGY STAR V3.0 Efficiency Requirements for commercial ice machines.

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated on a per-unit basis, based on the equipment type and daily ice harvest rate.

kWh = kWh_baseline – kWh_ee
kW = kWh / hours

Where:
kWh = gross annual kWh savings from the measure.
kWh_baseline = annual kWh usage for the base case, based on ice harvest rate H. See table below.
kWh_ee = annual kWh usage for the efficient case, based on ice harvest rate H. See table below.
kW = gross average kW savings from the measure.
Hours = Average annual equipment operating hours, see Hours section below.

Energy Savings Inputs for Commercial Ice Machine [2]

BC Measure ID	Measure Name	Program	Daily Ice Harvest Rate, H (lb ice/24 hr)	Baseline Daily Energy Use (kWh/100 lb ice)[1]	Efficient Daily Energy Use (kWh/100 lb ice)[3]
E21C1b039 E21C2b039 E21C3b060 E21C1c037 E21C2c037	Ice Making Head	LBES New SBES New Muni New LBES Mid SBES Mid	H < 300	10 – 0.01233 x H	9.20 – 0.01134 x H
			300 ≤ H < 800	7.05 – 0.0025 x H	6.49 – 0.0023 x H
			800 ≤ H < 1500	5.55 – 0.00063 x H	5.11 – 0.00058 x H
			1500 ≤ H < 4000	4.61	4.24
E21C1b040 E21C2b040 E21C3b061 E21C1c038 E21C2c038	Self Contained Unit	LBES New SBES New Muni New LBES Mid SBES Mid	50 ≤ H < 1000	7.97 – 0.00342 x H	7.17 – 0.00308 x H
			1000 ≤ H < 4000	4.55	4.13
			H < 110	14.79 – 0.0469 x H	12.57 – 0.0399 x H
E21C1b041 E21C2b041 E21C3b062 E21C1c039 E21C2c039	Remote Condensing Unit (Batch)	LBES New SBES New Muni New LBES Mid SBES Mid	110 ≤ H < 200	12.42 – 0.02533 x H	10.56 – 0.0215 x H
			200 ≤ H < 4000	7.35	6.25
E21C1b042 E21C2b042 E21C3b063 E21C1c040 E21C2c040	Remote Condensing Unit (Continuous)	LBES New SBES New Muni New LBES Mid SBES Mid	H < 800	9.7 – 0.0058 x H	7.76 – 0.00464 x H
			800 ≤ H < 4000	5.06	4.05

Measure Life:

The measure life for a new ice making machine is 8 years. [2]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_{E}	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b039	Ice Machine - Ice Making Head	LBES New	1.00	0.99	n/a	1.00	1.00	0.9	0.9

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b040	Ice Machine - Remote Cond./Split Unit - Batch	LBES New	1.00	0.99	n/a	1.00	1.00	0.9	0.9
E21C1b041	Ice Machine - Remote Cond./Split Unit - Continuous	LBES New	1.00	0.99	n/a	1.00	1.00	0.9	0.9
E21C1b042	Ice Machine - Self Contained	LBES New	1.00	0.99	n/a	1.00	1.00	0.9	0.9
E21C2b039 E21C3b060 E21C1c037 E21C2c037	Ice Machine - Ice Making Head	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.9	0.9
E21C2b040 E21C3b061 E21C1c038 E21C2c038	Ice Machine - Remote Cond./Split Unit - Batch	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.9	0.9
E21C2b041 E21C3b062 E21C1c039 E21C2c039	Ice Machine - Remote Cond./Split Unit - Continuous	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.9	0.9
E21C2b042 E21C3b063 E21C1c040 E21C2c040	Ice Machine - Self Contained	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.9	0.9

In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations.

Realization Rates:

100% realization rates are assumed because savings are based on researched assumptions. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [4]

Coincidence Factors:

Coincidence Factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[5]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c037 E21C2c037	Ice Machine - Ice Making Head	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c038 E21C2c038	Ice Machine - Remote Cond./Split Unit - Batch	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c039 E21C2c039	Ice Machine - Remote Cond./Split Unit - Continuous	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c040 E21C2c040	Ice Machine - Self Contained	LBES Mid SBES Mid	0.225	0.085	0	0.86

Energy Load Shape:

See Appendix 1 “C&I Load Shapes, “C&I Food Services”.

Endnotes:

1: 10 CFR 431.136. Effective January 28, 2018
2: FOOD SERVICE COMMERCIAL ICE MACHINE. SWFS006-01. (CA) December 2018.
3: ENERGY STAR Program Requirements For Automatic Commercial Ice Makers. V3.0.
4: DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities.
https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf
5: NMR, DNV-GL, and Tetra-Tech, Massachusetts Sponsors’ Commercial and Industrial Programs Free-ridership and Spillover Study, Aug. 14, 2018 (Table 48, Table 52)

2.15 Food Service – Oven

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Food Service

Description:

Combination Oven, Electric Convection Oven, Electric	Installation of a qualified ENERGY STAR commercial convection oven or commercial combination oven. ENERGY STAR commercial ovens save energy during preheat, cooking and idle times due to improved cooking efficiency, and preheat and idle energy rates. Combination ovens can be used either as convection ovens or as steamers.

Combination Oven, Gas Convection Oven, Gas Conveyor Oven, Gas Rack Oven, Gas	Installation of High Efficiency Gas Ovens

Baseline Efficiency:

The baseline efficiency case is a convection, combination, conveyor, or rack oven that meets applicable minimum federal efficiency standards and uses the same fuel as the proposed high efficiency equipment.

High Efficiency:

The high efficiency case is a commercial oven that meets the ENERGY STAR program requirements for its type and fuel, as shown below.[1] Note that combination ovens are rated based on their capacity in number of pans (P), and that no ENERGY STAR program requirements for conveyor ovens have yet been approved.

Oven Fuel	Measure Name	Efficiency Requirement	Idle rate
Electric	Convection Oven	≥ 71%	≤ 1.60 kW
Electric	Combination Oven	≥ 55% steam mode ≥ 76% convection mode	≤ 0.133P+0.6400 kW steam mode ≤ 0.080P+0.4989 kW convection mode
Gas	Convection Oven	≥ 46%	≤ 12,000 Btu/hr
Gas	Combination Oven	≥ 41% steam mode ≥ 56% convection mode	≤ 200P + 6,511 Btu/hr steam mode ≤ 150P + 5,425 Btu/hr convection mode

Gas	Conveyer Oven		
Gas	Rack Oven	≥ 48%	≤ 25,000 Btu/hr

Ovens must be rated based on ASTM F1496 (Convection Oven), ASTM F2861 (Combination Oven), and ASTM 2093 (Conveyor Oven and Rack Oven).

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed.

ΔkWh = kWh
ΔkW = kWh / hours
ΔMMBtu = MMBtu

Where:
ΔkWh = gross annual kWh savings from the measure. See table below.
ΔkW = gross average kW savings from the measure. See table below.
ΔMMBtu = gross average natural gas savings from the measure. See table below.
Hours = Annual hours of operation = 4,390 hr/yr at 12 hr/day

Energy Savings for Commercial Ovens

BC Measure ID	Measure Name	Program	ΔkW	ΔkWh	ΔMMBtu
E21C1b021 E21C2b021 E21C3b035	Electric Full Size Convection Oven	LBES New SBES New Muni New LBES Mid SBES Mid	0.70	2,787	n/a
E21C1b019 E21C2b019 E21C3b031	Electric Combination Oven	LBES New SBES New Muni New LBES Mid SBES Mid	3.50	15,095	n/a
G21C1b022 G21C2b022 G21C1c002 G21C2c002	Gas Convection Oven	LBES New SBES New LBES Mid SBES Mid	n/a	n/a	35.7
G21C1b021 G21C2b021 G21C1c001 G21C2c001	Gas Combination Oven	LBES New SBES New LBES Mid SBES Mid	n/a	n/a	110.3
G21C1b023 G21C2b023 G21C1c003 G21C2c003	Gas Conveyer Oven	LBES New SBES New LBES Mid SBES Mid	n/a	n/a	88.4

G21C1b026 G21C2b026 G21C1c007 G21C2c007	Gas Rack Oven	LBES New **SBES New** LBES Mid SBES Mid	n/a	n/a	211.3

Measure Life:

The measure life for a new commercial oven is 12 years. [2]

Other Resource Impacts:

There are no other resource impacts for these measures.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b021	Electric Convection Oven	LBES New	1.00	0.99	n/a	1.00	1.00	0.90	0.90
E21C1b019	Electric Combination Oven	LBES New	1.00	0.99	n/a	1.00	1.00	0.90	0.90
G21C1b022	Gas Convection Oven	LBES New	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1b021	Gas Combination Oven	LBES New	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1b023	Gas Conveyer Oven	LBES New	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1b026	Gas Rack Oven	LBES New	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C1b021 E21C2b021 E21C3b035 E21C1c019 E21C2c019	Electric Convection Oven	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
E21C1b019 E21C2b019 E21C3b031 E21C1c018 E21C2c018	Electric Combination Oven	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
G21C1b022 G21C2b022 G21C1c002 G21C2c002	Gas Convection Oven	SBES New LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1b021 G21C2b021 G21C1c001	Gas Combination Oven	SBES New LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C2c001									
G21C1b023 G21C2b023 G21C1c003 G21C2c003	Gas Conveyer Oven	SBES New LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1b026 G21C2b026 G21C1c007 G21C2c007	Gas Rack Oven	SBES New LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have 100% in service rate since programs include verification of equipment installations

Realization Rates:

Installations have a 100% realization rate because programs use researched values for savings estimates. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [3]

Coincidence Factors:

Coincidence Factors for electric ovens are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[4]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c019 E21C2c019	Electric Convection Oven	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c018 E21C2c018	Electric Combination Oven	LBES Mid SBES Mid	0.225	0.085	0	0.86
G21C1c002 G21C2c002	Gas Convection Oven	LBES Mid SBES Mid	0.237	0.07	0	0.83
G21C1c001 G21C2c001	Gas Combination Oven	LBES Mid SBES Mid	0.237	0.07	0	0.83
G21C1c003 G21C2c003	Gas Conveyer Oven	LBES Mid SBES Mid	0.237	0.07	0	0.83
G21C1c007 G21C2c007	Gas Rack Oven	LBES Mid SBES Mid	0.237	0.07	0	0.83

Energy Load Shape:

See Appendix 1"C&I Load Shapes, "C&I Food Services".

Endnotes:

1: ENERGY STAR Program Requirements for Commercial Ovens. Version 2.2. https://www.energystar.gov/sites/default/files/Commercial%20Ovens%20Final%20Version%202.2%20Specification.pdf
2: FSTC Life Cycle Savings Calculators https://fishnick.com/saveenergy/tools/calculators/**3:** DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf
4: NMR, DNV-GL, and Tetra-Tech, Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study, Aug. 14, 2018 (Table 48, Table 52)

2.16 Food Service – Steam Cooker

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Food Service

Description:

Electric Steam Cooker: Installation of a qualified ENERGY STAR commercial steam cooker. ENERGY STAR steam cookers save energy during cooling and idle times due to improved cooking efficiency and idle energy rates.

Gas Steam Cooker: The installation of an ENERGY STAR rated natural-gas fired steamer, either connectionless or steam-generator design. Qualified steamers reduce heat loss due to better insulation, improved heat exchange, and more efficient steam delivery systems.

Baseline Efficiency:

Electric Steam Cooker: The Baseline Efficiency case is an electric steam cooker with a cooking efficiency, pan production capacity, preheat energy, and idle energy rate as defined by any relevant U.S. federal requirements.

Gas Steam Cooker: The baseline efficiency case is a gas steam cooker with a cooking efficiency, pan production capacity, preheat energy, and idle energy rate as defined by any relevant U.S. federal requirements.

High Efficiency:

Electric Steam Cooker: The High Efficiency case is an electric steam cooker with a cooking energy efficiency, pan production capacity, preheat energy, and an idle energy rate meeting the minimum ENERGY STAR requirements.

Gas Steam Cooker: The high efficiency case is a gas steam cooker with a cooking energy efficiency, pan production capacity, preheat energy, and an idle energy rate meeting the minimum ENERGY STAR requirements.

Algorithms for Calculating Primary Energy Impact:

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW	ΔMMBtu
E21C1b048 E21C2b048 E21C3b079 E21C1c043 E21C2c043	Electric Steam Cooker	LBES New SBES New Muni New LBES Mid SBES Mid	30,156	6.89	n/a

G21C1b027 G21C2b027 G21C1c008 G21C2c008	Gas Steam Cooker	LBES New SBES New LBES Mid SBES Mid	n/a	n/a	370.7

Quantity = Number of pans
Hours = Average annual equipment operating hours. See Hours section below.

Measure Life:

The measure life for a new steamer is 12 years.[1]

Other Resource Impacts:

Electric Steam Cooker: Deemed annual water savings.

Gas Steam Cooker: Deemed annual water savings.[2]

Measure Name	Annual water savings (gal/unit)
Gas Steam Cooker	162,060

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b048	Electric Steam Cooker	LBES New	1.00	0.99	n/a	1.00	1.00	0.90	0.90
G21C1b027	Gas Steam Cooker	LBES New	1.00	n/a	1.00	1.00	1.00	n/a	n/a
E21C2b048 E21C3b079 E21C1c043 E21C2c043	Electric Steam Cooker	SBES New Muni New LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	0.90	0.90
G21C2b027 G21C1c008 G21C2c008	Gas Steam Cooker	SBES New LBES Mid SBES Mid	1.00	n/a	1.00	1.00	1.00	n/a	n/a

In-Service Rates:

All installations have a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [3]

Coincidence Factors:

Coincidence Factors are 0.9 for both summer and winter seasons to account for the fact that some restaurants close one day per week and some may not serve both lunch and dinner on weekdays.

Energy Load Shape:

See Appendix 1 See Appendix 1"C&I Load Shapes, "C&I Food Services".

Endnotes:

1: SupportTable_EUL.csv, from DEER Database for Energy-Efficient Resources; Version 2016, READI v.2.4.3 (Current Ex Ante data) found at http://www.deeresources.com/
2: ENERGY STAR Commercial Kitchen Equipment Calculator. Updated October 2016. https://www.energystar.gov/buildings/sites/default/uploads/files/commercial_kitchen_equipment_calculator.xlsx
3: DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

2.17 Food Service – Refrigerator

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Food Service

Description:

Installation of a qualified ENERGY STAR qualified reach-in refrigerator that replaces a standard efficiency unit of the same configuration and capacity. The refrigerator may have a solid door or transparent door. Measure savings are defined by configuration and internal volume as specified in the Energy Star commercial requirements presented below.

Baseline Efficiency:

The baseline case includes standard-efficiency, reach-in solid and transparent door refrigerators and are defined by the U.S. Department of Energy (DOE) federal requirements.

High Efficiency:

The high efficiency case is an ENERGY STAR qualified reach-in refrigerator having the same configuration and capacity as the baseline equipment.

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated and based on the Energy Star Commercial Kitchen Equipment Calculator.

$$\Delta kWh = kWh_{BL} - kWh_{EE}$$
$$kWh_{BL} = (kWh_D)_{BL} \times D$$
$$kWh_{EE} = (kWh_D)_{EE} \times D$$

Where,
ΔkWh = Annual electric energy savings (kWh)
kWh_{BL} = Annual electric energy consumption of baseline equipment (kWh). Calculate from table below.
kWh_{EE} = Annual electric energy consumption of efficient equipment (kWh). Calculate from table below.
kWh_D = Daily electric energy consumption (kWh)
D = Number of days of operation of the unit. Use site specific data if possible (365 days is default).
V = Internal volume of equipment (ft^3)

Equipment Daily Consumption[1,2]

Door Type	Size Thresholds	Baseline Refrigerator Daily Energy Consumption $(kWh_D)_{BL}$	Efficient Refrigerator Daily Energy Consumption $(kWh_D)_{EE}$
Solid Door	0 < V < 15	(0.05 x V) + 1.36	(0.022 x V) + 0.97
	15 < V < 30		(0.066 x V) + 0.31

	30 < V < 50		(0.04 x V) + 1.09
	50 < V		(0.024 x V) + 1.89
Transparent Door	0 < V < 15	(0.1 x V) + 0.86	(0.095 x V) + 0.445
	15 < V < 30		(0.05 x V) + 1.12
	30 < V < 50		(0.076 x V) + 0.34
	50 < V		(0.105 x V) - 1.111

Measure Life[3]:

BC Measure ID	Measure Name	Program	Measure Life
E21C1c041 E21C2c041	Refrigerator, Transparent Door	LBES Mid SBES Mid	12
E21C1c042 E21C2c042	Refrigerator, Solid Door	LBES Mid SBES Mid	12

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1c041 E21C2c041	Refrigerator, Transparent Door	LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C1c042 E21C2c042	Refrigerator, Solid Door	LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	1.00	1.00

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

All programs use a 100% coincidence factor unless an evaluation finds otherwise.

Energy Load Shape:

See Appendix 1

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[4]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c041 E21C2c041	Refrigerator, Transparent Door	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c042 E21C2c042	Refrigerator, Solid Door	LBES Mid SBES Mid	0.225	0.085	0	0.86

Future application of measure-specific NEI values will be considered by the NH Benefit/Cost (B/C) Working Group, per Commission Order No. 26,323 , December 31, 2019.

Endnotes:

1: Efficient equipment daily energy consumption is in line with ENERGY STAR. 2016. "ENERGY STAR® Program Requirements Product Specification for Commercial Refrigerators and Freezers - Eligibility Criteria Version 4.0." Effective on March 27, 2017.
2: Baseline equipment daily energy consumption is defined by the U.S. Department of Energy (DOE) federal requirements. Code of Federal Regulations at 10 CFR 431.66.
3: California Public Utilities Commission (CPUC), Energy Division. 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
4: NMR, DNV-GL, and Tetra-Tech, Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study, Aug. 14, 2018 (Table 48, Table 52)

2.18 Food Service – Freezer

Measure Code		[To Be Defined in ANB system]
Market		Commercial
Program Type		Lost Opportunity
Category		Food Service

Description:

Installation of a qualified ENERGY STAR qualified reach-in freezer that replaces a standard efficiency unit of the same configuration and capacity. The freezer may have a solid door or transparent door. Measure savings are defined by configuration and internal volume as specified in the ENERGY STAR commercial requirements presented below.

Baseline Efficiency:

The baseline case includes standard-efficiency, reach-in, solid and transparent door freezers and are defined by the U.S. Department of Energy (DOE) federal requirements.

High Efficiency:

The high efficiency case is an ENERGY STAR qualified reach-in freezer having the same configuration and capacity as the baseline equipment .

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated and based on the ENERGY STAR Commercial Kitchen Equipment Calculator.

$$\Delta kWh = kWh_{BL} - kWh_{EE}$$
$$kWh_{BL} = (kWh_D)_{BL} \times D$$
$$kWh_{EE} = (kWh_D)_{EE} \times D$$

Where,
ΔkWh = Annual electric energy savings (kWh)
kWh_{BL} = Annual electric energy consumption of baseline equipment (kWh). Calculate from table below.
kWh_{EE} = Annual electric energy consumption of efficient equipment (kWh). Calculate from table below.
kWh_D = Daily electric energy consumption (kWh)
D = Number of days of operation of the unit. Use site specific data if possible (365 days is default).
V = Internal volume of equipment (ft^3)

Equipment Daily Consumption[1,2]

Door Type	Size Thresholds	Baseline Freezer Daily Energy Consumption $(kWh_D)_{BL}$	Efficient Freezer Daily Energy Consumption $(kWh_D)_{EE}$
Solid Door	0 < V < 15	(0.22 x V) + 1.38	(0.021 x V) + 0.90

	15 < V < 30		(0.012 x V) + 2.248
	30 < V < 50		(0.285 x V) - 2.703
	50 < V		(0.142 x V) + 4.445
Transparent Door	All	(0.29 x V) + 2.95	(0.232 x V) + 2.36

Measure Life[3]:

BC Measure ID	Measure Name	Measure Life
E21C1c030 E21C2c030	Freezer, Transparent Door	12
E21C1c029 E21C2c029	Freezer, Solid Door	12

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1c030 E21C2c030	Freezer, Transparent Door	LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C1c029 E21C2c029	Freezer, Solid Door	LBES Mid SBES Mid	1.00	1.00	n/a	1.00	1.00	1.00	1.00

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

All programs use a 100% coincidence factor unless an evaluation finds otherwise.

Energy Load Shape:

See Appendix 1 C&I Load Shapes “C&I Food Service”.

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[4]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c030 E21C2c030	Freezer, Transparent Door	LBES Mid SBES Mid	0.225	0.085	0	0.86
E21C1c029 E21C2c029	Freezer, Solid Door	LBES Mid SBES Mid	0.225	0.085	0	0.86

Endnotes:
1: Efficient equipment daily energy consumption is in line with ENERGY STAR. 2016. "ENERGY STAR® Program Requirements Product Specification for Commercial Refrigerators and Freezers - Eligibility Criteria Version 4.0." Effective on March 27, 2017.
2: Baseline equipment daily energy consumption is defined by the U.S. Department of Energy (DOE) federal requirements. Code of Federal Regulations at 10 CFR 431.66.
3: California Public Utilities Commission (CPUC), Energy Division. 2014. "DEER2014-EUL-table-update_2014-02-05.xlsx."
4: NMR, DNV-GL, and Tetra-Tech, Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study, Aug. 14, 2018 (Table 48, Table 52)

2.19 Hot Water – Faucet Aerators

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	Hot Water

Description:

Installation of a faucet aerator with a flow rate of 1.5 GPM or less on an existing faucet with high flow in a commercial setting.

Baseline Efficiency:

The baseline efficiency case is an existing faucet aerator with Federal Standard flow rate of 2.2 GPM.[1]

High Efficiency:

The high efficiency case is a low flow faucet aerator with EPA WaterSense[2] specified maximum flow rate of 1.5 GPM.

