

**New Jersey Board of Public Utilities  
New Jersey Clean Energy Program  
Protocols to Measure Resource Savings**

**Revisions to  
~~FY2015~~FY2017~~FY2015~~ 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 Center for Energy, Economic and Environmental Policy (CEEPP) 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 CEEPP and other evaluation contractors 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  <a href="#">Customer-Tailored Pilot</a>



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. Following are the basic algorithms.

$$\text{Electric Demand Savings} = \Delta kW = kW_{\text{baseline}} - kW_{\text{energy efficient measure}}$$

$$\text{Electric Energy Savings} = \Delta kW \times \text{EFLH}$$

$$\text{Electric Peak Coincident Demand Savings} = \Delta kW \times \text{Coincidence Factor}$$

$$\text{Gas Energy Savings} = \Delta \text{Btuh} \times \text{EFLH}$$

Where:

EFLH = Equivalent Full Load Hours of operation for the installed measure. Total annual energy use (kWh) of an end use over a range of operating conditions divided by the connected full load of the end use in kW.

$$\Delta \text{Btuh} = \text{Btuh}_{\text{baseline input}} - \text{Btuh}_{\text{energy efficient measure input}}$$

Other resource savings will be calculated as appropriate.

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. As stated in the Guidelines, simulation software must be compliant with ASHRAE 90.1 2004 Section 11 or Appendix G.

## 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., delta watts, delta 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 ~~the-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](http://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  $\Delta$  kW,  $\Delta$  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  $\Delta$  kW,  $\Delta$  kWh, and gas energy savings values are based on high efficiency equipment versus existing equipment, where the programs specifically target early retirement or upgrades that would not otherwise

occur. Protocols for the Direct Install Program include degradation tables to calculate the efficiency of the replaced unit.

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

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

### **Resource Savings in Current and Future Program Years**

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

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

### **Prospective Application of the Protocols**

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

## **Resource Savings**

### ***Electric***

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

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

	Energy Savings	Coincident Peak Demand Savings
Summer	May through September	June through August
Winter	October through April	NA
On Peak (Monday - Friday)	8:00 a.m. to 8:00 p.m.	12:00 p.m. to 8:00 p.m.
Off Peak	M-F 8:00 p.m. to 8:00 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.

#### **Post-Implementation Review**

Program administrators will review application forms and tracking systems for all measures and conduct field inspections on a sample of installations. For some programs and jobs (e.g., custom, large process, large and complex comprehensive design), post-installation review and on-site verification of a sample of application forms and installations will be used to ensure the reliability of site-specific 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.

##### ***Measure Retention and Persistence of Savings***

The combined effect of measure retention and persistence is the ability of installed measures to maintain the initial level of energy savings or generation over the measure life. Measure retention and persistence effects were accounted for in the metered data that were based on C&I installations over an eight-year period. As a result, some protocols incorporate retention and persistence effects in the other input values. For other measures, if the measure is subject to a reduction in savings or generation over time, the reduction in retention or persistence is accounted for using factors in the calculation of resource savings (e.g., in-service rates for residential lighting measures, degradation of photovoltaic systems).

##### ***Interaction of Energy Savings***

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

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

For the Commercial and Industrial Efficient Construction program, the energy savings for lighting is increased by an amount specified in the protocol to account for HVAC interaction.

For commercial and industrial custom measures, interaction where relevant is accounted for in the site-specific analysis. In the Pay for Performance Program, interaction is addressed by the building simulation software program.

### **Calculation of the Value of Resource Savings**

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

In order to calculate the value of the energy savings for reporting and other purposes, the energy savings are determined at the customer level and then increased by the amount of the transmission and distribution losses to reflect the energy savings at the 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 1.076 for both energy and demand. The electric system loss factor was developed to be applicable to statewide programs. Therefore, average system losses at the margin based on a 10 year (2001 to 2010) average of the New Jersey state electricity supply and disposition dataset from the U.S. Energy Information Administration (EIA).

#### ***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
CO <sub>2</sub>	1.1 lbs per kWh saved	1,520 lbs per MWh saved	1,111.79 lbs per MWh saved
NO <sub>x</sub>	6.42 lbs per metric ton of CO <sub>2</sub> saved	2.8 lbs per MWh saved	0.95 lbs per MWh saved
SO <sub>2</sub>	10.26 lbs per metric ton of CO <sub>2</sub> saved	6.5 lbs per MWh saved	2.21 lbs per MWh saved
Hg	0.00005 lbs per metric ton of CO <sub>2</sub> 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
CO <sub>2</sub>	NA	11.7 lbs per therm saved
NO <sub>x</sub>	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 for Program Measures

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



## Residential Electric HVAC

### Protocols

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

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

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

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

### Algorithms

#### ***Central Air Conditioner (A/C) & Air Source Heat Pump (ASHP)***

*Cooling Energy Consumption and Peak Demand Savings – Central A/C & ASHP  
(High Efficiency Equipment Only)*

$$\text{Energy Impact (kWh)} = \text{CAPY}/1000 \times (1/\text{SEER}_b - 1/\text{SEER}_q) \times \text{EFLH}_c$$

$$\text{Peak Demand Impact (kW)} = \text{CAPY}/1000 \times (1/\text{EER}_b - 1/\text{EER}_q) \times \text{CF}$$

*Heating Energy Savings – ASHP*

$$\text{Energy Impact (kWh)} = \text{CAPY}/1000 \times (1/\text{HSPF}_b - 1/\text{HSPF}_q) \times \text{EFLH}_h$$

*Cooling Energy Savings for Proper Sizing and QIV*

$$\text{kWh}_p = \text{kWh}_q * \text{ESF}$$

*Cooling Demand Savings for Proper Sizing and QIV*

$$\text{kW}_p = \text{kW}_q * \text{DSF}$$

**Cooling Energy Consumption and Demand Savings – Central A/C & ASHP (During Existing System Maintenance)**

$$\text{Energy Impact (kWh)} = ((\text{CAPY}/(1000 \times \text{SEER}_m)) \times \text{EFLH}_c) \times \text{MF}$$

$$\text{Peak Demand Impact (kW)} = ((\text{CAPY}/(1000 \times \text{EER}_m)) \times \text{CF}) \times \text{MF}$$

**Cooling Energy Consumption and Demand Savings– Central A/C & ASHP (Duct Sealing)**

$$\text{Energy Impact (kWh)} = (\text{CAPY}/(1000 \times \text{SEER}_q)) \times \text{EFLH}_c \times \text{DuctSF}$$

$$\text{Peak Demand Impact (kW)} = ((\text{CAPY}/(1000 \times \text{EER}_q)) \times \text{CF}) \times \text{DuctSF}$$

**Ground Source Heat Pumps (GSHP)**

$$\text{Cooling Energy (kWh) Savings} = \text{CAPY}/1000 \times (1/(\text{EER}_{g,b} \times \text{GSER}) - (1/(\text{EER}_g \times \text{GSER}))) \times \text{EFLH}_c$$

$$\text{Heating Energy (kWh) Savings} = \text{CAPY}/1000 \times (1/(\text{COP}_{g,b} \times \text{GSOP}) - (1/(\text{COP}_g \times \text{GSOP}))) \times \text{EFLH}_h$$

$$\text{Peak Demand Impact (kW)} = \text{CAPY}/1000 \times (1/\text{EER}_{g,b} - (1/(\text{EER}_g \times \text{GSPK}))) \times \text{CF}$$

**GSHP Desuperheater**

$$\text{Energy (kWh) Savings} = \text{EDSH}$$

$$\text{Peak Demand Impact (kW)} = \text{PDSH}$$

**Furnace High Efficiency Fan**

$$\text{Heating Energy (kWh) Savings} = ((\text{CAPY}_q \times \text{EFLH}_{\text{HT}})/100,000 \text{ BTU/therm}) \times \text{FFS}_{\text{HT}}$$

$$\text{Cooling Energy (kWh) Savings} = \text{FFS}_{\text{CL}}$$

**Solar Domestic Hot Water (augmenting electric resistance DHW)**

$$\text{Heating Energy (kWh) Savings} = \text{ESav}_{\text{SDHW}}$$

$$\text{Peak Demand Impact (kW)} = \text{DSav}_{\text{SDHW}} \times \text{CF}_{\text{SDHW}}$$

**Heat Pump Hot Water (HPHW)**

$$\text{Heating Energy (kWh) Savings} = \text{ESav}_{\text{HPHW}}$$

$$\text{Peak Demand Impact (kW)} = \text{DSav}_{\text{HPPHW}} \times \text{CF}_{\text{HPPHW}}$$

### ***Drain Water Heat Recovery (DWHR)***

$$\text{Heating Energy (kWh) Savings} = \text{ESav}_{\text{DWHR}}$$

$$\text{Peak Demand Impact (kW)} = \text{DSav}_{\text{DWHR}} \times \text{CF}_{\text{DWHR}}$$

### **Definition of Terms**

CAPY = The cooling capacity (output) of the central air conditioner or heat pump being installed. This data is obtained from the Application Form based on the model number.

SEER<sub>b</sub> = The Seasonal Energy Efficiency Ratio of the Baseline Unit.

SEER<sub>q</sub> = The Seasonal Energy Efficiency Ratio of the qualifying unit being installed. This data is obtained from the Application Form based on the model number.

SEER<sub>m</sub> = The Seasonal Energy Efficiency Ratio of the Unit receiving maintenance

EER<sub>b</sub> = The Energy Efficiency Ratio of the Baseline Unit.

EER<sub>q</sub> = The Energy Efficiency Ratio of the unit being installed. This data is obtained from the Application Form based on the model number.

EER<sub>g</sub> = The EER of the ground source heat pump being installed. Note that EERs of GSHPs are measured differently than EERs of air source heat pumps (focusing on entering water temperatures rather than ambient air temperatures). The equivalent SEER of a GSHP can be estimated by multiplying EER<sub>g</sub> by 1.02.

EER<sub>g,b</sub> = The EER of a baseline ground source heat pump

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

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

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

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

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

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

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

HSPF<sub>b</sub> = The Heating Seasonal Performance Factor of the Baseline Unit.

HSPF<sub>q</sub> = The Heating Seasonal Performance Factor of the unit being installed. This data is obtained from the Application Form.

COP<sub>g</sub> = Coefficient of Performance of a GSHP

COP<sub>g,b</sub> = Baseline Coefficient of Performance of a GSHP

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

GSPK = The factor to convert EER<sub>g</sub> to the equivalent EER of an air conditioner to enable comparisons to the baseline unit.

EDSH = Assumed savings per desuperheater.

PDSH = Assumed peak demand savings per desuperheater.

ESav<sub>SDHW</sub> = Assumed energy savings per installed solar domestic hot water system with electric resistance heater backup.

DSav<sub>SDHW</sub> = Assumed demand savings per installed solar domestic hot water system with electric resistance heater backup.

CAPYY<sub>q</sub> = Output capacity of the qualifying heating unit in BTUs/hour

EFLH<sub>HT</sub> = The Equivalent Full Load Hours of operation for the average heating unit

FFS<sub>HT</sub> = Furnace fan savings (heating mode)

FFS<sub>CL</sub> = Furnace fan savings (cooling mode)

kWh<sub>p</sub> = Annual kWh due to proper sizing

kWh<sub>q</sub> = Annual kWh usage post-program

kW<sub>p</sub> = Annual kW due to proper sizing

$kW_q$  = Annual kW usage post-program

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

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

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

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

The 1000 used in the denominator is used to convert watts to kilowatts.

A summary of the input values and their data sources follows:

#### Residential Electric HVAC

Component	Type	Value	Sources
CAPY	Variable		Rebate Application
SEER <sub>b</sub>	Fixed	A/C Baseline = 13 ASHP Baseline = 14	1a 1b+1b
SEER <sub>q</sub>	Variable		Rebate Application
SEER <sub>m</sub>	Fixed	10	15
EER <sub>b</sub>	Fixed	Baseline = 11.3	2
EER <sub>q</sub>	Fixed	= (11.3/13) X SEER <sub>q</sub>	2
EER <sub>g</sub>	Variable		Rebate Application
EER <sub>g,b</sub>	Fixed	11.2	28
EER <sub>m</sub>	Fixed	8.69	19
GSER	Fixed	1.02	3
EFLH	Fixed	Cooling = 600 Hours Heating = 965Hours	4
ESF	Fixed	9.2%	22
DSF	Fixed	9.2%	22
kWh <sub>q</sub>	Variable		Rebate Application
kW <sub>q</sub>	Variable		Rebate Application
MF	Fixed	10%	20
DuctSF	Fixed	18%	14
CF	Fixed	70%	6
DSF	Fixed	2.9%	7

Component	Type	Value	Sources
HSPF <sub>b</sub>	Fixed	Baseline = 7.77878.2	8
HSPF <sub>q</sub>	Variable		Rebate Application
COP <sub>g</sub>	Variable		Rebate Application
COP <sub>g,b</sub>	Fixed	2.9	28
GSOP	Fixed	3.413	9
GSPK	Fixed	0.8416	10
EDSH	Fixed	1842 kWh	11
PDSH	Fixed	0.34 kW	12
ESav <sub>SDHW</sub>	Fixed	3100 kWh	21
DSav <sub>SDHW</sub>	Fixed	0.426 kW	21
CF <sub>SDHW</sub>	Fixed	20%	21
ESav <sub>HPPHW</sub>	Fixed	1687 kWh	23
DSav <sub>HPPHW</sub>	Fixed	0.37 kW	24
CF <sub>HPPHW</sub>	Fixed	70%	24
ESav <sub>DWHR</sub>	Fixed	1457 kWh	26, 23
DSav <sub>DWHR</sub>	Fixed	0.142 kW	27
CF <sub>DWHR</sub>	Fixed	20%	27
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%	13
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%	13
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%	13
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%	13
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%	13
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%	21

Component	Type	Value	Sources
HPWH Time Period Allocation Factors	Fixed	Summer/On-Peak 21% Summer/Off-Peak 22% Winter/On-Peak 28% Winter/Off-Peak 29%	25
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%	21
Capy <sub>q</sub>	Variable		Rebate Application
EFLH <sub>HT</sub>	Fixed	965 hours	16
FFS <sub>HT</sub>	Fixed	0.5 kWh	17
FFS <sub>CL</sub>	Fixed	105 kWh	18

Sources:

1. [a Survey of New Jersey HVAC equipment distributors, CLEAResult, March 2016](#)
- [b Federal Register, 76 FR 37408, June 27, 2011](#) [Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.](#)
- ~~1-2~~ Average EER for SEER 13 units.
- ~~2-3~~ VEIC estimate. Extrapolation of manufacturer data.
- ~~3-4~~ VEIC estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.
- ~~4-5~~ Xenergy, “New Jersey Residential HVAC Baseline Study”, (Xenergy, Washington, D.C., November 16, 2001).
- ~~5-6~~ NEEP, *Mid-Atlantic Technical Reference Manual*, May 2010.
- ~~6-7~~ Xenergy, “New Jersey Residential HVAC Baseline Study”, (Xenergy, Washington, D.C., November 16, 2001)
- ~~7-8~~ Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
- ~~8-9~~ Engineering calculation, HSPF/COP=3.413
- ~~9-10~~ VEIC Estimate. Extrapolation of manufacturer data.
- ~~10-11~~ VEIC estimate, based on PEPCo assumptions.
- ~~11-12~~ VEIC estimate, based on PEPCo assumptions.
- ~~12-13~~ Time period allocation factors used in cost-effectiveness analysis.
- ~~13-14~~ Northeast Energy Efficiency Partnerships, Inc., “Benefits of HVAC Contractor Training”, (February 2006): Appendix C Benefits of HVAC Contractor Training: Field Research Results 03-STAC-01
- ~~14-15~~ Minimum Federal Standard for new Central Air Conditioners between 1990 and 2006
- ~~15-16~~ NJ utility analysis of heating customers, annual gas heating usage
- ~~16-17~~ Scott Pigg (Energy Center of Wisconsin), “Electricity Use by New Furnaces: A Wisconsin Field Study”, Technical Report 230-1, October 2003.
- ~~17-18~~ Ibid., p. 34. ARI charts suggest there are about 20% more full load cooling hours in NJ than southern WI. Thus, average cooling savings in NJ are estimated at 95 to 115

- ~~18-19.~~ The same EER to SEER ratio used for SEER 13 units applied to SEER 10 units.  $EER_m = (11.3/13) * 10$
- ~~19-20.~~ VEIC estimate. Conservatively assumes less savings than for QIV because of the retrofit context
- ~~20-21.~~ 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.
- ~~21-22.~~ KEMA, *NJ Clean Energy Program Energy Impact Evaluation Protocol Review*. 2009.
- ~~22-23.~~ 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%20ORR&LI%20-%202011%20HPWH%20Field%20Evaluation%20Report%20FINAL%206\\_26\\_2012.pdf](http://www.ma-eeac.org/Docs/8.1_EMV%20Page/2012/2012%20Residential%20Studies/MA%20ORR&LI%20-%202011%20HPWH%20Field%20Evaluation%20Report%20FINAL%206_26_2012.pdf)
- ~~23-24.~~ 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](http://www1.eere.energy.gov/femp/pdfs/FTA_res_heat_pump.pdf))
- ~~24-25.~~ “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/>
- ~~25-26.~~ 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.
- ~~26-27.~~ 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:  $0.426 * 0.3 / 0.9 = 0.142$ .
- ~~27-28.~~ AHRI directory. Baseline values are the least efficient “Geothermal – Water-to – Air Heat Pumps” active in the directory, downloaded May 18, 2015.

### ***Combined space and water heating (Combo)***

Participants installing a qualifying boiler or furnace and a qualifying water heater at the same time earn a special incentive. For savings calculations, there is no special consideration. The heating system savings are calculated according to the appropriate algorithm and the water heating savings are calculated separately according to the system type.



## Residential Gas HVAC

### Protocols

The following two algorithms detail savings for gas heating and water heating equipment. They are to be used to determine gas energy savings between baseline standard units and the high efficiency units promoted in the program. The input values are based on data on typical customers supplied by the gas utilities, an analysis by the Federal Energy Management Program (FEMP), and customer information on the application form, confirmed with manufacturer data. The energy values are in therms.

### Space Heaters

#### Algorithms

Gas Savings =  $[(\text{Capy}_q/\text{AFUE}_b) - (\text{Capy}_q/\text{AFUE}_q)] * \text{EFLH} / 100,000 \text{ BTUs/therm}$

Low Income Gas Savings =  $[(\text{Capy}_q/\text{AFUE}_{LI}) - (\text{Capy}_q/\text{AFUE}_q)] * \text{EFLH} / 100,000 \text{ BTUs/therm}$

Gas Savings due to duct sealing =  $(\text{Cap}_{\text{avg}} \text{AFUE}_{\text{avg}}) * \text{EFLH} * (\text{DuctSF}_h/100,000 \text{ BTUs/therm})$

Average Heating Use (therms) =  $(\text{Cap}_{\text{avg}} / \text{AFUE}_{\text{avg}}) * \text{EFLH} / 100,000 \text{ BTUs/therm}$

$\text{EFLH} = \text{Average Heating Use} * \text{AFUE}_{\text{avg}} * 100,000 \text{ BTUs/therm} / \text{Cap}_{\text{avg}}$

Oil Savings for a qualifying boiler =  $\text{OsavBOILER}$

Oil Savings =  $[(\text{Capy}_q/\text{AFUE}_b) - (\text{Capy}_q/\text{AFUE}_q)] * \text{EFLH} / 100,000 \text{ BTUs/therm}$

Circulator Pumps Savings (kWh) =  $\text{Hours} * (\text{Watts}_{\text{Base}} - \text{Watts}_{\text{SEE}})/1000$

#### Definition of Variables

$\text{Capy}_q$  = Output capacity of qualifying unit output in BTUs/hour

$\text{Capy}_t$  = Output capacity of the typical heating unit output in Btus/hour

$\text{Capy}_{\text{avg}}$  = Output capacity of the average heating unit output in Btus/hour

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

$\text{DuctSF}_h$  = The Duct Sealing Factor or the assumed savings due to proper sealing of all heating ducts

$\text{AFUE}_{\text{avg}}$  = Annual Fuel Utilization Efficiency of the average furnace or boiler

AFUE<sub>q</sub> = Annual Fuel Utilization Efficiency of the qualifying baseline furnace or boiler

AFUE<sub>b</sub> = Annual Fuel Utilization Efficiency of the baseline furnace or boiler

AFUE<sub>LI</sub> = Annual Fuel Utilization Efficiency of the Low Income Program replaced furnace or boiler.

Average Heating Usage = The weighted average annual heating usage (therms) of typical New Jersey heating customers

Watts<sub>Base</sub> = Baseline connected kW

Watts<sub>EE</sub> = Efficient connected kW

### Space Heating

Component	Type	Value	Source
Capy <sub>q</sub>	Variable		Application
Capy <sub>t</sub>	Fixed	CAPY <sub>Q</sub>	1
DuctSF <sub>h</sub>	Fixed	13%	5
AFUE <sub>avg</sub>	Variable		Application
AFUE <sub>q</sub>	Variable		Application
AFUE <sub>b</sub>	Fixed	Gas Furnaces: 80% Gas Boilers: Water - 82% Steam – 80% Oil Boilers: Water – 84% Steam – 82% Electric Resistance Heating: 35%	2
AFUE <sub>LI</sub>	Variable		Application or utility estimates
EFLH <sup>1</sup>	Fixed	965 hours	3
Avg. Heating Usage	Fixed	860 therms	5
Time Period Allocation Factors	Fixed	Summer = 12% Winter = 88%	4
Watts <sub>Base</sub>	Fixed	87.8	8
Watts <sub>EE</sub>	Fixed	14.4	8
Hours	Fixed	2350	9

Sources:

<sup>1</sup> Residential Gas Measures EFLH are subject to change barring the results of impact evaluations.

1. NJ Residential HVAC Baseline Study
2. Federal minimum standards as of 2015.
3. NJ utility analysis of heating customers, annual gas heating usage
4. 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.
5. Northeast Energy Efficiency Partnerships, Inc., “Benefits of HVAC Contractor Training”, (February 2006): Appendix C Benefits of HVAC Contractor Training: Field Research Results 03-STAC-01
6. KEMA, *NJ Clean Energy Program Energy Impact Evaluation Protocol Review*. 2009.
7. Electric resistance heat calculated by determining the overall fuel cycle efficiency by dividing the average PJM heat rate (9,642 BTU per kWh) by the BTUs per kWh (3,413 BTU per kWh), giving a 2.83 BTU<sub>in</sub> per BTU<sub>out</sub>.
8. Efficiency Vermont Technical Reference Manual
9. Boiler run hours, based on Efficiency Vermont TRM methodology, where boilers have EFLH of 810 and the circ pump run hours are 1973. Therefore for NJ with 965 EFLH, the run hours can be estimated as  $965 * 1973/810 = 2350$

### **Water Heaters**

#### Algorithms

Gas Savings =  $((EF_q - EF_b)/EF_q) \times \text{Baseline Water Heater Usage}$

Gas Savings (Solar DHW) = GsavSHW

Gas Savings (Drain Water Heat Recover) = GsavDWHR \* Baseline Water Heater Usage

#### Definition of Variables

$EF_q$  = Energy factor of the qualifying energy efficient water heater.

Note: For qualifying units not rated with an Energy Factor, the estimated  $EF_q$  shall be used:

$$\begin{aligned} \text{Est. } EF_q &= Q_{\text{out}}/Q_{\text{in}} \\ &= 41,094^2 / (41,094/TE + \text{Volume} * \text{SLratio} * 24\text{hours}) \end{aligned}$$

Where: TE = Thermal (or Recovery) Efficiency of the unit as a percentage  
 Volume = Volume of storage water heater, in gallons.  
 SLratio = Average ratio of rated standby losses water heater (BTU loss per hour for > 90% TE units less than 130 Gallons = 9.73<sup>3</sup>)

<sup>2</sup> Based upon the test conditions of the DOE test protocol for residential water heaters, the amount of energy delivered is equal to 64.3 gallons \* density of water (8.3lb/gal) \* Specific heat of water (1 BTU/lb-F) and the temperature rise of 77degF (135F-58F).

<sup>3</sup> Based upon February, 2012 query of ARHI/GAMA database  
[http://cafs.ahrinet.org/gama\\_cafs/sdpsearch/search.jsp?table=CWH](http://cafs.ahrinet.org/gama_cafs/sdpsearch/search.jsp?table=CWH)

Gas & Propane Tankless Water Heaters<sup>1</sup>:  $EF_b = 0.67670670.82 - (0.0019 * \text{Gallons of Capacity})$

Gas & Propane Storage or Power Vented Water Heaters<sup>1</sup> :

55 gallons or less:  $EF_b = 0.675 - (0.0015 * \text{Gallons of Capacity})$

56 gallons or more:  $EF_b = 0.8012 - (0.00078 * \text{Gallons of Capacity})$

Baseline Water Heater Usage = Annual usage of the baseline water heater, in therms.

GsavSHW = Gas savings, in therms, for a solar hot water installation augmented by a new gas hot water heater.

GsavDWHR = Gas savings, as a percentage, for a drain water heat recovery installation in a home with a gas hot water heater.

### Water Heaters

Component	Type	Value	Source
$EF_q$	Variable		Application Form, confirmed with Manufacturer Data
TE	Variable		Application Form, confirmed with Manufacturer Data
Stdby	Variable		Application Form, confirmed with Manufacturer Data
$EF_b$	Variable	For Electric Resistance (only): 35%	Application Form, confirmed with Manufacturer Data
Baseline Water Heater Usage	Fixed	180 therms	2
Time Period Allocation Factors	Fixed	Summer = 50% Winter = 50%	3
GsavSHW	Fixed	130.27	4
GSavDWHR	Fixed	30%	5

Sources:

1. Federal EPACT Standard Table II.1, revised April 16, 2015~~Federal EPACT Standard for a 40-gallon-gas-water-heater. Calculated as  $0.62 - (0.0019 * \text{gallons of capacity})$ .~~
2. KEMA. *NJ Clean Energy Program Energy Impact Evaluation Protocol Review. 2009.*
3. Prorated based on 6 months in the summer period and 6 months in the winter period.
4. Savings derived from US DOE estimates for the SEEARP (ENERGY STAR® Residential Water Heaters: Final Criteria Analysis)

5. 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.

