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July 16, 2012

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Yazen Alami
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Re: In the Matter of the Motions to Protect Confidential Information and Waive Certain Requirements of O.A.C. 4901:1-24 by Ohio Power Company, Case No. 10-1599-EL-EEC

Dear Ms. McNeal,

Enclosed please find Ohio Power Company's (dba AEP Ohio) updated Prescriptive Protocol Workpapers for the 2012 program year to be filed in the above referenced docket.

Thank you for your attention to this matter.

Respectfully submitted,

/s/ Yazen Alami__________
Yazen Alami

Attachments

AEP Ohio Business Incentives

DNV KEMA Savings Workpaper

Appendix A — AEP Ohio Prescriptive Measures Protocols

A unit of American Electric Power

Table of Contents

This appendix provides DNV KEMA's workpapers that document the deemed savings used within the Business Incentives prescriptive program tracking system. DNV KEMA uses the "State of Ohio Energy Efficiency Technical Reference Manual: Including Predetermined Savings Values and Protocols for Determining Energy and Demand Savings" draft date of 8/6/10, (referenced as "Ohio TRM" throughout this appendix) for many of the measures described within this document. In cases where the TRM is not comprehensive, other sources are referenced or our own estimations are provided. For example, it is understood that interactive effects for lighting measures should be based on data or prototypical building models for Ohio weather. HVAC savings should also be building-specific. The current draft of the Ohio TRM presents both HVAC savings and interactive effects as independent of building type. Due to the interim nature of the TRM, DNV KEMA does not update the savings or assumptions for certain measures with the expectation that the future iteration of the Ohio TRM will include a more comprehensive approach for measures as indicated in DNV KEMA's comments in regards to the Ohio TRM.

All energy savings are presented on an annual basis and all demand savings are presented on an average of coincident peak basis.

Note: In February 2012, Oslo-based Det Norske Veritas (DNV) acquired KEMA's parent company, KEMA NV, to form a new subsidiary, DNV KEMA Energy & Sustainability (DNV KEMA). Together as one company, DNV KEMA is committed to driving the global transition toward a safe, reliable efficient and clean energy future. As DNV KEMA, KEMA Services, Inc. continues to deliver the same quality services to AEP Ohio.

Lighting

The following provides the assumptions and methods used for calculating energy savings. Most lighting measures presented in these work papers use the same methodology.

Baseline and retrofit equipment assumptions, i.e. wattages, are specific to the measure. Most lighting retrofits assume an early replacement of existing technologies where the baseline represents the equipment removed. This type of measure is considered a retrofit, not replace on burnout.

The lighting portion of this workpaper includes the documentation provided here, as well as the accompanying workbook.

All the lighting measures discussed here are applicable for the self-direct prescriptive lighting measures since lighting is consider as a retrofit measure that is consistent with the "as-found" protocol. Unless otherwise noted, none of these measures are applicable for new construction.

Savings Calculation Methodology

DNV KEMA calculated annual energy savings and the peak coincident demand savings using the equations below:

Non-coincident kW reduction = kW of existing equipment - kW of replacement equipment

Energy savings are based on the difference between baseline and efficient equipment connected wattage and annual operating hours, according to the following formula:

*kWh Reduction = non-coincident kW reduction * (Annual operating hours)*(Energy Interactive Effects)*

Coincident demand savings are calculated by applying the coincidence factor and the demand interactive effect, according to the following formula:

*Coincident kW savings = non-coincident kW reduction * Coincidence Factor * Demand interactive effect*

Interactive factors account for savings that the measures achieve through avoided air conditioning load because of reduced internal heat gains from energy-efficient lighting. The interactive effects do not apply to exterior or garage lighting.

Non-coincident Demand Reduction

Baseline and retrofit equipment assumptions are based on what DNV KEMA believes to be standard for the measure. Using this approach simplifies the default savings values. The baseline and retrofit fixtures are selected and the wattage assumptions are from a standard fixture wattage table found in the accompanying workbook. DNV KEMA assembled this table from multiple sources including the Pennsylvania TRM and California statewide non-residential retrofit program.

2008 DEER Data

Most lighting measure input parameters comes from the 2008 Database for Energy Efficiency Resources (DEER) Study[1] Savings are calculated by appyling operating hours and other parameters that define the energy savings. These workpapers base the energy savings methodology on the California 2008 DEER Study assumptions. The DEER database is a tool that was jointly developed by the California Public Utilities Commission (CPUC) and the California Energy Commission with support and input from the Investor-Owned Utilities and other interested stakeholders. DEER provides operating hours, interactive effects and coincidence factors by building type and California weather zone. It is clear that California and Ohio climate are not similar, but these values will be considered relevant until a clear direction is provided via the Ohio TRM for HVAC interactive effects. Many states, other than California, use the DEER Study as its resource for deemed savings.

DNV KEMA extracted required data elements from the DEER, as well as other sources, to use in calculating measure energy savings and to provide a simple, comprehensive list of lighting retrofit measures. The annual operating hours, the coincidence factors, and the interactive effect factors are all derived from 2008 DEER figures.

[1] 2008 Database for Energy Efficiency Resources (DEER), www.deeresources.com

Compact fluorescent lamps (CFLs), LED lighting (unless otherwise noted), cold cathode lamps, and integrated ballast ceramic metal halides use CFL lighting operating hours. Other lighting categories have different operating hours as shown below. Operating hour values for the three different Manufacturing/Industrial shifts, exterior and garage are taken from the Ohio TRM.

Ohio TRM and 2008 DEER building types are grouped as shown below. Lighting measure data is derived from DEER 2008. For DNV KEMA Building Types which are a combination of more than one DEER 2008 building type, measure data is averaged across the combined building types.

Table 1. Mapping Building Types

KEMA Workpaper Building Type	2008 DEER	Ohio TRM
Large Office	Office - Large	Office
Small Office	Office - Small	
School	Education – Primary School	School
	Education – Secondary School	
Small Retail/Service	Retail – Small	Retail
Large Retail/Service	Retail – 3-Story Large	
	Retail – Single-Story Large	
Hotel/Motel	Lodging – Hotel	Hotel/Motel
	Lodging – Motel	
Medical – Hospital	Health/Medical – Hospital	Health Care
Medical - Nursing Home	Health/Medical – Nursing Home	
Restaurant	Restaurant – Fast-Food	Food Service
	Restaurant – Sit-Down	
Grocery	Grocery	Food Sales
Conditioned Warehouse	Storage - Conditioned	Warehouse
Unconditioned Warehouse	Storage - Unconditioned	
Manufacturing – Light Industrial (1 shift)	*Ohio TRM	*Ohio TRM
Manufacturing – Light Industrial (2 shift)	*Ohio TRM	*Ohio TRM
Manufacturing – Light Industrial (3 shift)	*Ohio TRM	*Ohio TRM
College/University	Education – Community College	College
	Education – University	
Government/Municipal	Ave of Assembly & Large Office	Public Assembly
Assembly	Assembly	Public Assembly
Miscellaneous	*Average across all bldg types	*Average across all bldg

	(including garage and exterior)	types (including garage and exterior)
Garage (Ohio)	*Ohio TRM	*Ohio TRM
Exterior (Ohio)	*Ohio TRM	*Ohio TRM

Table 2. Annual Operating Hours by Building Type[2]

Building Type	Non-CFL	CFL
Large Office	2651	3151
Small Office	2594	3082
School	2245	2442
Small Retail/Service	3253	3721
Large Retail/Service	3401	3758
Hotel/Motel	6834	5572
Guest Rooms	NA	799
Medical - Hospital	4881	4084
Medical - Nursing Home	4260	3576
Restaurant	4825	4825
Grocery	4886	3876
Conditioned Warehouse	3441	2780
Unconditioned Warehouse	3441	2780
Manufacturing – Light Industrial (1 shift)	2857	2857
Manufacturing – Light Industrial (2 shift)	4730	4730
Manufacturing – Light Industrial (3 shift)	6631	6631
College/University	2523	2540
Government/Municipal	2547	2719
Assembly	2443	2286
Miscellaneous	4075	3775
Garage (Ohio)	8760	8760
Exterior (Ohio)	4300	4300

[2] Manufacturing/Industrial, Garage hours are taken from the Ohio TRM. Exterior operating hours are from Vermont Energy Investment Corporation's replies to the Ohio Utilities joint objections, dated Nov 15, 2010 and filed with the PUCO, 09-512-GE-UNC.

Table 3. Interactive Effects by Building Type

Building Type	EXIT		Non-CFL		CFL	
	Demand	Energy	Demand	Energy	Demand	Energy
Large Office	1.309	1.083	1.362	1.139	1.361	1.151
Small Office	1.411	1.194	1.345	1.262	1.338	1.240
School	1.495	1.199	1.393	1.230	1.359	1.233
Small Retail/Service	1.415	1.157	1.312	1.227	1.357	1.196
Large Retail/Service	1.411	1.150	1.329	1.186	1.406	1.187
Hotel/Motel and Guest Rooms	1.282	1.140	1.449	1.233	1.475	1.266
Medical – Hospital	1.137	1.114	1.143	1.129	1.185	1.129
Medical - Nursing Home	1.409	1.197	1.423	1.273	1.354	1.245
Restaurant	1.341	1.154	1.310	1.192	1.274	1.182
Grocery	1.289	1.061	1.277	1.076	1.266	1.060
Conditioned Warehouse	1.465	1.079	1.295	1.091	1.289	1.095
Unconditioned Warehouse	1.000	1.000	1.000	1.000	1.000	1.000
Manufacturing – Light Industrial (1 shift)	1.406	1.121	1.196	1.135	1.190	1.142
Manufacturing – Light Industrial (2 shift)	1.406	1.121	1.196	1.135	1.190	1.142
Manufacturing – Light Industrial (3 shift)	1.406	1.121	1.196	1.135	1.190	1.142
College/University	1.182	1.069	1.247	1.129	1.266	1.138
Government/Municipal	1.312	1.128	1.318	1.171	1.305	1.169
Assembly	1.315	1.173	1.273	1.202	1.248	1.186
Miscellaneous	1.299	1.114	1.262	1.151	1.263	1.151
Garage (Ohio)	1.000	1.000	1.000	1.000	1.000	1.000
Exterior (Ohio)	1.000	1.000	1.000	1.000	1.000	1.000

Table 4. Coincident Diversity Factors

Building Type	Non-CFL	CFL
Large Office	0.71	0.63
Small Office	0.69	0.67
School	0.64	0.65
Small Retail/Service	0.88	0.70
Large Retail/Service	0.81	0.66
Hotel/Motel and Guest Rooms	0.21	0.17
Medical - Hospital	0.82	0.72
Medical - Nursing Home	0.68	0.56
Restaurant	0.81	0.81
Grocery	0.69	0.50
Conditioned Warehouse	0.70	0.58
Unconditioned Warehouse	0.70	0.58
Manufacturing – Light Industrial (1 shift)	0.92	0.78
Manufacturing – Light Industrial (2 shift)	0.92	0.78
Manufacturing – Light Industrial (3 shift)	0.92	0.78
College/University	0.76	0.67
Government/Municipal	0.62	0.52
Assembly	0.53	0.41
Miscellaneous	0.68	0.59
Garage (Ohio)	1.00	1.00
Exterior (Ohio)	0.00	0.00

Measure Life and Incremental Measure Cost

The 2008 DEER provides measure life for several lighting measures, which vary by building type (operating hours) and ballast-rated hours. DNV KEMA used the 2005 DEER measure life for this report as a single number that is based on an average life.[3]

We have assumed an EUL of 11 years for T-12 to T-8 conversions. There has been discussion in the evaluation industry that a lower number might be warranted going forward as by statute, the manufacture of T-12s ends in 2012.

[3] The 2008 DEER uses 15 years as standard life if not using rated equipment life (such as the ballast) and actual operating hours.

Incremental costs are taken from a number of sources. The AEP Ohio 2009-2028 Energy Efficiency/Peak Demand Reduction Potential Study conducted in August of 2009 provides costs for some measures. Since this study was prepared specifically for AEP, the utility's costs are used whenever applicable. Because some measures listed or measure units in the study do not match with that of the program, costs are derived from other sources as well including DEER, DNV KEMA, and the Commonwealth Edison Company's 2008-10 Energy Efficiency and Demand Response Plan prepared by ICF International, referred to as the" ICF Portfolio Plan."

Incremental cost is cost difference between the energy efficient equipment and the less efficient option. In retrofit cases, the IMC is equal to the full measure cost since the cost of the less efficient option, i.e., not conducting the retrofit, is $0.

T5 Lamp and Ballast

Measure Description	This measure consists of replacing 4 foot T12 lamps and magnetic ballasts with T5 lamps and electronic ballast. The T5 lamps must have a color rendering index (CRI) ≥ 80 and be 4 ft. The electronic ballast must be high frequency (≥20 kHz), UL listed, and warranted against defects for 5 years. Ballasts must have a power factor (PF) ≥ 0.90 and a total harmonic distortion (THD) ≤20 percent at full light output.
Units	Per Lamp
Base Case Description	T12 lamps with magnetic ballasts

Measure Savings

The savings are presented in the following table. The annual operating hours, the coincidence factors, and the interactive effect factors are obtained from Tables 1-3.

Table 5. T12 to T5 Fluorescent Fixture Measure Savings, per lamp

Building Type	kWh	Coincident peak kW
Assembly	23.0	0.004
College/University	24.2	0.008
Conditioned Warehouse	31.9	0.008

Building Type	kWh	Coincident peak kW
Government/Municipal	25.3	0.007
Grocery	44.7	0.007
Hotel/Motel	71.6	0.003
Guest Rooms	8.6	0.002
Large Office	25.7	0.008
Large Retail/Service	34.3	0.009
Manufacturing – Light Industrial (1 shift)	27.6	0.009
Manufacturing – Light Industrial (2 shift)	45.6	0.009
Manufacturing – Light Industrial (3 shift)	64.0	0.009
Medical - Hospital	46.8	0.008
Medical - Nursing Home	46.1	0.008
Miscellaneous	39.9	0.007
Restaurant	48.9	0.009
School	23.5	0.008
Small Office	27.8	0.008
Small Retail/Service	33.9	0.010
Unconditioned Warehouse	29.2	0.006
Garage (Ohio)	74.5	0.009
Exterior (Ohio)	36.6	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 6. Baseline and Retrofit Wattages for T12 to T5 Fixture Retrofit

	Pre	Post
Measure Code	F42ES	F42GL
Description	Fluorescent, (2) 48", ES T12 lamp	Fluorescent, (2) 48", STD T5 lamp
Watts/Fixture	80	63

Measure Life and Incremental Measure Cost
The measure life is 11 years. The IMC is $18.54 per DNV KEMA research/experience.

