Type of Fixture	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage	Baseline Fixture Wattage	Fixture Savings (watts)
EXTGAR	LED/Induction 139W[9]		Metal Halide 200W[9]		139	232	93
EXTGAR	LED/Induction 175W[9]		Metal Halide 250W		175	295	120
EXTGAR	LED/Induction 274W[9]		Metal Halide 400W		274	458	184
EXTGAR	LED/Induction 304W[9]		Metal Halide 450W[9]		304	507	203
EXTGAR	LED/Induction 488W[9]		Metal Halide 750W		488	850	362
EXTGAR	LED/Induction 646W[9]		Metal Halide 1000W		646	1080	434

Effective Measure Life

Delamping 1 Lamp T-12 Fixtures:
11yrs
Source: DEER

Delamping and Adding Reflectors for 2 Lam pT8s:
11yrs
Source: DEER

Metal Halide
15yrs
Source: OHIO

Ceramic Metal Halide
16yrs
Source: DEER

Exterior and Garage HID Replacement
12 years

Coincidence Factor

Delamping 1 Lamp T-12 Fixtures:
1

Delamping and Adding Reflectors for 2 Lamp T8s:
1

Metal Halide
1

Ceramic Metal Halide
1

Exterior and Garage HID Replacement
TBD

Incremental Capital Cost

Delamping 1 Lamp T-12 Fixtures:
$25.71/Fixture
Source: DEER

Delamping and Adding Reflectors for 2 Lam pT8s:
$100/Fixture
Source: Estimated

Metal Halide

TBD

Ceramic Metal Halide

TBD

Exterior and Garage HID Replacement

$400 per unit under 175W HID replacement, $500 per unit 175 to 250W HID replacement, $800 per unit 250 to 400W HID replacement. (Engineering Judgment)

Incremental Annual O&M Cost

Delamping 1 Lamp T-12 Fixtures:

TBD

Delamping and Adding Reflectors for 2 Lam pT8s:

TBD

Metal Halide

See VT TRM for specifics Most likely not in the first year.

Ceramic Metal Halide

TBD

Exterior and Garage HID Replacement

TBD

Sources:

1. 2009 SPC Procedures Manual: Appendix B: 2009 Table of Standard Fixture Wattages. Ver. 1.6. SCE, 1 June 2009. Web. Accessed 16 Sept. 2009. <http://www.sce.com/b-rs/small-medium/spc/application-software-manual.htm>.
2. 2009 EPE Program Downloads. Wattage Table 2009. Web. Accessed 26 Sept. 2009. <http://www.epelectricefficiency.com/downloads.asp?section=ci>.
3. New Jersey Clean Energy Program: Protocols to Measure Resource Savings. December 2007.
4. Efficiency Vermont. Technical Reference User Manual: Measure Savings Algorithms and Cost Assumptions. December 30, 2008.
5. Energy-Efficiency and DSM Rules for Pennsylvania's Alternative Energy Portfolio Standard. Technical Reference Manual. September 7, 2005.
6. Impact Evaluation of Orange & Rockland's Small Commercial Lighting Program, 1993.
7. Exterior lighting 3,833 hours per year assumes 10.5 hours per day, typical average for photocell control.
8. Interactive factor data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant,

full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for the following Ohio cities: Cincinnati, Cleveland, Columbus and Dayton.

9. Exterior and Garage HID Replacement, LED and Induction Source

Traffic Signals

Traffic and Pedestrian Signal illuminated with light emitting diodes (LED) instead of incandescent lamps.

Algorithms

Energy Savings (kWh) = $\text{Watt}_{\text{base}} - \text{Watt}_{\text{eff}}$ X EFLH / 1000

Demand Savings (kW) = $\text{Watt}_{\text{basc}} - \text{Watt}_{\text{eff}}$ X CF / 1000

Definition of Terms

$\text{Watt}_{\text{base}}$ = Baseline Wattage of the fixture removed

Watt_{eff} = Efficient Wattage of the fixture installed

EFLH = Equivalent full load hours

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 71: ENERGY STAR LIGHTING

Component	Type	Applicability Conditions	Sources
$\text{Watt}_{\text{base}}$	Fixed	From Table 71 Below	1 and 2
Watt_{eff}	Fixed	From Table 71 Below	1 and 2
EFLH	Fixed	See Table 71 Below	1 and 2
CF	Fixed	Red = 0.55 Green = 0.43 Yellow = 0.02	1 and 2

TABLE 72: TRAFFIC SIGNALS

Traffic Fixture Type	Fixture Size and Color	Efficient Lamps	Baseline Lamps	EFLH	Efficient Fixture Wattage	Baseline Fixture Wattage	Energy Savings (in kWh)
Round Signals	8" Red	LED	Incandescent	4818	7	69	299
Round Signals	12" Red	LED	Incandescent	4818	6	150	694
Round Signals	8" Yellow	LED	Incandescent	175	10	69	10
Round Signals	12" Yellow	LED	Incandescent	175	13	150	24
Round Signals	8" Green	LED	Incandescent	3767	9	69	266
Round Signals	12" Green	LED	Incandescent	3767	12	150	520
Turn Arrows	8" Yellow	LED	Incandescent	701	7	116	76
Turn Arrows	12" Yellow	LED	Incandescent	701	9	116	75
Turn Arrows	8" Green	LED	Incandescent	701	7	116	76
Turn Arrows	12" Green	LED	Incandescent	701	7	116	76
Pedestrian Sign	12" Hand/Man	LED	Incandescent	8760	8	116	946

Reference specifications for above traffic signal wattages are from the following manufacturers:

1. 8" Incandescent traffic signal bulb: General Electric Traffic Signal Model 17325-69A21/TS
2. 12" Incandescent traffic signal bulb: General Electric Signal Model 35327-150PAR46/TS
3. Incandescent Arrows & Hand/Man Pedestrian Signs: General Electric Traffic Signal Model 19010-116A21/TS
4. 8" and 12" LED traffic signals: Leotek Models TSL-ES08 and TSL-ES12
5. 8" LED Yellow Arrow: General Electric Model DR4-YTA2-01A
6. 8" LED Green Arrow: General Electric Model DR4-GCA2-01A
7. 12" LED Yellow Arrow: Dialight Model 431-3334-001X
8. 12: LED Green Arrow: Dialight Model 432-2324-001X
9. LED Hand/Man Pedestrian Sign: Dialight 430-6450-001X

Source:

1. Technical Reference Manual for Pennsylvania Act 129 Energy Efficiency and Conservation Program and Act 213 Alternative Energy Portfolio Standards. Pennsylvania Public Utility Commission. May 2009.
2. PECO Comments on the PA TRM. March 30, 2009.

Light Tube Commercial Skylight

This technology is tubular skylight which is a 10” to 21” diameter skylight with a prismatic or translucent lens that reflects light captured from a roof opening through a highly specular reflective tube down to the mounted fixture height. When in use, a light tube fixture resembles a metal halide fixture. Uses include grocery, school, retail and other single story commercial buildings.

Algorithms

Non-Coincident Electric Demand Savings = ΔkW =Number of fixtures installed X kilowatts saved per fixture (kW_f)

Electric Energy Savings (kWh) = ΔkW X EFLH

Electric Peak Coincident Demand Savings (kW) = ΔkW X CF

Definition of Terms

ΔkW=Number of fixtures installed X kilowatts saved per fixture (kW_f)

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

EFLH = Equivalent full load hours

TABLE 73: LIGHT TUBE COMMERCIAL SKYLIGHT SAVINGS TABLE

Componen	**Type**	**Value**	**Source**
kW_f	Fixed	0.129 kW, Average of representative lighting fixture of equivalent lumen output	kW_f Calculation table below
CF	Fixed	CF=0.75	1 - Average of several building types for the 4p-5p peak period.
EFLH	Variable	2,400	2 - Standard daylighting calculator produce 3,200 daylight hours for Ohio, adjusting for 2 hours less each day and 10% less for overcast conditions give 2.400 hours/yr

TABLE 74: kWF CALCULATION TABLE

Brand/size	Lumen Output	Equivalent Fixture	kW	kWh
Solatube 21”	13,500-20,500	2-3LF32T8 172W	0.172	481.6
14”	6000-9100	1-3LF32T8	0.086	240.8
10”	3000-4600	3-18W quad	0.054	151.2
		AVERAGE	0.129	361.2

Effective Measure Life

14 years

Incremental Capital Cost

$500 per unit (Engineering Judgment)

Source:

1. RLW Analytics. *Coincidence Factor Study - Residential and Commercial Industrial Lighting Measures*. Spring 2007.
2. The United States Naval Meteorology and Oceanography Command (NMOC) provides a yearly table for input locations at http://aa.usno.navy.mil/data/docs/RS_OneYear.php

Lighting Controls

Lighting controls include occupancy sensors, daylight dimmer systems, and occupancy controlled hi-low controls for fluorescent and HID controls. The measurement of energy savings is based on algorithms with key variables (i.e., coincidence factor, equivalent full load hours) provided through existing end-use metering of a sample of facilities or from other utility programs with experience with these measures (i.e., % of annual lighting energy saved by lighting control). For lighting controls, the baseline is a manual switch.

Algorithms

Energy Savings (kWh) = kW_c X EFLH X $(1+IF_{kWh})$ X ESF

Demand Savings (kW) = kW_c X CF X $(1+IF_{kW})$ X ESF

Definition of Variables

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

kW_c = kW lighting load connected to control

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.

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

EFLH = Equivalent full load hours

TABLE 75: LIGHTING CONTROLS

Component	Type	Applicability Conditions	Source
kW_c	Variable	Load connected to control	EDU Data Gathering
ESF	Fixed	Occupancy Sensor, Controlled Hi-Low Fluorescent Control and controlled HID = 30% Daylight Dimmer System=50%	1 and 2

Component	Type	Applicability Conditions	Source
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	3, 4, and 5
IF_{kWh}	Fixed	Interior Fixture= 0.097 Exterior Fixture = 0	6
IF_{kW}	Fixed	Interior Fixture = 0.200 Exterior Fixture = 0	6
CF	Fixed	1	

Sources:

1. Levine, M., Geller, H., Koomey, J., Nadel S., Price, L., "Electricity Energy Use Efficiency: Experience with Technologies, Markets and Policies" ACEEE, 1992
2. Lighting control savings fractions consistent with current programs offered by National Grid, Northeast Utilities, Long Island Power Authority, NYSERDA, and Energy Efficient Vermont.
3. Energy-Efficiency and DSM Rules for Pennsylvania's Alternative Energy Portfolio Standard. Technical Reference Manual. September 7, 2005.
4. Impact Evaluation of Orange & Rockland's Small Commercial Lighting Program, 1993.
5. Exterior lighting 3,833 hours per year assumes 10.5 hours per day, typical average for photocell control.
6. Interactive factor data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for the following Ohio cities: Cincinnati, Cleveland, Columbus and Dayton.

Effective Measure Life

Switching Controls and Multilevel Daylight Sensor:

16yrs
Source: DEER

Coincidence Factor

Switching Controls and Multilevel Daylight Sensor:
1

Incremental Capital Cost

Switching Controls and Multilevel Daylight Sensor:
$483/Switch
Source: DEER_ADJ

Incremental Annual O&M Cost

Switching Controls and Multilevel Daylight Sensor:
TBD

20% Lighting Power Density (LPD) Reduction

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

Algorithms

Energy Savings (kWh) = kW_{save} X EFLH X IF_{kWh}

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

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

Definition of Variables

kW_{save} = lighting connected load kW saved

EFLH = Equivalent full load hours

IF_{kWh} = Waste heat factor for energy to account for cooling savings from efficient lighting.

IF_{kW} = Waste heat factor for demand to account for cooling savings from efficient lighting.

