EXHIBIT 1

Technical Reference Manual (TRM)
for
Ohio Senate Bill 221
Energy Efficiency and Conservation Program
and
09-512-GE-UNC

Submitted by Ohio Electric Utilities

The Cleveland Electric Illuminating Company
Columbus Southern Power Company
The Dayton Power and Light Company
Duke Energy Ohio
Ohio Edison Company
Ohio Power Company
The Toledo Edison Company

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FINAL

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Ohio Technical Reference Manual

Introduction

This Technical Reference Manual (TRM) was developed to comply with the Entry ordering that the electric and gas utilities shall observe the requirements set forth in Docket No. 09-512-GE-UNC. In the Docket the utilities are asked to collaborate and submit to the Commission, no later than October 15, 2009, values and proposed protocols for the measures identified on the energy efficiency measure list, submitted by the Electric Distribution Utilities (EDUs) to the commission on June 24, 2009. The savings algorithms and values developed here use measured and derived data either directly, or as input values into industry-accepted algorithms. The data and input values for the algorithms come from several sources including ENERGY STAR® standards, data gathered by EDUs or information available through other publically available sources, including the Pennsylvania Technical Reference Manual[1]. The standard input values are based on the best available measured or industry data, or were derived from a review of literature from various industry organizations, equipment manufacturers, previous EDU measurement and verification studies, or equipment suppliers. Input values reflect current federal and state codes. These data represent a reasonable starting point for assigning deemed savings, or deemed algorithms for estimating program savings.

The following third party consulting firms were consulted for this manual:

- Building Metrics, Inc.
- Franklin Energy Services, LLC
- Summit Blue Consulting, LLC
- The Cadmus Group, Inc.

Purpose

This TRM was developed for the purpose of estimating annual energy savings for a selection of energy efficient technologies and measures identified by the EDUs. This TRM provides guidance to the Contractor to be hired by the Commission to develop the Ohio TRM. The revised Ohio TRM will serve a dual purpose of being used to help determine compliance with the energy efficiency and conservation requirements of Senate Bill 221 (SB 221) and the requirements of Case 09-512-GE-UNC.

[1] "Annex: Technical Reference Manual (TRM) for Pennsylvania Act 129 Energy Efficiency and Conservation Program and Act 213 Alternative Energy Portfolio Standards." Pennsylvania Public Utility Commission, May, 2009. From Implementation of the Alternative Energy Portfolio Standards Act of 2004: Standards for the Participation of Demand Side Management Resources – Technical Reference Manual Update, Docket No. M-00051865.

The TRM should continue to be updated no less than annually to reflect the addition of technologies and measures needed to remain relevant and useful. To the extent that the manual provides deemed values for specific measure, the utilities believe that these should be considered minimum values for that measure, when M&V results are not available. Should a utility be able to outperform the deemed minimum savings standard, and can provide evidence or M&V studies to support the performance above the standard for a specific measure , the Commission should consider accepting the higher value, given that the higher level of performance is returning more energy savings than originally estimated, and that EDUs should be encouraged to seek new and innovative ways to improve programs, increase savings, and enhance marketability of energy efficiency efforts.

Resource savings to be estimated include electric energy (kWh) and capacity (kW – peak demand reduction) savings. The algorithms and values in this document support the determination of per unit savings for energy efficiency and demand response measures or programs.

General Framework

Energy and demand savings will be calculated using the algorithms, data and input values, and baselines estimates provided in this manual. Algorithm variables will be defined by each EDU to meet their current program offerings. Where applicable, EDU's will coordinate standard program offerings to minimize confusion by their customers and trade allies. The following sections outline the various components of this manual.

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. The following are the basic algorithms used in this TRM.

Non-Coincident 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.
$kW_{baseline}$ = maximum hourly demand at technology level
kW_{energy} efficient measure = maximum hourly demand at technology level

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 that particular measure. This may include factors to account for coincidence of multiple installations or interaction between different measures.

Data and Input Values

The input values for the algorithms come from EDU data gathering, worksheets, field tools, or from standard values based on measured or industry data. Site-specific data and EDU data gathering 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 from the Ohio utilities, 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. The sources of these values are footnoted in the applicable section.

Baseline Estimates

For all new construction and any replacement of non-working/end-of-life equipment appliances, the ΔkW and ΔkWh values are based on the current state or federal code for the items being replaced versus 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. In cases where working inefficient equipment is replaced, the full savings through the useful remaining life of the working equipment will be applied, followed by savings above the current state or federal code for the following life of the installed measure. The baseline estimates used in the TRM are documented in baseline studies or other market information. Baselines will be updated periodically to reflect changing codes, practices and market transformation effects.

Resource Savings in Current and Future Program Years

Energy efficiency reduction savings will apply corresponding to the calendar years and lasting for the approved life of the measure for meeting SB 221 benchmarks. Energy efficiency and demand response savings associated with SB221 can claim savings for up to the useful life of the asset.

Prospective Application of the TRM

The TRM will be applied prospectively. 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 level of SB 221 achievement, once awarded, by the Commission, nor will it alter any energy savings or demand reductions already in service and within measure life.

Electric Resource 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	May through September
Winter	October through April	NA
On Peak (Monday - Friday)	Utility specific	Utility specific
Off Peak (Weekends and Holidays)	Utility specific	NA

The time periods for energy savings and coincident peak demand savings were chosen to best fit the SB221 requirement, 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. In order to keep the complexity of the process for calculating energy savings' benefits to a reasonable level by using two time periods, the shoulder periods for spring and fall were split approximately evenly between the summer and winter periods. However, where possible, program cost effectiveness test results will be based on hourly savings estimates, produced by sub-metering or other M&V studies, in an effort to more accurately value the avoided cost contribution of these demand side resources within the larger least cost planning IRP context.

For capacity, the summer period May through September was selected to match the period of time required to meet the peak demand reduction requirements of SB221. This period also correlates with the highest avoided costs' time period for capacity. Coincidence factors are used to determine the impact of energy efficiency measures on peak demand. Again, where possible, the exact hour of system coincidence will be used, if available.

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 at the hourly level.

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 are often implicitly accounted for within metered data. In other cases, retention and persistence effects are unknown. Generally, these estimates of savings assume that the savings persist over time, unless otherwise specified. The measure lives/effective useful lives contained in the TRM include adjustments for persistence factors to the extent possible. Subsequent M&V studies will determine more specific estimates of persistence and retention for measures, and the TRM will be updated accordingly.

Interaction of Energy Savings

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. Interaction factors are also included in the algorithms for residential lighting and controls.

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. Interaction factors are also included in the algorithms for commercial lighting, lighting controls, evaporator fan controls, and door heater controls.

For commercial and industrial custom measures, interaction is accounted for in the site-specific analysis.

Programs involving multiple measures, such as home performance or comprehensive retrofit programs, interaction factors will be applied as appropriate using algorithms or a home energy rating tool.

Calculation of the Value of Resource Savings

The energy savings reported in this document are at the customer meter level. In order to calculate the value of the energy savings at the system level, the energy savings at the customer level are increased by the amount of the transmission and distribution losses to reflect the energy savings at the system level. The energy savings at the system level are then multiplied by the appropriate avoided costs to calculate the value of the benefits. In order to more accurately reflect the value of demand side resources, and in an effort to consistently compare demand resources to supply side resources within a least cost planning IRP framework, hourly savings estimates will be used where available or where provided by subsequent M&V studies.

System Savings = (Savings at Customer) X (T&D Loss Factor)

Value of Resource Savings = (System Savings) X (System Avoided Costs) + (Value of Other Resource Savings)

The value of the benefits for a particular measure will also include other resource savings where appropriate. Maintenance savings will be estimated in annual dollars levelized over the life of the measure.

Transmission and Distribution System Losses

The 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 based upon a utility specific multiplier for losses for both energy and demand. For programs which target the top hours of system peak, an alternate utility specific peak multiplier may be used to reflect higher peak losses for these times.

Measure Lives

For the purpose of calculating the Total Resource Cost Test for SB221, measures cannot claim savings for more than the average useful life of the asset.

Custom Measures

Custom measures are considered too complex or unique to be included in the list of standard measures provided 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 SB 221 achievements toward energy efficiency and demand response savings are determined on a case-by-case basis. All assumptions will be identified, explained and supported by documentation, by the EDU claiming custom measure savings.

Impact of Weather

To account for weather differences within Ohio, Equivalent Full Load Hours (ELFH) were taken from utility specific information and other data such as the US Department of

Energy's ENERGY STAR Calculator that provide ELFH values for seven Ohio cities: Akron, Cincinnati, Cleveland, Columbus, Dayton, Mansfield and Toledo. These cities provide a representative sample of the various climate and utility regions in Ohio.

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 or heat pump's cooling/heating energy use and peak demand. The algorithms also include the calculation of additional energy and demand savings due to the required proper sizing of high-efficiency units, equipment maintenance including corrections to refrigerant charge and air flow, and duct leakage sealing.

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.

Algorithms

Central Air Conditioner (A/C) and Air Source Heat Pump (ASHP)

Cooling Energy Consumption and Peak Demand Savings: Central A/C and ASHP (High Efficiency Equipment Only, Normal Replacement)

Energy Impact (kWh) = CAPY/1000 X RLF X ($1/SEER_b - 1/SEER_q$) X $EFLH_{cool}$

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

Heating Energy Savings: ASHP

Energy Impact (kWh) = CAPY/1000 X RLF X ($1/HSPF_b - 1/HSPF_q$) X $EFLH_{heat}$

Cooling Energy Consumption and Peak Demand Savings: Central A/C and ASHP (High Efficiency Equipment Only, Early Replacement)

Energy Impact (kWh) = CAPY/1000 X RLF X ($1/SEER_{er} - 1/SEER_q$) X $EFLH_{cool}$

Peak Demand Impact (kW) = CAPY/1000 X RLF X ($1/EER_{er} - 1/EER_q$) X CF

Heating Energy Savings: ASHP (Early Replacement)

Energy Impact (kWh) = CAPY/1000 X RLF X ($1/HSPF_{er} - 1/HSPF_q$) X $EFLH_{heat}$

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

Energy Impact (kWh) = $(CAPY \times RLF/(1000 \times SEER_q)) \times EFLH_{cool} \times PSF$

Peak Demand Impact (kW) = $((CAPY \times RLF/(1000 \times EER_q)) \times CF) \times PSF$

Cooling Energy Consumption and Demand Savings: Central A/C and ASHP (QIV)

Energy Impact (kWh) = $(((CAPY \times RLF/(1000 \times SEERq)) \times EFLH_{cool}) \times (1-PSF) \times QIF$

Peak Demand Impact (kW) = $((CAPY \times RLF/(1000 \times EERq)) \times CF) \times (1-PSF) \times QIF$

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

Energy Impact (kWh) = $((CAPY \times RLF/(1000 \times SEER_m)) \times EFLH_{cool}) \times MF$

Peak Demand Impact (kW) = $((CAPY \times RLF/(1000 \times EER_m)) \times CF) \times MF$

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

Energy Impact (kWh) = $(CAPY \times RLF/(1000 \times SEER_q)) \times EFLH_{cool} \times DuctSF$

Peak Demand Impact (kW) = $((CAPY \times RLF/(1000 \times EER_q)) \times CF) \times DuctSF$

Heating Energy Consumption Savings: Central ASHP (Duct Sealing)

Energy Impact (kWh) = $(CAPY \times RLF/(1000 \times HSPF)) \times EFLH_{heat} \times DuctSF$

Ground Source Heat Pumps (GSHP)

Cooling Energy (kWh) Savings = $CAPY/1000 \times RLF \times (1/SEER_b - (1/(EER_g \times GSER))) \times EFLH$

Heating Energy (kWh) Savings = $CAPY/1000 \times RLF \times (1/HSPF_b - (1/(COP_g \times GSOP))) \times EFLH$

Peak Demand Impact (kW) = $CAPY/1000 \times RLF \times (1/EER_b - (1/(EER_g \times GSPK))) \times CF$

GSHP Desuperheater

Energy (kWh) Savings = EDSH

Peak Demand Impact (kW) = PDSH

Definition of Terms

CAPY = The cooling capacity (output in Btuh) of the central air conditioner or heat pump being installed. These data are obtained from the EDU data gathering.

$SEER_b$ = 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 EDU's data gathering based on the model number.

$SEER_{er}$ = The Seasonal Energy Efficiency Ratio of the unit being removed before the end of its estimated useful life. This data should be obtained from the EDU's data gathering. If unobtainable use the savings values presented in Table 7.

$SEER_m$ = The Seasonal Energy Efficiency Ratio of an Existing 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 EDU data gathering based on the model number.

EER_{er} = The Energy Efficiency Ratio of the unit being removed before the end of its estimated useful life. This data should be obtained from the EDU's data gathering. If unobtainable use the savings values presented in Table 7.

EER_m = The Energy Efficiency Ratio of an Existing Unit receiving maintenance.

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.

RLF = rated load factor, which adjusts the unit capacity to account for over sizing. The RLF is defined as the ratio of the building peak cooling or heating load to the unit cooling or heating capacity.

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

$EFLH_{cool}$ = The Cooling Equivalent Full Load Hours of operation for the average unit.

$EFLH_{heat}$ = The Heating Equivalent Full Load Hours of operation for the average unit.

$EFLH_{fan}$ = The Furnace Fan Equivalent Full Load Hours of operation for the average unit.

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 heating and 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 EDU's data gathering.

$HSPF_{er}$ = The Heating Seasonal Performance Factor of the unit being removed before the end of its estimated useful life. This data should be obtained from the EDU's data gathering. If unobtainable use the savings values presented in Table 7.

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.[2]

PDSH = Assumed peak-demand savings per desuperheater.

[2] Desuperheaters are generally utilized to reduce the temperature of superheated steam to a desired set point for the protection of downstream piping and equipment or for the supply of saturated steam for heat transfer purposes.

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

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

1 ton of cooling capacity = 12,000 Btu per hour.