We have assumed an EUL of 11 years for T-12 conversions. There has been discussion in the evaluation industry that a lower number might be warranted going forward as by statute, the manufacture of T-12s ends in 2012.

Retrofit 54W T5 Lamps with ≤51 High Output T5 Lamps

Measure Description	This measure consists of replacing existing 54 watt T5HO lamps and electronic ballasts with reduced wattage T5HO lamps. The nominal wattage for reduced wattage T5HO lamps must be ≤51 watts to qualify.
Units	Per Lamp
Base Case Description	Standard 54 Watt T5HO lamps

Measure Savings

The savings are presented in the following table.

Table 7. 54W T5HO to <= 51W T5HO Fluorescent Fixture Measure Savings, per lamp

Building Type	kWh	Coincident peak kW
Assembly	8.1	0.002
College/University	8.5	0.003
Conditioned Warehouse	11.3	0.003
Government/Municipal	8.9	0.002
Grocery	15.8	0.003
Hotel/Motel	25.3	0.001
Guest Rooms	3.0	0.001
Large Office	9.1	0.003
Large Retail/Service	12.1	0.003
Manufacturing – Light Industrial (1 shift)	9.7	0.003
Manufacturing – Light Industrial (2 shift)	16.1	0.003
Manufacturing – Light Industrial (3 shift)	22.6	0.003
Medical – Hospital	16.5	0.003
Medical - Nursing Home	16.3	0.003
Miscellaneous	14.1	0.003
Restaurant	17.2	0.003
School	8.3	0.003
Small Office	9.8	0.003
Small Retail/Service	12.0	0.003
Unconditioned Warehouse	10.3	0.002
Garage (Ohio)	26.3	0.003
Exterior (Ohio)	12.9	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 8. Baseline and Retrofit Wattages for 54W T5HO to <= 51W T5HO Fixture Retrofit

	Pre	Post
Measure Code	F42GHL	F42GHL-R
Description	Fluorescent, (2) 48", STD HO T5 lamp	Fluorescent, (2) 48", RW HO T5 lamp
Watts/Fixture	117	111

Measure Life and Incremental Measure Cost
The measure life is 3 years. The IMC is $5 per DNV KEMA research/experience.

High Performance 4-foot T8 Lamps and Ballast – T12 Base

Measure Description	This measure consists of replacing existing T12 lamps and magnetic ballasts with high-performance T8 lamps. This measure is based on the Consortium for Energy Efficiency (CEE) high-performance T8 (www.cee1.org) and is summarized below. A list of qualified lamps and ballasts can be found on the same website. Both the lamp and ballast must meet the specification to qualify for an incentive. The incentive is calculated based on the number of lamps installed.
Units	Per lamp
Base Case Description	T12 lamp and magnetic ballasts

Table 9. High Performance T8 Specifications

Performance Characteristics for Systems				
Mean system efficacy	≥ 90 Mean Lumens per Watt (MLPW) for Instant Start Ballasts			
	≥ 88 MLPW for Programmed Rapid Start Ballasts			
Performance Characteristics for Lamps				
Color Rendering Index (CRI)	≥ 80			
Minimum initial lamp lumens	≥ 3100 Lumens[4]			
Lamp life	≥ 24,000 hours			
Lumen maintenance or minimum mean lumens	≥ 94% or ≥ 2,900 Mean Lumens			
Performance Characteristics for Ballasts				
Ballast Efficacy Factor (BEF) BEF = (BF x 100) / Ballast Input Watts	**Instant-Start Ballast (BEF)**			
	Lamps	Low BF ≤ 0.85	Norm 0.85 < BF ≤ 1.0	High BF ≥ 1.01
	1	≥ 3.08	≥ 3.11	≥ 3.03
	2	≥ 1.60	≥ 1.58	≥ 1.55
	3	≥ 1.04	≥ 1.05	≥ 1.04
	4	≥ 0.79	≥ 0.80	≥ 0.77
	Programmed Rapid Start Ballast (BEF)			
	1	≥ 2.84	≥ 2.84	≥ 2.95
	2	≥ 1.48	≥ 1.47	≥ 1.51
	3	≥ 0.97	≥ 1.00	≥ 1.00
	4	≥ 0.76	≥ 0.75	≥ 0.75
Ballast Frequency	20 to 33 kHz or ≥ 40 kHz			
Power Factor	≥ 0.90			
Total Harmonic Distortion	≤ 20%			

Measure Savings

The savings are presented in the following table.

Table 10. High-Performance 4-foot Lamp and Ballast Measure Savings – T12 Base (per lamp)

Building Type	kWh	Coincident peak kW
Assembly	35.3	0.007
College/University	37.0	0.012
Conditioned Warehouse	48.8	0.012
Government/Municipal	38.8	0.011
Grocery	68.3	0.011
Hotel/Motel	109.5	0.004

[4] For lamps with temperature ≥4500K, 2,950 minimum initial lamp lumens are specified.

Building Type	kWh	Coincident peak kW
Guest Rooms	13.1	0.003
Large Office	39.3	0.013
Large Retail/Service	52.4	0.014
Manufacturing – Light Industrial (1 shift)	42.2	0.014
Manufacturing – Light Industrial (2 shift)	69.8	0.014
Manufacturing – Light Industrial (3 shift)	97.8	0.014
Medical - Hospital	71.6	0.012
Medical - Nursing Home	70.5	0.013
Miscellaneous	61.0	0.011
Restaurant	74.7	0.014
School	35.9	0.012
Small Office	42.6	0.012
Small Retail/Service	51.9	0.015
Unconditioned Warehouse	44.7	0.009
Garage (Ohio)	113.9	0.013
Exterior (Ohio)	55.9	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 11. Baseline and Retrofit Wattages for High-Performance Fixture Retrofits

	Pre	Post
Measure Code	F42ES	F42LL-R
Description	Fluorescent, (2) 48", ES T12 lamp	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)
Watts/Fixture	80	54

Measure Life and Incremental Measure Cost
The measure life is 11 years. The IMC is $13.14 per AEP Ohio Potential Study.

We have assumed a EUL of 11 years for T-12 to T-8 conversions. There has been discussion in the evaluation industry that a lower number might be warranted going forward as by statute, the manufacture of T-12s ends in 2012.

High Performance 4-foot T8 Lamps and Ballast – T8 Base

Measure Description	This measure consists of replacing existing standard T8 lamps and ballasts with a ballast factor (BF) greater than 0.85 with high performance 32W T8 and electronic ballasts which have a BF less than or equal to 0.85. Both the lamp and ballast must meet the Consortium for Energy Efficiency (CEE) high performance T8 specification (www.cee1.org). The incentive is calculated based on the number of lamps installed.
Units	Per lamp
Base Case Description	Standard T8 lamp, and ballast with BF > 0.85

Measure Savings
The savings are presented in the following table.

Table 12. High-Performance 4-foot Lamp and Ballast – T8 Base Measure Savings (per lamp)

Building Type	kWh	Coincident peak kW
Assembly	9.5	0.002
College/University	10.0	0.003
Conditioned Warehouse	13.1	0.003
Government/Municipal	10.4	0.003
Grocery	18.4	0.003
Hotel/Motel	29.5	0.001
Guest Rooms	3.5	0.001
Large Office	10.6	0.003
Large Retail/Service	14.1	0.004
Manufacturing – Light Industrial (1 shift)	11.3	0.004
Manufacturing – Light Industrial (2 shift)	18.8	0.004
Manufacturing – Light Industrial (3 shift)	26.3	0.004
Medical - Hospital	19.3	0.003
Medical - Nursing Home	19.0	0.003
Miscellaneous	16.4	0.003
Restaurant	20.1	0.004
School	9.7	0.003
Small Office	11.5	0.003

Building Type	kWh	Coincident peak kW
Small Retail/Service	14.0	0.004
Unconditioned Warehouse	12.0	0.002
Garage (Ohio)	30.7	0.004
Exterior (Ohio)	15.1	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 13. Baseline and Retrofit Wattages for High-Performance Fixture Retrofits

	Pre	Post
Measure Code	F42ILL	F42ILL-R
Description	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, RLO (BF<0.85)
Watts/Fixture	59	52

Measure Life and Incremental Measure Cost
The measure life is 11 years per DEER 2005. The IMC is $13.14 per AEP Ohio Potential Study.

Reduced Wattage 4-foot T8 Lamps and Ballast – T12 Base

Measure Description	This measure consists of replacing existing T12 lamps and magnetic ballasts with reduced wattage (28 or 25W) T8 lamps and electronic ballasts. For reduced wattage 4-foot T8 lamps, the nominal wattage must be 28 W (≥2,585 Lumens) or 25 W (≥2,400 Lumens) to qualify. This measure is based on the Consortium for Energy Efficiency (CEE) reduced wattage specification (www.cee1.org) and is summarized in the table below. A list of qualified lamps and ballasts can be found on the CEE website. Both the lamp and ballast must meet the specification to qualify for an incentive. The incentive is calculated based on the number of lamps installed.
Units	Per lamp
Base Case Description	T12 lamp and magnetic ballasts

Table 14. Reduced Wattage T8 Specifications

Performance Characteristics for Systems		
Mean system efficacy	≥ 90 Mean Lumens per Watt (MLPW) for Instant Start Ballasts	
	≥ 88 MLPW for Programmed Rapid Start Ballasts	
Performance Characteristics for Lamps		
Color Rendering Index (CRI)	≥ 80	
Minimum initial lamp lumens	≥ 3100 Lumens[5]	
Lamp life	≥ 18,000 hours	
Lumen maintenance or minimum mean lumens	≥ 94% or ≥ 2585 Lumens for 28 W ≥ 2400 Lumens for 25 W	
Performance Characteristics for Ballasts		
Ballast Efficacy Factor (BEF) BEF = (BF x 100) / Ballast Input Watts	**28W Systems**	
	Lamps	All Ballast Factor Ranges
	1	> 3.52
	2	> 1.76
	3	≥ 1.16
	4	≥ 0.88
	25W Systems	
	1	≥ 3.95
	2	≥ 1.98
	3	≥ 1.32
	4	≥ 0.99
Ballast Frequency	20 to 33 kHz or ≥ 40 kHz	
Power Factor	≥ 0.90	
Total Harmonic Distortion	≤ 20%	

Measure Savings
Savings are summarized by the following table.

Table 15. Reduced Wattage 4-foot Lamp and Ballast – T12 Base Measure Savings (per lamp)

Building Type	kWh	Coincident peak kW
Assembly	35.2	0.007
College/University	37.0	0.012
Conditioned Warehouse	48.8	0.012

[5] For lamps with temperature ≥4500K, 2,950 minimum initial lamp lumens are specified.

Building Type	kWh	Coincident peak kW
Government/Municipal	38.8	0.011
Grocery	68.3	0.011
Hotel/Motel	109.5	0.004
Guest Rooms	13.1	0.003
Large Office	39.3	0.013
Large Retail/Service	52.4	0.014
Manufacturing – Light Industrial (1 shift)	42.2	0.014
Manufacturing – Light Industrial (2 shift)	69.8	0.014
Manufacturing – Light Industrial (3 shift)	97.8	0.014
Medical - Hospital	71.6	0.012
Medical - Nursing Home	70.5	0.013
Miscellaneous	61.0	0.011
Restaurant	74.7	0.014
School	35.9	0.012
Small Office	42.6	0.012
Small Retail/Service	51.9	0.015
Unconditioned Warehouse	44.7	0.009
Garage (Ohio)	113.9	0.013
Exterior (Ohio)	55.9	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 16. Baseline and Retrofit Wattages for Reduced Wattage Fixture Retrofits

	Pre	Post
Measure Code	F42ES	F42LL-R
Description	Fluorescent, (2) 48", ES T12 lamp	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)
Watts/Fixture	80	54

Measure Life and Incremental Measure Cost
The measure life is 11 years. The IMC is $13.14 per AEP Ohio Potential Study.

We have assumed a EUL of 11 years for T-12 to T-8 conversions. There has been discussion in the evaluation industry that a lower number might be warranted going forward as by statute, the manufacture of T-12s ends in 2012.

Reduced Wattage 4-foot T8 Lamps and Ballast – T8 Base

Measure Description	This measure consists of replacing existing standard T8 lamps and ballasts with a BF greater than 0.85 with reduced wattage 28W or 25W T8 lamps and electronic ballasts which have a BF less than or equal to 0.85. Both the lamp and ballast must meet the Consortium for Energy Efficiency (CEE) reduced wattage T8 specification (www.cee1.org) summarized below.The incentive is calculated based on the number of lamps installed.
Units	Per lamp
Base Case Description	T12 lamp and magnetic ballasts

Measure Savings
Savings are summarized by the following table.

Table 17. Measure Savings for Reduced Wattage 4-foot Lamp and Ballast – T8 Base (per lamp)

Building Type	kWh	Coincident peak kW
Assembly	4.1	0.001
College/University	4.3	0.001
Conditioned Warehouse	5.6	0.001
Government/Municipal	4.5	0.001
Grocery	7.9	0.001
Hotel/Motel	12.6	0.000
Guest Rooms	1.5	0.000
Large Office	4.5	0.001

Building Type	kWh	Coincident peak kW
Large Retail/Service	6.1	0.002
Manufacturing – Light Industrial (1 shift)	4.9	0.002
Manufacturing – Light Industrial (2 shift)	8.1	0.002
Manufacturing – Light Industrial (3 shift)	11.3	0.002
Medical - Hospital	8.3	0.001
Medical - Nursing Home	8.1	0.001
Miscellaneous	7.0	0.001
Restaurant	8.6	0.002
School	4.1	0.001
Small Office	4.9	0.001
Small Retail/Service	6.0	0.002
Unconditioned Warehouse	5.2	0.001
Garage (Ohio)	13.1	0.002
Exterior (Ohio)	6.5	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 18. Baseline and Retrofit Wattages for Reduced Wattage Fixture Retrofits

	Pre	Post
Measure Code	F42SSILL	F42SSILL-R
Description	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)
Watts/Fixture	48	45

Measure Life and Incremental Measure Cost
The measure life is 11 years per DEER 2005. The IMC is $13.14 per AEP Ohio Potential Study.