## 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

$$\text{Electricity Impact (kWh)} = ((\text{CFL}_{\text{watts}}) \times (\text{CFL}_{\text{hours}} \times 365))/1000$$

$$\text{Peak Demand Impact (kW)} = (\text{CFL}_{\text{watts}}) \times \text{Light CF}$$

##### Efficient Fixtures

$$\text{Electricity Impact (kWh)} = ((\text{Fixt}_{\text{watts}}) \times (\text{Fixt}_{\text{hours}} \times 365))/1000$$

$$\text{Peak Demand Impact (kW)} = (\text{Fixt}_{\text{watts}}) \times \text{Light CF}$$

##### Efficient Torchieres

$$\text{Electricity Impact (kWh)} = ((\text{Torch}_{\text{watts}}) \times (\text{Torch}_{\text{hours}} \times 365))/1000$$

$$\text{Peak Demand Impact (kW)} = (\text{Torch}_{\text{watts}}) \times \text{Light CF}$$

##### LED Screw In Lamp

$$\text{Electricity Impact (kWh)} = ((\text{LED}_{\text{watts}}) \times (\text{LED}_{\text{hours}} \times 365))/1000$$

$$\text{Peak Demand Impact (kW)} = (\text{LED}_{\text{watts}}) \times \text{Light CF}$$

LED Nightlight

$$\text{Electricity Impact (kWh)} = ((\text{LEDN}_{\text{watts}}) \times (\text{LEDN}_{\text{hours}} \times 365))/1000$$

**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

$$\text{Electricity Impact (kWh)} = \% \text{Electric DHW} * (\text{GPM}_{\text{base}} - \text{GPM}_{\text{ee}}) * \text{kWh}/\Delta\text{GPM}$$

$$\text{Peak Electric Demand Impact (kW)} = \text{Electricity Impact (kWh)} * \text{Demand Factor}$$

$$\text{Natural Gas Impact (therm)} = \% \text{Gas DHW} * (\text{GPM}_{\text{base}} - \text{GPM}_{\text{ee}}) * \text{therm}/\Delta\text{GPM}$$

Definition of Variables

$\% \text{Electric DHW}$  = proportion of water heating supplied by electricity

$\text{GPM}_{\text{base}}$  = Flow rate of the baseline showerhead (gallons per minute)

$\text{GPM}_{\text{ee}}$  = Flow rate of the efficient showerhead (gallons per minute)

$\text{kWh}/\Delta\text{GPM}$  = Electric energy savings of efficient showerhead per gallon per minute (GPM)

$\text{Demand Factor}$  = energy to demand factor

$\% \text{Gas DHW}$  = proportion of water heating supplied by natural gas

$\text{therm}/\Delta\text{GPM}$  = natural gas energy savings of efficient showerhead per gallon per minute (GPM)

*Low Flow Showerheads*

<b>Component</b>	<b>Type</b>	<b>Value</b>	<b>Sources</b>
%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/ $\Delta$ GPM	Fixed	SF = 360.1 MF = 336.9 Unknown = 390.1	3
therm/ $\Delta$ 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, pages 120ff. Available at <http://www.puc.pa.gov/pdocs/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 pages 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.

Algorithm

Electricity Impact (kWh) = %Electric DHW \* (GPM\_base – GPM\_ee) \* kWh/ΔGPM

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

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

Definition of Variables

%Electric DHW = proportion of water heating supplied by electricity

GPM\_base = Flow rate of the baseline faucet (gallons per minute)

GPM\_ee = Flow rate of the efficient faucet (gallons per minute)

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

Demand Factor = energy to demand factor

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

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

***Low Flow Faucet Aerators***

<b>Component</b>	<b>Type</b>	<b>Value</b>	<b>Sources</b>
%Electric DHW	Variable	Electric DHW = 100% Unknown = 13%	1
%Gas DHW	Variable	Natural Gas DHW = 100% Unknown = 81%	1
GPM_base	Variable	Rebate Application Unknown = 2.2	2
GPM_ee	Variable	Rebate Application Unknown = 1.5	2
kWh/ΔGPM	Fixed	SF = 60.5 MF = 71.0 Unknown = 63.7	3

Component	Type	Value	Sources
therm/ $\Delta$ 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, pages 114ff. Available at <http://www.puc.pa.gov/pdocs/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 pages 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.<sup>4</sup>

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

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

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

<sup>1</sup> Average hot water use per person were taken from: Lutz, James D., Liu, Xiaomin, McMahan, James E., Dunham, Camilla, Shown, Leslie J., McCure, Quandra T; "Modeling patterns of hot water use in households;" LBL-37805 Rev. Lawrence Berkeley Laboratory, 1996.

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

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

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

<sup>4</sup>The Cadmus Group, Inc. "Final Report Focus on Energy Evaluated Deemed Savings Changes." Prepared for the Public Service Commission of Wisconsin. November 26, 2013. Pages 15-16.

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

<b>Term</b>	<b>Definition</b>	<b>Value</b>
$\Delta$ Therm	Gas Savings	
Therm <sub>Std</sub>	Calculated therms standard tank	206
Therm <sub>Eff</sub>	Calculated therms replacement tank	177.52
Therm <sub>Out</sub>		
EF <sub>Std</sub>	Federal standard energy factor	(.67 – (.0019xvolume))=.58
Therm <sub>StdTank</sub>	Therms used by standard tank	223
Standby <sub>Std</sub>	Standby loss from standard water heater	434 BTU/hr*
AFUE <sub>Std</sub>	Efficiency (AFUE) of standard water heater	80%
Standby <sub>Eff</sub>	Standby loss from efficient water heater	397 BTU/hr**
AFUE <sub>Eff</sub>	Efficiency (AFUE) of efficient water heater	93%
Vol <sub>Std</sub>	Volume of standard water heater (gallons)	63.50
Vol <sub>Eff</sub>	Volume of efficient water heater (gallons)	51.20
°F/hr <sub>Std</sub>	Heat lost per hour from standard water heater tank	0.8
°F/hr <sub>Eff</sub>	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 Ref<sub>new</sub> term of the equation will be zero.

### **Algorithm**

$$\text{Electricity Impact (kWh)} = \text{Ref}_{\text{old}} - \text{Ref}_{\text{new}}$$

$$\text{Peak Demand Impact (kW)} = (\text{Ref}_{\text{old}} - \text{Ref}_{\text{new}}) * (\text{Ref DF})$$

### **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

$$\text{Electricity Impact (kWh)} = \text{ESC}_{\text{pre}} \times 0.05$$

$$\text{MMBtu savings} = (\text{GH}_{\text{pre}} \times 0.05)$$

#### ***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

$$\text{Electricity Impact (kWh)} = (\text{ECool}_{\text{pre}}) \times 0.10$$

$$\text{Peak Demand Impact (kW)} = (\text{Ecool}_{\text{pre}} \times 0.10) / \text{EFLH} \times \text{AC CF}$$

$$\text{MMBtu savings} = (\text{GH}_{\text{pre}} \times 0.02)$$

No CAC

$$\text{Electricity Impact (kWh)} = (\text{ESC}_{\text{pre.}}) \times 0.02$$

$$\text{MMBtu savings} = (\text{GH}_{\text{pre}} \times 0.02)$$

***Combined space and water heating (Combo)***

Participants installing a qualifying boiler or furnace and a qualifying water heater at the same time earn a special incentive. For savings calculations, there is no special consideration. The heating system savings are calculated according to the appropriate algorithm and the water heating savings are calculated separately according to the system type.

***Insulation Up-Grades***

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

$$\text{Electricity Impact (kWh)} = (\text{ESC}_{\text{pre}}) \times 0.08$$

$$\text{MMBtu savings} = \text{GH}_{\text{pre}} \times 0.13$$

***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

$$\text{Electricity Impact (kWh)} = (\text{ESC}_{\text{pre}}) \times 0.03$$

$$\text{MMBtu savings} = (\text{GH}_{\text{pre}} \times 0.03)$$

***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 pre-existing load.

Algorithm

$$\text{Electricity Impact (kWh)} = (\text{ESC}_{\text{pre}}) \times 0.17$$

$$\text{Peak Demand Impact (kW)} = (\text{Capy/EER} \times 1000) \times \text{HP CF} \times \text{DSF}$$

***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**

CFL<sub>watts</sub> = Average watts replaced for a CFL installation.

CFL<sub>hours</sub> = Average daily burn time for CFL replacements.

Fixt<sub>watts</sub> = Average watts replaced for an efficient fixture installation.

Fixt<sub>hours</sub> = Average daily burn time for CFL replacements.

Torch<sub>watts</sub> = Average watts replaced for a Torchiere replacement.

Torch<sub>hours</sub> = Average daily burn time for a Torchiere replacements.

LED<sub>watts</sub> = Average watts replaced for an LED installation.

LED<sub>hours</sub> = Average daily burn time for LED replacements.

LEDN<sub>watts</sub> = Average watts replaced for an LED nightlight installation.

LEDN<sub>hours</sub> = Average daily burn time for LED nightlight replacements.

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

HW<sub>eavg</sub> = Average electricity savings from typical electric hot water measure package.

HW<sub>gavg</sub> = Average natural gas savings from typical electric hot water measure package.

HW<sub>watts</sub> = Connected load reduction for typical hot water efficiency measures

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

Ref<sub>old</sub> = Annual energy consumption of existing refrigerator based on on-site monitoring.

Ref<sub>new</sub> = Rated annual energy consumption of the new refrigerator.

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

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

ESC<sub>pre</sub> = Pre-treatment electric space conditioning consumption.

ECool<sub>pre</sub> = Pre-treatment electric cooling consumption.

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

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

Capy = Capacity of Heat Pump in Btuh

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

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

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

GC<sub>pre</sub> = Pre-treatment gas consumption.

GH<sub>pre</sub> = Pre-treatment gas space heat consumption (=GC<sub>pre</sub> 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	Sources
CFL <sub>Watts</sub>	Fixed	42 Watts	1
CFL <sub>Hours</sub>	Fixed	2.5 hours	1
Fixt <sub>Watts</sub>	Fixed	100-120 Watts	1
Fixt <sub>Hours</sub>	Fixed	3.5 hours	1
Torch <sub>Watts</sub>	Fixed	245 Watts	1
Torch <sub>Hours</sub>	Fixed	3.5 hours	1
LED <sub>Watts</sub>	Fixed	52 Watts	14
LED <sub>Hours</sub>	Fixed	2.5 hours	14
LEDN <sub>Watts</sub>	Fixed	6.75 Watts	14
LEDN <sub>Hours</sub>	Fixed	12 hours	15
Light CF	Fixed	5%	2

<b>Component</b>	<b>Type</b>	<b>Value</b>	<b>Sources</b>
Elec. Water Heating Savings	Fixed	178 kWh	3
Gas Water Heating Savings	Fixed	1.01 MMBTU	3
WS Water Savings	Fixed	3,640 gal/year per home receiving low flow shower heads, plus 1,460 gal/year per home receiving aerators.	12
HW <sub>watts</sub>	Fixed	0.022 kW	4
HW CF	Fixed	75%	4
Ref <sub>old</sub>	Variable		Contractor Tracking
Ref <sub>new</sub>	Variable		Contractor Tracking and Manufacturer data
Ref DF	Fixed	0.000139 kW/kWh savings	5
RefCF	Fixed	100%	6
ESC <sub>pre</sub>	Variable		7
Ecool <sub>pre</sub>	Variable		7
ELFH	Fixed	650 hours	8
AC CF	Fixed	85%	4
Cap <sub>y</sub>	Fixed	33,000 Btu/hr	1
EER	Fixed	11.3	8
HP CF	Fixed	70%	9
DSF	Fixed	7%	10
GC <sub>pre</sub>	Variable		7
GH <sub>pre</sub>	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 Reference Manual – 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 (5pm 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 five minute showers per week for shower heads, and 4 gallons saved per day for aerators.
13. Heating: Prorated based on 12% of the annual degree days falling in the summer period and 88% of the annual degree days falling in the winter period.  
Non-Heating: Prorated based on 6 months in the summer period and 6 months in the winter period.
14. “NJ Comfort Partners Energy Saving Protocols and Engineering Estimates.”  
Apprise, June 2014. Available at  
<http://www.njcleanenergy.com/files/file/Protocol%20and%20Engineering%20Estimate%20Summary.pdf>
15. Pennsylvania Technical Reference Manual. June 2016. Page 27. Available at  
<http://www.puc.pa.gov/pcdocs/1370278.docx>

## Residential New Construction Program

### Protocols

#### *Single-Family, Multi-Single and Low-Rise Multifamily Building Shell*

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<sup>5</sup>. All program homes are modeled in REM/Rate to estimate annual energy consumption for heating, cooling and hot water. The program home is then modeled to a baseline specification using REM/Rate’s User Defined Reference Home (UDRH) feature. The UDRH baseline specification is ~~IECC 20096~~, [for homes permitted prior to March 21, 2016](#) and [IECC 2015 for homes permitted after March 21, 2016](#). The difference in modeled annual energy consumption between the program and UDRH baseline home is the project savings for heating, hot water, ~~and~~ cooling, [lighting and appliance](#) end uses. Coincident peak demand savings are also derived from REM/Rate modeled outputs, ~~but rely on additional program specific constants as described below.~~

The algorithms that calculate energy and demand savings are as follows:

Energy Savings = (Baseline home energy consumption – Program home energy consumption)

~~Coincident system peak electric demand savings = (Baseline home electric peak demand – Program home electric peak demand) X CF~~

~~Baseline Home Electric Peak demand =  $(PL_b \times OF_b) / (SEER_b \times BLEER \times 1,000)$~~

~~Program Home Electric Peak demand =  $(PL_p \times OF_p) / (EER_p \times 1,000)$~~

#### Definition of Terms

~~$PL_b$  = Peak load of the baseline home in Btuh.~~

~~$OF_b$  = The oversizing factor for the HVAC unit in the baseline home.~~

~~$SEER_b$  = The Seasonal Energy Efficiency Ratio of the baseline unit.~~

~~$BLEER$  = Factor to convert baseline  $SEER_b$  to  $EER_b$ .~~

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<sup>5</sup> Accredited Home Energy Rating Systems (HERS) software, <http://www.remrate.com/>

<sup>6</sup> ~~IECC 2009 has been the RNC baseline since January 2012. IECC 2009 was adopted by NJ in Sep 2010, effective Mar 2011.~~

$PL_{qf}$  = The actual predicted peak load for the program home constructed, in Btuh.

$OF_q$  = The oversizing factor for the HVAC unit in the program home.

$EER_q$  = The EER associated with the HVAC system in the program home.

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

A summary of the input values and their data sources follows:

Applicable to building completions from April 2003 to present

Component	Type	Value	Sources
$PL_b$	Variable		1
$OF_b$	Fixed	1.6	2
$SEER_b$	Fixed	13	3
BLEER	Fixed	0.92	4
$PL_{qf}$	Variable		1
$OF_q$	Fixed	1.15	5
$EER_q$	Variable		Program Application
CF	Fixed	0.70	6

Sources:

- 0. Peak load of the program and baseline homes are a direct output of the modeling software.
- 0. PSE&G 1997 Residential New Construction baseline study.
- 0. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200
- 0. Engineering calculation.
- 0. Program guideline for qualifying home.
- 0. Based on an analysis of six different utilities by Proctor Engineering.

The following table describes the baseline characteristics of Climate Zone 4 and 5 reference homes for single-family, multi-single and low-rise multifamily buildings.

**REM/Rate User Defined Reference Homes Definition**  
**Applicable to buildingbuildings permitted prior to -completions from January 2012 to present-March 21, 2016 -- Reflects IECC 2009**

<b>Not e</b>	<b>Data Point</b>	<b>Climate Zone 4</b>	<b>Climate Zone 5</b>
(1)	Ceiling Insulation	U=0.030	U=0.030
	Radiant Barrier	None	None
(1)	Rim/Band Joist	U=0.082	U=0.057
(1)	Exterior Walls - Wood	U=0.082	U=0.057
(1)	Exterior Walls - Steel	U=0.082	U=.057
	Foundation Walls	U=0.059	U=0.059
(1)	Doors	U=0.35	U=0.35
(1)	Windows	U=0.35 , SHGC=NR	U=0.35 , SHGC=NR
(1)	Glass Doors	U=0.35 , SHGC=NR	U=0.35 , SHGC=NR
(1)	Skylights	U=0.60 , SHGC=NR	U=0.60 , SHGC=NR
(2)	Floor	U=0.047	U=.033
	Unheated Slab on Grade	R-10, 2 ft	R-10, 2 ft
	Heated Slab on Grade	R-15, 2 ft	R-15, 2 ft
	Air Infiltration Rate	7 ACH50	7 ACH50
	Duct Leakage	8 cfm25 per 100ft <sup>2</sup> CFA	8 cfm25 per 100ft <sup>2</sup> CFA
(3)	Mechanical Ventilation	<del>AsBuilt</del> None	<del>AsBuilt</del> None
(4)	Lights and Appliances	Use RESNET Default	Use RESNET Default
	Thermostat	Manual	Manual
	Heating Efficiency		
(3) (5)	Furnace	80% AFUE	80% AFUE
	Boiler	80% AFUE	80% AFUE
	Combo Water Heater	76% AFUE (Recovery Efficiency)	76% AFUE (Recovery Efficiency)
	Air Source Heat Pump	7.7 HSPF	7.7 HSPF
	Cooling Efficiency		
	Central Air Conditioning & Window AC units	13.0 SEER	13.0 SEER
	Air Source Heat Pump	13.0 SEER	13.0 SEER
(4) (6)	Domestic WH Efficiency		
	Electric stand-alone tank	0.90 EF	0.90 EF
	Natural Gas stand-alone tank	0.58 EF	0.58 EF
	Electric instantaneous	0.93 EF	0.93 EF
	Natural Gas instantaneous	0.62 EF	0.62 EF
	Water Heater Tank Insulation	None	None
	Duct Insulation, attic supply	R-8	R-8
	Duct Insulation, all other	R-6	R-6
	Active Solar	None	None

REM/Rate User Defined Reference Homes Definition		
Applicable to <u>building buildings permitted prior to completions from January 2012 to present March 21, 2016 -- Reflects IECC 2009</u>		
Photovoltaics	None	None

**UDRH Table Notes**

(1)	<del>Varies with heating degree days (“HDD”). Above value reflects 5000 HDD average for New Jersey.</del> U values represent total wall system U value, including all components (i.e., clear wall, windows, doors). Type A-1 - Detached one and two family dwellings. Type A-2 - All other residential buildings, three stories in height or less.
(2)	All frame floors shall meet this requirement. There is no requirement for floors over basements and/or unvented crawl spaces when the basement and/or unvented crawl space walls are insulated.
(3)	<del>Energy and demand savings due to mechanical ventilation are calculated prescriptively, outside of the UDRH process. A value of ‘AsBuilt’ models the reference and program homes with the same ventilation equipment so that no savings are claimed or lost.</del>
(4)	<del>Energy and demand savings due to efficient lighting are calculated prescriptively, outside of the UDRH process.</del>
(3)(5)	MEC 95 minimum requirement is 78 AFUE. However, 80 AFUE is adopted for New Jersey based on typical minimum availability and practice.
(4)(6)	Based on the Federal Government standard for calculating EF (50 gallon assumed): •Gas-fired Storage-type EF: 0.67 - (0.0019 x Rated Storage Volume in gallons) •Electric Storage-type EF: 0.97 - (0.00132 x Rated Storage Volume in gallons) •Instantaneous Gas-fired EF: 0.62 - (0.0019 x Rated Storage Volume in gallons) •Instantaneous Electric EF: 0.93 - (0.0013 x Rated Storage Volume in gallons)

REM/Rate User Defined Reference Homes Definition			
Applicable to buildings permitted on or after March 21, 2016 -- Reflects IECC 2015			
Not	Data Point	Climate Zone 4	Climate Zone 5
(1)	Ceiling Insulation	U= 0.026	U=0.026
	Radiant Barrier	None	None
(1)	Rim/Band Joist	U=0.060	U=0.060
(1)	Exterior Walls - Wood	U=0.060	U=0.060
(1)	Exterior Walls - Steel	U=0.060	U=0.060
	Foundation Walls	U=0.059	U=0.050
(1)	Doors	U=0.35	U=0.32
(1)	Windows	U=0.35 , SHGC=40	U=0.32 , SHGC=NR
(1)	Glass Doors	U=0.35 , SHGC=40	U=0.32 , SHGC=NR
(1)	Skylights	U=0.55 , SHGC=40	U=0.55 , SHGC=NR
(2)	Floor	U=0.047	U=.033
	Unheated Slab on Grade	R-10, 2 ft	R-10, 2 ft

<b>REM/Rate User Defined Reference Homes Definition</b>			
<b>Applicable to buildings permitted on or after March 21, 2016 -- Reflects IECC 2015</b>			
	Heated Slab on Grade	R-15, 2 ft	R-15, 2 ft
(3)	Air Infiltration Rate	7 ACH50	7 ACH50
	Duct Leakage	4 cfm25 per 100ft <sup>2</sup> CFA	4 cfm25 per 100ft <sup>2</sup> CFA
	Mechanical Ventilation	Exhaust only	Exhaust only
	Lighting	75% efficient	75% efficient
	Appliances	Use RESNET Default	Use RESNET Default
(4)	Thermostat	Manual	Manual
	Heating Efficiency	-	-
(5)	Furnace	80% AFUE	80% AFUE
	Boiler	80% AFUE	80% AFUE
	Combo Water Heater	76% AFUE (Recovery Efficiency)	76% AFUE (Recovery Efficiency)
	Air Source Heat Pump	8.2 HSPF	8.2 HSPF
	Cooling Efficiency	-	-
	Central Air Conditioning & Window AC units	13.0 SEER	13.0 SEER
	Air Source Heat Pump	14.0 SEER	14.0 SEER
(6)	Domestic WH Efficiency	-	-
	Electric stand-alone tank	0.90 EF	0.90 EF
	Natural Gas stand-alone tank	0.60 EF	0.60 EF
	Electric instantaneous	0.93 EF	0.93 EF
	Natural Gas instantaneous	0.82 EF	0.82 EF
	Water Heater Tank Insulation	None	None
	Duct Insulation, attic	R-8	R-8
	Duct Insulation, all other	R-6	R-6
	Active Solar	None	None
	Photovoltaics	None	None

- (1) U values represent total system U value, including all components (i.e., clear wall, windows, doors).  
 Type A-1 - Detached one and two family dwellings.  
 Type A-2 - All other residential buildings, three stories in height or less.
- (2) All frame floors shall meet this requirement. There is no requirement for floors over basements and/or unvented crawl spaces when the basement and/or unvented crawl space walls are insulated.
- (3) Based on New Jersey's amendment making the IECC 2015 requirement for air leakage testing optional, there is no empirical evidence that baseline new construction is achieving the 3 ACH50 tightness level through a visual inspection of checklist air sealing items.
- (4) While the code requires a programmable actual programming is an occupant behavior, both the rated home and reference home are set at fixed temperatures of 68 heating and 78 cooling, so that no savings are counted or lost

(5)	MEC 95 minimum requirement is 78 AFUE. However, 80 AFUE is adopted for New Jersey based on typical minimum availability and practice.
(6)	Based on the Federal Government standard for calculating EF (50 gallon assumed): <ul style="list-style-type: none"> <li>•Gas-fired Storage-type EF: 0.675 - (0.0015 x Rated Storage Volume in gallons)</li> <li>•Electric Storage-type EF: 0.97 - (0.00132 x Rated Storage Volume in gallons)</li> <li>•Instantaneous Gas-fired EF: 0.82 - (0.0019 x Rated Storage Volume in gallons)</li> <li>•Instantaneous Electric EF: 0.93 - (0.0013 x Rated Storage Volume in gallons)</li> </ul>

Lighting and Appliances

Quantification of saving due to the addition of high efficiency clothes washers will be based on the algorithms presented for these end uses in the ENERGY STAR Products Program Protocols. The general form of the equation for the ENERGY STAR appliance and lighting measure savings algorithms is:

Number of Units X Savings per Unit

Within the RNC Program, energy savings due to efficient lighting will be based on a fixed average quantity of sockets per home derived from regional baseline studies. A fixed percentage of sockets will be assumed to be filled with efficient lighting due to energy code requirements and market transformation. These sockets will be subtracted from the average number of sockets per home and not counted toward program savings goals.

The following equation describes the method by which lightings savings are calculated for RNC:

$$\text{Lighting Energy Savings (kWh)} = (\text{TEU} - (\text{TU} \times \text{BEU})) \times \text{CFL}_{\text{save}} \times \text{BTM}$$

$$\text{Lighting Peak Demand Savings (kW)} = \text{Lighting Energy Savings} \times \text{CF}$$

Definition of Terms

TEU = Total efficient units

TU = Total units

BEU = Baseline efficient units

CFL<sub>save</sub> = Per-unit CFL savings

BTM = Building type multiplier

CF = Coincidence Factor

Component	Type	Value	Sources
TEU	Variable		1
TU	Fixed	60	2
BEU	Fixed	18%	3
CFL <sub>save</sub>	Fixed	28 kWh	4
BTM	Fixed	80% (MS); 50% (MF)	5
CF	Fixed	9.9%	6

### Sources

<sup>1</sup>Total efficient units is calculated as the average number of sockets per home X program requirement (percent of bulbs)

<sup>2</sup>The average quantity of sockets per home is assumed to be 60 for single family. There is a building type multiplier for multi single and multifamily units. This value is based on six regional Residential New Construction studies conducted between 2002 and 2012. These studies are: Northeast Utilities and United Illuminating Company Baseline Evaluation for the Energy Star Home New Construction Program Final Report (2002), Long Island Residential new Construction Technical Baseline Study (2004), Massachusetts ENERGY STAR Homes 2005 Baseline Study (2005), Maine Residential New Construction Technical Baseline Study (2008), Vermont Residential New Construction baseline Study Analysis of On-site Audits (2008), Residential Lighting Markdown Report, New England Residential Lighting Measure Life Study (2009), and the New York Energy Code Compliance Study (2012).

<sup>3</sup>The saturation rate, or percentage of sockets assumed to be filled with efficient lighting due to energy code requirements and market transformation, is 18%, based on a 2010 NMR Group study title, "Results of the Multistate CFL Modeling Effort."

<sup>4</sup>ENERGY STAR CFL Bulb protocol available at [http://mde.maryland.gov/programs/BusinessInfoCenter/Greening%20Your%20Business%20Facility/Informational%20Resources/Documents/www.mde.state.md.us/assets/document/CFL\\_LED\\_light\\_bulb\\_calculator.xls](http://mde.maryland.gov/programs/BusinessInfoCenter/Greening%20Your%20Business%20Facility/Informational%20Resources/Documents/www.mde.state.md.us/assets/document/CFL_LED_light_bulb_calculator.xls)

<sup>5</sup>The average number of sockets per home is based on single family detached homes. For multi single homes this value shall be multiplied by 80%. For multi family homes this number shall be multiplied by 50%. This number is based on VEIC analysis of the above six regional Residential New Construction studies.

