Table 6: Metal Halide Track (MHT) Lighting Baseline and Efficient Wattages

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTSee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTSbase)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
MHT	Metal Halide 20W		Two 50W Halogen		23	1	100	1	77
MHT	Metal Halide 39W		Two 75W Halogen		43	1	150	1	107
MHT	Metal Halide 70W		Three 75W Halogen		77	1	225	1	148

Table 7: Ceramic Metal Halide (CMH) Baseline and Efficient Wattages

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTSee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTSbase)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
CMH	Ceramic Metal Halide 20W		Two 50W Halogen		26	1	100	1	74
CMH	Ceramic Metal Halide 39W		Two 75W Halogen		45	1	150	1	105
CMH	Ceramic Metal Halide 50W		Three 65W Halogen		55	1	195	1	140
CMH	Ceramic Metal Halide 70W		Three 75W Halogen		79	1	225	1	146
CMH	Ceramic Metal Halide 100W		Three 90W Halogen		110	1	270	1	160
CMH	Ceramic Metal Halide 150W		Three 120W Halogen		163	1	360	1	197

Version Date & Revision History

Draft: Portfolio #

Effective date: Date TRM will become effective

End date: Date TRM will cease to be effective (or TBD)

Referenced Documents:

1. Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
2. Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.
3. 2010 Standard Performance Contract Procedures Manual: Appendix B: 2010 Table of Standard Fixture Wattages. Ver. 1.1, Southern California Edison. February 25, 2010. Web. Accessed June, 19 2010. <http://www.aesc-inc.com/download/SPC/2010SPCDocs/UnifiedManual/App%20B%20Standard%20Fixture%20Watts.pdf>
4. 2009 EPE Program Downloads. Wattage Table 2009. Web. Accessed September, 26 2009. <http://www.epelectricefficiency.com/downloads.asp?section=ci>.
5. New Jersey Clean Energy Program: Protocols to Measure Resource Savings. December 2007.
6. Thome and Nadel, Commercial Lighting Retrofits: A Briefing Report for Program Implementers, American Council for an Energy-Efficient Economy, April 2003.

Lighting Systems (Non-Controls) (Early Replacement, Retrofit)

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
This measure relates to the installation of new lighting equipment with efficiency that exceeds that of the existing equipment. This characterization could apply to measures such as compact fluorescent lamps (CFLs) and fixtures, linear fluorescent lamps and fixtures, linear fluorescent fixtures replacing high-intensity discharge (HID) fixtures in high-bay applications, high-intensity discharge (HID) fixtures, and delamping. This measure could relate to the early replacement of an existing unit before the end of its useful life or the retrofit of a unit in an existing facility.

Definition of Efficient Equipment
In order for this characterization to apply, the efficient equipment must have higher efficiency than the existing equipment.

Definition of Baseline Equipment
The baseline equipment is the existing equipment before the efficient equipment is installed. Default assumptions of the baseline equipment are presented in the tables below.

Deemed Calculation for this Measure

Annual kWh Savings = (WATTSbase – WATTSee) * HOURS * (1 + WHFe) / 1000

Summer Coincident Peak kW Savings = (WATTSbase – WATTSee) * CF * (1 + WHFd) / 1000

Deemed Lifetime of Efficient Equipment
The expected measure life is dependent on technology type as below:

Measure Type	Lifetime
Screw-in CFL	3.2 years[425]
Hardwired CFL	12 years[426]
High Bay Fluorescent Fixture	15 years[426]
High Efficiency Linear Fluorescent Fixture	15 years[426]
Pulse Start Metal Halide	7.5 years[427]
Metal Halide Track Lighting	15 years[428]
Ceramic Metal Halide	15 years[428]
Delamping	10[429]

[425] Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010. Assumes 12,000 hours lamp lifetime with extended burn times per start typical in commercial applications. Assuming 3,730 annual lighting operating hours for the commercial sector from the source document, the lamp lifetime is calculated as: 12,000 / 3,730 = 3.2 years

[426] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008

[427] The Energy Independence and Security Act of 2007 requires that as of January 1, 2009, metal halide fixtures designed for use with lamps ≥150 W and ≤500 W must use "probe start" ballasts with ballast efficiency ≥94% or "pulse start" ballasts with ballast efficiency ≥88%. This essentially means that new metal halide fixtures will utilize "pulse start" technology. Assuming that the age of the existing equipment being replaced is half of the total expected lifetime for a metal halide fixture (7.5 years), it is assumed that savings are only achieved for half of the lifetime of the new fixture at which point the customer would have had to replace the inefficient technology with "pulse start" technology negating any savings.

[428] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

[429] Based on a review of measure life assumptions in Oregon, California, and Iowa as presented in *Measure Life Study*, Energy & Resource Solutions. November 17, 2005, delamping lifetime assumptions range from 9 to 16 years. The high end or this range exceeds the assumed fixture lifetime and has been adjusted down to a more conservative 10 years to reflect expected persistence issues.

Deemed Measure Cost
The actual lighting measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments
O&M cost adjustments should be determined on a case-by-case basis.

Coincidence Factor
The summer peak coincidence factor for this measure is dependent on building type as below:

Building Type	CF[430]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00[431]
Exterior	0.00[432]
Other	0.65

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = (WATTSbase - WATTSee) * HOURS * (1 + WHFe) / 1000$$

Where:

WATTSbase = connected wattage of the baseline fixtures
= Actual wattage of the existing equipment for early replacement application. If actual wattage is unknown, refer to the Baseline and Efficient Fixture Wattages Table in the Reference Table section.

WATSSee = connected wattage of the high efficiency fixtures
= Actual wattage of the efficient equipment for early replacement application. If actual wattage is unknown, refer to the Baseline and Efficient Fixture Wattages Table in the Reference Table section.

HOURS = total operating hours of the lighting. If actual site-specific value is unknown, assume default values dependent on building type as below:

[430] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.
[431] Assumption consistent with 8,760 operating hours assumption.
[432] Assumes that no exterior lighting is operating during the summer on-peak demand period.

Building Type	HOURS[433]
Food Sales	5,544
Food Service	4,482
Health Care	3,677
Hotel/Motel	3,356
Office	3,526
Public Assembly	2,729
Public Services (non-food)	3,425
Retail	4,226
Warehouse	3,464
School	2,302
College	3,900
Industrial – 1 Shift	2,857[434]
Industrial – 2 Shift	4,730[435]
Industrial – 3 Shift	6,631[436]
Exterior	3,833[437]
Other	3,672

WHFe = lighting-HVAC Interation Factor for energy; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficent lighting.
= 0.095 (interior fixtures), 0.000 (exterior fixtures)[438]

1 / 1000 = conversion factor from watts to kilowatts

Summer Coincident Peak Demand Savings

$$\Delta kW = (WATTSbase - WATTSee) * CF * (1 + WHFd) / 1000$$

Where:

WHFd = lighting-HVAC waste heat factor for demand; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficent lighting.
= 0.200 (interior fixtures), 0.000 (exterior fixtures)[439]

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[433] Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, unless otherwise noted.
[434] UI and CL&P Program Savings Documentation for 2010 Program Year, United Illuminating Company, September 2009.
[435] Ibid.
[436] Ibid.
[437] Exterior lighting 3,833 hours per year assumes 10.5 hours per day; typical average for photocell control.
[438] 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. Values were weighted based on program participation data for a small commercial program conducted in Indiana for Duke Energy. See An Evaluation of the Indiana Small Commercial and Industrial Incentive Program. Prepared by TecMarket Works for Duke Energy. June 2007. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.
[439] 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

CF = Summer Peak Coincidence Factor for measure
Dependent on building type as below:

Building Type	CF[440]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00[441]
Exterior	0.00[442]
Other	0.65

Fossil Fuel Impact Descriptions and Calculation

$$\Delta MMBtu = \Delta kWh * IF_{MMBtu}$$

Where:

IF_{MMBtu} = lighting-HVAC Interation Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficent lighting.
= -0.0028 (interior fixtures), 0.0000 (exterior fixtures)[443]

Water Impact Descriptions and Calculation
n/a

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. Values were weighted based on program participation data for a small commercial program conducted in Indiana for Duke Energy. See An Evaluation of the Indiana Small Commercial and Industrial Incentive Program. Prepared by TecMarket Works for Duke Energy. June 2007. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

[440] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

[441] Assumption consistent with 8,760 operating hours assumption.

[442] Assumes that no exterior lighting is operating during the summer on-peak demand period.