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

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

TABLE 76: LIGHTING POWER DENSITY

Component	Type	Applicability Conditions	Source
kW_{save}	Variable		EDU Data Gathering

Component	Type	Applicability Conditions	Source
WHF_e	Fixed	Cooled space = 1.12 Refrigerated space: • Freezer spaces = 1.15; • Medium-temperature refrigerated spaces = 1.29 • High-temperature refrigerated spaces = 1.18 Uncooled space =1	1
WHF_d	Fixed	Cooled space = 1.34 Refrigerated space: • Freezer spaces = 1.5 • Medium-temperature refrigerated spaces = 1.29 • High-temperature refrigerated spaces = 1.18 Uncooled space = 1	1
EFLH	Variable		EDU Data Gathering
WSF_{base}	Variable		ASHRAE 90.1-2004
WSF_{effic}	Variable		ASHRAE 90.1-2004

Source:

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

Motors

The energy savings for premium efficient motors is related to motor efficiency. Premium efficient motors are about 5 percent more efficient than standard industry motors. From SB 221 application form or EDU data gathering calculate ΔkW where:

Algorithms

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

Energy Savings (kWh) = (ΔkW) X EFLH

Demand Savings (kW) = (ΔkW) X CF

Definition of Variables

hp_{base} = Rated horsepower of the baseline motor

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

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

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

η_{base} = Efficiency of the baseline motor

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

TABLE 77: MOTORS

Component	Type	Applicability Conditions	Source
EFLH	Variable	Based on Building Type and Location	VAV fans: 2790 HVAC pumps: 5520 Other: EDU Data Gathering
hp_{base}	Fixed	Comparable EPACT Motor Table Below	EPACT Directory
hp_{ee}	Variable	Nameplate	EDU Data Gathering

Component	Type	Applicability Conditions	Source
RLF_{base}	Fixed	0.80	Industry Data
RLF_{ee}	Variable	Nameplate	EDU Data Gathering
Efficiency – η_{base}	Fixed	Comparable EPACT Motor Table Below	From EPACT directory.
Efficiency - η_{ee}	Variable	Nameplate	EDU Data Gathering
CF	Fixed	38%	JCP&L metered data

TABLE 78: BASELINE MOTOR EFFICIENCIES - NBASE (EPACT)

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

Brushless DC or ECM Case Motors

Cooler and Freezer Case evaporator fans typically contain three to twelve evaporator fans that run nearly 24 hours each day, 365 days each year. Not only do these fans use electricity, but the heat that each fan generates must also be removed by the refrigeration system to keep the product cold, adding more to the annual electricity costs. If the cooler or freezer has single-phase power, the electricity usage can be reduced by choosing brushless DC motors instead of conventional, shaded-pole motors. Brushless DC motors are also sometimes known by the copyrighted trade name ECM (electronically commutated motor).

Algorithms

Energy Savings (kWh) = $(kW_{SP} - kW_{BDC}) \text{ X } DC_{Evap} \text{ X } BF \text{ X } 8760$

Demand Savings (kW) = $(kW_{SP} - kW_{BDC}) \text{ X } DC_{Evap} \text{ X } BF$

Definition of Terms

kW_{SP} = Connected load kW of a shaded pole evaporator fan (Average 0.0413 kW)

kW_{BDC} = Connected load kW of a brushless DC evaporator fan (0.0113kW)

DC_{Evap} = Duty cycle of the evaporator fan (100% for cooler, 94% for freezer)

BF = Bonus factor for reduced cooling load from replacing a shaded-pole evaporator fan with a lower wattage brushless DC fan (1.5 for low temp, 1.3 for medium temp, and 1.2 for high temp)

8760 = (hours/year)

TABLE 79: ECM CASE MOTORS

Component	Type	Applicability Conditions	Source
kW_{SP}	Fixed	0.0413 kW	1
kW_{BDC}	Variable	0.0113kW	2
DC_{Evap}	Fixed	Cooler = 100% Freezer = 94%	3
BF	Fixed	1.5 for low temp, 1.3 for medium temp, and 1.2 for high temp	4

Sources:

Algorithm: Efficiency Vermont TRM, December 30, 2008

1. Average based on Technical Data Sheets from Tyler Refrigeration (48W), Hussmann Refrigeration (46W), and Hill-Phoenix Refrigeration (30W)
2. Average based on Technical Data Sheets from Tyler Refrigeration (11W), Hussmann Refrigeration (9W), and Hill-Phoenix Refrigeration (14W)
3. A evaporator fan in a cooler runs all the time, but a freezer only runs 8273 hours per year due to defrost cycles (4 20-min defrost cycles per day)
4. Bonus factor (1+ 1/COP) assumes 2.0 COP for low temp, 3.5 COP for medium temp, and 5.4 COP for high temp, based on the average of standard reciprocating and discus compressor efficiencies with Saturated Suction Temperatures of -20°F, 20°F, and 45°F, respectively, and a condensing temperature of 90°F.

Pump Efficiency Improvements

Pump improvements can be done to optimize the design and control of water pumping systems. The measurement of energy and demand savings for commercial and industrial applications will vary with the type of pumping technology, operating hours, efficiency and current and proposed controls.

Typical Savings
The savings from pump system improvements will vary by building application, loads, climate and types of pumps. Typically a savings of about 15 percent can be achieved through pump upgrades.

Typical Pump Equations

BHP = (GPM X PSI X SG)/(1713 X N*m*) Or BHP = (GPM X FT X SG)/(3,960 X N*m*)

Algorithms

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

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

Definitions of Variables

HP = nameplate motor horsepower.

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

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

ESF = Energy Savings Factor. The energy savings factor is equal to 1 – FLH_{asd}/FLH_{base}. This factor can also be computed according to fan and pump laws assuming an average flow reduction and a cubic relationship between flow rate reduction and power draw savings. Typical total ESF improvements of about 15 percent can be expected.

EFLH = Full Load Hours of the pump related to particular commercial or industrial application

CF = Coincidence Demand Factor, .38 (same as motors)

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

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

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

TABLE 80: PUMP EFFICIENCY IMPROVEMENTS

Component	Type	Value	Source
HP of motor	Variable	Nameplate	EDU Data Gathering
RLF	Fixed	.80, same as motor	Engineering estimate
η_{motor}	Variable	Nameplate or manufacturer specs	EDU Data Gathering
ESF	15%	Engineering Estimate	1
EFLH	Fixed	Based on commercial or industrial operating hours	EDU Data Gathering
DSF	Variable	Dependent on base and variable peak demand	EDU Data Gathering
CF	Fixed	38% (based on motors)	Based on CF for motors

Effective Measure Life
15 years (DEER Database)

Coincidence Factor
.38 (Assumed same as motors)

Incremental Capital Cost
$TBD/HP

Sources:

1. Based on an average pumping efficiency improvement of about 15 percent. Thomas D. Van Liew, Cadmus Group.

HVAC Systems

The measurement of energy and demand savings for C/I Efficient HVAC for Room AC, Central AC and air cooled DX is based on algorithms. (Includes split systems, air to air heat pumps, packaged terminal systems, and water source heat pumps). The equations also cover maintenance and duct leakage sealing measures.

Algorithms

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

Energy Savings (kWh) = (CAPY/1000) X RLF X (1/SEER$_b$-1/SEER$_q$) X EFLH$_c$

Demand Savings (kW) = (CAPY/1000) X RLF X (1/EER$_b$-1/EER$_q$) X CF

Heating Energy Savings: ASHP

Energy Savings-Heating (kWh) = CAPY$_h$/1000 X RLF X (1/COP$_b$-1/COP$_q$) / 3.413 X EFLH$_h$

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

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

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

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

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

Energy Impact (kWh) = (CAPY X RLF /(1000 X SEER$_m$)) X EFLH$_c$ X DuctSF

Peak Demand Impact (kW) = ((CAPY X RLF /(1000 X EER$_m$)) X CF) X DuctSF

Add for ASHP:

Energy Impact-Heating (kWh) = CAPY$_h$/1000 X RLF X (1/COP$_m$) / 3.413 X EFLH$_h$ X DuctSF

Definition of Variables

BtuH = Heating capacity (output in Btuh) of the heat pump at 47°F, less the supplemental heat. These data are obtained from the EDU data gathering.

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.

$SEER_b$ = Seasonal average efficiency rating of the baseline unit. For units > 65,000, EER should be used for cooling savings.

$SEER_q$ = Seasonal average efficiency rating of the High Efficiency unit. For units > 65,000, EER should be used for cooling savings.

EER_b = Full load (peak) efficiency rating of the baseline unit.

EER_q = Full load (peak) efficiency rating of the High Efficiency unit.

$SEER_m$ = Seasonal average efficiency rating of an existing unit for maintenance purposes.

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.

EER_m = Full load (peak) efficiency rating of an existing unit for maintenance purposes.

COP_b = Heating coefficient of performance for baseline heat pumps. For units < 65,000 cooling capacity, use HSPF/3.413

COP_q = Heating coefficient of performance for High Efficiency heat pumps. For units < 65,000 cooling capacity, use HSPF/3.413

COP_m = Heating coefficient of performance for existing heat pumps for maintenance purposes.

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 ducts.

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

$EFLH_{cool}$ = 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.

TABLE 81: HVAC AND HEAT PUMPS

Component	Type	Value	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	EDU's Data Gathering
RLF	Fixed	0.91	10% over sizing assumed
SEER$_b$	Fixed	See Table 81 below	3
SEER$_q$	Variable	ARI or AHAM Values	EDU's Data Gathering
EER$_b$	Fixed	See Table 81 below	3
EER$_q$	Variable	ARI or AHAM Values	EDU's Data Gathering
SEER$_m$	Fixed	10	6
EER$_m$	Fixed	9.5	6
COP$_m$	Fixed	3.1	6
MF	Fixed	10%	4
DuctSF	Fixed	6%	5
CF	Fixed	0.74	2
EFLH	Fixed	Akron cooling = 801 Akron heating = 994 Cincinnati cooling = 941 Cincinnati heating = 713 Cleveland cooling = 820 Cleveland heating = 994 Columbus cooling = 910 Columbus heating = 829 Dayton cooling = 942 Dayton heating = 810 Mansfield cooling = 757 Mansfield heating = 919 Toledo cooling = 813 Toledo heating = 1,056	1

TABLE 82: HVAC BASELINE TABLE

Equipment Type	Baseline = ASHRAE Std. 90.1 - 2007
Unitary HVAC/Split Systems	
.<=5.4 tons (single phase):	13 SEER/11.1 EER(1ph),
.<=5.4 tons (three phase):	12 SEER/10.4 EER (3ph)
· >5.4 to 11.25 tons	10.1 EER
· >11.25 to 20 tons	9.5 EER
.> 20 to 63.33 tons	9.3 EER
.> 63.33 tons	9 EER

Equipment Type	Baseline = ASHRAE Std. 90.1 - 2007
Air-Air Heat Pump Systems (cooling) .<=5.4 tons (single phase): .<=5.4 tons (three phase): · >5.4 to 11.25 tons · >11.25 to 20 tons .>= 21 to 30 tons	13 SEER/11.1 EER(1ph), 12 SEER/10.4 EER (3ph) 9.9 EER 9.1 EER 8.8 EER
Air-Air Heat Pump Systems (heating) · <=5.4 tons: · >5.4 to 11.25 tons · >11.25 to 20 tons .>= 21 to 30 tons	8.1 HSPF (1ph), 7.7 HSPF (3ph) 3.2 COP 3.1 COP 3.1 COP
Water Source Heat Pumps (cooling) < 1.42 tons ≥ 1.42 tons	11.2 EER 12.0 EER
GWSHPs Open and Closed Loop All Capacities	16.2 EER
Package Terminal Systems (Replacements) PTAC (cooling) PTHP (cooling) PTHP (heating)	10.9 - (0.213 x Cap / 1000) EER 10.8 - (0.213 x Cap / 1000) EER 2.9 - (0.213 x Cap / 1000) COP

Estimated Useful Life

The estimated useful life for commercial AC and heat pump measures is 15 years. The estimated useful life for 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 83: MEASURE COSTS - HVAC

Measure	Cost	Unit	Source	Notes
AC <65,000 1 Ph	$55.57	ton	7	
AC <65,000 3 Ph	$118.88	ton	7	
AC >760,000	$98.39	ton	7	

AC 135,000 - 240,000	$110.89	ton	7	
AC 240,000 - 760,000	$115.13	ton	7	
AC 65,000 - 135,000	$149.13	ton	7	
HP <65,000 1 Ph	$73.52	ton	7	
HP <65,000 3 Ph	$186.50	ton	7	
HP >240,000	$129.83	ton	7	
HP 135,000 - 240,000	$125.44	ton	7	
HP 65,000 - 135,000	$182.43	ton	7	
PTAC	$110.48	ton	7	
PTAC - HP	$137.88	ton	7	
WLHP <17,000	$22.00	ton	7	
WLHP 17,000-65,000	$26.29	ton	7	
WLHP 65,000-135,000	$27.06	ton	7	

Sources:

1. Heating and cooling EFHL data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Efficiency specifications taken from ASHRAE Standard 90.1-2004
4. VEIC estimate. Conservatively assumes less savings than for QIV because of the retrofit context.
5. Duct sealing factor taken from average % change in distribution efficiency across NY climates from New York Standard Methods Manual. Averaged across building types using weights described above.
6. DEER study on commercial heat pumps.
7. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Electric Chillers

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

Algorithms

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

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

Definition of Variables

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

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

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

CF = Coincidence Factor – Represents the percentage of the total load which is on during electric system's Peak Window.

