

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

Revisions to  
**September~~December~~ 2010~~09~~ 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. Calculate lost margin revenue recovery (as approved by the BPU)
4. 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)
5. 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)	<p>Some prescriptive lighting measures (delta watts on the application form times standard operating hours in the protocols)</p> <p>Residential Electric HVAC (change in efficiency level times site-specific capacity times standard operating hours)</p> <p>Field screening tools that use site-specific input values</p> <p>Customer On-Site Renewable Energy</p>
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	<p>Custom</p> <p>Industrial process</p> <p>Complex comprehensive jobs (P4P)</p> <p>CHP</p>

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.

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

Electric Energy Savings =  $\Delta kW \times EFLH$

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

Gas Energy Savings =  $\Delta Btuh \times EFLH$

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.

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

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 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 (Weekends and Holidays)	8:00 p.m. to 8:00 a.m.	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 1.11 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 PJM data were utilized. This reflects a mix of different losses that occur related to delivery at different voltage levels. The 1.11 factor used for both energy and capacity is a weighted average loss factor and was adopted by consensus.

#### ***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-Present
CO <sub>2</sub>	1.1 lbs per kWh saved	1,520 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
SO <sub>2</sub>	10.26 lbs per metric ton of CO <sub>2</sub> saved	6.5 lbs per MWh saved
Hg	0.00005 lbs per metric ton of CO <sub>2</sub> saved	0.0000356 lbs 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-specific protocols.

## Residential Electric HVAC

### Protocols

The measurement plan for residential high efficiency cooling and heating equipment is based on algorithms that determine a central air conditioner's 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)***

$$\text{Cooling Energy (kWh) Savings} = \text{CAPY}/1000 \times (1/\text{SEER}_b - (1/(\text{EER}_g \times \text{GSER}))) \times \text{EFLH}_c$$

$$\text{Heating Energy (kWh) Savings} = \text{CAPY}/1000 \times (1/\text{HSPF}_b - (1/(\text{COP}_g \times \text{GSOP}))) \times \text{EFLH}_h$$

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

***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)***

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

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



### 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.

GSER = The factor to determine the SEER of a GSHP based on its EER<sub>g</sub>.

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.

$COP_g$  = Coefficient of Performance. This is a measure of the efficiency of a heat pump.

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

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

EDSH = Assumed savings per desuperheater.

PDSH = Assumed peak demand savings per desuperheater.

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

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

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

$EFLH_{HT}$  = The Equivalent Full Load Hours of operation for the average heating unit

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

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

$kWh_p$  = Annual kWh due to proper sizing

$kWh_q$  = Annual kWh usage post-program

$kW_p$  = Annual kW due to proper sizing

$kW_q$  = Annual kW usage post-program

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

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

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	Baseline = 13	1
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>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
HSPF <sub>b</sub>	Fixed	Baseline = 7.7	8
HSPF <sub>q</sub>	Variable		Rebate Application
COP <sub>g</sub>	Variable		Rebate Application
GSOP	Fixed	3.413	9
GSPK	Fixed	0.8416	10
EDSH	Fixed	1842 kWh	11
PDSH	Fixed	0.34 kW	12
ESa <sub>vSDHW</sub>	Fixed	3100 kWh	21
DSa <sub>vSDHW</sub>	Fixed	0.426 kW	21

Component	Type	Value	Sources
CF <sub>SDHW</sub>	Fixed	20%	21
ES <sub>vHPHW</sub>	Fixed	2662 kW	23
DS <sub>vHPHW</sub>	Fixed	0.25 kW	24
CF <sub>HPHW</sub>	Fixed	70%	24
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
<a href="#"><u>HPWH Time Period Allocation Factors</u></a>	<a href="#"><u>Fixed</u></a>	<a href="#"><u>Summer/On-Peak 21%</u></a> <a href="#"><u>Summer/Off-Peak 22%</u></a> <a href="#"><u>Winter/On-Peak 28%</u></a> <a href="#"><u>Winter/Off-Peak</u></a>	<a href="#"><u>25</u></a>
Cap <sub>yq</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. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
2. Average EER for SEER 13 units.
3. VEIC estimate. Extrapolation of manufacturer data.
4. VEIC estimate. Consistent with analysis of PEPCo and LIPA, and conservative relative to ARI.

5. Xenergy, "New Jersey Residential HVAC Baseline Study", (Xenergy, Washington, D.C., November 16, 2001).
6. Based on an analysis of 6 different utilities by Proctor Engineering.
7. Xenergy, "New Jersey Residential HVAC Baseline Study", (Xenergy, Washington, D.C., November 16, 2001)
8. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
9. Engineering calculation, HSPF/COP=3.413
10. VEIC Estimate. Extrapolation of manufacturer data.
11. VEIC estimate, based on PEPCo assumptions.
12. VEIC estimate, based on PEPCo assumptions.
13. Time period allocation factors used in cost-effectiveness analysis.
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
15. Minimum Federal Standard for new Central Air Conditioners between 1990 and 2006
16. NJ utility analysis of heating customers, annual gas heating usage
17. Scott Pigg (Energy Center of Wisconsin), "Electricity Use by New Furnaces: A Wisconsin Field Study", Technical Report 230-1, October 2003.
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
19. The same EER to SEER ratio used for SEER 13 units applied to SEER 10 units.  $EER_m = (11.3/13) * 10$
20. VEIC estimate. Conservatively assumes less savings than for QIV because of the retrofit context
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. Loadshape and coincidence factors were developed by VEIC from ASHRAE hot water hourly consumption and NREL Red Book insulation data.
22. KEMA, *NJ Clean Energy Program Energy Impact Evaluation Protocol Review*. 2009.
23. ENERGY STAR® Residential Water Heaters: Final Criteria Analysis, 2008 using conservative assumptions and values for annual EF (2.0) based upon minimum energy star criteria.
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. [Allocation periods assumed to match standard electric resistance water heaters \(p. 26\)](#)

## 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 for a qualifying furnace =  $\text{OsavFURNACE}$

#### 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

$\text{EFLH}$  = 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

$\text{AFUE}_q$  = Annual Fuel Utilization Efficiency of the qualifying baseline furnace or boiler

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

$AFUE_{LI}$  = 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

OsavBOILER = Per unit energy (MMBTU) savings for a qualifying oil-fired boiler

OsavFURNACE = Per unit energy (MMBTU) savings for a qualifying oil-fired furnace

### Space Heating

Component	Type	Value	Source
$Cap_{y_q}$	Variable		Application
$Cap_{y_t}$	Fixed	$CAP_{y_Q}$	1
DuctSF <sub>h</sub>	Fixed	13%	5
$AFUE_{avg}$	Variable		Application
$AFUE_q$	Variable		Application
$AFUE_b$	Fixed	Gas Furnaces: 80% Gas Boilers: 83% <u>Electric Resistance Heating: 35%</u>	2
$AFUE_{LI}$	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
OsavBOILER <sup>2</sup>	Fixed	5.2	7
OsavFURNACE	Fixed	5.2	7

#### Sources:

1. NJ Residential HVAC Baseline Study
2. Based on the quantity of models available by efficiency ratings as listed in the April 2003 Gamma Consumers Directory of Certified Efficiency Ratings.
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.

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

<sup>2</sup> For 2010 the State Energy Efficiency Appliance Rebate Program provided by the US DOE allows the NJCEP program to support incentives for oil and propane equipment. The savings for this equipment can be found in this section of the protocols.

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. Savings derived from US DOE estimates for the SEEARP (EPA Savings Calculator. Assumes default values but without Programmable Thermostat)

**Water Heaters**

Algorithms

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

Gas Savings (Solar DHW) = GsavSHW

Definition of Variables

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

$EF_b = 0.67 - (0.0019 * \text{Gallons of Capacity})$

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.

**Water Heaters**

Component	Type	Value	Source
$EF_q$	Variable		Application Form, confirmed with Manufacturer Data
$EF_b$	Variable	<u>Electric Resistance:</u> <u>35%</u>	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

Sources:

1. Federal EPACT Standard for a 40 gallon gas water heater. Calculated as  $0.62 - (0.0019 \times \text{gallons of capacity})$ .
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)

## 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 and fluorescent torchieres 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

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

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

#### *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.

### Algorithm

$$\text{Electricity Impact (kWh)} = \text{HW}_{\text{avg}}$$

$$\text{Gas Savings (MMBtu)} = \text{HW}_{\text{gavg}}$$

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

$$\text{Water Savings (gallons)} = \text{WS}$$

### ***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

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

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

### ***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

$\text{CFL}_{\text{watts}}$  = Average watts replaced for a CFL installation.

$\text{CFL}_{\text{hours}}$  = Average daily burn time for CFL replacements.

$\text{Fixt}_{\text{watts}}$  = Average watts replaced for an efficient fixture installation.

$\text{Fixt}_{\text{hours}}$  = Average daily burn time for CFL replacements.

$\text{Torch}_{\text{watts}}$  = Average watts replaced for a Torchiere replacement.

$\text{Torch}_{\text{hours}}$  = Average daily burn time for a Torchiere replacements.

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

$\text{HW}_{\text{avg}}$  = Average electricity savings from typical electric hot water measure package.

$\text{HW}_{\text{gavg}}$  = Average natural gas savings from typical electric hot water measure package.

$\text{HW}_{\text{watts}}$  = Connected load reduction for typical hot water efficiency measures

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

$\text{Ref}_{\text{old}}$  = Annual energy consumption of existing refrigerator based on on-site monitoring.

$\text{Ref}_{\text{new}}$  = Rated annual energy consumption of the new refrigerator.

RefDF = kW /kWh of savings. Refrigerator demand savings factor.

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

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
Light CF	Fixed	5%	2
Elec. Water Heating Savings	Fixed	178 kWh	3
Gas Water Heating	Fixed	1.01 MMBTU	3

Component	Type	Value	Sources
Savings			
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
Capy	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.



## Residential New Construction Program

### Protocols

#### *Insulation Up-Grades, Efficient Windows, Air Sealing, Efficient HVAC Equipment, and Duct Sealing*

Energy savings due to improvements in Residential New Construction will be a direct output of accredited Home Energy Ratings (HERS) software that meets the applicable Mortgage Industry National Home Energy Rating System Standards. REM/Rate is cited -as [an](#) example of an accredited software which has a module that compares the energy characteristics of the energy efficient home to the baseline/reference home and calculates savings.

The system peak electric demand savings will be calculated from the software output with the following savings algorithms, which are based on compliance and certification of the energy efficient home to the EPA's ENERGY STAR for New Homes program standard:

Peak demand of the baseline home =  $(PL_b \times OF_b) / (SEER_b \times BLEER \times 1,000)$

Peak demand of the qualifying home =  $(PL_q \times OF_q) / (EER_q \times 1,000)$

Coincident system peak electric demand savings = (Peak demand of the baseline home – Peak demand of the qualifying home) X CF

#### 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  $EER_b$ .

$PL_q$  = The actual predicted peak load for the program qualifying home constructed, in Btuh.

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

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

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

In ~~March 2011~~[July 2002](#) energy code changes took place with the adoption of ~~MEC-95~~[IECC 2009](#). This code change affects baselines for variables used in the protocols. Therefore, to reflect these changes, tables and or values are identified as needed for installations completed

during 2001 through March 2003 and for installations completed in April 2003 through the present after December 31, 2011. The application of the code changes to completions starting in April/January 2012 allows for the time lag between when the permits are issued and a when a home would reasonably be expected to be completed.

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
$PL_q$	Variable		Software Output
$OF_q$	Fixed	1.15	5
$EER_q$	Variable		Program Application
CF	Fixed	0.70	6

Sources:

1. Calculation of peak load of baseline home from the home energy rating tool, based on the reference home energy characteristics.
2. PSE&G 1997 Residential New Construction baseline study.
3. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200
4. Engineering calculation.
5. Program guideline for qualifying home.
6. Based on an analysis of six different utilities by Proctor Engineering.

**Lighting and Appliances**

Quantification of additional saving due to the addition of high efficiency lighting and clothes washers will be based on the algorithms presented for these appliances in the Energy Star Lighting Protocols and the Energy Star Appliances Protocols, respectively. These protocols are found in the Energy Star Products Program.

**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.

The following table describes the characteristics of the three reference homes.

New Jersey ENERGY STAR Homes

REMRate User Defined Reference Homes -- Applicable to building completions from January 2012 to present -- Reflects MEC 95IECC 2009

<u>Data Point</u>	<u>Single and Multiple Family Except as Noted.</u>	
	<u>Climate Zone 4</u>	<u>Climate Zone 5</u>
<u>Active Solar</u>	<u>None</u>	
<u>Ceiling Insulation</u>	<u>U=0.030 (1)</u>	<u>U=0.030 (1)</u>
<u>Radiant Barrier</u>	<u>None</u>	<u>None</u>
<u>Rim/Band Joist</u>	<u>U=0.082 (1)</u>	<u>U=0.057 (1)</u>
<u>Exterior Walls - Wood</u>	<u>U=0.082 (1)</u>	<u>U=0.057 (1)</u>
<u>Exterior Walls - Steel</u>	<u>U=0.082 (1)</u>	<u>U=0.057 (1)</u>
<u>Foundation Walls</u>	<u>U=0.059</u>	<u>U=0.059</u>
<u>Doors</u>	<u>U=0.35 (1)</u>	<u>U=0.35 (1)</u>
<u>Windows</u>	<u>U=0.35 (1), No SHGC req.</u>	<u>U=0.35 (1), No SHGC req.</u>
<u>Glass Doors</u>	<u>U=0.35 (1), No SHGC req.</u>	<u>U=0.35 (1), No SHGC req.</u>
<u>Skylights</u>	<u>U=0.60 (1), No SHGC req.</u>	<u>U=0.60 (1), No SHGC req.</u>
<u>Floor</u>	<u>U=0.047 (2)</u>	<u>U=0.033 (2)</u>
<u>Unheated Slab on Grade</u>	<u>R-10, 2 ft</u>	<u>R-10, 2 ft</u>
<u>Heated Slab on Grade</u>	<u>R-15, 2 ft</u>	<u>R-15, 2 ft</u>
<u>Air Infiltration Rate</u>	<u>7 ACH50</u>	<u>7 ACH50</u>
<u>Duct Leakage</u>	<u>8 cfm25 per 100ft<sup>2</sup> CFA</u>	<u>8 cfm25 per 100ft<sup>2</sup> CFA</u>
<u>Mechanical Ventilation</u>	<u>None</u>	
<u>Lights and Appliances</u>	<u>Use RESNET Default (3)</u>	<u>Use RESNET Default (3)</u>
<u>Setback Thermostat</u>	<u>Yes, where primary heat is forced hot air</u>	<u>Yes, where primary heating is forced hot air</u>
<u>Heating Efficiency</u>		
<u>Furnace</u>	<u>80% AFUE (4)</u>	<u>80% AFUE (4)</u>
<u>Boiler</u>	<u>80% AFUE</u>	<u>80% AFUE</u>

<u>Data Point</u>	<u>Single and Multiple Family Except as Noted.</u>		
<u>Combo Water Heater</u>	<u>76% AFUE (recovery efficiency)</u>	<u>76% AFUE (recovery efficiency)</u>	
<u>Air Source Heat Pump</u>	<u>7.7 HSPE</u>	<u>7.7 HSPE</u>	
<u>PTAC / PTHP</u>	<u>Not differentiated from air source HP</u>	<u>Not differentiated from air source HP</u>	
<u>Cooling Efficiency</u>			
<u>Central Air Conditioning</u>	<u>13.0 SEER</u>	<u>13.0 SEER</u>	
<u>Air Source Heat Pump</u>	<u>13.0 SEER</u>	<u>13.0 SEER</u>	
<u>PTAC / PTHP</u>	<u>Not differentiated from central AC</u>	<u>Not differentiated from central AC</u>	
<u>Window Air Conditioners</u>	<u>Not differentiated from central AC</u>	<u>Not differentiated from central AC</u>	
<u>Domestic WH Efficiency</u>			
<u>Electric stand-alone tank</u>	<u>0.90 EF (5)</u>	<u>0.90 EF (5)</u>	
<u>Natural Gas stand-alone tank</u>	<u>0.58 EF (5)</u>	<u>0.58 EF (5)</u>	
<u>Electric instantaneous</u>	<u>0.93 EF (5)</u>	<u>0.93 EF (5)</u>	
<u>Natural Gas instantaneous</u>	<u>0.62 EF (5)</u>	<u>0.62 EF (5)</u>	
<u>Water Heater Tank Insulation</u>	<u>None</u>	<u>None</u>	
<u>Duct Insulation, attic supply</u>	<u>R-8</u>	<u>R-8</u>	
<u>Duct Insulation, all other</u>	<u>R-6</u>	<u>R-6</u>	

**Comment [MSOffice1]:** Recommend deleted baseline values for GSHP (heating and cooling). There is no Federal standard. Also, NE HERS recommends entering a de-rated efficiency (~3.4 COP). If raters are following these guidelines no equipment savings may be realized

Notes:

- (1) Varies with heating degree-days ("HHD"). Above value reflects 5000 HDD average for New Jersey.  
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) Absent any NJ specific lighting study, lighting savings is derived from a baseline installed efficient lighting default of 10% per RESNET guidelines.
- (4) MEC 95 minimum requirement is 78 AFUE. However, 80 AFUE is adopted for New Jersey based on typical minimum availability and practice.
- (5) 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)

**Comment [PS2]:** Standards section 303.4.1.7.1 For calculation purposes, the rated home shall never have FL% less than 10%.

