State of Rhode Island:
Energy Efficiency Programs Evaluation Study

Task 2 Report: TRM Benchmarking & Best Practices Review of Evaluation Studies

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Contents

1 Introduction

The overarching goal of Energy Efficiency Programs Evaluation Study conducted by the BrightLine team is to understand whether there are improvements that can be made to the current evaluation measurement and verification (EM&V) process for National Grid's energy efficiency programs. The study is categorized into three tasks each with their own key objective:

- The key objective of Task 1 is to assess "Does the current Evaluation, Measurement, and Verification (EM&V) process in Rhode Island comply with national industry best practices for programs of its size and scope?"
- The key objective of Task 2 is to understand "Quantitatively, to what extent are National Grid's claimed energy savings accurate?"
- The key objective of Task 3 is to assess "Are there savings estimation and program implementation improvements that can be identified to help customers that have or are likely to experience a substantial difference in estimated gross energy savings versus installed gross energy savings and visible bill savings?"

This report presents outcomes from Task 2 wherein the BrightLine team reviewed the evaluation, measurement and verification (EM&V) methods employed by National Grid. The BrightLine team took a comprehensive look at the evaluation methodologies used for National Grid's energy efficiency programs, documented methods utilized and highlighted areas for improvement. Measures prioritized for review included those that contribute a majority of savings (at least 60%) within each customer class and fuel type. Research activities included the following:

- Catalog previous evaluations
- Review Rhode Island's Technical Reference Manual[1] (TRM) algorithm and assumptions
- Review previous evaluation reports for alignment with EM&V best practices
- Develop recommendations

The BrightLine team, with input from National Grid and the EE Study Working Group, identified and catalogued the evaluation studies that included the priority measures as part of the study and that were conducted within the past 4 years. All identified evaluation reports were included in the BrightLine team's review, which focused on the studies' alignment with EM&V best practices.

[1] A Technical Reference Manual is a resource used to help plan and evaluate energy efficiency programs and typically outline how much energy can be expected to be saved for certain energy efficiency and demand response measures, either through well documented stipulated (deemed) savings values or engineering algorithms.

Section 2 of this report presents outcomes of the team's review of TRM algorithms and assumptions. Graphical summary results from the BrightLine team's TRM review are presented in Appendix A. Section 3 of the report presents findings from the review of previous evaluation reports for alignment with EM&V best practices. Section 4 lays out overall conclusions and recommendations gleaned from Task 2 activities.

Overall, the BrightLine team finds that National Grid is following evaluation best practices, including regularly updating savings estimates for program-funded measures, and producing high quality evaluation reports that are based on robust research methods, sampling and analysis. Through the TRM benchmarking study the team identified a small number of measures that could benefit from updated savings estimates (small business showerheads, refrigerated case lighting, exit signs), or greater transparency of assumptions (LED Screw-in A-Lamp for single family retrofits and upstream lighting). Based on the TRM benchmarking effort the BrightLine team also recommends that National Grid increase transparency moving forward to allow those using the TRM to align assumptions more easily with source data. Increased transparency could include clearer directions on the source documentation referenced for assumptions such as hours of use and baseline information, and clearer direction on the application of realization rates for deemed savings values. Limitations in transparency makes it difficult to pinpoint which contributing values should be given additional consideration. In addition, Rhode Island could consider organizing its TRM by equipment or measure rather than its current format, which is organized by program. We understand that jurisdictions organize their TRMs in a way that best fits their needs and program, however, in general, the BrightLine team found the RI TRM difficult to navigate due to its current organizational structure.

The BrightLine team's review of past evaluation reports find that National Grid's procured evaluations are generally high-quality work products that adhere to industry standards and provide valuable insights to inform future program planning and implementation. The team identified minor issues warranting attention. Those minor issues pertained to sample design targets, assumptions or achieved confidence intervals that could have been more clearly described, and studies that could have benefited from additional actionable recommendations

2 TRM Algorithm and Assumptions Review

2.1 Benchmarking Task Overview

One objective of Task 2 is to document how savings were calculated for major contributors to National Grid's portfolio energy savings and to highlight areas for improvement. To do this, we focused on the calculation of savings for those measures that contributed approximately 60% of the savings within each customer class and fuel type, which are listed in Table 1.

Table 1: Priority Measures

Sector	Fuel Type	Program	Measure	% Savings Contribution
Residential	Electric	EnergyWise Single Family	LED Bulbs	8.8%
Residential	Electric	EnergyWise Single Family	LED Fixtures	
Residential	Electric	Opower	Opower	22.2%
Residential	Electric	Residential Lighting	CFL Bulbs	7.3%
Residential	Electric	Residential Lighting	CFL Fixtures	
Residential	Electric	Residential Lighting	LED Bulbs	48.6%
Residential	Electric	Residential Lighting	LED Fixtures	
Residential	Electric	Total		86.9%
Residential	Gas	EnergyWise Single Family	Weatherization	21.3%
Residential	Gas	Opower	Opower	47.8%
Residential	Gas	Total		69.1%
Low-Income	Electric	Income Eligible Multifamily	LED Bulbs	33.7%
Low-Income	Electric	Income Eligible Multifamily	LED Fixtures	
Low-Income	Electric	Income Eligible Services	LED Bulbs	30.1%
Low-Income	Electric	Total		63.8%
Low-Income	Gas	Income Eligible Multifamily	HVAC	17.5%
Low-Income	Gas	Income Eligible Multifamily	Weatherization	16.7%
Low-Income	Gas	Low Income Services (1-4 SF)	Weatherization	29.8%
Low-Income	Gas	Total		64.0%
Small Business	Electric	-	Prescriptive Lighting	76.7%
Small Business	Electric	Total		76.7%
Small Business	Gas	-	Aerator	23.7%
Small Business	Gas	-	Custom	21.6%
Small Business	Gas	-	Showerhead	24.1%
Small Business	Gas	Total		69.4%
Commercial & Industrial	Electric	Custom	Lighting	14.1%
Commercial & Industrial	Electric	LCI Upstream Lighting	LED Upstream Lighting	12.3%
Commercial & Industrial	Electric	Prescriptive	Lighting	28.9%
Commercial & Industrial	Electric	Prescriptive	Lighting Controls	4.2%
Commercial & Industrial	Electric	Total		59.5%
Commercial & Industrial	Gas	Custom	Comprehensive Design Assistance	6%
Commercial & Industrial	Gas	Custom	HVAC	21%
Commercial & Industrial	Gas	Custom	Process Improvements	11%
Commercial & Industrial	Gas	Custom	Steam Traps	16%
Commercial & Industrial	Gas	Prescriptive	Steam Traps	9%
Commercial & Industrial	Gas	Total		63%

Of the 30 measures listed, savings for 20 of the measures are calculated based on TRM algorithms and assumptions (deemed assumptions or site-specific assumptions), which are explained in more detail in the next section. Readers less familiar with the role of TRMs can find an explanation of TRMs in Section 2.2. The process of TRM benchmarking allows us to compare these well-researched algorithms and values with those dictated in TRMs in other jurisdictions. The value of this exercise is two-fold: it allows us to **identify measures and parameters that may rely on outdated or insufficient assumptions** based on their alignment with the research of peers, and by including five years of Rhode Island TRMs, it also allows us to **determine whether or not evaluation results have appropriately been incorporated into the Rhode Island TRMs**.

The BrightLine team benchmarked the 2016 – 2020 Rhode Island TRMs against the 22 TRMs listed below. The list includes all TRMs ranked in the top 10 in the American Council for an Energy Efficient Economy's (ACEEE) 2019 State Energy Efficiency Scorecard[2], all TRMs governing jurisdictions in the same climate zone as Rhode Island (this is discussed in greater detail below), all TRMs providing guidance for New England states[3], and any other TRMs updated recently enough to govern rebate programs launched in 2018. Those TRMs that are publicly available are the most recent versions available in their jurisdictions; others that have been provided privately to our team are not otherwise as easily accessible and may not be the current TRM in practice for the particular jurisdiction.

Table 2: TRMs Benchmarked for this Study

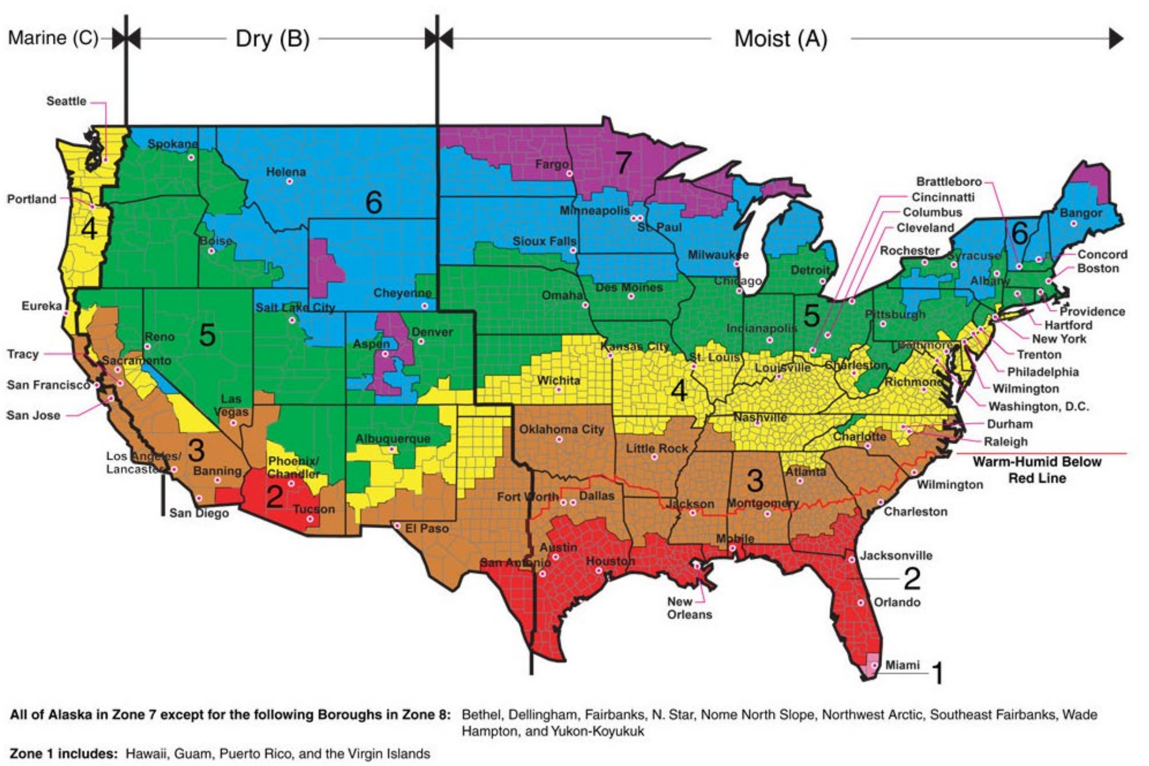
Ameren Missouri TRM, 2017	Maine TRM, 2017
Arkansas TRM V7, 2017	**Massachusetts TRM, 2016**
California Municipal Utilities TRM, 2016	**Michigan Master Measures Database, 2020**
Connecticut 11th Edition, 2016	**MidAtlantic TRM V8.0, 2018**
DC Sustainable Energy TRM, 2017	Minnesota TRM V2.1, 2018
Delaware TRM, 2016	**Missouri Statewide TRM, 2017**
Hawaii Energy TRM, 2018	**New Jersey Protocols, 2016**
IESO Measures & Assumptions List, 2019	**New York TRM V7, 2019**
Illinois TRM V7.0, 2019	**Ohio TRM, 2010**
Indiana TRM V1.0, 2013	**Pennsylvania TRM, 2021**
Iowa Statewide TRM V3.0, 2018	**Vermont TRM No. 2014-87, 2015**

For lighting measures, all TRMs listed above were included in the benchmarking exercise. However, the remaining measures (aerators, showerheads, steam traps, HVAC, and weatherization measures) rely on parameters that vary based on weather. The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) provides climate zone designations for weather-dependent calculations as shown in Figure 1. Per the map, Rhode Island falls within ASHRAE climate zone 5A. Those TRMs above that also pertain to climate zone 5A are notated in bold (15 of the 22 total TRMs). These are the only TRMs included in the benchmarking of weather-dependent measures.

[2] The State Energy Efficiency Scorecard ranks states on their policy and program efforts. It assesses performance, documents best practices, and recognizes leadership. The report captures the latest policy developments and state efforts to save energy and highlights opportunities and policy tools available to governors, state legislators, and regulators. ACEEE's full report can be accessed at the following link: https://www.aceee.org/sites/default/files/publications/researchreports/u1908.pdf

[3] New Hampshire is the only New England state that does not appear on the list as New Hampshire does not currently maintain its own Technical Reference Manual.

Figure 1: ASHRAE Climate Zone Map



2.2 Understanding TRMs

A TRM outlines how to quantify the energy savings associated with energy efficiency and demand response measures in a given jurisdiction. TRMs are often developed to be applicable statewide, governing multiple utilities that can choose to offer or not offer any of the measures described. In other cases, rebating entities themselves will create their own TRM where they feel it better captures the unique operating characteristics and associated energy savings within their specific region or customer base.

Each TRM contains a list of available energy efficiency and demand response measures, and each measure has an explicitly stated method for calculating savings:

- Deemed Savings: Savings are set per "measure unit" regardless of the unique operating characteristics that contribute to the actual savings achieved by the implementation of the measure, for example;

  kWh Savings = 7 kWh per LED lamp installed

- Calculated Savings: Savings are calculated based on the TRM algorithm provided and some accompanying assumed variables given one or multiple other unique input parameters, for example;

  *kWh Savings = (Baseline Lamp Wattage – Installed LED Wattage) * Annual Operating Hours*

> *Where any or all of the three variables might be collected on a per-unit basis, and any variables not collected would be assumed to be a TRM-dictated value, or "assumption"*

TRM algorithms and assumptions are created based on extensive research coupled with data collected through previous program participation and/or evaluations. While the algorithms and assumptions are believed to have a high level of confidence, they may vary regionally as appropriate to reflect the general trends of the customer base and regional norms. For example, lighting measures commonly include calculations that take into account the additional heating load on an HVAC system due to the lowered waste heat from the lighting upgrade; given that heating fuel types vary regionally, the quantification of those penalties will likely vary to properly reflect the heating fuel mix and associated HVAC equipment of the region.

Other variations in TRM algorithms and assumption may reflect a desired level of rigor (e.g., if a particular measure does not contribute much savings to the overall portfolio, collecting extensive data on it may be cost prohibitive), the availability of necessary data (e.g., if incentives are offered through a product distributor, specific operating characteristics such as annual hours of use of each measure unit may be unavailable), or a tradeoff between data quality and the accuracy of the savings calculations (e.g., if calculations rely on parameters that are not common knowledge, such as the efficiency rating of a hot water heater installed), accuracy of calculated savings would be negatively affected by incorrect inputs and would then be unreliable for any other use.

2.3 Understanding the Results

The TRM benchmarking task was completed using a proprietary tool designed for such analysis. The output of the tool includes the following details in infographic format (see Appendix A for graphic summary results):

- Common Algorithm: The common algorithm is determined by evaluating all equations for a particular measure from all TRMs and including all variables, effectively creating the "long form" of the single equation used in all TRMs. Where TRMs do not use particular terms within the common algorithm, the value associated with that term is then listed as N/A and omitted from the calculation. This might happen when one TRM is applicable only to electric measures and another is applicable to both gas and electric; where both gas and electric equipment types might exist, calculation of electric only savings will require an additional parameter that estimates the likelihood that the equipment is indeed electrically fueled. Where algorithms are fundamentally different, multiple "common algorithms" will be displayed.This might happen when TRMs are designed for differing availabilities of data such as one requiring blower door testing results to be provided by an accredited contractor versus another relying on input parameters that can be gleaned from product packaging and specifications.
- TRM Availability: This section shows how each of the analyzed TRMs and the 5 Rhode Island TRMs offer the measure in question, which could either be deemed, calculated, or not offered.

- Offering Overview: This section shows the breakdown of how often the measure is offered through a deemed track versus a calculated track for all TRMs offering the measure (excluding Rhode Island).
- Deemed Savings Comparison: This section provides a histogram detailing the frequency of the deemed or calculated savings values. The value associated with the most recent Rhode Island TRM to offer the measure is provided in blue on top of the histogram for reference.
- Key Parameters: This section provides a comparison of the Rhode Island deemed values or assumptions to the mean value across all TRMs for the key parameters contributing to the measure's savings.
- Key Parameter Comparison: Similar to the Deemed Savings Comparison section, this section provides histograms for important key parameters, highlighting the most recent Rhode Island value on top of the distribution of values from other TRMs.

The infographic printouts are designed for quick reference and do not contain all details contributing to the analysis. For additional detail, Section 2.4 of this report presents table comparisons of the TRM parameters for all priority measures. The table for each measure contains the following rows:

- Input Value: For measures that rely on calculated savings it is necessary to input particular values into the algorithm. For example, for lighting measures, many TRMs calculate savings on a per-project basis for the specific wattage of the lamp installed. Therefore, an input is required (i.e. the installed lamp wattage). In such an example, the row of the table titled "Input Value" shows the value that has been input into the equation. By default, the benchmarking tool overwrites all TRM values with the input value so that the savings displayed are representative of like measures (i.e. a 10-watt bulb across the board). However, for measures that rely on deemed saving, the overwriting of any one parameter will not change savings, as the savings don't rely on the inputs provided. This is to say that if savings are deemed at 40 kWh, the savings will show 40 kWh whether the installed lamp wattage shows 10W or 50W. Instances in which savings are deemed and are therefore not affected by input values are indicated in the tables with a superscript D next to each TRM where the savings are deemed.
- TRMs: The main body of the table provides the TRM assumptions contributing to the calculated or deemed savings for each TRM offering the measure, as well as the savings (kWh or MMBtu) in the final column.
- Mean: The first grey shaded row indicates the mean of the parameters referenced in the column header. The mean represents the mathematical average of all the values listed above in the table. By design, this does not factor Rhode Island's values into the calculation.
- Median: The second grey shaded row indicates the median of the parameters referenced in the column header. The median represents the midpoint of all values listed above in the table and is a measure of central tendency that helps to mitigate the possibility of bias introduced by outliers. By design, this does not factor Rhode Island's values into the calculation.

- Zone 5A Mean: The third grey shaded row indicates the mean of the parameters referenced in the column header, but only includes the values from TRMs within the Zone 5A region, which is the ASHRAE climate zone to which Rhode Island belongs.
- Rhode Island Values: Rhode Island TRM values for comparison are provided in the bottom five rows of the table for the 2016, 2017, 2018, 2019, and 2020 TRMs.

Note that light blue shaded rows represent jurisdictions that fall within the same ASHRAE climate zone as Rhode Island.

2.4 Benchmarking Results

As is evidenced by the results presented herein, TRMs vary widely as needed to accommodate the energy efficiency programs they govern. The compiled TRM algorithms and assumptions are presented in the following subsections to show comparisons and contrasts between National Grid's TRM and the TRMs chosen for benchmarking. Section 2.5 provides recommendations for improvements or revisions to the National Grid TRM, where calculation processes deviate from industry standards in terms of quantifying or not quantifying particular contributions to savings or TRM granularity.

Note that for a few measures outlined herein, the Rhode Island TRM includes a realization rate for the measure. It is our understanding that the realization rates have not been applied to the deemed savings values listed for each measure, however, it is expected that the noted realization rate is applied when reporting the 'adjusted gross savings value'. For purposes of this analysis, the BrightLine team has not applied realization rates to the RI values presented in the benchmarking tables because it is not always clear if the comparison TRM's factor a realization rate into the reported deemed savings value. We believe that the realization rate application has a minor impact on our analysis due to the value being close to 1.0. Specifically, the list below outlines the measures wherein a realization rate other than 1.0 is listed in RI's TRM. Based on these realization rates, the results and recommendations of our benchmarking activity would not change.

- Refrigerated Case Lighting (0.94)
- LED Exit Signs (1.03)
- Linear LED T8 Replacements (1.05)

2.4.1 Residential Electric Measures

Residential electric measures that were flagged as priority measures, based on their large contribution to the overall electric portfolio savings, include the Opower program and lighting measures from both the Residential Lighting and EnergyWise Single Family programs. As savings for Opower projects are not TRM-based (because they are custom in nature) lighting measures constitute the only benchmarked residential electric measures.

2.4.1.1 Lighting

The common energy savings algorithm for residential lighting measures is:

$$kWh = Qty \times \frac{Watts_{base} - Watts_{ee}}{1{,}000\ {}^{W}/_{kW}} \times Hours \times WHF\ \times ISR$$

Where:

- kWh = Electric energy savings
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture in watts
- $Watts_{ee}$ = Wattage of installed lamp or fixture in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts
- Hours = Annual operating hours
- WHF = Waste Heat Factor, which quantifies the additional energy consumption by heating system as the heating system has to work harder to replace the exhaust heat of the removed lighting
- ISR = In-service rate, which quantifies the percentage of measure units purchased which actually end up in use (e.g. more light bulbs could have been purchased than there are light fixtures with extras being kept in stock to replace as others burn out)

An alternative energy savings algorithm exists as follows:

$$kWh = Qty \times \frac{Watts_{base}}{1{,}000\ {}^{W}/_{kW}} \times \Delta WM\ \times Constant$$

Where:

- kWh = Electric energy savings achieved
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts
- ΔWM = "Delta watts multiplier", which provides a way to estimate the ($Watts_{base}$ – $Watts_{ee}$) when only the baseline wattage is known or can be collected
- Constant = Pre-determined constant that takes into account the TRM's deemed hours, waste heat factors, and in-service rates.

Comparisons of the key parameters across each TRM are presented by measure in the following tables for the common algorithm only. With regards to Table 3 and Table 4, it should be noted that National Grid no longer offers CFL measures and has not offered them in several years.

Notes on Waste Heat Factors

The Rhode Island TRM does not include Waste Heat Factors in the EnergyWise program[4], but does include them in the Energy Star Lighting program. TRMs that utilize waste heat factors (WHF) to quantify the increase in heating load due to the reduction of waste heat from the lighting system often provide a table of WHF values based on heating and cooling system type. To facilitate a balanced comparison of dissimilar strategies for quantifying Waste Heat Factors, we have opted to select the "Heating and Cooling Unknown" option from any such table, or an average of all options if an "Unknown" option was not provided.

Additionally, there are two common methods of applying Waste Heat Factors: one option is to use a multiplicative value as used in the common algorithm presented above (WHF); the other is to use an additive value (1 + WHF). For the purpose of this exercise, we have mathematically adjusted all published Waste Heat Factors to work with the common algorithm shown above. For example, the Pennsylvania TRM utilizes the latter methodology. In this manner, if the Waste Heat Factor was listed as -0.08, in order to match the algorithm utilized in the TRM benchmarking tool, we have transformed this variable to 1 + WHF, or 0.92.

Notes on Annual Operating Hours

Some TRMs assign Hours of Use per day or per year by location of installed lamp. Rhode Island's TRM does not assign operating hours in this manner. Therefore, to facilitate a balanced comparison, for the purposes of this exercise, we have opted to select the "Unknown" (or the equivalent of unknown) option from any such table.

[4] For retrofit programs, the increased heating value is not defined in the TRM lighting section but embedded in energy savings for participants receiving weatherization/heating system as determined through the billing analysis, which captures these interactive effects.

Table 3: CFL Screw-In Bulbs, Single-Family, Retrofit

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	53.00	10.00	792.60	0.97	0.93	0.10	N/A	5.00	Yes	30.84
DC Sustainable Energy Utility TRM (2017) [D]	N/A	N/A	N/A	1,423.00	1.12	0.88	0.11	N/A	5.00	No	45.90
Minnesota TRM V2.1 (2018) [D]	N/A	46.70	10.00	938.00	1.08	0.73	0.10	N/A	9.40	Yes	20.39
Connecticut 11th Edition (2016)	1,100.00	30.00	10.00	1,058.50	1.04	N/A	0.13	0.20	4.00	No	22.02
Indiana TRM V1.0 (2013)	N/A	N/A[1]	10.00	1,040.00	0.94	N/A	0.11	N/A	5.00	Yes	18.27
Massachusetts TRM (2016) [D]	N/A	N/A	N/A	1,200.00	N/A	0.95	0.14	0.18	7.00	Yes	38.30
Michigan Master Measures Database (2020) [D]	N/A	43.00	10.00	840.00	N/A	N/A	0.10	N/A	9.00	No	23.94
Missouri Statewide TRM (2017)	1,100.00	53.00	10.00	728.00	0.99	0.98	0.00	N/A	5.20	No	24.13
New Jersey Protocols (2016)	1,100.00	53.00	10.00	1,022.00	N/A	0.83	0.10	N/A	5.00	Yes	36.65
New York TRM V7 (2019)	1,100.00	53.00	10.00	1,168.00	1.05	0.92	0.08	N/A	7.00	No	48.40
Ohio TRM (2010)	N/A	N/A[1]	10.00	1,040.00	1.07	0.86	0.11	N/A	9.18	Yes	19.62
Vermont TRM No. 2014-87 (2015) [D]	N/A	N/A	10.00	694.00	N/A	0.80	N/A	N/A	7.00	No	20.50
Mean	1,100.00	47.39	10.00	995.34	1.03	0.88	0.10	0.19	6.48	-	29.08
Median	1,100.00	53.00	10.00	1,031.00	1.04	0.88	0.10	0.19	6.10	-	24.03
Zone 5A Mean	**1,100.00**	**47.25**	**10.00**	**948.39**	**1.04**	**0.88**	**0.12**	**0.19**	**6.75**	**-**	**36.10**
Rhode Island TRM (2020)	**Not Offered as a Prescriptive Measure**										
Rhode Island TRM (2019)	Not Offered as a Prescriptive Measure										
Rhode Island TRM (2018)	Not Offered as a Prescriptive Measure										
Rhode Island TRM (2017)	Not Offered as a Prescriptive Measure										
Rhode Island TRM (2016) (RI_0200)	N/A	N/A	10.00	1,022.00	N/A	1.00	0.13	0.16	5.00	Yes	43.50

[D]TRMs with deemed savings values
[1]Indiana and Ohio TRMs use the alternative algorithm which does not utilize a W_{base} value.

Table 4: CFL Screw-In Bulbs, Multifamily, Retrofit

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	53.00	10.00	792.60	0.97	0.93	0.10	N/A	5.00	Yes	30.84
DC Sustainable Energy Utility TRM (2017) D	N/A	N/A	N/A	5,950.00	1.13	0.88	0.11	N/A	5.00	No	194.00
Minnesota TRM V2.1 (2018) D	N/A	46.70	10.00	938.00	1.08	0.73	0.10	N/A	9.40	Yes	20.39
Connecticut 11th Edition (2016)	1,100.00	30.00	10.00	1,058.50	1.04	N/A	0.13	0.20	4.00	No	22.02
Indiana TRM V1.0 (2013)	N/A	N/A[1]	10.00	1,040.00	0.94	N/A	0.11	N/A	5.00	Yes	18.27
Massachusetts TRM (2016) D	N/A	N/A	N/A	985.50	N/A	0.97	0.13	0.16	7.00	Yes	38.80
Michigan Master Measures Database (2020) D	N/A	43.00	10.00	4,380.00	N/A	N/A	0.00	N/A	2.00	No	148.00
Missouri Statewide TRM (2017)	1,100.00	53.00	10.00	728.00	0.99	0.98	0.00	N/A	5.20	No	24.13
New Jersey Protocols (2016)	1,100.00	53.00	10.00	1,022.00	N/A	0.83	0.10	N/A	5.00	Yes	36.65
New York TRM V7 (2019)	1,100.00	53.00	10.00	1,168.00	1.02	0.92	0.08	N/A	7.00	No	47.28
Ohio TRM (2010)	N/A	N/A[1]	10.00	1,040.00	1.07	0.86	0.11	N/A	9.18	Yes	19.62
Vermont TRM No. 2014-87 (2015) D	N/A	N/A	10.00	694.00	N/A	0.80	N/A	N/A	7.00	No	20.50
Mean	1,100.00	47.39	10.00	1,649.72	1.03	0.88	0.09	0.18	5.90	-	51.71
Median	1,100.00	53.00	10.00	1,031.00	1.03	0.88	0.10	0.18	5.10	-	27.49
Zone 5A Mean	**1,100.00**	**46.40**	**10.00**	**1,346.22**	**1.01**	**0.89**	**0.08**	**0.18**	**5.71**	**-**	**41.70**
Rhode Island TRM (2020)	**Not Offered as a Prescriptive Measure**										
Rhode Island TRM (2019)	Not Offered as a Prescriptive Measure										
Rhode Island TRM (2018)	Not Offered as a Prescriptive Measure										
Rhode Island TRM (2017)	Not Offered as a Prescriptive Measure										
Rhode Island TRM (2016) (RI_0198)	N/A	N/A	10.00	1,022.00	N/A	1.00	0.13	0.16	5	Yes	56.21

D TRMs with deemed savings values

[1] Indiana and Ohio TRMs use the alternative algorithm which does not utilize a W_{base} value.

Table 5: LED Downlight/Reflector Bulb, Single-Family, Retrofit

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	75.00	10.00	792.60	0.97	0.93	0.10	N/A	5.00	Yes	46.63
California Municipal Utilities TRM (2016) D	N/A	50.00	10.00	541.00	1.02	1.00	0.04	N/A	15.00	Yes	22.00
DC Sustainable Energy Utility TRM (2017) D	N/A	65.00	10.00	1,423.00	1.12	0.95	0.11	N/A	5.00	Yes	80.39
Delaware TRM (2016)	1,100.00	65.00	10.00	679.00	0.98	1.00	0.06	N/A	20.00	Yes	36.45
Hawaii Energy TRM (2018) D	N/A	N/A	N/A	839.50	N/A	N/A	0.12	N/A	15.00	Yes	22.50
Maine TRM (2017) D	N/A	61.00	10.00	730.00	1.04	0.99	0.14	0.19	25.00	Yes	45.00
Minnesota TRM V2.1 (2018) D	N/A	65.00	10.00	938.00	1.08	0.73	0.10	N/A	20.00	Yes	39.01
Ameren Missouri TRM (2016) D	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	25.00	No	26.77
Connecticut 11th Edition (2016)	1,100.00	34.00	10.00	1,058.50	1.04	N/A	0.13	0.20	16.00	No	26.42
IESO Measures and Assumptions List (2019) D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Illinois TRM V7.0 (2019)	1,100.00	75.00	10.00	763.00	1.06	0.97	0.11	N/A	10.00	Yes	46.08
Indiana TRM V1.0 (2013)	N/A	60.00	10.00	1,040.00	0.94	1.00	0.11	N/A	15.00	Yes	48.95
Iowa Statewide TRM V3.0 (2018)	1,100.00	63.70	10.00	894.00	0.82	0.92	0.13	N/A	10.00	Yes	30.82
Massachusetts TRM (2016) D	N/A	N/A	N/A	1,200.00	N/A	1.00	0.14	0.18	8.00	Yes	50.80
Michigan Master Measures Database (2020) D	N/A	N/A	10.00	840.00	N/A	N/A	0.10	N/A	15.00	No	44.00
MidAtlantic TRM V8.0 (2018)	1,100.00	65.00	10.00	679.00	0.98	1.00	0.06	N/A	20.00	Yes	36.45
Missouri Statewide TRM (2017)	1,100.00	100.00	10.00	728.00	0.99	0.98	0.00	N/A	5.20	No	59.30
New Jersey Protocols (2016)	1,100.00	65.00	10.00	1,022.00	N/A	1.00	0.08	N/A	15.00	Yes	56.21
New York TRM V7 (2019)	1,100.00	65.00	10.00	913.00	1.05	0.92	0.08	N/A	20.00	No	48.40
Pennsylvania TRM (2021)	1,100.00	24.44[5]	10.00	1,095.75	0.99	0.98	0.11	N/A	15.00	Yes	14.24

[5] PA uses the following calculation for baseline wattage:

$$Watts_{base} = Lumen\ Output \div 45 \frac{\text{lumens}}{\text{watt}}$$

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Vermont TRM No. 2014-87 (2015) [D]	N/A	65.00	10.00	1,241.00	1.00	0.95	N/A	N/A	20.00	No	62.48
Mean	1,100.00	62.38	10.00	916.70	1.00	0.96	0.10	0.19	14.96	-	42.14
Median	1,100.00	65.00	10.00	894.00	1.00	0.98	0.10	0.19	15.00	-	44.50
Zone 5A Mean	1,100.00	61.71	10.00	956.19	0.99	0.97	0.10	0.19	14.94	-	42.38
Rhode Island TRM (2020) (LED Bulbs Reflectors)[D]	N/A	N/A	10.00	N/A	N/A	1.00	0.55	0.85	2.00	Yes	46.80
Rhode Island TRM (2019) (LED Bulbs Reflectors)[D]	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	3.00	Yes	51.00
Rhode Island TRM (2018) (LED Bulbs Reflector)[D]	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	6.00	Yes	47.60
Rhode Island TRM (2017) (RIER308)[D]	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	10.00	Yes	47.60
Rhode Island TRM (2016) (RI_0218)[D]	N/A	N/A	10.00	1,205.00	N/A	1.00	0.13	0.16	9.00	Yes	47.60

[D]TRMs with deemed savings values.

Table 6: LED Downlight/Reflector Bulb, In-Unit Multifamily, Retrofit

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	75.00	10.00	792.60	0.97	0.93	0.10	N/A	5.00	Yes	46.63
California Municipal Utilities TRM (2016) D	N/A	50.00	10.00	541.00	1.02	1.00	0.04	N/A	15.00	Yes	22.00
DC Sustainable Energy Utility TRM (2017) D	N/A	65.00	10.00	1,423.00	1.12	0.95	0.11	N/A	5.00	Yes	80.39
Delaware TRM (2016)	1,100.00	65.00	10.00	898.00	0.99	1.00	0.08	N/A	20.00	Yes	48.89
Hawaii Energy TRM (2018) D	N/A	N/A	N/A	839.50	N/A	N/A	0.12	N/A	15.00	Yes	22.50
Maine TRM (2017) D	N/A	61.00	10.00	730.00	1.04	0.99	0.14	0.19	25.00	Yes	45.00
Minnesota TRM V2.1 (2018) D	1,100.00	100.00	10.00	728.00	0.99	0.98	0.00	N/A	5.20	No	59.30
Ameren Missouri TRM (2016) D	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	25.00	No	26.77
Connecticut 11th Edition (2016)	1,100.00	34.00	10.00	1,058.50	1.04	N/A	0.13	0.20	16.00	No	26.42
IESO Measures and Assumptions List (2019) D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Illinois TRM V7.0 (2019)	1,100.00	75.00	10.00	763.00	1.04	0.97	0.11	N/A	10.00	Yes	45.21
Indiana TRM V1.0 (2013)	N/A	60.00	10.00	1,040.00	0.94	1.00	0.11	N/A	15.00	Yes	48.95
Iowa Statewide TRM V3.0 (2018)	1,100.00	63.70	10.00	894.00	0.82	0.92	0.13	N/A	10.00	Yes	30.82
Massachusetts TRM (2016) D	N/A	N/A	N/A	985.50	N/A	0.97	0.13	0.16	8.00	Yes	50.80
MidAtlantic TRM V8.0 (2018)	N/A	65.00	10.00	679.00	0.98	1.00	0.10	N/A	20.00	Yes	36.45
Missouri Statewide TRM (2017)	1,100.00	65.00	10.00	1,022.00	N/A	1.00	0.08	N/A	15.00	Yes	56.21
New Jersey Protocols (2016)	1,100.00	65.00	10.00	913.00	1.02	0.92	0.08	N/A	20.00	No	47.27
New York TRM V7 (2019)	1,100.00	24.44	10.00	1,095.75	0.99	0.98	0.11	N/A	15.00	Yes	14.24
Pennsylvania TRM (2021)	N/A	65.00	10.00	1,241.00	1.00	0.95	N/A	N/A	20.00	No	62.48
Vermont TRM No. 2014-87 (2015) D	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	25.00	No	26.77
Mean	1,100.00	62.21	10.00	920.23	1.00	0.97	0.10	0.18	15.22	-	41.95
Median	1,100.00	65.00	10.00	898.00	0.995	0.98	0.11	0.19	15.00	-	45.21
Zone 5A Mean	1,100.00	61.71	10.00	969.18	0.98	0.97	0.10	0.18	16.58	-	39.37

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Rhode Island TRM (2020) (Dwelling Int Reflector, Energywise MF)	N/A	65[1]	10.00	985.50[1]	N/A	1.00	0.55	0.85	6.00	Yes	54.20[1]
Rhode Island TRM (2019) (Dwelling Int Reflector, Energywise MF)	N/A	65[1]	10.00	985.50[1]	N/A	0.88	0.13	0.16	6.00	Yes	47.69[1]
Rhode Island TRM (2018) (Dwelling Int Reflector, Energywise MF)	N/A	65[1]	10.00	985.50[1]	N/A	1.00	0.13	0.16	15.00	Yes	54.20[1]
Rhode Island TRM (2017) (RIER311)	N/A	65[1]	10.00	985.50[1]	N/A	1.00	0.13	0.16	15.00	Yes	54.20[1]
Rhode Island TRM (2016) (RI_0212)	N/A	N/A	10.00	1,022.00	N/A	1.00	0.13	0.16	11.00	Yes	56.21

[D]TRMs with deemed savings values
[1]RI TRM also allows custom savings calculations using site-specific watts, hours, etc.

Table 7: LED Screw-In A-Lamp, Single-Family, Retrofit (EnergyWise and Energy Star)

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	53.00	10.00	792.60	0.97	0.97	0.10	N/A	5.00	Yes	32.07
California Municipal Utilities TRM (2016) [D]	N/A	43.00	10.00	541.00	1.02	1.00	0.04	N/A	15.00	Yes	18.00
DC Sustainable Energy Utility TRM (2017) [D]	N/A	N/A	10.00	1,423.00	1.02	0.97	0.11	N/A	15.00	Yes	12.90
Delaware TRM (2016)	1,100.00	53.00	10.00	679.00	0.98	0.98	0.06	N/A	16.30	Yes	27.93
Hawaii Energy TRM (2018) [D]	N/A	N/A	N/A	839.50	N/A	N/A	0.12	N/A	15.00	Yes	22.50
Maine TRM (2017) [D]	N/A	N/A	10.00	730.00	1.04	0.99	0.14	0.19	25.00	Yes	30.00
Minnesota TRM V2.1 (2018) [D]	N/A	43.00	10.00	938.00	1.08	0.73	0.10	N/A	16.00	Yes	24.29
Ameren Missouri TRM (2016) [D]	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	25.00	No	28.00
Connecticut 11th Edition (2016)	1,100.00	34.00	10.00	1,058.50	1.04	N/A	0.13	0.20	10.00	No	26.42
IESO Measures and Assumptions List (2019) [D]	N/A	N/A	N/A	1,095.00	N/A	N/A	N/A	N/A	17.00	Yes	28.50
Illinois TRM V7.0 (2019)	1,100.00	53.00	10.00	1,089.00	1.06	0.97	0.07	N/A	10.00	Yes	55.37
Indiana TRM V1.0 (2013)	N/A	60.00	10.00	1,040.00	0.94	1.00	0.11	N/A	15.00	Yes	48.95
Iowa Statewide TRM V3.0 (2018)	1,100.00	37.40	10.00	894.00	0.82	0.92	0.13	N/A	10.00	Yes	22.86
Massachusetts TRM (2016) [D]	N/A	N/A	N/A	1,200.00	N/A	1.00	0.14	0.18	9.00	Yes	34.10
Michigan Master Measures Database (2020) [D]	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MidAtlantic TRM V8.0 (2018)	1,100.00	53.00	10.00	679.00	0.98	0.98	0.06	N/A	16.30	Yes	27.93
Missouri Statewide TRM (2017)	1,100.00	53.00	10.00	728.00	0.99	0.98	0.00	N/A	19.00	Yes	28.45
New Jersey Protocols (2016)	1,100.00	53.00	10.00	1,022.00	N/A	1.00	0.08	N/A	15.00	Yes	43.95
New York TRM V7 (2019)	1,100.00	53.00	10.00	1,168.00	1.05	0.92	0.08	N/A	20.00	No	48.40
Pennsylvania TRM (2021)	1,100.00	24.44	10.00	1,095.75	0.99	0.98	0.11	N/A	15.00	Yes	14.24
Vermont TRM No. 2014-87 (2015) [D]	N/A	18.10	10.00	1,241.00	1.00	0.87	N/A	N/A	15.00	Yes	6.50
Mean	1,100.00	45.07	10.00	960.70	1.00	0.95	0.09	0.19	15.18	-	29.07
Median	1,100.00	53.00	10.00	1,022.00	1.00	0.98	0.10	0.19	15.00	-	27.96
Zone 5A Mean	1,100.00	43.89	10.00	1,025.85	0.99	0.96	0.09	0.19	15.10	-	31.82

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Rhode Island TRM (2020) (LED Bulbs, EnergyWise)	N/A	N/A	10.00	N/A	N/A	1.00	0.55	0.85	2.00	Yes	40.90
Rhode Island TRM (2019) (LED Bulbs, EnergyWise)	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	3.00	Yes	37.10
Rhode Island TRM (2018) (LED Bulbs, EnergyWise)	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	6.00	Yes	47.60
Rhode Island TRM (2017) (RIER289)	N/A	N/A	10.00	N/A	N/A	0.98	0.14	0.18	6.00	Yes	47.60
Rhode Island TRM (2016) (RI_0218)	N/A	N/A	10.00	1,205.00	N/A	1.00	0.13	0.16	9.00	Yes	47.60
Rhode Island TRM (2020) (LED A Lamps, Energy Star)	N/A	N/A	10.00	N/A	Deemed[1]	0.89	0.55	0.85	5.00	Yes	43.50
Rhode Island TRM (2019) (LED A Lamps, Energy Star)	N/A	N/A	10.00	N/A	Deemed[1]	0.93	0.14	0.18	5.00	Yes	42.10

[1]The Rhode Island TRM provides a deemed value of MMBTU savings associated with waste heat factors

Table 8: LED Screw-In A-Lamp, Single-Family, New Construction

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	53.00	10.00	792.60	0.97	0.97	0.10	N/A	5.00	Yes	32.07
California Municipal Utilities TRM (2016) [D]	N/A	43.00	10.00	541.00	1.02	1.00	0.04	N/A	15.00	Yes	18.00
DC Sustainable Energy Utility TRM (2017) [D]	N/A	N/A	N/A	1,423.00	1.02	0.97	0.11	N/A	15.00	Yes	12.90
Delaware TRM (2016)	1,100.00	53.00	10.00	679.00	0.98	0.98	0.06	N/A	16.30	Yes	27.93
Hawaii Energy TRM (2018) [D]	N/A	N/A	N/A	839.50	N/A	N/A	0.12	N/A	15.00	Yes	22.50
Maine TRM (2017) [D]	N/A	N/A	N/A	730.00	1.04	0.99	0.14	0.19	25.00	Yes	30.00
Minnesota TRM V2.1 (2018) [D]	N/A	43.00	10.00	938.00	1.08	0.73	0.10	N/A	16.00	Yes	24.29
Ameren Missouri TRM (2016) [D]	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	25.00	No	28.00
Connecticut 11th Edition (2016)	1,100.00	34.00	10.00	1,058.50	1.04	N/A	0.13	0.20	10.00	No	26.42
IESO Measures and Assumptions List (2019) [D]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	17.00	Yes	28.50
Illinois TRM V7.0 (2019)	1,100.00	53.00	10.00	1,089.00	1.06	0.97	0.07	N/A	10.00	Yes	55.37
Indiana TRM V1.0 (2013)	N/A	60.00	10.00	1,040.00	0.94	1.00	0.11	N/A	15.00	Yes	48.95
Iowa Statewide TRM V3.0 (2018)	1,100.00	37.40	10.00	894.00	0.82	0.92	0.13	N/A	10.00	Yes	22.86
Massachusetts TRM (2016) [D]	N/A	N/A	N/A	985.50	N/A	1.00	0.13	0.16	9.00	Yes	34.10
Michigan Master Measures Database (2020) [D]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MidAtlantic TRM V8.0 (2018)	1,100.00	53.00	10.00	679.00	0.98	0.98	0.06	N/A	16.30	Yes	27.93
Missouri Statewide TRM (2017)	1,100.00	53.00	10.00	728.00	0.99	0.98	0.00	N/A	19.00	Yes	28.45
New Jersey Protocols (2016)	1,100.00	53.00	10.00	1,022.00	N/A	1.00	0.08	N/A	15.00	Yes	43.95
New York TRM V7 (2019)	1,100.00	53.00	10.00	1,168.00	1.05	0.92	0.08	N/A	20.00	No	48.40
Pennsylvania TRM (2021)	1,100.00	24.44	10.00	1,095.75	0.99	0.98	0.11	N/A	15.00	Yes	14.24
Mean	1,100.00	47.14	10.00	923.70	1.00	0.96	0.09	0.18	15.19	-	29.57
Median	1,100.00	53.00	10.00	938.00	1.01	0.98	0.10	0.19	15.00	-	27.93
Zone 5A Mean	1,100.00	46.76	10.00	975.98	0.98	0.97	0.09	0.18	15.11	-	32.84
Rhode Island TRM (2020) (LEDs)	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	5.00[A]	Yes	36.90

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Rhode Island TRM (2019) (LED Fixture)	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	5.00	Yes	68.90
Rhode Island TRM (2018)	Not Offered as a Prescriptive Measure										
Rhode Island TRM (2017) (RIER064)	N/A	N/A	10.00	985.5	N/A	1.00	0.13	0.16	9.00	Yes	30.59
Rhode Island TRM (2016) (RI_0223)	N/A	N/A	10.00	1,022.00	N/A	1.00	0.13	0.16	9.00	No	33.00

[D]TRMs with deemed savings values
[A] Note that the measure life used in RI's TRM takes into account the changing baseline that would have been installed had the LEDs not been installed.

