**New Jersey Board of Public Utilities**

**New Jersey Clean Energy Program**

**Protocols to Measure Resource Savings**

**DRAFT Revisions to**

**FY2016 Protocols**

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**New Jersey’s Clean Energy Program Protocols**

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**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. Note, however, that renewable energy protocols are different from those required for REC certification in the state of New Jersey.

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
* Performance incentives for the market managers

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 measured 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  Customer On-Site Renewable Energy |
| 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 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 | N/A |
| **On Peak (Monday - Friday)** | 8 a.m. to 8 p.m. | 12 p.m. to 8 p.m. |
| **Off Peak** | M-F 8 p.m. to 8 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 two time periods, the knee periods for spring and fall were split approximately evenly between 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. This assumption will be assessed in the impact evaluation.

### 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, if any, 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 statewide conversion factors supplied by the NJDEP 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 Residential and 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 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 supply level.

### Electric Loss Factor

The electric loss factor applied to savings at the customer meter is 1.081[[1]](#footnote-2),[[2]](#footnote-3) 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 are calculated using the energy savings at the system level and multiplying them by factors developed by the New Jersey Department of Environmental Protection (NJDEP).

System average air emissions reduction factors provided by the NJDEP are:

Electric Emissions Factors

|  |  |  |  |
| --- | --- | --- | --- |
| Emissions  Product | Jan 2001–June 2002 | July 2003–February 2014 | March 2014–Present |
| CO2 | 1.1 lbs per kWh saved | 1,520 lbs per MWh saved | 1,111.79 lbs per MWh saved |
| NOX | 6.42 lbs per metric ton of CO2 saved | 2.8 lbs per MWh saved | 0.95 lbs per MWh saved |
| SO2 | 10.26 lbs per metric ton of CO2 saved | 6.5 lbs per MWh saved | 2.21 lbs per MWh saved |
| Hg | 0.00005 lbs per metric ton of CO2 saved | 0.0000356 lbs per MWh saved | 2.11 mg per MWh saved |

Gas Emissions Factors

|  |  |  |
| --- | --- | --- |
| Emissions  Product | Jan 2001–June 2002 | July 2003–Present |
| CO2 | NA | 11.7 lbs per therm saved |
| NOX | NA | 0.0092 lbs per therm saved |

All factors are provided by the NJ Department of Environmental Protection and are on an average system basis. They will be updated as new factors become available.

## Measure Lives

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

## Protocols Revision History

**Revision History of**

| **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. |

## 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.

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## 

### & Mini-split (AC or HP)

Cooling Energy and Peak Demand Savings:

Energy Savings (kWh/yr) = Tons \* 12 kBtuh/Ton \* (1/SEER*b –* 1/SEER*q* ) \* EFLHc

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* ) \* EFLHh

Proper Sizing and Quality Installation Verification (QIV):

Energy Savings (kWh*p*/yr) = kWh*q* \* ESF

Energy Savings (kWp/yr) =

During Existing System Maintenance:

Savings (kWh/yr) = (Tons \* 12 kBtuh/Ton \* SEERm) \* EFLHc \* MF

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

Duct Sealing:

Energy Savings (kWh/yr) = (Tons \* 12 kBtuh/Ton \* SEERq) \* EFLHc \* DuctSF

Savings (kW) = (Tons \* 12 kBtuh/Ton \* EERq) \* CF \* DuctSF

### 

Energy Savings (kWh/yr) = Tons \* 12 kBtuh/Ton \* (1/(EER*g,b* \* GSER) *–* (1/ (EER*g,q* \* GSER))) \* EFLHc

Peak Demand Savings (kW) = Tons \* 12 kBtuh/Ton \* (1/EER*g,b –* (1/ (EER*g,q* \* GSPK))) \* CF

Heating Energy Savings (kWh/yr) = Tons \* 12 kBtuh/Ton \* (1/(COP*g,b* \* GSOP) *–* (1/ (COP*g,q* \* GSOP))) \* EFLHh

### [Inactive 2017, Not Reviewed]

### Furnace High Efficiency Fan

Heating Energy Savings (kWh/yr) = (BtuHq /3.412 kWh/Btu) \* EFLH \* FFSHT

Cooling Energy Savings (kWh/yr) = FFSCL

### Solar Domestic Hot Water (augmenting electric resistance DHW) [Inactive 2017, Not Reviewed]

Heating Energy (kWh) Savings = ESavSDHW

Peak Demand Impact (kW) = DSavSDHW x CFSDHW

### 

Heating Energy Savings (kWh/yr) = ESavHPHW

Savings (kW) = DSavHPHW \* CFHPHW

### [Inactive 2017, Not Reviewed]

Tons = The rated cooling capacity of the unit being installed.

EERm = The Energy Efficiency Ratio of the Unit receiving maintenance

EER*g,q* = The EER of the ground source heat pump being installed.

(cooling or heating)

COP*g,q*

BtuH*q*

ESavDWHR = Assumed energy savings per installed drain water heat recovery unit in a household with an electric water heater.

DSavDWHR = Assumed demand savings per installed drain water heat recovery unit in a household with an electric water heater.

#### Summary of Inputs

| 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 |
| SEER*q* | Variable |  | Rebate Application |
| SEER*m* | Fixed | 13 | 1 |
| EER*b* | Fixed | Baseline = 11.3 | 2 |
| EER*q* | Fixed | = (11.3/13) X SEERq | 2 |
| EER*g,q* | Variable |  | Rebate Application |
| EER*g,b* | Fixed | 11.2 | 13 |
| EER*m* | Fixed | 8.69 | 2 |
| GSER | Fixed | 1.02 | 3 |
| EFLHc or h | Fixed | See Table Below | 12[[3]](#footnote-4) |
| ESF | Fixed | 9.2% | 12 |
| DSF | Fixed | 9.2% | 12 |
| kWhq | Variable |  | Rebate Application |
| kWq | Variable |  | Rebate Application |
| MF | Fixed | 10% | 11 |
| DuctSF | Fixed | 18% | 8 |
| 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,q* | Variable |  | Rebate Application |
| COPg,b | Fixed | 2.9 | 13 |
| GSOP | Fixed | 3.413 | 6 |
| GSPK | Fixed | 0.8416 | 3 |
| EDSH | Fixed | 1842 kWh | 14 |
| PDSH | Fixed | 0.34 kW | 14 |
| ESavSDHW | Fixed | 3100 kWh | 16 |
| DSavSDHW | Fixed | 0.426 kW | 16 |
| CFSDHW | Fixed | 20% | 16 |
| ESavHPHW | Fixed | 1687 kWh | 17 |
| DSavHPHW | Fixed | 0.37 kW | 18 |
| CFHPHW | Fixed | 70% | 18 |
| ESavDWHR | Fixed | 1457 kWh | 20, 17 |
| DSavDWHR | Fixed | 0.142 kW | 21 |
| CFDWHR | Fixed | 20% | 21 |
| 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% | 15 |
| 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% | 16 |
| HPWH Time Period Allocation Factors | Fixed | Summer/On-Peak 21%  Summer/Off-Peak 22%  Winter/On-Peak 28%  Winter/Off-Peak 29% | 19 |
| 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% | 16 |
| EFLHHT | Fixed | See Table Below | 123 |
| FFSHT | Fixed | 0.5 kWh | 9 |
| FFSCL | Fixed | 105 kWh | 10 |

EFLH Table

| Single Family Detached | Heating EFLH | Cooling EFLH |
| --- | --- | --- |
| Old | 867 | 670 |
| Average | 786 | 649 |
| New | 725 | 630 |

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. EERm = (11.3/13) \* 10.
3. Extrapolation of manufacturer data.
4. NEEP, *Mid-Atlantic Technical Reference Manual*, V6. May 2016.
5. Xenergy, “New Jersey Residential HVAC Baseline Study,” (Xenergy, Washington, D.C., November 16, 2001) Table E-8.
6. “Review of Emerging HVAC Technologies and Practices” 03-STAC-01 Emerging Technologies Report, October 2005, John Proctor, PE, p. 46.
7. Scott Pigg (Energy Center of Wisconsin), “Electricity Use by New Furnaces: A Wisconsin Field Study,” Technical Report 230-1, October 2003.
8. .
9. .
10. NY\_TRM – Version 4.0 April 2016. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 441. Derived from DOE2.2 simulations reflecting four different prototypical residential home types described in Appendix G.
11. AHRI directory; baseline values are the least efficient “Geothermal – Water-to –Air Heat Pumps” active in the directory, downloaded May 18, 2015.
12. VEIC estimate, based on PEPCo assumptions.
13. Time period allocation factors used in cost-effectiveness analysis.
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) = kBtu/hrin \* EFLH \* ((AFUE*q* /AFUE*b*) – 1) / 1000 kBtu/MMBtu

kBtu/hr*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

furnace

meeting current federal equipment standards

#### Summary of Inputs

Furnace Assumptions

|  |  |  |  |
| --- | --- | --- | --- |
| kBtu/hr*in* | Variable |  | Application |
| EFLH*h* | Fixed | See Table Below | 1[[4]](#footnote-5) |
| AFUE*q* | Variable |  | Application |
| 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% | 2 |

EFLH Table

| Single Family Detached | Heating EFLH | Cooling EFLH |
| --- | --- | --- |
| Old | 867 | 670 |
| Average | 786 | 649 |
| New | 725 | 630 |

1. NY\_TRM – Version 4.0 April 2016. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 441. Derived from DOE2.2 simulations reflecting four different prototypical residential home types described in Appendix G.
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>.

### 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

Fuel Savings (MMBtu/yr) = kBtuin/hr \* EFLHh \* ((AFUEq/AFUEb)-1) / 1000 kBtu/MMBtu

kBtuin/hr = Input capacity of qualifying unit

EFLHh = 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 |
| --- | --- | --- | --- |
| kBtuin | Variable |  | Application |
| EFLHh | Fixed | See Table Below | 1[[5]](#footnote-6) |
| AFUE*q* | Variable |  | Application |
| AFUE*b* | Fixed | Gas fired boiler – 82%  Oil fired boiler – 84% | 2 |

EFLH Table

| Single Family Detached | Heating EFLH | Cooling EFLH |
| --- | --- | --- |
| Old | 867 | 670 |
| Average | 786 | 649 |
| New | 725 | 630 |

1. NY\_TRM – Version 4.0 April 2016. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 441. Derived from DOE2.2 simulations reflecting four different prototypical residential home types described in Appendix G.
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.

### 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]](#footnote-7) for consumer and commercial water heaters.

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

MMBtu Boiler Fuel Savings/yr = kBtuin/hr \* EFLHh \* ((AFUEq/AFUEb)-1) / 1,000 kBtu/MMBTU

MMBtu DHW Fuel Savings/yr = (1 – (UEF*b* / UEF*q*)) × Baseline Water Heater Usage

kBtuin/hr= Input capacity of qualifying unit in kBtu/hr

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

AFUE*q* = Annual fuel utilization efficiency of the qualifying boiler

AFUE*b* = Annual fuel utilization efficiency of the baseline boiler

UEF*q* = Uniform energy factor of the qualifying energy efficient water heater.

UEF*b* = Uniform energy factor of the baseline water heater. In New Jersey the 2015 International Energy Conseration Code (IECC) generally defines the residential 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 |
| --- | --- | --- | --- |
| kBtuin/hr | Variable |  | Application |
| EFLH*h* | Fixed | See Table Below | 1[[7]](#footnote-8) |
| AFUE*q* | Variable |  | Application |
| AFUE*b* | Fixed | Gas fired boiler – 82%  Oil fired boiler – 84% | 2 |
| UEFb | Fixed | Storage Water Heater – 0.657 | 2 |
| UEFq | 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]](#footnote-9) assuming tank sizes of 30 gallons for small units, 40 gallons for medium units, and 55 gallons for large units.