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated using the Federal Energy Management Program ("FEMP") Energy Cost Calculator. [3] kW savings are calculated using the demand impact model.[4]

BC Measure ID	Measure Name	Fuel Type	Program	ΔkWh	ΔkW	ΔMMBtu
E21C1a028 E21C1b031 E21C1d030 E21C2a028 E21C2b031 E21C2d030 E21C3a044 E21C3b045 E21C3d046	Faucet Aerator	**Electric**	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	309	0.01	n/a
E21C3a045 E21C3b046 E21C3d047 G21C1a005 G21C1b017 G21C2a005 G21C2b017	Faucet Aerator	Gas	LBES Retro LBES New LBES DI LBES Retro LBES New SBES DI SBES New	n/a	n/a	1.7

E21C3a046 E21C3b047 E21C3d048	Faucet Aerator	Oil	Muni Retro Muni New Muni DI	n/a	n/a	1.7
E21C3a047 E21C3b048 E21C3d049	Faucet Aerator	Propane	Muni Retro Muni New Muni Gas	n/a	n/a	1.7

Measure Life:

The measure life for a faucet aerator is 10 years.[5]

Other Resource Impacts:

There are deemed water savings of 5,460 gallons/unit.[3]

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a028	Faucet Aerator	Electric	LBES Retro LBES New LBES DI	1.00	0.99	1.00	1.00	1.00	0.31	0.81
E21C3a045	Faucet Aerator	Gas	LBES Retro LBES New LBES DI	1.00	n/a	0.99	n/a	n/a	n/a	n/a
E21C3a046	Faucet Aerator	Oil	LBES Retro LBES New LBES DI	1.00	n/a	0.99	n/a	n/a	n/a	n/a
E21C3a047	Faucet Aerator	Propane	LBES Retro LBES New LBES DI	1.00	n/a	0.99	n/a	n/a	n/a	n/a
E21C1b031 E21C1d030 E21C2a028 E21C2b031 E21C2d030 E21C3a044 E21C3b045 E21C3d046	Faucet Aerator	Electric	SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	1.00	1.00	1.00	1.00	1.00	0.31	0.81
E21C3b046 E21C3d047 G21C1a005 G21C1b017 G21C2a005 G21C2b017	Faucet Aerator	Gas	LBES Retro LBES New SBES Retro SBES New	1.00	n/a	1.00	n/a	n/a	n/a	n/a

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C3b047 E21C3d048	Faucet Aerator	Oil	Muni Retro Muni New Muni Gas	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3b048 E21C3d049	Faucet Aerator	Propane	Muni Retro Muni New Muni Gas	1.00	n/a	1.00	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [6]

Coincidence Factors:

Summer and winter coincidence factors of 31% and 81% have been utilized per the MA demand impact model.[4]

Energy Load Shape:

For electric measures, see Appendix 1 C&I Load Shapes " Water Heater – Electric".
For non-electric measures, see Appendix 1 C&I Load Shapes "Non- Electric Measures"

Endnotes:
1: In 1998, the Department of Energy adopted a maximum flow rate standard of 2.2 gpm at 60 psi for all faucets: 63 Federal Register 13307; March 18, 1998. https://www.epa.gov/sites/production/files/2017-02/documents/ws-specification-home-final-suppstatement-v1.0.pdf
2: WaterSense: Bathroom Faucets. https://www.epa.gov/watersense/bathroom-faucets
3: Federal Energy Management Program ("FEMP") Energy Cost Calculator for Faucets and Showerheads. Available at: https://www.energy.gov/eere/femp/energy-cost-calculator-faucets-andshowerheads-0. On average, faucets are assumed to run 30 minutes per day, 260 days per year. Actual usage values should be used, when known, in lieu of default savings values.
4: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
5: Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks, GDS Associates, April 2009. http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
6: DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities.
https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

2.20 Hot Water – Pre-Rinse Spray Valve

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit/Lost Opportunity
Category	Hot Water

Description:

Pre-Rinse Spray Valve: Retrofitting existing standard spray nozzles in locations where service water is supplied by hot water heater with new low flow pre-rinse spray nozzles with an average flow rate of 1.6 GPM.

Baseline Efficiency:

Pre-Rinse Spray Valve, Gas: The baseline efficiency case is an existing efficiency spray valve.

High Efficiency:

Pre-rinse Spray Valve, Gas: The high efficiency case is a low flow pre-rinse spray valve with an average flow rate of 1.6 GPM. [1]

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results. [2 3]

BC Measure ID	Measure Name	Fuel Type	Program	ΔkWh	ΔMMBtu
E21C1a040 E21C1b046 E21C1d040 E21C2a040 E21C2b046 E21C2d040 E21C3a075 E21C3b074 E21C3d075	Pre-Rinse Spray Valve	Electric	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	126 kWh for grocery and 957 kWh for non-grocery facility type	
E21C3a076 E21C3b075 E21C3d076 G21C1a009 G21C1b020 G21C2a009 G21C2b020 G21C1c006 G21C2c006	Pre-Rinse Spray Valve	Gas	Muni Retro Muni New Muni DI LBES Retro LBES New SBES Retro SBES New LBES Mid SBES Mid		11.4

E21C3a077 E21C3b076 E21C3d077	Pre-Rinse Spray Valve,	Oil	LBES Retro SBES Retro Muni Retro		11.4
E21C3a078 E21C3b077 E21C3d078	Pre-Rinse Spray Valve	Propane	LBES Retro SBES Retro Muni Retro		11.4

Measure Life:

The measure life is 8 years.[2]

Other Resource Impacts:

There are water savings of 6,410 gallons per unit.[2]

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a040 E21C1b046 E21C1d040	Pre-Rinse Spray Valve	Electric	LBES Retro LBES New LBES DI	1.00	0.99	1.00	1.00	1.00	0.52	1.00
G21C1a009 G21C1b020	Pre-Rinse Spray Valve	Gas	LBES Retro LBES New	1.00	n/a	0.99	n/a	n/a	n/a	n/a
E21C2a040 E21C2b046 E21C2d040 E21C3a075 E21C3b074 E21C3d075	Pre-Rinse Spray Valve	Electric	SBES Retro SBES New SBES DI Retro Muni New Muni DI	1.00	1.00	1.00	1.00	1.00	0.52	1.00
E21C3a076 E21C3b075 E21C3d076 G21C2a009 G21C2b020 G21C2c006	Pre-Rinse Spray Valve	Gas	Muni Retro Muni New Muni DI SBES Retro SBES New LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3a077 E21C3b076 E21C3d077	Pre-Rinse Spray Valve,	Oil	Muni New Muni Retro	1.00	n/a	1.00	n/a	n/a	n/a	n/a

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
			Muni DI							
E21C3a078 E21C3b077 E21C3d078	Pre-Rinse Spray Valve	Propane	Muni New Muni Retro Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise. The LBES program uses a realization rate of 99.9% from a 2015 impact evaluation on commercial and industrial programs. [5]

Coincidence Factors:

A summer coincidence factor of 52% and a winter coincidence factor of 100% is utilized.[4]

Impact Factors for Calculating Net Savings (Upstream/Midstream Only)[6]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
G21C1c006 G21C2c006	Pre Rinse Spray Valve	LBES Mid SBES Mid	0.237	0.07	0	0.83

Energy Load Shape:

For electric measures, see Appendix 1 C&I Load Shapes " Water Heater – Electric".
For non-electric measures, see Appendix 1 C&I Load Shapes "Non- Electric Measures"

Endnotes:
1: Per Massachusetts program administrator internal analysis.
2: Impact Evaluation of Massachusetts Prescriptive Gas Pre-Rinse Spray Valves, DNV GL, November 2014. http://ma-eeac.org/wordpress/wp-content/uploads/Prescriptive-Gas-Pre-Rinse-Spray-Valve-Measure-Impact-Evaluation.pdf
3: Connecticut Program Savings Document 2020. Measure 3.2.1: Water-Saving Measures.
4: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
5: DNV GL, September 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. Prepared for NH Electric and Gas Utilities.
https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf

6: NMR Group, Inc. (2018). Massachusetts Sponsors' Commercial and Industrial Free-ridership and Spillover Study. 2018_NMR_CI FR-SO Report

2.21 Hot Water – Showerheads

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Hot Water

Description:

Thermostatic Shut-Off Valve: Installation of a stand-alone thermostatic shut-off valve on standard flow showerhead.
Low-Flow Showerhead, Electric, Gas, Oil, Propane: Installation of a low-flow showerhead with a flow rate of 1.5 GPM or less.

Baseline Efficiency:

Thermostatic Shut-Off Valve: The baseline efficiency is an existing standard-flow showerhead (2.5 GPM) with no thermostatic shut-off valve.
Low-Flow Showerhead, Electric, Gas, Oil, Propane: The baseline efficiency is an existing standard-flow showerhead (2.5 GPM).

High Efficiency:

Thermostatic Shut-Off Valve: The high efficiency case is a standard flow showerhead (2.5 GPM) with the addition of a stand-alone thermostatic shut-off valve.
Low-Flow Showerhead, Electric, Gas, Oil, Propane: The high efficiency case is a low-flow showerhead (1.5 GPM).

Algorithms for Calculating Primary Energy Impact:

Low-Flow Showerhead with Thermostatic Valve: Unit savings are deemed.[1] kW savings are calculated using the demand impact model.[2]

Low-Flow Showerhead, Electric and Low-Flow Showerhead, Gas: Unit savings are deemed. [3]

BC Measure ID	Measure Name	Fuel Type	Program	ΔkWh	ΔkW	ΔMMBtu
G21C1a006 G21C1b018 G21C2a006 G21C2b018	Thermostatic Shut-Off Valve	Gas	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	n/a	n/a	0.33

E21C1a033 E21C1b044 E21C1d033 E21C2a033 E21C2b044 E21C2d033 E21C3a056 E21C3b066 E21C3d056	Thermostatic Shut-Off Valve	Electric	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	69	0.01	
E21C3a058 E21C3b068 E21C3d058	Thermostatic Shut-Off Valve	Oil	Muni Retro Muni New Muni DI	n/a	n/a	0.33
E21C3a059 E21C3b069 E21C3d059	Thermostatic Shut-Off Valve	Propane	Muni Retro Muni New Muni DI	n/a	n/a	0.33
E21C1a034 E21C1b045 E21C1d034 E21C2a034 E21C2b045 E21C2d034 E21C3a060 E21C3b070 E21C3d060	Low-Flow Showerhead	Electric	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	507	0.09	
G21C1a007 G21C1b019 G21C2a007 G21C2b019	Low-Flow Showerhead	Gas	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni	n/a	n/a	2.65
E21C3a062 E21C3b072 E21C3d062	Low-Flow Showerhead	Oil	Muni Retro Muni New Muni DI	n/a	n/a	2.65
E21C3a063 E21C3b073 E21C3d063	Low-Flow Showerhead	Propane	Muni Retro Muni New Muni DI	n/a	n/a	2.65

Measure Life:

The measure life for all Showerheads is 10 years.[4]

Other Resource Impacts:

Thermostatic Shut-Off Valve: Annual water savings of 558 gallons per unit.[1]

Low-Flow Showerhead, Electric, Gas, Oil, Propane: Annual water savings of 7,300 gallons per unit.[3]

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1a006 G21C1b018 G21C2a006 G21C2b018	Thermostatic Shut-Off Valve, Gas	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C1a033 E21C1b044 E21C1d033 E21C2a033 E21C2b044 E21C2d033 E21C3a056 E21C3b066 E21C3d056	Thermostatic Shut-Off Valve, Electric	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	1.00	1.00	n/a	1.00	1.00	0.31	0.81
E21C3a058 E21C3b068 E21C3d058	Thermostatic Shut-Off Valve, Oil	Muni Retro Muni New Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3a059 E21C3b069 E21C3d059	Thermostatic Shut-Off Valve, Propane	Muni Retro Muni New Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C1a034 E21C1b045 E21C1d034 E21C2a034 E21C2b045 E21C2d034 E21C3a060 E21C3b070 E21C3d060	Low-Flow Showerhead, Electric	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni DI	1.00	1.00	n/a	1.00	1.00	0.31	0.81

G21C1a007 G21C1b019 G21C2a007 G21C2b019	Low-Flow Showerhead, Gas	LBES Retro LBES New LBES DI SBES Retro SBES New SBES DI Muni Retro Muni New Muni	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3a062 E21C3b072 E21C3d062	Low-Flow Showerhead, Oil	Muni Retro Muni New Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a
E21C3a063 E21C3b073 E21C3d063	Low-Flow Showerhead, Propane	Muni Retro Muni New Muni DI	1.00	n/a	1.00	n/a	n/a	n/a	n/a

In-Service Rates:

All programs have a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Summer and winter coincidence factors of 31% and 81% have been utilized per the MA demand impact model.[2]

Energy Load Shape:

For electric measures, see Appendix 1 C&I Load Shapes " Water Heater – Electric".
For non-electric measures, see Appendix 1 C&I Load Shapes "Non- Electric Measures"

Endnotes:
1: National Grid, 2014. Review of ShowerStart evolve. Calculation document provided in the MA TRM.
2: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
3: Federal Energy Management Program ("FEMP") Energy Cost Calculator for Faucets and Showerheads.. On average, showerheads are assumed to run 20 minutes per day, 365 days per year. Actual usage values should be used, when known, in lieu of default savings values. ΔMMBtu based on **Navigant Consulting (2018). Demand Impact Model Update.**
4: Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks, GDS Associates, April 2009. http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

2.22 Hot Water - Steam Traps

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

Repair or replace malfunctioning steam traps.

Baseline Efficiency:

The baseline efficiency case is a failed steam trap.

High Efficiency:

The high efficiency case is a repaired or replaced steam trap.

Algorithms for Calculating Primary Energy Impact:

Deemed annual unit savings are as detailed in the table below[1]:

BC Measure ID	Measure Name	Fuel Type	Program	ΔkWh	ΔMMBtu
G21C1a014 G21C2a014 E21C3a084 E21C3d084	Steam Trap	Gas	LBES Retro – Gas SBES Retro – Gas Muni Retro Muni DI	n/a	Low pressure (≤= 10 psig): 8.4 High pressure (>10 psig): 35.6
E21C3a085 E21C3d085	Steam Trap	Oil	Muni Retro Muni DI	n/a	Low pressure (≤= 10 psig): 8.4 High pressure (>10 psig): 35.6
E21C3a086 E21C3d086	Steam Trap	Propane	Muni Retro Muni DI	n/a	Low pressure (≤= 10 psig): 8.4 High pressure (>10 psig): 35.6

Measure Life:

The measure life is 6 years. [2]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1a014 G21C2a014 E21C3a084 E21C3d084	Steam Trap	Gas	LBES Retro – Gas SBES Retro – Gas Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a085 E21C3d085	Steam Trap	Oil	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a086 E21C3d086	Steam Trap	Propane	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Large Business Energy Solution uses a 99.9% electric realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

Energy Load Shape:

See Appendix 1 – “Boiler Distribution”.

Endnotes:

1: Energy and Resource Solutions, April 2018. Two-Tier Steam Trap Savings Study. Prepared for National Grid and Eversource of Massachusetts. http://ma-eeac.org/wordpress/wp-content/uploads/MA-CIEC-Two-Tier-Steam-Traps-Memo-FINAL.pdf

2: DNV GL, June 2015. Massachusetts 2013 Prescriptive Gas Impact Evaluation – Steam Trap Evaluation Phase I. Prepared for Massachusetts Gas Program Administrators and Massachusetts Energy Efficiency Advisory Council. http://ma-eeac.org/wordpress/wp-content/uploads/MA-2013-Prescriptive-Gas-Impact-Evaluation-Steam-Trap-Evaluation-Phase-1.pdf

2.23 HVAC – Boiler Reset Controls

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

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.

Baseline Efficiency:

The baseline efficiency case is a boiler without reset controls.

High Efficiency:

The high efficiency case is a boiler without reset controls.

Algorithms for Calculating Primary Energy Impact:

.
Unit savings are deemed based on study results.[1]

BC Measure ID	Measure Name	Fuel Type	Program	ΔMMBtu/unit
E21C3a019 E21C3d021 G21C1a010 G21C2a010	Boiler Reset Controls	Gas	Muni Retro Muni DI LBES Retro SBES Retro	35.5
E21C3a020 E21C3d022	Boiler Reset Control	Oil	Muni Retro Muni DI	35.5
E21C3a021 E21C3d023	Boiler Reset Control	Propane	Muni Retro Muni DI	35.5

Measure Life:

The measure life is 15 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C3a019 E21C3d021 G21C1a010 G21C2a010	Boiler Reset Controls	Gas	Muni Retro Muni DI LBES Retro SBES Retro	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a020 E21C3d022	Boiler Reset Control	Oil	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a021 E21C3d023	Boiler Reset Control	Propane	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

Energy Load Shape:

For electric measures, see Appendix 1 C&I Load Shapes “Boiler Distribution”.
For non-electric measures, see Appendix 1 C&I Load Shapes “Non- Electric Measures”

Endnotes:
1: GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts, as cited in the Massachusetts TRM. Study assumes 710.46 MMBTU base use with 5% savings factor. GDS_2009_Natural_Gas_Energy_Efficiency_Potential_in_MA.
2: ACEEE, 2006. Emerging Technologies Report: Advanced Boiler Controls.

2.24 HVAC – Circulator Pump

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

Single-phase circulator pumps used in C&I buildings used for hydronic heating and system hot water.

Baseline Efficiency:

The baseline system is a pump without an EC motor. The baseline system may have no control, a timer, aquastat, or be on demand. The baseline system is assumed to run a weighted average of these four control types.

High Efficiency:

The high efficiency case is a circulator pump with an ECM.

Algorithms for Calculating Primary Energy Impact:

Savings depend on application and pump size as described in table below.[1]

Size	Type	kW	kWh
<= 1 HP	Hydronic Heating	$\Delta kW = 0.245 * HP_{rated} + 0.02$	$\Delta kWh = 1{,}325 * HP_{rated} + 111$
<= 1 HP	Service Hot Water	$\Delta kW = 0.245 * HP_{rated} + 0.02$	$\Delta kWh = 2{,}780 * HP_{rated} + 233$
> 1 HP	Hydronic Heating	$\Delta kW = 0.265$	$\Delta kWh = 1{,}436$
> 1 HP	Service Hot Water	$\Delta kW = 0.265$	$\Delta kWh = 3{,}013$

Measure Life:

The measure life is 20 years.[2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[3]

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b018	Circulator Pump	LBES New	1.000	0.999	n/a	1.000	1.000	0.820	0.050
E21C2b018	Circulator Pump	SBES New	1.000	1.000	n/a	1.000	1.000	0.820	0.050
E21C3b030	Circulator Pump	Muni New	1.000	1.000	n/a	1.000	1.000	0.820	0.050
E21C1c001	Midstream Circulator Pump	LBES Midstream	1.000	1.000	n/a	1.000	1.000	0.820	0.050
E21C2c001	Midstream Circulator Pump	SBES Midstream	1.000	1.000	n/a	1.000	1.000	0.820	0.050

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

A summer coincidence factor of 82.0% and a winter coincidence factor of 5.0% are utilized.[3]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Heating & Cooling"

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):[4]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	2021 NTG
E21C1c001 E21C2c001	Midstream Circulator Pump	LBES Midstream SBES Midstream	0.225	0.085	0.000	0.860

Endnotes:
1: The Cadmus Group, 2017. Circulator Pump Technical Memo. Prepared for National Grid and Eversource engineers.

2: Energy & Resource Solutions, November 2005. Measure Life Study. Prepared for The Massachusetts Joint Utilities. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf
3: Navigant Consulting (2018). RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf
4: NMR, DNV GL, and Tetra Tech, August 2018. Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study. Prepared for Massachusetts Program Administrators. http://ma-eeac.org/wordpress/wp-content/uploads/TXC_49_CI-FR-SO-Report_14Aug2018.pdf

2.25 HVAC- Demand Control Ventilation

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

The measure controls the quantity of outside air to an air handling system based on detected space CO_2 levels. The installed systems monitor the CO_2 in the spaces or return air and reduce the outside air use when possible to save energy while meeting indoor air quality standards.

Baseline Efficiency:

The baseline efficiency case assumes the relevant HVAC equipment has no ventilation control.

High Efficiency:

The high efficiency case is the installation of an outside air intake control based on CO_2 sensors.

Algorithms for Calculating Primary Energy Impact:

The energy and demand savings are calculated using the following algorithms and inputs:

$$\Delta kWh = kBtuh \times \frac{1\ ton}{12\ kBtuh} \times Save_{kWh}$$

$$\Delta kW = kBtuh \times \frac{1\ ton}{12\ kBtuh} \times Save_{kW}$$

Where:

$kBtuh$ = Capacity of the cooling equipment in kBtu per hour

$Save_{kWh}$ = Average annual kWh reduction per ton of cooling capacity: 170 kWh/ton [1]

$Save_{kW}$ = Average kW reduction per ton of cooling capacity: 0.15 kW/ton [2]

Measure Life:

The measure life is 10 years.[3]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a018 E21C1d020	Demand Control Ventilation	LBES Retro LBES DI	1.000	0.999	n/a	1.000	1.000	0.820	0.050
E21C2a018 E21C2d020	Demand Control Ventilation	SBES Retro SBES DI	1.000	1.000	n/a	1.000	1.000	0.820	0.050
E21C3a024 E21C3d026	Demand Control Ventilation	Muni Retro Muni DI	1.000	1.000	n/a	1.000	1.000	0.820	0.050
E21C1c002 E21C2c002	Midstream Demand Control Ventilation	LBES Midstream SBES Midstream	1.000	1.000	n/a	1.000	1.000	0.820	0.050

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates[4]:

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

CFs are based on Massachusetts TRM standard assumptions.

Energy Load Shape:

Appendix 1 C&I Load Shapes– "C&I Heating and Cooling"

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):[5]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	2021 NTG
E21C1c002 E21C2c002	Midstream Demand Control Ventilation	LBES Midstream SBES Midstream	0.225	0.085	0.000	0.860

Endnotes:

1: Keena, Kevin, 2008. Analysis of CO2 Control Energy Savings on Unitary HVAC Units. Prepared for National Grid.

2: Keena, Kevin, 2008. Analysis of CO2 Control Energy Savings on Unitary HVAC Units. Prepared for National Grid.

3: Energy & Resource Solutions, November 2005. Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1. Measure life is assumed to be the same as Enthalpy Economizer. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf

4: New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Impact Evaluation report. Table 3

5: NMR, DNV GL, and Tetra Tech, August 2018. Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study. Prepared for Massachusetts Program Administrators. http://ma-eeac.org/wordpress/wp-content/uploads/TXC_49_CI-FR-SO-Report_14Aug2018.pdf

2.26 HVAC- Dual Enthalpy Economizer Controls

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

The measure is to upgrade the outside-air dry-bulb economizer to a dual enthalpy economizer. The system will continuously monitor the enthalpy of both the outside air and return air. The system will control the system dampers adjust the outside quantity based on the two readings.

Baseline Efficiency:

The baseline efficiency case for this measure assumes the relevant HVAC equipment is operating with a fixed dry-bulb economizer.

High Efficiency:

The high efficiency case is the installation of an outside air economizer utilizing two enthalpy sensors, one for outdoor air and one for return air.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = kBtuh \times \frac{1\ ton}{12\ kBtuh} \times SAVE_{kWh}$$

$$\Delta kW = kBtuh \times \frac{1\ ton}{12\ kBtuh} \times SAVE_{kW}$$

Where:

kBtu/h = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h)

$SAVE_{kWh}$ = Average annual kWh reduction per ton of cooling capacity: 289 kWh/ton [1]

$SAVE_{kW}$ = Average kW reduction per ton of cooling capacity: 0.289 kW/ton [2]

Measure Life:

The measure life is 10 years. [3]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a020 E21C1d022	Dual Enthalpy Economizer Controls	LBES Retro LBES DI	1.000	0.999	n/a	1.000	1.000	0.342	0.000
E21C2a020 E21C2d022	Dual Enthalpy Economizer Controls	SBES Retro SBES DI	1.000	1.000	n/a	1.000	1.000	0.342	0.000
E21C3a026 E21C3d028	Dual Enthalpy Economizer Controls	MES Retro MES DI	1.000	1.000	n/a	1.000	1.000	0.342	0.000
E21C1c004 E21C2c004	Midstream Dual Enthalpy Economizer Controls	LBES Midstream SBES Midstream	1.000	1.000	n/a	1.000	1.000	0.342	0.000

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Coincidence factors are based on 2011 NEEP C&I Unitary AC Loadshape Project [4]

Energy Load Shape:

See Appendix 1C&I Load Shapes – "C&I Heating and Cooling".

