New Jersey Board of Public Utilities

New Jersey's Clean Energy Program™

Protocols to Measure Resource Savings

FY2021 Addendum

Release Date: December 2, 2020
Board Approval Date: December 2, 2020

New Jersey's Clean Energy Program Protocols

Summary of Changes

The table below details interim modifications to the FY2020 Protocols that have been approved for program implementation as part of this FY2021 Protocols Addendum. The revisions herein are optional alternatives to the energy savings estimation methodologies prescribed in the FY2020 Protocols, as formally adopted for FY2021 programs. Adherence to the approaches prescribed by the FY2020 Protocols or the interim FY2021 Protocols both represent compliance with Board approved methods.

Addition/ Revision	Section/ Measure	Scope/Description of Change	Pg. # in FY2020 Protocols
Revision	Introduction: Purpose[1]	BPU adopted a net-to-gross factor of 1.0, to be applied to all programs.	5
Revision	Introduction: Transmission and Distribution System Losses	Increased Electric Loss Factor from 1.081 to 1.099; increased Gas Loss Factor from 1.0 to 1.02. Updated Gas Loss Factor source.	12
Revision	Combination Boilers	Updated EIA RECS 2009 data to reflect RECS 2015; updated Baseline Water Heater Usage from 23.6 MMBtu/yr to 17 MMBTU/yr.	26
Revision	Stand Alone Storage Water Heaters	Updated EIA RECS 2009 data to reflect RECS 2015; updated Baseline Water Heater Usage from 23.6 MMBtu/yr to 17 MMBTU/yr.	28
Revision	Instantaneous Water Heaters	Updated EIA RECS 2009 data to reflect RECS 2015; updated Baseline Water Heater Usage from 23.6 MMBtu/yr to 17 MMBTU/yr.	31
Revision	Comfort Partners Boiler/Furnace	Language specifies that baseline values can be taken from the Application, existing equipment or default values provided in the Value column in the Furnace or Boiler Assumptions table based on system type can be used, as presented in the Residential Gas HVAC section.	39
Revision	Other "Custom" Measures	Updated Light CF.	42

[1] Note that the Introduction section of the Protocols has been replicated in full in this addendum, with the revisions noted in this Summary of Changes. Although the gross savings estimation methods presented in this Addendum are optional, compliance with the Introduction section is required for FY21, except where dictates in this section conflict with the prescribed NJ Cost Test method. In such cases, the NJ Cost Test method supersedes this document.

Addition/ Revision	**Section/ Measure**	**Scope/Description of Change**	**Pg. # in FY2020 Protocols**
Revision	Residential New Construction Program	Expanded list of national platforms to include EPA ENERGY STAR Multifamily New Construction (MFNC) v1.1.	46
Revision	ENERGY STAR Appliances	Expanded section to distinguish Large and Small ENERGY STAR Appliances; updated qualifying equipment language from CEE Tiers to ENERGY STAR/Most Efficient; removed default values and incorporated energy savings calculations for refrigerator/freezers, clothes washers, clothes dryers, room air conditioners, and freezers.	53
Addition	EEP Low-Flow Showerheads	This measure applies to new or replacement low flow residential showerheads ($\leq$ 2.0 gpm) that are certified by WaterSense to use at least 20 percent less water than conventional showerheads. Calculations apply to water heating energy savings only. The measure includes calculations for kWh and therm savings.	n/a
Addition	EEP Door Sealing	This measure prevents air infiltration around the vertical sides and top of exterior residential doors or windows to fill gaps and prevent air infiltration. This measure is not intended for the bottom of doors. Savings equations for Door Sealing, Door Sweeps, and Foam Sealant are equivalent with appropriate defaults provided for each measure.	n/a
Addition	EEP Door Sweeps	This measure applies to a rigid product attached to the bottom of exterior doors to prevent air infiltration. Savings equations for Door Sealing, Door Sweeps, and Foam Sealant are equivalent with appropriate defaults provided for each measure.	n/a

Addition/ Revision	Section/ Measure	Scope/Description of Change	Pg. # in FY2020 Protocols
Addition	EEP Foam Sealant	This measure applies to insulating spray foam sealant that is used to fill gaps between conditioned and unconditioned spaces, such as around plumbing, HVAC, and electrical penetrations, and to fill gaps in framing systems. Savings equations for Door Sealing, Door Sweeps, and Foam Sealant are equivalent with appropriate defaults provided for each measure.	n/a
Revision	ENERGY STAR Clothes Washers	Updated to reflect RECS 2015.	53
Revision	ENERGY STAR Clothes Dryers	New qualifying category "Vented Electric, Compact (240V) (less than 4.4 cu-ft capacity)."	54
Revision	Residential ENERGY STAR Room Air Conditioner	Energy efficient RAC efficiencies updated to reflect ENERGY STAR Product Specification (V4.1) Updated CEER baseline values to CFR compliance. Deemed value for CEER base updated from 10.9 to 11.0; source updated from May 2018 V8 Mid-Atlantic TRM To Oct 2019 V9 Mid-Atlantic TRM.	60
Revision	Residential ENERGY STAR Dehumidifier	Updated annual operating hours from 1632 to 2160 and citation from ENERGY STAR calculators to ACEEE study.	62
Revision	Residential ENERGY STAR Lighting	Interior lighting hours decreased from 1,205 to 679 and exterior lighting hours decreased from 2,007 to 1,643; source updated from VT TRM to May 2019 V9 Mid-Atlantic TRM. NY TRM reference for CF removed; updated to May 2019 V9 Mid-Atlantic TRM. CF decreased from 0.08 to 0.06.	64

Addition/ Revision	**Section/ Measure**	**Scope/Description of Change**	**Pg. # in FY2020 Protocols**
Revision	Appliance Recycling Program	Gross annual energy savings per retired dehumidifier decreased from 196 kWh to 168 kWh, and summer demand savings per retired room air conditioner decreased from 0.114 to 0.04kW. Reference updated from 2016 Rhode Island TRM to 2020 Rhode Island TRM. Updated reference from May 2017 V7 Mid-Atlantic TRM to October 2019 V9 Mid-Atlantic TRM.	68
Revision	Ductless, Mini-Ducted or Hybrid Heat Pump Systems	Updated reference from 2018 V8 Mid-Atlantic TRM to 2019 V9 Mid-Atlantic TRM; updated CF.	78
Revision	Performance Lighting	Updated from ASHRAE Standard 90.1-2013 to ASHRAE Standard 90.1-2016. Removed 2017 V7 Mid-Atlantic Reference; updated with reference to original sources.	82
Addition	Horticultural LEDs	This measure is applicable to the installation of new DLC-qualified LED fixtures intended for indoor horticultural use. This method shall be used only for New Construction or fixture additions. Fixture replacements in indoor horticulture facilities shall utilize the standard method delineated in the Prescriptive Lighting section.	n/a
Revision	Motors	Updated language from ASHRAE 90.1-2013 to ASHRAE 90.1-2016.	94
Revision	Electric HVAC Systems	Updated language and HVAC Baseline Efficiencies from ASHRAE 90.1-2013 to ASHRAE 90.1-2016. Baseline efficiencies and equipment size ranges impacted. Updated Effective Full Load Hours source from 2018 V6 NY TRM to 2019 V7 NY TRM.	99

Addition/ Revision	Section/ Measure	Scope/Description of Change	Pg. # in FY2020 Protocols
Revision	Electric Chillers	Updated language from ASHRAE 90.1-2013 to ASHRAE 90.1-2016. Updated Effective Full Load Hours source from 2018 V6 NY TRM to 2019 V7 NY TRM.	109
Revision	Energy Efficient Glass Doors on Vertical Open Refrigerated Cases	Updated language from ASHRAE 90.1-2013 to ASHRAE 90.1-2016.	120
Addition	C&I Floating Head Pressure Control	This measure is applicable to the installation of refrigeration controls to lower the condensing pressure on commercial refrigeration systems during times of ambient temperatures below 75ºF. Savings based on deemed kWh/ton based on temperature range of refrigeration.	n/a
Addition	C&I Floating Suction Pressure Control	This measure is applicable to the installation of refrigeration controls to lower the condensing pressure on commercial refrigeration systems during times of ambient temperatures below 75ºF. Savings based on deemed kWh/ton based on temperature range of refrigeration.	n/a
Addition	C&I Low-Flow Faucet Aerators/Flow Control Valves	Measure previously in Direct Install Program section moved under the Commercial and Industrial Energy Efficient Construction section.	n/a
Addition	C&I Low-Flow Showerheads	Measure previously in Direct Install Program section moved under the Commercial and Industrial Energy Efficient Construction section.	n/a
Revision	Electric and Gas Convection Ovens, Gas Conveyor and Rack Ovens, Steamers, Fryers and Griddles	Updated new workpaper references that supersede previously published workpapers.	135

Addition/ Revision	Section/ Measure	Scope/Description of Change	Pg. # in FY2020 Protocols
Revision	Gas Chillers	Updated language from ASHRAE 90.1-2013 to ASHRAE 90.1-2016. Removed duplicative efficiency of baseline gas boiler. Updated Effective Full Load Hours source from 2018 V6 NY TRM to 2019 V7 NY TRM.	146
Revision	Stand Alone Storage Water Heaters	Updated language and Baseline Efficiencies of Stand Alone Storage Water Heaters from ASHRAE 90.1-2013 to ASHRAE 90.1-2016 for New Buildings. Equipment size range and New Building Baseline Efficiencies impacted. Incorporated provisions for quantifying energy savings based on UEF ratings for smaller systems, including adding therm savings equation, additional definitions of variables, and default assumptions.	152
Revision	Instantaneous Gas Water Heaters	Updated language and Baseline Efficiencies of Water Heaters from ASHRAE 90.1-2013 to ASHRAE 90.1-2016 for New Buildings. Equipment size range and New Building Baseline Efficiencies impacted. Incorporated provisions for quantifying energy savings based on UEF ratings for smaller systems including adding therm savings equation, additional definitions of variables, and default assumptions.	155
Revision	Prescriptive Boilers	Updated language from ASHRAE 90.1-2013 to ASHRAE 90.1-2016. Updated Effective Full Load Hours source from 2018 V6 NY TRM to 2019 V7 NY TRM.	158

Addition/ Revision	Section/ Measure	Scope/Description of Change	Pg. # in FY2020 Protocols
Revision	Prescriptive Furnaces	Updated language and defaults from ASHRAE 90.1-2013 to ASHRAE 90.1-2016, impacting baseline efficiency for gas fired and for oil fired furnaces < 225 kBTU. Updated Effective Full Load Hours source from 2018 V6 NY TRM to 2019 V7 NY TRM.	161
Addition	C&I Pipe Wrap Insulation	Measure previously in Direct Install Program section moved under the Commercial and Industrial Energy Efficient Construction section.	n/a
Revision	Combined Heat & Power	Added method for estimating Hg emissions reductions.	165
Revision	Pay for Performance Program	Updated from ASHRAE Standard 90.1-2013 to ASHRAE Standard 90.1-2016 baseline.	168
Revision	Low Flow Faucet Aerators, Showerheads, and Pre-rinse Spray Valves	Updated measure application to all C&I Prescriptive Programs, including Direct Install. Updated efficiency of water heating equipment reference from 2018 V6 NY TRM to 2019 V7 NY TRM. Updated assumed mains water temperature to align with Trenton TMY3 data.	182
Revision	Pipe Insulation	Updated measure application to all C&I Prescriptive Programs, including Direct Install. Updated default efficiency of electric equipment and reference from 2018 V6 NY TRM to 2019 V7 NY TRM.	186
Revision	SREC Registration Program	Historical estimated productivity of 1200 kWh per kWdc of installed solar capacity updated to 1154 Mwh per MWdc; justification outlined.	191
Revision	Appendix A Measure Lives	Several EUL values and sources updated/added for new measures.	192

Table of Contents

New Jersey Clean Energy Program
Protocols to Measure Resource Savings

Introduction

These protocols have been developed to measure resource savings, including electric energy capacity, natural gas, and other resource savings, and to measure electric energy and capacity from renewable energy and distributed generation systems. Specific protocols for determination of the resource savings or generation from each program are presented for each eligible measure and technology.

These protocols use measured and customer data as input values in industry-accepted algorithms. The data and input values for the algorithms come from the program application forms or from standard values. The standard input values are based on the recent impact evaluations and best available measured or industry data applicable for the New Jersey programs when impact evaluations are not available.

Purpose

These protocols were developed for the purpose of determining energy and resource savings for technologies and measures supported by New Jersey's Clean Energy Program, for programs administered by both the State of New Jersey, through the Board of Public Utilities (BPU), and by utilities or other parties who administer clean energy programs under the guidance of the New Jersey Board of Public Utilities. The protocols will be updated from time to time to reflect the addition of new programs, modifications to existing programs, and the results of future program evaluations. The protocols will be used consistently statewide to assess program impacts and calculate energy and resource savings to accomplish the following:

1. Report to the Board on program performance;
2. Provide inputs for planning and cost-effectiveness calculations;
3. Provide information to regulators and program administrators for determining eligibility for administrative performance incentives (to the extent that such incentives are approved by the BPU); and
4. Assess the environmental benefits of program implementation.

Resource savings to be measured include electric energy (kWh) and capacity (kW) savings, natural gas savings (therms), and savings of other resources (oil, propane, water, and maintenance), where applicable. In turn, these resource savings will be used to determine avoided environmental emissions. The Protocols are also utilized to support preliminary estimates of the electric energy and capacity from renewable energy and distributed generation systems and the associated environmental benefits.

The protocols in this document focus on the determination of the per unit savings for the energy efficiency measures, and the per unit generation for the renewable energy or distributed generation measures, included in the current programs approved by the Board. The number of adopted units to which these per unit savings or avoided generation apply are captured in the program tracking and reporting process, supported by market assessments for some programs. The unit count will reflect the direct participation and, through market assessments, the number of units due to market effects in comparison to a baseline level of adoptions. The BPU has adopted net savings for the purposes of evaluating energy efficiency and peak demand reduction program performance, determining compliance and performing cost-effectiveness testing. The BPU has adopted a net-to-gross factor of 1.0, which should be applied to all programs, including low-income programs. Staff anticipates that the net to gross factors may be adjusted in the future as the Evaluation, Measurement, and Verification Working Group conducts additional evaluation related to New Jersey specific net-to-gross factors, which may include measure-specific factors.[2]The protocols herein report gross savings and generation only; therefore, the simple net-to-gross ratio, as adopted, should be applied to the gross savings calculated through these protocols. Free riders and free drivers are not addressed in these protocols.

The outputs of the protocols are used to support the following:

- Regulatory reporting;
- Cost-effectiveness analysis; and
- Program evaluation.

These protocols provide the methods to measure per unit savings for program tracking and reporting. An annual evaluation plan prepared by the NJCEP Evaluation Contractor outlines the plans for assessing markets, including program progress in transforming markets, and to update key assumptions used in the protocols to assess program energy impacts. Reporting provides formats and definitions to be used to document program expenditures, participation rates, and program impacts, including energy and resource savings. The program tracking systems that support program evaluation and reporting will track and record the number of units adopted due to the program and assist in documenting the resource savings using the per unit savings values in the protocols. Cost-benefit analyses prepared by NJCEP Evaluation Contractors assess the impact of programs, including market effects, and their relationship to costs in a multi-year analysis.

Types of Protocols

In general, energy and demand savings will be calculated using measured and customer data as input values in algorithms in the protocols, tracking systems, and information from the program application forms, worksheets, and field tools.

[2] In re the Implementation of P.L. 2018, c.17 Regarding the Establishment of Energy Efficiency and Peak Demand Reduction Programs, In the Matter of the Clean Energy Act of 2018 – Utility Demographic Analysis, and In re Electric Public Utilities and Gas Public Utilities Offering Energy Efficiency and Conservation Programs, Invesing in Class I Renewable Energy Resources and Offering Class I Renewable Energy Programs in their Respective Service Territories on a Regulated Basis Pursuant to N.J.S.A 48:3-98.1 – Minimum Filing Requirements, BPU Docket Nos. QO19010040, QO19060748, and QO17091004, Order dated June 10, 2020 (Agenda Item 8D).

The following table summarizes the spectrum of protocols and approaches to be used for measuring energy and resource savings. No one protocol approach will serve all programs and measures.

Summary of Protocols and Approaches

Type of Measure	Type of Protocol	General Approach	Examples
1. Standard prescriptive measures	Standard formula and standard input values	Number of installed units times standard savings/unit	Residential lighting (number of units installed times standard savings/unit)
2. Measures with important variations in one or more input values (e.g., delta watts, efficiency level, capacity, load, etc.)	Standard formula with one or more site-specific input values	Standard formula in the protocols with one or more input values coming from the application form, worksheet, or field tool (e.g., delta watts, efficiency levels, unit capacity, site-specific load)	Some prescriptive lighting measures (delta watts on the application form times standard operating hours in the protocols) Residential Electric HVAC (change in efficiency level times site-specific capacity times standard operating hours) Field screening tools that use site-specific input values
3. Custom or site-specific measures, or measures in complex comprehensive jobs	Site-specific analysis	Greater degree of site-specific analysis, either in the number of site-specific input values, or in the use of special engineering algorithms, including building simulation programs	Custom Industrial process Complex comprehensive jobs (P4P) CHP Customer-Tailored Pilot

Three or four systems will work together to ensure accurate data on a given measure:

1. The application form that the customer or customer's agent submits with basic information.
2. Application worksheets and field tools with more detailed site-specific data, input values, and calculations (for some programs).
3. Program tracking systems that compile data and may do some calculations.

4. Protocols that contain algorithms and rely on standard or site-specific input values based on measured data. Parts or all of the protocols may ultimately be implemented within the tracking system, the application forms and worksheets, and the field tools.

Algorithms

The algorithms that have been developed to calculate the energy and or demand savings are driven by a change in efficiency level for the installed measure compared to a baseline level of efficiency. This change in efficiency is reflected in both demand and energy savings for electric measures and energy savings for gas.

Specific algorithms for each of the program measures may incorporate additional factors to reflect specific conditions associated with a program or measure. This may include factors to account for coincidence of multiple installations, or interaction between different measures.

When building simulation software programs are used to develop savings estimates for several measures in a comprehensive project, as in the Pay for Performance Program, the specific algorithms used are inherent in the software and account for interaction among measures by design. Detailed Simulation Guidelines have been developed for the Pay for Performance Program and are included in the Pay for Performance Program Guidelines. These Guidelines should be followed when building simulation is used to develop savings estimates.

Data and Input Values

The input values and algorithms in the protocols and on the program application forms are based on the best available and applicable data for the New Jersey programs. The input values for the algorithms come from the program application forms or from standard values based on measured or industry data.

Many input values, including site-specific data, come directly from the program application forms, worksheets, and field tools. Site-specific data on the application forms are used for measures with important variations in one or more input values (e.g., delta watts, efficiency level, capacity, etc.).

Standard input values are based on the best available measured or industry data, including metered data, measured data from prior evaluations (applied prospectively), field data and program results, and standards from industry associations. The standard values for most commercial and industrial measures are based on recent impact evaluations of New Jersey Programs.

For the standard input assumptions for which metered or measured data were not available, the input values (e.g., Δ watts, Δ efficiency, equipment capacity, operating hours, coincidence factors) were based on the best available industry data or standards. These input values were based on a review of literature from various industry organizations, equipment manufacturers, and suppliers.

For larger, comprehensive projects, as in the Pay for-Performance Program, measurement and verification (M&V) protocols are followed to better estimate site-specific energy use for the pre- and post-retrofit conditions. Guidelines for developing an M&V plan and protocols to follow for conducting M&V are included in the Pay for Performance Program Guidelines, available on the NJ Division of Clean Energy website at www.njcleanenergy.com. These guidelines and protocols should be followed when M&V is conducted to determine energy use for either the pre- or post-retrofit period.

Program evaluation will be used to assess key data and input values to either confirm that current values should continue to be used or update the values going forward.

Baseline Estimates

For most efficiency programs and measures, the electric savings values, (i.e., Δ kW, Δ kWh), and gas energy savings values are based on the energy use of standard new products vs. the high efficiency products promoted through the programs. The approach used for the new programs encourages residential and business consumers to purchase and install high efficiency equipment vs. new standard efficiency equipment. The baseline estimates used in the protocols are documented in the baseline studies or other market information. Baselines will be updated to reflect changing codes, practices and market transformation effects.

For the Direct Install and low income programs, some Δ kW, Δ kWh, and gas energy savings values are based on high efficiency equipment versus existing equipment, where the programs specifically target early retirement or upgrades that would not otherwise occur. Protocols for the Direct Install Program include degradation tables to calculate the efficiency of the replaced unit.

The Pay for Performance Program is a comprehensive program that requires participants to implement energy efficiency improvements that will achieve a minimum of 15% reduction in total source energy consumption. Due to the building simulation and measurement and verification (M&V) requirements associated with this Program, the baseline is the existing energy consumption of the facility, as reported through the U.S. EPA's Portfolio Manager benchmarking software.

Renewable energy and distributed generation program protocols assume that any electric energy or capacity produced by a renewable energy or distributed generation system displaces electric energy and capacity from the PJM grid.

Resource Savings in Current and Future Program Years

The Protocols support tracking and reporting the following categories of energy and resource savings:

1. Savings or generation from installations that were completed in the program year and prior program years due to the program's direct participation and documented market effects.
2. Savings or generation from program participant future adoptions due to program commitments.
3. Savings or generation from future adoptions due to market effects.

Prospective Application of the Protocols

The protocols will be applied prospectively. The input values are from the program application forms and standard input values (based on measured data including metered data and evaluation results). The protocols will be updated periodically based on evaluation results and available data, and then applied prospectively for future program years.

Resource Savings

Electric

Protocols have been developed to determine the electric energy and coincident peak demand savings.

Annual electric energy savings are calculated and then allocated separately by season (summer and winter) and time of day (on-peak and off-peak). Summer coincident peak demand savings are calculated using a demand savings protocol for each measure that includes a coincidence factor. Application of this coincidence factor converts the demand savings of the measure, which may not occur at time of system peak, to demand savings that is expected to occur during the Summer On-Peak period. These periods for energy savings and coincident peak demand savings are defined as follows:

	Energy Savings	**Coincident Peak Demand Savings**
Summer	May through September	June through August
Winter	October through April	NA
On Peak (Monday - Friday)	7 a.m. to 11 p.m.	12 p.m. to 8 p.m.
Off Peak	M-F 11 p.m. to 7 a.m. All day weekends and holidays	NA

The time periods for energy savings and coincident peak demand savings were chosen to best fit the seasonal avoided cost patterns for electric energy and capacity that were used for the energy efficiency program cost effectiveness purposes. For energy, the summer period May through September was selected based on the pattern of avoided costs for energy at the PJM level. In order to keep the complexity of the process for calculating energy savings benefits to a reasonable level by using only two time periods, the spring and fall periods were allocated approximately evenly to the summer and winter periods.

For capacity, the summer period June through August was selected to match the highest avoided costs time period for capacity. The experience in PJM and New Jersey has been that nearly all system peak events occur during these three months. Coincidence factors are used to calculate energy efficiency factors on peak demand. Renewable energy and distributed generation systems are assumed to be operating coincident with the PJM system peak.

Natural Gas

Protocols have been developed to determine the natural gas energy savings on a seasonal basis. The seasonal periods are defined as:

Summer – April through September
Winter – October through March

The time periods for gas savings were chosen to best fit the seasonal avoided gas cost pattern that was used for calculating energy efficiency program benefits for cost effectiveness purposes. However, given the changing seasonal cost patterns for gas supply, different time periods may be more appropriate to reflect a current outlook for the seasonal pattern at the time that the avoided cost benefits are calculated. The seasonal factors used in the following protocols that correspond to the above time periods reflect either base load or heating load usage. In the case of base load, one twelfth of the annual use is allocated to each month. In the case of heating load, the usage is prorated to each month based on the number of normal degree-days in each month. This approach makes it relatively easy to calculate new seasonal factors to best match different avoided cost patterns.

Other Resources

Some of the energy savings measures also result in environmental benefits and the saving of other resources. Environmental impacts are quantified based on conversion factors for electric, gas, and oil energy savings. Where identifiable and quantifiable, these other key resource savings, such as oil, will be estimated. Oil and propane savings are the major resources that have been identified. If other resources are significantly impacted, they will be included in the resource savings estimates.

Adjustments to Energy and Resource Savings

Coincidence with Electric System Peak

Coincidence factors are used to reflect the portion of the connected load savings or generation that is coincident with the electric system peak.

Interaction of Energy Savings

Interaction of energy savings is accounted for in certain programs as appropriate. For all other programs and measures, interaction of energy savings is zero.

For the Residential New Construction program, the interaction of energy savings is accounted for in the home energy rating tool that compares the efficient building to the baseline or reference building and calculates savings.

For the Commercial and Industrial Efficient Construction program, the energy savings for lighting is increased by an amount specified in the protocol to account for HVAC interaction. For commercial and industrial custom measures, interaction where relevant is accounted for in the site-specific analysis. In the Pay for Performance Program, interaction is addressed by the building simulation software program.

