PECO Energy Company

Proposed Revision of the Pennsylvania Alternative Energy Portfolio Standard

Technical Reference Manual (TRM)

Revisions to
September 2005 TRM

March 12, 2009

PLEASE NOTE:
This manual serves as a guide and reference to the Alternative Energy Portfolio Standards, Act 213 as well as Act 129.

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Pennsylvania Technical Reference Manual

Introduction

The Technical Reference Manual (TRM) has been developed to measure the resource savings from energy efficiency measures. The savings algorithms use measured and customer data as input values in industry-accepted algorithms. The data and input values for the algorithms come from application forms or standard values. The standard input values are based on the best available measured or industry data.

The standard values for most commercial and industrial (C&I) measures are supported by end use metering for key parameters for a sample of facilities and circuits, based on the metered data from past applications in other states. These C&I standard values are based on five years of data for most measures and two years of data for lighting.

Some electric input values were derived from a review of literature from various industry organizations, equipment manufacturers, and suppliers. These input values are updated to reflect changes in code, federal standards and recent program evaluations. [Discuss in working group]

Purpose

Based extensively on the New Jersey Clean Energy Program Protocols to Measure Resource Savings (2007), the TRM was developed for the purpose of estimating annual energy savings for a selection of energy efficient technologies and measures. The TRM provides guidance to the Administrator responsible for awarding certified Alternative Energy Credits ("certificates"). The TRM will be used to determine compliance with both the AEPS Act and the energy efficiency and conservation requirements of Act 129 of 2008. The TRM will continue to be updated from time to time to reflect the addition of technologies and measures as needed to remain relevant and useful.

(Note: edits inserted for clarity, language taken from Secretarial Letter)

Resource savings to be measured include electric energy (kWh) and capacity (kW) savings. The algorithms in this document focus on the determination of the per unit savings for the energy efficiency and demand response/demand reduction measures.

General Framework

In general, energy and demand savings will be measured using measured and customer data as input values in algorithms in the TRM, and information from the application/data gathering forms, worksheets, and field tools.

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

1. The application/data gathering form that the customer or customer's agent submits with basic information. (Note: edits inserted to maintain flexibility in program execution. The

assumption of the draft is that EDCs will have formal application form which has not yet been decided on or designed)

2. Application worksheets and field tools with more detailed site-specific data, input values, and calculations.
3. Algorithms that rely on standard or site-specific input values based on measured data. Parts or all of the algorithms 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 = $\Delta kW = kW_{baseline} - kW_{energy\ efficient\ measure}$

Electric Energy Savings = ΔkW X EFLH

Electric Peak Coincident Demand Savings = ΔkW X Coincidence Factor

Where:

EFLH = Equivalent Full Load Hours of operation for the installed measure.

Other resource savings will be calculated as appropriate.

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

Data and Input Values

The input values and algorithms are based on the best available and applicable data. The input values for the algorithms come from the application/data gathering forms or from standard values based on measured or industry data.

Many input values, including site-specific data, come directly from the application/data gathering 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 other state evaluations (applied prospectively), field data, and standards from industry associations. The standard values for most commercial and industrial measures are supported by end use metering for key parameters for a sample of facilities and circuits. These standard values are based on five years of metered data for most measures[1]. Data that were metered over that time period are from measures that were installed over an eight-year period. Many input values are based on program evaluations of New Jersey's Clean Energy Programs or similar programs in the northeast region.

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.

Baseline Estimates

For all new construction and any replacement of non-working equipment appliance efficiency measures, the Δ kW and Δ kWh values are based on the energy use of standard new products vs. new high efficiency products. The approach used for new technology encourages residential and business consumers to purchase and install high efficiency equipment and appliances vs. new standard efficiency equipment and appliances. For replacement/retirement of working equipment and appliance efficiency measures, the ΔkW and ΔkWh values are based on the average vintage efficiency of the items being replaced vs. new high efficiency products. The approach used for the replacement measures encourages residential and business consumers to replace working inefficient equipment and appliances with new high efficiency products rather than taking no action to upgrade or only replacing them with new standard efficiency products. The baseline estimates used in the TRM are documented in baseline studies or other market information. Baselines will be updated to reflect changing codes, practices and market transformation effects.

Resource Savings in Current and Future Program Years

Alternative Energy Credits and energy efficiency and demand response/demand reduction savings will apply in equal annual amounts corresponding to either PJM planning years or calendar years beginning with the year deemed appropriate by the Administrator, [In the working group we need to determine the role of the Administrator – if any] and lasting for the approved life of the measure.

Prospective Application of the TRM

The TRM will be applied prospectively. The input values are from the application forms and standard input values (based on measured data including metered data and evaluation results). The TRM will be updated periodically based on new information and available data, and then applied prospectively for future program years. Updates will not alter the number of AEPS credits, once awarded, by the Administrator, nor will it alter any energy savings or demand reductions already in service and within the measure life.

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[1] Values for lighting, air conditioners, chillers, and motors are based on measured usage from a large sample of participants from 1995 through 1999. Values for heat pumps reflect metered usage from 1996 through 1998, and variable speed drives reflect metered usage from 1995 through 1998.

(Note: edited for clarity).

Electric Resource Savings

Algorithms 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 algorithm 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.

Table 1: Periods for Energy Savings and Coincident Peak Demand Savings

	Energy Savings	Coincident Peak Demand Savings
Summer	May through September	June through September
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 Act 129 requirements, which reflects 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 September was selected to match the period of time required to measure the 100 highest hours of demand. This period also correlates with the highest avoided costs time period for capacity. The experience in PJM has been that nearly all of the 100 highest hours of an EDC's peak demand occur during these four months. Coincidence factors are used to determine the impact of the energy efficiency measures on peak demand. [Note: comments added to align the TRM with Act 129 implementation order]

Post-Implementation Review

The Administrator will review application/data gathering 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.
[Note: source of coincidence factor data for Pennsylvania need to be discussed in the working group]

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 algorithms 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).

Interaction of Energy Savings

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

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

For commercial and industrial custom measures, interaction where relevant is accounted for in the site-specific analysis.
[Note: paragraph deleted to align with Act 129 implementation order]

Transmission and Distribution System Losses

The TRM calculates 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 electric loss factor multiplied by the savings calculated from the algorithms will result in savings at the supply level.

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. These electric loss factors reflect losses at the margin.

Measure Lives

Measure lives are listed in Appendix A.

(Note: edited to align with ENERGYSTAR – see Appendix A.)

Custom Measures

Custom measures are measures that are considered too complex or unique to be included in the list of standard measures as outlined in the TRM. Also included are measures that may involve metered data, but require additional assumptions to arrive at a 'typical' level of savings as opposed to an exact measurement. The qualification for and availability of AEPS Credits and energy efficiency and demand response/demand reduction savings are determined on a case-by-case basis.

(Note: custom measures will be verified through M&V by the state evaluator}

Impact of Weather

This TRM is based on the New Jersey Protocols to Measure Resource Savings. To account for the climate differences between the two states, Equivalent Full Load Hours (ELFH) have been adjusted. Based on preliminary analyses, the climate in Pennsylvania (with the exception of the southeastern/Philadelphia region) tends to be cooler than the climate in New Jersey. A useful tool for comparing climates is Cooling Degree Days (CDD), which is the mean daily temperature at a particular location minus 65 degrees, summed up over all days. For example, if there is a three day heat wave where the temperature reached 90, 92, and 93, the CDD would be (90-65)+(92-65)+(93-65) = 80. Based upon data from NOAA, the annual Cooling Degree Days in Pennsylvania are 691, while in New Jersey there are 938. ELFH's have been adjusted using the percentage difference between the Cooling and Heating Degree days between New Jersey and the five Pennsylvania Climate Zones (Philadelphia, Pittsburgh, State College, Scranton, and Erie).[2] For electricity savings estimates, this difference will mostly impact summertime cooling savings in the downward direction. The HVAC and space heating savings estimates have been modified to account for these differences in climate. The Energy Star Room AC savings have also been modified based on data available from the online Energy Star savings calculator.

[Note: NOAA, the National Oceanic and Atmospheric Administration, is the recognized source of weather data. There are inaccuracies in the premise of the section e.g. statewide degree days vs. location specific degree days – this needs to be discussed in the working session.]

Algorithms for Energy Efficient Measures

The following pages present measure-specific algorithms.

[2] Each city represents the center location of each National Oceanic and Atmospheric Administration regional weather forecast zones in Pennsylvania.

Residential Electric HVAC

Algorithms

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/data gathering 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 algorithms 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.