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):[5]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	2021 NTG
E21C1c004 E21C2c004	Midstream Dual Enthalpy Economizer Controls	LBES Midstream SBES Midstream	0.225	0.085	0.000	0.860

Endnotes:
1, 2: Patel, Dinesh, 2001. Energy Analysis: Dual Enthalpy Control. Prepared for Eversource (NSTAR).
3: Energy & Resource Solutions, November (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities.https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf

4: Coincidence Factors are from 2011 NEEP HVAC Loadshape Study Table 0-5 (ISO_NE on Peak for NE-North)
https://neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf
5: NMR, DNV GL, and Tetra Tech, August 2018. Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study. Prepared for Massachusetts Program Administrators.
http://ma-eeac.org/wordpress/wp-content/uploads/TXC_49_CI-FR-SO-Report_14Aug2018.pdf

2.27 HVAC – Duct Insulation

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

For existing ductwork in non-conditioned spaces, insulate ductwork. This could include replacing un-insulated flexible duct with rigid insulated ductwork and installing 1" to 2" of duct-wrap insulation.

Baseline Efficiency:

The baseline efficiency case is existing, uninsulated ductwork in unconditioned spaces (e.g. attic or basement).

High Efficiency:

The high efficiency condition is insulated ductwork in unconditioned spaces.

Algorithms for Calculating Primary Energy Impact:

Deemed average annual MMBtu savings of 0.13[1] is assumed per unit, where unit is defined as number of square feet of ductwork treated.

Measure Life:

The measure life is 20 years.[1]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C3a027 E21C3d029	Duct Insulation	Electric	Muni Retro Muni DI	1.000	1.000	n/a	1.000	1.000	0.350	0.000
E21C3a028 E21C3d030	Duct Insulation	Gas	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a029 E21C3d031	Duct Insulation	Oil	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C3a030 E21C3d032	Duct Insulation	Propane	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100.0% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

For electric measures, a summer coincidence factor of 35.0% is utilized.[2]

Energy Load Shape:

For electric measures, see Appendix 1 C&I Load Shapes "Weighted HVAC – Multi-Family"
For non-electric measures, see Appendix 1 C&I Load Shapes "Non-Electric Measures".

Endnotes:

1: National Grid Staff Estimate, 2010. MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings. https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/5ee4885c6996f2b5047df743/view?authToken=fa8e547661bf80dea8750ffa5a1d3608215165882ceaf6ebc0b7193a1ab071622426a78ec0a491b80535c621447604a03ab75d3119793c326860fd96007eec8b851ba43c196fab

2: Navigant Consulting, 2018. RES1 Demand Impact Model Update. Weighted CF by end use (Table 3). http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

2.28 HVAC – Duct Sealing

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

For existing ductwork in non-conditioned spaces, seal ductwork. This could include sealing leaky fixed ductwork with mastic or aerosol.

Baseline Efficiency:

The baseline efficiency case is existing, non-sealed (leaky) in unconditioned spaces (e.g. attic or basement).

High Efficiency:

The high efficiency condition is air sealed ductwork in unconditioned spaces.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results:
Δ MMBtu = MMBtu/unit x Units
Where:
Unit = Number of square feet of ductwork treated
MMBtu/unit = Average annual MMBtu savings per unit: 0.13[1]

Measure Life:

The measure life is 20 years.[2]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a021 E21C1d023	Duct Sealing	Electric	LBES Retro LBES DI	1.000	0.999	n/a	1.000	1.000	0.350	0.000

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C2a021 E21C2d023	Duct Sealing	Electric	SBES Retro SBES DI	1.000	1.000	n/a	1.000	1.000	0.350	0.000
E21C3a031 E21C3d033	Duct Sealing	Electric	Muni Retro Muni DI	1.000	1.000	n/a	1.000	1.000	0.350	0.000
E21C3a032 E21C3d034	Duct Sealing	Gas	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a033 E21C3d035	Duct Sealing	Oil	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a034 E21C3d036	Duct Sealing	Propane	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise

Realization Rates:

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

A summer coincidence factor if 35.0% is utilized.[2]

Energy Load Shape:

For electric measures, see Appendix 1 C&I Load Shapes "Weighted HVAC- Multi-Family"
For non-electric measures, see Appendix 1 C&I Load Shapes "Non-Electric Measures"
.

Endnotes:
1: National Grid Staff Estimate, 2010. MA SBS-DI Duct Sealing and Insulation Scenario and Deemed Savings. https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/5ee4885c6996f2b5047df743/view?authToken=19819e606c75814d

e7e2d8af2fec676653fdc0f39f9bd79f566ee687c4851bcdb91e2216408550e53766db986dc9c0640b2776bb702f79b7f56a42e07d73a2cebf5c6abfb39bd1
2: Navigant Consulting, 2018. RES1 Demand Impact Model Update. Weighted CF by end use (Table 3). http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

2.29 HVAC – Energy Management System

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

The measure is the installation of a new building energy management system (EMS) or the expansion of an existing energy management system for control of non-lighting electric and gas end-uses in an existing building on existing equipment.

Baseline Efficiency:

The baseline for this measure assumes the relevant HVAC equipment has no centralized control.

High Efficiency:

The high efficiency case is the installation of a new EMS or the expansion of an existing EMS to control additional non-lighting electric or gas equipment. The EMS must be installed in an existing building on existing equipment.

Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings for energy management systems (EMS) are custom calculated using vendor tools. These tools are used to calculate energy and demand savings based on project-specific details including hours of operation, HVAC system equipment and efficiency and points controlled.

BC Measure ID	Measure Name	Fuel Type	Program	MMBtu/kWh
G21C1a012 G21C2a012	Energy Management System	Gas	LBES Retro – Gas SBES Retro – Gas	Calculated
E21C1a025 E21C1d027 E21C2a025 E21C2d027 E21C3a038 E21C3d040	Energy Management System	Electric	LBES Retro LBES DI SBES Retro SBES DI Muni Retro Muni DI	Calculated

Measure Life:

The measure life is 10 years.[1]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a025 E21C1d027	Energy Management System	LBES Retro LBES DI	1.000	0.999	1.000	1.000	1.000	0.950	1.000
E21C2a025 E21C2d027	Energy Management System	SBES Retro SBES DI	1.000	1.000	1.000	1.000	1.000	0.950	1.000
E21C3a038 E21C3d040	Energy Management System	Muni Retro Muni DI	1.000	1.000	1.000	1.000	1.000	0.950	1.000
G21C1a012 G21C2a012	Energy Management System	LBES Retro – Gas SBES Retro – Gas	1.000	n/a	1.000	1.000	1.000	0.000	0.000

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

A summer coincidence factor of 95.0% and a winter coincidence factor of 100.0% is utilized.[2]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Heating and Cooling"

Endnotes:

1: The Fleming Group, 1994. Persistence of Commercial/Industrial Non-Lighting Measures, Volume 3, Energy Management Control Systems. Prepared for New England Power Service Company.

2: New Hampshire common assumptions.

2.30 HVAC – Heat and Hot Water Combo Systems

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

Combo Condensing Furnace / Water Heater: Installation of a combination furnace.
Combo Condensing Boiler / Water Heater: This measure promotes the installation of a combined high-efficiency boiler and water heating unit. Combined boiler and water heating systems are more efficient than separate systems because they eliminate the standby heat losses of an additional tank.

Baseline Efficiency:

Combo Condensing Furnace / Water Heater: It is assumed that the baseline is an 85% AFUE furnace [1] and a separate high draw gas fired storage water heater with an efficiency rating of 0.63 UEF.
Combo Condensing Boiler / Water Heater: The baseline efficiency case is a standard efficiency gas-fired storage tank hot water heater with a separate standard efficiency boiler for space heating purposes.

High Efficiency:

Combo Condensing Furnace / Water Heater: A new combination 97% AFUE furnace and 0.90 tankless water heater.
Combo Condensing Boiler / Water Heater: The high efficiency case is either a condensing, integrated water heater/boiler with an AFUE of >=90% or AFUE>=95%.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[2]

BC Measure ID	Measure Name	ΔMMBtu
G21C1b012 G21C2b012	Combo Condensing Furnace/Water Heater, Gas	15.1
G21C1b011 G21C2b011	Combo Condensing Boiler/Water Heater, Gas	30.5

Measure Life:

Combo Condensing Furnace / Water Heater: The measure life is 18 years.[3]

Combo Condensing Boiler/Water Heater: 20 years.[4]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1b012 G21C2b012	Combo Condensing Furnace/Water Heater, Gas	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
G21C1b011 G21C2b011	Combo Condensing Boiler/Water Heater, Gas	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

Energy Load Shape:

See Appendix 1, C&I Load Shapes Table- "Heating and Cooling.

Endnotes:

1: Massachusetts TRM 2019 Plan-Year Report Version, 2020. Measure 3.30: HVAC Combo Furnace/Water Heater, Commercial Page 477.
2: The Cadmus Group, March 2015. High Efficiency Heating Equipment Impact Evaluation. Prepared for The Electric and Gas Program Administrators of Massachusetts, Part of the Residential Evaluation Program Area https://neep.org/sites/default/files/resources/High-Efficiency-Heating-Equipment-Impact-Evaluation-Final-Report.pdf
3: Environmental Protection Agency, 2009. Lifecycle Cost Estimate for Energy Star Furnace.
4: Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks, GDS Associates, April 2009. http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf

2.31 HVAC – Heating Systems - Boilers

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

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.

Baseline Efficiency:

Baseline efficiency is an 85% AFUE boiler.

High Efficiency:

High efficiency is per table of efficiency thresholds below.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results. [1]

BC Measure ID	Measure Name	Program	ΔMMBtu
G21C1b010 G21C2b010	<= 300 MBH (0.95 TE)	LBES New SBES New	17.7
G21C1b009 G21C2b009	<= 300 MBH (0.90 TE)	LBES New SBES New	14.7
G21C1b008 G21C2b008	301-499 MBH (0.90 TE)	LBES New SBES New	28.0
G21C1b007 G21C2b007	500-999 MBH (0.90 TE)	LBES New SBES New	51.4
G21C1b006 G21C2b006	1000-1700 MBH (0.90 TE)	LBES New SBES New	94.5
G21C1b005 G21C2b005	1701+ MBH (0.90 TE)	LBES New SBES New	165.3

Measure Life:

The measure life is 25 years. [2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1b010 G21C2b010	<= 300 MBH (0.95 TE)	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
G21C1b009 G21C2b009	<= 300 MBH (0.90 TE)	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
G21C1b008 G21C2b008	301-499 MBH (0.90 TE)	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
G21C1b007 G21C2b007	500-999 MBH (0.90 TE)	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
G21C1b006 G21C2b006	1000-1700 MBH (0.90 TE)	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
G21C1b005 G21C2b005	1701+ MBH (0.90 TE)	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

Energy Load Shape:

See Appendix 1 “C&I Heating & Cooling”.

Endnotes:

1: DNV GL, NMR, March 2017. Gas Boiler Market Characterization Study Phase II. Prepared for Massachusetts Program Administrators and Energy Efficiency Advisory Council. http://ma-eeac.org/wordpress/wp-content/uploads/Gas-Boiler-Market-Characterization-Study-Phase-II-Final-Report.pdf

2: ASHRAE Applications Handbook, 2003; Page 36.3.

2.32 HVAC – Heating Systems – Condensing Unit Heaters

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

Installation of a condensing gas-fired unit heater for space heating with capacity up to 300 MBH and minimum combustion efficiency of 90%.

Baseline Efficiency:

The baseline efficiency case is a 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. [1] As a note, the baseline efficiency referenced applies to 2016. Baseline requirements for 2017 and on have not been finalized.

High Efficiency:

The high efficiency case is a condensing gas unit heater with 90% AFUE or greater.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.[2]

BC Measure ID	Measure Name	Program	ΔMMBtu
G21C1b013 G21C2b013	Condensing Unit Heater (<= 300 MBH) – Gas	LBES New SBES New	40.9
E21C3b033	Condensing Unit Heater (<= 300 MBH) – Oil	MES New	40.9
E21C3b034	Condensing Unit Heater (<= 300 MBH) – Propane	MES New	40.9

Measure Life:

The measure life is 18 years. [3]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1b013 G21C2b013	Condensing Unit Heater – Gas	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3b033	Condensing Unit Heater – Oil	MES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3b034	Condensing Unit Heater – Propane	MES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

Energy Load Shape:

See Appendix 1 “C&I Heating & Cooling”.

Endnotes:

1: 2012 International Energy Conservation Code

2: NYSERDA Deemed Savings Database (Rev 11); Measure Name: A.UNIT-HEATER-COND.<300000.CI.).).N. The database provides savings of 204.6 MMBtu per million BTU/hr of heater input capacity. Assume average unit size of 200,000 BTU capacity.

3: Ecotrope, Inc., August 2003. Natural Gas Efficiency and Conservation Measure Resource Assessment for the Residential and Commercial Sectors. Prepared for the Energy Trust of Oregon. https://library.cee1.org/system/files/library/1366/544.pdf

2.33 HVAC – Heating Systems – Furnaces

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

The installation of a high efficiency natural gas warm air furnace with an electronically commutated motor (ECM) for the fan. High efficiency furnaces are better at converting fuel into direct heat and better insulated to reduce heat loss. ECM fan motors significantly reduce fan motor electric consumption as compared to both shaped-pole and permanent split capacitor motors.

Baseline Efficiency:

The baseline efficiency in an 85% AFUE furnace.

High Efficiency:

The high efficiency scenario assumes either a gas-fired furnace equal or higher than 95% AFUE or 97% AFUE.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results. [1]

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW	ΔMMBtu
G21C1b014 G21C2b014	Furnace, 95%	LBES New SBES New	168	0.124	5.7
G21C1b015 G21C2b015	Furnace, 97%	LBES New SBES New	168	0.124	6.7

Measure Life:

The measure life is 18 years. [2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[3]

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1b014 G21C2b014	Furnace, 95%	LBES New SBES New	1.000	1.000	1.000	n/a	n/a	0.000	0.160
G21C1b015 G21C2b015	Furnace, 97%	LBES New SBES New	1.000	1.000	1.000	n/a	n/a	0.000	0.160

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

A winter coincidence factor of 16% is utilized. Values pertain to other resource impacts for the EC motors.

Energy Load Shape:

See Appendix 1 "C&I Heating & Cooling".

Endnotes:

1: DNV-GL, 2015. Recalculation of Prescriptive Program Gas Furnace Savings Using New Baseline. Prepared for National Grid, Massachusetts.

2: ASHRAE Applications Handbook, 2003; Page 36.

3: Massachusetts TRM 2019 Plan-Year Report Version, 2020. Measure 3.42: HVAC Combo Furnace, Gas, Commercial Page 510

2.34 HVAC – Heating Systems – Infrared Heater

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

The installation of a gas-fired low intensity infrared heating system in place of unit heater, furnace, or other standard efficiency equipment. 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.

Baseline Efficiency:

The baseline efficiency case is a standard efficiency gas-fired unit heater with combustion efficiency of 80%.

High Efficiency:

The high efficiency case is a gas-fired low-intensity infrared heating unit.

Algorithms for Calculating Primary Energy Impact:

Unit savings are calculated as:

$$\Delta MMBtu = \frac{kBtu}{hr_{input}} \times \frac{EFLH_{heating}}{1000} \times \left(1 - \frac{HDD_{55}\,(55 - T_{design})}{HDD_{65}\,(55 - T_{design})}\right)$$

Where,

$\frac{kBtu}{hr_{input}}$ = Fuel input rating of the installed equipment

$EFLH_{heating}$ = Heating equivalent full-load hours

HDD_{55} = Heating degree days with 55-degree bases

HDD_{65} = Heating degree days with 65-degree base

T_{design} = Equipment design temperature

Alternatively, unit savings are deemed based on study results.[1]

BC Measure ID	Measure Name	Fuel Type	Program	ΔMMBtu
G21C1b016 G21C2b016	Infrared Heater	Gas	LBES New SBES New	12.0
E21C3b064	Infrared Heater	Propane	MES New	12.0

Measure Life:

The measure life is 17 years. [2]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1b016 G21C2b016	Infrared Heater	LBES New SBES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3b064	Infrared Heater	MES New	1.000	n/a	1.000	n/a	n/a	n/a	n/a

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Not applicable for this measure since no electric savings are claimed.

Energy Load Shape:

See Appendix 1 "C&I Heating & Cooling".

Endnotes:
1: KEMA, June 2013. Impact Evaluation of 2011 Prescriptive Gas Measures; Page 1-5. http://ma-eeac.org/wordpress/wp-content/uploads/Impact-Evaluation-of-2011-Prescription-Gas-Measures-6.27.13.pdf
2: Nexant, 2006. DSM Market Characterization Report. Prepared for Questar Gas.

2.35 HVAC – High Efficiency Chiller

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

This measure promotes the installation of efficient water-cooled and air-cooled water chilling packages for comfort cooling applications. Eligible chillers include air-cooled, water cooled rotary screw and scroll, and water-cooled centrifugal chillers for single chiller systems or for the lead chiller only in multi-chiller systems.

Baseline Efficiency:

The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in Chapter 13 of the aforementioned document, energy efficiency must be met via compliance with the International Energy Conservation Code (IECC) 2015.

The table below details the specific efficiency requirements by equipment type and capacity.

Chiller - Minimum Efficiency Requirements [1]:

	Size Category (Tons)	Units	Path A	Path A	Path B	Path B
			Full Load	IPLV	Full Load	IPLV
	Air-cooled chillers					
	< 150	EER	10.100	13.700	9.700	15.800
	≥ 150	EER	10.100	14.000	9.700	16.100
	Water cooled, electrically operated, positive displacement (rotary screw and scroll)					
	< 75	kW/ton	0.750	0.600	0.780	0.500
	≥ 75 and < 150	kW/ton	0.720	0.560	0.750	0.490
	≥ 150 and < 300	kW/ton	0.660	0.540	0.680	0.440
	≥ 300 and <600	kW/ton	0.610	0.520	0.625	0.410
	≥ 600	kW/ton	0.560	0.500	0.585	0.380
	Water cooled, electrically operated, centrifugal					
	< 150	kW/ton	0.610	0.550	0.695	0.440
	≥ 150 and < 300	kW/ton	0.610	0.550	0.635	0.400

	≥ 300 and < 400	kW/ton	0.560	0.520	0.595	0.390
	≥ 400 and <600	kW/ton	0.560	0.500	0.585	0.380
	≥ 600	kW/ton	0.560	0.500	0.585	0.380

For water cooled ≤300 tons positive displacement is the baseline. For > 300 tons Centrifugal is the baseline. 2 Path A is intended for applications where significant operating time is expected at full load. Path B is intended for applications where significant operating time is expected at part-load.

High Efficiency:

The high efficiency scenario assumes water chilling packages that exceed the efficiency levels required by Massachusetts State Building Code and meet the minimum efficiency requirements as stated in the New Construction HVAC energy efficiency rebate forms.

Algorithms for Calculating Primary Energy Impact:

Gross energy and demand savings for chiller installations may be custom calculated using the PA's Chillers savings calculation tool. These tools are used to calculated energy and demand savings based on site-specific chiller plant details including specific chiller plan equipment, operational staging, operating load profile and load profile.

Alternatively, the energy and demand savings may be calculated using the algorithms and inputs below. Please note that consistent efficiency types (FL or IPLV) must be used between the baseline and high efficiency cases. It is recommended that IPLV be used over FL efficiency types when possible.

Air-Cooled Chillers:
$kWh = Tons * (12/ EER_{BASE} - 12/ EER_{EE}) * Hours$
$kW = Tons * (12/ EER_{BASE} - 12/ EER_{EE})$

Water-Cooled Chillers:
$kWh = Tons * (kW/ ton_{BASE} - kW/ ton_{EE}) * Hours$
$kW = Tons * (kW/ ton_{BASE} - kW/ ton_{EE}) * (LF/100)$

Where:
Tons = Rated capacity of the cooling equipment
EER_{BASE} = Energy Efficiency Ratio of the baseline equipment. See table below for values.
EER_{EE} = Energy Efficiency Ratio of the efficient equipment. Site-specific.
kW/ton_{BASE} = Energy efficiency rating of the baseline equipment. See table below for values.
kW/ton_{EE} = Energy efficiency rating of the efficient equipment. Site-specific.
Hours = Equivalent full load hours for chiller operation

Measure Life:

The measure life is 23 years.[2]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b053	Chillers – IPLV used	LBES New	1.000	0.999	n/a	1.000	1.000	0.490	0.060
E21C2b053	Chillers – IPLV used	SBES New	1.000	1.000	n/a	1.000	1.000	0.490	0.060
E21C3b084	Chillers – IPLV used	Muni New	1.000	1.000	n/a	1.000	1.000	0.490	0.060
E21C1b052	Chillers – FL used	LBES New	1.000	0.999	n/a	1.000	1.000	0.860	0.100
E21C2b052	Chillers – FL used	SBES New	1.000	1.000	n/a	1.000	1.000	0.860	0.100
E21C3b083	Chillers – FL used	Muni New	1.000	1.000	n/a	1.000	1.000	0.860	0.100

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Coincidence factors are based on prospective statewide results from 2015 prescriptive chiller study. [3]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Electric Chiller (Combined)".

Endnotes:

1: Energy Solutions, 2018. Northeast Chillers Market Research.

2: Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. https://library.cee1.org/system/files/library/8842/CEE_Eval_MeasureLifeStudyLights%2526HVACGDS_1Jun2007.pdf

3: DNV GL, October 2015. Impact Evaluation of Prescriptive Chiller and Compressed Air Installations. Prepared for the MA PAs and EEAC. http://ma-eeac.org/wordpress/wp-content/uploads/MA30-Prescriptive-Chiller-and-CAIR-Report_FINAL_151026.pdf

2.36 HVAC – Hotel Occupancy Sensor

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

The measure is to the installation of hotel occupancy sensors (HOS) to control packaged terminal AC units (PTACs) with electric heat, heat pump units and/or fan coil units in hotels that operate all 12 months of the year.

Baseline Efficiency:

The baseline efficiency case assumes the equipment has no occupancy-based controls.

High Efficiency:

The high efficiency case is the installation of controls that include (a) occupancy sensors, (b) window/door switches for rooms that have operable window or patio doors, and (c) set back to 65°F in the heating mode and set forward to 78°F in the cooling mode when occupancy detector is in the unoccupied mode. Sensors controlled by a front desk system are not eligible.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on evaluation results[1].

BC Measure ID	Measure Name	Program	ΔkWh	ΔkW
E21C1a031 E21C1d031 E21C2a031 E21C2d031 E21C3a050 E21C3d050	Hotel Occupancy Sensor	LBES Retro LBES DI SBES Retro SBES DI Muni Retrofit Muni DI	438	0.090

Measure Life:

The measure life is 10 years.[2]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a031 E21C1d031	Hotel Occupancy Sensor	LBES Retro LBES DI	1.000	0.999	n/a	1.000	1.000	0.820	0.050
E21C2a031 E21C2d031	Hotel Occupancy Sensor	SBES Retro SBES DI	1.000	1.000	n/a	1.000	1.000	0.820	0.050
E21C3a050 E21C3d050	Hotel Occupancy Sensor	Muni Retro Muni DI	1.000	1.000	n/a	1.000	1.000	0.820	0.050

<u>In-Service Rates:</u>

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Coincidence factors are 82.0% for summer peak and 5.0% for winter peak.[3]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Heating and Cooling".