Calculation of the Value of Resource Savings

The calculation of the value of the resources saved is not part of the protocols. The protocols are limited to the determination of the per unit resource savings in physical terms.

In order to calculate the value of the energy savings for reporting and other purposes, the energy savings are determined at the customer level and then increased by the amount of the transmission and distribution losses to reflect the energy savings at the utility system level. The energy savings at the system level are then multiplied by the appropriate avoided costs to calculate the value of the benefits.

System Savings = (Savings at Customer) x (T&D Loss Factor)
Value of Resource Savings = (System Savings) x (System Avoided Costs + Environmental Adder) + (Value of Other Resource Savings)

The value of the benefits for a particular measure will also include the value of the water, oil, maintenance and other resource savings where appropriate. Maintenance savings will be estimated in annual dollars levelized over the life of the measure.

Transmission and Distribution System Losses

The protocols calculate the energy savings at the customer level. These savings need to be increased by the amount of transmission and distribution system losses in order to determine the energy savings at the system level. The following loss factors multiplied by the savings calculated from the protocols will result in savings at the system level.

Electric Loss Factor

The electric marginal distribution system loss factor applied to savings at the customer meter is 1.099[3,4] for both energy and demand. The electric system loss factor was developed to be applicable to statewide programs.

Gas Loss Factor

The gas loss factor is 1.02.[5,6] The gas loss factor was developed to be applicable to statewide programs.

These electric and gas loss factors reflect losses at the margin and are a consensus of the electric and gas utilities.

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[3] 20 year average line losses calculated from https://www.eia.gov/electricity/state/newjersey/xls/nj.xlsx.

[4] Marginal distribution system losses are assumed to be approximately 1.5 times average losses. See RAP's 2011 *Valuing the Contribution of Energy Efficiency to Avoid Marginal Line Losses and Reserve Requirements* p. 5, http://www.raponline.org/wp-content/uploads/2016/05/rap-lazar-eeandlinelosses-2011-08-17.pdf. ICF's 2005 *Avoided Energy Supply Costs in New England* at https://www9.nationalgridus.com/masselectric/non_html/avoided-cost-study.pdf, p. 100 (Exhibit 3-6) suggests a ratio of 1.25 for New England.

[5] https://nj.pseg.com/aboutpseg/regulatorypage/-/media/062F22BB0BD74392B34E4E477DD6BA9B.ashx.

[6] https://southjerseygas.com/SJG/media/pdf/SJG-2018_2019-USF_Lifeline-Annual-Filing.pdf.

Calculation of Clean Air Impacts

The amount of air emission reductions resulting from the energy savings is calculated using the energy savings at the system level and multiplying them by factors provided by the New Jersey Department of Environmental Protection, Office of Air and Energy Advisor, on June 25, 2019.

Using Weighted Average of 2018 PJM On-Peak and Off-Peak annual data**:**

Electric Emission Factors

Emissions Product	**Pounds per MWh**[7]
CO_2	1,292
NO_X	0.83
SO_2	0.67
Hg	1.1 mg/MWh[8]

Natural Gas Emission Factors

Emissions Product	**Current**
CO_2	11.7 lbs per therm saved
NO_X	0.0092 lbs per therm saved

<u>Assumptions</u>:
"Peak periods" are all non-holiday weekdays from 7 a.m. until 11 p.m., and "off-peak" periods are all other hours.

For 2017:
250 non-holiday weekdays
105 weekend days
10 weekday holiday days

On-Peak Hours:
250 non-holiday weekdays X 16 hours/day = 4,000 hours

Off-Peak Hours:
(105 weekend days + 10 weekday holidays) X 24 hours/day + 250 non-holiday weekdays X 8 hours/day = 4,760 hours

On-Peak Fraction = 4,000/8,760 = 45.7%
Off-Peak Fraction = 4,760/8,760 = 54.3%

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[7] Hg data is reported in mg/MWh.

[8] Applicable to NJ coal generation units only.

Measure Lives

Measure lives are provided in Appendix A for informational purposes and for use in other applications such as reporting lifetime savings or in benefit cost studies that span more than one year. The Pay for Performance Program uses the measure lives as included in Appendix A to determine measure-level and project-level cost effectiveness.

Protocols Revision History

Revision History of Protocols

Date Issued	Reviewer	Comments
October 2017	ERS	See ERS Memo, NJCEP Protocols - Comparative Measure Life Study and Summary of Measure Changes to NJCEP Protocols, September 5, 2017. Updated October 16, 2017, January 12, 2018.
May 2018	Program Administrator in consultation with Board Staff	Revisions to the January 12, 2018 version issued by ERS to reflect discussions at Utility Working Group Meetings, additional comments from Rate Counsel and further review of public comments.

Protocols for Program Measures

The following pages present measure or project-specific protocols. In those instances where measures are applicable to more than one program, the measures apply to all such programs unless otherwise specified.

Residential Gas HVAC

Protocols

The following sections detail savings calculations for gas space heating and gas water heating equipment in residential applications. They are to be used to determine gas energy savings between baseline standard units and the high efficiency units promoted in the program.

Combination Boilers

This section provides energy savings algorithms for qualifying gas combination boilers installed in residential settings. A combination boiler is defined as a boiler that provides domestic hot water and space heating. The input values are based on the specifications of the actual equipment being installed, federal equipment efficiency standards, DOE2.2 simulations completed by the New York State Joint Utilities and regional estimates of average baseline water heating energy usage.

This measure assumes the existing boiler system has failed or is at the end of its useful life and is replaced with a combination boiler. The baseline boiler unit has an efficiency as required by IECC 2015, which is the current residential code adopted by the state of New Jersey. For the water heating component, this measure assumes that the baseline water heater is a storage water heater, and customers replacing existing tankless water heaters are not eligible.

Note that as of June 12, 2017, the Federal Trade Commission has published a final rule updating the EnergyGuide label to reflect recent changes by the Department of Energy to the Code of Federal Regulations regarding the use of uniform energy factor (UEF) rather than the traditional energy factor (EF)[9] for consumer and commercial water heaters. The UEF is the newest measure of water heater overall efficiency. The higher the UEF value is, the more efficient the water heater. UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E.[10]

<u>Algorithms</u>

Fuel Savings (MMBtu/yr) = MMBtu/yr Boiler Fuel Savings + MMBtu/yr DHW Fuel Savings

MMBtu Boiler Fuel Savings/yr = Cap_{in} * $EFLH_h$ * (($AFUE_q$/$AFUE_b$)-1) / 1,000 kBtu/MMBTU

MMBtu DHW Fuel Savings/yr = (1 – (UEF_b / UEF_q)) × Baseline Water Heater Usage

Cap_{in} = Input capacity of qualifying unit in kBtu/hr

$EFLH_h$ = The Equivalent Full Load Hours of operation for the average unit during the heating season

$AFUE_q$ = Annual fuel utilization efficiency of the qualifying boiler

$AFUE_b$ = Annual fuel utilization efficiency of the baseline boiler

UEF_q = Uniform energy factor of the qualifying energy efficient water heater.

UEF_b = Uniform energy factor of the baseline water heater. In New Jersey the 2015 International Energy Conseration Code (IECC) generally defines the residential

[9] The final ruling on this change is available at: https://energy.gov/sites/prod/files/2016/12/f34/WH_Conversion_Final%20Rule.pdf.

[10] https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria.

energy efficiency code requirements, but the IECC does not include residential service water heating provisions, leaving federal equipment efficiency standards to define baseline.

Baseline Water Heater Usage = Annual usage of the baseline water heater

Summary of Inputs

Combination Boiler Assumptions

Component	Type	Value	Source
Cap_{in}	Variable		Application
$EFLH_h$	Fixed	965 hours	1
$AFUE_q$	Variable		Application
$AFUE_b$	Fixed	Gas fired boiler – 82% Oil fired boiler – 84%	2
UEF_b	Fixed	Storage Water Heater – 0.657	2
UEF_q	Fixed	0.87	3
Baseline Water Heater Usage	Fixed	17.0 MMBtu/yr	4

The referenced federal standards for the baseline UEF are dependent on both draw pattern and tank size. A weighted average baseline UEF was calculated with a medium draw pattern from the referenced federal standards and water heating equipment market data from the Energy Information Association 2009 residential energy consumption survey for NJ[11] assuming tank sizes of 30 gallons for small units, 40 gallons for medium units, and 55 gallons for large units.

Sources

1. NJ utility analysis of heating customers, annual gas usage..
2. US Government Publishing Office, June 2017, Electronic Code of Federal Regulations – Title 10, Chapter II, Subchapter D, Part 430, Subpart C, §430.32; available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=2942a69a6328c23266612378a0725e60&mc=true&node=se10.3.430_132&rgn=div8.
3. Minimum UEF for instantaneous (tankless) water heaters from Energy Star https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria.

[11] Available at: https://www.eia.gov/consumption/residential/data/2009/hc/hc8.8.xls.

4. US Energy Information Association, *2015 Residential Energy Consumption Survey Data (Mid-Atlantic)*; available at: https://www.eia.gov/consumption/residential/data/2015/c&e/ce3.2.xlsx

Stand Alone Storage Water Heaters

This section provides energy savings algorithms for qualifying stand alone storage hot water heaters installed in residential settings. This measure assumes that the baseline water heater is a code storage water heater. The input values are based on federal equipment efficiency standards and regional estimates of average baseline water heating energy usage.

Note that as of June 12, 2017, the Federal Trade Commission has published a final rule updating the EnergyGuide label to reflect recent changes by the Department of Energy to the Code of Federal Regulations regarding the use of uniform energy factor (UEF) rather than the traditional energy factor (EF)[12] for consumer and commercial water heaters. The UEF is the newest measure of water heater overall efficiency. The higher the UEF value is, the more efficient the water heater. UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E.[13]

Algorithms

Fuel Savings (MMBtu/yr) = $(1 - (UEF_b / UEF_q)) \times$ Baseline Water Heater Usage

Definition of Variables

UEF_q = Uniform energy factor of the qualifying energy efficient water heater.

UEF_b = Uniform energy factor of the baseline water heater. In New Jersey the 2015 International Energy Conservation Code (IECC) generally defines the residential energy efficiency code requirements, but the IECC does not include residential service water heating provisions, leaving federal equipment efficiency standards to define baseline.

Baseline Water Heater Usage = Annual usage of the baseline water heater

Summary of Inputs

Storage Water Heater

Component	Type	Value[a]	Sources
UEF_q	Variable		Application
UEF_b	Variable	If gas & less than 55 gal: $UEF_b = 0.6483-(0.0017\times V)$ If gas & more than 55 gal: $UEF_b = 0.7897-(0.0004\times V)$	1

[12] The final ruling on this change is available at: https://energy.gov/sites/prod/files/2016/12/f34/WH_Conversion_Final%20Rule.pdf.

[13] https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria.

Component	Type	Value[a]	Sources
Baseline Water Heater Usage	Fixed	17.0 MMBtu/yr	2

[a] V refers to volume of the installed storage water heater tank in gallons

The referenced federal standards for the baseline UEF are dependent on both draw pattern and tank size. The baseline UEF formulas shown in the table above are associated with medium draw patterns.

<u>Sources</u>

1. US Government Publishing Office, June 2017, *Electronic Code of Federal Regulations – Title 10, Part 430, Subpart C*; available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=2942a69a6328c23266612378a0725e60&mc=true&node=se10.3.430_132&rgn=div8.
2. US Energy Information Association, *2015 Residential Energy Consumption Survey Data (Mid-Atlantic)*; available at: https://www.eia.gov/consumption/residential/data/2015/c&e/ce3.2.xlsx.

Instantaneous Water Heaters

This section provides energy savings algorithms for qualifying instantaneous hot water heaters installed in residential settings. This measure assumes that the baseline water heater is either a code stand alone storage water heater, or a code instantaneous water heater. The input values are based on federal equipment efficiency standards and regional estimates of average baseline water heating energy usage.

Note that as of June 12, 2017, the Federal Trade Commission has published a final rule updating the EnergyGuide label to reflect recent changes by the Department of Energy to the Code of Federal Regulations regarding the use of uniform energy factor (UEF) rather than the traditional energy factor (EF)[14] for consumer and commercial water heaters. The UEF is the newest measure of water heater overall efficiency. The higher the UEF value is, the more efficient the water heater. UEF is determined by the Department of Energy's test method outlined in 10 CFR Part 430, Subpart B, Appendix E.[15]

Algorithms

Fuel Savings (MMBtu/yr) = $(1 - (UEF_b / UEF_q)) \times$ Baseline Water Heater Usage

Definition of Variables

UEF_q = Uniform energy factor of the qualifying energy efficient water heater.

UEF_b = Uniform energy factor of the baseline water heater. In New Jersey the 2015 International Energy Conservation Code (IECC) generally defines the residential energy efficiency code requirements, but the IECC does not include residential service water heating provisions, leaving federal equipment efficiency standards to define baseline.

Baseline Water Heater Usage = Annual usage of the baseline water heater

Summary of Inputs

Instantaneous Water Heaters

Component	**Type**	**Value**	**Source**
UEF_q	Variable		Application
UEF_b	Variable	Storage water heater – 0.657 Instantaneous water heater – 0.81	1
Baseline Water Heater Usage	Fixed	17.0 MMBtu/yr	2

[14] The final ruling on this change is available at: https://energy.gov/sites/prod/files/2016/12/f34/WH_Conversion_Final%20Rule.pdf

[15] https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria.

The referenced federal standards for the baseline UEF are dependent on both draw pattern and tank size. A weighted average baseline UEF was calculated with a medium draw pattern from the referenced federal standards and water heating equipment market data from the Energy Information Association 2009 residential energy consumption survey for NJ[16] assuming tank sizes of 30 gallons for small units, 40 gallons for medium units, and 55 gallons for large units.

<u>Sources</u>

1. US Government Publishing Office, June 2017, *Electronic Code of Federal Regulations – Title 10, Part 430, Subpart C*; available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=2942a69a6328c23266612378a0725e60&mc=true&node=se10.3.430_132&rgn=div8.
2. US Energy Information Association, *2009 Residential Energy Consumption Survey Data (Mid-Atlantic)*; available at: https://www.eia.gov/consumption/residential/data/2015/c&e/ce3.2.xlsx.

[16] *Available at* https://www.eia.gov/consumption/residential/data/2009/hc/hc8.8.xls.

Residential Low Income Program

Protocols

The protocols set out below are applicable to both the Comfort Partners component of the low income program currently implemented by the state's electric and gas public utilities, the Weatherization Assistance component of the low income program implemented by the New Jersey Department of Community Affairs (DCA), and low income programs administered by the state's electric and gas public utilities.

The savings protocols for low income programs are based upon estimated per unit installed savings. In some cases, such as lighting and refrigerators, the savings per unit estimate is based on direct observation or monitoring of the existing equipment being replaced. For other measures, for example air sealing and insulation, the protocols calculation is based on an average % savings of pre-treatment consumption.

Furnace/Boiler Replacement

Quantification of savings due to furnace and boiler replacements implemented under the low income programs will be based on the algorithms presented in the Residential Gas HVAC section of these Protocols. It is assumed that the baselines are the same for the low income programs and the Residential HVAC Program but existing system efficiency may be used for baseline, if known.

Other "Custom" Measures

In addition to the typical measures for which savings algorithms have been developed, it is assumed that there will be niche opportunities that should be identified and addressed. The savings for these custom measures will be reported based on the individual calculations supplied with the reporting. As necessary, the program working group will develop specific guidelines for frequent custom measures for use in reporting and contractor tracking.

<u>Definition of Terms</u>

CFL_{watts} = Average watts replaced for a CFL installation.

CFL_{hours} = Average daily burn time for CFL replacements.

$Fixt_{watts}$ = Average watts replaced for an efficient fixture installation.

$Fixt_{hours}$ = Average daily burn time for CFL replacements.

$Torch_{watts}$ = Average watts replaced for a Torchiere replacement.

$Torch_{hours}$ = Average daily burn time for a Torchiere replacements.

LED_{watts} = Average watts replaced for an LED installation.

LED_{hours} = Average daily burn time for LED replacements.

$LEDN_{watts}$ = Average watts replaced for an LED nightlight installation.

$LEDN_{hours}$ = Average daily burn time for LED nightlight replacements.

Light CF = Summer demand coincidence factor for all lighting measures. Currently fixed at 5%.

HW_{eavg} = Average electricity savings from typical electric hot water measure package.

HW_{gavg} = Average natural gas savings from typical electric hot water measure package.

HW_{watts} = Connected load reduction for typical hot water efficiency measures

HW CF = Summer demand coincidence factor for electric hot water measure package. Currently fixed at 75%.

Ref_{old} = Annual energy consumption of existing refrigerator based on on-site monitoring.

Ref_{new} = Rated annual energy consumption of the new refrigerator.

Ref DF = kW /kWh of savings. Refrigerator demand savings factor.

Ref CF = Summer demand coincidence factor for refrigeration. Currently 100%, diversity accounted for in the Ref DF factor.

ESC_{pre} = Pre-treatment electric space conditioning consumption.

$ECool_{pre}$ = Pre-treatment electric cooling consumption.

EFLH = Equivalent full load hours of operation for the average unit. This value is currently fixed at 650 hours.

AC CF = Summer demand coincidence factor for air conditioning. Currently 85%.

Capy = Capacity of Heat Pump in Btuh

EER = Energy Efficiency Ratio of average heat pump receiving charge and air flow service. Fixed at 9.2

HP CF = Summer demand coincidence factor for heat pump. Currently fixed at 70%.

DSF = Demand savings factor for charge and air flow correction. Currently fixed at 7%.

GC_{pre} = Pre-treatment gas consumption.

GH_{pre} = Pre-treatment gas space heat consumption (=.GC_{pre} less 300 therms if only total gas use is known.

WS = Water savings associated with water conservation measures. Currently fixed at 3,640 gallons per year per home receiving low-flow showerheads, plus 730 gallons saved per year aerator installed.

Residential Low Income

Component	Type	Value	Source
CFL_{Watts}	Fixed	42 watts	1
CFL_{Hours}	Fixed	2.5 hours	1
$Fixt_{Watts}$	Fixed	100–120 watts	1
$Fixt_{Hours}$	Fixed	3.5 hours	1
$Torch_{Watts}$	Fixed	245 watts	1
$Torch_{Hours}$	Fixed	3.5 hours	1
LEDWatts	Fixed	52 watts	14
LEDHours	Fixed	2.5 hours	14
LEDNWatts	Fixed	6.75 watts	14
LEDNHours	Fixed	12 hours	15
Light CF	Fixed	6%	2
Elec. Water Heating Savings	Fixed	178 kWh	3
Gas Water Heating Savings	Fixed	1.01 MMBtu	3
WS Water Savings	Fixed	3,640 gal/year per home receiving low-flow shower heads, plus 1,460 gal/year per home receiving aerators.	12
HW_{watts}	Fixed	0.022 kW	4
HW CF	Fixed	75%	4
Ref_{old}	Variable		Contractor Tracking
Ref_{new}	Variable		Contractor Tracking and Manufacturer data
Ref DF	Fixed	0.000139 kW/kWh savings	5
RefCF	Fixed	100%	6
ESC_{pre}	Variable		7
$Ecool_{pre}$	Variable		7

Component	Type	Value	Source
ELFH	Fixed	650 hours	8
AC CF	Fixed	85%	4
Capy	Fixed	33,000 Btu/hr	1
EER	Fixed	11.3	8
HP CF	Fixed	70%	9
DSF	Fixed	7%	10
GC_{pre}	Variable		7
GH_{pre}	Variable		7
Time Period Allocation Factors – Electric	Fixed	Summer/On-Peak 21% Summer/Off-Peak 22% Winter/On-Peak 28% Winter/Off-Peak 29%	11
Time Period Allocation Factors – Gas	Fixed	**Heating:** Summer 12% Winter 88% **Non-Heating:** Summer 50% Winter 50%	13

Sources/Notes:

1. Working group expected averages for product specific measures.
2. Efficiency Vermont, Technical Reference User Manual, 2019, p. 24.
3. Experience with average hot water measure savings from low income and direct install programs.
4. VEIC estimate.
5. UI Refrigerator Load Data profile, 16 kW (5 p.m. July) and 1,147 kWh annual consumption.
6. Diversity accounted for by Ref DF.
7. Billing histories and (for electricity) contractor calculations based on program procedures for estimating space conditioning and cooling consumption.
8. Average EER for SEER 13 units.
9. Analysis of data from 6 utilities by Proctor Engineering.
10. From Neme, Proctor and Nadel, 1999.
11. These allocations may change with actual penetration numbers are available.
12. VEIC estimate, assuming 1 GPM reduction for 14 5-minute showers per week for shower heads, and 4 gallons saved per day for aerators.
13. Heating: Prorated based on 12% of the annual degree days falling in the summer period and 88% of the annual degree days falling in the winter period.

Non-Heating: Prorated based on 6 months in the summer period and 6 months in the winter period.

14. "NJ Comfort Partners Energy Saving Protocols and Engineering Estimates," Apprise, June 2014, available at http://www.njcleanenergy.com/files/file/Protocol%20and%20Engineering%20Estimate%20Summary.pdf.
15. PA TRM 2021 Internal reference - Southern California Edison Company, "LED, Electroluminescent & Fluorescent Night Lights", Work Paper WPSCRELG0029 Rev. 1, February 2009, pp. 2–3.

Residential New Construction Program

Protocols

Whole building energy savings due to improvements in residential new construction and "gut" renovation projects are calculated using outputs from RESNET accredited Home Energy Rating System (HERS) modeling software.[17] All program homes are modeled using accredited software to estimate annual energy consumption for heating, cooling, hot water, and other end uses within the HERS asset rating. Standards for energy efficient new construction in New Jersey are based on national platforms, including IECC 2015, EPA ENERGY STAR® Certified New Homes Program, EPA ENERGY STAR Multifamily High-Rise Program (MFHR), EPA ENERGY STAR Multifamily New Construction (MFNC), and the DOE Zero Energy Ready Home (ZERH) Program. The Multifamily New Construction program offers two compliance pathways: the Energy Rating Index (ERI) pathway where dwelling units are individually rated and the ASHRAE pathway where the building as a whole is rated. All of these pathways are based on and incorporate by reference the applicable HERS standards, including but not limited to, the Mortgage Industry National Home Energy Rating System Standard & Addenda and ANSI/RESNET/ICC Standard 30.[18]

Single-Family, Multi-Single (townhomes), and Multifamily Units following the ERI pathway

The program home is then modeled to a baseline specification using a program-specific reference home (referred to in some software as a User Defined Reference Home or UDRH) feature. The program reference home specifications are set according to the lowest efficiency specified by applicable codes and standards, thereby representing a New Jersey specific baseline home against which the improved efficiency of program homes is measured.

The NJCEP reference home shall be updated as necessary over time to reflect the efficiency values of HERS Minimum Rated Features based on the following:

- The prescriptive minimum values of the IECC version applicable to the home for which savings are being calculated;
- The Federal Minimum Efficiency Standards applicable to each rated feature at the time of permitting (e.g., minimum AFUE and SEER ratings for heating and air conditioning equipment, etc.);
- An assessment of baseline practice, as available, in the event that either of the above standards reference a non-specific value (e.g., "visual inspection");
- Exclusion of specific rated features from the savings calculation in order to remove penalties for building science based best practice requirements of the

[17] Accredited Home Energy Rating Systems (HERS) software, http://www.resnet.us/professional/programs/software.

[18] http://www.resnet.us/professional/standards

program (e.g., by setting the reference and rated home to the same value for program-required mechanical ventilation); and

- Other approved adjustments as may be deemed necessary.

The RNC program currently specifies four standards for program qualification:

- IECC 2015 Energy Rating Index (for homes permitted on or after March 21, 2016)
- ENERGY STAR Certified Homes v3.1
- ENERGY STAR MFNC v1.1
- Zero Energy Ready Home &Zero Energy Home + RE

The difference in modeled annual energy consumption between the program and applicable baseline reference home is the projected savings for heating, hot water, cooling, lighting, appliances, and other end uses in the HERS Minimum Rated Features, as well as on-site renewable gereration, when applicable. Coincident peak demand savings are also derived from rated modeled outputs. The following table describes the baseline characteristics of Climate Zone 4 and 5 reference homes for single-family, multi-single and low-rise multifamily buildings.

