Introduction

This *Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures* ("TRM") documents for regulatory agencies, customers, and other stakeholders how the energy efficiency Program Administrators ("PAs") 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.

This document is available in an electronic database that allows interested parties to access reports and data in a consistent and easily accessible format. The electronic reports are accessible online via this link[1].

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.

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.

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 non-energy impacts (such as water savings or operation and maintenance cost savings). Data assumptions are based on Massachusetts PA data where available. Where Massachusetts-specific data is not available, assumptions may be based on: 1) manufacturer and industry data, 2) a combination of the best available data from jurisdictions in the same region, or 3) 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.

[1] https://etrm.anbetrack.com/#/workarea/home?token=6d6c45766e692f527044

TRM Update Process

Overview

This section describes the process for updating this document. The update process is synchronized with the filing of Three-Year Plans and Plan-Year/Term Reports by the PAs with the Department of Public Utilities ("Department").

Updates can include:

- additions of new measures;
- updates to existing measures due to:
    - changes in baseline equipment or practices, affecting measure savings
    - changes in efficient equipment or practices, affecting measure savings
    - changes to deemed savings due the revised assumptions for algorithm parameter values (e.g., due to new market research or evaluation studies)
    - other similar types of changes;
- updates to impact factors (e.g., due to new impact evaluation studies);
- discontinuance of existing measures; and
- updates to the glossary and other background material included in this document.

Each report edition is associated with a specific program year, which corresponds to the calendar year. This document is updated over time as needed to plan for future program savings.

Key Stakeholders and Responsibilities

Key stakeholders and their responsibilities for the TRM updates are detailed in the following table.

Stakeholder	Responsibilities
Coordinating Committee	Administrative coordination of activities, including: Assure collaboration and consensus by the PAs regarding updates Assure updates are compiled from the PAs and incorporated Coordinate with related program activities (e.g., evaluation and program reporting processes)
Program Administrators	Provide one or two representatives to the Coordinating Committee. Both the planning and evaluation functions should be represented on the Committee. Identify needed updates Coordinate with other PAs on all updates File updates with the Department
Department of Energy Resources	Provide one representative to the Coordinating Committee Assure coordination with PA submissions of program plans and reported savings