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

TABLE 2: RESIDENTIAL ELECTRIC HVAC

Component	Type	Applicability Conditions	Sources
RLF	Fixed	0.83	20% over sizing
CAPY	Variable		EDU Data Gathering
$SEER_b$	Fixed	Baseline = 13	1
$SEER_q$	Variable		EDU Data Gathering
$SEER_{er}$	Variable		EDU Data Gathering
$SEER_m$	Fixed	10	12
EER_b	Fixed	Baseline = 11.1	
EER_q	Fixed	Air conditioners: SEER 14 = 12.0 SEER 15 = 12.7 SEER 16 = 11.6 SEER 17 = 12.3 Heat Pumps: SEER 14 = 11.7 SEER 15 = 12.3 SEER 16 = 12.1 SEER 17 = 12.5 SEER 18 = 12.8	14
EER_{er}	Variable		EDU Data Gathering
EER_g	Variable		EDU Data Gathering
EER_m	Fixed	9.17	13
GSER	Fixed	1.02	2

Component	Type	Applicability Conditions	Sources
$EFLH_{cool}$	Fixed	Akron cooling = 454 Cincinnati cooling = 630 Cleveland cooling = 533 Columbus cooling = 567 Dayton cooling = 669 Mansfield cooling = 422 Toledo cooling = 492	15
$EFLH_{heat}$	Fixed	Akron heating = 1,576 Cincinnati heating = 1,394 Cleveland heating = 1,567 Columbus heating = 1,272 Dayton heating = 1,438 Mansfield heating = 1,391 Toledo heating = 1,628	15
PSF	Fixed	5%	11
QIF	Fixed	9.2%	3
MF	Fixed	10%	14
DuctSF	Fixed	6%	15
CF	Fixed	70%	4
DSF	Fixed	2.9%	5
$HSPF_b$	Fixed	Baseline = 7.7	6
$HSPF_q$	Variable		EDU Data Gathering
$HSPF_{er}$	Variable		EDU Data Gathering
COP_g	Variable		EDU Data Gathering
GSOP	Fixed	3.413	7
GSPK	Fixed	0.8416	8
EDSH	Fixed	1842 kWh	9
PDSH	Fixed	0.34 kW	10
$Capy_q$	Variable		EDU Data Gathering

Estimated Useful Life

The estimated useful life for residential AC, furnace and heat pump measures is 15 years. The estimated useful life for central AC maintenance is 10 years, and the estimated useful life of duct leakage sealing is 18 years.

Measure Costs

The incremental capital cost for normal replacements are listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 3: INCREMENTAL COST PER TON

Measure	Cost	Unit	Source	Notes
ASHP - SEER 14	$97.94	ton	16	
ASHP - SEER 15	$195.87	ton	16	
ASHP - SEER 16	$293.81	ton	16	
ASHP - SEER 17	$391.74	ton	16	
ASHP - SEER 18	$489.68	ton	16	
Furnace/AC - SEER 14	$92.62	ton	16	
Furnace/AC - SEER 15	$185.24	ton	16	
Furnace/AC - SEER 16	$277.86	ton	16	
Furnace/AC - SEER 17	$370.47	ton	16	
GSHP EER 19	$7,500.00	ton		Includes labor costs for system installation above ASHP base

Measure costs for add-on maintenance and duct sealing measures are listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 4: MAINTENANCE AND DUCT SEALING COSTS

Measure	Cost	Unit	Source	Notes
CAC maintenance	77.00	ton	16	Average over all RCA measures
Duct sealing	216.00	kSF floor	16	Per system costs averaged over building floor space

Alternative HVAC Early Replacement Measure Cost

Algorithm

$$Incremental\ Cost = Cost_{EE} - \frac{Cost_{BASE}}{(1+d)^{RUL}}$$

Definition of Terms

$Cost_{EE}$ = Total equipment and labor cost of installed energy efficient measure

$Cost_{BASE}$ = Total equipment and labor cost of installing a standard efficiency measure at end of the existing measure's effective useful life. Standard efficiency is defined as the minimum efficiency required by code.

d = EDU required discount rate

Remaining Useful Life (RUL) = At time of early replacement, RUL is the number of years the existing measure would have remained in operation. For purposes of implementation half of EUL should be used for RUL.

TABLE 5: EARLY REPLACEMENT INCREMENTAL COST

Component	**Type**	**Sources**
$Cost_{EE}$	Fixed	See Table 6
$Cost_{BASE}$	Variable	
d (discount rate)	Variable	EDU Discount Rate
RUL	Variable	EUL of Measure

TABLE 6: FULL EQUIPMENT COST PER TON

Measure	Cost	Unit	Source
ASHP - SEER 14	$964.73	ton	16
ASHP - SEER 15	$1,062.67	ton	16
ASHP - SEER 16	$1,160.60	ton	16
ASHP - SEER 17	$1,258.54	ton	16
ASHP - SEER 18	$1,356.47	ton	16
Furnace/AC - SEER 14	$878.12	ton	16
Furnace/AC - SEER 15	$970.74	ton	16
Furnace/AC - SEER 16	$1,063.36	ton	16
Furnace/AC - SEER 17	$1,155.98	ton	16

Sources:

1. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
2. VEIC estimate. Extrapolation of manufacturer data.
3. US Department of Energy, Energy Star Calculator. Accessed 9/1/2009.
4. Based on an analysis of six different utilities by Proctor Engineering.
5. Xenergy, "New Jersey Residential HVAC Baseline Study", (Xenergy, Washington, D.C., November 16, 2001).
6. Federal Register, Vol. 66, No. 14, Monday, January 22, 2001/Rules and Regulations, p. 7170-7200.
7. Engineering calculation, HSPF/COP=3.413.
8. VEIC Estimate. Extrapolation of manufacturer data.
9. VEIC estimate, based on PEPCo assumptions.
10. VEIC estimate, based on PEPCo assumptions.
11. 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.

12. Average SEER for existing AC from DEER study. Use for early replacement baseline. If SEER and/or unit size not known, see information below on "Alternative HVAC Early Retirement Algorithm."
13. VEIC estimate. Conservatively assumes less savings than for QIV because of the retrofit context.
14. EER by SEER taken from DEER update study. "2004-2005 Database for Energy Efficiency Resources (DEER) Update Study, Final Report," Itron, Inc., J.J. Hirsch and Associates, Synergy Consulting, and Quantum Consulting. December, 2005. Available at http://eega.cpuc.ca.gov/deer
15. Heating and cooling EFLH and duct sealing savings calculations extracted from simulations conducted for Duke Energy. Simulation methodology described in "An Evaluation of the Smart Saver Program in Ohio, Results of a Process and Impact Evaluation," conducted by TecMarket Works for Duke Energy, September, 2008.
16. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Alternative HVAC Early Replacement Algorithm

The electricity impact for a central air conditioning system or air source heat pump will be the gross annual energy and demand savings per central air conditioner or air source heat pump. The rated load factor was not used to calculate the early replacement savings. The following values by SEER apply to these measures:

TABLE 7: RESIDENTIAL HVAC EARLY REPLACEMENT

Component	SEER range	Type	Value	Sources
$ESav_{CAC}$	14 - 15	Fixed	1,303 kWh	1
$DSav_{CAC}$	14 - 15	Fixed	1.89 kW	1 and 2
$ESav_{CAC}$	16+	Fixed	1,597 kWh	1
$DSav_{CAC}$	16+	Fixed	2.09 kW	1 and 2
$ESav_{ASHP}$	14 - 15	Fixed	3040 kWh	1
$DSav_{ASHP}$	14 - 15	Fixed	1.98 kW	1 and 2
$ESav_{ASHP}$	16+	Fixed	3749 kWh	1
$DSav_{ASHP}$	16+	Fixed	2.14 kW	1 and 2

Sources:

1. CSG 2009 Residential In-field HVAC analysis for KCPL, adjusted for the Ohio utility region.
2. Coincidence factor already embedded in summer peak demand reduction estimates.

Furnace High Efficiency Fan

This section covers the electricity savings associated with electronically commutated (EC) motors used on gas furnace supply fans. Energy and demand saving are realized through reductions in fan power due to improved motor efficiency and variable flow operation. The approach utilizes DOE-2.2 simulations on a series of residential prototypical building models. The residential simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Ohio climate and building practices. Energy and demand impacts are normalized per thousand Btu/hr of furnace output capacity.

Algorithms

Electricity Impact (kWh) = kBtu/hr X (ΔKWH/kBtuh)

Demand Impact (kW) = 0

Definition of Terms

kBtuh = Heating output capacity of furnace with EC motor (1000 Btu/hr)

ΔKWH/kBtuh = unit energy savings per 1000 Btu/hr of heating output capacity

ΔKW/kBtuh = unit demand savings per 1000 Btu/hr of heating output capacity

CF_s = summer coincident peak factor

TABLE 8: HIGH EFFICIENCY FURNACE FAN

Component	Type	Value	Sources
kBtuh	Variable		EDC Data Gathering
ΔKWH/kBtuh	Fixed	Akron: 3.7 kWh/kBtuh Cincinnati: 2.7 kWh/kBtuh Cleveland: 3.5 kWh/kBtuh Columbus: 3.0 kWh/kBtuh Dayton: 3.3 kWh/kBtuh Mansfield: 4.0 kWh/kBtuh Toledo: 4.0 kWh/kB	1
ΔKW/kBtuh	Fixed	0	1

Component	Type	Value	Sources
CF_a	Fixed	0.71	2

Estimated Useful Life

The estimated useful life for residential furnace measures is 15 years.

Measure Costs

The incremental capital cost for normal replacements are listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 9: MEASURE COSTS – HIGH EFFICIENCY FURNACE FAN

Measure	Cost	Unit	Source	Notes
High Efficiency Furnace with EC motor	$15.00	kBtuh	3	

Sources:

1. Measure savings extracted from simulations conducted for Duke Energy. Simulation methodology described in "An Evaluation of the Smart Saver Program in Ohio, Results of a Process and Impact Evaluation," conducted by TecMarket Works for Duke Energy, September, 2008. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the residential HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Residential Shell Measures

Shell Insulation

This section covers improvements to the thermal conductance of the opaque building shell, which includes upgrading insulation in walls, ceilings, crawlspace wall and basement wall. Energy and demand saving are realized through reductions in the building heating and cooling loads. The approach utilizes DOE-2.2 simulations on a series of residential prototypical building models. The residential simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Ohio climate and building practices. Energy and demand impacts are normalized per thousand square feet of installed insulation.

Algorithms

Wall Insulation

Electricity Impact (kWh) = SF_{WALL} /1000 X (ΔKWH/kSF_{WALL})

Demand Impact (kW) = SF_{WALL} /1000 X (ΔKW/kSF_{WALL}) X CF_S

Ceiling Insulation

Electricity Impact (kWh) = SF_{CEIL} /1000 X (ΔKWH/kSF_{CEIL})

Demand Impact (kW) = SF_{CEIL} /1000 X (ΔKW/kSF_{CEIL}) X CF_S

Basement Wall Insulation

Electricity Impact (kWh) = SF_{BSMT} /1000 X (ΔKWH/kSF_{BSMT})

Demand Impact (kW) = SF_{BSMT} /1000 X (ΔKW/kSF_{BSMT}) X CF_S

Crawlspace Wall Insulation

Electricity Impact (kWh) = SF_{CRAWL} /1000 X (ΔKWH/kSF_{CRAWL})

Demand Impact (kW) = SF_{CRAWL} /1000 X (ΔKW/kSF_{CRAWL}) X CF_S

Definition of Terms

SF_{WALL} = surface area of installed wall insulation (square feet)

$\Delta KWH/kSF_{WALL}$ = unit energy savings per thousand square feet of wall insulation

$\Delta KW/kSF_{WALL}$ = unit demand savings per thousand square feet of wall insulation

SF_{CEIL} = surface area of installed ceiling insulation (square feet)

$\Delta KWH/kSF_{CEIL}$ = unit energy savings per thousand square feet of ceiling insulation

$\Delta KW/kSF_{CEIL}$ = unit demand savings per thousand square feet of ceiling insulation

SF_{BSMT} = surface area of installed basement wall insulation (square feet)

$\Delta KWH/kSF_{BSMT}$ = unit energy savings per thousand square feet of basement wall insulation

$\Delta KW/kSF_{BSMT}$ = unit demand savings per thousand square feet of basement wall insulation

SF_{CRAWL} = surface area of installed crawlspace wall insulation (square feet)

$\Delta KWH/kSF_{CRAWL}$ = unit energy savings per thousand square feet of crawlspace wall insulation

$\Delta KW/kSF_{CRAWL}$ = unit demand savings per thousand square feet of crawlspace wall insulation

CF_s = summer coincident peak factor

TABLE 10: SHELL INSULATION

Component	Type	Value	Sources
SF_{WALL}	Variable		EDC Data Gathering
$\Delta KWH/kSF_{WALL}$	Fixed	See wall insulation table below	1

Component	Type	Value	Sources
$\Delta KW/kSF_{WALL}$	Fixed	See wall insulation table below	1
SF_{CEIL}	Variable		EDC Data Gathering
$\Delta KWH/kSF_{CEIL}$	Fixed	See ceiling insulation table below	1
$\Delta KW/kSF_{CEIL}$	Fixed	See ceiling insulation table below	1
SF_{BSMT}	Variable		EDC Data Gathering
$\Delta KWH/kSF_{BSMT}$	Fixed	See basement wall insulation table below	1
$\Delta KW/kSF_{BSMT}$	Fixed	See basement wall insulation table below	1
SF_{CRAWL}	Variable		EDC Data Gathering
$\Delta KWH/kSF_{CRAWL}$	Fixed	See crawlspace wall insulation table below	1
$\Delta KW/kSF_{CRAWL}$	Fixed	See crawlspace wall insulation table below	1
CF_a	Fixed	0.71	2

TABLE 11: BASEMENT WALL INSULATION UNIT KWH AND KW SAVINGS

Climate	Existing Buildings		New Construction	
	kWh/kSF_{BSMT}	kW/kSF_{BSMT}	kWh/kSF_{BSMT}	kW/kSF_{BSMT}
Akron	392	-0.075	148	-0.022
Cincinnati	273	-0.056	108	-0.003
Cleveland	371	-0.058	148	-0.022
Columbus	203	-0.011	172	-0.003
Dayton	339	-0.068	133	-0.018
Mansfield	440	-0.074	167	-0.018
Toledo	419	-0.075	157	-0.018

TABLE 12: CRAWLSPACE WALL INSULATION UNIT KWH AND KW SAVINGS

Climate	Existing Buildings		New Construction	
	kWh/kSF_{CRAWL}	kW/kSF_{CRAWL}	kWh/kSF_{CRAWL}	kW/kSF_{CRAWL}
Akron	93	-0.037	84	-0.037
Cincinnati	36	0.008	30	0.000
Cleveland	78	-0.062	72	0.000
Columbus	79	-0.017	74	-0.030

Dayton	69	-0.052	66	-0.007
Mansfield	119	-0.031	88	-0.037
Toledo	107	-0.042	88	-0.030

TABLE 13: CEILING INSULATION UNIT KWH AND KW SAVINGS

Climate	Existing Buildings		New Construction	
	kWh/kSF_{CEIL}	kW/kSF_{CEIL}	kWh/kSF_{CEIL}	kW/kSF_{CEIL}
Akron	150	0.039	77	0.008
Cincinnati	142	0.024	68	0.008
Cleveland	153	0.036	81	0.016
Columbus	145	0.027	77	0.008
Dayton	151	0.028	77	0.008
Mansfield	152	0.010	80	0.008
Toledo	161	0.032	75	0.008

TABLE 14: WALL INSULATION UNIT KWH AND KW SAVINGS

Climate	Existing Buildings		New Construction	
	kWh/kSF_{WALL}	kW/kSF_{WALL}	kWh/kSF_{WALL}	kW/kSF_{WALL}
Akron	352	0.070	58	0.005
Cincinnati	316	0.064	53	0.005
Cleveland	359	0.069	62	0.010
Columbus	316	0.051	56	0.004
Dayton	343	0.055	56	0.004
Mansfield	371	0.050	61	0.005
Toledo	375	0.055	58	0.005

Estimated Useful Life

The estimated useful life for insulation measures is 20 years.

