New Jersey Board of Public Utilities

New Jersey's Clean Energy Program™

Protocols to Measure Resource Savings

FY2020

~~**Revisions to**~~
~~**FY2016 Protocols**~~

Release Date: May 2019
Board Approval Date: TDB

New Jersey's Clean Energy Program Protocols

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. 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:

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)
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 protocols report gross savings and generation only. Free riders and free drivers are not addressed in these Protocols. Further research in this area is planned.

The outputs of the Protocols are used to support:

- Regulatory reporting
- Cost-effectiveness analysis
- 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 EvaluationContractors assesses 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.

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 Office 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:

	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 loss factor applied to savings at the customer meter is 1.081[1,2] 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 1.0. The gas system does not have losses in the same sense that the electric system does. All of the gas gets from the “city gate” (delivery point to the distribution system) to the point of use except for unaccounted for gas (such as theft), gas lost due to system leakage or loss of gas that is purged when necessary to make system repairs. Since none of these types of “losses” is affected by a decrease in gas use due to energy efficiency at the customer, there are no losses for which to make any adjustment. Therefore, a system loss factor of 1.0 is appropriate for gas energy efficiency savings.

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

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 May 25, 2018.

Using Weighted Average of 2017 PJM On-Peak and Off-Peak annual data[3]**:**

---

[1] JPC&L, Summary of reconciliation factors January 1, 2017 – December 31, 2017.

[2] PSE&G Rate Class & Loss Factor Information

[3] 2013-2017 CO2, SO2 and NOx Emission Rates. PJM, March 15, 2018

Electric Emission Factors

Emissions Product	Pounds per MWh[4]
CO_2	1,374
NO_X	1.11
SO_2	0.98
Hg	1.1 mg/MWh[5]

Natural Gas Emission Factors

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

Assumptions:
"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%

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.

[4] Except that Hg data is reported in mg/MWh.
[5] NJ coal generation units only.

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 Electric HVAC

Protocols

The measurement plan for residential high efficiency cooling and heating equipment is based on algorithms that determine a central air conditioners or heat pump's cooling/heating energy use and peak demand. Input data is based both on fixed assumptions and data supplied from the high efficiency equipment rebate application form. The algorithms also include the calculation of additional energy and demand savings due to the required proper sizing of high efficiency units.

The savings will be allocated to summer/winter and on-peak/off-peak time periods based on load shapes from measured data and industry sources. The allocation factors are documented below in the input value table.

The protocols applicable for this program measure the energy savings directly related to the more efficient hardware installation. Estimates of energy savings due to the proper sizing of the equipment are also included.

The following is an explanation of the algorithms used and the nature and source of all required input data.

Central Air Conditioner (A/C) & Air Source Heat Pump (ASHP) & Mini-split (AC or HP)

<u>Algorithms</u>

Cooling Energy and Peak Demand Savings:

Energy Savings (kWh/yr) = Tons * 12 kBtuh/Ton * (1/$SEER_b$ – 1/$SEER_q$) * $EFLH_c$

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

Heating Energy Savings (ASHP and Mini-Split):

Energy Savings (kWh/yr) = Tons * 12 kBtuh/Ton * (1/$HSPF_b$ - 1/$HSPF_q$) * $EFLH_h$

Proper Sizing and Quality Installation Verification (QIV):

Energy Savings (kWh/yr) = kWh_q * ESF

Energy Savings (kW/yr) = kW_q* DSF

During Existing System Maintenance:

Energy Savings (kWh/yr) = (Tons * 12 kBtuh/Ton * $SEER_m$) * $EFLH_c$ * MF

Peak Demand Savings (kW) =(Tons * 12 kBtuh/Ton * EER_m) * CF * MF

Duct Sealing:

Energy Savings (kWh/yr) = (Tons * 12 kBtuh/Ton * $SEER_q$) * $EFLH_c$ * DuctSF

Peak Demand Savings (kW) = (Tons * 12 kBtuh/Ton * EER_q) * CF * DuctSF

Ground Source Heat Pumps (GSHP)

<u>Algorithms</u>

Energy Savings (kWh/yr) = Tons * 12 kBtuh/Ton * (1/($EER_{g,b}$ * GSER) – (1/ (EER_g * GSER))) * $EFLH_c$

Peak Demand Savings (kW) = Tons * 12 kBtuh/Ton * (1/$EER_{g,b}$ – (1/ (EER_g * GSPK))) * CF

Heating Energy Savings (kWh/yr) = Tons * 12 kBtuh/Ton * (1/($COP_{g,b}$ * GSOP) – (1/ (COP_g * GSOP))) * $EFLH_h$

GSHP Desuperheater

Energy (kWh) Savings = EDSH

Peak Demand Impact (kW) = PDSH

Furnace High Efficiency Fan

<u>Algorithms</u>

Heating Energy Savings (kWh/yr) = (Cap_q /3.412 kWh/Btu) * $EFLH_h$ * FFS_{HT}

Cooling Energy Savings (kWh/yr) = FFS_{CL}

Solar Domestic Hot Water (augmenting electric resistance DHW)

Heating Energy (kWh) Savings = $ESav_{SDHW}$

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

Heat Pump Hot Water (HPHW)

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

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

Drain Water Heat Recovery (DWHR)

Heating Energy (kWh) Savings = $ESav_{DWHR}$

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

<u>Definition of Terms</u>

Tons = The rated cooling capacity of the unit being installed. This data is obtained from the Application Form based on the model number.

$SEER_b$ = 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 based on the model number.

$SEER_m$ = The Seasonal Energy Efficiency Ratio of the Unit receiving maintenance

EER_m = The Energy Efficiency Ratio of the Unit receiving maintenance

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 based on the model number.

$EER_{g,q}$ = The EER of the ground source heat pump being installed. Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER_g by 1.02.

$EER_{g,b}$ = The EER of a baseline ground source heat pump

GSER = The factor to determine the SEER of a GSHP based on its EER.

EFLH = The Equivalent Full Load Hours of operation for the average unit (cooling or heating)

ESF = The Energy Savings Factor or the assumed saving due to proper sizing and proper installation.

MF = The Maintenance Factor or assumed savings due to completing recommended maintenance on installed cooling equipment.

DuctSF = The Duct Sealing Factor or the assumed savings due to proper sealing of all cooling ducts

CF = The coincidence factor which equates the installed unit's connected load to its demand at time of system peak.

DSF = The Demand Savings Factor or the assumed peak demand capacity saved due to proper sizing and proper installation.

$HSPF_b$ = The Heating Seasonal Performance Factor of the Baseline Unit.

$HSPF_q$ = The Heating Seasonal Performance Factor of the unit being installed. This data is obtained from the Application Form.

$COP_{g,q}$ = Coefficient of Performance of a GSHP

$COP_{g,b}$ = Baseline Coefficient of Performance of a GSHP

GSOP = The factor to determine the HSPF of a GSHP based on its COP.

GSPK = The factor to convert EER_g to the equivalent EER of an air conditioner to enable comparisons to the baseline unit.

EDSH = Assumed savings per desuperheater.
PDSH = Assumed peak demand savings per desuperheater.
$ESav_{SDHW}$ = Assumed energy savings per installed solar domestic hot water system with electric resistance heater backup.

$DSav_{SDHW}$ = Assumed demand savings per installed solar domestic hot water system with electric resistance heater backup.

Cap_q = Output capacity of the qualifying heating unit in BTUs/hour

EFLH = The Equivalent Full Load Hours of operation for the average heating unit

FFS_{HT} = Furnace fan savings (heating mode)

FFS_{CL} = Furnace fan savings (cooling mode)

kWh_q = Annual kWh usage post-program

kW_q = Annual kW usage post-program

$ESav_{HPHW}$ = Assumed energy savings per installed heat pump water heater.

$DSav_{HPHW}$ = Assumed demand savings per installed heat pump water heater.

$ESav_{DWHR}$ = Assumed energy savings per installed drain water heat recovery unit in a household with an electric water heater.

$DSav_{DWHR}$ = Assumed demand savings per installed drain water heat recovery unit in a household with an electric water heater.

Summary of Inputs

Residential Electric HVAC

Component	**Type**	**Value**	**Source**
Tons	Variable	Rated Capacity, Tons	Rebate Application
$SEER_b$	Fixed	Split Systems (A/C) = 13 Split Systems (HP) = 14 Single Package (A/C) = 14 Single Package (HP) = 14	1

Component	Type	Value	Source
$SEER_q$	Variable		Rebate Application
$SEER_m$	Fixed	13	1
EER_b	Fixed	Baseline = 11.3	2
EER_q	Fixed	= (11.3/13) * $SEER_q$	2
EER_g	Variable		Rebate Application
$EER_{g,b}$	Fixed	11.2	12
EER_m	Fixed	8.69	2
GSER	Fixed	1.02	3
$EFLH_{c\ or\ h}$	Fixed	Cooling = 600 Hours Heating = 965 Hours	11
ESF	Fixed	9.2%	10
DSF	Fixed	9.2%	10
kWh_q	Variable		Rebate Application
kW_q	Variable		Rebate Application
MF	Fixed	10%	3
DuctSF	Fixed	18%	13
CF	Fixed	69%	4
DSF	Fixed	2.9%	5
$HSPF_b$	Fixed	Split Systems (HP) = 8.2 Single Package (HP) = 8.0	1
$HSPF_q$	Variable		Rebate Application
COP_g	Variable		Rebate Application
$COP_{g,b}$	Fixed	2.9	12
GSOP	Fixed	3.413	6
GSPK	Fixed	0.8416	3
EDSH	Fixed	1842 kWh	3
PDSH	Fixed	0.34 kW	3
$ESav_{SDHW}$	Fixed	3100 kWh	14
$DSav_{SDHW}$	Fixed	0.426 kW	14
CF_{SDHW}	Fixed	20%	14
$ESAV_{HPHW}$	Fixed	1687 kWh	15
$DSav_{HPHW}$	Fixed	0.37 kW	16
CF_{HPHW}	Fixed	70%	16

Component	Type	Value	Source
$ESAV_{DWHR}$	Fixed	1457 kWh	15, 18
$DSav_{DWHR}$	Fixed	0.142 kW	19
CF_{DWHR}	Fixed	20%	19
Cooling – CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 64.9% Summer/Off-Peak 35.1% Winter/On-Peak 0% Winter/Off-Peak 0%	7
Cooling – ASHP Time Period Allocation Factors	Fixed	Summer/On-Peak 59.8% Summer/Off-Peak 40.2% Winter/On-Peak 0% Winter/Off-Peak 0%	7
Cooling – GSHP Time Period Allocation Factors	Fixed	Summer/On-Peak 51.7% Summer/Off-Peak 48.3% Winter/On-Peak 0% Winter/Off-Peak 0%	7
Heating – ASHP & GSHP Time Period Allocation Factors	Fixed	Summer/On-Peak 0.0% Summer/Off-Peak 0.0% Winter/On-Peak 47.9% Winter/Off-Peak 52.1%	7
GSHP Desuperheater Time Period Allocation Factors	Fixed	Summer/On-Peak 4.5% Summer/Off-Peak 4.2% Winter/On-Peak 43.7% Winter/Off-Peak 47.6%	7
SDHW Time Period Allocation Factors	Fixed	Summer/On-Peak 27.0% Summer/Off-Peak 15.0% Winter/On-Peak 42.0% Winter/Off-Peak 17.0%	14
HPWH Time Period Allocation Factors	Fixed	Summer/On-Peak 21% Summer/Off-Peak 22% Winter/On-Peak 28% Winter/Off-Peak 29%	17
DWHR Time Period Allocation Factors	Fixed	Summer/On-Peak 27.0% Summer/Off-Peak 15.0% Winter/On-Peak 42.0% Winter/Off-Peak 17.0%	14
$Capy_q$	Variable		Rebate Application
FFS_{HT}	Fixed	0.5 kWh	8
FFS_{CL}	Fixed	105 kWh	9

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=2942a69a6328c23266612378a0725e60&mc=true&node=se10.3.430_132&rgn=div8.
2. Average EER for SEER 13 units. The same EER to SEER ratio used for SEER 13 units applied to SEER 10 units. EER_m = (11.3/13) * 10.
3. VEIC estimate. Extrapolation of manufacturer data.
4. NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017.
5. Xenergy, "New Jersey Residential HVAC Baseline Study," (Xenergy, Washington, D.C., November 16, 2001) Table E-8.
6. Engineering calculation, HSPF/COP=3.413
7. Time period allocation factors used in cost-effectiveness analysis.
8. "Review of Emerging HVAC Technologies and Practices" 03-STAC-01 Emerging Technologies Report, October 2005, John Proctor, PE, p. 46.
9. Scott Pigg (Energy Center of Wisconsin), "Electricity Use by New Furnaces: A Wisconsin Field Study," Technical Report 230-1, October 2003.
10. KEMA, NI Clean Energy Program Energy Impact Evaluation Protocol Review. 2009.
11. VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.
12. AHRI directory; baseline values are the least efficient "Geothermal – Water-to –Air Heat Pumps" active in the directory, downloaded May 18, 2015.
13. NEEP, "Benefits of HVAC Contractor Training," Appendix C , February 2006.
14. Energy savings are estimated based on 2008 SRCC OG300 ratings for a typical 2 panel system with solar storage tank in Newark, NJ with electric DHW backup. Demand savings are estimated based on an estimated electric DHW demand of 2.13kW with 20% CF. Load shape and coincidence factors were developed by VEIC from ASHRAE Standard 90.2 Hot Water Draw Profile and NREL Red Book insulation data for Newark, NJ.
15. Table 1. (Page 2) From "Heat Pump Water Heaters Evaluation of Field Installed Performance." Steven Winter Associates, Inc. (2012). http://www.ma-eeac.org/Docs/8.1_EMV%20Page/2012/2012%20Residential%20Studies/MA%20RR&LI%20-%202011%20HPWH%20Field%20Evaluation%20Report%20FINAL%206_26_2012.pdf
16. VEIC Estimate based upon range derived from FEMP Federal Technology Alert: S9508031.3a (http://www1.eere.energy.gov/femp/pdfs/FTA_res_heat_pump.pdf)
17. "Electrical Use, Efficiency, and Peak Demand of Electric Resistance, Heat Pump, Desuperheater, and Solar Hot Water Systems", http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-215-90/
18. 30% savings (from Zaloum, C. Lafrance, M. Gusdorf, J. "Drain Water Heat Recovery Characterization and Modeling" Natural Resources Canada. 2007. Savings vary due

to a number of factors including make, model, installation-type, and household behaviors.) multiplied by standard electric resistance water heating baseline annual usage of 4,857 kWh cited in source #23 above.

19. Demand savings are estimated based on electric DHW demand of 2.13kW and 20% CF as in cited source #21 adjusting for the proportional difference of 30% savings relative to the 70% solar fraction: 0.426*0.3/0.9 = 0.142.

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.

Furnaces

This section provides energy savings algorithms for qualifying gas and oil furnaces installed in residential settings. The input values are based on the specifications of the actual equipment being installed, federal equipment efficiency standards, and the most recent impact evaluation of the residential Warm and Cool Advantage programs (2009).

This measure applies to replacement of failed equipment or end of useful life. The baseline unit is a code compliant unit with an efficiency as required by IECC 2015, which is the current residential code adopted by the state of New Jersey.

Algorithms

Fuel Savings (MMBtu/yr) = Cap_{in} * $EFLH_h$ * (($AFUE_q$ /$AFUE_b$) – 1) / 1000 kBtu/MMBtu

Definition of Variables

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

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

$AFUE_q$ = Annual Fuel Utilization Efficiency of the qualifying furnace

$AFUE_b$ = Annual Fuel Utilization Efficiency of the baseline furnace meeting current federal equipment standards

Summary of Inputs

Furnace Assumptions

Component	Type	Value	Source
Cap_{in}	Variable		Application
$EFLH_h$	Fixed	965 hours	1
$AFUE_q$	Variable		Application

Component	Type	Value	Source
$AFUE_b$	Fixed	Weatherized gas: 81% Weatherized oil: 78% Mobile home gas: 80% Mobile home oil: 75% Non-weatherized gas: 80% Non-weatherized oil: 83% Electric Resistance Heating: 35%	2,3

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. 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 btu_{in} per 1 btu_{out}.

Boilers

This section provides energy savings algorithms for qualifying boilers installed in residential settings. The input values are based on the specifications of the actual equipment being installed, federal equipment efficiency standards, and the most recent impact evaluation of the residential Warm and Cool Advantage programs (2009).

This measure applies to replacement of failed equipment or end of useful life. The baseline unit is a code compliant unit with an efficiency as required by IECC 2015, which is the current residential code adopted by the state of New Jersey.

Algorithms

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

Definition of Variables

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

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

$AFUE_q$ = Annual Fuel Utilization Efficiency of the qualifying boiler

$AFUE_b$ = Annual Fuel Utilization Efficiency of the baseline boiler

Summary of Inputs

Space Heating 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% Electric Resistance Heating: 35%	2,3

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. 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 btu_{in} per 1 btu_{out}.

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 end of 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)[6] for consumer and commercial water heaters. The UEF is 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.[7]

Algorithms

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.

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

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

UEF_b = Uniform energy factor of the baseline water heater. In New Jersey the 2015 International Energy Conseration 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

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	23.6 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[8] 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.

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

4. US Energy Information Association, *2009 Residential Energy Consumption Survey Data*[9]; available at: https://www.eia.gov/consumption/residential/data/2009/c&e/ce3.2.xlsx

Boiler Reset Controls

The following algorithm details savings for installation of boiler reset control on residential boilers. Energy savings are realized through a better control of boiler water temperature. Through the use of software settings, boiler reset controls use outside or return water temperature to control boiler firing and in turn the boiler water temperature.

The input values are based on data supplied by the utilities and customer information on the application form, confirmed with manufacturer data. Unit savings are based on study results.

Fuel Savings (MMBtu/yr) = (% Savings) * ($EFLH_h$ * Cap_{in}) / 1,000 kBtu/MMBtu

Definition of Variables

% Savings = Estimated percentage reduction in heating load due to boiler reset controls

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

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

Summary of Inputs

Boiler Reset Control Assumptions

Component	Type	Value	Source
% Savings	Fixed	5%	1
$EFLH_h$	Fixed	965 hours	2
Cap_{in}	Variable		Application

Sources

1. GDS Associates, Inc., Natural Gas Energy Efficiency Potential in Massachusetts, 2009, p. 38, Table 6-4, http://ma-eeac.org/wordpress/wp-content/uploads/5_Natural-Gas-EE-Potenial-in-MA.pdf.
2. NJ utility analysis of heating customers, annual gas usage..

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

[9] Data for 2015 will be available in 2018.

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)[10] for consumer and commercial water heaters. The UEF is 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.[11]

Algorithms

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

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 Conseration 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
Baseline Water Heater Usage	Fixed	23.6 MMBtu/yr	2

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

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

[11] 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. The baseline UEF formulas shown in the table above are associated with medium draw patterns.

Sources

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*[12]; available at: https://www.eia.gov/consumption/residential/data/2009/c&e/ce3.2.xlsx.

[12] Data for 2015 will be available in 2018.

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 an 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)[13] for consumer and commercial water heaters. The UEF is 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.[14]

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 Conseration 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	23.6 MMBtu/yr	2

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

[14] 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[15] assuming tank sizes of 30 gallons for small units, 40 gallons for medium units, and 55 gallons for large units.

Sources

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*[16]; available at: https://www.eia.gov/consumption/residential/data/2009/c&e/ce3.2.xlsx.

[15] Available at: https://www.eia.gov/consumption/residential/data/2009/hc/hc8.8.xls
[16] Data for 2015 will be available in 2018.

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 utilities and the Weatherization Assistance component of the Low-income Program implemented by the New Jersey Department of Community Affairs (DCA).