Update Cycle

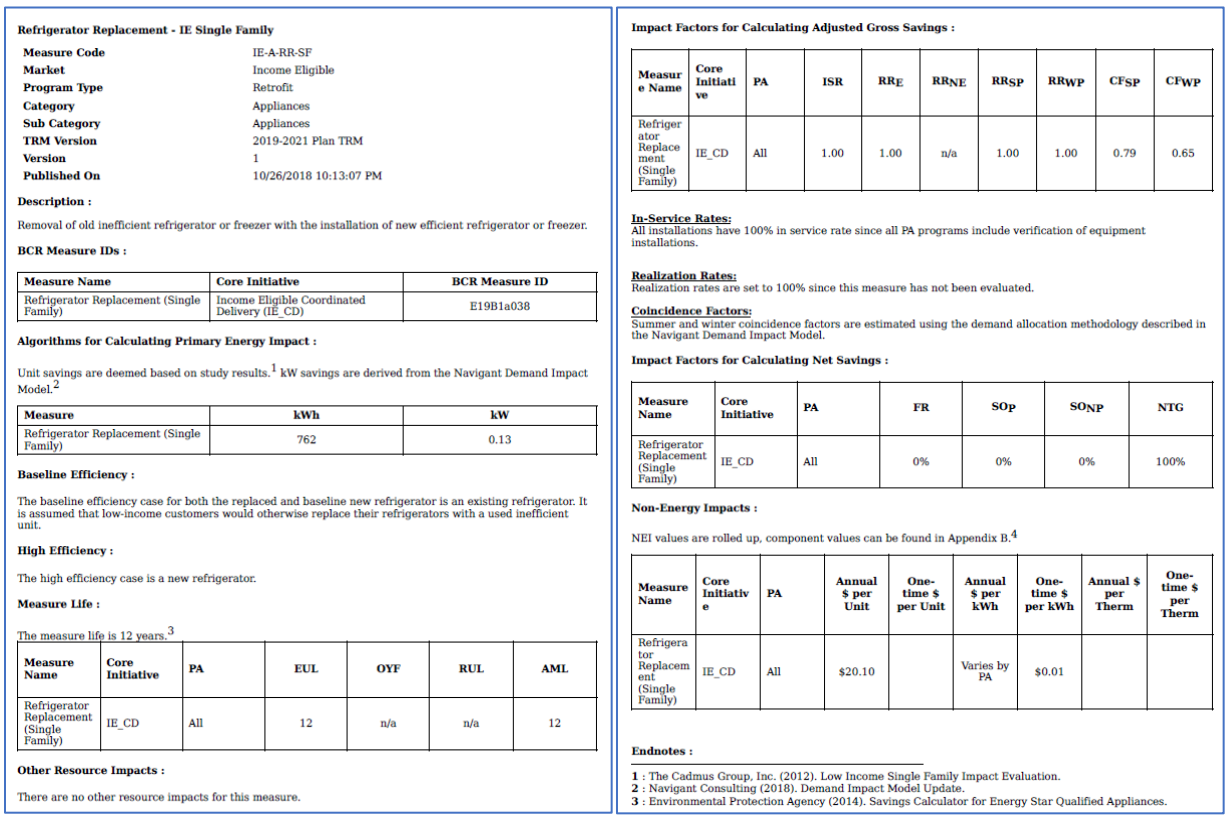
Per the Department, starting in 2022, new evaluation results will be applied on a prospective only basis instead of being applied both retrospectively and prospectively. The PAs will update gross savings assumptions and net and gross impact factors each year based on the latest evaluation studies and apply them on a prospective basis to calculate savings in subsequent years. At the beginning of each year, the latest TRM will be posted on Mass Save Data at this link.[2]

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 should be properly referenced.

The image below shows how a measure appears in this document and in the electronic report format. Each section of this measure report is described in more detail below.



Refrigerator Replacement - IE Single Family

Measure Code	IE-A-RR-SF
Market	Income Eligible
Program Type	Retrofit
Category	Appliances
Sub Category	Appliances
TRM Version	2019-2021 Plan TRM
Version	1
Published On	10/26/2018 10:13:07 PM

Description :

Removal of old inefficient refrigerator or freezer with the installation of new efficient refrigerator or freezer.

BCR Measure IDs :

Measure Name	Core Initiative	BCR Measure ID
Refrigerator Replacement (Single Family)	Income Eligible Coordinated Delivery (IE_CD)	E19B1a038

Algorithms for Calculating Primary Energy Impact :

Unit savings are deemed based on study results.[1] kW savings are derived from the Navigant Demand Impact Model.[2]

Measure	kWh	kW
Refrigerator Replacement (Single Family)	762	0.13

Baseline Efficiency :

The baseline efficiency case for both the replaced and baseline new refrigerator is an existing refrigerator. It is assumed that low-income customers would otherwise replace their refrigerators with a used inefficient unit.

High Efficiency :

The high efficiency case is a new refrigerator.

Measure Life :

The measure life is 12 years.[3]

Measure Name	Core Initiative	PA	EUL	OYF	RUL	AML
Refrigerator Replacement (Single Family)	IE_CD	All	12	n/a	n/a	12

Other Resource Impacts :

There are no other resource impacts for this measure.

Impact Factors for Calculating Adjusted Gross Savings :

Measure Name	Core Initiative	PA	ISR	RR_E	RR_{NE}	RR_{SP}	RR_{WP}	CF_{SP}	CF_{WP}
Refrigerator Replacement (Single Family)	IE_CD	All	1.00	1.00	n/a	1.00	1.00	0.79	0.65

In-Service Rates:
All installations have 100% in service rate since all PA programs include verification of equipment installations.

Realization Rates:
Realization rates are set to 100% since this measure has not been evaluated.