<b>Data Point</b>	<b>Single and Multiple Family Except as Noted.</b>		
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- 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)

<b>Data Point</b>	<b>Single and Multiple Family Except as Noted.</b>		
-	-		
Active Solar	None		
Ceiling Insulation	U=0.031 (1)		
Radiant Barrier	None		
Rim/Band Joist	U=0.141 Type A-1, U=0.215 Type A-2 (1)		
Exterior Walls—Wood	U=0.141 Type A-1, U=0.215 Type A-2 (1)		
Exterior Walls—Steel	U=0.141 Type A-1, U=0.215 Type A-2 (1)		
Foundation Walls	U=0.09		
Doors	U=0.141 Type A-1, U=0.215 Type A-2 (1)		
Windows	U=0.141 Type A-1, U=0.215 Type A-2 (1), No SHGC req.		
Glass Doors	U=0.141 Type A-1, U=0.215 Type A-2 (1), No SHGC req.		
Skylights	U=0.031 (1), No SHGC req.		
Floor over Garage	U=0.050 (1)		
Floor over Unheated Basement	U=0.050 (1)		
Floor over Crawlspace	U=0.050 (1)		
Floor over Outdoor Air	U=0.031 (1)		
Unheated Slab on Grade	R-0 edge/R-4.3 under		
Heated Slab on Grade	R-0 edge/R-6.4 under		
Air Infiltration Rate	0.51 ACH winter/0.51 ACH summer		
Duct Leakage	No Observable Duct Leakage		
Mechanical Ventilation	None		
Lights and Appliances	Use Default		

<b>Data Point</b>	<b>Single and Multiple Family Except as Noted.</b>		
Setback Thermostat	Yes for heating, no for cooling		
Heating Efficiency	-		
- Furnace	80% AFUE (3)		
- Boiler	80% AFUE		
- Combo Water Heater	76% AFUE (recovery efficiency)		
- Air Source Heat Pump	6.8 HSPF		
- Geothermal Heat Pump	Open-not modeled, 3.0 COP-closed		
- PTAC / PTHP	Not differentiated from air source HP		
Cooling Efficiency	-		
- Central Air Conditioning	13.0 SEER		
- Air Source Heat Pump	13.0 SEER		
- Geothermal Heat Pump	3.4 COP (11.6 EER)		
- PTAC / PTHP	Not differentiated from central AC		
- Window Air Conditioners	Not differentiated from central AC		
Domestic WH Efficiency	-		
- Electric	0.86 EF (4)		
- Natural Gas	0.53 EF (4)		
Water Heater Tank Insulation	None		
Duct Insulation	N/A		

**Notes:**

- (1) Varies with heating degree-days ("HDD"). Above value reflects 5000 HDD average for New Jersey. 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) Closest approximation to MEC 95 requirements given the limitations of REM/Rate UDRH scripting language.
- (3) MEC 95 minimum requirement is 78 AFUE. However, 80 AFUE is adopted for New Jersey based on typical minimum availability and practice.
- (4) Size dependent. – 50 gallon assumed.

**New Jersey ENERGY STAR Homes**

**REMRate User Defined Reference Homes — Applicable to building completions from January 2008 to present**

<b>Data Point</b>	<b>Single and Multiple Family Except as Noted.</b>		
Domestic WH Efficiency			
— Electric	<del>EF = 0.97 — (0.00132 * gallons) (1)</del>		
— Natural Gas	<del>EF = 0.67 — (0.0019 * gallons) (1)</del>		

**Notes:**

~~(1) Federal Government standard for calculating EF~~





## 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. Some of these market tracking mechanisms are under development. Per unit savings estimates are derived primarily from a 2000 Market Update Report by RLW for National Grid's appliance program and from previous NEEP screening tool assumptions (clothes washers).

Note that the pre-July 2001 refrigerator measure has been deleted given the timing of program implementation. As no field results are expected until July 2001, there was no need to quantify savings relative to the pre-July 2001 efficiency standards improvement for refrigerators.

#### ***ENERGY STAR Refrigerators***

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

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

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

Electricity Impact (kWh) =  $ESav_{REF2}$

Demand Impact (kW) =  $DSav_{REF2} \times CF_{REF}$

#### ***ENERGY STAR Clothes Washers (MEF of 1.8 to 2.19)***

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

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

Gas Impact (Therms) =  $EGSav_{CW}$

Water Impact (gallons) =  $WSav_{CW}$

#### ***ENERGY STAR Clothes Washers – Tier ~~2~~3 (MEF of 2.20 or greater)***

Electricity Impact (kWh) =  $ESav_{CW~~2~~3}$

New Jersey Clean Energy Program  
Protocols to Measure Resource Savings

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| Demand Impact (kW) =  $DS_{av_{CW23}} \times CF_{CW}$

| Gas Impact (Therms) =  $GS_{av_{CW23}}$

| Water Impact (gallons) =  $WS_{av_{CW23}}$

***ENERGY STAR Dishwashers***

Electricity Impact (kWh) =  $ES_{av_{DW}}$

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

Gas Impact (MMBtu) =  $EGS_{av_{DW}}$

Water Impact (gallons) =  $WS_{av_{DW}}$

***ENERGY STAR Dishwashers CEE Tier 1)***

Electricity Impact (kWh) =  $ES_{av_{DW1}}$

Demand Impact (kW) =  $DS_{av_{DW1}} \times CF_{DW}$

Gas Impact (MMBtu) =  $GS_{av_{DW1}}$

Water Impact (gallons) =  $WS_{av_{DW1}}$

***ENERGY STAR Dehumidifiers***

Electricity Impact (kWh) =  $ES_{av_{DH}}$

Demand Impact (kW) =  $DS_{av_{DH}} \times CF_{DH}$

***ENERGY STAR Room Air Conditioners***

Electricity Impact (kWh) =  $ES_{av_{RAC}}$

Demand Impact (kW) =  $DS_{av_{RAC}} \times CF_{RAC}$

***ENERGY STAR Televisions – CEE Tier 2 (15% > E-Star Tier 1)***

Electricity Impact (kWh) =  $ES_{av_{TV}}$

Demand Impact (kW) =  $DS_{av_{TV}} \times CF_{TV}$

***ENERGY STAR Set Top Boxes***

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

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

***ENERGY STAR Desktop Computers***

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

Demand Impact (kW) =  $DS_{avCMP} \times CF_{CMP}$

***ENERGY STAR LCD Monitor – (25% > E-Star Tier 2)***

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

Demand Impact (kW) =  $DS_{avMON} \times CF_{MON}$

***Efficient Pool Pumps – (Two speed or variable speed)***

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

Demand Impact (kW) =  $DS_{avPP} \times CF_{PP}$

***Pool Pump Timers***

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

Demand Impact (kW) =  $DS_{avPPT} \times CF_{PPT}$

**Definition of Terms**

$ES_{avREF}$  = Electricity savings per purchased ENERGY STAR refrigerator.

$DS_{avREF}$  = Summer demand savings per purchased ENERGY STAR refrigerator.

$ES_{avREF2}$  = Electricity savings per purchased ENERGY STAR refrigerator – CEE Tier 2.

$DS_{avREF2}$  = Summer demand savings per purchased ENERGY STAR refrigerator – CEE Tier 2.

$ES_{avCW}$  = Electricity savings per purchased ENERGY STAR clothes washer.

$DS_{avCW}$  = Summer demand savings per purchased ENERGY STAR clothes washer.

$GS_{avCW}$  = Gas savings per purchased clothes washer

WSav<sub>CW</sub> = Water savings per purchased clothes washer.

ESav<sub>CW3</sub> = Electricity savings per purchased ENERGY STAR clothes washer - Tier 3

DSav<sub>CW3</sub> = Summer demand savings per purchased ENERGY STAR clothes washer - Tier 3

GSav<sub>CW3</sub> = Gas savings per purchased ENERGY STAR clothes washer - Tier 3

WSav<sub>CW3</sub> = Water savings per purchased ENERGY STAR clothes washer – Tier 3

ESav<sub>DW</sub> = Electricity savings per purchased ENERGY STAR dishwasher.

DSav<sub>DW</sub> = Summer demand savings per purchased ENERGY STAR dishwasher.

GSav<sub>DW</sub> = Gas savings per purchased ENERGY STAR dishwasher

WSav<sub>DW</sub> = Water savings per purchased ENERGY STAR dishwasher.

ESav<sub>DW1</sub> = Electricity savings per purchased ENERGY STAR dishwasher – CEE Tier 1

DSav<sub>DW1</sub> = Summer demand savings per purchased ENERGY STAR dishwasher – CEE Tier 1

GSav<sub>DW1</sub> = Gas savings per purchased ENERGY STAR dishwasher – CEE Tier 1

WSav<sub>DW1</sub> = Water savings per purchased ENERGY STAR dishwasher – CEE Tier 1

ESav<sub>DH</sub> = Electricity savings per purchased ENERGY STAR dehumidifier

DSav<sub>DH</sub> = Summer demand savings per purchased ENERGY STAR dehumidifier

ESav<sub>RAC</sub> = Electricity savings per purchased ENERGY STAR room AC.

DSav<sub>RAC</sub> = Summer demand savings per purchased ENERGY STAR room AC.

ESav<sub>TV</sub> = Electricity savings per purchased ENERGY STAR TV meeting CEE Tier 2.

DSav<sub>TV</sub> = Summer demand savings per purchased ENERGY STAR TV meeting CEE Tier 2.

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>CMP</sub> = Electricity savings per purchased ENERGY STAR computer.

DSav<sub>CMP</sub> = Summer demand savings per purchased ENERGY STAR computer.

ESav<sub>MON</sub> = Electricity savings per purchased ENERGY STAR monitor exceeding Tier 2 by 15%.

DSav<sub>MON</sub> = Summer demand savings per purchased ENERGY STAR monitor exceeding Tier 2 by 15%.

ESav<sub>PP</sub> = Electricity savings per purchased efficient pool pump (Two speed or variable speed).

DSav<sub>PP</sub> = Summer demand savings per purchased pool pump (Two speed or variable speed).

ESav<sub>PPT</sub> = Electricity savings per purchased pool pump timer.

DSav<sub>PPT</sub> = Summer demand savings per purchased pool pump timer.

CF<sub>REF</sub>, CF<sub>CW</sub>, CF<sub>DW</sub>, CF<sub>DH</sub>, CF<sub>RAC</sub>, CF<sub>TV</sub>, CF<sub>STB</sub>, CF<sub>CMP</sub>, CF<sub>MON</sub>, CF<sub>PP</sub>, CF<sub>PPT</sub> = Summer demand coincidence factor. 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 except for room air conditioners where the CF is 58%.

#### ENERGY STAR Appliances

Component	Type	Value	Sources
ESav <sub>REF</sub>	Fixed	105 kWh	1
DSav <sub>REF</sub>	Fixed	0.0120 kW	1
ESav <sub>REF2</sub>	Fixed	131 kWh	16
DSav <sub>REF2</sub>	Fixed	0.0150 kW	16
REF Time Period Allocation Factors	Fixed	Summer/On-Peak 20.9% Summer/Off-Peak 21.7% Winter/On-Peak 28.0% Winter/Off-Peak 29.4%	2
ESav <sub>CW</sub>	Fixed	90 kWh	17
Gsav <sub>CW</sub>	Fixed	5.23 therms	17
DSav <sub>CW</sub>	Fixed	0.0119 kW	17
WSav <sub>CW</sub>	Fixed	6,846 gallons	17
ESav <sub>CW23</sub>	Fixed	128 kWh	3
Gsav <sub>CW23</sub>	Fixed	9.00 therms	3
DSav <sub>CW23</sub>	Fixed	0.0170 kW	3
WSav <sub>CW23</sub>	Fixed	9433 gallons	3
CW Electricity Time Period Allocation Factors	Fixed	Summer/On-Peak 24.5% Summer/Off-Peak 12.8% Winter/On-Peak 41.7% Winter/Off-Peak 21.0%	2
CW Gas Time Period Allocation Factors	Fixed	Summer 50% Winter 50%	
ESav <sub>DW</sub>	Fixed	45 kWh	4
Gsav <sub>DW</sub>	Fixed	1.35 therms	4

Component	Type	Value	Sources
DSav <sub>DW</sub>	Fixed	0.0123	4
WSav <sub>DW</sub>	Fixed	402 gallons	4
ESav <sub>DW1</sub>	Fixed	53 kWh	18
GSav <sub>DW1</sub>	Fixed	1.56 therms	18
DSav <sub>DW1</sub>	Fixed	0.0145 kW	18
WSav <sub>DW1</sub>	Fixed	497 gallons	18
DW Electricity Time Period Allocation Factors	Fixed	19.8%, 21.8%, 27.8%, 30.6%	2
DW Gas Time Period Allocation Factors	Fixed	Summer 50% Winter 50%	8
ESav <sub>DH</sub>	Fixed	71 kWh	9
DSav <sub>DH</sub>	Fixed	.0098 kW	10
ESav <sub>RAC</sub>	Fixed	56.4 kWh	5
DSav <sub>RAC</sub>	Fixed	0.1018 kW	6
CF <sub>REF</sub> , CF <sub>CW</sub> , CF <sub>DW</sub> , CF <sub>DH</sub> , CF <sub>RAC</sub>	Fixed	1.0, 1.0, 1.0, 1.0, 0.58	7
CF <sub>REF</sub> , CF <sub>CW</sub> , CF <sub>DW</sub> , CF <sub>DH</sub> , CF <sub>TV</sub> , CF <sub>STB</sub> , CF <sub>CMP</sub> , CF <sub>MON</sub> , CF <sub>RAC</sub>	Fixed	1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.58	7
RAC Time Period Allocation Factors	Fixed	65.1%, 34.9%, 0.0%, 0.0%	2
ESav <sub>TV</sub>	Fixed	146 kWh	11
DSav <sub>TV</sub>	Fixed	.0160 kW	11
TV Time Period Allocation Factors	Fixed	Summer/On-Peak 24.5% Summer/Off-Peak 9.0% Winter/On-Peak 48.0% Winter/Off-Peak 18.5%	11
ESav <sub>STB</sub>	Fixed	94 kWh	12
DSav <sub>STB</sub>	Fixed	0.0107 kW	12
STB Time Period Allocation Factors	Fixed	Summer/On-Peak 16.6% Summer/Off-Peak 16.8% Winter/On-Peak 32.5% Winter/Off-Peak 34.1%	12
ESav <sub>CMP</sub>	Fixed	87 kWh	13
DSav <sub>CMP</sub>	Fixed	.0039 kW	13
CMP Time Period Allocation Factors	Fixed	Summer/On-Peak 16.9% Summer/Off-Peak 16.4% Winter/On-Peak 33.8% Winter/Off-Peak 32.9%	13
ESav <sub>MON</sub>	Fixed	43 kWh	14
DSav <sub>MON</sub>	Fixed	.0075 kW	14

Component	Type	Value	Sources
MON Time Period Allocation Factors	Fixed	Summer/On-Peak 16.9% Summer/Off-Peak 16.4% Winter/On-Peak 33.8% Winter/Off-Peak 32.9%	14
ESav <sub>VPP</sub>	Fixed	1,235 kWh	15
DSav <sub>VPP</sub>	Fixed	.74 kW	15
PP Time Period Allocation Factors	Fixed	Summer/On-Peak 65% Summer/Off-Peak 35% Winter/On-Peak 0% Winter/Off-Peak 0%	15
ESav <sub>PPT</sub>	Fixed	1,006 kWh	15
DSav <sub>PPT</sub>	Fixed	.124 kW	15
PPT Time Period Allocation Factors	Fixed	Summer/On-Peak 23% Summer/Off-Peak 77% Winter/On-Peak 0% Winter/Off-Peak 0%	15

Sources:

1. Energy Star refrigerator Savings are derived from US Department of Energy estimates for the State Energy Efficient Appliance Rebate Program. Demand savings are estimated based on a flat 8760 hours of use during the year.
2. Time period allocation factors used in cost-effectiveness analysis. From residential appliance load shapes.
3. Energy and water savings based on Consortium for Energy Efficiency estimates. Assumes 75% of participants have gas water heating and 60% have gas drying (the balance being electric). Demand savings derived using NEEP screening clothes washer load shape
4. Energy Star dishwasher savings are derived from US Department of Energy estimates for the State Energy Efficient Appliance Rebate Program. Demand savings derived using dishwasher load shape.
5. Energy and demand savings from engineering estimate based on 600 hours of use. Based on delta watts for ENERGY STAR and non-ENERGY STAR units in five different size (cooling capacity) categories. Category weights from LBNL *Technical Support Document for ENERGY STAR Conservation Standards for Room Air Conditioners*.
6. Average demand savings based on engineering estimate.
7. Coincidence factors already embedded in summer peak demand reduction estimates with the exception of RAC. RAC CF is based on data from PEPCO.
8. Prorated based on 6 months in the summer period and 6 months in the winter period.
9. Energy Star Dehumidifier Savings Calculator (Calculator updated: 2/15/05; Constants updated 05/07). A weighted average based on the distribution of available ENERGY STAR products was used to determine savings.
10. Conservatively assumes same kW/kWh ratio as Refrigerators
11. Demand savings for TVs are derived from a comparison of an average of a 2007 US EPA data set and a January 2009 Energy star approved list. Energy savings are calculated based on hourly usage patterns defined in the US EPA 2007 revised TV specification.