The savings protocols for the low-income program 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.

Base Load Measures

Efficient Lighting

Savings from installation of screw-in CFLs, high performance fixtures, fluorescent torchieres, LEDs and LED nightlights are based on a straightforward algorithm that calculates the difference between existing and new wattage, and the average daily hours of usage for the lighting unit being replaced.

<u>Algorithm</u>

Compact Fluorescent Screw In Lamp

Energy Savings (kWh/yr) = $((CFL_{watts}) * (CFL_{hours} * 365))/1000$

Peak Demand Savings (kW) = $(CFL_{watts}) * \text{Light CF}$

Efficient Fixtures

Energy Savings (kWh/yr) = $((Fixt_{watts}) * (Fixt_{hours} * 365))/1000$

Peak Demand Savings (kW) = $(Fixt_{watts}) * \text{Light CF}$

Efficient Torchieres

Energy Savings (kWh/yr) = $((Torch_{watts}) * (Torch_{hours} * 365))/1000$

Peak Demand Savings (kW) = $(Torch_{watts}) * \text{Light CF}$

LED Screw In Lamp

Energy Savings (kWh/yr) = $((LED_{watts}) * (LED_{hours} * 365))/1000$

Peak Demand Savings (kW) = $(LED_{watts}) * \text{Light CF}$

LED Nightlight

Energy Savings (kWh/yr) = $((LEDN_{watts}) * (LEDN_{hours} * 365))/1000$

Hot Water Conservation Measures

The protocols savings estimates are based on an average package of domestic hot water measures typically installed by low-income programs.

Low Flow Showerheads

Savings for low-flow showerhead measures are determined using the total change in flow rate (gallons per minute) from the baseline (existing) showerhead to the efficient showerhead.

Algorithms

Energy Savings (kWh/yr) = %Electric DHW * (GPM_base – GPM_ee) * kWh/ΔGPM

Peak Demand Savings (kW) = Electricity Impact (kWh) * Demand Factor

Natural Gas Impact (therm) = %Gas DHW * (GPM_base – GPM_ee) * therm/ΔGPM

Definition of Variables

%Electric DHW = proportion of water heating supplied by electricity

GPM_base = Flow rate of the baseline showerhead (gallons per minute)

GPM_ee = Flow rate of the efficient showerhead (gallons per minute)

kWh/ΔGPM = Electric energy savings of efficient showerhead per gallon per minute (GPM)

Demand Factor = energy to demand factor

%Gas DHW = proportion of water heating supplied by natural gas

therm/ΔGPM = natural gas energy savings of efficient showerhead per gallon per minute (GPM)

Low Flow Showerheads

Component	Type	Value	Sources
% Electric DHW	Variable	Electric DHW = 100% Unknown = 13%	1
%Gas DHW	Variable	Natural Gas DHW = 100% Unknown = 81%	1
GPM_base	Variable	Rebate Application Unknown = 2.5	2
GPM_ee	Variable	Rebate Application Unknown = 1.5	2
kWh/ΔGPM	Fixed	SF = 360.1 MF = 336.9 Unknown = 390.1	3

Component	Type	Value	Sources
therm/ΔGPM	Fixed	SF = 15.5 MF = 16.9 Unknown = 16.8	3, 4
Demand Factor	Fixed	0.00008013	3

Sources

1. Unknown hot water heating fuel assumption taken from 2009 RECS data for New Jersey; see Table HC8.8 Water Heating in U.S. Homes in Northeast Region, Divisions, and States.
2. Flow rate specification taken from rebate application; default assumption for unknown flow rate taken from Pennsylvania Technical Reference Manual, effective June 2016, p. 120ff; available at http://www.puc.pa.gov/pcdocs/1370278.docx.
3. Default assumptions from Pennsylvania Technical Reference Manual (ibid).
4. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 4.0, effective June 1, 2015, pp. 657ff; default assumptions for housing demographic characteristics taken from PA TRM.

Low Flow Faucet Aerators

Savings for low-flow faucet aerator measures are determined using the total change in flow rate (gallons per minute) from the baseline (existing) faucet to the efficient faucet.

Algorithms

Energy Savings (kWh/yr) = %Electric DHW * (GPM_base – GPM_ee) * kWh/ΔGPM

Peak Demand Savings (kW) = Electricity Impact (kWh) * Demand Factor

Natural Gas Impact (therm) = %Gas DHW * (GPM_base – GPM_ee) * therm/ΔGPM

Definition of Variables

%Electric DHW = proportion of water heating supplied by electricity

GPM_base = Flow rate of the baseline faucet (gallons per minute)

GPM_ee = Flow rate of the efficient faucet (gallons per minute)

kWh/ΔGPM = Electric energy savings of efficient faucet per gallon per minute (GPM)

Demand Factor = energy to demand factor

%Gas DHW = proportion of water heating supplied by natural gas

therm/ΔGPM = natural gas energy savings of efficient faucet per gallon per minute (GPM)

Low Flow Faucet Aerators

Component	Type	Value	Source
% Electric DHW	Variable	Electric DHW = 100% Unknown = 13%	1
% Gas DHW	Variable	Natural Gas DHW = 100% Unknown = 81%	1
GPM_base	Variable	Rebate Application Unknown = 2.2	2
GPM_ee	Variable	Rebate Application Unknown = 1.5	2
kWh/ΔGPM	Fixed	SF = 60.5 MF = 71.0 Unknown = 63.7	3
therm/ΔGPM	Fixed	SF = 4.8 MF = 6.5 Unknown = 5.0	3, 4
Demand Factor	Fixed	0.000134	3

<u>Sources</u>

1. Unknown hot water heating fuel assumption taken from 2009 RECS data for New Jersey; see Table HC8.8 Water Heating in U.S. Homes in Northeast Region, Divisions, and States.
2. Flow rate specification taken from rebate application; default assumption for unknown flow rate taken from Pennsylvania Technical Reference Manual; effective June 2016, pp. 114ff; available at http://www.puc.pa.gov/pcdocs/1370278.docx.
3. Default assumptions from Pennsylvania Technical Reference Manual (ibid).
4. Illinois Statewide Technical Reference Manual for Energy Efficiency, Version 4.0, effective June 1, 2015, pp. 648ff; default assumptions for housing demographic characteristics taken from PA TRM.

Indirect Hot Water Heaters

Wisconsin's 2013 Focus on Energy Deemed Savings are as follows.[17]

$$\Delta Therm = Therm_{Std} - Therm_{Eff}$$

$$Therm_{Out} = EF_{Std} \times Therm_{StdTank}$$

$$Therm_{Std} = Standby_{Std} \times 8{,}760 \times 1/100{,}000/AFUE_{Std} + Therm_{Out} \times 1/AFUE_{std}$$

Average hot water use per person were taken from: Lutz, James D., Liu, Xiaomin, McMahan, James E., Dunham, Camilla, Shown, Leslie J., McCure, Quandra T; "Modeling patterns of hot water use in households;" LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996.

$$Therm_{Eff} = Standby_{Eff} \times 8{,}760 \times 1/100{,}000/AFUE_{Eff} + Therm_{Out} \times 1/AFUE_{Eff}$$

$$Standby_{Std} = Vol_{Std} \times \left(\frac{°F}{hr_{Std}}\right) \times 8.33$$

$$Standby_{Eff} = Vol_{Eff} \times \left(\frac{°F}{hr_{Eff}}\right) \times 8.33$$

Table IV-13. Definitions and Values for Indirect Hot Water Heaters

Term	Definition	Value
ΔTherm	Gas savings	
$Therm_{Std}$	Calculated therms standard tank	206
$Therm_{Eff}$	Calculated therms replacement tank	177.52
$Therm_{Out}$		
EF_{Std}	Federal standard energy factor	(.67 – (.0019xvolume))=.58
$Therm_{StdTank}$	Therms used by standard tank	223
$Standby_{Std}$	Standby loss from standard water heater	434 Btu/hr*
$AFUE_{Std}$	Efficiency (AFUE) of standard water heater	80%
$Standby_{Eff}$	Standby loss from efficient water heater	397 Btu/hr**
$AFUE_{Eff}$	Efficiency (AFUE) of efficient water heater	93%
Vol_{Std}	Volume of standard water heater (gallons)	63.50
Vol_{Eff}	Volume of efficient water heater (gallons)	51.20
$°F/hr_{Std}$	Heat lost per hour from standard water heater tank	0.8

[17] The Cadmus Group, Inc. "Final Report Focus on Energy Evaluated Deemed Savings Changes." *Prepared for the Public Service Commission of Wisconsin.* November 26, 2013. Pp. 15-16.

Term	Definition	Value
°F/hr$_{Eff}$	Heat lost per hour from efficient water heater tank	0.93
	Conversion factor: density of water (lbs./gallon)	8.33

*AHRI Database. **Data model look-ups of AHRI Certifications.

Water heater pipe wrap

This section provides energy savings algorithms for insulation on domestic hot water heater pipes. Un-insulated hot water carrying pipes lose considerable heat to outside air due to high thermal conductivity. In order to reduce this heat loss, pipes can be covered with a layer of insulation, which will reduce source heating demand, resulting in significant energy savings. The baseline case assumes un-insulated copper pipes and the qualifying condition assumes polyolefin (Polyethylene) Foam Tube insulation at 3/8" thick for 1/2" pipe and 1/2" thick for 3/4" pipe.

Algorithms

Energy Savings (kWh/yr) = $AKW_W \times L$

Fuel Savings (Ccf/yr) = $ACCF_W \times L$

Definition of Variables

AKW_W = Annual electric savings per linear foot of heating pipe insulation

$ACCF_W$ = Annual gas savings per linear foot of heating pipe insulation

L = Length of heating pipe insulation in ft

Summary of Inputs

Water Heater Pipe Wrap

Component	Type	Value	Source
AKW_W	Variable	See Table Below	1
$ACCF_W$	Variable	See Table Below	1
L	Variable		Application

Insulation Savings by Pipe Diameter

Pipe Diameter (in)	AKW_W (kWh/ft)	$ACCF_W$ (Ccf/ft)
0.50	10.4	0.55
0.75	15.9	0.85

Sources

1. NAIMA, 3E Plus software tool, Version 4.0, Released 2005; available from: https://insulationinstitute.org/tools-resources/free-3e-plus/

Efficient Refrigerators

The eligibility for refrigerator replacement is determined by comparing monitored consumption for the existing refrigerator with the rated consumption of the eligible replacement. Estimated savings are directly calculated based on the difference between these two values. Note that in the case where an under-utilized or unneeded refrigerator unit is removed, and no replacement is installed, the Ref_{new} term of the equation will be zero.

Algorithm

Energy Savings (kWh/yr) = $Ref_{old} – Ref_{new}$

Peak Demand Savings (kW) = $(Ref_{old} – Ref_{new})$ *(Ref DF)

Space Conditioning Measures

When available, gas heat measure savings will be based on heating use. If only total gas use is known, heating use will be estimated as total use less 300 therms.

Air Sealing

It is assumed that air sealing is the first priority among candidate space conditioning measures. Expected percentage savings is based on previous experiences with measured savings from similar programs. Note there are no summer coincident electric peak demand savings estimated at this time.

Algorithm

Energy Savings (kWh/yr) = ESC_{pre} * 0.05

MMBtu savings = (GHpre * 0.05)

Furnace/Boiler Replacement

Quantification of savings due to furnace and boiler replacements implemented under the low-income program will be based on the algorithms presented in the Residential Gas HVAC section of these Protocols.

Duct Sealing and Repair

The second priority for homes with either Central Air Conditioning (CAC) or some other form of ducted distribution of electric space conditioning (electric furnace, gas furnace or heat pump) is ensuring integrity and effectiveness of the ducted distribution system.

Algorithm

With CAC

Energy Savings (kWh/yr) = $(ECool_{pre})$ * 0.10

Peak Demand Savings (kW) = $(Ecool_{pre}$ * 0.10) / EFLH * AC CF

MMBtu savings = (GHpre * 0.02)

No CAC

Energy Savings (kWh/yr) = $(ESC_{pre.})$ * 0.02

MMBtu savings = (GHpre * 0.02)

Insulation Upgrades

For savings calculations, it is assumed that any applicable air sealing and duct sealing/repair have been done, thereby reducing the space conditioning load, before consideration of upgrading insulation. Attic insulation savings are then projected on the basis of the "new" load. Gas savings are somewhat greater, as homes with gas heat generally have less insulation.

Algorithm

Energy savings (kWh/yr) = $(ESC_{pre)}$ * 0.08

MMBtu savings = GH_{pre} * 0.13

Thermostat Replacement

Thermostats are eligible for consideration as an electric space conditioning measure only after the first three priority items. Savings projections are based on a conservative 3% of the "new" load after installation of any of the top three priority measures.

Algorithm

Energy Savings (kWh/yr) = $(ESC_{pre)}$ * 0.03

MMBtu savings = $(GH_{pre}$ * 0.03)

Heating and Cooling Equipment Maintenance Repair/Replacement

Savings projections for heat pump charge and air flow correction. Protocol savings account for shell measures having been installed that reduce the preexisting load.

Algorithm

Energy Savings (kWh/yr) = $(ESC_{pre)}$ * 0.17

Peak Demand Savings (kW) = (Capy/EER * 1000) * HP CF * DSF

Gas HVAC Repairs

This section provides energy savings algorithms for existing gas HVAC repairs in residential applications. The savings calculation requires measurement of steady state furnace efficiency before and after repairs using an electronic combustion analyzer. Alternatively, before and after repair efficiencies may be measured following the method described in ANSI/ASHRAE Standard 103-2007, Method of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers. Maximum post repair efficiency must not exceed equipment nameplate efficiency. Technicians performing repairs must provide documentation of before- and after-combustion analysis results.

<u>Algorithms</u>

$$\text{Fuel Savings (MMBtu/yr)} = Cap_{in} \times EFLH_h \times (1/SSE_b - 1/SSE_q) / 1{,}000\text{kBtu/MMBtu}$$

<u>Definition of Variables</u>

Cap_{in} = input capacity of existing unit in kBtu/hr

$EFLH_h$ = equivalent full load heating hours

SSE_b = Steady state efficiency of baseline gas HVAC equipment

SSE_q = Steady state efficiency of repaired gas HVAC equipment

<u>Summary of Inputs</u>

Gas HVAC Repairs

Component	Type	Value	Source
Furnace rating	Variable		Application
$EFLH_h$	Fixed	965	NJ utility analysis of heating customers, annual gas heating usage
SSE_q	Variable		Application
SSE_b	Variable		Application

Example: If a furnace has a 90 kBtu/hr input capacity, baseline efficiency of 85%, and post repairs efficiency of 90%, the fuel savings would be calculated as FS = 90kBtu/hr × 965 hr × (1/0.85 – 1/0.90)/1,000kBtu/MMBtu = 5.67 MMBtu/yr.

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	5%	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, 2016 – average for lighting products.
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. Pennsylvania Technical Reference Manual, June 2016, p. 27; available at http://www.puc.pa.gov/pcdocs/1370278.docxt.

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[18]. 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), and the DOE Zero Energy Ready Home (ZERH) Program. 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.[19]

Single-Family, Multi-Single (townhomes), Low-Rise Multifamily

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 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 program (e.g. by setting the reference and rated home to the same value for program-required mechanical ventilation);
- Other approved adjustments as may be deemed necessary.

---

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

The RNC program currently specifies three standards for program qualification:

- IECC 2015 Energy Rating Index (for homes permitted on or after March 21, 2016)
- ENERGY STAR Certified Homes v3.1
- 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)

Annual energy and summer coincident peak demand savings for qualifying MFHR construction projects shall be calculated from the Energy Star Performance Path Calculator (PPC)[20]. 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

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

ENERGY STAR Energy Efficient Products

Protocols

The following sections detail savings calculations ENERGY STAR Appliances and Lighting Products in residential and multi-family sectors.

ENERGY STAR 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.

ENERGY STAR Refrigerators – CEE Tier 1

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

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

ENERGY STAR Refrigerators – CEE Tier 2

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

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

ENERGY STAR Clothes Washers – CEE Tier 1

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

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

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

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

ENERGY STAR Clothes Washers – CEE Tier 2

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

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

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

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

ENERGY STAR Set Top Boxes [Inactive 2017, Not Reviewed]

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

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

Advanced Power Strip – Tier 1

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

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

Advanced Power Strip – Tier 2

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

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

ENERGY STAR Electric Clothes Dryers – Tier 1

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

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

ENERGY STAR Gas Clothes Dryers – Tier 1

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

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

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

ENERGY STAR Electric Clothes Dryers – Tier 2

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

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

ENERGY STAR Gas Clothes Dryers – Tier 2

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

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

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

~~ENERGY STAR Room AC – Tier 1 [Inactive 2017, Not Reviewed]~~

~~Electricity Impact (kWh) = $ESav_{RAC1}$~~

~~Demand Impact (kW) = $DSav_{RAC1}$~~

~~ENERGY STAR Room AC – Tier 2 [Inactive 2017, Not Reviewed]~~

~~Electricity Impact (kWh) = $ESav_{RAC2}$~~

~~Demand Impact (kW) = $DSav_{RAC2}$~~

ENERGY STAR Room Air Purifier [Inactive 2017, Not Reviewed]

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

Demand Savings (kW) = $DSav_{RAC2}$ is 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)**	$ESav_{RAP}$
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	$DSav_{RAC2}$
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 [Inactive 2017, Not Reviewed]

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

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

ENERGY STAR Soundbar [Inactive 2017, Not Reviewed]

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

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

Definition of Variables

$ESav_{REF1}$ = Electricity savings per purchased ENERGY STAR refrigerator – CEE Tier 1.

$DSav_{REF1}$ = Summer demand savings per purchased ENERGY STAR refrigerator – CEE Tier 1.

$ESav_{REF2}$ = Electricity savings per purchased ENERGY STAR refrigerator – CEE Tier 2.

$DSav_{REF2}$ = Summer demand savings per purchased ENERGY STAR refrigerator – CEE Tier 2.