Table 9: LED Screw-In A-Lamp, In-Unit Multifamily, Retrofit

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	53.00	10.00	792.60	0.97	0.97	0.10	N/A	5.00	Yes	32.07
California Municipal Utilities TRM (2016) [D]	N/A	43.00	10.00	541.00	1.02	1.00	0.04	N/A	15.00	Yes	18.00
DC Sustainable Energy Utility TRM (2017) [D]	N/A	N/A	N/A	1,423.00	1.02	1.00	0.11	N/A	15.00	Yes	13.30
Delaware TRM (2016)	1,100.00	53.00	10.00	898.00	0.99	0.98	0.08	N/A	20.00	Yes	37.61
Hawaii Energy TRM (2018) [D]	N/A	N/A	N/A	839.50	N/A	N/A	0.12	N/A	15.00	Yes	22.50
Maine TRM (2017) [D]	N/A	N/A	N/A	730.00	1.04	0.99	0.14	0.19	25.00	Yes	30.00
Minnesota TRM V2.1 (2018) [D]	N/A	43.00	10.00	938.00	1.08	0.73	0.10	N/A	16.00	Yes	24.29
Ameren Missouri TRM (2016) [D]	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	25.00	No	28.00
Connecticut 11th Edition (2016)	1,100.00	34.00	10.00	1,058.50	1.04	N/A	0.13	0.20	10.00	No	26.42
IESO Measures and Assumptions List (2019) [D]	N/A	N/A	N/A	1,095.00	N/A	N/A	N/A	N/A	17.00	Yes	28.50
Illinois TRM V7.0 (2019)	1,100.00	53.00	10.00	1,089.00	1.04	0.97	0.07	N/A	10.00	Yes	54.32
Indiana TRM V1.0 (2013)	N/A	60.00	10.00	1,040.00	0.94	1.00	0.11	N/A	15.00	Yes	48.95
Iowa Statewide TRM V3.0 (2018)	1,100.00	37.40	10.00	894.00	0.82	0.92	0.13	N/A	10.00	Yes	22.86
Massachusetts TRM (2016) [D]	N/A	N/A	N/A	985.50	N/A	0.97	0.13	0.16	9.00	Yes	43.00
MidAtlantic TRM V8.0 (2018)	1,100.00	53.00	10.00	679.00	0.98	0.98	0.06	N/A	16.30	Yes	27.92
Missouri Statewide TRM (2017)	1,100.00	53.00	10.00	728.00	0.99	0.98	0.00	N/A	19.00	Yes	28.45
New Jersey Protocols (2016)	1,100.00	53.00	10.00	1,022.00	N/A	1.00	0.08	N/A	15.00	Yes	43.95
New York TRM V7 (2019)	1,100.00	53.00	10.00	1,168.00	1.02	0.92	0.08	N/A	20.00	No	47.28
Pennsylvania TRM (2021)	1,100.00	24.44	10.00	1,095.75	0.99	0.98	0.11	N/A	15.00	Yes	14.24
Vermont TRM No. 2014-87 (2015) [D]	N/A	18.10	10.00	1,241.00	1.00	0.87	N/A	N/A	15.00	Yes	6.50
Mean	1,100.00	45.07	10.00	960.94	1.00	0.95	0.09	0.18	15.37	-	30.78
Median	1,100.00	53.00	10.00	985.50	1.00	0.98	0.10	0.19	15.00	-	28.22
Zone 5A Mean	1,100.00	43.89	10.00	1,007.98	0.98	0.96	0.09	0.18	15.10	-	34.49

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Rhode Island TRM (2020) (Dwelling Int LED Bulbs, EnergyWiseMF)[D]	N/A	N/A	N/A	N/A	N/A	1.00	0.55	0.85	5.00	Yes	33.30
Rhode Island TRM (2019) (Dwelling Int LED Bulbs, EnergyWiseMF)[D]	N/A	N/A	N/A	N/A	N/A	0.88	0.13	0.16	5.00	Yes	35.00
Rhode Island TRM (2018) (Dwelling Int LED Bulbs, EnergyWiseMF)[D]	N/A	N/A	N/A	N/A	N/A	1.00	0.13	0.16	9.00	Yes	35.00
Rhode Island TRM (2017) (RIER334)	N/A	TBD	10.00	TBD	N/A	1.00	0.13	0.16	9.00	Yes	35.00
Rhode Island TRM (2016) (RI_0215)	N/A	N/A	10.00	1,022.00	N/A	1.00	0.13	0.16	9.00	Yes	56.21

[D]TRMs with deemed savings values

2.4.2 Residential Gas Measures

Priority residential natural gas measures, based on their large contribution to the overall natural gas portfolio savings, included select measures from the Weatherization end use in the EnergyWise Single Family program.

2.4.2.1 Weatherization

The common energy savings algorithm for air sealing is:

$$MMBtu = \left(\frac{CFM50_{exist} - CFM50_{new}}{N_{heat}} \times 60 \times 24 \times HDD \times 0.018\right) \div 1{,}000{,}000 \div \eta_{heat}$$

Where:

- MMBtu = Natural gas savings achieved (one million British thermal units)
- $CFM50_{exist}$ = Air infiltration of the space (cubic feet per minute) prior to air sealing as determined through blower door testing performed by a qualified contractor
- $CFM50_{new}$ = Air infiltration (cubic feet per minute) of the space after air sealing as determined through blower door testing
- N_{heat} = Conversion from CFM50 to $CFM_{Natural}$ (natural air leakage)
- 60 = Conversion from minutes to hours
- 24 = Conversion from hours to days
- HDD = Heating degree days (degree days are the difference between the daily temperature mean and 65F°)
- 0.018 = Volumetric heat capacity of air
- 1,000,000 = Conversion from Btu to MMBtu
- η_{heat} = Efficiency of heating equipment

Comparisons of the key parameters across each TRM are presented in the following table. Note that because this is a weather-dependent measure, only TRMs relating to ASHRAE Climate Zone 5A have been included. Also note that the value presented for RI in Table 10 below is average savings from a complete package of weatherization measures and includes a combination of air sealing, insulation, duct sealing and duct insulation. The values for the other TRMs presented in Table 10 are typically for air sealing only.

Notes on HDD

Unlike some other TRM's, Rhode Island's TRM does not provide a table for HDD lookup based on city. Therefore, to facilitate a balanced comparison for purposes of this exercise, we used the average value from all cities in any such table.

Table 10: Weatherization, Single-Family

TRM	$CFM50_{exist}$	$CFM50_{new}$	N_{heat}	HDD	η_{heat}	Measure Life	MMBtu
Input Value:	*3,400*	*2,250*					
Connecticut 11th Edition (2016)	3,400.00	2,250.00	N/A	N/A	N/A	20.00	12.40
Illinois TRM V7.0 (2019)	3,400.00	2,250.00	21.38	4,332.00	0.72	20.00	8.39
Indiana TRM V1.0 (2013)	3,400.00	2,250.00	15.33	N/A	N/A	15.00	15.75
Iowa Statewide TRM V3.0 (2018)	3,400.00	2,250.00	18.98	5,052.00	0.74	15.00	10.72
Massachusetts TRM (2016) [D]	N/A	N/A	N/A	N/A	N/A	N/A	VENDOR[1]
MidAtlantic TRM V8.0 (2018)	3,400.00	2,250.00	21.44	3,229.67	0.66	15.00	6.80
Missouri Statewide TRM (2017)	3,400.00	2,250.00	20.33	4,037.00	0.71	15.00	8.34
New York TRM V7 (2019)	3,400.00	2,250.00	N/A	N/A	N/A	15.00	16.07
Ohio TRM (2010)	3,400.00	2,250.00	29.4	4,460.86	0.70	15.00	6.46
Mean	3,400.00	2,250.00	21.14	4,222.30	0.71	16.25	10.62
Median	3,400.00	2,250.00	20.85	4,332.00	0.71	15.00	9.56
Rhode Island TRM (2020)	N/A	N/A	N/A	N/A	N/A	25.00	11.09
Rhode Island TRM (2019)	N/A	N/A	N/A	N/A	N/A	25.00	11.09
Rhode Island TRM (2018)	N/A	N/A	N/A	N/A	N/A	15.00	11.09
Rhode Island TRM (2017) (RIGR083)	N/A	N/A	N/A	N/A	N/A	20.00	18.80
Rhode Island TRM (2016) (RI_0042)	N/A	N/A	N/A	N/A	N/A	20.00	18.80

[D] TRMs with deemed savings values
[1] The Massachusetts TRM stipulates that the vender performing the air sealing shall supply the energy savings value.

2.4.3 Low-Income Electric Measures

The flagged priority low-income electric measures, based on their large contribution to the overall electric portfolio savings, included lighting measures from the Income Eligible Services and the Income Eligible Multifamily programs.

2.4.3.1 Lighting

The common energy savings algorithm for lighting measures is:

$$kWh = Qty \times \frac{Watts_{base} - Watts_{ee}}{1{,}000\ {}^{W}/_{kW}} \times Hours \times WHF \times ISR$$

Where:

- kWh = Electric energy savings achieved
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture in watts
- $Watts_{ee}$ = Wattage of installed lamp or fixture in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts

- Hours = Annual operating hours
- WHF = Waste Heat Factor, which quantifies the additional energy consumption by heating system as the heating system has to work harder to replace the exhaust heat of the removed lighting
- ISR = In-service rate, which quantifies the percentage of measure units purchased which actually end up in use (e.g. more light bulbs could have been purchased than there are light fixtures with extras being kept in stock to replace as others burn out)

An alternative energy savings algorithm exists as follows:

$$kWh = Qty \times \frac{Watts_{base}}{1{,}000 \ {}^{W}/_{kW}} \times \Delta WM \ \times Constant$$

Where:

- kWh = Electric energy savings achieved
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts
- ΔWM = "Delta watts multiplier", which provides a way to estimate the ($Watts_{base}$ – $Watts_{ee}$) when only the baseline wattage is known or can be collected
- Constant = Pre-determined constant that takes into account the TRM's deemed hours, waste heat factors, and in-service rates.

Comparisons of the key parameters across each TRM are presented by measure in the following subsections for the common algorithm only.

Notes on Waste Heat Factors

The Rhode Island TRM does not include Waste Heat Factors. TRMs that utilize waste heat factors (WHF) to quantify the increase in heating load due to the reduction of waste heat from the lighting system often provide a table of WHF values based on heating and cooling system type. To facilitate a balanced comparison of Rhode Island's TRM with those that do include Waste Heat Factors, we have opted to select the "Heating and Cooling Unknown" option from any such table, or an average of all options if an "Unknown" option was not provided.

Additionally, there are two common methods of applying Waste Heat Factors: one option is to use a multiplicative value as used in the common algorithm presented above (WHF); the other is to use an additive value (1 + WHF). For the purpose of this exercise, we have mathematically adjusted all published Waste Heat Factors to work with the common algorithm shown above. For example, the Pennsylvania TRM utilizes the latter methodology. In this manner, if the Waste Heat Factor was listed as -0.08, in order to match the algorithm utilized in the TRMulator, we have transformed this variable to 1 + WHF, or 0.92.

Notes on Annual Operating Hours

Some TRMs assign Hours of Use per day or per year by location of installed lamp. Rhode Island's TRM does not assign operating hours in this manner. Therefore, to facilitate a balanced comparison, for the purposes of this exercise, we have opted to select the "Unknown" (or the equivalent of unknown) option from any such table.

Table 11: LED Downlight/Reflector Bulbs, In-Unit Multifamily, Low-Income

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	75.00	10.00	792.60	0.97	0.93	0.10	N/A	5.00	Yes	46.63
California Municipal Utilities TRM (2016) [D]	N/A	50.00	10.00	541.00	1.02	1.00	0.04	N/A	15.00	Yes	22.00
DC Sustainable Energy Utility TRM (2017) [D]	N/A	65.00	10.00	1,423.00	1.12	0.95	0.11	N/A	5.00	Yes	80.39
Delaware TRM (2016)	1,100.00	65.00	10.00	898.00	0.99	1.00	0.08	N/A	20.00	Yes	48.89
Hawaii Energy TRM (2018) [D]	N/A	N/A	N/A	839.50	N/A	N/A	0.12	N/A	15.00	Yes	22.50
Maine TRM (2017) [D]	N/A	61.00	10.00	730.00	1.04	0.99	0.14	0.19	25.00	Yes	45.00
Minnesota TRM V2.1 (2018) [D]	N/A	65.00	10.00	938.00	1.08	0.73	0.10	N/A	20.00	Yes	39.01
Ameren Missouri TRM (2016) [D]	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	25.00	No	28.00
Connecticut 11th Edition (2016)	1,100.00	34.00	10.00	1,058.50	1.04	N/A	0.13	0.20	16.00	No	26.42
IESO Measures and Assumptions List (2019)[D]	1,100.00	N/A	N/A	1,095.00	N/A	N/A	N/A	N/A	15.00	No	88.70
Illinois TRM V7.0 (2019)	1,100.00	75.00	10.00	763.00	1.04	0.97	0.11	N/A	10.00	Yes	45.21
Indiana TRM V1.0 (2013)	N/A	60.00	10.00	1,040.00	0.94	1.00	0.11	N/A	15.00	Yes	48.95
Iowa Statewide TRM V3.0 (2018)	1,100.00	63.70	10.00	894.00	0.82	0.92	0.13	N/A	10.00	Yes	30.82
Massachusetts TRM (2016) [D]	N/A	N/A	N/A	985.50	N/A	1.00	0.17	1.00	8.00	Yes	140.00
MidAtlantic TRM V8.0 (2018)	1,100.00	65.00	10.00	5,950.00	0.98	1.00	0.86	N/A	8.40	Yes	319.40
Missouri Statewide TRM (2017)	1,100.00	100.00	10.00	728.00	0.99	0.98	0.00	N/A	5.20	No	59.30
New Jersey Protocols (2016)	1,100.00	65.00	10.00	1,022.00	N/A	N/A	0.08	N/A	15.00	Yes	56.21
New York TRM V7 (2019)	1,100.00	65.00	10.00	913.00	1.02	0.92	0.08	N/A	20.00	No	47.27
Pennsylvania TRM (2021)	1,100.00	24.44	10.00	1,095.75	0.99	0.98	0.11	N/A	15.00	Yes	14.24
Mean	1,100.00	62.21	10.00	1,486.60	1.00	0.96	0.19	0.46	13.47	-	77.87
Median	1,100.00	65.00	10.00	961.75	1.01	0.98	0.11	0.20	15.00	-	46.63
Zone 5A Mean	1,100.00	61.35	10.00	1,413.16	0.98	0.97	0.18	0.60	13.55	-	75.38
Rhode Island TRM (2020) (Dwelling Int Reflector, LI Retrofit Multifamily)	N/A	65.00[1]	10.00	985.50[1]	N/A	1.00	0.55	0.85	6.00	Yes	54.20[1]
Rhode Island TRM (2019) (Dwelling Int Reflector, LI Retrofit Multifamily)	N/A	65.00[1]	10.00	985.50[1]	N/A	0.88	0.55	0.85	6.00	Yes	47.70[1]
Rhode Island TRM (2018) (Dwelling Int Reflector, LI Retrofit Multifamily)	N/A	65.00[1]	10.00	985.50[1]	N/A	1.00	0.13	0.16	9.00	Yes	54.20[1]
Rhode Island TRM (2017) (RIER321)	N/A	65.00[1]	10.00	985.50[1]	N/A	1.00	0.17	1.00	20.00	Yes	54.20[1]
Rhode Island TRM (2016)	Not Offered as a Prescriptive Measure										

[D]TRMs with deemed savings values
[1]RI TRM also allows and RI program uses custom savings calculations using site-specific watts, hours, etc. RI has no deemed wattage and hour values to compare to other TRMs and these values are site specific.

Table 12: LED Screw-In A-Lamp, In-Unit Multifamily, Low-Income

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Arkansas TRM V7 (2017)	1,100.00	53.00	10.00	792.60	0.97	0.97	0.10	N/A	5.00	Yes	32.07
California Municipal Utilities TRM (2016) [D]	N/A	43.00	10.00	541.00	1.02	1.00	0.04	N/A	15.00	Yes	18.00
DC Sustainable Energy Utility TRM (2017) [D]	N/A	N/A	10.00	1,423.00	1.02	1.00	0.11	N/A	15.00	Yes	13.30
Delaware TRM (2016)	1,100.00	53.00	10.00	898.00	0.99	0.98	0.08	N/A	20.00	Yes	37.61
Hawaii Energy TRM (2018) [D]	N/A	N/A	N/A	839.50	N/A	N/A	0.12	N/A	15.00	Yes	22.50
Maine TRM (2017) [D]	N/A	N/A	10.00	730.00	1.04	0.99	0.14	0.19	25.00	Yes	30.00
Minnesota TRM V2.1 (2018) [D]	N/A	43.00	10.00	938.00	1.08	0.73	0.10	N/A	16.00	Yes	24.29
Ameren Missouri TRM (2016) [D]	N/A	N/A	10.00	N/A	N/A	N/A	N/A	N/A	25.00	No	33.50
Connecticut 11th Edition (2016)	1,100.00	34.00	10.00	1,058.50	1.04	N/A	0.13	0.20	10.00	No	26.42
IESO Measures and Assumptions List (2019) [D]	1,100.00	31.00	N/A	1,277.00	N/A	N/A	N/A	N/A	20.00	Yes	20.40
Iowa Statewide TRM V3.0 (2018)	1,100.00	37.40	10.00	894.00	1.04	0.75	0.13	N/A	10.00	Yes	19.11
Massachusetts TRM (2016) [D]	N/A	N/A	N/A	985.50	N/A	1.00	0.17	1.00	9.00	Yes	49.20
Missouri Statewide TRM (2017)	1,100.00	53.00	10.00	728.00	0.99	0.98	0.00	N/A	19.00	Yes	28.45
New Jersey Protocols (2016)	1,100.00	52.00	10.00	912.50	N/A	N/A	0.05	N/A	15.00	Yes	38.33
Mean	1,100.00	44.38	10.00	924.43	1.02	0.95	0.10	0.46	15.64	-	28.08
Median	1,100.00	43.00	10.00	898.00	1.02	0.98	0.11	0.20	15.00	-	27.44
Zone 5A Mean	**1,100.00**	**41.48**	**10.00**	**975.92**	**1.02**	**0.91**	**0.10**	**0.60**	**15.43**	**-**	**30.77**
Rhode Island TRM (2020) (Dwelling Int LED Bulbs, LI Retrofit Multifamily) [D]	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**1.00**	**0.55**	**0.85**	**5.00**	**Yes**	**33.30**
Rhode Island TRM (2019) (Dwelling Int LED Bulbs, LI Retrofit Multifamily) [D]	N/A	N/A	N/A	N/A	N/A	0.88	0.13	0.16	5.00	Yes	41.00
Rhode Island TRM (2018) (Dwelling Int LED Bulbs, LI Retrofit Multifamily) [D]	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	9.00	Yes	41.00
Rhode Island TRM (2017) (RIER331) [D]	N/A	N/A	10.00	N/A	N/A	1.00	0.13	0.16	9.00	Yes	41.00
Rhode Island TRM (2016) (RI_0216)	N/A	N/A	10.00	1,022	N/A	1.00	0.13	0.16	9.00	Yes	56.21[1]

[D] TRMs with deemed savings values.

[1] RI TRM also allows and RI program uses custom savings calculations using site-specific watts, hours, etc. As shown in the table above RI has no deemed wattage and hour values to compare to other TRMs and these values are site specific.

Table 13: LED Screw-In A-Lamp, In-Unit Single-Family, Low-Income

TRM	Installed Lumens	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	E-STAR Required	kWh
Input Value:	*1,100.00*		*10.00*								
Ameren Missouri TRM (2017)	1100.00	53.00	10.00	728.00	0.990	0.92	0.00	N/A	19.00	Yes	28.51
Connecticut 11th Edition (2016)	1100.00	34.00	10.00	1058.50	1.040	N/A	0.13	0.20	10.00	No	26.42
Iowa Statewide TRM V3.0 (2018)	1100.00	37.40	10.00	894.00	1.040	0.75	0.13	N/A	10.00	Yes	19.11
Massachusetts TRM (2016)	N/A	N/A	N/A	985.50	N/A	1.00	0.13	0.16	9.00	Yes	43.00
Missouri Statewide TRM (2017)	1100.00	53.00	10.00	728.00	0.990	0.92	0.00	N/A	19.00	Yes	28.51
New Jersey Protocols (2016)	1100.00	52.00	10.00	912.50	N/A	N/A	0.05	N/A	15.00	Yes	38.33
Mean	1100.00	45.88	10.00	884.42	1.02	0.90	0.07	0.18	13.67	-	30.65
Median	1100.00	52.00	10.00	903.25	1.02	0.92	0.09	0.18	12.50	-	28.51
Zone 5A Mean	1,100.00	45.88	10.00	884.42	1.02	0.90	0.07	0.18	13.67	-	30.65
Rhode Island TRM (2020) (LED Bulbs LI)	N/A	N/A	N/A	1022.00	N/A	100%	0.55	0.85	5.00	Yes	18.00
Rhode Island TRM (2019) (LED Bulbs LI)	N/A	N/A	N/A	1022.00	N/A	100%	0.13	0.16	5.00	Yes	18.00
Rhode Island TRM (2018)	N/A	N/A	N/A	1022.00	N/A	100%	0.13	0.16	5.00	Yes	38.70
Rhode Island TRM (2017)	N/A	N/A	N/A	1022.00	N/A	100%	0.13	0.16	9.00	Yes	45.63
Rhode Island TRM (2016)	N/A	N/A	N/A	1022.00	N/A	100%	0.13	0.16	9.00	Yes	47.6

2.4.4 Low-Income Gas Measures

Priority low-income natural gas measures, based on their large contribution to the overall gas portfolio savings, included Custom HVAC from the Income Eligible Multifamily Program and Weatherization from both the Income Eligible Multifamily and Income Eligible Services SF Programs. Measures explored as part of the broader Weatherization measure include Air Sealing and Duct Insulation.

2.4.4.1 Air Sealing

The common energy savings algorithm for air sealing is:

$$MMBtu = \left(\frac{CFM50_{exist} - CFM50_{new}}{N_{heat}} \times 60 \times 24 \times HDD \times 0.018\right) \div 1{,}000{,}000 \div \eta_{heat}$$

Where:

- Mmbtu = Natural gas savings achieved
- $CFM50_{exist}$ = Air infiltration of the space prior to air sealing as determined through blower door testing performed by a qualified contractor
- $CFM50_{new}$ = Air infiltration of the space after air sealing as determined through blower door testing
- N_{heat} = Conversion from CFM50 to $CFM_{Natural}$ (natural air leakage)
- 60 = Conversion from minutes to hours
- 24 = Conversion from hours to days
- HDD = Heating degree days
- 0.018 = Volumetric heat capacity of air
- 1,000,000 = Conversion from Btu to MMBtu
- η_{heat} = Efficiency of heating equipment

Comparisons of the key parameters across each TRM are presented in the following table. Note that because this is a weather-dependent measure, only TRMs relating to ASHRAE Climate Zone 5A have been included.

Notes on HDD

Unlike some other TRM's, Rhode Island's TRM does not provide a table for HDD lookup based on city. Therefore, to facilitate a balanced comparison for purposes of this exercise, we used the average value from all cities in any such table.

Table 14: Air Sealing, Multifamily, Low-Income

TRM	$CFM50_{exist}$	$CFM50_{new}$	Nheat	HDD	ηheat	Measure Life	MMBtu
Input Value:	*3,400.00*	*2,250.00*					
Connecticut 11th Edition (2016)	3,400.00	2,250.00	N/A	N/A	N/A	20.00	12.40
Illinois TRM V7.0 (2019)	3,400.00	2,250.00	21.38	4,332.00	0.72	20.00	8.39
Indiana TRM V1.0 (2013)	3,400.00	2,250.00	15.33	N/A	N/A	15.00	15.75
Iowa Statewide TRM V3.0 (2018)	3,400.00	2,250.00	18.98	5,052.00	0.74	15.00	10.72
Massachusetts TRM (2016)	3,400.00	2,250.00	21.44	4,767.73	0.70	15.00	9.47
MidAtlantic TRM V8.0 (2018)	3,400.00	2,250.00	21.44	3,229.67	0.66	15.00	6.80
Missouri Statewide TRM (2017)	3,400.00	2,250.00	20.33	4,037.00	0.71	15.00	8.34
New Jersey Protocols (2016) [D]	N/A	N/A	N/A	N/A	N/A	30.00	5% HL[1]
New York TRM V7 (2019)	3,400.00	2,250.00	N/A	N/A	N/A	15.00	17.11
Ohio TRM (2010)	3,400.00	2,250.00	29.40	4,460.86	0.70	15.00	6.46
Mean	**3,400.00**	**2,250.00**	**21.19**	**4,313.21**	**0.71**	**17.50**	**10.60**
Median	**3,400.00**	**2,250.00**	**21.38**	**4,396.43**	**0.71**	**15.00**	**9.47**
Rhode Island TRM (2020)	**3,400.00**	**2,250.00**	**21.19**	**4,644**	**0.70**	**15.00**	**9.33**
Rhode Island TRM (2020)[2,D]	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**20.00**	**12.40**
Rhode Island TRM (2019)	3,400.00	2,250.00	21.19	4,644	0.70	15.00	9.33
Rhode Island TRM (2019)[2,D]	N/A	N/A	N/A	N/A	N/A	20.00	12.40
Rhode Island TRM (2018)	3,400.00	2,250.00	21.19	4,644	0.70	15.00	9.33
Rhode Island TRM (2018)[2,D]	N/A	N/A	N/A	N/A	N/A	20.00	18.80
Rhode Island TRM (2017)[2,D]	N/A	N/A	N/A	N/A	N/A	20.00	18.80
Rhode Island TRM (2016)[2,D]	N/A	N/A	N/A	N/A	N/A	20.00	18.80
Rhode Island TRM (2017)	Not Offered as Natural Gas Measure						
Rhode Island TRM (2016)	Not Offered as Natural Gas Measure						

[D]TRMs with deemed savings values
[1]The New Jersey TRM stipulates that the air sealing savings shall be equal to 5% of the building's heating load.
[2]TRMS with low-income single-family specific weatherization measures.

2.4.4.2 Duct Insulation

Duct sealing and duct insulation are closely related measures that are often used interchangeably within TRMs. For example, the Illinois Statewide TRM explicitly calls the associated measure "Duct Insulation and Sealing". The description of the measure then goes on to describe specifically the sealing of ducts. Because the measures are so often related, we have included both iterations of the measure in our analysis of "Duct Insulation". Where TRMs offered two separate measures for duct sealing and duct insulation, the duct insulation measure was analyzed.

The common energy savings algorithm for duct *sealing* is:

$$MMBtu = \left(\frac{DE_{post} - DE_{pre}}{DE_{post}} \times EFLH \times BTUH\right) \div 1{,}000{,}000 \div \eta_{heat}$$

Where:

- MMBtu = Natural gas savings achieved

- DE_{post} = Post-retrofit distribution efficiency
- DE_{pre} = Pre-retrofit distribution efficiency
- EFLH = Effective full-load hours of heating equipment, which quantifies how many hours the equipment would have run at its full capacity to create the same amount of load at varying percentages of its full capacity
- BTUH = Heating input capacity
- 1,000,000 = Conversion from Btu to MMBtu
- η_{heat} = Efficiency of heating equipment

The common energy savings algorithm for duct *insulation* is:

$$MMBtu = \left(\frac{1}{R_{exist}} - \frac{1}{R_{new}}\right) \times SF \times EFLH \times \Delta T \div 1{,}000{,}000 \div \eta_{heat}$$

Where:

- MMBtu = Natural gas savings achieved
- R_{exist} = Duct heat loss coefficient of existing duct
- R_{new} = Duct heat loss coefficient of insulated duct
- SF = Area of duct surface that has been insulated
- EFLH = Effective full-load hours of heating equipment, which quantifies how many hours the equipment would have run at its full capacity to create the same amount of load at varying percentages of its full capacity
- ΔT = Average temperature difference between ambient air and duct supply air
- 1,000,000 = Conversion from Btu to MMBtu
- η_{heat} = Efficiency of heating equipment

Comparisons of the key parameters across each TRM are presented in the following table. Note that because this is a weather-dependent measure, only TRMs relating to ASHRAE Climate Zone 5A have been included.

General Note

This measure was evaluated assuming 10 linear feet of 6" diameter duct have been insulated/sealed.

Notes on Effective Full Load Hours (EFLH)

Unlike other TRMs, Rhode Island's TRM does not provide a table for EFLH lookup based on city. To facilitate a balanced comparison, for purposes of this exercise we used the average valued from all cities in any such table.

Table 15: Duct Sealing and Insulation, Multifamily

TRM	Depost	Depre	EFLH	BTUH	Rexist	Rnew	ΔT	ηheat	Measure Life	MMBTU
Input Value:	*0.92*	*0.85*		*3,600.00*	*1.00*	*6.00*				
Connecticut 11th Edition (2016) D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.08
Illinois TRM V7.0 (2019)	0.92	0.85	1,656.33	3,600.00	N/A	N/A	N/A	0.80	20.00	0.57
Indiana TRM V1.0 (2013)	0.92	0.85	1,182.00	3,600.00	N/A	N/A	N/A	0.84	20.00	0.39
Iowa Statewide TRM V3.0 (2018)	N/A	N/A	520.00	N/A	1.00	6.00	84.90	0.87	20.00	0.66
MidAtlantic TRM V8.0 (2018)	0.92	0.85	620.00	3,600.00	N/A	N/A	N/A	0.84	15.00	0.20
Missouri Statewide TRM (2017) D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20.00	0.19
New Jersey Protocols (2016) D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2% HL[1]
New York TRM V7 (2019)	0.92	0.85	777.00	3,600.00	N/A	N/A	N/A	0.86	15.00	0.25
Ohio TRM (2010)	0.92	0.85	1,466.57	3,600.00	N/A	N/A	N/A	N/A	15.00	0.54
Mean	0.92	0.85	1,036.98	3,600.00	1.00	6.00	84.90	0.84	17.86	0.36
Median	0.92	0.85	979.50	3,600.00	1.00	6.00	84.90	0.84	20.00	0.32
Rhode Island TRM (2020)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7% HL[1]
Rhode Island TRM (2019)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7% HL[1]
Rhode Island TRM (2018)	Not Offered as a prescriptive measure									
Rhode Island TRM (2017) (RIGR104)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20.00	TBD[2]
Rhode Island TRM (2016)	Not Offered as Natural Gas Measure									

[D]TRMs with deemed savings values
[1]The New Jersey and 2020 Rhode Island TRMs stipulate that the duct sealing savings shall be equal to 2% and 7% of the building's heating load respectively. For RI, savings vary by area insulated and are just for duct sealing and not duct insulation.
[2]Savings to be calculated by RISE Engineering.

2.4.5 Small Business Electric Measures

The only priority small business electric measure, based on the contribution to the overall electric portfolio savings, is prescriptive lighting. Measures chosen within the broader measure of Prescriptive Lighting include Exterior LED Lighting, LED Refrigerated Case Lighting and LED Exit Signs.

2.4.5.1 Exterior LED Lighting

The common energy savings algorithm for LED lighting is:

$$kWh = \frac{Watts_{base} - Watts_{ee}}{1{,}000\ {}^{W}/_{kW}} \times Hours \times ISR$$

Where:

- kWh = Electric energy savings achieved
- $Watts_{base}$ = Wattage of removed lamp or fixture in watts
- $Watts_{ee}$ = Wattage of installed lamp or fixture in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts
- Hours = Annual operating hours
- ISR = In-service rate, which quantifies the percentage of widgets purchased which actually end up in use (e.g. more light bulbs could have been purchased than there are light fixtures with extras being kept in stock to replace as others burn out)

Comparisons of the key parameters across each TRM are presented in the following table.

<u>General Notes</u>

This measure has been evaluated for a 50-Watt LED area light replacing a 200-watt high-pressure sodium lamp.

<u>Notes on Annual Operating Hours</u>

Exterior lighting is somewhat unique in that there is an underlying assumption that the operating hours should be from dusk until dawn. This is different from standard lighting where operating hours are generally case-specific with guideline values to use based on some known parameter (i.e. space type, building type, lamp type, etc.). Because we feel it is important to understand what each TRM considers dusk-to-dawn operation, we did not want to overwrite TRM-specific HOU values with an input value. As such, we have used each TRM's dusk-to-dawn hours assumption unless the TRM explicitly specifies the hours of use should be case-specific, in which case we have used 4,380 as a standard assumption.

Table 16: Exterior LED Lighting

TRM	W_{base}	W_{ee}	Hours	ISR	CF Summer	CF Winter	Measure Life	kWh
Input Value:	*240.0*	*50.0*						
Arkansas TRM V7 (2017)	240.0	50.0	3,996	N/A	0.00	N/A	15.00	759.2
California Municipal Utilities TRM (2016)	240.0	50.0	EXT[1]	EXT[1]	EXT[1]	EXT[1]	EXT[1]	TBD[1]
DC Sustainable Energy Utility TRM (2017) [D]	240.0	50.0	3,642	1.00	0.04	N/A	15.00	474.9
Delaware TRM (2016)	240.0	50.0	3,338	1.00	0.00	N/A	15.00	794.4
Hawaii Energy TRM (2018) [D]	240.0	50.0	4,380	N/A	0.75	N/A	15.00	715.3
Maine TRM (2017) [D]	240.0	50.0	4,380[2]	1.00	0.04	0.70	13.00	1,042.4
Minnesota TRM V2.1 (2018) [D]	240.0	50.0	4,903	N/A	0.00	N/A	10.20	TBD[1]
Ameren Missouri TRM (2016) [D]	240.0	50.0	3,170	0.99	0.00	N/A	15.00	410.2
Connecticut 11th Edition (2016)	240.0	50.0	4,368	N/A			15.00	829.9
IESO Measures and Assumptions List (2019) [D]	240.0	50.0	4,200	N/A	0.05	N/A	12.00	583.8
Illinois TRM V7.0 (2019)	240.0	50.0	4,303	1.00	0.00	N/A	15.00	817.6
Iowa Statewide TRM V3.0 (2018)	240.0	50.0	4,100	1.00	0.00	N/A	15.00	779.0
Massachusetts TRM (2016)	240.0	50.0	4,380[2]	1.00	0.83	0.66	15.00	832.2
Michigan Master Measures Database (2020) [D]	240.0	50.0	4,319	N/A	0.00	N/A	12.00	489.0
MidAtlantic TRM V8.0 (2018)	240.0	50.0	3,338	1.00	0.00	N/A	15.00	794.4
Missouri Statewide TRM (2017)	240.0	50.0	4,000	N/A	0.00	N/A	15.00	760.0
New York TRM V7 (2019)	240.0	50.0	4,368	N/A	0.00	N/A	11.50	829.9
Pennsylvania TRM (2021)	240.0	50.0	3,833	1.00	0.00	N/A	15.00	728.3
Vermont TRM No. 2014-87 (2015)	240.0	50.0	3,059	0.98	N/A	N/A	15.00	596.6
Mean	240.0	50.0	4,150	1.00	0.00	0.68	15.00	721.8
Median	240.0	50.0	4,004	1.00	0.11	0.68	14.09	693.2
Zone 5A Mean	**240.0**	**50.0**	**3,953**	**1.00**	**0.09**	**0.66**	**14.21**	**657.7**
Rhode Island TRM (2020) (LED Exterior – HW)	**240.0**	**50.0**	**4,380[2]**	**1.00**	**0.46**	**0.50**	**13.00**	**832.2**
Rhode Island TRM (2019) (LED Exterior – HW)	240.0	50.0	4,380[2]	1.00	0.11	0.91	13.00	832.2
Rhode Island TRM (2018) (LED Exterior – HW)	240.0	50.0	4,380[2]	1.00	0.11	0.91	13.00	832.2
Rhode Island TRM (2017) (RIEC016)	240.0	50.0	4,380[2]	1.00	0.11	0.91	10.00	832.2
Rhode Island TRM (2016) (RI_0384)	240.0	50.0	4,380[2]	1.00	0.11	0.91	10.00	832.2

[1]TRM references an external source for hours that could not be found. As such, the calculation cannot be completed, and the kWh savings is shown as TBD.
[2]Specifies hours of use should be case specific; per disclosure in text above, a value of 4,380 has been assumed.

2.4.5.2 LED Refrigerated Case Lighting

The common energy savings algorithm for LED refrigerated case lighting is:

$$kWh = LF \times \frac{Watts_{base} - Watts_{ee}}{1{,}000\ {}^{W}/_{kW}} \times Hours \times WHF \ \times ISR$$

Where:

- kWh = Electric energy savings achieved
- LF = Linear feet of lighting installed, which is needed for TRMs that provide a wattage per lineal foot as opposed to per lamp or door
- $Watts_{base}$ = Wattage of removed lamp or fixture in watts
- $Watts_{ee}$ = Wattage of installed lamp or fixture in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts
- Hours = Annual operating hours
- WHF = Waste Heat Factor, which quantifies the interaction of the affected HVAC system with the reduced waste heat from the lighting measure
- ISR = In-service rate, which quantifies the percentage of widgets purchased which actually end up in use (e.g. more light bulbs could have been purchased than there are light fixtures with extras being kept in stock to replace as others burn out)

Comparisons of the key parameters across each TRM are presented in the following table.

General Notes

Of the 18 TRMs offering this measure, six require input for the installed lamp wattage, four require input for the removed lamp wattage, and two require input of annual operating hours. In order to make the formulae calculate for each TRM, this measure has been evaluated for a 6' 17.5-Watt LED replacing a 6' 55-Watt T12 operating for 6,200 hours.

Notes on Waste Heat Factors

Unlike other TRMs, Rhode Island's TRM does not provide separate waste heat factors for freezer and refrigerator cases. To facilitate a balanced comparison, for purposes of this exercise we have defaulted to the refrigerator value.

Table 17: Refrigerated Case Lighting

TRM	LF	W_{base}	W_{ee}	Hours	WHF	CF Summer	CF Winter	Measure Life	kWh
Input Value:	*1.00*	*55.00*	*17.50*	*6,200.00*					
Arkansas TRM V7 (2017)	N/A	55.00	17.50	*6,200.00*	1.25	0.95	N/A	15.00	290.63
California Municipal Utilities TRM (2016) D	1.00	N/A	N/A	6,200.00	1.59	0.56	N/A	16.00	1,012.00
DC Sustainable Energy Utility TRM (2017)	1.00	55.00	17.50	6,200.00	1.29	0.58	N/A	15.00	299.93
Delaware TRM (2016)	1.00	55.00	17.50	6,200.00	1.41	0.96	N/A	15.00	327.83
Hawaii Energy TRM (2018) D	1.00	55.00	17.50	6,200.00	1.04	1.00	N/A	16.00	242.50
Maine TRM (2017)	1.00	55.00	17.50	6,200.00	1.29	0.91	0.85	13.00	299.93
Minnesota TRM V2.1 (2018)	1.00	55.00	17.50	6,200.00	1.40	0.90	N/A	10.00	325.50
Connecticut 11th Edition (2016)	N/A	55.00	17.50	6,200.00	1.37	0.90	0.77	13.00	318.93
IESO Measures and Assumptions List (2019) D	N/A	0.00	0.00	6,200.00	N/A	N/A	N/A	8.00	200.40
Indiana TRM V1.0 (2013)	1.00	55.00	17.50	6,200.00	1.41	0.92	N/A	15.00	327.83
Massachusetts TRM (2016)	1.00	55.00	17.50	6,200.00[1]	1.45	N/A	N/A	13.00	475.67
Michigan Master Measure Database (2020) D	1.00	N/A	N/A	6,200.00	N/A	0.74	N/A	16.00	460.00
MidAtlantic TRM V8.0 (2018)	1.00	55.00	17.50	6,200.00	1.41	0.96	N/A	15.00	327.83
New Jersey Protocols (2016)	1.00	55.00	17.50	6,200.00	1.45	0.88	N/A	15.00	336.66
New York TRM V7 (2019)	N/A	55.00	17.50	6,200.00	1.39	1.00	N/A	16.00	323.84
Ohio TRM (2010)	1.00	55.00	17.50	6,200.00	1.41	0.92	N/A	8.10	327.83
Pennsylvania TRM (2021)	1.00	55.00	17.50	6,200.00	1.29	0.99	N/A	8.00	299.93
Vermont TRM No. 2014-87 (2015) D	1.00	55.00	17.50	6,200.00	1.29	N/A	N/A	15.00	2,124.36
Mean	1.00	55.00	17.50	6,200.00	1.28	0.88	0.81	13.45	462.31
Median	1.00	55.00	17.50	6,200.00	1.39	0.92	0.81	15.00	326.66
Zone 5A Mean	**1.00**	**55.00**	**17.50**	**6,200.00**	**1.25**	**0.91**	**0.77**	**12.92**	**502.11**
Rhode Island TRM (2020)	**N/A**	**55.00**	**17.50**	**6,200.00**	**1.54**	**1.00**	**1.00**	**13.00**	**380.90**
Rhode Island TRM (2019)	N/A	55.00	17.50	6,200.00	1.54	1.00	1.00	13.00	380.90
Rhode Island TRM (2018)	N/A	55.00	17.50	6,200.00	1.54	0.99	1.00	7.00	380.90
Rhode Island TRM (2017) (RIEC034)	N/A	55.00	17.50	6,200.00	1.54	1.00	1.00	13.00	380.90
Rhode Island TRM (2016) (RI_0276)	N/A	55.00	17.50	6,200.00[1]	1.54	1.00	1.00	13.00	505.89

D TRMs with deemed savings values

[1] Many TRMs do not utilize site-specific hours; they use an Hours value of 8,760 for refrigerated case lighting measures regardless of actual operating hours. RI uses site specific hours but this table assumes 6200 hours for comparison purposes for all TRMs.

2.4.5.3 LED Exit Signs

The common energy savings algorithm for LED Exit Signs is:

$$kWh = Qty \times \frac{Watts_{base} - Watts_{ee}}{1{,}000\ {}^{W}/_{kW}} \times Hours \times WHF \ \times ISR$$

Where:

- kWh = Electric energy savings achieved
- Qty = Quantity of exit signs installed
- $Watts_{base}$ = Wattage of removed fixture in watts
- $Watts_{ee}$ = Wattage of installed fixture in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts
- Hours = Annual operating hours
- WHF = Waste Heat Factor
- ISR = In-service rate, which quantifies the percentage of widgets purchased which actually end up in use (e.g. more exit signs could have been purchased than there are light fixtures with extras being kept in stock to replace as others burn out)

Comparisons of the key parameters across each TRM are presented by measure in the following subsections.

<u>Notes on Baseline Wattages</u>

Unlike other TRMs, Rhode Island's TRM does not provide baseline wattages based on the type of exit sign that existed prior to the retrofit (i.e., CFL or Incandescent; single or dual sided). To facilitate a balanced comparison, for purposes of this exercise we default to the dual-sided CFL. Where this value is not provided by the TRM, it is assumed to be 14 watts as that was the most common value.

<u>Notes on Installed Wattages</u>

Unlike other TRMs, Rhode Island's TRM dictates the use of site-specific wattages, and therefore does not provide installed wattages based on the type of exit sign installed (i.e., single-sided or dual-sided). To facilitate a balanced comparison, for purposes of this exercise we default to the dual-sided LED. Where this value is not provided by the TRM, it is assumed to be 4 watts as that was the most common value.

Table 18: LED Exit Signs

TRM	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	kWh
Input Value:									
Delaware TRM (2016)	16.00	4.00	8,760.00	1.00	1.00	1.00	N/A	5.00	105.12
Minnesota TRM V2.1 (2018)	14.00	4.00	8,760.00	1.10	1.00	1.00	N/A	16.00	95.92
Ameren Missouri TRM (2016) [D]	30.00	3.00	N/A	N/A	N/A	N/A	N/A	16.00	223.81
IESO Measures and Assumptions List (2019) [D]	N/A	N/A	8,760.00	N/A	N/A	N/A	N/A	10.00	245.30
Illinois TRM V7.0 (2019)	14.00	4.00	8,766.00	1.22	N/A	1.00	N/A	5.00	106.95
Indiana TRM V1.0 (2013) [D]	N/A	N/A	8,760.00	N/A	0.98	0.95	N/A	16.00	83.00
Iowa Statewide TRM V3.0 (2018)	14.00	4.00	8,766.00	1.15	N/A	0.64	N/A	13.00	100.81
Massachusetts TRM (2016)	14.00	5.00	8,766.00	N/A	1.00	0.83	0.66	13.00	78.89
Michigan Master Measures Database (2020) [D]	N/A	N/A	8,760.00	N/A	N/A	1.00	N/A	15.00	201.00
MidAtlantic TRM V8.0 (2018)	16.00	4.00	8,760.00	1.00	1.00	1.00	N/A	5.00	105.12
Missouri Statewide TRM (2017)	14.00	4.00	8,766.00	1.14	1.00	0.00	N/A	16.00	99.93
New York TRM V7 (2019)	20.00	4.00	3,013.00	1.03	N/A	1.00	N/A	Not Provided	49.61
Ohio TRM (2010) [D]	N/A	N/A	8,760.00	1.08	0.98	1.00	N/A	16.00	83.00
Pennsylvania TRM (2021)	20.00	4.00	8,760.00	1.00	1.00	1.00	N/A	5.00	140.16
Mean	17.20	4.00	8,319.77	1.08	1.00	0.87	0.66	11.62	122.76
Median	15.00	4.00	8,760.00	1.08	1.00	1.00	0.66	13.00	102.96
Zone 5A Mean	**17.75**	**4.00**	**8,239.73**	**1.09**	**0.99**	**0.84**	**0.66**	**11.82**	**126.46**
Rhode Island TRM (2020)	**14.00**	**5.00**	**8,760.00**	**N/A**	**1.00**	**0.62**	**0.44**	**13.00**	**78.84**
Rhode Island TRM (2019)	14.00	5.00	8,760.00	N/A	1.00	0.62	0.44	13.00	78.84
Rhode Island TRM (2018)	14.00	5.00	8,760.00	N/A	1.00	0.62	0.44	13.00	78.84
Rhode Island TRM (2017) (RIEC021)	14.00	5.00	8,760.00	N/A	1.00	1.00	1.00	13.00	78.84
Rhode Island TRM (2016) (RI_0227)	14.00	5.00	8,760.00	N/A	1.00	1.00	1.00	13.00	78.84

[D]TRMs with deemed savings values

2.4.6 Small Business Gas Measures

Priority small business natural gas measures, based on the large contribution to the overall natural gas portfolio savings, included Faucet Aerators, Showerheads, and custom measures. As custom measures are not calculated from TRM inputs, only the Faucet Aerators and Showerheads were benchmarked.