<u>Algorithms</u>

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)

Energy Impact (kWh) = CAPY/1000 X ($1/SEER_b$ – $1/SEER_q$) X EFLH

Peak Demand Impact (kW) = CAPY/1000 X ($1/EER_b$ – $1/EER_q$) X CF

Heating Energy Savings – ASHP

Energy Impact (kWh) = $Capy_q$/1000 X ($1/HSPF_b$ - $1/HSPF_q$) X EFLH

Cooling Energy Consumption and Demand Savings – Central A/C & ASHP (Proper Sizing)

Energy Impact (kWh) = (CAPY/($SEER_q$ X 1000)) X EFLH X PSF

Peak Demand Impact (kW) = ((CAPY/(EER_q X 1000)) X CF) X PSF

Cooling Energy Consumption and Demand Savings – Central A/C & ASHP (QIF)

Energy Impact (kWh) = (((CAPY/(1000 X SEERq)) X EFLH) X (1-PSF) X QIF

Peak Demand Impact (kW) = ((CAPY/(1000 X EERq)) X CF) X (1-PSF) X QIF

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

Energy Impact (kWh) = ((CAPY/(1000 X SEERm)) X EFLH) X MF

Peak Demand Impact (kW) = ((CAPY/(1000 X EERm)) X CF) X MF

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

Energy Impact (kWh) = (CAPY/(1000 X SEERq)) X EFLH X DuctSF

Peak Demand Impact (kW) = ((CAPY/(1000 X EERq)) X CF) X DuctSF

Ground Source Heat Pumps (GSHP)

Cooling Energy (kWh) Savings = CAPY/1000 X (1/$SEER_b$ – (1/(EER_g X GSER))) X EFLH

Heating Energy (kWh) Savings = $Capy_q$/1000 X (1/$HSPF_b$ – (1/(COP_g X GSOP))) X EFLH

Peak Demand Impact (kW) = CAPY/1000 X (1/EER_b – (1/(EER_g X GSPK))) X CF

GSHP Desuperheater

Energy (kWh) Savings = EDSH

Peak Demand Impact (kW) = PDSH

Furnace High Efficiency Fan

Heating Energy (kWh) Savings = (($Capy_q$ X $EFLH_{HT}$)/100,000 BTU/therm) X HFS
[Note: dimensional units need to be corrected]
Cooling Energy (kWh) Savings = CFS

(Note: edits are made for clarity)

Definition of Terms (Note:propose all terms to be organized in alphabetical order)

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

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

$SEER_q$ = The Seasonal Energy Efficiency Ratio of the qualifying unit being installed. This data is obtained from the Application/data gathering Form based on the model number.

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

EER_b = The Energy Efficiency Ratio of the Baseline Unit.

EER_q = The Energy Efficiency Ratio of the unit being installed. This data is obtained from the Application/data gathering Form based on the model number.

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

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

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

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

PSF = The Proper Sizing Factor or the assumed savings due to proper sizing of cooling equipment

QIF = The Quality Installation factor or assumed savings due to a verified quality installation of cooling equipment

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 Sizing Factor or the assumed peak demand capacity saved due to proper sizing and proper installation.

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

$HSPF_q$ = The Heating Seasonal Performance Factor of the unit being installed. This data is obtained from the Application/data gathering 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.[3]

PDSH = Assumed peak demand savings per desuperheater.

$Capy_q$ = Output capacity of the qualifying heating unit in Btuh

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

HFS = Heating fan savings

CFS = Cooling fan savings

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

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

Table 3: Residential Electric HVAC

Component	**Type**	**Value**	**Sources**
CAPY	Variable		Application/ data gathering
$SEER_b$	Fixed	Baseline = 13	1
$SEER_q$	Variable		Application/ data gathering
$SEER_m$	Fixed	10	15
EER_b	Fixed	Baseline = 11.3	2
EER_q	Fixed	= (11.3/13) X $SEER_q$	2
EER_g	Variable		Application/ data gathering
EER_m	Fixed	8.69	19
GSER	Fixed	1.02	3

[3] Desuperheaters are generally utilized to heat or pre-heat domestic hot water for use in a residence..

(Note edits to correct the definition and use of desuperheaters for applications intended in the TRM)

Component	Type	Value	Sources
EFLH	Fixed	Erie Cooling = 287 Hours Erie Heating = 877 Hours State College Cooling = 310 Hours State College Heating = 911 Hours Philadelphia Cooling = 1,032 Hours (edited to reflect ENERGY STAR estimate for Phila) Philadelphia Heating = 2,328 Hours (edited to reflect ENERGY STAR estimate for Phila) Scranton Cooling = 316 Hours Scranton Heating = 901 Hours Pittsburgh Cooling = 374 Hours Pittsburgh Heating = 847 Hours	4
ESF	Fixed	2.9%	5
PSF	Fixed	5%	14
QIF	Fixed	9.2%	4
MF	Fixed	10%	20
DuctSF	Fixed	18%	14
CF	Fixed	70%	6
DSF	Fixed	2.9%	7
$HSPF_b$	Fixed	Baseline = 7.7	8
$HSPF_q$	Variable		Application/ data gathering
COP_g	Variable		Application/ data gathering
GSOP	Fixed	3.413	9
GSPK	Fixed	0.8416	10
EDSH	Fixed	1842 kWh	11
PDSH	Fixed	0.34 kW	12

Component	Type	Value	Sources
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
$Capy_q$	Variable		Application/ data gathering
$EFLH_{HFS}$	Fixed	Erie = 877 Hours State College = 911 Hours Philadelphia = 2,328 Hours (edited to reflect ENERGY STAR estimate for Phila) Scranton = 901 Hours Pittsburgh = 847 Hours	4
HFS	Fixed	0.5 kWh	17
CFS	Fixed	105 kWh	18

[Note: edited for clarity]

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. KEMA, Inc, "New Jersey's Clean Energy Program Residential HVAC Impact Evaluation and Protocol Review", (July 23, 2008). Adjusted for Pennsylvania's climate regions.
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

Residential New Construction

Algorithms

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

The energy savings due to the Residential New Construction will be a direct output of the ENERGY STAR home energy rating software. This software 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 algorithms then applied:

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

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

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

(Note: energy savings are missing and need to be included)

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.

(Note: the above section deleted because it is NJ specific and does not apply to Pa.)

Table 5: Applicable to building completions after EE&C Plan is approved by the Commission

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		REM 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.

(Note : edited for prospective look)

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 Algorithms and the Energy Star Appliances Algorithms, respectively. These algorithms are found in the Energy Star Products.

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 tables describes the characteristics of the three reference homes.

(Note: the above section deleted because it is NJ specific and does not apply to Pa.)

Table 7: ENERGY STAR Homes
REMRate User Defined Reference Homes -- Applicable to building completions after EE&C Plan approved by the Commission

Data Point	Single and Multiple Family Except as Noted.		
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=0.99		
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		
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		

Data Point	Single and Multiple Family Except as Noted.		
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 ("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) 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.

[Note: updated for prospective look and values need to be reviewed in working group]

Table 8: ENERGY STAR Homes
REMRate User Defined Reference Homes -- Applicable to building completions after EE&C Plan approved by the Commission

Data Point	Single and Multiple Family Except as Noted.		
Domestic WH Efficiency Electric Natural Gas	 EF = 0.97 - (0.00132 * gallons) (1) EF = 0.67 - (0.0019 * gallons) (1)		

Notes:

(1) Federal Government standard for calculating EF

[Note: updated for prospective look]

ENERGY STAR Products

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

ENERGY STAR Appliances

Algorithms

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

Number of Units X Savings per Unit

To determine resource savings, the per unit estimates in the algorithms 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).

ENERGY STAR Refrigerators

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

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

ENERGY STAR Clothes Washers – Tier 2 (MEF of 2.00 to 2.19)

Electricity Impact (kWh) = $ESav_{CW2}$

Demand Impact (kW) = $DSav_{CW2}$ x CF_{CW}

ENERGY STAR Clothes Washers – Tier 3 (MEF of 2.20 or greater)

Electricity Impact (kWh) = $ESav_{CW3}$

Demand Impact (kW) = $DSav_{CW3}$ x CF_{CW}

ENERGY STAR Dishwashers

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

Demand Impact (kW) = $DSav_{DW}$ x CF_{DW}

ENERGY STAR Dehumidifiers

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

Demand Impact (kW) = $DSav_{DH}$ x CF_{DH}

ENERGY STAR Room Air Conditioners

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

Demand Impact (kW) = $DSav_{RAC}$ x CF_{RAC}

ENERGY STAR Freezer

Demand Impact (kW) = $kW_{BASE} – kW_{EE}$

Energy Impact (kWh) = $\Delta kW \times HOURS$

Definition of Terms

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

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

$ESav_{CW2}$ = Electricity savings per purchased ENERGY STAR clothes washer – Tier 2.