<sup>6</sup>ENERGY STAR CFL Bulb protocol

Program requirements for RNC Tiers are as follows:

Tier	Efficient Lighting
Tier 1	75%
Tier 2 <sup>2</sup>	80%

<sup>2</sup>Tier 2 follows the Performance path so actual efficient lighting may vary. The program assumes 80% as per the ENERGY STAR Reference Design home.



Tier 3	80%
Tier 3 Plus	80%

~~—Ventilation Equipment~~

~~Additional energy savings of 175 kWh and peak demand saving of 60 Watts will be added to the output of the home energy rating software to account for the installation of high efficiency ventilation equipment. These values are based on a baseline fan of 80 Watts and an efficient fan of 20 Watts running for 8 hours per day.~~

**Multifamily High Rise (MFHR) Protocols**

***Multifamily High Rise (MFHR)***

Annual energy and summer coincident peak demand savings for MFHR construction projects (4-6 stories) shall be calculated from the EPA Project Submittal document, 'As-Built Performance Path Calculator' (PPC). 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 Products Program

*ENERGY STAR Appliances, ENERGY STAR Lighting, ENERGY STAR Windows, and ENERGY STAR Audit*

### ENERGY STAR Appliances

#### Protocols

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

Number of Units X 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 Impact (kWh) =  $ES_{avREF1}$

Demand Impact (kW) =  $DS_{avREF1} \times CF_{REF}$

#### *ENERGY STAR Refrigerators – CEE Tier 2*

Electricity Impact (kWh) =  $ES_{avREF2}$

Demand Impact (kW) =  $DS_{avREF2} \times CF_{REF}$

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

Electricity Impact (kWh) =  $ES_{avCW1}$

Demand Impact (kW) =  $DS_{avCW1} \times CF_{CW}$

Gas Impact (Therms) =  $EGS_{avCW1}$

Water Impact (gallons) =  $WS_{avCW1}$

#### *ENERGY STAR Clothes Washers - CEE Tier 2*

Electricity Impact (kWh) =  $ES_{avCW2}$

Demand Impact (kW) =  $DS_{avCW2} \times CF_{CW}$

Gas Impact (Therms) =  $EGS_{avCW2}$

Water Impact (gallons) =  $WS_{avCW2}$

***ENERGY STAR Set Top Boxes***

Electricity Impact (kWh) =  $ES_{avSTB}$

Demand Impact (kW) =  $DS_{avSTB} \times CF_{STB}$

***Advanced Power Strip – Tier 1***

Electricity Impact (kWh) =  $ES_{avAPS}$

Demand Impact (kW) =  $DS_{avAPS} \times CF_{APS}$

***Advanced Power Strip – Tier 2***

Electricity Impact (kWh) =  $ES_{avAPS2}$

Demand Impact (kW) =  $DS_{avAPS2} \times CF_{APS}$

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

Electricity Impact (kWh) =  $ES_{avCDE1}$

Demand Impact (kW) =  $DS_{avCDE1} \times CF_{CD}$

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

Electricity Impact (kWh) =  $ES_{avCDG1}$

Demand Impact (kW) =  $DS_{avCDG1} \times CF_{CD}$

Gas Impact (Therms) =  $GS_{avCDG1}$

***ENERGY STAR 2014 Emerging Technology Award Electric Clothes Dryers – Tier 2***

Electricity Impact (kWh) =  $ES_{avCDE2}$

Demand Impact (kW) =  $DS_{avCDE2} \times CF_{CD}$

**ENERGY STAR 2014 Emerging Technology Award Gas Clothes Dryers – Tier 2**

Electricity Impact (kWh) =  $ES_{avCDG2}$

Demand Impact (kW) =  $DS_{avCDG2}$

Gas Impact (Therms) =  $GS_{avCDG1}$

**ENERGY STAR Room AC – Tier 1**

Electricity Impact (kWh) =  $ES_{avRAC1}$

Demand Impact (kW) =  $DS_{avRAC1}$

**ENERGY STAR Room AC – Tier 2**

Electricity Impact (kWh) =  $ES_{avRAC2}$

Demand Impact (kW) =  $DS_{avRAC2}$

**ENERGY STAR Room Air Purifier**

Electricity Impact (kWh) =  $ES_{avRAP}$

Where  $ES_{avRAP}$  is based on the CADR in table below

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

Demand Impact (kW) =  $DS_{avRAC2}$  is based on the CADR in the table below

<b><u>Room Air Purifier Deemed kW Table</u></b>	
<b><u>Clean Air Delivery Rate</u></b>	<b><u><math>DS_{avRAC2}</math></u></b>
<u>CADR 51-100</u>	<u>0.034</u>
<u>CADR 101-150</u>	<u>0.056</u>
<u>CADR 151-200</u>	<u>0.078</u>

<u>CADR 201-250</u>	<u>0.101</u>
<u>CADR Over 250</u>	<u>0.123</u>

**ENERGY STAR Freezer**

Electricity Impact (kWh) = ESav<sub>FRZ</sub>

Demand Impact (kW) = DSav<sub>FRZ</sub> based on table below

**ENERGY STAR Soundbar**

Electricity Impact (kWh) = ESav<sub>SDB</sub>

Demand Impact (kW) = DSav<sub>SDB</sub>

**Definition of Terms**

ESav<sub>REF1</sub> = Electricity savings per purchased ENERGY STAR refrigerator – CEE Tier 1.

DSav<sub>REF1</sub> = Summer demand savings per purchased ENERGY STAR refrigerator – CEE Tier 1.

ESav<sub>REF2</sub> = Electricity savings per purchased ENERGY STAR refrigerator – CEE Tier 2.

DSav<sub>REF2</sub> = Summer demand savings per purchased ENERGY STAR refrigerator – CEE Tier 2.

ESav<sub>CW1</sub> = Electricity savings per purchased ENERGY STAR clothes washer.

DSav<sub>CW1</sub> = Summer demand savings per purchased ENERGY STAR clothes washer.

GSav<sub>CW1</sub> = Gas savings per purchased clothes washer ENERGY STAR clothes washer.

WSav<sub>CW1</sub> = Water savings per purchased clothes washer ENERGY STAR clothes washer.

ESav<sub>CW2</sub> = Electricity savings per purchased CEE Tier 2 ENERGY STAR clothes washer.

DSav<sub>CW2</sub> = Summer demand savings per purchased CEE Tier 2 ENERGY STAR clothes washer.

GSav<sub>CW2</sub> = Gas savings per purchased CEE Tier 2 ENERGY STAR clothes washer

WSav<sub>CW2</sub> = Water savings per purchased CEE Tier 2 ENERGY STAR clothes washer.

ESav<sub>STB</sub> = Electricity savings per purchased ENERGY STAR set top box.

DSav<sub>STB</sub> = Summer demand savings per purchased ENERGY STAR set top box.

ESav<sub>APS1</sub> = Electricity savings per purchased advanced power strip.

DSav<sub>APS1</sub> = Summer demand savings per purchased advanced power strip.

ESav<sub>APS2</sub> = Electricity savings per purchased Tier 2 advanced power strip.

DSav<sub>APS2</sub> = Summer demand savings per purchased Tier 2 advanced power strip.

ESav<sub>CDE1</sub> = Electricity savings per purchased ENERGY STAR electric clothes dryer.

DSav<sub>CDE1</sub> = Summer demand savings per purchased ENERGY STAR electric clothes dryer.

ESav<sub>CDG1</sub> = Electricity savings per purchased ENERGY STAR gas clothes dryer.

DSav<sub>CDG1</sub> = summer demand savings per purchased ENERGY STAR gas clothes dryer.

GSav<sub>CDG1</sub> = Gas savings per purchased ENERGY STAR gas clothes dryer.

ESav<sub>CDE2</sub> = Electricity savings per purchased electric clothes dryer meeting the ENERGY STAR 2014 Emerging Technology Award criteria.

DSav<sub>CDE2</sub> = Demand savings per purchased electric clothes dryer meeting the ENERGY STAR 2014 Emerging Technology Award criteria.

ESav<sub>CDG2</sub> = Electricity savings per purchased gas clothes dryer meeting the ENERGY STAR 2014 Emerging Technology Award criteria.

DSav<sub>CDG2</sub> = Demand savings per purchased gas clothes dryer meeting the ENERGY STAR 2014 Emerging Technology Award criteria.

GSav<sub>CDG2</sub> = Gas savings per purchased ENERGY STAR gas clothes dryer meeting the ENERGY STAR 2014 Emerging Technology Award criteria.

ESav<sub>RAC1</sub> = Electricity savings per purchased ENERGY STAR room air conditioner.

DSav<sub>RAC1</sub> = Summer demand savings per purchased ENERGY STAR room air conditioner.

ESav<sub>RAC1</sub> = Electricity savings per purchased Tier 2 room air conditioner.

DSav<sub>RAC2</sub> = Summer demand savings per purchased Tier 2 room air conditioner.

ESav<sub>RAC1</sub> = Electricity savings per purchased ENERGY STAR room air purifier.

DSav<sub>RAP</sub> = Summer demand savings per purchased ENERGY STAR room air purifier.

ESav<sub>FRZ</sub> = Electricity savings per purchased ENERGY STAR freezer.

DSav<sub>FRZ</sub> = Summer demand savings per purchased ENERGY STAR freezer.

ESav<sub>SDB</sub> = Electricity savings per purchased ENERGY STAR soundbar.

DSav<sub>SDB</sub> = Summer demand savings per purchased ENERGY STAR soundbar

TAF = Temperature Adjustment Factor

LSAF = Load Shape Adjustment Factor

CF<sub>REF</sub>, CF<sub>CW</sub>, CF<sub>DH</sub>, CF<sub>RAC</sub>, CF<sub>STB</sub>, , , CF<sub>APS</sub>, CF<sub>CD</sub> = Summer demand coincidence factor.

**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
CF <sub>REF</sub> , CF <sub>CW</sub> , CF <sub>STB</sub> , CF <sub>APS</sub> , CF <sub>CD</sub>	Fixed	1.0, 1.0, 1.0, 1.0, 1.0, 1.0	4
<u>CF<sub>AC</sub></u>	<u>Fixed</u>	<u>0.31</u>	<u>14</u>
ESavSTB	Fixed	44 kWh	6
DSavSTB	Fixed	0.005 kW	6
ESavAPS1	Fixed	102.8 kWh	8
DSavAPS1	Fixed	0.012 kW	8
ESavAPS2	Fixed	346 kWh	9

Component	Type	Value	Sources
DSaV <sub>APS2</sub>	Fixed	0.039 kW	9
APS, STB Time Period Allocation Factors	Fixed	Summer/On-Peak 16% Summer/Off-Peak 17% Winter/On-Peak 32% Winter/Off-Peak 35%	10
ESaV <sub>CDE1</sub>	Fixed	186 kWh	12
DSaV <sub>CDE1</sub>	Fixed	0.016 kW	12
ESaV <sub>CDG1</sub>	Fixed	9 kWh	12
DSaV <sub>CDG1</sub>	Fixed	0.001 kW	12
GSaV <sub>CDG1</sub>	Fixed	5.8 therms	12
ESaV <sub>CDE2</sub>	Fixed	388 kWh	12,13
DSaV <sub>CDE2</sub>	Fixed	0.029 kW	12,13
<u>ESaV<sub>CDG2</sub></u>	<u>Fixed</u>	<u>42.94 kWh</u>	<u>14</u>
<u>DSaV<sub>CDG2</sub></u>	<u>Fixed</u>	<u>0.003 kW</u>	<u>14</u>
<u>GSaV<sub>CDG2</sub></u>	<u>Fixed</u>	<u>7.69 therms</u>	<u>14</u>
<u>ESaV<sub>RAC1</sub></u>	<u>Fixed</u>	<u>9 kWh</u>	<u>14</u>
<u>DSaV<sub>RAC1</sub></u>	<u>Fixed</u>	<u>0.008</u>	<u>14</u>
<u>ESaV<sub>RAC2</sub></u>	<u>Fixed</u>	<u>19.3 kWh</u>	<u>14</u>
<u>DSaV<sub>RAC2</sub></u>	<u>Fixed</u>	<u>0.018</u>	<u>14</u>
<u>ESaV<sub>RAP</sub></u>	<u>Variable</u>	<u>Dependent on CARD</u>	
<u>DSaV<sub>RAP</sub></u>	<u>Variable</u>	<u>Dependent on CADR</u>	
<u>ESaV<sub>FRZ</sub></u>	<u>Fixed</u>	<u>41.2 kWh</u>	<u>14</u>
<u>DSaV<sub>FRZ</sub></u>	<u>Fixed</u>	<u>0.0067 kW</u>	<u>14</u>
<u>ESaV<sub>SDB</sub></u>	<u>Fixed</u>	<u>44 kWh</u>	<u>15</u>
<u>DSaV<sub>SDB</sub></u>	<u>Fixed</u>	<u>0.0005 kW</u>	<u>15</u>
<u>TAF</u>	<u>Fixed</u>	<u>1.23</u>	<u>14</u>
<u>LSAF</u>	<u>Fixed</u>	<u>1.15</u>	<u>14</u>

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 page 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.cce1.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 NYSEDA Measure Characterization for Advanced Power Strips. Study based on review of:
  - a. Smart Strip Electrical Savings and Usability, Power Smart Engineering, October 27, 2008.
  - b. Final Field Research Report, Ecos Consulting, October 31, 2006. Prepared for California Energy Commission's PIER Program.
  - c. Developing and Testing Low Power Mode Measurement Methods, Lawrence Berkeley National Laboratory (LBNL), September 2004. Prepared for California Energy Commission's Public Interest Energy Research (PIER) Program.
  - d. 2005 Intrusive Residential Standby Survey Report, Energy Efficient Strategies, March, 2006.
9. Energy savings estimates are based on a California Plug Load Research Center report, "Tier 2 Advanced Power Strip Evaluation for Energy Saving Incentive." Demand savings estimated based on a flat 8760 hours of use during the year. Savings for Tier 2 APS are temporarily included pending additional support.
10. 2011 Efficiency Vermont Load shape for Advanced Power Strips
11. Advanced Power Strip Measure Life: David Rogers, Power Smart Engineering, October 2008: "Smart Strip electrical savings and usability", p22.
12. Clothes dryer energy and demand savings are based on Mid-Atlantic Technical Reference Manual Version 5.0 April 2015 page 237 available at <http://www.neep.org/mid-atlantic-technical-reference-manual-v5>. 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.
13. Savings for clothes dryers meeting the 2014 Emerging Technology Award criteria assume an average of measured performance and a 50% usage of both normal and most efficient dryer settings for eligible models.

- [14. Mid-Atlantic TRM V5](#)
- [15. Mid-Atlantic TRM V6 Draft](#)

## Residential ENERGY STAR Lighting

### Protocols

Savings from installation of screw-in ENERGY STAR CFLs, ENERGY STAR fluorescent torchieres, ENERGY STAR indoor fixtures and ENERGY STAR outdoor fixtures 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. An “in-service” rate is used to reflect the fact that not all lighting products purchased are actually installed.

The general form of the equation for the ENERGY STAR or other high efficiency lighting energy savings algorithm is:

Number of Units X Savings per Unit

Per unit savings estimates are derived primarily from a 2004 Nexus Market Research report evaluating similar retail lighting programs in New England (MA, RI and VT). Per unit savings will decrease for CFLs in operation after 2012 due to the effects of federal minimum efficiency standards for incandescent lighting. Because CFLs typically have rated lifespans of 6-8000 hours (5-7 years) and incandescent light bulbs are rated at 1000 hours (1 year), after 2013 there will be less of a difference between CFLs in service and the incandescents that they would have been replacing.

National lighting efficiency standards are being increased according to the Energy Independence and Security Act of 2007 (EISA).<sup>8</sup> EISA pertains to the efficiency of newly manufactured bulbs, not existing stock. Existing *Protocol* baselines and measure lifetimes will remain until the impact of the standard can be fully measured and quantified. The future EISA wattage standards are:

#### EISA Phase 1 Standard for General Service Bulbs

Rated Lumen Ranges	Maximum Rate Wattage	Minimum Rate Lifetime	Effective Date	Efficacy Ranges (lumens per watt)
1490-2600 (~90W – 150W)	72	1000 hrs	1/1/2012	21 – 36
1050-1489 (~75W – 90W)	53	1000 hrs	1/1/2013	20 – 28
750-1049 (~60W – 75W)	43	1000 hrs	1/1/2014	17 – 24
310-749 (~30W – 60W)	29	1000 hrs	1/1/2014	11 – 26

<sup>8</sup> EISA information available at <http://www1.eere.energy.gov/femp/regulations/eisa.html>

**ENERGY STAR CFL Standard and Specialty Bulbs**

***Standard CFL Wattage Equivalency 1***

<b>Minimum Lumens</b>	<b>Maximum Lumens</b>	<b>Watts<sub>base</sub></b>
<u>4000</u>	<u>6000</u>	<u>300</u>
<u>3001</u>	<u>3999</u>	<u>200</u>
<u>2550</u>	<u>3000</u>	<u>150</u>
<u>2000</u>	<u>2549</u>	<u>125</u>
<u>1600</u>	<u>1999</u>	<u>72</u>
<u>1100</u>	<u>1599</u>	<u>53</u>
<u>800</u>	<u>1099</u>	<u>43</u>
<u>450</u>	<u>799</u>	<u>29</u>
<u>250</u>	<u>449</u>	<u>25</u>

***Specialty CFL Wattage Equivalency 1***

<b>Bulb Type</b>	<b>Lower Lumen Range</b>	<b>Upper Lumen Range</b>	<b>WattsBase</b>
<b>3-Way</b>	<u>250</u>	<u>449</u>	<u>25</u>
	<u>450</u>	<u>799</u>	<u>40</u>
	<u>800</u>	<u>1099</u>	<u>60</u>
	<u>1100</u>	<u>1599</u>	<u>75</u>
	<u>1600</u>	<u>1999</u>	<u>100</u>
	<u>2000</u>	<u>2549</u>	<u>125</u>
	<u>2550</u>	<u>2999</u>	<u>150</u>
<b>Globe (medium and intermediate bases less than 750 lumens)</b>	<u>90</u>	<u>179</u>	<u>10</u>
	<u>180</u>	<u>249</u>	<u>15</u>
	<u>250</u>	<u>349</u>	<u>25</u>
	<u>350</u>	<u>749</u>	<u>40</u>
<b>Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)</b>	<u>70</u>	<u>89</u>	<u>10</u>
	<u>90</u>	<u>149</u>	<u>15</u>
	<u>150</u>	<u>299</u>	<u>25</u>
	<u>300</u>	<u>749</u>	<u>40</u>
<b>Globe (candelabra bases less than 1050 lumens)</b>	<u>90</u>	<u>179</u>	<u>10</u>
	<u>180</u>	<u>249</u>	<u>15</u>
	<u>250</u>	<u>349</u>	<u>25</u>
	<u>350</u>	<u>499</u>	<u>40</u>
	<u>500</u>	<u>1049</u>	<u>60</u>
<b>Decorative</b>	<u>70</u>	<u>89</u>	<u>10</u>
	<u>90</u>	<u>149</u>	<u>15</u>
	<u>150</u>	<u>299</u>	<u>25</u>

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
(Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	<u>300</u>	<u>499</u>	<u>40</u>
	<u>500</u>	<u>1049</u>	<u>60</u>
Reflector with medium screw bases w/ diameter <=2.25"	<u>400</u>	<u>449</u>	<u>40</u>
	<u>450</u>	<u>499</u>	<u>45</u>
	<u>500</u>	<u>649</u>	<u>50</u>
	<u>650</u>	<u>1199</u>	<u>65</u>
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter >2.5" (*see exceptions below)	<u>640</u>	<u>739</u>	<u>40</u>
	<u>740</u>	<u>849</u>	<u>45</u>
	<u>850</u>	<u>1179</u>	<u>50</u>
	<u>1180</u>	<u>1419</u>	<u>65</u>
	<u>1420</u>	<u>1789</u>	<u>75</u>
	<u>1790</u>	<u>2049</u>	<u>90</u>
	<u>2050</u>	<u>2579</u>	<u>100</u>
	<u>2580</u>	<u>3429</u>	<u>120</u>
	<u>3430</u>	<u>4270</u>	<u>150</u>
R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter > 2.26" and ≤ 2.5" (*see exceptions below)	<u>540</u>	<u>629</u>	<u>40</u>
	<u>630</u>	<u>719</u>	<u>45</u>
	<u>720</u>	<u>999</u>	<u>50</u>
	<u>1000</u>	<u>1199</u>	<u>65</u>
	<u>1200</u>	<u>1519</u>	<u>75</u>
	<u>1520</u>	<u>1729</u>	<u>90</u>
	<u>1730</u>	<u>2189</u>	<u>100</u>
	<u>2190</u>	<u>2899</u>	<u>120</u>
	<u>2900</u>	<u>3850</u>	<u>150</u>
*ER30, BR30, BR40, or ER40	<u>400</u>	<u>449</u>	<u>40</u>
	<u>450</u>	<u>499</u>	<u>45</u>
	<u>500</u>	<u>649-1179<sup>9</sup></u>	<u>50</u>
*BR30, BR40, or ER40	<u>650</u>	<u>1419</u>	<u>65</u>
*R20	<u>400</u>	<u>449</u>	<u>40</u>
	<u>450</u>	<u>719</u>	<u>45</u>
*All reflector lamps below lumen ranges specified above	<u>200</u>	<u>299</u>	<u>20</u>
	<u>300</u>	<u>399-639<sup>10</sup></u>	<u>30</u>

$$\text{Energy Savings (kWh)} = (\text{CFL}_{\text{watts}} \frac{[\text{CFL}_{\text{base}} - \text{CFL}_{\text{ee}}]}{1000}) \times \text{CFL}_{\text{hours}} \times 365 \times \text{CFL}_{\text{ISR}}$$

$$\text{Demand Savings (kW)} = \frac{[\text{CFL}_{\text{base}} - \text{CFL}_{\text{ee}}]}{1000} (\text{CFL}_{\text{watts}} / 1000) \times \text{CF} \times \text{CFL}_{\text{ISR}}$$

<sup>9</sup> The upper bounds for these categories depends on the lower bound of the next higher wattage, which varies by bulb type.

<sup>10</sup> As above.

ENERGY STAR Torchieres

Electricity Impact (kWh) = (Torch<sub>watts</sub>/1000) X Torch<sub>hours</sub> X 365 X Torch<sub>ISR</sub>

Peak Demand Impact (kW) = (Torch<sub>watts</sub>/1000) X Light CF X Torch<sub>ISR</sub>

ENERGY STAR Indoor Fixture

Electricity Impact (kWh) = (IF<sub>watts</sub>/1000) X IF<sub>hours</sub> X 365 X IF<sub>ISR</sub>

Peak Demand Impact (kW) = (IF<sub>watts</sub>/1000) X Light CF X IF<sub>ISR</sub>

ENERGY STAR Outdoor Fixture

Electricity Impact (kWh) = (OF<sub>watts</sub>/1000) X OF<sub>hours</sub> X 365 X OF<sub>ISR</sub>

Peak Demand Impact (kW) = (OF<sub>watts</sub>/1000) X Light CF X OF<sub>ISR</sub>

ENERGY STAR LED Recessed Downlights & Integral ~~Lamps~~LampsFixtures

***LED Fixture Wattage Equivalency***

<u>Bulb Type</u>	<u>Lower Lumen Range</u>	<u>Upper Lumen Range</u>	<u>WattsBase</u>
<u>Reflector with medium screw bases w/ diameter &lt;=2.25"</u>	<u>400</u>	<u>449</u>	<u>40</u>
	<u>450</u>	<u>499</u>	<u>45</u>
	<u>500</u>	<u>649</u>	<u>50</u>
	<u>650</u>	<u>1199</u>	<u>65</u>
<u>R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter &gt;2.5" (*see exceptions below)</u>	<u>640</u>	<u>739</u>	<u>40</u>
	<u>740</u>	<u>849</u>	<u>45</u>
	<u>850</u>	<u>1179</u>	<u>50</u>
	<u>1180</u>	<u>1419</u>	<u>65</u>
	<u>1420</u>	<u>1789</u>	<u>75</u>
	<u>1790</u>	<u>2049</u>	<u>90</u>
	<u>2050</u>	<u>2579</u>	<u>100</u>
	<u>2580</u>	<u>3429</u>	<u>120</u>
<u>R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter &gt; 2.26" and ≤ 2.5" (*see exceptions below)</u>	<u>3430</u>	<u>4270</u>	<u>150</u>
	<u>540</u>	<u>629</u>	<u>40</u>
	<u>630</u>	<u>719</u>	<u>45</u>
	<u>720</u>	<u>999</u>	<u>50</u>
	<u>1000</u>	<u>1199</u>	<u>65</u>
	<u>1200</u>	<u>1519</u>	<u>75</u>
	<u>1520</u>	<u>1729</u>	<u>90</u>
<u>1730</u>	<u>2189</u>	<u>100</u>	

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
	<u>2190</u>	<u>2899</u>	<u>120</u>
	<u>2900</u>	<u>3850</u>	<u>150</u>
<u>*ER30, BR30, BR40, or ER40</u>	<u>400</u>	<u>449</u>	<u>40</u>
	<u>450</u>	<u>499</u>	<u>45</u>
	<u>500</u>	<u>649-1179<sup>11</sup></u>	<u>50</u>
<u>*BR30, BR40, or ER40</u>	<u>650</u>	<u>1419</u>	<u>65</u>
<u>*R20</u>	<u>400</u>	<u>449</u>	<u>40</u>
	<u>450</u>	<u>719</u>	<u>45</u>
<u>*All reflector lamps below lumen ranges specified above</u>	<u>200</u>	<u>299</u>	<u>20</u>
	<u>300</u>	<u>399-639<sup>12</sup></u>	<u>30</u>

$$\text{Energy Savings (kWh)} = ((\text{LEDF}_{\text{base}} - \text{LEDF}_{\text{ec}}] / 1000) \times \text{LEDF}_{\text{Hours}} \times 365 \times \text{LEDF}_{\text{ISR}}$$

$$\text{Demand Savings (kW)} = ((\text{LEDF}_{\text{base}} - \text{LEDF}_{\text{ec}}] / 1000) \times \text{CF} \times \text{LEDF}_{\text{ISR}}$$

$$\text{Energy Savings (kWh)} = ((\text{LED}_{\text{watts}} / 1000) \times \text{LED}_{\text{Hours}} \times 365 \times \text{LED}_{\text{ISR}}$$

$$\text{Demand Savings (kW)} = (\text{LED}_{\text{watts}} / 1000) \times \text{CF} \times \text{LED}_{\text{ISR}}$$

#### ENERGY STAR LED Standard and Specialty Bulbs

##### LED Wattage Equivalency

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
<u>Standard</u>	<u>250</u>	<u>449</u>	<u>25</u>
	<u>450</u>	<u>799</u>	<u>29</u>
	<u>800</u>	<u>1099</u>	<u>43</u>
	<u>1100</u>	<u>1599</u>	<u>53</u>
	<u>1600</u>	<u>1999</u>	<u>72</u>
	<u>2000</u>	<u>2549</u>	<u>125</u>
	<u>2550</u>	<u>3000</u>	<u>150</u>
	<u>3001</u>	<u>3999</u>	<u>200</u>
	<u>4000</u>	<u>6000</u>	<u>300</u>
<u>3-Way</u>	<u>250</u>	<u>449</u>	<u>25</u>
	<u>450</u>	<u>799</u>	<u>40</u>
	<u>800</u>	<u>1099</u>	<u>60</u>
	<u>1100</u>	<u>1599</u>	<u>75</u>

<sup>11</sup> The upper bounds for these categories depends on the lower bound of the next higher wattage, which varies by bulb type.