REM/Rate User Defined Reference Homes Definition Applicable to buildings permitted prior to March 21, 2016 -- Reflects IECC 2009			
Note	**Data Point**	**Climate Zone 4**	**Climate Zone 5**
(1)	Ceiling Insulation	U=0.030	U=0.030
	Radiant Barrier	None	None
(1)	Rim/Band Joist	U=0.082	U=0.057
(1)	Exterior Walls - Wood	U=0.082	U=0.057
(1)	Exterior Walls - Steel	U=0.082	U=.057
	Foundation Walls	U=0.059	U=0.059
(1)	Doors	U=0.35	U=0.35
(1)	Windows	U=0.35 , SHGC=NR	U=0.35 , SHGC=NR
(1)	Glass Doors	U=0.35 , SHGC=NR	U=0.35 , SHGC=NR
(1)	Skylights	U=0.60 , SHGC=NR	U=0.60 , SHGC=NR
(2)	Floor	U=0.047	U=.033
	Unheated Slab on Grade	R-10, 2 ft	R-10, 2 ft
	Heated Slab on Grade	R-15, 2 ft	R-15, 2 ft
	Air Infiltration Rate	7 ACH50	7 ACH50
	Duct Leakage	8 cfm25 per 100ft^2 CFA	8 cfm25 per 100ft^2 CFA
	Mechanical Ventilation	None	None
	Lights and Appliances	Use RESNET Default	Use RESNET Default
	Thermostat	Manual	Manual
	Heating Efficiency		
(3)	Furnace	80% AFUE	80% AFUE
	Boiler	80% AFUE	80% AFUE
	Combo Water Heater	76% AFUE (Recovery Efficiency)	76% AFUE (Recovery Efficiency)
	Air Source Heat Pump	7.7 HSPF	7.7 HSPF
	Cooling Efficiency		
	Central Air Conditioning & Window AC units	13.0 SEER	13.0 SEER
	Air Source Heat Pump	13.0 SEER	13.0 SEER
(4)	Domestic WH Efficiency		
	Electric stand-alone tank	0.90 EF	0.90 EF
	Natural Gas stand-alone tank	0.58 EF	0.58 EF
	Electric instantaneous	0.93 EF	0.93 EF
	Natural Gas instantaneous	0.62 EF	0.62 EF
	Water Heater Tank Insulation	None	None
	Duct Insulation, attic supply	R-8	R-8
	Duct Insulation, all other	R-6	R-6
	Active Solar	None	None
	Photovoltaics	None	None

UDRH Table Notes

(1)	U values represent total wall system U value, including all components (i.e., clear wall, windows, doors). Type A-1 - Detached one and two family dwellings. Type A-2 - All other residential buildings, three stories in height or less.
(2)	All frame floors shall meet this requirement. There is no requirement for floors over basements and/or unvented crawl spaces when the basement and/or unvented crawl space walls are insulated.
(3)	MEC 95 minimum requirement is 78 AFUE. However, 80 AFUE is adopted for New Jersey based on typical minimum availability and practice.
(4)	Based on the Federal Government standard for calculating EF (50 gallon assumed): •Gas-fired Storage-type EF: 0.67 - (0.0019 x Rated Storage Volume in gallons) •Electric Storage-type EF: 0.97 - (0.00132 x Rated Storage Volume in gallons) •Instantaneous Gas-fired EF: 0.62 - (0.0019 x Rated Storage Volume in gallons) •Instantaneous Electric EF: 0.93 - (0.0013 x Rated Storage Volume in gallons)

REM/Rate User Defined Reference Homes Definition Applicable to buildings permitted on or after March 21, 2016 -- Reflects IECC 2015			
Note	**Data Point**	**Climate Zone 4**	**Climate Zone 5**
(1)	Ceiling Insulation	U= 0.026	U=0.026
	Radiant Barrier	None	None
(1)	Rim/Band Joist	U=0.060	U=0.060
(1)	Exterior Walls - Wood	U=0.060	U=0.060
(1)	Exterior Walls - Steel	U=0.060	U=0.060
	Foundation Walls	U=0.059	U=0.050
(1)	Doors	U=0.35	U=0.32
(1)	Windows	U=0.35 , SHGC=40	U=0.32 , SHGC=NR
(1)	Glass Doors	U=0.35 , SHGC=40	U=0.32 , SHGC=NR
(1)	Skylights	U=0.55 , SHGC=40	U=0.55 , SHGC=NR
(2)	Floor	U=0.047	U=.033
	Unheated Slab on Grade	R-10, 2 ft	R-10, 2 ft
	Heated Slab on Grade	R-15, 2 ft	R-15, 2 ft
(3)	Air Infiltration Rate	7 ACH50	7 ACH50
	Duct Leakage	4 cfm25 per 100ft^2 CFA	4 cfm25 per 100ft^2 CFA
	Mechanical Ventilation	Exhaust only	Exhaust only
	Lighting	75% efficient	75% efficient
	Appliances	Use RESNET Default	Use RESNET Default
(4)	Thermostat	Manual	Manual
	Heating Efficiency		
(5)	Furnace	80% AFUE	80% AFUE
	Boiler	80% AFUE	80% AFUE
	Combo Water Heater	76% AFUE (Recovery Efficiency)	76% AFUE (Recovery Efficiency)
	Air Source Heat Pump Cooling Efficiency	8.2 HSPF	8.2 HSPF
	Central Air Conditioning & Window AC units	13.0 SEER	13.0 SEER
	Air Source Heat Pump	14.0 SEER	14.0 SEER
(6)	Domestic WH Efficiency		
	Electric stand-alone tank	0.90 EF	0.90 EF
	Natural Gas stand-alone tank	0.60 EF	0.60 EF
	Electric instantaneous	0.93 EF	0.93 EF
	Natural Gas instantaneous	0.82 EF	0.82 EF
	Water Heater Tank Insulation	None	None
	Duct Insulation, attic	R-8	R-8
	Duct Insulation, all other	R-6	R-6
	Active Solar	None	None
	Photovoltaics	None	None

UDRH Table Notes

(1)	U values represent total system U value, including all components (i.e., clear wall, windows, doors). Type A-1 - Detached one and two family dwellings. Type A-2 - All other residential buildings, three stories in height or less.
(2)	All frame floors shall meet this requirement. There is no requirement for floors over basements and/or unvented crawl spaces when the basement and/or unvented crawl space walls are insulated.
(3)	Based on New Jersey's amendment making the IECC 2015 requirement for air leakage testing optional, there is no empirical evidence that baseline new construction is achieving the 3 ACH50 tightness level through a visual inspection of checklist air sealing items.
(4)	While the code requires a programmable actual programming is an occupant behavior, both the rated home and reference home are set at fixed temperatures of 68 heating and 78 cooling, so that no savings are counted or lost
(5)	MEC 95 minimum requirement is 78 AFUE. However, 80 AFUE is adopted for New Jersey based on typical minimum availability and practice.
(6)	Based on the Federal Government standard for calculating EF (50 gallon assumed): •Gas-fired Storage-type EF: 0.675 - (0.0015 x Rated Storage Volume in gallons) •Electric Storage-type EF: 0.97 - (0.00132 x Rated Storage Volume in gallons) •Instantaneous Gas-fired EF: 0.82 - (0.0019 x Rated Storage Volume in gallons) •Instantaneous Electric EF: 0.93 - (0.0013 x Rated Storage Volume in gallons

Multifamily High Rise (MFHR) and Multifamily New Construction (MFNC) following the ASHRAE pathway

Annual energy and summer coincident peak demand savings for qualifying MFHR construction projects shall be calculated from the Energy Star Performance Path Calculator (PPC).[19] The PPC captures outputs from EPA approved modeling software. Coincident peak demand is calculated only for the following end uses: space cooling, lighting, and ventilation. Clothes washer data cannot be parsed out of the PPC "Misc Equip' field. RNC coincident factors are applied to the MFHR demand savings.

Energy and demand savings are calculated using the following equations:

Energy Savings = Average Baseline energy (kWh/yr and/or therms/yr) - Proposed Design energy (kWh/yr and/or therms/yr)

Coincident peak demand = (Average Baseline non-coincident peak demand - Proposed Design non-coincident peak demand) * Coincidence Factor

[19] https://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_mfhr_guidance

Residential Energy Efficient Products

Protocols

The following sections detail savings calculations for ENERGY STAR Appliances, ENERGY STAR Lighting Products, low flow showerheads, and weatherization products in the residential and multi-family sectors.

Energy savings for energy efficient products fall into two categories – deemed savings and calculated savings. In general, savings for large appliances, weatherization products, and water heating measures are calculated, and savings for small appliances are deemed.

Low Flow Showerheads

Measure Description

This measure applies to new or replacement low flow residential showerheads (≤ 2.0 gpm) that are certified by WaterSense[20] to use at least 20 percent less water than conventional showerheads. By reducing the amount of water used while showering, these products save energy for water heating, water pumping, and water treatment. Calculations apply to water heating energy savings only.

Baseline Annual Energy Consumption

The baseline is a standard showerhead meeting federal maximum flow of 2.5 gpm.

Efficient Annual Energy Consumption

The efficient case is a WaterSense certified showerhead having a flowrate of 2.0 gpm or less.

Calculation Methodology

Annual Electric Energy Savings

$$\Delta kWh = Water\ Savings\ \left(\frac{gals}{year}\right) \times (T_{shower} - T_{main}) \times \frac{8.33\,\frac{Btu}{gal°F}}{3412\,\frac{Btu}{kWh}} \times \frac{1}{UEF_{elec}} \times F_{elec}$$

Summer Peak Coincident Demand Savings

$\Delta kW = 0$

Annual Gas Energy Savings

$$\Delta Therms = Water\ Savings\ \left(\frac{gals}{year}\right) \times (T_{shower} - T_{main}) \times 8.33\,\frac{Btu}{gal°F} \times \frac{1}{UEF_{gas}} \times F_{gas} \times \frac{1\ therm}{100{,}000\ Btu}$$

Where[21]

$$Water\ Savings\left(\frac{gals}{year}\right) = (GPM_{baseline} - GPM_{ee}) \times Throttle_{factor} \times \frac{minutes}{shower} \times \frac{showers}{day} \times 365\,\frac{days}{year}$$

T_{shower} = 105°F

T_{main} = 60.6°F [22]

UEF_{elec} = Uniform Energy Factor for electric water heaters = 0.9197

UEFgas[23] = Uniform Energy Factor for gas water heaters = 0.56

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[20] https://www.epa.gov/watersense/showerheads

[21] Where not otherwise stated, factors for showering are from Biermayer, P., Potential Water and Energy Savings from Showerheads, LBNL-58601 (2005).

[22] Average water inlet temperature for Trenton, New Jersey TMY3 weather data using the methodology presented in Burch, J., and C. Christensen, "Towards Development of an Algorithm for Mains Water Temperature," American Solar Energy Annual Conference Proceedings (2007).

[23] Average calculated for a 55-gallon tank based on based water heater size reported in the 2015 RECS Data for the Middle Atlantic states.

F_{elec} = Fraction of water heaters which are electric = 0.25[24]
F_{gas} = fraction of water heaters which are gas = 0.71
8.33 = Conversion factor for energy required (Btu) to heat one gallon of water by 1°F
GPMbaseline = 2.5
$Throttle_{factor}$ = 0.9
Minutes/shower = 8.2
Showers/day = 2.03 (based on 2.71 people/household[25] and 0.75 showers per day per person.

[24] From 2015 RECS microdata for Middle Atlantic Div 8. Of 228 households, fuel mix for water heating is 71% gas and 25% electric. No savings are attributed to 4% of households which use other fuel sources.

[25] US Census Data 2014-2018 for New Jersey.

Weatherization Products

The following sections detail savings calculations for weatherization products, including Door Sealing Material, Door Sweeps, and Foam Sealant.

Door Sealing Material, Door Sweeps, and Foam Sealant

Measure Descriptions

Door Sealing Material

This measure prevents air infiltration around the vertical sides and top of exterior residential doors or windows to fill gaps and prevent air infiltration. This measure is not intended for the bottom of doors.

Door Sweep

This measure applies to a rigid product attached to the bottom of exterior doors to prevent air infiltration.

Foam Sealant

This measure applies to insulating spray foam sealant that is used to fill gaps between conditioned and unconditioned spaces, such as around plumbing, HVAC, and electrical penetrations, and to fill gaps in framing systems.

Savings Methodology – Door Sealing Material, Door Sweeps, and Foam Sealant

Annual Electric Energy Savings

$$\Delta kWh = \Delta kWh_{cool} + \Delta kWh_{heat}$$

Where

$$\Delta kWh_{cool} = \left(\frac{1.08 \times \Delta CFM_{50} \times CDD \times 24\frac{hr}{day}}{N \times SEER \times 1{,}000\frac{W}{kW}} \times LM \times DUA\right) \times lin.ft.$$

$$\Delta kWh_{heat} = \left(\frac{1.08 \times \Delta CFM_{50} \times HDD \times 24\frac{hr}{day}}{N \times HSPF \times 1{,}000\frac{W}{kW}} \times F_{elec}\right) \times lin.ft.$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \Delta kWh_{cool} \times ETDF$$

Annual Gas Energy Savings

$$\Delta therms = \left(\frac{1.08 \times \Delta CFM_{50} \times HDD \times 24\frac{hr}{day}}{N \times \eta_{heat}} \times F_{gas} \times \frac{1\ Therm}{100{,}000\ Btu}\right) \times lin.ft.$$

Where

1.08 = Conversion factor for CFM air to Btu/hr°F $\left(\frac{BTU \times min}{hr \times °F \times ft^3}\right)$

ΔCFM_{50} = reduction in air leakage per unit of product (per Table 1).

CDD = 965[26]

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[26] CDD and HDD for Trenton, NJ from https://climate.rutgers.edu/stateclim_v1/norms/monthly/.

HDD = 5160[27]
N = Correlation factor (16.7)[28]
LM = Latent Multiplier (7.8)[29]
DUA = Discretionary Use Adjustment (0.75)
SEER = 12[30]
HPSF = 3.8[31]
η_{heat} = 0.80[32]
Lin.ft. = linear feet of installed product. For Door Sealing Material and Door Sweeps, use the installed product length. For Foam Sealant, calculate linear feet by multiplying package weight (oz.) by product yield per Table 1.
F_{elec} = Fraction of homes heated with electricity (13.6%)[33]
F_{gas} = Fraction of homes heated with gas (77.6%)
ETDF = Energy to Demand Factor (0.000017)[34]

Table 1. CFM50 by product type for weatherization materials.

Product	ΔCFM_{50}	Unit	Yield
Door sweep	0.639	cfm/lin.ft.	Varies by product length
Door sealing material	0.639	cfm/lin.ft.	Varies by product length
Spray foam	0.689	cfm/lin.ft.	13.42 lin.ft./oz.*
* Yield from Touch 'n Foam 12 oz. can @ 3/4" bead assuming 10% waste			

[27] CDD and HDD for Trenton, NJ from https://climate.rutgers.edu/stateclim_v1/norms/monthly/.

[28] Factor for 1.5 story building with normal exposure in zone 2, ENERGY STAR Home Sealing Specification, Version 1.0, October 2001 from https://www.energystar.gov/ia/home_improvement/home_sealing/ES_HS_Spec_v1_0b.pdf.

[29] Value for Philadelphia, Pennsylvania from 2021 Pennsylvania TRM.

[30] Weighted average value by cooling type for homes with cooling from 2015 RECS data in the Middle Atlantic states.

[31] Weighted average from 2015 RECS data for electrically heated homes. Of the 31 home heated with electricity, 3 were heat pumps, 14 central furnace, and 14 resistance (using default efficiencies Table 2-8 of the Pennsylvania TRM).

[32] Current federal minimum for furnaces per Table 1 in https://www.regulations.gov/document?D=EERE-2006-STD-0102-0008.

[33] U.S. EIA 2015 Residential Energy Consumption Survey microdata for main space heating fuel. 8.8% of homes are heated with fuel other than gas or electric and are not factored into savings.

[34] KEMA, Evaluation of the Weatherization Residential Assistance Partnership (WRAP) and Helps Programs, September 2010. http://www.energizect.com/sites/default/files/Final%20WRAP%20%20Helps%20Report.pdf.

ENERGY STAR Large Appliances

Refrigerator/Freezers

Measure Description

This measure is for a new or replacement residential ENERGY STAR or ENERGY STAR Most Efficient refrigerator or freezer that uses less electricity than a refrigerator or freezer meeting federal minimum efficiency requirements.

This measure applies only to refrigerators or combination refrigerator/freezers having an adjusted volume of 39 cubic feet or less, and freezers with a total adjusted volume of 30 cubic feet or less. Wine refrigerators are not eligible.

Baseline Annual Energy Consumption

The baseline for energy savings calculations is the maximum federal allowable electricity use (kWh/yr).[35] Maximum allowable electricity usage is calculated for the unit's adjusted volume, and varies by configuration (e.g., side-by-side, top freezer, etc.) and functionality (e.g., manual or automatic defrost, ice maker capability).

Efficient Annual Energy Consumption

The energy consumption of the efficient equipment is the Annual Energy Usage (kWh/yr) reported in the ENERGY STAR list of qualified products per DOE test procedures.[36]

Calculation Methodology

Annual Electric Energy Savings

$$\frac{\Delta kWh}{yr} = \left(\left(\frac{kWh}{yr}\right)_{baseline} - \left(\frac{kWh}{yr}\right)_{efficient} \right)$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \left(\left(\frac{kWh}{yr}\right)_{baseline} - \left(\frac{kWh}{yr}\right)_{efficient} \right) \times ETDF$$

Where

Δ kWh/yr = Annual Electric Energy Savings

ΔkW = Peak Demand Savings

$\left(\frac{kWh}{yr}\right)_{baseline}$ = U.S. Federal Standard Energy Consumption (kWh/yr) per ENERGY STAR certified residential freezers or ENERGY STAR certified residential refrigerators product list

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35 U.S. Department of Energy, *Energy and water conservation standards and their effective dates*, Code of Federal Regulations Title 10, Vol 3, Section 430.32. https://www.govinfo.gov/content/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf.

36 Current U.S. Department of Energy test procedures are found in 10 CFR 430.23(a) and part 430, subpart B, appendix A (refrigerators and refrigerator-freezers), and 10 CFR 430.23(b) and 10 CFR part 430, subpart B, appendix B (freezers).

$\left(\frac{kWh}{yr}\right)_{efficient}$ = Annual Energy Use for efficient equipment per ENERGY STAR certified residential freezers or ENERGY STAR certified residential refrigerators list.
ETDF = Energy to Demand Factor in kW/kWh (0.0001614)[37]

Annual Gas Energy Savings
There are no gas savings associated with this measure.

ENERGY STAR Clothes Dryers

Measure Description
This measure is for a new or replacement ENERGY STAR or ENERGY STAR Most Efficient residential clothes dryer.

Baseline Annual Energy Consumption
The baseline for energy savings calculations is a clothes dryer meeting the federal minimum combined energy factor for machines manufactured after January 2015.[38] Minimum combined energy factor varies by clothes dryer type.

Efficient Annual Energy Consumption
The energy consumption of the efficient equipment is calculated based on the combined energy factor of the ENERGY STAR or ENERGY STAR Most Efficient product and other variables as defined in the calculation methodology below.

Calculation Methodology
Annual Electric Energy Savings

$$\Delta kWh = \frac{Loads}{yr} \times \frac{Lbs}{Load} \times \left(\frac{1}{CEF_{baseline}} - \frac{1}{CEF_{EE}}\right) \times F_{elec}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = Peak\ Demand\ Savings\ (kW) = \frac{\Delta kWh}{\frac{Hours}{yr}} * CF$$

Annual Gas Energy Savings

$$\Delta therms = \frac{Loads}{yr} \times \frac{Lbs}{Load} \times \left(\frac{1}{CEF_{baseline}} - \frac{1}{CEF_{EE}}\right) \times (1 - F_{elec}) \times \left(\frac{3412\ Btu}{1\ kWh}\right) \times \left(\frac{1\ therm}{100{,}000\ Btu}\right)$$

Where
Loads/Year = 297[39]

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[37] The Energy to Demand factor from the 2021 Pennsylvania TRM. The value accounts for temperature-dependent operation; cooling energy savings is based on Blasnik, Etc., (July 2004), Measurement and Verification of Residential Refrigerator Energy Usage,

[38] U.S. Department of Energy, *Energy and water conservation standards and their effective dates*, Code of Federal Regulations Title 10, Vol 3, Section 430.32..

[39] 297 annual cycles per 2009 RECS data for New Jersey (See RECS 2009 Table HC3.8 Home Appliances in Homes in Northeast Region, Divisions, and States) and an average 10.4 lb load based on paired

Lbs/load = size of load, see Table 2. $CEF_{baseline}$, F_{elec}, and Load Size by Clothes Dryer Type.
$CEF_{baseline}$ = Combined Energy Factor of federal minimum compliant dryer, by type of dryer, per Table 2. $CEF_{baseline}$, F_{elec}, and Load Size by Clothes Dryer Type in lbs/kWh.
F_{elec} = Fraction of energy savings which is electricity
Hours/yr = 277[40]
CF = Coincidence Factor = 0.029[41]

Table 2. $CEF_{baseline}$, F_{elec}, and Load Size by Clothes Dryer Type

Clothes Dryer Type	$CEF_{baseline}$ (lbs/kWh)	F_{elec}	Lbs/Load[42,43]
Vented Gas	3.30	0.05	10.4
Ventless or Vented Electric, Standard (4.4 cu-ft or greater capacity)	3.73	1	10.4
Vented Electric, Compact (240V) (less than 4.4 cu-ft capacity)	3.27	1	3
Ventless or Vented Electric, Compact (120V) (less than 4.4 cu-ft capacity)	3.27	1	3
Ventless Electric, Compact (240V) (less than 4.4 cu-ft capacity)	2.55	1	3

ENERGY STAR Clothes Washers

Measure Description

This measure is for a new or replacement ENERGY STAR or ENERGY STAR Most Efficient residential clothes washer in single family or multi-family homes.

Baseline Annual Energy Consumption

The baseline for energy savings calculations is a clothes washer meeting the federal minimum Integrated Modified Energy Factor (IMEF) and not exceeding the federal maximum Integrated Water Factor (IWF), as determined by clothes washer configuration (top-load or front-load) and capacity. Energy usage includes the washer and dryer energy consumption and water heating energy usage.

Efficient Annual Energy Consumption

ENERGY STAR washers, *available at* http://www.neep.org/mid-atlantic-technical-reference-manual-v6. The updated 2015 RECS does not disaggregate this data by state.

[40] Hours per year are calculated based on 297 annual cycles and average 56 minutes per cycle. Average cycle time is based on Ecova, *Dryer Field Study*, Northwest Energy Efficiency Alliance (2014).

[41] Data for clothes washers from Navigant Consulting, *EmPOWER Maryland Draft Final Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Appliance Rebate Program*, March 21, 2014, p. 36.

[42] Average load size from New Jersey Protocols to Measure Resource Savings (FY2020) based on paired ENERGY STAR washers.

[43] Per DOE standard test procedures for compact washers 10 CFR 430, Subpart B, Appendix D1.

The energy consumption of the efficient equipment is calculated based on the IMEF and IWF of the ENERGY STAR or ENERGY STAR Most Efficient product and other variables as defined in the calculation methodology below.

Calculation Methodology
Annual Electric Energy Savings

$\Delta kWh = (\Delta kWh_{washer}) + \left(\Delta kWh_{dryer}\right) + (\Delta kWh_{wh})$

Where:

$$\Delta kWh_{washer} = Capacity\ \times (\frac{1}{IMEF_b} - \frac{1}{IMEF_{ee}}) \times \frac{Cycles}{yr} \times SF_{washer}$$

$$\Delta kWh_{dryer} = Capacity\ \times (\frac{1}{IMEF_b} - \frac{1}{IMEF_{ee}}) \times \frac{Cycles}{yr} \times SF_{dryer} \times\ F_{elec,dryer}$$

$$\Delta kWh_{wh} = Capacity\ \ \times (\frac{1}{IMEF_b} - \frac{1}{IMEF_{ee}}) \times \frac{Cycles}{yr} \times SF_{wh} \times F_{elec,wh}$$

Summer Peak Coincident Demand Savings

$$\Delta kW = \frac{\Delta kWh}{\frac{hrs}{yr}} * CF$$

Annual Gas Energy Savings

$\Delta therms = \ \Delta therms_{dryer} +\ \Delta therms_{wh}$

Where:

$$\Delta therms_{dryer} = \ Capacity\ \times (\frac{1}{IMEF_b} - \frac{1}{IMEF_{ee}}) \times \frac{Cycles}{yr} \times SF_{dryer} \times\ (1 -\ F_{elec,dryer}) \times \frac{3412\ Btu}{1\ kWh} \times \frac{1\ Therm}{100{,}000\ Btu}$$

$$\Delta therms_{wh} = \ Capacity\ \times (\frac{1}{IMEF_b} - \frac{1}{IMEF_{ee}}) \times \frac{Cycles}{yr} \times SF_{wh} \times\ (1 -\ F_{elec,wh}) \times \frac{3412\ Btu}{1\ kWh} \times \frac{1\ Therm}{100{,}000\ Btu}$$

Annual Water Savings

$$\frac{\Delta gallons}{year} = \left(IWF_{baseline} - IWF_{efficient}\right)\ \times Capacity\ \times \frac{Cycles}{yr}$$

Where:

Capacity = Rated volume (ft^3) of ENERGY STAR machine
$IMEF_b$ = Federal Minimum IMEF by configuration and capacity (see Table 3)
$IMEF_{ee}$ = IMEF for ENERGY STAR machine
SF_{washer} = portion of total savings attributed to machine (5%)[44]
SF_{wh} = portion of total savings attributed to water heating (19%)
SF_{dryer} = portion of total savings attributed to dryer energy usage (71%)

[44] Derived from ENERGY STAR savings calculator methodology and average portion of dryer savings for ENERGY STAR certified machines.