As an additional note, TRMs are generally divided into residential and commercial/industrial measures. For analysis of this Small Business sector, we have only included TRMs that offered the priority measures under the Commercial & Industrial section of their TRM. Many TRMs offer the faucet aerator and showerhead measures through their residential programs, but not their Commercial & Industrial programs. In those instances, the measure was not benchmarked as it was not considered relevant to this Small Business sector.

2.4.6.1 Faucet Aerator

The common energy savings algorithm for faucet aerators is:

$$MMBtu = ISR \times \%FUEL \times \left(\frac{GPM_{base} - GPM_{low}}{GPM_{base}}\right) \times 8.3 \times 1.0 \times (T_{out} - T_{in}) \times \frac{DF \times T_{person/day} \times N_{persons} \times Days}{N_{faucets}} \div 1{,}000{,}000 \div RE$$

Where:

- MMBtu = Natural gas savings achieved per year
- ISR = In-service rate, which quantifies the percentage of measure units purchased which actually end up in use (e.g. more aerators could have been purchased than there are sinks with extras being kept in stock or installed at another location)
- %FUEL = Adjustment for percentage of water heaters that are natural gas fired
- GPM_{base} = Average baseline aerator flow rate (gallons per minute)
- GPM_{low} = Average post-retrofit aerator flow rate (gallons per minute)
- 8.3 lbm/gal = Specific weight of water
- 1.0 Btu/°F/lbm = Heat Capacity of water
- T_{out} = Average mixed water temperature flowing from the faucet
- T_{in} = Average temperature of water entering the house
- DF = Adjustment for percentage of water flowing down drain
- $T_{person/day}$ = Average time of hot water usage per person per day
- $N_{persons}$ = Average number of persons
- Days = Average days of sink usage per year
- $N_{faucets}$ = Number of faucets over which water usage is split
- 1,000,000 = Conversion from Btu to MMBtu

- RE = Recovery efficiency of hot water heater

Comparisons of the key parameters across each TRM are presented in the following table. Note that because this is a weather-dependent measure, only TRMs relating to ASHRAE Climate Zone 5A have been included.

Table 19: Faucet Aerator

TRM	ISR	%FUEL	GPM_{base}	GPM_{low}	$T_{person/day}$	$N_{persons}$	Days	DF	Tout	Tin	$N_{faucets}$	RE	Measure Life	MMBTU
Input Value:				*1.00*										
Connecticut 11th Edition (2016) D	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.00	0.263
Illinois TRM V7.0 (2019)	0.95	1.00	1.39	1.00	1.00	10.00	250	N/A	91.00	54.10	N/A	0.67	10.00	0.306
Iowa Statewide TRM V3.0 (2018)	1.00	1.00	1.83	1.00	1.00	10.00	250	N/A	93.00	56.50	N/A	0.69	10.00	0.500
Massachusetts TRM (2016) D	N/A	N/A	2.20	1.00	N/A	N/A	260	N/A	N/A	N/A	N/A	N/A	10.00	1.700
Michigan Master Measure Database (2020) D	N/A	N/A	2.20	1.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.934
Missouri Statewide TRM (2017)	1.00	0.57	1.20	1.00	1.00	10.00	250	0.85	90.00	57.90	N/A	0.67	10.00	0.081
New York TRM V7 (2019)	N/A	N/A	1.54	1.00	15.00	N/A	250	N/A	88.00	48.56	1.00	0.80	10.00	0.588
Mean	0.98	0.86	1.73	1.00	4.50	10.00	252.00	0.85	90.50	54.26	1.00	0.71	10.00	0.91
Median	1.00	1.00	1.68	1.00	1.00	10.00	250.00	0.85	90.50	55.30	1.00	0.68	10.00	0.50
Rhode Island TRM (2020)	1.00	N/A	2.20	1.00	See Note 2	N/A	See Note 2	N/A	N/A	N/A	N/A	N/A	5.00	1.70
Rhode Island TRM (2019)	1.00	N/A	2.20	1.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.00	1.70
Rhode Island TRM (2018)	1.00	N/A	2.20	1.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.00	1.70
Rhode Island TRM (2017) (RIGC204)	1.00	N/A	2.20	1.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.00	TBD[1]
Rhode Island TRM (2016) (RI_0290)	1.00	N/A	2.20	1.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5.00	1.70

[D] TRMs with deemed savings values
[1] Savings mistakenly omitted from TRM
[2] The Rhode Island TRM provides annual operating hours of 130 hours, derived as 30 minutes per day for 260 days out of the year.

2.4.6.2 Showerhead

The common energy savings algorithm for showerheads is:

$$MMBtu = ISR \times \%FUEL \times \left(GPM_{base} - GPM_{low}\right) \times 8.3 \times 1.0 \times (T_{out} - T_{in}) \times DF \times T_{shower} \times N_{showers} \times Days \div 1{,}000{,}000 \div RE$$

Where:

- MMBtu = Natural gas savings achieved per year
- ISR = In-service rate, which quantifies the percentage of measure units purchased which actually end up in use (e.g. more showerheads could have been purchased than there are showers with extras being kept in stock or installed at another location)%
- FUEL = Adjustment for percentage of water heaters that are natural gas fired
- GPM_{base} = Average baseline shower flow rate (gallons per minute)
- GPM_{low} = Average post-retrofit shower flow rate (gallons per minute)
- 8.3 lbm/gal = Specific weight of water
- 1.0 Btu/°F/lbm = Heat Capacity of water
- T_{out} = Average mixed water temperature flowing from the faucet
- T_{in} = Average temperature of water entering the house
- DF = Adjustment for percentage of water flowing down drain
- T_{shower} = Average shower length
- $N_{showers}$ = Average number of showers per one showerhead per day
- Days = Average days of shower usage per year
- 1,000,000 = Conversion from Btu to MMBtu
- RE = Recovery efficiency of hot water heater

Comparisons of the key parameters across each TRM are presented in the following table. Note that because this is a weather-dependent measure, only TRMs relating to ASHRAE Climate Zone 5A have been included.

Table 20: Showerhead

TRM	ISR	%FUEL	GPM_{base}	GPM_{low}	T_{shower}	$N_{showers}$	Days	DF	Tout	Tin	RE	Measure Life	MMBTU
Input Value:				*1.50*									
Connecticut 11th Edition (2016) [D]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.00	0.65
Illinois TRM V7.0 (2019)	0.98	1.00	2.67	1.50	8.20	0.90	365.25	1.00	105.00	54.10	0.67	10.00	1.96
Iowa Statewide TRM V3.0 (2018)	0.98	1.00	2.50	1.50	7.80	0.90	365.25	1.00	101.00	56.50	0.69	10.00	1.35
Massachusetts TRM (2016) [D]	N/A	N/A	2.50	1.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.00	2.60
Michigan Master Measure Database (2020) [D]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.94
New York TRM V7 (2019)	N/A	0.57	1.80	1.50	8.20	0.90	365.00	N/A	105.00	48.56	0.80	10.00	0.47
Mean	**0.98**	**0.86**	**2.37**	**1.50**	**8.07**	**0.90**	**365.17**	**1.00**	**103.67**	**53.05**	**0.72**	**10.00**	**1.66**
Median	**1.00**	**1.00**	**2.50**	**1.50**	**8.20**	**0.90**	**365.25**	**1.00**	**105.00**	**54.10**	**0.69**	**10.00**	**1.65**
Rhode Island TRM (2020)	**1.00**	**N/A**	**2.50**	**1.50**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**10.00**	**5.20**
Rhode Island TRM (2019)	1.00	N/A	2.50	1.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.00	5.20
Rhode Island TRM (2018)	1.00	N/A	2.50	1.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.00	5.20
Rhode Island TRM (2017) (RIGC211)	1.00	N/A	2.50	1.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.00	TBD[1]
Rhode Island TRM (2016) (RI_0371)	1.00	N/A	2.50	1.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7.00	5.20

[D]TRMs with deemed savings values
[1]Savings to be calculated based on evaluation results

2.4.7 Commercial & Industrial Electric Measures

The commercial and industrial electric measures flagged as priority measures because of their large contribution to the overall electric portfolio savings, included upstream lighting, downstream prescriptive lighting, and custom lighting. As custom lighting does not rely on TRM inputs, it was not included in the benchmarking exercise. Measures explored as part of the downstream prescriptive lighting program include Linear LED T8 Replacements and Occupancy Sensors.

2.4.7.1 Upstream Lighting

Upstream lighting is unique in that in addition to describing the equipment involved in the measure, it also specifies the delivery channel; "upstream" means a rebate is provided to the product distributor to encourage the stocking and sale of energy efficient equipment. Many TRMs intentionally do not provide guidance on delivery channels and leave those decisions up to the party offering the programs. As such, the lack of a TRM's inclusion of a specific "Upstream Lighting" measure does not necessarily mean it is not offered in the jurisdiction covered by the TRM; it merely means the TRM has not provided guidance on the upstream delivery channel. It is likely that if a program chooses to offer an upstream lighting option where no details are provided in the TRM on how to do so, the standard lighting algorithms and assumptions would be used. The Rhode Island 2020 TRM does provide Upstream Lighting as a discrete measure.

The common energy savings algorithm for upstream lighting measures is:

$$kWh = \frac{Watts_{base} - Watts_{ee}}{1{,}000\ ^{W}/_{kW}} \times Hours \times WHF\ \times ISR \times (1 - Leakage)$$

Where:

- kWh = Electric energy savings achieved
- $Watts_{base}$ = Wattage of removed lamp in watts
- $Watts_{ee}$ = Wattage of installed lamp in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts
- Hours = Annual operating hours
- WHF = Waste Heat Factor, which quantifies the interaction of the affected HVAC system with the reduced waste heat from the lighting measure
- ISR = In-service rate, which quantifies the percentage of measure units purchased which actually end up in use (e.g. more light bulbs could have been purchased than there are light fixtures with extras being kept in stock to replace as others burn out)
- Leakage = The proportion of bulbs sold through the upstream program that ultimately become installed where it was not intended (in a different sector or outside of the utilities jurisdiction)

Comparisons of the key parameters across each TRM are presented by measure in the following subsections.

Notes on Waste Heat Factors (WHF)

The 2020 Rhode Island TRM assigns Waste Heat Factors based on evaluation results which included many types of heating and cooling systems (including no cooling at all). TRMs that utilize waste heat factors (WHF) to quantify the increase in heating load due to the reduction of waste heat from the lighting system often provide a table of WHF values based on heating and cooling system type. To facilitate a balanced comparison of Rhode Island's blended value with those that assign Waste Heat Factors based on a specific attribute, we have opted to select the "Heating and Cooling Unknown" option from any such table, or an average of all options if an "Unknown" option was not provided.

Additionally, there are two common methods of applying Waste Heat Factors: one option is to use a multiplicative value as used in the common algorithm presented above (WHF); the other is to use an additive value (1 + WHF). For the purpose of this exercise, we have mathematically adjusted all published Waste Heat Factors to work with the common algorithm shown above. For example, the Pennsylvania TRM utilizes the latter methodology. In this manner, if the Waste Heat Factor was listed as -0.08, in order to match the algorithm utilized in the TRMulator, we have transformed this variable to 1 + WHF, or 0.92.

Notes on Annual Operating Hours

The method of assigning annual operating hours for upstream lighting varies widely across TRMs. Some examples of assignment include by commercial building type, by lamp type, by lamp location, and by rated lumen output. The 2020 and 2019 Rhode Island TRMs assign Hours of Use per year by commercial building type as assigned in the Massachusetts TRM; the 2018 Rhode Island TRM assigned Hours of Use per year by lamp type. There is no best practice; the determination of this value should be chosen to be reflective of how the hours of use are known to vary within the customer base. For the purposes of this exercise, where values were assigned by lamp type, we used the appropriate value for the lamp selected in the sample calculation; for all other assignment strategies, we used the straight average of all options provided to determine the annual HOU.

Table 21: Upstream Lighting[1]

TRM	Installed Lumens	Wbase	Wee	Hours	WHF	ISR	Leakage	CF Summer	CF Winter	Measure Life	kWh
Input Value:	*1,100.00*		*4.00*								
DC Sustainable Energy Utility TRM (2017) [D]	N/A	20.50	4.00	4,029.00	1.11	0.97	N/A	0.58	N/A	5.80	37.21
Connecticut 11th Edition (2016) [D]	1,100.00	N/A	4.00	N/A	N/A	N/A	N/A	N/A	N/A	8.00	131.00
Illinois TRM V7.0 (2019)	1,100.00	53.00	4.00	3,266.00	1.22	1.00	0.02	1.00	N/A	15.00	193.29
Iowa Statewide TRM V3.0 (2018)	1,100.00	53.00	4.00	3,266.00	1.22	1.00	TBD[2]	1.00	N/A	15.00	TBD
Massachusetts TRM (2016)	N/A	INPUT	4.00	EXT[3]	1.22	1.00	N/A	0.72	0.53	2.83	TBD
Missouri Statewide TRM (2017)	1,100.00	100.00	4.00	728.00	0.99	0.98	N/A	0.00	N/A	8.00	59.30
Pennsylvania TRM (2021)	1,100.00	24.44	4.00	3,266.00	1.22	0.92	0.00	1.00	N/A	15.00	74.94
Vermont TRM No. 2014-87 (2015) [D]	N/A	11.80	4.00	3,500.00	1.03	0.90	N/A	N/A	N/A	5.00	11.04
Mean	1,100.00	37.53	4.00	2,579.29	1.00	0.967	0.01	0.61	0.27	9.33	84.46
Median	1,100.00	24.44	4.00	3,266.00	1.16	0.980	0.00	0.72	0.27	8.00	67.12
Zone 5A Mean	1,100.00	40.37	4.00	2,337.67	0.99	0.966	0.01	0.62	0.27	9.83	93.91
Rhode Island TRM (2020)	N/A	N/A	N/A	4,682.00	0.99	0.76	N/A	N/A	N/A	Not Provided	212.55
Rhode Island TRM (2019) (Table 6a and 6b)	N/A	N/A	N/A	4,682.00	0.99	0.76	N/A	N/A	N/A	Not Provided	212.55
Rhode Island TRM (2018) (Table 6)	N/A	N/A	N/A	2,400.00	1.03	0.67	N/A	N/A	N/A	Not Provided	36.00
Rhode Island TRM (2017) (Table 6)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	33.50
Rhode Island TRM (2016) (Table 6)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	33.50

[D]TRMs with deemed savings values
[1]This particular example explores the installation of a 4-Watt LED A-Lamp.
[2]Iowa TRM dictates that the leakage factor should be determined by the utility offering the upstream program
[3]Massachusetts TRM references an external source for hours that could not be found

2.4.7.2 Linear LED T8 Replacements

The common energy savings algorithm for commercial and industrial lighting measures is:

$$kWh = Qty \times \frac{Watts_{base} - Watts_{ee}}{1{,}000\ {}^{W}/_{kW}} \times Hours \times WHF \times ISR$$

Where:

- kWh = Electric energy savings achieved
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture in watts
- $Watts_{ee}$ = Wattage of installed lamp or fixture in watts
- 1,000 W/kW = Conversion from Watts to Kilowatts
- Hours = Annual operating hours
- WHF = Waste Heat Factor
- ISR = In-service rate

Comparisons of the key parameters across each TRM are presented by measure in the following subsections.

General Note

Rhode Island offers Linear LED lamps through the upstream program and as fixtures as a prescriptive downstream and custom measure, although the prescriptive downstream measure itself has mistakenly been left out of the TRM. Assumptions used in this comparison include that the equipment is a 4' 1-lamp fixture where a linear LED replaces an existing T8 lamp.

Notes on Waste Heat Factors

The 2020 Rhode Island TRM assigns Waste Heat Factors by light bulb type and makes no mention of the heating and cooling system. TRMs that utilize waste heat factors (WHF) to quantify the interaction of the affected HVAC system with the reduced waste heat from the lighting measure often provide a table of WHF values based on heating and cooling system type. To facilitate a balanced comparison of Rhode Island's TRM with those that do include Waste Heat Factors, we have opted to select the "Heating and Cooling Unknown" option from any such table, or an average of all options if an "Unknown" option was not provided. Additionally, there are two common methods of applying Waste Heat Factors: one option is to use a multiplicative value as used in the common algorithm presented above (WHF); the other is to use an additive value (1 + WHF). For the purpose of this exercise, we have mathematically adjusted all published Waste Heat Factors to work with the common algorithm shown above. For example, the Pennsylvania TRM utilizes the latter methodology. In this manner, if the Waste Heat Factor was listed as -0.08, in order to match the algorithm utilized in the TRMulator, we have transformed this variable to 1 + WHF, or 0.92.

Notes on Annual Operating Hours

The RI TRM does offer this measure as a prescriptive measure, but values are not provided in the current TRM. A lamp only LED measure is offered through its upstream program. As a custom measure, operating hours are site specific and determined on a case-by-case basis. Most TRMs assign Hours of Use per year by commercial building type, and do not provide an "unknown" option. For the purposes of this exercise, values noted in the following table are the "Office" option from any such TRM.

Table 22: Linear LED T8 Replacements

TRM	W_{base}	W_{ee}	Hours	WHF	ISR	CF Summer	CF Winter	Measure Life	kWh
Input Value:		*23.00*							
Arkansas TRM V7 (2017)	31.00	23.00	3,227.00	0.98	N/A	0.54	N/A	15.00	25.30
DC Sustainable Energy Utility TRM (2017)	29.10	23.00	3,642.00	1.13	0.97	0.58	N/A	15.00	24.42
Delaware TRM (2016)	29.50	23.00	3,009.00	1.00	1.00	0.70	N/A	15.00	19.56
Maine TRM (2017)	31.00	23.00	3,642.00	1.06	1.00	0.76	0.63	13.00	29.14
Minnesota TRM V2.1 (2018)	32.00[1]	23.00	4,439.00	1.10	1.00	0.70	N/A	16.00	43.75
Connecticut 11th Edition (2016)	31.00	23.00	3,748.00	1.17	N/A	0.70	0.54	13.00	34.93
IESO Measures and Assumptions List (2019) [D]	32.00	N/A	Varies	N/A	N/A	N/A	N/A	18.00	28.60
Massachusetts TRM (2016)	28.00	23.00	3,610.00	N/A	1.00	0.83	0.66	13.00	18.05
Michigan Master Measures Database (2020) [D]	32.00	N/A	2,669.00	N/A	N/A	0.49	N/A	18.00	40.00
MidAtlantic TRM V8.0 (2018)	29.50	23.00	3,009.00	1.00	1.00	0.70	N/A	15.00	19.56
New Jersey Protocols (2016)	32.00[1]	23.00	3,642.00	1.17	N/A	0.68	N/A	15.00	38.35
New York TRM V7 (2019)	31.00	23.00	3,013.00	1.03	N/A	1.00	N/A	15.00	24.80
Pennsylvania TRM (2021)	31.00	23.00	1,420.00	1.10	1.00	0.26	N/A	7.00	12.44
Vermont TRM No. 2014-87 (2015) [D]	29.10	23.00	3,642.00	1.03	0.98	N/A	N/A	15.00	35.39
Mean	30.59	23.00	3,285.54	1.07	0.99	0.66	0.61	14.50	28.16
Median	31.00	23.00	3,610.00	1.06	1.00	0.70	0.63	15.00	26.95
Zone 5A Mean	30.62	23.00	3,094.13	1.08	1.00	0.67	0.60	14.33	28.01
Rhode Island TRM (2020)	Specific parameter values not provided in the TRM								
Rhode Island TRM (2019)	Specific parameter values not provided in the TRM								
Rhode Island TRM (2018)	Specific parameter values not provided in the TRM								
Rhode Island TRM (2017)	Specific parameter values not provided in the TRM								
Rhode Island TRM (2016) (RI_0184)	Specific parameter values not provided in the TRM								

[D]TRMs with deemed savings values
[1]Minnesota and New Jersey TRMs did not provide an assumed wattage for baseline fixtures so 32 was used as the standard T8 wattage with no ballast factor applied

2.4.7.3 Occupancy Sensors

The common energy savings algorithm for occupancy sensors is:

$$kWh = \frac{Watts_{controlled}}{1{,}000\ {}^{W}/_{kW}} \times Hours_{Pre} \times SVG \times WHF\ \times ISR$$

Where:

- kWh = Electric energy savings achieved
- $Watts_{controlled}$ = Total wattage controlled by installed occupancy sensors
- 1,000 W/kW = Conversion from Watts to Kilowatts
- $Hours_{Pre}$ = Annual operating hours of lighting prior to installation of occupancy sensors
- SVG = Savings factor (represents the percentage reduction to the operating Hours from the non-controlled baseline lighting system)
- WHF = Waste Heat Factor
- ISR = In-service rate

Comparisons of the key parameters across each TRM are presented by measure in the following sections.

Notes on Waste Heat Factors

The 2020 Rhode Island TRM assigns Waste Heat Factors by light bulb type and makes no mention of the heating and cooling system. TRMs that utilize waste heat factors (WHF) to quantify the increase in heating load due to the reduction of waste heat from the lighting system often provide a table of WHF values based on heating and cooling system type. To facilitate a balanced comparison of Rhode Island's TRM with those that do include Waste Heat Factors, we have opted to select the "Heating and Cooling Unknown" option from any such table, or an average of all options if an "Unknown" option was not provided. Additionally, there are two common methods of applying Waste Heat Factors: one option is to use a multiplicative value as used in the common algorithm presented above (WHF); the other is to use an additive value (1 + WHF). For the purpose of this exercise, we have mathematically adjusted all published Waste Heat Factors to work with the common algorithm shown above. For example, the Pennsylvania TRM utilizes the latter methodology. In this manner, if the Waste Heat Factor was listed as -0.08, in order to match the algorithm utilized in the TRMulator, we have transformed this variable to 1 + WHF, or 0.92.

Notes on Annual Operating Hours

The Rhode Island TRM offers lighting controls as a prescriptive measure, although the measure itself has mistakenly been left out of the TRM. For this comparison, this measure was evaluated as part of the custom lighting track detailed in the Rhode Island TRM. As a custom measure, operating hours are site specific and determined on a case-by-case basis. Other TRMs assign Hours of Use per year by commercial building type. For the purposes of this exercise, values noted in the following table are the "Office" option from any such TRM.

Table 23: Occupancy Sensors

TRM	Per Sensor	Per kW Ctrl'd	Per Fixture Ctrl'd	HOU_{Pre}	Watts	SVG	WHF	ISR	CF Summer	CF Winter	Measure Life	kWh
Input Value:					*200.00*							
Arkansas TRM V7 (2017)				3,227.00	200.00	0.30	N/A	N/A	0.54	N/A	8.00	193.62
California Municipal Utilities TRM (2016)				3,748.00	200.00	0.22	N/A	1.00	0.70	0.54	8.00	164.91
DC Sustainable Energy Utility TRM (2017)				3,642.00	200.00	0.24	1.13	0.98	0.58	N/A	10.00	194.11
Delaware TRM (2016)				3,009.00	200.00	0.28	1.00	1.00	0.70	N/A	10.00	168.50
Hawaii Energy TRM (2018) [D]			X	3,650.00	N/A	0.33	1.00	N/A	0.12	N/A	8.00	67.84
Maine TRM (2017)				3,642.00	200.00	0.15	1.00	1.00	0.18	0.12	10.00	109.26
Minnesota TRM V2.1 (2018)				4,439.00	200.00	0.30	1.10	1.00	0.70	N/A	8.00	291.64
Ameren Missouri TRM (2016) [D]			X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11.00	206.97
Connecticut 11th Edition (2016)				3,748.00	200.00	0.30	N/A	1.00	0.70	0.54	9.00	224.88
IESO Measures and Assumptions List (2019) [D]	X			3,911.00	N/A	N/A	N/A	N/A	N/A	N/A	8.00	234.70
Illinois TRM V7.0 (2019)				3,266.00	200.00	0.24	1.22	N/A	1.00	N/A	8.00	80.33
Indiana TRM V1.0 (2013)				3,253.00	200.00	0.24	0.94	N/A	0.15	N/A	9.00	146.93
Iowa Statewide TRM V3.0 (2018)				2,920.00	304.00	0.24	1.15	N/A	0.64	N/A	8.00	245.00
Massachusetts TRM (2016)				INPUT[1]	200.00	N/A	N/A	1.00	0.18	0.12	10.00	TBD[1]
Michigan Master Measures Database (2020) [D]	X			2,669.00	N/A	N/A	N/A	N/A	0.49	N/A	10.00	288.30
MidAtlantic TRM V8.0 (2018)				3,009.00	200.00	0.28	1.00	1.00	0.70	N/A	10.00	168.50
Missouri Statewide TRM (2017)				3,170.00	200.00	0.24	1.14	N/A	TBD	N/A	8.00	173.46
New Jersey Protocols (2016)				3,642.00	200.00	0.30	1.05	N/A	0.68	N/A	15.00	229.44
New York TRM V7 (2019)				3,013.00	200.00	0.30	1.03	N/A	1.00	N/A	10.00	186.02
Ohio TRM (2010)				3,526.00	200.00	0.30	1.10	1.00	0.70	N/A	10.00	231.66
Pennsylvania TRM (2021)				1,420.00	200.00	0.24	1.10	1.00	0.26	N/A	8.00	74.64
Vermont TRM No. 2014-87 (2015)				3,642.00	200.00	0.24	1.03	0.98	0.26	N/A	10.00	176.97
Mean				3,327.30	200.00	0.26	1.07	1.00	0.56	0.40	9.33	188.98
Median				3,396.00	200,00	0.26	1.05	1.00	0.66	0.54	9.00	191.26
Zone 5A Mean				3,177.79	200.00	0.26	1.08	1.00	0.56	0.33	9.60	195.81
Rhode Island TRM (2020)				INPUT[1]	200.00	N/A	N/A	1.00	0.35	0.28	9.00	TBD[1]

TRM	Per Sensor	Per kW Ctrl'd	Per Fixture Ctrl'd	HOU_{Pre}	Watts	SVG	WHF	ISR	CF Summer	CF Winter	Measure Life	kWh
Rhode Island TRM (2019)				INPUT[1]	200.00	N/A	N/A	1.00	0.15	0.18	10.00	TBD[1]
Rhode Island TRM (2018)				INPUT[1]	200.00	N/A	N/A	1.00	0.15	0.18	10.00	TBD[1]
Rhode Island TRM (2017) (RIEC245)				INPUT[1]	200.00	N/A	N/A	1.00	0.15	0.18	10.00	TBD[1]
Rhode Island TRM (2016) (RI_0183)				INPUT[1]	200.00	N/A	N/A	1.00	0.15	0.18	10.00	TBD[1]

[D] TRMs with deemed savings values

[1] RI and MA TRMs rely on customer input of pre-retrofit and post-retrofit hours and do not provide standard assumptions, thus comparable values cannot be calculated.

2.4.8 Commercial & Industrial Gas Measures

The commercial and industrial gas measures flagged as priority measures included comprehensive design assistance, custom HVAC, custom process improvements, and custom and prescriptive steam traps. As custom measures do not rely on TRM inputs, all custom measures were not included in the benchmarking exercise. Only steam traps were benchmarked. Please note as with many measures steam traps are offered both as prescriptive measures with deemed savings as well as custom measures where a site-specific analysis is done using a standardized model. The discussion below deals with the prescriptive version of steam traps.

2.4.8.1 Steam Traps

The common energy savings algorithm for steam trap replacements is:

$$MMBtu = (24.24 \times Pia \times D^2 \times A \times FF) \times \frac{Hvap}{\eta_{heat}} \times Hours \times \%Leak \div 1{,}000{,}000$$

Where:

- MMBtu = Natural gas savings achieved
- 24.24 = Constant
- Pia = Inlet pressure
- D = Diameter of orifice
- A = Adjustment factor to account for reducing the maximum theoretical steam flow to the average steam flow
- FF = Flow factor
- H_{vap} = Heat of vaporization of steam
- η_{heat} = Efficiency of heating equipment
- Hours = Annual operating hours of the steam trap being treated
- %Leak = Percentage of traps leaking and needing replacement
- 1,000,000 = Conversion from Btu to MMBtu

Comparisons of the key parameters across each TRM are presented in the following table. Note that because this is a weather-dependent measure, only TRMs relating to ASHRAE Climate Zone 5A have been included.

<u>Notes on Hours</u>

Of the three TRMs included in the analysis, two of them require customer input for operating hours. Only Illinois provides an assumed value, which has been used as the input value in the table below.

Table 24. Steam Trap Replacements (High Pressure).

TRM	Pia	D	A	FF	H_{vap}	η_{heat}	Hours	Measure Life	% Leak	MMBtu
Input Value:	*47*	*0.25*					*8,282*			
Illinois TRM V7.0 (2019)	47	0.25	50%	1	915.00	0.72	8,282	6.00	27%	133.00
Missouri Statewide TRM (2017)	47	0.25	50%	1	912.00	0.72	8,282	6.00	27%	132.57
New York TRM V7 (2019)	47	0.25	50%	1	915.00	0.72	8,282	6.00	N/A	132.57
Mean	47	0.25	50%	1	913.00	0.72	8,282	6.50	27%	132.71
Median	47	0.25	50%	1	912.00	0.72	8,282	6.00	27%	132.57
Rhode Island TRM (2020)[6]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	35.60
Rhode Island TRM (2019)[6]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	35.60
Rhode Island TRM (2018)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	12.20
Rhode Island TRM (2017) (RIGC042)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	25.70
Rhode Island TRM (2016) (RI_0176)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	25.70

Table 25. Steam Trap Replacements (Low Pressure)

TRM	Pia	D	A	FF	H_{vap}	η_{heat}	Hours	Measure Life	% Leak	MMBtu
Input Value:	*15*	*0.25*					*8,282*			
Illinois TRM V7.0 (2019)	15	0.25	50%	1	944.00	0.72	8,282	6.00	27%	65.89
Missouri Statewide TRM (2017)	15	0.25	50%	1	945.00	0.72	8,282	6.00	27%	65.96
New York TRM V7 (2019)	15	0.25	50%	1	945.00	0.72	8,282	6.00	N/A	65.96
Mean	15	0.25	50%	1	945.00	0.72	8,282	6.50	27%	65.94
Median	15	0.25	50%	1	945.00	0.72	8,282	6.00	27%	65.93
Rhode Island TRM (2020)[6]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	8.40
Rhode Island TRM (2019)[6]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	8.40
Rhode Island TRM (2018)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	12.20
Rhode Island TRM (2017) (RIGC042)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	25.70
Rhode Island TRM (2016) (RI_0176)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.00	N/A	25.70

[6] Several of the values noted as 'N/A' can be found in the following study: http://ma-eeac.org/wordpress/wp-content/uploads/MA-CIEC-Two-Tier-Steam-Traps-Memo-FINAL.pdf

2.5 Conclusions & Recommendations

It is evident from the analysis conducted that National Grid regularly uses evaluation results for the enhancement of the Rhode Island TRM. Almost all measures received at least one update over the five years of evaluated TRMs. Of the 20 measures reviewed, the only measures that have not received any updates are the following:

- Small Business Showerheads
- Refrigerated Case Lighting
- Exit Signs

It is not always necessary that measures receive regular updates based on the technology, program contribution to overall savings, and market changes that may impact the need for updates.

Based on a review of the assumptions and savings, there are two measures that seem out of alignment with others in the industry in terms of calculation methods and/or assumptions. Of those measures found to be out of alignment and for which a representative comparison could be made, all report a higher savings value than the mean and median of the comparison group. However, one limitation of the Rhode Island TRM is that it does not provide transparency into assumptions used for the deemed measures, which makes it difficult to pinpoint which contributing values should be given additional consideration. The details of the development of the savings assumption are often found in the referenced studies, but could be more well documented in the TRM itself. National Grid should consider increasing transparency in TRMs moving forward to allow those using the TRM to readily align assumptions with source data. The measures identified as out of alignment are summarized in Table 26.

Table 26: Measures Flagged for Further Consideration

Measure	2020 RI TRM Savings	Mean	Median	Zone 5A Mean
LED Screw-in A-Lamp, Single Family, Retrofit (EnergyWise Program)	40.90 kWh	29.07 kWh	27.96 kWh	31.82 kWh
LED Screw-in A-Lamp, (Energy Star Program/ Residential Upstream Lighting)	43.50 kWh			
C&I Upstream Lighting	212.55 kWh	84.46 kWh	67.12 kWh	93.91 kWh

<u>C&I Upstream Lighting</u> savings reported in RI's TRM are more than double the comparative mean and more than triple the comparative median. The main contributor appears to be the hours of use assumption. As discussed in Section 2.4.7.1, the method of assigning annual operating hours for upstream lighting varies widely across TRMs making it difficult to make a useful comparison on this assumption. The values used in the calculations represent the average value from each TRM's possible selections, regardless of how they are assigned (e.g., the average value of all building type-specific values in a table where values are associated with building types, etc.). The hours of use values in the more recent Rhode Island TRMs are, on average,

higher than other TRMs compared herein. However, the Rhode Island TRM does provide direction for applying the specific hours of use value based on building type. Therefore, in direct application, the savings value could be closer in line with other TRMs. The BrightLine team recommends that National Grid revisit the hours of use currently provided in the Rhode Island TRM.

Residential Lighting measures, specifically the single-family LED screw-in A-Lamps, are greater than the comparative means by 10 kWh (or 33%). BrightLine recommends that Rhode Island review the underlying assumptions for these measures, such as baseline wattage and hours of use, to ensure that assumptions are accurate and appropriate given market conditions. It should be noted that according to National Grid, these assumptions have been updated but those values were not available for Brightline to review. For example, in the RI 2021 TRM, the 40.90 kWh savings value has been updated to 18 kWh based on the recently completed impact evaluation of the Single Family Retrofit program.

Steam Trap savings in the RI TRM are significantly lower than comparison TRM's with a deemed savings value of 35.6 compared to an average value of 132.7 for high pressure traps and a deemed savings value of 8.40 compared to an average value of 65.94 for low pressure traps. However, as only three other TRMs offered this measure, and each of them uses the same sources for all of their inputs, there is not enough data feeding the model to draw useful conclusions.

General Comments: Measures aside, in terms of general TRM format, all other analyzed TRMs are ordered by equipment or measure rather than program delivery channel. Within each measure, tables delineate where values differ across programs. The BrightLine team recommends adopting the RI TRM to a model that is more user-friendly; such as a model that aligns the information around the typical user's core concern and body of knowledge (i.e. the typical TRM user knows what they are installing but may not be familiar with the program offerings). In addition, some program offerings change more often than equipment and end-uses, therefore when organized by equipment or measure, the TRM can keep a consistent order year over year, which will benefit repeat users. We understand that jurisdictions will organize their TRMs in a way that best fits their needs and program, however, in general, the RI TRM was difficult to navigate due to the way it is organized.

In addition to these recommendations, some errors and omissions were noted in the 2020 TRM:

- The Upstream Lighting Measure references Table 6 for Measure Life, but Table 6 does not provide Measure Life.
- The MF Shell Insulation measure for the EnergyWise Multifamily Program shows HDD as "dependent on location, see table below". No such table follows.

3 Review Previous Evaluation Reports for Alignment with EM&V Best Practices

3.1 Summary

The BrightLine team, with support from National Grid, assembled all relevant evaluation studies related to a set of priority measures from each customer class within the past four years. These are the same measures included in the TRM Algorithm and Assumptions Review, with minor exceptions. These priority measures were identified based on a review of National Grid's program participation data and include those measures that contribute approximately 60% of the savings within each customer class and fuel type.

The measure categories and studies identified for this review were developed in cooperation with the Office of Energy Resources and National Grid. National Grid provided studies conducted in RI and MA from 2015 to 2018 and BrightLine identified the studies appropriate to address the measures selected. In some cases, those studies were evaluations conducted of National Grid's program offerings in Massachusetts.[7] See Appendix B for the final study Work Plan, which identifies the evaluation studies selected for this task.

The team reviewed each study for alignment with EM&V best practices. The BrightLine team and National Grid identified 25 evaluation studies related to energy efficiency programs in the following categories:

- C&I Electric
- C&I Gas
- Residential Electric
- Residential Gas
- Small Business Electric
- Small Business Gas
- Low Income

Following are notes for the reader to consider when reviewing Section 3:

- The evaluation study review summaries are presented by program category. However, some of the studies the team reviewed pertain to multiple program categories.[8] For those studies the team includes just one review matrix in this report, located within a report section pertaining to one of the relevant programs, and cross references that study within the other relevant sections of the report.

[7] The Massachusetts studies were managed by Massachusetts Program Administrators. Those studies' findings informed the Rhode Island programs and were referenced for the purposes of this analysis as the best available study for review. However, note that Rhode Island does not have control over the scope and deliverables of those efforts.

[8] For example, the Impact Evaluation of 2014 Custom Gas Installations in Rhode Island (2016) is relevant to both he C&I Gas and Small Business Gas program categories.

- One report the team identified was a market potential study and therefore the review was not applicable.
- Two evaluation studies had not yet been concluded and thus there was no report available to review. In total the team reviewed and prepared matrices for 22 unique evaluation studies.

Based on input from OER, the team developed a matrix template to capture best practice alignment in the following areas:

- Sample design – The approach used to select the sample units (i.e., the subset of the total population) that will be included in a data collection and analysis effort. This review looked at whether the sample design used in the study is consistent with industry best practices for studies of that type.
- Evaluation activities – The range of activities included in the research methods. This review looked at whether the evaluation activities used in the study are consistent with industry best practices for studies of that type.
- Documentation of assumptions – This review looked at whether key assumptions about a project or program that drive energy or demand savings calculations were well documented.
- Data sources – The data elements that served as the basis for study findings. This study looked at whether the data sources are consistent with best practices for the type of study in question.
- Relevance to TRM – A Technical Reference Manual (TRM) is the document used as the source for estimating energy and demand savings resulting from a program. This review noted which studies call for a change in estimated savings values included in the TRM.
- Documented confidence intervals – Confidence intervals measure the degree of uncertainty or certainty in a sampling method. This review looked at whether the study documented both the target and actual confidence intervals resulting from the data collection and analysis efforts.
- Findings & recommendations – The summary of key outcomes from a study. This review looked at whether the study included clear and actionable recommendations that are well aligned with the information presented in the main body of the study.

The BrightLine team populated a matrix for each targeted measure and program type. Each matrix documents distilled findings from the relevant evaluation study or studies, along with an assessment of alignment with best practices. Table 27 presents the rating symbols used to assess the evaluation studies.

Table 27: Matrix assessment key

Symbol	Description
✓	Study adheres to industry best practices for a particular review topic
✓-	Study generally adheres to industry best practices but exhibits minor deficiency
?	Study provides insufficient information upon which to determine if it adheres to industry best practices
✗	Study does not adhere to industry best practices
N/A	The assessment category is not applicable for the study

The best practice review drew from the following EM&V industry reference documents, with a primary focus on the first two documents on the list. The remaining sources were referenced as appropriate:

- Department of Energy Uniform Methods Project (UMP)
- International Performance Measurement and Verification Protocol (IPMVP)
- National Standard Practice Manual
- SEE Action Energy Efficiency Program Impact Evaluation Guide
- TRMs providing guidance for EE programs in relevant states
- Verified savings results from relevant evaluations
- Recently completed baseline studies capturing equipment patterns in the Northeast
- Federal codes and standards
- ENERGY STAR® Program Requirements
- Results of recent measure-specific studies

The following sections present the completed review matrices organized by measure category. Table 28: Summary of Reviewed Studies by Measure presents a summary of the identified measures of focus for this work and the related evaluation studies reviewed, along with a reference to the table number. Studies highlighted in light blue are those that pertain to multiple measures or program categories.

Table 28: Summary of Reviewed Studies by Measure

Priority Measure	Evaluation Studies	Table Reference # (Task 2 Report)
C&I Electric		
Prescriptive Lighting	Impact Evaluation of 2011 Rhode Island Prescriptive Retrofit Lighting Installations (2013)	Table 29
Upstream LED Lighting	Impact Evaluation of PY2015 Rhode Island Commercial and Industrial Upstream Lighting Initiative (2018)	Table 31
	Impact Evaluation of PY20xx Upstream Lighting Program (2019)	Not yet available
	P81 C&I Upstream Lighting ISR Analysis Summary – *Massachusetts* (2018)	Table 32
Custom Lighting	Rhode Island Commercial and Industrial Impact Evaluation of 2016 Custom Electric Installations (2020)	Table 33
	Impact Evaluation of PY2018 Custom Electric Installations (2019)	Not yet available
Prescriptive Lighting Controls	Impact Evaluation of 2010 Prescriptive Lighting Installations – *Massachusetts* (2013)	Table 30
C&I Gas		
Custom Comprehensive Design Assistance	Rhode Island Commercial & Industrial Impact Evaluation of 2013-2015 Custom Comprehensive Design Approach (2018)	Table 34
Custom (HVAC, Process and Steam Traps)	Impact Evaluation of 2014 Custom Gas Installations in Rhode Island (2016)	Table 35
	Impact Evaluation of PY2016 Custom Gas Installations in Rhode Island (2019)	Table 36
	Impact Evaluation of PY2017 Custom Gas Installations in Rhode Island (2020)	Table 38
Custom Steam Traps	Steam Trap Evaluation Phase 2 - *Massachusetts* (2017)	Table 37
Prescriptive Steam Traps		
Residential Electric		
Home Energy Reports (Opower)	Rhode Island Home Energy Report Program Impact and Process Evaluation (2017)	Table 39
EnergyWise Single Family-LED Bulbs and Fixtures	Impact Evaluation of 2014 EnergyWise Single Family Program, National Grid Rhode Island (2016);	Table 40
	Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)	Table 50
Residential Lighting - LED Bulbs and Fixtures	Northeast Residential Lighting Hours-of-Use Study (2014);	Table 41
	2016 RLPNC HOU Update Analysis - *Massachusetts* (2016);	Table 42
	MA Lighting Interactive Effects Results Memo (2016);	Table 43
	Delta Watt Update (MA19R02-E) (2019);	Table 44
	RI2311 National Grid Rhode Island Lighting Market Assessment (2018)	Table 45
Residential Lighting - CFL Bulbs and Fixtures	Northeast Residential Lighting Hours-of-Use Study (2014);	Table 41
	2016 RLPNC HOU Update Analysis - *Massachusetts* (2016);	Table 42
	MA Lighting Interactive Effects Results Memo (2016);	Table 43
	Delta Watt Update (MA19R02-E) (2019);	Table 44
	RLPNC Study 18-10 2018-19 Residential Lighting Market Assessment Study – *Massachusetts* (2019)	Table 46
Residential Gas		
Home Energy Reports (Opower)	Rhode Island Home Energy Report Program Impact and Process Evaluation (2017)	Table 39

Priority Measure	Evaluation Studies	Table Reference # (Task 2 Report)
Energy Wise - Weatherization	Impact Evaluation of 2014 EnergyWise Single Family Program, National Grid Rhode Island (2016)	Table 40
Small Business Electric		
Lighting	Rhode Island Small Business Energy Efficiency Program Prescriptive Lighting Study (2015)	Table 47
	Impact Evaluation of PY2016 RI C&I Small Business Initiative: Phase I (2018)	Table 48
Small Business Gas		
Aerator	Natural Gas Energy Efficiency Potential in Massachusetts (2009)	N/A*
Showerheads	Natural Gas Energy Efficiency Potential in Massachusetts (2009)	N/A*
Custom	Impact Evaluation of 2014 Custom Gas Installations in Rhode Island (2016)	Table 35
Low Income Electric		
Income Eligible MF - LED Bulbs and Fixtures	Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)	Table 50
Low Income Services - LED Bulbs and Fixtures	National Grid Rhode Island Income Eligible Services Impact Evaluation (2018)	Table 49
Low Income Gas		
Income Eligible MF - Weatherization	Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)	Table 50
Income Eligible MF - HVAC	Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)	Table 50
*These measures are addressed in an energy efficiency potential study. Because it is a potential study and not an evaluation study the evaluation matrix used for this work is not applicable.		

3.1.1 C&I Electric

Overall, the team found that the C&I electric-related evaluation studies are well aligned with EM&V industry best practices. Minor issues were identified related to sample design and documentation of assumptions for the Upstream Lighting report (2018) (see Table 32).