$DSav_{CW2}$ = Summer demand savings per purchased ENERGY STAR clothes washer – Tier 2.

$ESav_{CW3}$ = Electricity savings per purchased ENERGY STAR clothes washer - Tier 3

$DSav_{CW3}$ = Summer demand savings per purchased ENERGY STAR clothes washer - Tier 3

$ESav_{DW}$ = Electricity savings per purchased ENERGY STAR dishwasher.

$DSav_{DW}$ = Summer demand savings per purchased ENERGY STAR dishwasher.

$ESav_{DH}$ = Electricity savings per purchased ENERGY STAR dehumidifier

$DSav_{DH}$ = Summer demand savings per purchased ENERGY STAR dehumidifier

$ESav_{RAC}$ = Electricity savings per purchased ENERGY STAR room AC.

$DSav_{RAC}$ = Summer demand savings per purchased ENERGY STAR room AC.

$CF_{REF,}$ $CF_{CW,}$ CF_{DW}, CF_{DH}, CF_{RAC} = 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%.

ΔkW = gross customer connected load kW savings for the measure

kW_{BASE} = Baseline connected kW

kW_{EE} = Energy efficient connected kW

HOURS = average hours of use per year

Table 9: ENERGY STAR Appliances

Component	**Type**	**Value**	**Sources**
$ESav_{REF}$	Fixed	see Table 10 below	12
$DSav_{REF}$	Fixed	0.0125 kW	1
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
$ESav_{CW2}$	Fixed	111 kWh	3
$DSav_{CW2}$	Fixed	0.0147 kW	3
$WSav_{CW2}$	Fixed	7,693 gallons	3
$ESav_{CW3}$	Fixed	128 kWh	3
$DSav_{CW3}$	Fixed	0.0170 kW	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
$ESav_{DW}$	Fixed	82 kWh	4
$DSav_{DW}$	Fixed	0.0225	4
DW Electricity Time Period Allocation Factors	Fixed	19.8%, 21.8%, 27.8%, 30.6%	2
$ESav_{DH}$	Fixed	see Table 10 below	12
$DSav_{DH}$	Fixed	.0098 kW	10
$ESav_{RAC}$	Fixed	see Table 10 below	12
$DSav_{RAC}$	Fixed	0.1018 kW	6
$CF_{REF,}$ $CF_{CW,}$ CF_{DW}, CF_{DH}, CF_{RAC}	Fixed	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
kW_{BASE}	Fixed	0.0926	11
kW_{EE}	Fixed	0.0813	11
HOURS	Fixed	5000	11
ΔkW	Fixed	0.0113	11

[Note: updated to correct Table references]

Sources:

1. Energy Star Refrigerator Savings Calculator (Calculator updated: 2/15/05; Constants updated 05/07). Demand savings derived using refrigerator load shape.
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 and water savings from RLW Market Update. Assumes 37% electric hot water market share and 63% gas hot water market share. 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. Efficiency Vermont. Technical Reference User Manual: Measure Savings Algorithms and Cost Assumptions (July 2008).
12. All values are taken from the Energy Star Savings Calculators at www.energystar.gov

Table 10: Energy Savings from Energy Star Calculators

Refrigerator	
Manual Defrost	72 kWh
Partial Automatic Defrost	72 kWh
Top mount freezer without door ice	80 kWh
Side mount freezer without door ice	95 kWh
Bottom mount freezer without door ice	87 kWh
Top mount freezer with door ice	94 kWh
Side mount freezer with door ice	100 kWh
Freezers	
Upright with manual defrost	55 kWh
Upright with automatic defrost	80 kWh
Chest Freezer	52 kWh
Compact Upright with manual defrost	62 kWh
Compact Upright with automatic defrost	83 kWh
Compact Chest Freezer	55 kWh

Dehumidifier	
1-25 pints/day	54 kWh
25-35 pints/day	117 kWh
35-45 pints/day	213 kWh
45-54 pints/day	297 kWh
54-75 pints/day	342 kWh
75-185 pints/day	374 kWh
Room Air Conditioner (Load hours in parentheses)	
Allentown	74 kWh (784 hours)
Erie	46 kWh (482 hours)
Harrisburg	88 kWh (929 hours)
Philadelphia (Note: hours reflect ENERGY STAR estimates)	98 kWh (1032 hours)
Pittsburgh	70 kWh (737 hours)
Scranton	59 kWh (621 hours)
Williamsport	62 kWh (659 hours)

(Note: the locations in this table do not correlate to PA Climate Regions referenced in Table 3 – These are ENERGY STAR locations. The EFLH values listed here do not correlate to the original values that appear in Table 3).

Residential ENERGY STAR Lighting

Algorithms

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)

ENERGY STAR CFL Bulbs

Electricity Impact (kWh) = ((CFL_{watts} X (CFL_{hours} X 365))/1000) X ISR_{CFL}

Peak Demand Impact (kW) = (CFL_{watts}/1000) X Light CF

ENERGY STAR Torchieres

Electricity Impact (kWh) = (($Torch_{watts}$ X ($Torch_{hours}$ X 365))/1000) X ISR_{Torch}

Peak Demand Impact (kW) = ($Torch_{watts}$/1000) X Light CF

ENERGY STAR Indoor Fixture

Electricity Impact (kWh) = ((IF_{watts} X (IF_{hours} X 365))/1000) X ISR_{IF}

Peak Demand Impact (kW) = (IF_{watts}/1000) X Light CF

ENERGY STAR Outdoor Fixture

Electricity Impact (kWh) = ((OF_{watts} X (OF_{hours} X 365))/1000) X ISR_{OF}

Peak Demand Impact (kW) = (OF_{watts}/1000) X Light CF

Ceiling Fan with ENERGY STAR Light Fixture

Energy Savings (kWh) =180 kWh

Demand Savings (kW) = 0.01968

(Note: corrected errors in formulas)

Definition of Terms

CFL_{watts} = Average delta watts per purchased ENERGY STAR CFL

CFL_{hours} = Average hours of use per day per CFL

ISR_{CFL} = In-service rate per CFL

$Torch_{watts}$ = Average delta watts per purchased ENERGY STAR torchiere

$Torch_{hours}$ = Average hours of use per day per torchiere

ISR_{Torch} = In-service rate per Torchier

IF_{watts} = Average delta watts per purchased ENERGY STAR Indoor Fixture

IF_{hours} = Average hours of use per day per Indoor Fixture

ISR_{IF} = In-service rate per Indoor Fixture

OF_{watts} = Average delta watts per purchased ENERGY STAR Outdoor Fixture

OF_{hours} = Average hours of use per day per Outdoor Fixture

ISR_{OF} = In-service rate per Outdoor Fixture

Light CF = Summer demand coincidence factor.

ΔkWh = gross customer annual kWh savings for the measure

ΔkW = gross customer connected load kW savings for the measure

Table 11: ENERGY STAR Lighting

Component	Type	Value	Sources
CFL_{watts}	Fixed	48.7	1
CFL_{hours}	Fixed	3.4	2
ISR_{CFL}	Fixed	84%	3
$Torch_{watts}$	Fixed	115.8	1
$Torch_{hours}$	Fixed	3.0	2
ISR_{Torch}	Fixed	83%	3
IF_{watts}	Fixed	48.7	1
IF_{hours}	Fixed	2.6	2
ISR_{IF}	Fixed	95%	3
OF_{watts}	Fixed	94.7	1
OF_{hours}	Fixed	4.5	2
ISR_{OF}	Fixed	87%	3
Light CF	Fixed	5%	4
ΔkWh	Fixed	180 kWh	5
ΔkW	Fixed	0.01968	5

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. Ibid., p. 104 (Table 9-7). This table adjusts for differences between logged sample and the much larger telephone survey sample and should, therefore, have less bias.
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. Efficiency Vermont. Technical Reference User Manual: Measure Savings Algorithms and Cost Assumptions (July 2008).

ENERGY STAR Windows

Algorithms

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 algorithms 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. [Note: clarify market tracking mechanisms – 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.[4] 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) = $ESav_{HP}$

Demand Impact (kW) = $DSav_{HP}$ X CF

Electric Heat/CAC

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

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

Electric Heat/No CAC

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

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

(Note: edited for consistency, values need to be defined – discuss at working group)

[4] Energy Information Administration. *Residential Energy Consumption Survey*. 2005. http://www.eia.doe.gov/emeu/recs/recs2005/hc2005_tables/detailed_tables2005.html

Definition of Terms

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

Table 12: ENERGY STAR Windows

Component	Type	Value	Sources
$ESav_{HP}$	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
$ESav_{RES/CAC}$	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
$ESav_{RES/NOCAC}$	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
$DSav_{HP}$	Fixed	0.000602 kW	1
$DSav_{CAC}$	Fixed	0.000602 kW	1
$DSav_{NOCAC}$	Fixed	0.00 kW	1
CF	Fixed	0.75	3

[Note: values need to be clarified as to their applicability to Pa and how they should be applied]

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.