EFLH = Equivalent Full Load Hours – A measure of chiller use by season determined by measured kWh during the period divided by kW at design conditions

TABLE 84: ELECTRIC CHILLERS

Component	Type	Value	Source
Tons	Variable	From EDU Data Gathering	
kW/ton_b	Fixed	**Water Cooled Chillers (=<150 tons)** *Baseline:…………… 0.703 kW/Ton* **Water Cooled Chillers (151 to <300 tons)** *Baseline:…………… 0.634 kW/Ton* **Water Cooled Chillers (>301 tons)** *Baseline:…………… 0.577 kW/Ton* **Air Cooled Chillers (<150 tons)** *Baseline:…………… 1.256 kW/Ton*	3
kW/ton_q	Variable	ARI Standards 550/590-Latest edition	EDU Data Gathering
CF	Fixed	0.74	2
EFLH	Fixed	See table below	1
System type	Variable	CV reheat, no economizer CV reheat, economizer VAV reheat, economizer	EDU Data Gathering

TABLE 85: COOLING EFLH BY SYSTEM TYPE

System Type	Akron	Columbus	Cincinnati	Cleveland	Dayton	Mansfield	Toledo
CV reheat, no economizer	2,866	2,633	2,940	2,762	3,063	2,960	2,743
CV reheat, economizer	793	941	955	932	976	921	859
VAV reheat, economizer	788	946	974	768	896	669	848

Estimated Useful Life

The estimated useful life for commercial chiller measures is 20 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 86: MEASURE COSTS – COMMERCIAL CHILLER

Measure	Cost	Unit	Source	Notes
Efficient Air-Cooled Chiller	$126.00	ton	4	Average over all sizes and efficiencies
Efficient Screw Chiller	$90.00	ton	4	Average over all sizes and efficiencies
Efficient Centrifugal Chiller	$92.00	ton	4	Average over all sizes and efficiencies

Sources:

1. Cooling EFLH extracted from DOE-2.2 simulations conducted for Duke Energy.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Efficiency specifications taken from ASHRAE Standard 90.1-2004
4. Measure costs supplied by Duke Energy

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

Variable Frequency Drives for HVAC Applications

The measurement of energy and demand savings for C/I Variable Frequency Drive for VFD is for HVAC fans and water pumps only.

Algorithms

Energy Savings (kWh) = $0.746 \text{ X HP X RLF}/\eta_{motor} \text{ X FLHH X ESF}$
Demand Savings (kW) = $0.746 \text{ X HP X RLF}/\eta_{motor} \text{ X ESF}$

Definitions of Variables

HP = nameplate motor horsepower.

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

η_{motor} = Motor efficiency.

ESF = Energy Savings Factor. The energy savings factor is equal to $1 - FLH_{asd}/FLH_{base}$. Estimated average savings of 30 percent (based on metering and verification data)

FLHHs = Full Load Hours of the fan/pump.

DSF = .74 for HVAC.

TABLE 87: VARIABLE FREQUENCY DRIVES

Component	Type	Applicability Conditions	Source
Motor HP	Variable	Nameplate	EDU Data Gatherin
RLF	Fixed	.85	Estimated load facto
η_{motor}	Variable	Nameplate or manufacturer specs	EDU Data Gatherin
ESF	Fixed	30%	
FLHH	Fixed	See FLHH tables.	
DSF	Fixed	.74	

Air Compressors with Variable Frequency Drives (VFDs)

The measure relates to installing variable frequency drive (VFDs) on air compressors. VFDs to reduce demand (kW) and energy (kWh/year) consumed by a motor.

Algorithms

Energy Savings (kWh) = (HP X .746/kW X RLF X FLHRs)/N_{base} X ESF

Demand Savings (kW) = ((kWh/year)/FLHRs) X CF

Definitions of Variables

HP = nameplate motor horsepower

TABLE 88: AIR COMPRESSORS WITH VFDS

Component	**Type**	**Value**	**Source**
Motor HP	Variable	Nameplate	EDU Data Gathering
.746	Fixed	Conversion Factor	
RLF	Fixed	0.80	
FLHRs	Fixed	TBD based on commercial or industrial sector FLHRs	1
N_{base}	Variable	Fixed, nameplate (or engineering estimate)	
ESF	Fixed	30%	Engineering estimate based on data logging field sites
CF	Fixed	38%	Based on utility load profiles for Ohio

Effective Measure Life

15 years

Coincidence factor

.38

Incremental Capital Cost

$300/HP

Sources:

1. Engineering Cookbook (handbook), Standard equations for computing HP motor loads. Loren Cook Company, Second Edition,
2. Engineering Estimate: Based on post inspections, evaluation studies and engineering design requirements.
3. Industrial Efficiency Alliance, David Vanderbeek, Technical Director – Compressed Air, Northwest Energy Efficiency Alliance.
4. Database of Energy Efficiency Resources (DEER)

Air Compressors with Load/No Load

The measure relates to installing a Load/No Load Controls to air compressors. These controls can reduce the demand (kW) and energy (kWh/year) of the air compressor system for a particular motor system.

Algorithms

Energy Savings (kWh) = (HP X .746/kW X RLF X FLHRs)/$N_{\text{-base}}$ X ESF

Demand Savings (kW) = ((kWh/year)/FLHRs) X CF

Definitions of Variables

TABLE 89: AIR COMPRESSORS WITH LOAD AND NO LOAD CONTROLS

Component	Type	Value	Source
Motor HP	Variable	Nameplate	EDU Data Gathering
.746	Fixed	Conversion Factor	
RLF	Fixed	0.80	
FLHRs	Fixed	TBD based on commercial or industrial sector FLHRs	1
$N_{\text{-base}}$	Variable	Nameplate (or engineering estimate) or existing motor efficiency.	EDU Data Gathering
ESF	Fixed	15%	Engineering estimate based on data logging of field sites
CF	Fixed	38%	Based on utility load profiles for Ohio

Effective Measure Life

15 years

Coincidence factor

.38

Incremental Capital Cost

$200/HP (estimated)

Sources:

1. Engineering Cookbook Handbook, standard equations for computing HP motor loads. Loren Cook Company, Second Edition,
2. Engineering Estimate: Based on post inspections, evaluation studies and engineering design requirements.
3. Industrial Efficiency Alliance, David Vanderbeek, Technical Director – Compressed Air, Northwest Energy Efficiency Alliance.
4. Database of Energy Efficiency Resources (DEER)

Air Compressors with Variable Displacement

The measure relates to installing a variable displacement control systems on air compressors. These controls can reduce the demand (kW) and energy (kWh/year) of the air compressor system for a particular motor system.

Algorithms

Energy Savings (kWh) = (HP X .746/kW X RLF X FLHRs)/$N_{\text{-base}}$ X ESF

Demand Savings (kW) = ((kWh/year)/FLHRs) X CF

Definitions of Variables

TABLE 90: AIR COMPRESSORS WITH LOAD AND NO LOAD CONTROLS

Component	Type	Value	Source
Motor HP	Variable	Nameplate	EDU Data Gathering
.746	Fixed	Conversion Factor	
RLF	Fixed	0.80	
FLHRs	Fixed	TBD based on commercial or industrial sector FLHRs	1
$N_{\text{-base}}$	Variable	Nameplate (or engineering estimate) or existing motor efficiency.	
ESF	Fixed	20%	Engineering estimate based on data logging of field sites.
CF	Fixed	38%	Based on utility load profiles for Ohio

Effective Measure Life

15 years

Coincidence factor

.38

Incremental Capital Cost

$250/HP (estimated)

Sources:

1. Engineering Cookbook Handbook, standard equations for computing HP motor loads. Loren Cook Company, Second Edition,
2. Engineering Estimate: Based on post inspections, evaluation studies and engineering design requirements.
3. Industrial Efficiency Alliance, David Vanderbeek, Technical Director – Compressed Air, Northwest Energy Efficiency Alliance.
4. Database of Energy Efficiency Resources (DEER)

Outside Air Economizer with Two Enthalpy Sensors

This measure is to upgrade the outside air dry-bulb economizer to a dual enthalpy controlled economizer. The new control system will continuously monitor the enthalpy of both outside air and return air. The system will control the system dampers and adjust based on two readings.

Electricity Impact (kWh) = ton X (ΔKWH/ton)

Demand Impact (kW) = 0

Definition of Terms

ton = cooling capacity of unit with economizer added

ΔKWH/ton = unit energy savings per ton of cooling capacity

ΔKW/ton = unit demand savings per ton of cooling capacity

CF_s = summer coincident peak factor

TABLE 91: DUAL ENTHALPY ECONOMIZER

Component	**Type**	**Value**	**Sources**
ton	Variable		EDC Data Gathering
ΔKWH/ton	Fixed	Akron: 113 kWh/ ton Cincinnati: 107 kWh/ton Cleveland: 109 kWh/ ton Columbus: 120 kWh/ ton Dayton: 109 kWh/ ton Mansfield: 114 kWh/ ton Toledo: 110 kWh/ ton	1
ΔKW/ton	Fixed	0	1
CF_a	Fixed	0.74	2

Estimated Useful Life

The estimated useful life for economizer 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 92: MEASURE COSTS - ECONOMIZER

Measure	Cost	Unit	Source	Notes
Dual Enthalpy Economizer	$170.00	ton	3	

Sources:

1. Unit energy and demand savings data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Energy Recovery Ventilation > 450 CFM

This measure is to install an energy recovery unit (ERU) on HVAC applications to save heating and cooling energy. The savings from ERUs will varies greatly depending upon the building application, design, air flows and climate. Typical energy savings varies with the type of ERU and if the heat ERU is designed to recovery sensible and/or latent loads. It also varies with the heat exchanger (HX) effectiveness. Energy savings is based on outside air systems only. Energy savings is not for total cooling load.

Algorithms

Air Conditioning Algorithms:

Energy Savings (kWh) = (Btu/H1000) X 1/EER_b X $EFLH_c$ X ESF

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

Heat Pump Algorithms:

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

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

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 – .74 for HVAC systems.

EFLH = Equivalent Full Load Hours – See EFLH tables in HVAC section of TRM.

TABLE 93: HVAC AND HEAT PUMPS

Component	Type	Applicability Conditions	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	EDU Data Gathering
EERb	Variable	See air conditioning tables	EDU Data Gathering
CF	Fixed	74%	Engineering estimate
ESF	Fixed	22% for sensible heat recovery	Engineering estimate
ESF	Fixed	45% for latent heat recovery	Engineering estimate

Sources:

1. Association of Energy Engineers (AEE), Energy Engineering, Volume 106, Number 4.

Occupancy Sensor for HVAC System – Heat Pump

Occupancy sensors can be used to optimize the control of HVAC systems. These controls can reduce air conditioning and heating costs by regulating the operation of HVAC systems to areas are occupied. The amount of energy and demand savings will vary with type of HVAC system, efficiency of the HVAC system and the amount of area being controlled. The efficiencies of HVAC systems are provided in the HVAC section of TRM

Typical Savings

The savings from occupancy sensors will vary by building application, loads and climate. Typically a 20 percent savings can be achieved.

Algorithms

Heat Pump Algorithms:

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

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

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 94: OCCUPANCY SENSORS

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

Component	Type	Applicability Conditions	Source
ESF	Fixed	20%	Engineering estimate

Effective Measure Life

8 years, GDS Associates, Inc.

Coincidence Factor

.74 (based on Ohio utility supply profiles)

Incremental Cost

$250 per unit (estimated).