Table 29. C&I Electric: Prescriptive Lighting

C&I Electric: Prescriptive Lighting (and Lighting Controls)			
Evaluation Report: Impact Evaluation of 2011 Rhode Island Prescriptive Retrofit Lighting Installations (2013)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Sample included 18 retrofit projects stratified by total savings. Excluded New Construction projects. Annual kWh target: ±15% precision at 90% confidence; summer kW target: ±15% precision at 80% confidence.	✓	Targets meet National Grid requirements.
Evaluation Activities	Evaluated impacts from Systems and Controls measures only. Estimated realization rates for: annual kWh, connected kW, summer and winter on-peak coincidence factors, and HVAC interactive effects factor.	✓	Activities were appropriate given the study scope. Future evaluations may look to expand the study scope to address additional measures and provide more comprehensive feedback on program impacts.
Documentation of Assumptions	Sample design, verification and analysis methods are well documented, including application of logger data and analysis of HVAC interactive effects.	✓	Sufficient documentation of assumptions provided.
Data Sources	Physical inspections, interviews with facility personnel, long-term metering, review of program tracking estimates, weather data.	✓	Consistent with industry standards.
Relevance to TRM	Recommends using study results to update realization rate assumptions and using hours of use findings for future New Construction projects.	✓	Adjustments to savings assumptions recommended based on study outcomes.
Documented Confidence Intervals	Achieved C/P intervals reported for all metrics. Achieved relative precision and error ratios were high for some metrics (e.g., +/-47% precision at the 90% confidence level for lighting controls kWh savings, with error ratio of 0.81).	✓	C/P intervals documented appropriately. Sampling for future evaluations should take into consideration the high error ratio outcomes from this evaluation.
Findings & Recommendations	The study finds some underperformance relative to tracking estimates, largely due to errors in hours of use estimates.	✓	Findings are well documented.

Table 30. C&I Electric: Prescriptive Lighting Controls

C&I Electric: Prescriptive Lighting Controls			
Evaluation Report: Impact Evaluation of 2010 Prescriptive Lighting Installations – Massachusetts (2013)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Sample included 57 sites split between measure types. Sample design targeted +/-10% precision at the 90% confidence level for energy (kWh) and the +/-10% precision at the 80% confidence level for coincident peak summer demand (kW). These targets align with National Grid's requirements.	✓	Sample design approach appropriate for evaluation purposes.
Evaluation Activities	The study focused on the 2010 Prescriptive Lighting end-use categories and developed realization rates for gross energy savings and savings factors at the statewide level using 12 months of metered data collected from each site. It also provided realization rates for on-peak and seasonal summer and winter demand savings.	✓	Activities were appropriate given the study scope.
Documentation of Assumptions	Sample design assumed an error ratio of 0.4. Analysis assumptions are clearly documented, including those related to issues encountered for calculating refrigerated LED case lighting savings.	✓	Sufficient documentation of assumptions provided.
Data Sources	Data collection included physical inspection and inventory, interview with facility personnel, observation of site operating conditions and equipment, and 12 months of usage metering.	✓	Consistent with industry standards.
Relevance to TRM	Provided updated savings values for prescriptive lighting and new construction measures.	✓	Adjustments to savings assumptions recommended based on study outcomes.
Documented Confidence Intervals	Achieved confidence and precision are documented for all results.	✓	C/P intervals documented appropriately
Findings & Recommendations	Results included statewide level realization rates for annual kWh savings, percent on-peak kWh savings, and on-peak and seasonal demand (kW) coincidence factors at the times of the winter and summer peaks. Realization rates captured HVAC interactive effects that were excluded from gross savings estimates.	✓	Findings are well documented.

Table 31. C&I Electric: Upstream LED Lighting

C&I Electric: Upstream LED Lighting			
Evaluation Report: Impact Evaluation of PY2015 Rhode Island Commercial and Industrial Upstream Lighting Initiative (2018)			
	National Grid Evaluation Practices	**Alignment with Industry Standards**	
Sample Design	5 sample strata included: TLEDs, stairway kits, retrofit kits, A-lines and decoratives, and G24s. Targeted 90/15 confidence and precision based on the MA+RI population.	✓	Sample design approach appropriate for evaluation purposes.
Evaluation Activities	Updated RI-specific assumptions for: 1) ISR by facility and space type; 2) Hours of use; 3) Baseline for estimating delta watts; 4) realization rates; 5) Summer and winter peak coincidence factors and on-peak savings; 6) HVAC Interactive Effects. Data collection included site visits, interviews with facility personnel, and metering for lighting HOU.	✓	Activities are in line with industry standards.
Documentation of Assumptions	Assumptions are well documented. Error ratio was assumed to be lower than in the previous study.	✓	Sufficient documentation of assumptions provided.
Data Sources	A variety of primary data collection sources used, including site visits, interviews, and metering data.	✓	Consistent with industry standards.
Relevance to TRM	The study proposes new savings factors for multiple measures.	✓	Adjustments to savings assumptions recommended based on study outcomes.
Documented Confidence Intervals	Achieved C/P intervals reported for MA and RI separately and combined. Achieved relative precision and error ratios were higher than expected for several metrics.	✓	C/P documented appropriately. Sampling for future evaluations should take into consideration the high error ratio outcomes from this evaluation.
Findings & Recommendations	RI realization rates were significantly higher than MA. Made observations to improve accuracy of future evaluation efforts and provided insight into the impacts of market structure on effective program implementation. For 3 categories of LEDs auditors were unable to locate a large portion of products claimed in tracking data. Higher than expected error ratio resulted in greater uncertainty than expected.	✓	Findings and recommendations clearly outlined, RR's presented by state and MA and RI combined.
Other: Plans for combining future evaluation efforts across states	DNV GL noted plans for a new study to better understand the effects of combining programs from two states for evaluation.	N/A	Where program offerings, population characteristics and markets are similar combining evaluation efforts across two jurisdictions can be appropriate for some types of evaluation.

Table 32. C&I Electric: Upstream LED Lighting

C&I Electric: Upstream LED Lighting			
Evaluation Report: P81 C&I Upstream Lighting ISR Analysis Summary - Massachusetts (2018)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Sample design was not thoroughly discussed but it appears to have piggy backed on other studies. The memo notes that distribution of QC sites by measure category makes it difficult to extrapolate results to the population and recommends stratifying by both measure category and size in the future.	✓-	The sample design had limitations due to practical considerations related to cost-efficient study design. The memo recommends changes to sample design for future analysis.
Evaluation Activities	As part of the Process Evaluation and Site Visits for the C&I Upstream Lighting Initiative reviewed QC contractor and evaluation on-site data and completed 233 site visits to 2018 participant sites. Conducted consensus group discussion with the PAs and EEAC Consultants to consider changes for 2016 and 2017, and to provide an overall installation rate assumption for next program cycle.	✓	Study activities were appropriate to the research objectives.
Documentation of Assumptions	The memo included detailed tables of findings from measure category-level analysis. However, it does not explain what the categories represent.	✓-	The brief memo provided limited information on assumptions used for the analysis.
Data Sources	Data sources included site visits and analysis of QC data.	✓	Data sources were appropriate to the research objectives.
Relevance to TRM	The analysis recommends applying a new ISR value of 76% for the 2019-2021 program cycle.	✓	The memo recommends a new ISR value.
Documented Confidence Intervals	Confidence intervals are documented in summary tables for the measure category-level results.	✓	C/P intervals documented appropriately
Findings & Recommendations	The memo recommends using a new ISR of 76%, conducting rolling data collection going forward, and targeting a more representative sample in the future. It notes that all calculated in-service rates are included in the full report, which was to be finalized in the Fall of 2018.	✓	Findings and recommendations are clearly documented.

Table 33. C&I Electric: Custom Lighting

C&I Electric: Custom Lighting			
Evaluation Report: Rhode Island Commercial and Industrial Impact Evaluation of 2016 Custom Electric Installations			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	The study was designed to achieve ±10% at 90% confidence for custom electric projects overall with MA and RI combined and achieve ±15% at 90% confidence for lighting and non-lighting separately with MA and RI combined. Results in RI will be piggybacked with results in MA until sufficient samples can be conducted in RI alone to develop RI-specific findings.	✓	Sample design approach appropriate for evaluation purposes, including use of piggybacking results with MA.
Evaluation Activities	The evaluation collected and reviewed all the provided program documentation and collected data associated with each sampled project. Data collection methods included interviews of facility personnel, interviews of equipment vendors, on-site monitoring of operating equipment, receipt of data collected by the customer, and receipt of utility meter consumption data. Site-specific measurement and verification (M&V) plans were created for each sampled site.	✓	Rigorous activities selected which is in-line with industry standard.
Documentation of Assumptions	Report includes discussion of sampling assumptions and shows sampling strategy for MA and RI separately and over the three-year rolling evaluation cycle. Assumptions used in analysis are documented	✓	Sufficient documentation of assumptions provided.
Data Sources	Extensive primary data was used from sources described in "Evaluation Activities."	✓	Consistent with industry standards.
Relevance to TRM	N/A	N/A	Program does not utilize a technical reference manual as it is custom in nature.
Documented Confidence Intervals	For lighting RRs achieved +/-7.6% precision at the 90% (90/7.6) confidence interval for the combined energy savings realization rate. Achieved 90/12.3 for combined non-lighting RR. Results also reported for RI separately but the study is the first in a three-year rolling evaluation.	✓	C/P documented appropriately.
Findings & Recommendations	RR results are reported for both the statewide and combined levels and lighting and non-lighting for annual energy and peak demand savings. The study includes recommendations for application of the results, suggested revisions for future evaluations of the program, along with recommendations specific to hours of use, statement of sources, and requirements for application documentation submittals.	✓	Findings and recommendations clearly presented.

3.1.2 C&I Gas

Overall, the BrightLine team found that the C&I gas-related evaluation studies are well aligned with EM&V industry best practices. A minor issue was identified related to sample design for the Custom HVAC (2016) report (see Table 35).

Table 34. C&I Gas: Custom Comprehensive Design Assistance

C&I Gas: Custom Comprehensive Design Assistance			
Evaluation Report: Rhode Island Commercial & Industrial Impact Evaluation of 2013-2015 Custom Comprehensive Design Approach (2018)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Stratified sampling, designed to achieve 90/25 across both RI and MA	✓	Sample design is not necessarily industry standard, but the evaluation report clearly outlines why this sample design was selected and the reasoning is appropriate.
Evaluation Activities	Site Specific M&V plans developed for each sampled site. Data collection methods included interviews of facility personnel, interviews of equipment vendors, on-site monitoring of operating equipment, receipt of data collected by the customer, and receipt of utility meter consumption data.	✓	Appropriate activities utilized for a program of this nature
Documentation of Assumptions	Site specific M&V plans developed for each sampled site, wherein all necessary data and assumptions are documented and tracked.	✓	Site specific M&V plans are standard procedure for custom projects, allowing for sufficient documentation of assumptions per project
Data Sources	High level of primary data collection completed - site visits and interviews conducted for each sampled project	✓	For site-specific projects that are custom in nature and have large savings, primary data collection is preferred method
Relevance to TRM	N/A	N/A	Program does not utilize a technical reference manual as it is custom in nature
Documented Confidence Intervals	Achieved C/P intervals are reported for MA, RI, and MA+RI and kWh and kW - not for therms	✓	Objective of this study did not include an update to RR for gas measures.
Findings & Recommendations	Findings, recommendations, and future considerations included in Executive Summary and in full report	✓	Findings, recommendations and future considerations very well documented and explained
Other: Detailed evaluation findings provided with report	Site-specific evaluation summaries provided as Appendices	✓	Supporting evaluation documentation provided in Appendices very comprehensive and complete

Table 35. C&I Gas: Custom (2016)

C&I Gas: Custom			
Evaluation Report: Impact Evaluation of 2014 Custom Gas Installations in Rhode Island (2016)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Stratified sampling, targeted to achieve 80/20 across both RI and MA, with 80/19 in MA and 80/34 in RI. Final results were 80/17 in MA and 80/5 in RI and 80/8 in MA and RI combined	✓-	Targeted sampling C/P seemed low in comparison to industry standard - but achieved C/P is desirable. Understand that because on-sites were conducted for all sampled projects, the sample sizes need to stay low for budget reasons. However, NGrid should consider including documentation review as a stand-alone EM&V activity to help increase sample size.
Evaluation Activities	Site specific M&V plans developed for each sample project. Data collection included physical inspection and inventory, interview with facility personnel, observation of site operating conditions and equipment, and short-term metering. At each site, evaluator performed a facility walk-through that focused on verifying the post-retrofit or installed conditions of EE measure. Gas bills were acquired from National Grid. Evaluation methods included: hourly temperature spreadsheet models, bin temperature spreadsheet models, and billing analysis.	✓	Rigorous activities selected which is in-line with industry standard. However, as noted above, higher sample sizes could have been achieved if stand-alone project documentation reviews were also completed on additional projects.
Documentation of Assumptions	Each site report details the analysis methods used specific to each project including algorithms, assumptions, and calibration methods where applicable. The actual analytical techniques employed depended upon the applicant's methods, the measure, and site conditions.	✓	Site specific M&V plans are standard procedure for custom projects, allowing for sufficient documentation of assumptions per project
Data Sources	High level of primary data collection	✓	For site-specific projects that are custom in nature, primary data collection is preferred method. As noted, could consider increasing sample size by including documentation review as another data source
Relevance to TRM	N/A	N/A	Program does not utilize a technical reference manual as it is custom in nature
Documented Confidence Intervals	Achieved C/P intervals reported for MA and RI separately and combined	✓	C/P intervals documented appropriately
Findings & Recommendations	Findings and recommendations clearly outlined, RR's presented by state and MA and RI combined.	✓	Would have been interesting to see RR's by stratum and measure category, though with small sample sizes at the current rigor level, results would be limited in value. If less rigorous methods were used, more sites could be studied to inform results by stratum and measure.

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Table 36. C&I Gas: Custom (2019)

C&I Gas: Custom			
Evaluation Report: Impact Evaluation of PY2016 Custom Gas Installations in Rhode Island (2019)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	The primary sample design targeted ±15% relative precision for the entire National Grid territory in MA and RI's annual therms at the 80% confidence interval for PY2016 and 80/27 C/P for RI only. Assumed error ratio of 0.6 based on prior evaluations. Design meant to establish long-term staged M&V Approach of RI only sampled sites and, after the evaluation of 2017 sites, achieve a relative precision of ±10% at a confidence interval of 80% by combining at least 3 program years. PY2016 sample is considered to be year-2 in the staged (rolling) approach. Until three years of the rolling evaluation have been completed (PY2014, PY2016, and PY2017), final results for application to RI programs will be developed by combining with that year's sites in MA. Note this study covers all of Custom Gas not just HVAC.	✓	Sample design approach appropriate for evaluation purposes, expected C/P for RI is low compared to industry standards. Use of prior evaluation error ratio is good practice. Three-year rolling sample approach is good practice as well.
Evaluation Activities	Site specific M&V plans developed for each sample project. Data collection included physical inspection and inventory, interview with facility personnel, observation of site operating conditions and equipment, and metering. At each site, evaluator performed a facility walk-through that focused on verifying the post-retrofit or installed conditions of the energy efficiency measure. Gas bills were acquired from National Grid. Evaluation methods included: hourly temperature spreadsheet models, bin temperature spreadsheet models, and billing analysis.	✓	Rigorous activities selected which is in-line with industry standard. However, as noted above, higher sample sizes could have been achieved if stand-alone project documentation reviews were also completed on additional projects.
Documentation of Assumptions	Each site report details the analysis methods used specific to each project including algorithms, assumptions, and calibration methods where applicable. The actual analytical techniques employed depended upon the applicant's methods, the measure, and site conditions.	✓	Site specific M&V plans are standard procedure for custom projects, allowing for sufficient documentation of assumptions per project.
Data Sources	High level of primary data collection	✓	For site-specific projects that are custom in nature, primary data collection is preferred method. As noted, could consider increasing sample size by including documentation review as another data source.
Relevance to TRM	N/A	N/A	Program does not utilize a technical reference manual as it is custom in nature.

C&I Gas: Custom			
Evaluation Report: Impact Evaluation of PY2016 Custom Gas Installations in Rhode Island (2019)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Documented Confidence Intervals	Achieved C/P intervals reported for MA and RI separately and combined. Study achieved 80/11 for RI and 80/8 C/P for MA and RI combined. Expected C/P for RI only was 80/27.	✓	C/P intervals documented appropriately.
Findings & Recommendations	Findings and recommendations clearly outlined, RR's presented by state and MA and RI combined.	✓	Findings and recommendations clearly outlined, RR's presented by state and MA and RI combined.
Other: Detailed evaluation findings provided with report	Site-specific evaluation summaries provided as Appendices	✓	Supporting evaluation documentation provided in Appendices is comprehensive and complete.

Table 37. C&I Gas: Custom and Prescriptive Steam Traps

C&I Gas: Custom and Prescriptive Steam Traps			
Evaluation Report: Steam Trap Evaluation Phase 2 – Massachusetts (2017)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Evaluation included a screening process that began with all projects in the MA 2013-2014 participant database. Project files were requested for all custom and prescriptive projects that made it through the initial screening process (70) and attempted telephone interviews will all 70 facilities as well, ultimately conducting 55 interviews. Billing analysis was conducted on 41 sites (after another screening round) and of the 41, 28 sites met the criteria for parameter calibration.	✓	The evaluation included a rigorous screening process of all participating projects to ensure that only applicable projects were included in the final sample and analysis.
Evaluation Activities	Multiple data collection activities including stakeholder group engagement, secondary research, pre-installation vendor ride-alongs, participant data project file review (70 projects), post-installation phone interviews (55 projects), post-installation on-site visits (7 projects). Analysis activities included trap-level savings calculations, site-specific level billing analysis and engineering analysis.	✓	Evaluation activities consistent with industry best practices
Documentation of Assumptions	Clearly outlined assumptions and variables used for the evaluation.	✓	Documentation of assumptions and variables follows best practices
Data Sources	Multiple data collection activities including stakeholder group engagement, secondary research, pre-installation vendor ride-alongs, participant data project file review (70 projects), post-installation phone interviews (55 projects), post-installation on-site visits (7 projects).	✓	Rigorous data sources followed industry best practices
Relevance to TRM	Custom measure not applicable, deemed prescriptive savings value recommended for inclusion in TRM	✓	Evaluator recommended updated deemed savings value for prescriptive track inclusion in TRM, per industry best practice
Documented Confidence Intervals	Confidence intervals not reported	✓	Reporting of C/P is not appropriate based on overall objective of the study
Findings & Recommendations	Findings and recommendations clearly outlined with strong supporting detail and explanation for each recommendation.	✓	Conclusions, recommendations and future considerations very well documented and explained.

Table 38. C&I Gas: Custom (2020)

C&I Gas: Custom			
Evaluation Report: Impact Evaluation of PY2017 Custom Gas Installations in Rhode Island (2020)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	The primary sample design targeted ±20% relative precision for the National Grid territory in RI's annual therms at the 80% confidence interval for PY2016 and PY2017 combined. Assumed error ratio of 0.6 based on prior evaluations. The sample design for this round (PY2017) was developed assuming the results would be pooled with prior (and future) custom gas results. The general principle used in this design is that the results from each year would need to achieve ±35% precision at 80% confidence interval to maintain a three-year pooled result of ±20% precision at 80% confidence for gross therms savings RRs. DNV GL used Model-Based Statistical Sampling (MBSS) techniques to develop the sample design. Note this study covers all of Custom Gas not just HVAC.	✓	Sample design approach appropriate for evaluation purposes, expected C/P for Rhode Island is low compared to industry standards. Use of prior evaluation error ratio is good practice. Three-year rolling sample approach is good practice as well.
Evaluation Activities	Site specific M&V plans developed for each sample project. Data collection included physical inspection and inventory, interview with facility personnel, observation of site operating conditions and equipment, and short and long-term metering. At each site, evaluator performed a facility walk-through that focused on verifying the post-retrofit or installed conditions of the energy efficiency measure. Gas bills were acquired from National Grid.	✓	Rigorous activities selected which is in-line with industry standard. However, as noted above, higher sample sizes could have been achieved if less rigorous stand-alone project documentation reviews were also completed on additional projects.
Documentation of Assumptions	Each site report details the data collection and analysis methods specific to each project including site verification activities, algorithms, assumptions, metered data and reasons for discrepancy between reported and evaluated savings. Each site report also outlines the evaluators assessment of the applicant's description of baseline, installed equipment, operation and energy savings analysis method.	✓	Site specific M&V plans are standard procedure for custom projects, allowing for sufficient documentation of assumptions per project

C&I Gas: Custom			
Evaluation Report: Impact Evaluation of PY2017 Custom Gas Installations in Rhode Island (2020)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Data Sources	High level of primary data collection	✓	For site-specific projects that are custom in nature, primary data collection is preferred method. As noted, could consider increasing sample size by including documentation review as another data source
Relevance to TRM	N/A	N/A	Program does not utilize a technical reference manual as it is custom in nature
Documented Confidence Intervals	A rolling/staged evaluation approach was planned to be used to effectively produce RI independent results by the end of a 3-year rolling cycle or, results from a 2-year rolling cycle, if reasonable relative precisions are achieved. Results presented in this report did achieve reasonable precisions by combining just two program years (PY2016 and PY2017). Overall, the study achieved 85% RR with a relative precision of ±4.3% at 80% confidence interval.	✓	C/P intervals documented appropriately
Findings & Recommendations	Findings and recommendations clearly outlined	✓	Findings and recommendations clearly outlined
Detailed evaluation findings provided with report	Site-specific evaluation reports provided in Appendix	✓	Supporting evaluation documentation provided in Appendices very comprehensive and complete

3.1.3 Residential Electric

Overall, the team found that the residential electric-related evaluation studies are well aligned with EM&V industry best practices. Minor issues were identified related to sample design, documentation of confidence intervals and reporting of findings for some reports in this category (see Table 39, Table 42, Table 43, Table 44, Table 45, and Table 46). Specifically, the Home Energy Report program's 2017 impact evaluation report could have benefited from including a more comprehensive discussion of sample design for the randomized control trial study design. The 2016 impact evaluation of the EnergyWise Single Family Program (for PY 2014) did not include references to targets for the confidence level and precision for sample design, though it is standard practice to identify those targets in evaluation reports. In addition to the minor issues identified with these impact evaluation reports, the review identified potential issues with topic-focused studies conducted to inform and define key parameters used to estimate savings resulting from the installation of high efficiency lighting technologies including hours or use, delta watts, interactive effects, and market characterization. The team included several question marks in the matrices for these topic-focused studies (i.e., Table 42 through Table 46) to indicate where these reports lacked certain details and could benefit from additional information to better convey the study design and findings.

Table 39. Residential Electric: Home Energy Reports

Residential Electric: Home Energy Reports (Opower) Evaluation Report: Rhode Island Home Energy Report Program Impact and Process Evaluation (2017)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	This Randomized Control Trial program format embeds sample design into program design. The treatment and control group sizes appear to have been designed with a targeted 90% confidence level. However, the report includes limited discussion of sample design.	✓-	The report could include more comprehensive discussion of the sample design that was used to select program participants at the program design stage, recognizing the initial program design was not completed by a vendor other than the evaluation contractor.
Evaluation Activities	Activities included: 1) Program Process and Materials review; 2) Existing Customers HER Impacts Assessment; 3) New Movers Impacts Assessment; 4) eHER Impacts Assessment; 5) Baseline Segmentation Impacts Assessment; 6) Secondary Research Used randomized control trials (RCTs), ensuring equivalence between control and treatment groups. Used post-program regression (PPR) model as well as a Linear Fixed-Effects Regression (LFER) model to estimate savings for a set of cohorts. Estimated program uplift and double counting. [Persistence of savings is addressed through separate study.]	✓	Randomized experiments that estimate savings differences between treatment and control groups minimize bias and produce the most accurate results. The UMP recommends using panel regression analysis to estimate savings. Savings persistence, program uplift (causing increased participation in other programs) and double counting of savings should also be measured.
Documentation of Assumptions	Assumptions well documented	✓	Program evaluators should carefully document the research design, data collection and processing steps, analysis methods, and plan for calculating savings estimates.
Data Sources	Billing history of New Movers (customers with less than 12 months of billing history) and all other cohorts.	✓	Used meter data to estimate savings
Relevance to TRM	N/A	N/A	Program does not utilize a technical reference manual
Documented Confidence Intervals	Confidence interval of 90% reported for most cohorts, with the exception of New Movers.	✓	Consistent with industry practices.
Findings & Recommendations	Clearly stated and supported	✓	Specific actionable items are clearly defined.

Table 40. Residential Electric: EnergyWise Single Family- LED Bulbs and Fixtures

Residential Electric: EnergyWise Single Family- LED Bulbs and Fixtures Evaluation Report: Impact Evaluation of 2014 EnergyWise Single Family Program, National Grid Rhode Island (2016)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Sample for billing analysis included a program group made up of all records that met relevant criteria (i.e., households with sufficient billing data that started program participation in 2014) and a comparison group of similar households selected from 2015 tracking database which met relevant criteria (i.e., had not participated in any programs during 2013-14, sufficient billing data available and a reasonable usage pattern).	✓	Design of the billing analysis adhered to protocols for an evaluation of this type.
Evaluation Activities	Two-stage billing analysis and engineering calculations completed to determine electric savings by impact group, estimate LED savings by number of bulbs, and calculate gas and electric realization rates, among other objectives.	✓	Evaluation activities are consistent with evaluation best practices for similar types of programs.
Documentation of Assumptions	Report clearly describes how results of billing analysis were adjusted based on engineering analysis and additional research.	✓	Assumptions are clearly stated and appear to be appropriate
Data Sources	Program tracking data, billing data, weather data	✓	All relevant data sources utilized
Relevance to TRM	Study recommends updating future deemed savings based on study outcomes.	✓	It is common for evaluation results to inform future ex ante savings assumptions.
Documented Confidence Intervals	Billing analysis results documented to achieve overall precision of +/-16% for electric and +/-12% for gas at 90% confidence.	✓	Documented
Findings & Recommendations	Clearly stated and supported, specific to evaluation methods	✓	Specific actionable items are clearly defined.

Table 41. Residential Electric: Residential Lighting – LED Bulbs and Fixtures (1)

Residential Electric: Residential Lighting - LED Bulbs and Fixtures Evaluation Report: Northeast Residential Lighting Hours-of-Use Study (2014)			
National Grid Evaluation Practices		Alignment with Industry Standards	
Sample Design	The sample design for the HOU study encompassed RI, MA, NY, and CT and ultimately achieved a sample size of 848 homes. The overall sample size is based on the requirements for 90/10 statistical confidence/precision based on Cv that varied by room type (0.7 for all rooms with the exception of rooms classified as "other" which received a Cv of 1.0). The sample was weighted based on home type, income level, as well as by room and efficient versus non-efficient bulb types.	✓	It is standard practice for study design to meet prescribed confidence and precision targets based on assumed Cv. The study ultimately found higher variation in the sample resulting in larger Cv values. These findings are communicated for future design sample considerations.
Evaluation Activities	Light logger study including sampling, customer recruitment, site visit to install and retrieve loggers, HOU data analysis, and load shape analysis	✓	Evaluation activities are consistent with evaluation best practices for similar types of programs and follow guidance outlined in the Uniform Methods Project (UMP).
Documentation of Assumptions	Report provides discussion and detail for how sample outliers were handled, how HOU analysis was conducted including sinusoidal modeling, weighting calculations and methods, and how data and models were used to improve results with limited raw data.	✓	Assumptions are clearly stated and appear to be appropriate
Data Sources	Logger data; bulb saturation and location data	✓	All relevant data sources utilized
Relevance to TRM	Study recommends updating HOU parameters based on study outcomes.	✓	It is common for evaluation results to inform future ex ante savings assumptions.
Documented Confidence Intervals	Study sought 10% precision at the 90% confidence interval based on a Cv of 0.7 with the exception of outdoor sockets which was sampled assuming a 1.2 Cv.	✓	Study documents achieved Cv and notes recommended Cv for future evaluations. Confidence intervals and root mean squared errors are presented for model.
Findings & Recommendations	Clearly stated and supported.	✓	Specific actionable items and guidance are clearly defined.

Table 42. Residential Electric: Residential Lighting – LED Bulbs and Fixtures (2)

Residential Electric: Residential Lighting - LED Bulbs and Fixtures Evaluation Report: 2016 RLPNC HOU Update Analysis – Massachusetts (2016)			
National Grid Evaluation Practices		Alignment with Industry Standards	
Sample Design	Study is a memo outlining findings from is meta-analysis. Sample design from other studies are not detailed.	?	It is standard practice for study design to meet prescribed confidence and precision targets. Future studies and/or memos providing updated parameter estimates should specify confidence level and precision targets.
Evaluation Activities	No formal evaluation activities as memo outlines meta-analysis.	N/A	N/A
Documentation of Assumptions	Memo details data results from various studies and methods used to estimate parameter updates.	✓	Assumptions are clearly stated and appear to be appropriate
Data Sources	Prior evaluation studies	✓	All relevant data sources utilized
Relevance to TRM	Study recommends updating HOU parameters based on study outcomes.	✓	It is common for evaluation results to inform future ex ante savings assumptions.
Documented Confidence Intervals	Memo cites overall confidence interval from one study but does not provide resulting confidence/precision based on meta-analysis findings.	?	Parameter values are not always accompanied with confidence intervals; typically provided for regression-derived parameters.
Findings & Recommendations	Clearly stated and supported.	✓	Specific actionable items and guidance are clearly defined.

Table 43. Residential Electric: Residential Lighting – LED Bulbs and Fixtures (3)

Residential Electric: Residential Lighting - LED Bulbs and Fixtures Evaluation Report: MA Lighting Interactive Effects Results Memo (2016)			
National Grid Evaluation Practices		Alignment with Industry Standards	
Sample Design	This study is primarily informed by simulation models; however, some of these models rely on prior program evaluation data as well as billing data for model calibration purposes. Sample design from these data sources are not detailed in the memo.	?	It is standard practice for study design to meet prescribed confidence and precision targets. Future studies should specify confidence level and precision targets.
Evaluation Activities	Model simulation of multiple residential building types to estimate interactive effects between changes in lighting technology and subsequent impacts on HVAC systems.	✓	Evaluation activities are consistent with evaluation best practices and methods.
Documentation of Assumptions	Memo details data sources from various studies and methods used to estimate parameter updates.	✓	Assumptions are clearly stated and appear to be appropriate
Data Sources	Prior evaluation and market studies and DOE models including program tracking data, billing data, weather data, market saturation data	✓	All relevant data sources utilized.
Relevance to TRM	Goal of study was to develop state-wide (MA) IE factor as a parameter for estimating savings impacts from installing efficient lighting technologies.	✓	It is common for evaluation results to inform future ex ante savings assumptions.
Documented Confidence Intervals	Memo does not discuss confidence intervals and/or level of uncertainty from studies that informed the meta-analysis. This uncertainty is not presented in modeling outputs.	N/A	It is not common for model simulations to present confidence intervals.
Findings & Recommendations	Findings are clearly stated and supported; however, recommendations are not provided in memo.	✓-	Some actionable items and guidance are defined.

Table 44. Residential Electric: Residential Lighting – LED Bulbs and Fixtures (4)

Residential Electric: Residential Lighting - LED Bulbs and Fixtures Delta Watt Update (MA19R02-E) (2019)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Sampling was not conducted for this study as a census of available data was used for the analysis.	N/A	N/A
Evaluation Activities	Delta watts analysis using program sales data including data cleaning, technology type categorization, incandescent wattage equivalent review.	✓	Evaluation activities are consistent with evaluation best practices for similar types of studies
Documentation of Assumptions	Report details data sources from various studies and methods used to estimate parameter updates.	✓	Assumptions are clearly stated and appear to be appropriate
Data Sources	Program tracking sales data, internet research, shelf stocking study	✓	All relevant data sources utilized
Relevance to TRM	Goal of study was to develop state-wide (MA) LED delta watts inputs for the Lighting Market Adoption Models as a parameter for estimating savings impacts from installing efficient lighting technologies.	✓	It is common for evaluation results to inform future ex ante savings assumptions.
Documented Confidence Intervals	Report does not discuss confidence intervals and/or level of uncertainty based on the data used in the analysis.	✓-	Parameter values are not always accompanied with confidence intervals; typically provided for regression-derived parameters.
Findings & Recommendations	Findings are clearly stated and supported; considerations and guidance for future evaluations stated.	✓	Specific actionable items are clearly defined.

Table 45. Residential Electric: Residential Lighting – LED Bulbs and Fixtures (5)

Residential Electric: Residential Lighting - LED Bulbs and Fixtures RI2311 National Grid Rhode Island Lighting Market Assessment (2018)			
National Grid Evaluation Practices		Alignment with Industry Standards	
Sample Design	Study does not provide detail on sample design. Discussion for weighting applied to analysis is provided but no discussion on targeted statistical confidence or precision is available.	?	It is standard practice for study design to meet prescribed confidence and precision targets. Future studies should specify confidence level and precision targets to provide insight on level of uncertainty surrounding key parameters analyzed in study.
Evaluation Activities	Recruitment for on-site survey data collection; on-site visits consisted of lighting inventory and customer survey.	✓	Evaluation activities are consistent with evaluation best practices for similar types of studies.
Documentation of Assumptions	Report details data sources from various studies and methods used to estimate parameter updates.	✓	Assumptions are clearly stated and appear to be appropriate
Data Sources	On-site data collection; secondary survey data.	✓	All relevant data sources utilized.
Relevance to TRM	Goal of study was to assess the RI lighting market including but not limited to LED saturation, penetration, storage rates including calculated in-service rates.	✓	It is common for evaluation results to inform future ex ante savings assumptions.
Documented Confidence Intervals	Report does not discuss confidence intervals and/or level of uncertainty from studies that informed the analysis. Uncertainty is not presented with final parameter values.	?	Parameter values are not always accompanied with confidence intervals; typically provided for regression-derived parameters.
Findings & Recommendations	Findings are clearly stated and supported; however, very limited recommendations are made in report.	✓	Some actionable recommendations are defined.

Table 46. Residential Electric: Residential Lighting – CFL Bulbs and Fixtures

Residential Electric: Residential Lighting - CFL Bulbs and Fixtures RLPNC Study 18-10 2018-19 Residential Lighting Market Assessment Study (2019)			
National Grid Evaluation Practices		Alignment with Industry Standards	
Sample Design	Study does not provide detail on sample design. Discussion for weighting applied to analysis is provided but no discussion on targeted statistical confidence or precision is available.	?	It is standard practice for study design to meet prescribed confidence and precision targets. Future studies should specify confidence level and precision targets to provide insight on level of uncertainty surrounding key parameters analyzed in study.
Evaluation Activities	Recruitment for on-site survey data collection; on-site visits consisted of lighting inventory and customer survey.	✓	Evaluation activities are consistent with evaluation best practices for similar types of studies.
Documentation of Assumptions	Report details data sources from various studies and methods used to estimate parameter updates.	✓	Assumptions are clearly stated and appear to be appropriate
Data Sources	On-site data collection; secondary survey data.	✓	All relevant data sources utilized.
Relevance to TRM	Goal of study was to develop state-wide (MA) in-service rates, updated HOU, LED saturation, and other market indicators.	✓	It is common for evaluation results to inform future ex ante savings assumptions.
Documented Confidence Intervals	Report does not discuss confidence intervals and/or level of uncertainty from studies that informed the analysis. Uncertainty is not presented with final parameter values with the exception of HOU which provides actual confidence intervals of findings.	?	Parameter values are not always accompanied with confidence intervals; typically provided for regression-derived parameters.
Findings & Recommendations	Findings are clearly stated and supported; considerations and guidance for future evaluations stated.	✓	Specific actionable items are clearly defined.

See the summary table for the Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015) available in Section 3.1.7.

3.1.4 Residential Gas

See the summary tables for the Rhode Island Home Energy Report Program Impact and Process Evaluation (2017) and the Impact Evaluation of 2014 EnergyWise Single Family Program (2016), both available in Section 1.1.1.

3.1.5 Small Business Electric

Overall, the team found that the small business electric-related evaluation studies are well aligned with EM&V industry best practices. However, the Lighting Program study (2018) could benefit from minor improvements in the clarity of documenting assumptions and findings (see rows with a checkmark minus in Table 48).

Table 47. Small Business Electric: Lighting (2015)

Small Business Electric: Lighting			
Evaluation Report: Rhode Island Small Business Energy Efficiency Program Prescriptive Lighting Study (2015)			
	National Grid Evaluation Practices	**Alignment with Industry Standards**	
Sample Design	The stratified sampling targeted ±10% relative precision at the 90% confidence interval.	✓	Consistent with standard industry practice
Evaluation Activities	Reviewed program tracking data and project files, conducted site visits with metering and verification.	✓	This combination of evaluation activities is standard practice for traditional impact evaluations of similar programs.
Documentation of Assumptions	Assumptions for sampling statistics, HVAC interactive effects and expansion to the population are well documented.	✓	Clear documentation of assumptions support the accuracy of this and future evaluations
Data Sources	High level of primary data collection including program tracking data and site visits.	✓	The study used standard data sources for an evaluation of this type.
Relevance to TRM	Study recommends including HVAC interaction in future tracking system savings estimates.	✓	The study outcomes warrant minor adjustments to TRM assumptions.
Documented Confidence Intervals	Achieved C/P are reported.	✓	Results for demand savings are reported at the 80% confidence interval to be consistent with ISO-NE requirements for peak demand results. Precision ranged from +/-0.8% to +/-27%.
Findings & Recommendations	Calculated summer and winter coincidence factors, connected demand (kW), energy (kWh), annual hours of use (HOU) realization rates, percent on-peak energy savings, and summer and winter demand and energy HVAC interactive effects factors.	✓	The study provides clear findings and recommendations for minor adjustments to future savings assumptions.

Table 48. Small Business Electric: Lighting (2018)

Small Business Electric: Lighting			
Evaluation Report: Impact Evaluation of PY2016 RI C&I Small Business Initiative: Phase I (2019)			
	National Grid Evaluation Practices	**Alignment with Industry Standards**	
Sample Design	Sampling stratified and optimized for estimating overall summer peak demand savings with a targeted ±10% precision at the 80% confidence interval. Sampling for energy savings used a 90% confidence interval.	✓	Consistent with standard industry practice
Evaluation Activities	Verified energy and demand savings estimates for a sample of custom and prescriptive electric lighting projects through site inspection, monitoring, and analysis. The approach and methodology were consistent with those of the previous evaluation in 2015. The study also investigated baseline issues.	✓	This combination of evaluation activities is standard practice for traditional impact evaluations of similar programs.
Documentation of Assumptions	Assumptions are generally well documented, though there is inconsistency in reference to the sampling target for estimating summer peak demand savings.	✓-	The study could benefit from some minor improvements in the clarity of documenting assumptions.
Data Sources	High level of primary data collection including program tracking data and site visits with metering.	✓	The study used standard data sources for an evaluation of this type.
Relevance to TRM	Study recommends making future use of the MA+RI level results for prospective savings estimates and program planning for lamp and ballast measures, but not for controls.	✓	The study outcomes warrant minor adjustments to TRM assumptions.
Documented Confidence Intervals	Achieved C/P are reported. Precision for demand calculations ranged from +/- 0.07% to +/- 20%.	✓	Outcomes are well documented.
Findings & Recommendations	Provided proposed new savings factors for connected kW, Installation rate, Delta watts, Hours of use, summer and winter on-peak hours and coincidence factors and % on-peak kWh, summer and winter HVAC interactive effects, and gas heating penalty. Summary-level observations and recommendations included some unclear language (e.g., referencing a 90/10 sampling target which contradicted statements elsewhere in the report).	✓-	The study generally provides clear findings and recommendations with some areas for minor improvement in clarity.
Other: Lighting-only focus	Only 4% of the total savings came from non-lighting measures in this initiative in 2016. Therefore, this study focused on lighting measures only.	N/A	It would be beneficial to explore how to achieve savings from other measures, potentially combined with process evaluation efforts.

3.1.6 Small Business Gas

See the summary table for the Impact Evaluation of 2014, PY2016, and PY2017 Custom Gas Installations in Rhode Island available in Section 3.1.2. National Grid also identified a study of Natural Gas Energy Efficiency Potential in Massachusetts (2009) as relevant for showerhead and aerator measures. However, because that is a potential study the review matrix was not applicable.

3.1.7 Low Income Electric

Overall, the BrightLine team found that the low income electric-related evaluation studies are well aligned with EM&V industry best practices. One minor issue was identified related to reporting of recommendations for the Low Income Services – LED Bulbs and Fixtures (see Table 49).

Table 49. Low Income Electric: Low Income Services – LED Bulbs and Fixtures

Low Income Electric: Low Income Services - LED Bulbs and Fixtures			
Evaluation Report: National Grid Income Eligible Services Impact Evaluation (2018)			
	National Grid Evaluation Practices	**Alignment with Industry Standards**	
Sample Design	Billing analysis sample design driven largely by data quality issues and the need to isolate the effects of a particular measure.	✓	Sample design appeared to adhere to industry standards.
Evaluation Activities	Estimated program-attributable energy savings; provided measure-level and measure group-level energy savings and realization rates across all fuel types. Methods included billing analysis, assembly and use of engineering algorithms, and building simulation.	✓	Consistent with industry standards
Documentation of Assumptions	Report includes comprehensive summary table documenting factors informing differences in ex ante and ex post savings assumptions.	✓	Assumptions are well documented.
Data Sources	customer information and supplemental participant data; billing data for treatment and control groups; weather data	✓	Consistent with industry standards
Relevance to TRM	Findings should inform updates to future ex ante savings estimates.	✓	It is common for evaluation results to inform future ex ante savings assumptions.
Documented Confidence Intervals	Documentation is included for natural gas and electricity, but not delivered fuels. Natural gas billing analysis achieved +/-5% precision at 90% confidence level. Electric billing analysis achieved +/-11% precision at 90% confidence level.	✓	Documentation for natural gas and electric analyses were consistent with industry standards. The engineering adjustments and assumptions made for heating oil and propane do not facilitate a measurement of statistical significance.
Findings & Recommendations	Findings were clearly presented. Recommendations focused primarily on data keeping and evaluation methods.	✓-	Recommendations could include content that informs future measure offerings.
Other: Variation of method by measure type	The team used engineering algorithms to evaluate most measures. The billing analysis was limited to a small subset for which savings could be reported at or better than ±25% precision at the 90% confidence level.	N/A	

Table 50. Low Income Electric: Income Eligible MF-LED Bulbs and Fixtures

Low Income Electric: Income Eligible MF -LED Bulbs and Fixtures			
Evaluation Report: Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Two tasks involved sample design. The natural gas billing analysis required several data screens. The resulting sample closely resembled the initiative population as a whole. The common area lighting analysis included 3 sample strata based on claimed savings.	✓	Sample design for common area lighting, and other research activities that leveraged that sampling, was well explained.
Evaluation Activities	Activities included: Task 1- engineering analysis and literature review; Task 2 - natural gas billing analysis; Task 3 - common area lighting analysis; Task 4 - on-site verification and measure analysis; Task 5 - assessment of secondary impacts.	✓	Activities are appropriate to the analysis scope, and informed by stakeholder input. Benchmarking performed as part of the study found that billing analysis to estimate gas savings for similar programs is rare. However, the method has merits given the nature of the program.
Documentation of Assumptions	Assumptions are clearly documented. A decision to use higher pre-installation wattage than observed in the common area lighting study was questionable, though well documented in the report.	✓	Assumptions are clearly stated and appear to be appropriate
Data Sources	Program tracking data, billing data (and TOU metering data), TRM data, data collected on-site, secondary data	✓	All relevant data sources utilized
Relevance to TRM	Developed a Deemed Savings Workbook (DSW) in Microsoft Excel that presents proposed statewide savings estimate for non-custom measures	✓	The study proposes updated TRM values and methods for application
Documented Confidence Intervals	Relative precision for overall gas saving was +/-9% at 90% confidence; for common area lighting it was +/-3% at 90% confidence	✓	Documented
Findings & Recommendations	Results are well documented throughout; Recommendations (Study Considerations) are clear and reported in the Executive Summary only	✓	Overall findings and recommendations could be included in the main body of the report in addition to the Executive Summary

3.1.8 Low Income Gas

See the summary table for the Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015) available in Section 3.1.7. The BrightLine team identified that study as relevant for Income Eligible Multifamily Weatherization and HVAC measures.

3.1.9 Summary

Overall, based on a review of previous evaluation studies the team finds that evaluation studies procured for National Grid's programs are high quality work products that adhere to standard industry practices for evaluation. The team reviewed and prepared matrices for a total of 22 studies. With 7 criteria included in each matrix, the team evaluated and commented on 154 study elements in total. Of the 154 points reviewed the team identified 7 "question marks", where a study provides insufficient information upon which to determine if it adheres to industry best practices and 9 "check-minuses', where a study generally adheres to industry best practices but exhibits minor deficiency. . Table 51 summarizes which measure categories included studies for which the team identified question marks, and the nature of those question marks. In all cases the team found the issues to be minor in nature and likely due to the consultant having neglected to include sufficient detail in the report document. As shown, the team identified the greatest number of question marks for the Residential Electric-related studies. Questions marks were most common for the following criteria: sample design, documentation of confidence intervals, findings and recommendations, and documentation of assumptions. The team did not identify any other notable patterns or trends in terms of where question marks arose in the review.