Measure Costs

The full capital costs for adding insulation to existing buildings are listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 15: MEASURE COSTS - INSULATION

Measure	Cost	Unit	Source	Notes
Basement	$690.	kSF	3	Including labor

Crawlspace	$690.	kSF	3	Including labor
Ceiling	$757.	kSF	3	Including labor
Wall	$1,322.	kSF	3	Including labor

Sources:

1. Insulation measure savings calculations extracted from simulations conducted for Duke Energy. Simulation methodology described in "An Evaluation of the Smart Saver Program in Ohio, Results of a Process and Impact Evaluation," conducted by TecMarket Works for Duke Energy, September, 2008. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the residential HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Air Leakage Sealing

This section covers air leakage sealing to reduce the building infiltration rate. Air leakage sealing measures resulting in a 30% and a 50% reduction in the infiltration rate are included, both with and without upgraded attic insulation. Energy and demand saving are realized through reductions in the building heating and cooling loads. The approach utilizes DOE-2.2 simulations on a series of residential prototypical building models. The residential simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Ohio climate and building practices. Energy and demand impacts are normalized per thousand square feet of conditioned floor area.

Algorithms

30% Infiltration rate reduction

Electricity Impact (kWh) = SF_{FLOOR} /1000 X (ΔKWH/$kSF_{30\%}$)

Demand Impact (kW) = SF_{FLOOR} /1000 X (ΔKW/$kSF_{30\%}$) X CF_S

50% Infiltration rate reduction

Electricity Impact (kWh) = SF_{FLOOR} /1000 X (ΔKWH/$kSF_{50\%}$)

Demand Impact (kW) = SF_{FLOOR} /1000 X (ΔKW/$kSF_{50\%}$) X CF_S

30% Infiltration rate reduction with attic insulation

Electricity Impact (kWh) = SF_{FLOOR} /1000 X (ΔKWH/$kSF_{30\%\ plus\ attic}$)

Demand Impact (kW) = SF_{FLOOR} /1000 X (ΔKW/$kSF_{30\%\ plus\ attic}$) X CF_S

50% Infiltration rate reduction with attic insulation

Electricity Impact (kWh) = SF_{FLOOR} /1000 X (ΔKWH/$kSF_{50\%\ plus\ attic}$)

Demand Impact (kW) = SF_{FLOOR} /1000 X (ΔKW/$kSF_{50\%\ plus\ attic}$) X CF_S

Definition of Terms

$\Delta KWH/kSF_{30\%}$ = unit energy savings per thousand square feet of floor area for 30% infiltration reduction

$\Delta KW/kSF_{30\%}$ = unit demand savings per thousand square feet of floor area for 30% infiltration reduction

$\Delta KWH/kSF_{50\%}$ = unit energy savings per thousand square feet of floor area for 50% infiltration reduction

$\Delta KW/kSF_{50\%}$ = unit demand savings per thousand square feet of floor area for 50% infiltration reduction

$\Delta KWH/kSF_{30\%\text{ plus attic}}$ = unit energy savings per thousand square feet of floor area for 30% infiltration reduction plus attic insulation upgrade

$\Delta KW/kSF_{30\%\text{ plus attic}}$ = unit demand savings per thousand square feet of floor area for 30% infiltration reduction plus attic insulation upgrade

$\Delta KWH/kSF_{50\%\text{ plus attic}}$ = unit energy savings per thousand square feet of floor area for 50% infiltration reduction plus attic insulation upgrade

$\Delta KW/kSF_{50\%\text{ plus attic}}$ = unit demand savings per thousand square feet of floor area for 50% infiltration reduction plus attic insulation upgrade

SF_{FLOOR} = conditioned floor area of building

CF_s = summer coincident peak factor

TABLE 16: AIR LEAKAGE SEALING

Component	Type	Value	Sources
SF_{FLOOR}	Variable		EDC Data Gathering
$\Delta KWH/kSF_{30\%}$	Fixed	See 30% infiltration reduction table below	1
$\Delta KW/kSF_{30\%}$	Fixed	See 30% infiltration reduction table below	1
$\Delta KWH/kSF_{50\%}$	Fixed	See 50% infiltration reduction table below	1

Component	Type	Value	Sources
$\Delta KW/kSF_{50\%}$	Fixed	See 50% infiltration reduction table below	1
$\Delta KWH/kSF_{30\%\ plus\ attic}$	Fixed	See 30% infiltration reduction plus attic insulation table below	1
$\Delta KW/kSF_{30\%\ plus\ attic}$	Fixed	See 30% infiltration reduction plus attic insulation table below	1
$\Delta KWH/kSF_{50\%\ plus\ attic}$	Fixed	See 50% infiltration reduction plus attic insulation table below	1
$\Delta KW/kSF_{50\%\ plus\ attic}$	Fixed	See 50% infiltration reduction plus attic insulation table below	1
CF_a	Fixed	0.71	2

TABLE 17: 30% INFILTRATION REDUCTION UNIT KWH AND KW SAVINGS

	Existing Buildings	
Climate	$\Delta KWH/kSF_{30\%}$	$\Delta KW/kSF_{30\%}$
Akron	306	0.064
Cincinnati	244	0.081
Cleveland	304	0.072
Columbus	206	0.038
Dayton	272	0.058
Mansfield	348	0.104
Toledo	309	0.072

TABLE 18: 50% INFILTRATION REDUCTION UNIT KWH AND KW SAVINGS

	Existing Buildings	
Climate	$\Delta KWH/kSF_{50\%}$	$\Delta KW/kSF_{50\%}$
Akron	513	0.101
Cincinnati	407	0.139
Cleveland	509	0.122
Columbus	354	0.071
Dayton	465	0.105
Mansfield	593	0.184
Toledo	525	0.124

TABLE 19: 30% INFILTRATION REDUCTION PLUS ATTIC INSULATION UNIT KWH AND KW SAVINGS

Climate	Existing Buildings	
	ΔKW/kSF$_{30\% \text{ plus attic}}$	ΔKW/kSF$_{30\% \text{ plus attic}}$
Akron	407	0.090
Cincinnati	338	0.104
Cleveland	406	0.097
Columbus	302	0.061
Dayton	371	0.080
Mansfield	450	0.119
Toledo	417	0.093

TABLE 20: 50% INFILTRATION REDUCTION PLUS ATTIC INSULATION UNIT KWH AND KW SAVINGS

Climate	Existing Buildings	
	ΔKWH/kSF$_{50\% \text{ plus attic}}$	ΔKW/kSF$_{50\% \text{ plus attic}}$
Akron	613	0.127
Cincinnati	500	0.167
Cleveland	614	0.145
Columbus	450	0.093
Dayton	565	0.127
Mansfield	695	0.201
Toledo	632	0.142

Estimated Useful Life

The estimated useful life for air leakage sealing measures is 13 years.

Measure Costs

The full capital cost for air leakage sealing measures alone and in combination with adding insulation to existing buildings are listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 21: MEASURE COSTS – AIR LEAKAGE SEALING

Measure	Cost	Unit	Source	Notes
Air leakage sealing	$120	kSF	3	Including labor
Air leakage sealing plus insulation	$877.	kSF	3	Including labor

Sources:

1. Infiltration measure savings calculations extracted from simulations conducted for Duke Energy. Simulation methodology described in "An Evaluation of the Smart Saver Program in Ohio, Results of a Process and Impact Evaluation," conducted by TecMarket Works for Duke Energy, September, 2008. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the residential HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com.

Whole House Fan

This section covers whole-house fans used to improve ventilation rates when outdoor conditions are favorable. The whole house fan increases the ventilation rate from 2 air changes per hour to 10 air changes per hour during the cooling season when the outdoor air temperature is below 65°F, thus pre-cooling the building interior mass with outdoor air. Energy saving are realized through reductions in the building mechanical cooling loads. No peak savings are anticipated. The approach utilizes DOE-2.2 simulations on a series of residential prototypical building models. The residential simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Ohio climate and building practices. Energy and demand impacts are normalized per thousand square feet of conditioned floor area.

Algorithms

Whole-House Fan

Electricity Impact (kWh) = SF_{FLOOR} /1000 X ($\Delta KWH/kSF_{WWF}$)

Demand Impact (kW) = SF_{FLOOR} /1000 X ($\Delta KW/kSF_{WWF}$) X CF_S

Definition of Terms

$\Delta KWH/kSF_{WWF}$ = unit energy savings per thousand square feet of floor area for 30% infiltration reduction

$\Delta KW/kSF_{WWF}$ = unit demand savings per thousand square feet of floor area for 30% infiltration reduction

SF_{FLOOR} = conditioned floor area of building

CF_s = summer coincident peak factor

TABLE 22: WHOLE HOUSE FAN

Component	Type	Value	Sources

Component	Type	Value	Sources
SF_{FLOOR}	Variable		EDC Data Gathering
$\Delta KWH/kSF_{WWF}$	Fixed	Akron: 39 kWh/kSF Cincinnati: 40 kWh/kSF Cleveland: 32 kWh/kSF Columbus: 45 kWh/kSF Dayton: 34 kWh/kSF Mansfield: 41 kWh/kSF Toledo: 37 kWh/kSF	1
$\Delta KW/kSF_{WWF}$	Fixed	0.0 for all cities	1
CF_a	Fixed	0.71	2

Estimated Useful Life

The estimated useful life for a whole-house fan is 15 years.

Measure Costs

The full capital cost for adding whole house fans to existing buildings are listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 23: MEASURE COSTS – WHOLE HOUSE FAN

Measure	Cost	Unit	Source	Notes
Whole House Fan	$1,127	kSF	3	Including labor

Sources:

1. Whole house fan savings calculations extracted from simulations conducted for Duke Energy. Simulation methodology described in "An Evaluation of the Smart Saver Program in Ohio, Results of a Process and Impact Evaluation," conducted by TecMarket Works for Duke Energy, September, 2008. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the residential HVAC end-use.

Programmable Setback/Setup Thermostat for Heat Pump

Programmable setback/setup thermostats for heat pumps can be used to optimize the control of heat pump systems. The measurement of energy and demand savings for commercial and industrial applications will vary type of heat pump technology, operating hours, efficiency and current and proposed controls. The efficiencies as outlined HVAC section of TRM should be used.

Typical Savings

The savings from setback/setup thermostats will vary by building application, loads, climate and types of heat pumps. Typically a savings of 6 percent can be achieved.

Algorithms

Heat Pump Algorithms:

Energy Savings: Cooling (kWh) = $(Btu/H_c 1000) \times 1/EER_b \times EFLH_c \times ESF$

Energy Savings: Heating (kWh) = $(Btu/H_h 1000) \times 1/EER_b \times EFLH_h \times ESF$

Demand Savings (kW) = $Btu/H_h 1000 \times 1/EER_b \times ESF \times CF$

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

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.

CF = Coincidence Factor: The percentage of the total load which is on during electric system's peak window, .74 for HVAC applications.

EFLH = Equivalent Full Load Hours: A measure of full load hours by HVAC system. Please see HVAC section for more information FLHHS and FLCHs by city

ESF = Energy savings factor

TABLE 24: HVAC HEAT PUMPS – THERMOSTAT SETUP AND SETBACK

Component	Type	Applicability Conditions	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	EDU Data Gathering
EER_b	Variable	See air conditioning tables	EDU Data Gathering
CF	Fixed	74%	Engineering estimate
ESF	Fixed	6%	1

Effective Measure Life

10 years (DEER Database)

Coincidence Factor

.74 (based on Ohio utility supply profiles)

Incremental Cost

$145 per thermostat (DEER Database)

Sources:

1. Gas Networks Report by RLM Analytics, January 2007.

TABLE 25: HVAC HEAT PUMPS – THERMOSTAT SETUP AND SETBACK

Component	Type	Applicability Conditions	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	EDU Data Gathering
EER_b	Variable	See air conditioning tables	EDU Data Gathering
CF	Fixed	67%	Ohio load research data
ESF	Fixed	6%	1.

The same factors concerning efficiencies for heat pumps systems should used as was derived in air conditioning section of TRM, FLHHs as well as coincidence factors as applicable.

Sources:

1. Field Test of Energy Savings with Thermostat Setback, ASHRAE Journal.
2. Energy savings analysis using DOE.

Programmable Setup Thermostat for Air Conditioners

Programmable setup thermostats for air conditioners can be used to optimize the control of air conditioner systems. The measurement of energy and demand savings for commercial and industrial applications will vary with the type of air conditioning technology, operating hours, efficiency and current and proposed controls. The efficiencies as outlined HVAC section of TRM should be used.