Reduced Wattage 4-foot Lamp Only

Measure Description	This measure consists of replacing existing standard 32W T8 4' lamps and electronic ballasts with reduced wattage T8 lamps. The lamp must meet the Consortium for Energy Efficiency (CEE) reduced wattage T8 specification (www.cee1.org). The nominal wattage for 4 foot lamps must be 28W (≥2585 Lumens) or 25W (≥2400 Lumens) to qualify. T
Units	Per lamp
Base Case Description	Standard T8 fixtures

Measure Savings
Savings are summarized by the following table.

Table 19. Measure Savings for Reduced-Wattage 4-foot Lamp Only, per lamp

Building Type	kWh	Coincident peak kW
Assembly	13.6	0.003
College/University	14.2	0.005
Conditioned Warehouse	18.8	0.005
Government/Municipal	14.9	0.004
Grocery	26.3	0.004
Hotel/Motel	42.1	0.001
Guest Rooms	5.1	0.001
Large Office	15.1	0.005
Large Retail/Service	20.2	0.005
Manufacturing – Light Industrial (1 shift)	16.2	0.006
Manufacturing – Light Industrial (2 shift)	26.8	0.006
Manufacturing – Light Industrial (3 shift)	37.6	0.006
Medical - Hospital	27.6	0.005
Medical - Nursing Home	27.1	0.005
Miscellaneous	23.5	0.004
Restaurant	28.7	0.005
School	13.8	0.004
Small Office	16.4	0.005
Small Retail/Service	20.0	0.006

Building Type	kWh	Coincident peak kW
Unconditioned Warehouse	17.2	0.004
Garage (Ohio)	43.8	0.005
Exterior (Ohio)	21.5	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 20. Baseline and Retrofit Wattages for 4-foot RW T8 Lamp Only

	Pre	Post
Measure Code	F41ILL	F41SSILL
Description	Fluorescent, (1) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Fluorescent, (1) 48", Super T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)
Watts/Fixture	31	26

Measure Life and Incremental Measure Cost
The measure life is 3 years. The IMC is $2.10 per ICF Portfolio Plan and DNV KEMA's experience.

1-Lamp 8-foot T12 to 2-Lamp High Performance/Reduced Wattage 4-foot T8 Lamps and Ballast

Measure Description	This measure consists of replacing existing one 8-foot T12 lamp and magnetic ballast with high performance 32W or reduced wattage 4-foot T8 and electronic ballasts. Both the lamp and ballast must meet the Consortium for Energy Efficiency (CEE) high performance or reduced wattage T8 specification (www.cee1.org). The incentive is calculated based on the number of 4-foot lamps installed. Typically, this measure retrofit is in conjunction with a one 8-foot lamp removed (in a 2-lamp, 8-foot T12 to 2 –lamp, 4-foot T8 retrofit).
Units	Per 4-foot lamp
Base Case Description	T12 lamp and magnetic ballasts

Measure Savings
The savings are presented in the following table.

Table 21. Measure Savings for 1-Lamp 4-foot Lamp and Ballast (per lamp)

	High Performance		Reduced Wattage	
Building Type	kWh	Coincident peak kW	kWh	Coincident peak kW
Assembly	50.2	0.009	62.4	0.012
College/University	52.7	0.018	65.5	0.022
Conditioned Warehouse	69.5	0.017	86.3	0.021
Government/Municipal	55.2	0.015	68.6	0.019
Grocery	97.3	0.016	120.9	0.020
Hotel/Motel	155.8	0.005	193.7	0.007
Guest Rooms	18.7	0.005	23.3	0.006
Large Office	55.9	0.018	69.4	0.022
Large Retail/Service	74.6	0.020	92.8	0.025
Manufacturing – Light Industrial (1 shift)	60.0	0.020	74.6	0.025
Manufacturing – Light Industrial (2 shift)	99.3	0.020	123.5	0.025
Manufacturing – Light Industrial (3 shift)	139.2	0.020	173.1	0.025
Medical - Hospital	101.9	0.017	126.7	0.021
Medical - Nursing Home	100.3	0.018	124.7	0.022
Miscellaneous	86.8	0.016	107.9	0.020
Restaurant	106.4	0.020	132.2	0.024
School	51.1	0.017	63.5	0.021
Small Office	60.6	0.017	75.3	0.021
Small Retail/Service	73.8	0.021	91.8	0.026
Unconditioned Warehouse	63.7	0.013	79.1	0.016
Garage (Ohio)	162.1	0.019	201.5	0.023
Exterior (Ohio)	79.6	0.000	98.9	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 22. Baseline and Retrofit Wattages for 1-Lamp 8-foot T12 to 2-Lamp 4-foot T8 Fixture Retrofits

	Pre	High Performance Post	Reduced Wattage Post
Measure Code	F81SE	F42LL-R	F42SSILL-R
Description	Fluorescent, (1) 96", STD lamp	Fluorescent, (2) 48", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)	Fluorescent, (2) 48", Super T-8 lamp, Instant Start Ballast, RLO (BF<0.85)
Watts/Fixture	91	54	45

Demand reduction per 4-foot lamp installed is calculated as follows:

*(Pre-Watt/Fixture * 0.5) – (Post-Watt/Fixture * 0.5)*

Measure Life and Incremental Measure Cost

The measure life is 11 years.(assuming 20,000 hours rated lamp life for average operating hours per year). The IMC is $13.14 per AEP Ohio Potential Study.

We have assumed an EUL of 11 years for T-12 to T-8 conversions. There has been discussion in the evaluation industry that a lower number might be warranted going forward as by statute, the manufacture of T-12s ends in 2012.

Reduced Wattage 8-foot Lamp and Ballast

Measure Description	This measure consists of replacing existing T12 8' lamps and magnetic ballasts with reduced wattage T8 lamps and electronic ballasts. Eight foot lamps must have a minimum MLPW of 90 and must have a nominal wattage of 57W or less.
Units	Per lamp
Base Case Description	T12 lamp and magnetic ballasts or high watt T8 fixtures (for reduced wattage lamp only replacements).

Measure Savings

Savings are summarized by the following table.

Table 23. Measure Savings for Reduced-Wattage 8-foot Lamp and Ballast

Building Type	kWh	Coincident peak kW
Assembly	66.4	0.013
College/University	69.8	0.023
Conditioned Warehouse	92.0	0.022
Government/Municipal	73.0	0.020
Grocery	128.8	0.022
Hotel/Motel	206.4	0.007
Guest Rooms	24.8	0.006
Large Office	74.0	0.024
Large Retail/Service	98.8	0.026
Manufacturing – Light Industrial (1 shift)	79.4	0.027
Manufacturing – Light Industrial (2 shift)	131.5	0.027
Manufacturing – Light Industrial (3 shift)	184.4	0.027
Medical - Hospital	135.0	0.023
Medical - Nursing Home	132.9	0.024
Miscellaneous	114.9	0.021
Restaurant	140.9	0.026
School	67.6	0.022
Small Office	80.2	0.023
Small Retail/Service	97.8	0.028
Unconditioned Warehouse	84.3	0.017
Garage (Ohio)	214.6	0.025
Exterior (Ohio)	105.4	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 24. Baseline and Retrofit Wattages for 8-foot T8 Lamp and Ballast

	Pre	Post
Measure Code	F82SE	F82ILL
Description	Fluorescent, (2) 96", STD lamp	Fluorescent, (2) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)
Watts/Fixture	158	109

Measure Life and Incremental Measure Cost
The measure life is 11 years. The IMC is $36.91 per DEER 2008.

We have assumed an EUL of 11 years for T-12 to T-8 conversions. There has been discussion in the evaluation industry that a lower number might be warranted going forward as by statute, the manufacture of T-12s ends in 2012.

Reduced Wattage 8-foot Lamp Only

Measure Description	This measure consists of replacing existing 59W T8 8' lamps or 60W T12 8' lamps and electronic ballasts with reduced wattage T8. Eight foot lamps must have a minimum MLPW of 90 and must have a nominal wattage equal to or less than 57W.
Units	Per lamp
Base Case Description	59W T8 or 60W T12 with electronic ballasts

Measure Savings

Savings are summarized by the following table.

Table 25. Measure Savings for Reduced-Wattage 8-foot Lamp Only

Building Type	kWh	Coincident peak kW
Assembly	19.0	0.004
College/University	19.9	0.007
Conditioned Warehouse	26.3	0.006
Government/Municipal	20.9	0.006
Grocery	36.8	0.006
Hotel/Motel	59.0	0.002
Guest Rooms	7.1	0.002
Large Office	21.1	0.007

Building Type	kWh	Coincident peak kW
Large Retail/Service	28.2	0.008
Manufacturing – Light Industrial (1 shift)	22.7	0.008
Manufacturing – Light Industrial (2 shift)	37.6	0.008
Manufacturing – Light Industrial (3 shift)	52.7	0.008
Medical - Hospital	38.6	0.007
Medical - Nursing Home	38.0	0.007
Miscellaneous	32.8	0.006
Restaurant	40.2	0.007
School	19.3	0.006
Small Office	22.9	0.007
Small Retail/Service	27.9	0.008
Unconditioned Warehouse	24.1	0.005
Garage (Ohio)	61.3	0.007
Exterior (Ohio)	30.1	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 26. Baseline and Retrofit Wattages for 8-foot T8 Lamp Only

	Pre	Post
Measure Code	F81ILL	F81IELU
Description	Fluorescent, (1) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Flourescent, (1) 96" T-8 @ 57W lamp, Instant Start Ballast, NLO (0.85 < BF < 0.95)
Watts/Fixture	58	51

Measure Life and Incremental Measure Cost
The measure life is 3 years. The IMC is $5.50 per ICF Portfolio Plan and DNV KEMA's experience.

2-foot & 3-foot T8 Lamps and Ballast

Measure Description	This measure consists of replacing existing T12 lamps and magnetic ballasts with T8 lamps and electronic ballasts. The lamp must have a color rendering index (CRI) ≥ 80 and the ballast must have a total harmonic distortion (THD) ≤ 32% at full light output and power factor (PF) ≥ 0.90. Ballasts must also be warranted against defects for 5 years. When replacing an existing T8 fixture, low ballast factor of 0.85 or less must be installed.
Units	Per lamp
Base Case Description	T12 lamps and magnetic ballast

Measure Savings
The coincident kW and kWh savings are provided in the following table.

Table 27. Measure Savings for 2-foot Lamp and Ballast (per lamp)

	2-foot – T12 Base		2-foot – T8 Base	
Building Type	**kWh**	**Coincident peak kW**	**kWh**	**Coincident peak kW**
Assembly	31.2	0.006	6.8	0.001
College/University	32.8	0.011	7.1	0.002
Conditioned Warehouse	43.2	0.010	9.4	0.002
Government/Municipal	34.3	0.009	7.5	0.002
Grocery	60.5	0.010	13.1	0.002
Hotel/Motel	96.9	0.003	21.1	0.001
Guest Rooms	11.6	0.003	2.5	0.001
Large Office	34.7	0.011	7.5	0.002
Large Retail/Service	46.4	0.012	10.1	0.003
Manufacturing – Light Industrial (1 shift)	37.3	0.013	8.1	0.003
Manufacturing – Light Industrial (2 shift)	61.7	0.013	13.4	0.003
Manufacturing – Light Industrial (3 shift)	86.6	0.013	18.8	0.003
Medical - Hospital	63.4	0.011	13.8	0.002
Medical - Nursing Home	62.4	0.011	13.6	0.002
Miscellaneous	54.0	0.010	11.7	0.002
Restaurant	66.1	0.012	14.4	0.003
School	31.7	0.010	6.9	0.002
Small Office	37.6	0.011	8.2	0.002

	2-foot – T12 Base		2-foot – T8 Base	
Building Type	kWh	Coincident peak kW	kWh	Coincident peak kW
Small Retail/Service	45.9	0.013	10.0	0.003
Unconditioned Warehouse	39.6	0.008	8.6	0.002
Garage (Ohio)	100.7	0.012	21.9	0.003
Exterior (Ohio)	49.5	0.000	10.8	0.000

Table 28. Measure Savings for 3-foot Lamp and Ballast (per lamp)

	3-foot – T12 Base		3-foot – T8 Base	
Building Type	kWh	Coincident peak kW	kWh	Coincident peak kW
Assembly	38.0	0.007	5.4	0.001
College/University	39.9	0.013	5.7	0.002
Conditioned Warehouse	52.6	0.013	7.5	0.002
Government/Municipal	41.7	0.011	6.0	0.002
Grocery	73.6	0.012	10.5	0.002
Hotel/Motel	117.9	0.004	16.8	0.001
Guest Rooms	14.2	0.004	2.0	0.001
Large Office	42.3	0.014	6.0	0.002
Large Retail/Service	56.5	0.015	8.1	0.002
Manufacturing – Light Industrial (1 shift)	45.4	0.015	6.5	0.002
Manufacturing – Light Industrial (2 shift)	75.2	0.015	10.7	0.002
Manufacturing – Light Industrial (3 shift)	105.4	0.015	15.1	0.002
Medical - Hospital	77.1	0.013	11.0	0.002
Medical - Nursing Home	75.9	0.013	10.8	0.002
Miscellaneous	65.7	0.012	9.4	0.002
Restaurant	80.5	0.015	11.5	0.002
School	38.6	0.013	5.5	0.002
Small Office	45.8	0.013	6.5	0.002
Small Retail/Service	55.9	0.016	8.0	0.002
Unconditioned Warehouse	48.2	0.010	6.9	0.001
Garage (Ohio)	122.6	0.014	17.5	0.002
Exterior (Ohio)	60.2	0.000	8.6	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 29. Baseline and Retrofit Wattages for 2-foot Lamps – T12 Base

	Pre	Post
Measure Code	F22SS	F22ILL
Description	Fluorescent, (2) 24", STD lamp	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)
Watts/Fixture	56	33

Table 30. Baseline and Retrofit Wattages for 2-foot Lamps – T8 Base

	Pre	Post
Measure Code	F22ILL	F22ILL/T4-R
Description	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, RLO (BF<.85), Tandem 4 Lamp Ballast
Watts/Fixture	33	28

Table 31. Baseline and Retrofit Wattages for 3-foot Lamps – T12 Base

	Pre	Post
Measure Code	F32SE	F32ILL
Description	Fluorescent, (2) 36", STD lamp	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)
Watts/Fixture	74	46

Table 32. Baseline and Retrofit Wattages for 3-foot Lamps – T8 Base

	Pre	Post
Measure Code	F32LL	F32LL-R
Description	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, NLO (BF: .85-.95)	Fluorescent, (2) 36", T-8 lamp, Rapid Start Ballast, RLO (BF<0.85)
Watts/Fixture	46	42

Measure Life and Incremental Measure Cost
The measure life is 11 years per DEER 2005. The IMC is $10.50 for 2-foot lamp and $21.00 for 3-foot lamp per PG&E 2006 workpapers.