$F_{elec,wh}$ = portion of households having electric water heating (25%)[45]
$F_{elec,dryer}$ = portion of households having electric dryers (71%)
hrs/yr = operating hours for demand savings calculation (295)
CF = 0.029
Cycles/year = 283 (Single Family); 1138 (Multi Family)[46]

Table 3. Federal minimum Integrated Modified Energy Factor for clothes washers built after January 1, 2018.

Configuration	Capacity	Federal Min – IMEF (ft^3/kWh/cycle)	Federal Max – IWF (gal/cycle/ft^3)
Top Load	< 1.6 ft^3	1.15	12
Top Load	≥ 1.6 ft^3	1.57	6.5
Front Load	< 1.6 ft^3	1.13	8.3
Front Load	≥ 1.6 ft^3	1.84	4.7

[45] Per 2015 RECS microdata for Middle Atlantic States. Numbers do not total 100% because 4% use fuel other than natural gas or electricity.

[46] Single family from Federal testing standards (10 CFR 430.32). Multifamily from ENERGY STAR https://www.energystar.gov/ia/products/appliances/clotheswash/508_ColesvilleTowers.pdf.

ENERGY STAR Small Appliances

The general form of the equation for the ENERGY STAR Appliance Program measure savings algorithms is:

Number of Units * Savings per Unit

To determine resource savings, the per unit estimates in the protocols will be multiplied by the number of appliance units. The number of units will be determined using market assessments and market tracking.

<u>ENERGY STAR Refrigerators</u>

Electricity Savings (kWh/yr) = $ESav_{REF1}$

Peak Demand Savings (kW) = $DSav_{REF1}$ * CF_{REF}

<u>ENERGY STAR Most Efficient Refrigerators</u>

Electricity Savings (kWh/yr) = $ESav_{REF2}$

Peak Demand Savings (kW) = $DSav_{REF2}$ * CF_{REF}

<u>ENERGY STAR Clothes Washers</u>

Electricity Savings (kWh/yr) = $ESav_{CW1}$

Peak Demand Savings (kW) = $DSav_{CW1}$ * CF_{CW}

Gas Savings (Therms/yr) = $EGSav_{CW1}$

Water Savings (gallons/yr) = $WSav_{CW1}$

<u>ENERGY STAR Most Efficient Clothes Washers</u>

Electricity Savings (kWh/yr) = $ESav_{CW2}$

Peak Demand Savings (kW) = $DSav_{CW2}$ * CF_{CW}

Gas Savings (Therms/yr) = $EGSav_{CW2}$

Water Savings (gallons/yr) = $WSav_{CW2}$

<u>ENERGY STAR Set Top Boxes</u>

Electricity Impact (kWh) = $ESav_{STB}$

Demand Impact (kW) = $DSav_{STB}$ * CF_{STB}

<u>Advanced Power Strip – Tier 1</u>

Electricity Impact (kWh) = $ESav_{APS}$

Demand Impact (kW) = $DSav_{APS}$ * CF_{APS}

<u>Advanced Power Strip – Tier 2</u>

Electricity Impact (kWh/yr) = $ESav_{APS2}$

Demand Impact (kW) = $DSav_{APS2}$ * CF_{APS}

ENERGY STAR Electric Clothes Dryers

Electricity Savings (kWh/yr) = $ESav_{CDE1}$

Peak Demand Savings (kW) = $DSav_{CDE1}$ * CF_{CD}

ENERGY STAR Gas Clothes Dryers

Electricity Savings (kWh/yr) = $ESav_{CDG1}$

Peak Demand Savings (kW) = $DSav_{CDG1}$ * CF_{CD}

Gas Savings (Therms/yr) = $GSav_{CDG1}$

ENERGY STAR Most Efficient Electric Clothes Dryers

Electricity Savings (kWh/yr) = $ESav_{CDE2}$

Peak Demand Savings (kW) = $DSav_{CDE2}$ * CF_{CD}

ENERGY STAR Most Efficient Gas Clothes Dryers

Energy Savings (kWh/yr) = $ESav_{CDG2}$

Peak Demand Savings (kW) = $DSav_{CDG2}$ * CF_{CD}

Gas Savings (Therms/yr) = $GSav_{CDG2}$

ENERGY STAR Room Air Purifier

Electricity Impact (kWh) = $ESav_{RAP}$ based on the CADR in the table below

Demand Savings (kW) = $DSav_{RAP}$ based on the CADR in the table below

Where $ESav_{RAP}$ is based on the CADR in table below

Room Air Purifier Deemed kWh Table				
Clean Air Delivery Rate (CADR)	**CADR used in calculation**	**Baseline Unit Energy Consumption (kWh/year)**	**ENERGY STAR Unit Energy Consumption (kWh/year)**	**ESavRAP**
CADR 51-100	75	441	148	293
CADR 101-150	125	733	245	488
CADR 151-200	175	1025	342	683
CADR 201-250	225	1317	440	877
CADR Over 250	275	1609	537	1072

Room Air Purifier Deemed kW Table	
Clean Air Delivery Rate	**DSavRAP**
CADR 51-100	0.034
CADR 101-150	0.056
CADR 151-200	0.078
CADR 201-250	0.101
CADR Over 250	0.123

ENERGY STAR Freezer

Electricity Impact (kWh) = $ESav_{FRZ1}$

Demand Impact (kW) = $DSav_{FRZ1}$ based on table below

ENERGY STAR Most Efficient Freezer

Electricity Impact (kWh) = $ESav_{FRZ2}$

Demand Impact (kW) = $DSav_{FRZ2}$ based on table below

ENERGY STAR Soundbar

Electricity Impact (kWh) = $ESav_{SDB}$

Demand Impact (kW) = $DSav_{SDB}$

Definition of Variables

$ESav_{REF1}$ = Electricity savings per purchased ENERGY STAR refrigerator

$DSav_{REF1}$ = Summer demand savings per purchased ENERGY STAR refrigerator

$ESav_{REF2}$ = Electricity savings per purchased ENERGY STAR Most Efficient refrigerator .

$DSav_{REF2}$ = Summer demand savings per purchased ENERGY STAR Most Efficient refrigerator

$ESav_{CW1}$ = Electricity savings per purchased ENERGY STAR clothes washer.

$DSav_{CW1}$ = Summer demand savings per purchased ENERGY STAR clothes washer.

$GSav_{CW1}$ = Gas savings per purchased clothes washer ENERGY STAR clothes washer.

$WSav_{CW1}$ = Water savings per purchased clothes washer ENERGY STAR clothes washer.

$ESav_{CW2}$ = Electricity savings per purchased ENERGY STAR Most Efficient clothes washer.

$DSav_{CW2}$ = Summer demand savings per purchased ENERGY STAR Most Efficient clothes washer.

$GSav_{CW2}$ = Gas savings per purchased ENERGY STAR Most Efficient clothes washer

$WSav_{CW2}$ = Water savings per purchased ENERGY STAR Most Efficient clothes washer.

$ESav_{STB}$ = Electricity savings per purchased ENERGY STAR set top box.

$DSav_{STB}$ = Summer demand savings per purchased ENERGY STAR set top box.

$ESav_{APS1}$ = Electricity savings per purchased advanced power strip.

$DSav_{APS1}$ = Summer demand savings per purchased advanced power strip.

$ESav_{APS2}$ = Electricity savings per purchased Tier 2 advanced power strip.

$DSav_{APS2}$ = Summer demand savings per purchased Tier 2 advanced power strip.

$ESav_{CDE1}$ = Electricity savings per purchased ENERGY STAR electric clothes dryer.

$DSav_{CDE1}$ = Summer demand savings per purchased ENERGY STAR electric clothes dryer.

$ESav_{CDG1}$ = Electricity savings per purchased ENERGY STAR gas clothes dryer.

$DSav_{CDG1}$ = Summer demand savings per purchased ENERGY STAR gas clothes dryer.

$GSav_{CDG1}$ = Gas savings per purchased ENERGY STAR gas clothes dryer.

$ESav_{CDE2}$ = Electricity savings per purchased ENERGY STAR Most Efficient electric clothes dryer.

$DSav_{CDE2}$ = Demand savings per purchased ENERGY STAR Most Efficient electric clothes dryer.

$ESav_{CDG2}$ = Electricity savings per purchased ENERGY STAR Most Efficient gas clothes dryer.

$DSav_{CDG2}$ = Demand savings per purchased gas ENERGY STAR Most Efficient gas clothes dryer.

$GSav_{CDG2}$ = Gas savings per purchased ENERGY STAR Most Efficient gas clothes dryer,

$ESav_{RAC1}$ = Electricity savings per purchased ENERGY STAR room air conditioner.

$DSav_{RAC1}$ = Summer demand savings per purchased ENERGY STAR room air conditioner.

$ESav_{RAC2}$ = Electricity savings per purchased CEE Advanced Tier room air conditioner.

$DSav_{RAC2}$ = Summer demand savings per purchased CEE Advanced Tier room air conditioner.

$ESav_{RAP}$ = Electricity savings per purchased ENERGY STAR room air purifier.

$DSav_{RAP}$ = Summer demand savings per purchased ENERGY STAR room air purifier.

$ESav_{FRZ1}$ = Electricity savings per purchased ENERGY STAR freezer.

$DSav_{FRZ1}$ = Summer demand savings per purchased ENERGY STAR freezer.

$ESav_{FRZ2}$ = Electricity savings per purchased ENERGY STAR Most Efficient freezer.

$DSav_{FRZ2}$ = Summer demand savings per purchased ENERGY STAR Most Efficient freezer.

$ESav_{SDB}$ = Electricity savings per purchased ENERGY STAR soundbar.

$DSav_{SDB}$ = Summer demand savings per purchased ENERGY STAR soundbar

TAF = Temperature Adjustment Factor

LSAF = Load Shape Adjustment Factor

CF_{REF}, CF_{CW}, CF_{DH}, CF_{RAC}, CF_{STB}, CF_{APS}, CF_{CD} = Summer demand coincidence factor.

Summary of Inputs

ENERGY STAR Appliances Savings Values

Component	Type	Value	Sources
$ESav_{REF1}$	Variable	ΔkWh Calculated	1
$DSav_{REF1}$	Variable	ΔkW Calculated	1
$ESav_{REF2}$	Variable	ΔkWh Calculated	1
$DSav_{REF2}$	Variable	ΔkW Calculated	1

Component	Type	Value	Sources
REF Time Period Allocation Factors	Fixed	Summer/On-Peak 20.9% Summer/Off-Peak 21.7% Winter/On-Peak 28.0% Winter/Off-Peak 29.4%	2
$ESav_{CW1}$	Variable	ΔkWh Calculated	1
$Gsav_{CW1}$	Variable	Δtherms Calculated	1
$DSav_{CW1}$	Variable	ΔkW Calculated	1
$WSav_{CW1}$	Variable	Gallons/year Calculated	1
$ESav_{CW2}$	Variable	ΔkWh Calculated	1
$Gsav_{CW2}$	Variable	Δtherms Calculated	1
$DSav_{CW2}$	Variable	ΔkW Calculated	1
$WSav_{CW2}$	Variable	Gallons/year Calculated	1
CW, CD Electricity Time Period Allocation Factors	Fixed	Summer/On-Peak 24.5% Summer/Off-Peak 12.8% Winter/On-Peak 41.7% Winter/Off-Peak 21.0%	2
CW, CD Gas Time Period Allocation Factors	Fixed	Summer 50% Winter 50%	3
CF_{REF}, CF_{CW}, CF_{DH}, CF_{RAP}, CF_{STB}, CF_{APS}, CF_{SDB}, CF_{CD}	Fixed	1.0	4
$ESav_{STB}$	Fixed	44 kWh	5
$DSav_{STB}$	Fixed	0.005 kW	5
$ESav_{APS1}$	Fixed	102.8 kWh	6
$DSav_{APS1}$	Fixed	0.012 kW	6
$ESav_{APS2}$	Fixed	346 kWh	7
$DSav_{APS2}$	Fixed	0.039 kW	7
APS, STB Time Period Allocation Factors	Fixed	Summer/On-Peak 16% Summer/Off-Peak 17% Winter/On-Peak 32% Winter/Off-Peak 35%	8
$ESav_{CDE1}$	Variable	ΔkWh Calculated	1
$DSav_{CDE1}$	Variable	ΔkW Calculated	1
$ESav_{CDG1}$	Variable	ΔkWh Calculated	1
$DSav_{CDG1}$	Variable	ΔkW Calculated	1
$GSav_{CDG1}$	Variable	Δtherms Calculated	1
$ESav_{CDE2}$	Variable	ΔkWh Calculated	1
$DSav_{CDE2}$	Variable	ΔkW Calculated	1
$ESav_{CDG2}$	Variable	ΔkWh Calculated	1

Component	Type	Value	Sources
$DSav_{CDG2}$	Variable	ΔkW Calculated	1
$GSav_{CDG2}$	Variable	Δtherms Calculated	1
$ESav_{RAC1}$	Variable	ΔkWh Calculated	1
$DSav_{RAC1}$	Variable	ΔkW Calculated	1
$ESav_{RAC2}$	Variable	ΔkWh Calculated	1
$DSav_{RAC2}$	Variable	ΔkW Calculated	1
$ESav_{RAP}$	Variable	Lookup Value by CADR	1
$DSav_{RAP}$	Variable	Lookup Value by CADR	1
$ESav_{FRZ}$	Variable	ΔkWh Calculated	1
$DSav_{FRZ}$	Variable	ΔkW Calculated	1
$ESav_{SDB}$	Fixed	44 kWh	5
$DSav_{SDB}$	Fixed	0.0005 kW	5
TAF	Fixed	1.23	9
LSAF	Fixed	1.15	9

<u>Sources</u>

1. Algorithms located in this savings protocols.
2. Time period allocation factors used in cost-effectiveness analysis. From residential appliance load shapes.
3. Prorated based on 6 months in the summer period and 6 months in the winter period.
4. The coincidence of average appliance demand to summer system peak equals 1 for demand impacts for all appliances reflecting embedded coincidence in the DSav factor.
5. Energy savings represent the difference between the weighted average eligible ENERGY STAR V4.1 models (132 kWh) and minimum requirements of the 2012 voluntary agreement established by the cable industry and tied to ENERGY STAR V3.0 (88 kWh). Demand savings estimated based on a flat 8760 hours of use during the year. On average, demand savings are the same for both Active and Standby states and is based on 8760 hours usage.
6. 2010 NYSERDA Measure Characterization for Advanced Power Strips; study based on review of:
    a. Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
    b. Final Field Research Report, Ecos Consulting, October 31, 2006; prepared for California Energy Commission's PIER Program.
    c. Developing and Testing Low Power Mode Measurement Methods, Lawrence Berkeley National Laboratory (LBNL), September 2004; prepared for California Energy

       Commission's Public Interest Energy Research (PIER) Program.
    d. 2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March 2006.

7. Energy savings estimates are based on a California Plug Load Research Center report, “Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive.” Demand savings estimated based on a flat 8760 hours of use during the year. Savings for Tier 2 APS are temporarily included pending additional support.
8. 2011 Efficiency Vermont Load shape for Advanced Power Strips.
9. NEEP, *Mid-Atlantic Technical Reference Manual*, V6, May 2016.

Residential ENERGY STAR Room Air Conditioner

This measure relates to the purchase and installation of a room air conditioning unit that meets the ENERGY STAR minimum qualifying efficiency specifications as presented in this section. Note that if the AC unit is connected to a network in a way so as to enable it to respond to energy related commands, there is a 5% extra CEER allowance. In these instances, the efficient CEER would be 0.95 multiplied by the appropriate CEER from the table below.

<u>Algorithms</u>

$$\text{Energy Savings } \left(\frac{\text{kWh}}{\text{yr}}\right) = (\text{EFLH}_c * \text{BTU/hour} * (1/\text{CEER}_{\text{base}} - 1/\text{CEER}_{\text{ee}}))/1{,}000$$

$$\text{Peak Demand Savings (kW)} = \text{BTU/hour} * (1/\text{CEER}_{\text{base}} - 1/\text{CEER}_{\text{ee}})/1{,}000 * \text{CF}$$

<u>Definition of Variables</u>

$EFLH_c$ = Equivalent Full Load Hours of operation for the average unit during the cooling season
BTU/hour = Size of rebated unit
$CEER_{base}$ = Efficiency of baseline unit in BTUs per Watt-hour
$CEER_{ee}$ = Efficiency of ENERGY STAR unit in BTUs per Watt-hour
CF = Coincidence Factor

<u>Summary of Inputs</u>

Residential ENERGY STAR Room Air Conditioner

Component	Type	Value	Source
$EFLH_c$	Fixed	600	1
BTU/hour[47]	Variable	When available, the actual size of the rebated unit should be used in the calculation. In the absence of this data, the following default value can be used: 8,500	Application, 2
$CEER_{base}$[48]	Variable	See table below. If average deemed value required use 11.0	2

[47] Based on maximum capacity average from RLW Report: Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008, p. 22.

[48] Minimum Federal Standard for most common Room AC type – <8000 capacity range with louvered sides.

Component	Type	Value	Source
$CEER_{ee}$[49]	Variable	See table below. If average deemed value required use 12.0 for an ENERGY STAR unit	2
CF_{RAC}	Fixed	0.31	2

Standard and ENERGY STAR CEER Values for Room Air Conditioner

Product Type and Class (BTU/hour)		Federal Standard with louvered sides (CEER)	Federal Standard without louvered sides (CEER)	ENERGY STAR with louvered sides (CEER)	ENERGY STAR without louvered sides (CEER)
Without Reverse Cycle	< 6,000	11.0	10	12.1	11.0
	6,000 to 7,999	11	10	12.1	11.0
	8,000 to 10,999	10.9	9.6	12.0	10.6
	11,000 to 13,999	10.9	9.5	12.0	10.5
	14000 to 19,999	10.7	9.3	11.8	10.2
	20,000 to 27,999	9.4	9.4	10.3	10.3
	= 28,000	9.0	9.4	9.9	10.3
With Reverse Cycle	<14,000		9.3		10.2
	= 14,000		8.7		9.6
	< 20,000	9.8	N/A	10.8	N/A
	=20,000	9.3	N/A	10.2	N/A
Casement only		9.5		10.5	
Casement-Slider		10.4		11.4	

Sources

1. VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.
2. NEEP, *Mid-Atlantic Technical Reference Manual*, V9. October 2019, pp 77-80.

[49] Minimum qualifying for ENERGY STAR most common Room AC type – 8000-14,999 capacity range with louvered sides.

3. Energy Star Standards are from https://www.energystar.gov/products/heating_cooling/air_conditioning_room/key_product_criteria and Minimum Federal Standards from https://www.regulations.gov/document?D=EERE-2014-BT-STD-0059-0001.

Residential ENERGY STAR Dehumidifier

Description

This measure relates to the purchase and installation of an ENERGY STAR dehumidifier in lieu of a dehumidifier meeting federal minimum efficiency standards.

Savings

The baseline for this measure is a new dehumidifier meeting minimum Federal Standard efficiency based on capacity. The efficient case is a new unit meeting ENERGY STAR v5.0 key performance criteria. Savings are calculated based on assumed hours of operation (1632) and a summer peak coincidence factor of 0.37.

Algorithms

Energy Savings (kWh/yr) = Cap * 0.473 / 24 * Hrs * (1/(L/kWh_base)-1/(L/kWh_ee)

Peak Demand Savings (kW) = kWh Savings / Hrs * CF

Definition of Variables

Cap = Equipment capacity to remove moisture, in pints/day
0.473 = Conversion factor from pints to liters
24 = Hours per Day
Hrs = Annual operating hours
L/kWh_base = Federal Standard energy factor, in Liters per kWh
L/kWh_ee = ENERGY STAR energy factor, in Liters per kWh
CF = Coincidence Factor

Summary of Inputs

Component	Type	Value	Source
Cap	Variable	From Application. If unknown use default value from table below based on capacity range.	Rebate Application
Hrs	Fixed	2,160	e
L/kWh_base	Variable	See Table Below	2
L/kWh_ee	Variable	See Table Below	3
CF_{DH}	Fixed	37%	4
24	Fixed	Conversion	
0.473	Fixed	Conversion	

Energy Factors Table

Capacity Range (Pints/Day)	Federal Standard Minimum Energy Factor (L/kWh)	ENERGY STAR v5.0 Minimum Energy Factor (L/kWh)
0 to 25	1.3	1.57
> 25 to 50	1.6	1.8
> 50 to 75	2.8	3.3
> 75 to 185	2.8	3.3

Default Capacity, if unknown, and Energy Savings

Capacity Range (Pints/Day)	Capacity Assumed for Calculations	Federal Standard Energy Consumption (kWh/yr)	ENERGY STAR v5.0 Energy Consumption (kWh/yr)	Energy Savings (kWh/yr)	Demand Savings (kW)
0 to 25	20	495	410	85	0.0193
> 25 to 50	37	744	661	83	0.0187
> 50 to 75	62	712	604	108	0.0245
> 75 to 185	130	1,493	1,267	226	0.0513

Sources

1. Mattison, L., and D. Korn. 2012. Dehumidifiers: A Major Consumer of Residential Electricity. The Cadmus Group, Inc. August. At American Council for an Energy Efficient Economy, ACEEE Summer Study on Energy Efficiency in Buildings.
2. US Government Publishing Office, June 2017, *Electronic Code of Federal Regulations – Title 10, Chapter II, Subchapter D, Part 430, Subpart C §430.32(v)(2).* Available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=f32adaae941796de71c3efc014c2cebe&mc=true&node=pt10.3.430&rgn=div5#ap10.3.430_127.x1
3. Minimum efficiency for ENERGY STAR Program Requirements Product Specification for Dehumidifiers, Eligibility Criteria Version 5.0, effective October 31, 2019. Available at: https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Dehumidifiers%20Version%205.0%20Program%20Requirements_0.pdf
4. The Coincidence Factor derivation assumes usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September, totaling 4,392 possible operating hours. Summer peak is therefore calculated 1,632/4,392 = 0.372

Residential ENERGY STAR Lighting

Savings from the installation of screw-in ENERGY STAR CFLs, ENERGY STAR LED lamps, ENERGY STAR fluorescent torchieres, ENERGY STAR specialty LED fixtures, ENERGY STAR fixtures are based on a straightforward algorithm that calculates the difference between the baseline lamp/fixture wattage and new lamp/fixture wattage, and the average daily hours of usage for the lighting unit being replaced.

Using the tables provided in this section, the baseline lamp wattage reflects the input wattage associated with a lamp that is compliant with the corresponding standards included in the Energy and Independence and Security Act of 2007.

The coincidence factor (CF) discounts the peak demand savings to reflect the kW reduction realized during the summer on-peak demand period. This is based on typical operating schedules for the geographical area covered by the program.

HVAC interactive factors are applied to capture the additional savings or penalty associated with the impact of lighting measures on the building's HVAC system. A reduction in lighting load will result in additional cooling savings during the summer period, and a gas heating penalty during the winter period.

Algorithms

$$\text{Energy Savings }\left(\frac{\text{kWh}}{\text{yr}}\right) = \frac{(\text{Watts}_\text{b} * \text{Qty}_\text{b}) - (\text{Watts}_\text{q} * \text{Qty}_\text{q})}{1{,}000\,\frac{\text{Watts}}{\text{kW}}} * \text{Hrs} * (1 + \text{HVAC}_\text{e})$$

$$\text{Peak Demand Savings (kW)} = \frac{(\text{Watts}_\text{b} * \text{Qty}_\text{b}) - (\text{Watts}_\text{q} * \text{Qty}_\text{q})}{1{,}000\,\frac{\text{Watts}}{\text{kW}}} * CF * (1 + \text{HVAC}_\text{d})$$

$$\text{Fuel Penalty}\left(\frac{\text{MMBtu}}{\text{yr}}\right) = -\frac{(\text{Watts}_\text{b} * \text{Qty}_\text{b}) - (\text{Watts}_\text{q} * \text{Qty}_\text{q})}{1{,}000\,\frac{\text{Watts}}{\text{kW}}} * Hrs * \text{HF} * \left(\frac{0.003412}{\text{nHeat}}\right) * \%\text{FH}$$

Definition of Variables

Watts_b = Wattage of baseline connected fixture or lamp

Watts_q = Wattage of qualifying connected fixture or lamp

Qty_b = Quantity of baseline fixtures or lamps

Qty_q = Quantity of qualifying fixtures or lamps

Hrs = Annual lighting operating hours

CF = Coincidence factor

$HVAC_e$ = HVAC interaction factor for electric energy savings
$HVAC_d$ = HVAC interaction factor for peak demand reduction
HF = Heating factor, or percentage of lighting savings that must be heated
nHeat = Efficiency of heating system
%FH = Percentage of homes using fossil fuel heat

Summary of Inputs

Residential ENERGY STAR Lighting

Component	Type	Value	Source
$Watts_b$	Variable	See Tables below	2
$Watts_q$	Variable	Actual Lamp/Fixture Wattage	Application
Qty_b	Variable	Actual Lamp/Fixture Quantity	Application
Qty_q	Variable	Actual Lamp/Fixture Quantity	Application
Hrs	Variable	Interior: 679 hrs Exterior: 1,643 hrs	1
CF	Fixed	0.06	1
$HVAC_e$[50]	Fixed	0.023	1
$HVAC_d$[51]	Fixed	0.155	1
HF	Fixed	Interior: 0.47 Exterior: 0.00	1
nHeat[52]	Fixed	0.8	1
%FH[53]	Fixed	0.8	

[50] Derived based on assumptions found in the NEEP Mid-Atlantic TRM V9.