Occupancy Sensor for HVAC System – A/C Only

Occupancy sensors can be used to optimize the control of HVAC systems. These controls can reduce air conditioning and heating costs by regulating the operation of HVAC systems to areas are occupied. The amount of energy and demand savings will vary with type of HVAC system, efficiency of the HVAC system and the amount of area being controlled. The efficiencies as outlined HVAC section of TRM should be used.

Typical Savings
The savings from occupancy sensors will vary by building application, loads and climate. Typically a 20 percent savings (and sometimes higher) can be achieved.

Algorithms

Air Conditioning Algorithms:
Energy Savings (kWh) = (Btu/H1000) X 1/EER_b X EFLH X ESF

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

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 95: OCCUPANCY SENSORS – A/C ONLY

Component	Type	Applicability Conditions	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	EDU Data Gathering
EERb	Variable	See air conditioning tables	EDU Data Gathering
CF	Fixed	74%	Engineering estimate
ESF	Fixed	20%	Engineering estimate

Effective Measure Life

8 years, GDS Associates, Inc.

Coincidence Factor

.74 (based on Ohio utility supply profiles)

Incremental Cost

$250 per sensor (estimated)

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 between 6 percent savings can be achieved.

Algorithms

Heat Pump Algorithms:

Energy Savings-Cooling (kWh) = (Btu/H$_c$1000) X 1/EER$_b$ X EFLH$_c$ X ESF

Energy Savings-Heating (kWh) = (Btu/H$_h$1000) X 1/EER$_b$ X EFLH$_h$ X ESF

Demand Savings (kW) = Btu/H$_h$1000 X 1/EER$_b$ X ESF X 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 96: HVAC HEAT PUMPS – THERMOSTAT SETUP AND SETBACK

Component	Type	Applicability Conditions	Source
BtuH	Variable	ARI or AHAM or Manufacturer Data	EDU Data Gathering

Component	Type	Applicability Conditions	Source
EERb	Variable	See air conditioning tables	EDU Data Gathering
CF	Fixed	74%	Engineering estimate
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.

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.

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 2 to 3 percent per degree setup can be achieved for cooling energy savings for an 8 hour setup. Typical savings of about 16 percent, cooling energy only, can be achieved for an 8 degree setup for an 8 hour time period per day.

Algorithms

Air Conditioner Algorithms:

Energy Savings-Cooling (kWh) = $(Btu/H_c 1000)$ X $(1/EER_b-1/EER_q)$ X $EFLH_c$ X ESF

Demand Savings (kW) = (Btu/H1000 X $(1/EER_b-1/EER_q)$ 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 97: HVAC AIR CONDITIONERS – TEMPERATURE SETUP

Component	Type	Applicability Conditions	Source

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
EER_q	Variable	See air conditioning tables	EDU Data Gathering
CF	Fixed	74%	Engineering estimate
ESF	Fixed	6%	Engineering estimate

The same factors concerning efficiencies for air conditioners should be used as was derived in air conditioning section of TRM, FLHHs and Coincidence factors as applicable.

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.

Chilled Water Reset Controls

This section covers installation of chilled water reset controls in large commercial buildings with built-up HVAC systems. Reset controls allow the chillers to operate at a higher chilled water temperature during periods of low cooling loads. The baseline condition is assumed to be constant chilled water temperature of 45°F. The reset strategies use a 5°F reset. Energy saving are realized through improved chiller efficiency. No peak demand savings are anticipated. Data for both air-cooled and water-cooled chillers are shown. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. The commercial 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 ton of chiller capacity controlled.

Algorithms

Air-Cooled Chiller

Electricity Impact (kWh) = $\text{TON X } (\Delta\text{KWH/TON}_{\text{AIR COOLED}})$

Demand Impact (kW) = $\text{TON X } (\Delta\text{KW/TON}_{\text{AIR COOLED}})\text{X CF}_S$

Water-Cooled Chiller

Electricity Impact (kWh) = $\text{TON X } (\Delta\text{KWH/TON}_{\text{WATER COOLED}})$

Demand Impact (kW) = $\text{TON X } (\Delta\text{KW/TON}_{\text{WATER COOLED}})\text{X CF}_S$

Definition of Terms

TON = cooling capacity of controlled chillers

$\Delta\text{KWH/TON}_{\text{AIR COOLED}}$ = unit energy savings for 5°F reset per ton of air cooled chiller

$\Delta\text{KW/TON}_{\text{AIR COOLED}}$ = unit demand savings for 5°F reset per ton of air cooled chiller

$\Delta\text{KWH/TON}_{\text{WATER COOLED}}$ = unit energy savings for 5°F reset per ton of water cooled chiller

$\Delta\text{KW/TON}_{\text{WATER COOLED}}$ = unit demand savings for 5°F reset per ton of water cooled chiller

CF_s = summer coincident peak factor

TABLE 98: CHILLED WATER RESET CONTROLS

Component	Type	Value	Sources
TON	Variable		EDC Data Gathering
$\Delta KWH/TON_{AIR\ COOLED}$	Fixed	12 kWh/ton	1
$\Delta KW/TON_{AIR\ COOLED}$	Fixed	0	1
$\Delta KWH/TON_{WATER\ COOLED}$		30 kWh/ton	1
$\Delta KW/TON_{WATER\ COOLED}$	Fixed	0	1
CF_a	Fixed	0.74	2

Estimated Useful Life

The estimated useful life for economizer measures is 15 years.

Measure Costs

The full capital cost for adding chilled water reset controls to an existing central HVAC system are listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 99: MEASURE COSTS – CHILLED WATER RESET

Measure	Cost	Unit	Source	Notes
Chilled water reset control	$0.79	ton	3	DEER unit costs normalized per ton of chiller capacity

Sources:

1. Unit energy and demand savings data based on a prototypical large office building simulation run. The prototype is based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Commercial Measures

Commercial Plug Load-Smart Strip Plug Outlets

A smart strip plug outlet is an advanced power strip that senses when essential electronic components are shut off and then automatically cut offs the power supply to the remaining devices plugged into the strip. The energy savings are measured by estimating the number of hours that electronic devices at typical workstations are either in the "sleep" mode or shut off and the standby loads consumed by the devices at those times. The smart strip will eliminate these standby loads and result in measureable energy savings.

Algorithms

Electricity Impact (kWh) = NSTATIONS X {WORKDAYS X (WH_{SLEEP} + WH_{OFF}) + (365 – WORKDAYS) X $WH_{OFF/SS}$} / 1000

Demand Impact (kW) = 0, based on the assumption that most office equipment will be operating during the peak coincident hour

Definition of Terms

NSTATIONS – Number of workstations fully utilizing the smart strip plug

WORKDAYS – Average number of workdays, or business days, in a year

WH_{SLEEP} – The energy consumption of devices plugged into the strip when in "sleep" mode (Wh)

WH_{OFF} – The energy consumption of devices plugged into the strip when turned off (Wh)

$WH_{OFF/SS}$ – The energy consumption of devices plugged into the strip when turned off on non-business days (Saturdays, Sundays and holidays) (Wh)

TABLE 100: COMMERCIAL SMARTSTRIP PLUG OUTLET

Component	Type	Value	Sources
NSTATIONS	Variable		-
WORKDAYS	Fixed	240	1

Component	Type	Value	Sources
WH_{SLEEP}	Fixed	7.21	2
WH_{OFF}	Fixed	1.51	2
$WH_{OFF/SS}$	Fixed	1.90	2

Estimated Useful Life

The estimated useful life for a smart strip plug outlet is 8 years.

Sources:

1. Assumes 2 weeks of vacation and 2 weeks of holidays for a total of 48 work weeks annually
2. Standby loads sourced from Lawrence Berkeley National Laboratory http://standby.lbl.gov/summary-table.html. Hours of operation based on engineering estimations. See Table 100 Below

TABLE 101: STANDBY POWER CONSUMPTION FOR DEVICES USING SMART STRIP

Computer Peripherals	Watts in Sleep Mode	Hours in Sleep Mode	Watts When Off	Hours Off	Hours Off (Non-Workday)
Desktop Computer	21.13	4	2.84	12	24
CRT Monitor	12.14	4	0.8	12	24
Speakers	1.79	4	1.79	12	24
Modem	3.85	16	3.84	0	24
Charger	N/A	0	0.26	20	24
Printer	N/A	0	1.26	20	24
Scanner	2.48	0	2.48	20	24
Weighted Avg Watt-hours per mode	7.21		a. 1.51 (Workday) 1.90 (Non-Workday)		

Commercial Clothes Washers

ENERGY STAR qualified commercial 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 $\geq$1.8) over a standard clothes washer that is DOE 2007 compliant (MEF$\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 and Energy Star.

Algorithms

Clothes Washers – Electric Water Heating, Electric Dryer

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

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

Electric Energy Savings = $\Delta kWh = kWh_{baseline} - kWh_{energy\ efficient\ measure}$

Non-Coincident Electric Demand Savings = $\Delta kW = \Delta kWh/EFLH$

Electric Peak Coincident Demand Savings= $\Delta kW \text{ X } CF$

Clothes Washers – Electric Water Heating, Gas Dryer

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

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

Non-Coincident Electric Demand Savings = $\Delta kW = \Delta kWh/EFLH$

Electric Peak Coincident Demand Savings= $\Delta kW \text{ X } CF$

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 = $\Delta kW = \Delta kWh/EFLH$

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 102: COMMERCIAL CLOTHES WASHERS

Component	Type	Value	Sources
kWh_{washer}	Fixed	See Table 102 below	1, 2
kWh_{dryer}	Fixed	See Table 102 below	1, 2
LOAD	Fixed	950 cycles	3
$kW_{baseline}$	Fixed	Calculated	3
$kW_{energy\ efficient\ measure}$	Fixed	Calculated	3
CF	Fixed	0.06	4
EFLH	Fixed	8760	5

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

Table 103: 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

10 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)

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), insulation levels, and climate. Typically a 5 percent savings can be achieved.

Algorithms

Electric Domestic Hot Water:

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

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 - °F)

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

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

CF = coincidence factor, .06

365 = conversion factor (days/yr)

3413 = conversion factor (Btu/kWh)

Note, large (> 11 kW) commercial electric water heater efficiency is rated in terms of Standby Loss (Btu/hr) at a 70 degree F temperature difference. Overall loss coefficient is computed from the Standby Loss as follows:

UA = Standby Loss / 70

The baseline standby loss is calculated from ASHRAE 90.1-2004 as follows:

Baseline standby loss = $20 + 35 \times (\text{Volume})^{0.5}$

Where volume = tank storage capacity in gallons.

Small (≤ 11 kW) water heaters are rated in terms of Energy Factor (EF). The overall heat loss coefficient is estimated from the EF and recovery efficiency as described in the residential water heater section.

TABLE 104: DOMESTIC HOT WATER – HIGH EFFICIENCY WATER HEATERS

Component	Type	Applicability Conditions	Source
UA_{base}	Variable	ASHRAE 90.1 baseline according to unit size	2
UA_{ee}	Variable	Based on proposed water heater system.	Engineering estimate
ΔT_s	Variable	Based on customer water heater set point and surrounding air temperature	Engineering estimate
CF	Fixed	.06%	Engineering estimate

Estimated Useful Life

The estimated useful life for a high efficiency water heater is 15 years.

Source:

1. Lawrence Berkeley National Laboratory (LBNL), "Calculating Water Heater Energy Use and Standby Losses", 1999.
2. ASHRAE Standard 90.1 – 2004 Energy Standard for Buildings Except Low Rise Residential. American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA. 2004.

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) = $(GPD \times 8.33 \times \Delta T_w) / (3413 \times E_{t,b}) \times ESF$

Demand Savings (kW) = $(GPH \times 8.33 \times \Delta T_w) / (3413 \times E_{t,b})$

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 (°F)

CF = coincidence factor

365 = conversion factor (days/yr)

8.33 = conversion factor (Btu/gallon - °F)

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/Ton installed cost (engineering estimate).

TABLE 105: 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

Hot Water Circulation Pump Time Clock

This measure introduces a time clock to the domestic hot water circulation loop in a commercial application. Typically, a pump operates 24 hours per day and the time clock is assumed to reduce the hours of operation by half.