[443] 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. Values were weighted based on program participation data for a small commercial program conducted in Indiana for Duke Energy. See An Evaluation of the Indiana Small Commercial and Industrial Incentive Program. Prepared by TecMarket Works for Duke Energy. June 2007. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Reference Tables

Table 8: Baseline and Efficient Fixture Wattages

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS ee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS base)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
High Bay	T-5 46" Two Lamp High Output	Electronic - PRS	150W Metal Halide	Magnetic-CWA	117	4	190	3	73
High Bay	T-5 46" Three Lamp High Output	Electronic - PRS	250W Metal Halide	Magnetic-CWA	181	4	295	3	114
High Bay	T-5 46" Four Lamp High Output	Electronic – IS	400W Metal Halide	Magnetic-CWA	234	3	458	3	224
High Bay	T-5 46" Six Lamp High Output	Electronic – IS	400W Metal Halide	Magnetic-CWA	351	3	458	3	107
High Bay	T-5 46" Eight Lamp High Output	Electronic – IS	1000W Metal Halide	Magnetic-CWA	468	3	1080	3	612
High Bay	T-5 46" Six Lamp High Output (2 Fixtures)	Electronic – IS	1000W Metal Halide	Magnetic-CWA	702	3	1080	3	378
High Bay	T-8 48" Two Lamp Very High Output	Electronic – IS	150W Metal Halide	Magnetic-CWA	77	4	190	3	113
High Bay	T-8 48" Three Lamp Very High Output	Electronic – IS	150W Metal Halide	Magnetic-CWA	112	3	190	3	78
High Bay	T-8 48" Four Lamp Very High Output	Electronic – IS	250W Metal Halide	Magnetic-CWA	151	3	295	3	144
High Bay	T-8 48" Six Lamp Very High Output	Electronic – IS	400W Metal Halide	Magnetic-CWA	226	3	458	3	232
High Bay	T-8 48" Eight Lamp Very High Output	Electronic - PRS	400W Metal Halide	Magnetic-CWA	288	4	458	3	170
High Bay	T-8 48" Eight Lamp Very High Output (2 Fixtures)	Electronic – PRS	1000W Metal Halide	Magnetic-CWA	576	4	1080	3	504
HEF	T-8 24" One Lamp	Electronic	T-12 24" One Lamp	Magnetic-STD	18	3	28	3	10
HEF	T-8 24" Two Lamp	Electronic	T-12 24" Two Lamp	Magnetic-STD	32	3	56	3	24
HEF	T-8 24" Three Lamp	Electronic	T-12 24" Three Lamp	Magnetic-STD	50	3	62	3	12
HEF	T-8 24" Four Lamp	Electronic	T-12 24" Four Lamp	Magnetic-STD	65	3	112	3	47
HEF	T-8 36" One Lamp	Electronic	T-12 36" One Lamp	Magnetic-STD	25	3	46	3	21
HEF	T-8 36" Two Lamp	Electronic	T-12 36" Two Lamp	Magnetic-STD	46	3	81	3	35
HEF	T-8 36" Three Lamp	Electronic	T-12 36" Three Lamp	Magnetic-STD	70	3	127	3	57
HEF	T-8 36" Four Lamp	Electronic	T-12 36" Four Lamp	Magnetic-STD	88	3	162	3	[illegible]
HEF	T-8 48" One Lamp-28W	Electronic - IS	T-12 48" One Lamp-ES	Magnetic-ES	23.3	2	43	3	[illegible]
HEF	T-8 48" Two Lamp-28W	Electronic - IS	T-12 48" Two Lamp-ES	Magnetic-ES	47	2	72	3	[illegible]
HEF	T-8 48" Three Lamp-28W	Electronic - IS	T-12 48" Three Lamp-ES	Magnetic-ES	69.9	2	115	3	[illegible]

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS ee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS base)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
HEF	T-8 48" Four Lamp-28W	Electronic - IS	T-12 48" Four Lamp-ES	Magnetic-ES	92.6	2	144	3	51.4
HEF	T-8 48" One Lamp-25W	Electronic - IS	T-12 48" One Lamp-ES	Magnetic-ES	22	2	43	3	21
HEF	T-8 48" Two Lamp-25W	Electronic - IS	T-12 48" Two Lamp-ES	Magnetic-ES	41	2	72	3	31
HEF	T-8 48" Three Lamp-25W	Electronic - IS	T-12 48" Three Lamp-ES	Magnetic-ES	61.3	2	115	3	53.7
HEF	T-8 48" Four Lamp-25W	Electronic - IS	T-12 48" Four Lamp-ES	Magnetic-ES	80.5	2	144	3	63.5
HEF	T-8 96" One Lamp	Electronic - IS	T-12 96" One Lamp-ES	Magnetic-STD	58	3	75	3	17
HEF	T-8 96" Two Lamp	Electronic - IS	T-12 96" Two Lamp-ES	Magnetic-ES	109	3	123	3	14
HEF	T-8 96" Four Lamp	Electronic - IS	T-12 96" Four Lamp-ES	Magnetic-ES	219	3	246	3	27
HEF	High Performance T-8 48" One Lamp	Electronic	T-12 48" One Lamp-ES	Magnetic-ES	25	6	43	3	18
HEF	High Performance T-8 48" Two Lamp	Electronic	T-12 48" Two Lamp-ES	Magnetic-ES	48	6	72	3	23
HEF	High Performance T-8 48" Three Lamp	Electronic	T-12 48" Three Lamp-ES	Magnetic-ES	73	6	115	3	43
HEF	High Performance T-8 48" Four Lamp	Electronic	T-12 48" Four Lamp-ES	Magnetic-ES	96	6	144	3	50
MHT	Metal Halide 20W		Two 50W Halogen		23	1	100	1	77
MHT	Metal Halide 39W		Two 75W Halogen		43	1	150	1	107
MHT	Metal Halide 70W		Three 75W Halogen		77	1	225	1	148
CMH	Ceramic Metal Halide 20W		Two 50W Halogen		26	1	100	1	74
CMH	Ceramic Metal Halide 39W		Two 75W Halogen		45	1	150	1	105
CMH	Ceramic Metal Halide 50W		Three 65W Halogen		55	1	195	1	140
CMH	Ceramic Metal Halide 70W		Three 75W Halogen		79	1	225	1	146
CMH	Ceramic Metal Halide 100W		Three 90W Halogen		110	1	270	1	160
CMH	Ceramic Metal Halide 150W		Three 120W Halogen		163	1	360	1	197
Delamp	No Lamp	Magnetic-STD	T-12 18" One Lamp	Magnetic-STD	4	TBD	19	3	[illegible]
Delamp	No Lamp	No Ballast	T-12 18" One Lamp	Magnetic-STD	0	TBD	19	3	[illegible]
Delamp	No Lamp	Magnetic-STD	T-12 24" One Lamp	Magnetic-STD	8	TBD	28	3	[illegible]
Delamp	No Lamp	No Ballast	T-12 24" One Lamp	Magnetic-STD	0	TBD	28	3	[illegible]
Delamp	No Lamp	Magnetic-STD	T-12 36" One Lamp	Magnetic-STD	16	TBD	46	3	[illegible]
Delamp	No Lamp	No Ballast	T-12 36" One Lamp	Magnetic-STD	0	TBD	46	3	[illegible]
Delamp	No Lamp	Magnetic-STD	T-12 48" One Lamp	Magnetic-STD	21	TBD	60	3	[illegible]

Type of Measure	Efficient Lamp	Efficient Fixture Ballast Type	Baseline Lamp	Baseline Fixture Ballast Type	Efficient Fixture Wattage (WATTS ee)	Efficient Fixture Wattage Source	Baseline Fixture Wattage (WATTS base)	Baseline Fixture Wattage Source	Fixture Savings (Watts)
Delamp	No Lamp	No Ballast	T-12 48" One Lamp	Magnetic-STD	0	TBD	60	3	60
Delamp	No Lamp	Magnetic-STD	T-12 60" One Lamp	Magnetic-STD	13	TBD	63	3	50
Delamp	No Lamp	No Ballast	T-12 60" One Lamp	Magnetic-STD	0	TBD	63	3	63
Delamp	No Lamp	Magnetic-STD	T-12 72" One Lamp	Magnetic-STD	21	TBD	76	3	55
Delamp	No Lamp	No Ballast	T-12 72" One Lamp	Magnetic-STD	0	TBD	76	3	76
Delamp	No Lamp	Magnetic-STD	T-12 96" One Lamp	Magnetic-STD	15	TBD	90	TBD	75
Delamp	No Lamp	No Ballast	T-12 96" One Lamp	Magnetic-STD	0	TBD	90	TBD	90
Delamp	T-8 24" One Lamp	Electronic – IS	T-8 24" Two Lamp	Electronic - IS	16	TBD	33	TBD	17
Delamp	T-8 36" One Lamp	Electronic – IS	T-8 36" Two Lamp	Electronic - IS	21	TBD	46	TBD	25
Delamp	T-8 48" One Lamp	Electronic – IS	T-8 48" Two Lamp	Electronic - IS	27	TBD	59	TBD	32
Delamp	T-8 60" One Lamp	Electronic – IS	T-8 60" Two Lamp	Electronic - IS	32	TBD	72	TBD	40
Delamp	T-8 96" One Lamp	Electronic – IS	T-8 96" Two Lamp	Electronic - IS	50	TBD	109	TBD	59