EFLH Table

| Single Family Detached | Heating EFLH | Cooling EFLH |
| --- | --- | --- |
| Old | 867 | 670 |
| Average | 786 | 649 |
| New | 725 | 630 |

1. NY\_TRM – Version 4.0 April 2016. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 441. Derived from DOE2.2 simulations reflecting four different prototypical residential home types described in Appendix G.
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>.
4. US Energy Information Association, *2009 Residential Energy Consumption Survey Data[[9]](#footnote-10)*; 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.

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.

Fuel Savings (MMBtu/yr) = (% Savings) \* (EFLHh \* kBtuin/hr) / 1,000 kBtu/MMBtu

Definition of Variables

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

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

kBtuin/hr = Input capacity of boiler

#### Summary of Inputs

Boiler Reset Control Assumptions

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| % Savings | Fixed | 5% | 1 |
| EFLHh | Fixed | See Table Below | 2[[10]](#footnote-11) |
| kBtuin/hr | Variable |  | Application |

EFLH Table

| Single Family Detached | Heating EFLH | Cooling EFLH |
| --- | --- | --- |
| Old | 867 | 670 |
| Average | 786 | 649 |
| New | 725 | 630 |

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. NY\_TRM – Version 4.0 April 2016. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling. Page 441. Derived from DOE2.2 simulations reflecting four different prototypical residential home types described in Appendix G.

### Storage

This section provides energy savings algorithms for qualifying storage hot water heaters installed in residential settings. This measure assumes that the baseline water heater is a new storage water heater. The input values are based on federal equipment efficiency standards and regional estimates of average baseline water heating energy usage. Note, that as of June 12, 2017, the Federal Trade Commission has published a final rule updating the EnergyGuide label to reflect recent changes by the Department of Energy to the Code of Federal Regulations regarding the use of uniform energy factor (UEF) rather than the traditional energy factor (EF)[[11]](#footnote-12) for consumer and commercial water heaters.

Fuel Savings (MMBtu/yr) = (1 – (UEF*b* / UEF*q*)) × Baseline Water Heater Usage

#### 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.

#### Summary of Inputs

Storage Water Heater

| Component | Type | Valuea | Sources |
| --- | --- | --- | --- |
| UEF*q* | Variable |  | Application |
| UEF*b* | Variable | If gas & less than 55 gal: UEFb = 0.6483–(0.0017×V)  If gas & more than 55 gal: UEFb = 0.7897–(0.0004×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

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]](#footnote-13)*; available at: https://www.eia.gov/consumption/residential/data/2009/c&e/ce3.2.xlsx.

### Instantaneous

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 new storage water heater, or 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]](#footnote-14) for consumer and commercial water heaters.

#### Algorithms

Fuel Savings (MMBtu/yr) = (1 – (UEF*b* / UEF*q*)) × Baseline Water Heater Usage

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

|  |  |  |  |
| --- | --- | --- | --- |
| 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 |

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

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

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# 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.

#### Algorithm

Compact Fluorescent Screw In Lamp

Energy Savings (kWh/yr) = ((CFLwatts) X (CFLhours X 365))/1000

Peak Demand Savings (kW) = (CFLwatts) X Light CF

Efficient Fixtures

Energy Savings (kWh/yr) = ((Fixtwatts) X (Fixthours X 365))/1000

Peak Demand Savings (kW) = (Fixtwatts) X Light CF

Efficient Torchieres

Energy Savings (kWh/yr) = ((Torchwatts) X (Torchhours X 365))/1000

Peak Demand Savings (kW) = (Torchwatts) X Light CF

LED Screw In Lamp

Energy Savings (kWh/yr) = ((LEDwatts) X (LEDhours X 365))/1000

Peak Demand Savings (kW) = (LEDwatts) X Light CF

LED Nightlight

Energy Savings (kWh/yr) = ((LEDNwatts) X (LEDNhours X 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/∆GPM

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

Natural Gas Impact (therm) = %Gas DHW \* (GPM\_base – GPM\_ee) \* therm/∆GPM

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/∆GPM = 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/∆GPM = 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/∆GPM | Fixed | SF = 360.1  MF = 336.9  Unknown = 390.1 | 3 |
| therm/∆GPM | 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.

Energy Savings (kWh/yr) = %Electric DHW \* (GPM\_base – GPM\_ee) \* kWh/∆GPM

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

Natural Gas Impact (therm) = %Gas DHW \* (GPM\_base – GPM\_ee) \* therm/∆GPM

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/∆GPM = 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/∆GPM = 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/∆GPM | Fixed | SF = 60.5  MF = 71.0  Unknown = 63.7 | 3 |
| therm/∆GPM | Fixed | SF = 4.8  MF = 6.5  Unknown = 5.0 | 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, 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.[[16]](#footnote-19)

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.

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

| Term | Definition | Value |
| --- | --- | --- |
| ∆Therm | Gas savings |  |
| ThermStd | Calculated therms standard tank | 206 |
| ThermEff | Calculated therms replacement tank | 177.52 |
| ThermOut |  |  |
| EFStd | Federal standard energy factor | (.67 – (.0019xvolume))=.58 |
| ThermStdTank | Therms used by standard tank | 223 |
| StandbyStd | Standby loss from standard water heater | 434 Btu/hr\* |
| AFUEStd | Efficiency (AFUE) of standard water heater | 80% |
| StandbyEff | Standby loss from efficient water heater | 397 Btu/hr\*\* |
| AFUEEff | Efficiency (AFUE) of efficient water heater | 93% |
| VolStd | Volume of standard water heater (gallons) | 63.50 |
| VolEff | Volume of efficient water heater (gallons) | 51.20 |
| °F/hrStd | Heat lost per hour from standard water heater tank | 0.8 |
| °F/hrEff | 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.

### 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 Refnew term of the equation will be zero.

#### Algorithm

Energy Savings (kWh/yr) = Refold – Refnew

Peak Demand Savings (kW) = (Refold – Refnew)\*(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) = ESCpre X 0.05

MMBtu savings = (GHpre X 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) = (ECoolpre)X 0.10

Peak Demand Savings (kW) = (Ecoolpre X 0.10) / EFLH X AC CF

MMBtu savings = (GHpre X 0.02)

No CAC

Energy Savings (kWh/yr) = (ESCpre.) X 0.02

MMBtu savings = (GHpre X 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) = (ESCpre) X 0.08

MMBtu savings = GHpre X 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) = (ESCpre) X 0.03

MMBtu savings = (GHpre X 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) = (ESCpre) X 0.17

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

### 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.

#### Definition of Terms

CFLwatts = Average watts replaced for a CFL installation.

CFLhours = Average daily burn time for CFL replacements.

Fixtwatts = Average watts replaced for an efficient fixture installation.

Fixthours = Average daily burn time for CFL replacements.

Torchwatts = Average watts replaced for a Torchiere replacement.

Torchhours = Average daily burn time for a Torchiere replacements.

LEDwatts = Average watts replaced for an LED installation.

LEDhours = Average daily burn time for LED replacements.

LEDNwatts = Average watts replaced for an LED nightlight installation.

LEDNhours = Average daily burn time for LED nightlight replacements.

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

HWeavg = Average electricity savings from typical electric hot water measure package.

HWgavg = Average natural gas savings from typical electric hot water measure package.

HWwatts = 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%.

Refold = Annual energy consumption of existing refrigerator based on on-site monitoring.

Refnew = Rated annual energy consumption of the new refrigerator.

RefDF= 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.

ESCpre = Pre-treatment electric space conditioning consumption.

ECoolpre = 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%.

GCpre = Pre-treatment gas consumption.

GHpre = Pre-treatment gas space heat consumption (=.GCpre 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 |
| --- | --- | --- | --- |
| CFLWatts | Fixed | 42 watts | 1 |
| CFLHours | Fixed | 2.5 hours | 1 |
| FixtWatts | Fixed | 100–120 watts | 1 |
| FixtHours | Fixed | 3.5 hours | 1 |
| TorchWatts | Fixed | 245 watts | 1 |
| TorchHours | 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 |
| HWwatts | Fixed | 0.022 kW | 4 |
| HW CF | Fixed | 75% | 4 |
| Refold | Variable |  | Contractor Tracking |
| Refnew | Variable |  | Contractor Tracking and Manufacturer data |
| Ref DF | Fixed | 0.000139 kW/kWh savings | 5 |
| RefCF | Fixed | 100% | 6 |
| ESCpre | Variable |  | 7 |
| Ecoolpre | Variable |  | 7 |
| 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 |
| GCpre | Variable |  | 7 |
| GHpre | 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.

1. “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.pdft>.
2. Pennsylvania Technical Reference Manual, June 2016, p. 27; available at <http://www.puc.pa.gov/pcdocs/1370278.docxt>.

# Residential New Construction Program

## Protocols

Energy savings due to thermal shell and mechanical equipment improvements in residential new construction and “gut” renovation projects are calculated using outputs from REM/Rate™ modeling software[[17]](#footnote-20). All program homes are modeled in REM/Rate to estimate annual energy consumption for heating, cooling, and hot water. 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

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

The program home is then modeled to a baseline specification using REM/Rate’s User Defined Reference Home (UDRH) feature.

The RNC program currently specifies three standards for baseline reference:

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

The difference in modeled annual energy consumption between the program and baseline home is the project savings for heating, hot water, cooling, lighting and appliance end uses. Coincident peak demand savings are also derived from REM/Rate modeled outputs.















### Multifamily High Rise (MFHR)

Annual energy and summer coincident peak demand savings for MFHR construction projects (4–6 stories) shall be calculated from the Energy Star Performance Path Calculator (PPC)[[18]](#footnote-21). The PPC captures outputs from eQuest 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 and/or therms) - Proposed Design energy (kWh and/or therms)

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

# ENERGY STAR Energy Efficient Products

## Protocols

The following sections detail savings calculations ENERGY STAR Appliances and Lighting Products.

### 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) = ESavREF1

Peak Demand Savings (kW) = DSavREF1 \* CFREF

#### ENERGY STAR Refrigerators – CEE Tier 2

Electricity Savings (kWh/yr) = ESavREF2

Peak Demand Savings (kW) = DSavREF2 \* CFREF

#### ENERGY STAR Clothes Washers – CEE Tier 1

Electricity Savings (kWh/yr) = ESavCW1

Peak Demand Savings (kW) = DSavCW1 \* CFCW

Gas Savings (Therms/yr) = EGSavCW1

Water Savings (gallons/yr) = WSavCW1

#### ENERGY STAR Clothes Washers – CEE Tier 2

Electricity Savings (kWh/yr) = ESavCW2

Peak Demand Savings (kW) = DSavCW2 \* CFCW

Gas Savings (Therms/yr) = EGSavCW2

Water Savings (gallons/yr) = WSavCW2

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

Electricity Impact (kWh) = ESavSTB

Demand Impact (kW) = DSavSTB x CFSTB

#### Advanced Power Strip – Tier 1

Electricity Impact (kWh) = ESavAPS

Demand Impact (kW) = DSavAPS x CFAPS

#### Advanced Power Strip – Tier 2

Electricity Impact (kWh) = ESavAPS2

Demand Impact (kW) = DSavAPS2 x CFAPS

#### ENERGY STAR Electric Clothes Dryers – Tier 1

Electricity Savings (kWh/yr) = ESavCDE1

Peak Demand Savings (kW) = DSavCDE1 \* CFCD

#### ENERGY STAR Gas Clothes Dryers – Tier 1

Electricity Savings (kWh/yr) = ESavCDG1

Peak Demand Savings (kW) = DSavCDG1 \* CFCD

Gas Savings (Therms/yr) = GSavCDG1

#### ENERGY STAR Electric Clothes Dryers – Tier 2

Electricity Savings (kWh/yr) = ESavCDE2

Peak Demand Savings (kW) = DSavCDE2 x CFCD

#### ENERGY STAR Gas Clothes Dryers – Tier 2

Energy Savings (kWh/yr) = ESavCDG2

Peak Demand Savings (kW) = DSavCDG2 x CFCD

Gas Savings (Therms/yr) = GSavCDG2

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

Electricity Impact (kWh) = ESavRAC1

Demand Impact (kW) = DSavRAC1

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

Electricity Impact (kWh) = ESavRAC2

Demand Impact (kW) = DSavRAC2

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

Electricity Impact (kWh) = ESavRAPDemand Savings (kW)

Where ESavRAP is based on the CADR in table below

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

= DSavRAC2 is based on the CADR in the table below

|  |  |
| --- | --- |
| **Room Air Purifier Deemed kW Table** | |
| **Clean Air Delivery Rate** | DSavRAC2 |
| 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) = ESavFRZ

Demand Impact (kW) = DSavFRZ based on table below

#### ENERGY STAR Soundbar [Inactive 2017, Not Reviewed]

Electricity Impact (kWh) = ESavSDB

Demand Impact (kW) = DSavSDB

#### Definition of Variables

ESavREF1 = Electricity savings per purchased Energy Star refrigerator – CEE Tier 1.