<sup>12</sup> As above.

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
	<u>1600</u>	<u>1999</u>	<u>100</u>
	<u>2000</u>	<u>2549</u>	<u>125</u>
	<u>2550</u>	<u>2999</u>	<u>150</u>
<b>Globe</b> <b>(medium and intermediate bases less than 750 lumens)</b>	<u>90</u>	<u>179</u>	<u>10</u>
	<u>180</u>	<u>249</u>	<u>15</u>
	<u>250</u>	<u>349</u>	<u>25</u>
	<u>350</u>	<u>749</u>	<u>40</u>
<b>Decorative</b> <b>(Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)</b>	<u>70</u>	<u>89</u>	<u>10</u>
	<u>90</u>	<u>149</u>	<u>15</u>
	<u>150</u>	<u>299</u>	<u>25</u>
	<u>300</u>	<u>749</u>	<u>40</u>
<b>Globe</b> <b>(candelabra bases less than 1050 lumens)</b>	<u>90</u>	<u>179</u>	<u>10</u>
	<u>180</u>	<u>249</u>	<u>15</u>
	<u>250</u>	<u>349</u>	<u>25</u>
	<u>350</u>	<u>499</u>	<u>40</u>
	<u>500</u>	<u>1049</u>	<u>60</u>
<b>Decorative</b> <b>(Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)</b>	<u>70</u>	<u>89</u>	<u>10</u>
	<u>90</u>	<u>149</u>	<u>15</u>
	<u>150</u>	<u>299</u>	<u>25</u>
	<u>300</u>	<u>499</u>	<u>40</u>
	<u>500</u>	<u>1049</u>	<u>60</u>
<b>Reflector with medium screw bases w/ diameter &lt;=2.25"</b>	<u>400</u>	<u>449</u>	<u>40</u>
	<u>450</u>	<u>499</u>	<u>45</u>
	<u>500</u>	<u>649</u>	<u>50</u>
	<u>650</u>	<u>1199</u>	<u>65</u>
<b>R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter &gt;2.5" (*see exceptions below)</b>	<u>640</u>	<u>739</u>	<u>40</u>
	<u>740</u>	<u>849</u>	<u>45</u>
	<u>850</u>	<u>1179</u>	<u>50</u>
	<u>1180</u>	<u>1419</u>	<u>65</u>
	<u>1420</u>	<u>1789</u>	<u>75</u>
	<u>1790</u>	<u>2049</u>	<u>90</u>
	<u>2050</u>	<u>2579</u>	<u>100</u>
	<u>2580</u>	<u>3429</u>	<u>120</u>
	<u>3430</u>	<u>4270</u>	<u>150</u>
<b>R, PAR, ER, BR, BPAR or similar bulb shapes with medium screw bases w/ diameter &gt; 2.26" and ≤ 2.5" (*see exceptions below)</b>	<u>540</u>	<u>629</u>	<u>40</u>
	<u>630</u>	<u>719</u>	<u>45</u>
	<u>720</u>	<u>999</u>	<u>50</u>
	<u>1000</u>	<u>1199</u>	<u>65</u>
	<u>1200</u>	<u>1519</u>	<u>75</u>
	<u>1520</u>	<u>1729</u>	<u>90</u>





$I_{F_{hours}}$  = Average hours of use per day per Indoor Fixture

$I_{F_{ISR}}$  = In-service rate per Indoor Fixture

$O_{F_{watts}}$  = Average delta watts per purchased ENERGY STAR Outdoor Fixture

$O_{F_{hours}}$  = Average hours of use per day per Outdoor Fixture

$O_{F_{ISR}}$  = In-service rate per Outdoor Fixture

$CF_{Fixtures}$  = Summer demand coincidence factor for CFL fixtures.

$LED_{watts}$  = LED<sub>base</sub> = Based on lumens of the LED = Average delta watts per purchased LED recessed downlight or integral lamp

LED<sub>ec</sub> = Actual wattage of LED purchased/installed

LED<sub>hours</sub> = Average hours of use per day per LED recessed downlight or integral lamp

LED<sub>ISR</sub> = In-service rate per LED recessed downlight or integral lamp

LED<sub>Fbase</sub> = Based on lumens of the LED Fixture

LED<sub>Fec</sub> = Actual wattage of LED Fixture purchased/installed

LED<sub>Fhours</sub> = Average hours of use per day per LED Fixture recessed downlight or integral lamp

LED<sub>FISR</sub> = In-service rate per LED Fixture recessed downlight or integral lamp

### ENERGY STAR Lighting

Component	Type	Value	Sources
<del>CFL<sub>watts</sub></del> <del>CFL<sub>watts</sub></del> <del>CFL<sub>base</sub></del> <del>CFL<sub>watts</sub></del>	<del>Fixed</del> <del>Fixed</del> <del>Variable</del>	<del>32.99</del> <del>Based on lumens</del> <del>9</del>	<del>5</del> <del>5</del> <del>5</del>
<del>CFL<sub>ec</sub></del>	<del>Variable</del>	<del>Actual bulb wattage</del>	
<del>CFL<sub>hours</sub></del>	<del>Fixed</del>	<del>2.8</del>	<del>6</del>
<del>CFL<sub>ISR</sub></del>	<del>Fixed</del>	<del>83.4%</del>	<del>5</del>
<del>CF<sub>Bulb</sub></del>	<del>Fixed</del>	<del>9.9 %</del>	<del>4</del>
<del>Torch<sub>watts</sub></del>	<del>Fixed</del>	<del>78.5</del>	<del>1</del>
<del>Torch<sub>hours</sub></del>	<del>Fixed</del>	<del>3.0</del>	<del>2</del>
<del>Torch<sub>ISR</sub></del>	<del>Fixed</del>	<del>83%</del>	<del>3</del>
<del>I<sub>F<sub>watts</sub></sub></del>	<del>Fixed</del>	<del>32.9</del>	<del>1</del>
<del>I<sub>F<sub>hours</sub></sub></del>	<del>Fixed</del>	<del>2.6</del>	<del>2</del>
<del>I<sub>F<sub>ISR</sub></sub></del>	<del>Fixed</del>	<del>95%</del>	<del>3</del>

Component	Type	Value	Sources
OF <sub>watts</sub>	Fixed	64.2	1
OF <sub>hours</sub>	Fixed	4.5	2
OF <sub>ISR</sub>	Fixed	87%	3
CF <sub>Fixture</sub>	Fixed	5%	4
LED <sub>watts</sub>	Fixed Fixed Variable	36.88 Based on lumens <sup>8</sup>	7787
LED <sub>ce</sub>	Variable	Actual bulb wattage	
LED <sub>hours</sub>	Fixed	2.8	6
LED <sub>ISR</sub>	Fixed	100%	7
CF <sub>LED</sub>	Fixed	8.2%	
LEDF <sub>watts</sub>	Variable	Based on lumens	8
LEDF <sub>ce</sub>	Variable	Actual fixture wattage	
LEDF <sub>hours</sub>	Fixed	2.8	6
LEDF <sub>ISR</sub>	Fixed	100%	7
CF <sub>LEDF</sub>	Fixed	8.2%	

Sources:

1. Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 43 (Table 4-9) The delta watts are reduced by 22.2% in the same proportion to individual CFLs (48.5W to 32.9W) following full enactment of EISA requirements.
2. US Department of Energy, Energy Star Calculator.
3. Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004. p. 42 (Table 4-7). These values reflect both actual installations and the % of units planned to be installed within a year from the logged sample. The logged % is used because the adjusted values (i.e. to account for differences between logging and telephone survey samples) were not available for both installs and planned installs. However, this seems appropriate because the % actual installed in the logged sample from this table is essentially identical to the % after adjusting for differences between the logged group and the telephone sample (p. 100, Table 9-3).
4. RLW Analytics, "Development of Common Demand Impacts for Energy Efficiency Measures/Programs for the ISO Forward Capacity Market (FCM)", prepared for the New England State Program Working Group (SPWG), March 25, 2007, p. IV.
5. The average wattage (18.4W) of the standard CFL established in the 2009 "NJCEP Residential CFL Impact Evaluation and Protocol Review", September 28, 2008, p.3-8 (Table 3-6) is adjusted by a post-EISA multiplier (1.79) of the 2014 Mid-Atlantic Technical Reference Manual V4.0 for calculating the new delta watts after the incandescent bulb wattage is reduced (from 100W to 72W in 2012, 75W to 53W in 2013 and 60W to 43W and 40W to 29W in 2014).
6. RLW Analytics, *New England Residential Lighting Markdown Impact Evaluation*, January 20, 2009.
7. For determining demand savings the baseline was adopted from 2009 KEMA evaluation and represents the replacement of a 65W BR30 downlight and high efficiency is the average of ENERGY STAR qualified downlights (11/10/2009) with lighting output

exceeding 475 lumens. Due to the high incremental cost and limited market availability of products, the higher ISR reflects the assumption that every LED downlight purchased is directed towards immediate use.

8. [Mid-Atlantic TRM V5](#)

## Home Energy Reporting System

### Protocols

The purpose of the program is to provide information and tools that residential customers can use to make decisions about what actions to take to improve energy efficiency in their homes. The information is mailed in reports separately from a utility’s regular bill to create a neighbor-to-neighbor comparison where homes of similar size are compared to each other, as well as targeting energy saving tips to individuals. The quantity and timing of mailed reports will vary by utility and fuel type.

### *Home Energy Reporting System*

Gas Savings (Therms) =  $GS_{\text{VHERS}}$

Component	Type	Value	Sources
$GS_{\text{VHERS}}$	Fixed	13.1 therms	1

Sources:

1. The average natural gas savings from similar program offered to Puget Sound Energy customers. (Reference: Evidence from Two Large Field Experiments that Peer Comparison Feedback Can Reduce Residential Energy Usage, Ayres, 2009)

## Refrigerator/Freezer Retirement Program

### Protocols

The general form of the equation for the Refrigerator/Freezer Retirement Program savings algorithm is:

Number of Units X Savings per Unit

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

Unit savings are the product of average fridge/freezer consumption (gross annual savings), and a net to gross ratio that adjusts for both free ridership and the portion of retired units that are replaced with more efficient new units.

### Algorithm

New Jersey Clean Energy Program  
Protocols to Measure Resource Savings

TBD

Electricity Impact (kWh) = ESavRetFridge ESavRAC ESavDEH

Demand Impact (kW) = DSavRetFridge X 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.

**REFRIGERATOR/FREEZER RECYCLING**

<b>Component</b>	<b>Type</b>	<b>Value</b>	<b>Sources</b>
ESavRetFridge	Fixed	761 kWh	1
ESavRetFreezer	Fixed	639 kWh	1
<u>ESavRAC</u>	<u>Fixed</u>	<u>166 kWh</u>	<u>4</u>
<u>ESavDEH</u>	<u>Fixed</u>	<u>169 kWh</u>	<u>5</u>
DSavRetFridge	Fixed	0.114 kW	3
DSavRetFreezer	Fixed	0.114 kW	3
<u>DSavRAC</u>	<u>Fixed</u>	<u>0.16 kW</u>	<u>4</u>
<u>DSavDEH</u>	<u>Fixed</u>	<u>0.114</u>	<u>5</u>
CFRetFridge	Fixed	1	4

Sources:

1. Northeast Energy Efficiency Partnerships, “Mid-Atlantic Technical Reference Manual”, Version 4.0, June, 2014, p. 96. Savings incorporate regression analysis results of EmPower Maryland evaluation of the 2013 Appliance Recycling Program.
2. Northeast Energy Efficiency Partnerships, “Mid-Atlantic Technical Reference Manual”, Version 4.0, June, 2014, p. 98.
3. Coincidence factor already embedded in summer peak demand reduction estimates
4. Mid-Atlantic TRM V5
5. Rhode Island TRM 2016 Program Year - [https://www9.nationalgridus.com/non\\_html/eer/ri/PY2016%20RI%20TRM.pdf](https://www9.nationalgridus.com/non_html/eer/ri/PY2016%20RI%20TRM.pdf) (pg 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 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.<sup>15</sup>
- Software approved by the US Department of Energy's Weatherization Assistance Program.<sup>16</sup>
- RESNET approved rating software.<sup>17</sup>

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.

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<sup>15</sup> Information about BESTEST-EX can be found at [http://www.nrel.gov/buildings/bestest\\_ex.html](http://www.nrel.gov/buildings/bestest_ex.html).

<sup>16</sup> A listing of the approved software available at [http://www.waptac.org/data/files/Website\\_Docs/technical\\_tools/EnergyAuditMatrixTable2.pdf](http://www.waptac.org/data/files/Website_Docs/technical_tools/EnergyAuditMatrixTable2.pdf).

<sup>17</sup> A listing of the approved software available at <http://resnet.us>.

## Commercial and Industrial Energy Efficient Construction

### C&I Electric Protocols

#### *Baselines and Code Changes*

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. There are exceptions to this approach, as in the Direct Install program (see below).

Baseline data reflect [ASHRAE 90.1-2007 for existing building retrofit and ASHRAE 90.1-2013 for new construction and entire facility rehabilitation](#) unless otherwise noted for applications designated "2011".

~~The Energy Independence and Security Act of 2007 (EISA) was implemented on July 14, 2012 for general service fluorescent lamps and general service bulbs. EISA pertains to the efficiency of newly manufactured lamps, not existing stock. Existing *Protocol* baselines and measure lifetimes will remain until the impact of the standard can be fully measured and quantified. The future EISA wattage standards are:~~

**EISA Phase 1 Standard for General Service Fluorescent Lamps**

Lamp/Tube type	Correlated color temperature (CCT)	Minimum average lamp efficacy (lm/W)
4-foot medium bipin	≤4,500K	89
	>4,500K and ≤7,000K	88
2-foot U-shaped	≤4,500K	84
	>4,500K and ≤7,000K	81
8-foot slimline	≤4,500K	97
	>4,500K and ≤7,000K	93
8-foot high output	≤4,500K	92
	>4,500K and ≤7,000K	88
4-foot miniature bipin standard output	≤4,500K	86
	>4,500K and ≤7,000K	81
4-foot miniature bipin high output	≤4,500K	76
	>4,500K and ≤7,000K	72

The wattage table for general service light bulbs is located in the Residential ENERGY STAR Lighting section of the *Protocols*.

**Building Shell**

Building shell measures identified in an approved Local Government Energy Audit (or equivalent) ~~are eligible for program incentives for a limited time through ARRA funding~~ 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~~ energy analysis provided with the application submission.

**Performance Lighting**

For new construction and entire facility rehabilitation projects, savings are calculated by comparing the lighting power density of ~~fixture~~ fixtures being installed to the baseline power densities from ASHRAE 90.1 ~~2007~~ 2013.

Lighting equipment includes fluorescent fixtures, ballasts, compact fluorescent fixtures, ~~exit signs~~, LED fixtures, and metal halide lamps. The measurement of energy savings is based on algorithms with measurement of key variables (i.e., Coincidence Factor and Operating Hours)

through end-use metering data accumulated from a large sample of participating facilities from 1995 through 1999.

Algorithms

Demand Savings =  $\Delta kW \times CF \times (1+IF)$

Energy Savings =  $\Delta kW \times EFLH \times (1+IF)$

$\Delta kW = (LPD_{base} - LPD_{inst}) \times SF$

Definition of Variables

$\Delta kW$  = Change in connected load from baseline to efficient lighting level.

$LPD_{base}$  = 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)

$LPD_{inst}$  = Lighting power density of installed fixtures, equal to the sum of installed fixture wattage divided by floor area of the space where the fixtures are installed. Wattage of installed fixtures is based on table at [http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE\\_B\\_StandardFixtureWatts010108.pdf](http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE_B_StandardFixtureWatts010108.pdf).

SF = space floor area, Square Foot

CF = Coincidence Factor

EFLH = Equivalent Full Load Hours

IF = Interactive Factor

**Lighting Verification Summary Performance Lighting Summary**

Component	Type	Value	Source
$\Delta kW$	Fixed	See California SPC Table:  <a href="http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE_B_StandardFixtureWatts010108.pdf">http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE_B_StandardFixtureWatts010108.pdf</a>  And Formula Above.	<ul style="list-style-type: none"> <li>1</li> <li>Baseline LPD from ASHRAE 90.1-2007/2013/2007 Table 9.6.1</li> <li>Installed LPD, space type and floor area from customer application.</li> </ul>



Component	Type	Value	Source
CF	Fixed	See Lighting Table by <a href="#">Building Type</a>	2
IF	Fixed	See Lighting Table by Building Type	3
EFLH	Fixed	See Lighting Table by Building Type	3, 5

### Lighting by Building Type

Building Type	EFLH	CF	IF
Education – Primary School	1,440	0.57	0.15
Education – Secondary School	2,456	0.57	0.15
Education – Community College	3,416	0.64	0.15
Education – University	3,416	0.64	0.15
Grocery	6,019	0.88	0.13
Medical – Hospital	8,736	0.72	0.18
Medical – Clinic	4,007	0.72	0.18
Lodging Hotel (Guest Rooms)	1,145	0.67	0.14
Lodging Motel	8,736	1.00	0.14
Manufacturing – Light Industrial	4,781	0.63	0.04
Office- Large	3,642	0.68	0.17
Office-Small	3,642	0.68	0.17
Restaurant – Sit-Down	4,089	0.76	0.15
Restaurant – Fast-Food	6,188	0.76	0.15
Retail – 3-Story Large	4,103	0.78	0.11
Retail – Single-Story Large	4,103	0.78	0.11
Retail – Small	4,103	0.78	0.11
Storage Conditioned	4,290	0.69	0.06
Storage Heated or Unconditioned	4,290	0.69	0.00
Warehouse	4,009	0.69	0.06
Average = Miscellaneous	4,268	0.72	0.13

\*Note: Figures in italics are derived from NEEP Report – July 2011 (source #5)

#### Sources:

1. California Standard Performance Contracting Program
2. RLW Analytics, *Coincident Factor Study, Residential and Commercial & Industrial Lighting Measures*, 2007.
3. Quantum Consulting, Inc., for Pacific Gas & Electric Company, *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*, March 1, 1999
4. KEMA. *New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review*. 2009.
5. KEMA for NEEP. *C&I Lighting Load Shape Project*. July 19, 2011  
[http://www.neep.org/sites/default/files/products/NEEP\\_CI\\_Lighting\\_LS\\_FINAL\\_Report\\_ver\\_5\\_7-19-11.pdf](http://www.neep.org/sites/default/files/products/NEEP_CI_Lighting_LS_FINAL_Report_ver_5_7-19-11.pdf)

### ***Prescriptive Lighting***

This is a fixture replacement program for existing commercial customers targeted for facilities performing efficiency upgrades to their lighting systems.

The baseline for linear and U-bend fluorescent measures is standard T8 fixtures with electronic ballasts or actual existing HID fixtures.

~~The baseline for compact fluorescent is that the fixture replaced was 4 times the wattage of the replacement compact fluorescent.~~

The baseline for LED fixtures is the actual fixture being replaced.

The baseline for induction lighting is an equivalent pulse start metal halide fixture (6).

The baseline for LED refrigerator Case Lighting is that the fixture replaced was 2.63 times the wattage of the replacement LED (7).

New fixtures and technologies available after publication will be periodically updated. Baselines will be established based on the guidelines noted below.

#### Algorithms

$$\text{Demand Savings} = (\Delta kW) \times (CF) \times (1 + IF)$$

$$\text{Energy Savings} = (\Delta kW) \times (1 + IF) \times (EFLH)$$

$$\Delta kW = (\text{Number of fixtures installed} \times \text{baseline wattage for new fixture}) - (\text{number of replaced fixtures} \times \text{wattage from table})$$

\*For refrigerated case LED fixtures, the following protocols will be applied to account for the lighting and refrigeration energy savings associated with this measure.\*

#### Algorithms

$$\text{Demand Savings} = (\Delta kW) \times (CF) \times (1 + IF) \times (1 + (0.28 \times \text{Eff}))$$

$$\text{Energy Savings} = (\Delta kW) \times (1 + IF) \times EFLH \times (1 + (0.28 \times \text{Eff}))$$

#### Definition of Variables

$\Delta kW$  = Change in connected load from baseline to efficient lighting level.

CF = Coincidence Factor

New Jersey Clean Energy Program  
Protocols to Measure Resource Savings

TBD

EFLH = Equivalent Full Load Hours

IF = Interactive Factor

0.28 = Conversion from kW to tons (Refrigeration)

Eff = Efficiency of typical refrigeration system in kW/ton

### Prescriptive Lighting for Commercial Customers

Component	Type	Value	Source
$\Delta$ kW	Fixed	See Lighting Wattage Table derived from California SPC Table at:  <a href="http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE_B_StandardsFixtureWatts010108.pdf">http://www.sce.com/NR/rdonlyres/FC51087D-2848-42DF-A52A-BDBA1A09BF8D/0/SCE_B_StandardsFixtureWatts010108.pdf</a>	1
CF	Fixed	See Lighting Table by Building in Performance Lighting Section Above	2
EFLH	Fixed	See Lighting Table by Building in Performance Lighting Section Above	3, 4
IF	Fixed	See Lighting Table by Building Type in Performance Lighting Section Above	3
Eff	Fixed	1.6	5

#### Sources & Notes:

1. California Standard Performance Contracting Program
2. RLW Analytics, *Coincident Factor Study, Residential and Commercial & Industrial Lighting Measures*, 2007.
3. Quantum Consulting, Inc., for Pacific Gas & Electric Company, *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*, March 1, 1999
4. KEMA for NEEP. *C&I Lighting Load Shape Project*. July 19, 2011  
[http://www.neep.org/sites/default/files/products/NEEP\\_CI\\_Lighting\\_LS\\_FINAL\\_Report\\_ver\\_5\\_7-19-11.pdf](http://www.neep.org/sites/default/files/products/NEEP_CI_Lighting_LS_FINAL_Report_ver_5_7-19-11.pdf)
5. Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual*. 2004.
6. For induction Lighting, used the lowest PSMH that would produce a 30% reduction in wattage to the induction fixture, which is the minimum requirement for incentives replacing HID with induction lighting. Assume 5% increase for input wattage vs nominal wattage.

7. Based on assuming LED is 62% more efficient than replacement as per RPI study:  
[http://www.lrc.rpi.edu/programs/solidstate/pdf/SPIE4776-13\\_Raghavan.pdf](http://www.lrc.rpi.edu/programs/solidstate/pdf/SPIE4776-13_Raghavan.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

Demand Savings = kW<sub>c</sub> X SVG X CF X (1+ IF)

Energy Savings = kW<sub>c</sub> X SVG X EFLH X (1+IF)

Definition of Variables

SVG = % of annual lighting energy saved by lighting control; refer to table by control type

kW<sub>c</sub> = kW lighting load connected to control

IF = Interactive Factor – This applies to C&I interior lighting only. This represents the secondary demand and energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage. This value will be fixed at 5%.

CF = Coincidence Factor – This value represents the percentage of the total load which is on during electric system’s peak window.

EFLH = Equivalent full load hours.

**Lighting Controls**

Component	Type	Value	Source
kW <sub>c</sub>	Variable	Load connected to control	Application
SVG	Fixed	Occupancy Sensor, Controlled Hi-Low Fluorescent Control, LED and controlled HID = 30% Daylight Dimmer System=50%	See sources below
CF	Fixed	See Lighting Table by Building in Performance Lighting Section Above	1
EFLH	Fixed	See Lighting Table by Building in Performance Lighting Section Above	2, 3

Component	Type	Value	Source
IF	Fixed	See Lighting Table by Building in Performance Lighting Section Above	2

Sources:

1. RLW Analytics, *Coincident Factor Study, Residential and Commercial & Industrial Lighting Measures*, 2007.
2. Quantum Consulting, Inc., for Pacific Gas & Electric Company, *Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies*, March 1, 1999
3. KEMA for NEEP. *C&I Lighting Load Shape Project*. July 19, 2011  
[http://www.neep.org/sites/default/files/products/NEEP\\_CI\\_Lighting\\_LS\\_FINAL\\_Report\\_ver\\_5\\_7-19-11.pdf](http://www.neep.org/sites/default/files/products/NEEP_CI_Lighting_LS_FINAL_Report_ver_5_7-19-11.pdf)

**Motors**

For premium efficiency motors 1-200 HP.