<u>Endnotes</u>:

1: MassSave, 2010. Energy Analysis: Hotel Guest Occupancy Sensors. Prepared for National Grid and Eversource (NSTAR).

2: Energy and Resource Solutions, November 2005. Measure Life Study. Prepared for MA Joint Utilities. HOS measure life assumed to be the same as that for occupancy-based lighting controls. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf

3: New Hampshire Common Assumptions.

2.37 HVAC – Pipe Wrap

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

Pipe Wrap – Heating: Install insulation on steam pipes located in non-conditioned spaces.
Pipe Wrap – Hot Water: Install insulation on hot water heating pipes located in unconditioned spaces.

Baseline Efficiency:

Pipe Wrap – Heating: The baseline efficiency case is un-insulated steam piping in unconditioned space.
Pipe Wrap – Hot Water: The baseline efficiency case is un-insulated hot water heating piping in unconditioned space.

High Efficiency:

Pipe Wrap – Heating: The high efficiency condition is steam piping in unconditioned space with insulation installed.
Pipe Wrap – Hot Water: The high efficiency condition is hot water heating piping in unconditioned space with insulation installed.

Algorithms for Calculating Primary Energy Impact:

Gas unit savings are deemed based on study results.[1, 2] kW savings for hot water pipes with electric are calculated using the demand impact model.

Savings for steam pipes with electric heating is calculated as:

$$\Delta kWh = \frac{\left(\left(\frac{UA}{L}\right)_{baseline} - \left(\frac{UA}{L}\right)_{ee}\right)}{E_t \times 3{,}412} \times L \times \Delta T_{amb} \times hrs$$

Where,
$\left(\frac{UA}{L}\right)_{baseline}$ = Overall baseline heat transfer coefficient per unit length. 0.97 for 1.5”, 1.19 for 2”, and 1.70 for 3” copper pipes. For steel pipes, 1.23 for 1.5”, 1.51 for 2”, and 2.16 for 3”.

$\left(\frac{UA}{L}\right)_{ee}$ = Overall energy efficient heat transfer coefficient per unit length: 0.12 for all pipe sizes assuming fiber glass insulation of thickness equal to pipe diameter. Use 0.46 for rigid foam/cellular glass insulation of thickness equal to pipe diameter.

L = Length of the pipe insulated.

ΔT_{amb} = 85 °F.[1]
hrs = Annual operating hours.
E_t = Thermal efficiency of electric heater. Default value of 0.98.

$$\Delta kW = \frac{\Delta kWh}{8760}$$

Unit savings for gas measures are deemed based on an average of unit savings for 1.5 inch pipes and 3 inch pipes. [1]

Measure ID	**Measure Name**	**Fuel Type**	**Program**	**ΔkWh**	**ΔkW**	**ΔMMBtu/ linera foot**
G21C1a013 G21C2a013	Pipe Wrap – Heating	Gas	LBES Retro – Gas SBES Retro – Gas	n/a	n/a	.29[1]
G21C1a008 G21C2a008	Pipe Wrap – Hot Water	Gas	LBES Retro – Gas SBES Retro – Gas	n/a	n/a	.29[1]
E21C3a068 E21C3d068	Pipe Wrap – Heating	Gas	Muni Retro Muni DI	n/a	n/a	Calculated
E21C3a072 E21C3d072	Pipe Wrap – Hot Water	Gas	Muni Retro Muni DI	n/a	n/a	Calculated
E21C3a069 E21C3d069	Pipe Wrap – Heating	Oil	Muni Retro Muni DI	n/a	n/a	Calculated
E21C3a073 E21C3d073	Pipe Wrap – Hot Water	Oil	Muni Retro Muni DI	n/a	n/a	Calculated
E21C3a070 E21C3d070	Pipe Wrap – Heating	Propane	Muni Retro Muni DI	n/a	n/a	Calculated
E21C3a074 E21C3d074	Pipe Wrap – Hot Water	Propane	Muni Retro Muni DI	n/a	n/a	Calculated
E21C1a038 E21C1d038 E21C2a038 E21C2d038 E21C3a067 E21C3d067	Pipe Wrap – Heating	Electric	LBES Retro LBES DI SBES Retro SBES DI Muni Retro Muni DI	Calculated	Calculated	n/a
E21C1a039 E21C1d039 E21C2a039 E21C2d039 E21C3a071 E21C3d071	Pipe Wrap – Hot Water	Electric	LBES Retro LBES DI SBES Retro SBES DI Muni Retro Muni DI	Calculated	Calculated	n/a

Measure Life:

The measure life is 15 years.[3]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:[4]

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
G21C1a013 G21C2a013 E21C3a068 E21C3d068	Pipe Wrap – Heating	Gas	LBES Retro – Gas SBES Retro – Gas Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
G21C1a008 G21C2a008 E21C3a072 E21C3d072	Pipe Wrap – Hot Water	Gas	LBES Retro – Gas SBES Retro – Gas Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a069 E21C3d069	Pipe Wrap – Heating	Oil	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a073 E21C3d073	Pipe Wrap – Hot Water	Oil	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a070 E21C3d070	Pipe Wrap – Heating	Propane	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a074 E21C3d074	Pipe Wrap – Hot Water	Propane	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C1a038 E21C1d038	Pipe Wrap – Heating	Electric	LBES Retro LBES DI	1.000	0.999	n/a	1.000	1.000	0.000	0.433
E21C2a038 E21C2d038 E21C3a067 E21C3d067	Pipe Wrap – Heating	Electric	SBES Retro SBES DI Muni Retro Muni DI	1.000	1.000	n/a	1.000	1.000	0.000	0.433
E21C1a039 E21C1d039	Pipe Wrap – Hot Water	Electric	LBES Retro LBES DI	1.000	0.999	n/a	1.000	1.000	0.312	0.808
E21C2a039 E21C2d039 E21C3a071 E21C3d071	Pipe Wrap – Hot Water	Electric	SBES Retro SBES DI Muni Retro Muni DI	1.000	1.000	n/a	1.000	1.000	0.312	0.808

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Large Business Energy Solution uses a 99.9% electric realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

A summer coincidence factor of 31.2% and a winter coincidence factor of 80.8% is utilized for insulation of hot water pipes with electric heating. For heating pipes with electric heating, a winter coincidence factor of 43.3% is utilized.[4]

Energy Load Shape:

For electric heating measures, see Appendix 1 C&I Load Shapes "Hardwired Electric Heat".
For electric hot water measures, see Appendix 1 C&I Load Shapes "Water Heater – Electric".
For non-electric measures, see Appendix 1 C&I Load Shapes "Non-electric Measures"

Endnotes:

1: National Grid Staff Calculation, 2010. Pipe insulation for SBS DI measures 2010 Excel Workbook. https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/5ee4885c6996f2d3357df744/view?authToken=962981283a7d38ac721edb179c5b7bf83c006a08da8c2f38866e381295963d8580eab751291c33061971c75a15dc0166f2c592d030d479cbaf9f7aa54c0ecbf2fc61aac2f00300
2: The Cadmus Group, July 2012. Massachusetts Multifamily Program Impact Analysis July 2012 – Revised May 2013. https://api-plus.anbetrack.com/etrm-gateway/etrm/api/v1/etrm/documents/5ee4885a6996f2cca27df73e/view?authToken=c3f41e9663355f5cba1ed024ab30ea4536bb2244f8e59bbbb2456444aad0600f2a7cd274d4a1ed7bdf33fa580f77ea7fb83e6341e0a43e7d5f9b52e5a311a397d19c852102c00d
3: Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks, GDS Associates, April 2009. http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf
4: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

2.38 HVAC – Thermostat – Wi-Fi Communicating

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	HVAC

Description:

A Wi-Fi enabled communicating thermostat which allows remote set point adjustment and control via remote application. System requires an outdoor air temperature algorithm in the control logic to operate heating and cooling system.

Baseline Efficiency:

The baseline efficiency case is an HVAC system with either a manual or a programmable thermostat.

High Efficiency:

The high efficiency case is an HVAC system that has a Wi-Fi thermostat installed.

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on residential study results, adjusted for commercial buildings.[1]

BC Measure ID	Measure Name	Fuel Type	Program	ΔkWh	ΔkW	ΔMMBtu
E21C1a026 E21C1d028 E21C2a026 E21C2d028 E21C3a039 E21C3d041	Wi-Fi Thermostat	Electric	LBES Retro LBES DI SBES Retro SBES DI Muni Retro Muni DI	160.90	0.256	n/a
E21C3a040 E21C3d042 G21C1a016 G21C2a016	Wi-Fi Thermostat	Gas	Muni Retro Muni DI LBES Retro – Gas SBES Retro – Gas	n/a	n/a	3.11
E21C3a041 E21C3d043	Wi-Fi Thermostat	Oil	Muni Retro Muni DI	n/a	n/a	3.11
E21C3a042 E21C3d044	Wi-Fi Thermostat	Propane	Muni Retro Muni DI	n/a	n/a	3.11

Measure Life:

The measure life is 15 years.[2]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel Type	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a026 E21C1d028	Wi-Fi Thermostat	Electric	LBES Retro LBES DI	1.000	0.999	n/a	1.000	1.000	0.346	0.000
E21C2a026 E21C2d028 E21C3a039 E21C3d041	Wi-Fi Thermostat	Electric	SBES Retro SBES DI Muni Retro Muni DI	1.000	1.000	n/a	1.000	1.000	0.346	0.000
E21C3a040 E21C3d042 G21C1a016 G21C2a016	Wi-Fi Thermostat	Gas	Muni Retro Muni DI LBES Retro – Gas SBES Retro – Gas	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a041 E21C3d043	Wi-Fi Thermostat	Oil	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a
E21C3a042 E21C3d044	Wi-Fi Thermostat	Propane	Muni Retro Muni DI	1.000	n/a	1.000	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

Large Business Energy Solution uses a 99.9% electric realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

Summer and winter Coincidence Factors are estimated using demand allocation methodology described the Demand Impact Model.[3]

Energy Load Shape:

See Appendix 1 “Weighted HVAC- All Homes”

<u>Endnotes</u>:

1: Navigant Consulting, September 2018. Wi-Fi Thermostat Impact Evaluation--Secondary Research Study Memo. https://ma-eeac.org/wp-content/uploads/Wi-Fi-Thermostat-Impact-Evaluation-Secondary-Literature-Study_FINAL.pdf

The residential savings values for Wi-Fi communicating thermostats recommended in the 2018 Secondary Research Study memo are applied to the commercial measures in this chapter as it has not been possible to document savings from commercial Wi-Fi communicating measures. The residential values are not scaled up as the savings from the commercial measures are expected to be very low.

2: Assumed to have the same lifetime as a regular programmable thermostat. Environmental Protection Agency, 2010. Life Cycle Cost Estimate for ENERGY STAR Programmable Thermostat.
3: Navigant Consulting, 2018. RES1 Demand Impact Model Update. http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

2.39 HVAC – Unitary Air Conditioner

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

This measure promotes the installation of high efficiency unitary air conditioning equipment in lost opportunity applications. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure applies to air, water, and evaporatively-cooled unitary AC systems, both single-package and split systems.

Baseline Efficiency:

The baseline efficiency case for new installations assumes compliance with the efficiency requirements as mandated by New Hampshire State Building Code.

High Efficiency:

The high efficiency case assumes the HVAC equipment meets or exceeds the Consortium for Energy Efficiency's (CEE) specification. This specification results in cost-effective energy savings by specifying higher efficiency HVAC equipment while ensuring that several manufacturers produce compliant equipment. The CEE specification is reviewed and updated annually to reflect changes to the ASHRAE and IECC energy code baseline as well as improvements in the HVAC equipment technology. Equipment efficiency is the rated efficiency of the installed equipment for each project.

Algorithms for Calculating Primary Energy Impact:

For units with cooling capacities less than 65 kBtu/h:
$\Delta kWh = (kBtu/h)\ (1/\ SEER_{BASE} - 1/\ SEER_{EE})\ (EFLH_{Cool})$
$\Delta kW = (kBtu/h)\ (1/\ EER_{BASE} - 1/\ EER_{EE})$

For units with cooling capacities equal to or greater than 65 kBtu/h and EER available:
$\Delta kWh = (kBtu/h)\ (1/\ EER_{BASE} - 1/\ EER_{EE})\ (EFLH_{Cool})$
$\Delta kW = (kBtu/h)\ (1/\ EER_{BASE} - 1/\ EER_{EE})$

For units with cooling capacities equal to or greater than 65 kBtu/h and IEER available:
$\Delta kWh = (kBtu/h)\ (1/\ IEER_{BASE} - 1/\ IEER_{EE})\ (HoursCool)$ $\Delta kWh = (kBtu/h)\ (1/\ IEER_{BASE} - 1/\ IEER_{EE})$

Where:
ΔkWh = Gross annual kWh savings from the measure
ΔkW = Gross connected kW savings from the measure
kBtu/h = Capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).
$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of the baseline equipment

$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of the energy efficient equipment
$EFLH_{Cool}$ = Cooling equivalent full load hours
EER_{BASE} = Energy Efficiency Ratio of the baseline equipment
EER_{EE} = Energy Efficiency Ratio of the energy efficient equipment
$IEER_{BASE}$ = Integrated Energy Efficiency Ratio of the baseline equipment
$IEER_{EE}$ = Integrated Energy Efficiency Ratio of the energy efficient equipment
HoursCool = Annual Cooling Hours

The baseline efficiency values are based on the IECC 2015.[1]

Size (Btu/h)	Units with Electric Resistance of No Heating	Units with Heating Section Other Than Electric Resistance
< 65,000	13.0 SEER (Split System) 14.0 SEER (Single Package)	13.0 SEER (Split System) 14.0 SEER (Single Package)
≥65,000 and <135,000	11.2 EER 12.8 IEER	11.0 EER 12.6 IEER
≥135,000 and <240,000	11.0 EER 12.4 IEER	10.8 EER 12.2 IEER
≥240,000 and <760,000	10.0 EER 11.6 IEER	9.8 EER 11.4 IEER
≥760,000	9.7 EER 11.2 IEER	9.5 EER 11.0 IEER

Measure Life:

The measure life is 12 years. [1]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b049	Unitary Air Conditioner	LBES New	1.000	0.999	n/a	1.000	1.000	0.342	0.000
E21C2b049	Unitary Air Conditioner	SBES New	1.000	1.000	n/a	1.000	1.000	0.342	0.000
E21C3b080	Unitary Air Conditioner	Muni New	1.000	1.000	n/a	1.000	1.000	0.342	0.000
E21C1c007	Midstream Unitary Air Conditioners	LBES Midstream	1.000	1.000	n/a	1.000	1.000	0.342	0.000
E21C2c007	Midstream Unitary Air Conditioners	SBES Midstream	1.000	1.000	n/a	1.000	1.000	0.342	0.000

In-Service Rates:

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

A summer coincidence factor of 34.2% is utilized.[2]

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Electric Cooling Unitary Equipment".

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):[3]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	2021 NTG
E21C1c007 E21C2c007	Midstream Unitary Air Conditioners	LBES Midstream SBES Midstream	0.225	0.085	0.000	0.86

Endnotes:
1: 2015 IECC (CT Code) Table C403.2.3(1).
2: KEMA, August 2011. C&I Unitary HVAC Loadshape Project Table 0-5 (ISO_NE on Peak for NE-North)
https://neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf
3: NMR, DNV GL, and Tetra Tech, August 2018. Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study. Prepared for Massachusetts Program Administrators.
http://ma-eeac.org/wordpress/wp-content/uploads/TXC_49_CI-FR-SO-Report_14Aug2018.pdf

2.40 HVAC – Heat Pump Systems

Measure Code	[Code]
Market	Commercial
Program Type	Retrofit/Lost Opportunity
Category	HVAC

Description:

This measure includes the installation of ductless mini split, ground source and water source heat pumps to serve the space heating and space cooling loads in a C&I facility. “Water source” refers to systems that use ground or lake water rather than a boiler as a loop heat source. The savings for this measure are realized through the increased nameplate efficiency between the baseline and installed equipment.

Baseline Efficiency:

For lost opportunity, the baseline is a code compliant heat pump unit of the same type as the high efficiency unit. Details regarding heat pump baseline efficiencies based on capacity and type are provided in a tabular format along with the savings algorithms.

For early retirement (retrofit), it is assumed that the new unit replaces the pre-existing heat pump unit, which is not at the end of its useful life. In this case, the baseline is the pre-existing, inefficient heat pump unit.

High Efficiency:

The high efficiency (or energy efficient) case is the site-specific heat pump unit. The energy efficient heat pump unit is assumed to be of the same type as the baseline unit.

Algorithms for Calculating Primary Energy Impact:

The savings for this measure are attributable to the increase in nameplate efficiency between the baseline and installed units.
The algorithm for calculating electric demand savings is:

$$\Delta kW = \Delta kW_{cool} + \Delta kW_{heat}$$

$$\Delta kW_{cool} = Cap_{cool} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

$$\Delta kW_{heat} = Cap_{heat} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right)$$

$Cap_{heat} = Cap_{cool} \times 1.0$ if unit is a cold climate ductless mini split heat pump

$Cap_{heat} = Cap_{cool} \times 0.9$ for all other ductless mini split heat pump

$$Cap_{heat} = Cap_{cool} \times \left(\frac{HSPF_{EE}}{EER_{EE}}\right)$$ for water source and ground source heat pumps

The algorithm for calculating annual electric energy savings is:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

For ductless mini split heat pumps

$$\Delta kWh_{cool} = Cap_{cool} \times \left(\frac{1}{SEER_{BASE}} - \frac{1}{SEER_{EE}}\right) \times EFLH_{cool}$$

$$\Delta kWh_{heat} = Cap_{heat} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right) \times EFLH_{heat}$$

For water source and ground source heat pumps

$$\Delta kWh_{cool} = Cap_{cool} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right) \times EFLH_{cool}$$

$$\Delta kWh_{heat} = Cap_{heat} \times \left(\frac{1}{HSPF_{BASE}} - \frac{1}{HSPF_{EE}}\right) \times EFLH_{heat}$$

Where:

ΔkW = Gross annual demand savings for heat pump unit

ΔkW_{cool} = Gross annual cooling demand savings for heat pump unit

ΔkW_{heat} = Gross annual heating demand savings for heat pump unit. For non cold-climate ductless mini-split heat pump OR for facilities that employ supplemental heating sources (such as fossil fuel or electric resistance heat), ΔkW_{heat} = 0

Cap_{cool} = Cooling capacity (in kBtu/h) of the energy efficient heat pump unit, from equipment specifications

Cap_{heat} = Heating capacity (in kBtu/h) of the energy efficient pump unit, from equipment specifications. Use given equations to convert from cooling capacity value if standard equipment literature does not provide this value

EER_{BASE} = Energy Efficiency Ratio of the baseline heat pump equipment

EER_{EE} = Energy Efficiency Ratio of the energy efficient heat pump unit, from equipment specifications

$HSPF_{BASE}$ = Heating Seasonal Performance Factor of baseline heat pump equipment

$HSPF_{EE}$ = Heating Seasonal Performance Factor of energy efficient heat pump unit, from equipment specifications

ΔkWh_{cool} = Gross annual cooling savings for heat pump unitΔkWh_{heat} = Gross annual heating savings for heat pump unit

$SEER_{BASE}$ = Seasonal Energy Efficiency Ratio of baseline heat pump equipment
$SEER_{EE}$ = Seasonal Energy Efficiency Ratio of energy efficient heat pump unit, from equipment specifications
$EFLH_{cool}$ = Equivalent Full Load Hours for cooling
$EFLH_{heat}$ = Equivalent Full Load Hours for heating
0.9 = Conversion factor[1] to convert cooling capacity to heating capacity for ductless mini split heat pump units not on NEEP's cold climate air source heat pump (ccASHP) product list. The conversion factor for ccASHPs is 1.0.

Heat Pump Type	Cooling Capacity Range	Parameter	Value (Lost Opportunity)	Value (Retrofit)	Units
Ductless Mini Split	≤65,000 Btu/h	EER_{BASE}	12.73[2]	Pre-existing equipment EER	Btu/W-h
		$SEER_{BASE}$	14.00[3]	Pre-existing equipment SEER	Btu/W-h
		$HSPF_{BASE}$	8.20[3]	Pre-existing equipment HSPF	Btu/W-h
Water Source	<17,000 Btu/h	EER_{BASE}	12.20[3]	Pre-existing equipment EER	Btu/W-h
		$HSPF_{BASE}$	14.67[3]	Pre-existing equipment HSPF	Btu/W-h
	≥17,000 Btu/h	EER_{BASE}	13.00[3]	Pre-existing equipment EER	Btu/W-h
		$HSPF_{BASE}$	14.67[3]	Pre-existing equipment HSPF	Btu/W-h
Ground Source (Open Loop)	All Sizes	EER_{BASE}	18.00[3]	Pre-existing equipment EER	Btu/W-h
		$HSPF_{BASE}$	12.62[3]	Pre-existing equipment HSPF	Btu/W-h
Ground Source (Closed Loop)	All Sizes	EER_{BASE}	14.1[3]	Pre-existing equipment EER	Btu/W-h
		$HSPF_{BASE}$	10.91[3]	Pre-existing equipment HSPF	Btu/W-h
All		$HSPF_{BASE}$	3.142 For when baseline/pre-existing system is electric resistance heat		Btu/W-h
All		$EFLH_{cool}$	755[4]		hours
		$EFLH_{heat}$	1329[4]		hours

Measure Life:

The measure life is listed below by measure. Due to limitations with the avoided cost calculations in the Benefit/Cost Models, where measure lives are greater than 25 years, the models use a 25-year measure life.