Table 51: Summary of Question Marks Identified During Evaluation Study Review

Report Section / Measure Category	? Count[9]	✓ Count	✓- Count	✗ Count	Nature of Question Marks
3.1.1 C&I Electric	0	32	2	0	• P81 C&I Upstream Lighting ISR Analysis Summary (2018) [Massachusetts]: sample design and documentation of assumptions
3.1.2 C&I Gas	0	33	1	0	• Impact Evaluation of 2014 Custom Gas Installations in Rhode Island (2016): sample design
3.1.3 Residential Electric	7	42	3	0	• Rhode Island Home Energy Reports Program Impact and Process Evaluation (2017): sample design • 2016 RLPNC HOU Update Analysis (2016): sample design, documentation of confidence intervals • MA Lighting Interactive Effects Results Memo (2016) sample design, documentation of confidence intervals, findings and recommendations • Delta Watts Update (MA19R02-E) (2019): documentation of confidence intervals • RI2311 National Grid Rhode Island Lighting Market Assessment (2018): sample design, documentation of confidence intervals • RLPNC Study 18-10 2018-19 Residential Lighting Market Assessment Study (2919): sample design, documentation of confidence intervals
3.1.4 Residential Gas*	0	0		0	
3.1.5 Small Business Electric	0	12	2	0	• Impact Evaluation of PY2016 RI C&I Small Business Initiative: Phase I (2018): documentation of assumptions, findings and recommendations
3.1.6 Small Business Gas*	0	0		0	
3.1.7 Low Income Electric	0	13	1	0	• National Grid Income Eligible Services Impact Evaluation (2018): findings and recommendations
3.1.8 Low Income Gas*	0	0		0	

*Tables are duplicative and are presented in other sections.

[9] The numbers referenced here are shown in the measure category row corresponding to the section of the report in which the matrix is presented. Note that some matrices related to multiple measure categories, as indicated in Table 28.

4 Conclusion and Recommendations

The BrigthLine team finds that, on the whole, Rhode Island's TRM savings calculations and evaluation practices are strong and consistent with current industry standards. The team also identified minor areas for improvement. Several substantive recommendations emerged from the TRM benchmarking exercise. Those recommendations are summarized below and detailed in Section 2.5. The team identified only minimal issues in its review of previous evaluation studies' alignment with industry standards, as summarized below.

The benchmarking exercise indicated that National Grid regularly uses evaluation results for the enhancement of the Rhode Island TRM, and almost all measures received at least one update over the five years of evaluated TRMs. As discussed in more detail in Section 2.4 the team identified a handful of measures that seem out of alignment with others in the industry and noted that the Rhode Island TRM does not provide transparency into assumptions used for the deemed measures, making it difficult to determine which contributing values warrant additional consideration.

The TRM benchmarking component of this study provided recommendations to:

- Add applicable C&I prescriptive lighting into future TRMs
- More carefully consider hours of use assumptions for Upstream Lighting
- Review assumptions used to calculate savings values for LED Screw-In Lamps, to ensure they accurately align with market conditions.
- Explore potential adjustments to the steam trap deemed savings value.
- Organize the TRM by equipment and measure rather than by program or in another mode that makes the TRM easier for the reader to navigate.

The BrightLine team's review of previous evaluation reports finds that National Grid's procured evaluations are generally high-quality work products that provide actionable recommendations to inform future program planning and implementation. On the whole, the BrightLine team identified very few issues warranting attention. Those minor issues pertained to sample design targets, assumptions or achieved confidence intervals that could have been more clearly described, and studies that could have benefited from additional actionable recommendations. Since the identified issues were minor the BrightLine team believes they can be sufficiently addressed going forward by ensuring that expectations related to the evaluation objectives (e.g., those topics covered in the review matrices included in this report) are clearly communicating with future evaluation contractors. Since the issues identified in this review effort primarily pertained to documentation of sample design and outcomes, we recommend placing particular emphasis on those topics when communicating expectations to future evaluation contractors.

Appendix A. Graphic Summaries of TRM Reviews

RESIDENTIAL CFL SCREW-IN (SINGLE FAMILY, RETROFIT)

Rhode Island Evaluation | Residential Lighting | CFL Bulbs

COMMON ALGORITHM

kWh Savings = Qty x $(W_{base} - W_{ee})$/1,000 x Hours x WHF x ISR

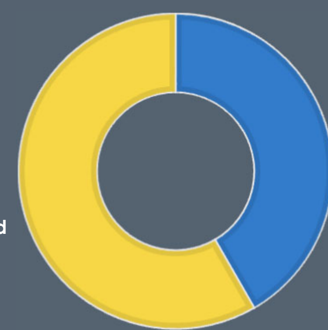
Rhode Island uses the common algorithm for this measure.

Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

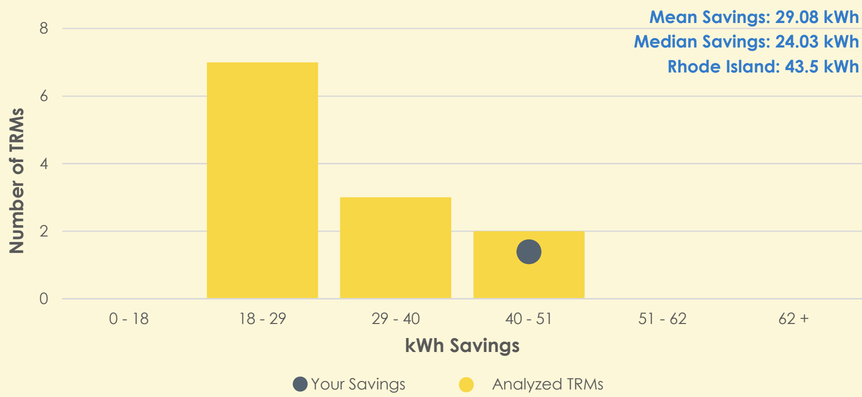
Deemed Measure	Calculated Measure	Measure Not Offered
Massachusetts (2016)	Arkansas (2017)	Ameren Missouri (2017)
Michigan (2020)	Connecticut (2016)	California Muni. (2016)
Minnesota (2018)	Indiana (2013)	Delaware (2016)
Rhode Island (2016)	Missouri Statewide (2017)	Hawaii (2018)
Vermont (2015)	New Jersey (2016)	Illinois (2019)
Washington D.C. (2017)	New York (2019)	Iowa (2018)
	Ohio (2010)	Maine (2017)
		MidAtlantic (2018)
		Ontario (2019)
		Pennsylvania (2021)

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 47.39 Watts
Rhode Island: Not Provided

Annual Hours of Use
Mean: 995 Hours
Rhode Island: 1022 Hours

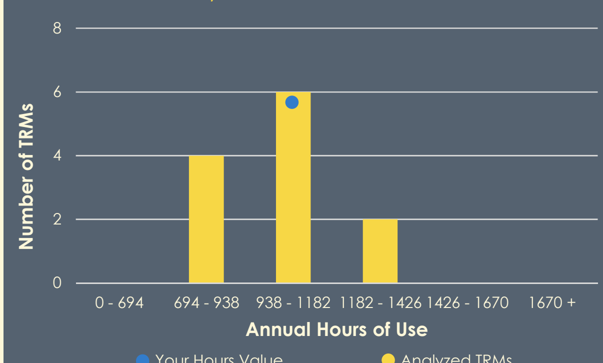
Waste Heat Factor
Mean: 1.032
Rhode Island: Not Used

In Service Rate
Mean: 0.88
Rhode Island: 1.00

As most TRMs require input of $Watts_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

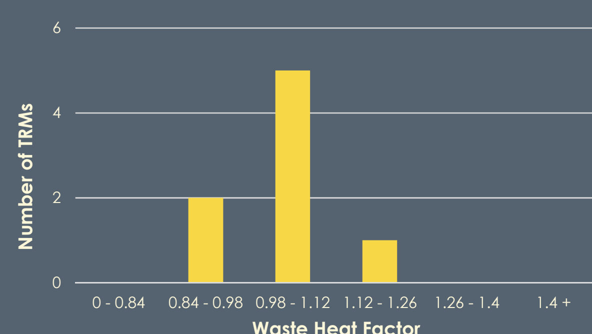
KEY PARAMETER COMPARISON

Mean Hours: 995
Median Hours: 1,031
Rhode Island: 1,022



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean WHF: 1.032
Median WHF: 1.044
Rhode Island: Not Used



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL CFL SCREW-IN (MULTIFAMILY, RETROFIT)

Rhode Island Evaluation | Residential Lighting | CFL Bulbs

COMMON ALGORITHM

$$kWh\ Savings = Qty \times (W_{base} - W_{ee})/1{,}000 \times Hours \times WHF \times ISR$$

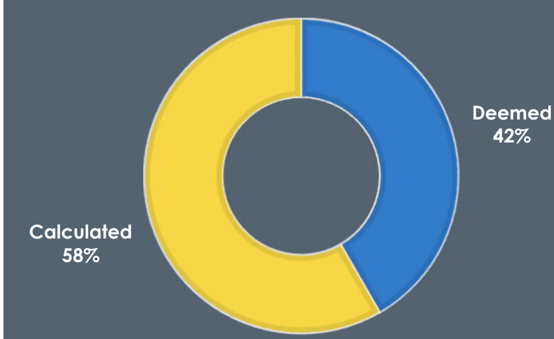
Rhode Island uses the common algorithm for this measure.

Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

Deemed Measure	Calculated Measure	Measure Not Offered
Massachusetts (2016)	Arkansas (2017)	Ameren Missouri (2017)
Michigan (2020)	Connecticut (2016)	California Muni. (2016)
Minnesota (2018)	Indiana (2013)	Delaware (2016)
Rhode Island (2016)	Missouri Statewide (2017)	Hawaii (2018)
Vermont (2015)	New Jersey (2016)	Illinois (2019)
Washington D.C. (2017)	New York (2019)	Iowa (2018)
	Ohio (2010)	Maine (2017)
		MidAtlantic (2018)
		Ontario (2019)
		Pennsylvania (2021)

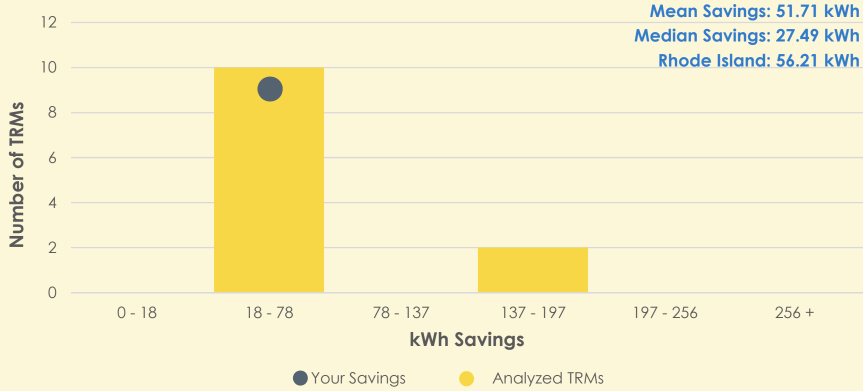
OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE

Mean Savings: 51.71 kWh
Median Savings: 27.49 kWh
Rhode Island: 56.21 kWh



KEY PARAMETERS

Baseline Wattage
Mean: 47.39 Watts
Rhode Island: Not Provided

Annual Hours of Use
Mean: 1650 Hours
Rhode Island: 1022 Hours

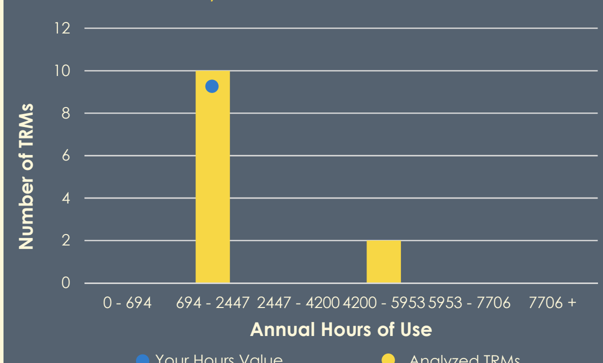
Waste Heat Factor
Mean: 1.03
Rhode Island: Not Used

In Service Rate
Mean: 0.88
Rhode Island: 1.00

As most TRMs require input of Watts $_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

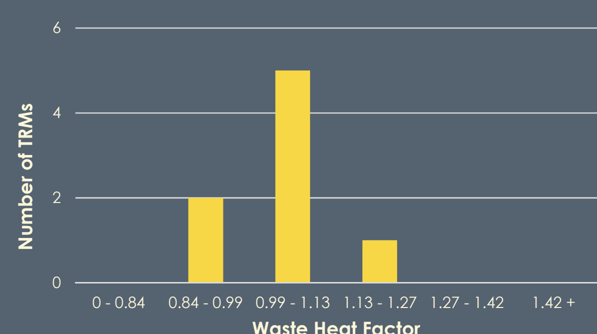
KEY PARAMETER COMPARISON

Mean Hours: 1,650
Median Hours: 1,031
Rhode Island: 1,022



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean WHF: 1.03
Median WHF: 1.032
Rhode Island: Not Used



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL LED DOWNLIGHT (SINGLE FAMILY, RETROFIT)

Rhode Island Evaluation | Residential Lighting | LED Fixtures

COMMON ALGORITHM

$$\text{kWh Savings} = \text{Qty} \times (W_{base} - W_{ee})/1{,}000 \times \text{Hours} \times \text{WHF} \times \text{ISR}$$

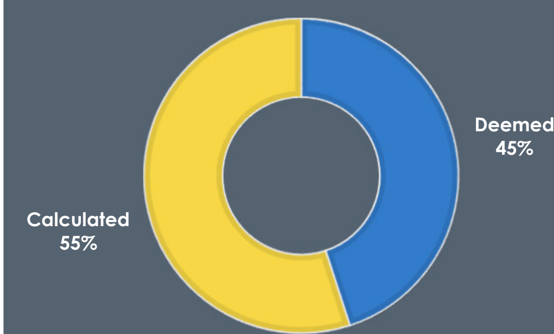
Rhode Island uses the common algorithm for this measure.

Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

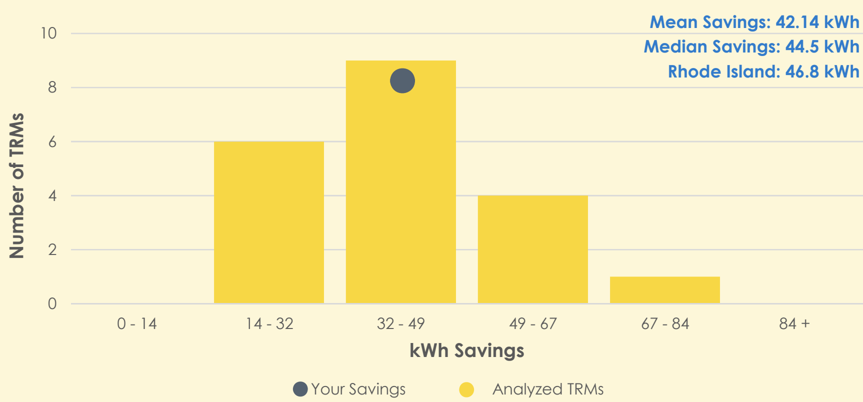
Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	Ohio (2010)
California Muni. (2016)	Connecticut (2016)	Ontario (2019)
Hawaii (2018)	Delaware (2016)	
Maine (2017)	Illinois (2019)	
Massachusetts (2016)	Indiana (2013)	
Michigan (2020)	Iowa (2018)	
Minnesota (2018)	MidAtlantic (2018)	
Rhode Island (2020)	Missouri Statewide (2017)	
Vermont (2015)	New Jersey (2016)	
Washington D.C. (2017)	New York (2019)	
	Pennsylvania (2021)	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 62.38 Watts
Rhode Island: Not Provided

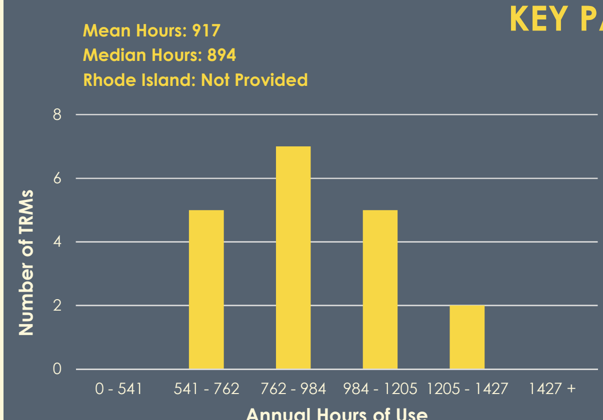
Annual Hours of Use
Mean: 917 Hours
Rhode Island: Not Provided

Waste Heat Factor
Mean: 1.005
Rhode Island: Not Used

In Service Rate
Mean: 0.96
Rhode Island: 1.00

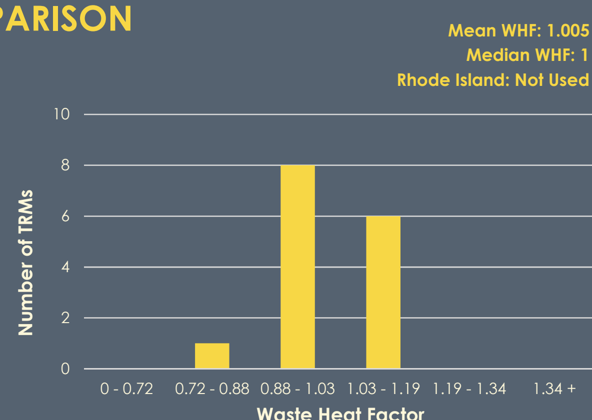
As most TRMs require input of $Watts_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

KEY PARAMETER COMPARISON



The Rhode Island TRM utilizes a deemed HOU value that is not disclosed in the TRM.

See accompanying report for detailed comparison of all key parameters across all TRMs.



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL LED DOWNLIGHT (MULTIFAMILY, RETROFIT)

Rhode Island Evaluation | Residential Lighting | LED Fixtures

COMMON ALGORITHM

$$\text{kWh Savings} = \text{Qty} \times (W_{base} - W_{ee})/1{,}000 \times \text{Hours} \times \text{WHF} \times \text{ISR}$$

Rhode Island uses the common algorithm for this measure.

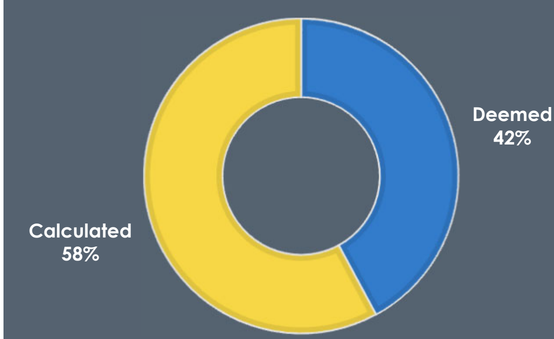
Where:

- Qty = Quantity of lamps or fixtures
- Watts_{base} = Wattage of removed lamp or fixture
- Watts_{ee} = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

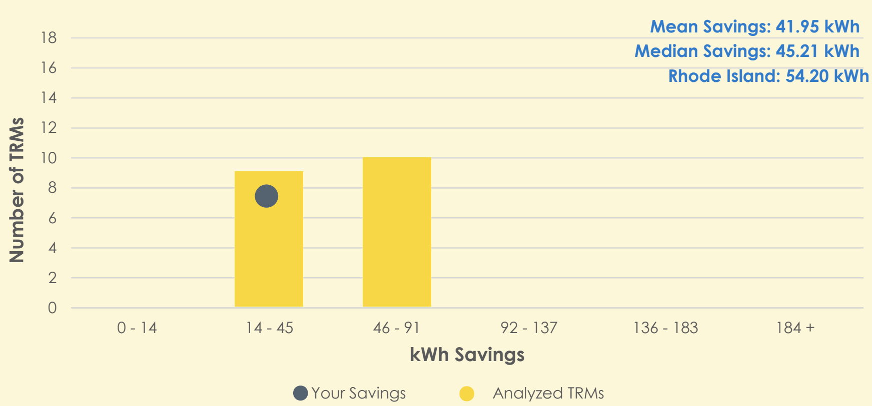
Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	Ohio (2010)
California Muni. (2016)	Connecticut (2016)	
Hawaii (2018)	Delaware (2016)	
Maine (2017)	Illinois (2019)	
Massachusetts (2016)	Indiana (2013)	
Minnesota (2018)	Iowa (2018)	
Rhode Island (2018)	MidAtlantic (2018)	
Vermont (2015)	Missouri Statewide (2017)	
Washington D.C. (2017)	New Jersey (2016)	
	New York (2019)	
	Pennsylvania (2021)	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 62.21 Watts
Rhode Island: 65 Watts

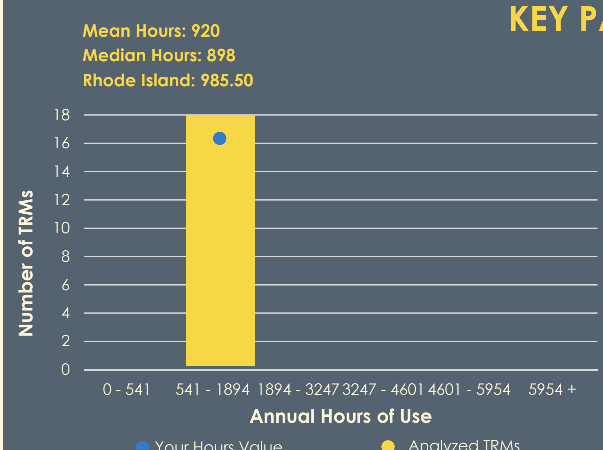
Annual Hours of Use
Mean: 920.23 Hours
Rhode Island: 985.50 Hours

Waste Heat Factor Mean: 1.00
Rhode Island: Not Used

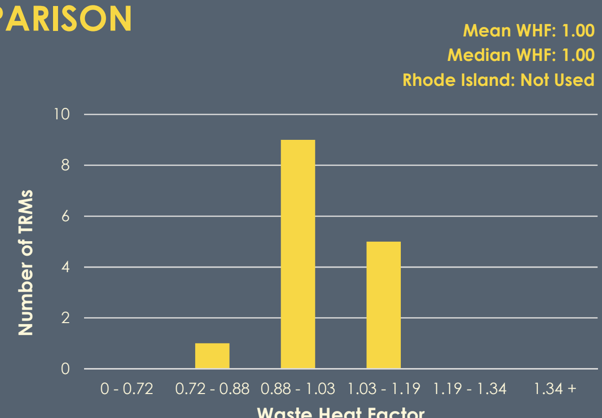
In Service Rate
Mean: 0.97
Rhode Island: 1.00

As most TRMs require input of Watts $_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

KEY PARAMETER COMPARISON



See accompanying report for detailed comparison of all key parameters across all TRMs.



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL LED SCREW-IN A-LAMP (SINGLE FAMILY, RETROFIT)

Rhode Island Evaluation | Residential Lighting | LED Bulbs

COMMON ALGORITHM

$$kWh\ Savings = Qty \times (W_{base} - W_{ee})/1{,}000 \times Hours \times WHF \times ISR$$

Rhode Island uses the common algorithm for this measure.

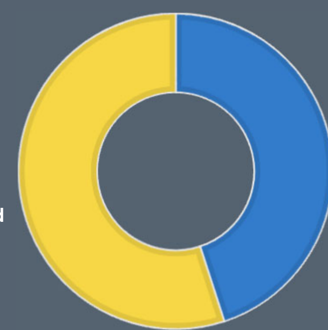
Where:

- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

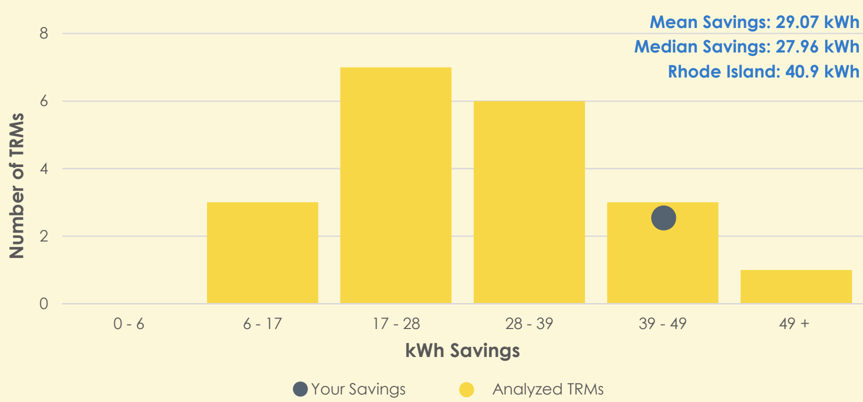
Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	Ohio (2010)
California Muni. (2016)	Connecticut (2016)	
Hawaii (2018)	Delaware (2016)	
Maine (2017)	Illinois (2019)	
Massachusetts (2016)	Indiana (2013)	
Michigan (2020)	Iowa (2018)	
Minnesota (2018)	MidAtlantic (2018)	
Ontario (2019)	Missouri Statewide (2017)	
Rhode Island (2020)	New Jersey (2016)	
Vermont (2015)	New York (2019)	
Washington D.C. (2017)	Pennsylvania (2021)	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 45.07 Watts
Rhode Island: Not Provided

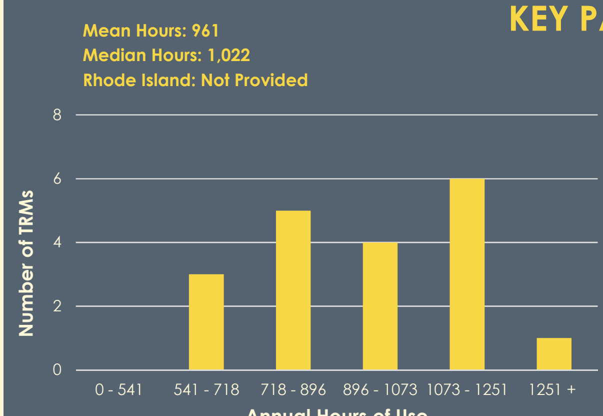
Annual Hours of Use
Mean: 961 Hours
Rhode Island: Not Provided

Waste Heat Factor
Mean: 0.998
Rhode Island: Not Used

In Service Rate
Mean: 0.95
Rhode Island: 1.00

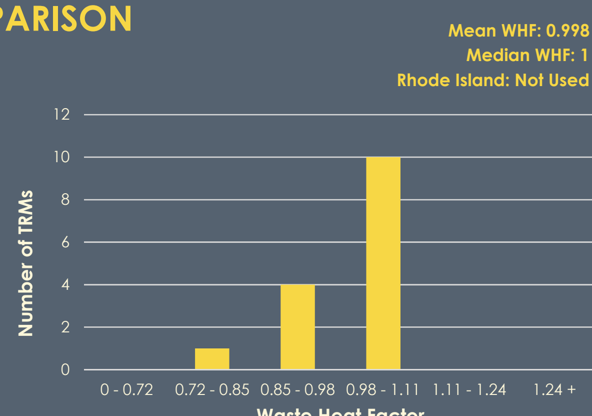
As most TRMs require input of $Watts_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

KEY PARAMETER COMPARISON



The Rhode Island TRM utilizes a deemed HOU value that is not disclosed in the TRM.

See accompanying report for detailed comparison of all key parameters across all TRMs.



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL LED SCREW-IN A-LAMP (SINGLE FAMILY, NEW CONSTRUCTION)

Rhode Island Evaluation | Residential Lighting | LED Bulbs

COMMON ALGORITHM

$$\text{kWh Savings} = \text{Qty} \times (W_{base} - W_{ee})/1{,}000 \times \text{Hours} \times \text{WHF} \times \text{ISR}$$

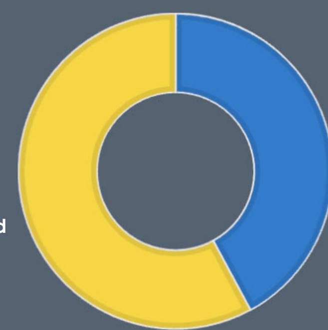
Rhode Island uses the common algorithm for this measure.

Where:
- Qty = Quantity of lamps or fixtures
- Watts_{base} = Wattage of removed lamp or fixture
- Watts_{ee} = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

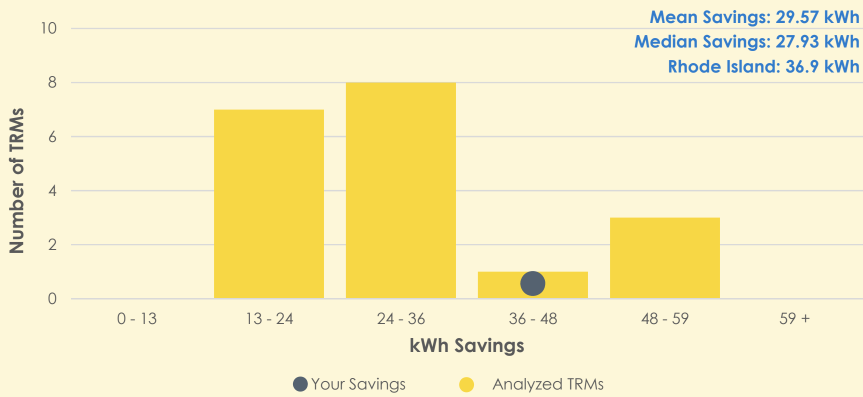
Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	Ohio (2010)
California Muni. (2016)	Connecticut (2016)	Vermont (2015)
Hawaii (2018)	Delaware (2016)	
Maine (2017)	Illinois (2019)	
Massachusetts (2016)	Indiana (2013)	
Michigan (2020)	Iowa (2018)	
Minnesota (2018)	MidAtlantic (2018)	
Ontario (2019)	Missouri Statewide (2017)	
Rhode Island (2020)	New Jersey (2016)	
Washington D.C. (2017)	New York (2019)	
	Pennsylvania (2021)	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 47.14 Watts
Rhode Island: Not Provided

Annual Hours of Use
Mean: 924 Hours
Rhode Island: Not Provided

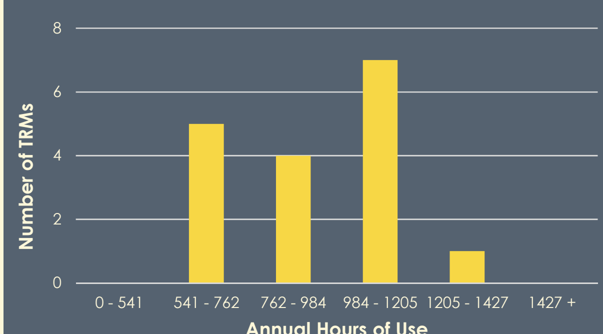
Waste Heat Factor
Mean: 0.998
Rhode Island: Not Used

In Service Rate
Mean: 0.96
Rhode Island: 1.00

As most TRMs require input of Watts_{ee}, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

KEY PARAMETER COMPARISON

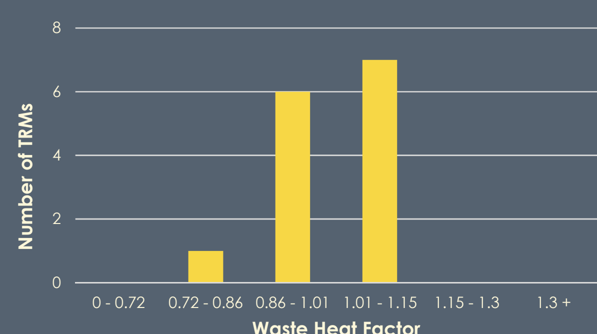
Mean Hours: 924
Median Hours: 938
Rhode Island: Not Provided



The Rhode Island TRM utilizes a deemed HOU value that is not disclosed in the TRM.

See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean WHF: 0.998
Median WHF: 1.006
Rhode Island: Not Used



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL LED SCREW-IN A-LAMP (MULTIFAMILY, RETROFIT)

Rhode Island Evaluation | Residential Lighting | LED Bulbs

COMMON ALGORITHM

$$kWh\ Savings = Qty \times (W_{base} - W_{ee})/1{,}000 \times Hours \times WHF \times ISR$$

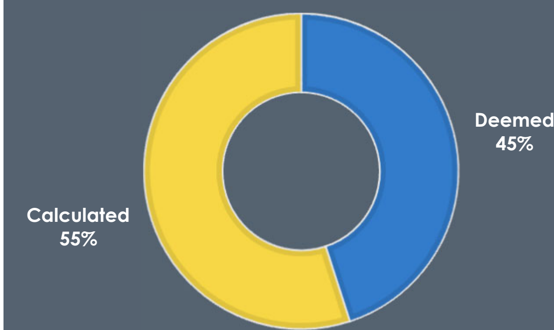
Rhode Island uses the common algorithm for this measure.

Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

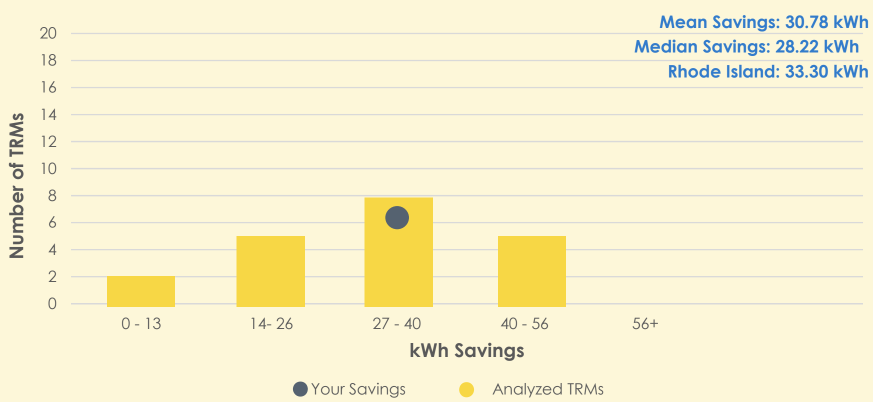
Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	Ohio (2010)
California Muni. (2016)	Connecticut (2016)	
Hawaii (2018)	Delaware (2016)	
Maine (2017)	Illinois (2019)	
Massachusetts (2016)	Indiana (2013)	
Minnesota (2018)	Iowa (2018)	
Ontario (2019)	MidAtlantic (2018)	
Rhode Island (2020)	Missouri Statewide (2017)	
Vermont (2015)	New Jersey (2016)	
Washington D.C. (2017)	New York (2019)	
	Pennsylvania (2021)	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 45.07 Watts
Rhode Island: Not Provided

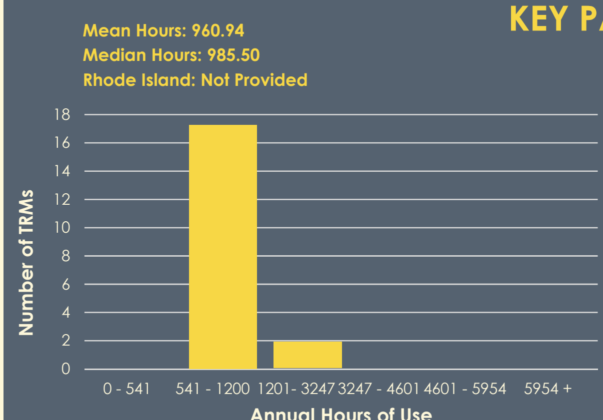
Annual Hours of Use
Mean: 960.94 Hours
Rhode Island: Not Provided

Waste Heat Factor
Mean: 1.00
Rhode Island: Not Used

In Service Rate
Mean: 0.95
Rhode Island: 1.00

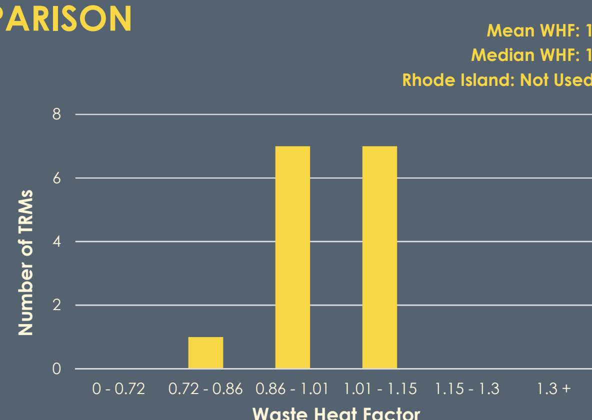
As most TRMs require input of $Watts_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

KEY PARAMETER COMPARISON



The Rhode Island TRM utilizes a deemed HOU value that is not disclosed in the TRM.

See accompanying report for detailed comparison of all key parameters across all TRMs.



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL AIR SEALING (SINGLE FAMILY)

Rhode Island Evaluation | Residential | Building Shell

COMMON ALGORITHM

$$\text{MMBtu Savings} = (\Delta CFM50 / N_{heat}) \times 60 \times 24 \times HDD \times 0.018 / 1{,}000{,}000 / \eta_{heat}$$

Rhode Island uses the common algorithm for this measure.

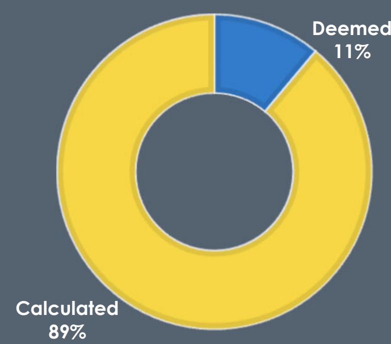
Where:

- $\Delta CFM50$ = Difference in pre- and post-retrofit blower door test
- N_{heat} = Conversion from CFM50 to $CFM_{Natural}$
- 60 = Conversion from minutes to hours
- 24 = Conversion from hours to days
- HDD = Heating degree days
- 0.018 = Volumetric heat capacity of air
- 1,000,000 = Conversion from Btu to MMBtu
- ηheat = Efficiency of heating equipment

TRM AVAILABILITY

Deemed Measure	Calculated Measure	Measure Not Offered
Massachusetts (2016)	Connecticut (2016)	Ameren Missouri (2017)
Rhode Island (2020)	Illinois (2019)	Arkansas (2017)
	Indiana (2013)	California Muni. (2016)
	Iowa (2018)	Delaware (2016)
	MidAtlantic (2018)	Hawaii (2018)
	Missouri Statewide (2017)	Maine (2017)
	New York (2019)	Michigan (2020)
	Ohio (2010)	Minnesota (2018)
		New Jersey (2016)
		Ontario (2019)
		Pennsylvania (2021)
		Vermont (2015)
		Washington D.C. (2017)

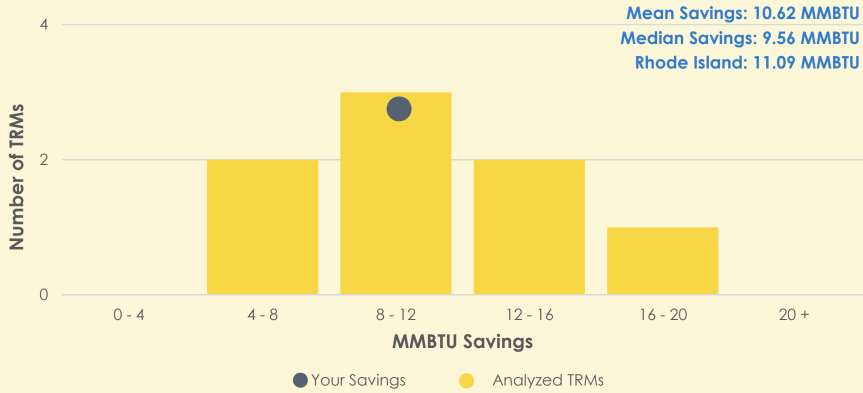
OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE

Mean Savings: 10.62 MMBTU
Median Savings: 9.56 MMBTU
Rhode Island: 11.09 MMBTU



KEY PARAMETERS

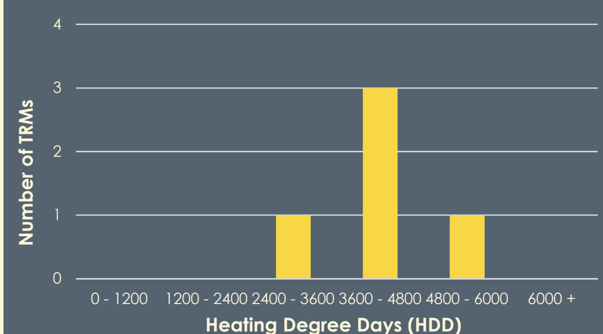
Heating Degree Days
Mean: 4,222
Rhode Island: Not Provided

Heating System Efficiency
Mean: 71%
Rhode Island: Not Provided

As most TRMs require input of ΔCFM50, a value of 1,150 was input for all TRM calculations. As such, the mean is not provided here.

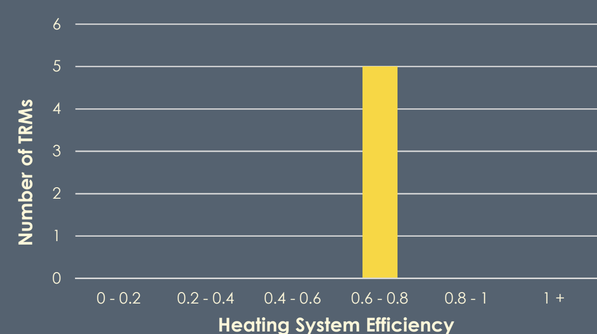
KEY PARAMETER COMPARISON

Mean HDD: 4,222
Median HDD: 4,332
Rhode Island HDD: Not Provided



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean ηheat: 71%
Median ηheat: 71%
Rhode Island ηheat: Not Provided



RESIDENTIAL LED DOWNLIGHT (MULTIFAMILY, LOW INCOME)

Rhode Island Evaluation | Residential Lighting | LED Fixtures

COMMON ALGORITHM[1]

kWh Savings = Qty x $(W_{base} - W_{ee})$/1,000 x Hours x WHF x ISR

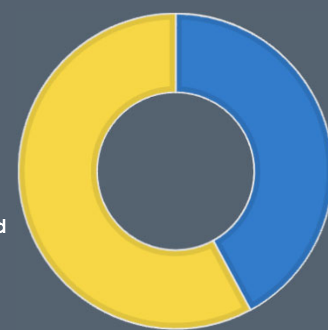
1. Rhode Island does not use the common algorithm for this meaure. Rhode Island stipulates the savings should be calculated by RISE engineering on a project-by-project basis.

Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

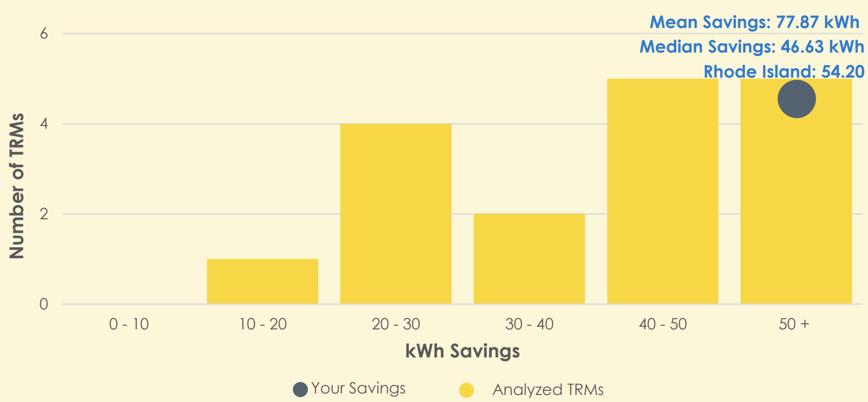
Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	Ohio (2010)
California Muni. (2016)	Connecticut (2016)	Vermont (2015)
Hawaii (2018)	Delaware (2016)	
Maine (2017)	Illinois (2019)	
Massachusetts (2016)	Indiana (2013)	
Minnesota (2018)	Iowa (2018)	
Ontario (2019)	MidAtlantic (2018)	
Rhode Island (2020)	Missouri Statewide (2017)	
Washington D.C. (2017)	New Jersey (2016)	
	New York (2019)	
	Pennsylvania (2021)	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 62.21 Watts
Rhode Island: 65.00 Watts

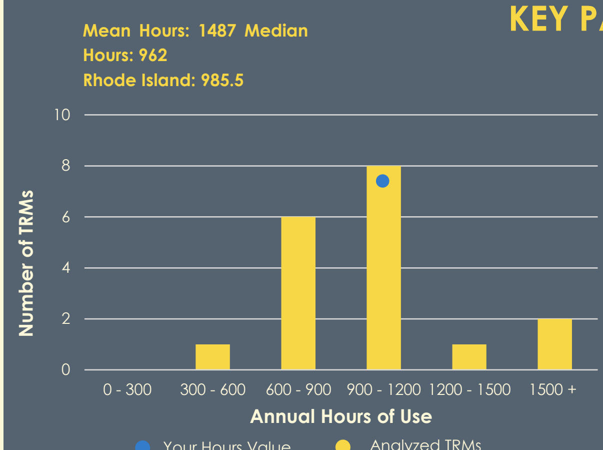
Annual Hours of Use
Mean: 1487 Hours
Rhode Island: 985.5 Hours

Waste Heat Factor
Mean: 1.00
Rhode Island: Not Used

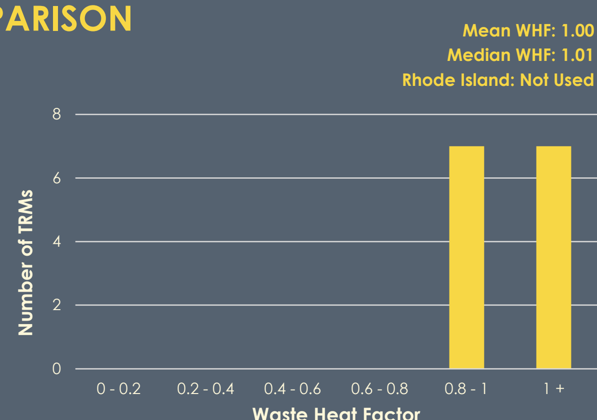
In Service Rate
Mean: 0.96
Rhode Island: 1.00

As most TRMs require input of $Watts_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

KEY PARAMETER COMPARISON



See accompanying report for detailed comparison of all key parameters across all TRMs.



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL LED SCREW-IN A-LAMP (MULTIFAMILY, LOW INCOME)

Rhode Island Evaluation | Residential Lighting | LED Bulbs

COMMON ALGORITHM

$$kWh\ Savings = Qty \times (W_{base} - W_{ee})/1{,}000 \times Hours \times WHF \times ISR$$

Rhode Island uses the common algorithm for this measure.