Ceramic Metal Halides or Pulse Start Metal Halides

Measure Description	This incentive applies to retrofits of mercury vapor, high pressure sodium, standard metal halide, incandescent or T12 with either pulse start metal halide or ceramic metal halide fixtures. Total replacement wattage must be lower than existing wattage to insure energy savings. Retrofit kits may be used on existing mercury vapor, standard metal halide or high pressure sodium fixtures only. Incentive is for one for one replacement only. Wattage is nominal lamp wattage of new lamp.
Units	Per Fixture
Base Case Description	High wattage HID fixtures

Measure Savings
Measure savings are presented in the following table. Wattage categories refer to retrofit wattage and not baseline wattage.

Table 33. Measure Savings for Metal Halide Retrofits, per fixture

	≤100W		101-200W		201-350W		351-400W		401-1000W	
Building Type	kWh	kW	kWh	kW	kWh	kW	kWh	kW	kWh	kW
Assembly	200.6	0.038	352.5	0.067	363.3	0.069	1,125.1	0.212	718.5	0.136
College/University	210.8	0.070	370.3	0.123	381.7	0.127	1,182.1	0.394	754.8	0.252
Conditioned Warehouse	277.8	0.067	488.0	0.118	503.1	0.121	1,558.0	0.376	994.8	0.240
Government/Municipal	220.6	0.060	387.6	0.106	399.5	0.109	1,237.2	0.339	790.0	0.216
Grocery	389.0	0.065	683.5	0.115	704.5	0.118	2,181.8	0.366	1,393.2	0.234
Hotel/Motel	623.3	0.022	1,095.0	0.039	1,128.7	0.040	3,495.5	0.123	2,232.1	0.079
Guest Rooms	74.8	0.019	131.4	0.033	135.5	0.034	419.6	0.106	268.0	0.068
Large Office	223.4	0.072	392.5	0.126	404.6	0.130	1,253.1	0.401	800.2	0.256
Large Retail/Service	298.5	0.080	524.4	0.140	540.5	0.145	1,673.9	0.448	1,068.9	0.286
Manufacturing – Light Industrial (1 shift)	240.0	0.082	421.6	0.143	434.5	0.148	1,345.7	0.458	859.3	0.292
Manufacturing – Light Industrial (2 shift)	397.3	0.082	697.9	0.143	719.4	0.148	2,227.9	0.458	1,422.7	0.292
Manufacturing – Light Industrial (3 shift)	556.9	0.082	978.4	0.143	1,008.5	0.148	3,123.4	0.458	1,994.4	0.292
Medical - Hospital	407.8	0.069	716.4	0.121	738.4	0.125	2,286.9	0.387	1,460.3	0.247
Medical - Nursing Home	401.3	0.071	705.0	0.125	726.7	0.129	2,250.5	0.400	1,437.1	0.255
Miscellaneous	347.2	0.063	609.9	0.111	628.6	0.114	1,946.9	0.355	1,243.2	0.226
Restaurant	425.4	0.078	747.4	0.137	770.4	0.142	2,385.8	0.438	1,523.5	0.280
School	204.2	0.066	358.7	0.116	369.8	0.120	1,145.2	0.372	731.3	0.237
Small Office	242.2	0.069	425.6	0.121	438.7	0.125	1,358.6	0.387	867.5	0.247
Small Retail/Service	295.4	0.085	518.9	0.149	534.9	0.154	1,656.4	0.476	1,057.7	0.304
Unconditioned Warehouse	254.6	0.052	447.3	0.091	461.1	0.094	1,428.0	0.291	911.9	0.186
Garage (Ohio)	648.2	0.074	1,138.8	0.130	1,173.8	0.134	3,635.4	0.415	2,321.4	0.265
Exterior (Ohio)	318.2	0.000	559.0	0.000	576.2	0.000	1,784.5	0.000	1,139.5	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 34. Baseline and Retrofit Metal Halide Wattages[6]

Measure Name	Pre Measure Code	Pre Fixture Description	Watts/Fixture (PRE)	Post Measure Code	Post Fixture Description	Watts/Fixture (POST)
Interior Pulse Start or Ceramic, 100W or Less	H50/2	Halogen Incandescent, (2) 50W lamp	100	CMH20 /1-L	Ceramic Metal Halide, (1) 20W lamp, Electronic Ballast	26
Interior Pulse Start or Ceramic, 101W - 200W	H300/1	Halogen Incandescent, (1) 300W lamp	300	MHPS/LR/150/1	Metal Halide Pulse Start, (1) 150W lamp w/ Linear Reactor Ballast	170
Interior Pulse Start or Ceramic, 201W - 350W	MH400/1	Metal Halide, (1) 400W lamp	458	MHPS/LR/300/1	Metal Halide Pulse Start, (1) 300W lamp w/ Linear Reactor Ballast	324
Interior Pulse Start or Ceramic, 351W - 400W	MH750/1	Metal Halide, (1) 750W lamp	850	MHPS/LR/400/1	Metal Halide Pulse Start, (1) 400W lamp w/ Linear Reactor Ballast	435
Interior Pulse Start or Ceramic, 401W - 1000W	MH1000/1	Metal Halide, (1) 1000W lamp	1080	MHPS/SCWA/750/1	Metal Halide Pulse Start, (1) 750W lamp w/ Super Constant Wattage Autotransformer Ballast	815

Measure Life and Incremental Measure Cost
The measure life is 16 years per DEER 2008. The IMC is summarized in the table below.

Table 35. Metal Halide Incremental Measure Cost

Wattage Category	Value	Source
100W or Less	$95	SCE WP[7]
101-200W	$207	DEER 2008
201-350W	$220	
351-400W	$237	
401-1000W		

[6]2006 PG&E Interior Pulse Start Metal Halide Workpaper, PG&E Directional Lighting CMH Workpaper, SCE Ceramic Metal Halide Workpaper (WPSCNRLG0054.1), 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report - Residential and Commercial Non-Weather Sensitive Measures.
[7] WPSCNRLG0054.1 Ceramic Metal Halide Fixtures, Southern California Edison Workpaper, 2008.

Ceramic Metal Halide Integral Ballast Lamp

Measure Description	Ceramic Metal Halide Integral Ballast lamps (CMHIB) include a ballast, ceramic metal light source, and reflector in the same package. Qualifying lamps are 25 watt or less CMHIB PAR lamps with a rated life 10,500 hours or greater.
Units	Per Lamp
Base Case Description	Incandescent or halogen lamps

Measure Savings

The coincident kW and kWh savings are provided by building type in the following table.

Table 36. Ceramic Metal Halide Integral Ballast lamps (CMHIB) Savings, per lamp

Building Type	kWh	Coincident peak kW
Assembly	108.4	0.020
College/University	113.9	0.038
Conditioned Warehouse	150.2	0.036
Government/Municipal	119.3	0.033
Grocery	210.3	0.035
Hotel/Motel	336.9	0.012
Guest Rooms	40.4	0.010
Large Office	120.8	0.039
Large Retail/Service	161.3	0.043
Manufacturing – Light Industrial (1 shift)	129.7	0.044
Manufacturing – Light Industrial (2 shift)	214.7	0.044
Manufacturing – Light Industrial (3 shift)	301.0	0.044
Medical - Hospital	220.4	0.037
Medical - Nursing Home	216.9	0.039
Miscellaneous	187.7	0.034
Restaurant	230.0	0.042
School	110.4	0.036
Small Office	130.9	0.037
Small Retail/Service	159.7	0.046
Unconditioned Warehouse	137.6	0.028
Garage (Ohio)	350.4	0.040

Building Type	kWh	Coincident peak kW
Exterior (Ohio)	172.0	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. CMHIB lighting is assumed to follow the operating hours and use the coincidence and energy factors of CFL lighting. Baseline and retrofit equipment assumptions are listed in the table below.

Base case wattages were collected for three major reflector halogen lamp manufacturers. The weighted average of the base case wattage based on the on the market share of the different lamp manufacturers is calculated to be 66 W per lamp[8]. For purposes of savings calculations, a 65 W halogen is assumed to be the basecase fixture.

Table 37. Baseline and Retrofit Wattages for CMHIB lamps

	Pre	Post
Measure Code	H65/1	CMH25/1
Description	Halogen Incandescent, (1) 65 Watt Lamp	Ceramic Metal Halide, (1) Self ballasted, 25 Watt Lamp
Watts/Fixture	65	25

Measure Life and Incremental Measure Cost

The measure life varies by building type, since measure life is dependent on building operating hours. These lamps are assumed to give a rated average life of 10,500 hours.[9] The average calculated life, using an average of all deemed operating hours, is 3 years. The measure cost is $25 per the PG&E workpaper.

[8] PG&E Workpaper - PGECOLTG102.1 – CMH Directional Lamp
[9] PG&E Workpaper - PGECOLTG102.1 – CMH Directional Lamp

Ceramic Discharge Metal Halide (CDM) Lamp

Measure Description	This measure consists of replacing a standard metal halide lamp with a ceramic discharge metal halide lamp. The Color Rendering Index (CRI) must be ≥ 80, and the mean efficacy must be ≥65 lumens per Watt. Lamp must be compatible with existing ballast to be eligible. The total replacement wattage must be lower than existing wattage to ensure energy savings.
Units	Per Fixture
Base Case Description	Standard quartz metal halide lamp

Measure Savings
Measure savings are presented in the following table.

Table 38. Measure Savings for Interior Ceramic Discharge Metal Halide (CDM) Lamp

Building Types	<149W CDM		150 - 249W CDM		250 - 399W CDM		400 - 849W CDM	
	Energy Savings (kWh)	Peak Demand Savings (kW)	Energy Savings (kWh)	Peak Demand Savings (kW)	Energy Savings (kWh)	Peak Demand Savings (kW)	Energy Savings (kWh)	Peak Demand Savings (kW)
Assembly	122.0	0.023	122.0	0.023	216.9	0.041	425.7	0.080
College/University	128.2	0.043	128.2	0.043	227.9	0.076	447.2	0.149
Conditioned Warehouse	168.9	0.041	168.9	0.041	300.3	0.073	589.4	0.142
Government/Municipal	134.2	0.037	134.2	0.037	238.5	0.065	468.1	0.128
Grocery	236.6	0.040	236.6	0.040	420.6	0.071	825.4	0.138
Hotel/Motel	379.0	0.013	379.0	0.013	673.8	0.024	1,322.4	0.047
Guest Rooms	45.5	0.012	45.5	0.012	80.9	0.020	158.7	0.040
Large Office	135.9	0.044	135.9	0.044	241.6	0.077	474.1	0.152
Large Retail/Service	181.5	0.049	181.5	0.049	322.7	0.086	633.3	0.169
Manufacturing – Light Industrial (1 shift)	145.9	0.050	145.9	0.050	259.4	0.088	509.1	0.173
Manufacturing – Light Industrial (2 shift)	241.6	0.050	241.6	0.050	429.5	0.088	842.9	0.173
Manufacturing – Light Industrial (3 shift)	338.7	0.050	338.7	0.050	602.1	0.088	1,181.6	0.173
Medical - Hospital	248.0	0.042	248.0	0.042	440.9	0.075	865.2	0.146
Medical - Nursing Home	244.0	0.043	244.0	0.043	433.8	0.077	851.4	0.151
Miscellaneous	211.1	0.038	211.1	0.038	375.3	0.068	736.5	0.134
Restaurant	258.7	0.048	258.7	0.048	459.9	0.084	902.6	0.166
School	124.2	0.040	124.2	0.040	220.8	0.072	433.3	0.141

Small Office	147.3	0.042	147.3	0.042	261.9	0.075	514.0	0.146
Small Retail/Service	179.6	0.052	179.6	0.052	319.3	0.092	626.7	0.180
Unconditioned Warehouse	154.8	0.032	154.8	0.032	275.3	0.056	540.2	0.110
Garage (Ohio)	394.2	0.045	394.2	0.045	700.8	0.080	1,375.3	0.157
Exterior (Ohio)	193.5	0.000	193.5	0.000	344.0	0.000	675.1	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below and are based on several custom projects from the previous program years, as well as from conversations with manufacturers and review of manufacturer product specification sheets.

Table 39. Baseline and Retrofit Probe Start Metal Halide to Cermaic Discharge Metal Halide Lamp Wattages

Measure Description	Basecase Nominal Lamp Wattage Range	New Nominal Lamp Wattage Range	Basecase Nominal Lamp Wattage	New Nominal Lamp Wattage	Basecase Fixture Wattage	New Total Fixture Wattage	Non-Coincident Savings per Fixture
<149W CDM	150-249	≤149	175	145	215	170	0.045
150 - 249W CDM	250-399	≤249	250	205	295	250	0.045
250 - 399W CDM	400-749	≤399	400	330	458	378	0.0802
400 - 849W CDM	850-1000	≤849	1000	830	1080	923	0.157

Measure Life and Incremental Measure Cost

The IMC and measure life is summarized in the table below. The IMCs are based on conversations with manufacturers of the equipment, and the life is the typical product life divided by the average operating hours.