[Note: there is no reference in the source – gas item]

ENERGY STAR Audit

Algorithms

No algorithm was developed to measure energy savings for this program. 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. Many measure installations that are likely to produce significant energy savings are covered in other programs. These savings are captured in the measured savings for those programs. The savings produced by this program that are not captured in other programs would be difficult to isolate and relatively expensive to measure.

Refrigerator/Freezer Retirement

Algorithms

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

Number of Units X Savings per Unit

To determine resource savings, the per unit estimates in the algorithms 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) = $ESav_{RetFridge}$ X NTG

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

(Note: edited for consistency)

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.

Table 13: 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

Algorithms

Conservation Services Group (CSG) implements Home Performance with Energy Star in several states. CSG has developed proprietary software known as HomeCheck 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.

CSG has provided a description of the methods and inputs utilized in the HomeCheck software to estimate energy savings. CSG has also provided a copy of an evaluation report prepared by Nexant which assessed the energy savings from participants in the Home Performance with Energy Star Program managed by the New York State Energy Research and Development Authority (NYSERDA)[5]. The report concluded that the savings estimated by HomeCheck and reported to NYSERDA were in general agreement with the savings estimates that resulted from the evaluation.

These algorithms incorporate the HomeCheck software by reference which will be utilized for estimating energy savings for Home Performance with Energy Star. The following is a summary of the HomeCheck software which was provided by CSG:
CSG's 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 algorithms, 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-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

[5] M&V Evaluation, Home Performance with Energy Star Program, Final Report, Prepared for the New York State Energy Research and Development Authority, Nexant, June 2005.

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
CSG is 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 CSG’s 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, CSG’s 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 Algorithms found in Energy Star Products.

Blue Line Innovations – PowerCost Monitor™

For homes with a PowerCost Monitor™ 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 Associates 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 Pennsylvania population of that fuel type.

Table 14: Reduction in Electricity Consumption per Mountain Study and the Correlating Pennsylvania Population

	Reduction in electricity consumption per Mountain Study	Pennsylvania Population
Non-electric water heating and non-electric space heating	5.1%	TBD
Homes with electric water heating and non-electric space heating	16.7%	TBD
Homes with electric space heating and electric water heating	1.2%	TBD

[Note: The table should be completed with Pa data.]

(Note: this entire section should be re-written and perhaps removed. The bulk of the text has little relevance the TRM in Pa.)

Commercial and Industrial Energy Efficient Construction

C&I Electric

Baselines and Code Changes

All baselines are designed to reflect current market practices which are generally the higher of code or available equipment, that are updated periodically to reflect upgrades in code, or information from evaluation results.

[Note: deleted as it is anticipated that the TRM will be updated as needed]

Lighting Equipment

For new construction and entire facility rehabilitation projects, savings are calculated using market-driven assumptions that presume a decision to upgrade the lighting system from an industry standard system. For existing commercial lighting, the most efficient T-12 lamp and magnetic ballast fixture serves as the baseline. For T-5 and T-8 fixtures replacing HID, 250 watt or greater T-12 fluorescent, or 250 watt or greater incandescent fixtures savings are calculated referencing pre-existing connected lighting load.

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.

<u>Algorithms</u>

Energy Savings (kWh) = ΔkW X EFLH X (1+IF)

Demand Savings (kW) = ΔkW X CF X (1+IF)

ΔkW is calculated from example worksheet below (For T-5 and T-8 fixtures replacing HID, 250 watt or greater T-12 fluorescent, or 250 watt or greater incandescent fixtures ΔkW is calculated using the formula below):

This worksheet is an example and does not represent that present stage of improvement to the worksheets presently being used to calculate program savings.

Code and Program Limits						
A	B	C	D	E	F	G
Building Type or Space Activity	Gross Lighted Area (sf)	Unit Lighting Power Allowance (Watts/sf)	Lighting Power Allowance (W) [B x C]	Program Limit (Watts/sf) [C x .08]	Lighting Power Limit (W) [B x E]	Composite Program Limit [sum F / sum B]
#1Dorm Bed/Study	42,752	1.40	59,853	0.98	41,897	
#2Dorm Bath	7,936	1.20	9,523	0.84	6,666	
#3Stairs	9,216	0.60	5,530	0.42	3,871	
	59,904		74,906		52,434	0.875299145
Installed Lighting Levels						
H	I	J	K	L	M	
Space ID	Luminaire Tag # if applicable	Luminaire Description	Number of Luminaires	Watts per Luminaire	Connected Watts [K x L]	
#1		32w T8	384	27	10,368	
#1&2		26W plt	128	61	7,808	
#1&#2		26w Quad	192	27	5,184	
#3		26w plt	24	27	648	
#3		13w plc	16	30	480	
	Other Wattage not applicable listed below				9,600	
			744		34,088	
N. Composite Connected Watts/Square Foot [sum M / sum B]				0.57		

(Note: not applicable to Pa TRM some of the mathematical computations are erroneous and need to be corrected)

Definition of Variables

ΔkW = Change in connected load from baseline to efficient lighting level. The baseline value is expressed in watts/square foot calculated as: (Watts/Sq.Ft. - Watts/Sq.Ft. (qualified equipment by same area))*Area Sq.Ft./1000 (see table above).

There is a lighting table used that is to be periodically updated that shows standardized values of fixture wattages for common lighting systems. These tables are based on evaluations of several manufacturers' wattage ratings for a given fixture type, and have been used in measuring energy and demand savings. The program administrator(s), in a cooperative effort will be responsible for the lighting tables.

CF = Coincidence Factor – the value represents the percentage of the total lighting connected load which is on during electric system's Peak Window. The Peak Window covers the time period from 12 noon to 8 p.m. These values are based on measured usage in the JCP&L service territory.

IF = Interactive Factor – 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.

EFLH = Equivalent Full Load Hours – represents the annual operating hours and is computed based on JCP&L metered data and divided into Large (facilities with over 50 kW of reduced load) and other size and building types.

Table 15: Lighting Verification Summary

Component	Type	Value	Source
ΔkW	Fixed	Change in connected load from baseline.	• Installed load is based on standard wattage tables and verified watts/sq.ft. • For commitments prior to 12/31/2007, baseline is 20% better than ASHRAE 90.1 1999 by space. • For commitments after 1/1/2008, baseline is *5* percent better than ASHRAE 90.1-*2004* by space.
CF	Fixed	Large Office* 65% Large Retail 81% Large Schools 41% Large All Other 63% All Hospitals 67% All Other Office 71% All Other Retail 84% Other Schools 40% All Other 69% Industrial 71% Continuous 90%	JCP&L metered data[6] Cost effectiveness study Estimate
IF	Fixed	5%	Impact of lighting watt reduction on air-conditioning load used in previous lighting savings.

[6] Results reflect metered use from 1995 – 1999.

Component	Type	Value	Source
EFLH	Fixed	See Table 15-a Below	JCP&L metered data[7]
Time Period Allocation Factors	Fixed	Summer/On-Peak 26% Summer/Off-Peak 16% Winter/On-Peak 36% Winter/Off-Peak 22%	

(Note: some of the sources in the table appear to be outdated and need to updated to current standards)

Table 15-a: Lighting Verification EFLH Values

		ELFH by Climate Zone				
		Erie	State College	Philadelphia	Scranton	Pittsburgh
Building Type	Large Office	3,675	3,523	2,927	3,913	3,455
	Large Retail	5,876	5,633	4,680	6,257	5,524
	Large Schools	2,542	2,437	2,025	2,707	2,390
	Large All Other	4,083	3,915	3,253	4,348	3,839
	All Hospitals	4,929	4,726	3,927	5,249	4,635
	All Other Office	3,180	3,049	2,533	3,387	2,990
	All Other Retail	4,986	4,781	3,972	5,310	4,688
	Other Schools	2,918	2,798	2,325	3,108	2,744
	All Other	3,180	3,049	2,533	3,387	2,990
	Industrial	5,350	5,130	4,262	5,697	5,030
	Continuous	7,773	7,453	6,192	8,278	7,309

* For facility with greater than 50kW reduction in load.
** For facilities that operate at or near 24 hours, 7 days per week.
(Note: the values in this table are incorrectly calculated using climate zone adjustments. The values should be based on building type and end use. The asterisks notes should be properly refereced and should be corrected. Corrected typographical error in the table title)
[Note: the applicability of this entire section should be discussed in the working group]

Traffic Signals (data from NJDOT)

[7] Results reflect metered use from 1995 – 1999, adjusted for Pennsylvania's climate zones.