Algorithms

Electricity Impact (kWh) = $HP \times 0.7457 \times LF / \eta_{MOTOR} \times (EFLH_{BASE} - EFLH_{CLOCK})$

Demand Impact (kW) = $HP \times 0.7457 \times LF / \eta_{MOTOR} \times CF$

Definition of Terms

HP = Horsepower rating of pump motor

LF = Load factor for pump motor

η_{MOTOR} = Rated efficiency of pump motor

$EFLH_{BASE}$ = Equivalent full load hours of operation for baseline pump

$EFLH_{CLOCK}$ = Equivalent full load hours of operation for installed hot water recirculation pump time clock

CF = Coincidence factor

TABLE 106: HOT WATER RECIRCULATION PUMP TIME CLOCK

Component	Type	Value	Sources
HP	Variable		
LF	Fixed	0.70	1
η_{MOTOR}	Fixed	0.75	2
$EFLH_{BASE}$	Fixed	8,760	Engineering Estimate
$EFLH_{CLOCK}$	Fixed	4,380	Engineering Estimate
CF	Fixed	0	

Estimated Useful Life

The estimated useful life for a hot water circulation pump time clock is 15 years.

Measure Costs

The incremental capital cost of a hot water circulation pump time clock is $296.20.

Sources:

1. Hill, R. and Englander, S. "Measured Loading of Energy Efficient Motors - the Missing Link in Engineering Estimates of Savings," *ACEEE 1994 Summer Study Conference*, Asilomar, CA.
2. Baldor Electric Company™ :http://www.baldor.com/products/product.asp?1=1&product=AC+Motors&family=Pump|vw_ACMotors_Pump

Commercial Shell Improvements

Window Film

This section covers installation of reflective window film in commercial buildings. The baseline condition is assumed to be double pane clear glass with a solar heat gain coefficient of 0.73 and U-value of 0.72 Btu/hr-SF-deg F. The window film is assumed to provide a solar heat gain coefficient of 0.40 or less. Energy and demand saving are realized through reductions in the building cooling loads. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. The commercial 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 window.

Algorithms

Window Film

Electricity Impact (kWh) = $SF_{WINDOW}/100 \text{ X } (\Delta KWH/100SF_{WINDOW})$

Demand Impact (kW) = $SF_{WINDOW}/100 \text{ X } (\Delta KW/100SF_{WINDOW}) \text{ X } CF_S$

Definition of Terms

SF_{ROOF} = glazing surface area of installed window film, not including frame (square feet)

$\Delta KWH/100SF_{WINDOW}$ = unit energy savings per 100 square feet of window film

$\Delta KW/100SF_{WINDOW}$ = unit demand savings per 100 square feet of window film

CF_s = summer coincident peak factor

TABLE 107: HIGH PERFORMANCE WINDOWS

Component	Type	Value	Sources
SF_{WINDOW}	Variable		EDC Data Gathering

Component	Type	Value	Sources
$\Delta KWH/100SF_{WINDOW}$	Fixed	Akron: 266 kWh/100 SF Cincinnati: 327 kWh/100 SF Cleveland: 282 kWh/100 SF Columbus: 283 kWh/100 SF Dayton: 299 kWh/100 SF Mansfield: 259 kWh/100 SF Toledo: 268 kWh/100 SF	1
$\Delta KW/100SF_{WINDOW}$	Fixed	Akron: 0.165 kW/100 SF Cincinnati: 0.149 kW/100 SF Cleveland: 0.146 kW/100 SF Columbus: 0.127 kW/100 SF Dayton: 0.161 kW/100 SF Mansfield: 0.148 kW/100 SF Toledo: 0.138 kW/100 SF	1
CF_a	Fixed	0.74	2

Estimated Useful Life

The estimated useful life for window films is 10 years.

Measure Costs

The full capital cost for adding window film to existing windows is listed below. No incremental O&M and periodic capital replacement costs are anticipated.

Table 108: Measure Costs – Window Films

Measure	Cost	Unit	Source	Notes
Window Film	$154.	100 SF	3	Including labor

Sources:

1. Unit energy and demand savings data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

High Performance Glazing

This section covers installation of high performance glazing in commercial buildings. The baseline condition is assumed to be double pane clear glass with a solar heat gain coefficient of 0.73 and U-value of 0.72 Btu/hr-SF-deg F. The efficient glazing must have a solar heat gain coefficient of 0.40 or less and U-value of 0.57 Btu/hr-SF-deg F or less. 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 commercial prototypical building models. The commercial 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 window.

Algorithms

High Performance Glazing

Electricity Impact (kWh) = $SF_{WINDOW}/100 \times (\Delta KWH/100SF_{WINDOW})$

Demand Impact (kW) = $SF_{WINDOW}/100 \times (\Delta KW/100SF_{WINDOW}) \times CF_S$

Definition of Terms

SF_{WINDOW} = glazing surface area of installed windows, not including frame (square feet)

$\Delta KWH/100SF_{WINDOW}$ = unit energy savings per 100 square feet of window

$\Delta KW/100SF_{WINDOW}$ = unit demand savings per 100 square feet of window

CF_s = summer coincident peak factor

TABLE 109: HIGH PERFORMANCE GLAZING

Component	Type	Value	Sources
SF_{WINDOW}	Variable		EDC Data Gathering

Component	Type	Value	Sources
$\Delta KWH/100SF_{WINDOW}$	Fixed	Akron: 272 Cincinnati: 326 kWh/100SF Cleveland: 289 kWh/100SF Columbus: 278 kWh/100SF Dayton: 303 kWh/100SF Mansfield: 266 Toledo: 276	1
$\Delta KW/100SF_{WINDOW}$	Fixed	Akron: 0.171 kW/100SF Cincinnati: 0.156 kW/100SF Cleveland: 0.152 kW/100SF Columbus: 0.132 kW/100SF Dayton: 0.159 kW/100SF Mansfield: 0.154 kW/100SF Toledo: 0.139 kW/100SF	1
CF_a	Fixed	0.74	2

Estimated Useful Life

The estimated useful life for high performance glazing in commercial applications is 20 years.

Measure Costs

The incremental capital cost for upgrading to high-performance glazing is listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 110: MEASURE COSTS – HIGH PERFORMANCE GLAZING

Measure	Cost	Unit	Source	Notes
High Performance Glazing	$1,396	100 SF	3	Labor excluded; incremental material cost only

Sources:

1. Unit energy and demand savings data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Cool Roof

This section covers installation of "cool roof" roofing materials in commercial buildings. The cool roof is assumed to have a solar absorptance of 0.3 compared to a standard roof with solar absorptance of 0.8. Energy and demand saving are realized through reductions in the building cooling loads. The approach utilizes DOE-2.2 simulations on a series of commercial prototypical building models. The commercial 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

Cool Roof

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

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

Definition of Terms

SF_{ROOF} = surface area of installed cool roof (square feet)

$\Delta KWH/kSF_{ROOF}$ = unit energy savings per thousand square feet of cool roof

$\Delta KW/kSF_{ROOF}$ = unit demand savings per thousand square feet of cool roof

CF_s = summer coincident peak factor

TABLE 111: COOL ROOF

Component	Type	Value	Sources
SF_{ROOF}	Variable		EDC Data Gathering
$\Delta KWH/kSF_{ROOF}$	Fixed	Akron: 165 kWh/kSF Cincinnati: 214 kWh/kSF Cleveland: 164 kWh/kSF Columbus: 187 kWh/kSF Dayton: 192 kWh/kSF Mansfield: 151 kWh/kSF Toledo: 174 kWh/kSF	1

Component	Type	Value	Sources
$\Delta KW/kSF_{ROOF}$	Fixed	Akron: 0.144 kW/kSF Cincinnati: 0.164 kW/kSF Cleveland: 0.096 kW/kSF Columbus: 0.123 kW/kSF Dayton: 0.153 kW/kSF Mansfield: 0.099 kW/kSF Toledo: 0.115 kW/kSF	1
CF_a	Fixed	0.74	2

Estimated Useful Life

The estimated useful life for cool roofs is 20 years.

Measure Costs

The incremental capital cost for installing a cool roof during normal roof replacement is listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 112: MEASURE COSTS – COOL ROOF

Measure	Cost	Unit	Source	Notes
Cool Roof	$665.	kSF	3	Incremental material costs only

Sources:

1. Unit energy and demand savings data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Roof Insulation

This section covers improvements to the roof insulation in commercial buildings. Roof insulation R-value is assumed to increase to R-18 from the baseline level assumed for each building type (see Appendix C). 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 commercial prototypical building models. The commercial 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

Roof Insulation

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

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

Definition of Terms

SF_{ROOF} = surface area of installed roof insulation (square feet)

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

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

CF_s = summer coincident peak factor

TABLE 113: ROOF INSULATION

Component	Type	Value	Sources
SF_{CEIL}	Variable		EDC Data Gathering
$\Delta KWH/kSF_{ROOF}$	Fixed	Akron: 46 kWh/kSF Cincinnati: 50 kWh/kSF Cleveland: 49 kWh/kSF Columbus: 42 kWh/kSF Dayton: 50 kWh/kSF Mansfield: 45 kWh/kSF Toledo: 50 kWh/kSF	1

Component	**Type**	**Value**	**Sources**
$\Delta KW/kSF_{ROOF}$	Fixed	Akron: 0.039 kW/kSF Cincinnati: 0.053 kW/kSF Cleveland: 0.031 kW/kSF Columbus: 0.033 kW/kSF Dayton: 0.042 kW/kSF Mansfield: 0.042 kW/kSF Toledo: 0.032 kW/kSF	1
CF_a	Fixed	0.74	2

Estimated Useful Life

The estimated useful life for roof insulation measures is 20 years.

Measure Costs

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

TABLE 114: MEASURE COSTS – ROOF INSULATION

Measure	Cost	Unit	Source	Notes
Roof Insulation	$616.	kSF	3	Including labor

Sources:

1. Unit energy and demand savings data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant, full service restaurant, assembly, big box retail, small retail, small office, light industrial and school building models. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Industrial Process Measures

Injection Molding Machine Barrel Wraps

Removable insulated blankets enclose the cylindrical barrels of an injection molding Machine. Surface temperatures of the barrels range from 300°F to 600°F, depending on the resins processed. Barrels are heated either with electric resistance band heaters or by friction from the mechanical screw which shears plastic material in the barrel generating frictional heat. Insulated blankets minimize the use of resistance heating without affecting temperature control of the resin.
Barrel wraps are held in place by straps. The only cost is for the equipment, there is no installation cost. Blankets are available either in standard sizes or can be custom manufactured.

Algorithms

Non-Coincident Electric Demand Savings = ΔkW = SPT X TON

Electric Energy Savings = ΔkW X EFLH

Electric Peak Coincident Demand Savings = ΔkW X CF

Definition of Terms

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

$kW_{energyefficientmeasure}$ = maximum hourly demand at technology level

CF = Coincidence Factor

SPT = Savings per ton = 75.1kW/ton based on survey of manufacturers

TON = Clamp ton capacity of injection molding machine

TABLE 115: BARREL WRAPS

Component	Type	Value	Source

EFLH[6]	Variable	4,962	if EDU Data Gathering is not available
CF[7]	Fixed	0.75	based on 4p-5p peak period
SPT	Fixed	75.1 kW/ton	Survey of Manufacturers[8]
TON	Variable	Measurement	EDU Data Gathering

Effective Measure Life

5 years (Engineering Judgment)

Incremental Capital Cost

$2 per machine ton (Engineering Judgment)

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[6] State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Deemed Savings Parameter Development. August 2009. PA Consulting Group Inc.

[7] PG&E 1996, RLW Schools, RLW CF, SDG&E Time of Use Surveys.

[8] Unitherm - www.unitherm.com/information/kwhstudies/index.htm. Uni-Vest - www.imscompany.com Jeda Equipment Services, Inc.

Engineered Nozzles

Engineered nozzles reduce the amount of air required to blow off parts or for drying. These nozzles utilize the Coandăeffect to pull in free air to accomplish tasks for up to 70% less compressed air. Engineered nozzles often replace simple copper tubes. Engineered nozzles have the added benefits of noise reduction and improved safety in systems with greater than 30 psig.