Table 40. Metal Halide Incremental Measure Cost

Measures	Life	Cost
<149W CDM	4.6	$50
150 - 249W CDM	4.6	$55
250 - 399W CDM	5.5	$58
400 - 849W CDM	3.7	$75

New T5/T8 Fluorescent Fixtures

Measure Description	This measure consists of replacing one or more existing fixtures with new fixtures containing T8 or T5 lamps and electronic ballasts. The T8 or T5 lamps must have a color rendering index (CRI) ≥ 80. The electronic ballast must be high frequency (≥20 kHz), UL listed, and warranted against defects for 5 years. Ballasts must have a power factor (PF) ≥ 0.90. Ballasts for 4-foot lamps must have total harmonic distortion (THD) ≤20 percent at full light output. For 2- and 3-foot lamps, ballasts must have THD ≤32% at full light output. High output T5/T8 lamps also qualify for this credit. Specifications of the new fixtures, lamps and ballasts must accompany the final application.
Units	Per Watt reduced
Base Case Description	Typically high wattage HID fixtures

Measure Savings

Table 41. Measure Savings for New T8/T5 Fluorescent Fixtures per Watt Reduced

Building Type	kWh	Coincident peak kW
Assembly	2.71	0.000512
College/University	2.85	0.000950
Conditioned Warehouse	3.75	0.000907
Government/Municipal	2.98	0.000817
Grocery	5.26	0.000881
Hotel/Motel	8.42	0.000297
Guest Rooms	1.01	0.000256
Large Office	3.02	0.000967
Large Retail/Service	4.03	0.001079
Manufacturing – Light Industrial (1 shift)	3.24	0.001103
Manufacturing – Light Industrial (2 shift)	5.37	0.001103
Manufacturing – Light Industrial (3 shift)	7.53	0.001103
Medical - Hospital	5.51	0.000932
Medical - Nursing Home	5.42	0.000963
Miscellaneous	4.69	0.000854
Restaurant	5.75	0.001056
School	2.76	0.000896

Building Type	kWh	Coincident peak kW
Small Office	3.27	0.000933
Small Retail/Service	3.99	0.001148
Unconditioned Warehouse	3.44	0.000700
Garage (Ohio)	8.76	0.001000
Exterior (Ohio)	4.30	0.000000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are variable. Because we define this measure with the number of watts reduced, the non-coincident demand savings will be one watt by definition.

Measure Life and Incremental Measure Cost
The measure life is 11 years per DEER 2005 equivalent t linear fluorescent fixtures. The IMC is $1.10 per DNV KEMA research/experience.

We have assumed an EUL of 11 years for T-12 to T-8 conversions. There has been discussion in the evaluation industry that a lower number might be warranted going forward as by statute, the manufacture of T-12s ends in 2012.

Exit Signs

Measure Description	High-efficiency exit signs must replace or retrofit an existing incandescent exit sign. Electroluminescent, photoluminescent, T1 and light-emitting diode (LED) exit signs are eligible under this category. Non-electrified and remote exit signs are not eligible. All new exit signs or retrofit exit signs must be UL924 listed, have a minimum lifetime of 10 years, and have an input wattage ≤ 5 Watts per face.
Units	Per Sign
Base Case Description	Incandescent Exit Signs

Measure Savings
The coincident kW and kWh savings are provided in the following table.

Table 42. Measure Savings for LED Exit Signs (per sign)

Building Type	kWh	Coincident peak kW
Assembly	324.7	0.016
College/University	292.5	0.037
Conditioned Warehouse	295.4	0.046
Government/Municipal	308.8	0.041
Grocery	290.4	0.040
Hotel/Motel	311.9	0.040
Guest Rooms	346.4	0.008
Large Office	296.5	0.041
Large Retail/Service	314.7	0.044
Manufacturing – Light Industrial (1 shift)	306.9	0.044
Manufacturing – Light Industrial (2 shift)	306.9	0.044
Manufacturing – Light Industrial (3 shift)	306.9	0.044
Medical - Hospital	305.0	0.036
Medical - Nursing Home	327.7	0.044
Miscellaneous	305.0	0.041
Restaurant	315.9	0.042
School	328.1	0.047
Small Office	326.9	0.044
Small Retail/Service	316.7	0.044
Unconditioned Warehouse	273.8	0.031
Garage (Ohio)	273.8	0.031
Exterior (Ohio)	273.8	0.031

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below. It is assumed that the CFL basecase accounts for 25% of installations, while the Incandescent basecase accounts for 75% of installations. This results in a weighted basecase average wattage of 35.25 W.

Table 43. Baseline and Retrofit Wattages Exit Signs

	Pre (Incandescent)	Pre (CFL)	Post
Measure Code	EI20/2	ECF7/2	ELED2/2
Description	EXIT Incandescent, (2) 20W lamp	EXIT Compact Fluorescent, (2) 7W lamp	EXIT Light Emitting Diode, (2) 2W lamp, Dual Sided
Watts/Fixture	40	21	4

Measure Life and Incremental Measure Cost
The measure life is 16 years per DEER 2008. The IMC is $82.54 per AEP Potential Study.

ENERGY STAR® and DesignLights Consortium (DLC) LED Lamp or Fixture

Measure Description	The LED lamp or fixuture must appear on either the ENERGY STAR qualified products list, or the Design Lights Consortium qualified products list.
Units	Per Watt reduced
Base Case Description	Less efficient lamp or fixture

Measure Savings
The coincident kW and kWh savings are provided in the following table.

Table 44. Measure Savings for LED lamp or fixture (per Watts reduced)

Building Type	kWh	Coincident peak kW
Assembly	2.71	0.000512
College/University	2.85	0.000950
Conditioned Warehouse	3.75	0.000907
Government/Municipal	2.98	0.000817
Grocery	5.26	0.000881
Hotel/Motel	8.42	0.000297
Guest Rooms	1.01	0.000256
Large Office	3.02	0.000967
Large Retail/Service	4.03	0.001079
Manufacturing – Light Industrial (1 shift)	3.24	0.001103
Manufacturing – Light Industrial (2 shift)	5.37	0.001103
Manufacturing – Light Industrial (3 shift)	7.53	0.001103
Medical - Hospital	5.51	0.000932

Building Type	kWh	Coincident peak kW
Medical - Nursing Home	5.42	0.000963
Miscellaneous	4.69	0.000854
Restaurant	5.75	0.001056
School	2.76	0.000896
Small Office	3.27	0.000933
Small Retail/Service	3.99	0.001148
Unconditioned Warehouse	3.44	0.000700
Garage (Ohio)	8.76	0.001000
Exterior (Ohio)	4.30	0.000000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. LED lighting is assumed to follow the operating hours and use the coincidence and energy factors of CFL lighting. The wattage reduction are inputsfrom the applicant.

Measure Life and Incremental Measure Cost
The measure life for the LED bulbs is taken from the ENERGY STAR® website, which lists most of LED fixtures as having an average rated lifetime of 35,000 hours. Using an average operating hours from across the building types, the estimated useful of LED fixtures is 7.7 years. The IMC is $2.97 per watt reduced based on DNV KEMA analysis of previous projects.

Non-standard LED or Induction Equipment

Measure Description	The non-standard LED measure is for LED equipment which is not yet listed by ENERGY STAR or DesignLights Consortium. LM-79 sheets must be provided for general illumination projects, and LM-80 sheets if available. Eligibility will be determined at the discretion of the program. The induction fixture must have a CRI of 80 or above and a mean efficacy of 50 or above.
Units	Per Watt reduced
Base Case Description	Less efficient lamp or fixture

Measure Savings
The coincident kW and kWh savings are provided in the following table.

Table 45. Measure Savings for Non-Standard LED or Induction Equipment (per Watt reduced)

Building Type	kWh	Coincident peak kW
Assembly	2.71	0.000512
College/University	2.85	0.000950
Conditioned Warehouse	3.75	0.000907
Government/Municipal	2.98	0.000817
Grocery	5.26	0.000881
Hotel/Motel	8.42	0.000297
Guest Rooms	1.01	0.000256
Large Office	3.02	0.000967
Large Retail/Service	4.03	0.001079
Manufacturing – Light Industrial (1 shift)	3.24	0.001103
Manufacturing – Light Industrial (2 shift)	5.37	0.001103
Manufacturing – Light Industrial (3 shift)	7.53	0.001103
Medical - Hospital	5.51	0.000932
Medical - Nursing Home	5.42	0.000963
Miscellaneous	4.69	0.000854
Restaurant	5.75	0.001056
School	2.76	0.000896
Small Office	3.27	0.000933
Small Retail/Service	3.99	0.001148
Unconditioned Warehouse	3.44	0.000700
Garage (Ohio)	8.76	0.001000
Exterior (Ohio)	4.30	0.000000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings arewere calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. LED lighting is assumed to follow the operating hours and use the coincidence and energy factors of CFL lighting. The wattage reduction are inputsfrom the applicant.

Measure Life and Incremental Measure Cost

The measure life for the LEDs is taken from the ENERGY STAR website, which lists most of LED fixtures as having an average rated lifetime of 35,000 hours. Using an average operating hours from across the building types, the estimated useful of LED fixtures is 7.7 years. The IMC is $2.97 per watt reduced based on DNV KEMA analysis of previous projects.

Non-standard Lighting

Measure Description	This measure is for lighting projects that do not fall into one of the measures offered elsewhere in the application. The new equipment must have a higher mean efficacy (lumens per watt) than the existing equipment. The following are not eligible under this measure: retrofitting to standard T8 and electronic ballast, retrofit to lower wattage lamp of the same technology, and retrofits with a measure life of less than 3 years. Examples of what is eligible are: high intensity discharge to compact fluorescent fixtures, high wattage CFL retrofits, and fixture removal as a part of a retrofit. Projects will be approved on a case by case basis, based on currently available industry standards.
Units	Per Watt reduced
Base Case Description	Less efficient lamp or fixture

Measure Savings
The coincident kW and kWh savings are provided in the following table.

Table 46. Measure Savings for Non-Standard Lighting (per Watt reduced)

Building Type	kWh	Coincident peak kW
Assembly	2.71	0.000512
College/University	2.85	0.000950
Conditioned Warehouse	3.75	0.000907
Government/Municipal	2.98	0.000817
Grocery	5.26	0.000881
Hotel/Motel	8.42	0.000297
Guest Rooms	1.01	0.000256
Large Office	3.02	0.000967
Large Retail/Service	4.03	0.001079
Manufacturing – Light Industrial (1 shift)	3.24	0.001103
Manufacturing – Light Industrial (2 shift)	5.37	0.001103
Manufacturing – Light Industrial (3 shift)	7.53	0.001103
Medical - Hospital	5.51	0.000932
Medical - Nursing Home	5.42	0.000963
Miscellaneous	4.69	0.000854
Restaurant	5.75	0.001056
School	2.76	0.000896
Small Office	3.27	0.000933
Small Retail/Service	3.99	0.001148
Unconditioned Warehouse	3.44	0.000700
Garage (Ohio)	8.76	0.001000
Exterior (Ohio)	4.30	0.000000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. LED lighting is assumed to follow the operating hours and use the coincidence and energy factors of CFL lighting.

Measure Life and Incremental Measure Cost
This measure includes a mix of options and therefore an estimate of 8 year is used for the EUL. The IMC is assumed to be $1.10 per Watt reduced based on DNV KEMA analysis of previous projects.

LED Open Signs

Measure Description	LED open signs must replace an existing neon open sign. LED drivers can be either electronic switching or linear magnetic, with the electronic switching supplies being the most efficient. Power adapters, also known as transformers, need to be UL listed. The on-off power switch may be found on either the power line or load side of the driver, with the line side location providing significantly lower standby losses when the sign is turned off and is not operating. Replacement signs cannot use more than 20% of the input power of the sign that is being replaced.
Units	Per Sign
Base Case Description	Neon open sign

Open signs are typically neon-type signs which are hung in store windows and used by businesses to advertise that they are open for business. These self-illuminated signs range from as small as 7 by 16 inches, to as large as 1 by 3 feet. They are usually supplied with a length of chain for suspension from the window frame and a line cord with plug to plug into a nearby electrical outlet. This measure proposes the replacement of an existing neon "open" sign with light emitting diode (LED) signs that include either magnetic or electronic switching of LED drivers.

Measure Savings

The coincident kW and kWh savings are provided in the following table. Open signs are assumed to be on during the typical operating hours of these buildings.

Table 47. Measure Savings for LED Open Signs (per sign)

Building Type	kWh	Coincident peak kW
Assembly	120.5	0.022
College/University	133.0	0.040
Conditioned Warehouse	181.3	0.037
Government/Municipal	134.2	0.033
Grocery	257.5	0.036
Hotel/Motel	360.2	0.011
Guest Rooms	42.1	0.009

Building Type	kWh	Coincident peak kW
Large Office	139.7	0.037
Large Retail/Service	179.2	0.043
Manufacturing – Light Industrial (1 shift)	150.6	0.049
Manufacturing – Light Industrial (2 shift)	249.3	0.049
Manufacturing – Light Industrial (3 shift)	349.5	0.049
Medical - Hospital	257.2	0.043
Medical - Nursing Home	224.5	0.036
Miscellaneous	214.8	0.036
Restaurant	254.3	0.043
School	118.3	0.034
Small Office	136.7	0.037
Small Retail/Service	171.4	0.046
Unconditioned Warehouse	181.3	0.037
Garage (Ohio)	461.7	0.053
Exterior (Ohio)	226.6	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Because it is not typical to purchase multiple open signs for one facility, the wattage savings from one sign will have a minimal effect on HVAC performance; as a result, a value of 0 is assigned to the interactive demand and energy factors.

Baseline wattage is assumed to be 64.9 W/ sign[10]. Retrofit equipment assumptions are listed in the table below.

[10] Information on new neon open signs was gathered from the following vendor/manufacturer sites: www.theneonstore.com,www.brightneonsigns.com,www.store.everything-neon.com, www.allneonsigns.com, www.neon-das.com, www.jantecneon.com; July 2010.

Table 48. Assumptions for Installed LED Wattages[11]

New LED Open Sign	Wattage
LED Small Rectangular	10.7
LED Oblong Shape	12.0
LED Large Rectangular	13.8
Weighted Average (kW_{inst})	12.2

Measure Life and Incremental Measure Cost
The measure life is assumed to be the same as that of an LED exit sign at 16 years.

The actual incremental cost of LED technology over new neon technology with electronic ballasts is about $50 to 100 per sign, or $75, on average per DNV KEMA Research[12].