Sources:

1. Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
2. Kuiken et al, Focus on Energy Evaluation, Business Programs: Deemed Savings Manual V1.0, KEMA, March 22, 2010.
3. 2010 Standard Performance Contract Procedures Manual: Appendix B: 2010 Table of Standard Fixture Wattages. Ver. 1.1, Southern California Edison. February 25, 2010. Web. Accessed June, 19 2010. <http://www.aesc-inc.com/download/SPC/2010SPCDocs/UnifiedManual/App%20B%20Standard%20Fixture%20Watts.pdf>
4. 2009 EPE Program Downloads. Wattage Table 2009. Web. Accessed September, 26 2009. <http://www.epelectricefficiency.com/downloads.asp?section=ci>.
5. New Jersey Clean Energy Program: Protocols to Measure Resource Savings. December 2007.
6. Thome and Nadel, Commercial Lighting Retrofits: A Briefing Report for Program Implementers, American Council for an Energy-Efficient Economy, April 2003.

Version Date & Revision History
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

Lighting Power Density Reduction (New Construction)

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
This measure relates to the implementation of various lighting design principles aimed at creating a quality and appropriate lighting experience while reducing unnecessary light usage. This is often done by a professional in a new construction situation. Techniques like maximizing daylighting, task lighting, lighting controls, and efficient fixtures are used to create a system of optimal functionality while reducing total lighting power density.

Definition of Efficient Equipment
In order for this characterization to apply, this measure assumes the high efficiency equipment consists of a lighting system that exceeds the lighting power density requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 505.5.2.

Definition of Baseline Equipment
The baseline efficiency assumes compliance with lighting power density requirements as mandated by the International Energy Conservation Code (IECC) 2006, Table 505.5.2.

Deemed Calculation for this Measure

Annual kWh Savings = (WATTSbase – WATTSee) / 1000 * AREA * HOURS * (1 +WHFe)

Summer Coincident Peak kW Savings = (WATTSbase – WATTSee) / 1000 * AREA * (1 + WHFd) * CF

Deemed Lifetime of Efficient Equipment
The expected measure life is measure is 15 years[444].

Deemed Measure Cost
The incremental capital costs for this measure vary by the assumed baseline and efficient equipment scenarios. Incremental costs by measure type are presented below:

Coincidence Factor
The summer peak coincidence factor for this measure is dependent on building type as below:

Building Type	CF[445]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50

[444] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
[445] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

Building Type	CF[445]
College	0.68
Industrial	0.76
Garage	1.00[446]
Other	0.65

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = ((WATTSbase – WATTSee) / 1000 * AREA * HOURS * (1 +WHFe)

Where:

WATTSbase[447] = allowed lighting wattage per square foot based on energy code requirements for building type; see table below for values:

Building Area Type	Lighting Power Density (W/ft^2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Gymnasium	1.1
Healthcare-Clinic	1.0
Hospital/Healthcare	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theatre	1.2
Multi-Family	0.7
Museum	1.1
Office	1.0
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theatre	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3
Retail	1.5
School/University	1.2

[446] Assumption consistent with 8,760 operating hours assumption.
[447] International Energy Conservation Code (IECC 2006) 2006, Table 505.5.2, Interior Lighting Power Allowances

Building Area Type	Lighting Power Density (W/ft^2)
Sports Arena	1.1
Town Hall	1.1
Transportation	1.0
Warehouse	0.8
Workshop	1.4

WATSSee = actual installed lighting wattage per square foot of the efficient lighting system for building type as determined by site-surveys or design diagrams.

1000 = conversion factor (W / kW)

AREA = area of the building in square feet; determined from site-specific information

HOURS = annual site-specific hours of operation of the lighting equipment; dependent on building type as below:

Building Type	HOURS[448]
Food Sales	5,544
Food Service	4,482
Health Care	3,677
Hotel/Motel	3,356
Office	3,526
Public Assembly	2,729
Public Services (non-food)	3,425
Retail	4,226
Warehouse	3,464
School	2,302
College	3,900
Industrial	4,745
Garage	8,760[449]
Other	3,672

WHFe = lighting-HVAC Interation Factor for energy; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficent lighting.
= 0.095 (interior fixtures), 0.000 (exterior fixtures)[450]

Summer Coincident Peak Demand Savings

ΔkW = (WATTSbase – WATTSee) * CF * (1 + WHFd) / 1000

Where:

[448] Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009

[449] Assumes operation 24 hours per day, 365 days per year.

[450] 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. Values were weighted based on program participation data for a small commercial program conducted in Indiana for Duke Energy. See An Evaluation of the Indiana Small Commercial and Industrial Incentive Program. Prepared by TecMarket Works for Duke Energy. June 2007. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

WHFd = lighting-HVAC waste heat factor for demand; this factor represents the reduced electric space cooling requirements due to the reduction of waste heat rejected by the efficent lighting.
= 0.200 (interior fixtures), 0.000 (exterior fixtures)[419]

CF = Summer Peak Coincidence Factor for measure
Dependent on building type as below:

Building Type	CF[451]
Food Sales	0.92
Food Service	0.83
Health Care	0.78
Hotel/Motel	0.37
Office	0.76
Public Assembly	0.65
Public Services (non-food)	0.64
Retail	0.84
Warehouse	0.79
School	0.50
College	0.68
Industrial	0.76
Garage	1.00[452]
Other	0.65

Fossil Fuel Impact Descriptions and Calculation
TBD[453]

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Referenced Documents: "Draft TRM - C&I Buildings Model Development.doc"

[451] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.
[452] Assumption consistent with 8,760 operating hours assumption.
[453] This section pending further information from utilities regarding the energy simulation models used to derive the lighting-HVAC interaction factors.

LED Case Lighting with/without Motion Sensors (New Construction; Retrofit – Early Replacement

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
This measure relates to the installation of LED lamps with and without motion sensors in vertical display refrigerators, coolers, and freezers replacing T8 or T12 linear fluorescent lamp technology. LED lamps should be systems intended for this application. LED lamps not only provide the same light output with lower connected wattages, but also produce less waste heat which decreases the cooling load on the refrigeration system and energy needed by the refrigerator compressor. Additional savings can be achieved from the installation of a motion sensor which automatically dims the lighting system when the space is unoccupied. Retrofit projects must completely remove the existing fluorescent fixture end connectors and ballasts to qualify, though wiring may be reused. Eligible fixtures include new, replacement, and retrofit. Savings and assumptions are based on a per door basis.

Definition of Efficient Equipment
In order for this characterization to apply, the efficient equipment is assumed to be LED case lighting with or without motion sensors on refrigerators, coolers, and freezers - specifically on vertical displays.

Definition of Baseline Equipment
In order for this characterization to apply, the baseline equipment is assumed to be T8 or T12 linear fluorescent lamps.

Deemed Calculation for this Measure

Annual kWh Savings = (WATTSbase – WATTSee) / 1000 * Ndoors * HOURS * (1 + WHFe) * ESF_{MC}

Summer Coincident Peak kW Savings = (WATTSbase – WATTSee) / 1000 * Ndoors * (1 + WHFd) * CF

Deemed Lifetime of Efficient Equipment
The expected measure life is assumed to be 8.1 years[454].

Deemed Measure Cost
The incremental capital cost for this measure is $250 per door (retrofit), and $150 (time of sale, new construction)[455].

If a motion sensor is installed, add an additional cost of $130 per 25ft of case[456].

Deemed O&M Cost Adjustments
The stream of baseline lamp replacement costs over the lifetime of the measure results in a Net Present Value[457] of $22.96. This computes to a levelized annual baseline replacement cost assumption of $4.07.

Coincidence Factor
The summer peak coincidence factor for this measure is assumed to be 92%[458].

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[454] Theobald, M. A., Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California, Pacific Gas and Electric Company, January 2006. Assumes annual operating hours of 6,205. <http://www.etcc-ca.com/images/stories/pdf/ETCC_Report_204.pdf>. The lifetime of the motion sensors is assumed to be equal to the lifetime of the LED lighting.
[455] Based on a review of TRM incremental cost assumptions from Oregon and Vermont, supplemented with completed project information from New York.
[456] "LED Case Lighting With and Without Motion Sensors" presentation, Michele Friedrich, PECI, January 2010.
[457] Using a discount rate of 5.7% (as is used for Efficiency Vermont). Assumes baseline ballast life exceeds the life of the LED assembly.