$ESav_{CW1}$ = 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 Tier 2 ENERGY STAR clothes washer.
$DSav_{CW2}$ = Summer demand savings per purchased Tier 2 ENERGY STAR clothes washer.
$GSav_{CW2}$ = Gas savings per purchased Tier 2 ENERGY STAR clothes washer
$WSav_{CW2}$ = Water savings per purchased Tier 2 ENERGY STAR 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 Tier 2 ENERGY STAR electric clothes dryer.
$DSav_{CDE2}$ = Demand savings per purchased Tier 2 ENERGY STAR electric clothes dryer.
$ESav_{CDG2}$ = Electricity savings per purchased Tier 2 ENERGY STAR gas clothes dryer.
$DSav_{CDG2}$ = Demand savings per purchased gas Tier 2 ENERGY STAR gas clothes dryer.
$GSav_{CDG2}$ = Gas savings per purchased Tier 2 ENERGY STAR 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.
$ESav_{RAC1}$ = Electricity savings per purchased Tier 2 room air conditioner.
$DSav_{RAC2}$ = Summer demand savings per purchased Tier 2 room air conditioner.
$ESav_{RAC1}$ = Electricity savings per purchased ENERGY STAR room air purifier.
$DSav_{RAP}$ = Summer demand savings per purchased ENERGY STAR room air purifier.
$ESav_{FRZ}$ = Electricity savings per purchased ENERGY STAR freezer.
$DSav_{FRZ}$ = Summer demand savings per purchased ENERGY STAR 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

Component	Type	Value	Sources
$ESav_{REF1}$	Fixed	59 kWh	5
$DSav_{REF1}$	Fixed	0.007 kW	5
$ESav_{REF2}$	Fixed	89 kWh	5
$DSav_{REF2}$	Fixed	0.01 kW	5
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%	1
$ESav_{CW1}$	Fixed	55 kWh	2
$Gsav_{CW1}$	Fixed	4.8 therms	2
$DSav_{CW1}$	Fixed	0.005 kW	2
$WSav_{CW1}$	Fixed	2175 gallons	2
$ESav_{CW2}$	Fixed	61 kWh	2
$Gsav_{CW2}$	Fixed	9.00 therms	2
$DSav_{CW2}$	Fixed	0.006 kW	2
$WSav_{CW2}$	Fixed	2966 gallons	2
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%	1
CW, CD Gas Time Period Allocation Factors	Fixed	Summer 50% Winter 50%	3
$CF_{REF,}$ $CF_{CW,}$ $CF_{STB,}$ $CF_{APS,}$ CF_{CD}	Fixed	1.0	4
CF_{RAC}	Fixed	0.31	14
$ESav_{STB}$	Fixed	44 kWh	7
$DSav_{STB}$	Fixed	0.005 kW	7
$ESav_{APS1}$	Fixed	102.8 kWh	8
$DSav_{APS1}$	Fixed	0.012 kW	8
$ESav_{APS2}$	Fixed	346 kWh	9
$DSav_{APS2}$	Fixed	0.039 kW	9
APS, STB Time Period Allocation Factors	Fixed	Summer/On-Peak 16% Summer/Off-Peak 17% Winter/On-Peak 32% Winter/Off-Peak 35%	10
$ESav_{CDE1}$	Fixed	186 kWh	12
$DSav_{CDE1}$	Fixed	0.016 kW	12

Component	Type	Value	Sources
$ESav_{CDG1}$	Fixed	9 kWh	12
$DSav_{CDG1}$	Fixed	0.001 kW	12
$GSav_{CDG1}$	Fixed	5.8 therms	12
$ESav_{CDE2}$	Fixed	388 kWh	12,13
$DSav_{CDE2}$	Fixed	0.029 kW	12,13
$ESav_{CDG2}$	Fixed	42.94 kWh	14
$DSav_{CDG2}$	Fixed	0.003 kW	14
$GSav_{CDG2}$	Fixed	7.69 therms	14
$ESav_{RAC1}$	Fixed	9 kWh	14
$DSav_{RAC1}$	Fixed	0.008	14
$ESav_{RAC2}$	Fixed	19.3 kWh	14
$DSav_{RAC2}$	Fixed	0.018	14
$ESav_{RAP}$	Variable	Dependent on CARD	
$DSav_{RAP}$	Variable	Dependent on CADR	
$ESav_{FRZ}$	Fixed	41.2 kWh	14
$DSav_{FRZ}$	Fixed	0.0067 kW	14
$ESav_{SDB}$	Fixed	44 kWh	14
$DSav_{SDB}$	Fixed	0.0005 kW	14
TAF	Fixed	1.23	14
LSAF	Fixed	1.15	14

Sources

1. Time period allocation factors used in cost-effectiveness analysis. From residential appliance load shapes.
2. Clothes washer energy and water savings estimates are based on clothes washers that exceed the federal standard with a shipment weighted average measured integrated modified energy factor (IMEF) of 1.66 and integrated water factor (IWF) of 5.92 versus that of ENERGY STAR models with IMEF of 2.26 and of 3.93 and CEE Tier 2 models at IMEF of 2.74 and WF of 3.21. See Mid-Atlantic Technical Reference Manual Version 6.0. This assumes 87% of participants have gas water heating and 56% have gas drying (the balance being electric) based on 2009 RECS data for New Jersey. Demand savings are calculated based on 317 annual cycles from 2009 RECS data for New Jersey. See 2009 RECS Table HC8.8 Water Heating in U.S. Homes in Northeast Region, Divisions, and States and Table HC3.8 Home Appliances in Homes in Northeast Region, Divisions, and States.
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 STAR and CEE Tier 2 refrigerator savings are based on refrigerators that exceed the federal standard with a shipment weighted average 2014 measured energy use of 592 kWh versus 533 kWh and 503 kWh respectively for eligible ENERGY STAR and CEE Tier 2 models. Demand savings estimated based on a flat 8760 hours of use during the year. Energy Star Ref: https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Residential-Refrigerators/p5st-her9 CEE Tier 2 Ref: http://library.cee1.org/content/qualifying-product-lists-residential-refrigerators.
6. 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.
7. Set top box lifetimes: National Resource Defense Counsel, *Cable and Satellite Set-Top Boxes Opportunities for Energy Savings*, 2005. http://www.nrdc.org/air/energy/energyeff/stb.pdf
8. 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.
9. 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.
10. 2011 Efficiency Vermont Load shape for Advanced Power Strips.
11. Advanced Power Strip Measure Life: David Rogers, Power Smart Engineering, October 2008: "Smart Strip electrical savings and usability," p 22.
12. Demand savings are calculated based on 297 annual cycles from 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 ENERGY STAR washers. Available at http://www.neep.org/mid-atlantic-technical-reference-manual-v6.
13. Savings for clothes dryers meeting the 2014 Emerging Technology Award criteria assume an average of measured performance and a 50% usage of both normal and most efficient dryer settings for eligible models.

14. 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 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.

Algorithms

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

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

Definition of Variables

$EFLH_c$ = 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

Summary of Inputs

Residential ENERGY STAR Room Air Conditioner

Component	Type	Value	Source
$EFLH_c$	Fixed	600	1
BTU/hour[21]	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
$CEER_{base}$[22]	Variable	See table below. If average deemed value required use 10.9	3
$CEER_{ee}$[23]	Variable	See table below. If average deemed value required use 12.0 for an ENERGY STAR unit	4
CF	Fixed	0.31	5

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	< 8,000	11.0	10	12.1	11.0
	8,000 to 10,999	10.9	9.6	12.0	10.6

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

[22] Minimum Federal Standard for most common Room AC type – 8000-14,999 capacity range with louvered sides.

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

	11,000 to 13,999	10.9	9.5	12.0	10.5
	14,000 to 19,999	10.7	9.3	11.8	10.2
	20,000 to 24,999	9.4	9.4	10.3	10.3
	25,000 to 27,999	9.0	9.4	10.3	10.3
	≥ 28,000	9.0	9.4	9.9	10.3
	< 14,000	N/A	9.3		10.2
With Reverse Cycle	≥ 14,000	N/A	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. Final Report Coincidence Factor Study Residential Room Air Conditioners, June 23, 2008, pg 22.
3. 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.
4. ENERGY STAR Program Requirements for Room Air Conditioners, Eligibility Criteria, Version 4.0, Effective October 26, 2015
5. NEEP, *Mid-Atlantic Technical Reference Manual*, V8. May 2018., pp 77-80.

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

$$\text{Energy Savings}\left(\frac{\text{kWh}}{\text{yr}}\right) = \frac{(\text{Watts}_b * \text{Qty}_b) - (\text{Watts}_q * \text{Qty}_q)}{1{,}000\,\frac{\text{Watts}}{\text{kW}}} * \text{Hrs} * (1 + \text{HVAC}_e)$$

$$\text{Peak Demand Savings (kW)} = \frac{(\text{Watts}_b * \text{Qty}_b) - (\text{Watts}_q * \text{Qty}_q)}{1{,}000\,\frac{\text{Watts}}{\text{kW}}} * CF * (1 + \text{HVAC}_d)$$

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

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	1
$Watts_q$	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: 1,205 hrs Exterior: 2,007 hrs	2
CF	Fixed	0.08	3
$HVAC_e$[24]	Fixed	0.051	1
$HVAC_d$[25]	Fixed	0.155	1
HF	Fixed	Interior: 0.47 Exterior: 0.00	1
nHeat[26]	Fixed	0.8	1
%FH[27]	Fixed	0.8	

[24] Derived based on assumptions found in the NEEP Mid-Atlantic TRM V7.

For electric cooling interactivity, value based on NEEP Mid-Atlantic TRM V7, pg. 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 V7, pg. 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

[25] From NEEP Mid-Atlantic TRM V7, pg. 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

[26] 10 CFR 430.32 (e)(ii); minimum AFUE for residential non-weatherized gas furnaces

[27] 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

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

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

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

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.

Sources

1. 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.”
2. Efficiency Vermont, Technical Reference User Manual, 2016, p. 265. The hours of use for this measure are based on the assumption that these will be installed in the highest use locations due to their high cost. Residential hours of use are based on average daily hours of use of 3.3, from Table 3-5, page 43, value for Living Space for Upstate New York, from NMR Group, Inc., Northeast Residential Lighting Hours-of-Use Study, prepared for CT Energy Efficiency Board, Cape Light Compact, Massachusetts Energy Efficiency Advisory Council, National Grid MA, National Grid RI, NYSERDA, Northeast Utilities, May 5, 2014.
3. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016, p.133. From the NY TRM: “From NY TRM 2016, for NYC due to proximity to NJ. From the NY TRM: “The coincidence factors were derived from an examination of studies throughout New England that calculated coincident factors based on the definition of system peak period at the time, as specified by the New England Power Pool and later, ISO-New England.”

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.

Algorithm

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

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

Definition of Terms

$ESav_{RetFridge}$ = 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.

Summary of Inputs

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	196 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	0.114 kW	3,2
$CF_{RetFridge,DEH}$	Fixed	1	1,2,3
CF_{RAC}	Fixed	0.31	1,2

Sources

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017.
2. Coincidence factor already embedded in summer peak demand reduction estimates
3. Rhode Island TRM 2016 Program Year - https://www9.nationalgridus.com/non_html/eer/ri/PY2016%20RI%20TRM.pdf (pg 20). *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).

Air Sealing

This section provides energy savings algorithms for the sealing air leakage paths to reduce the natural air infiltration rate through the installation of products and repairs to the building envelope.

It is assumed that air sealing is the first priority among candidate space conditioning measures. Expected percentage savings is based on previous experiences with measured savings from similar programs. Note there are no summer coincident electric peak demand savings estimated at this time.

The exterior envelope, as well as interior walls/partitions between conditioned and unconditioned spaces should be inspected and all gaps sealed. At a minimum, the following should be inspected and appropriate sealing implemented: caulk and weather strip doors and windows that leak air, repair or replace doors leading from conditioned to unconditioned space, seal air leaks between unconditioned and conditioned spaces, use foam sealant on larger gaps around windows, baseboards, and other places where air leakage may occur.

Algorithms

$$\text{Energy Savings}\left(\frac{\text{kWh}}{\text{yr}}\right) = \frac{\text{ft}^2}{1{,}000} \times \frac{\Delta\text{kWh}}{1{,}000\ \text{ft}^2}$$

$$\text{Fuel Savings}\left(\frac{\text{MMBtu}}{\text{yr}}\right) = \frac{\text{ft}^2}{1{,}000} \times \frac{\Delta\text{therm}}{1{,}000\ \text{ft}^2} \times 0.1$$

Definition of Variables

ft^2	= Square feet
$\Delta kWh/1{,}000ft^2$	= Annual electric energy savings per thousand square feet
$\Delta therm/1{,}000ft^2$	= Annual gas energy savings per thousand square feet
CF	= Coincidence factor
1,000	= Conversion factor from ft^2 to 1,000 ft^2
0.1	= Conversion factor from therm to MMBtu

Summary of Inputs

Residential Air Sealing

Component	Type	Value	Source
ft^2	Variable	Actual Square Footage	Application
$\Delta kWh/1{,}000ft^2$	Variable	See Table Below by Climate Zone	2
$\Delta therm/1{,}000ft^2$	Variable	See Table Below by Climate Zone	2
CF	Fixed	0.69	1, 2

Impact per 1,000 ft^2 Table[28]

Climate Zone	Vintage	kWh / 1,000 ft^2	therm/ 1,000 ft^2
4	Average	21	16
5	Average	12	19

Sources

1. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps
2. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V7, April 2019.

[28] Baseline infiltration rate for average building is 0.7 ACH. Energy savings based on a 15% reduction with 90% AFUE and 13 SEER ~~AC~~.

Duct Sealing and Repair

This section provides energy savings algorithms for the sealing and repair of residential space heating and air conditioning duct distribution systems.

The second priority for homes with either Central Air Conditioning (CAC) or some other form of ducted distribution of electric space conditioning (electric furnace, gas furnace or heat pump) is ensuring integrity and effectiveness of the ducted distribution system.

Evaluation of Distribution Efficiency – this methodology requires the evaluation of three duct characteristics below, and use of the Building Performance Institute's 'Distribution Efficiency Look-Up Table;

a. Percentage of duct work found within the conditioned space
b. Duct leakage evaluation
c. Duct insulation evaluation

Determine Distribution Efficiency by evaluating duct system before and after duct sealing using the Building Performance Institute's "Distribution Efficiency Look-Up Table" found below.

Algorithms

$$\text{Cooling Energy Savings } (kWh/yr) = \left\{\frac{\left[\frac{(\mathrm{DE}_{after} - \mathrm{DE}_{before})}{\mathrm{DE}_{before}}\right] \times EFLH_c \times Cap_c}{\mathrm{SEER} \times 1{,}000\ \frac{W}{kW}}\right\}$$

$$\text{Heating Energy Savings } (kWh/yr) = \left\{\frac{\left[\frac{(\mathrm{DE}_{after} - \mathrm{DE}_{before})}{\mathrm{DE}_{before}}\right] \times EFLH_h \times Cap_h}{\mathrm{HSPF} \times 1{,}000\ \frac{W}{kW}}\right\}$$

$$Peak\ Demand\ Savings\ (kW) = \frac{\Delta kWh_{cooling}}{EFLH_c} \times CF$$

$$\text{Fuel Savings } (MMBtu/yr) = \left\{\frac{\left[\frac{(\mathrm{DE}_{after} - \mathrm{DE}_{before})}{\mathrm{DE}_{before}}\right] \times EFLH_h \times Cap_h}{AFUE \times 1{,}000\ \frac{kBtu}{MMBtu}}\right\}$$

Definition of Variables

AFUE = Annual Fuel Utilization Efficiency

Cap_c = Capacity of Air Cooling System (kBTU/hr)

Cap_h = Capacity of Air Heating System (kBTU/hr)

HSPF = Heating Seasonal Performance Factor

CF = Coincidence Factor

DE_{after} = Distribution Efficiency After Duct Sealing

DE_{before} = Distribution Efficiency Before Duct Sealing

$EFLH_c$ = Equivalent Full Load Hours for Heating

$EFLH_h$ = Equivalent Full Load Hours for Cooling

SEER = The Seasonal Energy Efficiency Ratio

Summary of Inputs

Residential Duct Sealing and Repair

Component	**Type**	**Value**	**Source**
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, 2
Cap_c	Variable	From Application	Application
Cap_h	Variable	From Application	Application
HSPF	Fixed	Split Systems (HP) = 8.2 Single Package (HP) = 8.0	1
DE_{after}	Variable	See Distribution Efficiency Look-Up Table Below, assume Tight Leakage	4
DE_{before}	Variable	See Distribution Efficiency Look-Up Table Below, assume Average Leakage	4
$EFLH_{c\ or\ h}$	Variable	Cooling = 600 Hours Heating = 965 Hours	3
SEER	Fixed	Split Systems (A/C) = 13 Split Systems (HP) = 14 Single Package (A/C) = 14 Single Package (HP) = 14	1
CF	Fixed	0.69	5

Distribution Efficiency Look-Up Table[29]

Insulation	Location	Attic		Basement		Vented Crawl	
	HVAC Type	Heat	Cool	Heat	Cool	Heat	Cool
	Leakage \ Climate Zone	4&5	4&5	4&5	4&5	4&5	4&5
R-0	Leaky	69%	61%	93%	81%	74%	76%
	Average	73%	64%	94%	87%	78%	83%
	Tight	77%	73%	95%	94%	82%	91%
R-2	Leaky	76%	65%	94%	83%	80%	78%
	Average	82%	74%	96%	88%	85%	85%
	Tight	87%	84%	97%	95%	90%	93%
R-4+	Leaky	79%	67%	95%	83%	82%	79%
	Average	84%	77%	96%	89%	87%	86%
	Tight	90%	87%	98%	95%	92%	94%
R-8+	Leaky	80%	69%	95%	83%	84%	79%
	Average	86%	79%	97%	89%	89%	87%
	Tight	92%	90%	98%	95%	94%	94%

For duct systems partly in unconditioned and conditioned space, add the values from the Adders for Partial Conditioned Space table below to DE_{before} and DE_{after} determined from the Distribution Efficiency Look-Up Table above, with a max DE of 100%. Use the 50% adder values if 50% or more of the duct system is inside a conditioned space. Use the 80% adder values if 80% of more of the duct system is inside a conditioned space.

Adders for partial conditioned space[30]

Location	Attic				Basement				Vented Crawl			
HVAC Type	Heat		Cool		Heat		Cool		Heat		Cool	
Insulation \ Conditioned	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%	50%	80%
R-0	6%	4%	11%	9%	2%	3%	2%	3%	6%	3%	11%	5%
R-2	4%	5%	6%	7%	1%	1%	1%	2%	3%	2%	5%	3%
R-4+	3%	3%	4%	5%	1%	1%	1%	1%	2%	1%	4%	3%
R-8+	3%	2%	3%	3%	1%	1%	1%	1%	2%	1%	2%	2%

[29] Building Performance Institute, Distribution Efficiency Table

[30] Building Performance Institute, Distribution Efficiency Table

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=2942a69a6328c23266612378a0725e60&mc=true&node=se10.3.430_132&rgn=div8.
2. 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.
3. VEIC Estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

~~1.~~4. Building Performance Institute, Distribution Efficiency Table, http://www.bpi.org/files/pdf/DistributionEfficiencyTable-BlueSheet.pdf

~~2.~~5. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps, as reported in NEEP, *Mid-Atlantic Technical Reference Manual*, V8. 2018, pg 116

Insulation Upgrades

This section provides energy savings algorithms for the insulation of the attic floor and roof assembly.

Definition of Baseline Condition- The existing insulation R-value should include the total attic floor / roof assembly. An R-value of 5.0 should be assumed for the roof assembly plus the R-value of any existing insulation. Therefore, if there is no insulation currently present, the R-value of 5.0 should be used.