Table 16: Traffic Signals

Type of Fixture	kW Reduced	EFLH Total	Summer on-peak	Summer off-peak	Winter on-peak	Winter off-peak
8" red	0.052	5257	636	1125	1246	2250
12" red	0.120	5257	636	1125	1246	2250
8" green	0.051	3066	371	656	727	1312
12"green	0.117	3066	371	656	727	1312

(Note this table should be omitted a suggeste replacement is below)

Table 16: Comparison of Incandescent and LED Traffic Signals						
	Wattage	% Burn	Burn Hours	kWhs	Demand Savings	Energy Savings
Round Traffic Signals						
Red 8"	69	55%	4818	332	-	
Red 8" LED	7	55%	4818	34	0.062	299
Yellow 8"	69	2%	175.2	12	-	
Yellow 8" LED	13	2%	175.2	2	0.056	10
Green 8"	69	43%	3766.8	260	-	
Green 8" LED	6	43%	3766.8	23	0.063	237
Red 12"	150	55%	4818	723	-	
Red 12" LED	11	55%	4818	53	0.139	670
Yellow 12"	150	2%	175.2	26	-	
Yellow 12" LED	18	2%	175.2	3	0.132	23
Green 12"	150	43%	3766.8	565	-	
Green 12" LED	12	43%	3766.8	45	0.138	520
Turn Arrows						
Yellow 8"	69	8%	700.8	48	-	
Yellow 8" LED	9	8%	700.8	6	0.060	42
Yellow 12"	150	8%	700.8	105	-	
Yellow 12 LED	10	8%	700.8	7	0.140	98
Green 8"	69	8%	700.8	48	-	
Green 8" LED	9	8%	700.8	6	0.060	42
Green 12"	150	8%	700.8	105	-	
Green 12" LED	13	8%	700.8	9	0.137	96
Pedestrian Signs						
Hand/Man 12"	138	100%	8760	1209	-	
Hand/Man LED	13	100%	8760	114	0.125	1,095

Note: kWh and Energy

Savings are annual; Demand Savings listed are per lamp

Coincidence factor for demand savings = 55% for red and 43% for green, and 2% for yellow. [Note: edited for completeness]

[Note: other outdoor lighting such as street lighting and security lighting should be address. For example, more efficient sources should be identified to replace less efficient sources]

Prescriptive Lighting

Prescriptive Lighting is a fixture replacement program for existing commercial customers that is targeted at 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.

Algorithms

Energy Savings (kWh) = ΔkW X EFLH

Demand Savings (kW) = ΔkW X CF

> ΔkW=Number of fixtures installed X (baseline wattage for fixture type(from above baseline))-number of replaced fixtures X (wattage from table)

Table 17: Prescriptive Lighting for Commercial Customers

Component	Type	Value	Source
ΔkW	Fixed	See Prescriptive Lighting Savings Table (below)	From lighting tables
CF	Fixed	Average of the small retail and office from lighting verification summary table, 77.5%.	JCP&L metered data[8]
EFLH	Fixed	Average of small retail and office from lighting verification summary. Erie = 4,083 State College = 3,915 Philadelphia = 3,253 Scranton = 4,348 Pittsburgh = 3,839	JCP&L metered data, adjusted for Pennsylvania's climate zones.
Time Period Allocation Factors	Fixed	Summer/On-Peak 21% Summer/Off-Peak 22% Winter/On-Peak 28% Winter/Off-Peak 29%	

(Note: the EFLH values contained in this table are incorrectly based on adjusted climate zones and should be consistent across the state.)

Table 18: Prescriptive Lighting Savings Table

The table will be updated periodically to include new fixtures and technologies available after table publication. Baselines will be established based on the guidelines noted above.

[8] Results reflect metered use from 1995 – 1999.

Fixture Type	Type	New Watts (w/fixture)	Baseline (w/fixture)	Savings (w/fixture)
COMPACT FLUORESCENT (2) 11W CF/HW	CFL2	26	104	78
COMPACT FLUORESCENT (2) 13W CF/HW	CFL2	30	120	90
COMPACT FLUORESCENT (2) 18W CF/HW	CFL2	36	144	108
COMPACT FLUORESCENT (2) 18W QD/ELEC	CFL2	38	152	114
COMPACT FLUORESCENT (3) 18W	CFL2	54	225	171
COMPACT FLUORESCENT (2) 26W CF/HW	CFL2	53	212	159
COMPACT FLUORESCENT (2) 26W QD/ELEC	CFL2	54	216	162
COMPACT FLUORESCENT (2) 5W CF/HW	CFL2	14	56	42
COMPACT FLUORESCENT (2) 7W CF/HW	CFL2	18	72	54
COMPACT FLUORESCENT (2) 9W CF/HW	CFL2	22	88	66
COMPACT FLUORESCENT 11W CF/HW	CFL1	13	52	39
COMPACT FLUORESCENT 13W CF/HW	CFL1	15	60	45
COMPACT FLUORESCENT 18W CF/HW	CFL1	19	76	57
COMPACT FLUORESCENT 18W QD/ELEC	CFL1	22	88	66
COMPACT FLUORESCENT 20W CF/HW	CFL1	22	88	66
COMPACT FLUORESCENT 22W QD/ELEC	CFL1	26	104	78
COMPACT FLUORESCENT 26W CF/HW	CFL1	28	112	84
COMPACT FLUORESCENT 26W QD/ELEC	CFL1	27	108	81
COMPACT FLUORESCENT 28W CF/HW	CFL1	30	120	90
COMPACT FLUORESCENT 32W CF/HW	CFL1	34	136	102
COMPACT FLUORESCENT 36W CF/HW	CFL1	41	164	123
COMPACT FLUORESCENT 40W CF/HW	CFL1	45	180	135
COMPACT FLUORESCENT (2) 40W CF/HW	CFL2	71	180	109
COMPACT FLUORESCENT 5W CF/HW	CFL1	7	28	21
COMPACT FLUORESCENT 7W CF/HW	CFL1	10	40	30
COMPACT FLUORESCENT 9W CF/HW	CFL1	11	44	33
Low Bay T-5 2L FP54/T5/Elec/Ho	LOBA	117	250	133
Low Bay T-5 3L FP54/T5/Elec/Ho	LOBA	179	290	111
Low Bay T-5 4L FP54/T5/Elec/Ho	LOBA	234	409	175
Low Bay T-5 6L FP54/T5/Elec/Ho	LOBA	351	992	641
Low Bay T-8 2L4	LOBA	55	73	18
Low Bay T-8 2L8	LOBA	118	158	40
Low Bay T-8 3L4	LOBA	79	105	26
Low Bay T-8 4L4	LOBA	110	146	36
Low Bay T-8 4L8	LOBA	233	316	83
Low Bay T-8 6L4	LOBA	224	454	230
High Bay T-5 3L FP54/T5/Elec/Ho	HIBA	179	290	111
Fixture Type	**Type**	**New Watts (w/fixture)**	**Baseline (w/fixture)**	**Savings (w/fixture)**
High Bay T-5 4L FP54/T5/Elec/Ho	HIBA	234	409	175
High Bay T-5 6L FP54/T5/Elec/Ho	HIBA	351	992	641
High Bay T-8 8L4 FP54/T5/Elec/Ho	HIBA	468	1080	612
High Bay T-8 3L4	HIBA	79	105	26
High Bay T-8 4L4	HIBA	110	146	36
High Bay T-8 4L8	HIBA	233	316	83