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (WATTSbase – WATTSee) / 1000 * Ndoors * HOURS * (1 + WHFe) * ESF_{MC}

Where:

WATTSbase = connected wattage per door of the baseline fixtures; see table below for default values.

WATTSee = connected wattage per door of the high efficiency fixtures
= Actual installed. If actual installed wattage is unknown, see table below for default values.

LED Refrigerated Case Lighting System Baseline and Efficient Wattages[459]

Type of Measure	Efficient Lamp	Baseline Lamp	Efficient Fixture Wattage (WATTS ee)	Baseline Fixture Wattage (WATTS base)	Fixture Savings (Watts)
Refrigerated Case Lighting per door	5' LED Case Lighting System	5' T8 Case Lighting System	38	76	38
Refrigerated Case Lighting per door	6' LED Case Lighting System	6' T12HO Case Lighting System	46	112	66

1000 = conversion factor from watts to kilowatts

Ndoors = number of doors
= Actual installed

HOURS = annual operating hours; assume 6,205 operating hours per year[460] if actual operating hours are unknown

ESF_{MC} = Energy Savings Factor; additional savings percentage achieved with a motion sensor. Assume a value of 1.0 if no motion sensor is installed, or 1.43 if motion sensor is installed.[461]

WHFe = waste heat factor for energy to account for cooling savings from efficient lighting. For prescriptive refrigerated lighting measures, the default value is 0.41 for refrigerated space and 0.52 for freezer space[462].

Summer Coincident Peak Demand Savings

[458] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.

[459] From Pacific Gas & Electric 'LED Refrig Lighting ERCO_Talking_Points_v3.pdf.' The efficient wattage, 38 and 46 watts, are the maximum allowed watts for a 5-foot and 6-foot LED refrigerated case lighting system that meets the efficiency specifications of the Designlights Consortium.

[460] Theobald, M. A., Emerging Technologies Program: Application Assessment Report #0608, LED Supermarket Case Lighting Grocery Store, Northern California, Pacific Gas and Electric Company, January 2006. Assumes refrigerated case lighting typically operates 17 hours per day, 365 days per year.
<http://www.etcc-ca.com/images/stories/pdf/ETCC_Report_204.pdf>

[461] D. Bisbee, Sacramento Municipal Utility District, "Customer Advanced Technologies Program Technology Evaluation Report: LED Freezer Case Lighting Systems", July 2008.

[462] Values adopted from Hall, N. et al, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, TecMarket Works, September 1, 2009. This factor is a candidate from future adjustment due to climatic differences between Ohio and New York.

$$\Delta kW = (WATTSbase - WATTSee) / 1000 * Ndoors * (1 + WHFd) * CF$$

Where:

WHFd = waste heat factor for energy to account for cooling savings from efficient lighting. For prescriptive refrigerated lighting measures, the default value is 0.41 for refrigerated space and 0.52 for freezer space[463].

CF = Summer Peak Coincidence Factor for measure
= 0.92[464] (lighting in food sales)

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
The stream of baseline lamp replacement costs over the lifetime of the measure results in a Net Present Value[465] of $22.96. This computes to a levelized annual baseline replacement cost assumption of $4.07.

Baseline Lamp Cost:	$4
Baseline Lamp Life:	12,000
Baseline Lamp Labor Cost:	$5.00 (15 min @ $20 per hour labor)

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[463] Values adopted from Hall, N. et al, New York Standard Approach for Estimating Energy Savings from Energy Efficiency Measures in Commercial and Industrial Programs, TecMarket Works, September 1, 2009. This factor is a candidate from future adjustment due to climatic differences between Ohio and New York.
[464] Methodology adapted from Kuiken et al, "State of Wisconsin Public Service Commission of Wisconsin Focus on Energy Evaluation Business Programs: Deemed Savings Parameter Development", KEMA, November 13, 2009, assuming summer coincident peak period is defined as June through August on weekdays between 3:00 p.m. and 6:00 p.m., unless otherwise noted.
[465] Using a discount rate of 5.7% (as is used for Efficiency Vermont). Assumes baseline ballast life exceeds the life of the LED assembly.

LED Exit Signs (Retrofit)

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
These exit signs have a string of very small, typically red or green, glowing LEDs arranged in a circle or oval. The LEDs may also be arranged in a line on the side, top or bottom of the exit sign. LED exit signs provide the best balance of safety, low maintenance, and very low energy usage compared to other exit sign technologies.

Definition of Efficient Equipment
The efficient equipment is assumed to be an exit sign illuminated by light emitting diodes.

Definition of Baseline Equipment
The baseline equipment is assumed to be a fluorescent model.

Deemed Savings for this Measure

Annual kWh Savings	= 83 kWh
Summer Coincident Peak kW Savings	= 0.010 kW

Deemed Lifetime of Efficient Equipment
16 years[466]

Deemed Measure Cost
$30[467]

Deemed O&M Cost Adjustments
The stream of replacement costs over the lifetime of the measure results in a Net Present Value of $59. This computes to a levelized annual baseline replacement cost assumption of $6.04.[468]

Coincidence Factor
The summer peak coincidence factor for this measure is assumed to be 100%[469].

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWH = kW_{Save} \times HOURS \times ISR \times WHF_e$$

Where:

kW_{Save} = The difference in connected load between baseline equipment and efficient equipment = 0.009[470]

HOURS = Annual operating hours

[466] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008.
[467] NYSERDA Deemed Savings Database, Labor cost assumes 25 minutes @ $18/hr.
[468] This calculation assumes a replacement baseline CFL costs $4 with an estimated labor cost of $5 (assuming 20$/hour and a task time of 15 minutes). Lamp life is approximated as 2 years, assuming a 16,000 hour lamp life operating 8,760 hours per year.
[469] Assuming continuous operation of an LED exit sign, the Summer Peak Coincidence Factor is assumed to equal 1.0.
[470] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010

= 8760

ISR = In service rate, the percentage of rebated units that are actually in service.
= 98%[471]

WHF_e = Waste heat factor for energy; accounts for cooling savings from efficient lighting. The default value for this measure is 1.08 (calculated as (1 + (0.5*0.4 / 2.5))). Based on the assumption that 50% of spaces have mechanical cooling, with a typical 2.5 C.O.P. cooling system efficiency and 0.4 ASHRAE Lighting waste heat cooling factor for Ohio[472]
= 1.08

Summer Coincident Peak Demand Savings

$$\Delta kW = kW_{Save} \times ISR \times WHF_d$$

Where:

ISR = In service rate, the percentage of rebated units that are actually in service.
= 98%[473]

kW_{Save} = The difference in connected load between baseline equipment and efficient equipment
= 0.009[474]

WHF_d = Waste heat factor for demand to account for cooling savings from efficient lighting. For prescriptive measures, the default value for this measure is 1.17 (calculated as (1 + (0.5 * 0.85 / 2.5))). Based on the assumption that 50% of spaces have mechanical cooling, with a typical 2.5 COP cooling system efficiency and assuming 85% of lighting heat needs to be mechanically cooled at time of summer peak.[475]
= 1.17

Fossil Fuel Impact Descriptions and Calculation
n/a[476]

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
The stream of replacement costs over the lifetime of the measure results in a Net Present Value of $59. This computes to a levelized annual baseline replacement cost assumption of $6.04.[477]

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471 Ibid.
472 "Calculating Lighting and HVAC Interactions", Table 1, ASHRAE Journal, November 1993
473 Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions. February, 19, 2010
474 Efficiency Vermont TRM
475 "Calculating Lighting and HVAC Interactions", Table 1, ASHRAE Journal, November 1993; source assumes that 80% of lighting heat offsets heating requirements, and 90% of lighting heat needs to be mechanically cooled.
476 Pending additional information from utilities regarding the modeled waste heat factors for commercial lighting.
477 This calculation assumes a replacement baseline CFL costs $4 with an estimated labor cost of $5 (assuming 20$/hour and a task time of 15 minutes). Lamp life is approximated as 2 years, assuming a 16,000 hour lamp life operating 8,760 hours per year.

Traffic Signals (Retrofit)

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
Traffic and pedestrian signals are illuminated with light emitting diodes (LED) instead of incandescent lamps.

Definition of Efficient Equipment
Refer to the Table titled 'Traffic Signals Technology Equivalencies' for efficient technology wattage and savings assumptions.

Definition of Baseline Equipment
Refer to the Table titled 'Traffic Signals Technology Equivalencies' for baseline efficiencies and savings assumptions.