For electric cooling interactivity, value based on NEEP Mid-Atlantic TRM V9, p. 22: Calculated using defaults assuming 89% of homes have electric cooling (per RECS 2015 data) with an average 3.8 COP and a cooling load reduction of 33% of lighting savings; 0.89*(0.33 / 3.8) = 0.077

For electric heating interactivity, value based on NEEP Mid-Atlantic TRM V9, p. 22: Calculated using defaults assuming 20% of homes are electrically heated (per RECS 2015 data) with an average 1.74 COP and a heating load increase of 47% of lighting savings; -0.20*(0.47 / 1.74) = -0.054

Value of $HVAC_e$ established as the summation of these values; 0.077 – 0.054 = 0.023

[51] From NEEP Mid-Atlantic TRM V9, p. 24: Calculated using defaults assuming 89% of homes have electric cooling (per RECS 2015 data) with an average 3.8 COP and peak cooling load reduction of 66% of lighting savings; 0.89*(0.66 / 3.8) = 0.155

[52] 10 CFR 430.32 (e)(ii); minimum AFUE for residential non-weatherized gas furnaces.

[53] Based on RECS 2015 data for Middle Atlantic Region (Table HC6.7).

Standard CFL and LED Lamp Wattage Equivalency

Minimum Lumens	Maximum Lumens	$Watts_b$
4000	6000	300
3001	3999	200
2550	3000	150
2000	2549	125
1600	1999	72
1100	1599	53
800	1099	43
450	799	29
250	449	25

Decorative and non-G40 Globe CFL and LED Lamp Wattage Equivalency

	Minimum Lumens	Maximum Lumens	$Watts_b$
Decorative	500	699	43
Non-G40 Globe	500	574	43
	575	649	53
	650	1099	72
	1100	1300	150

Specialty LED Fixtures

Some LED products do not allow for a fixture-to-fixture comparison due to unique form factors, such as LED rope lights, sign lighting, and cove lighting.

In these instances, a similar savings and demand algorithm may be used, however with a different metric other than fixture quantity entered. For example, a comparison of watts per linear foot between LED and incandescent technologies would result in accurate energy savings calculations.

Algorithms

$$\text{Energy Savings } \left(\frac{\text{kWh}}{\text{yr}}\right) = \Delta\text{kW} * \text{Hrs} * (1 + \text{HVAC}_\text{e})$$

$$\text{Peak Demand Savings (kW)} = \Delta\text{kW} * \text{CF} * (1 + \text{HVAC}_\text{d})$$

$$\text{Fuel Penalty}\left(\frac{\text{MMBtu}}{\text{yr}}\right) = -\frac{(\text{Watts}_b * \text{Qty}_b) - (\text{Watts}_q * \text{Qty}_q)}{1{,}000\frac{\text{Watts}}{\text{kW}}} * \text{Hrs} * \text{HF} * \left(\frac{0.003412}{\text{nHeat}}\right) * \%\text{FH}$$

where:

$$\Delta kW = (linear\ feet\ of\ replaced\ lighting) * (baseline\ fixture\ wattage\ of\ lighting\ per\ foot) - (linear\ feet\ of\ installed\ LED\ lighting) * (wattage\ of\ new\ LED\ lighting\ per\ foot)$$

The remaining variables are unchanged from those presented above in the Summary of Inputs.

<u>Sources</u>

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V9. May 2019.,
2. NEEP, *Mid-Atlantic Technical Reference Manual*, V6. May 2016, p. 21, pp. 30–31, 38–39, 46–47, 51–52, and 59–60. From the NEEP Mid-Atlantic TRM: "Base wattage is based upon the post first phase of EISA wattage and wattage bins consistent with ENERGY STAR, v1.1."

Appliance Recycling Program

Protocols

The following sections detail savings calculations ENERGY STAR Appliance Recycling program.The general form of the equation for the Appliance Recycling Program savings algorithm is:

Number of Units * Savings per Unit

To determine resource savings, the per unit estimates in the protocols will be multiplied by the number of appliance units.

<u>Algorithm</u>

Energy Savings (kWh/yr) = $ESav_{RetFridge,RetFreezer,\ RAC,\ DEH}$

Peak Demand Savings (kW) = $DSav_{RetFridge,RetFreezer,\ RAC,\ DEH}$

<u>Definition of Terms</u>

$ESav_{RetFridge}$ = Gross annual energy savings per unit retired refrigerator

$ESav_{RetFreezer}$ = Gross annual energy savings per unit retired freezer

$ESav_{RAC}$ = Gross annual energy savings per unit retired room air conditioner

$ESav_{DEH}$ = Gross annual energy savings per unit retired dehumidifier

$DSav_{RetFridge}$ = Summer demand savings per retired refrigerator

$DSav_{RetFreezer}$ = Summer demand savings per retired freezer

$DSav_{RAC}$ = Summer demand savings per retired room air conditioner

$DSav_{DEH}$ = Summer demand savings per retired dehumidifier

$CF_{RetFridge,\ RAC,\ DEH}$ = Summer demand coincidence factor.

<u>Summary of Inputs</u>

Refrigerator/Freezer Recycling

Component	Type	Value	Source
$ESav_{RetFridge}$	Fixed	1,098 kWh	1
$ESav_{RetFreezer}$	Fixed	715 kWh	1
$ESav_{RAC}$	Fixed	89 kWh	1
$ESav_{DEH}$	Fixed	168 kWh	3
$DSav_{RetFridge}$	Fixed	0.164 kW	1,2
$DSav_{RetFreezer}$	Fixed	0.107 kW	1,2
$DSav_{RAC}$	Fixed	0.09 kW	1,2
$DSav_{DEH}$	Fixed	0.04 kW	3
$CF_{RetFridge,DEH}$	Fixed	1	1,2,3
CF_{RAC}	Fixed	0.31	1,2

Sources

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V9. October 2019.
2. Coincidence factor already embedded in summer peak demand reduction estimates
3. Rhode Island TRM 2020 Program Year - http://rieermc.ri.gov/wp-content/uploads/2019/11/ngrid-ri-2020-trm.pdf

   Dehumidifier value is from this source.

Residential Existing Homes Program

Protocols

The Residential Existing Homes Program section includes algorithms for Residential Electric HVAC, Residential Gas HVAC, and Home Performance with ENERGY STAR sections of previous version of the protocols. These protocols merge under the new Existing Homes Program as prescriptive single and bundled measures, including HVAC, enclosure, and whole house performance based (i.e., modeled savings).

Ductless, Mini-Ducted or Hybrid Heat Pump Systems

If installation of the Ductless, Mini-Ducted, or Hybrid system – furnace with heat pump will fully displace (fuel switching) or partially displace (as a secondary fuel source) the existing space heating and cooling load(s), the following algorithms shall be used:

Algorithms:

Displacing/replacing electric heat:

Cooling Energy Savings (kWh) = Cap_c * (1/$SEER_b$ * (1 + DuctSF * DL_c) – 1/$SEER_q$) * $EFLH_c$ / 1,000 W/kW

Heating Energy Savings (kWh) = Cap_h * (1/$HSPF_b$ * (1 + DuctSF* DL_h) – 1/$HSPF_q$) * $EFLH_h$ / 1,000 W/kW

Peak Demand Savings (kW) = Cap_c * (1/EER_b * (1 + DuctSF * DL_c) – 1/EER_q) / 1,000 W/kW * CF

Displacing/replacing Natural Gas, Fuel Oil, or Propane heat:

Cooling Energy Savings (kWh) = Cap_c * (1/$SEER_b$ * (1 + DuctSF * DL_c) – 1/$SEER_q$) * $EFLH_c$ / 1,000 W/kW

Heating Energy Savings (kWh) = Cap_h * (1/$HSPF_q$) * $EFLH_h$

Peak Demand Savings (kW) = Cap_c * (1/EER_b * (1 + DuctSF * DL_c) – 1/EER_q) / 1,000 W/kW * CF

If the existing heat system is gas fired, the savings from the measure represent the displaced gas heating consumption, and the ductless heat pump represents added electric load:

Heating Energy Savings (therm or gal) = HeatLoadFFReplaced * (1 + DuctSF * DL_h)

where,

HeatLoadFFReplaced = Heating load fossil fuel that the heat pump will now provide in place of Existing Fuel unit = (Cap_h * $EFLH_h$ *Econ)/ Fuel BTU / AFUE

Definition of Variables:

Cap_c = Heat pump Cooling capacity rating in Btu/h

$SEER_b$ = The Seasonal Energy Efficiency Ratio of the Baseline Unit.

$SEER_q$	= The Seasonal Energy Efficiency Ratio of the Qualifying unit being installed. This data is obtained from the Application Form
DuctSF	= The Duct Sealing Factor or the assumed savings due to proper sealing of all cooling and heating ducts
DL	= Duck leakage unit factor (cooling or heating)
EFLH	= The Equivalent Full Load Hours of operation for the average unit (cooling or heating)
Cap_h	= Output heat pump Heating capacity rating in Btu/h
$HSPF_b$	= The Heating Seasonal Performance Factor of the Baseline Unit.
$HSPF_q$	= The Heating Seasonal Performance Factor of the Qualifying unit being installed. This data is obtained from the Application Form.
EER_b	= The Energy efficiency Ratio of the Baseline Unit.
EER_q	= The Energy Efficiency Ratio of the unit being installed. This data is obtained from the Application Form.
CF	= The coincidence factor which equates the installed unit's connected load to its demand at time of system peak.
Econ	= Estimated percentage of load displaced based on economic balance point of heat pump
Fuel BTU	= Conversion Factor from BTU to Appropriate Unit (gallon or therm)
AFUE	= Annual Fuel Utilization Efficiency of the existing heating system

Summary of Inputs:

Component	Type	Value	Source
Cap_c	Variable	Rated Cooling Capacity, Btu/h	Application
$SEER_b$	Fixed	Split Systems (A/C) = 13 Split Systems (HP) = 14 Single Package (A/C) = 14 Single Package (HP) = 14	1
$SEER_q$	Variable		Application
DuctSF	Fixed	18%	2
DL_c	Fixed	Ducted cooling system = 1 Cooling System not ducted = 0	Application
$EFLH_{c\text{ or }h}$	Fixed	Cooling = 600 Hours Heating = 965 Hours	3
Cap_h	Variable	Rated Heating Capacity, Btu/h	Application
$HSPF_b$	Fixed	Split Systems (HP) = 8.2 Single Package (HP) = 8.0	1
$HSPF_q$	Variable		Application
DL_h	Fixed	Ducted heating system = 1 Heating System not ducted = 0	Application
EER_b	Fixed	11.3	4
EER_q	Variable	= (11.3/13) * $SEER_q$	Application

Component	Type	Value	Source
CF	Fixed	66% *(if controlled by thermostat)* 31% *(if controlled based on "need" similar to room AC)*	5
Econ	Fized	15%	
AFUE	Variable	Gas fired boiler = 82% Oil fired boiler = 84% Weatherized gas furnace = 81% Weatherized oil furnace = 78% Mobile home gas = 80% Mobile home oil = 75% Non-weatherized gas = 80% Non-weatherized oil = 83% Electric Resistance Heating = 35%	1, 6
Fuel BTU	Variable	Natural gas = 100,000 Oil = 138,000 Propane = 92,000	

Sources:

1. US Government Publishing Office, June 2017, Electronic Code of Federal Regulations – Title 10, Chapter II, Subchapter D, Part 430, Subpart C, §430.32. Available at: https://www.ecfr.gov/cgi-bin/text-idx?SID=ab9df9a70abde4e78f69db2c17520bbf&mc=true&node=pt10.3.430&rgn=div5#se10.3.430_132
2. NEEP, "Benefits of HVAC Contractor Training," Appendix C , February 2006.
3. VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.
4. Average EER for SEER 13 units. EER = (11.3/13)*13
5. NEEP, *Mid-Atlantic Technical Reference Manual*, V9. May 2019
6. Electric resistance heating calculated by determining overall fuel cycle efficiency by dividing the average PJM heat rate (9,642 btu/kWh) by the btu's per kWh (3,413 btu/kWh), resulting in 2.38 btuin per 1 btuout.

Commercial and Industrial Energy Efficient Construction

Protocols

In general, efficiency baselines are designed to reflect current market practices - typically, the higher of applicable codes or the minimum efficiency of available new equipment - and are updated periodically to reflect upgrades in code or information from evaluation results.

Baseline data reflect ASHRAE 90.1-2007 for existing building retrofit and ASHRAE 90.1-2016 for new construction, replacement of failed equipment, end of useful life, and entire facility rehabilitation.

Building shell measures identified in an approved Local Government Energy Audit (or equivalent) are eligible for incentives through the Custom and Pay for Performance programs. Savings for these measures will vary from project to project based on factors such as building size, existing levels of insulation and infiltration levels. As a result, energy savings for these installed building shell measures will be taken from what is provided in the approved audit and/or energy analysis provided with the application submission.

Performance Lighting

For new construction and entire facility rehabilitation projects, savings are calculated by comparing the lighting power density of fixtures being installed to the baseline lighting power density, or "lighting power allowance," from the building code. For the state of New Jersey, the applicable building code is ASHRAE 90.1 2016.

Lighting equipment includes fluorescent fixtures, ballasts, compact fluorescent fixtures, LED fixtures and lamps, and high-intensity discharge fixtures such as metal halide and high pressure sodium luminaires.

Algorithms

$$\text{DkW} = (\#\ of\ replaced\ fixtures) * (Watts_b) - (\#\ of\ fixtures\ installed) * \left(Watts_q\right) = \left(LPD_b - LPD_q\right) * (\text{SF})$$

$$\text{Energy Savings}\left(\frac{\text{kWh}}{\text{yr}}\right) = (\Delta\text{kW}) * (\text{Hrs}) * (1 + HVAC_e)$$

$$\text{Peak Demand Savings (kW)} = (\Delta\text{kW}) * (\text{CF}) * (1 + HVAC_d)$$

$$\text{Fuel Savings}\left(\frac{\text{MMBtu}}{\text{yr}}\right) = (\Delta\text{kW}) * (\text{Hrs}) * (\text{HVAC}_\text{g})$$

Definition of Variables

ΔkW	= Change in connected load from baseline to efficient lighting
$Watts_{b,q}$	= Wattage of existing baseline and qualifying equipment
LPD_b	= Baseline lighting power density in Watt per square foot of space floor area
LPD_q	= Lighting power density of qualified fixtures, equal to the sum of installed fixture wattage divided by floor area of the space where the fixtures are installed.
SF	= Space floor area, in square feet
CF	= Coincidence factor
Hrs	= Annual operating hours
$HVAC_d$	= HVAC Interactive Factor for peak demand savings
$HVAC_e$	= HVAC Interactive Factor for annual energy savings
$HVAC_g$	= HVAC Interactive Factor for annual energy savings

Summary of Inputs

Lighting Verification Performance Lighting

Component	Type	Value	Source
$Watts_{b,q}$	Variable	See NGrid Fixture Wattage Table Fixture counts and types, space type, floor area from customer application.	1
SF	Variable	From Customer Application	Application
CF	Fixed	See Table by Building Type	4
Hrs	Fixed	See Table by Building Type	4
$HVAC_d$	Fixed	See Table by Building Type	3, 5
$HVAC_e$	Fixed	See Table by Building Type	3, 5
$HVAC_g$	Fixed	See Table by Building Type	6
LPD_b	Variable	Lighting Power Density for, W/SF	2
LPD_q	Variable	Lighting Power Density, W/SF	Application

Hours of Operation and Coincidence Factor by Building Type

Building Type	Sector	CF	Hours
Grocery	Large Commercial/Industrial & Small Commercial	0.96	7,134
Medical - Clinic	Large Commercial/Industrial & Small Commercial	0.8	3,909
Medical - Hospital	Large Commercial/Industrial & Small Commercial	0.8	8,760[54]
Office	Large Commercial/Industrial	0.7	2,969
	Small Commercial	0.67	2,950
Other	Large Commercial/Industrial & Small Commercial	0.66	4,573
Retail	Large Commercial/Industrial	0.96	4,920
	Small Commercial	0.86	4,926
School	Large Commercial/Industrial & Small Commercial	0.50	2,575
Warehouse/ Industrial	Large Commercial/Industrial	0.7	4,116
	Small Commercial	0.68	3,799

[54] Assumes hospital operations are year round.

Building Type	Sector	CF	Hours
Multifamily – Common Areas[55]	Multifamily	0.86	5,950
Multifamily – In-Unit[36]	Multifamily	0.59	679
Multifamily – Exterior[36]	Multifamily	0.00	3,338

HVAC Interactive Effects

Building Type	Demand Waste Heat Factor ($HVAC_d$)		Annual Energy Waste Heat Factor by Cooling/Heating Type ($HVAC_e$)			
	AC (Utility)	AC (PJM)	AC/ NonElec	AC/ ElecRes	Heat Pump	NoAC/ ElecRes
Office	0.35	0.32	0.10	-0.15	-0.06	-0.25
Retail	0.27	0.26	0.06	-0.17	-0.05	-0.23
Education	0.44	0.44	0.10	-0.19	-0.04	-0.29
Warehouse	0.22	0.23	0.02	-0.25	-0.11	-0.27
Other[56]	0.34	0.32	0.08	-0.18	-0.07	-0.26

Interactive Factor (HVACg) for Annual Fuel Savings

Project Type	Fuel Type	Impact (MMBtu/ΔkWh)
Large Retrofit (> 200 kW)	C&I Gas Heat	-0.00023
Large Retrofit (> 200 kW)	Oil	-0.00046
Small Retrofit (≤ 200 kW)	Gas Heat	-0.001075
Small Retrofit (> 200 kW)	Oil Heat	-0.000120

<u>Sources</u>

1. Device Codes and Rated Lighting System Wattage Table Retrofit Program, National Grid, January 13, 2015. https://www1.nationalgridus.com/files/AddedPDF/POA/RILightingRetrofit1.pdf

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55 NEEP Mid-Atlantic TRM V9, p. 24.

56 Per the NEEP Mid-Atlantic TRM, v7: "The 'Other' building type should be used when the building type is known but not explicitly listed above. A description of the actual building type should be recorded in the project documentation."

2. ASHRAE Standards 90.1-2016, Energy Standard for Buildings Except Low Rise Residential Buildings, Table 9.5.1; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.
3. Average HVAC interactive effects by building type derived from "EmPOWER Maryland DRAFT Final Impact Evaluation Report Evaluation Year 4 (June 1, 2012 – May 31, 2013) Commercial & Industrial Prescriptive & Small Business Programs, Navigant, March 31, 2014. Values for Washington, D.C. and Delaware assume values from Maryland, Pepco and Maryland, DPL, respectively."
4. EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1, 2017 – May 31,
2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs,
Navigant, March, 2018.
5. DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council.
6. Northeast Energy Efficiency Partnerships & KEMA, C&I Lighting Load Shape Project FINAL Report - Prepared for the Regional Evaluation, Measurement and Verification Forum. July 19, 2011.

Indoor Horticulture LED

The method below is applicable to the installation of new DLC-qualified LED fixtures intended for indoor horticultural use. This method shall be used only for New Construction or fixture additions. Fixture replacements in indoor horticulture facilities shall utilize the standard method delineated in the Prescriptive Lighting section above.

<u>Algorithms</u>

$$\Delta \text{kW} = (\# \; of \; replaced \; fixtures) * (Watts_b) - (\# \; of \; fixtures \; installed) * (Watts_q)$$

$$(\# \; of \; replaced \; fixtures) = \frac{(\# \; of \; fixtures \; installed) * (Watts_q) * \frac{\mu mol}{J}_q}{(Watts_b) * \frac{\mu mol}{J}_b}$$

$$\text{Energy Savings} \left(\frac{\text{kWh}}{\text{yr}}\right) = (\Delta \text{kW}) * (Hrs) * (1 + HVAC_e)$$

$$\text{Peak Demand Savings (kW)} = (\Delta \text{kW}) * (CF) * (1 + HVAC_d)$$

<u>Definition of Variables</u>

ΔkW = Change in connected load from baseline to efficient lighting level.

$Watts_{b,q}$ = Wattage of existing baseline and qualifying equipment. Baseline wattage dependent upon qualifying equipment wattage.

$\mu mol/J_{b,q}$ = Photosynthetic photon efficacy measured

CF = Coincidence factor

Hrs = Annual hours of operation

$HVAC_d$ = HVAC interactive factor for peak demand savings

$HVAC_e$ = HVAC interactive factor for annual energy savings

<u>Summary of Inputs</u>

Indoor Horticulture LED for Commercial Customers

Component	Type	Value	Source
$Watts_b$	Variable	$Watts_q < 500 = 600$ $Watts_q > 500 = 1000$	1
$Watts_q$	Variable	From Customer Application, DLC	Application
$\mu mol/J_b$	Fixed	1.7	2, 3
$\mu mol/J_q$	Variable	From Customer Application, DLC	Application
CF	Fixed	1	4

Component	Type	Value	Source
Hrs	Variable	From Customer Application	Application
$HVAC_d$	Fixed	-0.49	4
$HVAC_e$	Fixed	0.43	4

Sources

1. LED and HID Horticultural Luminaire Testing Report, Lighting research Center, Rensselaer Polytechnic Institute, May 3, 2018; available at: https://www.lrc.rpi.edu/programs/energy/pdf/HorticulturalLightingReport-Final.pdf
2. Plant Lighting Efficiency and Efficacy; µmols per joule, Greenhouse Product News: https://gpnmag.com/article/plant-lighting-efficiency-and-efficacy-%CE%BCmol%C2%B7j-%C2%B9/
3. LED Grow Light Buyer's Guide, Chilled Grow Lights: https://chilledgrowlights.com/education/led_buyers_guide
4. Indoor Horticulture Lighting Study, Sacramento Municipal Utility District, March 14, 2018; available at: https://www.smud.org/-/media/Documents/Business-Solutions-and-Rebates/Advanced-Tech-Solutions/LED-Reports/Amplified-Farms-Indoor-Horticulture-LED-Study-Final.ashx.

Motors

For premium efficiency motors 1-200 HP.

Algorithms

From application form calculate ΔkW where:

$$\Delta kW = 0.746 * HP * IF_{VFD} * (1/\eta_{base} - 1/\eta_{prem})$$

Demand Savings = (ΔkW) * CF

Energy Savings = (ΔkW)*HRS * LF

Definition of Variables

ΔkW = kW Savings at full load

HP = Rated horsepower of qualifying motor, from nameplate/manufacturer specs.

LF = Load Factor, percent of full load at typical operating condition

IF_{VFD} = VFD Interaction Factor, 1.0 without VFD, 0.9 with VFD

η_{base} = Efficiency of the baseline motor

η_{prem} = Efficiency of the energy-efficient motor

HRS = Annual operating hours

CF = Coincidence Factor

Component	**Type**	**Value**	**Source**
HP	Variable	Nameplate/Manufacturer Spec. Sheet	Application
LF	Fixed	0.75	1
η_{base}	Fixed	ASHRAE 90.1-2016 Baseline Efficiency Table	ASHRAE
η_{prem}	Variable	Nameplate/Manufacturer Spec. Sheet	Application
IF_{VFD}	Fixed	1.0 or 0.9	3
Efficiency - η_{ee}	Variable	Nameplate/Manufacturer Spec. Sheet	Application
CF	Fixed	0.74	1
HRS	Fixed	Annual Operating Hours Table	1

NEMA ASHRAE 90.1-2016 Motor Efficiency Table – General Purpose Subtype I (Adapted from Table 10.8-1)

Motor Horsepower	**1200 RPM (6 pole)**		**1800 RPM (4 pole)**		**3600 RPM (2 pole)**	
	ODP	**TEFC**	**ODP**	**TEFC**	**ODP**	**TEFC**

1	.825	.825	.855	.855	.77	.77
1.5	.865	.875	.865	.865	.84	.84
2	.875	.885	.865	.865	.855	.855
3	.885	.895	.895	.895	.855	.865
5	.895	.895	.895	.895	.865	.885
7.5	.902	.91	.91	.917	.885	.895
10	.917	.91	.917	.917	.895	.902
15	.917	.917	.93	.924	.902	.91
20	.924	.917	.93	.930	.91	.91
25	.93	.93	.936	.936	.917	.917
30	.936	.93	.941	.936	.917	.917
40	.941	.941	.941	.941	.924	.924
50	.941	.941	.945	.945	.93	.93
60	.945	.945	.95	.950	.936	.936
75	.945	.945	.95	.954	.936	.936
100	.95	.95	.954	.954	.936	.941
125	.95	.95	.954	.954	.941	.95
150	.954	.958	.958	.958	.941	.95
200	.954	.958	.958	.962	.95	.954

Annual Operating Hours Table

Motor Horsepower	Operating Hours, HRS
1 to 5 HP	2,745
6 to 20 HP	3,391
21 to 50 HP	4,067
51 to 100 HP	5,329
101 to 200 HP	5,200

Electric HVAC Systems

This measure provides energy and demand savings algorithms for C&I Electric HVAC systems. The type of systems included in this measure are: split systems, single package systems, air to air cooled heat pumps, packaged terminal systems (PTAC and PTHP), single package vertical systems (SPVAC and SPVHP), central DX AC systems, water source heat pumps, ground water source heat pumps, and/or ground source heat pumps.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline unit is a code compliant unit with an efficiency as required by ASHRAE Std. 90.1 – 2016, which is the current code adopted by the state of New Jersey.