Coincidence Factors:
Summer and winter coincidence factors are estimated using the demand allocation methodology described in the Navigant Demand Impact Model.

Impact Factors for Calculating Net Savings :

Measure Name	Core Initiative	PA	FR	SO_P	SO_{NP}	NTG
Refrigerator Replacement (Single Family)	IE_CD	All	0%	0%	0%	100%

Non-Energy Impacts :

NEI values are rolled up, component values can be found in Appendix B.[4]

Measure Name	Core Initiative	PA	Annual $ per Unit	One-time $ per Unit	Annual $ per kWh	One-time $ per kWh	Annual $ per Therm	One-time $ per Therm
Refrigerator Replacement (Single Family)	IE_CD	All	$20.10		Varies by PA	$0.01		

Endnotes :

1 : The Cadmus Group, Inc. (2012). Low Income Single Family Impact Evaluation.
2 : Navigant Consulting (2018). Demand Impact Model Update.
3 : Environmental Protection Agency (2014). Savings Calculator for Energy Star Qualified Appliances.

[2] https://www.masssavedata.com/Public/TechnicalReferenceLibrary

Measure Summary

This section includes a high-level categorization of the energy efficiency measure:

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, Category, and Sub-Category: A way of categorizing similar measures.

TRM Version and Version: Indicates that information is for the 2022-2024 TRM and allows for differentiation between versions for potential future updates.

Published On: Date that the measure was published.

01: Description

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

02: BCR Measure IDs

This section provides an overview of all individual measures to which the TRM entry applies, including:

BCR Measure Name: <Name used in PAs Benefit-Cost models >
Core Initiative: <Per PA definition, also referred to as Program Name>
BCR Measure ID: <Unique ID used in PAs Benefit-Cost models>

03: 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 summarize electric and non-electric savings in a table that contains the following information:

BCR Measure Name: <Name used in PAs Benefit-Cost models >
Core Initiative: <Per PA definition, 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>

04: 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.

05: 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.

06: Measure Life

Measure Life includes equipment life, and the effects of measure persistence. Equipment life is the number of years that a measure is installed and will operate until failure. Measure persistence takes into account business turnover, early retirement of installed equipment, and other reasons measures might be removed or discontinued. As applicable, this section may include a table with the following information:

EUL: <Effective Useful Life>
OYF: <Out Year Factor>
RUL: <Remaining Useful Life>
AML: <Adjusted Measure Life>

07: Other Resource Impacts

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

08: 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.

09: Impact Factors for Calculating Net Savings

This section includes a table of impact factors for calculating net savings. These includes free ridership, spillover, and/or net-to-gross ratio. Further descriptions of the impact factors and the sources on which they are based are described below.

Initiative/Program Names

The mapping of full core initiative names to abbreviated names is given below.

Sector	Full Core Initiative Name	Abbreviation
Residential	A1a - Residential New Homes & Renovations	RES_NH&R
	A2a - Residential Coordinated Delivery	RES_CD
	A2c - Residential Retail	RES_RETAIL
	A2d - Residential Behavior	RES_BEHVR
	A2e - Residential Active Demand Reduction	RES_ADR
Income Eligible	B1a - Income Eligible Coordinated Delivery	IE_CD
	B1b -Income Eligible Active Demand Reduction	IE_ADR
C&I	C1a - C&I New Buildings & Major Renovations	CI_NB&MR
	C2a - C&I Existing Building Retrofit	CI_RETRO
	C2b - C&I New & Replacement Equipment	CI_EQUIP
	C2c - C&I Active Demand Reduction	CI_ADR

Impact Factors for Calculating Adjusted Gross and Net Savings

PAs 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 estimate 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 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. Definitions of the impact factors and other terms are also provided in Appendix D: Glossary.

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")
- Savings Persistence Factor ("SPF")
- 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 **savings persistence factor** is the portion of first-year energy or demand savings expected to persist over the life of the energy efficiency measure. The SPF is developed by conducting surveys of installed equipment several years after installation to determine the actual operational capability of the equipment. The SPF is 1.00 for most measures.