Algorithms

From application form calculate  $\Delta kW$  where:

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

Demand Savings =  $(\Delta kW) * CF$

Energy Savings =  $(\Delta kW) * HRS * LF$

Definition of Variables

$\Delta kW$  = kW Savings at full load

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

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

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

$\eta_{base}$  = Efficiency of the baseline motor

$\eta_{prem}$  = Efficiency of the energy-efficient motor

HRS = Annual operating hours

CF = Coincidence Factor

### Motors

Component	Type	Value	Source
HP	Variable	Nameplate/Manufacturer Spec. Sheet	Application
LF	Fixed	0.75	1
hp <sub>base</sub>	Fixed	<a href="#">EPACT ASHRAE 90.1-2013</a> Baseline Efficiency Table	<a href="#">EPACT Directory</a> <a href="#">ASHRAE Directory</a>
hp <sub>prem</sub>	Variable	Nameplate/Manufacturer Spec. Sheet	Application
IF <sub>VFD</sub>	Fixed	1.0 or 0.9	3
Efficiency - $\eta_{ee}$	Variable	Nameplate/Manufacturer Spec. Sheet	Application
CF	Fixed	0.74	1
HRS	Fixed	Annual Operating Hours Table	1

### EPAct Baseline Motor Efficiency Table

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

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



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

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

Annual Operating Hours Table

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

*Electronically Commutated Motors for Refrigeration*

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

## **EC Motor retrofits in Walk-in Coolers and Freezers**

### **Algorithms**

$$\Delta kW = ((\text{Amp}_{SEF} * \text{Volts}_{SEF} * (\text{Phase}_{EF})^{1/2})/1000) * \text{PF}_{EF} * \text{LR}65\%$$

$$\text{Gross kWh Savings} = kWh \text{ Savings}_{SEF} + kWh \text{ Savings}_{SRH}$$

$$kWh \text{ Savings}_{SEF} = ((\text{Amp}_{SEF} * \text{Volts}_{SEF} * (\text{Phase}_{EF})^{1/2})/1000) * \text{PF}_{EF} * \text{Operating Hours} * \text{LR}65\%$$

$$kWh \text{ Savings}_{SRH} = kWh \text{ Savings}_{SEF} * 0.28 * 1.6$$

### **PLEASE NOTE:**

“ $((\text{Amp}_{SEF} * \text{Volts}_{SEF} * (\text{Phase}_{EF})^{1/2})/1000) * \text{PF}_{EF}$ ” is equivalent to “ $HP * 0.746$ ”

### **Definition of Variables**

$\Delta kW$  = Demand Savings due to EC Motor Retrofit

$kWh \text{ Savings}_{SEF}$  = Savings due to Evaporator Fan Motors being replaced

$kWh \text{ Savings}_{SRH}$  = Savings due to reduced heat from Evaporator Fans

$\text{Amp}_{SEF}$  = Nameplate Amps of Evaporator Fan

$\text{Volts}_{SEF}$  = Nameplate Volts of Evaporator Fan

$\text{Phase}_{EF}$  = Phase of Evaporator Fan

$\text{PF}_{EF}$  = Evaporator Fan Power Factor

Operating Hours = Annual operating hours if Evaporator Fan Control

LR = Percent reduction of load by replacing motors

0.28 = Conversion from kW to tons (Refrigeration)

1.6 = Efficiency of typical refrigeration system in kW/ton

## **Case Motor Replacement**

### **Algorithms**

$$\text{Gross kWh Savings} = kWh \text{ Savings}_{SCM} + kWh \text{ Savings}_{SRH}$$

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

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

**Definition of Variables**

*kWh Savings<sub>CM</sub>* = Savings due to Case Motors being replaced

*kWh Savings<sub>RH</sub>* = 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

**ECM Fraction HP Motors**

<b>Component</b>	<b>Type</b>	<b>Value</b>	<b>Source</b>
Amps <sub>EF</sub>	Variable	Nameplate/Manufacturer Spec. Sheet	Application
Volt <sub>EF</sub>	Variable	Nameplate/Manufacturer Spec. Sheet	Application
Phase <sub>EF</sub>	Variable	Nameplate/Manufacturer Spec. Sheet	Application
PF <sub>EF</sub>	Fixed	0.55	1
Operating Hours	Fixed	Not Installed = 8,760 Installed = 5,600	
LR	Fixed	65%	2
ER	Fixed	Shaded Pole Motor Replaced = 53% PSC Motor Replaced = 29%	3
RT	Fixed	8500	
Eff	Fixed	1.6	

Sources:

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

**Electric HVAC Systems**

The measurement of energy and demand savings for C/I Efficient HVAC program for Room AC, Central AC, and air cooled DX is based on algorithms. (Includes split systems, [single package systems](#), air to [aircooled](#) heat pumps, packaged terminal systems, [water source heat pumps](#), [pumpsingle package vertical systems](#), central DX AC systems, [water source heat pumps](#), ground water [source heat pumps](#), and/or ground source heat pumps)

Algorithms

Air Conditioning Algorithms:

$$\text{Demand Savings} = (\text{BtuH}/1000) \times (1/\text{EER}_b - 1/\text{EER}_q) \times \text{CF}$$

$$\text{Energy Savings} = (\text{BtuH}/1000) \times (1/\text{EER}_b - 1/\text{EER}_q) \times \text{EFLH}$$

Heat Pump Algorithms

$$\text{Energy Savings-Cooling} = (\text{BtuH}_c/1000) \times (1/\text{EER}_b - 1/\text{EER}_q) \times \text{EFLH}_c$$

$$\text{Energy Savings-Heating} = \text{BtuH}_h/1000 \times ((1/(\text{COP}_b \times 3.412)) - (1/(\text{COP}_q \times 3.412))) \times \text{EFLH}_h$$

Where *c* is for cooling and *h* is for heating.

Definition of Variables

BtuH = Cooling capacity in Btu/Hour – This value comes from ARI/AHRI or AHAM rating or manufacturer data.

EER<sub>b</sub> = Energy Efficiency Ratio of the baseline unit. This data is found in the HVAC and Heat Pumps table below. For units < 65,000 BtuH, 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 Pump [verifications table below verification summary table](#). For units < 65,000 [BtuH](#), SEER and HSPF/3.412 should be used [in place of COP X 3.412](#), for cooling and heating savings, respectively.

$EER_q = \text{Energy COP}_q = \text{Coefficient of Performance of the High Efficiency unit}$  [Ratio of the high efficiency unit](#).— This value comes from the ARI/AHRI or AHAM directories or manufacturer data. For units < 65,000 [BtuH](#), SEER should be used [in place of EER](#).

$COP_q = \text{Coefficient of Performance of the High Efficiency unit}$ .— This value comes from the [ARI/AHRI or AHAM directories or manufacturer data](#). For units < 65,000 [BtuH](#), 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 will be based on existing measured usage and determined as the average number of operating hours during the peak window period.

EFLH = Equivalent Full Load Hours – This represents a measure of energy use by season during the on-peak and off peak periods. This value will be determined by existing measured data of kWh during the period divided by kW at design conditions.

### HVAC and Heat Pumps

Component	Type	Value	Source
BtuH	Variable	ARI/AHRI or AHAM or Manufacturer Data	Application
EER <sub>b</sub>	Variable	See Table below	Collaborative agreement and C/I baseline study
EER <sub>q</sub>	Variable	ARI/AHRI or AHAM Values	Application
CF	Fixed	67%	Engineering estimate
EFLH	Fixed	HVAC 1,495 HP cooling 381 HP heating 800	1, JCP&L metered data <sup>18</sup>

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<sup>18</sup> Results reflect metered use from 1995 – 1999.

### HVAC Baseline Table – Existing Buildings

Equipment Type	Baseline = ASHRAE Std. 90.1 - 2007
<u>Unitary HVAC/Split Systems and Single Package, Air Cooled</u> · ≤5.4 tons: · >5.4 to 11.25 tons · >11.25 to 20 tons · > 21 to 63 tons · >63 Tons	13 SEER 11 EER 10.8 EER 9.8 EER, <u>9.5 IPLV</u> 9.5 EER, <u>9.2 IPLV</u>
<u>Air-Air Cooled Heat Pump Systems, Split System and Single Package</u> · ≤5.4 tons: · >5.4 to 11.25 tons · >11.25 to 20 tons · ≥ 21	13 SEER, <u>7.7 HSPF</u> 10.8 EER, <u>3.3 heating COP</u> 10.4 EER, <u>3.2 heating COP</u> 9.3 EER, <u>9.0 IPLV, 3.2 heating COP</u>
<u>Package Terminal Systems</u> < 0.74 tons .75 – 1 ton > 1 ton	<u>12.5 - (0.213 * BTUHe/1000)</u>
<u>Water Source Heat Pumps</u> All Capacities ≤ 1.4 tons > 1.4 to 5.4 tons > 5.4 to 11.25 tons	12.0 EER <u>11.2 EER, 4.2 heating COP</u> <u>12.0 EER, 4.2 heating COP</u> <u>12.0 EER, 4.2 heating COP</u>
<u>Ground Water GWSHPs Source Heat Pumps</u> Open and Closed Loop All Capacities ≤ 11.25 tons	<u>16.2 EER, 3.6 heating COP</u>
<u>Ground Source Heat Pumps</u> ≤ 11.25 tons	<u>13.4 EER, 3.1 heating COP</u>
<u>Package Terminal Air Conditioners <sup>a</sup></u>	<u>12.5 - (0.213 * Cap/1,000), EER</u>
<u>Package Terminal Heat Pumps <sup>a</sup></u>	<u>12.3 - (0.213 * Cap/1,000), EER</u> <u>3.2 - (0.026 * Cap/1,000), heating COP</u>
<u>Single Package Vertical Air Conditioners</u> · ≤ 5.4 tons · > 5.4 to 11.25 tons · > 11.25 to 20 tons	<u>9.0 EER</u> <u>8.9 EER</u> <u>8.6 EER</u>
<u>Single Package Vertical Heat Pumps</u> · ≤ 5.4 tons · > 5.4 to 11.25 tons · > 11.25 to 20 tons	<u>9.0 EER, 3.0 heating COP</u> <u>8.9 EER, 3.0 heating COP</u> <u>8.6 EER, 2.9 heating COP</u>

**HVAC Baseline Table – New Construction**

<b>Equipment Type</b>	<b>Baseline = ASHRAE Std. 90.1 - 2013</b>
<u>Unitary HVAC/Split Systems and Single Package, Air Cooled</u> · <=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
<u>Air Cooled Heat Pump Systems, Split System and Single Package</u> · <=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
<u>Water Source Heat Pumps (water to air, water loop)</u> <=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
<u>Ground Water Source Heat Pumps</u> <=11.25 tons	18.0 EER, 3.7 heating COP
<u>Ground Source Heat Pumps (brine to air, ground loop)</u> <=11.25 tons	14.1 EER, 3.2 heating COP
<u>Package Terminal Air Conditioners <sup>a</sup></u>	14.0 - (0.300 * Cap/1,000), EER
<u>Package Terminal Heat Pumps <sup>a</sup></u>	14.0 - (0.300 * Cap/1,000), EER 3.7 – (0.052 * Cap/1,000), heating COP
<u>Single Package Vertical Air Conditioners</u> · <=5.4 tons · >5.4 to 11.25 tons · >11.25 to 20 tons	10.0 EER 10.0 EER 10.0 EER
<u>Single Package Vertical Heat Pumps</u> · <=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

a – Cap means the rated cooling capacity of the product in BtuH. If the unit’s capacity is less than 7,000 BtuH, use 7,000 BtuH in the calculation. If the unit’s capacity is greater than 15,000 BtuH, use 15,000 BtuH in the calculation



Baseline heat pump efficiency in heating mode must be based on ASHRAE 90.1-2007 table 6.8.1-B

**Sources:**

1. EFLH of 1,495 hours for Unitary HVAC is represented in the “C&I Unitary HVAC Load Shape Project Report”, Table 0-2, Mid-Atlantic region. This report was published August 2, 2011 and was performed by KEMA for NEEP.

[http://www.neep.org/sites/default/files/resources/NEEP\\_HVAC\\_Load\\_Shape\\_Report\\_Final\\_August2\\_0.pdf](http://www.neep.org/sites/default/files/resources/NEEP_HVAC_Load_Shape_Report_Final_August2_0.pdf)

**Fuel Use Economizers**

**Algorithms**

Electric Savings (kWh) = (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:**

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

([http://www.cleargreenpartners.com/attachments/File/NYSERDA\\_Report.pdf](http://www.cleargreenpartners.com/attachments/File/NYSERDA_Report.pdf))

**Dual Enthalpy Economizers**

**Algorithms**

Energy Savings (kWh) = OTF \* SF \* Cap/Eff

Demand Savings (kW) = Savings/Operating Hours

**Definition of Variables**

OTF = Operational Testing Factor

SF = Approximate savings factor based on regional temperature bin data (assume 4576 for equipment under 5.4 tons where a fixed damper is assumed for the baseline and 3318 for larger equipment where a dry bulb economizer is assumed for the baseline). (Units for savings factor are in kWh x rated EER per ton of cooling or kWh\*EER/Ton)

Cap = Capacity of connected cooling load (tons)

Eff = Cooling equipment energy efficiency ratio (EER)

Operating Hours = 4,438 = Approximate number of economizer operating hours

#### Dual Enthalpy Economizers

Component	Type	Value	Source
OTF	Fixed	1.0 when operational testing is performed, 0.8 otherwise	
SF		4576 for equipment under 5.4 tons, 3318 otherwise	1
Cap	Variable		<a href="#">Application</a>
Eff	Variable		<a href="#">Application</a>
Operating Hours	Fixed	4,438	2

Sources:

1. DOE-2 Simulation Modeling
2. ClimateQuest Economizer Savings Calculator

#### Electric Chillers

The measurement of energy and demand savings for C&I chillers is based on algorithms with key variables (i.e., kW/ton, Coincidence Factor, Equivalent Full Load Hours) measured through existing end-use metering of a sample of facilities.

#### Algorithms

For IPLV:

$$\text{Demand Savings} = \text{Tons} \times \text{PDC} \times (\text{IPLV}_b - \text{IPLV}_q)$$

$$\text{Energy Savings} = \text{Tons} \times \text{EFLH} \times (\text{IPLV}_b - \text{IPLV}_q)$$

For FLV:

$$\text{Demand Savings} = \text{Tons} \times \text{PDC} \times (\text{FLV}_b - \text{FLV}_q)$$

$$\text{Energy Savings} = \text{Tons} \times \text{EFLH} \times (\text{FLV}_b - \text{FLV}_q)$$

### Definition of Variables

Tons = Rated equipment cooling capacity

EFLH = Equivalent Full Load Hours – This represents a measure of chiller use by season determined by measured kWh during the period divided by kW at design conditions from JCP&L measurement data.

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

IPLV<sub>b</sub> = Integrated Part Load Value of baseline equipment, kW/Ton. The efficiency of the chiller under partial-load conditions.

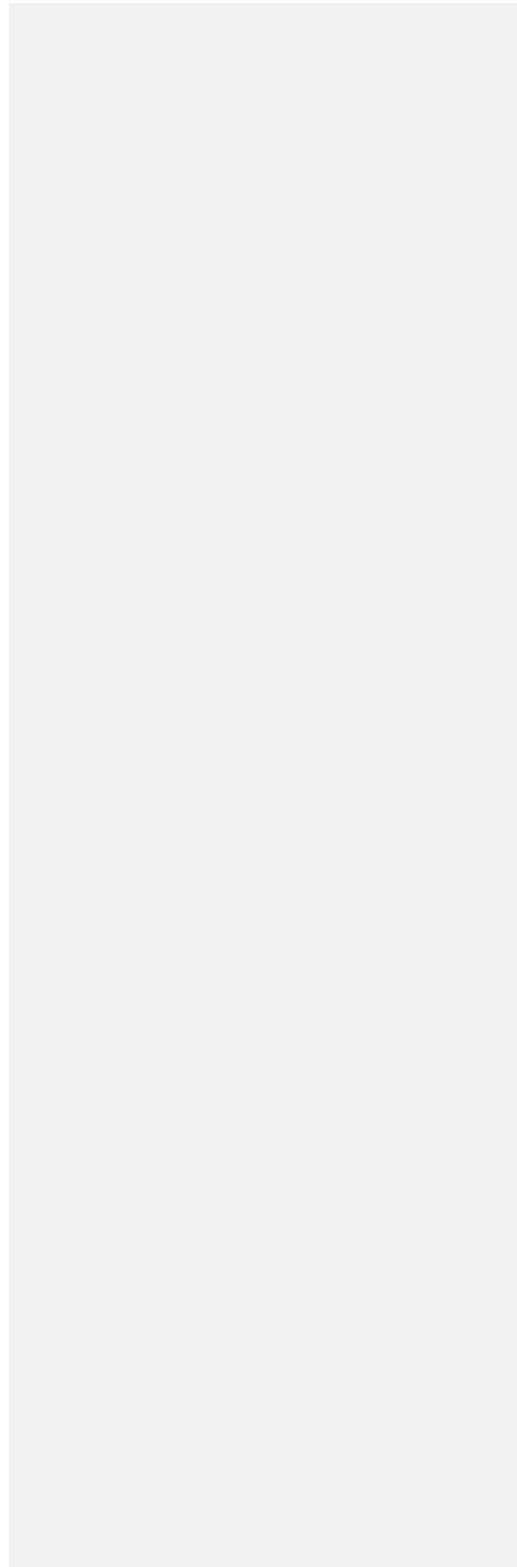
IPLV<sub>q</sub> = Integrated Part Load Value of qualifying equipment, kW/Ton. The efficiency of the chiller under partial-load conditions.

FLV<sub>b</sub> = Full Load Value of baseline equipment, kW/Ton. The efficiency of the chiller under full-load conditions.

FLV<sub>q</sub> = Full Load Value of qualifying equipment, kW/Ton. The efficiency of the chiller under full-load conditions.

|

Electric Chillers



<b>Component</b> <b>Electric Chillers Existing Buildings Component</b>	<b>Type</b>	<b>Situation</b>	<b>Value</b>	<b>Source</b>
<b>IPLV<sub>b</sub> (kW/ton)</b>	Fixed	Air Cooled: All Sizes	1.153	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Positive Displacement: <150 Tons	0.676	
		Water Cooled, Positive Displacement: 150 ≤ Tons < 300	0.628	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Positive Displacement: ≥ 300 Tons	0.572	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Centrifugal: <150 Tons	0.670	
		Water Cooled, Centrifugal: 150 ≤ Tons < 300	0.596	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Centrifugal: ≥ 300 Tons	0.549	ASHRAE 90.1-2007 Table C403.2.3(7)
		Air Cooled: All Sizes	1.153	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Positive Displacement: <150 Tons	0.676	ASHRAE 90.1-2007 Table C403.2.3(7)
<b>FLV<sub>b</sub> Full Load<sub>b</sub> (kW/ton)</b>	Fixed	Air Cooled: All Sizes	1.256	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Positive Displacement: <150 Tons	0.790	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Positive Displacement: 150 ≤ Tons < 300	0.718	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Positive Displacement: ≥ 300 Tons	0.639	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Centrifugal: <150 Tons	0.703	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Centrifugal: 150 ≤ Tons < 300	0.634	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Centrifugal: ≥ 300 Tons	0.576	ASHRAE 90.1-2007 Table C403.2.3(7)

		Air Cooled: All Sizes	1.256	ASHRAE 90.1-2007 Table C403.2.3(7)
		Water Cooled, Positive Displacement: < 150 Tons	0.790	ASHRAE 90.1-2007 Table C403.2.3(7)
Tons	Variable	All	Varies	From Application
IPLV <sub>q</sub> (kW/ton)	Variable	All	Varies	From Application (per AHRI Std. 550/590)
PDC	Fixed	All	67%	Engineering Estimate
EFLH	Fixed	All	1,360	California DEER
<b>Component</b>	<b>Type</b>	<b>Situation</b>	<b>Value</b>	<b>Source</b>
Tons	Variable	All	Varies	From Application
IPLV <sub>q</sub> (kW/ton)	Variable	All	Varies	From Application (per AHRI Std. 550/590)
PDC	Fixed	All	67%	Engineering Estimate
EFLH	Fixed	All	1,360	California DEER

**Electric Chillers – Existing Buildings**

<b>Type</b>	<b>Capacity</b>	<b>ASHRAE 90.1 2007 <sup>a</sup></b>			
		<b>Full Load COP</b>	<b>IPLV COP</b>	<b>Full Load kW/ton</b>	<b>IPLV kW/ton</b>
<u>Air Cooled</u>	tons < 150	2.80	3.05	1.256	1.153
	tons > 150	2.80	3.05	1.256	1.153
<u>Water Cooled Positive Displacement (rotary screw and scroll)</u>	tons < 75	4.45	5.20	0.790	0.676
	75 < tons < 150	4.45	5.20	0.790	0.676
	150 < tons < 300	4.90	5.60	0.718	0.628
	300 < tons < 600	5.50	6.15	0.639	0.572
	tons > 600	5.50	6.15	0.639	0.572
<u>Water Cooled Centrifugal</u>	tons < 150	5.00	5.25	0.703	0.670
	150 < tons < 300	5.55	5.90	0.634	0.596
	300 < tons < 400	6.10	6.40	0.576	0.549
	400 < tons < 600	6.10	6.40	0.576	0.549
	tons > 600	6.10	6.40	0.576	0.549

a - The 90.1 2007 efficiencies were used in the 90.1 2013 capacity categories for consistency between tables. The 2007 water cooled reciprocating category was removed and the 90.1 2007 water cooled screw and scroll efficiencies were used in

the appropriate 90.1 2013 water cooled positive displacement capacity categories (the water cooled reciprocating category was removed from ASHRAE 90.1 in 2010).

**Electric Chillers – New Construction**

Type	Capacity	ASHRAE 90.1 2013 effective 1/1/2015 <sup>a</sup>			
		Path A		Path B	
		Full Load kW/ton	IPLV kW/ton	Full Load kW/ton	IPLV kW/ton
Air Cooled	tons < 150	<i>10.1</i> 1.188	<i>13.7</i> 0.876	<i>9.7</i> 1.237	<i>15.8</i> 0.759
	tons > 150	<i>10.1</i> 1.188	<i>14.0</i> 0.857	<i>9.7</i> 1.237	<i>16.1</i> 0.745
Water Cooled Positive Displacement (rotary screw and scroll)	tons < 75	<i>0.750</i>	<i>0.600</i>	<i>0.780</i>	<i>0.500</i>
	75 < tons < 150	<i>0.720</i>	<i>0.560</i>	<i>0.750</i>	<i>0.490</i>
	150 < tons < 300	<i>0.660</i>	<i>0.540</i>	<i>0.680</i>	<i>0.440</i>
	300 < tons < 600	<i>0.610</i>	<i>0.520</i>	<i>0.625</i>	<i>0.410</i>
	tons > 600	<i>0.560</i>	<i>0.500</i>	<i>0.585</i>	<i>0.380</i>
Water Cooled Centrifugal	tons < 150	<i>0.610</i>	<i>0.550</i>	<i>0.695</i>	<i>0.440</i>
	150 < tons < 300	<i>0.610</i>	<i>0.550</i>	<i>0.635</i>	<i>0.400</i>
	300 < tons < 400	<i>0.560</i>	<i>0.520</i>	<i>0.595</i>	<i>0.390</i>
	400 < tons < 600	<i>0.560</i>	<i>0.500</i>	<i>0.585</i>	<i>0.380</i>
	tons > 600	<i>0.560</i>	<i>0.500</i>	<i>0.585</i>	<i>0.380</i>

a – Values in italics are EERs.

**Variable Frequency Drives**

The measurement of energy and demand savings for C/I Variable Frequency Drive for VFD applications is are for constant and variable air volume system HVAC fans, chilled water pumps, cooling tower fans, kitchen hood fans, boiler feed water pumps, and boiler draft fans only. VFD applications for other than this use should follow the custom path.

Algorithms

$$\text{Energy Savings (kWh)} = 0.746 * \text{HP} * \text{HRS} * \left( \frac{\text{ESF}}{\eta_{\text{motor}}} \right)$$

$$\text{Demand Savings (kW)} = 0.746 * \text{HP} * \left( \frac{\text{DSF}}{\eta_{\text{motor}}} \right)$$

Definitions of Variables

HP = nameplate motor horsepower or manufacturer spec. sheet per application

$\eta_{\text{motor}}$  = Motor efficiency at the peak load. Motor efficiency varies with load. At low loads relative to the rated hp (usually below 50%) efficiency often drops dramatically.

ESF = Energy Savings Factor. The energy savings factor is calculated by determining the ratio of the power requirement for baseline and VFD control at peak conditions.

DSF = Demand Savings Factor. The demand savings factor is calculated by determining the ratio of the power requirement for baseline and VFD control at peak conditions

HRS = annual operating hours

### Variable Frequency Drives

Component	Type	Value	Source
<i>Motor HP</i>	Variable	Nameplate/Manufacturer Spec. Sheet	Application
$\eta_{\text{motor}}$	Variable	Nameplate/Manufacturer Spec. Sheet	Application
ESF	Variable	See Table Below	Connecticut Light and Power
DSF	Variable	See Table Below	Connecticut Light and Power
HRS	Variable	>2,000	Application

### VFD Savings Factors

Component	Energy Savings Factor, ESF	Demand Savings Factor, DSF
Airfoil/Backward Inclined Fans	0.475	0.448
Forward Curved Fans	0.240	0.216
Chilled Water Pumps	0.580	0.201
Cooling Tower Fans	0.580	0.000

### *Air Compressors with Variable Frequency Drives*

The measurement of energy and demand savings for variable frequency drive (VFD) air compressors.

#### Algorithms



$$\text{Energy Savings (kWh)} = \text{HRS} * ( * (\text{Maximum kW/HP Savings}) * ) * \text{Motor HP}$$

$$\text{Demand Savings (kW)} = \text{PDC} * ( * (\text{Maximum kW/HP Savings}) * ) * \text{Motor HP}$$

$$\text{Maximum kW/HP Savings} = \text{Percent Energy Savings} * (0.746 / \text{EEF}_b)$$

Definitions of Variables

HRS = Annual compressor runtime (hours) from application.

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

EEF<sub>b</sub> = Efficiency of the industry standard compressor at average load

0.746 = kW to HP conversion factor

**Air Compressors with VFDs**

Component	Type	Value	Source
Motor HP	Variable	Nameplate	Application
Maximum kW/HP Savings	Fixed	0.274	Calculated
PDC	Fixed	0.865	1
HRS	Fixed	4957	2
Percent Energy Savings	Fixed	22%	3
EEF <sub>b</sub>	Fixed	0.60	3

Sources:

1. Aspen Systems Corporation, *Prescriptive Variable Speed Drive Incentive Program Support for Industrial Air Compressors*, June 20, 2005.
2. Xenergy, *Assessment of the Market for Compressed Air Efficiency Systems*. 2001.
3. ACEEE, *Modeling and Simulation of Air Compressor Energy Use*. 2005.