LED Channel Signs

Measure Description	LED channel sign incentive is available for retrofitting or replacing incandescent, HID, argon-mercury or neon-lighted channel letter signs. Replacement signs cannot use more than 20% of the actual input power of the sign that is replaced. Maximum letter height determines credit.
Units	Per letter
Base Case Description	Existing signage– Neon (red) channel letter signs and argon-mercury (white) channel letter signs.

Measure Savings[13]
The table below provides the non-coincident savings.

[11] Information on new LED open signs was gathered from the following vendor/manufacturer sites: www.bigtray.com, www.buyasignonline.com, www.displays2go.com, www.budgetlighting.com and the following companies were contacted via telephone: www.allneonsigns.com, www.neon-das.com, www.uslightingproducts.com, www.alldec.com; July 2010.
[12] See spreadsheet KEMA LED-Neon Open Signs_7-19-10

[13] PGECOLTG124 R1 LED Channel Signs.docx, May 2009.

Table 49. LED Channel Sign Wattage Reduction

Wattage Category	Average Wattage Reduction, per letter
≤ 2 ft	34
>2 ft	86

The following table summarizes the savings for LED channel signs.

Table 50. Savings for LED Channel Signs, per letter

	≤ 2 ft		>2 ft	
Building Type	kWh	Coincident peak kW	kWh	Coincident peak kW
Assembly	97.6	0.018	233.2	0.044
College/University	102.5	0.034	245.0	0.082
Conditioned Warehouse	135.1	0.033	322.9	0.078
Government/Municipal	107.3	0.029	256.4	0.070
Grocery	189.3	0.032	452.1	0.076
Hotel/Motel	303.2	0.011	724.4	0.026
Guest Rooms	36.4	0.009	87.0	0.022
Large Office	108.7	0.035	259.7	0.083
Large Retail/Service	145.2	0.039	346.9	0.093
Manufacturing – Light Industrial (1 shift)	116.7	0.040	278.9	0.095
Manufacturing – Light Industrial (2 shift)	193.3	0.040	461.7	0.095
Manufacturing – Light Industrial (3 shift)	270.9	0.040	647.3	0.095
Medical - Hospital	198.4	0.034	473.9	0.080
Medical - Nursing Home	195.2	0.035	466.4	0.083
Miscellaneous	168.9	0.031	403.5	0.073
Restaurant	207.0	0.038	494.4	0.091
School	99.3	0.032	237.3	0.077
Small Office	117.9	0.034	281.5	0.080
Small Retail/Service	143.7	0.041	343.3	0.099
Unconditioned Warehouse	123.9	0.025	295.9	0.060
Garage (Ohio)	315.4	0.036	753.4	0.086
Exterior (Ohio)	154.8	0.000	369.8	0.000

Measure Savings Analysis
The calculation methodology used by PG&E in the LED Channel Sign workpaper is outlined below. All the supporting documentation and spreadsheets are shown in the PG&E workpaper. Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Channel signs are assumed to utilize the same operating hours as the building type that they are associated with.

(1) Collected letter schematics showing linear feet of tubing and number of LED modules for each letter of the alphabet, both uppercase and lowercase, for 24 inch high letters and 36 inch high letters.
(2) The base case wattage (W/ft) and the energy efficient case wattage (W/module) input values were collected for each specific letter.
(3) A probability table, showing the frequency each letter appears in the English language, was integrated into the spreadsheet. By multiplying the wattage for each specific letter by the probability, a weighted average wattage per letter was obtained. This single value represents all 26 letters of that height and will be accurate over a range of signs with a weighted average watts/letter for red and white for uppercase and lowercase letters.
(4) This spreadsheet was then modified to account for the average height of signs in each category. (According to sign industry sources, the average height of a sign in the 2 feet or less category is 21 inches. The average height of a sign in the greater than 2 feet high category is 27 inches).
(5) The watts/letter values were then weighted assuming 70% of letters are uppercase and 30% of letters are lowercase, as well as 50% are red signs and 50% are white signs.

Measure Life and Incremental Measure Cost
Measure life is assumed to be 16 years for the signs to be consistent with LED exit signs.

The incremental cost for signs less than or equal to 2 ft. high is $35/letter and the incremental cost for signs greater than 2 ft. high is $154/letter.

Compact Fluorescent Fixtures, Hardwired

Measure Description	Hardwired CFL incentives apply only to complete new fixtures or modular (pin-based) retrofits with hardwired electronic ballasts. The CFL ballast must be programmed start or programmed rapid start with a PF ≥90 and THD ≤20%.
Units	Per fixture
Base Case Description	Incandescent or HID lamps.

Measure Savings

The following tables provide the measure savings using the above wattage reduction assumptions outlined in the Measure Savings analysis section.

Table 51. Measure Savings for Hardwired Compact Fluorescent Fixtures, per lamp

	29W or less		30W to 60 W		61W to 120W	
Building Type	kWh	Coincident peak kW	kWh	Coincident peak kW	kWh	Coincident peak kW
Assembly	149.1	0.028	246.7	0.047	249.4	0.047
College/University	158.9	0.046	263.0	0.077	265.9	0.078
Conditioned Warehouse	167.4	0.041	277.0	0.067	280.1	0.068
Government/Municipal	174.7	0.037	289.1	0.061	292.2	0.062
Grocery	226.0	0.034	373.9	0.057	378.0	0.058
Hotel/Motel	387.8	0.014	641.7	0.023	648.7	0.024
Guest Rooms	55.6	0.014	92.0	0.023	93.0	0.024
Large Office	199.5	0.047	330.0	0.077	333.7	0.078
Large Retail/Service	245.3	0.051	405.9	0.085	410.4	0.086
Manufacturing – Light Industrial (1 shift)	179.4	0.051	296.9	0.084	300.2	0.085
Manufacturing – Light Industrial (2 shift)	297.1	0.051	491.6	0.084	497.0	0.085
Manufacturing – Light Industrial (3 shift)	416.5	0.051	689.1	0.084	696.7	0.085
Medical - Hospital	253.6	0.047	419.6	0.078	424.2	0.079
Medical - Nursing Home	244.9	0.042	405.1	0.070	409.6	0.070
Miscellaneous	238.9	0.041	395.3	0.067	399.6	0.068
Restaurant	313.5	0.056	518.8	0.093	524.5	0.094
School	165.5	0.049	273.9	0.081	276.9	0.082
Small Office	210.2	0.050	347.8	0.082	351.6	0.083
Small Retail/Service	244.8	0.052	405.0	0.086	409.4	0.087
Unconditioned Warehouse	152.9	0.032	253.0	0.052	255.8	0.053
Garage (Ohio)	481.8	0.055	797.2	0.091	805.9	0.092

	29W or less		30W to 60 W		61W to 120W	
Building Type	kWh	Coincident peak kW	kWh	Coincident peak kW	kWh	Coincident peak kW
Exterior (Ohio)	236.5	0.000	391.3	0.000	395.6	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are listed in the table below.

Table 52. Baseline and Retrofit Wattages for Hardwired Compact Fluorescent Fixtures

Measure Name	Pre Measure Code	Pre Fixture Description	Watts/Fixture (PRE)	Post Measure Code	Post Fixture Description	Watts/Fixture (POST)
Interior HW CFL - 29W or Less	I75/1	Incandescent, (1) 75W lamp	75	CFM18/1-L	Compact Fluorescent, Multi, 4-pin, (1) 18W lamp	20
Interior HW CFL - 30W to 60W	I150/1	Incandescent, (1) 150W lamp	150	CFM57/1-L	CFL, Multi, 4-pin, (1) 57 W Lamp	59
Interior HW CFL - 61W to 120 W	I200/1	Incandescent, (1) 200W lamp	200	CFT50/2-BX	Compact Fluorescent, Biax, (2) 50W lamp	108

Measure Life and Incremental Measure Cost
The measure life is 12 years per DEER 2008. The IMC is $95 for ≤29 W and $132 for >30W per fixture per DNV KEMA's research/experience.

Cold Cathode

Measure Description	All cold cathode fluorescent lamps (CCFLs) must replace incandescent lamps of at least 10 W. Cold cathode lamps may be medium (Edison) or candelabra base. Product must be rated for at least 18,000 average life hours.
Units	Per lamp
Base Case Description	Incandescent

Measure Savings
Baseline and retrofit equipment assumptions are presented in table below.

Table 53. Cold Cathode Measure Savings, per lamp

Building Type	kWh	Coincident peak kW
Assembly	54.2	0.010
College/University	57.8	0.017
Conditioned Warehouse	60.9	0.015
Government/Municipal	63.5	0.014
Grocery	82.2	0.013
Hotel/Motel	141.0	0.005
Guest Rooms	20.2	0.005
Large Office	72.5	0.017
Large Retail/Service	89.2	0.019
Manufacturing – Light Industrial (1 shift)	65.3	0.018
Manufacturing – Light Industrial (2 shift)	108.0	0.018
Manufacturing – Light Industrial (3 shift)	151.5	0.018
Medical – Hospital	92.2	0.017
Medical - Nursing Home	89.0	0.015
Miscellaneous	86.9	0.015
Restaurant	114.0	0.021
School	60.2	0.018
Small Office	76.4	0.018
Small Retail/Service	89.0	0.019
Unconditioned Warehouse	55.6	0.012
Garage (Ohio)	175.2	0.020
Exterior (Ohio)	86.0	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Cold cathode lighting is assumed to follow the operating hours and use the coincidence and energy factors of CFL lighting. Baseline and retrofit equipment assumptions are listed in the table below.

Table 54. Baseline and Retrofit Wattages for Cold Cathode Lamps

	Pre	Post
Measure Code	I25/1	CFC5/1-SCRW
Description	Incandescent, (1) 25W lamp	CFL Cold Cathode (1) 5W screw-in Lamp, any bulb shape
Watts/Fixture	25	5

Measure Life and Incremental Measure Cost
The measure life is 5 years per SCE workpapers[14]. The IMC is $9.68 per PG&E workpapers[15].

Specialty Screw-in CFL

Measure Description	Replacing existing incandescent, metal halide, induction or other non-CFL lamps with specialty CFLs, such as PAR, 3-way or dimmable lamps. These lamps must meet ENERGY STAR® criteria, if available for the type of lamp. Maximum replacement wattage lamp is 40W. Lamps must have an efficacy ≥40 LPW.
Units	Per lamp
Base Case Description	Conventional, incandescent bulb
Measure Savings	Source: DNV KEMA
Measure Incremental Cost	Source: DNV KEMA $47
Effective Useful Life	Source: DEER 2008 2.5 years

Measure Savings
The savings are presented in the following table.

Table 55. Specialty Screw-in CFL Measure Savings, per lamp

Building Type	kWh	Coincident peak kW
Assembly	149.1	0.028
College/University	158.9	0.046
Conditioned Warehouse	167.4	0.041

[14] Southern California Edison Company, Cold Cathode Fluorescent Lamp Workpaper WPSCNRLG0063. 2007.
[15] Pacific Gas & Electric, Lighting WP.doc, 2006.

Building Type	kWh	Coincident peak kW
Government/Municipal	174.7	0.037
Grocery	226.0	0.034
Hotel/Motel	387.8	0.014
Guest Rooms	55.6	0.014
Large Office	199.5	0.047
Large Retail/Service	245.3	0.051
Manufacturing – Light Industrial (1 shift)	179.4	0.051
Manufacturing – Light Industrial (2 shift)	297.1	0.051
Manufacturing – Light Industrial (3 shift)	416.5	0.051
Medical - Hospital	253.6	0.047
Medical - Nursing Home	244.9	0.042
Miscellaneous	238.9	0.041
Restaurant	313.5	0.056
School	165.5	0.049
Small Office	210.2	0.050
Small Retail/Service	244.8	0.052
Unconditioned Warehouse	152.9	0.032
Garage (Ohio)	481.8	0.055
Exterior (Ohio)	236.5	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Specialty screw-in CFL lighting is assumed to follow the operating hours and use the coincidence and energy factors of CFL lighting. Baseline and retrofit equipment assumptions are listed in the table below.

Table 56. Baseline and Retrofit Wattages for Specialty Screw-in Compact Fluorescent Lamps

	Pre	Post
Measure Code	I75/1	CFS20/1
Description	Incandescent, (1) 75W lamp	Compact Fluorescent, spiral, (1) 20W lamp
Watts/Fixture	75	20

Measure Life and Incremental Measure Cost

The measure life is 2.5 years per DEER 2008. The IMC is $47 per DNV KEMA's research/experience.

Compact Fluorescent Lamps, Screw-in

Measure Description	This incentive applies to screw-in lamps and applies only if an incandescent or high-intensity discharge (HID) lamp is being replaced. All screw-in CFLs must be ENERGY STAR® rated. The lamp/ballast combination must have an efficacy ≥40 lumens per Watt (LPW). For screw-in CFLs, electronic ballasts are required for lamps ≥18 Watts.
Units	Per lamp
Base Case Description	Incandescent or HID lamps.

Measure Savings

The savings are presented in the following table. All wattage categories refer to retrofit wattage and not baseline wattage.

Table 57. Measure Savings for Screw-in CFL, per lamp

	≤15W		16-26W		27-40W	
Building Type	**kWh**	**Coincident peak kW**	**kWh**	**Coincident peak kW**	**kWh**	**Coincident peak kW**
Assembly	86.8	0.016	162.7	0.031	200.6	0.038
College/University	92.5	0.027	173.4	0.051	213.9	0.063
Conditioned Warehouse	97.4	0.024	182.6	0.044	225.3	0.055
Government/Municipal	101.7	0.022	190.6	0.041	235.1	0.050
Grocery	131.5	0.020	246.5	0.038	304.0	0.046
Hotel/Motel	225.6	0.008	423.1	0.015	521.8	0.019
Guest Rooms	32.4	0.008	60.7	0.015	74.8	0.019
Large Office	116.1	0.027	217.6	0.051	268.4	0.063
Large Retail/Service	142.7	0.030	267.6	0.056	330.1	0.069
Manufacturing – Light Industrial (1 shift)	104.4	0.030	195.8	0.055	241.4	0.068
Manufacturing – Light Industrial (2 shift)	172.9	0.030	324.1	0.055	399.7	0.068
Manufacturing – Light Industrial (3 shift)	242.3	0.030	454.4	0.055	560.4	0.068
Medical - Hospital	147.5	0.027	276.7	0.051	341.2	0.063

	≤15W		16-26W		27-40W	
Building Type	kWh	Coincident peak kW	kWh	Coincident peak kW	kWh	Coincident peak kW
Medical - Nursing Home	142.5	0.024	267.1	0.046	329.5	0.057
Miscellaneous	139.0	0.024	260.6	0.044	321.4	0.055
Restaurant	182.4	0.033	342.0	0.062	421.9	0.076
School	96.3	0.028	180.6	0.053	222.7	0.066
Small Office	122.3	0.029	229.3	0.054	282.8	0.067
Small Retail/Service	142.4	0.030	267.0	0.057	329.3	0.070
Unconditioned Warehouse	89.0	0.018	166.8	0.035	205.7	0.043
Garage (Ohio)	280.3	0.032	525.6	0.060	648.2	0.074
Exterior (Ohio)	137.6	0.000	258.0	0.000	318.2	0.000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are presented in the next table. Most lighting retrofits assume an early replacement of existing technologies where the baseline represents the equipment removed. The table shows the wattages used for the savings calculations.