High Bay T-8 6L4	HIBA	224	454	230
High Efficiency Fluorescent 1L2 (1) FO17T8/Elec	HEF	18	32	14
High Efficiency Fluorescent 1L2 (2) FO17T8/Elec	HEF	34	56	22
High Efficiency Fluorescent 1L2 (3) FO17T8/Elec	HEF	50	78	28
High Efficiency Fluorescent 1L2 (4) FO17T8/Elec	HEF	62	112	50
High Efficiency Fluorescent 1L3 (1) FO25T8/Elec	HEF	30	46	16
High Efficiency Fluorescent 1L3 (2) FO25T8/Elec	HEF	48	80	32
High Efficiency Fluorescent 1L3 (3) FO25T8/Elec	HEF	68	126	58
High Efficiency Fluorescent 1L3 (4) FO25T8/Elec	HEF	90	160	70
High Efficiency Fluorescent T-5 3L FP54/T5/Elec/Ho	HEF	179	290	111
High Efficiency Fluorescent T-5 4L FP54/T5/Elec/Ho	HEF	234	409	175
High Efficiency Fluorescent T-5 6L FP54/T5/Elec/Ho	HEF	351	992	641
High Efficiency Fluorescent T-8 1L4	HEF	28	42	14
High Efficiency Fluorescent T-8 1L8	HEF	67	78	11
High Efficiency Fluorescent T-8 2L2	HEF	62	94	32
High Efficiency Fluorescent T-8 2L4	HEF	55	73	18
High Efficiency Fluorescent T-8 2L8	HEF	118	158	40
High Efficiency Fluorescent T-8 3L4	HEF	79	105	26
High Efficiency Fluorescent T-8 4L4	HEF	110	146	36
High Efficiency Fluorescent T-8 4L8	HEF	233	316	83
LED Exit Sign	EXIT	20	18	2
PULSE START METAL HALIDE 1000 W	PSMH	1075	1080	5
PULSE START METAL HALIDE 150 W	PSMH	185	200	15
PULSE START METAL HALIDE 175 W	PSMH	208	285	77
PULSE START METAL HALIDE 200 W	PSMH	235	285	50
PULSE START METAL HALIDE 250 W	PSMH	288	454	166
PULSE START METAL HALIDE 300 W	PSMH	342	454	112
PULSE START METAL HALIDE 320 W	PSMH	368	454	86
PULSE START METAL HALIDE 350 W	PSMH	400	454	54
PULSE START METAL HALIDE 400 W	PSMH	450	454	4
PULSE START METAL HALIDE 750 W	PSMH	815	1075	260
Low Bay LED 85 W for 250 Metal Halide	LBLD	85	248	163
Low Bay LED 85 W for 2LHO T-8	LBLF	85	118	33

Lighting Controls

Lighting controls include occupancy sensors, daylight dimmer systems, occupancy controlled hi-low controls for fluorescent, and HID controls. 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.

Algorithms

Energy Savings (kWh) = kW_c X SVG X EFLH X (1+IF)

Demand Savings (kW) = kW_c X SVG X CF

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.

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

EFLH = Equivalent full load hours.

Table 19: Lighting Controls

Component	Type	Value	Source
kW_c	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	By building type and size see lighting verification summary table	Assumes same as JCP&L metered data
EFLH	Fixed	By building type and size see lighting verification summary table	JCP&L metered data, adjusted for Pennsylvania's climate zones.
Time Period Allocation Factors	Fixed	Summer/On-Peak 26% Summer/Off-Peak 16% Winter/On-Peak 36% Winter/Off-Peak 22%	

(Note: the value of IF is not defined in this table)

Sources:

- Northeast Utilities, *Determination of Energy Savings Document*, 1992
- Levine, M., Geller, H., Koomey, J., Nadel S., Price, L., "Electricity Energy Use Efficiency: Experience with Technologies, Markets and Policies" ACEEE, 1992

- Lighting control savings fractions consistent with current programs offered by National Grid, Northeast Utilities, Long Island Power Authority, NYSERDA, and Energy Efficient Vermont.

20% Lighting Power Density (LPD) Reduction

Lighting power density reduction is new construction efficient lighting with a reduced wattage.

Algorithms

Energy Savings (kWh) = kW_{save} X HOURS X WHF_e

Demand Savings (kW) = kW_{save} X WHF_d

$kW_{save} = (WSF_{base} - WSF_{effic})/1000$

(Note: algorithm edited for consistency)

Definition of Variables

kW_{save} = lighting connected load kW saved

HOURS = annual lighting hours of use per year

WHF_e = Waste heat factor for energy to account for cooling savings from efficient lighting.

WHF_d = Waste heat factor for demand to account for cooling savings from efficient lighting.

WSF_{base} = the baseline lighting watts per square foot or linear foot.

WSF_{effic} = the actual installed lighting watts per square foot or linear foot.

Table 20: Lighting Power Density

Component	Type	Value	Source
kW_{save}	Variable		Application
WHF_e	Fixed	Cooled space = 1.12 Refrigerated space: Freezer spaces = 1.15; Medium-temperature refrigerated spaces = 1.29; High-temperature refrigerated spaces = 1.18 Uncooled space =1	1
WHF_d	Fixed	Cooled space = 1.34 Refrigerated space: Freezer spaces = 1.5; Medium-temperature refrigerated spaces = 1.29; High-temperature refrigerated spaces = 1.18 Uncooled space = 1	1
HOURS	Variable		Application
WSF_{base}	Variable		ASHRAE 90.1-2004
WSF_{effic}	Variable		ASHRAE 90.1-2004

Source:

1. Efficiency Vermont. Technical Reference User Manual: Measure Savings Algorithms and Cost Assumptions (July 2008).

Fluorescent Lighting Fixture

A fluorescent lighting fixture is a high performance or 'super' T8 lamp ballast system.

Algorithms

Energy Savings (kWh) = $((Watts_{BASE} - Watts_{EE})/1000) \times HOURS \times WHF_e$

Demand Savings (kW) = $((Watts_{BASE} - Watts_{EE})/1000) \times WHF_d$

(Note: algorithm edited for consistency)

Definition of Variables

$Watts_{BASE}$ = Baseline connected kW.

$Watts_{EE}$ = Energy efficient connected kW.

WHF_d = Waste heat factor for demand to account for cooling savings from efficient lighting.

HOURS = annual lighting hours of use per year.

WHF_e = Waste heat factor for energy to account for cooling savings from efficient lighting

Table 21: Fluorescent Lighting Fixture

Component	Type	Value	Source
WHF_e	Fixed	Prescriptive measures, default = 1.17	1
WHF_d	Fixed	Prescriptive measures, default = 1.06	1
HOURS	Variable		Application
$Watts_{EE}$	Fixed	See $Watt_{EE}$ and $Watt_{BASE}$ Table (below)	1
$Watts_{BASE}$	Fixed	See $Watt_{EE}$ and $Watt_{BASE}$ Table (below)	1

Source:

1. Efficiency Vermont. Technical Reference User Manual: Measure Savings Algorithms and Cost Assumptions (July 2008).

Table 22: $Watts_{EE}$ and $Watts_{BASE}$

Equipment Description	WattsEE	WattsBASE
Relamp/Reballast to Super T8		
1 Lamp	25	40
2 Lamp	49	68
3 Lamp	72	110
4 Lamp	94	139
Super T8 Troffer/Wrap; Super T8 Industrial/Strip; Super T8 Indirect		
1 Lamp	25	32
2 Lamp	49	59
3 Lamp	72	88
4 Lamp	94	114

Motors

Algorithms

From application form calculate ΔkW where:

$$\Delta kW = 0.746 * [(hp_{base} \text{ X } RLF_{base})/\eta_{base} - (hp_{ee} \text{ X } RLF_{ee})/\eta_{ee}]$$

Energy Savings (kWh) = $(\Delta kW) X EFLH$

Demand Savings (kW) = $(\Delta kW) X CF$
[Note: edited for consistency]

Definition of Variables

hp_{base} = Rated horsepower of the baseline motor

hp_{ee} = Rate horsepower of the energy-efficient motor

RLF_{base} = Rated load factor of the baseline motor

RLF_{ee} = Rated load factor of the energy-efficient motor

η_{base} = Efficiency of the baseline motor

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

Table 23: Motors

Component	Type	Value	Source
Motor kW	Variable	Based on horsepower and efficiency	Application
EFLH	Fixed	Erie Commercial = 2,083 State College Commercial = 2,197 Philadelphia Commercial = 2,865 Scranton Commercial = 2,203 Pittsburgh Commercial = 2,298 Erie Industrial = 3,828 State College Industrial = 4,039 Philadelphia Industrial = 5,266 Scranton Industrial = 4,049 Pittsburgh Industrial = 4,223	JCP&L metered data[9] and PSEG audit data for industrial, adjusted for Pennsylvania's climate zones.
hp_{base}	Fixed	Comparable EPACT Motor Table Below	EPACT Directory
hp_{ee}	Variable	Nameplate	Application

[9] Results reflect metered use from 1995 – 1999, adjusted for Pennsylvania's climate zones.