Algorithm

Savings from reduction in Air Conditioning Load:

$$\text{Energy Savings}\left(\frac{\text{kWh}}{\text{yr}}\right) = \left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times \text{CDD} \times 24 \times \text{DUA} \times \text{Area} / 1{,}000 / \text{SEER}$$

Savings for homes with electric heat (Heat Pump or resistance):

$$\text{Energy Savings}\left(\frac{kWh}{yr}\right) = \left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times HDD \times 24 \times Area / 1{,}000 / HSPF$$

Savings from reduction in Heating Load (Therms, Fuel Oil, Propane):

$$\text{Fuel Savings (therm or gal)} = \left(\frac{1}{R_b} - \frac{1}{R_q}\right) \times \text{HDD} \times 24 \times \text{Area} / \text{Fuel Btu} / \text{AFUE}$$

Definition of Variables

AFUE	= Annual Fuel Utilization Efficiency
Area	= square footage of area covered by new insulation
CDD	= Cooling Degree Days
DUA	= Discretionary Use Adjustment
Fuel Btu	= Conversion Factor from BTU to Appropriate Unit (gallon or therm)
HDD	= Heating Degree Days
HSPF	= Heating Seasonal Performance Factor
R_b	= R-value of roof assembly plus any existing insulation
R_q	= R-value of roof assembly plus new insulation
SEER	= Efficiency in SEER of Air Conditioning equipment
1,000	= Conversion Factor from W to kWh
24	= Conversion Factor from days to hours

Residential Insulation Upgrades

Component	Type	Value	Source
R_b	Variable	Acutal R-value of roof assembly plus any existing insulation (Minimum of R-5)	Application
R_q	Variable	Actual R-value of roof assembly plus new insulation	Application
CDD	Variable	See Cooling Degree Days Table Below	2
HDD	Variable	See Heating Degree Days Table Below	2
DUA	Fixed	0.75	1
Area	Variable	Actual square footage of area covered by new insulation	Application
SEER	Fixed	Split Systems (A/C) = 13 Split Systems (HP) = 14 Single Package (A/C) = 14 Single Package (HP) = 14	4
HSPF	Fixed	Split Systems (HP) = 8.2 Single Package (HP) = 8.0	4
AFUE	Variable	Gas fired boiler = 82% Oil fired boiler = 84% Weatherized gas furnace = 81%	4, 5

Component	Type	Value	Source
		Weatherized oil furnace = 78% Mobile home gas = 80% Mobile home oil = 75% Non-weatherized gas = 80% Non-weatherized oil = 83% Electric Resistance Heating = 35%	
Fuel BTU	Variable	Natural gas = 100,000 Oil = 138,000 Propane = 92,000	
CF	Fixed	0.69	3

Heating Degree Days

Location	Heating Degree Days (65°F set point)
Atlantic City	4,905
Newark	4,872
Trenton	5,160

Cooling Degree Days

Location	Cooling Degree Days (65°F set point)
Atlantic City	1,055
Newark	1,192
Trenton	965

Sources

1. Energy Center of Wisconsin, May 2008 metering study; "Central Air Conditioning in Wisconsin, A Compilation of Recent Field Research", p31.
2. NOAA National Centers for Environmental Information – NCEI 1981-2010 Climate Normals
   Available from: https://www.ncdc.noaa.gov/cdo-web/datatools/normals
3. BG&E: Development of Residential Load Profile for Central Air Conditioners and Heat Pumps, as reported in NEEP, *Mid-Atlantic Technical Reference Manual*, V8. 2018, pg 260
4. 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.
5. 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.

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
$EFLH_{c\ or\ h}$	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	69%	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*, V8. May 2018
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.

Home Performance with ENERGY STAR Program

In order to implement Home Performance with ENERGY STAR, there are various standards a program implementer must adhere to in order to deliver the program. The program implementer must use software that meets a national standard for savings calculations from whole-house approaches such as home performance. The difference in modeled annual energy consumption between the program and existing home is the project savings for heating, hot water, cooling, lighting and appliance end uses.

The software the program implementer uses must adhere to at least one of the following standards:

- A software tool whose performance has passed testing according to the National Renewable Energy Laboratory's HERS BESTEST software energy simulation testing protocol.[31]
- Software approved by the US Department of Energy's Weatherization Assistance Program.[32]
- RESNET approved rating software.[33]

There are numerous software packages that comply with these standards. Some examples of the software packages are REM/Rate, Real Home Analyzer, EnergyGauge, TREAT, and HomeCheck.

---

[31] Information about BESTEST-EX can be found at http://www.nrel.gov/buildings/bestest-_ex.html

[32] A listing of the approved software available at http://www.waptac.org/data/files/Website_Docs/technical_tools/EnergyAuditMatrixTable2.pdf

[33] A listing of the approved software available at http://resnet.us

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 90.1-2013 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 program. 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.

C&I Electric Protocols

The following measures are outlined in this section: Performance Lighting, Prescriptive Lighting, Refrigerated Case LED Lights, Lighting Controls, ECMs for Refrigeration, Electric HVAC Systems, Fuel Use Economizers, Dual Enthalpy Economizers, Occupancy Controlled Thermostats, Electric Chillers, VFDs, and Commercial Refrigeration.

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 2013.

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.

<u>Algorithms</u>

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

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

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

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

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

Building Type	Sector	CF	Hours
Medical - Clinic	Large Commercial/Industrial & Small Commercial	0.8	3,909
Medical - Hospital	Large Commercial/Industrial & Small Commercial	0.8	8,760[34]
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
Unknown[35]	Large Commercial/Industrial	0.50	2,575
Multifamily – Common Areas[36]	Multifamily	0.86	5,950
Multifamily – In-Unit[36]	Multifamily	0.59	679
Multifamily – Exterior[36]	Multifamily	0.00	3,338

[34] Assume hospital operations are year round.
[35] 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. To encourage the use of building type-specific values, the assumed lighting coincidence factors for unknown building types have been set equal to the lowest values from the table."
[36] NEEP Mid-Atlantic TRM V8, page 25

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[37]	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	C&I Gas Heat	-0.00023
Large Retrofit	Oil	-0.00046
Small Retrofit	Gas Heat	-0.001075
Small Retrofit	Oil Heat	-0.000120

Sources

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
2. ASHRAE Standards 90.1-2013, Energy Standard for Buildings Except Low Rise Residential Buildings, Table 9.6.1.; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.
3. Average HVAC interactive effects by building type derived from the NEEP Mid-Atlantic TRM 2017, NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017, pp. 464-465. From NEEP TRM: "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.

[37] 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."

Values for Washington, D.C. and Delaware assume values from Maryland, Pepco and Maryland, DPL, respectively."

4. NEEP Mid-Atlantic TRM 2017, NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017, pp. 462-463.
5. Massachusetts TRM, 2016-2018 Program Years, October 2015. Original source: 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.

Prescriptive Lighting

This is a fixture replacement program for existing commercial customers targeted for facilities performing efficiency upgrades to their lighting systems. New fixtures and technologies available after publication will be periodically updated. Baselines will be established based on the guidelines noted below.

Algorithms

$$\Delta kW = (\#\ of\ replaced\ fixtures) * (baseline\ fixture\ wattage\ from\ table) - (\#\ of\ fixtures\ installed) * (wattage\ of\ new\ fixture)$$

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

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

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

Definition of Variables

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

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

$HVAC_g$ = HVAC interactive factor for annual fuel savings

Summary of Inputs

Prescriptive Lighting for Commercial Customers

Component	Type	Value	Source

Component	Type	Value	Source
ΔkW	Variable	See NGrid Fixture Wattage Table https://www1.nationalgridus.com/files/AddedPDF/POA/RILightingRetrofit1.pdf And formula above	1 Fixture counts and types, space type, floor area from customer application.
CF	Fixed	Table by Building in Performance Lighting Section Above	3
Hrs	Fixed	See Table by Building in Performance Lighting Section Above	3
$HVAC_d$	Fixed	See Table by Building Type in Performance Lighting Section Above	2
$HVAC_e$	Fixed	See Table by Building Type in Performance Lighting Section Above	2
$HVAC_g$	Fixed	See Table by Building Type in Performance Lighting Section Above	4

Sources

1. Device Codes and Rated Lighting System Wattage Table Retrofit Program, National Grid, January 13, 2015; available at: https://www1.nationalgridus.com/files/AddedPDF/POA/RILightingRetrofit1.pdf.
2. Average HVAC interactive effects by building type derived from the NEEP Mid-Atlantic TRM 2017, NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017, pp. 464-465. From NEEP TRM: "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.
3. NEEP Mid-Atlantic TRM 2017, NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017
4. Massachusetts TRM, 2016-2018 Program Years, October 2015. Original source: DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council

Refrigerated Case LED Lights

This measure includes the installation of LED lamps in commercial display refrigerators, coolers or freezers. The display lighting in a typical cooler or freezer add to the load on that unit by increasing power consumption of the unit when the lamp is on, and by adding heat to the inside of the unit that must be overcome through additional cooling.

Replacing fluorescent lamps with low heat generating LEDs reduces the energy consumption associated with the lighting components and reduces the amount of waste heat generated from the lamps that must be overcome by the unit's compressor cycles.

Algorithms

$$\text{Energy Savings } \left(\frac{\text{kWh}}{\text{yr}}\right) = units * (Lighting\ kWh_{base} - lighting\ kWh_{ee}) + Refrig_{sav}$$

$$\text{Peak Demand Savings (kW)} = units * (\text{kW}_{base} - \text{kW}_{ee}) * (1 + Comp_{factor}) * CF$$

$$Refrig_{sav} = units * (lighting\ kWh_{base} - lighting\ kWh_{ee}) * Comp_{eff}$$

Definition of Variables

Units = Number of LED linear lamps or fixtures installed

kW_b = Baseline fixture wattage

kW_q = Qualified LED fixture wattage

Lighting kWh_{base} = Total energy usage of lighting fixtures being replaced

Lighting kWh_{ee} = Total energy usage of new LED lighting fixtures are being installed

$Comp_{factor}$ = Compressor factor for cooler or freezer, depending on location of install

$Comp_{eff}$ = Compressor efficiency for cooler or freezer; the efficiency factors in portion of saved energy eliminated via the compressor

CF = Coincidence factor

Summary of Inputs

Refrigerated Case Assumptions

Component	Type	Value	Methodology	Source
Lighting kWh_{base}	Variable	Variable	Total lighting operating hours per year × wattage of baseline lighting; use 2 × LED watts as default	Application
Lighting kWh_{ee}	Variable	Variable	Total lighting operating hours per year × wattage of LED lighting.	Application
Hrs	Fixed	6,205		2
$Comp_{eff}$ – cooler	Fixed	0.41	Value is calculated by multiplying 0.51 (compressor efficiency for cooler) by 0.80 (portion of saved energy eliminated via the compressor).	1, 3

Component	Type	Value	Methodology	Source
$Comp_{eff}$ – freezer	Fixed	0.52	Value is calculated by multiplying 0.65 (compressor efficiency for cooler) × 0.80 (portion of saved energy eliminated via the compressor).	1
$Comp_{factor}$ – cooler	Fixed	0.40	Based on EER value of 1.8 kW/ton × 0.285 ton/kW × 0.8 (20% of case lighting load not converted into case cooling load) = 0.40	1
$Comp_{factor}$ – freezer	Fixed	0.51	Based on EER value of 2.3 kW/ton × 0.285 ton/kW × 0.8 (20% of case lighting load not converted into case cooling load) = 0.51	1
CF	Fixed	0.92		2

Sources

1. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016, pages 223-22
2. Pennsylvania PUC, Technical Reference Manual, June 2016, page 258. From PA TRM: "Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted. https://focusonenergy.com/sites/default/files/bpdeemedsavingsmanuav10_evaluationreport.pdf"
3. PA TRM, p.258. Values adopted from Hall, N. et al, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, TecMarket Works, September 1, 2009. http://www3.dps.ny.gov/W/PSCWeb.nsf/0/06f2fee55575bd8a852576e4006f9af7/$FILE/TechManualNYRevised10-15-10.pdf

Specialty LED Fixtures

Some LED fixtures do not adhere to the Prescriptive Lighting algorithm due to unique form factors that do not lend to a fixture-to-fixture comparison, such as LED rope lights, cove lighting, and so on.

In these instances, a similar algorithm may be used, 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

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

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

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

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

Definition of Variables

The remaining variables are unchanged from those presented in the Prescriptive Lighting section:

Summary of Inputs

Specialty Lighting for Commercial Customers

Component	Type	Value	Source
ΔkW	Variable	See algorithm above	Application
CF	Fixed	See Lighting Table by Building in Performance Lighting Section Above	1
Hrs	Variable	See Lighting Table by Building Type in Performance Lighting Section Above	1
$HVAC_d$	Fixed	See Lighting Table by Building Type in Performance Lighting Section Above	2
$HVAC_e$	Fixed	See Lighting Table by Building Type in Performance Lighting Section Above	2
$HVAC_g$	Fixed	See Lighting Table by Building Type in Prescriptive Lighting Section Above	3

Sources

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017.

2. Average HVAC interactive effects by building type derived from the NEEP Mid-Atlantic TRM 2017, NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017, pp. 464-465. From NEEP TRM: "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.
3. Massachusetts TRM, 2016-2018 Program Years, October 2015. Original source: DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council

Lighting Controls

Lighting controls include occupancy sensors, daylight dimmer systems, and occupancy controlled hi-low controls for fluorescent, LED and HID fixtures. The measurement of energy savings is based on algorithms with key variables (i.e., coincidence factor, equivalent full load hours) provided through existing end-use metering of a sample of facilities or from other utility programs with experience with these measures (i.e., % of annual lighting energy saved by lighting control). For lighting controls, the baseline is a manual switch, based on the findings of the New Jersey Commercial Energy Efficient Construction Baseline Study.

Algorithms

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

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

$$\text{Fuel Savings } \left(\frac{\text{MMBtu}}{\text{yr}}\right) = \text{kW}_c * \text{SVG} * (\text{Hrs}) * (\text{HVAC}_g)$$

Definition of Variables

SVG	= % of annual lighting energy saved by lighting control; refer to table by control type
kW_c	= kW lighting load connected to control
$HVAC_d$	= Interactive Factor – This applies to C&I interior lighting only. This represents the secondary demand in reduced HVAC consumption resulting from decreased indoor lighting wattage.
$HVAC_e$	= Interactive Factor – This applies to C&I interior lighting only. This represents the secondary energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage.
$HVAC_g$	= Interactive Factor – This applies to C&I interior lighting only. This represents the secondary energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage.
CF	= Coincidence factor
Hrs	= Annual hours of operation prior to installation of controls

Summary of Inputs

Lighting Controls

Component	Type	Value	Source
kW_c	Variable	Load connected to control	Application
SVG	Fixed	Occupancy Sensor, Controlled Hi-Low Fluorescent Control, LED and controlled HID = 31% Daylight Dimmer System= 40%	4, 5, 6
CF	Fixed	See Table by Building in Performance Lighting Section Above	1
Hrs	Fixed	See Table by Building in Performance Lighting Section Above	1
$HVAC_d$	Fixed	See Table by Building Type in Performance Lighting Section Above	2
$HVAC_e$	Fixed	See Table by Building Type in Performance Lighting Table Above	2
$HVAC_g$	Fixed	See Table by Building Type in Performance Lighting Table Above	3

Sources

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017.
2. Average HVAC interactive effects by building type derived from the NEEP Mid-Atlantic TRM 2017, NEEP, *Mid-Atlantic Technical Reference Manual*, V7. May 2017, pp. 464-465. From NEEP TRM: "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.
3. Massachusetts TRM, 2016-2018 Program Years, October 2015. Original source: DNV KEMA (2013). Impact Evaluation of 2010 Prescriptive Lighting Installations. Prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council
4. A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings, Lawrence Berkeley National Laboratory, September 2011.
5. LBNL, Quantifying National Energy Savings Potential of Lighting Controls in Commercial Buildings, May 2012.
6. Unified Facilities Criteria (UFC), Design: Interior, Exterior, Lighting and Controls. UFC 3-530-01. September 2012.

Motors [Inactive 2017, Not Reviewed]
For premium efficiency motors 1-200 HP.
<u>Algorithms</u>

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

<u>Definition of Variables</u>
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
hp_{base}	Fixed	ASHRAE 90.1-2013 Baseline Efficiency Table	ASHRAE
hp_{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

Baseline Motor Efficiency Table

Motor Horsepower	1200 RPM (6 pole)		1800 RPM (4 pole)		3600 RPM (2 pole)	
	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	0.8	0.8	0.825	0.825	na	0.755
1.5	0.84	0.855	0.84	0.84	0.825	0.825
2	0.855	0.865	0.84	0.84	0.84	0.84
3	0.865	0.875	0.865	0.875	0.84	0.855
5	0.875	0.875	0.875	0.875	0.855	0.875
7.5	0.885	0.895	0.885	0.895	0.875	0.885
10	0.9002	0.895	0.895	0.895	0.885	0.895
15	0.902	0.902	0.91	0.91	0.895	0.902
20	0.91	0.902	0.91	0.91	0.902	0.902
25	0.917	0.917	0.917	0.924	0.91	0.91
30	0.924	0.917	0.924	0.924	0.91	0.91
40	0.93	0.93	0.93	0.93	0.917	0.917
50	0.93	0.93	0.93	0.93	0.924	0.924
60	0.936	0.936	0.936	0.936	0.93	0.93
75	0.936	0.936	0.941	0.941	0.93	0.93
100	0.941	0.941	0.941	0.945	0.93	0.936
125	0.941	0.941	0.945	0.945	0.936	0.945
150	0.945	0.95	0.95	0.95	0.936	0.945
200	0.945	0.95	0.95	0.95	0.945	0.95

*Note: For the Direct Install Program, different baseline efficiency values are used.

NEMA ASHRAE 90.1-2013 Motor Efficiency Table – General Purpose Subtype I

Motor Horsepower	1200 RPM (6 pole)		1800 RPM (4 pole)		3600 RPM (2 pole)	
	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	0.825	0.825	0.855	0.855	0.77	0.77
1.5	0.865	0.875	0.865	0.865	0.84	0.84
2	0.875	0.885	0.865	0.865	0.855	0.855
3	0.885	0.895	0.895	0.895	0.855	0.865
5	0.895	0.895	0.895	0.895	0.865	0.885
7.5	0.902	0.91	0.91	0.917	0.885	0.895
10	0.917	0.91	0.917	0.917	0.895	0.902
15	0.917	0.917	0.93	0.924	0.902	0.91
20	0.924	0.917	0.93	0.93	0.91	0.91
25	0.93	0.93	0.936	0.936	0.917	0.917
30	0.936	0.93	0.941	0.936	0.917	0.917
40	0.941	0.941	0.941	0.941	0.924	0.924
50	0.941	0.941	0.945	0.945	0.93	0.93
60	0.945	0.945	0.95	0.95	0.936	0.936
75	0.945	0.945	0.95	0.954	0.936	0.936
100	0.95	0.95	0.954	0.954	0.936	0.941
100	0.95	0.95	0.954	0.954	0.941	0.95
150	0.954	0.958	0.958	0.958	0.941	0.95
200	0.954	0.958	0.958	0.962	0.95	0.954

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

Electronically Commutated Motors for Refrigeration

This measure is applicable to existing walk-in, multi-deck and free standing coolers and freezers with shaded pole or permanent split capacitor (PSC) motors. These fractional horsepower motors are significantly more efficient than mechanically commutated, brushed motors, particularly at low speeds or partial load. By employing variable-speed technology, EC motors are able to optimize fan speeds for changing load requirements. Because these motors are brushless and utilize DC power, losses due to friction and phase shifting are eliminated. Calculations of savings for this measure take into account both the increased efficiency of the motor as well as the reduction in refrigeration load due to motor heat loss.