12. Baseline energy savings for set top boxes is based on recent evaluation by Marbek / Ecos for BC Hydro, Feasibility Assessment of Canadian ENERGY STAR Set-Top Box Promotion Program (2009). On average, demand savings are the same for both Active and Standby states and is based on 8760 hours usage.
13. Energy savings for efficient computers is developed from an updated EPA data set (2008) accompanying the release of Version 5.0 ENERGY STAR Specification for Computers. Demand savings are calculated based on average power consumption in the idle (on) state.
14. Energy and demand savings for ultra efficient LCD monitors is based on a submittal to the California Energy Commission, Docket 07-AAER-3. Loadshape and coincidence factors are adopted from the efficient computer measure.
15. Energy and demand savings for efficient pool pumps are calculated based on California Energy Commission performance curves for two speed and variable speed pool pumps. Timers and Pool Pumps assume continued operation from June 1<sup>st</sup> to Sept 15<sup>th</sup>.
16. Refrigerator savings for CEE Tier 2 are derived from a 5% increase in performance over the US Department of Energy estimates for an ENERGY STAR unit in the State Energy Efficient Appliance Rebate Program.
17. Energy Star clothes washer savings are derived from US Department of Energy estimates for the State Energy Efficient Appliance Rebate Program. Demand savings derived using NEEP screening clothes washer load shape.
18. Energy Star clothes washer savings are derived from US Department of Energy estimates for the State Energy Efficient Appliance Rebate Program. Demand savings derived using dishwasher load shape.

## 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.

#### ENERGY STAR CFL Bulbs

$$\text{Energy Savings (kWh)} = (\Delta\text{kW}/1000) * \text{CFL}_{\text{hours}} * 365 * \text{ISR}_{\text{cfl}}$$

$$\text{Demand Savings (kW)} = (\Delta\text{kW}/1000) * \text{CF}$$

#### ENERGY STAR Torchieres

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

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

#### ENERGY STAR Indoor Fixture

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

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

#### ENERGY STAR Outdoor Fixture

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

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

#### ENERGY STAR LED Recessed Downlights & Integral Lamps

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

$$\text{Demand Savings (kW)} = (\text{LED}_{\text{DWN-watts}} / 1000) * \text{CF}$$

#### Definition of Terms

$\Delta W$  = Average difference in watts between baseline and ENERGY STAR CFL

$\text{CFL}_{\text{hours}}$  = Average hours of use per day per CFL

CF = Summer demand coincidence factor for lighting

$\text{ISR}_{\text{CFL}}$  = In-service rate per CFL

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Protocols to Measure Resource Savings

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Torch<sub>watts</sub> = Average delta watts per purchased ENERGY STAR torchiere

Torch<sub>hours</sub> = Average hours of use per day per torchiere

ISR<sub>Torch</sub> = In-service rate per Torchier

IF<sub>watts</sub> = Average delta watts per purchased ENERGY STAR Indoor Fixture

IF<sub>hours</sub> = Average hours of use per day per Indoor Fixture

ISR<sub>IF</sub> = In-service rate per Indoor Fixture

OF<sub>watts</sub> = Average delta watts per purchased ENERGY STAR Outdoor Fixture

OF<sub>hours</sub> = Average hours of use per day per Outdoor Fixture

ISR<sub>OF</sub> = In-service rate per Outdoor Fixture

Light CF = Summer demand coincidence factor for lighting.

LED<sub>DWN-watts</sub> = Average delta watts per purchased LED recessed downlight

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

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

#### ENERGY STAR Lighting

Component	Type	Value	Sources
$\Delta W$	Fixed	48.5	5
CFL <sub>hours</sub>	Fixed	2.8	6
ISR <sub>CFL</sub>	Fixed	83.4%	5
CF	Fixed	9.9 %	4
Torch <sub>watts</sub>	Fixed	115.8	1
Torch <sub>hours</sub>	Fixed	3.0	2
ISR <sub>Torch</sub>	Fixed	83%	3
IF <sub>watts</sub>	Fixed	48.7	1
IF <sub>hours</sub>	Fixed	2.6	2
ISR <sub>IF</sub>	Fixed	95%	3
OF <sub>watts</sub>	Fixed	94.7	1
OF <sub>hours</sub>	Fixed	4.5	2
ISR <sub>OF</sub>	Fixed	87%	3
Light CF	Fixed	5%	4
LED <sub>DWN-watts</sub>	Fixed	53.9	7

Component	Type	Value	Sources
LED <sub>hours</sub>	Fixed	2.8	6
ISR <sub>LED</sub>	Fixed	100%	7

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)
2. US Department of Energy, Energy Star Calculator.
3. Ibid., 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 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. KEMA, *NJ Clean Energy Program Energy Impact Evaluation Protocol Review*. 2009.
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.

## ENERGY STAR Windows

### Protocols

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

Square Feet of Window Area X Savings per Square Foot

To determine resource savings, the per square foot estimates in the protocols will be multiplied by the number of square feet of window area. The number of square feet of window area will be determined using market assessments and market tracking. Some of these market tracking mechanisms are under development. The per unit energy and demand savings estimates are based on prior building simulations of windows.

### ***ENERGY STAR Windows***

Savings estimates for ENERGY STAR Windows are based on modeling a typical 2,500 square foot home using REM Rate, the home energy rating tool. Savings are per square foot of qualifying window area. Savings will vary based on heating and cooling system type and fuel. These fuel and HVAC system market shares will need to be estimated from prior market research efforts or from future program evaluation results.

#### **Heat Pump**

Electricity Impact (kWh) =  $ES_{\text{vHP}}$

Demand Impact (kW) =  $DS_{\text{vHP}} \times CF$

#### **Gas Heat/CAC**

Electricity Impact (kWh) =  $ES_{\text{vGAS/CAC}}$

Demand Impact (kW) =  $DS_{\text{vCAC}} \times CF$

Gas Impact (therms) =  $GS_{\text{vGAS}}$

#### **Gas Heat/No CAC**

Electricity Impact (kWh) =  $ES_{\text{vGAS/NOCAC}}$

Demand Impact (kW) =  $DS_{\text{vNOCAC}} \times CF$

Gas Impact (therms) =  $GS_{\text{vGAS}}$

#### **Oil Heat/CAC**

Electricity Impact (kWh) =  $ES_{\text{vOIL/CAC}}$

Demand Impact (kW) =  $DS_{\text{vCAC}} \times CF$

Oil Impact (MMBtu) =  $OS_{\text{vOIL}}$

#### **Oil Heat/No CAC**

Electricity Impact (kWh) =  $ES_{\text{vOIL/NOCAC}}$

Demand Impact (kW) =  $DS_{\text{vNOCAC}} \times CF$

Oil Impact (MMBtu) =  $OS_{\text{vOIL}}$

### Electric Heat/CAC

Electricity Impact (kWh) =  $ESav_{RES/CAC}$

Demand Impact (kW) =  $DSav_{CAC} \times CF$

### Electric Heat/No CAC

Electricity Impact (kWh) =  $ESav_{RES/NOCAC}$

Demand Impact (kW) =  $DSav_{NOCAC} \times CF$

### Definition of Terms

$ESav_{HP}$  = Electricity savings (heating and cooling) with heat pump installed.

$ESav_{GAS/CAC}$  = Electricity savings with gas heating and central AC installed.

$ESav_{GAS/NOCAC}$  = Electricity savings with gas heating and no central AC installed.

$ESav_{OIL/CAC}$  = Electricity savings with oil heating and central AC installed.

$ESav_{OIL/NOCAC}$  = Electricity savings with oil heating and no central AC installed.

$ESav_{RES/CAC}$  = Electricity savings with electric resistance heating and central AC installed.

$ESav_{RES/NOCAC}$  = Electricity savings with electric resistance heating and no central AC installed.

$DSav_{HP}$  = Summer demand savings with heat pump installed.

$DSav_{CAC}$  = Summer demand savings with central AC installed.

$DSav_{NOCAC}$  = Summer demand savings with no central AC installed.

CF = System peak demand coincidence factor. Coincidence of building cooling demand to summer system peak.

$GSav_{GAS}$  = Gas savings with gas heating installed.

$OSav_{OIL}$  = Oil savings with oil heating installed.

### ENERGY STAR Windows

Component	Type	Value	Sources
ESav <sub>HP</sub>	Fixed	2.2395 kWh	1
HP Time Period Allocation Factors	Fixed	Summer/On-Peak 10% Summer/Off-Peak 7% Winter/On-Peak 40% Winter/Off-Peak 44%	2
ESav <sub>GAS/CAC</sub>	Fixed	0.2462 kWh	1
Gas/CAC Electricity Time Period Allocation Factors	Fixed	Summer/On-Peak 65% Summer/Off-Peak 35% Winter/On-Peak 0% Winter/Off-Peak 0%	2
ESav <sub>GAS/NOCAC</sub>	Fixed	0.00 kWh	1
Gas/No CAC Electricity Time Period Allocation Factors	Fixed	Summer/On-Peak 3% Summer/Off-Peak 3% Winter/On-Peak 45% Winter/Off-Peak 49%	2
Gas Heating Gas Time Period Allocation Factors	Fixed	Summer = 12% Winter = 88%	4
ESav <sub>OIL/CAC</sub>	Fixed	0.2462 kWh	1
Oil/CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 65% Summer/Off-Peak 35% Winter/On-Peak 0% Winter/Off-Peak 0%	2
ESav <sub>OIL/NOCAC</sub>	Fixed	0.00 kWh	1
Oil/No CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 3% Summer/Off-Peak 3% Winter/On-Peak 45% Winter/Off-Peak 49%	2
ESav <sub>RES/CAC</sub>	Fixed	4.0 kWh	1
Res/CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 10% Summer/Off-Peak 7% Winter/On-Peak 40% Winter/Off-Peak 44%	2
ESav <sub>RES/NOCAC</sub>	Fixed	3.97 kWh	1
Res/No CAC Time Period Allocation Factors	Fixed	Summer/On-Peak 3% Summer/Off-Peak 3% Winter/On-Peak 45% Winter/Off-Peak 49%	2
DSav <sub>HP</sub>	Fixed	0.000602 kW	1
DSav <sub>CAC</sub>	Fixed	0.000602 kW	1
DSav <sub>NOCAC</sub>	Fixed	0.00 kW	1
GSav <sub>GAS</sub>	Fixed	0.169 therms	1
OSav <sub>OIL</sub>	Fixed	0.0169 MMBtu	1

Component	Type	Value	Sources
CF	Fixed	0.75	3

Sources:

1. From REMRATE Modeling of a typical 2,500 sq. ft. NJ home. Savings expressed on a per sq. ft. of window area basis. New Brunswick climate data.
2. Time period allocation factors used in cost-effectiveness analysis.
3. Based on reduction in peak cooling load.
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.

## 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 and soon after 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.

#### *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

Electricity Impact (kWh) =  $ESav_{RetFridge} * NTG$

Demand Impact (kW) =  $DSav_{RetFridge} \times CF_{RetFridge}$

Definition of Terms

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

NTG = Net-to-Gross Adjustment factor.

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

$CF_{RetFridge}$  = Summer demand coincidence factor.

**REFRIGERATOR/FREEZER RECYCLING**

Component	Type	Value	Sources
$ESav_{RetFridge}$	Fixed	1,728 kWh	1
NTG	Fixed	55%	2
$DSav_{RetFridge}$	Fixed	.2376 kW	3
$CF_{RetFridge}$	Fixed	1	4

Sources:

1. The average power consumption of units retired under similar recent programs:
  - a. Fort Collins Utilities, February 2005. Refrigerator and Freezer Recycling Program 2004 Evaluation Report.
  - b. Midwest Energy Efficiency Alliance, 2005. 2005 Missouri Energy Star Refrigerator Rebate and Recycling Program Final Report
  - c. Pacific Gas and Electric, 2007. PGE ARP 2006-2008 Climate Change Impacts Model (spreadsheet)
  - d. Quantec, Aug 2005. Evaluation of the Utah Refrigerator and Freezer Recycling Program (Draft Final Report).
  - e. CPUC DEER website, <http://eega.cpuc.ca.gov/deer/measure.asp?s=1&c=2&sc=7&m=389059>
  - f. Snohomish PUD, February 2007. 2006 Refrigerator/Freezer Recycling Program Evaluation.
  - g. Ontario Energy Board, 2006. Total Resource Cost Guide.
2. The average net to gross ratios estimated for several recent programs
  - a. Fort Collins Utilities, February 2005. Refrigerator and Freezer Recycling Program 2004 Evaluation Report.
  - b. SCE, 2001. The Multi-Megawatt Refrigerator/Freezer Recycling Summer Initiative Program Final Report.
  - c. Pacific Gas and Electric, 2007. PGE ARP 2006-2008 Climate Change Impacts Model (spreadsheet)
  - d. Quantec, Aug 2005. Evaluation of the Utah Refrigerator and Freezer Recycling Program (Draft Final Report).
  - e. Snohomish PUD, February 2007. 2006 Refrigerator/Freezer Recycling Program Evaluation.
  - f. Ontario Energy Board, 2006. Total Resource Cost Guide.
3. Applied the kW to kWh ratio derived from Refrigerator savings in the ENERGY STAR Appliances Program.
4. Coincidence factor already embedded in summer peak demand reduction estimates



## 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>3</sup>
- Software approved by the US Department of Energy's Weatherization Assistance Program.<sup>4</sup>
- RESNET approved rating software.<sup>5</sup>

There are numerous software packages that comply with these standards. Some examples of the software packages are REM/Rate, EnergyGauge, TREAT, and HomeCheck. The HomeCheck software is described below as an example of a software that can be used to determine if a home qualifies for Home Performance with Energy Star.

### HomeCheck Software Example

The following section provides a description of the HomeCheck software, which is designed to enable an energy auditor to collect information about a customer's site, and, based on what is found through the energy audit, recommend energy savings measures and demonstrate the costs and savings associated with those recommendations. The HomeCheck software is also used to estimate the energy savings that are reported for this program. The HomeCheck software is described here as an example only of how the various software packages work.

These protocols incorporate the HomeCheck software by reference which will be utilized for estimating energy savings for the Home Performance with Energy Star Program. The Board intends to assess the savings reported from time to time and will make adjustments as necessary. The following is a summary of the HomeCheck software:

The HomeCheck software was designed to streamline the delivery of energy efficiency programs. The software provides the energy efficiency specialist with an easy-to-use guide for data collection, site and HVAC testing protocols, eligible efficiency measures, and estimated energy savings. The software is designed to enable an auditor to collect information about customers' sites and then, based on what he/she finds through the audit, recommend energy-

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<sup>3</sup> A new standard for BESTEST is currently being developed. The existing 1995 standard can be found at <http://www.nrel.gov/docs/legosti/fy96/7332a.pdf>.

<sup>4</sup> A listing of the approved software available at <http://www.waptac.org/si.asp?id=736>.

<sup>5</sup> A listing of the approved software available at <http://resnet.us>.

saving measures, demonstrate the costs and savings associated with those recommendations. It also enables an auditor/technician to track the delivery of services and installation of measures at a site.

This software is a part of an end-to-end solution for delivering high-volume retrofit programs, covering administrative functions such as customer relationship management, inspection scheduling, sub-contractor arranging, invoicing and reporting. The range of existing components of the site that can be assessed for potential upgrades is extensive and incorporates potential modifications to almost all energy using aspects of the home. The incorporation of building shell, equipment, distribution systems, lighting, appliances, diagnostic testing and indoor air quality represents a very broad and comprehensive ability to view the needs of a home.

The software is designed to combine two approaches to assessing energy savings opportunities at the site. One is a measure specific energy loss calculation, identifying the change in use of BTU's achieved by modifying a component of the site. Second, is the correlation between energy savings from various building improvements, and existing energy use patterns at a site. The use of both calculated savings and the analysis of existing energy use patterns, when possible, provides the most accurate prescription of the impact of changes at the site for an existing customer considering improvements on a retrofit basis.

This software is not designed to provide a load calculation for new equipment or a HERS rating to compare a site to a standard reference site. It is designed to guide facilities in planning improvements at the site with the goal of improved economics, comfort and safety. The software calculates various economic evaluations such as first year savings, simple payback, measure life cost-effectiveness, and Savings-to-Investment ratio (SIR).