RLF_{base}	Fixed	0.70-0.80	Industry Data
RLF_{ee}	Variable	Nameplate	Application
Efficiency – η_{base}	Fixed	Comparable EPACT Motor Table Below	From EPACT directory.
Efficiency - η_{ee}	Variable	Nameplate	Application
CF	Fixed	35%	JCP&L metered data
Time Period Allocation Factors	Fixed	Summer/On-Peak 25% Summer/Off-Peak 16% Winter/On-Peak 36% Winter/Off-Peak 23%	

(Note: Motor EFLH is incorrectly based on PA Climate zones)

Table 24: Baseline Motor Efficiencies - nbase (EPAct)

	Open Drip Proof (ODP) # of Poles			**Totally Enclosed Fan-Cooled (TEFC)**		
	6	*4*	*2*	*6*	*4*	*2*
	Speed (RPM)			**Speed (RPM)**		
Size HP	*1200*	*1800*	*3600*	*1200*	*1800*	*3600*
1	80.0%	82.5%	75.5%	80.0%	82.5%	75.5%
1.5	84.0%	84.0%	82.5%	85.5%	84.0%	82.5%
2	85.5%	84.0%	84.0%	86.5%	84.0%	84.0%
3	86.5%	86.5%	84.0%	87.5%	87.5%	85.5%
5	87.5%	87.5%	85.5%	87.5%	87.5%	87.5%
7.5	88.5%	88.5%	87.5%	89.5%	89.5%	88.5%
10	90.2%	89.5%	88.5%	89.5%	89.5%	89.5%
15	90.2%	91.0%	89.5%	90.2%	91.0%	90.2%
20	91.0%	91.0%	90.2%	90.2%	91.0%	90.2%
25	91.7%	91.7%	91.0%	91.7%	92.4%	91.0%
30	92.4%	92.4%	91.0%	91.7%	92.4%	91.0%
40	93.0%	93.0%	91.7%	93.0%	93.0%	91.7%
50	93.0%	93.0%	92.4%	93.0%	93.0%	92.4%
60	93.6%	93.6%	93.0%	93.6%	93.6%	93.0%
75	93.6%	94.1%	93.0%	93.6%	94.1%	93.0%
100	94.1%	94.1%	93.0%	94.1%	94.5%	93.6%
125	94.1%	94.5%	93.6%	94.1%	94.5%	94.5%
150	94.5%	95.0%	93.6%	95.0%	95.0%	94.5%
200	94.5%	95.0%	94.5%	95.0%	95.0%	95.0%

HVAC Systems

The measurement of energy and demand savings for C/I Efficient HVAC 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, ground water or ground source heat pumps)

Algorithms

Air Conditioning Algorithms:

Energy Savings (kWh) = (Btu/H1000) X ($1/EER_b$-$1/EER_q$) X EFLH

Demand Savings (kW) = (Btu/H1000) X ($1/EER_b$-$1/EER_q$) X CF

Heat Pump Algorithms

Energy Savings-Cooling (kWh) = (Btu/H_c1000) X ($1/EER_b$-$1/EER_q$) X $EFLH_c$

Demand Savings (kW) = (Btu/ H_c1000) X ($1/EER_b$-$1/EER_q$) X CF

Energy Savings-Heating (kWh) = Btu/H_h1000 X ($1/EER_b$-$1/EER_q$) X $EFLH_h$

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

Demand savings for heat pumps was missed in the first round of comments

Definition of Variables

BtuH = Cooling capacity in Btu/Hour.

EER_b = Efficiency rating of the baseline unit. For units < 65,000, SEER and HSPF should be used for cooling and heating savings, respectively.

EER_q = Efficiency rating of the High Efficiency unit. For units < 65,000, SEER and HSPF should be used for cooling and heating savings, respectively.

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

EFLH = Equivalent Full Load Hours – A measure of energy use by season during the on-peak and off peak periods. Value is determined by existing measured data of kWh during the period divided by kW at design conditions.

Table 25: HVAC and Heat Pumps

Component	Type	Value	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	Application
EER_b	Variable	See Table below	Collaborative

Component	Type	Value	Source
			agreement and C/I baseline study
EER_q	Variable	ARI or AHAM Values	Application
CF	Fixed	67%	Engineering estimate
EFLH	Fixed	Erie HVAC = 1,006 State College HVAC = 1,058 Philadelphia HVAC = 1,262 Scranton HVAC = 1,058 Pittsburgh HVAC = 1,081 Erie HP cooling = 79 State College HP cooling = 85 Philadelphia HP cooling = 1,032 Scranton HP cooling = 87 Pittsburgh HP cooling = 103 Erie HP heating = 965 State College HP heating = 1,002 Philadelphia HP heating = 2,328 Scranton HP heating = 991 Pittsburgh HP heating = 932	JCP&L metered data[10]
Cooling Time Period Allocation Factors	Fixed	Summer/On-Peak 45% Summer/Off-Peak 39% Winter/On-Peak 7% Winter/Off-Peak 9%	
Heating Time Period Allocation Factors	Fixed	Summer/On-Peak 0% Summer/Off-Peak 0% Winter/On-Peak 41% Winter/Off-Peak 58%	

(Note: EFLH values do not match previously stated values and are adjusted here to reflect ENERGY STAR estimates for Phila)

Table 26: HVAC Baseline Table

Equipment Type	Baseline = ASHRAE Std. 90.1 - 2007
Unitary HVAC/Split Systems	
.<=5.4 tons:	13 SEER
· >5.4 to 11.25 tons	10.1 EER
· >11.25 to 20 tons	9.5 EER
.> 20 to 63.33 tons	9.3 EER
.> 63.33 tons	9 EER

[10] Results reflect metered use from 1995 – 1999. Adjusted for Pennsylvania's climate zones.

Equipment Type	Baseline = ASHRAE Std. 90.1 - 2007
Air-Air Heat Pump Systems (cooling) · <=5.4 tons: · >5.4 to 11.25 tons · >11.25 to 20 tons .>= 21 to 30 tons	13 SEER 9.9 EER 9.1 EER 8.8 EER
Water Source Heat Pumps (cooling) < 1.42 tons ≥ 1.42 tons	11.2 EER 12.0 EER
GWSHPs Open and Closed Loop All Capacities	16.2 EER
Package Terminal Systems (Replacements) PTAC (cooling) PTHP (cooling) PTHP (heating)	10.9 - (0.213 x Cap / 1000) EER 10.8 - (0.213 x Cap / 1000) EER 2.9 - (0.213 x Cap / 1000) EER

Electric Chillers

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

Algorithms

Energy Savings (kWh) = Tons X (kW/ton_b – kW/ton_q) X EFLH

Demand Savings (kW) = Tons X (kW/ton_b – kW/ton_q) X CF

Definition of Variables

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

kW/ton_b = Baseline, found in the Chiller verification summary table.

kW/ton_q = This is the manufacturer data and equipment ratings in accordance with ARI Standard 550/590 latest edition.

CF = Coincidence Factor – Represents the percentage of the total load which is on during electric system's Peak Window derived from JCP&L metered data.

EFLH = Equivalent Full Load Hours – 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.

Table 27: Electric Chillers

Component	Type	Value	Source
Tons	Variable	From Rebate Application	
kW/ton$_b$	Fixed	**Water Cooled Chillers (=<150 tons)** *Baseline:………….. 0.703 kW/Ton* **Water Cooled Chillers (151 to <300 tons)** *Baseline:………….. 0.634 kW/Ton* **Water Cooled Chillers (>301 tons)** *Baseline:………….. 0.577 kW/Ton* **Air Cooled Chillers (<150 tons)** *Baseline:………….. 1.256 kW/Ton*	ASHRAE 90.1 2004
kW/ton$_q$	Variable	ARI Standards 550/590-Latest edition	Application
CF	Fixed	67%	Engineering estimate
EFLH	Fixed	Erie = 778 State College = 840 Philadelphia = 1,741 Scranton = 859 Pittsburgh = 1,016 [Note: EFLH need to be discussed in working group]	JCP&L metered data, adjusted for Pennsylvania's climate zones[11]
Time Period Allocation Factors	Fixed	Summer/On-Peak 45% Summer/Off-Peak 39% Winter/On-Peak 7% Winter/Off-Peak 9%	

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

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.

[11] Results reflect metered use from 1995 – 1999, adjusted for Pennsylvania's climate zones.

Algorithms

Energy Savings (kWh) = 0.746 X HP X RLF/η_{motor} X ESF X FLH_{base}

Demand Savings (kW) = 0.746 X HP X RLF/η_{motor} X DSF

(Note: algorithm edited for consistency)

Definitions of Variables

HP = nameplate motor horsepower

RLF = Rated Load Factor. Ratio of the peak running load to the nameplate rating of the motor

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

ESF = Energy Savings Factor. The energy savings factor is equal to 1 – FLH_{asd}/FLH_{base}. This factor can also be computed according to fan and pump laws assuming an average flow reduction and a cubic relationship between flow rate reduction and power draw savings

FLH_{asd} = Full Load Hours of the fan/pump with the VSD

FLH_{base} = Full Load Hours of the fan/pump with baseline drive

DSF = Demand Savings Factor, calculated by determining the ratio of the power requirement for baseline and VFD control at peak conditions

DSF = 1 – $(kW_{asd}/kW_{base})_{peak}$

kW_{asd} = peak demand of the motor under the variable control conditions

kW_{base} = peak demand of the motor under the base operating conditions

Table 28: Variable Frequency Drives

Component	**Type**	**Value**	**Source**
Motor HP	Variable	Nameplate	Application
kWh/motor HP	Fixed	1,653 for VAV air handler systems. 1,360 for chilled water pumps.	JCP&L metered data for VFD's[12] and chillers[13].
RLF	Variable	Dependent on HP and peak running load	

[12] Results reflect metered use from 1995 – 1998.
[13] Results reflect metered use from 1995 – 1999.