DSavREF1 = Summer demand savings per purchased Energy Star refrigerator – CEE Tier 1.

ESavREF2 = Electricity savings per purchased Energy Star refrigerator – CEE Tier 2.

DSavREF2 = Summer demand savings per purchased Energy Star refrigerator – CEE Tier 2.

ESavCW1 = Electricity savings per purchased Energy Star clothes washer.

DSavCW1 = Summer demand savings per purchased Energy Star clothes washer.

GSavCW1 = Gas savings per purchased clothes washer Energy Star clothes washer.

WSavCW1 = Water savings per purchased clothes washer Energy Star clothes washer.

ESavCW2 = Electricity savings per purchased Tier 2 Energy Star clothes washer.

DSavCW2 = Summer demand savings per purchased Tier 2 Energy Star clothes washer.

GSavCW2 = Gas savings per purchased Tier 2 Energy Star clothes washer

WSavCW2 = Water savings per purchased Tier 2 Energy Star clothes washer.

ESavSTB = Electricity savings per purchased Energy Star set top box.

DSavSTB = Summer demand savings per purchased Energy Star set top box.

ESavAPS1 = Electricity savings per purchased advanced power strip.

DSavAPS1 = Summer demand savings per purchased advanced power strip.

ESavAPS2 = Electricity savings per purchased Tier 2 advanced power strip.

DSavAPS2 = Summer demand savings per purchased Tier 2 advanced power strip.

ESavCDE1 = Electricity savings per purchased Energy Star electric clothes dryer.

DSavCDE1 = Summer demand savings per purchased Energy Star electric clothes dryer.

ESavCDG1 = Electricity savings per purchased Energy Star gas clothes dryer.

DSavCDG1 = Summer demand savings per purchased Energy Star gas clothes dryer.

GSavCDG1 = Gas savings per purchased Energy Star gas clothes dryer.

ESavCDE2 = Electricity savings per purchased Tier 2 Energy Star electric clothes dryer.

DSavCDE2 = Demand savings per purchased Tier 2 Energy Star electric clothes dryer.

ESavCDG2 = Electricity savings per purchased Tier 2 Energy Star gas clothes dryer.

DSavCDG2 = Demand savings per purchased gas Tier 2 Energy Star gas clothes dryer.

GSavCDG2 = Gas savings per purchased Tier 2 Energy Star gas clothes dryer,

ESavRAC1 = Electricity savings per purchased Energy Star room air conditioner.

DSav RAC1 = Summer demand savings per purchased Energy Star room air conditioner.

ESavRAC1 = Electricity savings per purchased Tier 2 room air conditioner.

DSav RAC2 = Summer demand savings per purchased Tier 2 room air conditioner.

ESavRAC1 = Electricity savings per purchased Energy Star room air purifier.

DSav RAP = Summer demand savings per purchased Energy Star room air purifier.

ESavFRZ = Electricity savings per purchased Energy Star freezer.

DSav FRZ = Summer demand savings per purchased Energy Star freezer.

ESavSDB = Electricity savings per purchased Energy Star soundbar.

DSavSDB = Summer demand savings per purchased Energy Star soundbar

TAF = Temperature Adjustment Factor

LSAF = Load Shape Adjustment Factor

CFREF, CFCW, , CFDH, CFRAC, , CFSTB, , , , CFAPS, CFCD = Summer demand coincidence factor.

#### Summary of Inputs

Energy Star Appliances

| Component | Type | Value | Sources |
| --- | --- | --- | --- |
| ESavREF1 | Fixed | 59 kWh | 5 |
| DSavREF1 | Fixed | 0.007 kW | 5 |
| ESavREF2 | Fixed | 89 kWh | 5 |
| DSavREF2 | 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 |
| ESavCW1 | Fixed | 55 kWh | 2 |
| GsavCW1 | Fixed | 4.8 therms | 2 |
| DSavCW1 | Fixed | 0.005 kW | 2 |
| WSavCW1 | Fixed | 2175 gallons | 2 |
| ESavCW2 | Fixed | 61 kWh | 2 |
| GsavCW2 | Fixed | 9.00 therms | 2 |
| DSavCW2 | Fixed | 0.006 kW | 2 |
| WSavCW2 | 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 |
| CFREF, CFCW,  CFSTB, CFAPS, CFCD | Fixed | 1.0 | 4 |
| CFAC | Fixed | 0.31 | 14 |
| ESavSTB | Fixed | 44 kWh | 7 |
| DSavSTB | Fixed | 0.005 kW | 7 |
| ESavAPS1 | Fixed | 102.8 kWh | 8 |
| DSavAPS1 | Fixed | 0.012 kW | 8 |
| ESavAPS2 | Fixed | 346 kWh | 9 |
| DSavAPS2 | 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 |
| ESavCDE1 | Fixed | 186 kWh | 12 |
| DSavCDE1 | Fixed | 0.016 kW | 12 |
| ESavCDG1 | Fixed | 9 kWh | 12 |
| DSavCDG1 | Fixed | 0.001 kW | 12 |
| GSavCDG1 | Fixed | 5.8 therms | 12 |
| ESavCDE2 | Fixed | 388 kWh | 12,13 |
| DSavCDE2 | Fixed | 0.029 kW | 12,13 |
| ESavCDG2 | Fixed | 42.94 kWh | 14 |
| DSavCDG2 | Fixed | 0.003 kW | 14 |
| GSavCDG2 | Fixed | 7.69 therms | 14 |
| ESavRAC1 | Fixed | 9 kWh | 14 |
| DSavRAC1 | Fixed | 0.008 | 14 |
| ESavRAC2 | Fixed | 19.3 kWh | 14 |
| DSavRAC2 | Fixed | 0.018 | 14 |
| ESavRAP | Variable | Dependent on CARD |  |
| DSavRAP | Variable | Dependent on CADR |  |
| ESavFRZ | Fixed | 41.2 kWh | 14 |
| DSavFRZ | Fixed | 0.0067 kW | 14 |
| ESavSDB | Fixed | 44 kWh | 14 |
| DSavSDB | 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 5.0 April 2015 p.209 available at <http://www.neep.org/mid-atlantic-technical-reference-manual-v5>. 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:
   1. Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
   2. Final Field Research Report, Ecos Consulting, October 31, 2006; prepared for California Energy Commission’s PIER Program.
   3. 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.

* 1. 2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March 2006.

1. 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.
2. 2011 Efficiency Vermont Load shape for Advanced Power Strips.
3. Advanced Power Strip Measure Life: David Rogers, Power Smart Engineering, October 2008: "Smart Strip electrical savings and usability,” p 22.
4. 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-v5>.
5. 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.







## 

### 

Wattsb = Wattage of baseline connected fixture or lamp

Wattsq = Wattage of qualifying connected fixture or lamp

Qtyb = Quantity of baseline fixtures or lamps

Qtyq = Quantity of energy-efficient fixtures or lamps

Hrs = Annual lighting operating hours

CF = Coincidence factor

HVACe = HVAC interaction factor for annual energy savings

HVACd = HVAC interaction factor for peak demand reduction

HVACg = HVAC interaction factor for annual gas fuel consumption

#### Summary of Inputs

Residential ENERGY STAR Lighting

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| Wattsb | Variable | See Tables below | 1 |
| Wattsq | Variable | Actual Lamp/Fixture Wattage | Application |
| Qtyb | Variable | Actual Lamp/Fixture Quantity | Application |
| Qtyq | Variable | Actual Lamp/Fixture Quantity | Application |
| Hrs | Variable | Interior: 1,205 hrs[[19]](#footnote-23)  Exterior: 2,007 hrs[[20]](#footnote-24) | 2 |
| CF | Fixed | 0.08 | 3[[21]](#footnote-25) |
| HVACe | Variable | See Tables below | 4[[22]](#footnote-26) | |
| HVACd | Variable | See Tables below | 42 | |
| HVACg | Variable | See Tables below | 42 | |

HVAC Interactive Factors





Standard CFL Lamp Wattage Equivalency

| Minimum Lumens | Maximum Lumens | Wattsb |
| --- | --- | --- |

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| --- | --- | --- |
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CFL Lamp Wattage Equivalency

| Bulb Type | Lower Lumen Range | Upper Lumen Range | Wattsb |
| --- | --- | --- | --- |
| 3-Way | 250 | 449 | 25 |
| 450 | 799 | 40 |
| 800 | 1099 | 60 |
| 1100 | 1599 | 75 |
| 1600 | 1999 | 100 |
| 2000 | 2549 | 125 |
| 2550 | 2999 | 150 |
| Globe  (medium and intermediate bases less than 750 lumens) | 90 | 179 | 10 |
| 180 | 249 | 15 |
| 250 | 349 | 25 |
| 350 | 749 | 40 |
| Decorative  (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens) | 70 | 89 | 10 |
| 90 | 149 | 15 |
| 150 | 299 | 25 |
| 300 | 749 | 40 |
| Globe  (candelabra bases less than 1050 lumens) | 90 | 179 | 10 |
| 180 | 249 | 15 |
| 250 | 349 | 25 |
| 350 | 499 | 40 |
| 500 | 1049 | 60 |
| Decorative  (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens) | 70 | 89 | 10 |
| 90 | 149 | 15 |
| 150 | 299 | 25 |
| 300 | 499 | 40 |
| 500 | 1049 | 60 |
| Reflector with medium screw bases w/ diameter <=2.25" | 400 | 449 | 40 |
| 450 | 499 | 45 |
| 500 | 649 | 50 |
| 650 | 1199 | 65 |
| R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter >2.5" (\*see exceptions below) | 640 | 739 | 40 |
| 740 | 849 | 45 |
| 850 | 1179 | 50 |
| 1180 | 1419 | 65 |
| 1420 | 1789 | 75 |
| 1790 | 2049 | 90 |
| 2050 | 2579 | 100 |
| 2580 | 3429 | 120 |
| 3430 | 4270 | 150 |
| R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26'' and ≤ 2.5" (\*see exceptions below) | 540 | 629 | 40 |
| 630 | 719 | 45 |
| 720 | 999 | 50 |
| 1000 | 1199 | 65 |
| 1200 | 1519 | 75 |
| 1520 | 1729 | 90 |
| 1730 | 2189 | 100 |
| 2190 | 2899 | 120 |
| 2900 | 3850 | 150 |
| \*ER30, BR30, BR40, or ER40 | 400 | 449 | 40 |
| 450 | 499 | 45 |
| 500 | >649 | 50 |
| \*BR30, BR40, or ER40 | 650 | 1419 | 65 |
| \*R20 | 400 | 449 | 40 |
| 450 | 719 | 45 |
| \*All reflector lamps  below lumen ranges specified above | 200 | 299 | 20 |
| 300 | >399 | 30 |