#### **Site-Level Parameters and Calculations**

There are a number of calculations and methodologies that apply across measures and form the basis for calculating savings potentials at a site.

#### **Heating Degree Days and Cooling Degree Hours**

Heat transfer calculations depend fundamentally on the temperature difference between inside and outside temperature. This temperature difference is often summarized on a seasonal basis using fixed heating degree-days (HDD) and cooling degree-hours CDH). The standard reference temperature for calculating HDD (the outside temperature at which the heating system is required), for example, has historically been 65°F. Modern houses have larger internal gains and more efficient thermal building envelopes than houses did when the 65°F standard was developed, leading to lower effective reference temperatures. This fact has been recognized in ASHRAE Fundamentals, which provides a variable-based degree-day method for calculating energy usage. CSG's Building Model calculates both HDD and CDH based on the specific characteristics and location of the site being treated.

#### **Building Loads, Other Parameters, and the Building Model**

Some are of the opinion that, in practice, detailed building load simulation tools are quite limited in their potential to improve upon simpler approaches due to their reliance on many factors that are not measurable or known, as well as limitations to the actual models themselves. Key to these

limitations is the Human Factor (e.g., sleeping with the windows open; extensive use of high-volume extractor fans, etc.) that is virtually impossible to model. As such, the basic concept behind the model was to develop a series of location specific lookup tables that would take the place of performing hourly calculations while allowing the model to perform for any location. The data in these tables would then be used along with a minimum set of technical data to calculate heating and cooling building loads.

In summary, the model uses:

- Lookup tables for various parameters that contain the following values for each of the 239 TMY2 weather stations:
  - Various heating and cooling infiltration factors
  - Heating degree days and heating hours for a temperature range of 40 to 72°F
  - Cooling degree hours and cooling hours for a temperature range of 68 to 84°F
  - Heating and cooling season solar gain factors
- Simple engineering algorithms based on accepted thermodynamic principles, adjusted to reflect known errors, the latest research and measured results
- Heating season iterative calculations to account for the feedback loop between conditioned hours, degree days, average “system on” indoor and outdoor temperatures and the building
- The thermal behavior of homes is complex and commonly accepted algorithms will on occasion predict unreasonably high savings, HomeCheck uses a proprietary methodology to identify and adjust these cases. This methodology imposes limits on savings projected by industry standard calculations, to account for interactivities and other factors that are difficult to model. These limits are based on measured experience in a wide variety of actual installations.

### **Usage Analysis**

The estimation of robust building loads through the modeling of a building is not always reliable. Thus, in addition to modeling the building, HomeCheck calculates a normalized annual consumption for heating and cooling, calculated from actual fuel consumption and weather data using a Seasonal Swing methodology. This methodology uses historic local weather data and site-specific usage to calculate heating and cooling loads. The methodology uses 30-year weather data to determine spring and fall shoulder periods when no heating or cooling is likely to be in use. The entered billing history is broken out into daily fuel consumption, and these daily consumption data along with the shoulder periods is used to calculate base load usage, and summer and winter seasonal swing fuel consumption.

### **Multiple HVAC Systems**

HVAC system and distribution seasonal efficiencies are used in all thermal shell measure algorithms. HVAC system and distribution seasonal efficiencies and thermostat load reduction adjustments are used when calculating the effect of interactivity between mechanical and architectural measures. If a site has multiple HVAC systems, weighted average seasonal efficiencies and thermostat load reduction adjustments are calculated based on the relative contributions (in terms of percent of total load) of each system.

### **Multiple Heating Fuels**

It is not unusual to find homes with multiple HVAC systems using different fuel types. In these cases it is necessary to aggregate the NACs for all fuel sources for use in shell savings algorithms. This is achieved by assigning a percentage contribution to total NAC for each system, converting this into BTU's, and aggregating the result. Estimated first year savings for thermal shell measures are then disaggregated into the component fuel types based on the pre-retrofit relative contributions of fuel types.

### **Interactivity**

To account for interactivity between architectural and mechanical measures, HomeCheck employs the following methodology, in order:

- Non interacted first year savings are calculated for each individual measure
- Non-interacted SIR (RawSIR) is calculated for each measure
- Measures are ranked in descending order of RawSIR
- Starting with the most cost-effective measure (as defined by RawSIR), first year savings are adjusted for each measure as follows:
  - Mechanical measures (such as thermostats, HVAC system upgrades or distribution system upgrades) are adjusted to account for the load reduction from measures with a higher RawSIR
  - Architectural measures are adjusted to account for overall HVAC system efficiency changes and thermostat load reduction changes. Architectural measures with a higher RawSIR than that of HVAC system measures are calculated using the existing efficiencies. Those with RawSIR's lower than that of heating equipment use the new heating efficiencies.
- Interacted SIR is then calculated for each measure, along with cumulative SIR for the entire job.
- All measures are then re-ranked in descending order of SIR
- The process is repeated, replacing RawSIR with SIR until the order of measures does not change

### **Lighting**

Quantification of additional saving due to the addition of high efficiency lighting will be based on the algorithms presented for these appliances in the Energy Star Lighting Protocols found in the Energy Star Products Program.

### **Energy Use Feedback Devices**

For homes with an energy use feedback device installed, a fixed annual electric savings of 320 kWh is estimated. These savings estimates are based on the following study: Mountain D, 2006, "The Impact of Real-Time Feedback on Residential Electricity Consumption: The Hydro One Pilot," Mountain Economic Consulting and Associated Inc., Ontario.

- Savings have been adjusted to account for the percentage of homes with non-electric space heating and/or non-electric DHW vs. homes with electric space heating and/or electric DHW.

The following grid outlines the savings observed in the Mountain study by fuel type and the correlating estimated NJ population of that fuel type.

	Reduction in electricity consumption per Mountain Study	NJ Population
Non-electric water heating and non-electric space heating	5.1%	70%
Homes with electric water heating and non-electric space heating	16.7%	20%
Homes with electric space heating and electric water heating	1.2%	10%

Savings were further adjusted by a 50% conservatism adjustment factor until more NJ specific data has been gathered.

### **Stand Alone Home Seal-Up**

As part of the HPwES program, certain participants are eligible for standalone home seal-up with installation of qualified furnaces or boilers. The following calculates savings from seal-up.

#### Algorithm

Natural Gas Impact (therms) = ((26 \* HDD \* CFM50 delta) \* (0.6)) / (n \* heating efficiency)

#### Definition of Terms

26 = Constant that combines heating capacity of air (0.018) with the factors 24 and 60 for relating CFM to HDD

HDD = annual heating degree days

CFM50 delta = (CFM50 per minus CFM50 post seal up) represents the effective reduction in air seal up leakage

0.6 = correlation factor for the CFM50 test

n = LBL correlation factor

Heating Efficiency = the overall efficiency of the heating unit

**HPWES STANDALONE SEAL-UP**

<b><u>Component</u></b>	<b><u>Type</u></b>	<b><u>Value</u></b>	<b><u>Sources</u></b>
<u>HDD</u>	<u>Variable</u>	<u>NGNJ = 4664</u>	<u>1</u>
<u>CFM50 Delta</u>	<u>Variable</u>		<u>Application</u>
<u>n</u>	<u>Variable</u>	<u>See Table Below</u>	<u>2</u>
<u>Heating Efficiency</u>	<u>Fixed</u>	<u>Furnaces = 80%</u> <u>Boilers = 83%</u>	<u>3</u>

n-Factor Table

Zone	# of stories →	1	1.5	2	3
1	Well-shielded	18.6	16.7	14.9	13.0
	Normal	15.5	14.0	12.4	10.9
	Exposed	14.0	12.6	11.2	9.8
2	Well-shielded	22.2	20.0	17.8	15.5
	Normal	18.5	16.7	14.8	13.0
	Exposed	16.7	15.0	13.3	11.7
3	Well-shielded	25.8	23.2	20.6	18.1
	Normal	21.5	19.4	17.2	15.1
	Exposed	19.4	17.4	15.5	13.5
4	Well-shielded	29.4	26.5	23.5	20.6
	Normal	24.5	22.1	19.6	17.2
	Exposed	22.1	19.8	17.6	15.4

Note: New Jersey is located in Zone 2

Sources:

1. NJNG company standard HDD, documented in NJNG BPU filings.
2. Residential Energy: Cost Savings and Comfort for Existing Buildings. John Krigger and Chris Dorsi. 2009.
3. Based on the quantity of models available by efficiency ratings as listed in the April 2003 Gamma Consumers Directory of Certified Efficiency Ratings.

## 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 90.1-1999 for program commitments made prior to December 31, 2007 and ASHRAE 90.1 2004 for commitments starting on January 1, 2008-2007 unless otherwise noted for applications designated "2011".

#### *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. 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.

#### *Performance Lighting*

For new construction and entire facility rehabilitation projects, savings are calculated by comparing lighting power density of fixture being installed to the baseline power densities from ASHRAE 90.1 2007<sup>4</sup>.

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

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

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

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

#### Definition of Variables

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

LPD<sub>base</sub> = 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<sub>inst</sub> = 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**

Component	Type	Value	Source
ΔkW	Fixed	See Lighting Wattage Table derived from the 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<sup>4</sup> Table 9.6.1</li> <li>• Installed LPD, space type and floor area from customer application.</li> </ul>
CF	Fixed	See Lighting Table by BuildingType	2
IF	Fixed	See Lighting Table by Building Type	3
EFLH	Fixed	See Lighting Table by Building Type	4



**Lighting Wattage Table**

<b>Fixture Type Installed</b>	<b>Fixture Installed</b>	<b>kW/Fixture</b>
Fluorescent - 1 L STD T-8	17 W (1) 2' T-8 Lamp	0.017
Fluorescent - 1 L STD T-8	25 W (1) 3' T-8 Lamp	0.023
Fluorescent - 1 L STD T-8	32 W (1) 4' T-8 Lamp	0.030
Fluorescent - 1 L STD T-8	40 W (1) 5' T-8 Lamp	0.035
Fluorescent - 1 L STD T-8	59 W (1) 8' T-8 Lamp	0.057
Fluorescent - 2 L STD T-8	17 W (2) 2' T-8 Lamp	0.032
Fluorescent - 2 L STD T-8	25 W (2) 3' T-8 Lamp	0.045
Fluorescent - 2 L STD T-8	32 W (2) 4' T-8 Lamp	0.056
Fluorescent - 2 L STD T-8	40 W (2) 5' T-8 Lamp	0.070
Fluorescent - 2 L STD T-8	59 W (2) 8' T-8 Lamp	0.109
Fluorescent - 3 L STD T-8	17 W (3) 2' T-8 Lamp	0.050
Fluorescent - 3 L STD T-8	25 W (3) 3' T-8 Lamp	0.070
Fluorescent - 3 L STD T-8	32 W (3) 4' T-8 Lamp	0.086
Fluorescent - 3 L STD T-8	40 W (3) 5' T-8 Lamp	0.106
Fluorescent - 3 L STD T-8	59 W (3) 8' T-8 Lamp	0.167
Fluorescent - 4 L STD T-8	17 W (4) 2' T-8 Lamp	0.065
Fluorescent - 4 L STD T-8	25 W (4) 3' T-8 Lamp	0.088
Fluorescent - 4 L STD T-8	32 W (4) 4' T-8 Lamp	0.111
Fluorescent - 4 L STD T-8	40 W (4) 5' T-8 Lamp	0.134
Fluorescent - 4 L STD T-8	59 W (4) 8' T-8 Lamp	0.219
Fluorescent - 5 L STD T-8	32 W (5) 4' T-8 Lamp	0.148
Fluorescent - 6 L STD T-8	32 W (6) 4' T-8 Lamp	0.172
Fluorescent - 6 L STD T-8	59 W (6) 8' T-8 Lamp	0.328
Fluorescent - 8 L STD T-8	32 W (8) 4' T-8 Lamp	0.217
Fluorescent - 1 L T-8 U-Tube	32 W (1) U-Tube T-8 Lamp	0.032
Fluorescent - 2 L T-8 U-Tube	32 W (2) U-Tube T-8 Lamp	0.059
Fluorescent - 3 L T-8 U-Tube	32 W (3) U-Tube T-8 Lamp	0.089
Fluorescent - 1 L STD T-5	14 W (1) 2' T-5 Lamp	0.018
Fluorescent - 1 L STD T-5	21 W (1) 3' T-5 Lamp	0.025
Fluorescent - 1 L STD T-5	28 W (1) 4' T-5 Lamp	0.033
Fluorescent - 1 L STD T-5	35 W (1) 5' T-5 Lamp	0.040
Fluorescent - 1 L STD T-5	14 W (2) 2' T-5 Lamp	0.034
Fluorescent - 2 L STD T-5	21 W (2) 3' T-5 Lamp	0.048
Fluorescent - 2 L STD T-5	28 W (2) 4' T-5 Lamp	0.064
Fluorescent - 2 L STD T-5	35 W (2) 5' T-5 Lamp	0.078
Fluorescent - 2 L STD T-5	14 W (3) 2' T-5 Lamp	0.052
Fluorescent - 2 L STD T-5	21 W (3) 3' T-5 Lamp	0.073
Fluorescent - 3 L STD T-5	28 W (3) 4' T-5 Lamp	0.097

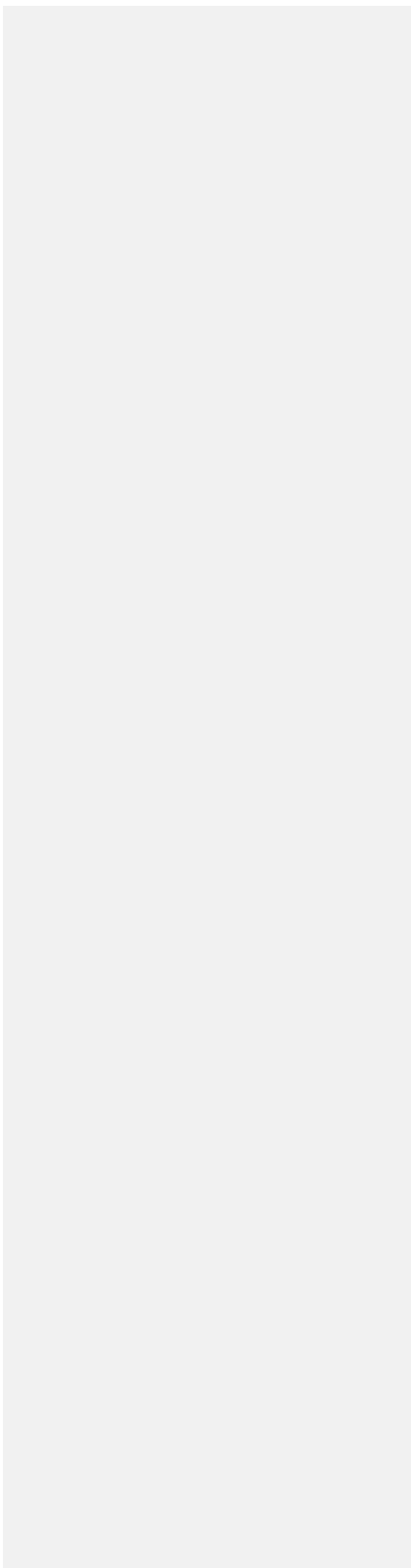
Fluorescent - 3 L STD T-5	35 W (3) 5' T-5 Lamp	0.118
Fluorescent - 3 L STD T-5	14 W (4) 2' T-5 Lamp	0.068
Fluorescent - 3 L STD T-5	21 W (4) 3' T-5 Lamp	0.096
Fluorescent - 3 L STD T-5	28 W (4) 4' T-5 Lamp	0.128
Fluorescent - 4 L STD T-5	35 W (4) 5' T-5 Lamp	0.156
Fluorescent - 4 L STD T-5	28 W (6) 4' T-5 Lamp	0.192
Fluorescent - 4 L STD T-5	35 W (6) 5' T-5 Lamp	0.234
Fluorescent - 4 L STD T-5	28 W (8) 4' T-5 Lamp	0.256
Fluorescent - T-5 HO	24 W (1) 2' T-5/HO Lamp	0.027
Fluorescent - T-5 HO	38 W (1) 3' T-5/HO Lamp	0.042
Fluorescent - T-5 HO	54 W (1) 4' T-5/HO Lamp	0.0605
Fluorescent - T-5 HO	80 W (1) 5' T-5/HO Lamp	0.089
Fluorescent - T-5 HO	24 W (2) 2' T-5/HO Lamp	0.052
Fluorescent - T-5 HO	38 W (2) 3' T-5/HO Lamp	0.085
Fluorescent - T-5 HO	54 W (2) 4' T-5/HO Lamp	0.117
Fluorescent - T-5 HO	24 W (3) 2' T-5/HO Lamp	0.079
Fluorescent - T-5 HO	38 W (3) 3' T-5/HO Lamp	0.127
Fluorescent - T-5 HO	54 W (3) 4' T-5/HO Lamp	0.179
Fluorescent - T-5 HO	24 W (4) 2' T-5/HO Lamp	0.104
Fluorescent - T-5 HO	38 W (4) 3' T-5/HO Lamp	0.17
Fluorescent - T-5 HO	54 W (4) 4' T-5/HO Lamp	0.234
Fluorescent - T-5 HO	38 W (6) 3' T-5/HO Lamp	0.255
Fluorescent - T-5 HO	54 W (6) 4' T-5/HO Lamp	0.351
Fluorescent - T-5 HO	38 W (8) 3' T-5/HO Lamp	0.34
Fluorescent - T-5 HO	54 W (8) 4' T-5/HO Lamp	0.468
Fluorescent - T-8 HO	32 W (1) 4' T-8/HO Lamp	0.0345
Fluorescent - T-8 HO	32 W (2) 4' T-8/HO Lamp	0.0675
Fluorescent - T-8 HO	32 W (3) 4' T-8/HO Lamp	0.0955
Fluorescent - T-8 HO	32 W (4) 4' T-8/HO Lamp	0.135
Fluorescent - T-8 HO	32 W (5) 4' T-8/HO Lamp	0.163
Fluorescent - T-8 HO	32 W (6) 4' T-8/HO Lamp	0.191
Fluorescent - T-8 HO	32 W (8) 4' T-8/HO Lamp	0.27
Fluorescent - T-8 HO	86 W (1) 8' T-8/HO Lamp	0.08
Fluorescent - T-8 HO	86 W (2) 8' T-8/HO Lamp	0.16
Fluorescent - T-8 HO	86 W (4) 8' T-8/HO Lamp	0.32
Metal Halide (non Pulse Start), 1 L	32 W (1) Metal Halide	0.043
Metal Halide (non Pulse Start), 1 L	50 W (1) Metal Halide	0.072
Metal Halide (non Pulse Start), 1 L	70 W (1) Metal Halide	0.095
Metal Halide (non Pulse Start), 1 L	100 W (1) Metal Halide	0.128
Metal Halide (non Pulse Start), 1 L	150 W (1) Metal Halide	0.19
Metal Halide (non Pulse Start), 1 L	175 W (1) Metal Halide	0.215