Where:

- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

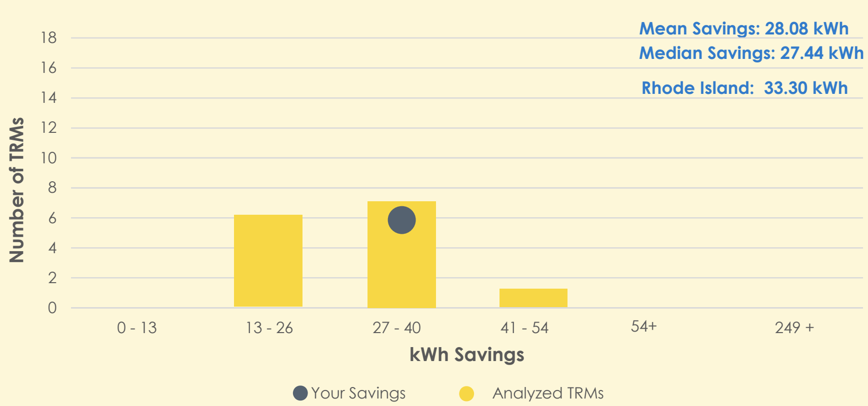
TRM AVAILABILITY

Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	Ohio (2010)
California Muni. (2016)	Connecticut (2016)	Vermont (2015)
Hawaii (2018)	Delaware (2016)	
Maine (2017)	Iowa (2018)	
Massachusetts (2016)	Missouri Statewide (2017)	
Minnesota (2018)	New Jersey (2016)	
Ontario (2019)		
Rhode Island (2020)		
Washington D.C. (2017)		

OFFERING OVERVIEW

Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



Per the 2020 TRM, savings to be calculated on a case-by-case basis by RISE Engineering.

KEY PARAMETERS

Baseline Wattage
Mean: 44.38 Watts
Rhode Island: Not Provided

Annual Hours of Use Mean: 924.43 Hours
Rhode Island: Not Provided

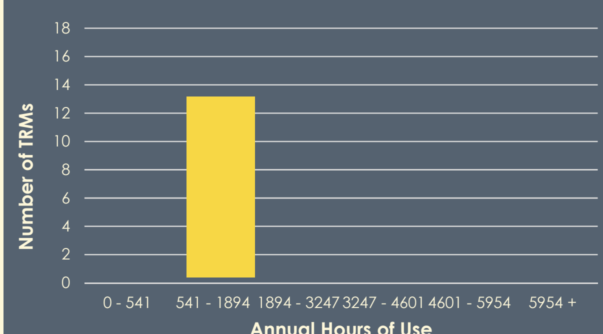
Waste Heat Factor
Mean: 1.02
Rhode Island: Not Used

In Service Rate
Mean: 0.95
Rhode Island: 1.00

As most TRMs require input of $Watts_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

KEY PARAMETER COMPARISON

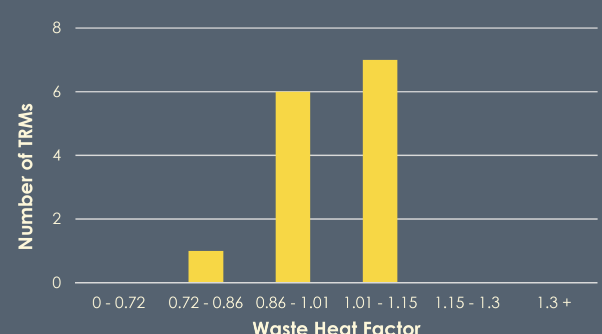
Mean Hours: 924.43
Median Hours: 898.00
Rhode Island: Not Provided



The Rhode Island TRM utilizes a deemed HOU value that is not disclosed in the TRM.

See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean WHF: 1.02
Median WHF: 1.02
Rhode Island: Not Used



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL LED SCREW-IN A-LAMP (SINGLE FAMILY, LOW INCOME)

Rhode Island Evaluation | Residential Lighting | LED Bulbs

COMMON ALGORITHM

$$\text{kWh Savings} = \text{Qty} \times (W_{base} - W_{ee})/1{,}000 \times \text{Hours} \times \text{WHF} \times \text{ISR}$$

Rhode Island uses the common algorithm for this measure.

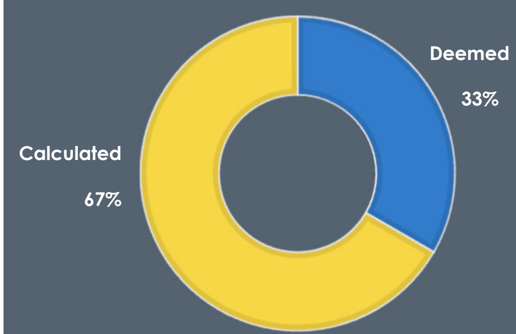
Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

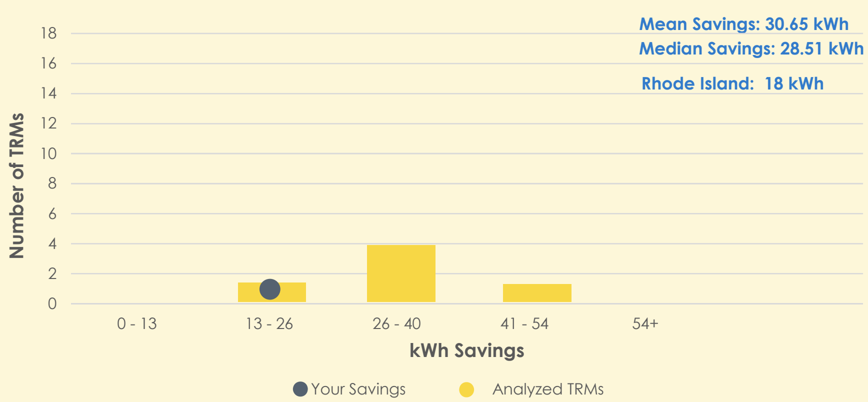
Deemed Measure
- Ameren Missouri (2017)
- Massachusetts (2016)
- **Rhode Island (2020)**

Calculated Measure
- Connecticut (2016)
- Iowa (2018)
- Missouri Statewide (2017)
- New Jersey (2016)

OFFERING OVERVIEW



HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage Mean: 45.88 Watts
Rhode Island: Not Provided

Annual Hours of Use Mean: 884.42 Hours
Rhode Island: 1022.00

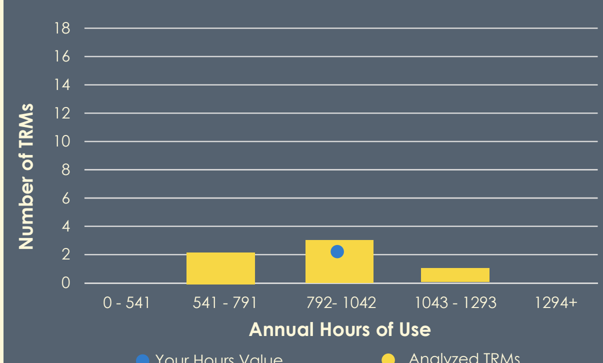
Waste Heat Factor
Mean: 1.02
Rhode Island: Not Used

In Service Rate
Mean: 0.90
Rhode Island: 1.00

As most TRMs require input of $Watts_{ee}$, a value of 10 was input for all TRM calculations. As such, the mean is not provided here.

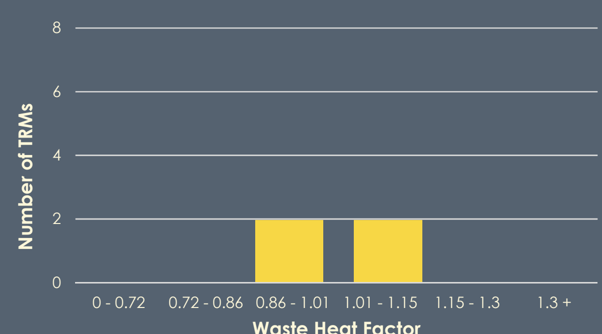
KEY PARAMETER COMPARISON

Mean Hours: 884.42
Median Hours: 903.25
Rhode Island: 1022.00



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean WHF: 1.02
Median WHF: 1.02
Rhode Island: Not Used



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

RESIDENTIAL AIR SEALING (MULTIFAMILY, LOW-INCOME)

Rhode Island Evaluation | Residential | Building Shell

COMMON ALGORITHM

$$\text{MMBtu Savings} = (\Delta CFM50 / N_{heat}) \times 60 \times 24 \times HDD \times 0.018 / 1{,}000{,}000 / \eta_{heat}$$

Rhode Island uses the common algorithm for this measure.

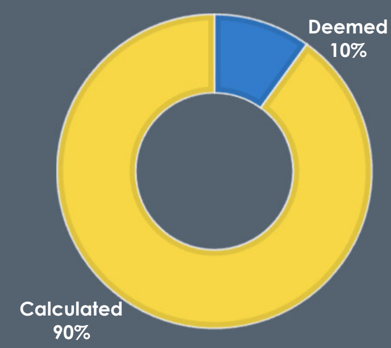
Where:

- $\Delta CFM50$ = Difference in pre- and post-retrofit blower door test
- N_{heat} = Conversion from CFM50 to $CFM_{Natural}$
- 60 = Conversion from minutes to hours
- 24 = Conversion from hours to days
- HDD = Heating degree days
- 0.018 = Volumetric heat capacity of air
- 1,000,000 = Conversion from Btu to MMBtu
- ηheat = Efficiency of heating equipment

TRM AVAILABILITY

Deemed Measure	Calculated Measure	Measure Not Offered
New Jersey (2016)	Connecticut (2016)	Ameren Missouri (2017)
	Illinois (2019)	Arkansas (2017)
	Indiana (2013)	California Muni. (2016)
	Iowa (2018)	Delaware (2016)
	Massachusetts (2016)	Hawaii (2018)
	MidAtlantic (2018)	Maine (2017)
	Missouri Statewide (2017)	Michigan (2020)
	New York (2019)	Minnesota (2018)
	Ohio (2010)	Ontario (2019)
	Rhode Island (2020)	Pennsylvania (2021)
		Vermont (2015)
		Washington D.C. (2017)

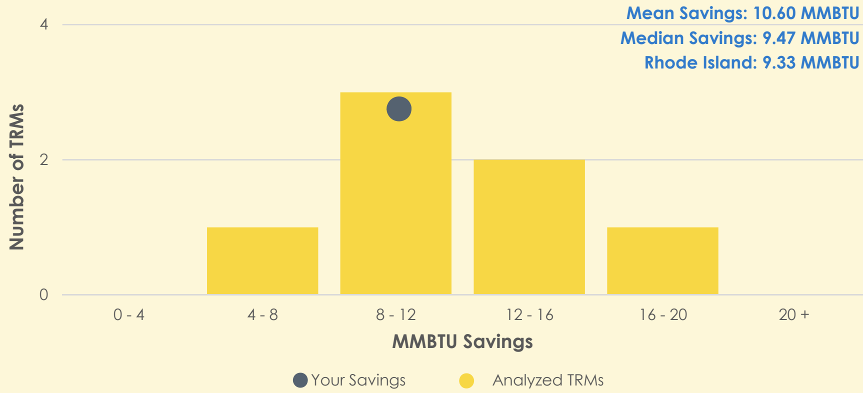
OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE

Mean Savings: 10.60 MMBTU
Median Savings: 9.47 MMBTU
Rhode Island: 9.33 MMBTU



KEY PARAMETERS

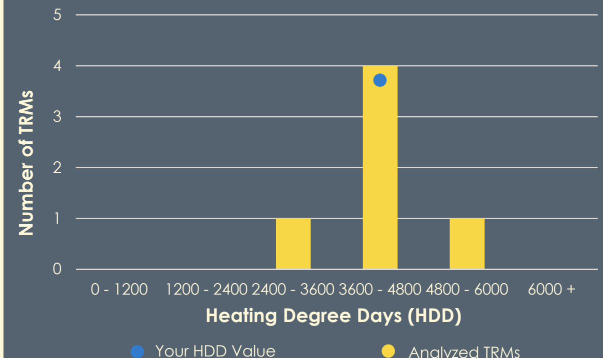
Heating Degree Days
Mean: 4,313
Rhode Island: 4,644

Heating System Efficiency
Mean: 71%
Rhode Island: 70%

As most TRMs require input of ΔCFM50, a value of 1,150 was input for all TRM calculations. As such, the mean is not provided here.

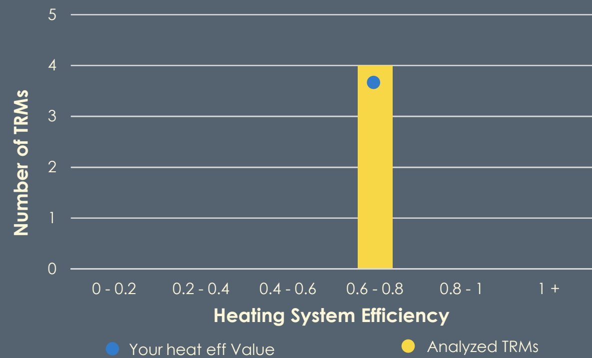
KEY PARAMETER COMPARISON

Mean HDD: 4,313
Median HDD: 4,396
Rhode Island HDD: 4,644



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean ηheat: 71%
Median ηheat: 71%
Rhode Island ηheat: 70%



RESIDENTIAL DUCT SEALING/ INSULATION (MULTIFAMILY, LOW INCOME)

Rhode Island Evaluation | Residential | Building Shell

COMMON ALGORITHM

$$MMBtu\ Savings = [(DE_{post} - DE_{pre}) / DE_{post} \times EFLH \times BTUH / 1{,}000{,}000 / \eta_{heat}$$

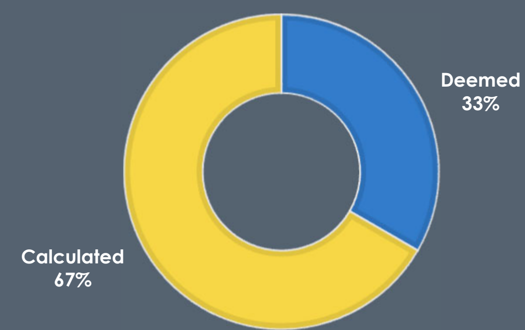
Where:
- DEpost = Post-retrofit distribution efficiency
- DEpre = Pre-retrofit distribution efficiency
- EFLH = Effective full load hours
- BTUH = Heating input capacity
- 1,000,000 = Conversion from Btu to MMBtu
- ηheat = Efficiency of heating equipment

Rhode Island does not use the common algorithm for this measure.

TRM AVAILABILITY

Deemed Measure	Calculated Measure	Measure Not Offered
Connecticut (2016)	Illinois (2019)	Ameren Missouri (2017)
Missouri Statewide (2017)	Indiana (2013)	Arkansas (2017)
New Jersey (2016)	Iowa (2018)	California Muni. (2016)
	MidAtlantic (2018)	Delaware (2016)
	New York (2019)	Hawaii (2018)
	Ohio (2010)	Maine (2017)
	Rhode Island (2020)	Massachusetts (2016)
		Michigan (2020)
		Minnesota (2018)
		Ontario (2019)
		Pennsylvania (2021)
		Vermont (2015)
		Washington D.C. (2017)

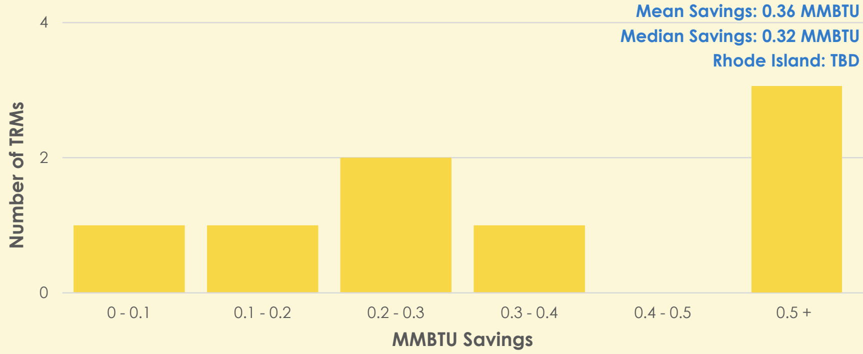
OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE

Mean Savings: 0.36 MMBTU
Median Savings: 0.32 MMBTU
Rhode Island: TBD



There is an error in the 2020 TRM whereby the table specified to provide the HDD value is missing. As such, the HDD value is unknown and savings cannot be calculated.

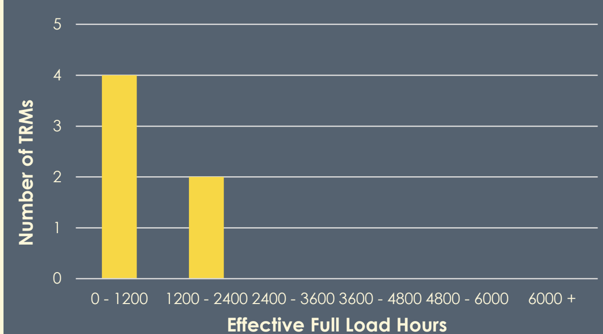
KEY PARAMETERS

Effective Full Load Hours
Mean: 1,037
Rhode Island: Not Provided

Heating System Efficiency
Mean: 84%
Rhode Island: Not Provided

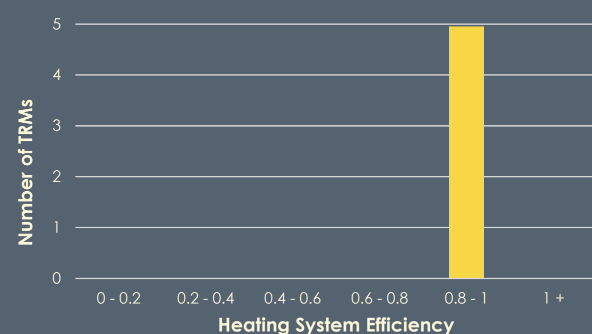
KEY PARAMETER COMPARISON

Mean EFLH: 1,037
Median EFLH: 980
Rhode Island EFLH: Not Provided



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean ηheat: 84%
Median ηheat: 84%
Rhode Island ηheat: Not Provided



COMMERCIAL Exterior LED Lighting

Rhode Island Evaluation | Commercial Lighting | Exterior LED

COMMON ALGORITHM

$$kWh\ Savings = Qty \times (W_{base} - W_{ee})/1{,}000 \times Hours \times WHF \times ISR$$

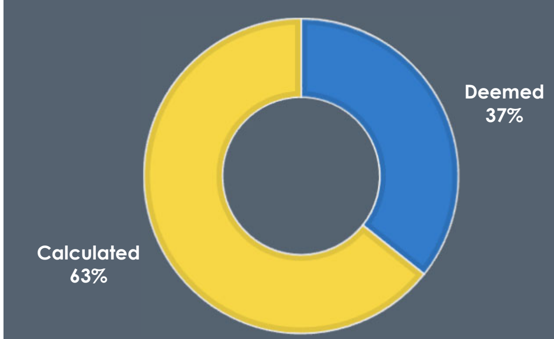
Rhode Island uses the common algorithm for this measure.

Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

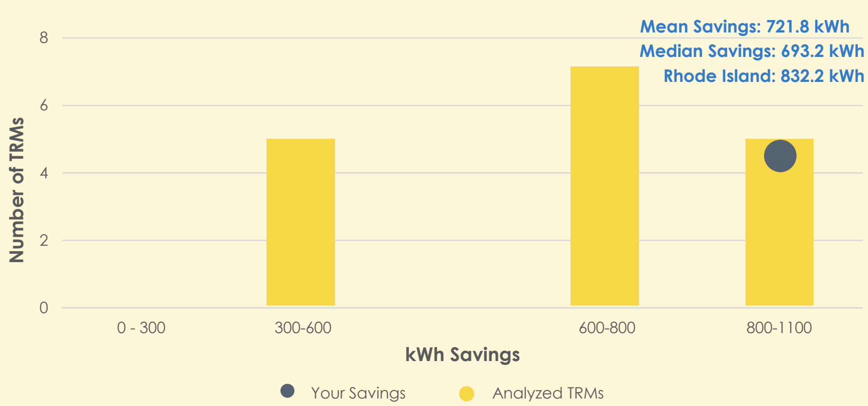
Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	New Jersey (2016)
Hawaii (2018)	California Muni. (2016)	
Maine (2017)	Connecticut (2016)	
Michigan (2020)	Delaware (2016)	
Minnesota (2018)	Illinois (2019)	
Ontario (2019)	Iowa (2018)	
Washington D.C. (2017)	Massachusetts (2016)	
	MidAtlantic (2018)	
	Missouri Statewide (2017)	
	New York (2019)	
	Pennsylvania (2021)	
	Rhode Island (2020)	
	Vermont (2015)	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



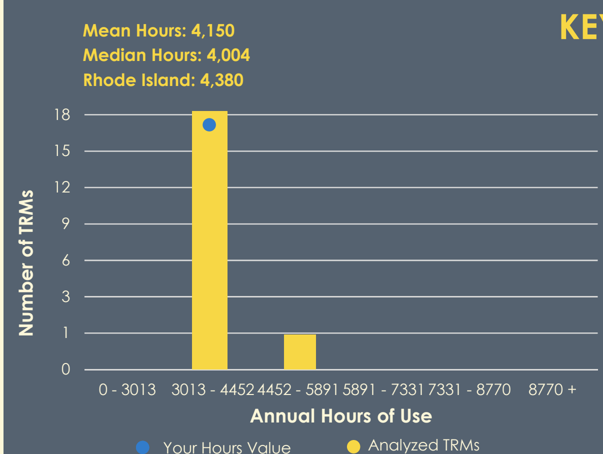
KEY PARAMETERS

Baseline Wattage Mean: 240 Watts
Rhode Island: 240 Watts

Annual Hours of Use
Mean: 4,150 Hours
Rhode Island: 4,380 Hours

In Service Rate
Mean: 1.00
Rhode Island: 1.00

KEY PARAMETER COMPARISON



See accompanying report for detailed comparison of all key parameters across all TRMs.

COMMERCIAL REFRIGERATED CASE LIGHTING

Rhode Island Evaluation | Commercial Lighting | Refrigerated Case Lighting

COMMON ALGORITHM

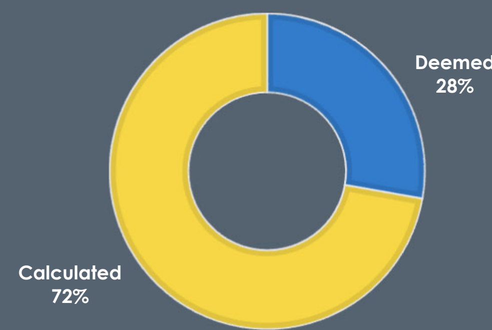
kWh Savings = LF x $(W_{base} - W_{ee})$/1,000 x Hours x WHF x ISR

Where:
- LF = Linear foot of refrigerated case
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service rate

TRM AVAILABILITY

Deemed Measure	Calculated Measure	Measure Not Offered
California Muni. (2016)	Arkansas (2017)	Ameren Missouri (2017)
Hawaii (2018)	Connecticut (2016)	Illinois (2019)
Michigan (2020)	Delaware (2016)	Iowa (2018)
Ontario (2019)	Indiana (2013)	Missouri Statewide (2017)
Vermont (2015)	Maine (2017)	
	Massachusetts (2016)	
	MidAtlantic (2018)	
	Minnesota (2018)	
	New Jersey (2016)	
	New York (2019)	
	Ohio (2010)	
	Pennsylvania (2021)	
	Rhode Island (2020)	
	Washington D.C. (2017)	

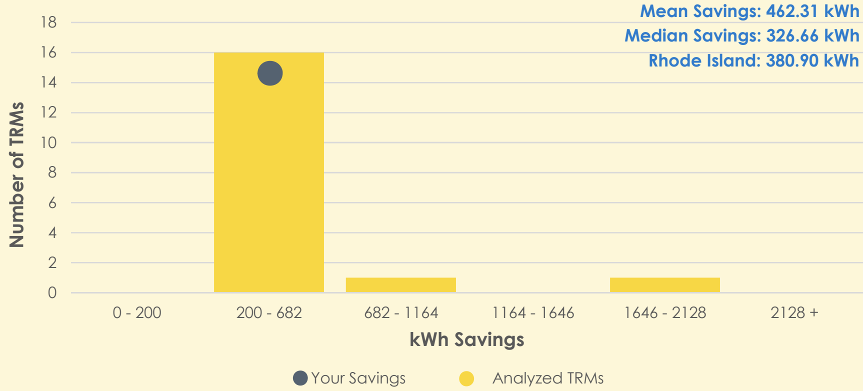
OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE

Mean Savings: 462.31 kWh
Median Savings: 326.66 kWh
Rhode Island: 380.90 kWh



KEY PARAMETERS

Annual Hours of Use
Mean: 6,200 Hours
Rhode Island: 6,200 Hours

Waste Heat Factor Mean: 1.28
Rhode Island: 1.54

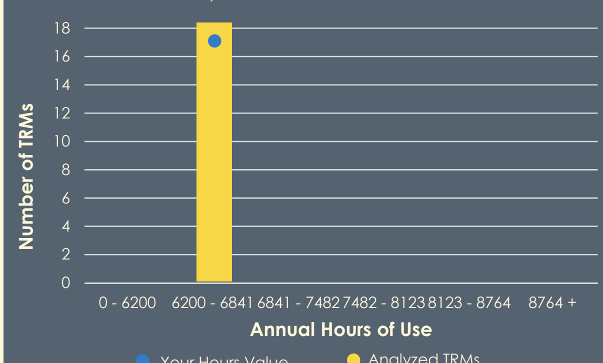
In Service Rate
Mean: 1.00
Rhode Island: 1.00

As most TRMs require input of $Watts_{base}$, a value of 55 was input for all TRM calculations. As such, the mean is not provided here.

As most TRMs require input of $Watts_{ee}$, a value of 17.5 was input for all TRM calculations. As such, the mean is not provided here.

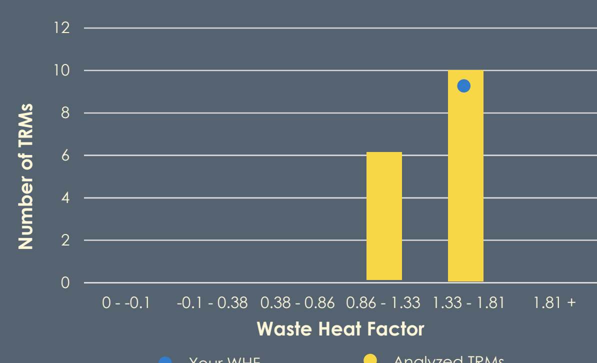
KEY PARAMETER COMPARISON

Mean Hours: 6,200
Median Hours: 6,200
Rhode Island: 6,200



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean WHF: 1.28
Median WHF: 1.39
Rhode Island: 1.54



COMMERCIAL LED EXIT SIGNS

Rhode Island Evaluation | Commercial Lighting | LED Exit Signs

COMMON ALGORITHM

$$kWh\ Savings = Qty \times (W_{base} - W_{ee})/1{,}000 \times Hours \times WHF \times ISR$$

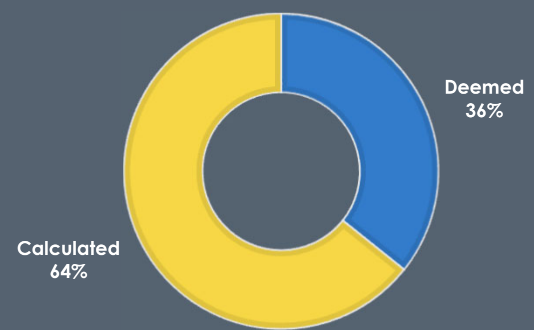
Rhode Island uses the common algorithm for this measure.

Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Delaware (2016)	Arkansas (2017)
Indiana (2013)	Illinois (2019)	California Muni. (2016)
Michigan (2020)	Iowa (2018)	Connecticut (2016)
Ohio (2010)	Massachusetts (2016)	Hawaii (2018)
Ontario (2019)	MidAtlantic (2018)	Maine (2017)
	Minnesota (2018)	New Jersey (2016)
	Missouri Statewide (2017)	Vermont (2015)
	New York (2019)	Washington D.C. (2017)
	Pennsylvania (2021)	
	Rhode Island (2020)	

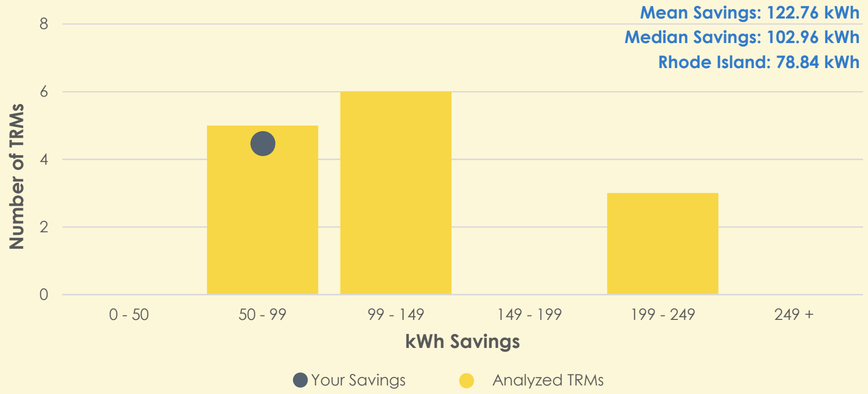
OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE

Mean Savings: 122.76 kWh
Median Savings: 102.96 kWh
Rhode Island: 78.84 kWh



KEY PARAMETERS

Baseline Wattage
Mean: 17.2 Watts
Rhode Island: 14.0 Watts

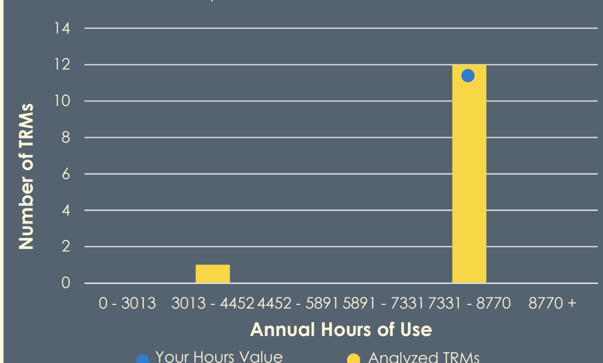
Annual Hours of Use
Mean: 8,320 Hours
Rhode Island: 8,760 Hours

Waste Heat Factor
Mean: 1.079
Rhode Island: Not Used

In Service Rate
Mean: 1.00
Rhode Island: 1.00

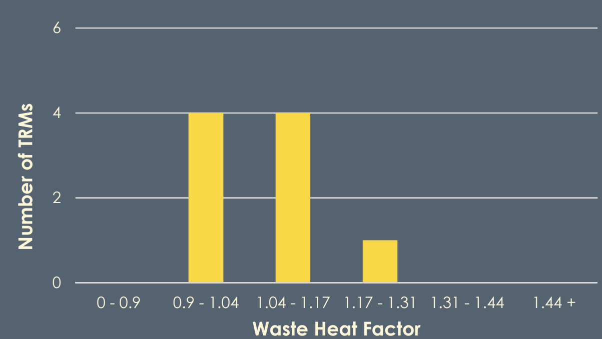
KEY PARAMETER COMPARISON

Mean Hours: 8,320
Median Hours: 8,760
Rhode Island: 8,760



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean WHF: 1.079
Median WHF: 1.08
Rhode Island: Not Used



Rhode Island does not utilize waste heat factors in the calculation of lighting savings.

COMMERCIAL FAUCET AERATORS (GAS)

Rhode Island Evaluation | Small Business | Water Heating

COMMON ALGORITHM

$$MMBtu\ Savings = ISR \times \%Fuel \times [(GPM_{base} - GPM_{low})/GPM_{base}] \times 8.3 \times 1.0 \times (T_{out} - T_{in}) \times (DF \times T_{person/day} \times N_{person} \times Days) / N_{faucets} / 1{,}000{,}000 / RE$$

Rhode Island uses the common algorithm for this measure.

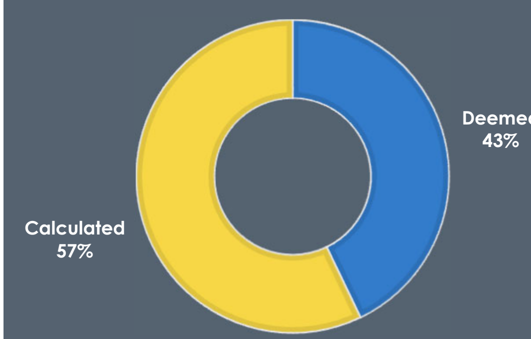
Where:

- ISR = In-service rate
- %Fuel = Percentage of water heaters using Natural Gas
- GPM = Flow rate (gallons per minute) pre (base) and post (low)
- Tout = Average temperature leaving faucet
- Tin = Average temperature enterting water heater
- DF = Adjustment for water flowing down drain
- Tperson/day = Average time of hot water use per person per day
- Npersons = Average number of persons
- Days = Average days of sink usage
- Nfaucets = Average number of faucets
- RE = Recovery efficiency of hot water heater

TRM AVAILABILITY

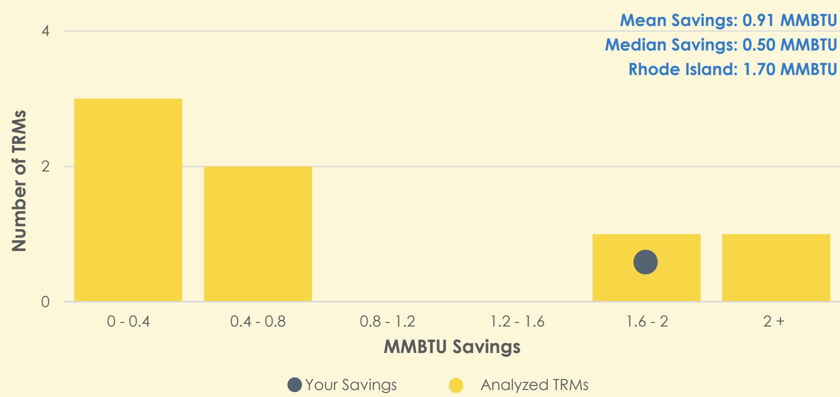
Deemed Measure	Calculated Measure	Measure Not Offered
Connecticut (2016)	Illinois (2019)	Ameren Missouri (2017)
Massachusetts (2016)	Iowa (2018)	Arkansas (2017)
Michigan (2020)	Missouri Statewide (2017)	California Muni. (2016)
Rhode Island (2020)	New York (2019)	Delaware (2016)
		Hawaii (2018)
		Indiana (2013)
		Maine (2017)
		MidAtlantic (2018)
		Minnesota (2018)
		New Jersey (2016)
		Ohio (2010)
		Ontario (2019)
		Pennsylvania (2021)
		Vermont (2015)
		Washington D.C. (2017)

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Flow Rate
Mean: 1.73 GPM
Rhode Island: 2.2 GPM

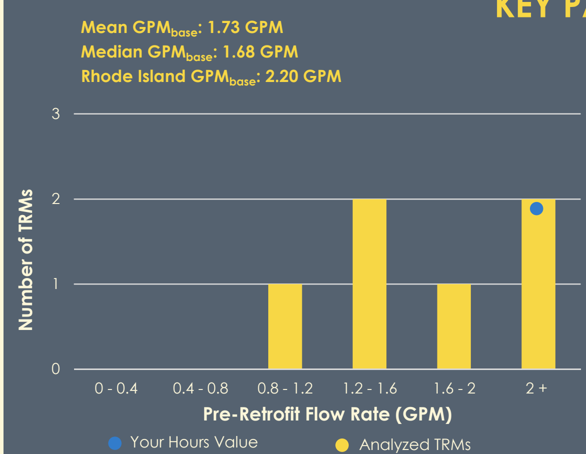
Days of Hot Water Use
Mean: 252 Days
Rhode Island: Not Provided

Faucet Temperature
Mean: 90.5°F
Rhode Island: Not Provided

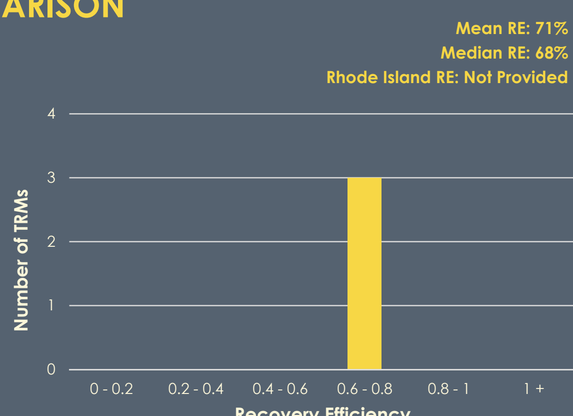
Entering Water Temperature
Mean: 54.3°F
Rhode Island: Not Provided

In Service Rate
Mean: 0.98
Rhode Island: 1.00

KEY PARAMETER COMPARISON



See accompanying report for detailed comparison of all key parameters across all TRMs.



COMMERCIAL SHOWERHEADS (GAS)

Rhode Island Evaluation | Small Business | Water Heating

COMMON ALGORITHM

$$\text{MMBtu Savings} = ISR \times \%Fuel \times [(GPM_{base} - GPM_{low})] \times 8.3 \times 1.0 \times (T_{out} - T_{in}) \times (DF \times T_{shower} \times N_{showers} \times Days) / N_{faucets} / 1{,}000{,}000 / RE$$

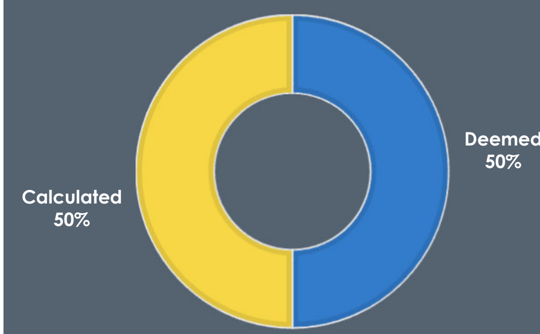
Rhode Island uses the common algorithm for this measure.

Where:
- ISR = In-service rate
- %Fuel = Percentage of water heaters using Natural Gas
- GPM = Flow rate (gallons per minute) pre (base) and post (low)
- Tout = Average temperature leaving faucet
- Tin = Average temperature enterting water heater
- DF = Adjustment for water flowing down drain
- Tshower = Average shower length
- Nshowers = Average number of showers per one showerhead
- Days = Average days of sink usage
- Nfaucets = Average number of faucets
- RE = Recovery efficiency of hot water heater

TRM AVAILABILITY

Deemed Measure	Calculated Measure	Measure Not Offered
Connecticut (2016)	Illinois (2019)	Ameren Missouri (2017)
Massachusetts (2016)	Iowa (2018)	Arkansas (2017)
Michigan (2020)	New York (2019)	California Muni. (2016)
Rhode Island (2020)		Delaware (2016)
		Hawaii (2018)
		Indiana (2013)
		Maine (2017)
		MidAtlantic (2018)
		Minnesota (2018)
		Missouri Statewide (2017)
		New Jersey (2016)
		Ohio (2010)
		Ontario (2019)
		Pennsylvania (2021)
		...and 2 more

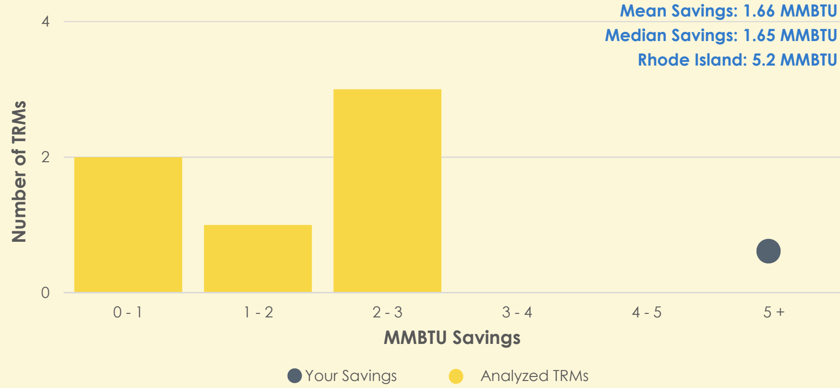
OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE

Mean Savings: 1.66 MMBTU
Median Savings: 1.65 MMBTU
Rhode Island: 5.2 MMBTU



KEY PARAMETERS

Baseline Flow Rate
Mean: 2.37 GPM
Rhode Island: 2.50 GPM

Days of Hot Water Use
Mean: 365.17 Days
Rhode Island: Not Provided

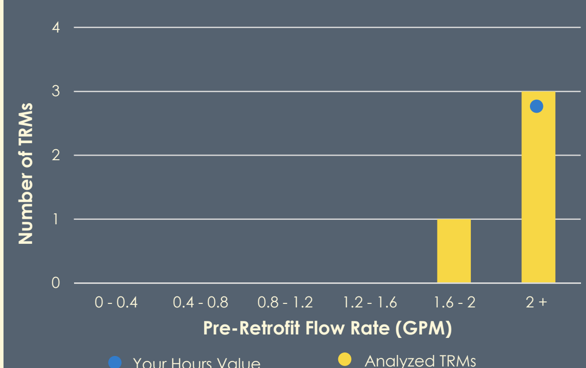
Faucet Temperature
Mean: 103.7°F
Rhode Island: Not Provided

Entering Water Temperature
Mean: 53.1°F
Rhode Island: Not Provided

In Service Rate
Mean: 0.98
Rhode Island: 1.00

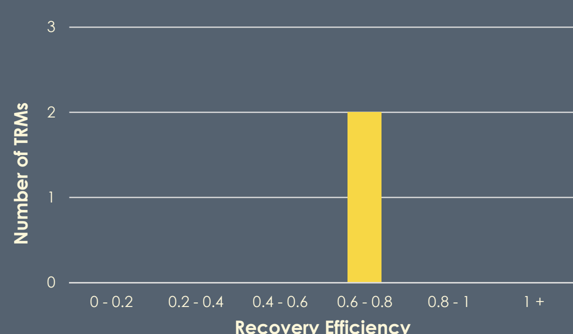
KEY PARAMETER COMPARISON

Mean GPM_{base}: 2.37 GPM
Median GPM_{base}: 2.50 GPM
Rhode Island GPM_{base}: 2.50 GPM



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean RE: 72%
Median RE: 69%
Rhode Island RE: Not Provided



COMMERCIAL UPSTREAM LIGHTING

Rhode Island Evaluation | Commercial Lighting | Upstream Lighting

COMMON ALGORITHM

kWh Savings =

$$Qty \times (W_{base} - W_{ee})/1{,}000 \times Hours \times WHF \times ISR \times (1 - Leakage)$$

Rhode Island uses the common algorithm for this measure.

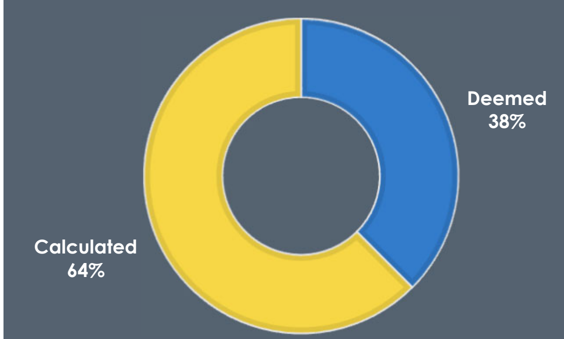
Where:

- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate
- Leakage = Proportion of bulbs installed in a residential setting

TRM AVAILABILITY

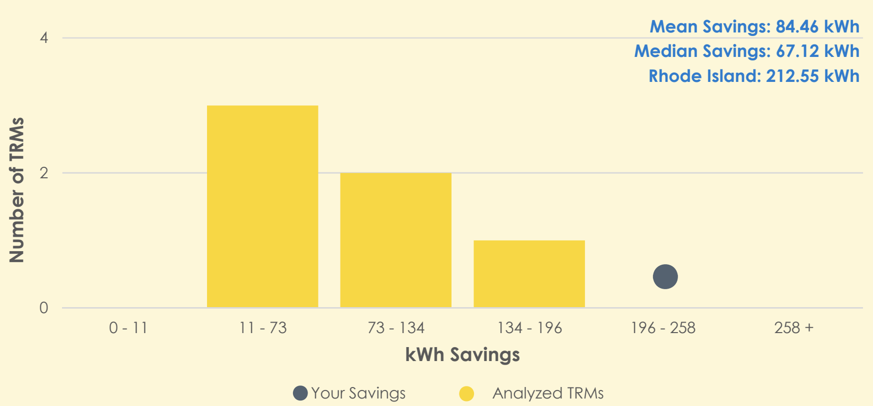
Deemed Measure	Calculated Measure	Measure Not Offered
Connecticut (2016)	Illinois (2019)	Ameren Missouri (2017)
Rhode Island (2020)	Iowa (2018)	Arkansas (2017)
Vermont (2015)	Massachusetts (2016)	California Muni. (2016)
Washington D.C. (2017)	Missouri Statewide (2017)	Delaware (2016)
	Pennsylvania (2021)	Hawaii (2018)
		Indiana (2013)
		Maine (2017)
		MidAtlantic (2018)
		Minnesota (2018)
		New Jersey (2016)
		New York (2019)
		Ohio (2010)
		Ontario (2019)

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 37.53 Watts
Rhode Island: Not Provided

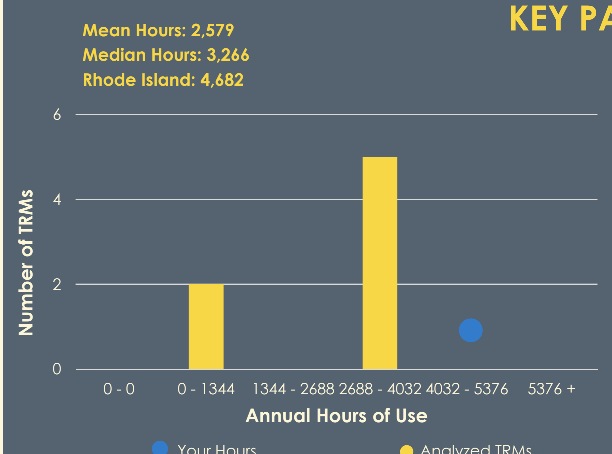
Annual Hours of Use
Mean: 2579 Hours
Rhode Island: 4,682 Hours

Waste Heat Factor
Mean: 1.00
Rhode Island: 0.99

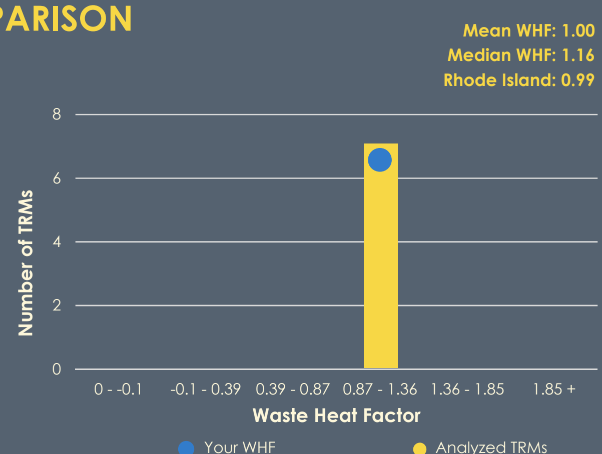
In Service Rate
Mean: 0.967
Rhode Island: 0.76

As most TRMs require input of Watts $_{ee}$, a value of 4 was input for all TRM calculations. As such, the mean is not provided here.