Typical Savings

The savings from setup thermostats will vary by building application, loads, climate and types of air conditioners. Typically a savings 6 percent can be achieved.

Algorithms

Air Conditioner Algorithms:

Energy Savings: Cooling (kWh) = (Btu/H_c1000) X 1/EER_b X $EFLH_c$ X ESF

Demand Savings (kW) = (Btu/H1000 X 1/EER_b X ESF X CF

Where $_c$ is for cooling.

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.

CF = Coincidence Factor – The percentage of the total load which is on during electric system's peak window, .74 for HVAC applications.

EFLH = Equivalent Full Load Hours – A measure of full load hours by HVAC system. Please see HVAC section for more information FLHHS and FLCHs by city.

ESF = Energy savings factor

TABLE 26: HVAC AIR CONDITIONERS – THERMOSTAT SETUP AND SETBACK

Component	Type	Applicability Conditions	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	EDU Data Gathering
EER_b	Variable	See air conditioning tables	EDU Data Gathering
CF	Fixed	74%	Ohio load research data
ESF	Fixed	6%	1

Effective Measure Life

10 years (DEER Database)

Coincidence Factor

.74 (based on Ohio utility supply profiles)

Incremental Cost

$145 per thermostat (DEER Database)

TABLE 27: HVAC AIR CONDITIONERS – TEMPERATURE SETUP

Component	Type	Applicability Conditions	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	EDU Data Gathering
EER_b	Variable	See air conditioning tables	EDU Data Gathering
CF	Fixed	74%	Ohio load research data
ESF	Fixed	6%	1

Sources:

1. Gas Networks, "Validating the Impact of Programmable Thermostats, RLW Analytics

Occupancy Sensor Power Strip

When added to a power strip, an occupancy sensor can help eliminate standby losses associated with home appliances such as televisions and printers.

Algorithms

Electricity Impact (kWh) = $WATTS_{STANDBY}$ / 1000 X $HOURS_{STANDBY}$

Demand Impact (kW) = $WATTS_{STANDBY}$ / 1000 X CF

Definition of Terms

$WATTS_{STANDBY}$ = power demand of the appliances when in standby mode

$HOURS_{STANDBY}$ = the hours per year that the appliances are not in use and the room is unoccupied

CF = Coincidence factor represents the probability that the appliances would be in standby mode at the time of the utility system peak

TABLE 28: OCCUPANCY SENSOR POWER STRIP

Component	Type	Value	Sources
$WATTS_{STANDBY}$	Fixed	32W for Entertainment system, 20W for home PC and peripherals	1
$HOURS_{STANDBY}$	Fixed	6935 hr/year for TV 7300 hr/yr for home PC	1
CF	Fixed	0.836	2

Estimated Useful Life

The estimated useful life for occupancy sensor power strips is 8 years.

Measure Costs

The incremental capital cost for occupancy sensor power strips is $85.00.

Sources:

1. Earth Aid Enterprises, 2008
2. Building America Research Benchmark Definition, National Renewable Energy Laboratory, December, 2006.

In-Home Energy Use Monitor

An in-home energy use monitor is a device that utilizes a sensor on the home's electric meter to read the real-time energy consumption of the residence and then transmit the data to a monitor inside the home. The occupants can utilize the monitor to determine how much electricity is being used in real-time, the cost of that electricity, and the peak usage in any 24-hour period. Energy savings are estimated based on actual data.

Algorithms

Electricity Impact (kWh) = KWHBASE X ESF

Demand Impact (kW) = ELECTRICITY IMPACT / 365 X BABF

Definition of Terms

KWHBASE = Average annual consumption of typical home for baseline reference

ESF = Energy savings estimate as derived from study of in-home energy use monitor results for Hydro One in Ontario, Canada

BABF = Building America Benchmark Factor for miscellaneous electric loads. Demand savings are calculated by equally distributing energy savings to a daily basis and then applying the hourly value sourced from the "Building America Research Benchmark Definition." This implies coincidence as well as diversity.

TABLE 29: IN HOME ENERGY USE MONITOR

Component	Type	Value	Sources
KWHBASE	Variable		
ESF	Fixed	6.5%	1
BABF	Fixed	0.044	2

Estimated Useful Life

The estimated useful life for an in home energy use monitor is 5 years.

Measure Costs

TBD.

Sources:

1. The Impact of Real-Time Feedback on Residential Electricity Consumption: The Hydro One Pilot, Dean C. Mountain, Ph. D., Mountain Economic Consulting and Associates, Inc. March, 2006. Table 9: Households' Perceived Expected Savings, page 42.

Energy Savings (% of Annual Use)	Average Energy Savings (%)	Percent Homes Realizing Savings	Weighted Average Percent Savings
0-5	2.5	52.1%	
5-10	7.5	30.3%	
10-15	12.5	11.1%	
15-20	17.5	5.1%	
>20	20	1.3%	
			6.5%

Source: Hydro One Report

2. Building America Research Benchmark Definition, National Renewable Energy Laboratory, December, 2006.

Residential New Construction

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

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

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

Algorithms

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.

Definition of Terms

PL_b = Peak load of the baseline home in Btuh.

OF_b = The over sizing 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 over sizing 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.

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

TABLE 30: RESIDENTIAL NEW CONSTRUCTION

Applicable to Building Completions from April 2003 to Present

Component	Type	Value	Sources
PL_b	Variable		1
OF_b	Fixed	1.6	2
$SEER_b$	Fixed	13	3
BLEER	Fixed	0.92	4
PL_q	Variable		Software Output
OF_q	Fixed	1.15	5
EER_q	Variable		EDU's Data Gathering
CF	Fixed	0.70	6

Sources:

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

Lighting and Appliances

Quantification of additional saving due to the addition of high-efficiency lighting and clothes washers will be based on the algorithms presented for these appliances in the ENERGY STAR Lighting Algorithms and the ENERGY STAR Appliances Algorithms, respectively. These algorithms are found in 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 eight-hours per day.

The following tables describe the characteristics of the three reference homes.

Table 31: ENERGY STAR Homes

REMRate User Defined Reference Homes.
Applicable to building completions from April 2003 to present. Reflects MEC 95.

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	7.7 HSPF
Geothermal Heat Pump	Open not modeled, 3.0 COP closed
PTAC / PTHP	Not differentiated from air source HP
Cooling Efficiency	
Central Air Conditioning	13.0 SEER
Air Source Heat Pump	13.0 SEER
Geothermal Heat Pump	3.4 COP (11.6 EER)
PTAC / PTHP	Not differentiated from central AC
Window Air Conditioners	Not differentiated from central AC
Domestic WH Efficiency	

Data Point	Single and Multiple Family Except as Noted.
Electric	0.97 EF (4)
Natural Gas	0.67 EF (4)
Water Heater Tank Insulation	None
Duct Insulation	N/A

Notes:

TABLE 32: ENERGY STAR HOMES

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

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

Residential Clothes Washers

ENERGY STAR qualified residential clothes washers wash more clothes per load than standard clothes washers and use less water and energy to do so. This calculation is comparing the annual energy savings resulting from purchasing an ENERGY STAR qualified clothes washer (MEF ≥ 1.8) over a standard clothes washer with the federal standard (MEF$\geq$1.26). Tiers 1, 2, 3 rated clothes washers (MEF$\geq$1.80, 2.00, 2.20 respectively) were also compared to a standard washer.

A spreadsheet calculation was performed using industry data put together by the US Department of Energy Life Cycle Calculator, Wisconsin Focus on Energy and EPA.

Algorithms

Clothes Washers – Electric Water Heating, Electric Dryer

Baseline Electric Energy = $kWh_{baseline}$ = (kWh_{washer} + kWh_{dryer}) X LOAD

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = (kWh_{washer} + kWh_{dryer}) X LOAD

Electric Energy Savings = ΔkWh = $kWh_{baseline}$ – $kWh_{energy\ efficient\ measure}$

Non-Coincident Electric Demand Savings = ΔkW = ΔkWh/EFLH

Electric Peak Coincident Demand Savings= ΔkW X CF

Clothes Washers – Electric Water Heating, Gas Dryer

Baseline Electric Energy = $kWh_{baseline}$ = kWh_{washer} X LOAD

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = $kWh_{baseline}$ = kWh_{washer} X LOAD

Non-Coincident Electric Demand Savings = ΔkW = ΔkWh/EFLH

Electric Peak Coincident Demand Savings= ΔkW X CF

Clothes Washers – Gas Water Heating, Electric Dryer

Baseline Electric Energy = $kWh_{baseline}$ = kWh_{dryer} X LOAD

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = kWh_{dryer} X LOAD

Non-Coincident Electric Demand Savings = ΔkW = ΔkWh/EFLH

Electric Peak Coincident Demand Savings= ΔkW X CF

Definition of Terms

kWh_{washer}= Calculated annual energy usage of the washer

kWh_{dryer}= Calculated annual energy usage of the dryer

LOAD= number of annual loads or cycles

$kW_{baseline}$= maximum hourly demand of baseline washer

$kW_{energy\ efficient\ measure}$= maximum hourly demand of energy efficient washer

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

EFLH = The Equivalent Full Load Hours of operation for the average unit (hours)

TABLE 33: CLOTHES WASHERS

Component	Type	Value	Sources
kWh_{washer}	Fixed	See Table 34 below	1, 2
kWh_{dryer}	Fixed	See Table 34 below	1, 2
LOAD	Fixed	392 cycles	3
$kW_{baseline}$	Fixed	Calculated	3
$kW_{energy\ efficient\ measure}$	Fixed	Calculated	3
CF	Fixed	0.06	4
EFLH	Fixed	8760	5

TABLE 34: MEF & KWH/LOAD VALUES

	Conventional	Energy Star/CEE Tier 1	CEE Tier 2	CEE Tier 3
MEF	1.26	1.80	2.00	2.20
Electric Water Heating kWh/Load	0.819	0.387	0.311	0.263
Electric Dryer kWh/Load	1.27	1.055	0.975	0.896

Effective Measure Life

14 years (DEER)

Incremental Capital Cost

$347 per unit less ENERGY STAR/CEE Tier1, $475 per unit CEE Tier 2, $604 per unit CEE Tier 3 (DEER)

Sources:

1. U.S. Department of Energy
2. Consortium for Energy Efficiency
3. ENERGY STAR Clothes Washer Calculator; used assumed loads for residential and commercial clothes washers
4. Technical Reference User Manual (TRM) No. 4-19, Efficiency Vermont, 9/5/2003
5. Engineering judgment – only used for estimating demand savings

ENERGY STAR Products

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

ENERGY STAR Appliances

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.

Algorithms

ENERGY STAR Refrigerators

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

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

ENERGY STAR Clothes Washers

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

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

ENERGY STAR Dishwashers

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

Demand Impact (kW) = $DSav_{REF}$ 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) = ΔkW X HOURS

Definition of Terms

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

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

$ESav_{DW}$ = 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_{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 35: ENERGY STAR APPLIANCES

Component	Type	Value	Sources

Component	Type	Value	Sources
$ESav_{REF}$	Fixed	see Table 36 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
$ESav_{DW}$	Fixed	see Table 36 below	12
$DSav_{DW}$	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 36 below	12
$DSav_{DH}$	Fixed	.0098 kW	10
$ESav_{RAC}$	Fixed	see Table 36 below	12
$DSav_{RAC}$	Fixed	0.1018 kW	6
CF_{REF}, CF_{DW}, CF_{DH}, CF_{RAC}	Fixed	1.0, 1.0, 1.0, 0.89	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

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 "United Illuminating Company and Connecticut Light & Power Final Report, 2005 Coincidence Factor Study", January 4, 2007, prepared by RLW Analytics.
8. Prorated based on six months in the summer period and six 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 36: 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)	
Cincinnati	94 kWh (996 hours)
Cleveland	60 kWh (639 hours)
Columbus	78 kWh (828hours)
Dayton	89 kWh (947 hours)

Akron	67 kWh (714 hours)
Toledo	61 kWh (649hours)
Mansfield	67 kWh (711 hours)
Dishwasher	
With Gas Hot Water Heater	77 kWh
With Electric Hot Water Heater	137 kWh
Clothes Washer	
With Gas Hot Water Heater	26 kWh
With Electric Hot Water Heater	258 kWh

Low-Flow Showerhead

A low-flow showerhead uses less water than a regular showerhead, hence saving energy by reducing the amount of water that is to be heated. To calculate energy savings baseline and efficient water use is first calculated using data from the Building America Benchmark (BABM). BABM was again used to determine the hot water set point and mains water temperature.

Algorithms

Electricity Impact (kWh) = $\sum_{i=1 \text{ to } 12}$ [{8.33 X GPD X DM_i X NUMPEOPLE X SHWR X ($GPM_{LOWFLOW}$ / GPM_{BASE}) X (T_{SET}-$T_{i\ MAINS}$) X C_i} / 3413] / EF

Demand Impact (kW) = ELECTRICITY IMPACT X BABF / 365

Definition of Terms

GPD = Average daily water consumption per person (gallons/day).

DM = Days in a month

NUMPEOPLE = Number of full time residents in household

SHWR = Multiplier for water consumption dedicated to showers only.

$GPM_{LOWFLOW}$ = Flow rate of low-flow showerhead gallons per minute

GPM_{BASE} = Flow rate of base showerhead in gallons per minute

T_{SET} = Set point temperature of water heating element in degrees °F

$T_{i\ MAINS}$ = Mains water temperature for a particular month in degrees °F

C_i = Multiplier to get mixed water temperature for that month

8.33 = Conversion factor (Btu / gallons - °F)

3413 = Conversion factor, (Btu / kWh)

EF = Energy factor of the domestic water heating tank

BABF = Building America Benchmark Factor. Demand savings are calculated by equally distributing energy savings to a daily basis and then applying the hourly value sourced from the "Building America Research Benchmark Definition." This implies coincidence as well as diversity.

TABLE 37: LOW FLOW SHOWERHEAD

Component	Type	Value	Sources
GPD	Fixed	See Table 38 Below	1
NUMPEOPLE	Variable		
SHWR	Fixed	25%	2
DM	Variable	28,30,31	
$GPM_{LOWFLOW}$	Variable	Based on Low-flow showerhead installed	
GPM_{BASE}	Fixed	2.5 GPM	
T_{SET}	Fixed	120 F	2
T_{MAINS}	Variable	Monthly. See Table 39 Below	3
C_i	Variable	Shown in Table 40	5
BABF	Fixed	0.0417	2
EF	Fixed	0.864 for electric water heaters 0.544 for gas water heaters	2

Estimated Useful Life

The estimated useful life for a low flow showerhead is 10 years.