Metal Halide (non Pulse Start), 1 L	250 W (1) Metal Halide	0.295
Metal Halide (non Pulse Start), 1 L	400 W (1) Metal Halide	0.458
Metal Halide (non Pulse Start), 1 L	750 W (1) Metal Halide	0.85
Metal Halide (non Pulse Start), 1 L	1000 W (1) Metal Halide	1.08
Metal Halide (non Pulse Start), 1 L	1500 W (1) Metal Halide	1.61
Metal Halide (non Pulse Start), 2 L	400 W (2) Metal Halide	0.916
Pulse Start Metal Halide	150 W - Pulse Start Metal Halide	0.185
Pulse Start Metal Halide	175 W - Pulse Start Metal Halide	0.208
Pulse Start Metal Halide	200 W - Pulse Start Metal Halide	0.235
Pulse Start Metal Halide	250 W - Pulse Start Metal Halide	0.288
Pulse Start Metal Halide	300 W - Pulse Start Metal Halide	0.342
Pulse Start Metal Halide	320 W - Pulse Start Metal Halide	0.368
Pulse Start Metal Halide	350 W - Pulse Start Metal Halide	0.4
Pulse Start Metal Halide	400 W - Pulse Start Metal Halide	0.45
Pulse Start Metal Halide	750 W - Pulse Start Metal Halide	0.815
Pulse Start Metal Halide	1000 W - Pulse Start Metal Halide	1.075
LED Exit Sign	Light Emitting Diode, (1) 2 W, Single Sided	0.006
LED Exit Sign	Light Emitting Diode, (2) 2 W, Dual Sided	0.009
CFL - Twin Tube	1 Lamp, 32 W	0.034
CFL - Twin Tube	1 Lamp, 40 W	0.043
CFL - Twin Tube	2 Lamp, 32 W	0.062
CFL - Twin Tube	2 Lamp, 40 W	0.072
CFL - Twin Tube	3 Lamp, 40 W	0.105
CFL - Twin Tube	6 Lamp, 32 W	0.186
CFL - Quad Tube	1 Lamp, 13 W	0.015
CFL - Quad Tube	1 Lamp, 18 W	0.020
CFL - Quad Tube	1 Lamp, 26 W	0.027
CFL - Quad Tube	2 Lamp, 13 W	0.028
CFL - Quad Tube	2 Lamp, 18 W	0.038
CFL - Quad Tube	2 Lamp, 26 W	0.050
CFL - Quad Tube	6 Lamp, 26 W	0.150
CFL - Screw-in	7 W	0.007
CFL - Screw-in	9 W	0.009
CFL - Screw-in	11 W	0.011
CFL - Screw-in	13 W	0.013
CFL - Screw-in	15 W	0.015
CFL - Screw-in	16 W	0.016
CFL - Screw-in	17 W	0.017
CFL - Screw-in	18 W	0.018
CFL - Screw-in	20 W	0.02
CFL - Screw-in	23 W	0.023

CFL - Screw-in	25 W	0.025
CFL - Screw-in	28 W	0.028
Mercury Vapor	40 W, 1 Lamp	0.05
Mercury Vapor	50 W, 1 Lamp	0.074
Mercury Vapor	75 W, 1 Lamp	0.093
Mercury Vapor	100 W, 1 Lamp	0.125
Mercury Vapor	175 W, 1 Lamp	0.205
Mercury Vapor	250 W, 1 Lamp	0.29
Mercury Vapor	400 W, 1 Lamp	0.455
Mercury Vapor	700 W, 1 Lamp	0.78
Mercury Vapor	1000 W, 1 Lamp	1.075
Mercury Vapor	400 W, 2 Lamp	0.91
High Pressure Sodium	35 W	0.046
High Pressure Sodium	50 W	0.066
High Pressure Sodium	70 W	0.095
High Pressure Sodium	100 W	0.138
High Pressure Sodium	150 W	0.188
High Pressure Sodium	200 W	0.25
High Pressure Sodium	250 W	0.295
High Pressure Sodium	310 W	0.365
High Pressure Sodium	360 W	0.414
High Pressure Sodium	400 W	0.465
High Pressure Sodium	1000 W	1.1
Halogen Incandescent	42 W, 1 Lamp	0.042
Halogen Incandescent	45 W, 1 Lamp	0.045
Halogen Incandescent	50 W, 1 Lamp	0.055
Halogen Incandescent	52 W, 1 Lamp	0.052
Halogen Incandescent	55 W, 1 Lamp	0.055
Halogen Incandescent	60 W, 1 Lamp	0.060
Halogen Incandescent	72 W, 1 Lamp	0.072
Halogen Incandescent	75 W, 1 Lamp	0.075
Halogen Incandescent	90 W, 1 Lamp	0.090
Halogen Incandescent	100 W, 1 Lamp	0.100
Halogen Incandescent	150 W, 1 Lamp	0.150
Halogen Incandescent	300 W, 1 Lamp	0.300
Halogen Incandescent	500 W, 1 Lamp	0.500
Halogen Incandescent	45 W, 2 Lamp	0.090
Halogen Incandescent	50 W, 2 Lamp	0.100
Halogen Incandescent	55 W, 2 Lamp	0.110
Halogen Incandescent	75 W, 2 Lamp	0.150
Halogen Incandescent	90 W, 2 Lamp	0.180

Halogen Incandescent	150 W, 2 Lamp	0.300
Incandescent, 1 L	15 W, 1 Lamp	0.015
Incandescent, 1 L	20 W, 1 Lamp	0.02
Incandescent, 1 L	25 W, 1 Lamp	0.025
Incandescent, 1 L	34 W, 1 Lamp	0.034
Incandescent, 1 L	36 W, 1 Lamp	0.036
Incandescent, 1 L	40 W, 1 Lamp	0.04
Incandescent, 1 L	42 W, 1 Lamp	0.042
Incandescent, 1 L	45 W, 1 Lamp	0.045
Incandescent, 1 L	50 W, 1 Lamp	0.05
Incandescent, 1 L	52 W, 1 Lamp	0.052
Incandescent, 1 L	54 W, 1 Lamp	0.054
Incandescent, 1 L	55 W, 1 Lamp	0.055
Incandescent, 1 L	60 W, 1 Lamp	0.06
Incandescent, 1 L	65 W, 1 Lamp	0.065
Incandescent, 1 L	67 W, 1 Lamp	0.067
Incandescent, 1 L	69 W, 1 Lamp	0.069
Incandescent, 1 L	72 W, 1 Lamp	0.072
Incandescent, 1 L	75 W, 1 Lamp	0.075
Incandescent, 1 L	80 W, 1 Lamp	0.08
Incandescent, 1 L	85 W, 1 Lamp	0.085
Incandescent, 1 L	90 W, 1 Lamp	0.09
Incandescent, 1 L	93 W, 1 Lamp	0.093
Incandescent, 1 L	95 W, 1 Lamp	0.095
Incandescent, 1 L	120 W, 1 Lamp	0.12
Incandescent, 1 L	125 W, 1 Lamp	0.125
Incandescent, 1 L	135 W, 1 Lamp	0.135
Incandescent, 1 L	150 W, 1 Lamp	0.15
Incandescent, 1 L	170 W, 1 Lamp	0.17
Incandescent, 1 L	200 W, 1 Lamp	0.2
Incandescent, 1 L	250 W, 1 Lamp	0.25
Incandescent, 1 L	300 W, 1 Lamp	0.3
Incandescent, 1 L	400 W, 1 Lamp	0.4
Incandescent, 1 L	448 W, 1 Lamp	0.448
Incandescent, 1 L	500 W, 1 Lamp	0.5
Incandescent, 1 L	750 W, 1 Lamp	0.75
Incandescent, 1 L	1000 W, 1 Lamp	1
Incandescent, 1 L	1500 W, 1 Lamp	1.5
Incandescent, 1 L	2000 W, 1 Lamp	2
Incandescent, 2 L	15 W, 2 Lamp	0.03
Incandescent, 2 L	20 W, 2 Lamp	0.04

Incandescent, 2 L	25 W, 2 Lamp	0.05
Incandescent, 2 L	34 W, 2 Lamp	0.068
Incandescent, 2 L	40 W, 2 Lamp	0.08
Incandescent, 2 L	50 W, 2 Lamp	0.1
Incandescent, 2 L	52 W, 2 Lamp	0.104
Incandescent, 2 L	54 W, 2 Lamp	0.108
Incandescent, 2 L	55 W, 2 Lamp	0.11
Incandescent, 2 L	60 W, 2 Lamp	0.12
Incandescent, 2 L	65 W, 2 Lamp	0.13
Incandescent, 2 L	67 W, 2 Lamp	0.134
Incandescent, 2 L	75 W, 2 Lamp	0.15
Incandescent, 2 L	90 W, 2 Lamp	0.18
Incandescent, 2 L	95 W, 2 Lamp	0.19
Incandescent, 2 L	100 W, 2 Lamp	0.2
Incandescent, 2 L	120 W, 2 Lamp	0.24
Incandescent, 2 L	135 W, 2 Lamp	0.27
Incandescent, 2 L	150 W, 2 Lamp	0.3
Incandescent, 2 L	200 W, 2 Lamp	0.4
Incandescent, 3 L	60 W, 3 Lamp	0.18
Incandescent, 3 L	67 W, 3 Lamp	0.201
Incandescent, 3 L	75 W, 3 Lamp	0.225
Incandescent, 3 L	90 W, 3 Lamp	0.27
Incandescent, 3 L	100 W, 3 Lamp	0.3
Incandescent, 4 L	25 W, 4 Lamp	0.1
Incandescent, 4 L	60 W, 4 Lamp	0.24
Incandescent, 4 L	75 W, 4 Lamp	0.3
Incandescent, 4 L	100 W, 4 Lamp	0.4
Incandescent, 5 L	60 W, 5 Lamp	0.3
Incandescent, 5 L	100 W, 5 Lamp	0.5
Induction	40 W	0.045
Induction	50 W	0.055
Induction	55 W	0.060
Induction	80 W	0.085
Induction	85 W	0.090
Induction	150 W	0.155
Induction	165 W	0.170
LED Strips, Center Strip	38 W, 5'	0.038
LED Strips, Center Strip	46 W, 6'	0.046
LED Strips, End Strip	19 W, 5'	0.019
LED Strips, End Strip	23 W, 6'	0.023
Low Bay LED	85 W	0.085



### **Lighting by Building Type**

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<b>Building Type</b>	<b>EFLH</b>	<b>CF</b>	<b>IF</b>
Education – Primary School	1,440	0.57	0.15
Education – Secondary School	2,305	0.57	0.15
Education – Community College	3,792	0.64	0.15
Education – University	3,073	0.64	0.15
Grocery	5,824	0.88	0.13
Medical – Hospital	8,736	0.72	0.18
Medical – Clinic	4,212	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	4,290	0.63	0.04
Office- Large	2,808	0.68	0.17
Office-Small	2,808	0.68	0.17
Restaurant – Sit-Down	4,368	0.76	0.15
Restaurant – Fast-Food	6,188	0.76	0.15
Retail – 3-Story Large	4,259	0.78	0.11
Retail – Single-Story Large	4,368	0.78	0.11
Retail – Small	4,004	0.78	0.11
Storage Conditioned	4,290	0.69	0.06
Storage Heated or Unconditioned	4,290	0.69	0.00
Warehouse	3,900	0.69	0.06
Average = Miscellaneous	4,242	0.72	0.13

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. 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
5. KEMA. *New Jersey’s Clean Energy Program Energy Impact Evaluation and Protocol Review*. 2009.



### ***Prescriptive Lighting***

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

The baseline is existing T-12 fixtures with energy efficient lamps and magnetic ballast.

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 LED strip 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

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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
ΔkW	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
IF	Fixed	See Lighting Table by Building Type in Performance Lighting Section Above	4
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. 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
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.

5.7. 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)

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### ***Lighting Controls***

Lighting controls include occupancy sensors, daylight dimmer systems, and occupancy controlled hi-low controls for fluorescent, 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 =  $kW_c \times SVG \times CF \times (1 + IF)$

Energy Savings =  $kW_c \times SVG \times EFLH \times (1 + IF)$

### Definition of Variables

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

$kW_c$  = kW lighting load connected to control

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 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
IF	Fixed	See Lighting Table by Building in Performance Lighting Section Above	3

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. 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

### ***Motors***

For premium efficiency motors 1-200 HP.

#### Algorithms

From application form calculate ΔkW where:

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

$$\text{Demand Savings} = (\Delta kW) * CF$$

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

#### Definition of Variables

ΔkW = kW Savings at full load

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

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

IF<sub>VFD</sub> = VFD Interaction Factor, 1.0 without VFD, 0.9 with VFD

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

$\eta_{\text{prem}}$  = 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	EPACT Baseline Efficiency Table	EPACT Directory
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

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

### NEMA Premium Motor Efficiency Table

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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

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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

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

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

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

#### Definition of Variables

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

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

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

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

$Phase_{EF}$  = Phase of Evaporator Fan

$PF_{EF}$  = Evaporator Fan Power Factor

Operating Hours = Annual operating hours if Evaporator Fan Control

LR = Percent reduction of load by replacing motors

0.28 = Conversion from kW to tons (Refrigeration)

1.6 = Efficiency of typical refrigeration system in kW/ton

#### Case Motor Replacement

##### Algorithms

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

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

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

##### Definition of Variables

$kWh Savings_{CM}$  = Savings due to Case Motors being replaced

$kWh Savings_{RH}$  = Savings due to reduced heat from Case Motors



kW = Metered load of Case Motors

ER = Energy reduction if a motor is being replaced

RT = Average runtime of Case Motors

0.28 = Conversion from kW to tons (Refrigeration)

Eff = Efficiency of typical refrigeration system in kW/ton

#### ECM Fraction HP Motors

Component	Type	Value	Source
Amps <sub>EF</sub>	Variable	Nameplate/Manufacturer Spec. Sheet	Application
Volts <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, air to air heat pumps, packaged terminal systems, water source heat pumps, central DX AC systems, ground water 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

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

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

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.

$\text{COP}_b$  = Coefficient of Performance of the baseline unit. This data is found in the HVAC and Heat Pump verification summary table. For units < 65,000, SEER and HSPF/3.412 should be used for cooling and heating savings, respectively.