<u>Algorithms</u>

Air Conditioning Algorithms:

Energy Savings (kWh/yr) = N * Tons * 12 kBtuh/Ton * ($1/EER_b$-$1/EER_q$) * $EFLH_c$

Peak Demand Savings (kW) = N * Tons * 12 kBtuh/Ton * ($1/EER_b$-$1/EER_q$) * CF

Heat Pump Algorithms:

Cooling Energy Savings (kWh/yr) = N * Tons * 12 kBtuh/Ton * ($1/EER_b$-$1/EER_q$) * $EFLH_c$

Heating Energy Savings (Btu/yr) = N * Tons * 12 kBtuh/Ton * ((1/ (COP_b * 3.412))-(1/ (COP_q * 3.412)) * $EFLH_h$

Where $_c$ is for cooling and $_h$ is for heating.

<u>Definition of Variables</u>

N = Number of units

Tons = Rated cooling capacity of unit.This value comes from ARI/AHRI or AHAM rating or manufacturer data.

EER_b = Energy Efficiency Ratio of the baseline unit. This data is found in the HVAC and Heat Pumps table below. For units < 65,000 BtuH (5.4 tons), SEER should be used in place of EER.

COP_b = Coefficient of Performance of the baseline unit. This data is found in the HVAC and Heat Pumps table below. For units < 65,000 BtuH (5.4 tons), SEER and HSPF/3.412 should be used in place of COP * 3.412 for cooling and heating savings, respectively.

EER_q = Energy Efficiency Ratio of the high efficiency unit. This value comes from the ARI/AHRI or AHAM directories or manufacturer data. For units < 65,000 (5.4 tons) BtuH, SEER should be used in place of EER.

COP_q = Coefficient of Performance of the high efficiency unit. This value comes from the ARI/AHRI or AHAM directories or manufacturer data. For units < 65,000 BtuH

(5.4 tons), SEER and HSPF/3.412 should be used in place of COP * 3.412 for cooling and heating savings, respectively.

CF = Coincidence Factor – This value represents the percentage of the total load which is on during electric system's Peak Window. This value is based on existing measured usage and determined as the average number of operating hours during the peak window period.

$EFLH_{c\ or\ h}$ = Equivalent Full Load Hours – This represents a measure of energy use by season during the on-peak and off-peak periods.

Summary of Inputs

HVAC and Heat Pumps

Component	Type	Value	Source
Tons	Variable	Rated Capacity, Tons	Application
EER_b	Variable	See Table below	1
EER_q	Variable	ARI/AHRI or AHAM Values	Application
CF	Fixed	50%	2
$EFLH_{(c\ or\ h)}$	Variable	See Tables below	3

HVAC Baseline Efficiencies Table – New Construction/EUL/RoF

Equipment Type	Baseline = ASHRAE Std. 90.1 – 2016
Unitary HVAC/Split Systems and Single Package, Air Cooled	
<=5.4 tons, split	14 SEER
<=5.4 tons, single	14 SEER
>5.4 to 11.25 tons	11.0 EER, 12.7 IEER
>11.25 to 20 tons	10.8 EER, 12.2 IEER
> 21 to 63 tons	9.8 EER, 11.4 IEER
>63 Tons	9.5 EER, 11.0 IEER
Air Cooled Heat Pump Systems, Split System and Single Package	
<=5.4 tons, split	14 SEER, 8.2 HSPF
<=5.4 tons, single	14 SEER, 8.0 HSPF
>5.4 to 11.25 tons	10.8 EER, 12 IEER, 3.3 heating COP
>11.25 to 20 tons	10.4 EER, 11.4 IEER, 3.2 heating COP
>= 21	9.3 EER, 10.4 IEER, 3.2 heating COP

Equipment Type	Baseline = ASHRAE Std. 90.1 – 2016
Water Source Heat Pumps (water to air, water loop) <=1.4 tons >1.4 to 5.4 tons >5.4 to 11.25 tons	 12.2 EER, 4.3 heating COP 13.0 EER, 4.3 heating COP 13.0 EER, 4.3 heating COP
Ground Water Source Heat Pumps <=11.25 tons	18.0 EER, 3.7 heating COP
Ground Source Heat Pumps (brine to air, ground loop) <=11.25 tons	14.1 EER, 3.2 heating COP
Package Terminal Air Conditioners[57]	14.0 – (0.300 * Cap/1,000), EER
Package Terminal Heat Pumps	14.0 – (0.300 * Cap/1,000), EER 3.7 – (0.052 * Cap/1,000), heating COP
Single Package Vertical Air Conditioners <=5.4 tons >5.4 to 11.25 tons >11.25 to 20 tons	 10.0 EER 10.0 EER 10.0 EER
Single Package Vertical Heat Pumps <=5.4 tons >5.4 to 11.25 tons >11.25 to 20 tons	 10.0 EER, 3.0 heating COP 10.0 EER, 3.0 heating COP 10.0 EER, 3.0 heating COP

EFLH Table

Facility Type	Heating $EFLH_h$	Cooling $EFLH_c$
Assembly	603	669
Auto repair	1910	426
Dormitory	465	800
Hospital	3366	1424
Light industrial	714	549
Lodging – Hotel	1077	2918
Lodging – Motel	619	1233
Office – large	2034	720
Office – small	431	955

[57] Cap means the rated cooling capacity of the product in Btu/h.

Facility Type	Heating $EFLH_h$	Cooling $EFLH_c$
Other	681	736
Religious worship	722	279
Restaurant – fast food	813	645
Restaurant – full service	821	574
Retail – big box	191	1279
Retail – Grocery	191	1279
Retail – small	545	882
Retail – large	2101	1068
School – Community college	1431	846
School – postsecondary	1191	1208
School – primary	840	394
School – secondary	901	466
Warehouse	452	400

Multi-family EFLH by Vintage

Facility Type	Prior to 1979	From 1979 to 2006	From 2007 through Present
Low-rise, Cooling	507	550	562
Low-rise, Heating	757	723	503
High-rise, Cooling	793	843	954
High-rise, Heating	526	395	219

Sources

1. ASHRAE Standards 90.1-2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.
2. C&I Unitary HVAC Load Shape Project Final Report. August 2011, v.1.1, p. 12, Table O-5. The CF reported here is a center point for NJ chosen between the CF for urban NY and for the Mid-Atlantic region in the PJM peak periods. Available at: http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf.
3. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V7, April 2019. Appendix G – Equivalent

Full-Load Hours (EFLH), For Heating and Cooling. Page 675-680. EFLH values for NYC due to proximity to NJ.

Electric Chillers

The measurement of energy and demand savings for C&I chillers is based on algorithms with key variables.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline unit is a code compliant unit with an efficiency as required by ASHRAE Std. 90.1 – 2016, which is the current code adopted by the state of New Jersey.

Algorithms

For IPLV:

Energy Savings (kWh/yr) = N * Tons * EFLH * ($IPLV_b$ – $IPLV_q$)

Peak Demand Savings (kW) = N * Tons * PDC * ($IPLV_b$ – $IPLV_q$)

For FLV:

Energy Savings (kWh/yr) = N * Tons * EFLH * (FLV_b – FLV_q)

Peak Demand Savings (kW) = N * Tons * PDC * (FLV_b – FLV_q)

Definition of Variables

N = Number of units

Tons = Rated capacity of coolling equipment.

EFLH = Equivalent Full Load Hours – This represents a measure of energy use by season during the on-peak and off peak periods.

PDC = Peak Duty Cycle: fraction of time the compressor runs during peak hours

$IPLV_b$ = Integrated Part Load Value of baseline equipment, kW/Ton. The efficiency of the chiller under partial-load conditions.

$IPLV_q$ = Integrated Part Load Value of qualifying equipment, kW/Ton. The efficiency of the chiller under partial-load conditions.

FLV_b = Full Load Value of baseline equipment, kW/Ton. The efficiency of the chiller under full-load conditions.

FLV_q = Full Load Value of qualifying equipment, kW/Ton. The efficiency of the chiller under full-load conditions.

Summary of Inputs

Electric Chiller Assumptions

Electric Chillers Component	Type	Situation	Value	Source
Tons	Rated Capacity, Tons	All	Varies	From Application
$IPLV_b$ (kW/ton)	Variable	See table below	Varies	1

Electric Chillers Component	Type	Situation	Value	Source
$IPLV_q$ (kW/ton)	Variable	All	Varies	From Application (per AHRI Std. 550/590)
FLV_b (kW/ton)	Variable	See table below	Varies	1
FLV_q (kW/ton)	Variable	All	Varies	From Application (per AHRI Std. 550/590)
PDC	Fixed	All	67%	Engineering Estimate
EFLH	Variable	All	See Table Below	2

Electric Chillers – New Construction

Type	Capacity	ASHRAE 90.1 2016 Table 6.8.1-3) Path A Full Load kW/ton	Path A IPLV kW/ton	Path B Full Load kW/ton	Path B IPLV kW/ton
Air Cooled	tons < 150	*10.1* 1.188	*13.7* 0.876	*9.7* 1.237	*15.8* 0.759
	tons ≥ 150	*10.1* 1.188	*14.0* 0.857	*9.7* 1.237	*16.1* 0.745
Water Cooled Positive Displacement (rotary screw and scroll)	tons < 75	0.750	0.600	0.780	0.500
	75 ≤ tons < 150	0.720	0.560	0.750	0.490
	150 ≤ tons < 300	0.660	0.540	0.680	0.440
	300 ≤ tons < 600	0.610	0.520	0.625	0.410
	tons ≥ 600	0.560	0.500	0.585	0.380
Water Cooled Centrifugal	tons < 150	0.610	0.550	0.695	0.440
	150 ≤ tons < 300	0.610	0.550	0.635	0.400
	300 ≤ tons < 400	0.560	0.520	0.595	0.390
	400 ≤ tons < 600	0.560	0.500	0.585	0.380
	tons ≥ 600	0.560	0.500	0.585	0.380

a – Values in italics are EERs.

EFLH Table

Facility Type	Cooling EFLH
Assembly	669
Auto repair	426
Dormitory	800
Hospital	1424
Light industrial	549
Lodging – Hotel	2918
Lodging – Motel	1233
Office – large	720
Office – small	955
Other	736
Religious worship	279
Restaurant – fast food	645
Restaurant – full service	574
Retail – big box	1279
Retail – Grocery	1279
Retail – small	882
Retail – large	1068
School – Community college	846
School – postsecondary	1208
School – primary	394
School – secondary	466
Warehouse	400

Multi-family EFLH by Vintage

Facility Type	Prior to 1979	From 1979 to 2006	From 2007 through Present
Low-rise, Cooling	507	550	562
High-rise, Cooling	793	843	954

<u>Sources</u>

1. ASHRAE Standards 90.1-2016. *Energy Standard for Buildings Except Low Rise Residential Buildings*. https://www.ashrae.org/standards-research--technology/standards--guidelines. Table 6.8.1-3
2. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V7, April 2019. Appendix G –

Equivalent Full-Load Hours (EFLH), For Heating and Cooling. P. 675-680.
EFLH values for NYC due to proximity to NJ.

Energy Efficient Glass Doors on Vertical Open Refrigerated Cases

This measure applies to retrofitting vertical, open, refrigerated display cases with high efficiency glass doors that have either no anti-sweat heaters ("zero energy doors"), or very low energy anti- sweat heaters. The deemed savings factors are derived from the results of a controlled test designed to measure the impact of this measure. The results of the test were presented at the 2010 International Refrigeration and Air Conditioning conference.

Algorithms

Energy Savings (kWh/yr): ΔkWh = ESF × CL

Peak Demand Savings (kW): ΔkW = ΔkWh / Hours

Heating Energy Savings: ΔTherms = HSF * CL

Definition of Variables

ΔkWh = Gross customer annual kWh savings for the measure
ΔkW = Gross customer connected load kW savings for the measure
ESF = Stipulated annual electric savings per linear foot of case
HSF = Stipulated annual heating savings factor per linear foot of case
CL = Case Length, open length of the refrigerated case in feet (from application)
Hours = Hours per year that case is in operation, use 8,760 unless otherwise indicated.

Summary of Inputs

Glass Doors - Commercial Refrigeration

Component	Type	Value	Source
ESF	Fixed	395 kWh/year-foot	Derived from the following sources: 1,2,3,4,5
HSF	Fixed	10.5 Therms/year-foot	Derived from the following sources: 1,2,3,4,5
CL	Variable		Rebate Application or Manufacturer Data
Hours	Fixed	8,760 Default	3

Sources

1. *Energy Use of Doored and Open Vertical Refrigerated Display*, Brian Fricke and Bryan Becker, University of Missouri – Kansas City, 2010; presented at the 2010

International Refrigeration and Air Conditioning Conference, School of Mechanical Engineering, Purdue University, Paper #1154; available at: http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2153&context=iracc http://docs.lib.purdue.edu/iracc/1154

2. Refrigeration COP of 2.2 used in derivation of savings factors – Kuiken et al, Focus on Energy Evaluation, Business Program: Deemed Savings Manual V 1.0, KEMA, March 22, 2010.
3. HVAC COP of 3.2 used in derivation of savings factors – ASHRAE Standards 90.1-2007 and 2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*. https://www.ashrae.org/standards-research--technology/standards--guidelines, Table 6.8.1A.
4. Gas boiler efficiency of 80% used in derivation of savings factors – ASHRAE Standards 90.1-2007 and 2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*. https://www.ashrae.org/standards-research--technology/standards--guidelines, Table 6.8.1-6.
5. DOE Typical Meteorological Year (TMY3) data for Trenton, Newark, and Atlantic City.

Floating Head Pressure Control and Floating Suction Pressure Control

This measure is applicable to the installation of refrigeration controls to lower the condensing pressure on commercial refrigeration systems during times of ambient temperatures below 75ºF.

Algorithms

Energy Savings (kWh/yr) = Tons *(ΔkWh/ton)

Definition of Variables

Tons = System tons, from manufacturer data

(ΔkWh/ton) = Electricity energy savings per ton of cooling system retrofitted based on technology type and case temperature

Summary of Inputs

Floating Head and Suction Pressure Control - Commercial Refrigeration

Component	Type	Value	Source
Ton	Variable	Manufacturer data	Application
(ΔkWh/ton)	Variable	Floating Head Pressure Control Low temperature (-35F to -5F) F = 2,376 Medium temperature (0F to 30F) F = 926	1
		Floating Suction Pressure Control Low temperature (-35F to -5F) F = 356 Medium temperature (0F to 30F) F = 139	2

Sources

1. Pennsylvania Technical Reference Manual; effective August 2019; available at http://www.puc.pa.gov/filing_resources/issues_laws_regulations/act_129_information/technical_reference_manual.aspx
2. DOE Better Buildings: Maximizing Supermarket Refrigeration System Energy Efficiency, Mitchell & Zogg

Low Flow Faucet Aerators, Showerheads, and Pre-rinse Spray Valves

The following algorithms detail savings for low-flow showerheads, faucet aerators, and pre-rinse spray valves in commercial, multi-family, and some public sectors. These devices save water heating energy by reducing the total flow rate from hot water sources.

The measurement of energy savings associated with these low-flow devices is based on algorithms with key variables obtained from analysis by the Federal Energy Management Program (FEMP), published data from the Environmental Protection Agency water conservations studies, and customer information provided on the application form. The energy values are in Btu for natural gas fired water heaters or kWh for electric water heaters.

Low Flow Faucet Aerators and Showerheads

Algorithm

Therm or kWh Fuel Savings/yr = N * M * D * (F_b – F_q) * (8.33 * DT / EFF)/ C

Definition of Variables

N = Number of fixtures

M = Minutes per day of device usage

D = Days per year of device usage

F_b = Baseline device flow rate (gal/m)

F_q = Low flow device flow rate (gal/m)

8.33 = Heat content of water (Btu/gal/°F)

DT = Difference in temperature (°F) between cold intake and output

EFF = Efficiency of water heating equipment

C = Conversion factor from Btu to therms or kWh = (100,000 for gas water heating (Therms), 3,413 for electric water heating (kWh)

Summary of Inputs

Low Flow Faucet Aerators and Showerheads

Component	Type	Value	Source
N	Variable		Application
M	Fixed	Aerators 30 minutes	1
		Shower heads 20 minutes	
D	Fixed	Aerators 260 days	1
		Shower heads 365 days	
F_b	Fixed	Aerators 2.2 gpm	
		Showerhead 2.5 gpm	
F_q	Fixed	Aerators <=1.5 gpm (kitchen) <=0.5 gpm (public restroom) <=1.5 gpm (private restroom)	2,3,4
		Showerheads <=2 gpm	4
DT	Fixed	Aerators 27.4°F	5
		Showerheads 44.4°F	6
EFF	Fixed	98% electric 80% natural gas	7,8

Sources

1. FEMP Cost Calculator; located at: https://energy.gov/eere/femp/energy-cost-calculator-faucets-and-showerheads-0#output.
2. EPA WaterSense requirements for faucet aerators; available at: https://www.epa.gov/watersense/bathroom-faucets.
3. Department of Energy, Best Management Practice #7, Faucets and Showerheads; available at: https://energy.gov/eere/femp/best-management-practice-7-faucets-and-showerheads
4. EPA WaterSense requirements for showerheads; available at: https://www.epa.gov/watersense/showerheads.
5. Based on an assumed average faucet operating temperature of 88°F per New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings*

from Energy Efficiency Programs, V7, April 2019, pg 319 and the average water inlet temperature of 60.6°F for Trenton, New Jersey derived from TMY3 weather data using the methodology presented in Burch, J., and C. Christensen, "Towards Development of an Algorithm for Mains Water Temperature," American Solar Energy Annual Conference Proceedings (2007).

6. Based on an assumed average shower temperature of 105°F per New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V7, April 2019, pg. 333 and the average water inlet temperature of 60.6°F for Trenton, New Jersey derived from TMY3 weather data using the methodology presented in Burch, J., and C. Christensen, "Towards Development of an Algorithm for Mains Water Temperature," American Solar Energy Annual Conference Proceedings (2007).
7. New York State Joint Utilities, *e*, V7, April 2019, pg. 320..
8. ASHRAE Standards 90.1-2007. *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: e.

Low Flow Pre-rinse Spray Valves

Algorithm

Therm or kWh Fuel Savings/yr = N * H * D * (F_b – F_q) * (8.33 * DT / EFF) / C

Definition of Variables

N = Number of fixtures

H = Hours per day of device usage

D = Days per year of device usage

F_b = Baseline device flow rate (gal/m)

F_q = Low flow device flow rate (gal/m)

8.33 = Heat content of water (Btu/gal/°F)

DT = Difference in temperature (°F) between cold intake and output

Eff = Percent efficiency of water heating equipment

C = Conversion factor from Btu to Therms or kWh = (100,000 for gas water heating (Therms), 3,413 for electric water heating (kWh))

Summary of Inputs

Low Flow Pre-Rinse Spray Valves

Component	Type	Value	Source
N	Variable		Application
H	Fixed	1.06 hours	1
D	Fixed	344 days	1
F_b	Fixed	1.6 gpm	2
F_q	Variable	<=1.28 gpm	3
DT	Fixed	59.4°F	4
Eff	Variable	98% electric 80% natural gas	5, 6

Sources

1. EPA WaterSense Specification for Commercial Pre-Rinse Spray Valves Supporting Statement, September 19, 2013, Appendix A, Page 7.
2. EPA Energy Policy Act of 2005, p. 40, Title I, Subtitle C.
3. EPA WaterSense Specification for Commercial Pre-Rinse Spray Valves, available at: https://www.epa.gov/watersense/pre-rinse-spray-valves.
4. Based on an assumed average PRSV operating temperature of 120°F per New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V7, April 2019, pg 324 and the average water inlet temperature of 60.6°F for Trenton, New Jersey derived from TMY3 weather data using the methodology presented in Burch, J., and C. Christensen, “Towards Development of an Algorithm for Mains Water Temperature,” American Solar Energy Annual Conference Proceedings (2007).
5. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V7, April 2019, pg. 320.
6. ASHRAE Standards 90.1-2007, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.

Food Service Measures Protocols

Energy efficient electric or natural gas cooking equipment of the following listed types utilized in commercial food service applications which have performance rated in accordance with the listed ASTM standards:

- Electric and gas combination oven/steamer – ASTM F2861
- Gas convection ovens – ASTM F1496
- Gas conveyor ovens – ASTM F1817
- Gas rack ovens – ASTM F2093
- Electric and gas small vat fryers – ASTM F1361
- Electric and gas large vat fryers – ASTM F2144
- Electric and gas steamers – ASTM F1484
- Electric and gas griddles – ASTM F1275
- Hot food holding cabinets –CEE Tier II
- Commercial dishwashers – ENERGY STARRefrigerators, Freezers – ENERGY STAR
- Ice Machines – ARI Standard 810

Electric and Gas Convection Ovens, Gas Conveyor and Rack Ovens, Steamers, Fryers, and Griddles

The measurement of energy savings for these measures are based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Energy Savings (kWh/yr or Therms/yr) = $D * (E_p + E_i + E_c)$

Peak Demand Savings (kW) = kWh Savings / $(D * H)$

Preheat Savings†: $E_p = P * (PE_b – PE_q)$

Idle Savings†: $E_i = (I_b – I_q) * ((H – (P*P_t)) – (I_b/PC_b – I_q/PC_q) * Lbs)$

Cooking Savings: $E_c = Lbs * Heat * (1/Eff_b – 1/Eff_q) / C$

† – For gas equipment, convert these intermediate values to therms by dividing the result by 100,000 Btu/therm

Definition of Variables
(See tables of values below for more information)[58]

D	= Operating Days per Year
P	= Number of Preheats per Day
PE_b	= Baseline Equipment Preheat Energy
PE_q	= Qualifying Equipment Preheat Energy
I_b	= Baseline Equipment Idle Energy Rate
I_q	= Qualifying Equipment Idle Energy Rate
H	= Daily Operating Hours
P_t	= Preheat Duration
PC_b	= Baseline Equipment Production Capacity
PC_q	= Qualifying Equipment Production Capacity
Lbs	= Total Daily Food Production
Heat	= Heat to Food
Eff_b	= Baseline Equipment Convection Mode Cooking Efficiency
Eff_q	= Qualifying Equipment Convection Mode Cooking Efficiency
C	= Conversion Factor from Btu to kWh or Therms

[58] Savings algorithm, baseline values, assumed values, and lifetimes developed from information on the Food Service Technology Center program's website, www.fishnick.com, by Fisher-Nickel, Inc., funded by California utility customers, and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission. Work paper citations under respective equipment tables.

Summary of Inputs

Table 1: Electric Convection Ovens				
Variable	***Baseline***		***Qualifying***	
	Full Size	*Half Size*	*Full Size*	*Half Size*
D - Operating Days per Year	Table 11	Table 11	Table 11	Table 11
P - Number of Preheats per Day	1	1	1	1
PE_b & PE_q - Preheat Energy (kWh)	1.50	1.00	1.00	0.90
I_b & I_q - Idle Energy Rate (kW)	2.00	1.50	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	70	45	82	53
Lbs - Total Daily Food Production (lbs)	100	100	100	100
Heat - Heat to Food (Btu/lb)	250	250	250	250
Eff_b & Eff_q - Heavy Load Cooking Efficiency	65%	65%	Application	Application
C - Btu/kWh	3,412	3,412	3,412	3,412

Source: PGECOFST101 R6, "Commercial Convection Oven – Electric and Gas," 2016.

Table 2: Gas Convection Ovens				
Variable	***Baseline***		***Qualifying***	
	Full Size	*Half Size*	*Full Size*	*Half Size*
D - Operating Days per Year	Table 11	Table 11	Table 11	Table 11
P - Number of Preheats per Day	1	1	1	1
PE_b & PE_q - Preheat Energy (Btu)	19,000	13,000	11,000	7,500
I_b & I_q - Idle Energy Rate (Btu/h)	18,000	12,000	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	70	45	83	55
Lbs - Total Daily Food Production (lbs)	100	100	100	100
Heat - Heat to Food (Btu/lb)	250	250	250	250
Eff_b & Eff_q - Heavy Load Cooking Efficiency	30%	30%	Application	Application
C - Btu/Therm	100,000	100,000	100,000	100,000

Source: PGECOFST101 R6, "Commercial Convection Oven – Electric and Gas," 2016.