EC Motor Retrofits in Walk-in Coolers and Freezers

<u>Algorithms</u>

$\Delta kW = ((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * PF_{EF} * LR65\%$

Gross Energy Savings (kWh/yr) = $kWh\ Savings_{EF} + kWh\ Savings_{RH}$

$kWh\ Savings_{EF} = ((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * PF_{EF} * \text{Operating Hours} * LR65\%$

$kWh\ Savings_{RH} = kWh\ Savings_{EF} * 0.28 * 1.6$

<u>*PLEASE NOTE:*</u>

*"$((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * PF_{EF}$" is equivalent to "HP * 0.746"*

<u>Definition of Variables</u>

ΔkW = Demand Savings due to EC Motor Retrofit

$kWh\ Savings_{EF}$ = Savings due to Evaporator Fan Motors being replaced

$kWh\ Savings_{RH}$ = Savings due to reduced heat from Evaporator Fans

$Amps_{EF}$ = Nameplate Amps of Evaporator Fan

$Volts_{EF}$ = Nameplate Volts of Evaporator Fan

$Phase_{EF}$ = Phase of Evaporator Fan

PF_{EF} = Evaporator Fan Power Factor

Operating Hours = Annual operating hours if Evaporator Fan Control

LR = Percent reduction of load by replacing motors

0.28 = Conversion from kW to tons (Refrigeration)

1.6 = Efficiency of typical refrigeration system in kW/ton

Case Motor Replacement

Algorithms

Gross Energy Savings (kWh/yr) = $kWh\ Savings_{CM} + kWh\ Savings_{RH}$

$kWh\ Savings_{CM}$ = kW * ER * RT8, 500

$kWh\ Savings_{RH}$ = kWh $Savings_{EF}$ * 0.28 * Eff

Definition of Variables

$kWh\ Savings_{CM}$	= Savings due to Case Motors being replaced
$kWh\ Savings_{RH}$	= Savings due to reduced heat from Case Motors
kW	= Metered load of Case Motors
ER	= Energy reduction if a motor is being replaced
RT	= Average runtime of Case Motors
0.28	= Conversion from kW to tons (Refrigeration)
Eff	= Efficiency of typical refrigeration system in kW/ton

Summary of Inputs

ECM Fraction HP Motors

Component	Type	Value	Source
$Amps_{EF}$	Variable	Nameplate/Manufacturer Spec. Sheet	Application
$Volts_{EF}$	Variable	Nameplate/Manufacturer Spec. Sheet	Application
$Phase_{EF}$	Variable	Nameplate/Manufacturer Spec. Sheet	Application
PF_{EF}	Fixed	0.55	1
Operating Hours	Fixed	Not Installed = 8,760 Installed = 5,600	
LR	Fixed	65%	2
ER	Fixed	Shaded Pole Motor Replaced = 53% PSC Motor Replaced = 29%	3
RT	Fixed	8500	
Eff	Fixed	1.6	

Sources

1. Select Energy Services, Inc., *Cooler Control Measure Impact Spreadsheet User's Manual*, 2004.
2. This value is an estimate by NRM based on several pre- and post- meter readings of installations. This is supported by RLW report for National Grid, "Small Business Services, Custom Measure Impact Evaluation," March 23, 2007.
3. Based on numerous pre- and post- meterings conducted by NRM.

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 – 2013, 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 – 2013
Unitary HVAC/Split Systems and Single Package, Air Cooled	
<=5.4 tons, split	13 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, 11.0 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 – 2013
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[38]	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

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

Facility Type	Heating $EFLH_h$	Cooling $EFLH_c$
Lodging – Motel	619	1233
Office – large	2034	720
Office – small	431	955
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 – ~~large~~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

<u>Sources</u>

1. ASHRAE Standards 90.1-2013, *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*, V6, April 2018. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 535-540. EFLH values for NYC due to proximity to NJ.

Fuel Use Economizers

Algorithms

Energy Savings (kWh/yr) = (AEU * 0.13)

Definition of Variables

AEU = Annual Electric Usage for an uncontrolled AC or refrigeration unit (kWh) = (Input power in kW) * (annual run time)

0.13 = Approximate energy savings factor related to installation of fuel use economizers

Sources

1. Approximate energy savings factor of 0.13 based on average % savings for test sites represented in Table 2 (p. 3) of NYSERDA Study: A Technology Demonstration and Validation Project for Intellidyne Energy Saving Controls; Intellidyne LLC & Brookhaven National Laboratories; 2006; available at: http://www.cleargreenpartners.com/attachments/File/NYSERDA_Report.pdf.

Dual Enthalpy Economizers

The following algorithm details savings for dual enthalpy economizers. They are to be used to determine electric energy savings between baseline standard units and the high efficiency units promoted in the program. The baseline condition is assumed to be a rooftop unit with fixed outside air (no economizer). The high efficiency units are equipped with sensors that monitor the enthalpy of outside air and return air and modulate the outside air damper to optimize energy performance.

Algorithms

Electric energy savings (kWh/yr) = N * Tons * (ΔkWh/ton)

Peak Demand Savings (kW) = 0[39] kW

Definition of Variables

N = Number of units

Tons = Rated capacity of the cooling system retrofitted with an economizer

ΔkWh/ton = Stipulated per building type electricity energy savings per ton of cooling system retrofitted with an economizer

---

[39] Economizer savings occur when outdoor air enthalpy is relatively low, and these conditions mostly exist outside of defined system peak demand periods, therefore, the seasonal peak demand savings for this measure are assumed to be negligible.

Summary of Inputs

Dual Enthalpy Economizers

Component	Type	Value	Source
N	Variable		Application
Tons	Variable	Rated Capacity, Tons	Application
ΔkWh/ton	Fixed	See Table Below	1

Savings per Ton of Cooling System

Building Type	Savings (ΔkWh/ton)
Assembly	27
Big Box Retail	152
Fast Food Restaurant	39
Full Service Restaurant	31
Light Industrial	25
Primary School	42
Small Office	186
Small Retail	95
Religious	6
Warehouse	2
Other	61

1. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V6, April 2018. Appendix J – Commercial HVAC Unit Savings. P.565. Values for NYC due to proximity to NJ, the input values are based on data provided on the application form and stipulated savings values derived from DOE 2.2 simulations of a series of prototypical small commercial buildings.

Occupancy Controlled Thermostats

The program has received a large amount of custom electric applications for the installation of Occupancy Controlled Thermostats in hotels, motels, and, most recently, university dormitories.

Standard practice today is thermostats which are manually controlled by occupants to regulate temperature within a facility. An occupancy controlled thermostat is a thermostat paired with a sensor and/or door detector to identify movement and determine if a room is occupied or unoccupied. If occupancy is sensed by the sensor, the thermostat goes into an occupied mode (i.e., programmed setpoint). If a pre-programmed time frame elapses (i.e., 30 minutes) and no occupancy is sensed during that time, the thermostat goes into an unoccupied mode (e.g., setback setpoint or off) until occupancy is sensed again. This type of thermostat is often used in hotels to conserve energy.

The occupancy controlled thermostat reduces the consumption of electricity and/or gas by requiring less heating and/or cooling when a room or a facility is vacant or unoccupied.

<u>Algorithms</u>

Cooling Energy Savings (kWh/yr) = $(((T_c * (H+5) + S_c * (168 - (H+5)))/168) - T_c) * (P_c * Cap_{hp} * 12 * EFLH_c/EER_{hp})$

Heating Energy Savings (kWh/yr) = $(T_h - ((T_h * (H+5) + S_h * (168 - (H+5)))/168)) * (P_h * Cap_{hp} * 12 * EFLH_h/EER_{hp})$

Heating Energy Savings (Therms/yr) = $(T_h - ((T_h * (H+5) + S_h * (168 - (H+5)))/168) * (P_h * Cap_h * EFLH_h/AFUE_h/100{,}000)$

<u>Definition of Variables</u>

T_h = Heating Season Facility Temp. (°F)

T_c = Cooling Season Facility Temp. (°F)

S_h = Heating Season Setback Temp. (°F)

S_c = Cooling Season Setup Temp. (°F)

H = Weekly Occupied Hours

Cap_{hp} = Connected load capacity of heat pump/AC (Tons) – Provided on Application.

Cap_h = Connected heating load capacity (Btu/hr) – Provided on Application.

$EFLH_c$ = Equivalent full load cooling hours

$EFLH_h$ = Equivalent full load heating hours

P_h = Heating season percent savings per degree setback

P_c = Cooling season percent savings per degree setup

$AFUE_h$ = Heating equipment efficiency – Provided on Application.

EER_{hp} = Heat pump/AC equipment efficiency – Provided on Application

12	= Conversion factor from Tons to kBtu/hr to acquire consumption in kWh.
168	= Hours per week.
7	= Assumed weekly hours for setback/setup adjustment period (based on 1 setback/setup per day, 7 days per week).

<u>Summary of Inputs</u>

Occupancy Controlled Thermostats

Component	Type	Value	Source
T_h	Variable		Application
T_c	Variable		Application
S_h	Fixed	T_h-5°	
S_c	Fixed	T_c+5°	
H	Variable		Application; Default of 84 hrs/week
Cap_{hp}	Variable		Application
Cap_h	Variable		Application
$EFLH_{c,h}$	Variable	See Table Below	1
P_h	Fixed	3%	2
P_c	Fixed	6%	2
$AFUE_h$	Variable		Application
EER_{hp}	Variable		Application

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
Other	681	736
Religious worship	722	279
Restaurant – fast food	813	645
Restaurant – full service	821	574

Facility Type	Heating $EFLH_h$	Cooling $EFLH_c$
Retail – big box	191	1279
Retail – Grocery	191	1279
Retail – ~~large~~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

~~3.~~6. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V6, April 2018. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 535-540. EFLH values for NYC due to proximity to NJ.

~~4.~~7. ENERGY STAR Products website.

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 – 2013, 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
$IPLV_q$ (kW/ton)	Variable	All	Varies	From Application (per AHRI Std.

Electric Chillers Component	Type	Situation	Value	Source
				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 2013 effective 1/1/2015 [a]			
		Path A		Path B	
		Full Load kW/ton	IPLV kW/ton	Full Load kW/ton	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

Facility Type	Cooling EFLH
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 – largesmall	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

Sources

1. ASHRAE Standards 90.1-2013. *Energy Standard for Buildings Except Low Rise Residential Buildings*. https://www.ashrae.org/standards-research--technology/standards--guidelines.
2. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V6, April 2018. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 535-540. EFLH values for NYC due to proximity to NJ.

Variable Frequency Drives

This section provides algorithms and assumptions for reporting of energy and demand savings for C/I Variable Frequency Drive (VFD) installations for HVAC systems including: supply air fans, return air fans, chilled water and condenser water pumps, hot water circulation pumps, water source heat pump circulation pumps, cooling tower fans, and boiler feed water pumps. VFD applications for other end uses should follow the custom path.

<u>Algorithms</u>

Energy Savings (kWh/yr) = N * HP * ESF

Peak Demand Savings (kW) = N * HP * DSF

<u>Definitions of Variables</u>

N = Number of motors controlled by VFD(s) per application

HP = Nameplate motor horsepower or manufacturer specification sheet per application

ESF = Energy Savings Factor (kWh/year per HP)

DSF = Demand Savings Factor (kW per HP)

<u>Summary of Inputs</u>

Variable Frequency Drives

Component	Type	Value	Source
HP	Variable	Nameplate/Manufacturer Spec. Sheet	Application
ESF	Variable	See Table Below	Derived value based on the following sources: 1, 2, 3
DSF	Variable	See Table Below	Derived value based on the following sources: 1, 2, 3

The ESF for the supply and return fans and circulating pumps are derived from a 2014 NEEP-funded study of 400 VFD installations in eight northeast states. The derived values are based on actual logged input power data and reflect average operating hours, load factors, and motor efficiencies for the sample. Savings factors representing cooling tower fans and boiler feed water pumps are not reflected in the NEEP report. Values representing these applications are taken from April 2018 New York TRM, Appendix K, and represent average values derived from DOE2.2 simulation of various building types and climate zones, supplemented with results from an earlier analysis of actual program data completed by NSTAR in 2010.

The DSF are derived from the same sources. The NEEP values reflect the actual average impact for the category occurring in the PJM defined peak demand period. The NY values are based on a similar but not identically defined peak period. In all cases the values are expressed in kW/HP rating of the controlled motor and reflect average load factors during the peak period and motor efficiencies for the sample.

VFD Savings Factors

Application	ESF (kWh/Year-HP)	DSF (kW/HP)	Source
Supply Air Fan	2,033	0.286	1
Return Air Fan	1,788	0.297	1
CHW or CW Pump	1,633	0.185	1
HHW Pump	1,548	0.096	1
WSHP Pump	2,562	0.234	1
CT Fan	290	-0.025	2, 3
Boiler Feedwater Pump	1,588	0.498	2, 3

Sources

1. Cadmus, NEEP – Variable Speed Drive Loadshape Project, August 2014; available at: http://www.neep.org/variable-speed-drive-loadshape-study-final-report.
2. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V6, April 2018. Appendix K – VFD savings factors derived from DOE2.2 simulations reflecting a range of building types and climate zones.
3. Chan, Tumin Formulation of Prescriptive Incentive for VFD, and Motors and VFD Impact Tables, NSTAR 2010.

Variable Speed Air Compressors

This measure applies to the installation of variable speed air compressors in retrofit installations where they replace fixed speed compressor with either inlet vane modulation, load no load, or variable displacement flow control. The measure also applies to "lost opportunity" installations including new construction, the expansion of existing facilites, or replacement of existing equipment at end of life. In all cases the baseline is assumed to be a fixed speed compressor with one of the flow control methods described above.

The measure applies to variable speed air compressor up to 75 HP. For larger installations, the implementation cost and energy savings varies significantly between installations and the deemed savings factors provided here are not applicable. Custom protocols should be applied to derive savings and incentive levels for installations larger than 75 HP.

<u>Algorithms</u>

Energy Savings (kWh/yr) = HRS * SF * HP * 0.746

Peak Demand Savings (kW) = HP * CF * 0.746

<u>Definition of Variables</u>

= Annual compressor run time from application, (hours/year).

0.746 = Conversion factor = HP to kW

SF = Deemed Savings factor from savings factor table, kW/nameplate HP.

HP = Nameplate motor HP for variable speed air compressor, HP.

CF = Coincidence factor applicable to commercial compressed air installations

<u>Summary of Inputs</u>

Air Compressors with VFDs

Component	Type	Value	Source
HP	Variable	Nameplate	Application
SF	Fixed	0.186	1
HRS	Variable	6,978 hours/year	Application, default value from source 1
CF	Fixed	1.05	1

Sources

1. Impact Evaluation of 2014 RI Prescriptive Compressed Air Installations, National Grid, Prepared by KEMA, July 15, 2016.

New and Retrofit Kitchen Hoods with Variable Frequency Drives

Kitchen Hoods with Variable Frequency Control utilize optical and temperature sensors at the hood inlet to monitor cooking activity. Kitchen hood exhaust fans are throttled in response to real time ventilation requirements. Energy savings result from fan power reduction during part load operation as well as a decrease in heating and cooling requirement of make-up air.

<u>Algorithms</u>

Electric Fan Savings (kWh/yr) = N * (HP * *LF * 0.746/FEFF) * RH * PR

Heating Savings (MMBtu/yr) = SF * CFM/SF * OF * FR * HDD * 24 * 1.08 / (HEFF * 1,000,000)

Cooling Savings (kWh/yr) = SF * CFM/SF * OF * FR * CDD * 24 * 1.08 / (CEFF * 3,412)

<u>Definition of Variables</u>

N = Number of Kitchen Hood Fan Motors

HP = Kitchen Hood Fan Motor HP

LF = Existing Motor Loading Factor

0.746 = Conversion factor = HP to kW

F_{EFF} = Efficiency of Kitchen Hood Fan Motors (%)

RH = Kitchen Hood Fan Run Hours

PR = Fan Motor Power Reduction resultant from VFD/Control Installation

SF = Kitchen Square Footage

CFM/SF = Code required ventilation rate per square foot for Commercial Kitchen spaces

OF = Ventilation rate oversize factor (compared to code requirement)

FR = Flow Reduction resultant from VFD/Control Installation

HDD_{mod} = Modified Heating Degree Days based on location and facility type

CDD_{mod} = Modified Cooling Degree Days based on location and facility type

24 = Hours per Day

1.08 = Sensible heat factor for air ((Btu/hr) / (CFM * Deg F))

H_{EFF} = Efficiency of Heating System (AFUE %)

C_{EFF} = Efficiency of Cooling System (COP)

3,412 = Conversion factor from Btu to kWh (3,412 Btu = 1 kWh)

1,000,000 = Btu/MMBtu

Summary of Inputs

Kitchen Hoods with VFDs

Component	Type	Value	Source
N	Variable	Quantity	Application
HP	Variable	Nameplate	Application
LF	Fixed	0.9	Melink Analysis Sample[40]
F_{EFF}	Variable	Based on Motor HP	NEMA Premium Efficiency, TEFC 1800 RPM
RH	Variable	See Table Below	2
PR	Variable	See Table Below	2
SF	Variable	Kitchen Square Footage	Application
CFM / SF	Fixed	0.7	1
OF	Fixed	1.4	Estimated Typical Kitchen Design[41]
FR	Variable	Based on Facility Type	2
HDD_{mod}	Variable	See Table Below	3
CDD_{mod}	Variable	See Table Below	4
H_{EFF}	Fixed	0.8	Estimated Heating System Efficiency[42]
C_{EFF}	Fixed	3.00	Estimated Cooling System Efficiency[43]

[40] To assist with development of this protocol, Melink Corporation provided several sample analyses performed on typical facilities utilizing Intelli-Hood control systems. The analysis performed is used nationwide by Melink to develop energy savings and financial reports related to installation of these systems for interested building owners. Melink's analysis is mirrored in this protocol and includes several of the assumed values utilized here, including an average 0.9 load factor on hood fan motors, as well as operating hours for typical campus, lodging, restaurant and supermarket facility types.

[41] Oversize factor of 1.4 is a best estimate based on past experience, assessments conducted at facilities with commercial food service equipment and approximations based on Melink sample analyses, which lead to average commercial kitchen ventilation rate of 1 CFM/SF (0.7 * 1.4). While exact ventilation rate is dependent on installed equipment and other factors, this figure is meant to represent average ventilation across potential retrofit and new installation projects.

[42] A typical heating system efficiency of 80% AFUE is assumed based on estimates of average facility size, heating system age, and past and present code requirements, as well as assumptions indicated in Melink sample analyses. This figure is meant to represent average heating system efficiency across potential retrofit and new installation projects.

[43] A typical cooling system efficiency of 3.00 COP (10.24 EER, 1.17 kW/Ton) is assumed based on estimates of average facility size, cooling system age, and past and present code requirements, as well as assumptions indicated in Melink sample analyses. This figure is meant to represent average cooling system efficiency across potential retrofit and new installation projects.

Facility-Specific Values Table

Facility Type	Run Hours	Power Reduction (PR)	Flow Reduction (FR)
Campus	5250	0.568	0.295
Lodging	8736	0.618	0.330
Restaurant	5824	0.552	0.295
Supermarket	5824	0.597	0.320
Other	5250	0.584	0.310

Modified Heating Degree Days Table

Building Type	Heating Energy Density (kBtu/sf)	Degree Day Adjustment Factor	Atlantic City (HDD)	Newark (HDD)	Philadelphia (HDD)	Monticello (HDD)
Education	29.5	0.55	2792	2783	2655	3886
Food Sales	35.6	0.66	3369	3359	3204	4689
Food Service	39.0	0.73	3691	3680	3510	5137
Health Care	53.6	1.00	5073	5057	4824	7060
Lodging	15.0	0.28	1420	1415	1350	1976
Retail	29.3	0.55	2773	2764	2637	3859
Office	28.1	0.52	2660	2651	2529	3701
Public Assembly	33.8	0.63	3199	3189	3042	4452
Public Order/Safety	24.1	0.45	2281	2274	2169	3174
Religious Worship	29.1	0.54	2754	2745	2619	3833
Service	47.8	0.89	4524	4510	4302	6296
Warehouse/Storage	20.2	0.38	1912	1906	1818	2661

Modified Cooling Degree Days Table

Building Type	Degree Day Adjustment Factor	Atlantic City (CDD)	Newark (CDD)	Philadelphia (CDD)	Monticello (CDD)
Education	0.55	824	893	806	625
Food Sales	0.66	989	1071	967	750
Food Service	0.73	1094	1185	1069	830
Health Care	1.00	1499	1623	1465	1137
Lodging	0.28	420	454	410	318
Retail	0.55	824	893	806	625
Office	0.52	779	844	762	591
Public Assembly	0.63	944	1022	923	716
Public Order/Safety	0.45	675	730	659	512
Religious Worship	0.54	809	876	791	614
Service	0.89	1334	1444	1304	1012
Warehouse/Storage	0.38	570	617	557	432

Sources

1. ASHRAE Standards 62.1-2013, Standards for Ventilation and IAQ. https://www.ashrae.org/standards-research--technology/standards--guidelines, Table 6.5.
2. Facility Specific Values table constructed based on consolidation of Melink sample analysis data. Facility run hours were averaged across all like sample analyses. Fan

power and flow reductions were calculated utilizing fan power profiles included in each sample analysis.