$\text{COP}_q$  = Coefficient of Performance of the High Efficiency unit – This value comes from the ARI/AHRI or AHAM directories or manufacturer data. For units < 65,000, SEER and HSPF/3.412 should be used 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**

<b>Component</b>	<b>Type</b>	<b>Value</b>	<b>Source</b>
BtuH	Variable	ARI/AHRI or AHAM or Manufacturer Data	Application
$\text{EER}_b$	Variable	See Table below	Collaborative agreement and C/I baseline study
$\text{EER}_q$	Variable	ARI/AHRI or AHAM Values	Application

Component	Type	Value	Source
CF	Fixed	67%	Engineering estimate
EFLH	Fixed	HVAC 1,131 HP cooling 381 HP heating 800	JCP&L metered data <sup>6</sup>

**HVAC Baseline Table**

Equipment Type	Baseline = ASHRAE Std. 90.1 - 2004
Unitary HVAC/Split Systems, Air Cooled · <=5.4 tons: · >5.4 to 11.25 tons · >11.25 to 20 tons · > 21 to 63 tons · >63 Tons	13 SEER <del>10.1</del> EER <del>9.5</del> 10.8 EER <del>9.3</del> 9.8 EER <del>9.5</del> 9 EER
Air-Air Heat Pump Systems · <=5.4 tons: · >5.4 to 11.25 tons · >11.25 to 20 tons · >= 21	13 SEER <del>9.9</del> 10.8 EER <del>9.1</del> 10.4 EER <del>8.8</del> 9.3 EER
Package Terminal Systems < 0.74 tons .75 – 1 ton > 1 ton	12.5-(0.213*BTUHc/1000)
Water Source Heat Pumps All Capacities	12.0 EER
GWSHPs Open and Closed Loop All Capacities	16.2 EER

Baseline heat pump efficiency in heating mode must be based on ASHRAE 90.1-2007~~4~~ table 6.8.1 B

## Dual Enthalpy Economizers

### Algorithms

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

Demand Savings (kW) = Savings/Operating Hours

### Definition of Variables

<sup>6</sup> Results reflect metered use from 1995 – 1999.

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 program 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:

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

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

For FLV:

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

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

#### 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

Component	Type	Situation	Value	Source
IPLV <sub>b</sub> (kW/ton)	Fixed	Air Cooled with Condenser (All)	1.153	ASHRAE 90.1-2007 <del>4</del>
		Air Cooled w/o Condenser (All)	1.019	
		Water Cooled, reciprocating	0.696	ASHRAE 90.1-2007 <del>4</del>
		Water Cooled (<150 tons)	0.676	ASHRAE 90.1-2007 <del>4</del>
		Water Cooled (151 to 300 tons)	0.628	
		Water Cooled, screw/scroll (>300 tons)	0.572	ASHRAE 90.1-2007 <del>4</del>
		Water Cooled, centrifugal (<150 tons)	0.670	ASHRAE 90.1-2007 <del>4</del>
		Water Cooled, centrifugal (>=150 tons to 300 tons)	0.596	ASHRAE 90.1-2007 <del>4</del>
Water Cooled, centrifugal >300 tons)	0.549	ASHRAE 90.1-2007 <del>4</del>		
FLV <sub>b</sub> (kW/ton)	Fixed	Air Cooled with Condenser (All)	1.256	ASHRAE 90.1-2007 <del>4</del>
		Air Cooled w/o Condenser (All)	1.135	<del>ASHRAE 90.1-2007</del>
		Water Cooled, reciprocating	0.837	ASHRAE 90.1-2007 <del>4</del>
		Water Cooled (<150 tons)	0.790	ASHRAE 90.1-2007 <del>4</del>
		Water Cooled (151 to 300 tons)	0.718	<del>ASHRAE 90.1-2007</del>
		Water Cooled, screw/scroll (>300 tons)	0.639	ASHRAE 90.1-2007 <del>4</del>
		Water Cooled, centrifugal (<150 tons)	0.7034	ASHRAE 90.1-2007 <del>4</del>
		Water Cooled, centrifugal (>=150 tons to 300 tons)	0.634	ASHRAE 90.1-2007 <del>4</del>
Water Cooled, centrifugal >300 tons)	0.577	ASHRAE 90.1-2007 <del>4</del>		
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

#### **Variable Frequency Drives**

The measurement of energy and demand savings for C/I Variable Frequency Drive for VFD applications is for HVAC fans and water pumps only. VFD applications for other than this use should follow the custom path.

#### Algorithms

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

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

New Jersey Clean Energy Program  
 Protocols to Measure Resource Savings

May/December 2011/09

Definitions of Variables

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

$\eta_{motor}$  = 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**

<b>Component</b>	<b>Type</b>	<b>Value</b>	<b>Source</b>
<i>Motor HP</i>	Variable	Nameplate/Manufacturer Spec. Sheet	Application
$\eta_{motor}$	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**

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

<b>Component</b>	<b>Energy Savings Factor, ESF</b>	<b>Demand Savings Factor, DSF</b>
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

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***Air Compressors with Variable Frequency Drives***

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

Algorithms

Energy Savings (kWh) = HRS\*(Maximum kW/HP Savings)\*Motor HP

Demand Savings (kW) = PDC\*(Maximum kW/HP Savings)\*Motor HP

Maximum kW/HP Savings = Percent Energy Savings \* (0.746 / EFF<sub>b</sub>)

Definitions of Variables

HRS = Annual compressor runtime (hours) from application.

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

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

0.746 = kW to HP conversion factor

**Air Compressors with VFDs**

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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
EFF <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.



**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

<u>Component</u>	<u>Type</u>	<u>Value</u>	<u>Source</u>
<u>HG</u>	<u>Fixed</u>	<u>760</u>	<u>PG&amp;E study by ENCON Mechanical &amp; Nuclear Engineering, 1992</u>
<u>EF</u>	<u>Fixed</u>	<u>0.85</u>	<u>PG&amp;E study by ENCON Mechanical &amp; Nuclear Engineering, 1992</u>
<u>CL</u>	<u>Variable</u>		<u>Rebate Application or Manufacturer Data</u>
<u>EER</u>	<u>Fixed</u>	<u>9.0</u>	<u>Average based on custom applications for the NJCEP C&amp;I Program in 2010</u>
<u>Usage</u>	<u>Fixed</u>	<u>8760</u>	<u>365 days/year, 24 hours/day</u>

## 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<sub>b</sub> = The baseline efficiency for electric chillers, as shown in the Gas Chiller Verification Summary table below.

kW/Ton<sub>gc</sub> = 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 <sub>q</sub>	Variable		Rebate Application or Manufacturer Data
BE <sub>b</sub>	Fixed	75%	ASHRAE 90.1-2004
IR	Variable		Rebate Application or Manufacturer Data
Tons	Variable		Rebate Application
MMBtu	Variable		Rebate Application
kW/Ton <sub>b</sub>	Fixed	<p>&lt;100 tons 1.25 kW/ton</p> <p><b>100 to &lt; 150 tons</b> 0.703 kW/ton</p> <p><b>150 to &lt;300 tons:</b> 0.634 kW/Ton</p> <p><b>300 tons or more:</b> 0.577 kW/ton</p>	<p>Collaborative agreement and C/I baseline study</p> <p>Assumes new electric chiller baseline using air cooled unit for chillers less than 100 tons; water cooled for chillers greater than 100 tons</p>
kW/Ton <sub>gc</sub>	Variable		Manufacturer Data
COP	Variable		Manufacturer Data

Component	Type	Value	Source
CF	Fixed	67%	Engineering estimate
EFLH	Fixed	1,360	JCP&L Measured data <sup>7</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.

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.  
Protocols to be developed.

#### **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.

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<sup>7</sup> Results reflect metered use from 1995 – 1999.  
New Jersey Clean Energy Program  
Protocols to Measure Resource Savings  
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Algorithms

$$\text{Demand Savings (kW)} = \text{IR} \times \text{EFF}/3412 \times \text{CF}$$

$$\text{Energy Savings (kWh)} = \text{IR} \times \text{EFF}/3412 \times \text{EFLH}$$

$$\text{Gas Usage Increase} = \text{IR} \times \text{EFLH}$$

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
EFLH	Fixed	1,000	PSE&G
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

$$\text{Gas Savings} = ((\text{EFF}_q - \text{EFF}_b)/\text{EFF}_q) \times \text{Energy Use Density} \times (\text{Area}/1000)$$

Definition of Variables

EFF<sub>q</sub> = Efficiency of the qualifying energy efficient water heater.

$EFF_b$  = Efficiency of the baseline water heater.

Area = Square feet served by the water heater

### Water Heaters

Component	Type	Value	Source
$EFF_q$	Variable		Application
$EFF_b$	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 <del>4</del>
Energy Use Density	Variable	See Table Below	1
Fluid Capacity	Variable		Application
<del>Time Period Allocation Factors</del>	<del>Fixed</del>	<del>Summer 50% Winter 50%</del>	

## Energy Use Density Lookup Table

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Building Type	Energy Use Density (kBtu/1000 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.

### Furnaces and 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.

### Infrared Heaters

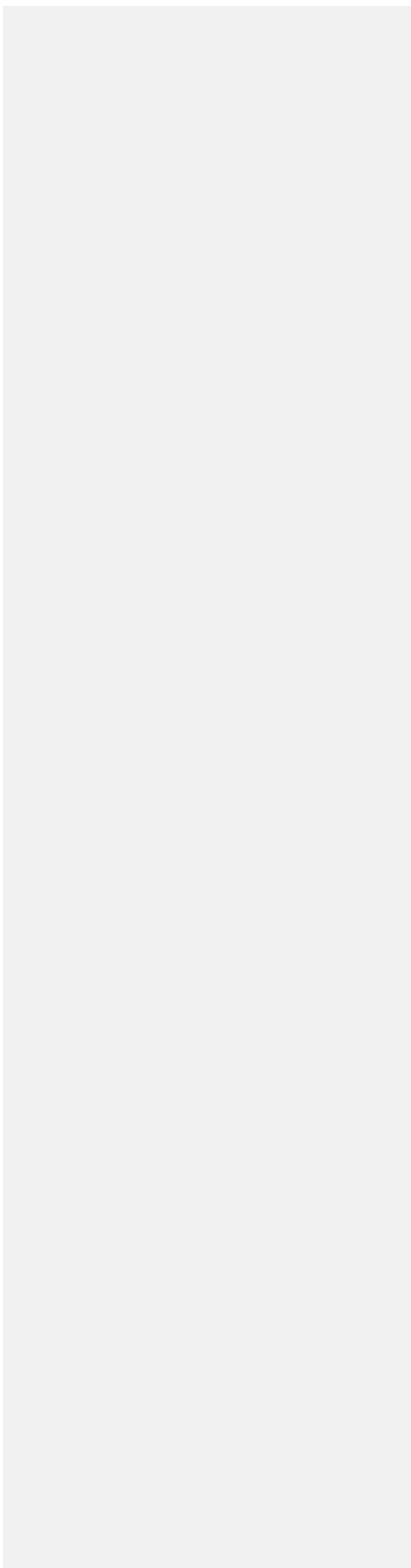
Opportunities to target replacement of existing unit heater equipment with gas or propane infrared heating is an available measure under the Direct Install Program.

### Algorithms

GasFuel Savings =

$$\left[ \frac{(0.8 \times CAPY_{in} \times HDD_{mod} \times 24)}{\Delta T \times 100,000} \right] \times \left( \frac{1}{AFUE_b} - \frac{1}{AFUE_q} \right)$$

$$\left[ \frac{(OF \times CAPY_{in} \times HDD_{mod} \times 24)}{\Delta T \times HC_{fuel}} \right] \times \left( 1 - \frac{AFUE_b \times ICF}{AFUE_q} \right)$$





Definition of Variables

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

CAPY<sub>in</sub> = Input capacity of the baseline furnace, boiler or heater in Btu/hour

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

24 = Hours/Day

ΔT = design temperature difference, with balance temperatures = 65° F and outdoor temperature in table below

HC<sub>fuel</sub> = Conversion from Btu to therms of gas or gallons of oil or propane (100,000 btu/therm; 138,700 btu/gal of #2 oil; 92,000 btu/gal of propane)

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

For projects where infrared heater(s) are proposed as a measure:

AFUE<sub>b</sub> = Annual Fuel Utilization Efficiency of the baseline unit heater(s)

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

ICF = Infrared Compensation Factor (ICF = 0.8 for IR Heaters, 1.0 for furnaces/boilers)<sup>2</sup>  
0.8 = Oversize factor of standard boiler or furnace, equivalent to 25% of capacity

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

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

For projects where infrared heater(s) are proposed as a measure:

AFUE<sub>b</sub> = Annual Fuel Utilization Efficiency of the baseline unit heater(s)

CAPY<sub>in</sub> = Capacity of the furnace or boiler in Btu/hour

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

ΔT = design temperature difference, with balance temperatures = 65° F and outdoor temperature in table below

C = Conversion from Btu to therms of gas or gallons of oil or propane (100,000 btu/therm; 138,700 btu/gal of oil; 92,000 btu/gal of propane)

**Furnaces and Boilers**

Component	Type	Value	Source
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Component	Type	Value	Source
AFUE <sub>g</sub>	Variable		Application
AFUE <sub>b</sub>	Fixed	Furnaces: 78% Boilers: 80% Infrared: 78%	EPACT Standard for furnaces and boilers
CAPY <sub>in</sub>	Variable		Application
ΔT	Variable	See Table Below	1
HDD <sub>mod</sub>	Fixed	See Table Below	1

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)

### 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

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

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~~— Compressed Air System Optimization~~

~~— Protocols~~

~~— Compressed Air Systems~~

~~— The energy and peak demand savings due to Compressed Air Optimization measures will be based on an a site-specific engineering analysis completed for each participating site. The engineering analysis will determine what increase in efficiency will be realized through program participation. This will be compared to the site-specific baseline condition to estimate savings.~~

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## Combined Heat and Power (CHP) Program

### Protocols

The measurement of energy and demand savings for Combined Heat and Power (CHP) systems is based primarily on the characteristics of the individual CHP systems subject to the general principles set out below. The majority of the inputs used to estimate energy and demand impacts of CHP systems will be drawn from individual project applications.

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

#### *Distributed Generation*

**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 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)

**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 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>8</sup>

The New Jersey Department of Environmental Protection (DEP) has provided the BPU with emission factors that are used to calculate the emission savings from energy efficiency and

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<sup>8</sup> Summit Blue, Draft Energy Efficiency Market Assessment of New Jersey Clean Energy Program, Book III, Page 196, May 26, 2006

renewable energy projects. These factors should be used to calculate the base emission factors which the CHP system emission factors would be compared to. The emissions from the CHP system would be subtracted from the base emissions to determine the net emission changes as follows:

**Base Emission Factors**

**DEP Emissions Reduction Factors** for electric programs are as follows:

- CO2 (Carbon Dioxide) emissions are reduced by 1,520 lbs. per MWh saved
- NOx (Nitric Oxide) emission reductions are 2.8 lbs. per MWh saved
- SO2 (Sulfur Dioxide) emission reductions are 6.5 lbs. per MWh saved
- Hg (Mercury) emission reductions are 0.0000356 lbs. per MWh saved

**CHP Emission Reduction Algorithms**

$$\text{CO2 ER (lbs)} = (1,520 * \text{MWh}) - (\text{CHP CO2EF} * \text{MWh})$$

$$\text{NOx ER (lbs)} = (2.8 * \text{MWh}) - (\text{CHP NOxEF} * \text{MWh})$$

$$\text{SO2 ER (lbs)} = (6.5 * \text{MWh}) - (\text{CHP SO2EF} * \text{MWh})$$

$$\text{HG ER (lbs)} = (0.0000356 * \text{MWh}) - (\text{CHP HGEF} * \text{MWh})$$

**Definitions**

ER = Emission reductions in pounds

CHP EF = the emission factors of the CHP system in pounds per MWh for each type of emission

MWh = the estimated annual and lifetime generation from the CHP system

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

## Pay for Performance Program

### Protocols

The Pay for Performance Program is a comprehensive program targeted at existing commercial and industrial buildings that have an average annual demand of 2100 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.

#### Exceptions to 15% Energy Use Reduction Requirement for Participation

This exception will be limited to sectors such as manufacturing, pharmaceutical, chemical, refinery, packaging, food/beverage, data center, transportation, mining/mineral, paper/pulp, biotechnology, etc. The manufacturing and/or processing loads use should be equal to or greater than 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.

In order for a project to qualify for incentives under the Pay for Performance Program, the Partner<sub>s</sub> must create a whole-building simulation, 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. The requirements are meant to facilitate consistent modeling among modelers, establish modeling guidelines for measures that ASHRAE 90.1 leaves to the Rating Authority to determine, and ensure that these modeling results are used to drive energy-efficient design from the beginning of the design process. Savings estimates calculated by the simulation software and included in the final approved Energy Reduction Plan will be applied to the Pay for Performance program.

#### **Modeling Software Requirements**

Simulation software must be compliant with ASHRAE 90.1 2007<sup>4</sup> 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.

If the approved simulation tool used for the project cannot adequately model a design, material, or device, then the energy savings associated with this component may be calculated using an external calculation method (custom spreadsheets, proprietary software, or thermodynamically-similar component model) that can approximate the expected performance of the particular component that cannot be modeled explicitly in the approved software tool. The resulting savings may then be subtracted from the usage projected by post-retrofit model. External calculation methods must include detailed documentation and require prior approval by the Market Manager.

#### **Baseline Conditions**

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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.

### **Measurement & Verification Guidelines**

A building-specific metering plan is a required component of each Energy Reduction Plan. The Metering Plan should follow the M&V Guidelines (Appendix A) and shall be included in Section VI of the Energy Reduction Plan. The Metering Plan must, in general, address the following for each measure and building:

1. How will the post-retrofit usage be measured or otherwise determined and how will that relate to the pre-construction conditions/equipment?
2. What factors or variables affect energy consumption of both baseline and post-retrofit conditions (e.g. outside and indoor air temperature, humidity, occupancy, operating hours)?
3. How will these factors/variables be measured and used to adjust the baseline or post-retrofit energy usage, if necessary, so savings can be determined?