Measure Costs

The estimated incremental cost for a low flow showerhead is $45.96.

Sources:

1. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Multifamily Programs", New York Department of Public Service, July, 2009.
2. Building America Research Benchmark Definition, National Renewable Energy Laboratory, December, 2006.
3. This is a user entered value. The range given here is based on the measure definition.
4. Building America Research Benchmark Definition, National Renewable Energy Laboratory, December, 2006. Water mains temperatures in Table 39.

Table 38: Hot Water Use By Household Size

Number of people	Gal/person-day
2	18
3	22
4	16
5 or more	12

Source: New York Department of Public Service

Table 39: Monthly Mains Water Temperature for Selected Cities (°F)

	Cincinnati	Cleveland	Columbus	Dayton
January	49.1	47.1	48.6	47.0
February	48.0	45.8	47.4	45.8
March	50.0	47.3	49.1	47.4
April	54.4	51.1	53.1	51.4
May	60.1	56.3	58.4	56.8
June	65.7	61.4	63.6	62.3
July	69.7	65.2	67.4	66.2
August	71.0	66.7	68.7	67.7
September	69.3	65.5	67.3	66.4
October	65.1	61.8	63.5	62.5
November	59.4	56.7	58.2	57.1
December	53.7	51.5	52.9	51.7
Annual Average	59.7	56.4	58.2	56.9
Annual Average-All Cities	57.8			

5. Mixed water temperature is assumed to be 105 F, the multiplier is calculated as $(T_{MIX} - T_{MAINS})/(T_{SET} - T_{MAINS})$

Table 40: Monthly Mixed Water Temperature Multiplier

Mixed Water Temperature Multiplier	
January	0.80
February	0.80
March	0.80
April	0.78
May	0.77
June	0.75

July	0.73
August	0.72
September	0.73
October	0.74
November	0.76
December	0.78

Residential ENERGY STAR Lighting

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.

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

Algorithms

ENERGY STAR CFL Bulbs

Electricity Impact (kWh) = (($Watt_{INC}$ – $Watt_{CFL}$) X (CFL_{hours} X 365))/1000) X ISR_{CFL} X (1+IF)

Peak Demand Impact (kW) = ($Watt_{INC}$ – $Watt_{CFL}$) X Light CF X (1+IF)

ENERGY STAR Torchieres

Electricity Impact (kWh) = (($Torch_{watts}$ X ($Torch_{hours}$ X 365))/1000) X ISR_{Torch} X (1+IF)

Peak Demand Impact (kW) = ($Torch_{watts}$) X Light CF X (1+IF)

ENERGY STAR Indoor Fixture

Electricity Impact (kWh) = ((IF_{watts} X (IF_{hours} X 365))/1000) X ISR_{IF} X (1+IF)

Peak Demand Impact (kW) = (IF_{watts}) X Light CF X (1+IF)

ENERGY STAR Outdoor Fixture

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

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

Ceiling Fan with ENERGY STAR Light Fixture

Energy Savings (kWh) =180 kWh

Demand Savings (kW) = 0.01968

Definition of Terms

$Watt_{INC}$ = Wattage of Incandescent removed

$Watt_{CFL}$ = Wattage of ENERGY STAR CFL installed

IF = Interactive Factor. This represents the secondary demand and energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage.

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 torchiere

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

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

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

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

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

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

Light CF = Summer demand coincidence factor.

TABLE 41: ENERGY STAR LIGHTING

Component	Type	Applicability Conditions	Sources
$Watt_{INC}$	Fixed	From Table 41 Below	1
$Watt_{CFL}$	Variable		Data Gathering

Component	Type	Applicability Conditions	Sources
CFL_{hours}	Fixed	3.63	5
IF	Fixed		
ISR_{CFL}	Fixed	100%	4
$Torch_{watts}$	Fixed	115.8	2
$Torch_{hours}$	Fixed	3.0	3
ISR_{Torch}	Fixed	100%	4
In_{watts}	Fixed	48.7	2
In_{hours}	Fixed	2.6	3
ISR_{In}	Fixed	100%	4
Out_{watts}	Fixed	94.7	2
Out_{hours}	Fixed	4.5	3
ISR_{Out}	Fixed	100%	4
Light CF	Fixed	15%	5

TABLE 42: EQUIVALENT WATTAGE RANGE OF CFL LAMPS FOR REPLACING INCANDESCENT LAMPS[1]

Energy Use for Incandescent Lamps (in watts)	Minimum Light Output (in lumens)	Energy Use for common ENERGY STAR qualified CFLs (in watts)
25	250	4 to 9
40	450	9 to 13
60	800	13 to 15
75	1100	18 to 25
100	1600	23 to 30
125	2000	28 to 40
150	2600	30 to 52

Sources:

1. ENERGY STAR Website, Frequently Asked Questions: Answer ID 2563. 17 June 2008. Web. <http://energystar.custhelp.com/cgi-bin/energystar.cfg/php/enduser/std_adp.php?p_faqid=2563&p_sid=e5iYhSIj&p_lva=2562&p_accessibility=0&p_redirect=&p_sp=cF9zcmNoPTEmcF9zb3J0X2J5PSZwX2dyaWRzb3J0PSZwX3Jvd19jbnQ9NSw1JnBfcHJvZHM9MCZwX2NhdHM9JnBfcHY9JnBfY3Y9JnBfcGFnZT0xJnBfc2VhcmNoX3RleHQ9bHVtZW4%2A&p_li=>. 24 Sept. 2009.
2. 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)
3. 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.

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 % 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. US Department of Energy, ENERGY STAR Calculator. Accessed 3-16-2009.
5. "An Evaluation of ENERGY STAR Products: Results of a Process and Impact Evaluation of Duke Energy's CFL Promotion and Lighting Logger Programs", Prepared by TecMarket Works for Duke Energy, September, 2008.

LED Holiday Lights

LED Holiday lights use light emitting diodes instead of the incandescent bulbs typically found in seasonal decorations and displays.

Algorithms

Electricity Impact (kWh) = NUMSTRINGS X ($WATTS_{BASE}$ – $WATTS_{LED}$) / 1000 X HOURS

Demand Impact (kW) = NUMSTRINGS X ($WATTS_{BASE}$ – $WATTS_{LED}$) / 1000 X CF

Interactive impacts on HVAC ignored because of the short period of use and disconnect of this measure's time of use from summer peak.

Definition of Terms

NUMSTRINGS = Number of strings (or strands) of LED lights being installed. Assumes that 4 strings of LED lights containing 70 lamps per string (280 total) will replace one string of 300 incandescent bulbs

$WATTS_{BASE}$ = Power demand of light strand to be replaced (W). Mini-light strings require 0.48W/lamp. A typical "string" of holiday lights has 300-500 individual lights.

$WATTS_{LED}$ = Power demand of LED strand being installed (W)

HOURS = Hours per year that lights are in use (hours)

CF = Coincidence Factor, ratio of demand at the time of system peak to the total connected load

TABLE 43: LED HOLIDAY LIGHTS

Component	Type	Value	Sources
NUMSTRINGS	Variable		
$WATTS_{BASE}$	Fixed	144W	1
$WATTS_{LED}$	Fixed	14 W	1
HOURS	Fixed	150 hrs/year (5 hr/day, 30 days/yr)	1
CF	Fixed	0	Engineering Estimate

Estimated Useful Life

The estimated useful life for LED holiday lights is 16 years.

Measure Costs

The estimated incremental cost for LED holiday lights is $10.00.

Sources:

1. "Energy Efficiency Fact Sheet, Holiday Lights" Washington State University, 2007. http://www.energyideas.org/documents/factsheets/holidaylighting.pdf

LED Night Light

An LED night light offers a low cost, high efficiency alternative to the traditional incandescent night lights typically used. LEDs are particularly well suited to this end use because of the low levels of light required for the task. Red LEDs have the added advantage in that their color spectrum has less of an impact on circadian rhythms than sources that produce white light.

Algorithms

Electricity Impact (kWh) = $(DEMAND_{BASE} - DEMAND_{LED}) / 1000 \times HOURS$

Demand Impact (kW) = $(DEMAND_{BASE} - DEMAND_{LED}) / 1000 \times CF$

Definition of Terms

$DEMAND_{BASE}$ = Power demand of old light being replaced (W)

$DEMAND_{LED}$ = Power demand of LED night light being installed (W)

HOURS = hours per year that light is in use (hours).

CF = Coincidence Factor, probability of light being in use at the time of system peak (%).

Interactive impacts ignored due to the relative impact of night lights relative to typical HVAC loads.

Definition of Terms

TABLE 44: LED NIGHT LIGHT

Component	Type	Value	Sources
DEMANDBASE	Fixed	5W (typical C7 lamp)	1
DEMANDLED	Fixed	0.33W	2
HOURS	Fixed	2920 (8hr/day X 365days/yr)	
CF	Fixed	0	

Estimated Useful Life

The estimated useful life for an LED night light is 16 years.

Measure Costs

The estimated incremental capital cost for this measure is $3.00.

Sources:
1. http://www.hardwareandtools.com/invt/u578995
2. http://members.misty.com/don/nitelite.html

LED Exit Sign

This measure applies to illuminated exit signs found in all commercial buildings, as required by code. Signs can be one or two sided with an LED model expected to replace either an incandescent or fluorescent model.

Algorithms

Electricity Impact (kWh) = ($WATTS_{BASE}$ – $WATTS_{LED}$) / 1000 X HOURS X ($1+IF_E$)

Demand Impact (kW) = ($WATTS_{BASE}$ – $WATTS_{LED}$) / 1000 X CF X ($1+IF_D$)

Definition of Terms

$WATTS_{BASE}$ = Power demand of sign to be replaced (W)

$WATTS_{LED}$ = Power demand of LED sign being installed (W)

HOURS = hours per year that sign is in use (hours)

CF = Coincidence Factor, probability of sign being in use at the time of system peak (%)

IF_E = HVAC Interactive Factor, Electricity - fractional decrease in annual electricity use due to reduced operation of HVAC equipment used to remove sensible heat from lights.

IF_D = HVAC Interactive Factor, Demand - fractional increase in demand savings due to reduced operation of air conditioning equipment during summer peak period

TABLE 45: LED LIGHTING FOR MULTIFAMILY RESIDENTIAL

Component	Type	Value	Sources
$WATTS_{BASE}$	Fixed	31.0	1
$WATTS_{LED}$	Fixed	3.8	1
HOURS	Fixed	8760	1
CF	Fixed	1	1
IF_E	Variable	-0.04	EDU Data Gathering
IF_D	Variable	0.14	EDU Data Gathering

Estimated Useful Life

The estimated useful life for an LED exit sign is 16 years.

Measure Costs

The estimated incremental cost for an LED exit sign is $101.50.

Sources:

1. Efficiency Maine Commercial Technical Reference Manual No. 2006-1

Occupancy Sensor Lighting Control for Multifamily Common Area

Energy and demand savings are calculated for the installation of occupancy sensors in common areas of multifamily buildings. Common areas include laundry rooms, common restrooms, and other areas of "uneven" usage patterns.

Algorithms

WATTS / 1000 X 8760 X ESF

Electricity Impact (kWh) = WATTS / 1000 X 8760 X ESF X (1+ IF_E)

Demand Impact (kW) = WATTS / 1000 X CF X (1+ IF_D)

Definition of Terms

WATTS = the total rated wattage of the lighting fixtures controlled by the sensor

ESF = =Energy savings factor for installation of occupancy sensors in multifamily common areas. Assumes the baseline scenario of no controls and 24-hour use.

CF = Coincidence factor

IF_E = HVAC Interactive Factor, Electricity - fractional decrease in annual electricity use due to reduced operation of HVAC equipment used to remove sensible heat from lights.

IF_D = HVAC Interactive Factor, Demand - fractional increase in demand savings due to reduced operation of air conditioning equipment during summer peak period

TABLE 46: OCCUPANCY SENSORS

Component	Type	Value	Sources
WATTS	Variable		
ESF	Fixed	50%	1
CF	Fixed	1	Engineering Estimate
IF_E	Fixed	-0.04	EDU Data Gathering

Component	Type	Value	Sources
IF_D	Fixed	0.14	EDU Data Gathering

Sources:

1. Ameren Illinois Utilities, Act on Energy Multifamily Programs, "Multifamily Common Area Lighting Program Overview", December, 2008. http://www.actonenergy.com/portals/0/forms/multifamily-common-area-lighting-overview.pdf

Estimated Useful Life

The estimated useful life for a occupancy sensor for common area is 8.8 years.

Measure Costs

The incremental cost for a photocell control for common area is $91.

Photocell Lighting Control for Multifamily Common Area

A Photocell can be used to automatically control either outdoor lamps or indoor lamps adjacent to skylights and windows. When lights need to be on all night (i.e. for security), a photocell provides maximum savings by eliminating the need for manual operation or a more expensive control method such as a seasonal time clock. A single photocell can control multiple lights simultaneously.

Algorithms

Electricity Impact (kWh) = WATTS / 1000 X ($HOURS_{BASE}$ – $HOURS_{PC}$) X ($1+IF_E$)

Demand Impact (kW) = WATTS / 1000 X CF X ($1+IF_D$)

Definition of Terms

WATTS = the rated demand of the light(s) being controlled by the photocell

$HOURS_{BASE}$ = total hours of operation for the light before the photocell is installed

$HOURS_{PC}$ = total hours of operation the light would incur if controlled by a photocell.

CF = Coincidence factor

IF_E = HVAC Interactive Factor, Electricity - fractional decrease in annual electricity use due to reduced operation of HVAC equipment used to remove sensible heat from lights.

IF_D = HVAC Interactive Factor, Demand - fractional increase in demand savings due to reduced operation of air conditioning equipment during summer peak period

TABLE 47: PHOTOCELL LIGHTING

Component	Type	Value	Sources
WATTS	Variable	Site Specific	
$HOURS_{BASE}$	Variable	Depends on whether the lights are controlled by a central switch, individual tenants, or a time clock.	