BC Measure ID	Measure Name	Program	Measure Life
E21C1a022	Ductless Mini Split Heat Pump	LBES Retrofit	12[5]
E21C1d024	Ductless Mini Split Heat Pump	LBES DI	12[5]
E21C2a022	Ductless Mini Split Heat Pump	SBES Retrofit	12[5]
E21C2d024	Ductless Mini Split Heat Pump	SBES DI	12[5]
E21C3a035	Ductless Mini Split Heat Pump	Muni Retrofit	12[5]
E21C3d037	Ductless Mini Split Heat Pump	Muni DI	12[5]
E21C1b050	Water Source Heat Pump	LBES New	26[6]
E21C2b050	Water Source Heat Pump	SBES New	26[6]
E21C3b081	Water Source Heat Pump	Muni New	26[6]
E21C1b035	Ground Source Heat Pump	LBES New	26[6]
E21C2b035	Ground Source Heat Pump	SBES New	26[6]
E21C3b056	Ground Source Heat Pump	Muni New	26[6]
E21C1c003	Midstream DMSHP Systems	LBES Midstream	12[5]
E21C2c003	Midstream DMSHP Systems	SBES Midstream	12[5]
E21C1c006	Midstream Heat Pump Systems	LBES Midstream	12[5]
E21C2c006	Midstream Heat Pump Systems	SBES Midstream	12[5]
E21C1c009	Midstream Water Source Heat Pump Systems	LBES Midstream	26[6]
E21C2c009	Midstream Water Source Heat Pump Systems	SBES Midstream	26[6]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a022	Ductless Mini Split Heat Pump	LBES Retrofit	1.000	0.999	1.000	1.000	1.000	0.342	0.000

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1d024	Ductless Mini Split Heat Pump	LBES DI	1.000	0.999	1.000	1.000	1.000	0.342	0.000
E21C2a022	Ductless Mini Split Heat Pump	SBES Retrofit	1.000	1.000	1.000	1.000	1.000	0.342	0.000
E21C2d024	Ductless Mini Split Heat Pump	SBES DI	1.000	1.000	1.000	1.000	1.000	0.342	0.000
E21C3a035	Ductless Mini Split Heat Pump	Muni Retrofit	1.000	1.000	1.000	1.000	1.000	0.342	0.000
E21C3d037	Ductless Mini Split Heat Pump	Muni DI	1.000	1.000	1.000	1.000	1.000	0.342	0.000
E21C1b050	Water Source Heat Pump	LBES New	1.000	0.999	1.000	1.000	1.000	0.342	0.342
E21C2b050	Water Source Heat Pump	SBES New	1.000	1.000	1.000	1.000	1.000	0.342	0.342
E21C3b081	Water Source Heat Pump	Muni New	1.000	1.000	1.000	1.000	1.000	0.342	0.342
E21C1b035	Ground Source Heat Pump	LBES New	1.000	0.999	1.000	1.000	1.000	0.342	0.342
E21C2b035	Ground Source Heat Pump	SBES New	1.000	1.000	1.000	1.000	1.000	0.342	0.342
E21C3b056	Ground Source Heat Pump	Muni New	1.000	1.000	1.000	1.000	1.000	0.342	0.342
E21C1c003	Midstream DMSHP Systems	LBES Midstream	1.000	1.000	1.000	1.000	1.000	0.342	0.000
E21C2c003	Midstream DMSHP Systems	SBES Midstream	1.000	1.000	1.000	1.000	1.000	0.342	0.000
E21C1c006	Midstream Heat Pump Systems	LBES Midstream	1.000	1.000	1.000	1.000	1.000	0.342	0.000
E21C2c006	Midstream Heat Pump Systems	SBES Midstream	1.000	1.000	1.000	1.000	1.000	0.342	0.000
E21C1c009	Midstream Water Source Heat Pump Systems	LBES Midstream	1.000	1.000	1.000	1.000	1.000	0.342	0.342
E21C2c009	Midstream Water Source Heat Pump Systems	SBES Midstream	1.000	1.000	1.000	1.000	1.000	0.342	0.342

In-Service Rates:

All installations have 100.0% in-service-rates since programs include verification of equipment installations.

Realization Rates[7]:

All programs use 100.0% realization rate except for LBES (Retrofit, Direct Install, and NEC), which use a value of 99.9%.

Coincidence Factors[8]:

For ductless mini split heat pumps, summer coincidence factor is 34.2% and a winter coincidence factor is 0%.
For cold-climate ductless mini split heat pumps, is 34.2% and a winter coincidence factor is 34.2%.
For water source heat pumps and ground source heat pumps, summer & winter coincidence factor is 34.2%.

Energy Load Shape:

For ductless mini split heat pumps, see Appendix 1 – "DMSHP"
For water source and ground source heat pumps, see Appendix 1 – "Central Heat Pump"

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):[9]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	2021 NTG
E21C1c003 E21C2c003	Midstream DMSHP Systems	LBES Midstream SBES Midstream	0.225	0.085	0.000	0.860
E21C1c006 E21C2c006	Midstream Heat Pump Systems	LBES Midstream SBES Midstream	0.225	0.085	0.000	0.860
E21C1c009 E21C2c009	Midstream Water Source Heat Pump Systems	LBES Midstream SBES Midstream	0.225	0.085	0.000	0.860

Endnotes:
1: Conversion factor is based on internal ERS analysis of Mass Save and NEEP ccASHP product data.
2: Since IECC 2015 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.
3: International Energy Conservation Code 2015, table C403.2.3(2) Minimum Efficiency Requirements: Electrically Operated Unitary and Applied Heat Pumps
4: KEMA((2011). C&I Unitary AC Loadshape Project - Final Report. KEMA_2011_CI Unitary HVAC Load Shape Project
5: DNV GL (2018). Expected Useful Life (EUL) Estimation for Air-Conditioning Equipment from Current Age Distribution Memo. https://ma-eeac.org/wp-content/uploads/Final-memo-on-P73-Track-D-EUL-estimation-results-to-date-v2.pdf

6:http://weblegacy.ashrae.org/publicdatabase/system_service_life.asp?c_region=2&state=NA&building_function=NA&c_size=0&c_age=0&c_height=0&c_class=0&c_location=0&selected_system_type=1&c_equipment_type=NA. . See mean age of replaced water-to-air, geothermal heat pumps
7: New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Impact Evaluation report. Table 3
8. Coincidence Factors are from 2011 NEEP HVAC Loadshape Study Table 0-5 (ISO_NE on Peak for NE-North)
9: NMR, DNV GL, and Tetra Tech, August 2018. Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study. Prepared for Massachusetts Program Administrators. http://ma-eeac.org/wordpress/wp-content/uploads/TXC_49_CI-FR-SO-Report_14Aug2018.pdf

2.41 HVAC – VRF Systems

Measure Code	[Code]
Market	Commercial
Program Type	Lost Opportunity
Category	HVAC

Description:

This measure includes in the installation of high-efficiency variable flow refrigerant (VRF) heat pumps.

Baseline Efficiency:

The baseline is a code compliant VRF heat pump unit. Details regarding heat pump baseline efficiencies based on capacity and type are provided in a tabular format along with the savings algorithms.

High Efficiency:

The high efficiency case is the site-specific VRF heat pump unit.

Algorithms for Calculating Primary Energy Impact:

The savings for this measure are attributable to the increase in nameplate efficiency between the baseline and installed units.

The algorithm for calculating electric demand savings is: :

$$\Delta kW = Cap_{cool} \times \left(\frac{1}{EER_{BASE}} - \frac{1}{EER_{EE}}\right)$$

Where:
ΔkW = Gross annual demand savings for VRF unit
Cap_{cool} = Cooling capacity (in kBtu/h) of the energy efficient VRF unit, from equipment specifications
EER_{BASE} = Energy Efficiency Ratio of the baseline VRF equipment
EER_{EE} = Energy Efficiency Ratio of the energy efficient VRF unit, from equipment specifications

The algorithm for calculating annual electric energy savings is:

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

$$\Delta kWh_{cool} = Cap_{cool} \times \left(\frac{1}{IEER_{BASE}} - \frac{1}{IEER_{EE}}\right) \times EFLH_{cool}$$

$$\Delta kWh_{heat} = \frac{Cap_{heat}}{3.412} \times \left(\frac{1}{COP_{BASE}} - \frac{1}{COP_{EE}}\right) \times EFLH_{heat}$$

Where:

ΔkWh_{cool} = Gross annual cooling savings for VRF unit
ΔkWh_{heat} = Gross annual heating savings for VRF unit
Cap_{cool} = Cooling capacity (in kBtu/h) of the energy efficient VRF unit, from equipment specifications
Cap_{heat} = Heating capacity (in kBtu/h) of the energy efficient VRF unit, from equipment specifications.
$IEER_{BASE}$ = Integrated Energy Efficiency Ratio of baseline VRF equipment
$IEER_{EE}$ = Integrated Energy Efficiency Ratio of energy efficient VRF unit
COP_{BASE} = Coefficient of performance in heating mode of baseline VRF equipment
COP_{EE} = Coefficient of performance in heating mode of energy efficient VRF unit

VRF System Type	Parameter	Value[1]
Air Cooled	EER_{BASE}	11
	$IEER_{BASE}$	12.9
	COP_{BASE}	3.3
Water Cooled	EER_{BASE}	12
	$IEER_{BASE}$	16.0
	COP_{BASE}	4.2

Measure Life:

The measure life is 12 years.[2]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1c008 E21C2c008	Midstream VRF	LBES Midstream SBES Midstream	1.000	1.000	n/a	1.000	1.000	0.342	0.000

<u>In-Service Rates:</u>

All installations have a 100.0% in-service rate unless an evaluation finds otherwise.

Realization Rates:

All installations have a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

The summer coincidence factor is 34.2% and the winter coincidence factor is 0%.[3]

Energy Load Shape:

See Appendix 1 – "Central Heat Pump".

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):[4]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	2021 NTG
E21C1c008 E21C2c008	Midstream VRF	LBES Midstream SBES Midstream	0.225	0.085	0.000	0.860

Endnotes:
1: ANSI/ASHRAE/IES Standard 90.1-2013. Table 6.8.1-10
2: Energy & Resource Solutions, November. Measure Life Study. Prepared for The Massachusetts Joint Utilities. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf
3. Coincidence Factors are from 2011 NEEP HVAC Loadshape Study Table 0-5 (ISO_NE on Peak for NE-North)
4: NMR, DNV GL, and Tetra Tech, August 2018. Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study. Prepared for Massachusetts Program Administrators. http://ma-eeac.org/wordpress/wp-content/uploads/TXC_49_CI-FR-SO-Report_14Aug2018.pdf

2.42 Refrigeration – Cooler Night Cover

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Description:

Installation of retractable aluminium woven fabric covers for open type refrigerated display cases, where the covers are deployed during the facility unoccupied hours in order to reduce refrigeration energy consumption.

Baseline Efficiency:

The baseline efficiency case is the annual operation of open-display cooler cases.

High Efficiency:

The high efficiency case is the use of night covers to protect the exposed area of display cooler cases during unoccupied hours.

Algorithms for Calculating Primary Energy Impact:

ΔkWh = (Width) x (Save) x (Hours)
Δ kW = (Width) x (Save)

Where:
Δ kWh = Energy Savings
Δ kW = Connected load reduction
Width = Width of the opening that the night covers protect (ft)
Save = Savings factor based on the temperature of the case (kW/ft). See table below [1]
Hours = Annual hours that the night covers are in use

Cooler Case Temperature	Savings Factor
Low Temperature (-35 F to -5 F)	0.03 kW/ft
Medium Temperature (0 F to 30 F)	0.02 kW/ft
High Temperature (35 F to 55 F)	0.01 kW/ft

Measure Life:

The measure life for refrigeration add-on measures are 10 years. [2]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a017 E21C1d019	Cooler Night Covers	LBES Retro LBES DI	1.000	0.999	n/a	1.000	1.000	0.000	0.000
E21C2a017 E21C2d019	Cooler Night Covers	SBES Retro SBES DI	1.000	1.000	n/a	1.000	1.000	0.000	0.000
E21C3a023 E21C3d025	Cooler Night Covers	Muni Retro Muni DI	1.000	1.000	n/a	1.000	1.000	0.000	0.000

In-Service Rates:

All installations have 100% in-service rate since all programs require verification of equipment installation.

Realization Rates:

Large Business Energy Solution uses a 99.9% realization rate. All other programs use a 100.0% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Coincidence factors are 0.0% since night cover usage occurs outside of peak demand hours.

Energy Load Shape:

See Appendix 1 C&I Load Shapes– "C&I Refrigeration".

Endnotes:

1: CL&P Program Savings Documentation for 2011 Program Year, 2010. Factors based on Southern California Edison (1997). Effects of the Low Emissive Shields on Performance and Power Use of a Refrigerated Display Case. https://www.econofrost.com/wp-content/uploads/2016/03/Ashrae.pdf

2: Energy & Resource Solutions, November 2005. Measure Life Study. Prepared for The Massachusetts Joint Utilities; Page 4-5 to 4-6. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf

2.43 Lighting – Controls

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit/Lost Opportunity
Category	Lighting

Description:

This measure includes the installation of lighting controls in both lost-opportunity and retrofit applications. Occupancy sensors and daylight dimming controls are both included. Traffic-sensing occupancy sensors that control refrigerated case LEDs are also included as a separate section.

Baseline Efficiency:

The baseline efficiency case for retrofit applications is no controls.

The baseline efficiency case for new construction is code-compliant controls as mandated by the New Hampshire Building Code, which currently reflects IECC 2015 and ASHRAE Standard 90.1-2013.

The baseline efficiency case for refrigerated case LEDs is no controls.

High Efficiency:

The high efficiency case for retrofit applications is lighting fixtures connected to controls that reduce the pre-retrofit hours of operation.

The high efficiency case for new construction applications is lighting fixture controls that reduce the hours of operation further beyond code-compliant controls.

The high efficiency case for refrigerated case LEDs is traffic-sensing controls that are mounted on cases to dim case lighting from a high level to a low-power mode (assumed to be 25% of full power consumption) in less than 2 minutes when on traffic is sensed in the aisle.

Algorithms for Calculating Primary Energy Impact:

<u>For retrofit applications:</u>
ΔkWh = Controlled_kW × Hours_base × (%_sav)
ΔkW = (Controlled_kW)

Where:
Controlled_kW = controlled fixture wattage
Hours_base = total annual hours that the connected kW operated in the pre-retrofit case
%_sav = percentage of kWh that is saved by utilizing this control measure, as shown in the study-informed deemed savings table below.[1]

Control Type	% Savings Factor
Lighting Controls – Daylighting Dimming	0.28
Lighting Controls – Occupancy Sensor	0.24
Lighting Controls - Integral Dual Sensor	0.30
Lighting Controls - Integral Dual Sensors with Adaptive, Network-Capable Controls	0.35
Lighting Controls - Exterior Photocell	0.50

For lost opportunity applications:
ΔkWh = Controlled_kW × (Hours_base – Hours_ee)
ΔkW = (Controlled_kW)

Where:
Controlled_kW = controlled fixture wattage
Hours_base = total annual hours that the connected Watts would have operated with code-compliant controls
Hours_ee = total annual hours that the connected kW operate with controls implemented, as determined on a per-application basis.

For refrigerated case LED controls:
ΔkWh = ΔkWh_lights + ΔkWh_refg
ΔkWh_lights = ΔkW_lights × Hours
ΔkW_lights = kW_hi – (0.85 × kW_hi + 0.15 × kW_lo)
ΔkWh_refg = ΔkWh_lights × 0.28 × Eff_RS

Where:
ΔkWh_lights = the lighting equipment contribution to savings
ΔkWh_refg = refrigeration interactive effects
kW_hi = the high-level lighting power per case, with deemed values shown in the table below
kW_lo = the low-level lighting power per case, with deemed values shown in the table below
Hours = the number of operating hours at the site, from application or deemed value shown in table below
0.85 = deemed fraction of time at high power[3]
0.15 = deemed fraction of time at low power[3]
0.28 = unit conversion between kW and tons of refrigeration
Eff_RS = efficiency of typical refrigeration system, with deemed values shown in the table below

Input	System type	Deemed Value	Unit	Source
kW_hi	5’ case side mounted	13	W	4
	5’ case center mounted	26	W	
	6’ case side mounted	16	W	
	6’ case center mounted	32	W	
kW_lo	5’ case side mounted	8.5	W	4
	5’ case center mounted	17	W	
	6’ case side mounted	11	W	
	6’ case center mounted	21	W	

Hours, if not available from site	All	4,910	Hr/yr	4
Eff_RS	Small business	1.6	kW/ton	5
	Large business	1.9	kW/ton	

Measure Life:

The table below provides measure life for control measures.[2,3]

BC Measure ID	Measure Name	Program	Measure Life
E21C1a009 E21C1d011 E21C2a009 E21C2d011 E21C3a009 E21C3d011	Daylight Dimming	LBES Retrofit, LBES DI, SBES Retrofit, SBES DI, MES Retrofit, MES DI	9
E21C1b009 E21C2b009 E21C3b009	Daylight Dimming	LBES New, SBES New, MES New	10
E21C1a014 E21C1d016 E21C2a014 E21C2d016 E21C3a014 E21C3d016	Lighting Occupancy Sensors	LBES Retrofit, LBES DI, SBES Retrofit, SBES DI, MES Retrofit, MES DI	10
E21C1b014 E21C2b014 E21C3b014	Lighting Occupancy Sensors	LBES New, SBES New, MES New	10

Other Resource Impacts:

Heating penalties for large C&I occupancy sensors are from a 12-month MA data logging study.[4] Penalties for small business and municipal programs are from the 2018 MA small business lighting impact evaluation.[6]

BC Measure ID	Measure Name	Program	MMBtu/kWh
E21C1a009 E21C1b009 E21C1d011	Daylight Dimming	LBES	-0.002728
E21C2a009 E21C2b009 E21C2d011 E21C3a009 E21C3b009 E21C3d011	Daylight Dimming	SBES, MES	-0.004080
E21C1a014 E21C1b014 E21C1d016	Lighting Occupancy Sensors	LBES	-0.002728
E21C2a014 E21C2b014 E21C2d016 E21C3a014 E21C3b014 E21C3d016	Lighting Occupancy Sensors	SBES, MES	-0.004080

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a009 E21C1b009 E21C1d011	Daylight Dimming	LBES	1.000	0.999	1.000	1.000	1.000	0.138	0.134
E21C1a014 E21C1b014 E21C1d016	Lighting Occupancy Sensors	LBES	1.000	0.999	1.000	1.000	1.000	0.138	0.134
E21C2a009 E21C2b009 E21C2d011 E21C3a009 E21C3b009 E21C3d011	Daylight Dimming	SBES, MES	1.000	1.000	1.000	1.000	1.000	0.170	0.130
E21C2a014 E21C2b014 E21C2d016 E21C3a014 E21C3b014 E21C3d016	Lighting Occupancy Sensors	SBES, MES	1.000	1.000	1.000	1.000	1.000	0.180	0.130

<u>In-Service Rates:</u>

All installations have a 100% in-service-rate unless an evaluation finds otherwise.

Realization Rates:

Realization rates are 100% until evaluated. NH evaluations that have sampled a non-statistically significant number of lighting controls projects produced realization rates slightly greater than 100%, including for Large Business custom electric sites and Small Business and Municipal lighting projects, some of which included controls.[8, 9]
For refrigerated case lighting controls, realization rates are defaulted to 100% as the cited research for savings calculations is a study, and not an evaluation.[3]

Coincidence Factors:

Summer and winter coincidence factors for small business and municipal programs are based on a MA study of lighting occupancy sensors in small businesses.[5] For large businesses, coincidence factors are based on a MA impact evaluation of the large C&I prescriptive lighting program.[4]

Impact Factors for Calculating Net Savings[10]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1a009 E21C1b009 E21C1d011 E21C2a009 E21C2b009 E21C2d011 E21C3a009 E21C3b009 E21C3d011	Daylight Dimming	LBES, SBES, MES	11%	5%	0%	94%
E21C1a014 E21C1b014 E21C1d016 E21C2a014 E21C2b014 E21C2d016 E21C3a014 E21C3b014 E21C3d016	Lighting Occupancy Sensors	LBES, SBES, MES	11%	5%	0%	94%

Energy Load Shape:

Energy load shapes are based on site-level metering of project sites in MA.[7]

Measure Name	Summer On-peak	Winter On-peak	Summer Off-peak	Winter Off-peak
Interior Lighting	34.3%	30.3%	18.1%	17.4%
Exterior Lighting	19.2%	20.1%	29.0%	31.6%

Endnotes:

1: DNV KEMA, October 27, 2014. Retrofit Lighting Controls Measures Summary of Findings. Final Report. (MA). https://ma-eeac.org/wp-content/uploads/Lighting-Retrofit-Control-Measures-Final-Report.pdf (NOTE: Report applies to daylight dimming and occupancy sensors. Dual sensor control savings factors are engineering calculated. Exterior controls factor only apply to On/Off photocells for lighting systems that operate on 24 hours per day, 7 days per week. Exterior controls with bi-level occupancy, dimming functions, or any other advanced/networked controls would receive a <0.50 savings factor in accordance with the table provided. Savings for integral occupancy sensors for high bay fixtures are custom calculated.)
2: ERS, November 17, 2005. Measure Life Study. Prepared for MA Joint Utilities. https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf
3: Southern California Edison, January 2016. Refrigerated Case Door Aisle Traffic Sensor. Work paper SCE13CS003, revision 2.. http://www.deeresources.net/workpapers
4: DNV KEMA, June 21, 2013. Impact Evaluation of 2010 Prescriptive Lighting Installations. (MA) https://ma-eeac.org/wp-content/uploads/Impact-Evaluation-of-2010-Prescriptive-Lighting-Installations-Final-Report-6-21-13.pdf
5: Cadmus Group, October 23, 2012. Small Business Direct Install Program: Pre/Post Lighting Occupancy Sensor Study. (MA) Available as appendix C-1 in https://ma-eeac.org/wp-content/uploads/Massachusetts-Small-Business-Direct-Install_2010-2012-Impact-Evaluations-1.29.13.pdf
6: DNV GL, ERS, June 7, 2018. Impact Evaluation of PY2016 Small Business Initiative: Phase I https://ma-eeac.org/wp-content/uploads/P69-Impact-Eval-of-MA-Small-Business-Initiative-Phase-I-Lighting_Report_FINAL.pdf
7: DNV GL, 2018. P72 Prescriptive C&I Loadshapes of Savings.
8: DNV GL, June 21, 2018. Impact Evaluation of 2016 New Hampshire Commercial & Industrial Small Business and Municipal Lighting. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/small-business-and-municipal-lighting-impact-evaluation.pdf. See sample projects including controls, which produced an overall realization rate of 106.6%.
9: DNV GL, September 25, 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf See 100.8% realization rate for custom electric measures in table 16.
10: EMI, September 25, 2019 . C1644 EO Net-to-Gross Study, Final Report. https://www.energizect.com/sites/default/files/C1644%20-%20EO%20NTG%20Final%20Report_9.25.19.pdf
Downstream NTG values are based on Energy Opportunities NTG Study Results for Lighting shown in Table ES-1-1 on p. ES-3.

2.44 **Lighting - Retrofit**

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Lighting

Description:

This measure includes efficient lighting products including, but not limited to, efficient Light-Emitting Diode (LED) lamps and fixtures, promoted through direct install retrofit programs, and installed in commercial and industrial buildings (C&I).

Midstream measures include efficient lighting products including, but not limited to, efficient Light-Emitting Diode (LED) lamps and fixtures, promoted through point-of-sale (also referred to as midstream) distributors.

Baseline Efficiency:

For C&I lighting retrofit installations, the baseline efficiency case is project-specific and is determined using actual fixture counts and wattages from the existing space.

All midstream measures assume a blend of retrofit and lost opportunity baseline,[1] determined using assumed wattages for each of the replaced lamps or fixtures

High Efficiency:

For C&I lighting retrofit installations, the high efficiency case is project-specific and is determined using actual fixture counts and wattages for the project.

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh = \left(\sum_{i=1}^{n} ((Count_{\_i} * Watts_{\_i} / 1000)_{BASE}) - \sum_{j=1}^{n} (Count_{\_j} * Watts_{\_j}/1000)_{EE} \right) \times (Hours)$

$\Delta kW = \sum_{i=1}^{n} ((Count_{i} * Watts_{i} / 1000)_{BASE}) - \sum_{j=1}^{n} (Count_{j} * Watts_{j}/1000)_{EE})$

Where:

n = Total number of fixture types in baseline or pre-retrofit case

m = Total number of installed fixture types

$Count_{\_i}$ = Quantity of existing fixtures of type i.

$Watts_{\_i}$ = Existing fixture or baseline wattage for fixture type i

$Count_{\_j}$ = Quantity of efficient fixtures of type j.

$Watts_{\_j}$ = Efficient fixture wattage for fixture type j.

1000 = Conversion factor: 1000 watts per kW.