Table 58. Baseline and Retrofit Wattages for Screw-in CFLs

Measure Name	Pre Measure Code	Pre Fixture Description	Watts/Fixture (PRE)	Post Measure Code	Post Fixture Description	Watts/Fixture (POST)
Interior CFL - Screw-in (15W or less)	I40/1	Incandescent, (1) 40W lamp	40	CF8/1-SCRW	CFL, (1) 8 W screw-in Lamp, any bulb shape	8
Interior CFL - Screw-in (16W to 26W)	I75/1	Incandescent, (1) 75W lamp	75	CF15/1-SCRW	CFL, (1) 15 W screw-in Lamp, any bulb shape	15
Interior CFL - Screw-in (27W to 40W)	I100/1	Incandescent, (1) 100W lamp	100	CF26/1-SCRW	CFL, (1) 26 W screw-in Lamp, any bulb shape	26

Measure Life and Incremental Measure Cost
The measure life is 2.5 years per DEER 2008. The IMC is $4.13 per AEP Ohio Potential Study.

Permanent Lamp Removal

Measure Description	Incentives are paid for the permanent removal of existing 8', 4', 3' and 2' fluorescent lamps. Unused lamps, lamp holders, and ballasts must be permanently removed from the fixture. This measure is applicable when retrofitting from T12 lamps to T8 lamps or simply removing lamps from a T8 fixture. Removing lamps from a T12 fixture that is not being retrofitted with T8 lamps are not eligible for this incentive.
Units	Per lamp
Base Case Description	T12 fluorescent fixtures before removal of lamps.

Incentives are paid for the removal of fluorescent lamps from existing fixtures. Permanent lamp removal is the net reduction in the total quantity of *lamps* after a project is completed, regardless of the number of fixtures. This measure is applicable when retrofitting from T12 lamps to T8 or T5 lamps or reconfiguring a T8 or T5 fixture to reduce the number of lamps. Removing lamps from a T12 fixture that is not being retrofitted with T8 or T5 lamps does not qualify for this credit.

Customers are responsible for determining whether or not to use reflectors in combination with lamp removal in order to maintain adequate lighting levels. Lighting levels are expected to meet the Illuminating Engineering Society of North America (IESNA) recommended light levels. Unused lamps, lamp holders, and ballasts must be permanently removed from the fixture and disposed of in accordance with local regulations. A pre-approval application is required for lamp removal projects.

Measure Savings
Savings are summarized by the following table.

Table 59. Measure Savings for T12 Lamp Removal, per lamp

	8-foot T12		4-foot T12		3-foot T12		2-foot T12	
Building Type	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**kW**
Assembly	187.1	0.035	108.4	0.020	100.3	0.019	69.1	0.013
College/University	196.5	0.066	113.9	0.038	105.4	0.035	72.6	0.024
Conditioned Warehouse	259.0	0.063	150.2	0.036	138.9	0.034	95.7	0.023
Government/Municipal	205.7	0.056	119.3	0.033	110.3	0.030	76.0	0.021
Grocery	362.8	0.061	210.3	0.035	194.5	0.033	134.1	0.022
Hotel/Motel	581.2	0.020	336.9	0.012	311.6	0.011	214.8	0.008
Guest Rooms	69.8	0.018	40.4	0.010	37.4	0.009	25.8	0.007
Large Office	208.3	0.067	120.8	0.039	111.7	0.036	77.0	0.025
Large Retail/Service	278.3	0.074	161.3	0.043	149.2	0.040	102.9	0.028

	8-foot T12		4-foot T12		3-foot T12		2-foot T12	
Building Type	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**kW**
Manufacturing – Light Industrial (1 shift)	223.7	0.076	129.7	0.044	120.0	0.041	82.7	0.028
Manufacturing – Light Industrial (2 shift)	370.4	0.076	214.7	0.044	198.6	0.041	136.9	0.028
Manufacturing – Light Industrial (3 shift)	519.3	0.076	301.0	0.044	278.5	0.041	191.9	0.028
Medical - Hospital	380.2	0.064	220.4	0.037	203.9	0.034	140.5	0.024
Medical - Nursing Home	374.2	0.066	216.9	0.039	200.7	0.036	138.3	0.025
Miscellaneous	323.7	0.059	187.7	0.034	173.6	0.032	119.6	0.022
Restaurant	396.7	0.073	230.0	0.042	212.7	0.039	146.6	0.027
School	190.4	0.062	110.4	0.036	102.1	0.033	70.4	0.023
Small Office	225.9	0.064	130.9	0.037	121.1	0.035	83.5	0.024
Small Retail/Service	275.4	0.079	159.7	0.046	147.7	0.042	101.8	0.029
Unconditioned Warehouse	237.4	0.048	137.6	0.028	127.3	0.026	87.7	0.018
Garage (Ohio)	604.4	0.069	350.4	0.040	324.1	0.037	223.4	0.026
Exterior (Ohio)	296.7	0.000	172.0	0.000	159.1	0.000	109.7	0.000

Table 60. Measure Savings for T8 Lamp Removal, per lamp

	8-foot T8		4-foot T8		3-foot T8		2-foot T8	
Building Type	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**kW**	**kWh**	**kW**
Assembly	187.1	0.035	108.4	0.020	62.4	0.012	44.7	0.008
College/University	155.2	0.052	84.0	0.028	65.5	0.022	47.0	0.016
Conditioned Warehouse	204.6	0.049	110.7	0.027	86.3	0.021	61.9	0.015
Government/Municipal	162.5	0.045	87.9	0.024	68.6	0.019	49.2	0.013
Grocery	286.5	0.048	155.1	0.026	120.9	0.020	86.7	0.015
Hotel/Motel	459.0	0.016	248.5	0.009	193.7	0.007	139.0	0.005
Guest Rooms	55.1	0.014	29.8	0.008	23.3	0.006	16.7	0.004
Large Office	164.6	0.053	89.1	0.029	69.4	0.022	49.8	0.016
Large Retail/Service	219.8	0.059	119.0	0.032	92.8	0.025	66.6	0.018
Manufacturing – Light Industrial (1 shift)	176.7	0.060	95.7	0.033	74.6	0.025	53.5	0.018
Manufacturing – Light Industrial (2 shift)	292.6	0.060	158.4	0.033	123.5	0.025	88.6	0.018
Manufacturing – Light Industrial (3 shift)	410.2	0.060	222.0	0.033	173.1	0.025	124.2	0.018
Medical - Hospital	300.3	0.051	162.6	0.027	126.7	0.021	90.9	0.015
Medical - Nursing Home	295.6	0.052	160.0	0.028	124.7	0.022	89.5	0.016
Miscellaneous	255.7	0.047	138.4	0.025	107.9	0.020	77.4	0.014
Restaurant	313.3	0.058	169.6	0.031	132.2	0.024	94.9	0.017

Building Type	8-foot T8		4-foot T8		3-foot T8		2-foot T8	
	kWh	kW	kWh	kW	kWh	kW	kWh	kW
School	150.4	0.049	81.4	0.026	63.5	0.021	45.5	0.015
Small Office	178.4	0.051	96.6	0.028	75.3	0.021	54.0	0.015
Small Retail/Service	217.5	0.063	117.7	0.034	91.8	0.026	65.9	0.019
Unconditioned Warehouse	187.5	0.038	101.5	0.021	79.1	0.016	56.8	0.012
Garage (Ohio)	477.4	0.055	258.4	0.030	201.5	0.023	144.5	0.017
Exterior (Ohio)	234.4	0.000	172.0	0.000	98.9	0.000	71.0	0.000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline equipment assumptions are listed in the table below. Each lamp type wattage reduction is converted to a per lamp basis for savings analysis. The retrofit wattage is assumed to be zero (post measure code, “removed”. This measure only considers the lamp removed. The lamp installed/retrofit is captured in another measure

Table 61. Baseline Wattages for T12 Lamp Removal

Lamp Removed	Pre Measure Code	Pre Fixture Description	Watts/Fixture (PRE)
8-ft T12	F82ES	Fluorescent, (2) 96", ES lamp	138
4-ft T12	F42ES	Fluorescent, (2) 48", ES lamp	80
3-ft T12	F32SE	Fluorescent, (2) 36", STD lamp	74
2-ft T12	F22SE	Fluorescent, (2) 24", STD lamp	51

Table 62. Baseline Wattages for T8 Lamp Removal

Lamp Removed	Pre Measure Code	Pre Fixture Description	Watts/Fixture (PRE)
8-ft T8	F82ILL	Fluorescent, (2) 96", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	109
4-ft T8	F42ILL	Fluorescent, (2) 48", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	59
3-ft T8	F32ILL	Fluorescent, (2) 36", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	46
2-ft T8	F22ILL	Fluorescent, (2) 24", T-8 lamp, Instant Start Ballast, NLO (BF: .85-.95)	33

Measure Life and Incremental Measure Cost

The measure life is 11 years per DEER 2005. The cost is $25 per lamp removed per a DNV KEMA assumption.

Occupancy Sensors

Measure Description	Passive infrared, ultrasonic detectors and fixture-integrated sensors or sensors with a combination thereof are eligible. All sensors must be hard-wired and control interior lighting fixtures. The incentive is per Watt controlled.
Units	Per Connected Watt
Base Case Description	No Sensor

Measure Savings

The following table summarizes the measure savings.

Table 63. Measure Savings for Occupancy Sensor per Connected Watt

Building Type	kWh	Coincident peak kW
Assembly	0.81	0.00015
College/University	0.85	0.00006
Conditioned Warehouse	1.13	0.00006
Government/Municipal	0.89	0.00006
Grocery	1.58	0.00006
Hotel/Motel	2.53	0.00007
Guest Rooms	0.30	0.00008
Large Office	0.91	0.00006
Large Retail/Service	1.21	0.00006
Manufacturing – Light Industrial (1 shift)	0.97	0.00005
Manufacturing – Light Industrial (2 shift)	1.61	0.00005
Manufacturing – Light Industrial (3 shift)	2.26	0.00005
Medical - Hospital	1.65	0.00005
Medical - Nursing Home	1.63	0.00006
Miscellaneous	1.41	0.00006
Restaurant	1.72	0.00006
School	0.83	0.00006
Small Office	0.98	0.00006
Small Retail/Service	1.20	0.00006

Building Type	kWh	Coincident peak kW
Unconditioned Warehouse	1.03	0.00005

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the Operating hours, energy, and demand factors outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are variable. Because we define this measure with the number of watts reduced, the non-coincident demand savings will be one watt by definition.

Energy savings are calculated by applying the annual operating hours and the energy interactive effect, according to the following formula:

*kWh Reduction = Connected wattage/1000 * Annual operating hours * Energy interactive effect*Energy Savings Factor*

Coincident demand savings are calculated by applying the coincidence factor and the demand interactive effect, according to the following formula:

*Coincident kW savings = Connected wattage/1000 * Energy Savings Factor * Coincidence Factor * Demand interactive effect*

The Ohio TRM defines the Energy Savings Factor for Occupancy Sensors as 30%. The Ohio TRM also defines the summer peak coincidence factor for occupancy sensors as 0.15.[16] The baseline for this measure is fixtures that do not include any automatic controls, i.e., manual switches. Since the unit is defined as per connected Watt, the baseline demand is one watt.

Measure Life and Incremental Measure Cost
The measure life is 8 years per DEER 2008. The IMC is $0.38 per Ohio TRM, if it is assumed that 4, 2-lamp T8 fixtures are controlled per sensor and one 4-lamp T5 high output for integrated fixture.

[16] Ohio TRM, Page 151

Daylighting Controls

Measure Description	This measure consists of the installation of daylighting controls in spaces with reasonable amounts of sunlight exposure and areas where task lighting is not critical.
Units	Per watt controlled
Base Case Description	No lighting controls

This measure consists of the installation of daylighting controls. These systems use photoelectric controls to take advantage of available daylight in interior building spaces. These controls can be used to turn lights off/on, A-B switching, or stepped or continuous dimming. The on/off controller should turn off artificial lighting when the interior illuminance meets the desired indoor lighting level. Daylight sensor controls are required to be commissioned in order to ensure proper sensor calibration and energy savings.

Measure Savings

The following table summarizes the measure savings.

Table 64. Measure Savings for Daylighting Controls per Watt Controlled

Building Type	kWh	Coincident peak kW
Assembly	0.81	0.00015
College/University	0.85	0.00034
Conditioned Warehouse	1.13	0.00035
Government/Municipal	0.89	0.00036
Grocery	1.58	0.00034
Hotel/Motel	2.53	0.00039
Guest Rooms	0.30	0.00008
Large Office	0.91	0.00037
Large Retail/Service	1.21	0.00036
Manufacturing – Light Industrial (1 shift)	0.97	0.00032
Manufacturing – Light Industrial (2 shift)	1.61	0.00032
Manufacturing – Light Industrial (3 shift)	2.26	0.00032
Medical - Hospital	1.65	0.00031
Medical - Nursing Home	1.63	0.00038
Miscellaneous	1.41	0.00034
Restaurant	1.72	0.00035

Building Type	kWh	Coincident peak kW
School	0.83	0.00038
Small Office	0.98	0.00036
Small Retail/Service	1.20	0.00035
Unconditioned Warehouse	1.03	0.00027

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the operating hours, energy, and demand factors outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are variable. Because we define this measure with the number of watts reduced, the non-coincident demand savings will be one watt by definition.