Deemed Savings for this Measure

Annual kWh Savings $= (W_{base} - W_{eff}) \times HOURS / 1000$

Summer Coincident Peak kW Savings $= (W_{base} - W_{eff}) \times CF / 1000$

Deemed Lifetime of Efficient Equipment
The assumed lifetime of an LED traffic signal is 100,000 hours (manufacturer's estimate), capped at 10 years.[478] The life in years is calculated by dividing 100,000 hrs by the annual operating hours for the particular signal type.

Deemed Measure Cost
The actual measure installation cost should be used (including material and labor).

Deemed O&M Cost Adjustments[479]
Because LEDs last much longer than incandescent bulbs, LEDs offer operation and maintenance (O&M) savings over the life of the lamps for avoided replacement lamps and the labor to install them. The following assumptions are used to calculate the O&M savings:
Incandescent bulb cost: $3 per bulb
Labor cost to replace incandescent lamp: $60 per signal
Life of incandescent bulb: 8000 hours

Coincidence Factor[480]
The summer peak coincidence factor (CF) for this measure is dependent on lamp type as below:

Lamp Type	CF
Red Balls, always changing or flashing	0.55
Red Arrows	0.90
Green Arrows	0.10
Green, always changing or flashing	0.43
Flashing Yellow	0.50
Yellow	0.02

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[478] ACEEE, (1998) *A Market Transformation Opportunity Assessment for LED Traffic Signals*, http://www.cee1.org/gov/led/led-ace3/ace3led.pdf
[479] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010
[480] Ibid

Lamp Type	CF
"Hand" Don't Walk Signal	0.75
"Man" Walk Signal	0.21

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = (W_{base} - W_{eff}) \times HOURS / 1000$$

Where:

W_{base}	= The connected load of the baseline equipment = see Table 'Traffic Signals Technology Equivalencies'
W_{eff}	= The connected load of the baseline equipment = see Table 'Traffic Signals Technology Equivalencies'
EFLH	= annual operating hours of the lamp = see Table 'Traffic Signals Technology Equivalencies'
1000	= conversion factor (W/kW)

For example, an 8 inch red, round signal:

$$\Delta kWh = ((69 - 7) \times 4818) / 1000$$
$$= 299 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = (W_{base} - W_{eff}) \times CF / 1000$$

Where:

W_{base}	= The connected load of the baseline equipment = see Table 'Traffic Signals Technology Equivalencies'
W_{eff}	= The connected load of the baseline equipment = see Table 'Traffic Signals Technology Equivalencies'
CF	= Summer Peak Coincidence Factor for measure =

Lamp Type	CF
Red Balls, always changing or flashing	0.55
Red Arrows	0.90
Green Arrows	0.10
Green, always changing or flashing	0.43
Flashing Yellow	0.50
Yellow	0.02
"Hand" Don't Walk Signal	0.75
"Man" Walk Signal	0.21

For example, an 8 inch red, round signal:

$$\Delta kW = ((69 - 7) \times 0.55) / 1000$$

= 0.0341 kW

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Reference Tables

Traffic Signals Technology Equivalencies[481]

Traffic Fixture Type	Fixture Size and Color	Efficient Lamps	Baseline Lamps	HOURS	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
Flashing Signal	8" Red	LED	Incandescent	4380	7	69	272
Flashing Signal	12" Red	LED	Incandescent	4380	6	150	631
Flashing Signal	8" Yellow	LED	Incandescent	4380	10	69	258
Flashing Signal	12" Yellow	LED	Incandescent	4380	13	150	600
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

[481] 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

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

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End date:	Date TRM will cease to be effective (or TBD)

Light Tube Commercial Skylight (Time of Sale)

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
A tubular skylight which is 10" to 21" in diameter with a prismatic or translucent lens is installed on the roof of a commercial facility. The lens reflects light captured from the 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.

Definition of Efficient Equipment
In order for this characterization to apply, the efficient equipment is assumed to be a tubular skylight that concentrates and directs light from the roof to an area inside the facility.

Definition of Baseline Equipment
The baseline equipment for this measure is a T8 Fluorescent Lamp with comparable luminosity. The specifications for the baseline lamp depend on the size of the Light Tube being installed. See Table 'kW/fixture Calculation Table' in the Reference Tables section for details.

Deemed Savings for this Measure

Annual kWh Savings = kW_f x 2400

Summer Coincident Peak kW Savings = NumFixtures x kW_f x 0.75

Deemed Lifetime of Efficient Equipment
The estimated useful life for a light tube commercial skylight is 10 years[482]

Deemed Measure Cost
If available, actual incremental cost should be used. For analysis purposes, assume an incremental cost for a light tube commercial skylight is $500[483]

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
The coincidence factor for a light tube commercial skylight is 0.75. This was determined by taking the average of several building types for the 4p-5p peak period.[484]

REFERENCE SECTION

Calculation of Savings

Energy Savings

$$\Delta kWh = kW_f \times EFLH$$

Where:

kW_f = kilowatts saved per fixture

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[482] Equal to the manufacturers standard warranty
[483] Based on a review of available manufacturer pricing information
[484] RLW Analytics. Coincidence Factor Study - Residential and Commercial Industrial Lighting Measures. Spring 2007.

= See table below

EFLH = equivalent full load hours

= 2400

For example, 3 light tubes installed:

$$\Delta kWh = 3 \times 0.129 \times 2400$$

$$= 928.8 \text{ kWh}$$

Summer Coincident Peak Demand Savings

$$\Delta kW = NumFixtures \times kW_f \times CF$$

Where:

ΔkW_f = kilowatts saved per fixture

= See table below

CF = coincidence factor

= 0.75

NumFixtures = number of fixtures being installed

For example, 3 light tubes installed:

$$\Delta kW = 3 \times 0.129 \times 0.75$$

$$= 0.29 \text{ kW}$$

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Reference Tables

kW/fixture Calculation Table:

Brand/size	Lumen Output[485]	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**

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[485] Solatube Test Report (2005). http://www.mainegreenbuilding.com/files/file/solatube/stb_lumens_datasheet.pdf

ENERGY STAR Room Air Conditioner for Commercial Use (Time of Sale)

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
This measure relates to the purchase and installation of a room air conditioning unit that meets either the ENERGY STAR[486] or Consortium for Energy Efficiency (CEE) Super-Efficient Home Appliances Initiative (SEHA) Tier 1[487] minimum qualifying efficiency specifications, in place of a baseline unit meeting minimum Federal Standard efficiency ratings. Applicable units are with and without louvered sides, without reverse cycle (i.e., heating), and casement.

Definition of Efficient Equipment
To qualify for this measure the new room air conditioning unit must meet either the ENERGY STAR or CEE SEHA Tier 1 efficiency standards.

Definition of Baseline Equipment
The baseline assumption is a new room air conditioning unit that meets the current minimum federal efficiency standard.

Deemed Calculation for this Measure

Annual kWh Savings = (CAP) * [(1/EERbase) – (1/EERee)] * EFLH

Summer Coincident Peak kW Savings = (CAP) * [(1/EERbase) – (1/EERee)] * 0.74

Deemed Lifetime of Efficient Equipment
The measure life is assumed to be 12 years [488].

Deemed Measure Cost
The incremental cost for this measure is assumed to be $40 for an ENERGY STAR unit and $80 for a CEE TIER 1 unit [489].

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
The coincidence factor for this measure is assumed to be 0.74 [490].

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = (CAP) * [(1/EERbase) – (1/EERee)] * EFLH

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486 "ENERGY STAR Program Requirements for Room Air Conditioners, Partner Commitments", U.S. Environmental Protection Agency, Accessed on 7/17/10. <http://www.energystar.gov/ia/partners/product_specs/program_reqs/room_air_conditioners_prog_req.pdf>
487 "CEE Super-Efficient Home Appliances Initiative – High-Efficiency Specifications for Room Air Conditioners", Consortium for Energy Efficiency, Accessed on 7/17/10. <http://www.cee1.org/resid/seha/rm-ac/rm-ac_specs.pdf>
488 Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007. http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf
489 Based on field study conducted by Efficiency Vermont
490 Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Where:

CAP = cooling capacity of the unit in Btu/h
= Actual installed

EERbase = Energy Efficiency Ratio of the baseline equipment; see table below for default values.