LED Downlight Fixture Wattage Equivalency

| Bulb Type | Lower Lumen Range | Upper Lumen Range | Wattsb |
| --- | --- | --- | --- |
| Reflector with medium screw bases w/ diameter <=2.25" | 400 | 449 | 40 |
| 450 | 499 | 45 |
| 500 | 649 | 50 |
| 650 | 1199 | 65 |
| R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter >2.5" (\*see exceptions below) | 640 | 739 | 40 |
| 740 | 849 | 45 |
| 850 | 1179 | 50 |
| 1180 | 1419 | 65 |
| 1420 | 1789 | 75 |
| 1790 | 2049 | 90 |
| 2050 | 2579 | 100 |
| 2580 | 3429 | 120 |
| 3430 | 4270 | 150 |
| R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26'' and ≤ 2.5" (\*see exceptions below) | 540 | 629 | 40 |
| 630 | 719 | 45 |
| 720 | 999 | 50 |
| 1000 | 1199 | 65 |
| 1200 | 1519 | 75 |
| 1520 | 1729 | 90 |
| 1730 | 2189 | 100 |
| 2190 | 2899 | 120 |
| 2900 | 3850 | 150 |
| \*ER30, BR30, BR40, or ER40 | 400 | 449 | 40 |
| 450 | 499 | 45 |
| 500 | >649 | 50 |
| \*BR30, BR40, or ER40 | 650 | 1419 | 65 |
| \*R20 | 400 | 449 | 40 |
| 450 | 719 | 45 |
| \*All reflector lamps  below lumen ranges specified above | 200 | 299 | 20 |
| 300 | >399 | 30 |

LED Lamp Wattage Equivalency

| Bulb Type | Lower Lumen Range | Upper Lumen Range | Wattsb |
| --- | --- | --- | --- |
| Standard | 250 | 449 | 25 |
| 450 | 799 | 29 |
| 800 | 1099 | 43 |
| 1100 | 1599 | 53 |
| 1600 | 1999 | 72 |
| 2000 | 2549 | 125 |
| 2550 | 3000 | 150 |
| 3001 | 3999 | 200 |
| 4000 | 6000 | 300 |
| 3-Way | 250 | 449 | 25 |
| 450 | 799 | 40 |
| 800 | 1099 | 60 |
| 1100 | 1599 | 75 |
| 1600 | 1999 | 100 |
| 2000 | 2549 | 125 |
| 2550 | 2999 | 150 |
| Globe  (medium and intermediate bases less than 750 lumens) | 90 | 179 | 10 |
| 180 | 249 | 15 |
| 250 | 349 | 25 |
| 350 | 749 | 40 |
| Decorative  (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens) | 70 | 89 | 10 |
| 90 | 149 | 15 |
| 150 | 299 | 25 |
| 300 | 749 | 40 |
| Globe  (candelabra bases less than 1050 lumens) | 90 | 179 | 10 |
| 180 | 249 | 15 |
| 250 | 349 | 25 |
| 350 | 499 | 40 |
| 500 | 1049 | 60 |
| Decorative  (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens) | 70 | 89 | 10 |
| 90 | 149 | 15 |
| 150 | 299 | 25 |
| 300 | 499 | 40 |
| 500 | 1049 | 60 |
| Reflector with medium screw bases w/ diameter <=2.25" | 400 | 449 | 40 |
| 450 | 499 | 45 |
| 500 | 649 | 50 |
| 650 | 1199 | 65 |
| R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter >2.5" (\*see exceptions below) | 640 | 739 | 40 |
| 740 | 849 | 45 |
| 850 | 1179 | 50 |
| 1180 | 1419 | 65 |
| 1420 | 1789 | 75 |
| 1790 | 2049 | 90 |
| 2050 | 2579 | 100 |
| 2580 | 3429 | 120 |
| 3430 | 4270 | 150 |
| R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26'' and ≤ 2.5" (\*see exceptions below) | 540 | 629 | 40 |
| 630 | 719 | 45 |
| 720 | 999 | 50 |
| 1000 | 1199 | 65 |
| 1200 | 1519 | 75 |
| 1520 | 1729 | 90 |
| 1730 | 2189 | 100 |
| 2190 | 2899 | 120 |
| 2900 | 3850 | 150 |
| \*ER30, BR30, BR40, or ER40 | 400 | 449 | 40 |
| 450 | 499 | 45 |
| 500 | >649 | 50 |
| \*BR30, BR40, or ER40 | 650 | 1419 | 65 |
| \*R20 | 400 | 449 | 40 |
| 450 | 719 | 45 |
| \*All reflector lamps  below lumen ranges specified above | 200 | 299 | 20 |
| 300 | >399 | 30 |

#### 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.

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*–*

The remaining variables are unchanged from those presented above.

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.”
4. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016. Appendix D – HVAC Interactive Effects Multipliers, p. 344 and 345.

Coincidence factor: p. 133

# Appliance Recycling Program

## 

The following sections detail savings calculations ENERGY STAR Refrigerator/Freezer retirement program.The general form of the equation for the Refrigerator/Freezer Retirement 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) = ESavRetFridge, ESavRAC, ESavDEH

Peak Demand Savings (kW) = DSavRetFridge \* CFRetFridge

#### Definition of Terms

ESavRetFridge = Gross annual energy savings per unit retired refrigerator

ESavRetFreezer = Gross annual energy savings per unit retired freezer

DSavRetFridge = Summer demand savings per retired refrigerator

DSavRetFreezer = Summer demand savings per retired freezer

CFRetFridge = Summer demand coincidence factor.

#### Summary of Inputs

Refrigerator/Freezer Recycling

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| ESavRetFridge | Fixed | 761 kWh | 1 |
| ESavRetFreezer | Fixed | 639 kWh | 1 |
| ESavRAC | Fixed | 166 kWh | 1 |
| ESavDEH | Fixed | 169 kWh | 3 |
| DSavRetFridge | Fixed | 0.114 kW | 2 |
| DSavRetFreezer | Fixed | 0.114 kW | 2 |
| DSavRAC | Fixed | 0.16 kW | 1 |
| DSavDEH | Fixed | 0.114 | 3 |
| CFRetFridge | Fixed | 1 | 1 |

#### Sources

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V6. May 2016.
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> (p. 20).

# 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.[[23]](#footnote-27)
* Software approved by the US Department of Energy’s Weatherization Assistance Program.[[24]](#footnote-28)
* RESNET approved rating software.[[25]](#footnote-29)

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.

# 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

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, , Electric Chillers, VFDs, and Commercial Refrigeration.

### 

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.

#### Algorithms

Definition of Variables

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

LPDb  = Baseline lighting power density in Watt per square foot of space floor area, based on ASHRAE 90.1 Table 9.6.1 (Space-by-Space Method)

LPDq = 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

HVACd = HVAC Interactive Factor for peak demand savings

HVACe = HVAC Interactive Factor for annual energy savings

HVACg = HVAC Interactive Factor for annual energy savings

#### Summary of Inputs

Lighting Verification Performance Lighting

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| ΔkW | Variable | See NGrid Fixture Wattage Table:  <https://www1.nationalgridus.com/files/AddedPDF/POA/RILightingRetrofit1.pdf>  And Formula Above. | 1  Baseline LPD from ASHRAE 90.1-2013 Table 9.6.1  Fixture counts and types, space type, floor area from customer application. |
| SF | Variable | From Customer |  |
| CF | Fixed | See Lighting Table by Building Type | 3 |
| Hrs | Fixed | See Lighting Table by Building Type | 5 |
| HVACd | Fixed | See Lighting Table by Building Type | 2 |
| HVACe | Fixed | See Lighting Table by Building Type | 2 |
| HVACg | Fixed | -0.000175 | 4 |

Yearly Lighting Hours of Operation by Building Type

|  |  |  |  |
| --- | --- | --- | --- |
| **Building Type** | **Yearly Hours of Operation** | | |
| Education | 2,456 | | |
| Grocery | 6,019 | | |
| Lodging | 4,808 | | |
| Manufacturing | 4,781 | | |
| Health | 4,007 | | |
| Municipal | 3,116 | | |
| Office | 3,642 | | |
| Other | 4,268 | | |
| Public assembly | 3,035 | | |
| Religious | 2,648 | | |
| Restaurant | 4,089 | | |
| Retail | 4,103 | | |
| Service | 3,521 | | |
| University/college | *3,416* | | |
| Warehouse | 4,009 | | |

Coincidence Factors by Building Type

|  |  |
| --- | --- |
| Building Type | CF |
| Education | 0.45 |
| Exterior | 0.00 |
| Grocery | 0.93 |
| Health | 0.52 |
| Industrial/Manufacturing – 1 Shift | 0.57 |
| Industrial/Manufacturing – 2 Shift | 0.57 |
| Industrial/Manufacturing – 3 Shift | 0.57 |
| Institutional/Public Service | 0.23 |
| Lodging | 0.45 |
| Miscellaneous/Other | 0.58 |
| Multi-Family Common Areas | 0.62 |
| Office | 0.48 |
| Parking Garage | 0.62 |
| Restaurant | 0.77 |
| Retail | 0.66 |
| Street Lighting | 0.00 |
| Warehouse | 0.48 |

**HVAC Interactive Effects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Building Type** | **Demand Waste Heat Factor (HVACd)** | | **Annual Energy Waste Heat Factor by Cooling/Heating Type (HVACe)** | | | |
| **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 | 0.24 | 0.02 | -0.25 | -0.11 | -0.27 |
| Other[[26]](#footnote-30) | 0.34 | 0.32 | 0.08 | -0.18 | -0.07 | -0.26 |

|  |
| --- |
|  |

#### 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. Average HVAC interactive effects by building type derived from the NEEP Mid-Atlantic TRM 2016, NEEP, *Mid-Atlantic Technical Reference Manual*, V6. May 2016, pp. 506-507. 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. Pennsylvania PUC, *Technical Reference Manual,* June 2016, pp. 229–230. for these values include the following:
4. The Mid-Atlantic TRM – Northeast Energy Efficiency Partnerships, Mid-Atlantic Technical Reference Manual, Version 2.0, submitted by Vermont Energy Investment Corporation, July, 2011.
5. Development of Interior Lighting Hours of Use and Coincidence Factor Values for EmPOWER Maryland Commercial Lighting Program Evaluations, Itron, 2010.
6. California Public Utility Commission. Database for Energy Efficiency Resources, 2008
7. Small Commercial Contract Group Direct Impact Evaluation Report prepared by Itron for the California Public Utilities Commission Energy Division, February 9, 2010
8. State of Ohio Energy Efficiency Technical Reference Manual, Vermont Energy Investment Corporation, August 6, 2010.
9. UI and CL&P Program Savings Documentation for 2013 Program Year, United Illuminating Company, September 2012.
10. CL&P and UI 2008 program documentation (referenced above) cites an estimated 4,368 hours, only 68 hours greater than dusk to down operating hours. ESNA RP-20-98; Lighting for Parking Facilities acknowledges "Garages usually require supplemental daytime luminance in above-ground facilities, and full day and night lighting for underground facilities." Emphasis added. The adopted assumption of 6,552 increases the CL&P and UI value by 50% (suggest data logging to document greater hours i.e., 8760 hours per year).
11. Pennsylvania Statewide Act 129 2014 Commercial & Residential Lighting Metering Study. Prepared for Pennsylvania Public Utilities Commission. January 13, 2015. <http://www.puc.pa.gov/pcdocs/1340978.pdf>
12. 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.
13. 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

*–*

#### Definition of Variables

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

CF = Coincidence factor

Hrs = Annual hours of operation

HVACd = HVAC interactive factor for peak demand savings

HVACe = HVAC interactive factor for annual energy savings

HVACg = HVAC interactive factor for annual fuel savings

Summary of InputsPrescriptive Lighting for Commercial Customers

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| ΔkW | FVariable | See NGrid Fixture Wattage Table  <https://www1.nationalgridus.com/files/AddedPDF/POA/RILightingRetrofit1.pdf> | 1 |
| CF | Fixed | See Lighting Table by Building in Performance Lighting Section Above | 3 |
| Hrs | Fixed | See Lighting Table by Building in Performance Lighting Section Above | 5 |
| HVACd | Fixed | See Lighting Table by Building Type in Performance Lighting Section Above | 2 |
| HVACe | Fixed | See Lighting Table by Building Type in Performance Lighting Section Above | 2 |
| HVACg | Fixed |  | 4 |