The options and methods used for measurement and verification in the Pay for Performance Program are adopted from those defined in the 2002 International Performance Measurement and Verifications Protocol (IPMVP) and the 2008 Federal Energy Management Program (FEMP) M&V Guideline version 3.0. Of the four basic options are outlined in the IPMVP, Option D must be followed for all projects in the Pay for Performance Program. M&V protocols for Options A and B may be used as guidelines for data collection. All metering results will be used to calibrate the simulation model. Option C is not applicable for the Program.

**Option A – Partially Measured Retrofit Isolation:** Savings are predicted using engineering or statistical methods that do not involve long-term measurement. This option will generally be accepted only where other methods are not cost effective and the savings are very predictable and reliable.

**Option B – Retrofit Isolation:** Involves short-term or continuous metering during the performance period to determine energy consumption. Measurements are usually taken at the device or system level.

**Option C – Whole Facility:** Involves (1) comparing monthly billing data recorded for the whole building or project site by a utility meter or sub-meters, before and after project installation, and (2) analyzing that data to account for any variables, such as weather or occupancy levels. Energy savings can be determined once the variables are recognized and adjusted to match pre-installation conditions.

**Option D – Calibrated Simulation:** Involves using software to create a simulated model of a building based on blueprints and site surveys. The model is calibrated by comparing it with billing or end-use monitored data. Models of the project are typically constructed for (1) the existing base case, and (2) a case with the energy measures installed.



## 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*

<i>System</i>	<i>Units</i>	<i>Pre-1960</i>	<i>1960-1969</i>	<i>1970-1974</i>	<i>1975-1983</i>	<i>1984-1987</i>	<i>1988-1991</i>	<i>1992-present</i>
<i>Unitary HVAC / Split Systems</i>								
<i>&lt;= 5.4 tons</i>	<i>SEER</i>	<i>5.0</i>	<i>6.1</i>	<i>6.5</i>	<i>7.4</i>	<i>8.7</i>	<i>9.4</i>	<i>10</i>
<i>5.4 - 11.25 tons</i>	<i>EER</i>	<i>3.9</i>	<i>4.7</i>	<i>5.1</i>	<i>5.7</i>	<i>6.8</i>	<i>7.3</i>	<i>7.8</i>
<i>11.25 - 20 tons</i>	<i>EER</i>	<i>3.7</i>	<i>4.5</i>	<i>4.8</i>	<i>5.4</i>	<i>6.4</i>	<i>6.9</i>	<i>7.3</i>
<i>Air-Air Heat Pump Systems</i>								
<i>&lt;= 5.4 tons</i>	<i>SEER</i>	<i>5.0</i>	<i>6.1</i>	<i>6.5</i>	<i>7.4</i>	<i>8.7</i>	<i>9.4</i>	<i>10</i>
<i>5.4 - 11.25 tons</i>	<i>EER</i>	<i>3.8</i>	<i>4.6</i>	<i>5.0</i>	<i>5.6</i>	<i>6.6</i>	<i>7.2</i>	<i>7.6</i>
<i>Packaged Terminal Systems</i>								
<i>&lt; 0.74 tons</i>	<i>EER</i>	<i>5.0</i>	<i>6.1</i>	<i>6.1</i>	<i>6.7</i>	<i>7.7</i>	<i>8.1</i>	<i>8.5</i>
<i>0.75 - 1 ton</i>	<i>EER</i>	<i>4.8</i>	<i>5.9</i>	<i>5.9</i>	<i>6.4</i>	<i>7.4</i>	<i>7.8</i>	<i>8.2</i>
<i>&gt; 1 ton</i>	<i>EER</i>	<i>4.7</i>	<i>5.7</i>	<i>5.7</i>	<i>6.3</i>	<i>7.2</i>	<i>7.6</i>	<i>7.9</i>
<i>Water Source Heat Pumps</i>								
<i>All Capacities</i>	<i>EER</i>	<i>5.9</i>	<i>7.2</i>	<i>7.2</i>	<i>7.9</i>	<i>9.1</i>	<i>9.5</i>	<i>10</i>

*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.*

### 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  $\eta_{\text{base}}$ . 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.

<i>Motor HP</i>	<i>Baseline Efficiency</i>
<i>1</i>	<i>0.75</i>
<i>1.5</i>	<i>0.775</i>
<i>2</i>	<i>0.80</i>
<i>3</i>	<i>0.825</i>
<i>5</i>	<i>0.84</i>
<i>7.5</i>	<i>0.845</i>
<i>10</i>	<i>0.85</i>

*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

$$\text{Gross kWh Savings} = \text{kWh Savings}_{EF} + \text{kWh Savings}_{RH} + \text{kWh Savings}_{EC}$$

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

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

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

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

#### Definition of Variables

- kWh Savings<sub>EF</sub>* = Savings due to Evaporator Fan being off
- kWh Savings<sub>RH</sub>* = Savings due to reduced heat from Evaporator Fans
- kWh Savings<sub>EC</sub>* = Savings due to the electronic controls on compressor and evaporator
- Amps<sub>EF</sub> = Nameplate Amps of Evaporator Fan
- Volts<sub>EF</sub> = Nameplate Volts of Evaporator Fan
- Phase<sub>EF</sub> = 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<sub>CP</sub> = Nameplate Amps of Compressor
- Volts<sub>CP</sub> = 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 = Diversity Factor or 0.228<sup>5</sup>

#### Notes

- (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

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

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

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

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

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

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

- (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

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

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

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

### 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>

(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

$$\text{kWh Savings} = (((\text{Watts}_B - \text{Watts}_{\text{LED}})/1000) * H) * (1 + (0.28 * 1.6))$$

$$\text{kW Savings} = ((\text{Watts}_B - \text{Watts}_{\text{LED}})/1000) * (1 + (0.28 * 1.6))$$

#### Definition of Variables

Watts<sub>B</sub> = Baseline Lighting Wattage

Watts<sub>LED</sub> = 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>9</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>

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<sup>9</sup> Select Energy Services, Inc. *Cooler Control Measure Impact Spreadsheet User's Manual*. 2004.

### Algorithms

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

### 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

### Notes

- (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.

## **Gas Space and Water Heating Measures**

### ***Gas Furnaces and Boilers***

Replacement of existing gas, oil, or propane 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 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-1960	1960-1969	1970-1974	1975-1983	1984-1987	1988-1991	1992-present
Gas <i>or</i> Propane Furnace	AFUE	0.60	0.60	0.65	0.68	0.68	0.76	0.78
Gas <i>or</i> Propane Boiler	AFUE	0.60	0.60	0.65	0.65	0.70	0.77	0.80
Oil Furnace or Boiler	AFUE	0.60	0.65	0.72	0.75	0.80	0.80	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.

**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). 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, a value of **0.63** will be used for the variable identified as AFUE<sub>b</sub>. This age-based efficiency is 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.

Source: Unit Heaters Deserve Attention For Commercial Programs, Sachs, Harvey M., April 2003, Report Number A031

**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**

System	Units	Pre-1960	1960-1969	1970-1974	1975-1983	1984-1987	1988-1991	1992-present
Gas Storage	EF	0.47	0.47	0.47	0.49	0.55	0.55	0.56
Oil Storage	EF	0.47	0.47	0.47	0.48	0.49	0.54	0.56
Gas/Oil >50 gal, >75 kBtuh	T <sub>e</sub>	0.65	0.65	0.65	0.68	0.76	0.76	0.77

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

## Food Service Measures

### *Electric and Gas Fryers*

Energy efficient electric or natural gas fryers and vat fryers utilized in commercial food service applications which have performance rated in accordance with ASTM Standard Test Method 1361-F or 2144-F for small and large vat fryers respectively. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

#### Algorithms

$$\text{Savings} = (D * ((P * E * (1 / \text{EFF}_b - 1 / \text{EFF}_q)) + (I_b * (H - (P / \text{Cap}_b)) - I_q * (H - (P / \text{Cap}_q)))) / C$$

#### Definition of Variables

Savings = gross customer annual energy savings for the measure in ΔkWh for electric fryer, or ΔMMBTU for gas fryer.

D = Operating days per year

P = Average production per day (lb/day) (assume 150)

E = Energy to Food (Btu/lb) (assume 570)

EFF<sub>b</sub> = Heavy Load Efficiency of Baseline Unit

EFF<sub>q</sub> = Heavy Load Efficiency of Qualifying Unit

I<sub>b</sub> = Idle Energy Rate of Baseline Unit (Btu/hr)

I<sub>q</sub> = Idle Energy Rate of Qualifying Unit (Btu/hr)

H = Operating hours per day (assume 12)

Cap<sub>b</sub> = Production Capacity of Baseline Unit (lb/hr)

Cap<sub>q</sub> = Production Capacity of Qualifying Unit (lb/hr)

C = Conversion Factor (3,412 Btu/kWh or 1,000,000 Btu/MMBtu)

#### Baseline Condition

Electric fryers: EFF<sub>b</sub> = 0.75

I<sub>b</sub> = 3583 Btu/hr

Cap<sub>b</sub> = 65 lb/hr

Gas fryers: EFF<sub>b</sub> = 0.35

I<sub>b</sub> = 14000 Btu/hr

Cap<sub>b</sub> = 60 lb/hr

#### Measure Cost and Incentive Amount

The standardized cost and incentive amounts for this measure will be based on contractor bids in response to the forthcoming RFP planned for issuance in April 2009.

#### 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 Steamers***

Energy efficient electric or natural gas steamers utilized in commercial food service applications which have performance rated in accordance with ASTM Standard Test Method 1484-F. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

#### Algorithms

$$\text{Savings} = (D * ((P * E * (1 / \text{EFF}_b - 1 / \text{EFF}_q)) + (I_b * (H - (P / \text{Cap}_b)) - I_q * (H - (P / \text{Cap}_q)))) / C$$

#### Definitions

Savings = gross customer annual energy savings for the measure in ΔkWh for electric steamer or ΔMMBTU for gas steamer.

D = Operating days per year

P = Average production per day (lb/day) (assume 100)

E = Energy to Food (Btu/lb) (assume 105)

EFF<sub>b</sub> = Heavy Load Efficiency of Baseline Unit

EFF<sub>q</sub> = Heavy Load Efficiency of Qualifying Unit

I<sub>b</sub> = Idle Energy Rate of Baseline Unit (Btu/hr)

I<sub>q</sub> = Idle Energy Rate of Qualifying Unit (Btu/hr)

H = Operating hours per day (assume 12)

Cap<sub>b</sub> = Production Capacity of Baseline Unit (lb/hr)

Cap<sub>q</sub> = Production Capacity of Qualifying Unit (lb/hr)

C = Conversion Factor (3,412 Btu/kWh or 1,000,000 Btu/MMBtu)

#### Baseline Condition

Electric steamers: EFF<sub>b</sub> = 0.26

I<sub>b</sub> = 3412 Btu/hr

Cap<sub>b</sub> = 70 lb/hr

Gas steamers: EFF<sub>b</sub> = 0.15

I<sub>b</sub> = 11000 Btu/hr

Cap<sub>b</sub> = 65 lb/hr

#### Measure Cost and Incentive Amount

The standardized cost and incentive amounts for this measure will be based on contractor bids in response to the forthcoming RFP planned for issuance in April 2009.

#### 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 Griddles***

Energy efficient electric or natural gas griddles utilized in commercial food service applications which have performance rated in accordance with ASTM Standard Test Method 1275-F. The measurement of energy savings for this measure is based on algorithms with key variables provided by manufacturer data or prescribed herein.

#### Algorithms

$$\text{Savings} = (D * ((P * E * (1 / \text{EFF}_b - 1 / \text{EFF}_q)) + (I_b * (H - (P / \text{Cap}_b)) - I_q * (H - (P / \text{Cap}_q)))) / C$$

#### Definition of Variables

Savings = gross customer annual energy savings for the measure in ΔkWh for electric griddle or ΔMMBTU for gas griddle.

D = Operating days per year

P = Average production per day (lb/day) (assume 100)

E = Energy to Food (Btu/lb) (assume 475)

EFF<sub>b</sub> = Heavy Load Efficiency of Baseline Unit

EFF<sub>q</sub> = Heavy Load Efficiency of Qualifying Unit

I<sub>b</sub> = Idle Energy Rate of Baseline Unit (Btu/hr)

I<sub>q</sub> = Idle Energy Rate of Qualifying Unit (Btu/hr)

H = Operating hours per day (assume 12)

Cap<sub>b</sub> = Production Capacity of Baseline Unit (lb/hr)

Cap<sub>q</sub> = Production Capacity of Qualifying Unit (lb/hr)

C = Conversion Factor (3,412 Btu/kWh or 1,000,000 Btu/MMBtu)

#### Baseline Condition

Electric griddles: EFF<sub>b</sub> = 0.60

I<sub>b</sub> = 8189 Btu/hr

Cap<sub>b</sub> = 35 lb/hr

Gas griddles: EFF<sub>b</sub> = 0.30

I<sub>b</sub> = 21000 Btu/hr

Cap<sub>b</sub> = 25 lb/hr

#### Measure Cost and Incentive Amount

The standardized cost and incentive amounts for this measure will be based on contractor bids in response to the forthcoming RFP planned for issuance in April 2009.

#### 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 Ovens***

Energy efficient electric or natural gas ovens 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, convection – ASTM 1639-F
- Gas conveyor and rack ovens – ASTM 1817-F

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

#### Algorithms

$$\text{Savings} = (D * ((P * E * (1 / \text{EFF}_b - 1 / \text{EFF}_q)) + (I_b * (H - (P / \text{Cap}_b)) - I_q * (H - (P / \text{Cap}_q)))) / C$$

#### Definitions

Savings = gross customer annual energy savings for the measure in  $\Delta$ kWh for electric oven or  $\Delta$ MMBTU for gas oven.

D = Operating days per year

P = Average production per day (lb/day)

- Electric Combination Ovens = 200
- Gas Combination Ovens = 200
- Electric Convection Ovens = 100
- Gas Convection Ovens = 100
- Gas Conveyor Ovens = 300
- Gas Rack Ovens = 1200

E = Energy to Food (Btu/lb) (assume 250)

$\text{EFF}_b$  = Heavy Load Efficiency of Baseline Unit

$\text{EFF}_q$  = Heavy Load Efficiency of Qualifying Unit

$I_b$  = Idle Energy Rate of Baseline Unit (Btu/hr)

$I_q$  = Idle Energy Rate of Qualifying Unit (Btu/hr)

H = Operating hours per day (assume 12)

$\text{Cap}_b$  = Production Capacity of Baseline Unit (lb/hr)

$\text{Cap}_q$  = Production Capacity of Qualifying Unit (lb/hr)

C = Conversion Factor (3,412 Btu/kWh or 1,000,000 Btu/MMBtu)

#### Baseline Condition from which savings are calculated

Electric Combination Ovens:     $\text{EFF}_b = 0.44$   
    $I_b = 25590 \text{ Btu/hr}$   
    $\text{Cap}_b = 80 \text{ lb/hr}$

Gas Combination Ovens:         $\text{EFF}_b = 0.35$   
    $I_b = 28000 \text{ Btu/hr}$   
    $\text{Cap}_b = 80 \text{ lb/hr}$

Electric Convection Ovens:	EFF <sub>b</sub> = 0.65 I <sub>b</sub> = 6824 Btu/hr Cap <sub>b</sub> = 70 lb/hr
Gas Convection Ovens:	EFF <sub>b</sub> = 0.30 I <sub>b</sub> = 18000 Btu/hr Cap <sub>b</sub> = 70 lb/hr
Gas Conveyor Ovens:	EFF <sub>b</sub> = 0.20 I <sub>b</sub> = 70000 Btu/hr Cap <sub>b</sub> = 215 lb/hr
Gas Rack Ovens:	EFF <sub>b</sub> = 0.30 I <sub>b</sub> = 65000 Btu/hr Cap <sub>b</sub> = 250 lb/hr

#### Measure Cost and Incentive Amount

The standardized cost and incentive amounts for this measure will be based on contractor bids in response to the forthcoming RFP planned for issuance in April 2009.

#### 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

$$\text{Cooling Energy Savings (kWh)} = (((T_c \cdot (H+5) + S_c \cdot (168 - (H+5))) / 168) \cdot P_c \cdot \text{Cap}_{hp} \cdot 12 \cdot \text{EFLH}_c / \text{EER}_{hp})$$

$$\text{Heating Energy Savings (kWh)} = (((T_h \cdot (H+5) + S_h \cdot (168 - (H+5))) / 168) \cdot P_h \cdot \text{Cap}_{hp} \cdot 12 \cdot \text{EFLH}_h / \text{EER}_{hp})$$

$$\text{Heating Energy Savings (Therms)} = (T_h - (T_h \cdot (H+5) + S_h \cdot (168 - (H+5))) / 168) \cdot P_h \cdot \text{Cap}_{hp} \cdot \text{EFLH}_h / \text{AFUE}_h / 100,000$$

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<sub>hp</sub> = Connected load capacity of heat pump/AC (Tons) – Provided on Application.