Algorithms

Non-Coincident Electric Demand Savings = ΔkW = KWSCFM X ($FLOW_{baseline}$ - $FLOW_{eng}$) X PR

Electric Energy Savings = ΔkW X EFLH

Electric Peak Coincident Demand Savings = ΔkW X CF

Definition of Terms

TABLE 116: ENGINEERED NOZZLES

Component	Type	Value	Source
Shop air pressure	Fixed	80 psi	Standard Industrial Practice
KWSCFM[9]	Fixed	0.16 kW/SCFM	Range of 0.15-0.24 per DOE study
$FLOW_{baseline}$	Fixed	See chart below	5
$FLOW_{eng}$	Fixed	See chart below	6
PR[10]	Fixed	0.6	Average of power reduction of air compressors based on CFM reduction
EFLH[11]	Variable	4,962	if EDU Data Gathering is not available
CF[12]	Fixed	0.75	based on 4p-5p peak

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[9] Improving Compressed Air System Performance - a Sourcebook for Industry. U.S. Department of Energy - Energy Efficiency and Renewable Energy

[10] Based on Part Load Curve data from CAC

[11] State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Deemed Savings Parameter Development. August 2009. PA Consulting Group Inc.

[12] PG&E 1996, RLW Schools, RLW CF, SDG&E Time of Use Surveys.

			period

TABLE 117: ΔSCFM FOR OPEN FLOW VS. ENGINEERED NOZZLES

	Open Flow (SCFM)[13] **FLOW$_{baseline}$**	**Engineered Nozzle (SCFM)[14]** **FLOW$_{eng}$**	**ΔSCFM**
1/8" Nozzle	21	6	15
1/4" Nozzle	58	11	47

Effective Measure Life

5 years (Engineering Judgment)

Incremental Capital Cost

$80 per unit (Engineering Judgment)

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[13] Machinery's Handbook 25th Edition.

[14] Survey of Engineered Nozzle Suppliers

Insulated Pellet Dryers

Resin pellets used in injection molders and extruders are typically dried using electrically heated and desiccant dried air. Flexible ducts in the 3" to 8" diameter size range circulate the drying air. Air temperatures usually range from 160°F to 200°F. Uninsulated duct heat loss must be replaced by electric resistance heaters. Most facilities have pellet dryers running constantly to maintain pellet dryness at all times.

Algorithms

Non-Coincident Electric Demand Savings = ΔkW = LENGTH X ($kW_{baseline}$ - $kW_{energyefficientmethod}$)

Electric Energy Savings = ΔkW X EFLH

Electric Peak Coincident Demand Savings = ΔkW X CF

Definition of Terms

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

$kW_{baseline}$ = maximum hourly demand at technology level

$kW_{energyefficientmeasure}$ = maximum hourly demand at technology level

LENGTH = Pipe and insulation length, ft

CF = Coincidence Factor

TABLE 118: INSULATED PELLET DRYERS

Component	Type	Value	Source
LENGTH	Variable	Measurement	EDU Data Gathering
EFLH[15]	Variable	4,962	if EDU Data Gathering is not available
CF[16]	Fixed	0.75	based on 4p-5p peak period

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[15] State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Deemed Savings Parameter Development. August 2009. PA Consulting Group Inc.

[16] PG&E 1996, RLW Schools, RLW CF, SDG&E Time of Use Surveys.

TABLE 119: ELECTRIC DEMAND FOR LOAD TEMPERATURES AND DUCT DIAMETERS[17]

Temperature (°F)	Duct Diameter (in)	$KW_{baseline}$	$KW_{energyefficientmethod}$	ΔKW
160	3	0.03/ft	0.01/ft	0.02/ft
	4	0.04/ft	0.01/ft	0.03/ft
	5	0.05/ft	0.01/ft	0.04/ft
	6	0.06/ft	0.01/ft	0.05/ft
	8	0.09/ft	0.01/ft	0.08/ft
170	3	0.03/ft	0.01/ft	0.03/ft
	4	0.05/ft	0.01/ft	0.04/ft
	5	0.06/ft	0.01/ft	0.05/ft
	6	0.07/ft	0.01/ft	0.06/ft
	8	0.10/ft	0.01/ft	0.09/ft
180	3	0.04/ft	0.01/ft	0.03/ft
	4	0.05/ft	0.01/ft	0.04/ft
	5	0.07/ft	0.01/ft	0.06/ft
	6	0.08/ft	0.01/ft	0.07/ft
	8	0.11/ft	0.01/ft	0.10/ft
190	3	0.04/ft	0.01/ft	0.04/ft
	4	0.06/ft	0.01/ft	0.05/ft
	5	0.07/ft	0.01/ft	0.06/ft
	6	0.09/ft	0.01/ft	0.08/ft
	8	0.13/ft	0.02/ft	0.11/ft
200	3	0.05/ft	0.01/ft	0.04/ft
	4	0.07/ft	0.01/ft	0.06/ft
	5	0.08/ft	0.01/ft	0.07/ft
	6	0.10/ft	0.01/ft	0.09/ft
	8	0.14/ft	0.02/ft	0.12/ft

Effective Measure Life

5 years (Engineering Judgment)

Incremental Capital Cost

$33 per foot 3” diam., $43 per foot 4” diam., $54 per foot 5” diam., $65 per foot 6” diam., $86 per foot 8” diam. (Engineering Judgment)

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[17] Value is calculated from standard pipe insulation calculation assuming 1.5” thick insulation, R = 6.

Pre-Rinse Sprayers (Electric)

Installing devices such as the low-flow pre-rinse sprayer is an inexpensive and lasting approach to water conservation. These products help to save energy by reducing the amount of energy needed to process, move, and heat the water. This measure will compare annual energy savings between a standard pre-rinse sprayer head with a flow rate of 2.23 gallons per minute and a low-flow pre-rinse sprayer with a flow rate of 1.12 gallons per minute.

Algorithms

Non-Coincident Electric Demand Savings = ΔkW = kWh / EFLH = kW

Electric Energy Savings (kWh)= GPYS X 8.3 X (AWT – TSW) / 3413

Electric Peak Coincident Demand Savings = ΔkW X Coincidence Factor (CF)

Definition of Terms

GPYS (Gallons saved per year) = (EGPM X ($HRTW_b$ X 60Min X 52Weeks)) - (PGM X ($HRTW_e$ X 60Min X 52Weeks))

EGPM= Existing gallons per minute

PGPM= Proposed gallons per minute

$HRTW_b$= Hours run time per week baseline

$HRTW_e$= Hours run time per week efficient technology

Week= 7 day week/ 52 weeks/year

TSW= Temperature of supply water

AWT= Application water temperature

GPY= Gallons per year

GPYS= Gallons per year saved

kWh= Kilowatt hours

kW= Kilowatt

EFLH= Equivalent Full Load Hours

TABLE 120: PRE-RINSE SPRAYERS

Component	Type	Value	Sources
TSW	Fixed for area	60°F	2
AWT	Fixed	128°F	1
EFLH	Fixed for building type	4,482, (used only for demand estimate)	4
CF	fixed	.5, conservative estimate from values show for various facility types 4p-5p, considering sprayers are generally used after meals	3
EGPM	Fixed	2.23 gpm	1
PGPM	Fixed	1.12 gpm	1
$HRTW_b$	Fixed	3.8 hrs/wk	1
$HRTW_e$	Fixed	5.1 hrs/wk	1

Effective Measure Life

5 years (Engineering Judgment)

Incremental Capital Cost

$35 per unit (Engineering Judgment)

Sources:

1. CALMAC Study: Impact and Process Evaluation Final Report for California Urban Water Conservation Council 2004-5 Pre-Rinse Spray Valve Installation Program (Phase 2)
2. USGS, Ground water temperature, National Water Information System (NWIS)
3. Analytics. *Coincidence Factor Study - Residential and Commercial Industrial Lighting Measures*. Spring 2007.
4. State of Wisconsin Public Service Commission of Wisconsin, Focus on Energy Evaluation, Business Programs: Deemed Savings Parameter Development. August 2009. PA Consulting Group Inc.

Food Service and Related Measures

Combination Ovens

Measure data for savings calculations have been developed based on average equipment characteristics for customer participants for the Food Service Equipment program. Annual energy use was calculated based on preheat, idle, and cooking-energy efficiency and production capacity test results from applying ASTM F1639-05.

Algorithms

Combination Ovens

Electric Energy Savings (kWh) = LB X E_{FOOD}/EFF + IDLE X (EFLH – LB/PC – PRE_{TIME} /60) + PRE_{ENERGY}

Baseline Non-Coincident Demand ($kW_{baseline}$) = $kWh_{baseline}$/(EFLH X 365 days)

Energy Efficient Non-Coincident Demand ($kW_{energy\ efficient\ measure}$) = $kWh_{energy\ efficient\ measure}$/(EFLH X 365 days)

Non-Coincident Electric Demand Savings = ΔkW = $kW_{baseline}$ – $kW_{energy\ efficient\ measure}$

Electric Peak Coincident Demand Savings= ΔkW X CF

Definition of Terms

LB= Pounds of food cooked per day (lb/day)

E_{FOOD}= ASTM Energy to Food (kWh/lb); kWh/pound of energy absorbed by food product during cooking

EFF= Heavy Load Cooking Energy Efficiency (%)

IDLE= Idle Energy Rate (kW)

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

PC= Production Capacity (lbs/hr)

PRE_{TIME}= Preheat time (min/day)

PRE_{ENERGY}= Preheat energy (kWh/day)

$kWh_{baseline}$ = Calculated annual energy usage of the baseline oven (kWh)

$kWh_{energy\ efficient\ measure}$ = Calculated annual energy usage of the energy efficient oven (kWh)

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

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

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

TABLE 121: ENERGY EFFICIENT OVENS

Component	Type	Value	Sources
LB	Fixed	200 lbs	1
E_{FOOD}	Fixed	0.0732 kWh/lb	2
EFF	Fixed	See Table XX below	1, 3
IDLE	Fixed	See Table XX below	1, 3
EFLH	Fixed	12 hrs/day	1
PC	Fixed	See Table XX below	1, 3
PRE_{TIME}	Fixed	15 min/day	1
PRE_{ENERGY}	Fixed	See Table XX below	1, 3
$kWh_{baseline}$	Fixed	Calculated in kWh Equation	1, 3
$kWh_{energy\ efficient\ measure}$	Fixed	Calculated in kWh Equation	1, 3
$kW_{baseline}$	Fixed	Calculated in kW Equation	1, 3
$kW_{energy\ efficient\ measure}$	Fixed	Calculated in kW Equation	1, 3
CF	Fixed	0.84	4

Sources:

1. Food Service Technology Center
2. American Society for Testing and Materials
3. ENERGY STAR
4. RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

TABLE 122: BASELINE & EFFICIENT VALUES – ENERGY EFFICIENT OVENS

Performance	Baseline Model	Energy Efficient Model
Preheat Energy (kWh)	3	1.5
Idle Energy Rate (kW)	7.5	3
Heavy Load Cooking Energy Efficiency (%)	44%	60%
Production Capacity (lbs/hr)	80	100

Effective Measure Life

12 years (Food Service Technology Center)

Incremental Capital Cost

$16,884 per unit (Food Service Technology Center)

Convection Ovens

Measure data for savings calculations are based on average equipment characteristics for customer participants for the Food Service Equipment program. Annual energy use was calculated based on preheat, idle, and cooking energy efficiency and production capacity test results from applying ASTM F1496.