Capacity (Btu/h)	Federal Standard with louvered sides (EER)	Federal Standard without louvered sides (EER)	Federal Standard Casement-Only (EER)	Federal Standard Casement-Slider (EER)
< 8,000	>= 9.7	>=9.0	>=8.7	>=9.5
8,000 to 13,999	>= 9.8	>=8.5	>=8.7	>=9.5
14,000 to 19,999	>=9.7	>=8.5	>=8.7	>=9.5
≥ 20,000	>=8.5	>=8.5	>=8.7	>=9.5

EERee = Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed efficiency of the ENERGY STAR or CEE SEHA Tier 1 compliant unit. See table below for minimum requirements:

Capacity (Btu/h)	ENERGY STAR with louvered sides (EER)	CEE SEHA Tier 1 with louvered sides (EER)	ENERGY STAR without louvered sides (EER)	ENERGY STAR Casement-Only (EER)	ENERGY STAR Casement-Slider (EER)
< 8,000	>=10.7	>=11.2	>=9.9	>=9.6	>=10.5
8,000 to 13,999	>= 10.8	>=11.3	>=9.4	>=9.6	>=10.5
14,000 to 19,999	>=10.7	>=11.2	>=9.4	>=9.6	>=10.5
≥ 20,000	>=9.4	>=9.8	>=9.4	>=9.6	>=10.5

EFLH = cooling equivalent full load hours; see table below for default values:

City	Equivalent Full Load Hours Cooling ($EFLH_i$)[491]
Akron	801
Cincinnati	941
Cleveland	820
Columbus	910
Dayton	942
Mansfield	757
Toledo	813

Summer Coincident Peak Demand Savings

$$\Delta kW = (CAP) * [(1/EERbase) - (1/EERee)] * CF$$

Where:

[491] Heating and cooling EFLH 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. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

CF = Summer Peak Coincidence Factor for measure
= 0.74 [492]

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History
Draft: Portfolio #
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End date: Date TRM will cease to be effective (or TBD)

Referenced Documents: "Draft TRM - C&I Buildings Model Development.doc"

[492] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Single-Package and Split System Unitary Air Conditioners (Time of Sale, New Construction)

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
This measure promotes the installation of high-efficiency unitary air-, water-, and evaporatively cooled air conditioning equipment, both single-package and split systems. Air conditioning (AC) systems are a major consumer of electricity and systems that exceed baseline efficiencies can save considerable amounts of energy. This measure could apply to the replacing of an existing unit at the end of its useful life or the installation of a new unit in a new or existing building.

Definition of Efficient Equipment
In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air-, water-, or evaporatively cooled air conditioner that exceeds the energy efficiency requirements of the International Energy Conservation Code (IECC) 2006, Table 503.2.3(1).

Definition of Baseline Equipment
In order for this characterization to apply, the efficient equipment is assumed to be a standard-efficiency air-, water, or evaporatively cooled air conditioner that meets the energy efficiency requirements of the International Energy Conservation Code (IECC) 2006, Table 503.2.3(1). The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Deemed Calculation for this Measure

For units with cooling capacities less than 65 kBtu/h:

Annual kWh Savings = (kBtu/h) * [(1/SEERbase) – (1/SEERee)] * EFLH

Summer Coincident Peak kW Savings = (kBtu/h) * [(1/EERbase) – (1/EERee)] *CF

For units with cooling capacities equal to or greater than 65 kBtu/h:

Annual kWh Savings = (kBtu/h) * [(1/EERbase) – (1/EERee)] * EFLH

Summer Coincident Peak kW Savings = (kBtu/h) * [(1/EERbase) – (1/EERee)] *CF

Deemed Lifetime of Efficient Equipment
The expected measure life is assumed to be 15 years.[493]

Deemed Measure Cost
The incremental capital cost for this measure is assumed to be $100 per ton.[494]

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
The summer peak coincidence factor for this measure is assumed to be 74%[495].

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[493] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.
[494] Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.
[495] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

REFERENCE SECTION

Calculation of Savings

Energy Savings

For units with cooling capacities less than 65 kBtu/h:

$$\Delta kWH = (kBtu/h) * [(1/SEERbase) - (1/SEERee)] * EFLH$$

For units with cooling capacities equal to or greater than 65 kBtu/h:

$$\Delta kWH = (kBtu/h) * [(1/EERbase) - (1/EERee)] * EFLH$$

Where:

kBtu/h = capacity of the cooling equipment actually installed in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).

SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for default values:

Equipment Type	Size Category	Subcategory	Baseline Efficiency[496]
Air conditioners, air cooled	<65,000 Btu/h	Split system	13.0 SEER[a]
		Single package	13.0 SEER[a]
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	10.3 EER
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	9.7 EER
	≥240,000 Btu/h and <760,000 Btu/h	Split system and single package	9.5 EER
	≥760,000 Btu/h	Split system and single package	9.2 EER
Air conditioners, Water and evaporatively cooled	<65,000 Btu/h	Split system and single package	12.1 EER
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package	11.5 EER
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package	11.0 EER
	≥240,000 Btu/h	Split system and single package	11.0 EER

a. As manadated by federal equipment manufacturing standards <http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr12058.pdf>

SEERee = Seasonal Energy Efficiency Ratio of the energy efficient equipment (actually installed).

EERbase = Energy Efficiency Ratio of the baseline equipment; see table above for default values. Since IECC 2006 does not provide EER requirements for air-cooled air conditioners < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.

[496] International Energy Conservation Code (IECC 2006) 2006, Table 503.2.3(1), Unitary Air Conditioners and Condensing Units, Electrically Operated, Minimum Efficiency Requirements, unless otherwise noted.

EERee = Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/h, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1.
= Actual installed

EFLH = cooling equivalent full load hours; see table below for default values:

City	Equivalent Full Load Hours Cooling (EFLH)[497]
Akron	801
Cincinnati	941
Cleveland	820
Columbus	910
Dayton	942
Mansfield	757
Toledo	813

Summer Coincident Peak Demand Savings

$\Delta kW = (BtuH * (1/EERbase - 1/EERee))/1000 * CF$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.74 [498]

Fossil Fuel Impact Descriptions and Calculation

n/a

Water Impact Descriptions and Calculation

n/a

Deemed O&M Cost Adjustment Calculation

n/a

Version Date & Revision History

Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

Referenced Documents: "Draft TRM - C&I Buildings Model Development.doc"

[497] Heating and cooling EFLH 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. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

[498] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Pending verification based on information from the utilities.

Heat Pump Systems (Time of Sale, New Construction)

Official Measure Code (Measure Number: X-X-X-X (Program name, End Use)

Description
This measure applies to the installation of high-efficiency air cooled, water source, ground water source, and ground source heat pump systems. This measure could apply to replacing an existing unit at the end of it's useful life, or installation of a new unit in a new or existing building.

Definition of Efficient Equipment
In order for this characterization to apply, the efficient equipment is assumed to be a high-efficiency air cooled, water source, ground water source, or ground source heat pump system that exceeds the energy efficiency requirements of the International Energy Conservation Code (IECC) 2006, Table 503.2.3(2).

Definition of Baseline Equipment
In order for this characterization to apply, the baseline equipment is assumed to be a standard-efficiency air cooled, water source, ground water source, or ground source heat pump system that meets the energy efficiency requirements of the International Energy Conservation Code (IECC) 2006, Table 503.2.3(2). The rating conditions for the baseline and efficient equipment efficiencies must be equivalent.

Deemed Calculation for this Measure

For units with cooling capacities less than 65 kBtu/h:

$$\text{Annual kWh Savings} = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$$

$$\text{Annual kWh Savings}_{cool} = (\text{kBtu/h}) * [(1/\text{SEERbase}) - (1/\text{SEERee})] * \text{EFLH}_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (\text{kBtu/h}) * [(1/\text{HSPFbase}) - (1/\text{HSPFee})] * \text{EFLH}_{heat}$$

$$\text{Summer Coincident Peak kW Savings} = (\text{kBtu/h}) * [(1/\text{EERbase}) - (1/\text{EERee})] * \text{CF}$$

For units with cooling capacities equal to or greater than 65 kBtu/h:

$$\text{Annual kWh Savings} = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$$

$$\text{Annual kWh Savings}_{cool} = (\text{kBtu/h}_{cool}) * [(1/\text{EERbase}) - (1/\text{EERee})] * \text{EFLH}_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (\text{kBtu/h}_{heat})/3.412 * [(1/\text{COPbase}) - (1/\text{COPee})] * \text{EFLH}_{heat}$$

$$\text{Summer Coincident Peak kW Savings} = (\text{kBtu/h}_{cool}) * [(1/\text{EERbase}) - (1/\text{EERee})] * \text{CF}$$

Deemed Lifetime of Efficient Equipment
The expected measure life is assumed to be 15 years.[499]

Deemed Measure Cost
For analysis purposes, the incremental capital cost for this measure is assumed as $100 per ton for air-cooled units.[500] The incremental cost for all other equipment types should be determined on a site-specific basis.