Cap<sub>h</sub> = Connected heating load capacity (Btu/hr) – Provided on Application.

EFLH<sub>c</sub> = Equivalent full load cooling hours

EFLH<sub>h</sub> = Equivalent full load heating hours

P<sub>h</sub> = Heating season percent savings per degree setback

P<sub>c</sub> = Cooling season percent savings per degree setup

AFUE<sub>h</sub> = Heating equipment efficiency – Provided on Application.

EER<sub>hp</sub> = 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 <sub>h</sub>	Variable		Application
T <sub>c</sub>	Variable		Application
S <sub>h</sub>	Fixed	T <sub>h</sub> -5°	
S <sub>c</sub>	Fixed	T <sub>c</sub> +5°	
H	Variable		Application; Default of 56 hrs/week
Cap <sub>hp</sub>	Variable		Application
Cap <sub>h</sub>	Variable		Application
EFLH <sub>c</sub>	Fixed	381	1
EFLH <sub>h</sub>	Fixed	900	PSE&G
P <sub>h</sub>	Fixed	3%	2

Component	Type	Value	Source
P <sub>c</sub>	Fixed	6%	2
AFUE <sub>h</sub>	Variable		Application
EER <sub>hp</sub>	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



### Duel 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:

(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".

(3) ConEd Solutions (2000) "A Report

### **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

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N = Number of fixtures

H = Hours per day of device usage

D = Days per year of facility operation

F<sub>base</sub> = Baseline device flow rate (gal/m)

F<sub>eff</sub> = Low flow device flow rate (gal/m)

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

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

Eff = Percent efficiency of water heating equipment

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

#### 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

$$\text{Electric Savings (kWh)} = 0.05 * \text{HVAC}_E$$

$$\text{Gas Savings (Therms)} = 0.05 * \text{HVAC}_G$$

### Definition of Variables

$\text{HVAC}_E$  = Total electric HVAC consumption (kWh)

$\text{HVAC}_G$  = Total gas HVAC consumption (Therms)

### Demand Control Ventilation Using CO<sub>2</sub> Sensors

Component	Type	Value	Source
$\text{HVAC}_E$	Variable		Application
$\text{HVAC}_G$	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

$$\text{Energy Savings (kWh)} = (L * (\text{HLC}_{\text{base}} - \text{HLC}_{\text{ee}}) / C) * \Delta T * 8,760$$

Definition of Variables

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

$\text{HLC}_{\text{base}}$  = Pipe heat loss coefficient by pipe diameter (baseline) (Btu/hr-°F-ft)

$\text{HLC}_{\text{ee}}$  = Pipe heat loss coefficient by pipe diameter (proposed) (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))

$\Delta T$  = 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
$\text{HLC}_{\text{base}}$	Fixed	See Table Below	
$\text{HLC}_{\text{ee}}$	Fixed	See Table Below	
$\Delta T$	Variable	Default is 65°F	EPRI Study

**Pipe Heat Loss Coefficient Table**

Pipe Diam. (in.)	$\text{HLC}_{\text{base}}$	$\text{HLC}_{\text{ee}}$
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

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Source: Engineering Methods for Estimating the Impacts of Demand-Side Management Programs, Volume 2, EPRI, 1993

## Cool Cities Program

### Protocol

CITYgreen's energy conservation study utilizes methods developed by Jill Mahon of AMERICAN FORESTS, interpolated from research by Dr. Greg McPherson of the USDA Forest Service. The program estimates the energy conservation benefits of trees resulting from direct shading of residential buildings.

Trees are most effective when located to shade air conditioners, windows, or walls and when located on the side of the home receiving the most solar exposure in addition to other criteria. In many parts of the country the west side is most valuable, followed by the east and the south, although this ranking can change based on geographical considerations.

CITYgreen assigns each tree an energy rating, 1 through 5, based on location characteristics listed above and information about tree size and shape. For example, in many parts of the country, a large tree located near the west side of a building and shading an air conditioner or window would be assigned a maximum energy rating.

Each tree then is assumed to reduce a home's annual energy bill by a percentage associated with energy rank, which varies based on the climate being studied. The percentage savings produced by each tree around a home are multiplied by a home's average annual cooling cost (\$600.00 for New Jersey). CITYgreen adds the results together to produce the savings per home, which are in turn summed to estimate savings per site.

### Methodology

The measurement plan for tree plantings for reducing energy use by shading communities is based on a randomly selected sample study area in each of the selected neighborhoods where trees were planted. A sample study area in the planted neighborhood is used due to the large volume of field data needed to calculate energy savings over time for the tree plantings. In the sample study area, averages are created to extrapolate savings over the planted areas within a municipality.

The sample study area is a single location randomly selected, which includes over 10% of the initial planting area within each municipality. The data within that sample study area are collected to run a growth model and then a tree energy savings model year by year after the initial year's calculations. Currently the best fitting model for modeling the tree planting energy savings over the Cool Cities Initiative planting areas is CITYgreen 5.4.

The program assigns an energy rating (0= No Savings, 5= Maximum Savings) to each tree that has been field verified and inventoried based on the following criteria:

- Distance from residential building structure
- Orientation to the building

- Ability to shade a window and/or an air conditioner

CITYgreen incorporates research from eleven cities distributed across the United States. Users are asked to identify their region of the United States; the program uses data from the nearest of those eleven cities. If data is available from more than one city within the region, the user is asked to identify which is closest to the project location.

The user is prompted to enter the annual cooling cost (\$600 for NJ). Multipliers associated with each energy rating (representing percent energy use-reduction) are assigned to each tree. Each home’s annual energy use is multiplied by each associated tree’s multiplier to produce an estimate of dollar and kilowatt savings per household, not including inflation.

Multipliers used in CITYgreen were interpolated from “Modeling Benefits and Costs of Community Tree Planting in 12 U.S. Cities” and “Chicago’s Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project.”

Dr. McPherson’s research found that a second tree located in an optimal location provides about 2/3 as much savings as the first. Therefore, when more than one tree is assigned a rating of 5 for a given home, only one tree is assumed to provide the full benefits: the rest are assumed to provide 2/3 of the equivalent of a number 5 energy rating.

CITYgreen’s tree growth model was developed by AMERICAN FORESTS. The program “grows” the tree trunk diameter at breast-height (DBH), the tree height, and the tree canopy according to species and year of growth selected. CITYgreen also considers the area of the country your projection is in, since trees grow at different rates in different parts of the country. Currently modeling has been with Northeast setting. The program uses the following method, derived from Nowak, Susinni, Stevens, and Luley, to estimate growth:

<b>Tree Growth Rate</b>	<b>Trunk DBH (Inches/Year)</b>	<b>Height (Inches/Year)</b>
Slow-Growing Trees	0.1	1.0
Medium-Growing Trees	0.25	1.5
Fast-Growing Trees	0.5	3.0

The height change is determined by multiplying the number of growth years by the height growth rate assigned to the species. The tree trunk diameter (DBH) changes are projected by adding the existing DBH (inches) to the number of growth years multiplied by the DBH growth rate assigned to the species.

A growth factor was derived for individual tree species based on the DBH and canopy area trends taken from AMERICAN FORESTS’ composite tree species database of more than 13,000 trees. This growth factor is multiplied by the calculated tree trunk DBH growth for each species to estimate projected canopy radius and canopy area in square feet. By looking at the largest inventoried specimen from each species, a maximum potential growth has been determined for nearly all tree species in the CITYgreen species database. The canopy growth factor is based on a linear regression of canopy radius divided by tree trunk DBH.

To accumulate the energy savings, the energy savings model runs for one year. Then the growth model runs for one year and then the energy savings model runs for one year on the new growth projection, repeating this process for 30 years of growth. The process gives 31 year of savings, because the first year was before one year's growth.

The 31 years of energy savings are summed for the study area. To determine the energy savings over all the planting areas within a municipality, a ratio relationship is used between area and total savings.

#### **Calculation for total energy savings**

$$\text{TES/SAMES} = \text{TPA/SA}$$

$$(\text{SAMES}) \text{ TES/SAMES} = (\text{SAMES}) \text{ TPA/SA}$$

$$\text{TES} = (\text{SAMES}) \text{ TPA/SA}$$

TES – Total Energy Savings

SAMES – Sample Area Modeled Energy Savings

SA – Sample Area

TPA – Total Planting Area

#### **Definition of Terms**

Air conditioning unit – Any air conditioner unit below three stories

Average annual cooling cost – The average amount of energy used in one year to cool a home. Currently the Cool Cities Initiative is using \$600 per annual cooling cost.

Diameter at breast-height (DBH) – A standard measurement of the diameter of a tree trunk at 4.5 feet above the ground.

Initial planting area – The area that was first planted in a municipality.

Municipality – The controlling governing body of a selected area. This would be a city, town, township, borough, or village.

Window – A three-foot by four-foot window under three stories. If a window is much larger than this it is counted as two, for example a four-foot by six-foot window counts as two windows.

Year of growth – The projected growth in one year's time.

#### **References**

1. AMERICAN FORESTS 2002. [CITYgreen calculating the value of nature Version 5.0](#). Washington, DC: AMERICAN FORESTS. Much of the information is directly from this source.



2. Energy Information Administration. "Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings," Voluntary Reporting of Greenhouse Gases, September 1996. Washington, DC: U.S. Department of Energy.
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4. McPherson, Greg, Sacamano, Paul and Steve Wensman, 1993. "Modelling Benefits and Costs of Community Tree-Planting in 12 U.S. Cities." USDA Forest Service.
5. Nowak, David J., Stevens, Jack C., Luley, Christopher J. and Susan M. Susinni. 1996. "Effects of Urban Tree Management on Atmospheric Carbon Dioxide," Syracuse, NY: Unpublished manuscript, (To be submitted to the Journal of Arboriculture)
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## **Customer On-Site Renewable Energy Program (CORE) and Renewable Energy Incentive Program (REIP)**

### **Protocols**

The energy and demand impacts for customer sited generation systems participating in the CORE program are based on algorithms that estimate each systems annual energy production and coincident peak capacity production. Input data are based on fixed assumptions, engineering estimates and data supplied from the program's technical worksheets and inspection forms. The reported generation will be based on as installed conditions, as verified by site inspection documentation.

For solar electric generation, an industry standard calculation tool (PVWATTS from the National Renewable Energy Laboratory) is used for estimating PV system annual outputs.

For wind installations estimated annual energy output is calculated using approved wind resource data maps, wind speed at proposed hub height, and approved annual estimated power curves for each turbine.

For fuel cell and sustainable biomass projects the protocols include recommended formats but the energy and peak capacity for each project will be estimated on a case by case basis. This level of flexibility allows for the use of more detailed case specific engineering data in the protocol reporting.

For all technicalities, the customer sited generation protocols report the gross electrical generation from the system. Therefore, for example, the estimates for production from sustainable biomass projects do not account for estimated consumption of the applicable biomass fuel.

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

### Algorithms

#### ***Photovoltaic Systems***

PVWATTS (Version 1) is used to estimate the energy generated by photovoltaic systems. PVWATTS was developed and is available through the Renewable Resource Data Center (RReDC). The RReDC is supported by the National Center for Photovoltaics (NCPV) and managed by the Department of Energy's Office of Energy Efficiency and Renewable Energy. The RReDC is maintained by the Distributed Energy Resources Center of the National Renewable Energy Laboratory. The subroutines used to calculate the energy generation are based on information developed by Sandia National Laboratories. PVWATTS is available through the RReDC website, [http://rredc.nrel.gov/solar/codes\\_algs/PVWATTS/](http://rredc.nrel.gov/solar/codes_algs/PVWATTS/). Note that program generation algorithms have used Version 1 of PVWATTS.

The following input values are used by PVWATTS to estimate average annual energy production. These are collected and/or are available for each PV project on the PV technical worksheet and inspection documentation.

- System Rated Output (AC output based on DC output at Standard Rating Conditions and default DC/AC ratings)
- Fixed, Single or Double Axis Tracking
- Array Tilt angle (for fixed axis only)
- Array Azimuth (for fixed axis only)
- Weather data (based on closest weather station data for Version 1)

The Peak demand impact for photovoltaic systems is estimated separately from the annual energy output. Summer and winter peak impacts are based on research conducted by Richard Perez, of SUNY Albany, ([http://www.nrel.gov/ncpv/documents/pv\\_util.html](http://www.nrel.gov/ncpv/documents/pv_util.html)). The estimated summer effective load carrying capacity (ELCC) for New Jersey is 60% to 70%. A value of 65% is adopted for these protocols.

Summer Peak Impact (kW) = System Rated Output \* Summer Effective Load Carrying Capacity (ELCC).

Winter Peak Impact (kW) = System Rated Output \* Winter Effective Load Carrying Capacity (WELCC).

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

**Photovoltaic Systems**

Component	Type	Value	Sources
System Rated Output (SRO)	Variable		Application Technical Worksheet, and inspection documentation
Fixed, Single, Double Axis tracking	Variable		Application Technical Worksheet, and inspection documentation
Array Tilt	Variable		Application Technical Worksheet, and inspection documentation
Azimuth Angle	Variable		Application Technical Worksheet, and inspection documentation
Weather Data	Variable	City, State – four sites will be used (Wilkes Barre PA, Newark NJ, Philadelphia PA, and Atlantic City,	Application Technical Worksheet – Version 2 if adopted provides average resource data based on 40 km square grid.

Component	Type	Value	Sources
		NJ	
ELCC	Fixed	65%	<a href="http://www.nrel.gov/ncpv/documents/pv_util.html">http://www.nrel.gov/ncpv/documents/pv_util.html</a>
WELCC	Fixed	8%	Monitored system data from White Plains NY

### Wind Systems

Estimated annual energy output for wind systems will be based on the program's method for calculating the Expected Performance Based Buy-down for system rebates. These calculations are derived from industry data resources and calculation methods. Currently there is a lack of data on the peak impact of small wind systems in New Jersey and an estimate of 0% will be used. This value will be updated if supporting data are identified.

Annual Energy Output (kWh) is a function of:

- Average annual wind speed (using one of three approved wind resource maps) at 50 meters for the proposed site
- The proposed hub height for the turbine
- An approved annual energy output curve for each turbine

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

### Wind Systems

Component	Type	Value	Sources
Average annual wind speed at 50 meters (m/s) or (mph)	Variable		Application Technical Worksheet, verified by checking against approved wind resource maps
Turbine hub height as installed	Variable		Application Technical Worksheet, verified by inspection documentation
Annual energy output power curve for proposed turbine	Variable look up based on wind speed and hub height at each location		Annual energy output power curves based on manufacturer's published data. Values checked against industry experience and acceptance for use in other jurisdictions.
Summer Peak Impact	Fixed	0%	Data on peak impact not available at this time
Winter Peak Impact	Fixed	0%	Data on peak impact not available at this time

### ***Sustainable Biomass***

Estimated annual energy output and peak impacts for sustainable biomass systems will be based on case specific engineering estimates and manufacturer data.

### **SREC-Only Program**

The measurement of energy and demand impacts for photovoltaic systems participating in the SREC-Only program is based on the rules and protocols for metering, reporting and verification in N.J.A.C. 14:8-2.9. For systems less than 10 kW, the methods used in the CORE section about for estimating each system's annual energy production and coincident peak capacity production are acceptable. For systems greater than 10 kW must submit megawatt-hour production of electrical energy. Reported generation will be based on as installed conditions, as verified by site inspection documentation.

### **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.

## Appendix A Measure Lives

### NEW JERSEY STATEWIDE ENERGY-EFFICIENCY PROGRAMS Measure Lives Used in Cost-Effectiveness Screening July 2001

PROGRAM/Measure	Measure Life
<b><u>Residential Programs</u></b>	
Energy Star Appliances	
ES Refrigerator post 2001	17
ES Refrigerator 2001	17
ES Dishwasher	13
ES Clotheswasher	20
ES Dehumidifier	11
ES RAC	10
Energy Star Lighting	
CFL	6.4
Recessed Can Fluorescent Fixture	20
torchiere residential	10
Fixtures Other	20
Energy Star Windows	
WIN-heat pump	20
WIN-gas heat/CAC	20
WIN-gas No CAC	20
Win-elec No AC	20
Win-elec AC	20
Refrigerator/Freezer Retirement	
Refrigerator/Freezer retirement	8
Residential New Construction	
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 Clotheswasher	20
Recessed Can Fluor Fixture	20
Fixtures Other	20
Efficient Ventilation Fans w/Timer	10
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PROGRAM/Measure	Measure Life
<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
<b>Low-Income Program</b>	
Air sealing electric heat	17
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	17
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

**Non-Residential Programs**

**C&I Construction**

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PROGRAM/Measure	Measure Life
Commercial Lighting — New	15
Commercial Lighting — Remodel/Replacement	15
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 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*
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*
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



PROGRAM/Measure	Measure Life
Steamers	10
Griddles	12
Ovens	12

\* 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.