Algorithms

Convection Ovens

Electric Energy Savings (kWh) = LB X E_{FOOD}/EFF + IDLE X (EFLH – LB/PC – PRE_{TIME} /60) + PRE_{ENERGY}

Baseline Non-Coincident Demand ($kW_{baseline}$) = $kWh_{baseline}$/(EFLH X 365 days)

Energy Efficient Non-Coincident Demand ($kW_{energy\ efficient\ measure}$) = $kWh_{energy\ efficient\ measure}$/(EFLH X 365 days)

Non-Coincident Electric Demand Savings = ΔkW = $kW_{baseline}$ – $kW_{energy\ efficient\ measure}$

Electric Peak Coincident Demand Savings= ΔkW X CF

Definition of Terms

LB= Pounds of food cooked per day (lb/day)

E_{FOOD}= ASTM Energy to Food (kWh/lb); kWh/pound of energy absorbed by food product during cooking

EFF= Heavy Load Cooking Energy Efficiency (%)

IDLE= Idle Energy Rate (kW)

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

PC= Production Capacity (lbs/hr)

PRE_{TIME}= Preheat time (min/day)

PRE_{ENERGY}= Preheat energy (kWh/day)

$kWh_{baseline}$ = Calculated annual energy usage of the baseline oven (kWh)

$kWh_{energy\ efficient\ measure}$ = Calculated annual energy usage of the energy efficient oven (kWh)

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

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

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

TABLE 123: CONVECTION OVENS

Component	Type	Value	Sources
LB	Fixed	100 lbs	1
E_{FOOD}	Fixed	0.0732 kWh/lb	2
EFF	Fixed	See Table 123 below	1, 3
IDLE	Fixed	See Table 123 below	1, 3
EFLH	Fixed	12 hrs/day	1
PC	Fixed	See Table 123 below	1, 3
PRE_{TIME}	Fixed	15 min/day	1
PRE_{ENERGY}	Fixed	See Table 123 below	1, 3
$kWh_{baseline}$	Fixed	Calculated in kWh Equation	1, 3
$kWh_{energy\ efficient\ measure}$	Fixed	Calculated in kWh Equation	1, 3
$kW_{baseline}$	Fixed	Calculated in kW Equation	1, 3
$kW_{energy\ efficient\ measure}$	Fixed	Calculated in kW Equation	1, 3
CF	Fixed	0.84	4

Sources:

1. Food Service Technology Center
2. American Society for Testing and Materials
3. ENERGY STAR
4. RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

TABLE 124: BASELINE & EFFICIENT VALUES – CONVECTION OVENS

Performance	Baseline Model	Energy Efficient Model
Preheat Energy (kWh)	1.5	1
Idle Energy Rate (kW)	2	1.5
Heavy Load Cooking Energy Efficiency (%)	65%	70%
Production Capacity (lbs/hr)	70	80

Effective Measure Life

12 years (Food Service Technology Center)

Incremental Capital Cost

$2,713 per unit (Food Service Technology Center)

Engineered CKV Hood

This section covers installation of an engineered commercial kitchen ventilation (CKV) hood on a restaurant cook line. Engineered CKV systems can reduce the ventilation rates for the cook line ventilation hoods by 50% to 60%. The size of the hoods and the ventilation air requirements vary widely by restaurant, so the impacts of this technology were normalized per 100 cfm of ventilation air reduction. The makeup air for the system is assumed to be introduced through the kitchen HVAC systems, rather than through a dedicated makeup air heater. Energy and demand saving are realized through reductions in the outdoor air ventilation rates, resulting in a reduction in heating and cooling loads. The approach utilizes DOE-2.2 simulations on fast food and full service restaurant building models. The commercial simulation models are adapted from the California Database for Energy Efficiency Resources (DEER) study, with changes to reflect Ohio climate and building practices.

Algorithms

Engineered CKV Hood

Electricity Impact (kWh) = $\Delta CFM_{HOOD}/100 \text{ X } (\Delta KWH/100CFM_{HOOD})$

Demand Impact (kW) = $\Delta CFM_{HOOD}/100 \text{ X } (\Delta KW/100CFM_{HOOD}) \text{ X } CF_S$

Definition of Terms

ΔCFM_{HOOD} = reduction in air flow rate due to engineered hood

$\Delta KWH/100CFM_{HOOD}$ = unit energy savings per 100 cfm of air flow reduction

$\Delta KW/100CFM_{HOOD}$ = unit demand savings per 100 cfm of air flow reduction

CF_s = summer coincident peak factor

TABLE 125: ENGINEERED CKV HOOD

Component	Type	Value	Sources
ΔCFM_{HOOD}	Variable		EDC Data Gathering

Component	Type	Value	Sources
$\Delta KWH/100CFM_{HOOD}$	Fixed	Akron: 690 kWh/100 CFM Cincinnati: 671 kWh/100 CFM Cleveland: 688 kWh/100 CFM Columbus: 659 kWh/100 CFM Dayton: 696 kWh/100 CFM Mansfield: 693 kWh/100 CFM Toledo: 712 kWh/100 CFM	1
$\Delta KW/100CFM_{HOOD}$	Fixed	Akron: 0.2 kW/100 CFM Cincinnati: 0.2 kW/100 CFM Cleveland: 0.2 kW/100 CFM Columbus: 0.24 kW/100 CFM Dayton: 0.28 kW/100 CFM Mansfield: 0.16 kW/100 CFM Toledo: 0.2 kW/100 CFM	1
CF_a	Fixed	0.74	2

Estimated Useful Life

The estimated useful life for CKV hoods is 20 years.

Measure Costs

The incremental capital cost for upgrading from a standard hood to an engineered hood per 100 cfm of air flow reduction is listed below. No incremental O&M and periodic capital replacement costs are anticipated.

TABLE 126: MEASURE COSTS – ENGINEERED CKV HOOD

Measure	Cost	Unit	Source	Notes
Engineered CKV Hood	$300.	100 CFM reduction	3	Incremental costs only without labor.

Sources:

1. Unit energy and demand savings data based on a series of prototypical small commercial building simulation runs. Values shown are weighted averages across fast food restaurant and full service restaurants. The prototypes are based on the California DEER study prototypes, modified for local construction practices. Simulations were run using TMY3 weather data for each of the cities listed. See Appendix C for more information.
2. Coincidence factor supplied by Duke Energy for the commercial HVAC end-use.
3. Measure costs taken from 2005 DEER measure Cost Study. www.deeresources.com

Steam Cookers

Measure data for savings calculations are based on average equipment characteristics for customer participants for the Food Service Equipment program. Annual energy use was calculated based on preheat, idle, and potato cooking energy efficiency and production capacity test results from applying ASTM F1484.

Algorithms

Steam Cookers

Electric Energy Savings (kWh) = $LB \times E_{FOOD}/EFF + IDLE \times (EFLH - LB/PC - PRE_{TIME}/60) + PRE_{ENERGY}$

Baseline Non-Coincident Demand ($kW_{baseline}$) = $kWh_{baseline}/(EFLH \times 365 \text{ days})$

Energy Efficient Non-Coincident Demand ($kW_{energy\ efficient\ measure}$) = $kWh_{energy\ efficient\ measure}/(EFLH \times 365 \text{ days})$

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

Electric Peak Coincident Demand Savings= $\Delta kW \times CF$

Definition of Terms

LB= Pounds of food cooked per day (lb/day)

E_{FOOD}= ASTM Energy to Food (kWh/lb); kWh/pound of energy absorbed by food product during cooking

EFF= Heavy Load Cooking Energy Efficiency (%)

IDLE= Idle Energy Rate (kW)

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

PC= Production Capacity (lbs/hr)

PRE_{TIME}= Preheat time (min/day)

PRE_{ENERGY}= Preheat energy (kWh/day)

$kWh_{baseline}$ = Calculated annual energy usage of the baseline oven (kWh)

$kWh_{energy\ efficient\ measure}$ = Calculated annual energy usage of the energy efficient oven (kWh)

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

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

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

TABLE 127: STEAM COOKERS

Component	Type	Value	Sources
LB	Fixed	See Table 127 below	1
E_{FOOD}	Fixed	0.0308 kWh/lb	2
EFF	Fixed	See Table 127 below	1, 3
IDLE	Fixed	See Table 127 below	1, 3
EFLH	Fixed	12 hrs/day	1
PC	Fixed	See Table 127 below	1, 3
PRE_{TIME}	Fixed	15 min/day	1
PRE_{ENERGY}	Fixed	1.5 kWh/day	1, 3
$kWh_{energy\ efficient\ measure}$	Fixed	Calculated in kWh Equation	1, 3
$kW_{baseline}$	Fixed	Calculated in kW Equation	1, 3
$kW_{energy\ efficient\ measure}$	Fixed	Calculated in kW Equation	1, 3
CF	Fixed	0.84	4

Sources:

1. Food Service Technology Center
2. American Society for Testing and Materials
3. ENERGY STAR
4. RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

TABLE 128: BASELINE VALUES – STEAM COOKER

Performance	Baseline Model			
	3	4	5	6
Pan Capacity	1	1.325	1.675	2
Idle Energy Rate (kW)	70	87	103	120
Production Capacity (lb/h)	100	128	160	192
Pounds of Food Cooked per Day	1.91	1.91	1.91	1.91
Residual Energy Rate (kW)	20%	20%	20%	20%
Heavy Load Cooking Energy Efficiency				

TABLE 129: EFFICIENT VALUES – STEAM COOKER

Performance	Energy Efficient Model

	3	4	5	6
Pan Capacity	0.4	0.53	0.67	0.8
Idle Energy Rate (kW)	50	67	83	100
Production Capacity (lb/h)	100	128	160	192
Pounds of Food Cooked per Day	0.12	0.12	0.12	0.12
Residual Energy Rate (kW)	50%	50%	50%	50%
Heavy Load Cooking Energy Efficiency				

Effective Measure Life

12 years (Food Service Technology Center)

Incremental Capital Cost

$4,150 per unit (Food Service Technology Center)

ENERGY STAR Fryers

Measure data for savings calculations have been developed based on average equipment characteristics for customer participants for the Food Service Equipment program. Annual energy use was calculated based on preheat, idle, and cooking-energy efficiency and production capacity test results from applying ASTM F1361-05.

Algorithms

ENERGY STAR Fryers

Electric Energy Savings (kWh) = LB X E_{FOOD}/EFF + IDLE X (EFLH – LB/PC – PRE_{TIME} /60) + PRE_{ENERGY}

Baseline Non-Coincident Demand ($kW_{baseline}$) = $kWh_{baseline}$/(EFLH X 365 days)

Energy Efficient Non-Coincident Demand ($kW_{energy\ efficient\ measure}$) = $kWh_{energy\ efficient\ measure}$/(EFLH X 365 days)

Non-Coincident Electric Demand Savings = ΔkW = $kW_{baseline}$ – $kW_{energy\ efficient\ measure}$

Electric Peak Coincident Demand Savings= ΔkW X CF

Definition of Terms

LB= Pounds of food cooked per day (lb/day)

E_{FOOD}= ASTM Energy to Food (kWh/lb); kWh/pound of energy absorbed by food product during cooking

EFF= Heavy Load Cooking Energy Efficiency (%)

IDLE= Idle Energy Rate (kW)

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

PC= Production Capacity (lbs/hr)

PRE_{TIME}= Preheat time (min/day)

PRE_{ENERGY}= Preheat energy (kWh/day)

$kWh_{baseline}$ = Calculated annual energy usage of the baseline oven (kWh)

$kWh_{energy\ efficient\ measure}$ = Calculated annual energy usage of the energy efficient oven (kWh)

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

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

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

TABLE 130: FRYERS

Component	Type	Value	Sources
LB	Fixed	150 lbs	1
E_{FOOD}	Fixed	0.167 kWh/lb	2
EFF	Fixed	See Table 130 below	1, 3
IDLE	Fixed	See Table 130 below	1, 3
EFLH	Fixed	16 hrs/day	1
PC	Fixed	See Table 130 below	1, 3
PRE_{TIME}	Fixed	15 min/day	1
PRE_{ENERGY}	Fixed	See Table 130 below	1, 3
$kWh_{baseline}$	Fixed	Calculated in kWh Equation	1, 3
$kWh_{energy\ efficient\ measure}$	Fixed	Calculated in kWh Equation	1, 3
$kW_{baseline}$	Fixed	Calculated in kW Equation	1, 3
$kW_{energy\ efficient\ measure}$	Fixed	Calculated in kW Equation	1, 3
CF	Fixed	0.84	4

Sources:

1. Food Service Technology Center
2. American Society for Testing and Materials
3. ENERGY STAR
4. RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

TABLE 131: BASELINE & EFFICIENT VALUES - FRYER

Performance (per frypot)	Baseline Model	Energy Efficient Model
Preheat Energy (kWh)	2.3	1.7
Idle Energy Rate (kW)	1.05	1
Heavy Load Cooking Energy Efficiency (%)	75%	80%
Production Capacity (lbs/hr)	65	70

Effective Measure Life

12 years (Food Service Technology Center)

Incremental Capital Cost

$4,708 per unit (Food Service Technology Center)

ENERGY STAR Hot Food Holding Cabinets

Commercial insulated hot food holding cabinet models that meet program requirements incorporate better insulation, reducing heat loss, and may also offer additional energy saving devices such as magnetic door electric gaskets, auto-door closures, or dutch doors. The insulation of the cabinet also offers better temperature uniformity within the cabinet from top to bottom. This means that qualified hot food holding cabinets are more efficient at maintaining food temperature while using less energy.