Table 3: Gas Conveyor Ovens		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PEb & PEq - Preheat Energy (Btu)	21,270	15,000
Ib & Iq - Idle Energy Rate (Btu/hr)	55,000	Application
H - Operating Hours per Day	Table 11	Table 11
Pt - Preheat Duration (hrs)	0.25	0.25
PCb & PCq - Production Capacity (lbs/hr)	114	158
Lbs - Total Daily Food Production (lbs)	190	190
Heat - Heat to Food (Btu/lb)	250	250
Effb & Effq - Heavy Load Cooking Efficiency	30%	Application
C - Btu/Therm	100,000	100,000

Source: SWFS008-01 R1, "Conveyor Oven, Gas, Commercial," 2019.

Table 4: Gas Rack Ovens				
Variable	***Baseline***		***Qualifying***	
	Double Rack	*Single Rack*	*Double Rack*	*Single Rack*
D - Operating Days per Year	Table 11	Table 11	Table 5	Table 5
P - Number of Preheats per Day	1	1	1	1
PE_b & PE_q - Preheat Energy (Btu)	100,000	50,000	85,000	44,000
I_b & I_q - Idle Energy Rate (Btu/h)	65,000	43,000	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 5	Table 5
P_t - Preheat Duration (hrs)	0.33	0.33	0.33	0.33
PC_b & PC_q - Production Capacity (lbs/hr)	250	130	280	140
Lbs - Total Daily Food Production (lbs)	1200	600	1200	600
Heat - Heat to Food (Btu/lb)	235	235	235	235
Eff_b & Eff_q - Heavy Load Cooking Efficiency	30%	30%	Application	Application
C - Btu/Therm	100,000	100,000	100,000	100,000

Source: PGECOFST109, "Commercial Rack Oven– Gas," 2016.

Table 5: Electric Steamers		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (kWh)	1.50	1.50
I_b & I_q - Idle Energy Rate (kW)	0.167 x No. of Pans	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	11.7 x No. of Pans	14.7 x No. of Pans
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	105	105
Eff_b & Eff_q - Heavy Load Cooking Efficiency	26%	Application
C - Btu/kWh	3,412	3,412

Source: PGECOFST104 R6, "Commercial Steam Cooker – Electric and Gas," 2016.

Table 6: Gas Steamers		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE_b & PE_q - Preheat Energy (Btu)	20,000	9,000
I_b & I_q - Idle Energy Rate (Btu/h)	2,500 x No. of Pans	Application
H - Operating Hours per Day	Table 11	Table 11
P_t - Preheat Duration (hrs)	0.25	0.25
PC_b & PC_q - Production Capacity (lbs/hr)	23.3 x No. of Pans	20.8 x No. of Pans
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	105	105
Eff_b & Eff_q - Heavy Load Cooking Efficiency	15%	Application
C - Btu/Therm	100,000	100,000

Source: PGECOFST104 R6, "Commercial Steam Cooker – Electric and Gas," 2016.

Table 7: Electric Fryers		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PEb & PEq - Preheat Energy (kWh)	2.40	1.90
Ib & Iq - Idle Energy Rate (kW)	1.2	Application
H - Operating Hours per Day	Table 11	Table 11
Pt - Preheat Duration (hrs)	0.25	0.25
PCb & PCq - Production Capacity (lbs/hr)	65	71
Lbs - Total Daily Food Production (lbs)	150	150
Heat - Heat to Food (Btu/lb)	570	570
Effb & Effq - Heavy Load Cooking Efficiency	75%	Application
C - Btu/kWh	3,412	3,412

Source: PGECOFST102 R6, "Commercial Fryer – Electric and Gas," 2016.

Table 8: Gas Fryers		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PEb & PEq - Preheat Energy (Btu)	18,500	16,000
Ib & Iq - Idle Energy Rate (Btu/h)	17,000	Application
H - Operating Hours per Day	Table 11	Table 11
Pt - Preheat Duration (hrs)	0.25	0.25
PCb & PCq - Production Capacity (lbs/hr)	60	67
Lbs - Total Daily Food Production (lbs)	150	150
Heat - Heat to Food (Btu/lb)	570	570
Effb & Effq - Heavy Load Cooking Efficiency	35%	Application
C - Btu/Therm	100,000	100,000

Source: PGECOFST102 R6, "Commercial Fryer – Electric and Gas," 2016.

Table 9: Electric Griddles		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PEb & PEq - Preheat Energy (kWh)	1.3 x Griddle Width (ft)	0.7 x Griddle Width (ft)
Ib & Iq - Idle Energy Rate (kW)	0.8 x Griddle Width (ft)	Application
H - Operating Hours per Day	Table 11	Table 11
Pt - Preheat Duration (hrs)	0.25	0.25
PCb & PCq - Production Capacity (lbs/hr)	11.7 x Griddle Width (ft)	16.3 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Effb & Effq - Heavy Load Cooking Efficiency	60%	Application
C - Btu/kWh	3,412	3,412

Source: SWFS004-01 R1, "Commercial Griddle – Electric & Gas," 2018.

Table 10: Gas Griddle s		
Variable	***Baseline***	***Qualifying***
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PEb & PEq - Preheat Energy (Btu)	7,000 x Griddle Width (ft)	5,000 x Griddle Width (ft)
Ib & Iq - Idle Energy Rate (Btu/h)	7,000 x Griddle Width (ft)	Application
H - Operating Hours per Day	Table 11	Table 11
Pt - Preheat Duration (hrs)	0.25	0.25
PCb & PCq - Production Capacity (lbs/hr)	8.4 x Griddle Width (ft)	16.4 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Effb & Effq - Heavy Load Cooking Efficiency	30%	Application
C - Btu/Therm	100,000	100,000

Source: SWFS004-01 R1, "Commercial Griddle – Electric & Gas," 2018.

Table 11: Operating Days/Hours by Building Type		
Building Type	**Days/Year**	**Hours/Day**
Education - Primary School	180	8
Education - Secondary School	210	11
Education - Community College	237	16
Education - University	192	16
Grocery	364	16
Medical - Hospital	364	24
Medical - Clinic	351	12
Lodging Hotel (Guest Rooms)	229	5
Lodging Motel	364	24
Manufacturing - Light Industrial	330	13
Office - Large	234	12
Office - Small	234	12
Restaurant - Sit-Down	364	12
Restaurant - Fast-Food	364	17
Retail - 3-Story Large	355	12
Retail - Single-Story Large	364	12
Retail - Small	364	11
Storage Conditioned	330	13
Storage Heated or Unconditioned	330	13
Warehouse	325	12
Average = Miscellaneous	303	14

C&I Gas Protocols

The following measures are outlined in this section: Gas Chillers, Gas Fired Desiccants, Water Heating Equipment, Space Heating Equipment, and Fuel Use Economizers.

Gas Chillers

The measurement of energy savings for C&I gas fired chillers and chiller heaters is based on algorithms with key variables captured on the application form or from manufacturer's data sheets and collaborative/utility studies.

For certain fixed components, studies, and surveys developed by the utilities in the state or based on a review of manufacturer's data, other utilities, regulatory commissions or consultants' reports will be used to update the values for future filings.

Algorithms

Winter Gas Savings (MMBtu/yr) = $(VBE_q - BE_b)/VBE_q * IR * EFLH_c$

Energy Savings (kWh/yr) = Tons * $(kW/Ton_b - kW/Ton_{gc}) * EFLH_c$

Summer Gas Usage (MMBtu/yr) = MMBtu Output Capacity / COP * $EFLH_c$

Net Energy Savings (kWh/yr) = Energy Savings + Winter Gas Savings – Summer Gas Usage

Peak Demand Savings (kW) = Tons * $(kW/Ton_b - kW/Ton_{gc})$ * CF

Definition of Terms

VBE_q = Vacuum Boiler Efficiency

BE_b = Efficiency of the baseline gas boiler

IR = Input Rating = MMBtu/hour

Tons = The rated capacity of the chiller (in tons) at site design conditions accepted by the program

kW/Ton_b = The baseline efficiency for electric chillers, as shown in the Gas Chiller Verification Summary table below.

kW/Ton_{gc} = Parasitic electrical requirement for gas chiller.

COP = Efficiency of the gas chiller

MMBtu Output Capacity = Cooling Capacity of gas chiller in MMBtu.

CF = Coincidence Factor. This value represents the percentage of the total load that is on during electric system peak.

$EFLH_c$ = Equivalent Full Load Hours. This represents a measure of chiller use by cooling season.

Summary of Inputs

Gas Chillers

Component	Type	Value	Source
VBE_q	Variable		Application or Manufacturer Data
BE_b	Fixed	80% Et	1, Assumes a baseline hot water boiler with rated input >300 MBh and ≤ 2,500 MBh.
IR	Variable		Application or Manufacturer Data
Tons	Rated Capacity, Tons		Application
MMBtu	Variable		Application
kW/Ton_b	Fixed	<100 tones 1.25 kW/ton 100 to < 150 tons 0.703 kW/ton 150 to <300 tons: 0.634 kW/Ton 300 tons or more: 0.577 kW/ton	Collaborative agreement and C/I baseline study Assumes new electric chiller baseline using air cooled unit for chillers less than 100 tons; water cooled for chillers greater than 100 tons
kW/Ton_{gc}	Variable		Manufacturer Data
COP	Variable		Manufacturer Data
CF	Fixed	67%	Engineering estimate
$EFLH_c$	Variable	See Table Below	2

$EFLH_c$ Table

Facility Type	Cooling $EFLH_c$
Assembly	669
Auto repair	426
Dormitory	800
Hospital	1424
Light industrial	549
Lodging – Hotel	2918
Lodging – Motel	1233
Office – large	720
Office – small	955
Other	736
Religious worship	279
Restaurant – fast food	645
Restaurant – full service	574
Retail – big box	1279
Retail – grocery	1279
Retail – small	882
Retail – large	1068
School – community college	846
School – postsecondary	1208
School – primary	394
School – secondary	466
Warehouse	400

Multi-family EFLH by Vintage

Facility Type	Prior to 1979	From 1979 to 2006	From 2007 through Present
Low-rise, Cooling	507	550	562
Low-rise, Heating	757	723	503
High-rise, Cooling	793	843	954
High-rise, Heating	526	395	219

Sources

1. ASHRAE Standards 90.1-2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines. Table 6.8.1 – 6
2. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V7, April 2019. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. P. 675-680. EFLH values for NYC due to proximity to NJ.

Stand Alone Storage Water Heaters

This prescriptive measure is intended for stand alone storage water heaters installed in commercial facilities. The savings algorithms are based on installed equipment specifications and data from the Commercial Building Energy Consumption Survey (CBECS).

Baseline efficiencies are set by current and previous equipment performance standards. In New Jersey ASHRAE 90.1 defines the commercial energy code requirements. For new buildings, ASHRAE 90.1-2016 standards apply, and for existing buildings, ASHRAE 90.1-2007 standards are assumed.

Note that for stand alone storage water heaters with a rated input capacity greater than 75 kBtu/hr, equipment standards are defined in terms of thermal efficiency. Equipment below this input capacity is rated in terms of energy factor. Energy factor is determined on a 24 hour basis and includes standby or storage loss effects, while thermal efficiency does not. Therefore, if the equipment is large enough to be rated in terms of thermal efficiency, a percent standby loss factor must be included in the calculation as shown in the algorithms.

Algorithms

Fuel Savings (MMBtu/yr) = ((1 – (EFF_b / EFF_q) + SLF[59]) * Energy Use Density * Area / 1000 kBtu/MMBtu

where,

SLF = (SL_b – SL_q) / Cap_q

Fuel Savings (Therms) = ((GPD x 365 x 8.33 x $deltaT_{main}$)/1000) x (1/UEF_b – 1/UEF_q)

Definition of Variables

EFF_q = Efficiency of the qualifying water heater.

EFF_b = Efficiency of the baseline water heater, commercial grade.

EF_b = Energy Factor of the baseline water heater, commercial grade.

UEF_b = Uniform Energy Factor of baseline water heater

UEF_q = Uniform Energy Factor of proposed efficient water heater

Energy Use Density = Annual baseline water heater energy use per square foot of commercial space served (MMBtu/sq.ft./yr)

Area = Square feet of building area served by the water heater

SLF = Standby loss factor for savings of qualifying water heater over baseline

[59] Standby losses only apply if the stand alone storage water heater is rated for more than 75 kBtu/hr.

$SL_{b\ or\ q}$ = Standby losses in kBtu/hr of the baseline and qualifying storage water heater respectively. The baseline standby losses is calculated assuming the baseline water heater has the same input capacity rating as the qualifying unit's input capacity using ASHRAE equipment performance standards. The qualifying unit's standby losses are available on the AHRI certificate provided with the application.

Cap_q = Rated input capacity of the qualifying water heater

GPD = Gallons per day

$deltaT_{main}$ = Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)

<u>Summary of Inputs</u>

Stand Alone Storage Water Heater Assumptions

Component	Type	Value	Source
EFF_q	Variable		Application
EFF_b	Variable	See Table Below	1, 2
EF_b	Variable	See Table Below	1, 2
Energy Use Density	Variable	See Table Below	3
Area	Variable		Application
Cap_q	Variable		Application
SL_b	Variable	See Table Below	1 & Application
SL_q	Variable		Application
GPD	Variable	46	4
UEF_b	Variable	See Table Below	3
UEF_q	Variable		Application
$deltaT_{main}$		64.1	5

Efficiency of Baseline Stand Alone Storage Water Heaters

ASHRAE 90.1-2007 and 2016[a]			
Equipment Type	**Size Category (Input)**	**Existing Building Baseline Efficiency (ASHRAE 90.1-2007)**	**New Building Baseline Efficiency (ASHRAE 90.1-2016)**
Gas Storage Water Heaters	≤ 75 kBtu/hr	EF = 0.62 – 0.0019 × V	EF = 0.67 – 0.0005 × V
Gas Storage Water Heaters	> 75 - <= 105kBtu/hr	TE = 0.80 SL = (Cap_q / 0.8 + 110 × √V) / 1000	Very Small DP: UEF=0.2674 – (0.0009 x Vr

			Low DP: UEF = 0.5362 – (0.0012 x Vr) Medium DP: UEF = 0.6002 – (0.0011 x Vr) High DP: UEF = 0.6597 – (0.0009 x Vr)
Gas Storage Water Heaters	> 105 kBtu/hr		TE = 0.80 Cap_q / 0.8 + 110 × √V)

a – EF is energy factor, TE is thermal efficiency, V is the volume of the installed storage water heater, and Cap_q is the rated input of the proposed storage water heater

Energy Use Density Look-up Table

Building Type	Energy Use Density (kBtu/SF/yr)
Education	7.0
Food sales	4.4
Food service	39.2
Health care	23.7
Inpatient	34.3
Outpatient	3.9
Lodging	26.5
Retail (other than mall)	2.5
Enclosed and strip malls	14.1
Office	4.8
Public assembly	2.1
Public order and safety	21.4
Religious worship	0.9
Service	15
Warehouse and storage	2.9
Other	2.3

Example: If a water heater of 150 kBtu/hr input capacity and 100 gallons storage capacity is installed in an existing building, the baseline standby losses would be calculated as SL = (150 kBtu/hr / 0.8 + 110 × √100) / 1000 = 1.29 kBtu/hr. If the proposed equipment's standby losses were rated for 1.0 kBtu/hr, the standby loss factor for savings would be SLF = (1.29 – 1.0) / 150 = 0.0019.

In the above example, if the unit was rated for 96% thermal efficiency, and installed in an office building space of 10,000 ft^2, the annual energy savings would be ((1 – 0.8/0.96) + 0.0019) × 4.8 × 10000 / 1000 = 8.1 MMBtus/yr

<u>Sources</u>

1. ASHRAE Standards 90.1-2007, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.
2. ASHRAE Standards 90.1-2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines. Table 7.8
3. Energy Information Administration, *Commercial Building Energy Consumption Survey Data*, 2012; available at: https://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/e7.cfm.
4. Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.

5. NEEP, “Mid-Atlantic Technical Reference Manual Version 9”, October 2019. Pg 191

Instantaneous Gas Water Heaters

This prescriptive measure is intended for instantaneous water heaters installed in commercial facilities. This measure assumes that the baseline water heater is either a code stand alone storage water heater, or a code instantaneous water heater. The savings algorithms are based on installed equipment specifications and data from the Commercial Building Energy Consumption Survey (CBECS).

Baseline efficiencies are set by current and previous equipment performance standards. In New Jersey ASHRAE 90.1 defines the commercial energy code requirements. For new buildings, ASHRAE 90.1-2016 standards apply, and for existing buildings, ASHRAE 90.1-2007 standards are assumed.

If the qualifying instantaneous water heater is greater than 200 kBtu/hr and replacing a stand alone storage water heater, use a baseline storage water heater efficiency greater than 75 kBtu/hr. Similarly, if the qualifying instantaneous water heater is less than 200 kBtu/hr, and replacing a stand alone storage water heater, use an efficiency for equipment less than 75 kBtu/hr.

Note, that for stand alone storage tank water heaters rated above 75 kBtu/hr, and instantaneous water heaters above 200 kBtu/hr, equipment standards are defined in terms of thermal efficiency. Equipment below these levels is rated in terms of energy factor. Energy factor is determined on a 24 hour basis and includes standby or storage loss effects, while thermal efficiency does not. Therefore, if the equipment is large enough to be rated in terms of thermal efficiency, a percent standby loss factor must be included in the calculation as shown in the algorithms.

Algorithms

Fuel Savings (MMBtu/yr) = ((1 – (EFF_b / EFF_q) + SLF[60]) * Energy Use Density * Area

Where,

$SLF = 0.775 \times Cap_q^{-0.778}$

Fuel Savings (Therms) = ((GPD x 365 x 8.33 x $deltaT_{main}$)/1000) x (1/UEF_b – 1/UEF_q)

Definition of Variables

EFF_q = Efficiency of the qualifying instantaneous water heater.

EFF_b = Efficiency of the baseline water heater, commercial grade.

EF_b = Efficiency of the baseline water heater, commercial grade.

[60] Standby losses only apply if the baseline water heater is a stand alone storage water heater rated for more than 75 kBtu/hr.

SLF = Standby loss factor of the baseline water heater fuel usage. This was calculated from standby loss and input capacity data for commercial water heaters exported from the AHRI database.

Energy Use Density = Annual baseline water heater energy use per square foot of commercial space served (MMBtu/sq.ft./yr)

Area = Square feet of building area served by the water heater

Cap_q = Rated input capacity of the qualifying water heater

UEF_b = Uniform Energy Factor of baseline water heater

UEF_q = Uniform Energy Factor of proposed efficient water heater

GPD = Gallons per day

$deltaT_{main}$ = Average temperature difference between water heater set point temperature and the supply water temperature in water main (°F)

Summary of Inputs

Water Heater Assumptions

Component	Type	Value	Source
EFF_q	Variable		Application
EFF_b	Variable	See Table Below If storage water heater < 75 kBtu/Hhr or instantaneous water heater < 200 kBtu/hr: EF Otherwise TE. EF = Energy Factor TE = Thermal Efficiency	1, 2
EF_b	Variable	See Table Below	1, 2
Energy Use Density	Variable	See Table Below	3
Area	Variable		Application
GPD	Variable	46	4
UEF_b	Variable	See Table Below	2
UEF_q	Variable		Application
deltaTmain		64.1	5

Efficiency of Baseline Water Heaters

ASHRAE 90.1-2007 and 2016[a]			
Equipment Type	**Size Category (Input)**	**Existing Building Baseline Efficiency (ASHRAE 90.1-2007)**	**New Building Baseline Efficiency (ASHRAE 90.1-2016)**
Gas Storage Water Heaters[61]	≤ 75 kBtu/hr	EF = 0.54	EF = 0.67 – 0.0005 × V
Gas Storage Water Heaters	> 75 to < 105 kBtu/hr	TE = 0.80	Very Small DP: UEF=0.2674 – (0.0009 x Vr Low DP: UEF = 0.5362 – (0.0012 x Vr) Medium DP: UEF = 0.6002 – (0.0011 x Vr) High DP: UEF = 0.6597 – (0.0009 x Vr)
Gas Storage Water Heaters	105 kBtu/hr		TE = 0.80 Cap_q / 0.8 + 110 × √V)
Gas Instantaneous Water Heaters[62]	< 200 kBtu/hr	EF = 0.62	EF = 0.80 (<10 gal)

a – EF means energy factor and TE means thermal efficiency

Energy Use Density Look-up Table

Building Type	Energy Use Density (kBtu/SF/yr)
Education	7.0
Food sales	4.4
Food service	39.2
Health care	23.7
Inpatient	34.3
Outpatient	3.9
Lodging	26.5
Retail (other than mall)	2.5
Enclosed and strip malls	14.1
Office	4.8
Public assembly	2.1

[61] For qualifying instantaneous water heaters less than 200kBtu/hr, the storage water heater tank size is assumed to be 40 gallons.

[62] For instantaneous water heaters rated for less than 200 kBtu/hr, the tank size is assumed to be 1 gallon.

Building Type	Energy Use Density (kBtu/SF/yr)
Public order and safety	21.4
Religious worship	0.9
Service	15
Warehouse and storage	2.9
Other	2.3

Sources

1. ASHRAE Standards 90.1-2007, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.
2. ASHRAE Standards 90.1-2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.
3. Energy Information Administration, *Commercial Building Energy Consumption Survey Data*, 2012; available at: https://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/e7.cfm.
4. Water Research Foundation: Residential End Uses of Water, Version 2, April 2016, p. 5; 17.2 GPD equated from the report findings indicating an average 2.65 people per household and 45.5 GPD per household.
5. NEEP, "Mid-Atlantic Technical Reference Manual Version 9", October 2019. Pg 191

Prescriptive Boilers

This prescriptive measure targets the use of smaller-scale boilers (less than or equal to 4000 MBH) and furnaces (no size limitation) in all commercial facilities. Larger sized boilers are treated under the custom measure path.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline unit is a code compliant unit with an efficiency as required by ASHRAE Std. 90.1 – 2016, which is the current code adopted by the State of New Jersey.

Algorithms

Fuel Savings (MMBtu/yr) = Cap_{in} * $EFLH_h$ * ((Eff_q/Eff_b)-1) / 1000 kBtu/MMBtu

Definition of Variables

Cap_{in} = Input capacity of qualifying unit in kBtu/hr

$EFLH_h$ = The Equivalent Full Load Hours of operation for the average unit during the heating season in hours

Eff_b = Boiler Baseline Efficiency

Eff_q = Boiler Proposed Efficiency

1000 = Conversion from kBtu to MMBtu

Summary of Inputs

Prescriptive Boilers

Component	Type	Value	Source
Cap_{in}	Variable		Application
$EFLH_h$	Fixed	See Table Below	1
Eff_b	Variable	See Table Below	2
Eff_q	Variable		Application

$EFLH_h$ Table

Facility Type	Heating EFLH
Assembly	603
Auto repair	1910
Dormitory	465
Hospital	3366
Light industrial	714
Lodging – Hotel	1077
Lodging – Motel	619
Office – large	2034
Office – small	431
Other	681
Religious worship	722

Facility Type	Heating EFLH
Restaurant – fast food	813
Restaurant – full service	821
Retail – big box	191
Retail – Grocery	191
Retail – small	545
Retail – large	2101
School – Community college	1431
School – postsecondary	1191
School – primary	840
School – secondary	901
Warehouse	452

Multi-family EFLH by Vintage

Facility Type	Prior to 1979	From 1979 to 2006	From 2007 through Present
Low-rise, Heating	757	723	503
High-rise, Heating	526	395	219

Baseline Boiler Efficiencies (Eff_b)

Boiler Type	Size Category (kBtu input)	Standard 90.1-2016
Hot Water – Gas fired	< 300 ≥ 300 and ≤ 2,500 > 2,500	82% AFUE 80% Et 82% Ec
Hot Water – Oil fired	< 300 ≥ 300 and ≤ 2,500 > 2,500	84% AFUE 82% Et 84% Ec
Steam – Gas fired	< 300	80% AFUE
Steam – Gas fired, all except natural draft	≥ 300 and ≤ 2,500	79% Et
Steam – Gas fired, all except	> 2,500	79% Ec

Boiler Type	Size Category (kBtu input)	Standard 90.1-2016
Steam – Gas fired, natural draft	≥ 300 and ≤ 2,500	79% Et
Steam – Gas fired, natural draft	> 2,500	79% Ec
Steam – Oil fired	< 300 ≥ 300 and ≤ 2,500 > 2,500	82% AFUE 81% Et 81% Ec

Sources

1. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V7, April 2019. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. P. 675-680. EFLH values for NYC due to proximity to NJ.
2. ASHRAE Standards 90.1-2016. *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines. Table 6.8.1-6

Prescriptive Furnaces

The methodology outlined below shall be adopted for estimating savings for installation of qualifying furnaces.

This measure applies to new construction, replacement of failed equipment, or end of useful life. The baseline unit is a code compliant unit with an efficiency as required by ASHRAE Std. 90.1 – 2016, which is the current code adopted by the State of New Jersey.