3. KEMA, June 2009, New Jersey's Clean Energy Program Smartstart Program Protocol Review; available at: http://www.njcleanenergy.com/files/file/Library/HVAC%20Evaluation%20Report%20-%20Final%20June%2011%202009.pdf.
4. Modified Cooling Degree Days table utilizes Degree Day Adjustment factors from Heating Degree Days table and cooling degree days for each of the four representative cities as indicated by degreedays.net.

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 2013, *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 2013, *Energy Standard for Buildings Except Low Rise Residential Buildings*. https://www.ashrae.org/standards-research--technology/standards--guidelines, Table 6.8.1F.
5. DOE Typical Meteorological Year (TMY3) data for Trenton, Newark, and Atlantic City.

Aluminum Night Covers

This measure is applicable to existing open-type refrigerated display cases where considerable heat is lost through an opening that is directly exposed to ambient air. These retractable aluminum woven fabric covers provide a barrier between the contents of the case and the outside environment. They are employed during non-business hours to significantly reduce heat loss from these cases when contents need not be visible.

Savings approximations are based on the report, “Effects of the Low Emissivity Shields on performance and Power use of a refrigerated display case,” by Southern California Edison, August 8, 1997. Southern California Edison (SCE) conducted this test at its state-of-the-art Refrigeration Technology and Test Center (RTTC), located in Irwindale, CA. The RTTC’s sophisticated instrumentation and data acquisition system provided detailed tracking of the refrigeration system’s critical temperature and pressure points during the test period. These readings were then utilized to quantify various heat transfer and power related parameters within the refrigeration cycle. The results of SCE’s test focused on three typical scenarios found mostly in supermarkets: low, medium and high temperature cases.

<u>Algorithms</u>

Energy Savings (kWh/yr) = W * H * F

<u>Definition of Variables</u>

W = Width of protected opening in ft.

H = Hours per year covers are in place

F = Savings factor based on case temperature

<u>Summary of Inputs</u>

Aluminum Night Covers - Commercial Refrigeration

Component	Type	Value	Source
W	Variable		Application
H	Variable		Application
F	Variable	Low temperature (-35F to -5F) F = 0.1 kW/ft Medium temperature (0F to 30F) F = 0.06 kW/ft High temperature (35F to 55F) F = 0.04 kW/ft	1

<u>Sources</u>

1. Southern California Edison (SCE), “Effects of the Low Emissivity Shields on performance and Power use of a refrigerated display case,” August 8, 1997.

Walk-in Cooler/Freezer Evaporator Fan Control

This measure is applicable to existing walk-in coolers and freezers that have evaporator fans which run continuously. The measure adds a control system feature to automatically shut off evaporator fans when the cooler's thermostat is not calling for cooling. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein. These savings take into account evaporator fan shut off and associated savings as a result of less heat being introduced into the walk-in, as well as the savings from the compressor, which is now being controlled through electronic temperature control.

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system.[44]

Algorithms

Gross Energy Savings (kWh/yr) = $kWh\ Savings_{EF}$ + $kWh\ Savings_{RH}$ + $kWh\ Savings_{EC}$

kWh SavingsEF = $((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * 0.55 * 8{,}760 * 35.52\%$

kWh SavingsRH = $kWh\ Savings_{EF} * 0.28 * 1.6$

kWh SavingsEC = $(((Amps_{CP} * Volts_{CP} * (Phase_{CP})^{1/2})/1000) * 0.85 * ((35\% * WH) + (55\% * NWH)) * 5\%) + (((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * 0.55 * 8{,}760 * 35.52\% * 5\%)$

Gross kW Savings = $((Amps_{EF} * Volts_{EF} * (Phase_{EF})^{1/2})/1000) * 0.55 * D$

Definition of Variables

$kWh\ Savings_{EF}$	= Savings due to Evaporator Fan being off
$kWh\ Savings_{RH}$	= Savings due to reduced heat from Evaporator Fans
$kWh\ Savings_{EC}$	= Savings due to the electronic controls on compressor and evaporator
$Amps_{EF}$	= Nameplate Amps of Evaporator Fan
$Volts_{EF}$	= Nameplate Volts of Evaporator Fan
$Phase_{EF}$	= Phase of Evaporator Fan
0.55	= Evaporator Fan Motor power factor
8,760	= Annual Operating Hours

[44] Several case studies related to NRM's Cooltrol system can be found at: http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html.

35.52%	= Percent of time Evaporator Fan is turned off
0.28	= Conversion from kW to tons (Refrigeration)
1.6	= Efficiency of typical refrigeration system in kW/ton [3]
$Amps_{CP}$	= Nameplate Amps of Compressor
$Volts_{CP}$	= Nameplate Volts of Compressor
$Phase_{CP}$	= Phase of Compressor
0.85	= Compressor power factor.
35%	= Compressor duty cycle during winter months
WH	= Compressor hours during winter months
55%	= Compressor duty cycle during non-winter months
NWH	= Compressor hours during non-winter months (6,565)
5%	= Reduced run time of Compressor and Evaporator due to electronic controls
D	= Diversity Factor

<u>Summary of Inputs</u>

Evaporator Fan Control - Commercial Refrigeration

Component	Type	Value	Source
$Amps_{EF}$	Variable	Manufacturer data	Application
$Volts_{EF}$	Variable	Manufacturer data	Application
$Phase_{EF}$	Variable	Manufacturer data	Application
0.55	Variable	Default	Estimate
8,760	Variable	Default	Estimate
35.52%	Variable	Default	Estimate[45]
0.28	Variable	Conversion	
1.6	Variable	Default	Estimate, 1
$Amps_{CP}$	Variable	Manufacturer data	Application
$Volts_{CP}$	Variable	Manufacturer data	Application
$Phase_{CP}$	Variable	Manufacturer data	Application
0.85	Variable	Default	Estimate
35%	Variable	Default	Estimate

[45] This value is an estimate by NRM based on hundreds of downloads of hours of use data from the electronic controller. It is an 'average' savings number and has been validated through several Third Party Impact Evaluation Studies including study performed by HEC, "Analysis of Walk-in Cooler Air Economizers," p. 22, Table 9, October 10, 2000 for National Grid.

Component	Type	Value	Source
WH	Variable	2,195 - Default	Estimate
55%	Variable	Default	Estimate
NWH	Variable	6,565 - Default	Estimate
5%	Variable	Default	2
D	Variable	0.228	3

<u>Sources</u>

1. Select Energy Services, Inc. Cooler Control Measure Impact Spreadsheet User's Manual. 2004.
2. This percentage has been collaborated by several utility sponsored 3rd Party studies including study conducted by Select Energy Services for NSTAR, March 9, 2004.
3. Based on the report "Savings from Walk-In Cooler Air Economizers and Evaporator Fan Controls," HEC, June 28, 1996.

Cooler and Freezer Door Heater Control

This measure is applicable to existing walk-in coolers and freezers that have continuously operating electric heaters on the doors to prevent condensation formation. This measure adds a control system feature to shut off the door heaters when the humidity level is low enough such that condensation will not occur if the heaters are off. This is performed by measuring the ambient humidity and temperature of the store, calculating the dewpoint, and using PWM (pulse width modulation) to control the anti-sweat heaters based on specific algorithms for freezer doors. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system.[46]

Low Temperature (Freezer) Door Heater Control

Algorithms

Energy Savings (kWh/yr) = (kW_{DH} * 8,760) – ((40% * kW_{DH} * 4,000) + (65% * kW_{DH} * 4,760))

Peak Demand Savings (kW) = kW_{DH} * 46% * 75%

Definition of Variables

kW_{DH} = Total demand (kW) of the freezer door heaters, based on nameplate volts and amps.

8,760 = Annual run hours of Freezer Door Heater before controls.

40% = Percent of total run power of door heaters with controls providing maximum reduction

4,000 = Number of hours door heaters run at 40% power.

65% = Percent of total run power of door heaters with controls providing minimum reduction

4,760 = Number of hours door heaters run at 65% power.

46% = Freezer Door Heater off time

75% = Adjustment factor to account for diversity and coincidence at peak demand

---

[46] Several case studies related to NRM's Cooltrol system can be found at: http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html

Medium Temperature (Cooler) Door Heater Control

Algorithms

Energy Savings (kWh/yr) = (kW_{DH} * 8,760) – (60% * kW_{DH} * 3,760)

Peak Demand Savings (kW) = kW_{DH} * 74% * 75%

Definition of Variables

kW_{DH} = Total demand (kW) of the cooler door heaters, based on nameplate volts and amps.

8,760 = Annual run hours of Cooler Door Heater before controls.

60% = Percent of total run power of door heaters with controls providing minimum reduction

3,760 = Number of hours door heaters run at 60% power.

74% = Cooler Door Heater off time

75% = Adjustment factor to account for diversity and coincidence at peak demand

Summary of Inputs

Door Heater Controls - Commercial Refrigeration

Component	**Type**	**Value**	**Source**
kW_{DH}	Variable	Manufacturer data	Application
8,760	Variable	Default	Estimate
40%	Variable	Default	Estimate, 1
4,000	Variable	Default	Estimate
65%	Variable	Default	Estimate, 2
4,760	Variable	Default	Estimate
46%	Variable	Default	Estimate, 2
75%	Variable	Default	Estimate, 1
60%	Variable	Default	Estimate
3,760	Variable	Default	Estimate
74%	Variable	Default	Estimate, 2

Sources

1. Estimated by NRM based on their experience of monitoring the equipment at various sites.
2. This value is an estimate by National Resource Management based on hundreds of downloads of hours of use data from Door Heater controllers. This supported by 3rd Party Analysis conducted by Select Energy for NSTAR, "Cooler Control Measure Impact Spreadsheet Users' Manual," P.5, March 9, 2004.

Electric Defrost Control

This measure is applicable to existing evaporator fans with a traditional electric defrost mechanism. This control system overrides defrost of evaporator fans when unnecessary, reducing annual energy consumption. The estimates for savings take into account savings from reduced defrosts as well as the reduction in heat gain from the defrost process.

Independent Testing was performed by Intertek Testing Service on a Walk-in Freezer that was retrofitted with Smart Electric Defrost capability. A baseline of 28 electric defrosts per week were established as the baseline for a two week period without the Smart Electric Defrost capability. With Smart Electric Defrost capability an average skip rate of 43.64% was observed for the following two week period.

<u>Algorithms</u>

Gross Energy Savings (kWh/yr) = $kWh\ Savings_{Defrost} + kWh\ Savings_{RH}$

$kWh\ Savings_{Defrost} = KW_{\text{Defrost}} * 0.667 * 4 * 365 * 35\%$

$kWh\ Savings_{RH} = kWh\ Savings_{Defrost} * 0.28 * 1.6$

<u>Definition of Variables</u>

$kWh\ Savings_{Defrost}$	= Savings due to reduction of defrosts
$kWh\ Savings_{RH}$	= Savings due to reduction in refrigeration load
KW_{Defrost}	= Nameplate Load of Electric Defrost
0.667	= Average Length of Electric Defrost in hours
4	= Average Number of Electric Defrosts per day
365	= Conversion factor = Days per Year
35%	= Average Number of Defrosts that will be eliminated in year
0.28	= Conversion factor = kW to tons (Refrigeration)
1.6	= Efficiency of typical refrigeration system in kW/ton

<u>Summary of Inputs</u>

Electric Defrost Controls - Commercial Refrigeration

Component	Type	Value	Source
kW_{DH}	Variable	Manufacturer data	Application
0.667	Variable	Default	Estimate
4	Variable	Default	Estimate
35%	Variable	Default	Estimate
1.6	Variable	Default	1

<u>Sources</u>

1. Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual*. 2004.

Novelty Cooler Shutoff

This measure is applicable to existing reach-in novelty coolers which run continuously. The measure adds a control system feature to automatically shut off novelty coolers based on pre-set store operating hours. Based on programmed hours, the control mechanism shuts off the cooler at end of business, and begins operation on reduced cycles. Regular operation begins the following day an hour before start of business. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system.[47]

Algorithms

$$\text{Energy Savings (kWh/yr)} = (((\text{Amps}_{NC} * \text{Volts}_{NC} * (\text{Phase}_{NC})^{1/2})/1000) * 0.85) * ((0.45 * ((CH - 1) * 91)) + (0.5 * ((CH - 1) * 274)))$$

Definition of Variables

Amps_{NC} = Nameplate Amps of Novelty Cooler

Volts_{NC} = Nameplate Volts of Novelty Cooler

Phase_{NC} = Phase of Novelty Cooler

0.85 = Novelty Cooler power factor

0.45 = Duty cycle during winter month nights

CH = Closed Store hours

91 = Number of days in winter months

0.5 = Duty cycle during non-winter month nights [3]

274 = Number of days in non-winter months

Summary of Inputs

Novelty Cooler - Commercial Refrigeration

Component	Type	Value	Source
Amps_{NC}	Variable	Manufacturer data	Application
Volts_{NC}	Variable	Manufacturer data	Application
Phase_{NC}	Variable	Manufacturer data	Application

[47] Several case studies related to NRM's Cooltrol system can be found at: http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html.

Component	Type	Value	Source
0.85	Variable	Default	Estimate, 1
0.45	Variable	Default	Estimate, 2
CH	Variable	Default	Estimate
91	Variable	Default	Estimate
0.5	Variable	Default	Estimate
274	Variable	Default	Estimate

<u>Sources</u>

1. Estimated by NRM based on their experience of monitoring the equipment at various sites.
2. Duty Cycles are consistent with third-party study done by Select Energy for NSTAR "Cooler Control Measure Impact Spreadsheet Users Manual," p. 5, March 9, 2004.

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 Combination Oven/Steamer

The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

<u>Algorithms</u>

Energy Savings (kWh/yr or Therms/yr) = $D*(E_p + E_{ic} + E_{is} + E_{cc} + E_{cs})$

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

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

Convection Mode Idle Savings†: $E_{ic} = (I_{cb} – I_{cq})*((H – (P*P_t)) – (I_{cb}/PC_{cb} – I_{cq}/PC_{cq})*Lbs)*(1 – S_t)$

Steam Mode Idle Savings†: $E_{is} = (I_{sb} – I_{sq})*((H – (P*P_t)) – (I_{sb}/PC_{sb} – I_{sq}/PC_{sq})*Lbs)*S_t$

Convection Mode Cooking Savings: $E_{cc} = Lbs*(1-S_t)*Heat_c*(1/Eff_{cb} – 1/Eff_{cq})/C$

Steam Mode Cooking Savings: $E_{cs} = Lbs*S_t*Heat_s*(1/Eff_{sb} – 1/Eff_{sq})/C$

† – 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)[48]

C	= Conversion Factor from Btu to kWh or Therms
D	= Operating Days per Year
Effcb	= Baseline Equipment Convection Mode Cooking Efficiency
Effcq	= Qualifying Equipment Convection Mode Cooking Efficiency
Effsb	= Baseline Equipment Steam Mode Cooking Efficiency
Effsq	= Qualifying Equipment Steam Mode Cooking Efficiency
H	= Daily Operating Hours
Heatc	= Convection Mode Heat to Food
Heats	= Steam Mode Heat to Food
Icb	= Baseline Equipment Convection Mode Idle Energy Rate
Icq	= Qualifying Equipment Convection Mode Idle Energy Rate
Isb	= Baseline Equipment Steam Mode Idle Energy Rate
Isq	= Qualifying Equipment Steam Mode Idle Energy Rate
Lbs	= Total Daily Food Production
P	= Number of Preheats per Day
PCcb	= Baseline Equipment Convection Mode Production Capacity
PCcq	= Qualifying Equipment Convection Mode Production Capacity
PCsb	= Baseline Equipment Steam Mode Production Capacity
PCsq	= Qualifying Equipment Steam Mode Production Capacity
PEb	= Baseline Equipment Preheat Energy
PEq	= Qualifying Equipment Preheat Energy
Pt	= Preheat Duration
St	= Percentage of Time in Steam Mode

[48] 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. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission. Values for Tables 1 and 2 from PG&E Work Paper PGECOFST100, "Commercial Combination Ovens/Steam –Electric and Gas," Revision 6, 2016.

Summary of Inputs

Table 1: Electric Combination Oven/Steamers						
Variable	*Baseline*			*Qualifying*		
	<15 Pans	*15-28 Pans*	*>28 Pans*	*<15 Pans*	*15-28 Pans*	*>28 Pans*
D - Operating Days per Year	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P - Number of Preheats per Day	1	1	1	1	1	1
PE_b & PE_q - Preheat Energy (kWh)	3.00	3.75	5.63	1.50	2.00	3.00
I_{cb} & I_{cq} - Convection Mode Idle Energy Rate (kW)	3.00	3.75	5.25	Application	Application	Application
H - Operating Hours per Day	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P_t - Preheat Duration (hrs)	0.25	0.25	0.25	0.25	0.25	0.25
PC_{cb} & PC_{cq} - Convection Mode Prod. Capacity (lbs/hr)	80	100	275	100	125	325
Lbs - Total Daily Food Production (lbs)	200	250	400	200	250	400
S_t - Percentage of Time in Steam Mode	50%	50%	50%	50%	50%	50%
I_{sb} & I_{sq} - Steam Mode Idle Energy Rate (kW)	10.0	12.5	18.0	Application	Application	Application
PC_{sb} & PC_{sq} - Steam Mode Prod. Capacity (lbs/hr)	100	150	350	120	200	400
$Heat_c$ - Convection Heat to Food (Btu/lb)	250	250	250	250	250	250
Eff_{cb} & Eff_{cq} - Convection Mode Cooking Efficiency	65%	65%	65%	Application	Application	Application
C - Btu/kWh	3,412	3,412	3,412	3,412	3,412	3,412
$Heat_s$ - Steam Heat to Food (Btu/lb)	105	105	105	105	105	105
Eff_{sb} & Eff_{sq} - Steam Mode Cooking Efficiency	40%	40%	40%	Application	Application	Application

Table 2: Gas Combination Oven/Steamers						
Variable	*Baseline*			*Qualifying*		
	<15 Pans	*15-28 Pans*	*>28 Pans*	*<15 Pans*	*15-28 Pans*	*>28 Pans*
D - Operating Days per Year	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P - Number of Preheats per Day	1	1	1	1	1	1
PE_b & PE_q - Preheat Energy (Btu)	18,000	22,000	32,000	13,000	16,000	24,000
I_{cb} & I_{cq} - Convection Mode Idle Energy Rate (Btu/h)	15,000	20,000	30,000	Application	Application	Application
H - Operating Hours per Day	Table 3	Table 3	Table 3	Table 3	Table 3	Table 3
P_t - Preheat Duration (h)	0.25	0.25	0.25	0.25	0.25	0.25
PC_{cb} & PC_{cq} - Convection Mode Prod. Capacity (lbs/h)	80	100	275	100	125	325
Lbs - Total Daily Food Production (lbs)	200	250	400	200	250	400
S_t - Percentage of Time in Steam Mode	50%	50%	50%	50%	50%	50%
I_{sb} & I_{sq} - Steam Mode Idle Energy Rate (kW)	45,000	60,000	80,000	Application	Application	Application
PC_{sb} & PC_{sq} - Steam Mode Prod. Capacity (lbs/h)	100	150	350	120	200	400
$Heat_c$ - Convection Heat to Food (Btu/lb)	250	250	250	250	250	250
Eff_{cb} & Eff_{cq} - Convection Mode Cooking Efficiency	35%	35%	35%	Application	Application	Application
C - Btu/Therm	100,000	100,000	100,000	100,000	100,000	100,000
$Heat_s$ - Steam Heat to Food (Btu/lb)	105	105	105	105	105	105
Eff_{sb} & Eff_{sq} - Steam Mode Cooking Efficiency	20%	20%	20%	Application	Application	Application

Table 3: 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

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)[49]

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

[49] 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. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission. Values for Tables 1 and 2 from PG&E Work Paper PGECOFST100, "Commercial Combination Ovens/Steam –Electric and Gas," Revision 6, 2016.