Component	Type	Value	Sources
$HOURS_{PC}$	Fixed	4380 (8760/2) assumes 12 hours of darkness on average	Engineering Estimate
CF	Variable	Based on Utility Load Profile	
IF_E	Fixed	-0.04	EDU Data Gathering
IF_D	Fixed	0.14	EDU Data Gathering

Estimated Useful Life

The estimated useful life for a occupancy sensor for common area is 8.8 years.

Measure Costs

The incremental cost for a photocell control for common area is $172.

Window Replacement

This section covers replacing existing windows with ENERGY STAR windows. Energy and saving are realized through reductions in the building heating and cooling loads. The approach utilizes DOE-2.2 simulations on a series of residential prototypical building models. The residential simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Ohio climate and building practices. Energy and demand impacts are normalized per 100 square feet of conditioned floor area.

Algorithms

Window Replacement

Electricity Impact (kWh) = SF_{WINDOW} / 100 X (ΔKWH/100 SF_{WINDOW})

Demand Impact (kW) = SF_{WINDOW} /100 X (ΔKW/100 SF_{WINDOW}) X CF_S

Definition of Terms

ΔKWH/100SF_{WINDOW} = unit energy savings per 100 square feet of window installed

ΔKW/100SF_{WINDOW} = unit demand savings per 100 square foot of window installed

SF_{FLOOR} = window glazing area in square feet, not including frame.

CF_s = summer coincident peak factor

TABLE 48: WINDOW REPLACEMENT

Component	Type	Value	Sources
SF_{WINDOW}	Variable		EDC Data Gathering
ΔKWH/100SF_{WINDOW}	Fixed	Akron: 351kWh/100SF Cincinnati: 348 kWh/100SF Cleveland: 361 kWh/100SF Columbus: 322 kWh/100SF Dayton: 351 kWh/100SF Mansfield: 356kWh/100SF Toledo: 355kWh/100SF	1

Component	Type	Value	Sources
$\Delta KW/100SF_{WINDOW}$	Fixed	Akron: 0.173 kW/100SF Cincinnati: 0.161 kW/100SF Cleveland: 0.188 kW/100SF Columbus: 0.161 kW/100SF Dayton: 0.180 kW/100SF Mansfield: 0.155 kW/100SF Toledo: 0.173 kW/100SF	1
CF_a	Fixed	0.71	2

Sources:

1. Window replacement savings calculations extracted from simulations conducted for Duke Energy. Simulation methodology described in "An Evaluation of the Smart Saver Program in Ohio, Results of a Process and Impact Evaluation," conducted by TecMarket Works for Duke Energy, September, 2008. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the residential HVAC end-use.

Residential Solar Hot Water Heater

A solar hot water heater reduces the amount of energy needed to heat water for domestic purposes by using the heat radiated from the sun. The amount of energy saved is calculated by first estimating the base energy use and then multiplying it with the solar fraction of the system.

Algorithms

Electricity Impact (kWh) = $\sum_{i=1 \text{ to } 12}$ [{8.33 X (NUMPEOPLE X GPD X NUMDAYS*i*) /3413} X (T_{SET}-$T_{i\ MAINS}$) X SF] / EF

Demand Impact (kW) = ELECTRICITY IMPACT X BABF / 365

Definition of Terms

3413 = Conversion factor, (Btu / kWh)

8.33 = Conversion factor (Btu / gallons - °F)

NUMPEOPLE = Number of full time residents in house

GPD= average daily water consumption (gallons/day)

NUMDAYS = Number of days in month

T_{SET} = Set point temperature of water heating element in degrees °F

$T_{i\ MAINS}$ = Mains water temperature for a particular month in degrees °F

BABF = Building America Benchmark Factor. Demand savings are calculated by equally distributing energy savings to a daily basis and then applying the hourly value sourced from the "Building America Research Benchmark Definition." This implies coincidence as well as diversity.

SF = Solar fraction of the solar hot water heating system

TABLE 49: RESIDENTIAL SOLAR HOT WATER HEATER

Component	Type	Value	Sources
NUMPEOPLE	Variable		
GPD	Fixed	See Table 49 Below	2
NUMDAYS	Fixed	28,30,31	

Component	Type	Value	Sources
TSET	Fixed	120 F	1
TMAINS	Variable	Shown in Table 50	1
BABF	Fixed	0.0417	1
EF	Fixed	0.864 for electric water heaters 0.544 for gas water heaters	1
SF	Variable		

Estimated Useful Life

The estimated useful life for Solar DHW is 15 years.

Measure Costs

The incremental capital cost for residential solar hot water heater is $4500.00.

Sources:

1. Building America Research Benchmark Definition, National Renewable Energy Laboratory, December, 2006.
2. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Multifamily Programs", New York Department of Public Service, July, 2009.

TABLE 50: HOT WATER USE BY HOUSEHOLD SIZE

Number of people	Gal/person-day
2	18
3	22
4	16
5 or more	12

Source: New York Department of Public Service

TABLE 51: MONTHLY MAINS WATER TEMPERATURE FOR SELECTED CITIES (°F)

	Cincinnati	Cleveland	Columbus	Dayton
January	49.1	47.1	48.6	47.0
February	48.0	45.8	47.4	45.8
March	50.0	47.3	49.1	47.4
April	54.4	51.1	53.1	51.4
May	60.1	56.3	58.4	56.8
June	65.7	61.4	63.6	62.3

July	69.7	65.2	67.4	66.2
August	71.0	66.7	68.7	67.7
September	69.3	65.5	67.3	66.4
October	65.1	61.8	63.5	62.5
November	59.4	56.7	58.2	57.1
December	53.7	51.5	52.9	51.7
Annual Average	59.7	56.4	58.2	56.9
Annual Average-All Cities	57.8			

Heat Pump Water Heaters

Heat pump water heaters (HPWHs) can be added to existing domestic hot water (DHW) systems to improve the overall efficiency. HPWHs utilize refrigerants (like an air source heat pump) and have much higher coefficients of performance (COP) than standard electric waters. HPWHs remove waste heat from surrounding air sources and preheat the DHW supply system. HPWHs come in a variety of sizes and the size of HPWH will depend on the desired temperature output and amount of hot water needed by application. The savings from water heater heat pumps will depend on the design, size (capacity), water heating requirements, building application and climate. Typically a 35 percent overall savings can be achieved if properly designed and installed.

Algorithms

Energy Savings (kWh) = (GPD X 8.33 X ΔT_w) / (3413 X $E_{t,b}$) X ESF

Demand Savings (kW) = (GPH X 8.33 X ΔT_w) / (3413 X $E_{t,b}$)

Definition of Variables

GPD = average daily water consumption (gallons/day)
GPH = Hourly water consumption (gallons/hour)
$E_{t,b}$ = baseline water heater thermal efficiency
ESF = energy saving factor
ΔT_s =temperature difference between the supply cold water temperature and the hot water deliver temperature (^oF)
CF = coincidence factor
365 = conversion factor (days/yr)
8.33 = conversion factor (Btu/gallon - ^oF)
3413 = conversion factor (Btu/kWh)

Effective Measure Life

10 years (DEER Database)

Coincidence Factor

.06 (based on Ohio utility supply profiles)

Incremental Cost

$1,500 installed cost, (1-ton unit, engineering estimate).

TABLE 52: DOMESTIC HOT WATER – WATER HEATER HEAT PUMPS

Component	Type	Value	Source
GPD	Variable	Based on customer water consumption	EDU Data Gathering
GPH	Variable	Based on customer water consumption per hour.	EDU Data Gathering
ΔT_w	Variable	Based on customer water heater set point and incoming water temperature.	EDU Data Gathering
$E_{t,b}$	Variable	Based on water heater system efficiency.	EDU Data Gathering
ESF	35%	Energy savings factor	Engineering estimate
CF	Fixed	.06.	Engineering estimate

Residential Domestic Hot Water - High Efficiency Water Heaters

The savings from high efficiency water heaters related to the insulation level will depend on the size (capacity), load requirements, insulation levels, and climate. Typically a 5-10 percent savings can be achieved.

Algorithms

Electric Domestic Hot Water:

Energy Savings (kWh) = $((UA_{BASE} - UA_{EE}) \text{ X } \Delta T_s \text{ X } 8760) / 3413$

Demand Savings (kW) = $(UA_{BASE} - UA_{EE}) \text{ X } \Delta T_s \text{ X } CF) / 3413$

Definition of Variables

UA_{BASE} = overall heat loss coefficient of baseline water heater (Btu/hr - °F). Where,

$$UA_{BASE} = (1 / EF_{BASE}) - (1 / RE) / [67.5 \text{ X } \{0.000584 - (1 / (RE \text{ X } CAP_{BASE}))\}]$$

UA_{EE} = overall heat loss coefficient of high efficiency water heater (Btu/hr - °F). Where,

$$UA_{EE} = (1 / EF_{EE}) - (1 / RE_{EE}) / [67.5 \text{ X } \{0.000584 - (1 / (RE \text{ X } CAP_{EE}))\}]$$

ΔT_s =temperature difference between the stored hot water and the surrounding air (°F)

CF = coincidence factor

8760 = Number of hours in year

3413 = conversion factor (Btu/kWh)

67.5 = conversion factor

0.000584 = conversion factor

TABLE 53: DOMESTIC HOT WATER – HIGH EFFICIENCY WATER HEATERS

Component	Type	Value	Source
UABASE	Variable	Calculated based on customer data	Engineering estimate
UAEE	Variable	Calculated based on customer data	Engineering estimate
RE	Fixed	See Table XXX Below	1
EF_{BASE}	Variable	Based on current water heater system.	
EF_{EE}	Variable	Based on proposed water heater system	
CAP_{BASE}	Variable	Based on current water heater system.	
CAP_{EE}	Variable	Based on proposed water heater system	

Component	Type	Value	Source
ΔT_s	Variable	Based on customer water heater set point and surrounding air temperature	Engineering estimate
CF	Fixed	0.0417	Engineering estimate

TABLE 54: RECOVERY EFFICIENCIES FOR BASELINE AND EFFICIENT WATER HEATERS

Water Heater Type	Recovery efficiency
Electric	0.97
Gas	0.75

Effective Measure Life

13 years

Coincidence Factor

0.0417

Sources:

Algorithm: Source: Lawrence Berkeley National Laboratory (LBNL), "Calculating Water Heater Energy Use and Standby Losses", 1999.

1. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Multifamily Programs", New York Department of Public Service, July, 2009

Drain Water Heat Recovery

The most common method for estimating savings from drain water waste heat recovery uses the relatively simple and effective Number of Transfer Units (NTU) method. The primary inputs for this calculation are the discharge temperature (i.e., the water temperature coming into the heat recovery device), the heat exchanger's effectiveness ratio, the average temperature of the water entering from the city water main, and the efficiency of the primary water heater (boiler, tank, etc). The number of people per household is the key input from the customers.

Algorithms

Electricity Impact (kWh) = [{EFFECTIVENESS X (8.33 X GPD X NUMPEOPLE X SHWR X 365) X (TEMPDRAIN – TEMPMAINS)} / 3413] / RECOVERYEFF

Demand Impact (kW) = ELECTRICITYIMPACT X BABF / 365

Definition of Terms

EFFECTIVENESS = Heat exchanger effectiveness derived from manufacturer provided data as found in Natural Resources Canada study

GPD = Average daily water consumption per person (gallons/day).

NUMPEOPLE = Number of full time residents in household

SHWR = Multiplier for water consumption dedicated to showers only.

TEMPDRAIN = Temperature of water entering drain from shower.

TEMPMAINS = Temperature of water entering house from main water pipe. Temperature varies monthly and by region, as noted in table below. Annual average utilized for this estimate.

RECOVERYEFF = Tank recovery efficiency.

BABF = Building America Benchmark Factor. Demand savings are calculated by equally distributing energy savings to a daily basis and then applying the hourly value sourced from the "Building America Research Benchmark Definition." This implies coincidence as well as diversity.

3413 = Conversion factor, (Btu / kWh)

8.33 = Conversion factor (Btu / gallons - °F)

TABLE 55: DRAIN WATER HEAT RECOVERY

Component	Type	Value	Sources
EFFECTIVENESS	Fixed	45.4%	1
GPD	Fixed	See Table 55 Below	3
NUMPEOPLE	Variable		
SHWR	Fixed	25%	2
TEMPDRAIN	Fixed	95°F	Engineering Estimate
TEMPMAINS	Fixed	57.8°F	4
BABF	Fixed	0.0417	2

Estimated Useful Life

The estimated useful life for a drain water heat recovery system is 20 years.

Measure Costs

The incremental cost for a drain water heat recovery system is $742.00.

Sources:

1. Natural Resources Canada, "Drain Water Heat Recovery Characterization and Modeling" June 29, 2007
2. Building America Research Benchmark Definition, National Renewable Energy Laboratory, December, 2006.
3. "New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Multifamily Programs", New York Department of Public Service, July, 2009.
4. Building America Research Benchmark Definition, National Renewable Energy Laboratory, December, 2006. Water mains temperatures in Table XXX

TABLE 56: HOT WATER USE BY HOUSEHOLD SIZE

Number of people	Gal/person-day
2	18
3	22
4	16
5 or more	12

Source: New York Department of Public Service

TABLE 57: WATER MAINS TEMPERATURES FOR SELECT CITIES

	Cincinnati, OH	**Cleveland, OH**	**Columbus, OH**	**Dayton, OH**
January	49.1	47.1	48.6	47.0
February	48.0	45.8	47.4	45.8
March	50.0	47.3	49.1	47.4
April	54.4	51.1	53.1	51.4
May	60.1	56.3	58.4	56.8
June	65.7	61.4	63.6	62.3
July	69.7	65.2	67.4	66.2
August	71.0	66.7	68.7	67.7
September	69.3	65.5	67.3	66.4
October	65.1	61.8	63.5	62.5
November	59.4	56.7	58.2	57.1
December	53.7	51.5	52.9	51.7
Annual Average	59.7	56.4	58.2	56.9
Annual Average-All Cities	57.8			

Domestic Hot Water – Insulation Wraps

The savings from insulation wraps or blankets will depend on the size (capacity), insulation levels and climate. Typically a 5 percent energy savings can be achieved.