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[499] Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, Inc., June 2007.
[500] Based on a review of TRM incremental cost assumptions from Vermont, Wisconsin, and California.

Deemed O&M Cost Adjustments
n/a

Coincidence Factor
The summer peak coincidence factor for this measure is assumed to be 74%[501].

REFERENCE SECTION

Calculation of Savings

Energy Savings

For units with cooling capacities less than 65 kBtu/h:

$$\Delta kWh = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$$

$$\text{Annual kWh Savings}_{cool} = (kBtu/h_{cool}) * [(1/SEERbase) - (1/SEERee)] * EFLH_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (kBtu/h_{cool}) * [(1/HSPFbase) - (1/HSPFee)] * EFLH_{heat}$$

For units with cooling capacities equal to or greater than 65 kBtu/h:

$$\Delta kWh = \text{Annual kWh Savings}_{cool} + \text{Annual kWh Savings}_{heat}$$

$$\text{Annual kWh Savings}_{cool} = (kBtu/h_{cool}) * [(1/EERbase) - (1/EERee)] * EFLH_{cool}$$

$$\text{Annual kWh Savings}_{heat} = (kBtu/h_{heat})/3.412 * [(1/COPbase) - (1/COPee)] * EFLH_{heat}$$

Where:

$kBtu/h_{cool}$ = capacity of the cooling equipment in kBtu per hour (1 ton of cooling capacity equals 12 kBtu/h).
= Actual installed

SEERbase = Seasonal Energy Efficiency Ratio of the baseline equipment; see table below for values.

Equipment Type	Size Category (Cooling Capacity)	Subcategory or Rating Condition	Baseline Efficiency (Cooling Mode)[502]	Baseline Efficiency (Heating Mode)[503]
Air cooled	<65,000 Btu/h	Split system	13.0 SEER[a]	7.7 HSPF[a]
		Single package	13.0 SEER[a]	7.7 HSPF[a]
	≥65,000 Btu/h and <135,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	10.1 EER	3.2 COP
	≥135,000 Btu/h and <240,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	9.3 EER	3.1 COP

[501] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Verification of this factor is pending information from the utilities.
[502] International Energy Conservation Code (IECC 2006) 2006, Table 503.2.3(2), Unitary And Applied Heat Pumps, Electrically Operated, Minimum Efficiency Requirements, unless otherwise noted.
[503] Ibid.

Equipment Type	Size Category (Cooling Capacity)	Subcategory or Rating Condition	Baseline Efficiency (Cooling Mode)[502]	Baseline Efficiency (Heating Mode)[503]
	≥240,000 Btu/h	Split system and single package / 47°F db/43°F wb outdoor air	9.0 EER	3.1 COP
Water source	<17,000 Btu/h	86°F entering water (Cooling Mode) / 68°F entering water (Heating Mode)	11.2 EER	4.2 COP
	≥17,000 Btu/h and <135,000 Btu/h	86°F entering water / 68°F entering water (Heating Mode)	12.0 EER	4.2 COP
Groundwater source	<135,000 Btu/h	59°F entering water (Cooling Mode) / 50°F entering water (Heating Mode)	16.2 EER	3.6 COP
Ground source	<135,000 Btu/h	77°F entering water / 32°F entering water (Heating Mode)	13.4 EER	3.1 COP

a. As manadated by federal equipment manufacturing standards <http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/74fr12058.pdf>

SEERee = Seasonal Energy Efficiency Ratio of the energy efficient equipment.
= Actual installed

$EFLH_{cool}$ = cooling mode equivalent full load hours; see table below for default values:

City	Equivalent Full Load Hours Cooling ($EFLH_{cool}$)	Equivalent Full Load Hours Heating ($EFLH_{heat}$)[504]
Akron	801	994
Cincinnati	941	713
Cleveland	820	994
Columbus	910	829
Dayton	942	810
Mansfield	757	919
Toledo	813	1,056

HSPFbase = Heating Seasonal Performance Factor of the baseline equipment; see table above for values.

HSPFee = Heating Seasonal Performance Factor of the energy efficient equipment.
= Actual installed

$EFLH_{heat}$ = heating mode equivalent full load hours; see table above for default values.

EERbase = Energy Efficiency Ratio of the baseline equipment; see the table above for values. Since IECC 2006 does not provide EER requirements for air-cooled heat pumps < 65 kBtu/h, assume the following conversion from SEER to EER: EER≈SEER/1.1.

[504] Heating and cooling EFLH 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. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

EERee	= Energy Efficiency Ratio of the energy efficient equipment. For air-cooled air conditioners < 65 kBtu/h, if the actual EERee is unknown, assume the following conversion from SEER to EER: EER≈SEER/1.1. = Actual installed
$kBtu/h_{heat}$	= capacity of the heating equipment in kBtu per hour. = Actual installed
3.412	= Btu per Wh.
COPbase	= coefficient of performance of the baseline equipment; see table above for values.
COPee	= coefficient of performance of the energy efficient equipment. = Actual installed

Summer Coincident Peak Demand Savings

$$\Delta kW = (kBtu/h_{cool}) * [(1/EERbase) - (1/EERee)] * CF$$

Where:

CF = Summer Peak Coincidence Factor for measure
= 0.74 [505]

Fossil Fuel Impact Descriptions and Calculation
n/a

Water Impact Descriptions and Calculation
n/a

Deemed O&M Cost Adjustment Calculation
n/a

Version Date & Revision History
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

Referenced Documents: "Draft TRM - C&I Buildings Model Development.doc"

[505] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Verification of these factors pending information from the utilities.

Outside Air Economizer with Dual-Enthalpy Sensors (Time of Sale, Retrofit – New Equipment)

Official Measure Code (Measure Number: X-X-X-X (Efficient Products, Lighting End Use)

Description
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 the two readings.

Definition of Efficient Equipment
The efficient equipment is a dual-enthalpy economizer on the HVAC system.

Definition of Baseline Equipment
The existing condition for this measure is an outside air dry-bulb economizer.

Deemed Calculation for this Measure

Annual kWh Savings = TONS x ΔkWh_{ton}

Summer Coincident Peak kW Savings = 0

Deemed Lifetime of Efficient Equipment
The expected lifetime of the measure is 10 years[506] .

Deemed Measure Cost
The incremental cost for this measure is assumed to be $400[507]

Deemed O&M Cost Adjustments
There are no expected O&M cost adjustments for this measure.

Coincidence Factor
There are no expected summer peak kW savings for this measure, so the coincidence factor is 0.

REFERENCE SECTION

Calculation of Savings

Energy Savings

ΔkWh = TONS x ΔkWh_{ton}

Where:

TONS = the rated capacity of the unit controlled by the economizer. To be collected with the application.

ΔkWh_{ton} = the kWh savings per ton, based on region of the state. See table below in the "Reference Table" section.

[506] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008
[507] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010. Value derived from Efficiency Vermont project experience and conversations with suppliers.

For example, an economizer on a 10 ton air conditioning unit in a big box retail building in Cleveland:

$\Delta kWh = 10 \times 145$

$= 1{,}450\ kWh$

Summer Coincident Peak Demand Savings

$\Delta kW = 0$

Baseline Adjustment

There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

There are no expected fossil fuel impacts associated with this measure.

Deemed O&M Cost Adjustment Calculation

There are no expected O&M costs or savings associated with this measure.

Reference Table

Dual Enthalpy Economizer Savings[508]

Building Type	City	ΔkWh_{ton}	ΔkW_{ton}	$\Delta MMBtu_{ton}$
Assembly	Akron	23	0.0	0.0
	Cincinnati	28	0.0	0.0
	Cleveland	27	0.0	0.0
	Columbus	28	0.0	0.0
	Dayton	23	0.0	0.0
	Mansfield	29	0.0	0.0
	Toledo	28	0.0	0.0
Big Box Retail	Akron	148	0.0	0.0
	Cincinnati	144	0.0	0.0
	Cleveland	145	0.0	0.0
	Columbus	157	0.0	0.0
	Dayton	143	0.0	0.0
	Mansfield	157	0.0	0.0
	Toledo	145	0.0	0.0
Fast Food Restaurant	Akron	35	0.0	0.0
	Cincinnati	32	0.0	0.0
	Cleveland	34	0.0	0.0
	Columbus	39	0.0	0.0
	Dayton	33	0.0	0.0
	Mansfield	37	0.0	0.0
	Toledo	35	0.0	0.0
Full-Service Restaurant	Akron	20	0.0	0.0
	Cincinnati	18	0.0	0.0
	Cleveland	20	0.0	0.0