C = Conversion Factor from Btu to kWh or Therms

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
PE_b & PE_q - Preheat Energy (Btu)	35,000	18,000
I_b & I_q - Idle Energy Rate (Btu/hr)	70,000	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)	114	167
Lbs - Total Daily Food Production (lbs)	190	190
Heat - Heat to Food (Btu/lb)	250	250
Eff_b & Eff_q - Heavy Load Cooking Efficiency	20%	Application
C - Btu/Therm	100,000	100,000

Source: PGECOFST117 R5, "Commercial Conveyor Oven– Gas," 2014.

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
PE_b & PE_q - Preheat Energy (kWh)	2.40	1.90
I_b & I_q - Idle Energy Rate (kW)	1.2	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)	71	71
Lbs - Total Daily Food Production (lbs)	150	150
Heat - Heat to Food (Btu/lb)	570	570
Eff_b & Eff_q - 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
PE_b & PE_q - Preheat Energy (Btu)	18,500	16,000
I_b & I_q - Idle Energy Rate (Btu/h)	17,000	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)	75	75
Lbs - Total Daily Food Production (lbs)	150	150
Heat - Heat to Food (Btu/lb)	570	570
Eff_b & Eff_q - 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
PE_b & PE_q - Preheat Energy (kWh)	1.3 x Griddle Width (ft)	0.7 x Griddle Width (ft)
I_b & I_q - Idle Energy Rate (kW)	0.8 x Griddle Width (ft)	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 Griddle Width (ft)	13.3 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Eff_b & Eff_q - Heavy Load Cooking Efficiency	60%	Application
C - Btu/kWh	3,412	3,412

Source: PGECOFST103 R7, "Commercial Griddle – Electric and Gas," 2016.

Table 10: Gas Griddles		
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)	7,000 x Griddle Width (ft)	5,000 x Griddle Width (ft)
I_b & I_q - Idle Energy Rate (Btu/h)	7,000 x Griddle Width (ft)	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)	8.3 x Griddle Width (ft)	15 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Eff_b & Eff_q - Heavy Load Cooking Efficiency	30%	Application
C - Btu/Therm	100,000	100,000

Source: PGECOFST103 R7, "Commercial Griddle – Electric and Gas," 2016.

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

Insulated Food Holding Cabinets

The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Energy Savings (kWh/yr) = D * H * (I_b – I_q)

Peak Demand Savings (kW) = I_b – I_q

Definition of Variables
(See tables of values below for more information)[50]

D = Operating Days per Year

H = Daily Operating Hours

I_b = Baseline Equipment Idle Energy Rate

I_q = Qualifying Equipment Idle Energy Rate

Summary of Inputs

Table 1: Insulated Food Holding Cabinets

Variable	***Baseline***			***Qualifying***		
	Full Size	*3/4 Size*	*1/2 Size*	*Full Size*	*3/4 Size*	*1/2 Size*
D - Operating Days per Year	Table 2	Table 2	Table 2	Table 2	Table 2	Table 2
I_b & I_q - Idle Energy Rate (kW)	1.00	0.69	0.38	Application	Application	Application
H - Operating Hours per Day	Table 2	Table 2	Table 2	Table 2	Table 2	Table 2

Source: PGECOFST105 R5, "Insulated Holding Cabinet – Electric," 2016.

[50] 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. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

Table 2: 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

Commercial Dishwashers

This measure is applicable to replacement of existing dishwashers with energy efficient under counter, door type, single-rack and multi-rack conveyor machines testing in accordance with NSF/ANSI 3-2007, ASTM F1696, and ASTM F1920 standards. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Energy Savings (kWh/yr or Therms/yr) = $E_{Build} + E_{Boost} + E_{Idle}$

Peak Demand Savings (kW) = kWh Savings/8760

Note: Depending on water heating system configuration (e.g. gas building water heater with electric booster water heater), annual energy savings may be reported in both therms and kWh.

Definition of Variables
(See tables below for more information)[51]

E_{Build} = Annual Building Water Heater Energy Savings, in kWh or Therms (from tables below)

E_{Boost} = Annual Booster Water Heater Energy Savings, in kWh or Therms (from tables below)

E_{Idle} = Annual Dishwasher Idle Energy Savings, in kWh (from tables below)

8760 = Hours per Year

Summary of Inputs

[51] 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. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission and from the Savings Calculator for ENERGY STAR Qualified Commercial Kitchen Equipment.

Table 1: Low Temperature Dishwasher Savings					
Dishwasher Type	Electric Building Water Heater Savings (kWh)	Gas Building Water Heater Savings (Therms)	Electric Booster Water Heater Savings (kWh)	Gas Booster Water Heater Savings (Therms)	Idle Energy Savings (kWh)
Under Counter	1,213	56.2	0	0.0	0
Door Type	12,135	562.1	0	0.0	0
Single Tank Conveyor	11,384	527.3	0	0.0	0
Multi Tank Conveyor	17,465	809.0	0	0.0	0

Table 2: High Temperature Dishwasher Savings					
Dishwasher Type	Electric Building Water Heater Savings (kWh)	Gas Building Water Heater Savings (Therms)	Electric Booster Water Heater Savings (kWh)	Gas Booster Water Heater Savings (Therms)	Idle Energy Savings (kWh)
Under Counter	4,754	220.2	2,717	110.1	0
Door Type	8,875	411.1	5,071	205.5	198
Single Tank Conveyor	11,126	515.3	6,358	257.7	1,752
Multi Tank Conveyor	21,734	1,006.7	12,419	503.3	0

Commercial Refrigerators and Freezers

This measure is applicable to replacement of existing commercial grade refrigerators and freezers with energy efficient glass and solid door units complying with ANSI/ASHRAE Standard 72-2005, Method of Testing Commercial Refrigerators and Freezers. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Energy Savings (kWh/yr) = D * (E_b – E_q)

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

Definition of Variables
(See tables below for more information)[52]

D = Operating Days per Year (assume 365)

H = Daily Operating Hours (assume 24)

E_b = Daily kWh Consumption of Baseline Equipment (from Table 1 below)

E_q = Daily kWh Consumption of Qualifying Equipment (from Application)

Summary of Inputs

Table 1: Baseline Equipment Daily kWh Consumption	
Proposed Equipment Type	***kWh Consumption (V = Unit Volume in ft^3)***
Glass Door Freezer	0.75V + 4.1
Glass Door Refrigerator	0.12V + 3.34
Solid Door Freezer	0.4V + 1.38
Solid Door Refrigerator	0.1V + 2.04

Commercial Ice Machines

This measure is applicable to replacement of existing ice makers with energy efficient, air-cooled ice machines tested in accordance with ARI Standard 810. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Algorithms

Energy Savings (kWh/yr) = D * DC * (IHR/100) * (E_b – E_q)

[52] 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. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

Peak Demand Savings (kW) = kWh Savings / (D * 24 * DC)

Definition of Variables
(See tables below for more information)[53]

D = Operating Days per Year (assume 365)

DC = Duty Cycle, defined as Ice Harvest Rate/Actual Daily Ice Production (assume 75%)

IHR = Proposed Equipment Ice Harvest Rate in lbs/day (from Application)

E_b = kWh Consumption of Baseline Equipment in kWh/100 lbs (from Table 1 below)

E_q = kWh Consumption of Qualifying Equipment in kWh/100 lbs (from Application)

24 = Hours per Day

Summary of Inputs

Table 1: Baseline Energy Consumption

Ice Harvest Rate (lbs/day)	*Baseline Energy Consumption (kWh/100 lbs)*
0-100	18.0
101-200	16.0
201-300	11.0
301-400	8.5
401-500	7.6
501-1000	6.9
1001-1500	6.4
1501	6.1

[53] 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. and funded by California utility customers and administered by Pacific Gas and Electric Company under the auspices of the California Public Utility Commission.

C&I Gas Protocols

The following measures are outlined in this section: Gas Chillers, Gas Fired Dessicants, 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	75% 80% Et	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 – ~~large~~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

<u>Sources</u>

1. ASHRAE Standards 90.1-2013, *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*, V6, April 2018. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 535-540. EFLH values for NYC due to proximity to NJ.

Gas Fired Dessicants

Gas-fired desiccant systems employ a desiccant wheel (a rotating disk filled with a dry desiccant such as silica gel, titanium gel, or dry lithium chloride) which adsorbs outside air moisture, reducing the air's latent heat content. This air is then conditioned by the building's cooling system, before being delivered to the occupied space. By reducing the relative humidity of the air, the operating temperature of the building can be increased, as comfort levels are maintained at higher temperatures when air moisture content is decreased. Electric savings are realized from a reduction in the required cooling load as a result of decreased humidity.

In order to maintain the usefulness of the desiccant (to keep it dry) hot air must be passed through the desiccant that has been used to remove moisture from the outside air. To supply this hot air, a gas-fired heater is employed to heat "regeneration" air, which picks up moisture from the saturated desiccant and exhausts it to the outside. As a result, in addition to electric benefits, these systems will also incur a natural gas penalty.

Electric savings and natural gas consumption will vary significantly from system to system depending on regional temperature and humidity, facility type, occupancy, site processes, desiccant system design parameters, ventilation requirements and cooling load and system specifications. Due to the multitude of site and equipment specific factors, along with the relative infrequency of these systems, gas-fired desiccant systems will be treated on a case-by-case basis.

Gas Booster Water Heaters

C&I gas booster water heaters are substitutes for electric water heaters. The measurement of energy savings is based on engineering algorithms with key variables (i.e., Input Rating Coincidence Factor, Equivalent Full Load Hours) provided by manufacturer data or measured through existing end-use metering of a sample of facilities.

<u>Algorithms</u>

Energy Savings (kWh/yr) = IR * EFF/3,412 * EFLH

Peak Demand Savings (kW) = IR * EFF/3,412 * CF

Gas Usage Increase (MMBtu/yr) = IR * EFLH

Net Energy Savings (kWh/yr) = Electric Energy Savings – Gas Usage Increase/3,412

<u>Definition of Variables</u>

IR = Input Rating in MMBtu/hr

EFF = Efficiency

CF = Coincidence Factor

EFLH = Equivalent Full Load Hours

The 3412 used in the denominator is used to convert Btus to kWh.

Summary of Inputs

Gas Booster Water Heaters

Component	Type	Value	Source
IR	Variable		Application or Manufacturer Data
CF	Fixed	30%	Summit Blue NJ Market Assessment
EFLH	Fixed	1,000	PSE&G
EFF	Variable		Application Form or Manufacturer Data

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 90.1-2013 standards apply, and for existing buildings, ASHRAE 90.1-2007 standards are assumed.

Note, that forstand 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.

<u>Algorithms</u>

Fuel Savings (MMBtu/yr) = ((1 – (EFF_b / EFF_q) + SLF[54]) * Energy Use Density * Area / 1000 kBtu/MMBtu

where,

SLF = (SL_b – SL_q) / Cap_q

<u>Definition of Variables</u>

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.

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

$SL_{b \text{ or } q}$ = 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

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

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

Summary of Inputs

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

Efficiency of Baseline Stand Alone Storage Water Heaters

ASHRAE 90.1-2007 and 2013[a]			
Equipment Type	**Size Category (Input)**	**Existing Building Baseline Efficiency (ASHRAE 90.1-2007)**	**New Building Baseline Efficiency (ASHRAE 90.1-2013)**
Gas Storage Water Heaters	≤ 75 kBtu/hr	$EF = 0.62 – 0.0019 \times V$	$EF = 0.67 – 0.0005 \times V$
Gas Storage Water Heaters	> 75 kBtu/hr	$TE = 0.80$ $SL = (Cap_q / 0.8 + 110 \times \sqrt{V}) / 1000$	$TE = 0.80$ $SL = (Cap_q / 0.799 + 16.6 \times \sqrt{V}) / 1000$

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

Sources

3. 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.
4. ASHRAE Standards 90.1-2013, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.
5. 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.

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 90.1-2013 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[55]) * Energy Use Density * Area

Where,

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

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.

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.

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

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

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

Efficiency of Baseline Water Heaters

ASHRAE 90.1-2007 and 2013[a]			
Equipment Type	**Size Category (Input)**	**Existing Building Baseline Efficiency (ASHRAE 90.1-2007)**	**New Building Baseline Efficiency (ASHRAE 90.1-2013)**
Gas Storage Water Heaters[56]	≤ 75 kBtu/hr	EF = 0.54	EF = 0.65
Gas Storage Water Heaters	> 75 kBtu/hr	TE = 0.80	TE = 0.80
Gas Instantaneous Water Heaters[57]	< 200 kBtu/hr	EF = 0.62	EF = 0.62
Gas Instantaneous Water Heaters	≥ 200 kBtu/hr	TE = 0.80	TE = 0.80

a – EF means energy factor and TE means thermal efficiency

---

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

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

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

<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 90.1-2013, *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.

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 – 2013, which is the current code adopted by the state of New Jersey.

<u>Algorithms</u>

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

<u>Definition of Variables</u>

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

<u>Summary of Inputs</u>

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 – ~~large~~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 90.1-2013
Hot Water – Gas fired	< 300 ≥ 300 and ≤ 2,500		82% AFUE 80% Et 82% Ec
Hot Water – Oil fired	< 300 ≥ 300 and ≤ 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
Steam – Gas fired, natural draft	≥ 300 and ≤		77% Et

Boiler Type	Size Category (kBtu input)		Standard 90.1-2013
Steam – Gas fired, natural draft	> 2,500		77% Ec
Steam – Oil fired	< 300 ≥ 300 and ≤ 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*, V6, April 2018. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 535-540. EFLH values for NYC due to proximity to NJ.
2. ASHRAE Standards 90.1-2013. *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.

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 – 2013, 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

Facility Type	Heating EFLH
Religious worship	722
Restaurant – fast food	813
Restaurant – full service	821
Retail – big box	191
Retail – Grocery	191
Retail – ~~large~~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 90.1-2013
Gas Fired	< 225	78% AFUE
	≥ 225	80% Ec
Oil Fired	< 225	78% AFUE
	≥ 225	81% Et

Sources

1. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V6, April 2018. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 535-540. EFLH values for NYC due to proximity to NJ.

2. ASHRAE Standards 90.1-2013, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: https://www.ashrae.org/standards-research--technology/standards--guidelines.

Infrared Heaters

This measures outlines the deemed savings for the installation of a gas-fired low intensity infrared heating system in place of unit heater, furnace, or other standard efficiency equipment. The deemed savings are based on a Massachusetts Impact Evaluation Study.

Summary of Assumptions

Variable	Value	Source
Deemed Savings	12.0 MBtu/yr	1

Sources

1. KEMA, Impact Evaluation of 2011 Prescriptive Gas Measures; prepared for Massachusetts Energy Efficiency Program Administrators and Massachusetts Energy Efficiency Advisory Council, 2013, pp. 1–5.

Electronic Fuel Use Economizers

Algorithms

Fuel Savings (MMBtu) = (AFU * 0.13)

AFU = Annual Fuel Usage for an uncontrolled (gas, oil, propane) HVAC unit (MMBtu or gallons) = (Input power in MMBtu or gallons) * (annual run time)

0.13 = Approximate energy savings factor related to installation of fuel use economizers[1].

Sources :

Approximate energy savings factor of 0.13 based on average % savings for test sites represented in Table 2 (page 3) of NYSERDA Study: A Technology Demonstration and Validation Project for Intellidyne Energy Saving Controls; Intellidyne LLC & Brookhaven National Laboratories; 2006 (http://www.cleargreenpartners.com/attachments/File/NYSERDA_Report.pdf)

Combined Heat & Power 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 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.

Distributed Generation

Net Electricity Generation (MWh) = Estimated electric generation provided on the project application, as adjusted during the project review and approval process.

Peak Electric Demand (kW) = Electric demand reduction delivered by the CHP system provided on the project application, as adjusted during the project review and approval process.

Total Fuel Consumption or Fuel Consumed by Prime Mover (MMBtu @HHV) = Total heating value of used by CHP system provided on the project application, as adjusted during the project review and approval process.

Energy Savings Impact

Gas Energy Savings or Fuel Offset (MMBtu @HHV): Gas savings should be reported on a consistent basis by all applicants as the reduction in fuel related to the recapture of thermal energy (e.g., reduction in boiler gas associated with the recapture of waste heat from the CHP engine or turbine, or a fuel cell with heat recovery.)

Electric Energy Savings or Offset Chiller Electricity Use (MWh): Electric energy savings should be reported only in cases where the recapture of thermal energy from the CHP system is used to drive an absorption chiller that would displace electricity previously consumed for cooling.

Emission Reductions

For many CHP applications there can be substantial emission benefits due to the superior emission rates of many new CHP engines and turbines as compared to the average emission rate of electric generation units on the margin of the grid. However, CHP engines and turbines produce emissions, which should be offset against the displaced emissions from the electricity that would have been generated by the grid.

Electric and natural gas emissions factors are presented in the Introduction section of the Protocols and are used to calculate the emission savings from energy efficiency and renewable energy projects. These factors should be used to calculate the base emission factors which the CHP system emission factors would be compared to. The emissions from the CHP system would be subtracted from the base emissions to determine the net emission changes as follows:

CHP Emissions Reduction Associated with PJM Grid

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

Algorithms

CO_2 ER (lbs) = [$CO_{2emission}$ * Net Electricity Generation (MWh) + Gas Energy Savings (MMBtu) * CO2 EF_{NG}] – [CHP CO_2 EF_f * Total Fuel Consumption (MMBtu)]

NO_x ER (lbs) = [$NO_{xemission}$ * Net Electricity Generation (MWh) + Gas Energy Savings (MMBtu) * NOx EF_{NG}] – [CHP NO_X EF_f * Total Fuel Consumption (MMBtu)]

SO_2 ER (lbs) = [$SO_{2emission}$ * Net Electricity Generation (MWh) + Gas Energy Savings (MMBtu) * SO2 EF_{NG}] – [CHP SO_2 EF_f * Total Fuel Consumption (MMBtu)]

Definition of Variables

$CO_{2emission}$ = See emmisions tables summarized in Introduction section of Protocols

$NO_{Xemission}$ = See emmisions tables summarized in Introduction section of Protocols

$SO_{2emission}$ = See emmisions tables summarized in Introduction section of Protocols

EF_{NG} values associated with boiler fuel displacement :

CO2 EF_{NG} = See emmisions tables summarized in Introduction section of Protocols

NOX EF_{NG} = See emmisions tables summarized in Introduction section of Protocols

SO2 EF_{NG} = See emmisions tables summarized in Introduction section of Protocols

CHP EF_f (lb/MMBtu) = Emission factor of fuel type used in the CHP system, which will vary with different projects based on the types of prime movers and emission control devices used.

Emission reductions from any CHP system energy savings, as discussed above, would be treated the same as any other energy savings reported.

Sources

1. Simons, George, Stephan Barsun, and Charles Kurnik. 2016. *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-7A40-67307. http://www.nrel.gov/docs/fy17osti/67307.pdf.

Sustainable Biomass Biopower

Estimated annual energy generation and peak impacts for sustainable biomass systems will be determined on a case-by-case basis based on the information provided by project applicants and inspection data for verification of as-installed conditions.

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[58].

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*[59] simulation requirements.
  Path 2 – Under this option the Partner will develop a baseline building using ASHRAE 90.1-2013 Appendix G *modified by Addendum BM*[60].