Algorithms

Energy Savings (kWh) = $((UA_{base} - UA_{ee}) \times 365 \times 24 \times \Delta T_s) / 3413$

Demand Savings (kW) = $(UA_{base} - UA_{ee}) \times \Delta T_s \times CF) / 3413$

Definition of Variables

UA_{base} = overall heat loss coefficient of baseline water heater (Btu/hr - ^oF)

UA_{ee} = overall heat loss coefficient of water heater (Btu/hr - ^oF)

ΔT_s =temperature difference between the stored hot water and the surrounding air (^oF)

CF = coincidence factor

365 = conversion factor (days/yr)

3413 = conversion factor (Btu/kWh)

TABLE 58: DOMESTIC HOT WATER – INSULATION WRAP

Component	Type	Applicability Conditions	Source
UA_{base}	Variable	Based on current pipe insulation.	1, EDU Data Gathering
UA_{ee}	Variable	Based on proposed pipe insulation	EDU Data Gathering based on insulation level of wrap
ΔT_s	Variable	Based on customer water heater set point and surrounding air temperature	3
CF	Fixed	.06.	2

Effective Measure Life

7 years, GDS Associates Inc.

Coincidence Factor

.06 (based on Ohio utility supply profiles)

Incremental Cost

$28 per warp, 50 gallon tank, DEER cost database.

Sources:

1 Building America Benchmark Analysis
2 AEP Ohio coincidence factors for peak hours
3. Water Mains temperatures for AEP-Ohio and AEP-Columbus
4. Lawrence Berkeley National Laboratory (LBNL), "Calculating Water Heater Energy Use and Standby Losses", 1999.

TABLE 59: WATER MAINS TEMPERATURES

Water Mains Temperatures	North (AEPOhio)	South (AEPColumbus)
January	46.2	48.6
February	44.9	47.4
March	46.4	49.1
April	50.3	53.1
May	55.6	58.4
June	60.9	63.6
July	64.9	67.4
August	66.4	68.7
September	65.2	67.3
October	61.5	63.5
November	56.3	58.2
December	50.9	52.9

TABLE 60: UA VALUES BASED ON HOUSING TYPE

Housing Type	Tank UA Values (BTU/hr-°F)
Single Family New	5.445
Single Family Existing	4.336
Multi-Family	3.964

Mobile Home	3.964

Domestic Hot Water – Pipe Insulation

The savings from insulating piping is associated with domestic hot water (DHW) system distribution system and will depend on the size of the pipe, current and proposed insulation levels, building application and climate. Typically a 5 percent savings in distribution losses can be achieved.

Algorithms

Energy Savings (kWh) = $((UA_{base} - UA_{ee}) \times 365 \times 24 \times \Delta T_s) / 3413$

Demand Savings (kW) = $(UA_{base} - UA_{ee}) \times \Delta T_s \times CF) / 3413$

Definition of Variables

UA_{base} = overall heat loss coefficient of baseline pipe (Btu/hr - ^oF/foot)

UA_{ee} = overall heat loss coefficient of insulated pipe (Btu/hr - ^oF/foot)

ΔT_s =temperature difference between the pipe and surrounding air for first 8 feet. (^oF)

CF = coincidence factor

365 = conversion factor (days/yr)

3413 = conversion factor (Btu/kWh)

TABLE 61: DOMESTIC HOT WATER – PIPE INSULATION

Component	Type	Applicability Conditions	Source
$UA_{base\ pipe}$	Variable	Based on current pipe thermal properties.	EDU Data Gathering
$UA_{ee\ pipe}$	Variable	Based on proposed pipe thermal properties with insulation.	EDU Data Gathering (based on proposed system)Engineering estimate
ΔT_s	Variable	Based on customer water distribution, water heater set point and surrounding air temperature	3
CF	Fixed	.06	2

Effective Measure Life

15 years, GDS Associates, Inc.

Coincidence Factor

.06 (based on Ohio utility supply profiles)

Incremental Cost

$23, (based on $2.80/liner foot at 8 foot length, DEER cost database.

Sources:

1. Building America Benchmark Analysis
2. AEP Ohio coincidence factors for peak hours
3. Water Mains temperatures for AEP-Ohio and AEP-Columbus
4. Lawrence Berkeley National Laboratory (LBNL), "Calculating Water Heater EnergyUse and Standby Losses", 1999.
5. IECC International Energy Conservation Code, 2006, Page 22

TABLE 62: WATER MAINS TEMPERATURES

Water Mains Temperatures	North (AEPOhio)	South (AEPColumbus)
January	46.2	48.6
February	44.9	47.4
March	46.4	49.1
April	50.3	53.1
May	55.6	58.4
June	60.9	63.6
July	64.9	67.4
August	66.4	68.7
September	65.2	67.3
October	61.5	63.5
November	56.3	58.2
December	50.9	52.9

TABLE 63: UA VALUES BASED ON ¾ STEEL PIPE FOR FIRST 8 FEET

Description	PipeUA Values (BTU/in/h X Ft^2)

Residential Applications	.5

Residential Pool Pump - Variable Speed Drive (VSD)

The measurement of energy and demand savings for the replacement of a standard residential pool pump with a new pump equipped with variable speed drive (VSD) control.

Algorithms

Electricity Impact (kWh) = ΔkW X POOLDAYS X HOURS

Demand Impact (kW) = HP X 0.7457 X $[(LF_{BASE} / \eta_{MOTOR/BASE}) - ((LF_{VSD}{}^{X}) / (\eta_{MOTOR/VSD} \times \eta_{VSD})] \times CF$

Definition of Terms

ΔkW = Demand impact in kW

POOLDAYS = Number of days pool pump operates in a year. Assumed Memorial day to Labor Day

HP = Horsepower rating of pump motor

LF_{BASE} = Load factor for baseline pump motor

LF_{VSD} = Load factor for VSD pump motor

X = Exponent applied to calculate percentage savings at given motor loading *j*. For fan motors X = 2.5, for pump motors X = 2.2

$\eta_{MOTOR/BASE}$ = Motor efficiency at the peak load of baseline pump motor

$\eta_{MOTOR/VSD}$ = Motor efficiency at the peak load of VSD pump motor

η_{VSD} = Effciency loss due to power consumption of VSD controls

HOURS = Hours of daily operation for installed measure. Based on manufacturer's data for hours of operation required to circulate pool water once per day.

CF = coincidence factor

TABLE 64: RESIDENTIAL POOL PUMP - VSD

Component	Type	Value	Sources
HP	Variable		

Component	Type	Value	Sources
LF_{BASE}	Fixed	1	1
LF_{VSD}	Fixed	0.36	1
X	Fixed	2.5	4
$\eta_{MOTOR/BASE}$	Fixed	84.7%	2
$\eta_{MOTOR/VSD}$	Fixed	90%	3
η_{VSD}	Fixed	95%	3
HOURS	Fixed	10	1
CF	Variable	Based on Utility Data	

Estimated Useful Life

The estimated useful life for a variable speed pool pump is 10 years.

Measure Costs

The incremental capital cost for a variable speed pool pump varies by installation type. The incremental cost for a retrofit is $707.73, and $434.41 for a new pump.

Sources:

1. Pentair Pool Pump Energy Savings Calculator - http://www.pentairpool.com/pool_pump_calc/index.htm#
2. Base motor efficiencies are based on NEMA premium TEFC 1.5 HP 1800 RPM motors per the CEE Premium Motors Initiative (www.cee1.org)
3. Variable speed motor efficiencies are based on Permanent Magnet Efficiencies of 93%-95% for full load with less than a 5% drop for reduced loads. (http://www.nrel.gov/docs/fy01osti/26785.pdf).
4. Efficiency Vermont, "Technical Reference Manual (TRM) No. 2006-43", April, 2007, p. 20

ENERGY STAR Audit/Residential Audit Programs

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.

TABLE 65: RESIDENTIAL AUDIT PROGRAMS

Component	Type	Value	Sources
Audit Recommendations	Fixed	375 kWh	1
Audit Recommendations w/ Energy Efficiency Kit	Fixed	200 kWh	2
Per additional CFL bulb offered	Fixed	68 kWh	3
Online Audit	Fixed	300 kWh	4, 5

Sources:

1. Average audit recommendations savings from "Process and Energy Impact Evaluation of the Home Energy House Call Program in Ohio", "Energy Impact Evaluation of the Personalized Energy Report in Kentucky", "[KY] PER Billing Analysis", "Energy Impact and Customer Satisfaction Evaluation of the Personalized Energy Report Program in Ohio", and "Energy Efficiency Website Program Impact Evaluation", prepared by TecMarket Works and Integral Analytics for Duke Energy.
2. Average energy efficiency kit savings from "Energy Impact Evaluation of the Personalized Energy Report in Kentucky" and ""Energy Impact Evaluation of the Personalized Energy Report in Kentucky", prepared by TecMarket Works for Duke Energy.
3. From "An Evaluation of Energy Star Products: Results of a Process and Impact Evaluation of Duke Energy's CFL Promotion and Lighting Logger Programs", prepared by TecMarket Works for Duke Energy.
4. Aclara Software Survey of participating utilities using Aclara's online energy software.
5. California Online Audit Study, Summit Blue. Results adjusted for differences in household characteristics including home square footage and age.

Refrigerator/Freezer and Freezer Retirement

The general form of the equation for the Refrigerator/Freezer and 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).

Algorithms

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

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

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

Demand Impact (kW) = $DSav_{RetFreezer}$ X $CF_{RetFreezer}$<u>Definition of Terms</u>

$ESav_{RetFridge}$ = Gross annual energy savings per retired refrigerator/freezer

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

$CF_{RetFridge}$ = Summer demand coincidence factor for retired refrigerator/freezer.

$ESav_{Freezer}$ = Gross annual energy savings per retired freezer.

$DSav_{Freezer}$ = Summer demand savings per retired freezer.

$CF_{Freezer}$ = Summer demand coincidence factor for retired freezer.

TABLE 66: REFRIGERATOR/FREEZER RECYCLING

Component	Type	Value	Sources
$ESav_{RetFridge}$	Fixed	1647 kWh	1
$DSav_{RetFridge}$	Fixed	0.19 kW	1
$CF_{RetFridge}$	Fixed	1	3
$ESav_{Freezer}$	Fixed	1222 kWh	1
$DSav_{Freezer}$	Fixed	0.14 kW	1
$CF_{Freezer}$	Fixed	1	3

Sources:

1. ADM & Associates 2004-2005 California Statewide Appliance Recycling Program study
2. Coincidence factor already embedded in summer peak demand reduction estimates

Refrigerator Replacement

This program may provide replacements for inefficient or non-working refrigerators in qualifying customer's homes. These refrigerators may be replaced when testing shows that they are inefficient. To determine refrigerator efficiency, two hour metering may be conducted by the Supplier according to certain protocols.

Algorithms

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

Definition of Terms

$ESav_{ReplFridge}$ = Gross annual energy savings per retired refrigerator/freezer

TABLE 67: REFRIGERATOR REPLACEMENT

Component	Value	Sources
kWh	1176	1

Sources:

1. "Low Income Refrigeration Program, Duke Energy Kentucky and Ohio Savings Analysis July 1, 2007 – June 30, 2008", prepared by Morgan Marketing Partners for Duke Energy.

Home Performance with ENERGY STAR

In order to implement Home Performance with ENERGY STAR, there are various standards a program implementer must adhere to in order to deliver the program. The program implementer must use software that meets a national standard for savings calculations from whole-house approaches such as home performance. The software program implementer must adhere to at least one of the following standards:

- A software tool whose performance has passed testing according to the National Renewable Energy Laboratory's HERS BESTEST software energy simulation testing protocol.[3]
- Software approved by the US Department of Energy's Weatherization Assistance Program.[4]
- RESNET approved rating software.[5]

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

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.

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

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

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

Commercial and Industrial Energy Efficient Construction

C&I Electric

Baselines and Code Changes

All baselines are designed to reflect the applicable code or standard. Where a measure is not covered by a code or standard, current market practices that are updated periodically will be used.

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.

C&I Lighting

Algorithms

Energy Savings (kWh) = $(Watt_{base}$ X $\#_{base}) - (Watt_{eff}$ X $\#_{eff})$ X EFLH X $(1 + IF_{kWh})$ / 1000

Demand Savings (kW) = $(Watt_{base}$ X $\#_{base}) - (Watt_{eff}$ X $\#_{eff})$ X CF X $(1 + IF_{kW})$ / 1000

Definition of Terms

$Watt_{base}$ = Baseline Wattage of the fixture removed

$Watt_{eff}$ = Efficient Wattage of the fixture installed

$\#_{base}$ = Number of baseline fixtures removed

$\#_{eff}$ = Number of efficient fixtures installed

IF_{kWh} = Interactive Factor. This represents the secondary energy savings in reduced HVAC consumption resulting from decreased indoor lighting wattage. Only applies to interior fixtures.

IF_{kW} = Interactive Factor. This represents the secondary demand savings in reduced HVAC consumption resulting from decreased indoor lighting wattage. Only applies to interior fixtures.

EFLH = Equivalent full load hours of daily operation for installed measure

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

1000 = Conversion Factor (W/kW)

TABLE 68: ENERGY STAR LIGHTING

Component	Type	Applicability Conditions	Sources
$Watt_{base}$	Fixed	From Table 69 Below	1, 2, 3 and 4
$Watt_{eff}$	Fixed	From Table 69 Below	1, 2, 3 and 4
$\#_{base}$	Variable		
$\#_{eff}$	Variable		
EFLH	Fixed	Office = 3,435 Restaurant = 4,156 Retail = 3,068 Grocery/Supermarket = 4,612 Warehouse = 2,388 School = 2,080 College = 5,010 Health = 3,392 Hospital = 4,532 Hotel/Motel = 2,697 Manufacturing = 5,913 Exterior Lighting = 3,833 Garage = 8,760	5, 6, and 7
IF_{kWh}	Fixed	Interior Fixture= 0.097 Exterior Fixture = 0	8
IF_{kW}	Fixed	Interior Fixture = 0.200 Exterior Fixture = 0	8
CF	Fixed	1	

TABLE 69: FIXTURE TYPE ABBREVIATIONS

Fixture	Type of Fixture
CFL1	One Lamp CFL Fixture
CFL2	Two Lamp CFL Fixture
CFL3	Three Lamp CFL Fixture
Low Bay	Low Bay Fixture
High Bay	High Bay Fixture
HEF	High Efficiency Fluorescent Fixture
EXIT	Exit Sign Fixture
PSMH	Pulse Start Metal Halide Fixture
LBLED	Low Bay LED Fixture
Delamp	Delamping a Fixture
MHTH	Metal Halide Track Head Fixture
CMH	Ceramic Metal Halide Fixture
EXTGAR	Exterior and Garage Fixtures

Table 70: 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.