***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**

$$\text{Electric Fan Savings (kWh)} = Q * (HP * LF * 0.746 / FEFF) * RH * PR$$

$$\text{Heating Savings (MMBtu)} = SF * CFM/SF * OF * FR * HDD_{mod} * 24 * 1.08 / (HEFF * 1,000,000)$$

$$\text{Cooling Savings (kWh)} = SF * CFM/SF * OF * FR * CDD_{mod} * 24 * 1.08 / (CEFF * 3,412)$$

**Definition of Variables**

Q=Quantity 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

HDD<sub>mod</sub> = Modified Heating Degree Days based on location and facility type

CDD<sub>mod</sub> = 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)

3412 = Conversion factor from Btu to kWh (3412 Btu = 1 kWh)

~~1000000~~ 1,000,000 ~~1000000~~ = Btu/MMBtu

**Kitchen Hoods with VFDs**

Component	Type	Value	Source
Q	Variable	Quantity	Application
HP	Variable	Nameplate	Application
LF	Fixed	0.9	Melink Analysis Sample <sup>1</sup>
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 <del>2007-2013</del> Table 6.44 <del>5</del> 4
OF	Fixed	1.4	Estimated Typical Kitchen Design <sup>2</sup>
FR	Variable	Based on Facility Type	Facility Specific Value Table
HDD <sub>mod</sub>	Variable		Heating Degree Day Table
CDD <sub>mod</sub>	Variable		Cooling Degree Day Table
HEFF	Fixed	0.8	8.1E <sup>3</sup> Estimated Heating System Efficiency <sup>3</sup> ASHRAE 90.1 2007 Table 6.8.1E <sup>3</sup> 81E <sup>3</sup> Estimated Heating System Efficiency <sup>3</sup> 81E <sup>3</sup> 81E <sup>3</sup>
CEFF	Fixed	3.00	Estimated Cooling System Efficiency <sup>4</sup>

**Facility-Specific Values Table<sup>5</sup>**

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

**Modified Heating Degree Days Table<sup>6</sup>**

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

**Modified Cooling Degree Days Table<sup>7</sup>**

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

**Sources:**

1. 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, *Smartstart Program Protocol Review*. 2009.

- 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.

**Commercial Refrigeration Measures**

For Aluminum Night Curtains, Door Heater Controls, Electric Defrost Controls, Evaporator Fan Controls, and Novelty Cooler Shutoff, see applicable protocols for the commercial Direct Install program.

For Energy Efficient Doors for Open Refrigerated Cases:

Algorithms

Demand Savings:  $\Delta kW = (HG \times EF \times CL) / (EER \times 1000)$

Annual Energy Savings:  $\Delta kWh = \Delta kW \times Usage$

Definition of Terms

$\Delta kW$  = gross customer connected load kW savings for the measure (kW)

HG = Loss of cold air or heat gain for refrigerated cases with no cover (Btu/hr-ft opening)

EF = Efficiency Factor, fraction of heat gain prevented by case door

CL = Case Length, open length of the refrigerated case in feet (from application)

EER = Compressor efficiency (Btu/hr-watt)

1000 = Conversion from watts to kW (W/kW).

$\Delta kWh$  = gross customer annual kWh savings for the measure (kWh)

Usage = hours per year

**Commercial Refrigeration**

Component	Type	Value	Source
HG	Fixed	760	PG&E study by ENCON Mechanical & Nuclear Engineering, 1992
EF	Fixed	0.85	PG&E study by ENCON Mechanical & Nuclear Engineering, 1992

Component	Type	Value	Source
CL	Variable		Rebate Application or Manufacturer Data
EER	Fixed	9.0	Average based on custom applications for the NJCEP C&I Program in 2010
Usage	Fixed	<del>8760</del> 8,760	365 days/year, 24 hours/day

### Commercial Refrigerators and Freezers

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

#### Algorithms

$$\text{Annual Energy Savings (kWh)} = D * (E_b - E_q)$$

$$\text{Demand Savings (kW)} = \text{kWh Savings} / (D * H)$$

#### Definition of Variables

D = Operating Days per Year (assume 365)

H = Daily Operating Hours (assume 24)

E<sub>b</sub> = Daily kWh Consumption of Baseline Equipment (from Table 1 below)

E<sub>q</sub> = Daily kWh Consumption of Qualifying Equipment (from Application)

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

Source: [Source](#) [Source](#) [Source](#) [Source](#) [Source](#)

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.

### 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

$$\text{Annual Energy Savings (kWh)} = D * DC * (IHR/100) * (E_b - E_q)$$

$$\text{Demand Savings (kW)} = \text{kWh Savings} / (D * 24 * DC)$$

#### 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)

E<sub>b</sub> = kWh Consumption of Baseline Equipment in kWh/100 lbs (from Table 1 below)

E<sub>q</sub> = kWh Consumption of Qualifying Equipment in kWh/100 lbs (from Application)

24 = Hours per Day

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

#### Sources:

##### Source

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.

### Commercial Dishwashers

This measure is applicable to replacement of existing dishwashers with energy efficient under counter, door type, single-rack and multi-rack conveyor machines testing in accordance with NSF/ANSI 3-2007, ASTM F1696, and ASTM F1920 standards. The measurement of



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

Algorithms

Annual Energy Savings (kWh or Therms) = E<sub>Build</sub> + E<sub>Boost</sub> + E<sub>Idle</sub>

Demand Savings (kW) = kWh Savings/8760

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

Definition of Variables

E<sub>Build</sub> = Annual Building Water Heater Energy Savings, in kWh or Therms (from tables below)

E<sub>Boost</sub> = Annual Booster Water Heater Energy Savings, in kWh or Therms (from tables below)

E<sub>Idle</sub> = Annual Dishwasher Idle Energy Savings, in kWh (from tables below)

8760 = Hours per Year

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

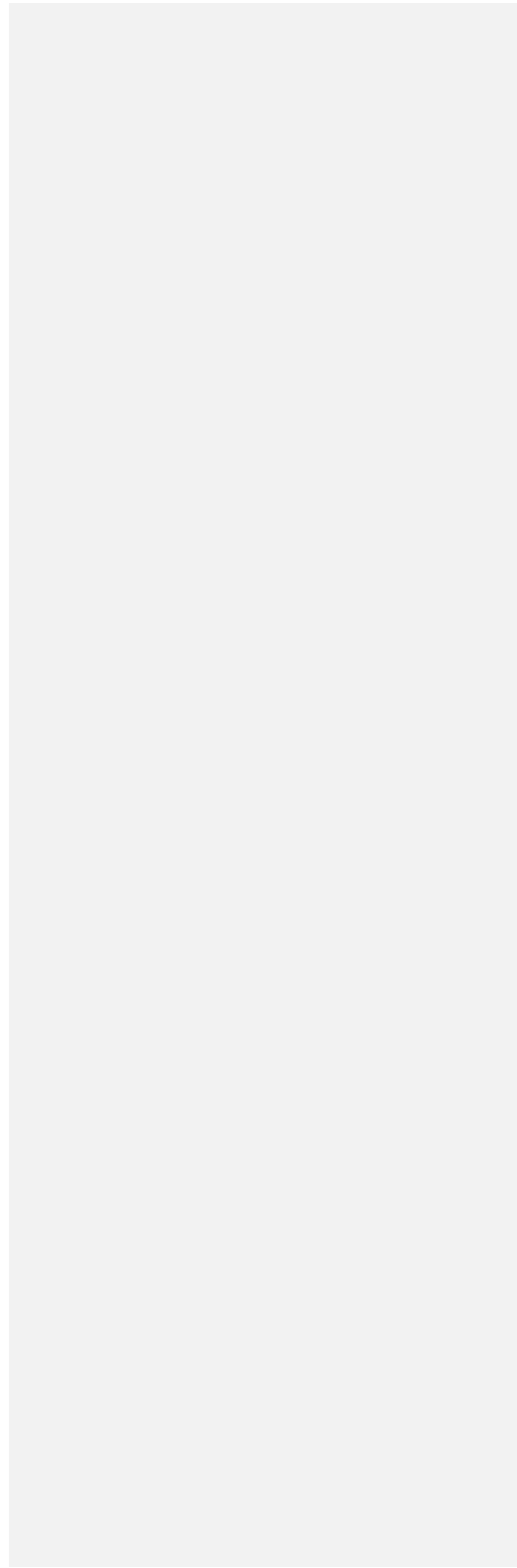
Table 2: High Temperature Dishwasher Savings					
Dishwasher Type	Electric Building Water Heater Savings (kWh)	Gas Building Water Heater Savings (Therms)	Electric Booster Water Heater Savings (kWh)	Gas Booster Water Heater Savings (Therms)	Idle Energy Savings (kWh)
Under Counter	4,754	220.2	2,717	110.1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

Sources:

Source

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 and from the *Savings Calculator for ENERGY STAR Qualified Commercial Kitchen Equipment*.



## C&I Construction Gas Protocols

For measures installed as part of the Direct Install program, different baselines will be utilized to estimate savings as defined further in the Direct Install section of these Protocols.

The following fuel conversions will be used to calculate energy savings for propane and oil equipment for all eligible C&I programs including C&I Construction, Direct Install, and Pay for Performance.

1 therm of gas = 1.087 gal of propane = 0.721 gal of #2 oil

1 therm = 100,000 Btu

1 gal of propane = 92,000 Btu

1 gal of #2 oil = 138,700 Btu

### Gas Chillers

The measurement of energy savings for C&I gas fired chillers and chiller heaters is based on algorithms with key variables (i.e., Equivalent Full Load Hours, Vacuum Boiler Efficiency, Input Rating, Coincidence Factor) provided by manufacturer data or measured through existing end-use metering of a sample of facilities.

#### Algorithms

Winter Gas Savings =  $(VBE_q - BE_b) / VBE_q \times IR \times EFLH$

Electric Demand Savings = Tons X  $(kW/Ton_b - kW/Ton_{gc}) \times CF$

Electric Energy Savings = Tons X  $(kW/Ton_b - kW/Ton_{gc}) \times EFLH$

Summer Gas Usage (MMBtu) = MMBtu Output Capacity / COP X EFLH

Net Energy Savings = Electric Energy Savings + Winter Gas Savings – Summer Gas Usage

#### Definition of Terms

$VBE_q$  = Vacuum Boiler Efficiency

$BE_b$  = Efficiency of the baseline gas boiler

IR = Input Rating = Therms/hour

Tons = The 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.

### Gas Chillers

Component	Type	Value	Source
$VBE_q$	Variable		Rebate Application or Manufacturer Data
$BE_b$	Fixed	75% <del>80</del> 75% <del>Et</del>	<a href="#">ASHRAE 90.1-2013 Table 6.8.1 – 6</a>  <a href="#">Assumes a baseline hot water boiler with rated input &gt;300 MBh and ≤ 2,500 MBh. ASHRAE 90.1-2004/2004/2013 Table 6.8.1 – 6</a>  <a href="#">Assumes a baseline hot water boiler with rated input &gt;300 MBh and ≤ 2,500 MBh. 2004</a>
IR	Variable		Rebate Application or Manufacturer Data
Tons	Variable		Rebate Application
MMBtu	Variable		Rebate Application

Component	Type	Value	Source
kW/Ton <sup>b</sup>	Fixed	<100 tons 1.25 kW/ton  <b>100 to &lt; 150 tons</b> 0.703 kW/ton  <b>150 to &lt;300 tons:</b> 0.634 kW/Ton  <b>300 tons or more:</b> 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 <sup>gc</sup>	Variable		Manufacturer Data
COP	Variable		Manufacturer Data
CF	Fixed	67%	Engineering estimate
EFLH	Fixed	1,360	JCP&L Measured data <sup>19</sup>

Variable data will be captured on the application form or from manufacturer’s data sheets and collaborative/utility studies.

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

### **Gas Fired Desiccants**

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.

<sup>19</sup> Results reflect metered use from 1995 – 1999.

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

Demand Savings (kW) = IR X EFF/3.4123412 X CF

Energy Savings (kWh) = IR X EFF/3.4123412 X EFLH

Gas Usage Increase = IR X EFLH

Net Energy Savings = Electric Energy Savings – Gas Usage Increase  
(Calculated in MMBtu)

Definition of Variables

IR = Input Rating in Btuh

EFF = Efficiency

CF = Coincidence Factor

EFLH = Equivalent Full Load Hours

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

**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

Component	Type	Value	Source
EF	Variable		Application Form or Manufacturer Data

**Water Heaters**

This prescriptive measure targets solely the use of smaller-scale domestic water heaters (50 gallons or less per unit) in all commercial facilities. Larger gas water heaters are treated under the custom measure path. The measurement of energy savings for C&I gas water heaters is based on algorithms with key variables (i.e., energy factor) provided by manufacturer data.

Algorithms

$$\text{Gas Savings} = ((\text{EFF}_q - \text{EFF}_b) / \text{EFF}_q) \times \text{Energy Use Density} \times (\text{Area})$$

Definition of Variables

$\text{EFF}_q$  = Efficiency of the qualifying energy efficient water heater.

$\text{EFF}_b$  = Efficiency of the baseline water heater.

Area = Square feet served by the water heater

**Water Heaters**

Component	Type	Value	Source
$\text{EFF}_q$	Variable		Application
$\text{EFF}_b$	Fixed	<50 gal or <75,000 Btu/h: EF >50 gal or >75,000 Btu/h: TE EF = Energy Factor TE = Thermal Efficiency	From ASHRAE 90.1 2007
Energy Use Density	Variable	See Table Below	1
Fluid Capacity	Variable		Application

**Water Heaters – Existing Buildings**

<u>ASHRAE 90.1-2007</u>			
<u>Equipment Type</u>	<u>Size Category (Input)</u>	<u>Subcategory or Rating Condition</u>	<u>Performance Required<sup>a</sup></u>

Gas Storage Water Heaters	$\leq 75,000$ BtuH	$\geq 20$ gal	$0.62 - 0.0019V$ EF
Gas Storage Water Heaters	$> 75,000$ BtuH	$\leq 4,000$ (BtuH)/gal	$80\% Et (Q/800 + 110 \sqrt{V})$ SL, BtuH
Gas Instantaneous Water Heaters	$> 50,000$ BtuH and $< 200,000$ BtuH	$> 4,000$ (BtuH)/gal and $< 2$ gal	$0.62 - 0.0019V$ EF
Gas Instantaneous Water Heaters	$> 200,000$ BtuH <sup>be</sup>	$> 4,000$ (BtuH)/gal and $< 10$ gal	$80\% E_t$
Gas Instantaneous Water Heaters	$> 200,000$ BtuH	$> 4,000$ (BtuH)/gal and $\geq 10$ gal	$80\% Et (Q/800 + 110 \sqrt{V})$ SL, BtuH

a - Energy factor (EF) and thermal efficiency (Et) are minimum requirements, while standby loss (SL) is maximum BtuH based on a 70°F temperature difference between stored water and ambient requirements. In the EF equation, V is the rated volume in gallons. In the SL equation, V is the rated volume in gallons and Q is the nameplate input rate in BtuH.

be - Instantaneous water heaters with input rates below 200,000 BtuH must comply with these requirements if the water heater is designed to heat water to temperatures of 180°F or higher.

#### Water Heaters – New Construction

<b>ASHRAE 90.1-2013 (most current requirement as of February 2016)</b>			
<b>Equipment Type</b>	<b>Size Category (Input)</b>	<b>Subcategory or Rating Condition</b>	<b>Performance Required<sup>a</sup></b>
Gas Storage Water Heaters	$\leq 75,000$ BtuH	$\geq 20$ gal	$0.67 - 0.0005V$ EF
Gas Storage Water Heaters	$> 75,000$ BtuH	$\leq 4,000$ (BtuH)/gal	$80\% Et (Q/799 + 16.6 \sqrt{V})$ SL, BtuH
Gas Instantaneous Water Heaters	$> 50,000$ BtuH and $< 200,000$ BtuH	$\geq 4,000$ (BtuH)/gal and $< 2$ gal	$0.62 - 0.0005V$ EF
Gas Instantaneous Water Heaters	$> 200,000$ BtuH <sup>bd</sup>	$\geq 4,000$ (BtuH)/gal and $< 10$ gal	$80\% E_t$
Gas Instantaneous Water Heaters	$> 200,000$ BtuH	$\geq 4,000$ (BtuH)/gal and $\geq 10$ gal	$80\% Et (Q/799 + 16.6 \sqrt{V})$ SL, BtuH



a - Energy factor (EF) and thermal efficiency (Et) are minimum requirements, while standby loss (SL) is maximum BtuH -based on a 70°F temperature difference between stored water and ambient requirements. In the EF equation, V is the rated volume in gallons. In the SL equation, V is the rated volume in gallons and Q is the nameplate input rate in BtuH. ~~V<sub>m</sub> is the measured volume in the tank.~~

bd - Instantaneous water heaters with input rates below 200,000 BtuH must comply with these requirements if the water heater is designed to heat water to temperatures of 180°F or higher.

**Energy Use Density Lookup Table**

Building Type	Energy Use Density (kBtu/SF/yr)
Education	5.2
Food Sales	3.2
Food Service	40.0
Health Care	28.9
- Inpatient	39.4
- Outpatient	3.5
Lodging	29.2
Retail (Other Than Mall)	1.0
Office	1.6
Public Assembly	0.9
Public Order and Safety	15.1
Religious Worship	0.9
Service	0.9
Warehouse and Storage	0.7
Other	1.7

Sources:

1. Energy Information Administration, *Commercial Building Energy Consumption Survey*. 2003.

**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. The measurement of energy savings for C&I gas, oil, and propane fired furnaces and boilers is based on algorithms with key variables (i.e. Annual Fuel Utilization Efficiency, capacity of the furnace, EFLH) provided by manufacturer data or utility data. Savings are calculated for four zones throughout the state by heating degree days and for twelve different building types.

Algorithms

$$Gas\ Savings\ for\ Boilers\ (Therms) = \frac{OF * HDD_{mod} * 24}{\Delta T * HC_{fuel}} * IR_B * \left[ 1 - \left( \frac{Eff_B}{Eff_Q} \right) \right]$$

Definition of Variables

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

HDD<sub>mod</sub> = HDD by zone and building type

ΔT = design temperature difference

HC<sub>fuel</sub> = Conversion from Btu to Therms of gas (100,000 Btu/Therm)

IR<sub>B</sub> = Boiler Baseline Input Rating (~~Btu/Hr~~)

Eff<sub>B</sub> = Boiler Baseline Efficiency

Eff<sub>Q</sub> = Boiler Proposed Efficiency

**Prescriptive Boilers**

Component	Type	Value	Source
OF	Fixed	0.8	
IR <sub>B</sub>	Variable		Application
HC <sub>fuel</sub>	Fixed	100,000 Btu/Therm	
Eff <sub>B</sub>	Variable	See Table Below	2
Eff <sub>Q</sub>	Variable		Application
ΔT	Variable	See Table Below	1
HDD <sub>mod</sub>	Fixed	See Table Below	1

**Adjusted Heating Degree Days by Building Type**

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

**Heating Degree Days and Outdoor Design Temperature by Zone**

New Jersey Clean Energy Program  
 Protocols to Measure Resource Savings

**TBD**

Weather Station	HDD	Outdoor Design Temperature (F)
Atlantic City	5073	13
Newark	5057	14
Philadelphia, PA	4824	15
Monticello, NY	7060	8

### Baseline Boiler Efficiencies (Eff<sub>b</sub>)

Boiler Type	Size Category (MBh input)	Existing Buildings Standard 90.1-2007	New Construction Standard 90.1-2013
Hot Water	< 300	80% AFUE	82% AFUE
Hot Water	> 300 and < 2,500	75% Et	80% Et
Hot Water	> 2,500	80% Ec	82% Ec
Steam	< 300	75% AFUE	80% AFUE
Steam, all except natural draft	> 300 and < 2,500	75% Et	79% Et
Steam, all except natural draft	> 2,500	80% Ec	79% Et
Steam, natural draft	> 300 and < 2,500	75% Et	77% Et
Steam, natural draft	> 2,500	80% Ec	77% Et

### Sources:

1. KEMA, *Smartstart Program Protocol Review*. 2009.
2. ASHRAE 90.1 2007

### Infrared Heaters, Furnaces and Direct Install Boilers

The methodology outlined below shall be adopted for estimating savings for installation of qualifying furnaces and infrared heaters as well as Direct Install boilers in order to accommodate resizing.

### Algorithms

#### Gas Savings (Therms)

$$\begin{aligned}
 &= \left[ \frac{OF \times HDD_{mod} \times 24 \times ((CAPY_{B,out} \times AFUE_q) - (CAPY_{Q,out} \times AFUE_b \times ICF))}{\Delta T \times HC_{fuel} \times AFUE_b \times AFUE_q \times ICF} \right] \text{Gas Savings (Therms)} \\
 &= \left[ \frac{OF \times HDD_{mod} \times 24 \times ((CAPY_{B,out} \times Eff \times AFUE_q) - (CAPY_{Q,out} \times AFUE_{eff_b} \times ICF))}{\Delta T \times HC_{fuel} \times AFUE_{eff_b} \times AFUE_{eff_q} \times ICF} \right] \left[ \frac{OF \times HDD_{mod} \times 24 \times ((CAPY_{B,out} \times AFUE_q) - (CAPY_{Q,out} \times AFUE_b \times ICF))}{\Delta T \times HC_{fuel} \times AFUE_b \times AFUE_q \times ICF} \right] \\
 &\text{Boiler Savings} = \frac{OF * HDD_{mod} * 24 * \text{Boiler}_{Baseline} \text{ Input Rating Btu/Hr} * [1 - (\text{Boiler}_{Baseline} \text{ eff} / \text{Boiler}_{Proposed} \text{ eff})]}{\Delta T * HC_{fuel}}
 \end{aligned}$$

### Definition of Variables

OF = Oversize factor of standard furnace/boiler/heater (OF=0.8)

New Jersey Clean Energy Program  
 Protocols to Measure Resource Savings

TBD

CAPY<sub>B.out</sub> = Total output capacity of the baseline furnace/boiler/heater(s) in Btu/hour

$\frac{AFUE_Q \cdot Eff_{AFUE_Q}}{AFUE_B}$  = Efficiency of qualifying furnace/boiler/heater(s) (AFUE %)

CAPY<sub>Q.out</sub> = Total output capacity of the qualifying furnace/boiler/heater(s) in Btu/hour

$\frac{AFUE_B \cdot Eff_{AFUE_B}}{AFUE_Q}$  = Efficiency of baseline furnace/boiler/heater(s) (AFUE %)

ICF = Infrared Compensation Factor (ICF = 0.8 for IR Heaters, 1.0 for Furnaces/Boilers)<sup>2</sup>

HDD<sub>mod</sub> = HDD by zone and building type

24 = Hours/Day

ΔT = design temperature difference

HC<sub>fuel</sub> = Conversion from Btu to Therms of gas (100,000 Btu/Therm)

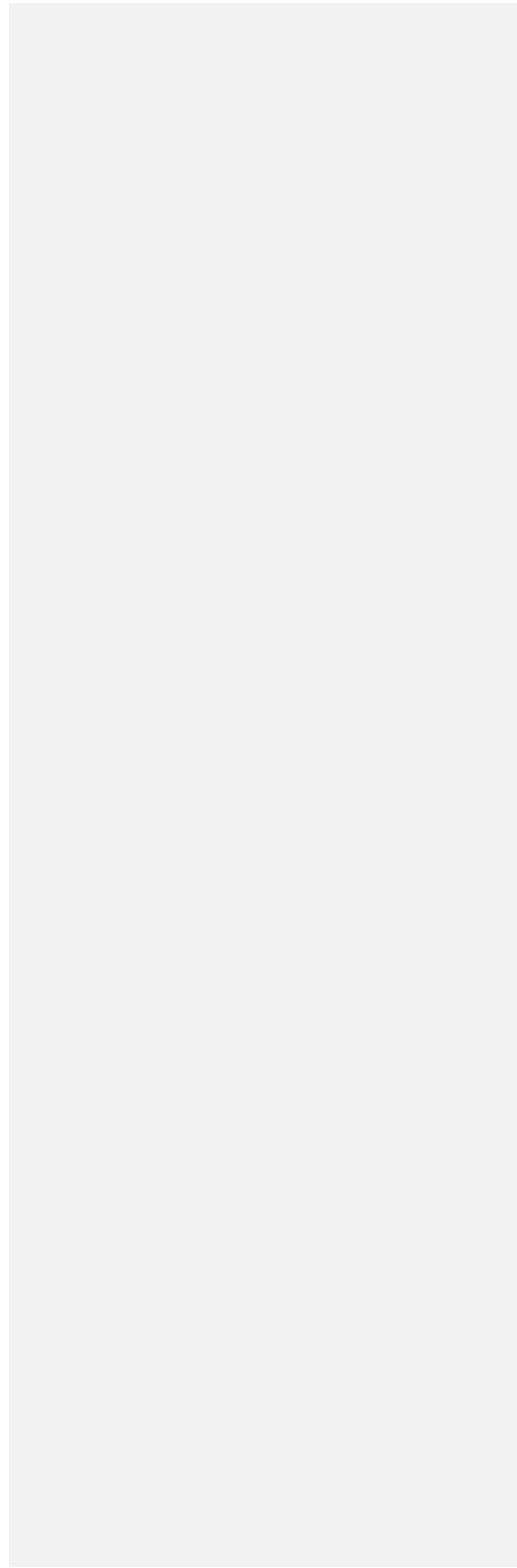
### **IR Heaters, Furnaces and Boilers**

Component	Type	Value	Source
OF	Fixed	0.8	
IRB	Variable		Application
HC <sub>fuel</sub>	Fixed	100,000 Btu/Therm	
Eff <sub>B</sub>	Variable, Fixed	See Table Below	Application, 3
Eff <sub>Q</sub>	Variable	See Table Below	Application
$\frac{AFUE_Q \cdot AFUE_B \cdot Eff_{AFUE_Q}}{AFUE_B}$	Variable		Application
$\frac{AFUE_B \cdot Eff_{AFUE_B}}{AFUE_Q}$	Fixed	Furnaces: 78% Boilers: 80% <sup>a</sup> Infrared: 78%	EPACT Standard for furnaces and boilers
CAPY <sub>B/Q, Out</sub>	Variable		Application
ΔT	Variable	See Table Below	1
HDD <sub>mod</sub>	Fixed	See Table Below	1

<sup>a</sup> – 80% efficiency used for Direct Install protocols only. SmartStart gas boiler efficiencies referenced in Boiler Baseline Efficiency table.