Hours = Lighting annual hours of operation.

For retrofit installations, the annual hours of operation is project-specific and determined using actual building operation data in which the lighting equipment was installed. If site specific hours of operation are unavailable or if vendor estimates of building operating hours are unrealistically different from standard building type operating hours, then refer to the operating hours defined for midstream lighting, which is based on a program evaluation from CT.[1]

For Midstream:

$\Delta kWh = n * (DeltaWatts/1000) * Hours$

$\Delta kW = n * DeltaWatts /1000$

Where:
n = Total number of fixture or lamp types in project.
DeltaWatts = Calculated difference between efficient and baseline wattage (see table below)
1000 = Conversion factor: 1000 watts per kW.
Hours = Lighting annual hours of operation.

The following delta watt values are based on C&I Upstream Lighting, Mass Saves.[2]

Product	Product Type	delta Watts[2]
BR20/PAR20	Screw-In LEDs	28.1
BR20/PAR30	Screw-In LEDs	38.1
BR40/PAR38	Screw-In LEDs	44.2
MR16	Screw-In LEDs	22.1
A-line, 75/100w	Screw-In LEDs	30.5
Decoratives	Screw-In LEDs	13.6
LED Retrofit kit, <25W	Screw-In LEDs	38.4
LED Retrofit kit, >25W	Screw-In LEDs	49.656.6
Stairwell Kit, Low-Output w/sensor	LED Stairwell Kits	41.319.2
Stairwell Kit, Mid-Output w/sensor	LED Stairwell Kits	35.640.0
G24 LED	Screw-In LEDs	15.3
G23 LED	Screw-In LEDs	8.4
T8 TLED, 4ft	Linear LEDs	13.8
T8 TLED, 2ft	Linear LEDs	6.9
A-line, 40/60w	Screw-In LEDs	21.7
2x4 LED Fixture Standard	Linear LEDs	33.0
2x4 LED Fixture Premium	Linear LEDs	37.0
2x2 LED Fixture Standard	Linear LEDs	29.0
2x2 LED Fixture Premium	Linear LEDs	33.0
1x4 LED Fixture Standard	Linear LEDs	16.0
1x4 LED Fixture Premium	Linear LEDs	20.0
2x4 LED Fixture Standard w Controls	Linear LEDs w Controls	42.9
2x4 LED Fixture Premium w Controls	Linear LEDs w Controls	48.1
2x2 LED Fixture Standard w Controls	Linear LEDs w Controls	37.7

2x2 LED Fixture Premium w Controls	Linear LEDs w Controls	42.9
1x4 LED Fixture Standard w Controls	Linear LEDs w Controls	20.8
1x4 LED Fixture Premium w Controls	Linear LEDs w Controls	26.0
T5 LED	Linear LEDs	20.0
U-Bend LED	Linear LEDs	23.4
High/Low Bay 50-99W	High Bay/Low Bay	174.0
High/Low Bay 100-199W	High Bay/Low Bay	229.0
High/Low Bay >= 200W	High Bay/Low Bay	334.0
Exterior LED 20-99W	Exterior LEDs	101.5
Exterior LED 100-199W	Exterior LEDs	176.5
Exterior LED >= 200W	Exterior LEDs	231.5
1x4 LED Troffer Retrofit Kit - Premium	Linear LEDs	37.3
1x4 LED Troffer Retrofit Kit - Standard	Linear LEDs	29.5
2x2 LED Troffer Retrofit Kit - Premium	Linear LEDs	19.6
2x2 LED Troffer Retrofit Kit - Standard	Linear LEDs	18.1
2x4 LED Troffer Retrofit Kit - Premium	Linear LEDs	56.2
2x4 LED Troffer Retrofit Kit - Standard	Linear LEDs	53.5
LED Ambient/Strip/Wrap	Linear LEDs	21.8
Mogul High Bay	High Bay/Low Bay	283.6
Mogul Low Bay	High Bay/Low Bay	191.0
Mogul Ext 175W	Exterior LEDs	141.9
Mogul Ext 250W	Exterior LEDs	184.9
Mogul Ext 400W	Exterior LEDs	283.3
LED Tubes, 3ft Type A	Linear LEDs	12.0
LED Tubes, 8ft Type A	Linear LEDs	25.1
Parking Garage, 20-99W - Standard	Exterior LEDs	122.9
Parking Garage, 20-99W - Premium	Exterior LEDs	130.5
Parking Garage, 100-199W - Standard	Exterior LEDs	249.4
Parking Garage, 100-199W - Premium	Exterior LEDs	253.9
Parking Garage, >= 200W - Standard	Exterior LEDs	561.6
Parking Garage, >= 200W - Premium	Exterior LEDs	583.1
High/Low Bay LED, 20-99W w/controls	High Bay/Low Bay w Controls	189.5
High/Low Bay LED, 100-199W w/controls	High Bay/Low Bay w Controls	260.1
High/Low Bay LED, >= 200W w/controls	High Bay/Low Bay w Controls	388.4

Midstream lighting measures will calculate gross energy savings using annual hours of operation defined for the building type in which the lamp was installed. These categories and hours of use are defined in the table below.

Midstream Hours of Use by Building Type

The following hours of operation are based on a program evaluation from CT.[3] Parking garages are included as an additional building type category that has not yet been evaluated. A review of TRM best practices indicates 8760 hours of use for parking garages.

Building Type	Hours of Use
24x7 lighting	8,760
Automotive	4,056
Education	2,967
Grocery	5,468
Health Care	5,564
Hotel/Motel	3,064
Industrial	5,793
Large Office	4,098
Other	6,211*
Parking Lot/ Streetlights	6,887
Religious Building/ Convention Center	913
Restaurant	5,018
Retail	4,939
Small Office	3,748
Warehouse	5,667
Parking Garage	8,760

*Other includes recreational and entertainment facilities, service-oriented facilities, and other miscellaneous building types.

Measure Life:

The table below summarizes the adjusted measure lives (AML) for each measure. Note these AML values account for the estimated fraction of program lighting measures that are assumed to be lost opportunity (replace on failure) vs. retrofit (early replacement) based on MA evaluation research, as well as future year adjustments driven by expectations of high efficiency market adoption.

Measure Category	Measure	AML
Ambient Linear	TLED	10.53
Ambient Linear	LED Fixture	10.99
High/Low Bay	TLED	12.81
High/Low Bay	LED Fixture	12.84 r
High/Low Bay	LED Lamp	12.56
Exterior/Outdoor	TLED	10.12
Exterior/Outdoor	LED Fixture	10.18

Exterior/Outdoor	LED Lamp	9.74
Screw-Based	A-Line	4.69
Screw-Based	Downlight/Track	5.86
Screw-Based	Decorative	3.78

The table below summarizes the adjusted measure lives (AML) for each of the midstream measures. Note these AML values account for the estimated fraction of program lighting measures that are assumed to be lost opportunity (replace on failure) vs. retrofit (early replacement) based on MA evaluation research, as well as future year adjustments driven by expectations of high efficiency market adoption.[4]

BC Measure ID	Measure Category	Measure	Program	AML
E21C1c015 E21C2c015	Ambient Linear	TLED	LBES Midstream, SBES Midstream	10.53
E21C1c013 E21C2c013 E21C1c014 E21C2c014	Ambient Linear	LED Fixture	LBES Midstream, SBES Midstream	10.99
E21C1c012 E21C2c012	High/Low Bay	TLED	LBES Midstream, SBES Midstream	12.81
E21C1c012 E21C2c012	High/Low Bay	LED Fixture	LBES Midstream, SBES Midstream	12.84
E21C1c012 E21C2c012	High/Low Bay	LED Lamp	LBES Midstream, SBES Midstream	12.56
E21C1c011 E21C2c011	Exterior/Outdoor	TLED	LBES Midstream, SBES Midstream	10.12
E21C1c011 E21C2c011	Exterior/Outdoor	LED Fixture	LBES Midstream, SBES Midstream	10.18
E21C1c011 E21C2c011	Exterior/Outdoor	LED Lamp	LBES Midstream, SBES Midstream	9.74
E21C1c016 E21C2c016	Screw-Based	A-Line	LBES Midstream, SBES Midstream	4.69

E21C1c010 E21C2c010	Screw-Based	Downlight/Track	LBES Midstream, SBES Midstream	5.86
E21C1c016 E21C2c016	Screw-Based	Decorative	LBES Midstream, SBES Midstream	3.78

Other Resource Impacts:

Heating penalties for downstream, interior lighting systems (non-turnkey) are from a 12-month MA data logging study.[3] Penalties for interior turnkey are from the 2018 MA small business lighting impact evaluation.[4]

BC Measure ID	Measure Name	Program	MMBtu/kWh
E21C1a012 E21C1a013 E21C2a012 E21C2a013 E21C3a012 E21C3a013	Interior Lighting	LBES, SBES, MES	-0.000691
E21C1d014 E21C1d015 E21C2d014 E21C2d015 E21C3d014 E21C3d015	Interior Lighting (turnkey direct-install)	LBES, SBES, MES	-0.004080
E21C1a010 E21C1a011 E21C1d012 E21C1d013 E21C2a010 E21C2a011 E21C2d012 E21C2d013 E21C3a010 E21C3a011 E21C3d012 E21C3d013	Exterior Lighting	LBES, SBES, MES	n/a

Midstream: The following heating penalties are associated with lighting projects, determined from MA lighting evaluations.[5]

BC Measure ID	Measure Name	Program	MMBtu/kWh

E21C1c010 E21C2c010	LED Downlight	LBES Midstream, SBES Midstream	-0.000329
E21C1c011 E21C2c011	LED Exterior	LBES Midstream, SBES Midstream	N/A
E21C1c012 E21C2c012	LED High Bay/Low Bay	LBES Midstream, SBES Midstream	-0.000162
E21C1c013 E21C2c013	LED Linear Fixture	LBES Midstream, SBES Midstream	-0.000162
E21C1c014 E21C2c014	LED Linear Fixture with Controls	LBES Midstream, SBES Midstream	-0.000162
E21C1c015 E21C2c015	LED Linear Lamp	LBES Midstream, SBES Midstream	-0.000162
E21C1c016 E21C2c016	LED Screw In	LBES Midstream, SBES Midstream	-0.000329
E21C1c017 E21C2c017	LED Stairwell Kit	LBES Midstream, SBES Midstream	N/A

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a012 E21C1a013	Interior Lighting	LBES	1.000	0.999	1.000	1.000	0.504	0.389
E21C2a012 E21C2a013 E21C3a012 E21C3a013	Interior Lighting	SBES, MES	1.000	1.066	1.135	1.000	0.504	0.389
E21C1a010 E21C1a011	Exterior Lighting	LBES	1.000	0.999	1.000	1.000	0.000	1.000
E21C2a010 E21C2a011 E21C3a010 E21C3a011	Exterior Lighting	SBES, MES	1.000	1.027	1.000	1.000	0.000	1.000
E21C1d014 E21C1d015	Interior Lighting (turnkey direct-install)	LBES	1.000	0.999	1.000	1.000	0.504	0.389
E21C2d014 E21C2d015 E21C3d014 E21C3d015	Interior Lighting (turnkey direct-install)	SBES, MES	1.000	1.066	1.135	1.000	0.504	0.389

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1d012 E21C1d013	Exterior Lighting (turnkey direct-install)	LBES	1.000	0.999	1.000	1.000	0.000	1.000
E21C2d012 E21C2d013 E21C3d012 E21C3d013	Exterior Lighting (turnkey direct-install)	SBES, MES	1.000	1.027	1.000	1.000	0.000	1.000

Midstream:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1c010 E21C2c010	LED Downlight	LBES Midstream, SBES Midstream	0.859	1.267	1.000	1.000	0.70	0.49
E21C1c011 E21C2c011	LED Exterior	LBES Midstream, SBES Midstream	0.955	0.989	1.000	1.000	0.00	1.00
E21C1c012 E21C2c012	LED High Bay/Low Bay	LBES Midstream, SBES Midstream	0.996	0.747	1.000	1.000	0.83	0.65
E21C1c013 E21C2c013	LED Linear Fixture	LBES Midstream, SBES Midstream	0.971	1.135	1.000	1.000	0.83	0.65
E21C1c014 E21C2c014	LED Linear Fixture with Controls	LBES Midstream, SBES Midstream	0.971	1.135	1.000	1.000	0.83	0.65
E21C1c015 E21C2c015	LED Linear Lamp	LBES Midstream, SBES Midstream	0.971	1.135	1.000	1.000	0.83	0.65
E21C1c016 E21C2c016	LED Screw In	LBES Midstream, SBES Midstream	0.714	1.712	1.000	1.000	0.70	0.49
E21C1c017 E21C2c017	LED Stairwell Kit	LBES Midstream, SBES Midstream	0.955	0.989	1.000	1.000	0.82	0.82

In-Service Rates:

All downstream installations have 100.0% in service rate since programs include verification of equipment installations.

Midstream in-service rates are based on the C1635 Impact Evaluation of PY 2016 and 2017 Energy Opportunities (EO) Program Report.[8]

Realization Rates:

Large Business Energy Solutions uses a 99.9% realization rate. Realization rates for Small Business Energy Solutions and Municipal Energy Solutions are based on NH evaluation results for municipal and small business facilities.[5] They account for operational hours of use adjustments, electric HVAC interactive adjustments for kWh and summer peak kW, and other adjustments. Exterior lighting realization rates account for the same adjustments except the HVAC interactive adjustment.

Midstream realization rates are based on the C1635 Impact Evaluation of PY 2016 and 2017 Energy Opportunities (EO) Program Report. [8] The HVAC interaction adjustment factor is determined from MA[8, 2] and CT[8] lighting project evaluations.

<u>Coincidence Factors:</u>

Summer and winter coincidence factors are based on NH evaluation results. [5, 6]
Midstream summer and winter coincidence factors are based on MA 2017 Upstream Lighting Impact evaluation.[9] LED screw-in coincident factors also applied to LED downlights.

Impact Factors for Calculating Net Savings:

Midstream and downstream free-ridership and spillover are based on study results from CT—which is the nearby jurisdiction with programs and markets most similar to those in NH.[10]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1c010 E21C2c010	LED Downlight	LBES Midstream, SBES Midstream	27%	11%	0%	84%
E21C1c011 E21C2c011	LED Exterior	LBES Midstream, SBES Midstream	27%	11%	0%	84%
E21C1c012 E21C2c012	LED High Bay/Low Bay	LBES Midstream, SBES Midstream	27%	11%	0%	84%
E21C1c013 E21C2c013	LED Linear Fixture	LBES Midstream, SBES Midstream	27%	11%	0%	84%
E21C1c014 E21C2c014	LED Linear Fixture with Controls	LBES Midstream, SBES Midstream	27%	11%	0%	84%
E21C1c015 E21C2c015	LED Linear Lamp	LBES Midstream, SBES Midstream	27%	11%	0%	84%
E21C1c016 E21C2c016	LED Screw In	LBES Midstream, SBES Midstream	50%	23%	0%	73%
E21C1c017 E21C2c017	LED Stairwell Kit	LBES Midstream, SBES Midstream	27%	11%	0%	84%
E21C1a012 E21C1a013 E21C2a012 E21C2a013 E21C3a012 E21C3a013	Interior Lighting	LBES, SBES, MES	11%	5%	0%	94%

E21C1d014 E21C1d015 E21C2d014 E21C2d015 E21C3d014 E21C3d015	Interior Lighting (turnkey direct-install)	LBES, SBES, MES	11%	5%	0%	94%
E21C1a010 E21C1a011 E21C2a010 E21C2a011 E21C3a010 E21C3a011	Exterior Lighting	LBES, SBES, MES	11%	5%	0%	94%
E21C1d012 E21C1d013 E21C2d012 E21C2d013 E21C3d012 E21C3d013	Exterior Lighting (turnkey direct-install)	LBES, SBES, MES	11%	5%	0%	94%

Energy Load Shape:

Energy load shapes are based on site-level metering of project sites in MA.[7]

Measure Name	Summer On-peak	Winter On-peak	Summer Off-peak	Winter Off-peak
Interior Lighting	34.3%	30.3%	18.1%	17.4%
Exterior Lighting	19.2%	20.1%	29.0%	31.6%

Endnotes:

1: DNV GL, June 30, 2020. C1635 Impact Evaluation of PY 2016 & 2017 Energy Opportunities Program, Draft Report. Table 5-17. Interior Fixture Hours of Use Results by Building Type. Available at: https://www.energizect.com/connecticut-energy-efficiency-board/evaluation-reports

2: DNV GL, April 6, 2020. MA19C14-E-LGHTMKT: 2019 C&I Lighting Inventory and Market Model Updates. https://ma-eeac.org/wp-content/uploads/MA19C14-E-LGHTMKT_2019-CI-Lighting-Inventory-and-Market-Model-Report_Final_2020.04.06.pdf

3: DNV KEMA, June 21, 2013. Impact Evaluation of 2010 Prescriptive Lighting Installations. https://ma-eeac.org/wp-content/uploads/Impact-Evaluation-of-2010-Prescriptive-Lighting-Installations-Final-Report-6-21-13.pdf

4: DNV GL, ERS, June 7, 2018. Impact Evaluation of PY2016 Small Business Initiative: Phase I https://ma-eeac.org/wp-content/uploads/P69-Impact-Eval-of-MA-Small-Business-Initiative-Phase-I-Lighting_Report_FINAL.pdf

5: DNV GL, June 21, 2018. Impact Evaluation of 2016 New Hampshire Commercial & Industrial Small Business and Municipal Lighting. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/small-business-and-municipal-lighting-impact-evaluation.pdf

6: DNV GL, September 25, 2015. New Hampshire Utilities Large Commercial & Industrial (C&I) Retrofit and New Equipment & Construction Program Impact Evaluation. https://puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/New%20Hampshire%20Large%20C&I%20Program%20Impact%20Study%20Final%20Report.pdf
7: DNV GL, 2018. P72 Prescriptive C&I Loadshapes of Savings.
8: DNV GL, June 30, 2020, C1635 Impact Evaluation of PY 2016 and 2017 Energy Opportunities (EO) Program. Table 6-14: Upstream Lighting In-Service Rate Results and Table 6-19: Upstream Lighting kWh Realization Rate Recommendations Without In-Service Rates. Prepared for Connecticut Energy Efficiency Board (EEB). Available at: https://www.energizect.com/connecticut-energy-efficiency-board/evaluation-reports
9: DNV GL, November 22, 2017. Impact Evaluation of PY2015 Massachusetts Commercial and Industrial Upstream Lighting Initiative. https://ma-eeac.org/wp-content/uploads/Upstream-Lighting-Initiative-Impact-Evaluation-PY2015.pdf
10: EMI, September 25, 2019 . C1644 EO Net-to-Gross Study, Final Report. https://www.energizect.com/sites/default/files/C1644%20-%20EO%20NTG%20Final%20Report_9.25.19.pdf
Mistream NTG values are based on Recommendation 2 on p. ES-6 and p. 51. For midstream, screw in values are applied to screw in lights, and linear values are applied to all other light types, which is consistent with the application of screw in and linear NTG values in the MA TRM. Downstream NTG values are based on Energy Opportunities NTG Study Results for Lighting shown in Table ES-1-1 on p. ES-3.

2.45 Lighting – New Construction and Major Renovation

Measure Code	TBD
Market	Commercial
Program Type	Lost opportunity
Category	Lighting

Description:

The implementation of various lighting design principles aimed at creating a quality and appropriate lighting experience while reducing unnecessary light usage. This is often done by a professional in a new construction or major renovation situation. Advanced lighting design uses techniques like maximizing task lighting and efficient fixtures to create a system of optimal energy efficiency and functionality.

Baseline Efficiency:

The Baseline Efficiency assumes compliance with lighting power density requirements as mandated by New Hampshire State Building Code, which currently reflects IECC 2015 with direct reference for compliance to ASHRAE Standard 90.1-2013. These standards specify the maximum lighting power densities (LPDs) by building type (building area method) and interior space type (space-by-space method). LPDs apply to all new construction and major renovation projects.

High Efficiency:

The high efficiency scenario assumes lighting systems that achieve lighting power densities below those required by New Hampshire State Building Code. Actual site lighting power densities should be determined on a case-by-case basis. Please refer to the current year application form for minimum percentage better than code efficiency requirements.

Algorithms for Calculating Primary Energy Impact:

$\Delta kWh = \sum_{i=1}^{n} ((LPD\_base\_i - Controlled \times LPD\_proposed\_i) \times Area\_i \times Hours\_i \times 1/1000)$

$\Delta kWFixture \sum_{i=1}^{n} ((LPD\_base\_i - LPD\_proposed\_i) \times 1/1000 \times Area\_i \times 1/1000)$

$\Delta kWControlled = \sum_{i=1}^{n} (LPD\_proposed\_i \times Area\_i \times 1/1000)$

Where:

n = Total number of spaces, or 1 for Building Area Method
LPD_base_i = Baseline lighting power density for building or space type i (Watts/ft^2)
Area_i = Area of building or space i (ft^2)
Hours_i = Annual hours of operation of the lighting equipment for space type i
LPD_proposed_i = Proposed lighting power density for building or space type i (Watts/ft^2)
Controlled = Min % of controlled lighting above required amounts

1000 = Conversion factor: 1000 watts per 1 kW
Note on HVAC system interaction: Additional Electric savings from cooling system interaction are included in the calculation of adjusted gross savings for Lighting Systems projects. The HVAC interaction adjustment factor is determined from lighting project evaluations and is included in the energy realization rates and demand coincidence factors and realization rates.

Measure Life:

Measure lives are deemed based on study results from MA.[1]

BC Measure ID	Measure Name	Program	Measure Life
E21C1b013 E21C2b013 E21C3b013	Performance Lighting (Interior)	LBES, SBES, MES	15
E21C1b011 E21C2b011 E21C3b011	Performance Lighting (Exterior)	LBES, SBES, MES	15
E21C1b012 E21C2b012 E21C3b012	Performance Lighting w/ controls (Interior)	LBES, SBES, MES	15
E21C1b010 E21C2b010 E21C3b010	Performance Lighting w/ controls (Exterior)	LBES, SBES, MES	15

Other Resource Impacts:

Heating penalties are from alighting program evaluation performed on lighting systems in Massachusetts.[2]

BC Measure ID	Measure Name	Program	MMBtu/kWh
E21C1b012 E21C2b012 E21C3b012 E21C1b013 E21C2b013 E21C3b013	Performance lighting (interior) w/ and w/out controls	LBES, SBES, MES	-0.000162279
E21C1b010 E21C2b010 E21C3b010 E21C1b011 E21C2b011 E21C3b011	Performance lighting (exterior) w/ and w/out controls	LBES, SBES, MES	n/a

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1b012 E21C1b013	Performance lighting (interior)	LBES	1.000	0.999	1.000	1.000	1.000	0.504	0.389
E21C2b012 E21C3b012 E21C2b013 E21C3b013	Performance lighting (interior)	SBES, MES	1.000	1.066	1.000	1.135	1.000	0.504	0.389
E21C1b010 E21C1b011	Performance lighting (exterior)	LBES	1.000	0.999	1.000	1.000	1.000	0.000	1.000
E21C2b010 E21C3b010 E21C2b011 E21C3b011	Performance lighting (exterior)	SBES, MES	1.000	1.027	1.000	1.000	1.000	0.000	1.000

In-Service Rates:

All installations have a 100.0% in service rate unless an evaluation finds otherwise.