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 90.1-2013 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

---

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

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

[60] Addendum BM sets a common baseline building approach that will remain the same for ASHRAE 90.1-2013 and all future iterations of ASHRAE 90.1, and is roughly equivalent to ASHRAE 90.1-2004. To comply with ASHRAE 90.1-2013, 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 Management

Program (“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.

Electric HVAC Systems

Replacement of existing electric HVAC equipment with high efficiency units is a proposed measure under the *C&I Energy Efficienct Construction Electric HVAC Systems* Protocols. The Direct Install savings protocol will be the same as previously stated in this document with the exception of the assumption for baseline efficiency.

Efficiency baselines are designed to reflect current market practices, which in this case reflect ASHRAE 90.1-2007. For the Direct Install program, the following values will be used for the variable identified as $SEER_b$ EER_b COP_b $IPLV_b$ and $HSPF_b$

HVAC Baseline Table – Direct Install

Equipment Type	Baseline = ASHRAE Std. 90.1-2007
Unitary HVAC/Split Systems and Single Package, Air Cooled · <=5.4 tons · >5.4 to 11.25 tons · >11.25 to 20 tons	 13 SEER 11 EER 10.8 EER
Air-Air Cooled Heat Pump Systems, Split System and Single Package · <=5.4 tons · >5.4 to 11.25 tons · >11.25 to 20 tons	 13 SEER, 7.7 HSPF 10.8 EER, 3.3 heating COP 10.4 EER, 3.2 heating COP
Water Source Heat Pumps All Capacities	12.0 EER

Motors [Inactive 2017, Not Reviewed]

Replacement of existing motors with high efficiency units is a proposed measure under the Direct Install Program. (See C&I Construction Motors Protocols). The savings protocol will be the same as previously stated in this document with the exception of the assumption for baseline efficiency. For the Direct Install program, the following values will be used for the variable identified as η_{base}. These efficiencies are used in estimating savings associated with the Direct Install Program because as an early replacement program, equipment is replaced as a direct result of the program.

Motor HP	**Baseline Efficiency**
1	0.75
1.5	0.775
2	0.80
3	0.825
5	0.84
7.5	0.845
10	0.85
>10	Use EPAct Baseline Motor Efficiency Table on pg. 72

Source: Opportunities for Energy Savings in the Residential and Commercial Sectors with High-Efficiency Electric Motors, US DOE, 1999, Figure 4-4, page 4-5.

Variable Frequency Drives

Installation of variable frequency motor drive systems is a proposed measure under 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.

Refrigeration Measures

Installation of the following refrigeration measures are proposed under the Commercial and Industrial Energy Efficient Construction Program. Because there is no baseline assumption included in the protocols for these measures, the savings protocol will be exactly the same as previously stated in this document.

Walk-in Cooler/Freezer Evaporator Fan Control

Cooler and Freezer Door Heater Control

Electric Defrost Control

Aluminum Night Covers

Novelty Cooler Shutoff

Energy Efficient Glass Doors on Open Refrigerated Cases

ECM on Evaporator Fans

Refrigerated Vending Machine Control

Refrigerated Case LED Lighting (Prescriptive Lighting)

Vending Machine Controls

This measures outlines the deemed savings for the installation of a gas-fired low intensity infrared heating system in place of unit heater, furnace, or other standard efficiency equipment

Algorithms

Electric Savings (kWh/yr) = kW_v * Hrs * SF

Peak Demand Savings (kW) = kW_v * SF

Definition of Variables

kW_v = Connected kW of equipment

Hrs = Operating hours of equipment

SF = Percent savings factor of equipment

Summary of Assumptions

Variable	Type	Value	Source
kW_v	Refrigerated beverage vending machine Non-refrigerated snack vending machine Glass front refrigerated coolers	0.4 kW 0.085 kW 0.46 kW	1
Hrs	Hours of operating of vending machine	Variable, default 8,760 hours	Application
SF	Refrigerated beverage vending machine Non-refrigerated snack vending machine Glass front refrigerated coolers	46% 46% 30%	1

Sources

1. Massachusetts Technical Reference Manual, October 2015.

Gas Water Heating Measures

Replacement of existing gas, oil, and propane water heaters with high efficiency units is a proposed measure under the C&I Energy Efficienct Construction GasHVAC Systems Protocols. The Direct Install savings protocol will be the same as previously stated in this document with the baselines designed to reflect current market practices, which in this case reflect ASHRAE 90.1-2007. These tables are included in the C&I Protocol.

Gas Space Heating Measures

Boilers

Replacement of existing gas, oil, and propane boilers with high efficiency units is a proposed measure under the C&I Energy Efficienct Construction GasHVAC Systems Protocols. The Direct Install savings protocol will be the same as previously stated in this document with the exception of the assumption for baseline efficiency.

Efficiency baselines are designed to reflect current market practices, which in this case reflect ASHRAE 90.1-2007. For the Direct Install program, the following values will be used for the variable identified as Eff_b.

Baseline Boiler Efficiencies (Eff_b)

Boiler Type	Size Category (kBtu input)	Standard 90.1-2007
Hot Water – Gas fired	< 300 ≥ 300 and ≤ 2,500	80% AFUE 75% Et
Hot Water – Oil fired	< 300 ≥ 300 and ≤ 2,500	80% AFUE 78% Et
Steam – Gas fired	< 300	75% AFUE
Steam, all except natural draft	≥ 300 and ≤ 2,500	75% Et
Steam, natural draft	≥ 300 and ≤ 2,500	75% Et
Steam – Oil fired	< 300 ≥ 300 and ≤ 2,500	80% AFUE 78% Et

Small Commercial Boilers [Inactive 2017, Not Reviewed]

This section will apply only for boilers that are closed loop and for space heating.

For Boilers that are under 5000 MBtuH use the calculator from the Federal Energy Management Program at:
http://www1.eere.energy.gov/femp/technologies/eep_boilers_calc.html

Gas, Oil, and Propane Furnaces

Replacement of existing gas, oil, and propane furnaces with high efficiency units is a proposed measure under the C&I Energy Efficienct Construction Gas HVAC Systems Protocols. The Direct Install savings protocol will be the same as previously stated in this document with the exception of the assumption for baseline efficiency.

Efficiency baselines are designed to reflect current market practices, which in this case reflect ASHRAE 90.1-2007. For the Direct Install program, the following values will be used for the variable identified as Eff_b.

Baseline Furnace Efficiencies (Effb)

Furnace Type	Size Category (kBtu input)	Standard 90.1-2007
Gas Fired	< 225	78% AFUE
Oil Fired	< 225	78% AFUE

Infrared Heating

Replacement of existing atmospherically vented heating with infrared heating is is a proposed measure under *Commercial and Industrial Energy Efficient Construction*. Because this is a deemed savings measure the protocol will be exactly the same as previously stated in this document.

Programmable Thermostats

This measure provides savings algorithms for programmable thermostats installed through the direct install program in commercial buildings. The baseline for this measure is manual thermostats that require occupant adjustment to change the space temperature. Non-communicating programmable thermostats achieve energy savings over manual thermostats by automatically setting temperatures back in the winter, or up in the summer, per a factory default schedule, or a user modified schedule. Setback/set up schedules achieve heating fuel savings in the winter, and cooling electric savings in the summer.

The savings factors for this measure come from the Michigan Energy Measures Database (MEMD), which shows deemed cooling and heating savings per 1,000 square feet of building space. The MEMD savings values for programmable thermostats were determined through measurement and verification of installed thermostats in a variety of commercial building types. For this measure, values for the Detroit airport locale are used because the ambient temperatures are closest to those for the New Jersey locale, and results are averaged across HVAC equipment types.

There are no peak demand savings for this measure, and motel and auto repair space types are excluded from this measure.

Algorithms

Fuel Savings (MMBtu/yr) = $SQFT_{1000}$ * SF_{heat}

Energy Savings (kWh/yr) = $SQFT_{1000}$ * SF_{cool}

Definition of Variables

$SQFT_{1000}$ = Number of thousands of square feet of building space[61]

SF_{heat} = Heating savings factor (MMBtu per 1,000 ft^2 of building space)

SF_{cool} = Cooling savings factor (kWh per 1,000 ft^2 of building space)

Summary of Inputs

Programmable Thermostat Assumptions

Component	**Type**	**Value**	**Source**
$SQFT_{1000}$	Variable	Customer specified	Application
SF_{heat}	Fixed	1.68 MMBtu / 1,000 ft^2	1
SF_{cool}	Fixed	74.7 kWh / 1,000 ft^2	1

Sources

1. Michigan Public Service Commission. *2017 Michigan Energy Measures Database (MEMD) with Weather Sensitive Weighting Tool*. Available for download at: http://www.michigan.gov/mpsc/0,4639,7-159-52495_55129---,00.html

[61] For example, a 5,000 ft^2 building would have a $SQFT_{1000}$ value of 5

Boiler Reset Controls

The following algorithm detail savings for installation of boiler reset control on commercial boilers. Energy savings are realized through a better control on boiler water temperature. Through the use of software settings, boiler reset controls use outside or return water temperature to control boiler firing and in turn the boiler water temperature.

The input values are based on data supplied by the utilities and customer information on the application form, confirmed with manufacturer data. Unit savings are deemed based on study results.

<u>Algorithms</u>

Fuel Savings (MMBtu/yr) = (% Savings) * ($EFLH_h$ * Cap_{in}/hr) / 1,000 kBtu/MMBtu

<u>Definition of Variables</u>

% Savings = Estimated percentage reduction in heating load due to boiler reset controls (5%)

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

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

<u>Summary of Inputs</u>

Boiler Reset Control Assumptions

Component	Type	Value	Source
% Savings	Fixed	5%	1
$EFLH_h$	Variable	See Table Below	2
Cap_{in}	Variable		Application

Small Commercial $EFLH_h$

Building	$EFLH_h$
Assembly	603
Auto Repair	1910
Fast Food Restaurant	813
Full Service Restaurant	821
Light Industrial	714
Motel	619
Primary School	840
Religious Worship	722
Small Office	431
Small Retail	545
Warehouse	452
Other	681

Multi-family $EFLH_h$ 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

<u>Sources</u>

1. GDS Associates, Inc. Natural Gas Energy Efficiency Potential in Massachusetts, 2009, p. 38 Table 6-4.
2. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V6, April 2018. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 535-540. EFLH values for NYC due to proximity to NJ.

Dual Enthalpy Economizers

Installation of Dual Enthalpy Economizers 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.

Electronic Fuel-Use Economizers (Boilers, Furnaces, AC)

These devices are microprocessor-based fuel-saving controls for commercial HVAC. They optimize energy consumption by adjusting burner or compressor run patterns to match the system's load. They can be used to control gas or oil consumption for any type of boiler or forced air furnace system. Installation of variable Fuel Use Economizers 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.

Demand-Controlled Ventilation Using CO_2 Sensors

Maintaining acceptable air quality requires standard ventilation systems designers to determine ventilation rates based on maximum estimated occupancy levels and published CFM/occupant requirements. During low occupancy periods, this approach results in higher ventilation rates than are required to maintain acceptable levels of air quality. This excess ventilation air must be conditioned and therefore results in wasted energy.

Building occupants exhale CO_2, and the CO_2 concentration in the air increases in proportion to the number of occupants. The CO_2 concentration provides a good indicator of overall air quality. Demand control ventilation (DCV) systems monitor indoor air CO_2 concentrations and use this data to automatically modulate dampers and regulate the amount of outdoor air that is supplied for ventilation. DCV is most suited for facilities where occupancy levels are known to fluctuate considerably.

The magnitude of energy savings associated with DCV is a function of the type of facility, hours of operation, occupancy schedule, ambient air conditions, space temperature set points, and the heating and cooling system efficiencies. Typical values representing this factors were used to derive deemed savings factors per CFM of the design ventilation rate for various space types. These deemed savings factors are utilized in the following algorithms to predict site specific savings.

<u>Algorithms</u>

Energy Savings (kWh/yr) = CESF * CFM

Peak Demand Savings (kW) = CDSF * CFM

Fuel Savings (MMBtu/yr) = HSF * CFM

<u>Definition of Variables</u>

CESF = Cooling Energy Savings Factor (kWh/CFM)

CDSF = Cooling Demand Savings Factor (kW/CFM)

HSF = Heating Savings Factor (MMBtu/CFM)

CFM = Baseline Design Ventilation Rate of Controlled Space (CFM)

<u>Summary of Inputs</u>

Demand Controlled Ventilation Using CO_2 SensorsComponent	Type	Value	Source
CESF	Fixed	0.0484 MMBtu/CFM See Table 2	1

Demand Controlled Ventilation Using CO_2 SensorsComponent	Type	Value	Source
CDSF	Fixed		1
HSF	Fixed		1
CFM	Variable		Application

Savings Factors for Demand-Controlled Ventilation Using CO_2 Sensors

Component	CESF	CDSF	HSF
Assembly	2.720	0.0014	0.074
Auditorium – Community Center	1.500	0.0015	0.043
Gymnasium	2.558	0.0013	0.069
Office Building	2.544	0.0013	0.068
Elementary School	1.079	0.0013	0.029
High School	2.529	0.0015	0.072
Shopping Center	1.934	0.0012	0.050
Other	2.544	0.0013	0.068

Sources

1. ERS spreadsheet derivation of deemed savings factors for demand control ventilation. *DCV Deemed savings Analysis.* Based on DOE-2 default space occupancy profiles and initially developed for NYSERDA in 2010, revised to reflect typical New Jersey weather data.

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

The following algorithm details savings for low-flow showerheads and faucet aerators in residential, 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

Btu 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 = 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
H	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 25°F	5
		Showerheads 50°F	6
EFF	Fixed	97% electric 80% natural gas	7,8

<u>Sources</u>

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. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V6, April 2018. Calculated using T_{shower} and T_{main} for Faucet – Low-flow aerator measure in NYC. Values for both T_{faucet} and T_{main} found on p. 81.
6. New York State Joint Utilities, *New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs*, V6, April 2018. Calculated using T_{sh} and T_{main} for Showerhead – Low-flow measure in NYC. Values for both T_{shower} and T_{main} found on p. 92.
7. New York State Joint Utilities, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, V6, April 2018. From "Baseline Efficiencies from which Savings are Calculated section with table on p. 88.
8. 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.

Low Flow Pre-rinse Spray Valves

Algorithm

Btu 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	75°F	4
Eff	Variable	97% 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. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016. Calculated using T_{heater} and T_{main} for Low-flow Pre-rinse spray valve measure. Values for both T_{sh} and T_{main} found on p. 184, Table 1 and p. 184, Table 2, respectively.
5. NY, *Standard Approach for Estimating Energy Savings*, V4, April, p. 177, Table 1.
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.

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.

<u>Algorithms</u>

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

<u>Definition of Variables</u>

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

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	97% electric 80% natural gas	3, 4
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. 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.
4. New York State Joint Utilities, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs, V6, April 2018. From "Baseline Efficiencies from which Savings are Calculated section with table on p. 88.

Lighting and Lighting Controls

For lighting and lighting control projects performed by Direct Install programs, use the C&I prescriptive lighting tables for the lighting types identified within those tables. For any fixtures not listed on the table, go to the source table for that fixture. If the fixture is not on the source table, then use manufacture cut sheets for replacement kW to calculate the savings.

Eligible measures include:

<u>Prescriptive Lighting</u>

T8

T5

CFL Screw-In

LED Screw-In

LED Linear Tubes

LED Hard-Wired Fixtures

<u>Lighting Controls</u>

Occupancy Sensors

High-Bay Occupancy Sensors

Photocell with Dimmable Ballast

C&I Large Energy Users Incentive Program

The purpose of the program is to foster self-investment in energy-efficiency, and combined heat and power projects while providing necessary financial support to large commercial and industrial utility customers in New Jersey.

Protocols

Please refer to the Pay for Performance Existing Buildings protocols to calculate demand and energy savings for the Large Energy Users Program. If a project addresses a specific end-use technology, protocols for that technology should be used.

C&I Customer-Tailored Energy Efficiency Pilot Program

The purpose of the program is to better serve the needs of specific commercial and industrial customers whose usage is too large for them to qualify for the Direct Install program, but too low for the Large Energy Users Program.

Protocols

Please refer to the Pay for Performance Existing Buildings protocols to calculate demand and energy savings for comprehensive projects in the Customer Tailored Pilot Program. If a project addresses a specific end-use technology, protocols for that technology should be used.

Renewable Energy Program Protocols

SREC Registration Program (SRP)

The energy and demand impacts for customer sited solar PV generation systems participating in the program are based on fixed assumptions which are applied to the total project system capacity. The annual electricity generation is derived by multiplying the estimated annual production factor of 1,200 kWh per kW by the total system capacity (kW) to yield the estimated annual output (kWh).[62] The combined values for all projects participating in a specified period are then summed up and converted to MWh for reporting purposes.

[62] Estimated annual production factor is based on combined average calculation of the PV Watts estimated annual output for the Newark and Atlantic City weather stations.

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[63] (DEER) unless otherwise noted.

Measure	Measure Life
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
Solar Water Heater	20[64]
Building Shell End-Use	

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

[64] Michigan Energy Measures Database 2019 https://www.michigan.gov/documents/mpsc/mi_master_measure_database_2019-102618_637684_7.xlsx

Measure	Measure Life
Air Sealing	15[65]
Duct Sealing and Repair	18
Insulation Upgrades	20
Doors	30[66]
Weather Stripping	15[67]

[65] Mid-Atlantic TRM V7, http://www.neep.org/mid-atlantic-technical-reference-manual-v7 and NY TRM V6, http://www3.dps.ny.gov/W/PSCWeb.nsf/All/72C23DECFF52920A85257F1100671BDD

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

[67] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs –Residential, Multi-Family,and Commercial/Industrial Measures Version 6.1 2019 http://www3.dps.ny.gov/W/PSCWeb.nsf/96f0fec0b45a3c6485257688006a701a/72c23decff52920a85257f1100671bdd/$FILE/TRM%20Version%206.1%20-%20January%202019.pdf

Appliances/Electronics End-Use	
ES Refrigerator	14
ES Freezer	11
ES Dishwasher	11
ES Clothes washer	11
ES RAC	9
ES Air Purifier	9[68]
ES Set Top Box	4[59]
ES Sound Bar	10[59]
Advanced Power Strips	8
ES Clothes Dryer	12
Refrigerator Retirement	5
Freezer Retirement	4
CO Alarm	7[69]
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[70]
Programmable Thermostats	11
Demand-Controlled Ventilation Using CO2 Sensors	15
Boiler Reset Controls	10
Building Shell End-Use	

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

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

[70] NY TRM V6, http://www3.dps.ny.gov/W/PSCWeb.nsf/All/72C23DECFF52920A85257F1100671BDD

Air Sealing	15[71]
Insulation	20
Doors	30[72]
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[73]	4
Printer[74]	6
Renewable and Other	
Fuel Cell	15[75]
Solar Panels	25
Combined Heat & Power (CHP) System ≤ 1 MW[76]	15

[71] Same as Residential, Mid-Atlantic TRM V7, http://www.neep.org/mid-atlantic-technical-reference-manual-v7and NY TRM V6,http://www3.dps.ny.gov/W/PSCWeb.nsf/All/72C23DECFF52920A85257F1100671BDD
[72] Energy Star https://www.energystar.gov/ia/partners/prod_development/revisions/downloads/windows_doors/Draft6_V1_Criteria_Analysis_Report.pdf
[73] Energy Star Consumer Electronics Calculator https://www.energystar.gov/sites/default/files/asset/document/Consumer_Electronics_Calculator.xlsx
[74] Ibid.
[75] LBNL Report "A Total Cost of Ownership Model for Solid Oxide Fuel Cells in Combined Heat and Power and Power-Only Applications" December 2015
[76] 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.

Combined Heat & Power (CHP) System > 1 MW[77]	20

[77] 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.