KEY PARAMETER COMPARISON



See accompanying report for detailed comparison of all key parameters across all TRMs.



COMMERCIAL LINEAR LED T8 REPLACEMENTS

Rhode Island Evaluation | Commercial Lighting | Linear LED T8 Replacements

COMMON ALGORITHM

$$kWh\ Savings = Qty \times (W_{base} - W_{ee})/1{,}000 \times Hours \times WHF \times ISR$$

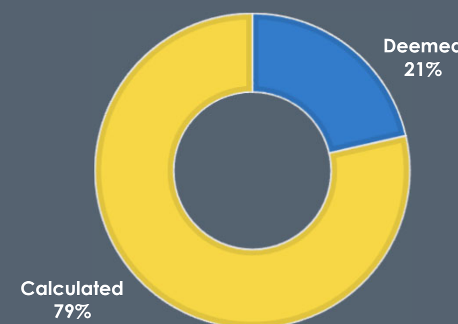
Rhode Island uses the common algorithm for this measure.

Where:
- Qty = Quantity of lamps or fixtures
- $Watts_{base}$ = Wattage of removed lamp or fixture
- $Watts_{ee}$ = Wattage of installed lamp or fixture
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- WHF = Waste Heat Factor
- ISR = In-service Rate

TRM AVAILABILITY

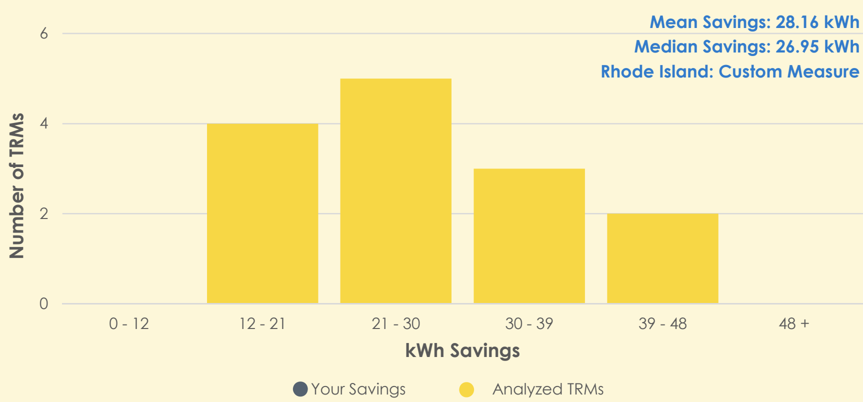
Deemed Measure	Calculated Measure	Measure Not Offered
Michigan (2020)	Arkansas (2017)	Ameren Missouri (2017)
Ontario (2019)	Connecticut (2016)	California Muni. (2016)
Vermont (2015)	Delaware (2016)	Hawaii (2018)
	Maine (2017)	Illinois (2019)
	Massachusetts (2016)	Indiana (2013)
	MidAtlantic (2018)	Iowa (2018)
	Minnesota (2018)	Missouri Statewide (2017)
	New Jersey (2016)	Ohio (2010)
	New York (2019)	
	Pennsylvania (2021)	
	Rhode Island (2020)	
	Washington D.C. (2017)	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Baseline Wattage
Mean: 30.59 Watts
Rhode Island: Not Provided

Annual Hours of Use
Mean: 3,286 Hours
Rhode Island: Site Specific

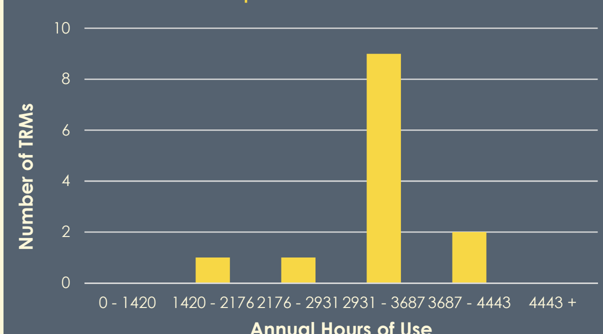
Waste Heat Factor
Mean: 1.069
Rhode Island: Not Used

In Service Rate
Mean: 0.99
Rhode Island: Site Specific

As most TRMs require input of $Watts_{ee}$, a value of 23 was input for all TRM calculations. As such, the mean is not provided here.

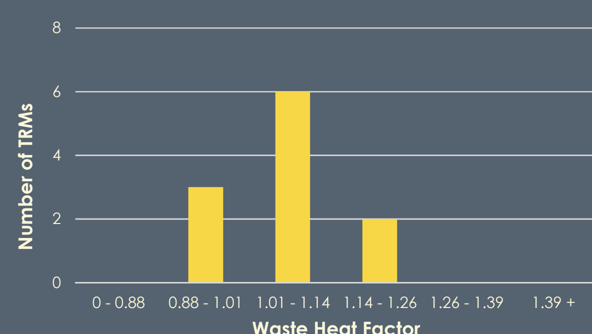
KEY PARAMETER COMPARISON

Mean Hours: 3,286
Median Hours: 3,610
Rhode Island: Site Specific



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean WHF: 1.069
Median WHF: 1.06
Rhode Island: Not Used



COMMERCIAL OCCUPANCY SENSORS

Rhode Island Evaluation | Commercial Lighting | Occupancy Sensors

COMMON ALGORITHM

kWh Savings = Watts/1,000 x Hours x SVG x WHF x ISR

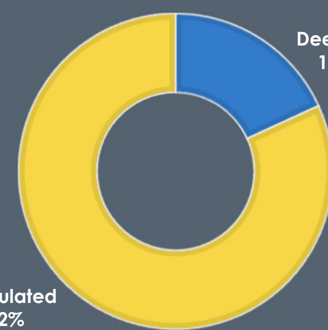
Where:
- Watts = Total wattage of controlled fixtures
- 1,000 = Conversion from Watts to Kilowatts
- Hours = Annual Operating Hours
- SVG = Savings Factor
- WHF = Waste Heat Factor
- ISR = In-service Rate

Rhode Island uses an alternate algorithm for this measure whereby site specific pre- and post-retrofit hours are used.

TRM AVAILABILITY

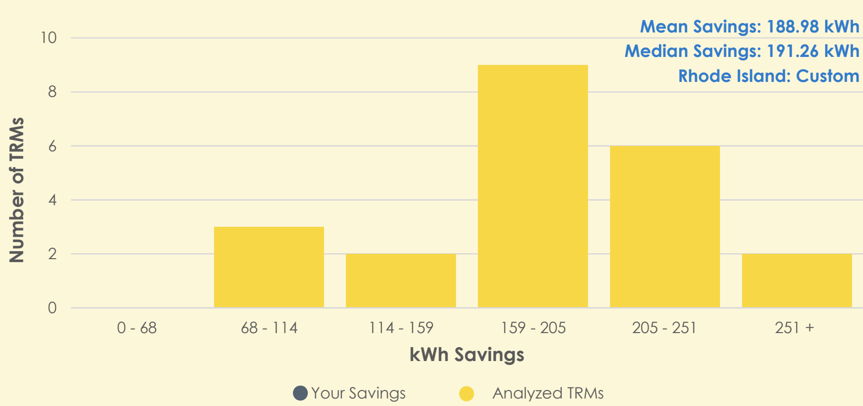
Deemed Measure	Calculated Measure	Measure Not Offered
Ameren Missouri (2017)	Arkansas (2017)	
Hawaii (2018)	California Muni. (2016)	
Michigan (2020)	Connecticut (2016)	
Ontario (2019)	Delaware (2016)	
	Illinois (2019)	
	Indiana (2013)	
	Iowa (2018)	
	Maine (2017)	
	Massachusetts (2016)	
	MidAtlantic (2018)	
	Minnesota (2018)	
	Missouri Statewide (2017)	
	New Jersey (2016)	
	New York (2019)	
	...and 5 more	

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Savings Factor
Mean: 0.26
Rhode Island: Not Used

Annual Hours of Use
Mean: 3,327 Hours
Rhode Island: Site Specific

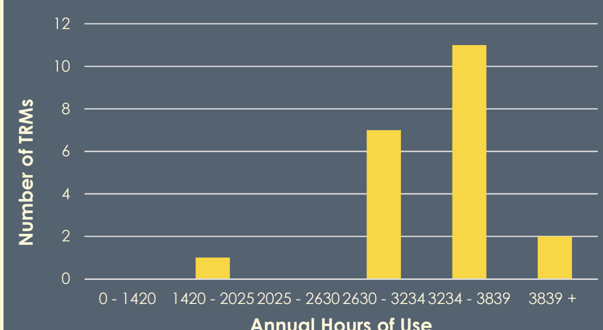
Waste Heat Factor Mean: 1.07
Rhode Island: Not Used

In Service Rate
Mean: 1.00
Rhode Island: 1.00

As most TRMs require input of Watts, a value of 200 was input for all TRM calculations. As such, the mean is not provided here.

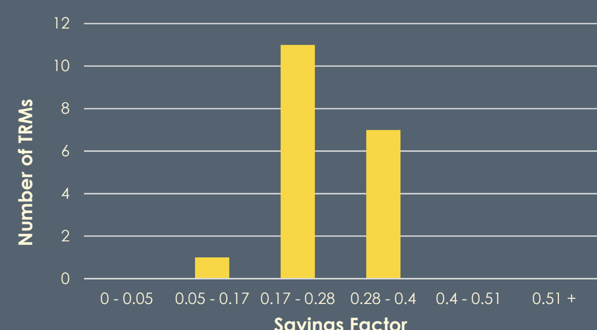
KEY PARAMETER COMPARISON

Mean Hours: 3,327
Median Hours: 3,396
Rhode Island: Site Specific



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean SVG: 0.26
Median SVG: 0.26
Rhode Island: Not Used



COMMERCIAL STEAM TRAPS

Rhode Island Evaluation | Commercial | HVAC

COMMON ALGORITHM

$$\text{MMBtu Savings} = (24.24 \times \text{Pia} \times D^2 \times A \times FF) \times H_{vap} / \eta_{heat} \times \text{Hours} \times \%\text{Leak} / 1{,}000{,}000$$

Rhode Island uses the common algorithm for this measure.

Where:
- Pia = Inlet pressure
- D = Diameter of orifice
- A = Adjustment factor
- FF = Flow factor
- Hvap = Heat of vaporization of steam
- ηheat = Efficiency of heating equipment
- Hours = Annual operating hours of steam plant
- %Leak = Percentage of traps leaking and needing replacement

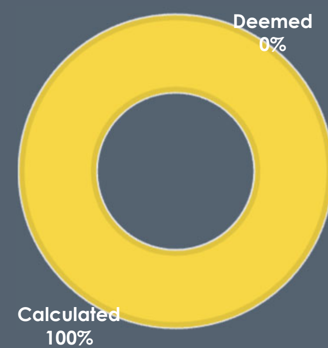
TRM AVAILABILITY

Deemed Measure
- **Rhode Island (2020)**

Calculated Measure
- Illinois (2019)
- Missouri Statewide (2017)
- New York (2019)

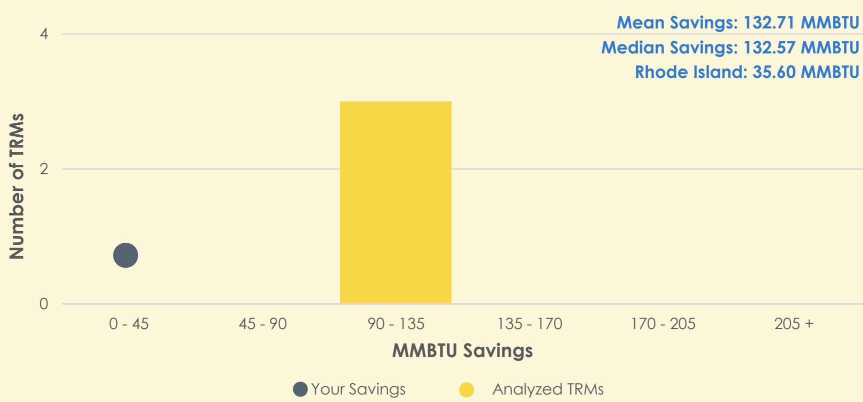
Measure Not Offered
- Ameren Missouri (2017)
- Arkansas (2017)
- California Muni. (2016)
- Connecticut (2016)
- Delaware (2016)
- Hawaii (2018)
- Indiana (2013)
- Iowa (2018)
- Maine (2017)
- Massachusetts (2016)
- MidAtlantic (2018)
- Minnesota (2018)
- New Jersey (2016)
- Ohio (2010)
- …and 4 more

OFFERING OVERVIEW



Excludes Rhode Island TRMs

HOW YOUR DEEMED SAVINGS COMPARE



KEY PARAMETERS

Heat of Vaporization
Mean: 913.00
Rhode Island: Not Provided

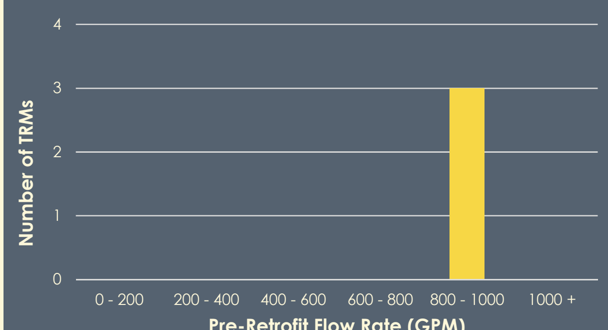
Heating System Efficiency
Mean: 72%
Rhode Island: Not Provided

Percentage of Traps Leaking
Mean: 27%
Rhode Island: Not Provided

As most TRMs require input of Pia, D, and Hours, values of 47, 0.25, and 8,282 were input respectively for all TRM calculations. As such, the means are not provided here.

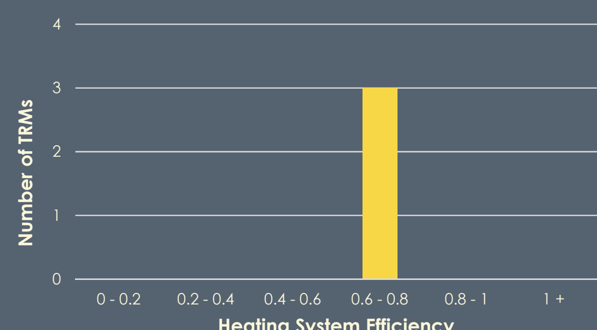
KEY PARAMETER COMPARISON

Mean Hvap: 913.00
Median Hvap: 912.00
Rhode Island Hvap: Not Provided



See accompanying report for detailed comparison of all key parameters across all TRMs.

Mean ηheat: 72%
Median ηheat: 72%
Rhode Island ηheat: Not Provided



Appendix B. Work Plan

Work Plan: Energy Efficiency Programs Evaluation Study

September 10, 2019

Submitted to: Office of Energy Resources, State of Rhode Island

Submitted by:

brightline GROUP

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Contents

1 Introduction

The overarching goal of this Energy Efficiency Programs Evaluation Study is to understand whether there are improvements that can be made to the current evaluation measurement and verification (EM&V) process for National Grid's energy efficiency programs. The study is categorized into three tasks each with their own key objective:

- The key objective of Task 1 is to assess "Does the current Evaluation, Measurement, and Verification (EM&V) process in Rhode Island comply with national industry best practices for programs of its size and scope?"
- The key objective of Task 2 is to understand "Quantitatively, to what extent are National Grid's claimed energy savings accurate?".
- The key objective of Task 3 is to assess "Are there savings estimation and program implementation improvements that can be identified to help customers that have or are likely to experience a substantial difference in estimated gross energy savings versus installed gross energy savings and visible bill savings?"

1.1 Evaluation Management

1.1.1 Project Management

Through careful planning, hard work, and clear communication, the BrightLine team's goal is to produce findings that enhance the implementation and evaluation processes, support program innovations and continuous improvement, and facilitate regulatory reporting requirements.

The BrightLine team has systems in place for effective project management, reporting, and maintaining frequent communications on project status, findings, and other relevant information with project stakeholders. We will proactively implement and promote a four-pronged approach to ensure that the OER, the BrightLine team, and other project stakeholders work together, are kept fully apprised of important developments, and serve as active participants in the project. Specifically, our project manager will take the following steps:

1. Set up and facilitate regularly scheduled bi-monthly meetings and quarterly webinars, as noted on the schedule provided in Section 3,
2. Set up and facilitate ad hoc meetings as needed,
3. Be responsible for ensuring that all communications are disseminated to all appropriate parties, and
4. Work to ensure that the OER and team member leads have unrestricted access to one another.

1.1.2 Quality Control and Working Group Feedback

The BrightLine team ensures quality control by adhering to professional project management procedures that are based on planning, monitoring, and control, as well as on constant communication among all parties. Project administration is predicated on effective work planning, schedule and program controls, coordination of tasks, and internal reviews of work. Our team will work to ensure quality control of all interim and final deliverables through the following approach:

- Consistently communicate with the OER and the Working Group via oral and written channels through regularly scheduled monthly meetings and quarterly webinars, as noted on the project schedule provided in Section 3. This regular line of communication will keep the OER and Working Group apprised of the study progress, keep them aware of any concerns or observations that arise during the process, while at the same time, providing the opportunity for the BrightLine team to receive and incorporate feedback from the Working Group into its analysis.
- Prioritizing and scheduling projects/tasks to best suit the needs of the OER and the Working Group.
- Provide internal and peer reviews of work prior to submission to the OER to ensure any errors or omissions are identified and rectified. Work completed by each team member will be reviewed by at least one other team member as applicable.
- Provide a description of evaluation deliverables including interview instruments, data collection forms, memos, reports, etc. to ensure the OER and Working Group can set expectations and structure feedback to the BrightLine team accordingly. The review timeline for deliverables and data gathering instruments is included in the schedule found in Section 3.

1.2 Summary of Evaluation Activities

The BrightLine team will assess the overall EM&V process for National Grid's energy efficiency program and seek to understand whether there are improvements that can be made to the current EM&V process.

Task 1 will assess Rhode Island (National Grid's) EM&V processes and outcomes with the intent of addressing the Rhode Island Offices of Energy Resources (OER)'s research question; "Does the current Evaluation, Measurement, and Verification (EM&V) process in Rhode Island comply with national industry best practices for programs of its size and scope?". For Task 1, we will identify the current state of Rhode Island's EM&V process through stakeholder interviews and the review of Rhode Island's EM&V documentation. We will also review EM&V processes throughout the country to identify best practices to assess if/how these best practices could be applied to improve Rhode Island's EM&V process.

The objective of Task 2 is to review National Grid's energy efficiency programs in terms of achieved energy savings with emphasis on the employed EM&V methods. A comprehensive look at the evaluation methodologies used for National Grid's programs will document portfolio achievements and highlight areas for improvement. As part of this task, the BrightLine team will identify the priority measures in National Grid's programs over the past four years for both sectors and fuel types. The review of these priority measures will depend on whether the evaluations are based on fully or partially deemed savings (via TRM algorithm and assumptions) or if the measures have been evaluated using independent (non-TRM) methods. For measures that are partially deemed or otherwise calculated via TRM algorithm and assumptions, we will review the prescribed methodologies benchmarking them against those of other TRMs offering comparable measures. For non-TRM measures, we will perform a thorough comparison of the performed EM&V practices relative to industry standards. The review will focus on accuracy and appropriateness based on industry standard methodologies. We will review the evaluation methods, sample design, documentation of assumptions utilized, documentation of achieved confidence and precision, among other metrics as appropriate for the study being review.

The key objective of Task 3 is to assess "Are there savings estimation and program implementation improvements that can be identified to help customers that have or are likely to experience a substantial difference in estimated gross energy savings versus installed gross energy savings and visible bill savings?". In order to assess this key objective, the BrightLine team will first conduct an analysis of C&I customer electric and gas usage, pre and post project implementation, to compare actual energy savings (installed gross energy savings and visible bill savings) to reported energy savings (i.e. estimated gross energy savings). Second, based on the findings from the billing analysis, we will conduct follow-up customer interviews and site visits to understand any large discrepancy in reported and actual energy bill savings.

Section 2 outlines key activities that will be conducted for each task.

2 Approach and Methods

This section discusses the data collection and analysis approach for completing the three tasks identified for this study.

2.1 Task 1: Review of EM&V Process

EM&V looks different across the nation. There are statewide EM&V models, statewide oversight with utility models, program administrators that separate process and impact evaluations, and those that prefer to comprehensively assess programs' evaluations by combining process, impact, and perhaps market evaluations in one study.

This task will critically assess Rhode Island (National Grid's) EM&V processes and outcomes with the intent of addressing the Rhode Island Offices of Energy Resources (OER)'s research question:

> *"Does the current Evaluation, Measurement, and Verification (EM&V) process in Rhode Island comply with national industry best practices for programs of its size and scope?"*

Specifically, the BrightLine team will use primary and secondary research to review:

- The electric and gas distribution company's EM&V study specification approach and determination for which studies are based on Rhode Island versus Massachusetts' results
- Frequency and level of investment of Rhode Island-specific studies
- Trade-off analysis of conducting Rhode Island-specific research and any limitations of applying results from other jurisdictions
- Approach for applying results for annual reporting and program and portfolio planning
- Effectiveness of the EM&V process for program administrators and OER
- Any concerns about the EM&V process and related costs or application of results including timeliness of receiving preliminary and final results
- Calculation of non-energy impacts and how they are incorporated in cost-effectiveness testing and reporting

2.1.1 Review of Rhode Island Documentation

The BrightLine team will review Rhode Island's EM&V processes and reports to better understand the existing EM&V process. Specifically, we will review and characterize prior EM&V activities per publicly available evaluation reports and through Energy Efficiency and Resource Management Council's (EERMC) quarterly and annual reports. These resources will be used to document the EM&V studies completed, by program or market, and review how the results are used for reporting. Findings from this activity will inform the guide development for the interviews with EM&V stakeholders in Rhode Island, as well as the development of benchmarking criteria. (The OER and Working Group should expect to receive the guide for review around August 26, with a requested one week review period for feedback.)

The documentation review will also be useful for planning for the benchmarking task. As discussed below, the BrightLine team will review and capture information on other states' EM&V frameworks and activities, also referred to as benchmarking. The team will consider information being collected and documented within these reports to guide what should be reviewed as part of the benchmarking activity.

Progress on this task has already been made. As part of the data request, the BrightLine team requested that National Grid summarize the existing EM&V processes, which has been received. We also received EM&V reports from 2013 through 2018 and will organize the reports into categories based on certain characteristics, like sector, program type, and evaluation activities.

2.1.2 Interview EM&V Stakeholders

To better understand the Rhode Island's current EM&V process from all perspectives, the BrightLine team will conduct up to eight phone interviews with EM&V stakeholders. These interviews will also focus on how EM&V findings and recommendations are applied to Rhode Island programs, both retrospectively and prospectively, as well as any potential pain points in the current EM&V process. Interviews will focus on the prior two years' evaluations. Interviewers will reference EM&V reports from the prior two years to use as a basis to discuss the EM&V process and the use and application of EM&V results.

On approval of this scope of work we will begin recruitment and scheduling interviews. The estimated start date for recruitment is August 28 with interviews conducted September 3 through September 20. The BrightLine team will develop a semi-structured interview guide. This guide will be provided in advance of the interviews and as part of the recruiting communication.

2.1.3 Assess EM&V Practices in Other Jurisdictions

The BrightLine team will review other states' EM&V practices through a combination of review of publicly available information and reports as well as primary in-depth interviews. The purpose of this activity is to identify best – most effective – practices to provide context around Rhode Island's EM&V activities and inform opportunities for improvement.

First, the team will review and summarize EM&V and reporting approaches applied in other states. We will prioritize the review of EM&V processes from states of similar size and investment to Rhode Island but will also explore processes in states dissimilar to Rhode Island to better understand the EM&V landscape and best practices across the country. Before we begin this review, we will outline criteria to benchmark and compare the EM&V approaches across states – possible criteria may include, EM&V budget, EM&V requirements, state demographics, or region. These criteria will be outlined in a memo for the OER to review, prior to the completion of any benchmarking work.

The research will be strengthened through informal conversations with managers from select program administrators about the value and considerations of their EM&V processes. We will leverage our experience providing EM&V across the country, as well publicly available sources such as regional energy efficiency organizations and American Council for an Energy Efficient Economy reports and websites, to identify program administrators to interview. The BrightLine team will recommend an interview list for review and approval prior to reaching out to potential interviewees.

2.1.4 Reporting

Task 1 research will culminate with a stand-alone section in the draft and final report, documenting and visualizing Rhode Island processes, and considerations that may improve accuracy, impactfulness, effectiveness, and/or experiences with EM&V.

Much like a customer journey map, the BrightLine team will use the research to visualize the EM&V process from the OER, EERMC and electric and gas distribution company's perspectives, showcase what is working well, and highlight EM&V pain points to identify areas for process improvements. The deliverable will include recommendations for any process improvements along with the supporting rationale for those recommendations, considering Rhode Island's regulatory requirements and programming spend.

2.2 Task 2: Independently Review All Current Estimates of Savings/Verify the Use of EM&V Industry Standards

The objective of Task 2 is to review National Grid's energy efficiency programs in terms of claimed energy savings with emphasis on the employed EM&V methods. A comprehensive look at the evaluation methodologies used for National Grid's programs will document how savings were calculated for major parts of the portfolio's achievements and highlight areas for improvement. After a thorough review of National Grid's program participation data, we will identify the priority measures to include in the review specifically those measures that contribute approximately 60% of the savings within each customer class and fuel type.

Appendix A presents our summary of the program tracking data for each sector and fuel type covering program years 2015 – 2018, where sector share (%) is the proportion of energy savings within the sector attributable to each measure. Based on this summary, the BrightLine team identified the measures in Table 1 to include in our review.

Table 1: Priority Measures Identified for Review

Sector - Fuel	Program	Measure
Residential - Electric	Opower	Opower
	EnergyWise SingleFamily	LED Bulbs and Fixtures
	Residential Lighting	CFL Bulbs and Fixtures
		LED Bulbs and Fixtures
Residential - Gas	Opower	Opower
	Energy Wise	Weatherization
Low Income - Electric	Income Eligible Multifamily	LED Bulbs and Fixtures
	Low Income Services	LED Bulbs and Fixtures
Low Income - Gas	Income Eligible Multifamily	HVAC
		Weatherization
	Low Income Services	Weatherization
Small Business - Electric	Small Business	Prescriptive Lighting
Small Business - Gas	Small Business	Aerator
		Showerhead
		Custom
C&I - Electric	Prescriptive	Lighting
		Lighting Controls
	Custom	Lighting
	LCI - Upstream Lighting	LED Lighting Systems
C&I - Gas	Prescriptive	Steam Traps
	Custom	Comprehensive Design Assistance
		HVAC
		Process
		Steam Traps

The remaining subsections outline the specific research activities to be conducted on the identified measures.

2.2.1 Catalog Previous Evaluations

The BrightLine team will review evaluation studies for the identified priority measures from each sector and fuel type within the past four years. We will use this review to populate a table that summarizes the types of evaluation methodologies and sampling strategies employed for each prioritized program and measure. Through this audit process, we also intend to verify that previous evaluations which have led to the development of TRM assumptions and impact factors rely on current industry standards and best practices.

Tables found in Appendix B outline the evaluation studies that will be reviewed for the priority measures identified in Table 1 above. These are preliminary tables based on the initial review of available evaluation reports covering program years 2015 – 2018. This list may be amended based on information found in these reports. In other words, it may be determined that some reports are not applicable to the priority measures and/or reports may be added based on information gathered during the review.

2.2.2 TRM Algorithm and Assumptions Review

Where savings for priority measures are claimed using deemed, partially deemed or otherwise calculated savings via TRM algorithm and assumptions, we will review the prescribed methodologies benchmarking them against those of other TRMs offering comparable measures. The BrightLine team has built an application for TRM benchmarking that houses equations and assumptions for 237 measures across 30 known TRMs. TRM benchmarking allows us to quickly identify measures that are expected to have outdated or insufficient assumptions.

Results of the TRM benchmarking will include the following:

- List of TRMs offering a similar measure
- Descriptive statistics surrounding evaluation methodology (Deemed vs. Calculated)
- Common algorithm
- Table of equation parameters by TRM
- Visual representation of Rhode Island deemed values to analyzed TRMs

Similar Measures: Many TRMs have measures that use the same algorithms and assumptions but may have different names. For example, measures named "Water Heater Jackets", "Water Heater Tank Insulation", "Water Heater Blanket", "Water Heater Wrap", and "Tank Wrap" all refer to savings achieved by increasing the insulation of a domestic hot water heater. All of these measures are analyzed the same way and thus can be used for benchmarking against one another.

For measures that are deemed weather dependent, we will filter the results to only those TRMs providing guidance to regions residing in ASHRAE Zone 5A. This includes:

- Ameren Missouri's 2016 TRM
- Connecticut 11th Edition TRM
- IESO Measures and Assumptions List (2015)
- Illinois TRM V6.0 (2018)
- Indiana TRM V1.0 (2013)
- Iowa Statewide TRM V3.0 (2018)
- Massachusetts TRM (2012)
- Michigan Master Measures Database (2018)
- MidAtlantic TRM V7.0 (2017)

- New Jersey Protocols (2016)
- New York TRM V5 (2018)
- Ohio TRM (2010)
- Pennsylvania TRM (2016)
- Vermont TRM No. 2014-87 (2015)

Weather Dependent measures include measures within the following end uses:

- Building Shell
- HVAC
- Refrigeration
- Water Heating
- Lighting Interactive Effects

2.2.3 EM&V Best Practices Review

For measures that have been evaluated using independent (non-TRM) methods, we will perform a thorough comparison of EM&V practices relative to industry standards. We will review the evaluation methods, sample design, documentation of assumptions utilized, documentation of achieved confidence and precision, among other metrics as appropriate for the study being review. Our research will draw from the following secondary sources as deemed appropriate, such as the Department of Energy Uniform Methods Project, the International Performance Measurement and Verification Protocol, the National Standard Practice Manual, results of recent measure-specific studies, the ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources (ISO-NE M-MVDR), among others.

2.2.4 Reporting

The BrightLine team will outline the findings of our review in a table format that presents the results of our review, summarizing the characteristics of the evaluation methods for the measure or program being reviewed, noting alignment with industry standards and if not, reasons why. The preliminary report will also include any recommendations, opportunities, and challenges found for each review. Table 2 provides a proposed illustrative example of how the review findings will be displayed. We will discuss the proposed table with the OER and the Working Group and refine this table based on those discussions.

Table 2: Proposed Illustrative Evaluation Methods Review Matrix

C&I Gas: Example Measure/Program			
National Grid Evaluation Practices		**Alignment with Industry Standards**	
Sample Design	Census with filters	✓	Using a census minimizes sampling uncertainty.
Evaluation Activities	Pre/post billing analysis, phone interviews, site visits	✓	Use of tiered evaluation activities to improve billing analysis is an industry best practice.
Documentation of Assumptions	Baseline and efficient cases described	✓	Billing analysis methods accurately assess pre- and post-retrofit conditions for this measure.
Data Sources	High level of primary data collection	✓	Results are generated through participant pre/post billing analysis
Relevance to TRM	Updated TRM values generated	?	NGrid adopted updated values in 2018. Report recommended adoption in 2017.
Documented Confidence Intervals	Achieved C/P intervals not reported	✗	Future evaluations should state achieved C/P intervals associated with findings
Findings & Recommendations	Clearly stated and supported	✓	Specific actionable items are clearly defined.
Other: ____________	As appropriate based on study being reviewed		

2.3 Task 3: Analysis of Bills and Customer Experience Evaluation

There are two key objectives for Task 3. The first is to develop weather-normalized estimates of annual energy savings via pre/post billing analysis for C&I customers that participated in National Grid's gas or electric retrofit programs. The annual energy savings estimates drawn from the billing analysis will be compared to the gross savings estimates stored in National Grid's tracking data. This comparison will inform the second key objective, which is to conduct follow-up customer interviews and site visits to understand any large discrepancies between the gross savings estimates stored in the tracking data and the savings estimates derived from the billing analyses. The findings from these research efforts will help the BrightLine team answer one of the research questions posed in the RFP:

> *"Are there savings estimation and program implementation improvements that can be identified to help customers that have or are likely to experience a substantial difference in estimated gross energy savings versus installed gross energy savings or visible bill savings?"*

In the research question posed above, there are three sets of savings identified – a source of potential confusion. Our team is assuming "estimated gross energy savings" represents the gross savings estimate from National Grid's tracking data, "installed gross energy savings" represents the weather-normalized savings estimates derived from a billing analysis, and "visible bill savings" represent the non-weather-normalized savings estimates (e.g., avoided energy use estimates) derived from a billing analysis. Our methods for producing weather-normalized savings estimates and non-weather-normalized savings estimate are discussed in Section 2.3.2. Also note that we have included definitions of terms in an appendix (Appendix C).

2.3.1 Analysis of Bills

For the billing analysis component of this task, our team does not plan to select a sample from the population of commercial and industrial (C&I) energy conservation measures (ECMs). Rather, we intend to perform a billing analysis for all C&I participants who installed a retrofit measure that is expected to produce at least 5% savings.[1] Initially, the plan was to perform the analyses just for retrofit measures installed in a commercial office and/or retail building. Discussion at the kickoff meeting called into question the ability to reliably assign participants to a business type via the tracking data. A follow-up review of the tracking data indicates disaggregating by building type may prove difficult.[2] If a key that maps accounts to building types is provided, we can limit the scope to commercial office and retail buildings. Otherwise, we have no reservations about the scope including retrofit measures across all building types.

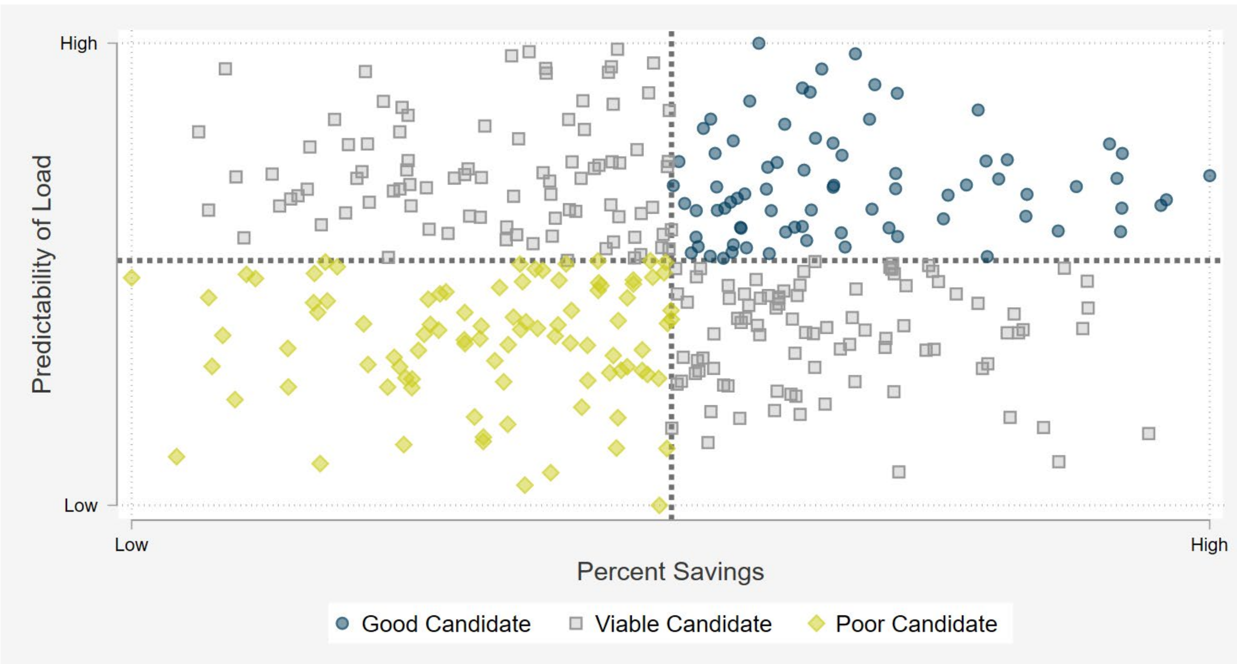
The scope proposed above is admittedly ambitious. Our team is under no illusion that a billing analysis is the best option to measure savings for each and every C&I retrofit measure – some projects will be better candidates for a billing analysis than others. Predictable load patterns will facilitate the precise measurement of savings, as will relatively larger effect sizes. If a site's load pattern is highly volatile and cannot be linked to other independent variables, or if the effect of the ECM is expected to be small relative to annual consumption, a billing analysis may not return a reliable or precise estimate of savings. Figure 1 illustrates our view of the interplay between the size of the effect (percent savings) and the predictability of load (as measured via R^2 or some other metric). Projects in the top right quadrant represent good candidates for a billing analysis – the load is predictable and the effect size is large. Such projects would be the focus of our research efforts. Projects in the lower left quadrant are poor candidates for a billing analysis. As noted, we do not plan to perform billing analyses for projects that resulted in less than 5% savings (relative to pre-installation annual usage). Projects in either of the other two quadrants are viable candidates for a billing analysis – a relatively small effect can be detected if load is highly predictable, and a relatively large effect can be detected even if much of the variation in consumption cannot be explained via weather or other external variables. Predictability of the load (uncertainty) and the effect size factor into another metric called relative precision (otherwise known as fractional savings uncertainty, FSU), which is the ratio of

[1] The numerator in the percent savings calculation will be the gross savings estimate stored in National Grid's tracking data. The denominator will be the weather-normalized annual load at the facility prior to the installation of the retrofit measure.

[2] In the C&I custom gas tracking data, 87% of retrofit measures have a missing building type. In the C&I prescriptive gas tracking data, 63% of retrofit measures had either a missing or "other" building type. In the C&I custom electric tracking data, 15% of retrofit measures have an "other" building type. In the C&I prescriptive electric tracking, 27% of retrofit measures have an "other" building type.

uncertainty to savings. Consider a project that saves 100,000 kWh/year according to the billing analysis results. If the margin of error (uncertainty) of the billing analysis results is ±40,000 kWh/year, the relative precision would be equal to 40%. According to ASHRAE Guideline 14, the maximum level of relative precision is 50% (at the 68% confidence level).[3] Our team will calculate relative precision at an agreed upon confidence level (preferably higher than 68%) for each billing analysis performed and we do not intend to report on cases where relative precision exceeds 50% (other than a summary of how frequently this occurred and whether or not higher relative precision values were correlated with certain measures or business types). Note that the relative precision screening will occur *after* all billing analyses have been completed, not before.

Figure 1: Billing Analysis Candidacy



Other Considerations for a Billing Analysis

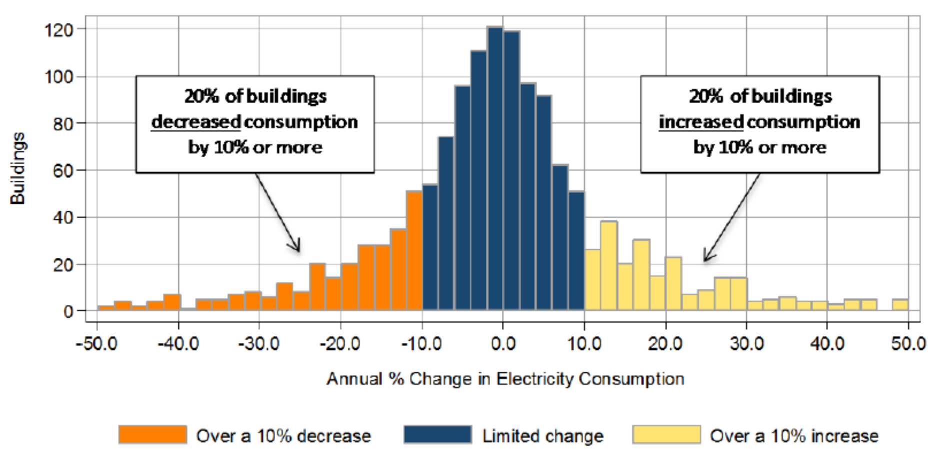
Other matters, too, may affect the results produced by a billing analysis. Any non-routine events, such as a temporary closure in the pre or post period, confound the energy impact of the ECM if not properly accounted for. Non-routine events could potentially be revealed to our team through the customer interview process, but we cannot filter for these with 100% certainty prior to performing the billing analyses. During the data cleaning process, we can look for large spikes or drops in consumption that could potentially be explained by a non-routine event. If found, affected months can be removed from the billing analysis.

[3] ASHRAE. 2014. ASHRAE Guideline 14-2014 – Measurement of Energy, Demand, and Water Savings. Atlanta, Ga.: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

A pre/post billing analysis generally assumes that the only differences between the pre period and the post period are the weather and the measure itself. In reality, there are other factors that play into how a business uses energy. One such factor for some businesses is the performance of the economy. For example, a manufacturing warehouse that was hit hard by the recently imposed tariffs may reduce the number of operating days or shifts. Such a scenario could lead to instances where the tracking data savings estimate and the billing analysis savings estimate are very different, as the change in consumption is unrelated to weather or the ECM. In aggregate, we expect that such situations will even out – there will sites where the billing analysis over-estimates savings because of unrelated reductions in consumption and sites where the billing analysis under-estimates savings because of unrelated increases in consumption. If the interviews and site visits reveal situations similar to the example posed above, our team can revisit the billing analyses for the relevant customers with the additional information collected through the interviews.

Some of the variation in energy use from year to year simply cannot be explained. Even absent energy efficiency measures, buildings can experience year to year changes in electricity consumption that are greater than 10% in either direction.[4] This conclusion is drawn from an ACEEE paper, co-authored by BrightLine team-member Josh Bode, that sought to determine how much energy consumption varies from year to year without ECMs. Figure 2, which is drawn from said paper, shows the percent change in annual electricity consumption for a sample of commercial buildings. Importantly, the distribution is centered at zero, but 40% of buildings saw changes in excess of 10% in magnitude.

Figure 2: Year to Year Changes in Energy Consumption Absent EE



[4] Bode, J, Caririllo, L., Basarkar, M. 2014. Whole Building Energy Efficiency and Energy Savings Estimation: Does Smart Meter Data with Pre-screening Open up Design and Evaluation Opportunities?

Similarly, in a 2013 paper that examined commercial building energy usage profiles by Phillip Price and David Jump[5], the authors concluded: "In most buildings and most years, the largest source of year-to-year change in energy use is neither energy conservation measures nor year-to-year variation in weather, it is changes in characteristics of building operation and occupant behavior such as operating hours, thermostat settings, the number of occupants, the type of activities performed in the building, and so on." Hence, much of the variation in energy consumption from one year to the next cannot be explained by variables that are readily available.

We expect that we might also encounter some account and meter matching issues. We can only request billing data for accounts/meters that are represented in the tracking data. This can create issues, as we are blind to other accounts/meters that should potentially be aggregated for the billing analysis. For example, consider a case where there are five meters at one site and the ECM affects two or three of the meters. This is something our billing analysis would not initially capture. We do not want to aggregate meters as a rule, as this exacerbates any signal-to-noise issues in the data. (If the ECM only affects one meter, then aggregating billing data for that meter with other related meters only serves to dilute the size of the savings signal.) If we find any projects that show greater than 100% savings, BrightLine will follow up with National Grid to determine if billing data for additional accounts/meters should be requested.

2.3.1.1 Tracking Data Review

Prior to completing the Work Plan, our team was provided with tracking data for C&I custom electric measures, C&I prescriptive electric measures, C&I custom gas measures, and C&I prescriptive gas measures. Between November 2012 and December 2018, the tracking data shows 11,566 unique retrofit measures were installed across 426 unique gas accounts and 1,578 unique electric accounts. Table 3 contains a summary of the counts. The "customer number" field represents a unique identifier for each customer that can be used to connect electric and gas accounts. Across retrofit measures in the four sets of tracking data, there were 1,843 unique customer numbers.