A spreadsheet calculation was performed comparing an equation for the base equipment energy usage (dependent on unit volume) to the ENERGY STAR specification (dependent on unit volume). Average sizes (as determined from ENERGY STAR database of existing equipment) in three different size ranges were evaluated.

Algorithms

ENERGY STAR Hot Food Holding Cabinets

$kW_{baseline}$ = VOL X WATTS/1000

$kW_{energy\ efficient\ measure}$ = VOL X WATTS/1000

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

Electric Energy Savings (kWh) = ΔkW X EFLH

Electric Peak Coincident Demand Savings = ΔkW X CF

Definition of Terms

VOL= Internal Volume (ft^3)

WATTS= Energy consumed per volume of cabinet (W/ft^3)

EFLH= Equivalent Full Load Hours of operation for the installed measure (hrs)

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

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

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

TABLE 132: HOT FOOD HOLDING CABINETS

Component	Type	Value	Sources
VOL	Fixed	See Table 132 below	3
WATTS	Fixed	See Table 132 below	1, 3
HOURS	Fixed	15 hours/day; 5475 hrs/yr	1, 3
$kW_{baseline}$	Fixed	Calculated in kW Equation	1, 3
$kW_{energy\ efficient\ measure}$	Fixed	Calculated in kW Equation	1, 3
CF	Fixed	0.84	4

Sources:

1. Food Service Technology Center
2. American Society for Testing and Materials
3. ENERGY STAR
4. RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

TABLE 133: BASELINE & EFFICIENT VALUES – HOT FOOD HOLDING CABINET

	Full Size	Three-Quarter Size	Half Size
Internal Volume (ft^3)	20	12	8
Baseline Watts per Volume (W/ft^3)	70	70	70
Proposed Watts per Volume (W/ft^3)	22	27	29

Effective Measure Life

12 years (Food Service Technology Center)

Incremental Capital Cost

$1,783 per unit (Food Service Technology Center)

ENERGY STAR Ice Machines

A spreadsheet analysis of all equipment in the Air-conditioning & Refrigeration Institute (ARI) directory (the regulating agency that provides the testing standard for ice machines) was completed. Trendlines of equipment that qualifies and equipment that doesn't qualify in each equipment specification category were compared. Savings was calculated based on the trendline comparison for each piece of qualifying equipment.

All qualifying equipment was then grouped back together and sorted by size. This list was separated by size category (increments of 100 lbs of ice production per day). The average savings in each size range was determined. After analyzing the different size categories it was determined that the equipment could be put into the larger groupings of <500 lbs, 500-1000 lbs and >1000 lbs.

Algorithms

ENERGY STAR Ice Machines

Electric Energy Savings (kWh) = ($kWh_{baseline}$/100 lbs – $kWh_{energy\ efficient\ measure}$/100 lbs) X CAP/100 lbs X 365 days X LOAD

Non-Coincident Electric Demand Savings (ΔkW) = kWh/EFLH

Electric Peak Coincident Demand Savings = ΔkW X CF

Definition of Terms

$kWh_{baseline}$ = Calculated annual energy usage of the baseline oven (kWh)

$kWh_{energy\ efficient\ measure}$ = Calculated annual energy usage of the energy efficient oven (kWh)

CAP= Capacity of ice machine (lbs/24 hours)

LOAD= Load factor (%)

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

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

TABLE 134: ENERGY STAR ICE MACHINES

Component	Type	Value	Sources
$kWh_{baseline}$	Fixed	See Table 134 below	1

Component	Type	Value	Sources
$kWh_{energy\ efficient\ measure}$	Fixed	See Table 134 below	1
CAP	Fixed	See Table 134 below	2
LOAD	Fixed	75%	1
EFLH	Fixed	8760	1
CF	Fixed	0.84	3

Sources:

1. Energy Star Calculator
2. EDC Data Gathering
3. RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

TABLE 135: BASELINE AND PROPOSED VALUES – ICE MACHINES

Capacity	Base kWh	Proposed kWh
<500 lbs/24 hrs	5,925	5,364
500-1000 lbs/24 hrs	15,756	14,157
>1000 lbs/24 hrs	21,171	17,393

Effective Measure Life

12 years (ENERGY STAR)

Incremental Capital Cost

$600 per unit less than 500 lbs, $1,500 per unit 500 to 1,000 lbs, $2,000 per unit over 1,000 lbs. (ENERGY STAR)

Griddles

Measure data for savings calculations are based on average equipment characteristics for customer participants for the Food Service Equipment program. Annual energy use was calculated based on preheat, idle, and cooking energy efficiency and production capacity test results from applying ASTM F1275.

Algorithms

Griddles

Electric Energy Savings (kWh) = $LB \times E_{FOOD}/EFF + IDLE \times (EFLH - LB/PC - PRE_{TIME}/60) + PRE_{ENERGY}$

Baseline Non-Coincident Demand ($kW_{baseline}$) = $kWh_{baseline}/(EFLH \times 365 \text{ days})$

Energy Efficient Non-Coincident Demand ($kW_{energy\ efficient\ measure}$) = $kWh_{energy\ efficient\ measure}/(EFLH \times 365 \text{ days})$

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

Electric Peak Coincident Demand Savings= $\Delta kW \times CF$

Definition of Terms

LB= Pounds of food cooked per day (lb/day)

E_{FOOD}= ASTM Energy to Food (kWh/lb); kWh/pound of energy absorbed by food product during cooking

EFF= Heavy Load Cooking Energy Efficiency %

IDLE= Idle Energy Rate (kW)

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

PC= Production Capacity (lbs/hr)

PRE_{TIME}= Preheat time (min/day)

PRE_{ENERGY}= Preheat energy (kWh/day)

$kWh_{baseline}$ = Calculated annual energy usage of the baseline oven (kWh)

$kWh_{energy\ efficient\ measure}$ = Calculated annual energy usage of the energy efficient oven (kWh)

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

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

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

TABLE 136: GRIDDLES

Component	Type	Value	Sources
LB	Fixed	100 lbs	1
E_{FOOD}	Fixed	0.139 kWh/lb	2
EFF	Fixed	See Table 136 below	1, 3
IDLE	Fixed	See Table 136 below	1, 3
EFLH	Fixed	12 hrs/day	1
PC	Fixed	See Table 136 below	1, 3
PRE_{TIME}	Fixed	15 min/day	1
PRE_{ENERGY}	Fixed	See Table 136 below	1, 3
$kWh_{baseline}$	Fixed	Calculated in kWh Equation	1, 3
$kWh_{energy\ efficient\ measure}$	Fixed	Calculated in kWh Equation	1, 3
$kW_{baseline}$	Fixed	Calculated in kW Equation	1, 3
$kW_{energy\ efficient\ measure}$	Fixed	Calculated in kW Equation	1, 3
CF	Fixed	0.84	4

Sources:

1. Food Service Technology Center
2. American Society for Testing and Materials
3. ENERGY STAR
4. RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

TABLE 137: BASELINE & EFFICIENT VALUES - GRIDDLES

Performance	Baseline Model	Energy Efficient Model
Idle Energy Rate (kW)	2.5	2.3
Cooking-Energy Efficiency (%)	65%	70%
Production Capacity (lb/h)	35	40
Preheat Energy (kWh)	4	2

Effective Measure Life

12 years (Food Service Technology Center)

Incremental Capital Cost

$3,604 per unit (Food Service Technology Center)

Refrigeration Measures

ENERGY STAR Commercial Solid Door Refrigerators & Freezers

A spreadsheet calculation was performed comparing an equation for the base equipment energy usage (dependent on unit volume) to the ENERGY STAR specification (dependent on unit volume). Average sizes (as determined from ENERGY STAR database of existing equipment) in four different size ranges were evaluated.

Algorithms

<15 ft^3 Solid Door Refrigerators

Baseline Electric Energy = $kWh_{baseline}$ = 0.1 X VOL + 2.04

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = 0.089 X VOL + 1.411

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

Electric Peak Coincident Demand Savings= ΔkW X CF

15-30 ft^3 Solid Door Refrigerators

Baseline Electric Energy = $kWh_{baseline}$ = 0.1 X VOL + 2.04

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = 0.037 X VOL + 2.200

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

Electric Peak Coincident Demand Savings= ΔkW X CF

30-50 ft^3 Solid Door Refrigerators

Baseline Electric Energy = $kWh_{baseline}$ = 0.1 X VOL + 2.04

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = 0.056 X VOL + 1.635

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

Electric Peak Coincident Demand Savings= ΔkW X CF

50 ft^3 Solid Door Refrigerators

Baseline Electric Energy = $kWh_{baseline}$ = 0.1 X VOL + 2.04

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = 0.060 X VOL + 1.416

Non-Coincident Electric Demand Savings = $\Delta kW = \Delta kWh/EFLH$

Electric Peak Coincident Demand Savings= ΔkW X CF

<15 ft^3 Solid Door Freezers

Baseline Electric Energy = $kWh_{baseline}$ = 0.4 X VOL + 1.38

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = 0.250 X VOL + 1.250

Non-Coincident Electric Demand Savings = $\Delta kW = \Delta kWh/EFLH$

Electric Peak Coincident Demand Savings= ΔkW X CF

15-30 ft^3 Solid Door Freezers

Baseline Electric Energy = $kWh_{baseline}$ = 0.4 X VOL + 1.38

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = 0.400 X VOL – 1.000

Non-Coincident Electric Demand Savings = $\Delta kW = \Delta kWh/EFLH$

Electric Peak Coincident Demand Savings= ΔkW X CF

30-50 ft^3 Solid Door Freezers

Baseline Electric Energy = $kWh_{baseline}$ = 0.4 X VOL + 1.38

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = 0.163 X VOL + 6.125

Non-Coincident Electric Demand Savings = $\Delta kW = \Delta kWh/EFLH$

Electric Peak Coincident Demand Savings= ΔkW X CF

>50 ft^3 Solid Door Freezers

Baseline Electric Energy = $kWh_{baseline}$ = 0.4 X VOL + 1.38

Energy Efficient Electric Energy = $kWh_{energy\ efficient\ measure}$ = 0.158 X VOL + 6.333

Non-Coincident Electric Demand Savings = $\Delta kW = \Delta kWh/EFLH$

Electric Peak Coincident Demand Savings= ΔkW X CF

Definition of Terms

VOL= Volume of refrigerator or freezer (ft^3)

$kWh_{baseline}$ = Calculated annual energy usage of the baseline refrigerator or freezer (kWh)

$kWh_{energy\ efficient\ measure}$ = Calculated annual energy usage of the energy efficient refrigerator or freezer (kWh)

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

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

TABLE 138: FREEZERS

Component	Type	Value	Sources
VOL	Fixed	See Table 138, 139 below	1, 2
$kWh_{baseline}$	Fixed	See Table 138, 139 below	1, 2
$kWh_{energy\ efficient\ measure}$	Fixed	See Table 138, 139 below	1, 2
EFLH	Fixed	8760 hours	1, 2
CF	Fixed	0.84	3

Sources:

1. Energy Star Calculator
2. Consortium for Energy Efficiency
3. RLW Analytics. *Coincidence Factor Study – Residential and Commercial Industrial Lighting Measures*. Spring 2007.

TABLE 139: REFRIGERATOR VOLUMES & KWH

	Refrigerator <15 ft³	Refrigerator 15-30 ft³	Refrigerator 30-50 ft³	Refrigerator >50 ft³
Internal Volume (Average size per range)	10	23	40	62
kWh per year	840	1,114	1,414	1,875

TABLE 140: FREEZER VOLUMES & KWH

	Freezer <15 ft³	Freezer 15-30 ft³	Freezer 30-50 ft³	Freezer >50 ft³
Internal Volume (Average size per range)	10	23	40	63
kWh per year	1,369	2,993	4,615	5,945

Effective Measure Life

12 years for refrigerators and freezers (ENERGY STAR, DEER)

Incremental Capital Cost

Refrigerators - $250 per unit less than 15ft3, $500 per unit 15 to 30 ft3, $750 per unit 30-50 ft3, $900 per unit over 50ft3. (ENERGY STAR, CEE)

Freezers -$150 per unit less than 15ft3, $400 per unit 15 to 30 ft3, $550 per unit 30-50 ft3, $700 per unit over 50ft3. (ENERGY STAR, CEE)