η_{motor}	Variable	Nameplate or manufacturer specs	Application
ESF	Variable	Dependent on full load of base and VFD	
FLH_{asd}	Variable	Nameplate	Application
FLH_{base}	Fixed		Manufacturer Data
DSF	Variable	Dependent on base and variable peak demand	
kW_{asd}	Variable	Nameplate	Application
kW_{base}	Fixed		Manufacturer Data
Time Period Allocation Factors	Fixed	Summer/On-Peak 22% Summer/Off-Peak 10% Winter/On-Peak 47% Winter/Off-Peak 21%	

Air Compressors with Variable Frequency Drives

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

Algorithms

Energy Savings (kWh) = 774 X HP

Demand Savings (kW) = 0.129 X HP

Coincident Peak Demand Savings (kW) = 0.106 X HP

(Note: algorithms edited for consistency)

Definitions of Variables

HP = nameplate motor horsepower

Table 29: Air Compressors with VFDs

Component	**Type**	**Value**	**Source**
Motor HP	Variable	Nameplate	Application
kWh/motor HP	Fixed	774	Aspen Systems Study[14]
kW/motor HP	Fixed	0.129	Aspen Systems Study
Coincident Peak kW/motor HP	Fixed	0.106	Aspen Systems Study

[14] Aspen Systems Corporation, Prescriptive Variable Speed Drive Incentive Development Support for Industrial Air Compressors, Executive Summary, June 20, 2005

Time Period Allocation Factors	Fixed	Summer/On-Peak 28% Summer/Off-Peak 39% Winter/On-Peak 14% Winter/Off-Peak 19%	

Demand Response Programs

Commercial and Industrial Application, Residential Applications

Commercial and Industrial Applications

Algorithms

The general form of the equation for the commercial and industrial demand response measure savings algorithms is:

Load Response Demand Savings for an Individual Application
Total Demand Savings is The Sum of Individual Application Savings

Direct Load Control (Commercial Air Conditioners and Heat Pumps)

Load response demand savings (kW) = (Btu/ H1000) X (1/EER_i) X CF

Energy Savings attributable to load response (kWh) = (Btu/H1000) X (1/EER_i) X CF X Hours

<u>Definition of Variables</u>

BtuH = Cooling capacity in Btu/Hour for the air conditioner or heat pump.

EERi = Efficiency rating of the installed air conditioner or heat pump.

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

Hours = Number of hours through out the year that the measure is called

Component	Type	Value	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	Application
EER_i	Variable	ARI or AHAM or Manufacturer Data	Application
CF	Fixed	67%	Engineering estimate

Note: the energy and demand savings calculations presented above are derived directly from the commercial HVAC algorithms for air conditioners and heat pumps presented earlier in the TRM

Custom Applications

Each commercial and industrial application will be treated independently as a custom project. An application must be submitted, containing adequate documentation fully describing the energy efficiency measures installed or proposed and an explanation of how the installed facilities qualify for Alternative Energy Credits. Each project application will be required to include[15]:

1. Project Name
2. Project Utility Company
3. Project Location
4. Type of facilities in which the measures, systems, processes, or strategies will be implemented
5. Customer class and end-use served
6. Estimated demand reduction value (kW) per measure including supporting documentation (i.e. engineering estimates or documentation of verified savings from comparable projects)
7. Estimated energy reduction value (kWh) throughout the year
8. The date by which commercial operation is expected

[Note: section needs to be updated to account for renewables and missing technologies i.e. thermal storage]

[15] Criteria taken from ISO New England's *Measurement and Verification of Demand Reduction Value from Demand Resources*. October 1, 2007.

Residential Applications

Algorithms

The general form of the equation for the residential demand response measure savings algorithms is:

Number of Units X Savings per Unit

To determine resource savings, the per unit estimates in the algorithms will be multiplied by the number of demand response units. The number of units will be determined by the program. Per unit savings estimates will be estimated by each specific measure.

Direct Load Control (Air Conditioning Cycling and Pool Pump Load Control)

Electricity Impact (kWh) = DSav X Units X Hours

Demand Impact (kW) = DSav X Units

Definition of Terms

DSav = Demand Saved in One Hour in kW
Units = Number of Units in the Program
Hours = Number or hours throughout the year the measure operates

(Note: Edits in this section are made to correct errors in algorithm and for consistency)

Component	**Type**	**Value**	**Sources**
ESav	Fixed	Air conditioning Cycling = 0.72 kW Pool Pump Load Control = 0.75 kW	1
Units	Variable		Application
Hours	Variable		Application

Sources:

1. Public Service Electric and Gas Company. *Petition for Approval of Demand Response Programs*. August 5, 2008.

Measure Lives Used in Cost-Effectiveness Screening February 2008[16]

PROGRAM/Measure	Measure Life
Residential Programs	
Energy Star Appliances	
Energy Star Refrigerator post-2001	13
Energy Star Refrigerator 2001	13
Energy Star Dishwasher	11
Energy Star Clothes Washer	11
Energy Star Dehumidifier	12
Energy Star Room Air Conditioners	10
Energy Star Lighting	
Compact Fluorescent Light Bulb	6.4
Recessed Can Fluorescent Fixture	20
Torchieres (Residential)	10
Fixtures Other	20
Energy Star Windows	
WINDOW -heat pump	20
WINDOW -gas heat with central air conditioning	20
WINDOW – electric heat without central air conditioning	20
WINDOW – electric heat with central air conditioning	20
Refrigerator/Freezer Retirement	
Refrigerator/Freezer retirement	8
Residential New Construction	
Single Family - gas heat with central air conditioner	20
Single Family - oil heat with central air conditioner	20
Single Family - all electric	20
Multiple Single Family (Townhouse) – gas heat with central air conditioner	20
Multiple Single Family (Townhouse) – oil heat with central air conditioner	20
Multiple Single Family (Townhouse) - all electric	20
Multi-Family – gas heat with central air conditioner	20
Multi-Family - oil heat with central air conditioner	20
Multi-Family - all electric	20
Energy Star Clothes Washer	11
Recessed Can Fluorescent Fixture	20
Fixtures Other	20

[16] Energy Star Appliances, Energy Star Lighting, and several Residential Electric HVAC measures lives updated February 2008. U.S. Environmental Protection Agency and U.S. Department of Energy, Energy Star. <http://www.energystar.gov/>.

PROGRAM/Measure	Measure Life
Efficient Ventilation Fans with Timer	10
Residential Electric HVAC	
Central Air Conditioner SEER 13	14
Central Air Conditioner SEER 14	14
Air Source Heat Pump SEER 13	12
Air Source Heat Pump SEER 14	12
Central Air Conditioner proper sizing/install	14
Central Air Conditioner Quality Installation Verification	14
Central Air Conditioner Maintenance	7
Central Air Conditioner duct sealing	14
Air Source Heat Pump proper sizing/install	12
Energy Star Thermostat (Central Air Conditioner)	15
Energy Star Thermostat (Heat Pump)	15
Ground Source Heat Pump	30
Central Air Conditioner SEER 15	14
Air Source Heat Pump SEER 15	12
Home Performance with ENERGY STAR	
Blue Line Innovations – PowerCost MonitorTM	5
Non-Residential Programs	
C&I Construction	
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	20
Commercial Chillers — Replacement	20
Commercial Small Motors (1-10 horsepower) — New or Replacement	20
Commercial Medium Motors (11-75 horsepower) — New or Replacement	20
Commercial Large Motors (76-200 horsepower) — New or Replacement	20
Commercial Variable Speed Drive — New	15
Commercial Variable Speed Drive — 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	20

PROGRAM/Measure	Measure Life
Industrial Chillers — Replacement	20
Industrial Small Motors (1-10 horsepower) — New or Replacement	20
Industrial Medium Motors (11-75 horsepower) — New or Replacement	20
Industrial Large Motors (76-200 horsepower) — New or Replacement	20
Industrial Variable Speed Drive — New	15
Industrial Variable Speed Drive — Retrofit	15
Industrial Custom — Non-Process	18
Industrial Custom — Process	10
Building O&M	
O&M savings	3

[Note: table heading corrected to match footnote]