[5] Price, P., Jump, D, Granderson, J. Sohn, M. Addy, N. 2013. Commercial Building Energy Baseline Modeling Software: Performance Metrics and Method Testing with Open Source Models and Implications for Proprietary Software Testing

Table 3: Tracking Data Accounts – Retrofit Measures Only

Tracking Data Component	Unique Measures	Unique Application IDs	Unique Account Numbers	Unique Customer Numbers
Custom Electric	833	617	407	395
Prescriptive Electric	9,723	1,981	1,315	1,262
Custom Gas	585	552	318	256
Prescriptive Gas	425	425	131	112
Total	11,566	3,575	2,004	1,843

Table 4 shows average gross savings estimates for the measures in the tracking data. The custom electric tracking data has a field for gross therms savings estimates in addition to gross kWh savings estimates – this field contains mostly 0s and is not summarized in the table. A similar field is in the gas tracking data (gross kWh savings estimates) but is not populated.

Table 4: Average Gross Savings – Retrofit Measures Only

Tracking Data Component	Average Gross Savings Estimate per Measure	Average Gross Savings Estimate per Account
Custom Electric	161,165 kWh	329,853 kWh
Prescriptive Electric	15,690 kWh	116,013 kWh
Custom Gas	13,175 therms	24,238 therms
Prescriptive Gas	2,614 therms	8,480 therms

After finalizing the Work Plan, our team will:

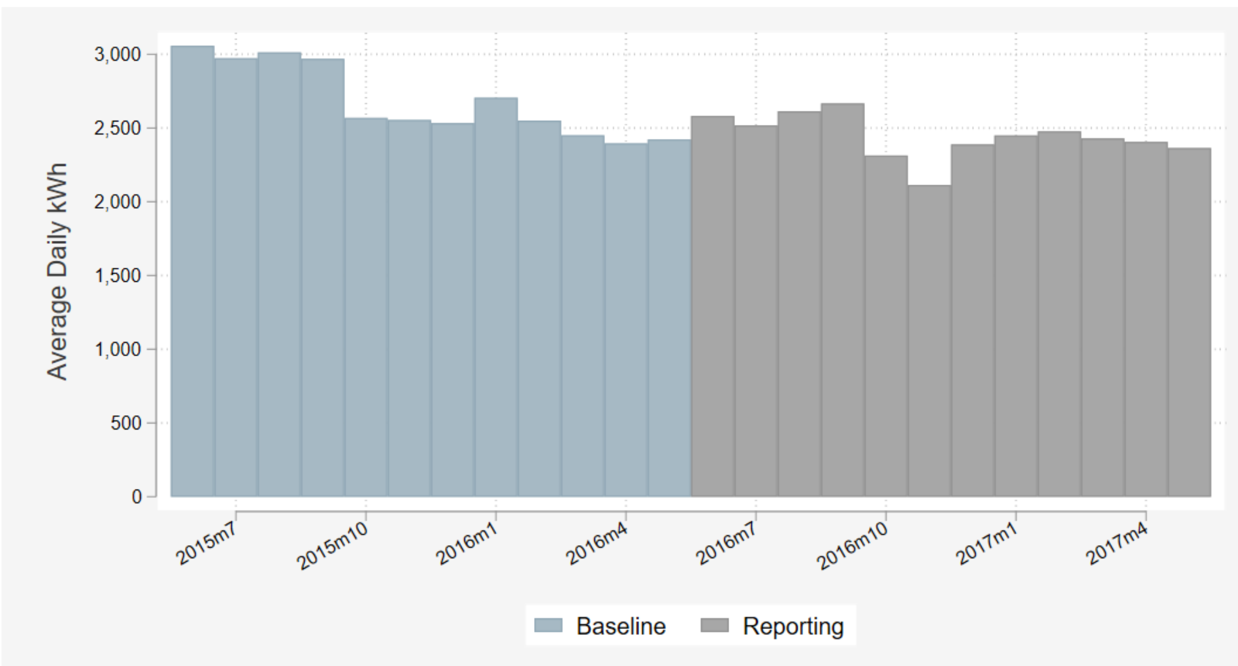
1. Determine cases where multiple retrofit measures were installed by the same account/premise. For such cases, we will track the earliest and the latest installation dates. We will also track which facilities had both gas and electric measures installed. This information will feed into the regression modeling component of the billing analyses.
2. Identify the accounts that implemented measure(s) in a timeframe that would likely allow for twelve months of pre/post billing data. A review of the project completion dates in the tracking data indicates that twelve months of post billing data should be available for most of the relevant accounts, as most retrofit measures were installed over a year ago. Note that our team will perform billing analyses even if twelve months of pre/post billing data are not available, but we would caution that the results from a billing analysis are generally more reliable with a longer period of both pre-installation bills and post-installation bills.
3. Prepare gas and electric billing data requests for National Grid. We will not perform a billing analysis for each account in the billing requests. Billing data will be used to determine the annual load at each facility (prior to installation of the ECM or ECMs), which can then be used to determine the percent savings of each measure. (The numerator in this calculation will be

the gross savings estimate from National Grid's tracking data.) Only projects expected to produce at least 5% savings will receive a billing analysis; other projects will be filtered out.

2.3.1.2 Analysis Methods

A billing analysis seeks to estimate the effect an ECM has on energy consumption through an investigation of gas/electric bills. Figure 3 shows 24 months of electric bills for a hypothetical participant – 12 months of bills that predate the ECM and 12 months of bills that follow the installation of the ECM. Clearly, the bills in the post (or "reporting") period are a bit lower – but why? Is the difference attributable to the ECM? Could the difference be explained by differences in weather in the two periods? Is the difference just noise (i.e., random year-to-year variation that cannot be explained)? Does the difference result from a combination of these factors? These are the questions that a billing analysis seeks to answer. The final output in a billing analysis is an estimate of savings that are attributable to the ECM (and a corresponding measure of uncertainty – the "margin of error" – which represents how much we think the savings estimate could be off by).

Figure 3: Monthly Electric Bills – Illustrative Example



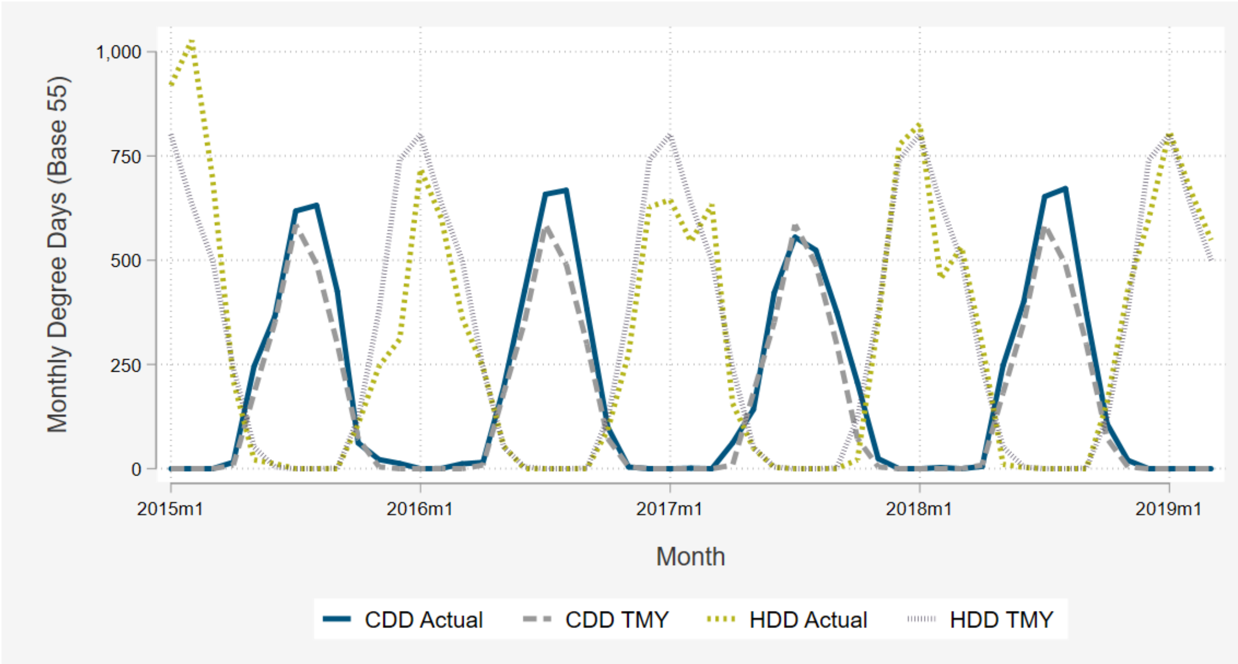
The amount of uncertainty around the savings estimate is a function of several factors, notably (1) the magnitude of the expected savings relative to annual consumption, (2) the ability to explain variation in energy consumption with external variables like weather, and (3) the amount of random variation in consumption. As noted in 2.3.1, our team plans to perform a billing analysis for each retrofit project that is expected to produce at least 5% savings. That said, we expect some of the billing analyses to produce more precise savings estimate (less uncertainty) than others, as some ECMs will produce more savings (i.e., a larger signal to detect) than others and the relationship between consumption and weather will be stronger for some sites than others.

For each analysis, we will produce savings estimates with two different approaches. The primary approach will yield an estimate of weather-normalized savings. This approach controls for the fact that the weather observed during the baseline and reporting periods may have been atypical for the region. In other words, the primary approach answers this question: What amount of savings would we expect to observe annually given typical regional weather?

The secondary approach, which also relies on weather data as an input, yields an estimate of avoided energy use. This approach removes the notion of a "typical weather year" from the equation. Instead, the secondary approach answers this question: If the relationship between weather and consumption during the baseline period carried over into the reporting period, how much energy use was avoided? Avoided energy use is calculated as the difference between predicted post energy use (via a pre period regression model and post period weather conditions) and actual post energy use. Steps taken in producing an estimate of savings – be it a weather-normalized estimate or not – are discussed in subsequent sub-sections.

Our belief is that the primary approach will yield a more robust estimate of savings because it accommodates for changes in weather from year to year. As an illustration, see Figure 4. This figure shows actual Rhode Island weather against typical meteorological year (TMY) weather for the region. The 2017 summer was fairly typical, and the 2018 summer was a bit warmer than usual. Supposing no ECMs were installed at a given facility, it is likely that consumption during the 2018 summer is higher than consumption during the 2017 summer (due to a greater cooling load). A chiller measure installed in spring 2018 would likely show more savings in an avoided energy use model than a normalized model because summer 2018 was warmer than usual. That said, we believe the secondary approach (avoided energy use) is useful in that it mimics the viewpoint of program participants – they see their bills, not what their bills *would have been* if the weather had been more typical.

Figure 4: Historical and Typical Weather in Providence, RI



Clean the Billing Data

As with any data stream, billing data is susceptible to data errors. The most common error we see with billing data involves duplicate records. Sometimes these are exact duplicates and one record can simply be dropped. Sometimes the duplicate records have identical read dates but different consumption values and these values may need to be summed. If we find such errors, we will consult with NGRID to verify that we handle them appropriately.

On top of looking for duplicates, our team will identify periods affected by estimated reads. When found, our team intends to redistribute consumption between the estimated cycle(s) and the first non-estimated cycle following the estimate cycle(s) to account for any true-ups that were made related to the estimated reads. We will also employ outlier detection methods to flag outliers (unusually large or small usage records). Commonly used methods are the IQR rule and the Z-score method. If we find outliers, we will seek explanations – perhaps the facility had an extended period in which they were closed for maintenance, or perhaps the outlier is simply a data entry error.

Other data sources, like weather data, should be cleaned as well. Weather data for a number of zip codes will be downloaded from the National Oceanic and Atmospheric Administration (NOAA). Our team has a system that streamlines that downloading of weather data, so downloading weather data across several areas will not be problematic. After downloading the weather data, there are three key data cleaning tasks. First, make sure all customers are mapped to the nearest weather station (based on service address zip code). Second, make sure the weather data is in the right time zone. This is less of a concern when the analysis is done at the monthly level, but it is still the right thing to do. Finally, remove "missing" weather records – these are commonly denoted with a 999 or 9999. Failing to remove erroneous values like these will surely lead to some unusual results.

Create an Analysis File

Once the billing data has been cleaned, usage records should be standardized to allow for an "apples to apples" comparison. The idea here is that some months (or billing cycles, as the case may be) are longer than others, so those longer months may show higher total consumption just by virtue of being a day (or more) longer. The fix is to divide total consumption for the billing cycle by the number of days in the billing cycle. For electric consumption, as an example, this produces a kWh/day value for each billing cycle. These standardized values will be the basis of our analysis.

Other critical steps in creating an analysis file include correctly identifying the pre and post periods and also identifying periods that could be affected by multiple ECMs (gas or electric). Here, we will rely on NGRID's tracking data. If it is found that multiple ECMs were installed at the location of interest, our team will define the pre period as the period before any ECMs were installed and the post period as the period after which *all* ECMs have been installed. (Discussions with the Working Group indicate that the "project completion date" stored in the tracking data may not always be spot on. As such, we may test how sensitive the results are to different post period start dates – the project completion date, one month after the project completion date, etc.) The billing analysis will then return an estimate of the sum of the ECM impacts.

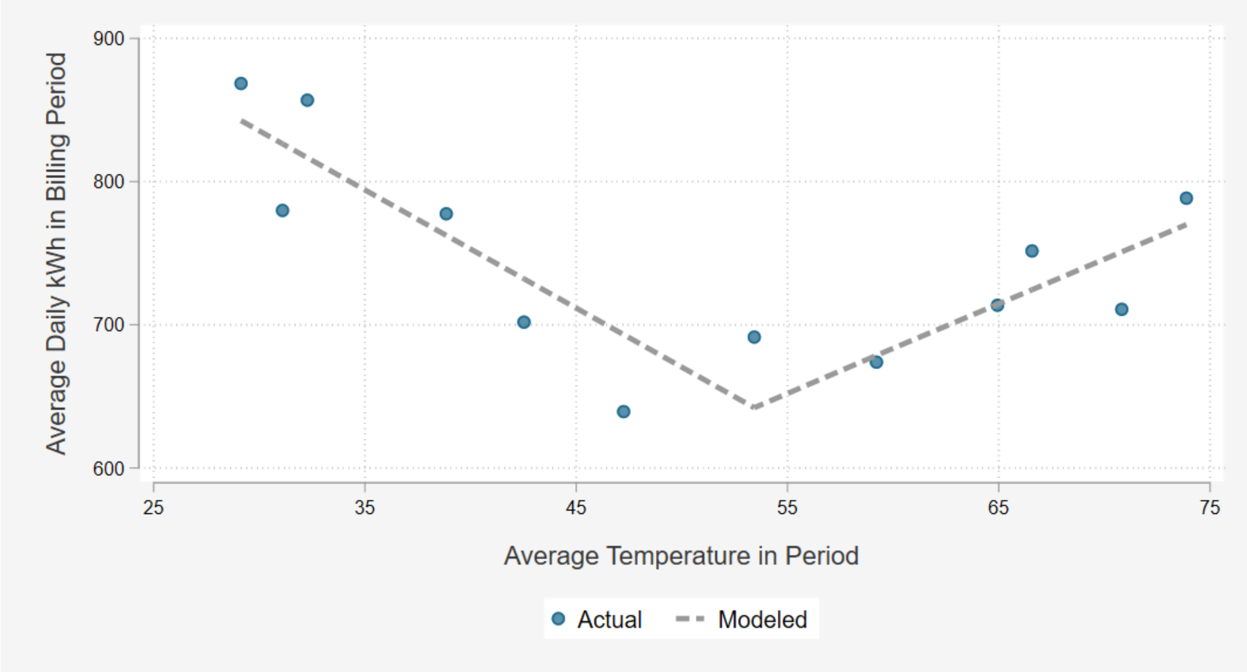
As a final step, the billing data and the weather data should be merged. The only complication here deals with the variation in billing cycles, which typically do not align with calendar months.

Develop Regression Models & Examine Regression Diagnostics

Gas/electric consumption will vary from month to month (see Figure 3 for an example). Some of this variation can be explained by external variables like temperature or operating hours. Some of the variation occurs naturally and cannot be explained. A "regression model" is a mathematical equation that attempts to explain some of the variation in the response variable (consumption, in this case) as a function of other external (or "explanatory") variables. Figure 5 provides an illustration. In the figure, there is definitely a link between consumption (average daily kWh) and temperature.[6] A regression model simply summarizes this relationship – see the gray trend line. Though a trend is apparent, there is still some unexplained variation in consumption (actual consumption tends to vary around predicted consumption).

[6] Such relationships are said to be "statistically significant" if it is unlikely that the trend could happen by random chance alone. Though the eye-test is useful, there are key values provided in regression output that help researchers determine which explanatory variables have statistically significant relationships with the response variable. ("Regression output" is standardized output generated by statistical analysis software that summarizes the regression model.)

Figure 5: Consumption Against Temperature – Illustrative Example



For this research effort, we expect the main explanatory variables to be weather-related – cooling degree days (CDD) and heating degree days (HDD). The general form of the regression model we intend to use is as follows:

$$Consumption = Intercept + \beta_1 * (\text{CDD}) + \beta_2 * (\text{HDD}) + Random\ Error$$

In this equation, β_1 represents the change in consumption per each additional CDD, and β_2 represents the change in consumption per each additional HDD. These values (as well as the "Intercept" term) will be estimated separately for the baseline and reporting periods. In other words, for each billing analysis, our team will produce two different regression models. The estimates of β_1 and β_2 will vary from model to model and from one billing analysis to the next. Also note that the degree day base may change from one billing analysis to the next. Our team will loop through a number of different bases to determine which provides the best fit for each account. "Best fit" will be determined by regression modeling, but Figure 5 can be used to illustrate the idea. In this figure, a degree day base around 55 provides a better fit than a degree day base around 65 would, as the point in which the trend changes is around 55.

After developing the regression models, it is important to check some of the underlying assumptions that are foundational to regression. The distribution of the residuals (where a "residual" is the difference between actual consumption and predicted consumption) is of particular interest. Specifically, the residuals should not be correlated with each other. That is, the difference between actual and predicted consumption in January should have no effect on the same difference in

February. There are other conditions that must be validated, too, but a full discussion of those conditions is not warranted here.

Estimate Savings

As discussed at the beginning of this section, our team plans to estimate savings associated with the installation of the ECM with two different approaches. The primary approach will yield a weather-normalized estimate of savings and the second approach removes "weather normalization" from the procedure in an attempt to mimic the customer's point of view. The discussion below concerns the primary approach. The secondary approach follows a similar trajectory.

As noted earlier, our team will develop separate regression models for the reporting and baseline periods for each billing analysis. Once the models have been created, we will estimate weather-normalized consumption in both periods. This can be accomplished by plugging TMY weather data into the regression models. The savings estimate is then the difference between weather-normalized baseline period consumption and weather-normalized reporting period consumption. To illustrate this process, suppose our model for baseline consumption is as follows:

$$Avg. Daily\ Consumption = 617 + 6.89 * (Avg. Daily\ CDD55) + 10.08 * (Avg. Daily\ HDD55)$$

And suppose our model for reporting period consumption (post-installation of the ECM) is as follows:

$$Avg. Daily\ Consumption = 496 + 9.54 * (Avg. Daily\ CDD55) + 9.82 * (Avg. Daily\ HDD55)$$

With the models in hand, the next step is to estimate weather-normalized consumption. This relies on TMY weather data, which is available on the internet.[7] The second and third columns of Table 5 show average daily CDD55 and HDD55 for Providence, Rhode Island, based on the TMY file. Plugging those values into the equations shown above will yield the values in the "Predicted Daily Consumption" columns. Those are the estimates of weather-normalized (daily) consumption. The difference between these estimates represents savings. Multiplying the daily savings estimate by the number of days in the month (or, more generally, the number of days in the billing cycle) will yield an estimate of monthly savings. Summing the monthly savings estimates across the year yields the weather-normalized annual savings estimate (39,843 kWh in the example below). The annual savings estimate can be expressed as percent savings by dividing by average annual consumption in the baseline period (and multiplying by 100%).

[7] Available at https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html

Table 5: Weather-Normalized Savings – Illustrative Example

Month	Average Daily TMY Weather		Predicted Daily Consumption		Average Savings	
	CDD55	HDD55	Baseline	Reporting	Daily	Monthly
1	0.0	25.9	878	750	127.9	3,964
2	0.0	22.7	846	719	127.1	3,558
3	0.0	16.2	780	655	125.4	3,886
4	0.3	8.0	700	578	122.5	3,675
5	5.9	1.6	674	568	106.0	3,287
6	11.7	0.1	699	609	90.1	2,704
7	18.9	0.0	747	676	71.1	2,204
8	15.8	0.0	726	647	79.2	2,456
9	10.0	0.0	686	592	94.7	2,842
10	2.3	3.9	673	557	116.0	3,596
11	0.1	12.6	745	621	124.1	3,722
12	0.0	23.9	858	731	127.4	3,949
Total	---	---	---	---	---	39,843

One complication is that some sites may not be able to provide a full year of baseline period data and a full year of reporting period data. A billing analysis can still be performed in such cases, but more information typically leads to a more precise estimate of savings.

For the secondary approach (avoided energy use), the reporting period regression model will not be used. Rather, the reporting period weather data will be plugged into the baseline period regression model to produce adjusted reporting period consumption. The savings estimate is then the difference between baseline period consumption and adjusted reporting period consumption. Figure 6 summarizes the primary and secondary approaches.

Figure 6: Types of Billing Analysis

Regardless of which approach is used, each billing analysis will produce three main outputs: (1) an estimate of energy savings (either kWh or therms) for each site, (2) an estimate of the percent impact for each site, and (3) a margin of error for the savings estimate. Combining (1) and (3) yields an interval estimate known as a confidence interval.[8] These outputs will be compared to the savings value from the tracking data. Relevant comparisons include:

[8] As an example, suppose (1) is 100,000 kWh and (3) is 8,000 kWh. The resulting confidence interval would be 92,000 kWh – 108,000 kWh. We'd expect the annual savings produced by the ECM to fall in this interval. The magnitude of the margin of error is tied to how much volatility is in the consumption data, the size of the savings signal relative to annual consumption at the facility, and the strength of the bond between consumption and weather.

- A ratio of the billing analysis savings estimate to the tracking data savings estimate. Ideally, this ratio will be around 1 (i.e., the two savings estimates agree) for each project. We will look at the distribution of these ratios across sites, measure categories, and business types (to the extent possible) to determine if any patterns show up (e.g., are billing and tracking savings estimates closer when the percent impact is larger? Are billing and tracking savings estimates closer for certain measure categories?).
- Does the tracking data savings estimate fall within the interval estimate produced by the billing analysis?
- Does zero fall within the interval estimate produced by the billing analysis? This indicates that the billing analysis did not return statistically significant evidence of savings.

Findings from such comparisons will be used to inform the customer interviews discussed in the next section. As noted, our reporting and interviewing efforts will focus on projects that are good candidates for a billing analysis rather than projects that are poor candidates for a billing analysis (low percent savings and volatile consumption patterns). Prior to beginning the customer interviews and site visits, the BrightLine team will provide a brief memo to the OER and Working Group outlining our findings from the billing analysis and our recommendation for the number of customer interviews and site visits to conduct.

2.3.2 Customer Interviews

For some sites where the tracking data savings estimate and the billing analysis savings estimate differ by a significant amount, our team intends to perform customer interviews via telephone. We will also perform site visits for a subset of the customers who are selected for interviews. Some findings that would trigger a deeper dive include:

- The tracking data savings estimate is greater than the annual consumption at the facility pre-retrofit. This would potentially flag crossed up data (e.g., the account number listed in the tracking data isn't where the project was actually installed) or an issue with the tracking data estimate.
- The billing analysis savings estimate and the tracking data savings estimate differ by at least 25% (and the tracking data savings estimate does not fall within the margin of error for the billing analysis savings estimate). This 25% threshold is from the RFP.
- A statistically significant increase in consumption from one year to the next (controlling for the effects of weather).

The customer interviews can then be used to identify the root of these problems. For example, the interviews could reveal operational changes or non-routine events (like a temporary closure) that the research team would otherwise be unaware of.

The interviews will include questions to glean an understanding of the customers' expectations, the source of these expectations, and perceptions of the changes to their electric and gas bills based on the projects implemented and will also attempt to pinpoint the reasons for the adjusted tracked savings. Expected root causes to be explored, and questions to help customers identify them are listed below. However, additional questions will be included where the regression analysis leads to more specific anomalies in the expected savings.

- Issues with operation of rebated equipment
  - When was the equipment installed?
  - When did the equipment become fully operational?
  - Were there any setbacks into the startup of the equipment once installed?
  - If so, how were setbacks rectified?
- Changes to customer load due to unrelated equipment
  - What equipment upgrades, if any, have you made unrelated to the rebated equipment since its installation?
  - Have you successfully phased out any unneeded equipment since the installation of the rebated equipment?
  - Have you made any major changes to the sequencing of other equipment?
- Changes to operation of facility
  - Have there been any changes to the building footprint?
  - Have there been any significant changes to the number of employees, good produced or customers serviced?
  - Have there been any changes to the scheduled operating hours?

For sites receiving an in-person interview, we will also request a tour of the site through which we can visually inspect equipment to find pieces of equipment installed within the post-retrofit billing cycles that were not rebated or disclosed. Additionally, the tour of the facility could help us identify measures that are not working as intended, such as finding exterior lighting under photocell control to be on during the day. As appropriate, findings from the interviews and site visits can be used to update the billing analyses for the relevant sites.

2.3.3 Reporting

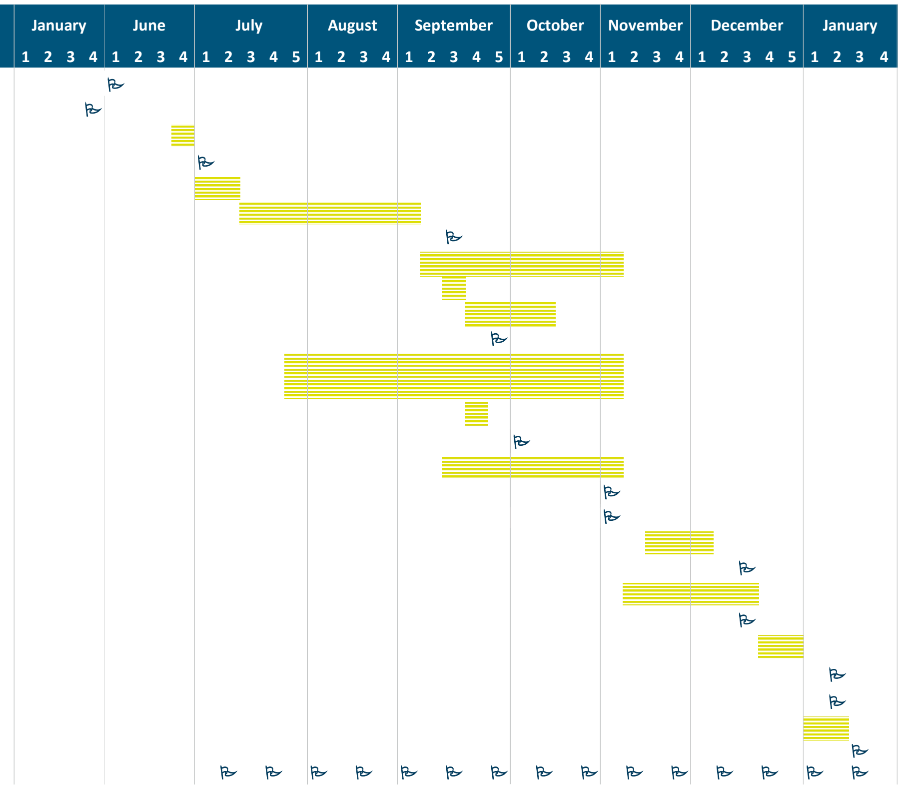
Findings from the billing analyses and follow-up customer interviews and site visits will be folded into the preliminary and final reports. Additionally, our team will provide Excel files with all of the data used in the billing analyses. These files will also show output from our regression models. Our team can also provide a summary Excel file that shows the findings from each independent billing analysis. Relevant fields could include the tracking data savings estimate, the billing analysis savings estimate, the margin of error of the billing analysis savings estimate, fractional savings uncertainty, an estimate of the percent impact, average annual load at the facility, the number of pre/post months used in the analysis, and a note on whether or not the billing analysis savings estimate is statistically significant.

3 Project Schedule

Figure 7 presents the project schedule for the evaluation activities outlined in this Work Plan, including interim and final deliverables, bi-monthly and quarterly update meetings, and timeframes for OER and the Working Group to review interim and preliminary deliverables.

Figure 7: Project Schedule

Task/Deliverable	Start	End	Milestone
Contract Executed			6/6/2019
Kick-off Meeting			1/29/2019
Develop Workplan	6/24/2019	6/28/2019	
Work Plan Submitted for Review			6/28/2019
Work Plan Review by Working Group	6/28/2019	7/12/2019	
Revise Work Plan and Review by Working Group	7/12/2019	9/4/2019	
Final Work Plan Approved			9/13/2019
Task 1 Review of EM&V Process	9/9/2019	11/4/2019	
Interview Guide Review by Working Group	9/16/2019	9/23/2019	
Interviews with EM&V stakeholders	9/24/2019	10/11/2019	
Quarterly Update			9/27/2019
Task 2 Independently Review All Current Estimates of Savings/Verify the Use of EM&V Industry Standards	7/26/2019	11/4/2019	
Evaluation Methods Review Matrix Discussion with Working Group	9/23/2019	9/27/2019	
Final Evaluation Methods Review Matrix Approved			10/4/2019
Task 3 Analysis of Bills and Customer Experience Evaluation	9/16/2019	11/4/2019	
Quarterly Update			11/8/2019
Discuss phone interview and site visit number with Working Group			11/8/2019
Task 3 Site Visit and Interviews	11/11/2019	12/6/2019	
Preliminary Findings Presentation			12/18/2019
Draft Reporting	11/4/2019	12/20/2019	
Draft Reports Submitted			12/20/2019
Draft Reports Review by Working Group	12/20/2019	1/2/2020	
Final Findings Presentation			1/15/2020
Quarterly Update			1/15/2020
Final Reporting	1/2/2020	1/17/2020	
Final Reports Submitted			1/22/2020
Bi-Monthly Check-in Meeting with OER			



Appendix A – Draft Measure Summary Tables

Table 6: Residential - Electric Measure Summary, Program Years 2015 – 2018

Sector - Fuel	Program	Measure	Sector Share (%)
Res Electric	OPower	OPower	22.2%
	EnergyWise Single Family	LED Bulbs and Fixtures	8.8%
		CFL Bulbs and Fixtures	0.3%
		AC	0.0%
		Aerator	0.0%
		Domestic Water Heating	0.0%
		Lighting-Misc	0.2%
		Showerhead	0.0%
		Smart Strip	0.7%
		Thermostat	0.2%
		Weatherization	0.6%
	EnergyWise MultiFamily	LED Bulbs and Fixtures	1.8%
		CFL Bulbs and Fixtures	0.0%
		Aerator	0.0%
		Custom Non-Lighting	0.1%
		Domestic Water Heating	0.0%
		Education	0.0%
		Lighting-Misc	0.3%
		Refrigerator	0.0%
		Showerhead	0.0%
		Smart Strip	0.2%
		Thermostat	0.1%
		Vending Miser	0.0%
		VFD	0.0%
		Weatherization	0.2%
	ES Homes	Energy Star Homes	1.0%
	Energy Star Products	Air Cleaner	0.1%
		Clothes Dryer	0.1%
		Clothes Washer	0.0%
		Computer	0.4%
		Dehumidifiers	0.2%
		Freezers	0.0%
		Pool Pump	0.2%
		Recycling	2.0%

Sector - Fuel	Program	Measure	Sector Share (%)
		Refrigerator	0.0%
		Room AC	0.0%
		Showerhead	0.1%
		Smart Strip	0.6%
		Television	0.0%
	HVAC	Air Conditioner	0.1%
		ECM	0.2%
		Heat Pump	0.3%
		Heat Pump Water Heater	0.4%
		Thermostat	0.1%
		Weatherization	0.0%
	Residential Lighting	CFL Bulbs and Fixtures	7.3%
		LED Bulbs and Fixtures	48.6%
		Lighting-Misc	2.2%
		TOTAL	100%

Table 7: Residential - Gas Measure Summary, Program Years 2015 – 2018

Sector - Fuel	Program	Measure	Sector Share (%)
Residential - Gas	OPower	OPower	47.8%
	ES Homes	Energy Star Homes	5.5%
	Energy Wise	Aerator	0.0%
		DHW	0.2%
		Showerhead	0.0%
		Thermostat	2.3%
		Weatherization	21.3%
	Energy Wise Multifamily	Aerator	0.1%
		Custom Non-Lighting	0.1%
		DHW	0.4%
		Showerhead	0.3%
		Thermostat	1.7%
		Weatherization	4.5%
	Residential Gas & Water Heating	DHW	1.0%
		HVAC	9.7%
		HVAC - Misc	0.0%
		Thermostat	5.1%
		TOTAL	100%

Table 8: Low Income - Electric Measure Summary, Program Years 2015 – 2018

Sector - Fuel	Program	Measure	Sector Share (%)
Low Income - Electric	Income Eligible Multifamily	Aerator	0.1%
		CFL Bulbs and Fixtures	0.4%
		Custom Non-Lighting	3.6%
		DHW	0.0%
		Education	0.6%
		HVAC	0.1%
		LED Bulbs and Fixtures	33.7%
		Lighting-Misc	1.8%
		Refrigerator	0.1%
		Showerhead	0.1%
		Smart Strip	1.2%
		Thermostat	0.0%
		Vending Miser	0.1%
		VFD	0.8%
		Weatherization	0.2%
	Low Income Services	AC	1.2%
		Appliance Package	1.2%
		CFL Bulbs and Fixtures	3.3%
		Dehumidifiers	0.7%
		DHW	0.0%
		Education	4.5%
		Freezers	1.1%
		Heat Pump	0.0%
		Heat Pump Water Heater	0.0%
		HVAC	0.6%
		LED Bulbs and Fixtures	30.1%
		Refrigerator	8.5%
		Smart Strip	3.4%
		Thermostat	0.0%
		Weatherization	2.6%
		TOTAL	100%

Table 9: Low Income - Gas Measure Summary, Program Years 2015 – 2018

Sector - Fuel	Program	Measure	Sector Share (%)
Low Income - Gas	Income Eligible Multifamily	Aerator	1.5%
		Custom Non-Lighting	10.3%
		DHW	7.5%
		HVAC	17.5%
		Showerhead	1.2%
		Thermostat	4.3%
		Weatherization	16.7%
	Low Income Services	HVAC	11.0%
		Weatherization	29.8%
		TOTAL	100%

Table 10: Small Business - Electric Measure Summary, Program Years 2015 – 2018

Sector - Fuel	Measure	Sector Share (%)
Small Business - Electric	Coolers	1.5%
	Custom Non-Lighting	3.1%
	Custom Lighting	16.4%
	Custom Refrigeration Lighting	0.6%
	Vending Machines	0.1%
	Water Heating	0.0%
	Lighting Controls	1.0%
	Prescriptive Lighting	76.7%
	Thermostats	0.2%
	Refrigerator Recycling	0.3%
	Total	100.0%

Table 11: Small Business - Gas Measure Summary, Program Years 2015 – 2018

Sector - Fuel	Measure	Sector Share (%)
Small Business - Gas	Aerator	23.7%
	Boiler Reset Control	9.3%
	Custom	21.6%
	Duct Insulation Sealing	0.4%
	Pipe Insulation	0.1%
	Pre-Rinse Spray Valve	15.1%
	Showerhead	24.1%
	Thermostat	5.8%
	Total	100.0%

Table 12: C&I - Electric Measure Summary, Program Years 2015 – 2018

Sector - Fuel	Program	Measure	Sector Share (%)
C&I - Electric	Prescriptive	Compressed Air	1.1%
		HVAC Controls	1.6%
		HVAC Equipment	3.0%
		Food Service	0.0%
		Lighting	28.9%
		Lighting Controls	4.2%
		Verified Savings Projects	0.4%
		VFD	3.2%
	Custom	Advanced Building	0.1%
		Building Shell	0.1%
		CHP	4.7%
		Comprehensive Design/Redesign	2.3%
		Compressed Air	2.1%
		Food Service	0.1%
		HVAC Controls	2.3%
		HVAC Equipment	1.4%
		Lighting	14.1%
		Misc	1.3%
		Motors	0.0%
		O&M	0.1%
		Process Cooling	1.3%
		Process Equipment and Systems	2.2%
		Refrigeration	3.1%
		Transformers	0.0%
		Verified Savings Projects	0.0%
		VFD	1.7%
	New Construction - Upstream HVAC	HVAC Building Energy Mgmt Systems-HVAC Controls	0.0%
		HVAC Equipment-Air Cooled Air Conditioner	0.4%
		HVAC Equipment-Air Cooled Heat Pump	0.0%
		HVAC Equipment-ECM Pump	0.0%
		HVAC Equipment-HVAC System Components	0.0%
		HVAC Equipment-Water Source Heat Pump	0.0%
	LCI - Upstream Lighting	Interior Lighting-Upstream Lighting	0.4%
		Lighting System-Exterior LED	0.3%
		Lighting System-Fixture Control	0.0%
		Lighting System-High/Low Bay LED	2.3%
		Lighting System-LED Lighting Upstream	12.3%
		Lighting System-Upstream Linear LED Lighting	4.0%
		Lighting System-Upstream Stairwell LEDs	0.9%
Total			100%

Table 13: C&I – Gas Measure Summary, Program Years 2015 – 2018

Sector - Fuel	Program	Measure	Sector Share (%)
C&I Gas	Prescriptive	Direct Fire Heater 3000+ MBH	0%
		Domestic Water Heating	0%
		Fryer	1%
		Furnace w ECM >=95	0%
		Heating	4%
		Indirect WH	3%
		Kitchen Equipment	1%
		MFHR	0%
		Ovens	0%
		Rebate	0%
		Safety	2%
		Steam Traps	9%
		Steamer	0%
		Thermostat	0%
	Custom	Advanced Buildings	0%
		Air Seal	1%
		Boiler	3%
		Comprehensive Design Assistance	6%
		Custom -Prescriptive Measures	4%
		Domestic Water Heating	1%
		Drives-Non HVAC	0%
		Duct Insulation	0%
		Furnaces	0%
		Heat Recover Vent	2%
		HVAC	21%
		Insulation	2%
		Iinsulation Duct and Pipe	2%
		Operation & Maintenance	1%
		Other	7%
		Process	11%
		Steam Traps	16%
		Verified Savings	1%
		TOTAL	100%

Appendix B – Evaluation Studies for Review

Table 14: Residential – Electric Report Review List

Priority Measure	Evaluation Studies
Opower	Rhode Island Home Energy Report Program Impact and Process Evaluation (2017)
EnergyWise Single Family- LED Bulbs and Fixtures	Impact Evaluation of 2014 EnergyWise Single Family Program (2016); Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)
Residential Lighting - LED Bulbs and Fixtures	Northeast Residential Lighting Hours-of-Use Study (2014); 2016 RLPNC HOU Update Analysis (2016); MA Lighting Interactive Effects Results Memo (2016); Delta Watt Update (MA19R02-E) (2019); RI2311 National Grid Rhode Island Lighting Market Assessment (2018)
Residential Lighting - CFL Bulbs and Fixtures	Northeast Residential Lighting Hours-of-Use Study (2014); 2016 RLPNC HOU Update Analysis (2016); MA Lighting Interactive Effects Results Memo (2016); Delta Watt Update (MA19R02-E) (2019); RLPNC Study 18-10 2018-19 Residential Lighting Market Assessment Study (2019)

Table 15: Residential – Gas Report Review List

Priority Measure	Evaluation Studies
Opower	Rhode Island Home Energy Report Program Impact and Process Evaluation (2017)
Energy Wise - Weatherization	Impact Evaluation of 2014 EnergyWise Single Family Program (2016)

Table 16: Low Income – Electric Report Review List

Priority Measure	Evaluation Studies
Income Eligible MF -LED Bulbs and Fixtures	Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)
Low Income Services - LED Bulbs and Fixtures	National Grid Income Eligible Services Impact Evaluation (2018)

Table 17: Low Income – Gas Report Review List

Priority Measure	Evaluation Studies
Income Eligible MF - Weatherization	Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)
Income Eligible MF - HVAC	Massachusetts Low-Income Multifamily Initiative Impact Evaluation (2015)

Table 18: Small Business – Electric Report Review List

Priority Measure	Evaluation Studies
Lighting	Rhode Island Small Business Energy Efficiency Program Prescriptive Lighting Study (2015)
	Impact Evaluation of PY2016 RI C&I Small Business Initiative: Phase I (2018)

Table 19: Small Business – Gas Report Review List

Priority Measure	Evaluation Studies
Aerator	Natural Gas Energy Efficiency Potential in Massachusetts (2009)
Showerheads	Natural Gas Energy Efficiency Potential in Massachusetts (2009)
Custom	Impact Evaluation of 2014 Custom Gas Installations in Rhode Island (2016)

Table 20: C&I– Electric Report Review List

Priority Measure	Evaluation Studies
Prescriptive Lighting	Impact Evaluation of 2011 Rhode Island Prescriptive Retrofit Lighting Installations (2013)
Upstream LED Lighting	Impact Evaluation of PY2015 Rhode Island Commercial and Industrial Upstream Lighting Initiative (2018)
	Impact Evaluation of PY20xx Upstream Lighting Program (2019)*
	P81 C&I Upstream Lighting ISR Analysis Summary
Custom Lighting	Impact Evaluation of PY2016 Custom Electric Installations (2019)*
	Impact Evaluation of PY2018 Custom Electric Installations (2019)*
Prescriptive Lighting Controls	Impact Evaluation of 2010 Prescriptive Lighting Installations (2013)

*Anticipated publication date in Q3 or Q4 2019. Study will be included in Task 2 if timeline permits.

Table 21: C&I– Gas Report Review List

<table>
<tr><th>Priority Measure</th><th>Evaluation Studies</th></tr>
<tr><td>Custom Comprehensive Design Assistance</td><td>Rhode Island Commercial & Industrial Impact Evaluation of 2013-2015 Custom Comprehensive Design Approach (2018)</td></tr>
<tr><td>Custom HVAC</td><td rowspan="2">Impact Evaluation of 2014 Custom Gas Installations in Rhode Island (2016);
Impact Evaluation of PY2016 Custom Gas Installations (2019)*;
Impact Evaluation of PY2017 Custom Gas Installations (2019)*</td></tr>
<tr><td>Custom Process</td></tr>
<tr><td>Custom Steam Traps</td><td rowspan="2">Steam Trap Evaluation Phase 2 (2017)</td></tr>
<tr><td>Prescriptive Steam Traps</td></tr>
</table>

*Anticipated publication date in Q3 or Q4 2019. Study will be included in Task 2 if timeline permits.

Appendix C – Definition of Terms

Adjusted reporting period consumption: An estimate of what reporting period consumption would have been if the relationship between weather and consumption from the baseline period continues into the reporting period.

Avoided energy use: An estimate of consumption that was avoided due to the installation of the ECM. This estimate is not weather-normalized or annualized. As such, it mimics the viewpoint of program participants who only see their bills (not what their bills *would have been* under typical weather conditions).

Baseline period: This is the period before installation of the ECM begins/occurs. It is also known as the "pre" period.

Baseline period consumption: Actual consumption during the baseline period, measured with customer bills.

Claimed energy savings – the amount of energy savings (kWh, therms) reported to the Rhode Island Public Utilities Commission in its annual reporting that are used to determine the accomplishment of goals in the annual Energy Efficiency Plan and the amount of the utility's incentive payments.

Cooling degree days (CDD): Either zero or the average daily temperature minus the degree day base (which is commonly somewhere between 55° F and 65° F), whichever is larger. For a day with an average temperature of 80° F, CDD would be 15 if the base is 65° or 25 if the base is 55°.

Deemed measure: A measure where the individual parameters, energy and/or demand savings estimates, or calculation methods (1) have been developed from data sources (such as prior metering studies) and analytical methods that are widely considered acceptable for the measure and purpose, and (2) are applicable to the situation being evaluated.[9]

Degree day base: A temperature that serves as a de facto split between heating season (or heating loads) and cooling season (or cooling loads).

Estimated gross energy savings: Gross energy savings estimates drawn from NGRID tracking data.

Heating degree days (HDD): Either zero or the degree day base (which is commonly somewhere between 55° F and 65° F) minus the average daily temperature, whichever is larger. For a day with an average temperature of 60° F, HDD would be 5 if the base is 65° or 0 if the base is 55°.

Installed gross energy savings: A weather-normalized estimate of gross annual energy savings derived from a billing analysis. (See "weather-normalized savings estimate.")

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[9] https://aceee.org/sector/state-policy/toolkit/emv

Reporting period: This is the period after installation of the ECM finishes. It is also known as the "post" period.

Reporting period consumption: Actual consumption during the reporting period, measured with customer bills.

Typical meteorological year (TMY) weather: Per NREL's TMY user manual, TMY data represent an "annual data set that holds hourly meteorological values that typify conditions at a specific location over a longer period of time, such as 30 years."[10]

Visible bill savings: See "avoided energy use."

Weather-normalized savings estimate: This is an estimate of what annual energy savings would be during a year in which weather for the region is typical (as opposed to unusually warm/cold).

Weather-normalized baseline period consumption: This is an estimate of what energy consumption during the baseline period *would have been* if baseline period weather had been typical (as opposed to unusually warm/cold).

Weather-normalized reporting period consumption: This is an estimate of what energy consumption during the reporting period *would have been* if reporting period weather had been typical (as opposed to unusually warm/cold).

[10] Users Manual for TMY3 Data Sets. Wilcox, S., and Marion, W. on behalf of the National Renewable Energy Laboratory. Revised May 2008. https://www.nrel.gov/docs/fy08osti/43156.pdf

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