Sources:

1. KEMA, *Smartstart Program Protocol Review*. 2009.
2. [http://www.spaceray.com/1\\_space-ray\\_faqs.php](http://www.spaceray.com/1_space-ray_faqs.php)
3. ASHRAE 90.1-2007



### Adjusted Heating Degree Days by Building Type

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### Heating Degree Days and Outdoor Design Temperature by Zone

Weather Station	HDD	Outdoor Design Temperature (F)
Atlantic City	5073	13
Newark	5057	14
Philadelphia, PA	4824	15
Monticello, NY	7060	8

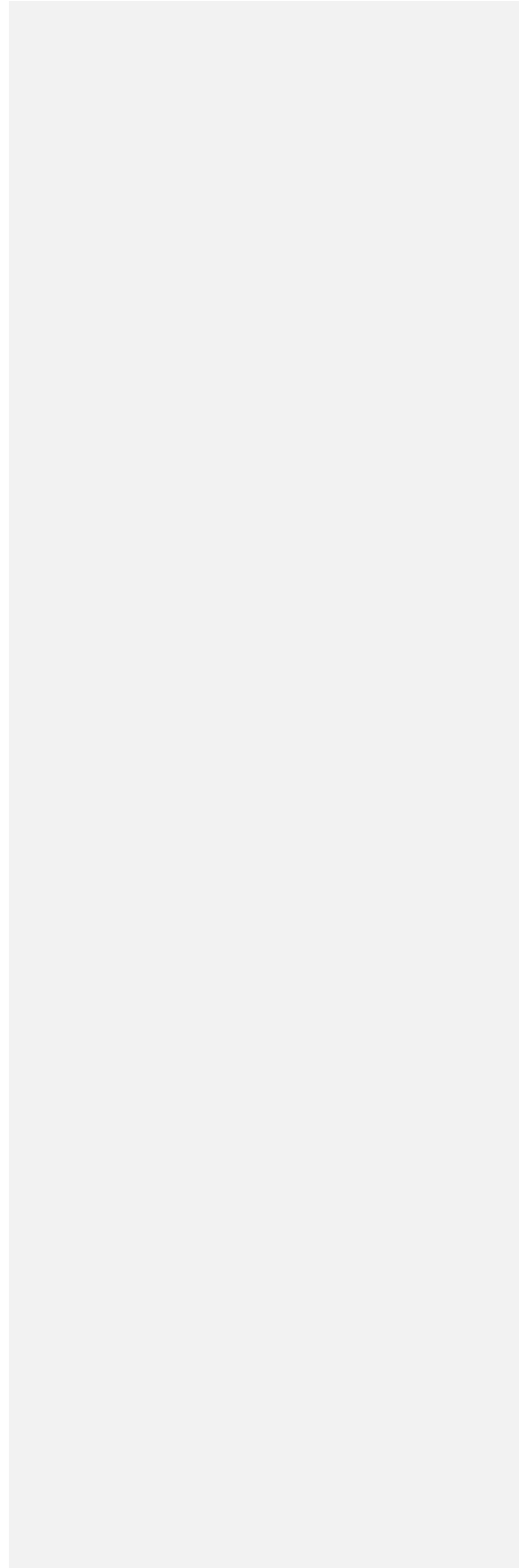
### Baseline Boiler Efficiencies (Eff<sub>b</sub>)

Size Category (MBh input)		Hot Water	Steam
Min	Max		
0	300	80% AFUE	75% AFUE
300	2500	75% Et	75% Et
2500	4000	80% Ec	76% Et
Baseline ASHRAE 90.1 2007			

#### Sources:

1. [KEMA, Smartstart Program Protocol Review. 2009.](#)
2. [http://www.spaceray.com/1\\_space-ray\\_faqs.php](http://www.spaceray.com/1_space-ray_faqs.php)

|



## *Fuel Use Economizers*

### **Algorithms**

Fuel Savings (MMBtu) = (AFU \* 0.13)

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

0.13 = Approximate energy savings factor related to installation of fuel use economizers<sup>1</sup>.

#### Sources:

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



## Distributed Energy Resource (DER)-Combined Heat and Power (CHP) and Fuel Cell Program

### Protocols

The measurement of energy and demand savings for Combined Heat and Power (CHP)/fuel cell 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/fuel cell systems will be drawn from individual project applications.

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

#### *Distributed Generation*

**Electric Generation (MWh)** = Estimated annual and lifetime electric generation in MWh provided on the project application, as adjusted during the project review and approval process.

**Electric Demand (kW)** = Electric capacity of the CHP/fuel cell system in kW provided on the project application, as adjusted during the project review and approval process.

#### *Energy Savings*

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

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

#### *Emission Reductions*

For many CHP/fuel cell 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.<sup>20</sup>

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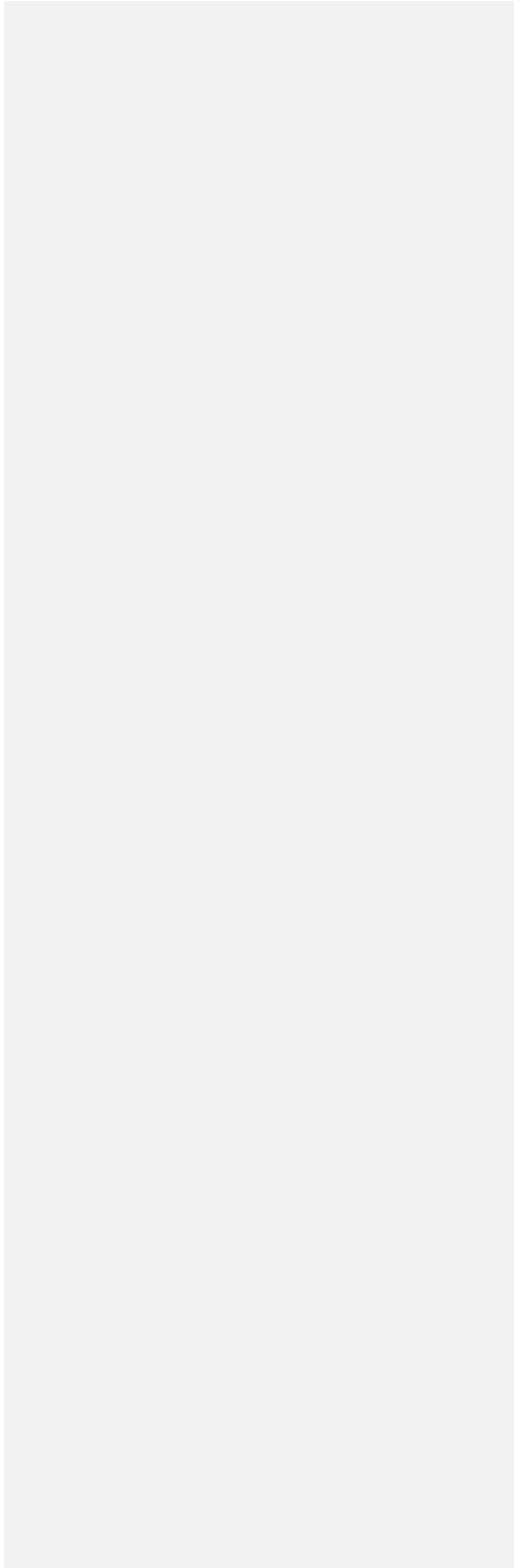
<sup>20</sup> Summit Blue, Draft Energy Efficiency Market Assessment of New Jersey Clean Energy Program, Book III, Page 196, May 26, 2006



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

**Sustainable Biomass**

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 of 15% reduction in total source energy consumption.

### Energy Savings Requirements

#### Existing Buildings

Projects are required to identify and implement energy efficiency improvements that will achieve a minimum of 15% reduction in total source energy consumption as measured from existing energy use. (for existing buildings) and 15% energy cost savings from the current state energy code (for new construction). Further, no more than 50% of the total savings may be derived from lighting measures, ~~sSavings~~savings may not come from a single measure and no more than 50% of the total savings may be derived from lighting measures. Lighting savings up to 70% of total projected savings can be considered but the minimum savings required will increase proportionately as demonstrated in the table below.

Lighting Savings	Minimum Source Energy Target
51%	16%
52%	17%
53%	18%
54%	19%
55%	20%
56%	21%
57%	22%
58%	23%
59%	24%
60%	25%
61%	26%
62%	27%
63%	28%
64%	29%
65%	30%
66%	31%
67%	32%
68%	33%
69%	34%
70%	35%

~~At~~The total package of measures must have at least a 10% internal rate of return (IRR), and ~~At~~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.

An exception to the 15% savings requirement will be limited 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 100,000 kWh, 350 MMBTU or 4% of total facility consumption, whichever is greater. Exceptions must be pre-approved by Market Manager and currently only apply to existing buildings component of program

#### New Construction and Gut Rehabilitation

Projects are required to identify and implement energy efficiency improvements that will achieve a minimum of 5% energy cost savings for C&I buildings, and 15% for multifamily, as measured from ASHRAE 90.1-2013 baseline. Equivalent performance targets for ASHRAE Building Energy Quotient (bEQ) As-Designed and ASHRAE 90.1-2013 with Addendum BM are provided in the program guidelines (see Baseline Conditions below).

Each project must have at least one measure addressing each envelope, heating, cooling, and lighting systems. Buildings that are not heated (e.g. refrigerated warehouse) or not cooled (e.g. warehouse) will not be required to have a measure addressing the missing building system.

#### **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 twelve months of energy use from all sources. Site energy use is converted to source energy use following EPA's site-to-source conversion factors<sup>21</sup>.

##### New Construction

Project may establish building baseline in one of two ways:

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<sup>21</sup> <https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf>

- 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<sup>22</sup> 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<sup>23</sup>.

(for existing buildings) or current state energy code, such as ASHRAE 90.1 2007 (for new construction).

### 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).

### 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.

<sup>22</sup> <http://buildingenergyquotient.org/asdesigned.html>

<sup>23</sup> 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.

### 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 for 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~~—or at the end of the Commissioning process (for new construction) and may vary from committed/installed savings. 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 all measures proposed under the Direct Install Program. This section includes protocols for measures that are not included in other sections of the Protocols. In addition, for several of the where Direct Install Protocols uses algorithms and inputs from the “Commercial and Industrial Energy Efficient Construction” section of the Protocols, different equipment baselines will be used to reflect the Direct Install includes early retirement. Baseline equipment efficiency shown in this section is an estimate of existing equipment efficiency rather than currently available standard efficiency.

### Electric HVAC Systems

Replacement of existing electric HVAC equipment with high efficiency units is a proposed measure under the Direct Install Program. (See C&I Construction Electric HVAC Systems 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 EER<sub>b</sub>. These age-based 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.

#### *Default Values for Mechanical System Efficiencies – Age-Based*

System	Units	Pre-1992	1992-present
Unitary HVAC / Split Systems			
<= 5.4 tons	SEER	9.10	10.00
5.4 - 11.25 tons	EER	7.70	8.46
11.25 - 20 tons	EER	7.56	8.31
Air-Air Heat Pump Systems			
<= 5.4 tons	SEER	9.10	10.00
5.4 - 11.25 tons	EER	7.56	8.31
Packaged Terminal Systems			
< 0.74 tons	EER	8.03	8.50
0.75 - 1 ton	EER	7.80	8.26
> 1 ton	EER	7.50	7.94
Water Source Heat Pumps			
All Capacities	EER	9.45	10.00

Source: Based on the 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”.

### Motors

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  $\eta_{base}$ . These efficiencies are used in estimating savings associated with the Direct Install Program because as an early replacement program, equipment is replaced as a direct result of the program.

Motor HP	Baseline Efficiency
1	0.75
1.5	0.775
2	0.80
3	0.825
5	0.84
7.5	0.845
10	0.85
>10	Use EPA Act 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 the Direct Install Program. (See C&I Construction Motors Protocols). 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

### *Walk-in Cooler/Freezer Evaporator Fan Control*

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

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system.<sup>1</sup>

#### Algorithms

Gross kWh Savings =  $kWh Savings_{EF} + kWh Savings_{RH} + kWh Savings_{EC}$

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

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

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

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

#### Definition of Variables

$kWh Savings_{EF}$  = Savings due to Evaporator Fan being off

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

$kWh Savings_{EC}$  = Savings due to the electronic controls on compressor and evaporator

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

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

$Phase_{EF}$  = Phase of Evaporator Fan

0.55 = Evaporator Fan Motor power factor.

8,760 = Annual Operating Hours

35.52% = Percent of time Evaporator Fan is turned off.<sup>2</sup>

0.28 = Conversion from kW to tons (Refrigeration).

1.6 = Efficiency of typical refrigeration system in kW/ton.<sup>3</sup>

$Amps_{CP}$  = Nameplate Amps of Compressor

$Volts_{CP}$  = Nameplate Volts of Compressor

Phase<sub>CP</sub> = Phase of Compressor  
0.85 = 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.<sup>4</sup>  
D = 0.228 or Diversity Factor<sup>5</sup>

Sources:

- (1) Several case studies related to NRM's Cooltrol system can be found at:  
[http://www.nrminc.com/national\\_resource\\_management\\_case\\_studies\\_cooltrol\\_cooler\\_control\\_systems.html](http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html)
- (2) This value is an estimate by NRM based on hundreds of downloads of hours of use data from the electronic controller. It is an 'average' savings number and has been validated through several 3<sup>rd</sup> Party Impact Evaluation Studies including study performed by HEC, "Analysis of Walk-in Cooler Air Economizers", Page 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 3<sup>rd</sup> 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. This is performed by measuring the ambient humidity and temperature of the store, calculating the dewpoint, and using PWM (pulse width modulation) to control the anti-sweat heaters based on specific algorithms for freezer doors. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system.<sup>1</sup>

#### Low Temperature (Freezer) Door Heater Control

##### Algorithms

$$\text{kWh Savings} = (\text{kW}_{\text{DH}} * 8,760) - ((40\% * \text{kW}_{\text{DH}} * 4,000) + (65\% * \text{kW}_{\text{DH}} * 4,760))$$

$$\text{kW Savings} = \text{kW}_{\text{DH}} * 46\% * 75\%$$

#### Definition of Variables

- kW<sub>DH</sub> = 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.<sup>2</sup>
- 4,000 = Number of hours door heaters run at 40% power.
- 65% = Percent of total run power of door heaters with controls providing minimum reduction.<sup>2</sup>
- 4,760 = Number of hours door heaters run at 65% power.
- 46% = Freezer Door Heater off time.<sup>3</sup>
- 75% = Adjustment factor to account for diversity and coincidence at peak demand time.<sup>2</sup>

#### Medium Temperature (Cooler) Door Heater Control

##### Algorithms

$$\text{kWh Savings} = (\text{kW}_{\text{DH}} * 8,760) - (60\% * \text{kW}_{\text{DH}} * 3,760)$$

$$\text{kW Savings} = \text{kW}_{\text{DH}} * 74\% * 75\%$$

#### Definition of Variables

- kW<sub>DH</sub> = Total demand (kW) of the cooler door heaters, based on nameplate volts and amps.
- 8,760 = Annual run hours of Cooler Door Heater before controls.
- 60% = Percent of total run power of door heaters with controls providing minimum reduction.<sup>2</sup>
- 3,760 = Number of hours door heaters run at 60% power.
- 74% = Cooler Door Heater off time.<sup>3</sup>
- 75% = Adjustment factor to account for diversity and coincidence at peak demand time.<sup>2</sup>

#### Notes/Sources:

- (1) Several case studies related to NRM's Cooltrol system can be found at:  
[http://www.nrminc.com/national\\_resource\\_management\\_case\\_studies\\_cooltrol\\_cooler\\_control\\_systems.html](http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html)
- (2) Estimated by NRM based on their experience of monitoring the equipment at various sites.
- (3) This value is an estimate by National Resource Management based on hundreds of downloads of hours of use data from Door Heater controllers. This supported by 3<sup>rd</sup> Party Analysis conducted by Select Energy for NSTAR, "Cooler Control Measure Impact Spreadsheet Users' Manual", Page 5, March 9, 2004.

### ***Aluminum Night Covers***

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

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

#### Algorithms

$$\text{kWh Savings} = W * H * F$$

#### 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:
  - Low temperature (-35F to -5F) F = 0.1 kW/ft
  - Medium temperature (0F to 30F) F = 0.06 kW/ft
  - High temperature (35F to 55F) F = 0.04 kW/ft

### ***Electric Defrost Control***

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

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

### Algorithms

Gross kWh Savings =  $kWh Savings_{Defrost} + kWh Savings_{RH}$

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

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

### Definition of Variables

$kWh Savings_{Defrost}$  = Savings due to reduction of defrosts

$kWh Savings_{RH}$  = Savings due to reduction in refrigeration load

$KW_{Defrost}$  = Nameplate Load of Electric Defrost

0.667 = Average Length of Electric Defrost in hours

4 = Average Number of Electric Defrosts per day

365 = 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<sup>1</sup>

### Sources:

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

### **LED Lighting for Coolers and Freezers**

This measure is applicable to existing walk-in and reach-in coolers and freezers with non-LED lighting. LED lighting is not only more efficient, but also provides higher quality lighting for cooler and freezer displays as they are more suited for cold environments. In addition, LEDs have a longer operating life than fluorescents in cooler and freezer applications, which results in reduced life cycle costs. The estimated savings for this measure take into account both reduced wattage of replacement lighting and reduced refrigeration load from lighting heat loss.

### Algorithms

kWh Savings =  $((Watts_B - Watts_{LED})/1000) * H * (1 + (0.28 * 1.6))$

kW Savings =  $((Watts_B - Watts_{LED})/1000) * (1 + (0.28 * 1.6))$

### Definition of Variables

$Watts_B$  = Baseline Lighting Wattage

$Watts_{LED}$  = LED Lighting Wattage

1000 = Conversion from W to kW

H = Lighting Operating Hours

0.28 = Conversion from kW to tons (Refrigeration)

1.6 = Efficiency of typical refrigeration system in kW/ton<sup>24</sup>

### ***Novelty Cooler Shutoff***

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

Several case studies have been performed that verify the accuracy of these savings. The algorithms below are based on field-tested approximations of energy savings realized through installation of National Resource Management Inc. (NRM)'s Cooltrol® energy management system.<sup>1</sup>

### Algorithms

kWh Savings = (((Amps<sub>NC</sub> \* Volts<sub>NC</sub> \* (Phase<sub>NC</sub>)<sup>1/2</sup>)/1000) \* 0.85) \* ((0.45 \* ((CH - 1) \* 91)) + (0.5 \* ((CH - 1) \* 274)))

### Definition of Variables

Amps<sub>NC</sub> = Nameplate Amps of Novelty Cooler

Volts<sub>NC</sub> = Nameplate Volts of Novelty Cooler

Phase<sub>NC</sub> = Phase of Novelty Cooler

0.85 = Novelty Cooler power factor<sup>2</sup>

0.45 = Duty cycle during winter month nights<sup>3</sup>

CH = Closed Store hours

91 = Number of days in winter months

0.5 = Duty cycle during non-winter month nights<sup>3</sup>

274 = Number of days in non-winter months

### NotesSources:

- (1) Several case studies related to NRM's Cooltrol system can be found at:  
[http://www.nrminc.com/national\\_resource\\_management\\_case\\_studies\\_cooltrol\\_cooler\\_control\\_systems.html](http://www.nrminc.com/national_resource_management_case_studies_cooltrol_cooler_control_systems.html)
- (2) Estimated by NRM based on their experience of monitoring the equipment at various sites.
- (3) Duty Cycles are consistent with 3<sup>rd</sup> Party study done by Select Energy for NSTAR "Cooler Control Measure Impact Spreadsheet Users' Manual", page 5, March 9, 2004.

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<sup>24</sup> Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual*. 2004.

## Gas Space and Water Heating Measures

### Gas Furnaces and Boilers

Replacement of existing gas, oil, or propane furnaces and boilers with high efficiency units is a proposed measure under the Direct Install Program. (See C&I Construction Gas 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 AFUE<sub>b</sub>. These age-based 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.

#### Default Values for Mechanical System Efficiencies – Age-Based

System	Units	Pre-1992	1992- present
Gas or Propane Furnace	AFUE	0.73	0.78
Gas or Propane Boiler	AFUE	0.70	0.80
Oil Furnace or Boiler	AFUE	0.77	0.80

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

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

For Boilers that are under 5000 MBtuH/MBtuA use the calculator from the Federal Energy Management Program at:

[http://www1.eere.energy.gov/femp/technologies/eep\\_boilers\\_calc.html](http://www1.eere.energy.gov/femp/technologies/eep_boilers_calc.html)



### ***Gas and Propane Infrared Heating***

Replacement of existing atmospherically vented heating with gas or propane infrared heating is an available measure under the Direct Install Program. (See C&I Construction Gas Protocols).

### ***Gas Water Heating***

Replacement of existing gas furnaces and boilers with gas high efficiency units is a proposed measure under the Direct Install Program. (See C&I Construction Gas 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 EFF<sub>b</sub>. These age-based 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.

#### ***Default Values for Water Heating System Efficiencies – Age-Based***

<b>Water Heater Type</b>	<b>Units</b>	<b>Pre-1992</b>	<b>1992- present</b>
Gas	EF	0.53	0.56
Oil	EF	0.5	0.56
Electric	EF	0.87	0.88

**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”.

### **Food Service Measures**

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

- Electric combination and convection ovens – ASTM 1639-F
- Gas combination and convection ovens – ASTM 1639-F
- Gas conveyor and rack ovens – ASTM 1817-F

- Electric and gas small vat fryers – ASTM 1361-F
- Electric and gas large vat fryers – ASTM 2144-F
- Electric and gas steamers – ASTM 1484-F
- Electric and gas griddles – ASTM 1275-F
- Hot food holding cabinets – ATM F2140-11

### ***Electric and Gas Combination Oven/Steamer***

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

#### Algorithms

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

$$\text{Demand Savings (kW)} = \text{kWh Savings} / (D * H)$$

$$\text{Preheat Savings}^\dagger: E_p = P * (PE_b - PE_q)$$

$$\text{Convection Mode Idle Savings}^\dagger: E_{ic} = (I_{cb} - I_{cq}) * ((H - (P * P_t)) - (I_{cb}/PC_{cb} - I_{cq}/PC_{cq}) * Lbs) * (1 - S_t)$$

$$\text{Steam Mode Idle Savings}^\dagger: E_{is} = (I_{sb} - I_{sq}) * ((H - (P * P_t)) - (I_{sb}/PC_{sb} - I_{sq}/PC_{sq}) * Lbs) * S_t$$

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

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

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

#### Definition of Variables (See tables of values below for more information)

D = Operating Days per Year

P = Number of Preheats per Day

PE<sub>b</sub> = Baseline Equipment Preheat Energy

PE<sub>q</sub> = Qualifying Equipment Preheat Energy

I<sub>cb</sub> = Baseline Equipment Convection Mode Idle Energy Rate

I<sub>cq</sub> = Qualifying Equipment Convection Mode Idle Energy Rate

H = Daily Operating Hours

P<sub>t</sub> = Preheat Duration

PC<sub>cb</sub> = Baseline Equipment Convection Mode Production Capacity

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$PC_{cq}$  = Qualifying Equipment Convection Mode Production Capacity  
 Lbs = Total Daily Food Production  
 $S_t$  = Percentage of Time in Steam Mode  
 $I_{sb}$  = Baseline Equipment Steam Mode Idle Energy Rate  
 $I_{sq}$  = Qualifying Equipment Steam Mode Idle Energy Rate  
 $PC_{sb}$  = Baseline Equipment Steam Mode Production Capacity  
 $PC_{sq}$  = Qualifying Equipment Steam Mode Production Capacity  
 $Heat_c$  = Convection Mode Heat to Food  
 $Eff_{cb}$  = Baseline Equipment Convection Mode Cooking Efficiency  
 $Eff_{cq}$  = Qualifying Equipment Convection Mode Cooking Efficiency  
 $C$  = Conversion Factor from Btu to kWh or Therms  
 $Heat_s$  = Steam Mode Heat to Food  
 $Eff_{sb}$  = Baseline Equipment Steam Mode Cooking Efficiency  
 $Eff_{sq}$  = Qualifying Equipment Steam Mode Cooking Efficiency

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

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

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

**Sources:** Source:

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.