**Interactive Factor (HVACg) for Annual Fuel Savings**

|  |  |  |
| --- | --- | --- |
| **Project Type** | **Fuel Type** | **Impact (MMBtu/∆kWh)** |
| 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 |

### 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.

#### of Variables

Units = Number of LED linear lamps or fixtures installed

kWb = Baseline fixture wattage

kWq = Qualified LED fixture wattage

Lighting kWhbase = Total energy usage of lighting fixtures being replaced

Lighting kWhee = Total energy usage of new LED lighting fixtures are being installed

Compfactor = Compressor factor for cooler or freezer, depending on location of install

Compeff = 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 kWhbase | Variable | Variable | Total lighting operating hours per year × wattage of baseline lighting; use 2 × LED watts as default | Application |
| Lighting kWhee | Variable | Variable | Total lighting operating hours per year × wattage of LED lighting. | Application |
| Hrs | Fixed | 6,205 |  | 2 |
| OCompeff – 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).See also 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> | 1 |
| OCompeff – 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 |
| Compfactor –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 |
| Compfactor –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 |

Typical applications of LED case lighting are shown below (1):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Measure description** | **Baseline** | **Measure watts** | **Baseline watts** | **Fixture savings** |
| 5 foot LED case light | 5 ft T8 lamp with normal light output | 38 | 76 | 38 |
| 6 foot LED case light | 6 ft T12lamp with high light output | 46 | 112 | 66 |

#### 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>”

### 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.

*–*

#### 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 | 2 |
| Hrs | Fixed | See Lighting Table by Building in Performance Lighting Section Above | 2 |
| HVACd | Fixed | See Lighting Table by Building Type in Performance Lighting Section Above | 1 |
| HVACe | Fixed | See Lighting Table by Building Type in Performance Lighting Section Above | 1 |

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V6. May 2016, pp 504-507.
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”

### 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

=

=

#### 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

= 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.

= 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 = **24%**  Daylight Dimmer System=**28%** | 2 |
| CF | Fixed | See Lighting Table by Building in Performance Lighting Section Above | 1 |
| Hrs | Fixed | See Lighting Table by Building in Performance Lighting Section Above | 1, 2 |
| HVACd | Fixed | See HVAC Interactive Effects Table Lighting Table by Building Type in Performance Lighting Section Above | 1 |
| HVACe | Fixed | See HVAC Interactive Effects Table by Building Type in Performance Lighting Table Above | 1 |

#### Sources

1. NEEP, *Mid-Atlantic Technical Reference Manual*, V6. May 2016, pp 505-507. Sources per NEEP TRM: “
   1. 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
   2. C&I Lighting Load Shape Project FINAL Report, KEMA, 2011
   3. 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.”
2. A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings, Lawrence Berkeley National Laboratory, September 2011.



### 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*

#### Algorithms

∆kW = ((AmpsEF \* VoltsEF \* (PhaseEF) 1/2)/1000) \* PFEF \* LR65%

Gross kWh Savings = *kWh SavingsEF* + *kWh SavingsRH*

*kWh SavingsEF* = ((AmpsEF \* VoltsEF \* (PhaseEF) 1/2)/1000) \* PFEF \* Operating Hours \* LR65%

*kWh SavingsRH* = kWh SavingsEF \* 0.28 \* 1.6

*PLEASE NOTE:*

*“((AmpsEF \* VoltsEF \* (PhaseEF) 1/2)/1000) \* PFEF” is equivalent to “HP \* 0.746”*

#### Definition of Variables

∆kW = Demand Savings due to EC Motor Retrofit

*kWh SavingsEF*  = Savings due to Evaporator Fan Motors being replaced

*kWh SavingsRH* = Savings due to reduced heat from Evaporator Fans

AmpsEF = Nameplate Amps of Evaporator Fan

VoltsEF = Nameplate Volts of Evaporator Fan

PhaseEF = Phase of Evaporator Fan

PFEF = 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 kWh Savings = *kWh SavingsCM* + *kWh SavingsRH*

*kWh SavingsCM* = kW \* ER \* RT8, 500

*kWh SavingsRH* = kWh SavingsEF \* 0.28 \* Eff

#### Definition of Variables

*kWh SavingsCM* = Savings due to Case Motors being replaced

*kWh SavingsRH* = 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 |
| --- | --- | --- | --- |
| AmpsEF | Variable | Nameplate/Manufacturer Spec. Sheet | Application |
| VoltsEF | Variable | Nameplate/Manufacturer Spec. Sheet | Application |
| PhaseEF | Variable | Nameplate/Manufacturer Spec. Sheet | Application |
| PFEF | 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 |  |

1. SourcesSelect 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.

#### Algorithms

*Air Conditioning Algorithms:*

Energy Savings (kWh/yr) = N \* Tons \* 12 kBtuh/Ton \* (1/EER*b*-1/EER*q*) \* EFLHc

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.

#### Definition of Variables

N = Number of units

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

EERb  = 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 X 3.412 for cooling and heating savings, respectively.

EERq  = 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 X 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.

EFLHc 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 |
| EERb | Variable | See Table below | 1 |
| EERq | Variable | ARI/AHRI or AHAM Values | Application |
| CF | Fixed | 50% | 2 |
| EFLH(c or h) | Variable | See Table below | 3[[27]](#footnote-31) |

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  <=5.4 tons, single  >5.4 to 11.25 tons  >11.25 to 20 tons  > 21 to 63 tons  >63 Tons | 13 SEER  14 SEER  11.0 EER, 12.7 IEER  10.8 EER, 12.2 IEER  9.8 EER, 11.4 IEER  9.5 EER, 11.0 IEER |
| Air Cooled Heat Pump Systems, Split System and Single Package  <=5.4 tons, split  <=5.4 tons, single  >5.4 to 11.25 tons  >11.25 to 20 tons  >= 21 | 14 SEER, 8.2 HSPF  14 SEER, 8.0 HSPF  10.8 EER, 11.0 IEER, 3.3 heating COP  10.4 EER, 11.4 IEER, 3.2 heating COP  9.3 EER, 10.4 IEER, 3.2 heating COP |
| 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[[28]](#footnote-33) | 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 | Cooling EFLH |
| --- | --- | --- |
| 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 |
| Retail – big box | 191 | 1279 |
| Retail – Grocery | 191 | 1279 |
| Retail – large | 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 |

#### Sources

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>.

1. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016, Appendix G – Equivalent Full-Load Hours (EFLH) for Heating and Cooling, pp. 443‒444. Derived from DOE2.2 simulations reflecting a range of building types and climate zones.

### 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.

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.

#### Algorithms

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

Peak Demand Savings (kW) = 0[[29]](#footnote-34) 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

#### Summary of Inputs

Dual Enthalpy Economizers

| Component | | Type | | Value | Source |
| --- | --- | --- | --- | --- | --- |
| N | | Variable | |  | Application |
| Tons | | Variable | | Rated Capacity, Tons | Application |
| ΔkWh/ton | | Fixed | |  | 1[[30]](#footnote-35) |

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. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016. Appendix J – Commercial HVAC Unit Savings. P.455.

### 

If occupancy is sensed by the sensor, the thermostat goes into an occupied mode (i.e., If a pre-programmed time frame elapses (i.e.,

Th = Heating Season Facility Temp. (°F)

Tc = Cooling Season Facility Temp. (°F)

Sh = Heating Season Setback Temp. (°F)

Sc = Cooling Season Setup Temp. (°F)

H = Weekly Occupied Hours

Caphp = Connected load capacity of heat pump/AC (Tons) – Provided on Application.

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

EFLHc = Equivalent full load cooling hours

EFLHh = Equivalent full load heating hours

Ph = Heating season percent savings per degree setback

Pc = Cooling season percent savings per degree setup

AFUEh = Heating equipment efficiency – Provided on Application.

EERhp = 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.

5 = Assumed weekly hours for setback/setup adjustment period (based on 1 setback/setup per day, 5 days per week).

#### Summary of Inputs

Occupancy Controlled Thermostats

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| Th | Variable |  | Application |
| Tc | Variable |  | Application |
| Sh | Fixed | Th-5° |  |
| Sc | Fixed | Tc+5° |  |
| H | Variable |  | Application; Default of 56 hrs/week |
| Caphp | Variable |  | Application |
| Caph | Variable |  | Application |
| EFLHc | Fixed | 381 | 1 |
| EFLHh | Fixed | 900 | PSE&G |
| Ph | Fixed | 3% | 2 |
| Pc | Fixed | 6% | 2 |
| AFUEh | Variable |  | Application |
| EERhp | Variable |  | Application |

#### Sources

1. JCP&L metered data from 1995–1999 .
2. .

### 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 \* (IPLVb – IPLVq)

Peak Demand Savings (kW) = N \* Tons \* PDC \* (IPLVb – IPLVq)

*For FLV:*

Energy Savings (kWh/yr) = N \* Tons \* EFLH \* (FLVb – FLVq)

Peak Demand Savings (kW) = N \* Tons \* PDC \* (FLVb – FLVq)

#### Definition of Variables

N = Number of units

Tons = Rated capacity of cooling 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

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

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

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

FLVq  = 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 |
| IPLVb (kW/ton) |  | See table below | Varies | 1 |
| IPLVq (kW/ton) | Variable | All | Varies | From Application (per AHRI Std. 550/590) |
| FLVb (kW/ton) |  | See table below | Varies | 1 |
| FLVq (kW/ton) |  | All | Varies | From (per AHRI Std. 550/590) |
| PDC | Fixed | All | 67% | Engineering Estimate |
| EFLH |  | All | See Table Below | 2[[31]](#footnote-36) |



Electric Chillers – New Construction

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | ASHRAE 90.1 2013 | | | |
|  |  | **effective 1/1/2015 a** | | | |
|  |  | Path A | | Path B | |
| Type | Capacity | Full Load kW/ton | IPLV kW/ton | Full Load kW/ton | IPLV kW/ton |
| Air Cooled |  | *10.1* | *13.7* | *9.7* | *15.8* |
| tons < 150 | 1.188 | 0.876 | 1.237 | 0.759 |
|  | *10.1* | *14.0* | *9.7* | *16.1* |
| tons > 150 | 1.188 | 0.857 | 1.237 | 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.

Table

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

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. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling; pp. 443–444. Derived from DOE2.2 simulations reflecting a range of building types and climate zones.

### 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.

Algorithms

Energy Savings (kWh/year) = N \* HP \* ESF

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

Definitions of Variables

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)

#### Summary of Inputs

Variable Frequency Drives

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Type | Value | Source |
| Motor HP | Variable | Nameplate/Manufacturer Spec. Sheet | Application |
| ESF | Variable | See Table Below | 1, 2, 3 |
| DSF | Variable | See Table Below | 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 2016 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



|  |  |  |  |
| --- | --- | --- | --- |
|  | 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. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016, 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.

***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.

Energy Savings (kWh) = HRS \* SF \* Motor HP

Peak Demand Savings (kW) = Motor HP \* CF

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

0.746 = kW to HP conversion factorSF = Deemed Savings factor from savings factor table, kW/nameplate HP.

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

CF = Coincidence factor applicable to commercial compressed air installations

#### Summary of Inputs

Air Compressors with VFDs

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

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.