All Lighting wattages come from the SCE Appendix B: 2009 Table of Standard Fixture Wattages except for lamp types which are denoted with a source reference.

Type of Fixture	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage	Baseline Fixture Wattage	Fixture Savings (watts)
CFL1	One 5W CFL Twin	Magnetic-STD	One 25W Incandescent		9	25	16
CFL1	One 7W CFL Twin	Magnetic-STD	One 40W Incandescent		10	40	30
CFL1	One 9W CFL Twin	Magnetic-STD	One 40W Incandescent		11	40	29
CFL1	One 11W CFL Twin[3]	Magnetic-STD	One 40W Incandescent		13	40	27
CFL1	One 13W CFL Twin	Magnetic-STD	One 60W Incandescent		17	60	43
CFL1	One 18W CFL Twin[2]	Magnetic-STD	One 75W Incandescent		20	75	55
CFL1	One 20W CFL Twin[3]	Magnetic-STD	One 75W Incandescent		22	75	53
CFL1	One 26W CFL Twin[2]	Magnetic-STD	One 100W Incandescent		32	100	68
CFL1	One 28W CFL Twin	Magnetic-STD	One 125W Incandescent		33	125	92
CFL1	One 32W CFL Twin	Electronic	One 125W Incandescent		34	125	91
CFL1	One 36W CFL Twin	Magnetic-STD	One 150W Incandescent		41	150	109
CFL1	One 40W CFL Twin	Magnetic-STD	One 150W Incandescent		46	150	104
CFL1	One 18W CFL Quad	Electronic	One 75W Incandescent		20	75	55
CFL1	One 22W CFL Quad	Magnetic-STD	One 75W Incandescent		24	75	51
CFL1	One 26W CFL Quad	Electronic	One 100W Incandescent		27	100	73
CFL2	Two 5W CFL Twin	Magnetic-STD	One 40W Incandescent		18	40	22
CFL2	Two 7W CFL Twin	Magnetic-STD	One 60W Incandescent		21	60	39

Type of Fixture	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage	Baseline Fixture Wattage	Fixture Savings (watts)
CFL2	Two 9W CFL Twin	Magnetic-STD	One 75W Incandescent		23	75	52
CFL2	Two 11W CFL Twin[3]	Magnetic-STD	One 100W Incandescent		26	100	74
CFL2	Two 13W CFL Twin	Magnetic-STD	One 100W Incandescent		31	100	69
CFL2	Two 18W CFL Twin[2]	Magnetic-STD	One 150W Incandescent		38	150	112
CFL2	Two 26W CFL Twin[2]	Magnetic-STD	One 200W Incandescent		51	200	149
CFL2	Two 40W CFL Twin	Magnetic-STD	One 200W Incandescent		85	200	115
CFL2	Two 18W CFL Quad	Electronic	One 150W Incandescent		38	150	112
CFL2	Two 26W CFL Quad	Electronic	One 200W Incandescent		50	200	150
CFL3	Three 18W CFL Twin[3]	Magnetic-STD	One 200W Incandescent		54	200	146
Low Bay	T-5 46" Two Lamp High Output	Electronic - IS	T-12 48" Three Lamp High Output	Magnetic-STD	117	230	113
Low Bay	T-5 46" Three Lamp High Output	Electronic - IS	T-12 48" Four Lamp High Output	Magnetic-STD	179	290	111
Low Bay	T-5 46" Four Lamp High Output	Electronic - IS	400W Metal Halide		234	458	224
Low Bay	T-5 46" Six Lamp High Output	Electronic - IS	400W Metal Halide		351	458	107
Low Bay	T-8 48" Two Lamp	Electronic - IS	T-12 48" Two Lamp-ES	Magnetic-ES	59	72	13
Low Bay	T-8 48" Three Lamp	Electronic - IS	T-12 48" Three Lamp-ES	Magnetic-ES	89	115	26
Low Bay	T-8 48" Four Lamp	Electronic - IS	T-12 48" Four Lamp-ES	Magnetic-ES	112	144	32
Low Bay	T-8 48" Six Lamp	Electronic - IS	T-12 48" Six Lamp-ES	Magnetic-ES	175	216	41
Low Bay	T-8 96" Two Lamp	Electronic - IS	T-12 96" Two Lamp-ES	Magnetic-ES	109	123	14
Low Bay	T-8 96" Four Lamp	Electronic - IS	T-12 96" Four Lamp-ES	Magnetic-ES	219	246	27
High Bay	T-5 46" Three Lamp High Output	Electronic - IS	T-12 48" 4L F48T12 High Output	Magnetic-STD	179	290	111
High Bay	T-5 46" Four Lamp High Output	Electronic - IS	400W Metal Halide		234	458	224
High Bay	T-5 46" Six Lamp High Output	Electronic - IS	400W Metal Halide		351	458	107
High Bay	T-5 46" Eight Lamp High Output	Electronic - IS	1000W Metal Halide		468	1080	612
High Bay	T-8 48" Three Lamp Very High Output	Electronic - IS	150W Metal Halide		112	190	78

Type of Fixture	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage	Baseline Fixture Wattage	Fixture Savings (watts)
High Bay	T-8 48" Four Lamp Very High Output	Electronic - IS	250W Metal Halide		151	295	144
High Bay	T-8 48" Six Lamp Very High Output	Electronic - IS	400W Metal Halide		226	458	232
High Bay	T-8 96" Four Lamp High Output	Electronic	400W Metal Halide		320	458	138
HEF	T-8 24" One Lamp	Electronic	T-12 24" One Lamp	Magnetic-STD	18	28	10
HEF	T-8 24" Two Lamp	Electronic	T-12 24" Two Lamp	Magnetic-STD	32	56	24
HEF	T-8 24" Three Lamp	Electronic	T-12 24" Three Lamp	Magnetic-STD	50	62	12
HEF	T-8 24" Four Lamp	Electronic	T-12 24" Four Lamp	Magnetic-STD	65	112	47
HEF	T-8 36" One Lamp	Electronic	T-12 36" One Lamp	Magnetic-STD	25	46	21
HEF	T-8 36" Two Lamp	Electronic	T-12 36" Two Lamp	Magnetic-STD	46	81	35
HEF	T-8 36" Three Lamp	Electronic	T-12 36" Three Lamp	Magnetic-STD	70	127	57
HEF	T-8 36" Four Lamp	Electronic	T-12 36" Four Lamp	Magnetic-STD	88	162	74
HEF	T-8 48" One Lamp-28W[2]	Electronic - IS	T-12 48" One Lamp-ES	Magnetic-ES	27	43	16
HEF	T-8 48" Two Lamp-28W[2]	Electronic - IS	T-12 48" Two Lamp-ES	Magnetic-ES	52	72	20
HEF	T-8 48" Three Lamp-28W[2]	Electronic - IS	T-12 48" Three Lamp-ES	Magnetic-ES	76	115	39
HEF	T-8 48" Four Lamp-28W[2]	Electronic - IS	T-12 48" Four Lamp-ES	Magnetic-ES	94	144	50
HEF	T-8 96" One Lamp	Electronic - IS	T-12 96" One Lamp-ES	Magnetic-STD	58	75	17
HEF	T-8 96" Two Lamp	Electronic - IS	T-12 96" Two Lamp-ES	Magnetic-ES	109	123	14
HEF	T-8 96" Four Lamp	Electronic - IS	T-12 96" Four Lamp-ES	Magnetic-ES	219	246	27
HEF	T-8 48" One Lamp-25W[4]	Electronic	T-12 48" One Lamp-ES	Magnetic-ES	25	43	18
HEF	T-8 48" Two Lamp-25W[4]	Electronic	T-12 48" Two Lamp-ES	Magnetic-ES	49	72	23
HEF	T-8 48" Three Lamp-25W[4]	Electronic	T-12 48" Three Lamp-ES	Magnetic-ES	72	115	43
HEF	T-8 48" Four Lamp-25W[4]	Electronic	T-12 48" Four Lamp-ES	Magnetic-ES	94	144	50
HEF	T-8 48" One Lamp-25W[4]	Electronic	T-8 48" One Lamp[4]	Electronic	25	32	7
HEF	T-8 48" Two Lamp-25W[4]	Electronic	T-8 48" Two Lamp	Electronic	49	59	10

Type of Fixture	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage	Baseline Fixture Wattage	Fixture Savings (watts)
HEF	T-8 48" Three Lamp-25W[4]	Electronic	T-8 48" Three Lamp	Electronic	72	89	17
HEF	T-8 48" Four Lamp-25W[4]	Electronic	T-8 48" Four Lamp	Electronic	94	112	18
EXIT	Exit - LED 2W Lamp, Dual Sided		Exit - Two 9W CFL Lamp Fixture	Magnetic-STD	9	20	11
PSMH	Pulse Start Metal Halide 150 W[3]	Magnetic-CWA	Metal Halide 150 W		185	190	5
PSMH	Pulse Start Metal Halide 175 W	Magnetic-CWA	Metal Halide 175 W		208	215	7
PSMH	Pulse Start Metal Halide 200 W	Magnetic-CWA	Metal Halide 250 W		232	295	63
PSMH	Pulse Start Metal Halide 250 W	Magnetic-CWA	Metal Halide 250 W		288	295	7
PSMH	Pulse Start Metal Halide 300 W[3]	Magnetic-CWA	Metal Halide 400 W		342	458	116
PSMH	Pulse Start Metal Halide 320 W	Magnetic-CWA	Metal Halide 400 W		365	458	93
PSMH	Pulse Start Metal Halide 350 W	Magnetic-CWA	Metal Halide 400 W		400	458	58
PSMH	Pulse Start Metal Halide 400 W	Magnetic-CWA	Metal Halide 400 W		456	458	2
PSMH	Pulse Start Metal Halide 750 W	Magnetic-CWA	Metal Halide 750 W		818	850	32
PSMH	Pulse Start Metal Halide 1000 W	Magnetic-CWA	Metal Halide 1000W		1080	1080	0
LBLED	Low Bay LED 85 W[3]		Metal Halide 250 W		85	295	210
LBLED	Low Bay LED 85 W[3]		T-8 96" Two Lamp High Output	Electronic	85	160	75
Delamp	No Lamp	Magnetic-STD	T-12 18" One Lamp	Magnetic-STD	4	19	15
Delamp	No Lamp	No Ballast	T-12 18" One Lamp	Magnetic-STD	0	19	19
Delamp	No Lamp	Magnetic-STD	T-12 24" One Lamp	Magnetic-STD	8	28	20
Delamp	No Lamp	No Ballast	T-12 24" One Lamp	Magnetic-STD	0	28	28
Delamp	No Lamp	Magnetic-STD	T-12 36" One Lamp	Magnetic-STD	16	46	30
Delamp	No Lamp	No Ballast	T-12 36" One Lamp	Magnetic-STD	0	46	46
Delamp	No Lamp	Magnetic-STD	T-12 48" One Lamp	Magnetic-STD	21	60	39
Delamp	No Lamp	No Ballast	T-12 48" One Lamp	Magnetic-STD	0	60	60
Delamp	No Lamp	Magnetic-STD	T-12 60" One Lamp	Magnetic-STD	13	63	50

Type of Fixture	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage	Baseline Fixture Wattage	Fixture Savings (watts)
Delamp	No Lamp	No Ballast	T-12 60" One Lamp	Magnetic-STD	0	63	63
Delamp	No Lamp	Magnetic-STD	T-12 72" One Lamp	Magnetic-STD	21	76	55
Delamp	No Lamp	No Ballast	T-12 72" One Lamp	Magnetic-STD	0	76	76
Delamp	No Lamp	Magnetic-STD	T-12 96" One Lamp	Magnetic-STD	15	90	75
Delamp	No Lamp	No Ballast	T-12 96" One Lamp	Magnetic-STD	0	90	90
Delamp	T-8 24" One Lamp	Electronic - IS	T-8 24" Two Lamp	Electronic - IS	16	33	17
Delamp	T-8 36" One Lamp	Electronic - IS	T-8 36" Two Lamp	Electronic - IS	21	46	25
Delamp	T-8 48" One Lamp	Electronic - IS	T-8 48" Two Lamp	Electronic - IS	27	59	32
Delamp	T-8 60" One Lamp	Electronic - IS	T-8 60" Two Lamp	Electronic - IS	32	72	40
Delamp	T-8 96" One Lamp	Electronic - IS	T-8 96" Two Lamp	Electronic - IS	50	109	59
MHTH	Metal Halide 20W[4]		Two 50W Halogen[4]		23	100	77
MHTH	Metal Halide 39W[4]		Two 75W Halogen[4]		43	150	107
MHTH	Metal Halide 70W[4]		Three 75W Halogen[4]		77	225	148
CMH	Ceramic Metal Halide 20W[4]		Two 50W Halogen[4]		26	100	74
CMH	Ceramic Metal Halide 39W[4]		Two 75W Halogen[4]		45	150	105
CMH	Ceramic Metal Halide 50W[4]		Three 65W Halogen[4]		55	195	140
CMH	Ceramic Metal Halide 70W[4]		Three 75W Halogen[4]		79	225	146
CMH	Ceramic Metal Halide 100W[4]		Three 90W Halogen[4]		110	270	160
CMH	Ceramic Metal Halide 150W[4]		Three 120W Halogen[4]		163	360	197
EXTGAR	LED/Induction 99W[9]		High Pressure Sodium 150W[9]		99	165	66
EXTGAR	LED/Induction 150W[9]		High Pressure Sodium 200W[9]		150	250	100
EXTGAR	LED/Induction 177W[9]		High Pressure Sodium 250W[9]		177	295	118
EXTGAR	LED/Induction 279W[9]		High Pressure Sodium 400W[9]		279	465	186
EXTGAR	LED/Induction 110W[9]		Metal Halide 150W		110	190	80