***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

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

Demand Savings (kW) =  $kWh \text{ Savings} / (D * H)$

Preheat Savings<sup>†</sup>:  $E_p = P * (PE_b - PE_q)$

Idle Savings<sup>†</sup>:  $E_i = (I_b - I_q) * (H - (P * P_t)) - (I_b / PC_b - I_q / PC_q) * Lbs$

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

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

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

D = Operating Days per Year

P = Number of Preheats per Day

PE<sub>b</sub> = Baseline Equipment Preheat Energy

PE<sub>q</sub> = Qualifying Equipment Preheat Energy

I<sub>b</sub> = Baseline Equipment Idle Energy Rate

I<sub>q</sub> = Qualifying Equipment Idle Energy Rate

H = Daily Operating Hours

P<sub>t</sub> = Preheat Duration

PC<sub>b</sub> = Baseline Equipment Production Capacity

PC<sub>q</sub> = Qualifying Equipment Production Capacity

Lbs = Total Daily Food Production

Heat = Heat to Food

Eff<sub>b</sub> = Baseline Equipment Convection Mode Cooking Efficiency

Eff<sub>q</sub> = Qualifying Equipment Convection Mode Cooking Efficiency

C = Conversion Factor from Btu to kWh or Therms

<b>Table 1: Electric Convection Ovens</b>				
<i>Variable</i>	<i>Baseline</i>		<i>Qualifying</i>	
	<i>Full Size</i>	<i>Half Size</i>	<i>Full Size</i>	<i>Half Size</i>
D - Operating Days per Year	Table 11	Table 11	Table 11	Table 11
P - Number of Preheats per Day	1	1	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (kWh)	1.50	1.00	1.00	0.90
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (kW)	2.00	1.50	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	70	45	82	53
Lbs - Total Daily Food Production (lbs)	100	100	100	100
Heat - Heat to Food (Btu/lb)	250	250	250	250
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	65%	65%	Application	Application
C - Btu/kWh	3,412	3,412	3,412	3,412

<b>Table 2: Gas Convection Ovens</b>				
<i>Variable</i>	<i>Baseline</i>		<i>Qualifying</i>	
	<i>Full Size</i>	<i>Half Size</i>	<i>Full Size</i>	<i>Half Size</i>
D - Operating Days per Year	Table 11	Table 11	Table 11	Table 11
P - Number of Preheats per Day	1	1	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (Btu)	19,000	13,000	11,000	7,500
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (Btu/h)	18,000	12,000	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	70	45	83	55
Lbs - Total Daily Food Production (lbs)	100	100	100	100
Heat - Heat to Food (Btu/lb)	250	250	250	250
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	30%	30%	Application	Application
C - Btu/Therm	100,000	100,000	100,000	100,000

<b>Table 3: Gas Conveyor Ovens</b>		
<i>Variable</i>	<i>Baseline</i>	<i>Qualifying</i>
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (Btu)	35,000	18,000
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (Btu/hr)	70,000	Application
H - Operating Hours per Day	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	114	167
Lbs - Total Daily Food Production (lbs)	190	190
Heat - Heat to Food (Btu/lb)	250	250
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	20%	Application
C - Btu/Therm	100,000	100,000

<b>Table 4: Gas Rack Ovens</b>				
<i>Variable</i>	<i>Baseline</i>		<i>Qualifying</i>	
	<i>Double Rack</i>	<i>Single Rack</i>	<i>Double Rack</i>	<i>Single Rack</i>
D - Operating Days per Year	Table 11	Table 11	Table 5	Table 5
P - Number of Preheats per Day	1	1	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (Btu)	100,000	50,000	85,000	44,000
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (Btu/h)	65,000	43,000	Application	Application
H - Operating Hours per Day	Table 11	Table 11	Table 5	Table 5
P <sub>t</sub> - Preheat Duration (hrs)	0.33	0.33	0.33	0.33
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	250	130	280	140
Lbs - Total Daily Food Production (lbs)	1200	600	1200	600
Heat - Heat to Food (Btu/lb)	235	235	235	235
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	30%	30%	Application	Application
C - Btu/Therm	100,000	100,000	100,000	100,000

<b>Table 5: Electric Steamers</b>		
<i>Variable</i>	<i>Baseline</i>	<i>Qualifying</i>
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (kWh)	1.50	1.50
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (kW)	0.167 x No. of Pans	Application
H - Operating Hours per Day	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	11.7 x No. of Pans	14.7 x No. of Pans
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	105	105
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	26%	Application
C - Btu/kWh	3,412	3,412

<b>Table 6: Gas Steamers</b>		
<i>Variable</i>	<i>Baseline</i>	<i>Qualifying</i>
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (Btu)	20,000	9,000
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (Btu/h)	2,500 x No. of Pans	Application
H - Operating Hours per Day	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	23.3 x No. of Pans	20.8 x No. of Pans
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	105	105
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	15%	Application
C - Btu/Therm	100,000	100,000

<b>Table 7: Electric Fryers</b>		
<i>Variable</i>	<i>Baseline</i>	<i>Qualifying</i>
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (kWh)	2.40	1.90
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (kW)	1.2	Application
H - Operating Hours per Day	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	71	71
Lbs - Total Daily Food Production (lbs)	150	150
Heat - Heat to Food (Btu/lb)	570	570
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	75%	Application
C - Btu/kWh	3,412	3,412

<b>Table 8: Gas Fryers</b>		
<i>Variable</i>	<i>Baseline</i>	<i>Qualifying</i>
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (Btu)	18,500	16,000
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (Btu/h)	17,000	Application
H - Operating Hours per Day	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	75	75
Lbs - Total Daily Food Production (lbs)	150	150
Heat - Heat to Food (Btu/lb)	570	570
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	35%	Application
C - Btu/Therm	100,000	100,000

<b>Table 9: Electric Griddles</b>		
<i>Variable</i>	<i>Baseline</i>	<i>Qualifying</i>
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (kWh)	1.3 x Griddle Width (ft)	0.7 x Griddle Width (ft)
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (kW)	0.8 x Griddle Width (ft)	Application
H - Operating Hours per Day	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	11.7 x Griddle Width (ft)	13.3 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	60%	Application
C - Btu/kWh	3,412	3,412



Table 10: Gas Griddles		
Variable	Baseline	Qualifying
D - Operating Days per Year	Table 11	Table 11
P - Number of Preheats per Day	1	1
PE <sub>b</sub> & PE <sub>q</sub> - Preheat Energy (Btu)	7,000 x Griddle Width (ft)	5,000 x Griddle Width (ft)
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (Btu/h)	7,000 x Griddle Width (ft)	Application
H - Operating Hours per Day	Table 11	Table 11
P <sub>t</sub> - Preheat Duration (hrs)	0.25	0.25
PC <sub>b</sub> & PC <sub>q</sub> - Production Capacity (lbs/hr)	8.3 x Griddle Width (ft)	15 x Griddle Width (ft)
Lbs - Total Daily Food Production (lbs)	100	100
Heat - Heat to Food (Btu/lb)	475	475
Eff <sub>b</sub> & Eff <sub>q</sub> - Heavy Load Cooking Efficiency	30%	Application
C - Btu/Therm	100,000	100,000

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

Sources:  
Source

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.

**Insulated Food Holding Cabinets**

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

Algorithms

Annual Energy Savings (kWh) =  $D * H * (I_b - I_q)$

Demand Savings (kW) =  $I_b - I_q$

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

D = Operating Days per Year

H = Daily Operating Hours

I<sub>b</sub> = Baseline Equipment Idle Energy Rate

I<sub>q</sub> = Qualifying Equipment Idle Energy Rate

Table 1: Insulated Food Holding Cabinets						
Variable	Baseline			Qualifying		
	Full Size	3/4 Size	1/2 Size	Full Size	3/4 Size	1/2 Size
D - Operating Days per Year	Table 2	Table 2	Table 2	Table 2	Table 2	Table 2
I <sub>b</sub> & I <sub>q</sub> - Idle Energy Rate (kW)	1.00	0.69	0.38	Application	Application	Application
H - Operating Hours per Day	Table 2	Table 2	Table 2	Table 2	Table 2	Table 2

Table 2: Operating Days/Hours by Building Type		
Building Type	Days/Year	Hours/Day
Education - Primary School	180	8
Education - Secondary School	210	11
Education - Community College	237	16
Education - University	192	16
Grocery	364	16
Medical - Hospital	364	24
Medical - Clinic	351	12
Lodging Hotel (Guest Rooms)	229	5
Lodging Motel	364	24
Manufacturing - Light Industrial	330	13
Office - Large	234	12
Office - Small	234	12
Restaurant - Sit-Down	364	12
Restaurant - Fast-Food	364	17
Retail - 3-Story Large	355	12
Retail - Single-Story Large	364	12
Retail - Small	364	11
Storage Conditioned	330	13
Storage Heated or Unconditioned	330	13
Warehouse	325	12
Average = Miscellaneous	303	14

### Sources:

#### Source

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.

## **Occupancy Controlled Thermostats**

The program has received a large amount of custom electric applications for the installation of Occupancy Controlled Thermostats in hotels, motels, and, most recently, university dormitories. Due to the number of applications, consistent incentive amounts (\$75 per thermostat) and predictable savings of the technology TRC recommends that a prescriptive application be created for this technology.

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

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

### Algorithms

$$\text{Cooling Energy Savings (kWh)} = \left( \left( T_c * \frac{(H+5)}{168} + S_c * \frac{(168 - (H+5))}{168} \right) T_c \right) * \left( P_c * \text{Cap}_{hp} * 12 * \frac{\text{EFLH}_c}{\text{EER}_{hp}} \right)$$

$$\text{Heating Energy Savings (kWh)} = \left( \left( T_h * \frac{(H+5)}{168} + S_h * \frac{(168 - (H+5))}{168} \right) T_h \right) * \left( P_h * \text{Cap}_{hp} * 12 * \frac{\text{EFLH}_h}{\text{EER}_{hp}} \right)$$

$$\text{Heating Energy Savings (Therms)} = \left( \left( T_h * \frac{(H+5)}{168} + S_h * \frac{(168 - (H+5))}{168} \right) T_h \right) * \left( P_h * \text{Cap}_{hp} * \frac{\text{EFLH}_h}{\text{AFUE}_h / 100,000} \right)$$

### Definition of Variables

T<sub>h</sub> = Heating Season Facility Temp. (°F)

T<sub>c</sub> = Cooling Season Facility Temp. (°F)

S<sub>h</sub> = Heating Season Setback Temp. (°F)

S<sub>c</sub> = Cooling Season Setup Temp. (°F)

H = Weekly Occupied Hours

$Cap_{hp}$  = Connected load capacity of heat pump/AC (Tons) – Provided on Application.  
 $Cap_h$  = Connected heating load capacity (Btu/hr) – Provided on Application.  
 $EFLH_c$  = Equivalent full load cooling hours  
 $EFLH_h$  = Equivalent full load heating hours  
 $P_h$  = Heating season percent savings per degree setback  
 $P_c$  = Cooling season percent savings per degree setup  
 $AFUE_h$  = Heating equipment efficiency – Provided on Application.  
 $EER_{hp}$  = Heat pump/AC equipment efficiency – Provided on Application  
12 = Conversion factor from Tons to kBtu/hr to acquire consumption in kWh.  
168 = Hours per week.  
5 = Assumed weekly hours for setback/setup adjustment period (based on 1 setback/setup per day, 5 days per week).

### Occupancy Controlled Thermostats

Component	Type	Value	Source
$T_h$	Variable		Application
$T_c$	Variable		Application
$S_h$	Fixed	$T_h - 5^\circ$	
$S_c$	Fixed	$T_c + 5^\circ$	
H	Variable		Application; Default of 56 hrs/week
$Cap_{hp}$	Variable		Application
$Cap_h$	Variable		Application
$EFLH_c$	Fixed	381	1
$EFLH_h$	Fixed	900	PSE&G
$P_h$	Fixed	3%	2
$P_c$	Fixed	6%	2
$AFUE_h$	Variable		Application
$EER_{hp}$	Variable		Application

Sources:

1. JCP&L metered data from 1995-1999
2. ENERGY STAR Products website

### Dual Enthalpy Economizers

Dual enthalpy economizers are used to control a ventilation system's outside air intake in order to reduce a facility's total cooling load. An economizer monitors the outside air to ensure that its temperature (sensible heat) and humidity (latent heat) are low enough to utilize outside air to provide cooling in place of the cooling system's compressor. This reduces the demand on the cooling system, lowering its usage hours, saving energy.

The measurement of energy savings associated with dual enthalpy economizers is based on algorithms with key variables provided through DOE-2 simulation modeling and ClimateQuest's economizer savings calculator. Savings are calculated per ton of connected cooling load. The baseline conditions are fixed damper for equipment under 5.4 tons and dry bulb economizer otherwise.

Algorithms

Energy Savings (kWh) =  $OTF * SF * Cap / Eff$

Demand Savings (kW) = Savings/Operating Hours

Definition of Variables

OTF = Operational Testing Factor

SF = Approximate savings factor based on regional temperature bin data (assume 4576 for equipment under 5.4 tons where a fixed damper is assumed for the baseline and 3318 for larger equipment where a dry bulb economizer is assumed for the baseline). (Units for savings factor are in kWh x rated EER per ton of cooling or kWh\*EER/Ton)

Cap = Capacity of connected cooling load (tons)

Eff = Cooling equipment energy efficiency ratio (EER)

Operating Hours = 4,438 = Approximate number of economizer operating hours

**Dual Enthalpy Economizers**

Component	Type	Value	Source
OTF	Fixed	1.0 when operational testing is performed, 0.8 otherwise	
SF		4576 for equipment under 5.4 tons, 3318 otherwise	1
Cap	Variable		<a href="#">Application</a>
Eff	Variable		<a href="#">Application</a>
Operating Hours	Fixed	4,438	2

Sources:

- 3. DOE-2 Simulation Modeling
- 4. ClimateQuest Economizer Savings Calculator

## Electronic Fuel-Use Economizers

These devices are microprocessor-based fuel-saving controls for commercial HVAC. They optimize energy consumption by adjusting burner or compressor run patterns to match the system's load. They can be used to control gas or oil consumption for any type of boiler or forced air furnace system. There are also fuel use economizers available that control the electric consumption for commercial air conditioning and refrigeration units by optimizing compressor cycles to maximize energy efficiency.<sup>1</sup>

A recent study of Fuel-use economizer controls by the New York State Energy Research and Development Authority (NYSERDA) in conjunction with Brookhaven National Laboratories (BNL) found that the typical energy savings for these devices generally varies between 10.08% and 19.15%, when used under normal operating conditions and normalized for typical annual degree-days in the New York metro area.<sup>2</sup> The NYSERDA study tested at each of the different models of fuel-use economizers manufactured by *Intellidyne, LLC*, (under the brand name *IntelliCon*). Operational data was recorded for various commercial heating, cooling, and refrigeration systems (of different sizes and fuel types) with and without the *IntelliCon* fuel-use economizers added. The average energy savings across all system and fuel types and operational conditions was found to be 13%. Another study of *IntelliCon* fuel-use economizers by Consolidated Edison, Inc. (ConEd) found a similar range of savings for the devices when the devices were studied as a control option for commercial refrigeration units at supermarkets in New York City and the surrounding area.<sup>3</sup>

Test results in both studies showed a very good payback for the devices across all applications studied. However, no discernable pattern was evident to determine which installations are most likely to yield the highest savings. Though 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 average savings found in the NYSERDA study. Annual energy savings for each approved fuel-use economizer installation (for any *IntelliCon* brand or equivalent devices) can be estimated as simply 13% of the expected annual energy usage for the HVAC (or refrigeration) system without the device.

### Algorithms

$$\text{Electric Savings (kWh)} = (\text{AEU} * 0.13)$$

$$\text{Fuel Savings (MMBtu)} = (\text{AFU} * 0.13)$$

### Definition of Variables

AEU = Annual Electric Usage for an uncontrolled AC or refrigeration unit (kWh)

AFU = Annual Fuel Usage for an uncontrolled (gas, oil, propane) HVAC unit (MMBtu or gallons)

Notes:Sources:

(1) Some examples of the different types of fuel-use economizer controls available on the market can be found at: [http://www.intellidynellc.com/02\\_prods.htm](http://www.intellidynellc.com/02_prods.htm)

(2) NYSERDA (2007) "A Technology Demonstration and Validation Project for Intellidyne Energy Saving Controls".

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(3) ConEd Solutions (2000) "Report on Intellidyne Unit Installation at Six Key Food Supermarkets".

## Low Flow Devices

Low flow showerheads, faucet aerators and pre-rinse spray valves save water heating energy by reducing the total flow rate from water sources.

The measurement of energy savings associated with low flow devices is based on algorithms with key variables provided through Fisher-Nickel's Life Cycle cost calculators.

### Algorithms

$$\text{Savings} = N \times (60 \times H \times D \times (F_{\text{base}} - F_{\text{eff}}) \times 8.33 \times DT \times (1/\text{Eff}) / C$$

### Definition of Variables

60 = Conversion from hours to minutes

N = Number of fixtures

H = Hours per day of device usage

D = Days per year of facility operation

$F_{\text{base}}$  = Baseline device flow rate (gal/m)

$F_{\text{eff}}$  = Low flow device flow rate (gal/m)

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

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

Eff = Percent efficiency of water heating equipment

New Jersey Clean Energy Program  
Protocols to Measure Resource Savings

TBD

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

### Low Flow Devices

Component	Type	Value	Source
N	Variable		Application
H	Fixed	3 for pre-rinse spray valves	1
H	Fixed	20 minutes for showerheads 30 minutes for aerators	2
D	Variable		<a href="#">Application</a>
F <sub>base</sub>	Variable		<a href="#">Application</a>
F <sub>eff</sub>	Variable	Max of 1.0 gpm for lavatory aerators, 2.2 for kitchen aerators and 2.0 gpm for showerheads per EPA's Water Sense Label	<a href="#">Application</a>
DT	Fixed	50°F for showerheads and faucet aerators, 70°F for pre-rinse spray valves	1
Eff	Variable	default of 80% for gas water heaters and 95% for electric water heaters	<a href="#">Application</a>

Sources:

1. Fisher-Nickel Life Cycle cost calculator
2. FEMP Cost Calculator located at [http://www1.eere.energy.gov/femp/technologies/eep\\_faucets\\_showerheads\\_calc.html](http://www1.eere.energy.gov/femp/technologies/eep_faucets_showerheads_calc.html)

### Demand Control Ventilation Using CO<sub>2</sub> Sensors

Demand control ventilation (DCV) monitors indoor air CO<sub>2</sub> content as a result of occupancy production levels and uses this data to regulate the amount of outdoor air that is permitted for ventilation. In order to ensure adequate air quality, standard ventilation systems permit outside air based on estimated occupancy levels in CFM/occupant. However, during low occupancy hours, the space may become over ventilated due to decreased CO<sub>2</sub> levels. This air must be conditioned and, therefore, unnecessary ventilation results in wasted energy. DCV reduces unnecessary outdoor air intake by regulating ventilation based on actual CO<sub>2</sub> levels, saving energy. DCV is most suited for facilities where occupancy levels are known to fluctuate considerably.

The measurement of energy savings associated with DCV is based on hours of operation, occupancy schedule, return air enthalpy, return air dry bulb temperature, system air flow, outside air reduction, cooling system efficiency, and other factors. As a conservative simplification of complex algorithms, DCV is assumed to save 5% of total facility HVAC load in appropriate building types based on FEMP DCV documentation.



Algorithms

Electric Savings (kWh) = 0.05 \* HVAC<sub>E</sub>

Gas Savings (Therms) = 0.05 \* HVAC<sub>G</sub>

Definition of Variables

HVAC<sub>E</sub> = Total electric HVAC consumption (kWh)

HVAC<sub>G</sub> = Total gas HVAC consumption (Therms)

**Demand Control Ventilation Using CO<sub>2</sub> Sensors**

Component	Type	Value	Source
HVAC <sub>E</sub>	Variable		Application
HVAC <sub>G</sub>	Variable		Application

**Pipe Insulation**

Un-insulated hot water carrying pipes lose considerable heat to outside air due to high thermal conductivity. In order to reduce this heat loss, pipes can be covered with a layer of fiberglass insulation, which will reduce source heating demand, resulting in significant energy savings.

The measurement of energy savings associated with pipe insulation is based on the length of the supply pipe, pipe diameter, relative thermal conductivity of bare and insulated piping and the temperature difference between supplied water and outside air temperature as indicated in the EPRI report referenced below. The baseline case is un-insulated copper pipe and the default proposed case is 0.5” of fiberglass insulation.

Algorithms

Energy Savings (kWh) = (L \* ((HLC<sub>base</sub> - HLC<sub>ee</sub>) / C) \* ΔT) \* 8,760

Definition of Variables

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

HLC<sub>base</sub> = Pipe heat loss coefficient by pipe diameter (baseline) (BtuH Btu/hr °F-ft)

HLC<sub>ee</sub> = Pipe heat loss coefficient by pipe diameter (proposed) (BtuH Btu/hr °F-ft)

C = Conversion from Btu to kWh or Therms (3,413 for kWh (Electric Water Heating), 100,000 for Therms (Gas Water Heating))

ΔT = Average temperature difference between supplied water and outside air temperature (°F)

8,760 = Hours per year

### Pipe Insulation

Component	Type	Value	Source
L	Variable		Application
HLC <sub>base</sub>	Fixed	See Table Below	
HLC <sub>ee</sub>	Fixed	See Table Below	
ΔT	Variable	Default is 65°F	EPRI Study

### Pipe Heat Loss Coefficient Table

Pipe Diam. (in.)	HLC <sub>base</sub>	HLC <sub>ee</sub>	Pipe Diam. (in.)	HLC <sub>base</sub>	HLC <sub>ee</sub>
0.75	0.43	0.25	0.75	0.43	0.25
1.00	0.54	0.29	1.00	0.54	0.29
1.25	0.64	0.33	1.25	0.64	0.33
1.50	0.76	0.36	1.50	0.76	0.36
2.00	0.94	0.42	2.00	0.94	0.42
2.50	1.00	0.48	2.50	1.00	0.48
3.00	1.30	0.56	3.00	1.30	0.56
4.00	1.70	0.69	4.00	1.70	0.69

Field Code Changed

### Sources:

Pipe Diam. (in.)	HLC <sub>base</sub>	HLC <sub>ee</sub>
0.75	0.43	0.25
1.00	0.54	0.29
1.25	0.64	0.33
1.50	0.76	0.36
2.00	0.94	0.42
2.50	1.00	0.48
3.00	1.30	0.56
4.00	1.70	0.69

Source: Engineering Methods for Estimating the Impacts of Demand-Side Management Programs, Volume 2, EPRI, 1993

### 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.

## **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 the Large Energy Users 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).<sup>25</sup> The combined values for all projects participating in a specified period are then summed up and converted to MWh for reporting purposes.

### Renewable Non-SRP

#### Sustainable Biomass

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.

#### Renewable Electric Storage

The impact of Renewable Electric Storage, if any on net renewable energy generation will be analyzed over the coming year based upon quarterly performance reporting that is required of participants in this program.

### ~~Renewable Energy Program: Grid-Connected~~

~~Energy savings/generation for projects installed pursuant to the Renewable Energy Program: Grid-Connected 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. The reported savings for each project participant in the REDI will be calculated and presented for review by the Office of Clean Energy.~~

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<sup>25</sup> Estimated annual production factor is based on combined average calculation of the PV Watts estimated annual output for the Newark and Atlantic City weather stations.

## Appendix A Measure Lives

### NEW JERSEY STATEWIDE ENERGY-EFFICIENCY PROGRAMS Measure Lives Used in Cost-Effectiveness Screening April 2012

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 should be utilized.

PROGRAM/Measure	Measure Life
<b><i>Residential Programs</i></b>	
<b>Energy Star Appliances</b>	
ES Refrigerator post 2001	12
ES Refrigerator 2001	12
ES Freezer	11
ES Dishwasher	10
ES Clothes washer	11
ES Dehumidifier	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
<b>Energy Star Lighting</b>	
CFL	5
Indoor Fluorescent Fixture	20
Torchiere Residential	10
Fixtures Other	20
LED	1520
<b>Energy Star Windows</b>	
WIN-heat pump	20
WIN-gas heat/CAC	20
WIN-gas No CAC	20
WIN-oil heat/CAC	20
WIN-oil No CAC	20
Win-elec No AC	20

Win-elec AC	20
<b>Refrigerator/Freezer Retirement</b>	
Refrigerator/Freezer retirement	8
<b>Residential New Construction</b>	
SF gas w/CAC	20
SF gas w/o CAC	20
SF oil w/CAC	20
SF all electric	20
TH gas w/CAC	20
TH gas w/o CAC	20
TH oil w/CAC	20
TH all electric	20
MF gas w/AC	20
MF gas w/o AC	20
MF oil w/CAC	20
MF all electric	20
ES Clothes washer	20
Recessed Can Fluor Fixture	20
Fixtures Other	20
Efficient Ventilation Fans w/Timer	10

<b>PROGRAM/Measure</b>	<b>Measure Life</b>
<b><i>Residential Programs</i></b>	
<b>Residential Electric HVAC</b>	
CAC 13	15
CAC 14	15
ASHP 13	15
ASHP 14	15
CAC proper sizing/install	15
CAC QIV	15
CAC Maintenance	7
CAC duct sealing	15
ASHP proper sizing/install	15
E-Star T-stat (CAC)	15
E-star T-stat (HP)	15
GSHP	30
CAC 15	15
ASHP 15	15
<b>Residential Gas HVAC</b>	
High Efficiency Furnace	20
High Efficiency Boiler	20

High Efficiency Gas DHW	10
E-Star T-stat	15
Boiler Reset Controls	7
<b>Low-Income Program</b>	
Air sealing electric heat	30
Duct Leak Fossil Heat & CAC	15
typical fossil fuel heat	17
typical electric DHW pkg	10
typical fossil fuel DHW pkg	10
screw-in CFLs	6.4
high-performance fixtures	20
fluorescent torchieres	10
TF 14	20
TF 16	20
TF 18	20
SS 20	20
TF 21	20
SS 22	20
TF 25	20
audit fees	20
Attic Insulation- ESH	30
Duct Leak - ESH	15
T-Stat- ESH	5
HP charge air flow	8
electric arrears reduction	1
gas arrears reduction	1
<b>Home Performance with ENERGY STAR</b>	
Blue Line Innovations – PowerCost Monitor™	5

<b>PROGRAM/Measure</b>	<b>Measure Life</b>
<b><i>Non-Residential Programs</i></b>	
<b>C&amp;I Construction</b>	
Commercial Lighting — New	15
Commercial Lighting — Remodel/Replacement	15
Commercial Lighting Controls — Remodel/Replacement	18
Commercial Custom — New	18
Commercial Chiller Optimization	18
Commercial Unitary HVAC — New - Tier 1	15
Commercial Unitary HVAC — Replacement - Tier 1	15
Commercial Unitary HVAC — New - Tier 2	15
Commercial Unitary HVAC — Replacement Tier 2	15

Commercial Chillers — New	25
Commercial Chillers — Replacement	25
Commercial Small Motors (1-10 HP) — New or Replacement	20
Commercial Medium Motors (11-75 HP) — New or Replacement	20
Commercial Large Motors (76-200 HP) — New or Replacement	20
Commercial VSDs — New	15
Commercial VSDs — Retrofit	15
Commercial Air Handlers Units	20
Commercial Heat Exchangers	24
Commercial Burner Replacement	20
Commercial Boilers	25
Commercial Controls (electric/electronic)	15
Commercial Controls (Pneumatic)	10
Commercial Comprehensive New Construction Design	18
Commercial Custom — Replacement	18
Industrial Lighting — New	15
Industrial Lighting — Remodel/Replacement	15
Industrial Unitary HVAC — New - Tier 1	15
Industrial Unitary HVAC — Replacement - Tier 1	15
Industrial Unitary HVAC — New - Tier 2	15
Industrial Unitary HVAC — Replacement Tier 2	15
Industrial Chillers — New	25
Industrial Chillers — Replacement	25
Industrial Small Motors (1-10 HP) — New or Replacement	20
Industrial Medium Motors (11-75 HP) — New or Replacement	20
Industrial Large Motors (76-200 HP) — New or Replacement	20
Industrial VSDs — New	15
Industrial VSDs — Retrofit	15
Industrial Custom — Non-Process	18
Industrial Custom — Process	10
Industrial Air Handler Units	20
Industrial Heat Exchangers	20
Industrial Burner Replacements	20
Small Commercial Gas Furnace — New or Replacement	20
Infrared Heating	17
Small Commercial Gas Boiler — New or Replacement	20
Small Commercial Gas DHW — New or Replacement	10
C&I Gas Absorption Chiller — New or Replacement	25
C&I Gas Custom — New or Replacement (Engine Driven Chiller)	25
C&I Gas Custom — New or Replacement (Gas Efficiency Measures)	18



PROGRAM/Measure	Measure Life
<b><i>Non-Residential Programs</i></b>	
Building O&M	
O&M savings	3
Compressed Air	
Compressed Air (GWh participant)	8
Refrigeration	
Evaporator Fan Control	10
Cooler and Freezer Door Heater Control	10
Polyethylene Strip Curtains	4
Food Service	
Fryers	12
Steamers	10
Griddles	12
Ovens	12

PROGRAM/Measure	Measure Life
Solar Panels	25
CHP System ≤1 MW	15
CHP System >1 MW	20
Fuel Cells	<del>20</del>

\* For custom applications, projects will be evaluated upon industry/multiplier data but not to exceed value in above table unless authorized by the Market Manager. Reported savings will be calculated per measure life indicated in this table.