#### Algorithms

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

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

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

#### Definition of Variables

N = Number of Kitchen Hood Fan Motors

HP = Kitchen Hood Fan Motor HP

LF = Existing Motor Loading Factor

0.746 = Conversion from HP to kW

FEFF = 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

HDDmod = Modified Heating Degree Days based on location and facility type

CDDmod = 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))

HEFF = Efficiency of Heating System (AFUE %)

CEFF = 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 Sample1 |
| *FEFF* | Variable | Based on Motor HP | NEMA Premium Efficiency, TEFC 1800 RPM |
| *RH* | Variable | Based on Facility Type | Facility Specific Value Table |
| *PR* | Variable | Based on Facility Type | Facility Specific Value Table |
| *SF* | Variable | Kitchen Square Footage | Application |
| *CFM / SF* | Fixed | 0.7 | ASHRAE 62.1 2013 Table 6.5 |
| *OF* | Fixed | 1.4 | Estimated Typical Kitchen Design2 |
| *FR* | Variable | Based on Facility Type | Facility Specific Value Table |
| *HDDmod* | Variable |  | Heating Degree Day Table |
| *CDDmod* | Variable |  | Cooling Degree Day Table |
| *HEFF* | Fixed | 0.8 | 8.1F3Estimated Heating System Efficiency3 |
| *CEFF* | Fixed | 3.00 | Estimated Cooling System Efficiency4 |

Facility-Specific Values Table5



Modified Heating Degree Days Table6



Modified Cooling Degree Days Table7



#### Sources

1. 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.
2. 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.
3. 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.
4. 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.
5. 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.
6. 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>.
7. 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 x 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

Commercial Refrigeration

| Component | Type | Value | | | Source | |
| --- | --- | --- | --- | --- | --- | --- |
| ESF | Fixed | 395 kWh/year-foot | | | 1,2,3,4,5 | |
| HSF | Fixed | 10.5 Therms/year-foot | | | 1,2,3,4,5 | |
| CL | Variable |  | | | Rebate Application or Manufacturer Data | |
| UHours | Fixed | 8,760/year unless otherwise specified | | | 3 Continuous Operation | |

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. 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.

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.

#### Algorithms

#### Definition of Variables

W = Width of protected opening in ft.

H = Hours per year covers are in place

F = Savings factor based on case temperature:

### 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 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.

(NRM)’s Cooltrol® energy management system.[1]

Algorithms

*kWh SavingsEF* = Savings due to Evaporator Fan being off

*kWh SavingsRH* = Savings due to reduced heat from Evaporator Fans

*kWh SavingsEC* = Savings due to the electronic controls on compressor and evaporator

AmpsEF = Nameplate Amps of Evaporator Fan

VoltsEF = Nameplate Volts of Evaporator Fan

PhaseEF = Phase of Evaporator Fan

0.55 = Evaporator Fan Motor power factor

8,760 = Annual Operating Hours

35.52% = Percent of time Evaporator Fan is turned off.[2]

0.28 = Conversion from kW to tons (Refrigeration)

1.6 = Efficiency of typical refrigeration system in kW/ton [3]

AmpsCP  = Nameplate Amps of Compressor

VoltsCP = Nameplate Volts of Compressor

PhaseCP = Phase of Compressor

= Compressor power factor.

35% = Compressor duty cycle during winter months (estimated)

WH = Compressor hours during winter months (2,195)

55% = Compressor duty cycle during non-winter months (estimated)

NWH = Compressor hours during non-winter months (6,565)

5% = Reduced run time of Compressor and Evaporator due to electronic controls [4]

D = 0.228 or Diversity Factor [5]

1. <http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html>.
2. 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.
3. Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User’s Manual.* 2004.
4. This percentage has been collaborated by several utility sponsored 3rd Party studies including study conducted by Select Energy Services for NSTAR, March 9, 2004.
5. 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.

[1]

*Control*

#### Algorithms

kWh Savings = (kWDH \* 8,760) – ((40% \* kWDH \* 4,000) + (65% \* kWDH \* 4,760))

kW Savings = kWDH \* 46% \* 75%

#### Definition of Variables

kWDH = 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 [2]

[3]

[3]

75% = Adjustment factor to account for diversity and coincidence at peak demand [2]

Energy Savings (kWh/yr) = (kWDH \* 8,760) – (60% \* kWDH \* 3,760)

Peak Demand Savings (kW) = kWDH \* 74% \* 75%

#### Definition of Variables

[3]

75% = Adjustment factor to account for diversity and coincidence at peak demand [2]

#### Sources

1. This supported by 3rd Party Analysis conducted by Select Energy for NSTAR, “Cooler Control Measure Impact Spreadsheet Users’ Manual,” P.5, March 9, 2004.

### 

*kWh SavingsDefrost*=

*kWh SavingsDefrost* = Savings due to reduction of defrosts

*kWh SavingsRH* = Savings due to reduction in refrigeration load

KWDefrost = Nameplate Load of Electric Defrost

0.667 = Average Length of Electric Defrost in hours

4 = Average Number of Electric Defrosts per day

365 = Number of Days in Year

35% = Average Number of Defrosts that will be eliminated in year

0.28 = Conversion from kW to tons (Refrigeration)

1.6 = Efficiency of typical refrigeration system in kW/ton [1]

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

### Novelty Cooler Shutoff

[1]

AmpsNC = Nameplate Amps of Novelty Cooler

VoltsNC  = Nameplate Volts of Novelty Cooler

PhaseNC = Phase of Novelty Cooler

0.85 = Novelty Cooler power factor [2]

0.45 = Duty cycle during winter month nights [3]

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

1. <http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html>.
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.

## Protocols

* Electric and gas combination oven/steamer – ASTM F2861
* 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

this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

#### Algorithms

Energy Savings (kWh/yr or Therms/yr) = D\*(Ep + Eic + Eis + Ecc + Ecs)

Peak

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

#### 

(See tables of values below for more information)

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 = 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

#### Summary of Inputs







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.

### 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 \* (Ep + Ei + Ec)

Peak

1/Effq) / 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)

D = Operating Days per Year

P = Number of Preheats per Day

PEb = Baseline Equipment Preheat Energy

PEq = Qualifying Equipment Preheat Energy

Ib = Baseline Equipment Idle Energy Rate

Iq = Qualifying Equipment Idle Energy Rate

H = Daily Operating Hours

Pt = Preheat Duration

PCb = Baseline Equipment Production Capacity

PCq = Qualifying Equipment Production Capacity

Lbs = Total Daily Food Production

Heat = Heat to Food

Effb = Baseline Equipment Convection Mode Cooking Efficiency

Effq = Qualifying Equipment Convection Mode Cooking Efficiency

C = Conversion Factor from Btu to kWh or Therms

#### Summary of Inputs



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



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



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



Source: PGECOFST109, “Commercial Rack Oven– Gas,” 2016.



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



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



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



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



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



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



#### Sources

Baseline efficiency and idle load rate values developed based on Fishnick Food Service Technology Center LEED suggested baselines and prescriptive measures, 2011.

### Insulated Food Holding Cabinets

for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

#### Algorithms

Energy Savings (kWh/yr) = D \* H \* (Ib – Iq)

Peak

#### Definition of Variables

(See tables of values below for more information)

D = Operating Days per Year

H = Daily Operating Hours

Ib = Baseline Equipment Idle Energy Rate

Iq = Qualifying Equipment Idle Energy Rate

#### Summary of Inputs



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



#### Sources

### 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.

#### Algorithms

Energy Savings (kWh/yr or Therms/yr) = EBuild + EBoost + EIdle

Peak

EBuild = Annual Building Water Heater Energy Savings, in kWh or Therms (from tables below)

EBoost = Annual Booster Water Heater Energy Savings, in kWh or Therms (from tables below)

EIdle = Annual Dishwasher Idle Energy Savings, in kWh (from tables below)

8760 = Hours per Year

#### Summary of Inputs





#### Sources

### 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.

Energy Savings (kWh/yr) = D \* (Eb – Eq)

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

#### Definition of Variables

D = Operating Days per Year (assume 365)

H = Daily Operating Hours (assume 24)

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

Eq = Daily kWh Consumption of Qualifying Equipment (from )

#### Summary of Inputs



#### Sources

### 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) = D \* DC \* (IHR/100) \* (Eb – Eq)

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

#### Definition of Variables

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)

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

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

24 = Hours per Day

#### Summary of Inputs



#### Sources

Savings algorithm, baseline values, assumed values and lifetimes developed from information on the Food Service Technology Center program’s website, [www.fishnick.com](http://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.

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*)/VBEq \* IR \* EFLH

Energy Savings (kWh/yr) = Tons \* (kW/Ton*b* – kW/Ton*gc*) \* EFLH

Summer Gas Usage (MMBtu/yr) = MMBtu Output Capacity / COP \* EFLH

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

Peak Demand Savings (kW) = Tons \* (kW/Ton*b* – kW/Tongc) \* 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 = Equivalent Full Load Hours. This represents a measure of chiller use by season.

#### Summary of Inputs

Gas Chillers

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| VBE*q* | Variable |  | Rebate Application or Manufacturer Data |
| BE*b* | Fixed | 75%80% Et | ASHRAE 90.1-2013 Table 6.8.1 – 6  Assumes a baseline hot water boiler with rated input >300 MBh and ≤ 2,500 MBh. |
| IR | Variable |  | Rebate Application or Manufacturer Data |
| Tons | Variable |  | Rebate Application |
| MMBtu | Variable |  | Rebate 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 | Variable | See table below | 1 |

EFLH Table

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

#### Sources

1. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016. Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling, pp. 443–444. Derived from DOE2.2 simulations reflecting a range of building types and climate zones

### 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.

#### Algorithms

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

#### Definition of Variables

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 Form or Manufacturer Data |
| CF | Fixed | 30% | Summit Blue NJ Market Assessment |
| EFLH | Fixed | 1,000 | PSE&G |
| EF | Variable |  | Application Form or Manufacturer Data |

### Tank Style (Storage) Water Heaters

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

#### Algorithms

Fuel Savings (MMBtu/yr) = ((1 – (EFF*b* / EFF*q*) + %SL[[32]](#footnote-38)) \* Energy Use Density \* Area / 1000 kBtu/MMBtu

where,

%SL = (SL*b* – SL*q*) / kBtu/hr*q*

#### Definition of Variables

EFF*q* = Efficiency of the qualifying storage water heater.

EFF*bc* = Efficiency of the baseline water heater, commercial grade.

UEF*b* = Efficiency of the baseline water heater, residential 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

%SL = Percent standby loss savings of qualifying storage water heater over baseline

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

kBtu/hr*q* = Rated input capacity of the qualifying storage water heater

#### Summary of Inputs

Water Heater Assumptions

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| EFF*q* | Variable |  | Application |
| EFF*b* | Variable | See Table Below | 1, 2 | |
| UEF*b* | Variable | See baseline values in residential storage water heater measure | 1, 2 | |
| Energy Use Density | Variable | See Table Below | 3 |
| Area | Variable |  | Application |
| kBtu/hr*q* | Variable |  |  | |
| SL*b* | Variable | See Table Below | 1 & Application | |
| SL*q* | Variable |  | Application | |

Efficiency of Baseline Water Heaters

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ASHRAE 90.1-2007 and 2013a | | | | | | | |
| 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 × V | | | EF = 0.67 – 0.0005 × V | |
| Gas Storage Water Heaters | > 75 kBtu/hr | | TE = 0.80  SL = (kBtu/hr*q* / 0.8 + 110 × √V) / 1000 | | | TE = 0.80  SL = (kBtu/hr*q* / 0.799 + 16.6 × √V) / 1000 | |

a – EF is energy factor, TE is thermal efficiency, V is the volume of the installed storage water heater, and kBtu/hr*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 percent standby loss savings would be %SL = (1.29 – 1.0) / 100 = 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 ft2, the annual energy savings would be ((1 – 0.8/0.96) + 0.0019) × 4.8 × 10000 / 1000 = 8.1 MMBtus/yr

#### Sources

1. ASHRAE Standards 90.1-2007, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: <https://www.ashrae.org/standards-research--technology/standards--guidelines>.
2. ASHRAE Standards 90.1-2013, *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>.

### Instantaneous Gas Water Heaters

This prescriptive measure is intended for instantaneous 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.