Realization Rates:

Large Business Energy Solutions uses a 99.9% realization rate. Energy and demand realization rates for Small Business Energy Solutions and Municipal Energy Solutions are based on a NH study of municipal and small business customers.[3] Realization rates for summer peak demand savings in interior systems reflect a 113.5% HVAC interactive multiplier.

Coincidence Factors:

All coincidence factors are based on a NH study of municipal and small business customers.[3]

Impact Factors for Calculating Net Savings[5]:

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	NTG
E21C1b013 E21C2b013 E21C3b013	Performance Lighting (Interior)	LBES, SBES, MES	11%	5%	0%	94%
E21C1b011 E21C2b011 E21C3b011	Performance Lighting (Exterior)	LBES, SBES, MES	11%	5%	0%	94%
E21C1b012 E21C2b012 E21C3b012	Performance Lighting w/ controls (Interior)	LBES, SBES, MES	11%	5%	0%	94%
E21C1b010 E21C2b010 E21C3b010	Performance Lighting w/ controls (Exterior)	LBES, SBES, MES	11%	5%	0%	94%

Energy Load Shape:

Energy load shapes are based the MA P72 C&I loadshape study.[4]

Measure Name	Summer On-peak	Winter On-peak	Summer Off-peak	Winter Off-peak
Interior Lighting	34.3%	30.3%	18.1%	17.4%
Exterior Lighting	19.2%	20.1%	29.0%	31.6%

Endnotes:

1: DNV GL, ERS, July 22, 2019. Lighting Outyear Factor and Equivalent Measure Life. https://ma-eeac.org/wp-content/uploads/Lighting-Outyear-Factor-and-Equivalent-Measure-Life-Update_Final.pdf

2: DNV GL, ERS, NMR, November 22, 2017. Impact Evaluation of PY2015 Massachusetts Commercial and Industrial Upstream Lighting Initiative https://ma-eeac.org/wp-content/uploads/Upstream-Lighting-Initiative-Impact-Evaluation-PY2015.pdf

3: DNV GL, June 21, 2018. Impact Evaluation of 2016 New Hampshire Commercial & Industrial Small Business and Municipal Lighting https://www.puc.nh.gov/Electric/Monitoring%20and%20Evaluation%20Reports/small-business-and-municipal-lighting-impact-evaluation.pdf

4: DNV GL, 2018. P72 Prescriptive C&I Loadshapes of Savings

5: DNV GL June 30, 2020. C1635 Impact Evaluation of PY 2016 & 2017 Energy Opportunities Program, Table 5-20. (CT). Available at: https://www.energizect.com/connecticut-energy-efficiency-board/evaluation-reports

5: EMI, September 25, 2019 . C1644 EO Net-to-Gross Study, Final Report. https://www.energizect.com/sites/default/files/C1644%20-%20EO%20NTG%20Final%20Report_9.25.19.pdf

Downstream NTG values are based on Energy Opportunities NTG Study Results for Lighting shown in Table ES-1-1 on p. ES-3.

2.46 Motors & Drives - Variable Frequency Drive

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit/Lost Opportunity
Category	Motors and Drives

Description:

This measure covers the installation of variable speed drives according to the terms and conditions stated on the statewide worksheet. The measure covers multiple end use types and building types. The installation of this measure saves energy since the power required to rotate a pump or fan at lower speeds requires less power than when rotated at full speed.

Baseline Efficiency:

The baseline efficiency case measure varies with equipment type. All baselines assume either a constant or 2-speed motor. Air or water volume/temperature is controlled using valves, dampers, and/or reheats. If the project includes a motor replacement, air or water volume/temperature is controlled using valves, dampers, and/or reheats.

High Efficiency:

In the high efficiency case, pump flow or fan air volume is directly controlled using downstream information. The pump or fan will automatically adjust its speed based on inputted set points and the downstream feedback it receives.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = HP \times \frac{kWh}{HP} \Delta kW_{SP} = HP \times \frac{kW_{SP}}{HP} \Delta kW_{WP} = HP \times \frac{kW_{WP}}{HP}$$

Where:

HP = Rated horsepower for the impacted motor

η = Motor efficiency

$\frac{kWh}{HP}$ = Annual electric energy reduction based on building and equipment type. See table below.

$\frac{kW_{SP}}{HP}$ = Summer demand reduction based on building and equipment type. See table below.

$\frac{kW_{WP}}{HP}$ = Winter demand reduction based on building and equipment type. See table below.

Savings factors below already account for motor efficiency and consequently an adjustment is not required in the algorithm.

Savings Factors for C&I VFDs without Motor Replacement (kWh/HP [1] and kW/HP) [2]

Building Type	Building Exhaust Fan	Cooling Tower Fan	Chilled Water Pump	Boiler Feed Water Pump	Hot Water Circulating Pump	MAF - Make-up Air Fan	Return Fan	Supply Fan	WS Heat Pump
Annual Energy Savings Factors (kWh/HP)									
University/College	3641	449	745	2316	2344	3220	1067	1023	3061
Elem/High School	3563	365	628	1933	1957	3402	879	840	2561
Multi-Family	3202	889	1374	2340	2400	3082	1374	1319	3713
Hotel/Motel	3151	809	1239	2195	2239	3368	1334	1290	3433
Health	3375	1705	2427	2349	2406	3002	1577	1487	3670
Warehouse	3310	455	816	2002	2087	3229	1253	1205	2818
Restaurant	3440	993	1566	1977	2047	2628	1425	1363	3542
Retail	3092	633	1049	1949	2000	2392	1206	1146	2998
Grocery	3126	918	1632	1653	1681	2230	1408	1297	3285
Offices	3332	950	1370	1866	1896	3346	1135	1076	3235
Summer Demand Savings Factors (kW/HP_{SP})									
University/College	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Elem/High School	0.377	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Multi-Family	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Hotel/Motel	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Health	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Warehouse	0.109	-0.023	0.174	0.457	0.091	0.261	0.287	0.274	0.218
Restaurant	0.261	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Retail	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Grocery	0.261	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Offices	0.109	-0.023	0.174	0.457	0.091	0.109	0.287	0.274	0.218
Winter Demand Savings Factors (kW/HP_{WP})									
University/College	0.377	-0.006	0.184	0.457	0.21	0.109	0.26	0.252	0.282
Elem/High School	0.457	-0.006	0.184	0.457	0.21	0.109	0.26	0.252	0.282
Multi-Family	0.109	-0.006	0.184	0.355	0.21	0.109	0.26	0.252	0.282
Hotel/Motel	0.109	-0.006	0.184	0.418	0.21	0.109	0.26	0.252	0.282

Health	0.377	-0.006	0.184	0.275	0.21	0.109	0.26	0.252	0.282
Warehouse	0.377	-0.006	0.184	0.178	0.21	0.261	0.26	0.252	0.282
Restaurant	0.109	-0.006	0.184	0.355	0.21	0.109	0.26	0.252	0.282
Retail	0.109	-0.006	0.184	0.275	0.21	0.109	0.26	0.252	0.282
Grocery	0.457	-0.006	0.184	0.418	0.21	0.109	0.26	0.252	0.282
Offices	0.457	-0.006	0.184	0.418	0.21	0.109	0.26	0.252	0.282

Savings Factors for C&I VFDs with Motor Replacement (kWh/HP [1] and kW/HP [2]) :

Building Type	**Building Exhaust Fan**	**Cooling Tower Fan**	**Chilled Water Pump**	**Boiler Feed Water Pump**	**Hot Water Circulating Pump**	**MAF - Make-up Air Fan**	**Return Fan**	**Supply Fan**
Annual Energy Savings Factors (kWh/HP)								
University/College	3,802	486	780	2,415	2,442	3,381	1,143	1,100
Elem/High School	3,721	396	657	2,015	2,040	3,561	941	903
Multi-Family	3,368	954	1,435	2,443	2,504	3,248	1,466	1,412
Hotel/Motel	3,317	866	1,294	2,291	2,335	3,534	1,425	1,381
Health	3,541	1,815	2,535	2,453	2,510	3,168	1,676	1,586
Warehouse	3,476	496	853	2,098	2,183	3,396	1,342	1,294
Restaurant	3,606	1,066	1,636	2,067	2,138	2,794	1,519	1,457
Retail	3,258	685	1,097	2,036	2,087	2,558	1,288	1,229
Grocery	3,292	1,001	1,710	1,724	1,753	2,396	1,498	1,386
Offices	3,498	1,014	1,432	1,947	1,977	3,512	1,210	1,151
Summer Demand Savings Factors (kW/HP_{SP})								
University/College	0.257	(0.004)	0.465	0.952	0.190	0.257	0.679	0.706
Elem/High School	1.187	(0.006)	0.697	1.428	0.286	0.385	1.019	1.058
Multi-Family	0.385	(0.006)	0.697	1.428	0.286	0.385	1.019	1.058
Hotel/Motel	0.257	(0.004)	0.465	0.952	0.190	0.257	0.679	0.706
Health	0.128	(0.002)	0.232	0.476	0.095	0.128	0.340	0.353
Warehouse	0.770	(0.012)	1.394	2.855	0.571	1.677	2.038	2.117
Restaurant	0.839	(0.006)	0.697	1.428	0.286	0.385	1.019	1.058
Retail	0.514	(0.008)	0.930	1.904	0.381	0.514	1.358	1.411
Grocery	0.280	(0.002)	0.232	0.476	0.095	0.128	0.340	0.353
Offices	0.257	(0.004)	0.465	0.952	0.190	0.257	0.679	0.706
Winter Demand Savings Factors (kW/HP_{WP})								
University/College	0.791	(0.001)	0.384	0.952	0.437	0.257	0.563	0.544
Elem/High School	1.428	(0.002)	0.575	1.428	0.655	0.385	0.844	0.816
Multi-Family	0.385	(0.002)	0.575	1.123	0.661	0.385	0.844	0.816

Hotel/Motel	0.257	(0.001)	0.384	0.874	0.438	0.257	0.563	0.544
Health	0.396	(0.001)	0.192	0.294	0.223	0.128	0.281	0.272
Warehouse	2.374	(0.003)	1.151	1.181	1.384	1.677	1.688	1.632
Restaurant	0.385	(0.002)	0.575	1.123	0.661	0.385	0.844	0.816
Retail	0.514	(0.002)	0.767	1.178	0.893	0.514	1.125	1.088
Grocery	0.476	(0.001)	0.192	0.437	0.219	0.128	0.281	0.272
Offices	0.952	(0.001)	0.384	0.874	0.438	0.257	0.563	0.544

Measure Life:

The measure life for lost opportunity is 15 years. For retrofit, this measure was determined to be an add on, single baseline measure, so it will leverage the same 15 year life as lost opportunity. [3]

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a043 E21C1d043 E21C2a043 E21C2d043 E21C3a087 E21C3d087	Variable Frequency Drive	LBES Retro LBES DI SBES Retro SBES DI Muni Retro Muni DI	1.00	0.946	n/a	1.265	1.415	1.00	1.00
E21C1a044 E21C1d044 E21C2a044 E21C2d044 E21C3a088 E21C3d088	Variable Frequency Drive with Motor	LBES Retro LBES DI SBES Retro SBES DI Muni Retro Muni DI	1.00	0.946	n/a	1.265	1.415	1.00	1.00

In-Service Rates:

All installations have a 100% in-service rate unless an evaluation finds otherwise.

Realization Rates:

Realization rates are based on study results.[4]

Coincidence Factors:

CFs for all programs set to 100% since summer and winter demand savings are based on evaluation results.

Energy Load Shape:

See Appendix 1 C&I Load Shape “C&I VFD (Combined)”.

Endnotes:

1: Chan, Tumin, 2010. Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR.

2: For Chilled Water Pump, Hot Water Circ. Pump, Return Fan, Supply Fan, and WSHP Circ. Loop: kW/HP estimates derived from Cadmus, 2012. Variable Speed Drive Loadshape Project. Prepared for the NEEP Regional Evaluation, Measurement & Verification Forum. Other drive type kW/HP savings estimates based on Chan, Tumin (2010). Formulation of a Prescriptive Incentive for the VFD and Motors & VFD impact tables at NSTAR. Prepared for NSTAR.

3: Energy & Resource Solutions, November (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities.https://www.ers-inc.com/wp-content/uploads/2018/04/Measure-Life-Study_MA-Joint-Utilities_ERS.pdf, Baseline Categories and preliminary Out Year Factors are described at a high level in DNV GL, ERS (2018). Portfolio Model Companion Sheet. Additional background on the baseline categorization given in DNV GL, ERS (2018). Portfolio Model Methods and Assumptions – Electric and Natural Gas Memo

4: DNV GL (2020). Impact Evaluation of PY 2017 Small Business Initiative Non-Lighting Measures.

2.47 **Refrigeration - Case Motor Replacement**

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Description:

Replacement of shaded-pole (SP) or permanently-split capacitor (PSC) motors with electronically commutated motors (ECMs) in the evaporators for multi-deck and freestanding coolers and freezers, typically on the retail floor of convenience stores, liquor stores, and grocery stores.[1]

Baseline Efficiency:

The baseline efficiency case is the existing case motor, either SP or PSC type.

High Efficiency:

The high efficiency case is the replacement of the existing case motor with an ECM.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = \Delta kWh_{Motor} + \Delta kWh_{Heat}$$
$$\Delta kWh_{Motor} = kW_{Motor} \times LRF \times Hours$$
$$\Delta kWh_{Heat} = \Delta kWh_{Motor} \times 0.28 \times Eff_{RS}$$
$$\Delta kW = \frac{\Delta kWh}{8{,}760}$$

Where:

ΔkWh_{Motor} = Energy savings due to increased efficiency of case motor
ΔkWh_{Heat} = Energy savings due to reduced heat from evaporator fans
kW_{Motor} = Rated input power of the existing case motor
LRF = Load reduction factor: 53% when SP motors are replaced, 29% when PSC motors are replaced[2].
.$Hours$ = Average runtime of case motors (8,500 hours)[3]
0.28 = Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.
Eff_{RS} = Efficiency of typical refrigeration system (1.6 kW/ton) [4]
ΔkW = Average demand savings
8,760 = Hours per year

Measure Life:

The measure life is 15 years[5]. This measure is determined to have an add-on single baseline in retrofit scenarios.

This measure is determined to have an add-on single baseline in retrofit scenarios.

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a016	Case Motor Replacement	Electric	LBES - Retrofit	1.00	0.999	n/a	1.00	1.00	1.00	1.00
E21C1d018	Case Motor Replacement	Electric	LBES – Direct Install	1.00	0.999	n/a	1.00	1.00	1.00	1.00
E21C2a016	Case Motor Replacement	Electric	SBES - Retrofit	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C2d018	Case Motor Replacement	Electric	SBES – Direct Install	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C3a016	Case Motor Replacement	Electric	Muni - Retrofit	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C3d018	Case Motor Replacement	Electric	Muni – Direct Install	1.00	1.00	n/a	1.00	1.00	1.00	1.00

<u>In-Service Rates:</u>

All installations have a 100% in service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

All programs use a coincidence factor of 100% since demand savings are average and expected to be consistent.

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Refrigeration".

<u>Endnotes</u>:
1: The assumptions and algorithms used in this section are specific to NRM products.
2: Load factor is an estimate by NRM based on several pre- and post-meter readings of installations
3: Conservative value based on 15 years of NRM field observations and experience.
4: Select Energy (2004). Cooler Control Measure Impact Spreadsheet Users' Manual. Prepared for NSTAR.

5: Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations.

2.48 Refrigeration – Door Heater Controls

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Description:

Installation of controls to reduce the run time of door and frame heaters for freezers and walk-in or reach-in coolers. The reduced heating results in a reduced cooling load.

Baseline Efficiency:

The baseline efficiency case is a cooler or freezer door heater that operates 8,760 hours per year without any controls.

High Efficiency:

The high efficiency case is a cooler or freezer door heater connected to a heater control system, which controls the door heaters by measuring the ambient humidity and temperature of the store, calculating the dew point, and using pulse width modulation (PWM) to control the anti-sweat heater based on specific algorithms for freezer and cooler doors. Door temperature is typically maintained about 5°F above the store air dew point temperature.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kW = \frac{\mathrm{V} \times \mathrm{A}}{1{,}000} \times \%Off$$
$$\Delta kWh = \Delta kW \times 8{,}760$$

Where:
V = Nameplate heater voltage
A = Nameplate heater amperage
$\%Off$ = Controlled door heater off time: 46% for freezers and 74% for coolers[1]
8,760 = Hours per year

Measure Life:

The measure life is 10 years[2].

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a019	Door Heater Controls	Electric	LBES - Retrofit	1.00	0.999	n/a	1.00	1.00	0.50	1.00
E21C1d021	Door Heater Controls	Electric	LBES – Direct Install	1.00	0.999	n/a	1.00	1.00	0.50	1.00
E21C2a019	Door Heater Controls	Electric	SBES - Retrofit	1.00	1.00	n/a	1.00	1.00	0.50	1.00
E21C2d021	Door Heater Controls	Electric	SBES – Direct Install	1.00	1.00	n/a	1.00	1.00	0.50	1.00
E21C3a025	Door Heater Controls	Electric	Muni - Retrofit	1.00	1.00	n/a	1.00	1.00	0.50	1.00
E21C3d027	Door Heater Controls	Electric	Muni – Direct Install	1.00	1.00	n/a	1.00	1.00	0.50	1.00

In-Service Rates:

All installations have a 100% in service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

The CF values are based on MA TRM[3] until NH-specific evaluations are available.

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Refrigeration".

Endnotes:

1:The value is an estimate by NRM based on hundreds of downloads of hours of use data from Door Heater controllers. These values are also supported by Select Energy Services, Inc. (2004). Cooler Control Measure Impact Spreadsheet User's Manual. Prepared for NSTAR. .

2: Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; Table 1-1

3: MA TRM (2020). 2019 Pan-Year Report Version. 3.82. Refrigeration – Door Heater Controls

2.49 Refrigeration – Electronic Defrost Control

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Description:

Install a controller to activate evaporator defrost only when necessary in a refrigeration system.

Baseline Efficiency:

The baseline efficiency case is an evaporator electric defrost system that uses a time clock to initiate defrost.

High Efficiency:

The high efficiency case is an evaporator electric defrost system with defrost controls based on refrigeration system runtime or load conditions.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = \Delta kWh_{Defrost} + \Delta kWh_{Heat}$$
$$\Delta kWh_{Defrost} = kW_{Defrost} \times Hr/Day \times 365 \times DRF$$
$$\Delta kWh_{Heat} = \Delta kWh_{Defrost} \times 0.28 \times Eff_{RS}$$
$$\Delta kW = \frac{\Delta kWh}{8{,}760}$$

Where:
$\Delta kWh_{Defrost}$ = Energy savings due to reduced runtime of defrost heaters
ΔkWh_{Heat} = Energy savings due to reduced heat from the defrost heaters
$kW_{Defrost}$ = Rated input power of the defrost heater
Hr/Day = Existing scheduled defrost hours per day
DRF = Defrost reduction factor – annual average of 35%[1]
365 = Days per year
0.28 = Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.
Eff_{RS} = Efficiency of typical refrigeration system (1.6 kW/ton) [2]
ΔkW = Average demand savings
8,760 = Hours per year

Measure Life:

The measure life is 10 years[3].

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a024	Electronic Defrost Control	Electric	LBES - Retrofit	1.00	0.999	n/a	1.00	1.00	1.00	1.00
E21C1d026	Electronic Defrost Control	Electric	LBES – Direct Install	1.00	0.999	n/a	1.00	1.00	1.00	1.00
E21C2a024	Electronic Defrost Control	Electric	SBES - Retrofit	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C2d026	Electronic Defrost Control	Electric	SBES – Direct Install	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C3a037	Electronic Defrost Control	Electric	Muni - Retrofit	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C3d039	Electronic Defrost Control	Electric	Muni – Direct Install	1.00	1.00	n/a	1.00	1.00	1.00	1.00

<u>In-Service Rates:</u>

All installations have a 100% in service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

All programs set coincident factors to 100% since demand savings are average and expected to be consistent.

Energy Load Shape:

See Appendix 1 C&I Load Shapes “C&I Refrigeration”.

Endnotes:

1: Supported by 3rd party evaluation: Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability.

2: Assumed average refrigeration efficiency for typical installations. Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). Cooler Control Measure Impact Spreadsheet Users’ Manual. Prepared for NSTAR.

3: Energy & Resource Solutions (2005). Measure Life Study – refrigeration controls for large C&I retrofit. Prepared for The Massachusetts Joint Utilities.

2.50 Refrigeration – Evaporator Fan Control

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Description:

Installation of controls to modulate the evaporator fans based on the temperature in a refrigerated space.

Baseline Efficiency:

The baseline efficiency case is an evaporator fan which runs for 8,760 annual hours.

High Efficiency:

The high efficiency case is an evaporator fan with controls to reduce the fan speed or cycle the fan off when the refrigerated space temperature setpoint is met.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = \Delta kWh_{Fan} + \Delta kWh_{Heat} + \Delta kWh_{Control}$$

$$kW_{Fan} = \frac{V \times A \times PF \times \sqrt{Phase}}{1{,}000}$$

$$\Delta kWh_{Fan} = kW_{Fan} \times \%Off \times 8760$$

$$\Delta kWh_{Heat} = \Delta kWh_{Fan} \times 0.28 \times Eff_{RS}$$

$$\Delta kWh_{Control} = [\mathrm{kW_{CP}} \times Hours_{CP} + kW_{Fan} \times (1 - \%Off) \times 8760] \times 5\%$$

$$\Delta kW = \frac{\Delta kWh}{8760}$$

Where:
ΔkWh_{Fan} = Energy savings due to reduced runtime of evaporator fans
ΔkWh_{Heat} = Energy savings due to reduced heat from the defrost heaters
$\Delta kWh_{Control}$ = Energy savings due to optimized controls, estimated at 5% of compressor and fan energy by consensus estimates used in MA TRM
V = Rated fan motor voltage
A = Rated fan motor amperage per, phase-to-ground
PF = Typical evaporator fan motor power factor, 0.55[1]
$Phase$ = Phase of electric power supplying the evaporator motor
$\%Off$ = Reduction in annual evaporator fan run hours, 46%[2].
8760 = Hours per year
kW_{CP} = Nameplate input kW of the compressor
$Hours_{CP}$ = Equivalent full load hours of compressor operations: 4,072 hours[3]
0.28 = Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.
Eff_{RS} = Efficiency of typical refrigeration system (1.6 kW/ton) [3]

ΔkW = Average demand savings
8,760 = Hours per year

Measure Life:

The measure life is 10 years[4].

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a027	Evaporator Fan Control	Electric	LBES - Retrofit	1.00	0.999	n/a	1.00	1.00	1.00	1.00
E21C1d029	Evaporator Fan Control	Electric	LBES – Direct Install	1.00	0.999	n/a	1.00	1.00	1.00	1.00
E21C2a027	Evaporator Fan Control	Electric	SBES - Retrofit	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C2d029	Evaporator Fan Control	Electric	SBES – Direct Install	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C3a043	Evaporator Fan Control	Electric	Muni - Retrofit	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C3d045	Evaporator Fan Control	Electric	Muni – Direct Install	1.00	1.00	n/a	1.00	1.00	1.00	1.00

In-Service Rates:

All installations have a 100% in service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

All programs use CF values of 100% since demand savings are average and expected to be consistent.