Algorithms

Fuel Savings (MMBtu/yr) = Cap_{in} * $EFLH_h$ * ((Eff_q/Eff_b)-1) / 1000 kBtu/MMBtu

Definition of Variables

Cap_{in} = Input capacity of qualifying unit in kBtu/hr

$EFLH_h$ = The Equivalent Full Load Hours of operation for the average unit during the heating season in hours

Eff_b = Furnace Baseline Efficiency

Eff_q = Furnace Proposed Efficiency

1000 = Conversion from kBtu to MMBtu

Summary of Inputs

Prescriptive Furnaces

Component	Type	Value	Source
Cap_{in}	Variable		Application
$EFLH_h$	Fixed	See Table Below	1
Eff_q	Variable		Application
Eff_b	Fixed	See Table Below	2

$EFLH_h$ Table

Facility Type	Heating EFLH
Assembly	603
Auto repair	1910
Dormitory	465
Hospital	3366
Light industrial	714
Lodging – Hotel	1077
Lodging – Motel	619
Office – large	2034
Office – small	431
Other	681
Religious worship	722

Facility Type	Heating EFLH
Restaurant – fast food	813
Restaurant – full service	821
Retail – big box	191
Retail – Grocery	191
Retail – small	545
Retail – large	2101
School – Community college	1431
School – postsecondary	1191
School – primary	840
School – secondary	901
Warehouse	452

Multi-family EFLH by Vintage

Facility Type	Prior to 1979	From 1979 to 2006	From 2007 through Present
Low-rise, Heating	757	723	503
High-rise, Heating	526	395	219

Baseline Furnace Efficiencies (Eff_b)

Furnace Type	Size Category (kBtu input)	Standard 90.1-2016
Gas Fired	< 225 ≥ 225	78% AFUE or 80% Et 80% Et
Oil Fired	< 225 ≥ 225	78% AFUE 81% Et

<u>Sources</u>

1. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V, April 2019. Appendix G – Equivalent

Full-Load Hours (EFLH), For Heating and Cooling. Page 675-680. EFLH values for NYC due to proximity to NJ.

2. ASHRAE Standards 90.1-2016, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines. (Table 6.8.1-5)

Pipe Insulation

This measure applies to insulation installed on previously bare hot water distribution piping located in unconditioned spaces. Deemed savings factors were derived using the North American Insulation Manufacturers Association, 3E Plus Version 4.1 heat loss calculation tool. The savings factors represent average values for copper or steel pipe with mineral fiber or polyolefin tube pipe insulation. Savings are a function of pipe size and insulation thickness. A table of savings factors for nominal pipe size ranging from ½ inch to 4 inches, with insulation ranging from ½ inch to 2 inches thick is provided.

The savings factors are based on a fluid temperature of 180°F, and an ambient temperature of 50°F, resulting in a temperature differential of 130°F. If the actual temperature differential varies significantly from this value, the reported savings should be scaled proportionally.

The default value for annual operating hours represents the average annual hours when space heating is required. For non-space heating applications, the value should be adjusted to reflect the annual hours when the hot fluid is circulated.

Algorithms

Fossil Fuel Source:

Fuel Savings (MMBtu/yr) = SF * L * Oper Hrs / EFF

Electric Source:

Energy Savings (kWh/yr) = SF * L * Oper Hrs / EFF / C

Scaling: Only applicable if differential between the fluid temperature and space temperature is significantly different than 130°F. If this is the case, the fuel or electric savings calculated with the above formulas should be multiplied by the resulting scaling factor deroived as:

Scaling Factor (unitless) = (FT – ST)/130

Fuel or electric savinsg calculated using the derived savings factors should be multiplied by the acaling factor.

Scaled Savings (MMBtu/year or kWh/yr) = Calculated Savings * Savings Factor

Definition of Variables

SF = Savings factor derived from #E Plus Version 4.1 tool, Btu/hr-ft see table below

L = Length of pipe from water heating source to hot water application, ft

Oper Hrs = hours per year fluid flows in pipe, hours

EFF = Efficiency of equipment providing heat to the fluid

C (kWh) = Conversion factor from Btu to kWh = 3,413 for electric water heating

FT = Fluid Temperature (°F)

ST = Space temperature (°F)

Summary of Inputs

Pipe Insulation

Component	Type	Value	Source
SF	Fixed	See Table Below	1
L	Variable		Application
Oper Hrs	Fixed	4,282 hrs/year (default value reflects average heating season hours)	2
EFF	Fixed	98% electric 80% natural gas	3
FT	Variable		Application
ST	Variable		Application

Savings Factor

	Savings, Btu/hr-ft			
Nominal Pipe Size, Inches	0.5" Insulation	1.0" Insulation	1.5" Insulation	2.0" Insulation
0.50	47	53	56	57
0.75	58	64	68	70
1.00	72	82	85	87
1.25	89	100	107	108
1.50	100	115	120	125
2.00	128	143	148	153
2.50	153	171	182	185
3.00	195	221	230	236
3.50	224	241	248	253
4.00	232	263	274	281

Sources

1. North American Insulation Manufacturers Association, 3E Plus, Version 4.1, heat loss calculation tool, August 2012.
2. NOAA, Typical Meteorological Year (TMY3) weather data – Newark, Trenton, and Atlantic City averaged.

3. New York State Joint Utilities, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, V7, April 2019. pg 283.

Combined Heat & Power – Fuel Cell Program

Protocols

The measurement of energy and demand savings for Combined Heat and Power (CHP) systems is based primarily on the characteristics of the individual systems subject to the general principles set out below. The majority of the inputs used to estimate energy and demand impacts of CHP systems will be drawn from individual project applications. Eligible systems include: powered by non-renewable or renewable fuel sources, gas internal combustion engine, gas combustion turbine, microturbine, and fuel cells with and without heat recovery.

The NJ Protocol is to follow the National Renewable Energy Laboratory's Combined Heat and Power, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures [1]. The product should be all of the below outputs, as applicable:

a. Annual energy input to the generator, HHV basis (MMBtu/yr)
b. Annual electricity generated, net of all parasitic loads (kWh/yr)
c. Annual fossil fuel energy savings from heat recovery (MMBtu/yr)
d. Annual electric energy savings from heat recovery, including absorption chiller sourced savings if chiller installation is included as part of the system installation (kWh/yr)
e. Annual overall CHP fuel conversion efficiency, HHV basis (%)
f. Annual electric conversion efficiency, net of parasitics, HHV basis (%)

CHP systems typically use fossil fuels to generate electricity that displaces electric generation from other sources. Therefore, the electricity generated from a CHP system should not be reported as either electric energy savings or renewable energy generation. Alternatively, electric generation and capacity from CHP systems should be reported as Distributed Generation (DG) separate from energy savings and renewable energy generation. However, any waste heat recaptured and utilized should be reported as energy savings as discussed below.

CHP Emissions Reduction Associated with PJM Grid

(Assuming that the useful thermal output will displace natural gas)

<u>Algorithms</u>

CO_2 ER (lbs) = (CO_2 EF_{elec} – CO_2 EF_{CHP}) * Net Electricity Generation (MWh) + CO_2 EF_{elec} * Electric Energy Savings (MWh) + CO_2 EF_{NG} * Gas Energy Savings (MMBtu) * 10

NO_x ER (tons) = (NO_x EF_{elec} – NO_x EF_{CHP}) * Net Electricity Generation (MWh) + NO_x EF_{elec} * Electric Energy Savings (MWh) + NO_x EF_{NG} * Gas Energy Savings (MMBtu) * 10

SO_2 ER (lbs) = (SO_2 EF_{elec} – SO_2 EF_{CHP}) * Net Electricity Generation (MWh) + SO_2 EF_{elec} * Electric Energy Savings (MWh)

Hg (grams) = (Electric Energy Savings (MWh) * Hg EF_{elec})/1,000

Definition of Variables

CO_2 EF_{elec} = CO_2 Electric Emissions Factor – see emissions tables summarized in Introduction section of Protocols

NO_x EF_{elec} = NO_x Electric Emissions Factor – see emissions tables summarized in Introduction section of Protocols

SO_2 EF_{elec} = SO_2 Electric Emissions Factor – see emissions tables summarized in Introduction section of Protocols

Hg EF_{elec} = Hg Electric Emissions Factor – see emissions tables summarized in Introduction section of Protocols

CO_2 EF_{CHP} = CO_2 Emissions Factor of the CHP system (in lbs/MWh), which will vary with different projects based on the types of prime movers and emission control devices used

NO_x EF_{CHP} = NO_x Emissions Factor of the CHP system (in lbs/MWh), which will vary with different projects based on the types of prime movers and emission control devices used

SO_2 EF_{CHP} = SO_2 Emissions Factor of the CHP system (in lbs/MWh), which will vary with different projects based on the types of prime movers and emission control devices used

CO_2 EF_{NG} = CO_2 Natural Gas Emissions Factor associated with boiler fuel displacement – see emissions tables summarized in Introduction section of Protocols

NO_x EF_{NG} = NO_x Natural Gas Emissions Factor associated with boiler fuel displacement – see emissions tables summarized in Introduction section of Protocols

10 = Conversion from MMBtu to therms (1 MMBtu = 10 therms)

Sources

1. Simons, George, Stephan Barsun, and Charles Kurnik. 2017. *Chapter 23: Combined Heat and Power, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures*. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68579. https://www.nrel.gov/docs/fy17osti/68579.pdf

Pay for Performance Program

Protocols

The Pay for Performance Program is a comprehensive program targeted at existing commercial and industrial (C&I) buildings that have an average annual peak demand of 200 kW or greater; as well as select multifamily buildings with annual peak demand of 100 kW or greater. Participants in the Pay for Performance Program are required to identify and implement energy efficiency improvements that will achieve a minimum savings target.

Energy Savings Requirements

For Existing Buildings, projects are required to identify and implement comprehensive energy efficiency improvements that will achieve a minimum of 15% reduction in total source energy consumption as measured from existing energy use. For New Consturction, including major rehabilitation, projects are required to identify and implement comprehensive energy efficiency measures that achieve a minimum 5% energy cost savings for commercial and industrial buildings, and 15% for multifamily, from the current state energy code.

Existing Buildings projects must include multiple measures, where lighting measures do not exceed 50% of total savings (exceptions apply, see program guidelines). New Construction projects must have at least one measure addressing each envelope, heating, cooling, and lighting systems. Buildings that are not heated (e.g., refrigerated warehouse) or not cooled (e.g., warehouse) will not be required to have a measure addressing the missing building system.

In both program components, the total package of measures must have at least 50% of the savings must come from investor-owned electricity and/or natural gas. If 50% of the savings does not meet this criteria, then the project must save a minimum of 100,000 kWh or 2,000 therms from investor-owned utility accounts.

For Existing Buildings, an exception to the 15% savings requirement is available to sectors such as manufacturing, pharmaceutical, chemical, refinery, packaging, food/beverage, data center, transportation, mining/mineral, paper/pulp, biotechnology, etc, as well as hospitals. The manufacturing and/or processing loads use should be equal to or greater than approximately 50% of the total metered energy use. Instead of the 15% savings requirement, the project must deliver a minimum energy savings of 4% of total facility consumption.

Software Requirements

In order for a project to qualify for incentives under the Pay for Performance Program, the Partner must create a whole-building energy simulation to demonstrate energy savings from recommended energy efficiency measures, as described in detail in the Simulation Guidelines section of the Pay for Performance Program Guidelines. The primary source for developing the Simulation Guidelines is ASHRAE Guideline 14. Simulation software must be compliant with ASHRAE 90.1 Section 11 or Appendix G. Examples of allowed tools include eQUEST, HAP, EnergyPlus, Trane Trace, DOE 2.1.

Approval for use in LEED and Federal Tax Deductions for Commercial Buildings program may serve as the proxy to demonstrate compliance with the requirement.

Baseline Conditions

Existing Buildings

Baseline from which energy savings are measured will be based off the most recent 12 months of energy use from all sources. Site energy use is converted to source energy use following EPA's site-to-source conversion factors[63].

New Construction

Project may establish building baseline in one of two ways:

- *Path 1* – Under this path, the Partner will develop a single energy model representing the proposed project design using prescribed modeling assumptions that follow *ASHRAE Building Energy Quotient (bEQ) As-Designed* [64] simulation requirements.
  Path 2 – Under this option the Partner will develop a baseline building using ASHRAE 90.1-2016 Appendix G *modified by Addendum BM*[65].

Measure Savings

Measures must be modeled to demonstrate proposed energy/energy cost savings according to Pay for Performance program guidelines, including meeting or exceeding Minimum Performance Standards, or current state or local energy code, whichever is more stringent. Minimum Performance Standards generally align with C&I SmartStart Program equipment requirements.

Existing Buildings

Measures must be modeled within the approved simulation software and modeled incrementally to ensure interactive savings are taken into account.

New Construction

Measures must be modeled based on the baseline path chosen:

- *Path 1* – Modeled within the same proposed design energy model, but as parametric runs or alternatives downgraded to code compliant parameters.
- *Path 2* – Modeled as interactive improvements to the ASHRAE 90.1-2016 Appendix G baseline (with Addendum BM accepted).

In the event that a software tool cannot adequately model a particular measure or component, or in cases where Program Manager permits savings calculations outside of

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[63] https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf.

[64] http://buildingenergyquotient.org/asdesigned.html.

[65] Addendum BM sets a common baseline building approach that will remain the same for ASHRAE 90.1-2016 and all future iterations of ASHRAE 90.1 and is roughly equivalent to ASHRAE 90.1-2004. To comply with ASHRAE 90.1-2016, a proposed building has to have energy cost savings of 11-40% from the Addendum BM baseline, depending on the building type and climate zone.

the model, projects are required to use stipulated savings calculations as outlined in the Program Guidelines or within these Protocols as applicable. If stipulated savings do not exist within these documents, the Program Maanger will work with the applicant to establish acceptable industry calculations.

Measurement & Verification

Existing Buildings

The Program metering requirements are based on the 2010 International Performance Measurement and Verifications Protocol ("IPMVP") and the 2008 Federal Energy ManagementProgram ("FEMP") M&V Guidelines, Version 3.0. All projects must follow Option D, Calibrated Simulation, as defined by the IPMVP. Calibrated simulation involves the use of computer software to predict building energy consumption and savings from energy-efficiency measures. Options A and B, as defined by the IPMVP, may be used as guidelines for data collection to help create a more accurate model. Additionally, for the existing buildings component, Option C is used to measure actual savings using twelve months of post-retrofit utility data.

New Construction

Projects are required to commission all energy efficiency measures. Further, projects are required to complete a benchmark through *EPA's ENERGY STAR Portfolio Manager* to demonstrate operational performance based on the building's first year of operation. Building types not eligible ofor ENERGY STAR Score may demonstrate compliance through *ASHRAE Building Energy Quotient (bEQ) In-Operation.*

Energy Savings Reporting

Committed energy savings are reported upon approval of the Energy Reduction Plan and are based on modeling results of recommended measures as described above. Installed energy savings are reported upon installation of recommended measures and are based on modeling results. Unless significant changes to the scope of work occurred during construction, installed savings will be equal to committed savings. Verified savings are reported at the end of the performance period (for Existing Buildings) and are based on twelve (12) months of post-retrofit utility bills compared to pre-retrofit utility bills used during Energy Reduction Plan development. For New Construction, verified savings are not currently reported. Note that only installed savings are reported on New Jersey's Clean Energy Quarterly Financial and Energy Savings Reports.

Direct Install Program

Protocols

This section identifies the protocols for measures proposed under the Direct Install Program. Several of the measures use algorithms and inputs identical to the *Commercial and Industrial Energy Efficient Construction* section of the Protocols, and as such, the user is directed to that section for the specific protocol. Other measures may have similar algorithms and inputs, but identify different equipment baselines to reflect the Direct Install early replacement program where equipment is replaced as a direct result of the program. For those measures, the applicable baseline tables are included in this section, but the user is directed to the C&I section of the Protocols for algorithms and other inputs.

Low Flow Faucet Aerators, Showerheads, and Pre-rinse Spray Valves

Installation of Low Flow Faucet Aerators, Showerheads, and Pre-rinse Spray Valves are a proposed measure under the Commercial and Industrial Energy Efficient Construction. Because there is no baseline assumption included in the protocols for this measure, the savings protocol will be exactly the same as previously stated in this document.

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Pipe Insulation

Installation of hot water pipe insulation is a proposed measure under the Commercial and Industrial Energy Efficient Construction. Because there is no baseline assumption included in the protocols for this measure, the savings protocol will be exactly the same as previously stated in this document.

Renewable Energy Program Protocols

SREC Registration Program (SRP) and Transition Incentive Program

The electricity generation estimated to be produced by the total fleet of installed solar capacity is frequently used by Staff in seeking public stakeholder input on policy recommendations developed for Board consideration. The protocols have historically used an estimated productivity of 1200 kWh per kWdc of installed solar capacity. To inform the solar transition stakeholder proceeding, Staff received a report titled New Jersey Solar Performance Analysis prepared by PJM-EIS based upon data from the Generation Attribute Tracking System ("GATS") on February 1, 2019. The analysis based upon the SRECs created in GATS for solar electric generation facilities reporting full year metered electricity showed a five year average productivity of 1169 MWh per MWdc (equivalent to 1169 kWh per kWdc). In their analysis, PJM-EIS showed a high correlation between annual solar irradiance and reported solar productivity. On January 8, 2020, PJM-EIS supplied an updated analysis with data from Energy Year 2019 which ended on May 31, 2019. In EY19, solar electric generation facilities reporting full year of metered electricity produced 1110 MWh per MWdc. PJM-EIS calculated the six year average solar performance of 1159 MWh/MWdc and a ten year average solar performance of 1154 MWh/MWdc. Staff recommend that the Board adopt a protocol of 1154 MWh per MWdc for the statewide fleet of installed solar capacity.

Appendix A
Measure Lives

NEW JERSEY STATEWIDE ENERGY-EFFICIENCY PROGRAMS
Measure Lives Used in Cost-Effectiveness Screening

If actual measure lives are available through nameplate information or other manufacturing specifications with proper documentation, those measure lives should be utilized to calculate lifetime savings. In the absence of the actual measure life, Protocol measure lives listed below should be utilized. Measure life values listed below are from the California Database of Energy Efficient Resources[66] (DEER) unless otherwise noted.

Measure	Measure Life (Years)
Residential Sector	
Lighting End Use	
CFL	5
LED	15
HVAC End Use	
Central Air Conditioner (CAC)	15
CAC QIV	15
Air Source Heat Pump (ASHP)	15
Mini-Split (AC or HP)	17
Ground Source Heat Pumps (GSHP)	25
Furnace High Efficiency Fan	15
Heat Pump Hot Water (HPHW)	10
Furnaces	20
Boilers	20
Combination Boilers	20
Boiler Reset Controls	10
Heating and Cooling Equipment Maintenance Repair/Replacement	10
Thermostat Replacement	11
Hot Water End-Use	
Storage Water Heaters	11
Instantaneous Water Heaters	20
Low Flow Showerhead	10[67]

[66] http://www.deeresources.com/

[67] P. C-6 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007, *available at* http://www.energizect.com/sites/default/files/Measure%20Life%20Report%202007.

Measure	Measure Life (Years)
Solar Water Heater	20[68]
Building Shell End-Use	
Air Sealing	15[69]
Duct Sealing and Repair	18
Insulation Upgrades	30[70]
Doors	30[71]
Door Sealing Materials, Door Sweeps, and Spray Foam Sealant	15[72]

Appliances/Electronics End-Use	
ES Refrigerator	14[73]
ES Freezer	14
ES Dishwasher	11
ES Clothes washer	11[74]
ES RAC	9
ES Air Purifier	9[75]
ES Dehumidifier	12[76]
ES Set Top Box	4[77]

[68] Michigan Energy Measures Database 2020 https://www.michigan.gov/mpsc/0,9535,7-395-93309_94801_94808_94811---,00.html.

[69] GDS Associates, "Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures," June 2007.

[70] GDS Associates, Inc., "Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures," June 2007, Table 1 – Residential Measures

[71] Energy Star, https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/windows_doors/Draft6_V1_Criteria_Analysis_Report.pdf.

[72] GDS Associates, Inc., "Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures," June 2007, Table 1 – Residential Measures

[73] California Public Utilities Commission Database for Energy Efficient Resources EUL Support Table for 2020, High Efficiency Refrigerator Measures, *available at* http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx, Accessed April 2020.

[74] DEER Database (2014) (EUL ID: Appl-EffCW)

[75] ENERGY STAR® Savings Calculator for ENERGY STAR® Qualified Appliances (last updated October 1, 2016), *available at* https://www.energystar.gov/sites/default/files/asset/document/appliance_calculator.xlsx

[76] ENERGY STAR Dehumidifier Calculator.

[77] Set top box lifetimes: National Resource Defense Counsel, *Cable and Satellite Set-Top Boxes Opportunities for Energy Savings*, 2005, *available at* http://www.nrdc.org/air/energy/energyeff/stb.pdf.

ES Sound Bar	7[78]
Advanced Power Strips	8[79]
ES Clothes Dryer	12[80]
Refrigerator Retirement	5
Freezer Retirement	4
CO Alarm	7[81]
Commercial Sector	
Lighting End Use	
Performance Lighting	15
Prescriptive Lighting	15
Refrigerated Case LED Lights	16
Specialty LED Fixtures (Signage)	16
Lighting Controls	8
HVAC End Use	
Electronically Commutated Motors for Refrigeration	15
Electric HVAC Systems	15
Fuel Use Economizers	15
Dual Enthalpy Economizers	10
Occupancy Controlled Thermostats	11
Electric Chillers	20
Gas Chillers	25 (ERS)
Prescriptive Boilers	20
Prescriptive Furnaces	20
Commercial Small Motors (1-10 HP)	15
Commercial Small Motors (11-75 HP)	15
Commercial Small Motors (76-200 HP)	15
Small Commercial Gas Boiler	20
Infrared Heaters	17[82]
Programmable Thermostats	11
Demand-Controlled Ventilation Using CO2 Sensors	15
Boiler Reset Controls	10
Building Shell End-Use	

[78] Retail Products Platform Product Analysis, Last Updated May 25, 2016, *available at* https://drive.google.com/file/d/0B9Fd3ckbKJp5OEpWSHg1eksyZ1U/view.

[79] Advanced Power Strip Measure Life: David Rogers, Power Smart Engineering, October 2008: "Smart Strip electrical savings and usability," p. 22.

[80] Estimate based on U.S. EPA (2011), *ENERGY STAR Market & Industry Scoping Report: Residential Clothes Dryers*.

[81] https://www.firstalert.com/community/safety-corner/6-things-to-know-about-carbon-monoxide-alarms/

[82] GDS Associates, Inc., "Natural Gas Efficiency Potential Study," DTE Energy, July 29, 2016, *available at* https://www.michigan.gov/documents/mpsc/DTE_2016_NG_ee_potential_study_w_appendices_vFINAL_554360_7.pdf.

Air Sealing	15[83]
Insulation	30[84]
Doors	30[85]
VFDs End Use	
Variable Frequency Drives	15
New and Retrofit Kitchen Hoods with Variable Frequency Drives	15 (ERS)
Refrigeration End Use	
Energy Efficient Glass Doors on Vertical Open Refrigerated Cases	12
Aluminum Night Covers	5
Walk-in Cooler/Freezer Evaporator Fan Control	16
Cooler and Freezer Door Heater Control	12
Electric Defrost Control	10 (ERS)
Novelty Cooler Shutoff	5
Vending Machine Controls	5
Food Service Equipment End-Use	
Electric and Gas Combination Oven/Steamer	12
Electric and Gas Convection Ovens, Gas Conveyor and Rack Ovens, Steamers, Fryers, and Griddles	12
Insulated Food Holding Cabinets	12
Commercial Dishwashers Commercial Refrigerators and Freezers	15 12
Commercial Ice Machines	10
Hot Water End-Use	
Tank Style (Storage) Water Heaters	15
Instantaneous Gas Water Heaters	20
Low Flow Faucet Aerators and Showerheads	10
Low Flow Pre-rinse Spray Valves	5
Pipe Insulation	11
Appliances/Electronics End-Use	
Computer[86]	4
Printer[87]	6
Renewable and Other	
Fuel Cell	15[88]

[83] GDS Associates, “Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures,” June 2007.

[84] Energy Trust uses 30 years for commercial applications. CEC uses 30 years for insulation in Title 24 analysis.

[85] Energy Star, https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/windows_doors/Draft6_V1_Criteria_Analysis_Report.pdf.

[86] Energy Star Office Equipment Calculator, http://www.energystar.gov/sites/default/files/asset/document/Office%20Equipment%20Calculator.xlsx.

[87] Ibid.

[88] LBNL Report, "A Total Cost of Ownership Model for Solid Oxide Fuel Cells in Combined Heat and Power and Power-Only Applications," December 2015.

Solar Panels	25
Combined Heat & Power (CHP) System ≤ 1 MW[89]	15
Combined Heat & Power (CHP) System > 1 MW[90]	20

[89] Size of individual prime-mover, not the overall system. For example, a project with three 75kW internal combustion engines should be assigned a 17-year measure life for small systems.

[90] Size of individual prime-mover, not the overall system. For example, a project with three 75kW internal combustion engines should be assigned a 17-year measure life for small systems.