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

Note, that for 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*) + %SL[[33]](#footnote-39)) \* Energy Use Density \* Area

Where,

%SL = 0.775 × (kBtu/hrqualifying input)-0.778

#### Definition of Variables

EFF*q* = Efficiency of the qualifying instantaneous water heater.

EFF*b* = Efficiency of the baseline water heater, commercial grade.

UEF*b* = Efficiency of the baseline water heater, residential grade.

%SL = Percent standby losses of the baseline water heater fuel usage. This was calculated from standby loss and input capacity data for commercial water heaters exported from the AHRI database.

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

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

#### 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 |
| UEF*b* | Variable | See baseline values in residential instantaneous water heater measure |  |
| Energy Use Density | Variable | See Table Below | 3 |
| Area | Variable |  | Application |

Efficiency of Baseline Water Heaters

|  |  |  |  |
| --- | --- | --- | --- |
| ASHRAE 90.1-2007 and 2013a | | | |
| 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[[34]](#footnote-40) | ≤ 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[[35]](#footnote-41) | < 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

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 |

#### Sources

1. ASHRAE Standards 90.1-2007, *Energy Standard for Buildings Except Low Rise Residential Buildings*; available at: <https://www.ashrae.org/standards-research--technology/standards--guidelines>.
2. ASHRAE Standards 90.1-2013, *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. Savings are calculated for four zones throughout the state by heating degree days and for twelve different building types.

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

#### Definition of Variables

OF = Oversize factor of standard boiler (OF=0.8)

HDDmod = HDD by zone and building type

∆T = design temperature difference

kBtuin/hr = Input capacity of qualifying unit

Effb = Boiler Baseline Efficiency

Effq = Boiler Proposed Efficiency

1000 = Conversion from kBtu to MMBtu

#### Summary of Inputs

Prescriptive Boilers

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Type | Value | Source |
| OF | Fixed | 0.8 |  |
| kBtuin/hr | Variable |  | Application |
| Effb | Variable | See Table Below | 2 |
| Effq | Variable |  | Application |
| ∆T | Variable | See Table Below | 1 |
| HDDmod | Fixed | See Table Below | 1 |

Adjusted Heating Degree Days by Building Type

Heating Degree Days and Outdoor Design Temperature by Zone



Baseline Boiler Efficiencies (Effb)

|  |  |  |  |
| --- | --- | --- | --- |
| Boiler Type | Size Category  (kBtu input) |  | Standard 90.1-2013 |
| Hot Water – Gas fired | < 300  > 300 and < 2,500  > 2,500 |  | 82% AFUE  80% Et |
| Hot Water – Oil fired | < 300  > 300 and < 2,500  > 2,500 | 84% AFUE  82% Et  84% Ec |  |
| Steam – Gas fired | < 300 | 80% AFUE |  |
| Steam – Gas fired, all except natural draft | > 300 and < 2,500 | 79% Et |  |
| Steam – Gas fired, all except natural draft | > 2,500 |  | 79% Ec |
| Steam – Gas fired, natural draft | > 300 and < 2,500 |  | 77% Et |
| Steam – Gas fired, natural draft | > 2,500 |  | 77% Ec |
| Steam – Oil fired | < 300  > 300 and < 2,500  > 2,500 | 82% AFUE  81% Et  81% Ec |  |

#### Sources

1. KEMA, June 2009, New Jersey’s Clean Energy Program Residential HVAC Impact Evaluation and Protocol Review; available at: <http://www.njcleanenergy.com/files/file/Library/SmartStart%20Protocol%20Review%20-%20Final%20July%2010%202009.pdf>.
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

#### Definition of Variables

OF = Oversize factor of standard boiler (OF=0.8)

HDDmod = HDD by zone and building type

∆T = design temperature difference

kBtuin/hr = Input capacity of qualifying unit

Effb = Furnace Baseline Efficiency

Effq = Furnace Proposed Efficiency

1000 = Conversion from kBtu to MMBtu

#### Summary of Inputs

Prescriptive Furnaces

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Type | Value | Source |
| OF | Fixed | 0.8 |  |
| Eff*q* | Variable |  | Application |
| Eff*b* | Fixed | See Table Below | 2 |
| CAPYB/Q, Out | Variable |  | Application |
| ∆T | Variable | See Table Below | 1 |
| HDDmod | Fixed | See Table Below | 1 |

Adjusted Heating Degree Days by Building Type



Heating Degree Days and Outdoor Design Temperature by Zone



Baseline Furnace Efficiencies (Effb)

|  |  |  |
| --- | --- | --- |
| Furnace Type | Size Category  (kBtu input) | Standard 90.1-2013 |
| Gas Fired | < 225  ≥ 225 | 78% AFUE  80% Ec |
| Oil Fired | < 225  ≥ 225 | 78% AFUE  81% Et |

#### Sources

1. KEMA, June 2013, New Jersey’s Clean Energy Program Residential HVAC Impact Evaluation and Protocol Review; available at: <http://www.njcleanenergy.com/files/file/Library/HVAC%20Evaluation%20Report%20-%20Final%20June%2011%202009.pdf>.
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>.

### 

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[1].

#### 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

The following algorithms detail savings for the installation of electronic fuel use economizers on commercial boilers and furnace systems. Here, the baseline system is a boiler or furnace that does not have fuel economizers installed.

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

The savings are based on research performed by ERS for the Massachusetts Technical Assessment Committee (MTAC) for one of the systems available in the marketplace. The research was based on data collected through a combination of third party technical reviews and impact evaluation M&V data, both billing analysis and field measurements. ERS observed that the savings vary between 1% and 10%. In general, it was observed that the installations with the oversized boilers (estimated as sites with lower average firing rates) are most likely to yield the highest savings. The actual savings will vary somewhat from project to project, it is reasonable to assume that program-wide energy savings across all approved fuel-use economizers measures will likely be close to the weighted average of 4% of the baseline use.

#### Algorithms

Fuel Savings (MMBtu) = (AFU \* SF)

Definition of Variables

SF = Savings factor, based on data collected through a combination of third party technical reviews and impact evaluation M&V data, both billing analysis and field measurements.

#### Summary of Inputs

Electronic Fuel Use Economizer Assumptions

| Component | Type | Value | Source |
| --- | --- | --- | --- |
| AFU | Variable |  | Application |
| SF | Fixed | 0.04 | 1 |

#### Sources

1. IntelliCon Boiler Controls and Savings Potential,” presentation delivered to MTAC by ERS on April 6, 2015.

# Combined Heat & Power Program

## Protocols

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### 

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:

* 1. Annual energy input to the generator, HHV basis (MMBtu/yr)
  2. Annual electricity generated, net of all parasitic loads (kWh/yr)
  3. Annual fossil fuel energy savings from heat recovery (MMBtu/yr)
  4. 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)
  5. Annual overall CHP fuel conversion efficiency, HHV basis (%)
  6. 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.

### 

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):

Electric Energy Savings or Offset Chiller Electricity Use (MWh):

### 

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.

NJDEP) has provided the BPU with emission factors that are used to calculate the emission savings from energy efficiency and renewable energy projects.

### CHP Emissions Reduction Associated with PJM Grid [2]

#### Algorithms

ER (lbs) = [CO2emission \* Net Electricity Generation (MWh) + Gas Energy Savings (MMBtu) \* CO2 EFNG] – [CHP CO2 EFf \* Total Fuel Consumption (MMBtu)]

NOx ER (lbs) = [NOxemission \* Net Electricity Generation (MWh) + Gas Energy Savings (MMBtu) \* NOx EFNG] – [CHP NOX EFf \* Total Fuel Consumption (MMBtu)]

SO2 ER (lbs) = [SO2emission \* Net Electricity Generation (MWh) + Gas Energy Savings (MMBtu) \* SO2 EFNG] – [CHP SO2 EFf \* Total Fuel Consumption (MMBtu)]

#### Definition of Variables

CO2emission = 992 lbs per MWh

NOXemission = 0.75 lbs per MWh

SO2emission = 1.32 lbs per MWh

[3]:

CO2 EFNG = 118 lb/MMBtu

(average for all boilers)

SO2 EFNG = 0.0006 lb/MMBtu

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.

#### 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>.
2. PJM report; “2012–2016 CO2, SO2 and NOX Emission Rates,” March 2017. PJM system average values for the year 2016 are used.
3. US EPA AP-42: AP-42, Compilation of Air Pollutant Emission Factors, 5th Edition, Chapter 1.4 Natural Gas Combustion <https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.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

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[[36]](#footnote-43).

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 [[37]](#footnote-44)* 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[[38]](#footnote-45).*

**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 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 ηbase. 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

Electric Savings (kWh/yr) = kW*v* \* Hrs \* SF

Peak Demand Savings (kW) = kW*v* \* SF

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

, 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 Effb.

Baseline Boiler Efficiencies (Effb)

|  |  |  |
| --- | --- | --- |
| 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 |

***Source: 2006 Mortgage Industry National Home Energy Ratings Systems Standards, Table 303.7.1(3) Default Values for Mechanical System Efficiencies (Age-based), RESNET.***

NOTE – The age-based efficiencies in the above table have been interpolated from RESNET standards and current baseline figures utilized in NJ C&I Energy Efficiency Rebate programs. With no equivalent resource available specific to small commercial equipment, these combined resources reflect the closest approximation to typical efficiencies of mechanical equipment present in Direct Install project facilities. The Direct Install program is targeted towards small commercial customers. As such, eligible equipment must not exceed a maximum capacity determined to be commonplace in the small C&I sector. In most cases, these capacity ranges correlate well with equipment certified by AHRI under the designation “Residential”.

### 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 Effb.

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) = SQFT1000 \* SFheat

Energy Savings (kWh/yr) = SQFT1000 \* SFcool

Definition of Variables

SQFT1000 = Number of thousands of

square feet of building space[[39]](#footnote-47)

SFheat = Heating savings factor (MMBtu per 1,000 ft2 of building space)

SFcool = Cooling savings factor (kWh

per 1

,000 ft2 of building space)

#### Summary of Inputs

### 

Programmable Thermostat Assumptions

| Component | | Type | | Value | Source |
| --- | --- | --- | --- | --- | --- |
| SQFT1000 | | Variable | | Customer specified | Application |
| SFheat | | Fixed | | 1.68 MMBtu / 1,000 ft2 | 1 |
| SFcool | | Fixed | | 74.7 kWh / 1,000 ft2 | 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>

### 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.

Algorithms

Fuel Savings (MMBtu/yr) = (% Savings) \* (EFLHh \* kBtuin/hr) / 1,000 kBtu/MMBtu

Definition of Variables

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

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

kBtuin/hr = Input capacity of boiler

#### Summary of Inputs

Boiler Reset Control Assumptions

| **Component** | **Type** | **Value** | **Source** |
| --- | --- | --- | --- |
| % Savings | Fixed | 5% | 1 |
| EFLHh | Variable | See Table 1 | 2[[40]](#footnote-48) |
| kBtuin/hr | Variable |  | Application |

Small Commercial EFLHh

| Building | EFLHh |
| --- | --- |
| 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 |

#### Sources

1. GDS Associates, Inc. Natural Gas Energy Efficiency Potential in Massachusetts, 2009, p. 38 Table 6-4.
2. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016, Appendix G – Equivalent Full-Load Hours (EFLH), For Heating and Cooling, p. 444. Derived from DOE2.2 simulations reflecting a range of building types and climate zones.

### 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)

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 CO2 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 CO2, and the CO2 concentration in the air increases in proportion to the number of occupants. The CO2 concentration provides a good indicator of overall air quality. Demand control ventilation (DCV) systems monitor indoor air CO2 concentrations and use this data to automatically modulate dampers and regulate the amount of outdoor air that is supplied for ventilation.

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.