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Refrigeration".

Endnotes:
1: Conservative value based on 15 years of NRM field observations and experience.

2: The value is an estimate by NRM based on hundreds of downloads of hours of use data. These values are also supported by Select Energy Services, Inc. (2004). Cooler Control Measure Impact Spreadsheet User's Manual. Prepared for NSTAR
3: Conservative value based on 15 years of NRM field observations and experience. Value supported by Select Energy (2004). Cooler Control Measure Impact Spreadsheet Users' Manual. Prepared for NSTAR.
4: Energy & Resource Solutions (2005). Measure Life Study – fan control retrofit. Prepared for The Massachusetts Joint Utilities.

2.51 Refrigeration – Novelty Cooler Shutoff

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Description:

Installation of controls to shut off a facility's novelty coolers for non-perishable goods based on pre-programmed store hours.

Baseline Efficiency:

The baseline efficiency case a novelty cooler energized for 8,760 annual hours.

High Efficiency:

The high efficiency case is a novelty cooler whose energized hours follow the store's occupied hours, and is de-energized during unoccupied hours.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = kW_{NC} \times \mathrm{DC}_{\mathrm{AVG}} \times (Hours_{UNOCC} - 1) \times 365$$
$$\Delta kW = 0$$

Where:
kW_{NC} = Rated nameplate input power to the novelty cooler
$\mathrm{DC}_{\mathrm{AVG}}$ = Weighted average annual duty cycle: 49%[1]
$Hours_{UNOCC}$ = Daily unoccupied hours of the store
365 = Days per year

Measure Life:

The measure life is 10 years[2].

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a037	Novelty Cooler Shutoff	Electric	LBES - Retrofit	1.00	0.999	n/a	1.00	1.00	0.00	0.00
E21C1d037	Novelty Cooler Shutoff	Electric	LBES – Direct Install	1.00	0.999	n/a	1.00	1.00	0.00	0.00
E21C2a037	Novelty Cooler Shutoff	Electric	SBES - Retrofit	1.00	1.00	n/a	1.00	1.00	0.00	0.00
E21C2d037	Novelty Cooler Shutoff	Electric	SBES – Direct Install	1.00	1.00	n/a	1.00	1.00	0.00	0.00
E21C3a066	Novelty Cooler Shutoff	Electric	Muni - Retrofit	1.00	1.00	n/a	1.00	1.00	0.00	0.00
E21C3d066	Novelty Cooler Shutoff	Electric	Muni – Direct Install	1.00	1.00	n/a	1.00	1.00	0.00	0.00

In-Service Rates:

All installations have a 100% in service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Coincidence factors are zero since all energy savings occur during off-peak hours.

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Refrigeration".

Endnotes:

1: Estimated value from NRM experience, supported by Select Energy Services, Inc. (2004). Cooler Control Measure Impact Spreadsheet Users' Manual. Prepared for NSTAR. The study gives a less conservative value than used by NRM.

2: Energy & Resource Solutions (2005). Measure Life Study – cooler shutoff retrofit. Prepared for The Massachusetts Joint Utilities.

2.52 Refrigeration – Vending Miser

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Description:

Installation of controls intended to reduce the energy consumption of vending machine lighting and refrigeration systems. Qualifying controls must power down these systems during periods of inactivity but, in the case of refrigerated machines, must always maintain a cool product that meets customer expectations. This measure applies to refrigerated beverage vending machines, non-refrigerated snack vending machines, and glass front refrigerated coolers. This measure should not be applied to ENERGY STAR® qualified vending machines, as they already have built-in controls.

Baseline Efficiency:

The baseline efficiency case is a standard efficiency refrigerated beverage vending machine, nonrefrigerated snack vending machine, or glass front refrigerated cooler without a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

High Efficiency:

The high efficiency case is a standard efficiency refrigerated beverage vending machine, non-refrigerated snack vending machine, or glass front refrigerated cooler with a control system capable of powering down lighting and refrigeration systems during periods of inactivity.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = kW_{rated} \times Hours \times SAVE$$

$$\Delta kW = \frac{\Delta kWh}{Hours}$$

Where:

kW_{rated} = Rated kW of connected equipment; if not available, use default values in table below

$Hours$ = Annual operating hours of connected equipment; if not available, use default value of 8,760

$SAVE$ = Percent savings factor, see table below for values

Vending Machine and Cooler Controls Savings Factors [1]

Equipment Type	kW rated	SAVE
Refrigerated Beverage Vending Machines	0.40	46%
Non-Refrigerated Snack Vending Machines	0.085	25%
Glass Front Refrigerated Coolers	0.46	35%

Measure Life:

The measure life is 5 years[2].

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a045	Vending Miser	Electric	LBES - Retrofit	1.00	0.999	n/a	1.00	1.00	0.00	0.00
E21C1d045	Vending Miser	Electric	LBES – Direct Install	1.00	0.999	n/a	1.00	1.00	0.00	0.00
E21C2a045	Vending Miser	Electric	SBES - Retrofit	1.00	1.00	n/a	1.00	1.00	0.00	0.00
E21C2d045	Vending Miser	Electric	SBES – Direct Install	1.00	1.00	n/a	1.00	1.00	0.00	0.00
E21C3a089	Vending Miser	Electric	Muni - Retrofit	1.00	1.00	n/a	1.00	1.00	0.00	0.00
E21C3d089	Vending Miser	Electric	Muni – Direct Install	1.00	1.00	n/a	1.00	1.00	0.00	0.00

In-Service Rates:

All installations have a 100% in service rate unless an evaluation finds otherwise.

Realization Rates:

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

Coincidence factors are 0.00 since energy savings occur during off-peak hours (hours of vending machine inactivity).

Energy Load Shape:

See Appendix 1 C&I Load Shapes " C&I Refrigeration".

Endnotes:
1: USA Technologies Energy Management Product Sheets (2006). USA_Tech_2006_Energy_Management_Product_Sheets

2: Energy & Resource Solutions (2005). Measure Life Study – vending control retrofit. Prepared for The Massachusetts Joint Utilities.

2.53 Refrigeration – ECM Evaporator Fan Motors for Walk-in Coolers and Freezers

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Retrofit
Category	Refrigeration

Description:

Installation of various sizes of electronically commutated motors (ECMs) in walk-in coolers and freezers to replace existing evaporator fan motors.

Baseline Efficiency:

The baseline efficiency case is an existing evaporator fan motor which is not ECM.

High Efficiency:

The high efficiency case is the replacement of existing evaporator fan motors with ECMs.

Algorithms for Calculating Primary Energy Impact:

$$\Delta kWh = \Delta kWh_{Motor} + \Delta kWh_{Heat}$$

$$\Delta kWh_{Motor} = \frac{V \times A \times PF \times \sqrt{Phase}}{1{,}000} \times LRF \times Hours$$

$$\Delta kWh_{Heat} = \Delta kWh_{Motor} \times 0.28 \times Eff_{RS}$$

$$\Delta kW = \frac{\Delta kWh}{8{,}760}$$

Where:

ΔkWh_{Motor} = Energy savings due to increased efficiency of evaporator motor
ΔkWh_{Heat} = Energy savings due to reduced heat from evaporator fans
V = Rated fan motor voltage
A = Rated fan motor amperage per, phase-to-ground
PF = Typical existing fan motor power factor, 0.55[1]
$Phase$ = Phase of electric power supplying the evaporator motor
LRF = Load reduction factor of 65%[2].
$Hours$ = Annual fan operating hours
0.28 = Conversion of kW to tons: 3,413 Btuh/kW divided by 12,000 Btuh/ton.
Eff_{RS} = Efficiency of typical refrigeration system (1.6 kW/ton) [1]
ΔkW = Average demand savings
8,760 = Hours per year

Measure Life:

The measure life is 15 years[3].

Other Resource Impacts:

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Fuel	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1a023	ECM Evaporator Fan Motors for Walk-in Cooler/Freezer	Electric	LBES - Retrofit	1.00	0.999	n/a	1.00	1.00	1.00	1.00
E21C1d025	ECM Evaporator Fan Motors for Walk-in Cooler/Freezer	Electric	LBES – Direct Install	1.00	0.999	n/a	1.00	1.00	1.00	1.00
E21C2a023	ECM Evaporator Fan Motors for Walk-in Cooler/Freezer	Electric	SBES - Retrofit	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C2d025	ECM Evaporator Fan Motors for Walk-in Cooler/Freezer	Electric	SBES – Direct Install	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C3a036	ECM Evaporator Fan Motors for Walk-in Cooler/Freezer	Electric	Muni - Retrofit	1.00	1.00	n/a	1.00	1.00	1.00	1.00
E21C3d038	ECM Evaporator Fan Motors for Walk-in Cooler/Freezer	Electric	Muni – Direct Install	1.00	1.00	n/a	1.00	1.00	1.00	1.00

<u>In-Service Rates:</u>

All installations have a 100% in service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

Coincidence Factors:

All programs set coincident factors to 100% since demand savings are average and expected to be consistent.

Energy Load Shape:

See Appendix 1 C&I Load Shapes "C&I Refrigeration".

Endnotes:
1: Conservative value based on 15 years of NRM field observations and experience.
2: Load factor is an estimate by NRM based on several pre- and post-meter readings of installations; the value is supported by RLW Analytics (2007). Small Business Services Custom Measure Impact Evaluation. Prepared for National Grid.
3: Energy & Resource Solutions (2005). Measure Life Study. Prepared for The Massachusetts Joint Utilities; 15-year measure life for retrofit motor installations.

2.54 Midstream Hot Water – Water Heaters

Measure Code	[To Be Defined in ANB system]
Market	Commercial
Program Type	Lost Opportunity
Category	**Hot Water**

Description:

- Midstream Heat Pump Water Heater 120 gallons
- Midstream Heat Pump Water Heater 80 gallons.
- Midstream Heat Pump Water Heater 50 gallons.
- Midstream Indirect Water Heater, Gas: Indirect water heaters use a storage tank that is heated by the main boiler. The energy stored by the water tank allows the boiler to turn off and on less often, saving considerable energy.
- Midstream On Demand Tankless Water Heater, Gas: 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.
- Midstream Volume Water Heater, Gas: Installation of a high-efficiency gas-fired water heater.
- Midstream Condensing Water Heater, Gas: Installation of a high efficiency condensing gas water heater
-

Baseline Efficiency:

All Water Heaters: The baseline efficiency case assumes compliance with the efficiency requirements as mandated by Massachusetts State Building Code. As described in the MA State Building Code, energy efficiency must be met via compliance with the relevant International Energy Conservation Code (IECC).

- Midstream Heat Pump Water Heater
- Midstream Indirect Water Heater: For indirect water heaters the baseline is a hot water boiler operating at 78% recovery efficiency. Additionally, a baseline storage water heater was assumed for purpose of estimating standby losses. [1]
- Midstream On Demand Tankless Water Heater, Gas: For on-demand tankless water heaters the baseline is a code-compliant gas-fired storage water heater with EF = 0.61.[1]
- Midstream Volume Water Heater, Gas: The assumed baseline is a code specified 80% TE volume water heater.
- Midstream Condensing Water Heater, Gas: The assumed baseline is a code specified 80% TE water heater.

High Efficiency:

- Midstream Heat Pump Water Heater
- Midstream Indirect Water Heater: The high efficiency scenario is an indirect water heater with a Combined Appliance Efficiency (CAE) of 85% or greater.
- Midstream On Demand Tankless Water Heater, Gas: The high efficiency equipment is either a gas-fired instantaneous hot water heater with an Energy Factor of at least 0.90.

- Midstream Volume Water Heater, Gas: The high efficiency case is a volume water heater with a 94% TE
- Midstream Condensing Water Heater, Gas: The high efficiency case is a high efficiency stand alone commercial water heater with a thermal efficiency of 94% or greater and a capacity greater than 75,000 btu/h.
-

Algorithms for Calculating Primary Energy Impact:

Unit savings are deemed based on study results.

BC Measure ID	Measure Name	Program	ΔkWh	ΔMMBtu	ΔMMBtu / Mbtuh
E21C1c044 E21C2c044	Midstream Heat Pump Water Heater, 120 gallons	LBES Mid SBES Mid			
E21C1c046 E21C2c046	Midstream Heat Pump Water Heater, 80 gallons	LBES Mid SBES Mid			
E21C1c045 E21C2c045	Midstream Heat Pump Water Heater, 50 gallons	LBES Mid SBES Mid	914.63		
G21C1c009 G21C2c009	Midstream Indirect Water Heater	LBES Mid SBES Mid		19.0[2]	
G21C1c010 G21C2c010	Midstream on Demand Tankless Water Heater	LBES Mid SBES Mid		8.9[2]	
G21C1c011 G21C2c011	Midstream Volume Water Heater	LBES Mid SBES Mid			0.6077[2]
G21C1c012 G21C2c012	Midstream Condensing Gas Water Heater	LBES Mid SBES Mid			0.1441[2]

Measure Life:

BC Measure ID	Measure Name	Program	Measure Life
E21C1c044 E21C2c044 E21C1c045 E21C2c045 E21C1c046 E21C2c046	Midstream Heat Pump Water Heater, 120 gallons Midstream Heat Pump Water Heater, 80 gallons Midstream Heat Pump Water Heater, 50 gallons	LBES Mid SBES Mid	13[6]
G21C1c009 G21C2c009	Midstream Indirect Water Heater:	LBES Mid SBES Mid	15 [3]
G21C1c010 G21C2c010	Midstream on Demand Tankless Water Heater, Gas:	LBES Mid SBES Mid	20 [4]
G21C1c011	Midstream Volume Water Heater, Gas:	LBES Mid	15[3]

G21C2c011		SBES Mid	
G21C1c012 G21C2c012	Midstream Condensing Gas Water Heater	LBES Mid SBES Mid	15[3]

Other Resource Impacts:

There are no other resource impacts identified for this measure.

Impact Factors for Calculating Adjusted Gross Savings:

BC Measure ID	Measure Name	Program	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
E21C1c044 E21C2c044	Midstream Heat Pump Water Heater, 120 gallons	LBES Mid SBES Mid	1.00	1.00	n/a	n/a	n/a	0.413	0.747
E21C1c046 E21C2c046	Midstream Heat Pump Water Heater, 80 gallons	LBES Mid SBES Mid	1.00	1.00	n/a	n/a	n/a	0.413	0.747
E21C1c045 E21C2c045	Midstream Heat Pump Water Heater, 50 gallons	LBES Mid SBES Mid	1.00	1.00	n/a	n/a	n/a	0.413	0.747
G21C1c009 G21C2c009	Midstream Indirect Water Heater	LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1c010 G21C2c010	Midstream on Demand Tankless Water Heater, Gas	LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1c011 G21C2c011	Midstream Volume Water Heater, Gas	LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a
G21C1c012 G21C2c012	Midstream Condensing Gas Water Heater	LBES Mid SBES Mid	1.00	n/a	1.00	n/a	n/a	n/a	n/a

<u>In-Service Rates:</u>

All installations have a 100% in-service rate unless an evaluation finds otherwise.

<u>Realization Rates:</u>

All programs use a 100% realization rate unless an evaluation finds otherwise.

<u>Coincidence Factors:</u>

A summer coincidence factor of 43.1% and a winter coincidence factor of 74.7% are utilized.

Energy Load Shape:

For heat pump water heaters, see Appendix 1 – " Water Heater - Heat Pump".
For all remaining water heaters, see Appendix 1 – " Water Heater – Natural Gas/Fuel Oil".

Impact Factors for Calculating Net Savings (Upstream/Midstream Only):[5,7]

BC Measure ID	Measure Name	Program	FR	SO_P	SO_{NP}	2021 NTG
E21C1c044 E21C2c044 E21C1c045 E21C2c045 E21C1c046 E21C2c046	Midstream Heat Pump Water Heater, 120 gallons Midstream Heat Pump Water Heater, 80 gallons Midstream Heat Pump Water Heater, 50 gallons	LBES Mid SBES Mid	22.5%	8.5%	0.0%	86%
G21C1c009 G21C2c009	Midstream Indirect Water Heater	LBES Mid SBES Mid	70.00%	0.0%	0.0%	30.00%
G21C1c010 G21C2c010	Midstream on Demand Tankless Water Heater	LBES Mid SBES Mid	40.0%	0%	0.0%	60.00%
G21C1c011 G21C2c011	Midstream Volume Water Heater	LBES Mid SBES Mid	40.0%	0%	0.0%	60.00%
G21C1c012 G21C2c012	Midstream Condensing Gas Water Heater	LBES Mid SBES Mid	70.00%	0%	0.0%	30.00%

Endnotes:

1: Title 10, Code of Federal Regulations, Part 430 - Energy Conservation Program for Consumer Products, Subpart C - Energy and Water Conservation Standards and Their Effective Dates. January 1, 2010; Energy Conservation standards for Residential Water Heaters, Direct Heating Equipment, and Pool Heaters: Final Rule, Federal Register, 75 FR 20112, April 16, 2010

2: Savings for indirect water heaters are based on: KEMA, June 27, 2013. Impact Evaluation of 2011 Prescriptive Gas Measures Final Report. https://ma-eeac.org/wp-content/uploads/Impact-Evaluation-of-2011-Prescription-Gas-Measures-6.27.13.pdf

For volume and tankless water heaters, savings are based on: Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures. 2019 Plan-Year Report Version. May 2020.

3: GDS Associates, Inc. (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks;

4: Hewitt, D. Pratt, J. & Smith, G., December 2005. Tankless Gas Water Heaters: Oregon Market Status. Prepared for the Energy Trust of Oregon. https://www.energytrust.org/wp-content/uploads/2016/11/051206_TanklessGasWaterHeaters0.pdf

5: NMR, DNV GL, and Tetra Tech, August 2018. Massachusetts Sponsors' Commercial and Industrial Programs Free-ridership and Spillover Study. Prepared for Massachusetts Program Administrators. http://ma-eeac.org/wordpress/wp-content/uploads/TXC_49_CI-FR-SO-Report_14Aug2018.pdf

6: Navigant Consulting (2018). Water Heating, Boiler, and Furnace Cost Study (RES 19) Add-On Task Residential Water Heater Analysis Memo. 2018 Navigant Water Heater Analysis Memo

7: DNV GL, NMR, Tetra Tech (2018) Massachusetts Commercial and Industrial Upstream HVAC/Heat Pump and Hot Water NTG and Market Effects Indicator Study. https://ma-eeac.org/wp-content/uploads/TXC_35_Report_5Sep2018_FINAL.pdf

Appendix 1: Energy Load Shapes

The section includes a table or reference with the time-of-use pattern of a typical customer's electrical energy consumption for each segment and end use. Because the value of avoided energy varies throughout the year, load shapes are used to allocate energy savings into specific time periods in order to better reflect its time-dependent value. Load shapes are defined as follows based on ISO-NE definitions:

- Summer On-Peak: 7 am to 11 pm, weekdays, during the months of June through September, except ISO-NE holidays;
- Summer Off-Peak: All other hours during the months of June through September (includes weekends and holidays);
- Winter On-Peak: 7 am to 11 pm, weekdays, during the months of October through May, except ISO-NE holidays; and
- Winter Off-Peak: All other hours during the months of October through May (includes weekends and holidays).

Table A1.1. Residential Energy Load Shapes

Load Shape Description	Total Energy			
	Summer		Winter	
	On Peak	Off Peak	On Peak	Off Peak
Non-Electric Measures	0.0%	0.0%	0.0%	0.0%
Clothes Washer	18.3%	15.4%	36.4%	29.9%
24-hour operation	15.2%	18.3%	30.5%	36.1%
Clothes Dryer - Electric	16.9%	14.2%	38.9%	30.0%
Clothes Dryer - Natural Gas	15.9%	16.4%	37.6%	30.1%
Hardwired Electric Heat	0.0%	0.0%	43.1%	56.9%
Lighting	19.0%	15.1%	35.1%	30.7%
Primary TV and Peripherals	15.4%	17.6%	32.2%	34.8%
Primary Desktop Computer	17.5%	17.3%	33.5%	31.7%
Primary Refrigerator	18.2%	20.9%	29.0%	31.9%
Secondary Refrigerator	19.9%	23.6%	26.3%	30.2%
Freezer	17.1%	20.7%	28.7%	33.6%
Dehumidifier	24.9%	29.7%	22.0%	23.3%
Pool Pump	54.5%	38.2%	4.9%	2.4%
Dishwasher	14.8%	16.3%	34.1%	34.8%
Water Heater - Electric	15.2%	11.9%	41.5%	31.4%
Water Heater - Heat Pump	14.9%	13.0%	39.1%	33.0%
Water Heater - Natural Gas/Fuel Oil	13.3%	11.6%	40.9%	34.2%
Central Air Conditioner/Heat Pump (Cooling)	47.3%	42.2%	6.6%	3.8%

Room or Window Air Conditioner	47.5%	47.4%	2.9%	2.2%
Mini-Split Air Conditioner/Heat Pump (Cooling)	43.4%	40.2%	7.4%	9.0%
Mini-Split Heat Pump (Heating)	0.0%	0.0%	42.9%	57.1%
Furnace Fan	0.0%	0.0%	44.6%	55.4%
Boiler Distribution	0.0%	0.0%	45.0%	55.0%
Weighted HVAC - All Homes	23.2%	21.7%	25.4%	29.7%
Weighted HVAC - Multi-family	25.2%	23.7%	23.2%	27.9%
Weighted HVAC - Multi-family Low Income	22.4%	21.6%	25.4%	30.6%
Weighted HVAC - Single Family	22.5%	20.8%	26.1%	30.5%
Weighted HVAC - Single Family Low Income	23.1%	21.7%	25.3%	29.9%
Central Heat Pump	10.1%	9.0%	35.1%	45.7%
DMSHP	8.0%	7.4%	36.4%	48.2%
Electric Resistance with AC	6.0%	5.0%	45.0%	44.0%

Source: Navigant (2018). RES1 Demand Impact Model Update

Table A1.2. Commercial and Industrial Energy Load Shapes

C&I energy load shapes, except where noted in the chapters, are derived from site-level metering of project sites in MA. See DNV GL, 2018. P72 Prescriptive C&I Load shapes of Savings.

Load Shape Description	Total Energy			
	Summer		Winter	
	On Peak	Off Peak	On Peak	Off Peak
C&I Compressed Air - VFD Compressor	26.5%	23.7%	25.9%	23.9%
C&I Compressed Air - Air Dryer	22.4%	27.7%	21.7%	28.1%
C&I Electric Chiller (Combined)	39.4%	38.5%	11.3%	10.8%
C&I Electric Cooling Unitary Equipment	52.7%	34.1%	8.6%	4.6%
C&I Exterior Lighting	19.2%	29.0%	20.1%	31.6%
C&I Interior Lighting - Prescriptive	34.3%	18.1%	30.3%	17.4%
C&I Interior Lighting - Custom	32.3%	19.4%	29.8%	18.6%
C&I Lighting Controls	32.1%	17.7%	31.3%	19.0%
C&I Refrigeration	23.3%	26.8%	22.6%	27.3%
C&I VFDs (Combined)	23.8%	25.3%	23.7%	27.2%
C&I Food Services	16.0%	17.0%	32.0%	35.0%
C&I Heating & Cooling	34.9%	22.1%	26.4%	16.6%