[508] Unit energy, demand, and gas savings data is based on a series of prototypical small commercial building simulation runs. 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. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Building Type	City	ΔkWh$_{ton}$	ΔkW$_{ton}$	ΔMMBtu$_{ton}$
	Columbus	23	0.0	0.0
	Dayton	20	0.0	0.0
	Mansfield	22	0.0	0.0
	Toledo	19	0.0	0.0
Light Industrial	Akron	36	0.0	0.0
	Cincinnati	43	0.0	0.0
	Cleveland	39	0.0	0.0
	Columbus	43	0.0	0.0
	Dayton	35	0.0	0.0
	Mansfield	37	0.0	0.0
	Toledo	42	0.0	0.0
Primary School	Akron	51	0.0	0.0
	Cincinnati	57	0.0	0.0
	Cleveland	52	0.0	0.0
	Columbus	55	0.0	0.0
	Dayton	52	0.0	0.0
	Mansfield	53	0.0	0.0
	Toledo	49	0.0	0.0
Small Office	Akron	191	0.0	0.0
	Cincinnati	185	0.0	0.0
	Cleveland	184	0.0	0.0
	Columbus	206	0.0	0.0
	Dayton	189	0.0	0.0
	Mansfield	191	0.0	0.0
	Toledo	194	0.0	0.0
Small Retail	Akron	122	0.0	0.0
	Cincinnati	115	0.0	0.0
	Cleveland	117	0.0	0.0
	Columbus	129	0.0	0.0
	Dayton	117	0.0	0.0
	Mansfield	124	0.0	0.0
	Toledo	116	0.0	0.0

Version Date & Revision History
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

Referenced Documents: "Draft TRM - C&I Buildings Model Development.doc"

Chilled Water Reset Controls (Retrofit – New Equipment)

Official Measure Code (Measure Number: X-X-X-X (Efficient Products, Lighting End Use)

Description
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[509]. Energy savings are realized through improved chiller efficiency. 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.

Definition of Efficient Equipment
The efficient condition is a chilled water reset, with the maximum chilled water temperature of 50°F.

Definition of Baseline Equipment
The baseline condition is a fixed chilled water temperature of 45°F.

Deemed Calculation for this Measure

Annual kWh Savings = $TONS \times \Delta kWh_{ton}$

Summer Coincident Peak kW Savings = $TONS \times \Delta kW_{ton}$

Annual MMBTU Savings = $TONS \times \Delta MMBtu_{ton}$

Deemed Lifetime of Efficient Equipment
The expected lifetime of the measure is 10 years[510] .

Deemed Measure Cost
The full installed cost for this measure is $681.34 per control[511].

Deemed O&M Cost Adjustments
There are no expected O&M cost adjustments for this measure.

Coincidence Factor
The summer peak coincidence factor for this measure is assumed to be 74%[512].

REFERENCE SECTION

Calculation of Savings

[509] ASHRAE 90.1 2004 requires chilled and hot water temperature reset for systems with a capacity greater than 300,000 BTU/h. To avoid incenting code, this characterization should apply to smaller systems and retrofits only.
[510] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008
[511] Efficiency Vermont Technical Reference User Manual (TRM) Measure Savings Algorithms and Cost Assumptions, February, 19, 2010. Value derived from Efficiency Vermont project experience and conversations with suppliers.
[512] Coincidence factor supplied by Duke Energy for the commercial HVAC end-use. Verification of this factor is pending information from the utilities.

Energy Savings

ΔkWh = TONS x ΔkWh_{ton}

Where:

TONS = the rated capacity of the unit controlled by the economizer. To be collected with the application.

ΔkWh_{ton} = the kWh savings per ton, this depends on whether the chiller is air-cooled or water-cooled. See table below.

For example, chilled water reset on a 10-ton constant volume air-cooled chiller in Cleveland:

ΔkWh = 10 x 13
= 130 kWh

Summer Coincident Peak Demand Savings

ΔkW = TONS x ΔkW_{ton} x CF

Where:

ΔkW_{ton} = the kW savings per ton, this depends on whether the chiller is air-cooled or water-cooled. See table below.

CF = The summer coincident peak factor, or 0.74.

For example, chilled water reset on a 10-ton constant volume air-cooled chiller in Cleveland:

ΔkW = 10 x (-0.012) x 0.74
= -0.089 kW

Baseline Adjustment

There are no expected future code changes to affect this measure.

Fossil Fuel Impact Descriptions and Calculation

$\Delta MMBtu$ = TONS x $\Delta MMBtu_{ton}$

Where:

$\Delta MMBtu_{ton}$ = the gas savings per ton, this depends on whether the chiller is air-cooled or water-cooled. See table below.

For example, chilled water reset on a 10-ton constant volume air-cooled chiller in Cleveland:

$\Delta MMBtu$ = 10 x 0.08
= 0.8 MMBtu

Deemed O&M Cost Adjustment Calculation

There are no expected O&M costs or savings associated with this measure.

Reference Tables

Table 9: Chilled water reset controls[513]

System Type	City	ΔkWh_{ton}	ΔkW_{ton}	$\Delta MMBtu_{ton}$
Air-Cooled Chiller with Constant Volume Reheat	Akron	17	-0.009	0.11
	Cincinnati	13	-0.009	0.11
	Cleveland	13	-0.012	0.08
	Columbus	13	-0.011	0.10
	Dayton	14	-0.037	0.12
	Mansfield	19	-0.028	0.16
	Toledo	16	0.006	0.12
Air-Cooled Chiller with Variable Air Volume Reheat	Akron	10	-0.011	0.04
	Cincinnati	10	-0.010	0.04
	Cleveland	11	-0.012	0.03
	Columbus	11	-0.010	0.07
	Dayton	11	-0.009	0.05
	Mansfield	11	-0.012	0.04
	Toledo	11	0.011	0.07
Water-Cooled Chiller with Constant Volume Reheat	Akron	38	0.004	0.11
	Cincinnati	31	-0.012	0.11
	Cleveland	34	-0.008	0.08
	Columbus	31	0.004	0.10
	Dayton	34	-0.016	0.12
	Mansfield	41	-0.015	0.16
	Toledo	36	0.004	0.12
Water-Cooled Chiller with Variable Air Volume Reheat	Akron	27	0.004	0.04
	Cincinnati	26	-0.002	0.04
	Cleveland	28	-0.008	0.03
	Columbus	27	0.003	0.07
	Dayton	29	-0.015	0.05
	Mansfield	29	-0.004	0.04
	Toledo	29	0.059	0.07

Version Date & Revision History
Draft: Portfolio #
Effective date: Date TRM will become effective
End date: Date TRM will cease to be effective (or TBD)

Referenced Documents: "Draft TRM - C&I Buildings Model Development.doc"

[513] Unit energy, demand, and gas savings data is based on a series of prototypical small commercial building simulation runs. 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. Building prototypes used in the energy modeling are described in Appendix A - Prototypical Building Energy Simulation Model Development.

Variable Frequency Drives for HVAC Applications (Time of Sale, Retrofit – New Equipment)

Official Measure Code (Measure Number: X-X-X-X (Efficient Products, Lighting End Use)

Description
A variable frequency drive installed on an HVAC system pump or fan motor. The VFD will modulate the speed of the motor when it is not needed to run at full load. Since the power of the motor is proportional to the cube of the speed, this will result in significant energy savings.

Definition of Efficient Equipment
The efficient condition is a variable frequency drive on an HVAC system pump or fan motor.

Definition of Baseline Equipment
For VFDs on fans, the baseline is chosen from the reference table below. For VFDs on pumps, the baseline is a constant volume motor.

Deemed Calculation for this Measure

Annual kWh Savings = BHP / η_{motor} x HOURS x ESF

Summer Coincident Peak kW Savings = BHP / η_{motor} x DSF

Deemed Lifetime of Efficient Equipment
The expected lifetime of the measure is 15 years.[514]

Deemed Measure Cost
See table below[515]

HP	Total Installed Cost
5	$1,330
7.5	$1,622
10	$1,898
15	$2,518
20	$3,059

Deemed O&M Cost Adjustments
There are no expected O&M savings associated with this measure.

Coincidence Factor
The demand savings factor (DSF) is already based upon coincident savings, and thus there is no additional coincidence factor for this characterization.

REFERENCE SECTION

Calculation of Savings

Energy Savings

[514] 2008 Database for Energy-Efficiency Resources (DEER), Version 2008.2.05, "Effective/Remaining Useful Life Values", California Public Utilities Commission, December 16, 2008
[515] Equipment Costs from Granger 2008 Catalog pp. 286-289, average across available voltages and models. Labor costs from RSMeans Mechanical Cost Data, 2008. Used average cost adjustment for all cities listed in Ohio. See 'OH VFD cost analysis.xls'