#### Algorithms

Energy Savings (kWh/yr) = CESF x CFM

Peak Demand Savings (kW) = CDSF x CFM

Savings Factor (MMBtu) = HSF X CFM

#### Definition of Variables

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)

#### Summary of Inputs

| Demand Controlled Ventilation Using CO2 SensorsComponent | Type | Value | Source |
| --- | --- | --- | --- |
| CESF | Fixed | 0.0484 MMBtu/CFMSee Table 2 | 1 |
| CDSF | Fixed |  | 1 |
| HSF | Fixed |  | 1 |
| CFM | Variable |  | Application |

Savings for Demand-Controlled Ventilation Using CO2 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 values 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. 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*

Btu or KWh Fuel Savings/yr = N x H x D x (Fb – Fq) x (8.33 x DT / EFF )/ C

Definition of Variables

N = Number of fixtures

device usage

Fb = Baseline device flow rate (gal/m)

Fq = 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 |
| Fb | Fixed | Aerators  2.2 gpm |  |
| Showerhead  2.5 gpm |
| Fq | 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 |

#### Sources

1. FEMP Cost Calculator; located at: [https://energy.gov/eere/femp/energy-cost-calculator-faucets-and-showerheads-0#output](https://energy.gov/eere/femp/energy-cost-calculator-faucets-and-showerheads-0" \l "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. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016. using Tfaucet and Tmain for Faucet – Low-flow aerator measure. Values for both Tfaucet and Tmain found on p. 177, Table 1 and p. 178, Table 2 respectively.
6. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016. Calculated using Tsh and Tmain for Showerhead – Low-flow measure. Values for both Tsh and Tmain found on p. 181, Table 1 and p. 181, Table 2, respectively.
7. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016, p. 177, Table 1.
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 x H x D x (Fb – Fq) x (8.33 x DT / EFF) / C

H = Hours per year of device usage

D = Days per year of device usage

Fb = Baseline device flow rate (gal/m)

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

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

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 |  | 1.06 hours | 1 |
| D | Fixed | 344 days | 1 |
| Fb | Fixed | 1.6 gpm | 2 |
| Fq | 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 Theater and Tmain for Low-flow Pre-rinse spray valve measure. Values for both Tsh and Tmain 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. If the actual temperature differential varies significantly from this value, the reported savings should be scaled proportionally.

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

#### Algorithms

*Fossil Fuel Source:*

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

*Electric Source:*

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

Definition of Variables

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

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

Operating Hours = 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)

#### 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 |

Deemed Savings Values



#### 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. NY, *Standard Approach for Estimating Energy Savings*, V4, April 2016, p. 177, Table 1. Derived from DOE2.2 simulations reflecting a range of building types and climate zones.

### 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:

#### Prescriptive Lighting

T8

T5

CFL Screw-In

LED Screw-In

LED Linear Tubes

LED Hard-Wired Fixtures

#### Lighting Controls

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).[[41]](#footnote-49) The combined values for all projects participating in a specified period are then summed up and converted to MWh for reporting purposes.

# Appendix A Measure Lives

|  |
| --- |
| **NEW JERSEY STATEWIDE ENERGY-EFFICIENCY PROGRAMS** |
| **Measure Lives Used in Cost-Effectiveness Screening**  **Updated October 2017** |

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[[42]](#footnote-50).

|  |  |
| --- | --- |
| **Measure** | **Measure Life** |
| **Residential Sector** | |
| **Lighting End Use** |  |
| CFL | 7 |
| LED | 16 |
| **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) | 20 |
| Furnace High Efficiency Fan | 18 |
| Heat Pump Hot Water (HPHW) | 11 |
| Furnaces | 18 |
| Boilers | 20 |
| Combination Boilers | 19 |
| Boiler Reset Controls | 16 |
| Heating and Cooling Equipment Maintenance Repair/Replacement | 7 |
| Thermostat Replacement | 5 |
| **Hot Water End-Use** |  |
| Storage Water Heaters | 13 |
| Instantaneous Water Heaters | 20 |
| **Building Shell End-Use** |  |
| Air Sealing | 15 |
| Duct Sealing and Repair | 15 |
| Insulation Upgrades | 20 |

|  |  |
| --- | --- |
| **Appliances/Electronics End-Use** |  |
| ES Refrigerator | 12 |
| ES Freezer | 11 |
| ES Dishwasher | 10 |
| ES Clothes washer | 11 |
| ES RAC | 10 |
| ES Air Purifier | 9 |
| ES Set Top Box | 4 |
| ES Sound Bar | 10 |
| Advanced Power Strips | 4 |
| ES Clothes Dryer | 12 |
| Refrigerator/Freezer Retirement | 8 |
| **Commercial Sector** | |
| **Lighting End Use** |  |
| Performance Lighting | 15 |
| Prescriptive Lighting | 15 |
| Refrigerated Case LED Lights | 9 |
| Specialty LED Fixtures (Signage) | 15 |
| Lighting Controls | 9 |
| **HVAC End Use** |  |
| Electronically Commutated Motors for Refrigeration | 15 |
| Electric HVAC Systems | 15 |
| Fuel Use Economizers | 15 |
| Dual Enthalpy Economizers | 10 |
| Occupancy Controlled Thermostats | 13 |
| Electric Chillers | 22 |
| Gas Chillers | 25 |
| Gas Fired Desiccants | NA |
| Prescriptive Boilers | 22 |
| Prescriptive Furnaces | 20 |
| Commercial Small Motors (1-10 HP) | 20 |
| Commercial Small Motors (11-75 HP) | 20 |
| Commercial Small Motors (76-200 HP) | 20 |
| Small Commercial Gas Boiler | 20 |
| Infrared Heaters | 17 |
| Electronic Fuel Use Economizers | 15 |
| Programmable Thermostats | 12 |
| Demand-Controlled Ventilation Using CO2 Sensors | 10 |
| Boiler Reset Controls | 16 |
| **VFDs End Use** |  |
| Variable Frequency Drives | 15 |
| New and Retrofit Kitchen Hoods with Variable Frequency Drives | 15 |
| **Refrigeration End Use** |  |
| Energy Efficient Glass Doors on Vertical Open Refrigerated Cases | 12 |
| Aluminum Night Covers | 6 |
| Walk-in Cooler/Freezer Evaporator Fan Control | 13 |
| Cooler and Freezer Door Heater Control | 12 |
| Electric Defrost Control | 10 |
| Novelty Cooler Shutoff | 8 |
| 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 | 15 |
| Commercial Refrigerators and Freezers | 12 |
| Commercial Ice Machines | 9 |
| **Hot Water End-Use** |  |
| Gas Booster Water Heaters | NA |
| Tank Style (Storage) Water Heaters | 14 |
| Instantaneous Gas Water Heaters | 20 |
| Low Flow Faucet Aerators and Showerheads | 9 |
| Low Flow Pre-rinse Spray Valves | 5 |
| Pipe Insulation | 13 |
| **Combined Heat & Power Program** |  |
| Fuel Cell | 5 |
| Combustion Gas Turbine | 17 |
| IC Small <= 200 KW\* | 17 |
| IC Large > 200 KW\* | 20 |
| Micro Turbine | 15 |
| Steam Turbine | 25 |

\*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.

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1. JPC&L, Summary of reconciliation factors January 1, 2017 – December 31, 2017. [↑](#footnote-ref-2)
2. PSE&G Rate Class & Loss Factor Information [↑](#footnote-ref-3)
3. From NY TRM 2016, for NYC due to proximity to NJ; for single family detached [↑](#footnote-ref-4)
4. From NY TRM 2016, for NYC due to proximity to NJ; for single family detached [↑](#footnote-ref-5)
5. From NY TRM 2016, for NYC due to proximity to NJ; for single family detached [↑](#footnote-ref-6)
6. The final ruling on this change is available at: <https://energy.gov/sites/prod/files/2016/12/f34/WH_Conversion_Final%20Rule.pdf>. [↑](#footnote-ref-7)
7. From NY TRM 2016, for NYC due to proximity to NJ; for single family detached [↑](#footnote-ref-8)
8. Available at: <https://www.eia.gov/consumption/residential/data/2009/hc/hc8.8.xls> [↑](#footnote-ref-9)
9. Data for 2015 will be available in 2018. [↑](#footnote-ref-10)
10. From NY TRM 2016, for NYC due to proximity to NJ; for single family detached [↑](#footnote-ref-11)
11. The final ruling on this change is available at: <https://energy.gov/sites/prod/files/2016/12/f34/WH_Conversion_Final%20Rule.pdf> [↑](#footnote-ref-12)
12. Data for 2015 will be available in 2018. [↑](#footnote-ref-13)
13. The final ruling on this change is available at: <https://energy.gov/sites/prod/files/2016/12/f34/WH_Conversion_Final%20Rule.pdf> [↑](#footnote-ref-14)
14. Available at: <https://www.eia.gov/consumption/residential/data/2009/hc/hc8.8.xls> [↑](#footnote-ref-15)
15. Data for 2015 will be available in 2018. [↑](#footnote-ref-16)
16. 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. [↑](#footnote-ref-19)
17. Accredited Home Energy Rating Systems (HERS) software, http://www.remrate.com/ [↑](#footnote-ref-20)
18. https://www.energystar.gov/index.cfm?c=bldrs\_lenders\_raters.nh\_mfhr\_guidance [↑](#footnote-ref-21)
19. From EVT TRM 2015: “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, p. 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.” [↑](#footnote-ref-23)
20. From EVT TRM 2015 : “Based on average daily hours of use of 5.5 for exterior lighting, from Table 3-1, p. 34 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.” [↑](#footnote-ref-24)
21. 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.” [↑](#footnote-ref-25)
22. From NY TRM 2016, for NYC due to proximity to NJ; for single family residential and multi-family low rise [↑](#footnote-ref-26)
23. Information about BESTEST-EX can be found at [http://www.nrel.gov/buildings/bestest-\_ex.html](http://www.nrel.gov/buildings/bestest-ex.html) [↑](#footnote-ref-27)
24. A listing of the approved software available at <http://www.waptac.org/data/files/Website_Docs/technical_tools/EnergyAuditMatrixTable2.pdf> [↑](#footnote-ref-28)
25. A listing of the approved software available at <http://resnet.us> [↑](#footnote-ref-29)
26. Per the NEEP Mid-Atlantic TRM: “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.” [↑](#footnote-ref-30)
27. From NY TRM 2016, for NYC due to proximity to NJ; for small commercial and large commercial buildings [↑](#footnote-ref-31)
28. Cap means the rated cooling capacity of the product in Btu/h. [↑](#footnote-ref-33)
29. 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. [↑](#footnote-ref-34)
30. From NY TRM 2016, for NYC due to proximity to NJ for small commercial and large ommercial buildings [↑](#footnote-ref-35)
31. From NY TRM 2016, for NYC due to proximity to NJ; for small commercial and large commercial buildings [↑](#footnote-ref-36)
32. Standby losses only apply if the storage water heater is rated for more than 75 kBtu/hr [↑](#footnote-ref-38)
33. Standby losses only apply if the baseline water heater is a storage water heater rated for more than 75 kBtu/hr [↑](#footnote-ref-39)
34. Note, for qualifying instantaneous water heaters less than 200kBtu/hr, the storage water heater tank size is assumed to be 40 gallons. [↑](#footnote-ref-40)
35. For instantaneous water heaters rated for less than 200 kBtu/hr, the tank size is assumed to be 1 gallon. [↑](#footnote-ref-41)
36. <https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf> [↑](#footnote-ref-43)
37. <http://buildingenergyquotient.org/asdesigned.html> [↑](#footnote-ref-44)
38. 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. [↑](#footnote-ref-45)
39. For example, a 5,000 ft2 building would have a SQFT1000 value of 5 [↑](#footnote-ref-47)
40. From NY TRM 2016, for NYC due to proximity to NJ; for small commercial and large commercial buildings [↑](#footnote-ref-48)
41. 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. [↑](#footnote-ref-49)
42. ERS Memo, *Comparative Measure Life Study and Summary of Measure Changes to NJCEP Protocols*, September 5, 2017. Updated October 16, 2017. [↑](#footnote-ref-50)