In contrast to savings persistence, *measure persistence* takes into account business turnover, early retirement of installed equipment, and other reasons the installed equipment might be removed or discontinued. Measure persistence is generally incorporated as part of the measure life, and therefore is not included as a separate impact factor.

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 both the on-peak and seasonal peak periods 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:
- 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:
- 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." 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.

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** (SO_P) and **non-participant spillover** (SO_{NP}).

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.

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.

Standard Net-to-Gross Formulas

The TRM measure entries provide algorithms for calculating the gross savings for those efficiency measures. The following standard formulas show how the impact factors are applied to calculate the adjusted gross savings, which in turn are used to calculate the net savings. These are the calculations used by the PAs to track and report gross and net savings. The gross savings reported by the PAs are the unadjusted gross savings without the application of any impact factors.

Calculation of Net Annual Electric Energy Savings

$$adj\_gross\_kWh = gross\_kWh \times RR_E \times SPF \times ISR$$
$$net\_kWh = adj\_gross\_kWh \times NTG$$

Calculation of Net Summer Electric Peak Demand Coincident kW Savings

$$adj\_gross\_kW_{SP} = gross\_kW \times RR_{SP} \times SPF \times ISR \times CF_{SP}$$
$$net\_kW_{SP} = adj\_gross\_kW_{SP} \times NTG$$

Calculation of Net Winter Electric Peak Demand Coincident kW Savings

$$adj\_gross\_kW_{WP} = gross\_kW \times RR_{WP} \times SPF \times ISR \times CF_{WP}$$
$$net\_kW_{WP} = adj\_gross\_kW_{WP} \times NTG$$

Calculation of Net Annual Natural Gas Energy Savings

$$adj\_gross\_MMBtu = gross\_MMBtu \times RR_{NE} \times SPF \times ISR$$
$$net\_MMbtu = adj\_gross\_MMBtu \times NTG$$

Depending on the evaluation study methodology:

- NTG is equal to $(1 - FR + SO_P + SO_{NP})$, or
- NTG is a single value with no distinction of FR, SO_P, SO_{NP}, and/or other factors that cannot be reliably isolated.

Where:

$Gross\_kWh$ = Gross Annual kWh Savings

adj_gross_kWh = Adjusted Gross Annual kWh Savings

net_kWh = Net Annual kWh Savings

$Gross\_kW_{SP}$ = Gross Connected kW Savings (summer peak)

$adj\_gross\_kW_{SP}$ = Adjusted Gross Connected kW Savings (summer peak)

$Gross\_kW_{WP}$ = Gross Connected kW Savings (winter peak)

$adj\_gross\_kW_{WP}$ = Adjusted Gross Connected kW Savings (winter peak)

net_kW_{SP} = Adjusted Gross Connected kW Savings (summer peak)

net_kW_{WP} = Net Coincident kW Savings (winter peak)

$Gross\_MMBtu$ = Gross Annual MMBtu Savings

adj_gross_MMBtu = Adjusted Gross Annual MMBtu Savings

net_MMBtu = Net Annual MMBtu Savings

SPF = Savings Persistence Factor

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

NTG = Net-to-Gross Ratio

FR = Free-Ridership Factor

SO_P = Participant Spillover Factor

SO_{NP} = Non-Participant Spillover Factor

Calculations of Coincident Peak Demand kW Using "Seasonal Peak" Coincidence Factors

The formulas above for peak demand kW savings use the "on-peak" Coincidence Factors: (CF_{SP}, CF_{WP}), which apply the "on-peak" coincidence methodology as allowed for submission to the FCM. The alternative methodology is the "seasonal peak" methodology, which uses the identical formulas, but substituting the "seasonal peak" Coincidence Factors for the "on-peak" coincidence factors:

CF_{SSP} = Peak Coincidence Factor for Summer Seasonal Peak

CF_{WSP} = Peak Coincidence Factor for Winter Seasonal Peak