Energy savings are calculated by applying the annual operating hours and the energy interactive effect, according to the following formula:

*kWh Reduction = Connected wattage/1000 * Annual operating hours * Energy interactive effect*Energy Savings Factor*

Coincident demand savings are calculated by applying the coincidence factor and the demand interactive effect, according to the following formula:

*Coincident kW savings = Connected wattage/1000 * Energy Savings Factor * Coincidence Factor * Demand interactive effect*

The Ohio TRM defines the energy savings factor for daylighting as 30%. The Ohio TRM also defines the summer peak coincidence factor for occupancy sensors as 0.9[17] The baseline for this measure is fixtures that do not include any automatic controls, i.e., manual switches.

Measure Life and Incremental Measure Cost

The measure life is 8 years per DEER 2008. The IMC is $0.28 per the Ohio TRM, if it is assumed that 4, 2-lamp T8 fixtures are controlled per sensor (at $65 per sensor).

[17] Ohio TRM, Page 151

Daylighting Controls with Occupancy Sensors

Measure Description	This measure consists of the installation of both occupancy sensors daylighting controls to control the same fixture(s). These systems use photoelectric controls to take advantage of available daylight in interior building spaces, as well as occupancy controls to shut off the light when the ambient light from outdoors is low, and no one is using the space. These controls can be used to turn lights off/on, A-B switching, or stepped or continuous dimming. The on/off controller should turn off artificial lighting when the interior illuminance meets the desired indoor lighting level. Daylight sensor controls are required to be commissioned in order to ensure proper sensor calibration and energy savings.
Units	Per watt controlled
Base Case Description	No lighting controls

Measure Savings

The following table summarizes the measure savings.

Table 65. Measure Savings for Daylighting Controls with Occupancy Sensors per Watt Controlled

Building Type	kWh	Coincident peak kW
Assembly	0.87	0.00016
College/University	0.92	0.00036
Conditioned Warehouse	1.21	0.00038
Government/Municipal	0.96	0.00038
Grocery	1.69	0.00037
Hotel/Motel	2.71	0.00042
Guest Rooms	0.33	0.00008
Large Office	0.97	0.00039
Large Retail/Service	1.30	0.00039
Manufacturing – Light Industrial (1 shift)	1.04	0.00035
Manufacturing – Light Industrial (2 shift)	1.73	0.00035
Manufacturing – Light Industrial (3 shift)	2.42	0.00035
Medical - Hospital	1.77	0.00033
Medical - Nursing Home	1.75	0.00041
Miscellaneous	1.51	0.00037

Building Type	kWh	Coincident peak kW
Restaurant	1.85	0.00038
School	0.89	0.00040
Small Office	1.05	0.00039
Small Retail/Service	1.29	0.00038
Unconditioned Warehouse	1.11	0.00029

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the operating hours, energy, and demand factors outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Baseline and retrofit equipment assumptions are variable. Because we define this measure with the number of watts reduced, the non-coincident demand savings will be one watt by definition.

Energy savings are calculated by applying the annual operating hours and the energy interactive effect, according to the following formula:

*kWh Reduction = Connected wattage/1000 * Annual operating hours * Energy interactive effect*Energy Savings Factor*

Coincident demand savings are calculated by applying the coincidence factor and the demand interactive effect, according to the following formula:

*Coincident kW savings = Connected wattage/1000 * Energy Savings Factor * Coincidence Factor * Demand interactive effect*

The Ohio TRM defines the energy savings factor for daylighting as 30%, and from occupancy sensors as 30%. A model of a typical day in an office was created, to estimate how much of these savings might have overlapped, and the combined energy savings factor was calculated to be 0.322. The Ohio TRM also defines the summer peak coincidence factor for occupancy sensors as 0.9[18] The baseline for this measure is fixtures that do not include any automatic controls, i.e., manual switches. Since the unit is defined as per connected Watt, the baseline demand is one watt.

[18] Ohio TRM, Page 151

Measure Life and Incremental Measure Cost
The measure life is 8 years per DEER 2008. The IMC is $0.66 per Watt controlled based on DNV KEMA estimations informed by the Ohio TRM.

Bi-level Exterior or Garage Lighting Fixtures

Measure Description	The lighting system must have stepped-dimming occupancy controls that operates at full power and full light output when the space is occupied and at reduced power level and reduced light output (at least 50%) when unoccupied. The sensors must control exterior or parking garage lighting fixtures, must be hard-wired, and can be passive-infrared occupancy sensor or microwave occupancy sensor.
Units	Total Watts controlled of fixture at full light output
Base Case Description	Fixture at full level output

Measure Savings

Table 66. Measure Savings for Bi-level Exterior or Garage Lighting Fixtures

Building Type	kWh	Coincident peak kW
Garage (Ohio)	1.31	0.00014
Exterior (Ohio)	0.65	0.00000

Measure Savings Analysis
This measure assumes that the sensor would be able to dim down the bi-level fixture 50% at least 30% of the time. Operating hours for garage and exterior are from the lighting calculation section near the beginning of this document. Equations for the energy and demand savings are provided below:

Energy Savings = Watts Controlled x Operating Hours x 50% x 30% / 1000

Demand Savings = Watts Controlled x 50% x 30% x DIF x CF

Measure Life and Incremental Measure Cost
The measure life is 8 years per DEER 2005. The IMC is $0.19 per watt controlled based on DNV KEMA analysis.

Photocells

Measure Description	Installing photo cells on exterior lighting They switch outdoor lights on at dusk and off at dawn.
Units	Per Watt Controlled
Base Case Description	Existing controls are with time clock, only.

Photocells control lighting fixtures by sensing the amount of sunlight in the area and switching lights off when enough sunlight is present. The measure assumes that the existing exterior lights are controlled by a time clock and the measure retrofits those with a new photocell. Photo cells must control the on/off schedule of lighting equipment based upon the safety guidelines that determine the appropriate footcandle requirements for the area being controlled by photo cell.

Measure Savings
The coincident peak kW is 0 and kWh savings is 0.47 kWh/year per controlled wattage.

Measure Savings Analysis
Without, exterior lights are assumed to operate approximately 4,300 hours per year, based on approximately 12 hours per day. With a photocell, the lights would operate approximately 10.5 hours per day according to the Ohio TRM. The energy savings factor is calculated using the following expression:

ESF = (4300 – 3833) / 4300 = 0.109

Energy savings are calculated by applying the annual operating hours and the energy interactive factor, i.e. 1.0, according to the following formula:

*kWh Reduction = Connected wattage/1000 * ESF * EIF * 4300 = 0.47 kWh per watt controlled*

Coincident peak demand savings are zero, since the savings occur off peak.

Measure Life and Incremental Measure Cost
The measure life is 8 years per DEER 2008. The IMC is $0.18 per DEER 2005, if it is assumed that (4) 70W metal halide fixtures are controlled per sensor (at $60 per sensor).

Time Clocks for Lighting

Measure Description	Time clocks are an electrical device that control lighting equipment by turning the equipment on and off according to a set schedule. This measure applies to both internal and external lighting. These clocks can program lights to switch off during weekends, for example. The time clocks must be installed with a 3 hour battery pack so that schedule information will not be lost during any power outages. Astronomical time clocks (where on-off times are in accordance with sunrise and sunset) are required for outdoor lighting when photocells are not in use.
Units	Per Watt Controlled
Base Case Description	No control system

Measure Savings

Table 67. Measure Savings for TimeClock Lighting Controls per Watt Controlled

Building Type	kWh	Coincident peak kW
Assembly	0.271	0.00005
College/University	0.285	0.00011
Conditioned Warehouse	0.375	0.00012
Government/Municipal	0.298	0.00012
Grocery	0.526	0.00011
Hotel/Motel	0.842	0.00013
Guest Rooms	0.101	0.00003
Large Office	0.302	0.00012
Large Retail/Service	0.403	0.00012
Manufacturing – Light Industrial (1 shift)	0.324	0.00011
Manufacturing – Light Industrial (2 shift)	0.537	0.00011
Manufacturing – Light Industrial (3 shift)	0.753	0.00011
Medical - Hospital	0.551	0.00010
Medical - Nursing Home	0.542	0.00013
Miscellaneous	0.469	0.00011
Restaurant	0.575	0.00012
School	0.276	0.00013
Small Office	0.327	0.00012
Small Retail/Service	0.399	0.00012

Building Type	kWh	Coincident peak kW
Unconditioned Warehouse	0.344	0.00009
Garage (Ohio)	0.876	0.00009
Exterior (Ohio)	0.430	0.00009

Measure Savings Analysis
Energy savings are calculated by applying the annual operating hours, energy savings factor, and the energy interactive factor, according to the following formula:

*kWh Reduction = Connected wattage/1000 * Annual operating hours * Energy Savings Factor * Energy Interactive Factor*

Coincident demand savings are calculated by applying the coincidence factor and the demand interactive effect, according to the following formula:

*Coincident kW savings = Controlled wattage/1000 * Energy Savings Factor * Coincidence Factor * Demand interactive factor*

The Ohio TRM defines the energy savings factor for timeclocks is 10%. The Ohio TRM also defines the summer peak coincidence factor for occupancy sensors as 0.[19]

Measure Life and Incremental Measure Cost
The measure life is 8 years per DEER 2008. The IMC is $0.15 per the Ohio TRM, if it is assumed that 8, 70W metal halide fixtures are controlled per sensor (at $103 per sensor).

[19] Ohio TRM, Page 151

Photocells Plus Time Clocks for Lighting

Measure Description	Installing photocells and time clocks on exterior lighting. They switch outdoor lights on at dusk and off at dawn as well as on and off during periods of non-use typically 2am – 6am. See photocells and timeclocks for their specifications.
Units	Per Watt Controlled
Base Case Description	No control system

Measure Savings

Table 68. Measure Savings for Daylighting Controls per Connected Watt

Building Type	kWh	Coincident peak kW
Exterior (Ohio)	1.74	0

Measure Savings Analysis

It is assumed that the baseline is manual control, and adding a time clock will allow the customer to turn off their lights an additional 4 hours a night for 365 days/year, while the photocell saves 3 hours per day for 3 months, or 280 hours.

4 hours/day x 365 days/year x 1kW/1000W = 1.46 kWh/year
3 hours/day x 31 days x 3 months/year x 1kW/1000W=0.28 kWh/year.

1.46 kWh/year +0.28 kWh/year = 1.76 kWh/year.

Measure Life and Incremental Measure Cost

The measure life is 8 years per DEER 2008.

The IMC for photocell is $0.18 per DEER 2005, if it is assumed that (4) 70W metal halide fixtures are controlled per sensor (at $60 per sensor).

The IMC for timeclock is based on $103 per unit per the draft Ohio TRM. If a timeclock controls six 250W PS metal halide at 295W per fixture, then the cost is $0.06 per watt controlled.

Therefore, the combined incremental measure cost is $0.24 per watt controlled

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LED Traffic Signals

Measure Description	Signals shall have a maximum LED module wattage of 17. Credits are offered for LED traffic lights on a per-signal basis (including arrows) that replace or retrofit an existing incandescent traffic signal. At minimum, red and green lamps must be retrofitted to qualify for the signal credit. Lights must be hard-wired, with the exception of pedestrian hand signals. Credits are not available for spare lights.
Units	Per Signal
Base Case Description	Incandescent fixtures

LED traffic signals can save 80-90 percent of the energy typically consumed by incandescent traffic signals and LED signals generally last 5-10 times longer. Since traffic signals operate 24 hours a day, 365 days a year, the opportunity for energy savings is significant, particularly in the peak demand. LED Traffic signals perform better than incandescent models and are a better value. They also have lower maintenance costs because they need to be replaced less frequently.

Measure Savings

The energy savings vary for red, green and yellow signals. Savings also vary for round lamps, arrows and pedestrian signals (per the OH TRM).

Table 69. Measure Savings Traffic and Pedestrian Signals, per signal

Measure Name	kWh	Coincident Peak kW
Green 8 inch ROUND	226.0	0.026
Green 12 inch ROUND	519.8	0.059
Yellow 8 inch ROUND	10.3	0.001
Yellow 12 inch ROUND	24.0	0.003
Red 8 inch ROUND	298.7	0.034
Red 12 inch ROUND	693.8	0.079
Green 8 inch ARROW	76.4	0.011
Green 12 inch ARROW	76.4	0.011
Yellow 8 inch ARROW	76.4	0.002
Yellow 12 inch ARROW	75.0	0.002
Red 8 inch ARROW	76.4	0.098
Red 12 inch ARROW	76.4	0.098
Walk/Don't Walk - 9 inch	946.1	0.108
Walk/Don't Walk - 12 inch	946.1	0.108

Measure Savings Analysis
Operating hours, coincident factors, and baseline and refrofit wattages are from values found in the Ohio TRM (pg 187). Reference for savings for Red Turn Arrows do not appear in the Ohio TRM, so specifications for Green Turn Arrows are used.

Measure Life and Incremental Measure Cost
The measure life is assumed to be 6 for traffic and 8 years for pedestrian signals. The IMC is $90 and $140 for traffic and pedestrian signal, respectively. Data is from the Michigan Statewide database 2010.

New Construction – Lighting Power Density

Measure Description	This measure consists of lighting retrofits exceeding ASHRAE 90.1-2007 lighting power density (LPD) requirements by at least 10% (maximum 50%).
Units	Per kiloWatt Reduced
Base Case Description	ASHRAE 90.1 LPD - 2007

Measure Savings

The savings are presented in the following table.

Table 70. Lighting Power Density, per kW Reduced

Building Type	kWh	Coincident peak kW
Assembly	2.71	0.000512
College/University	2.85	0.000950
Conditioned Warehouse	3.75	0.000907
Government/Municipal	2.98	0.000817
Grocery	5.26	0.000881
Hotel/Motel	8.42	0.000297
Guest Rooms	1.01	0.000256
Large Office	3.02	0.000967
Large Retail/Service	4.03	0.001079
Manufacturing – Light Industrial (1 shift)	3.24	0.001103
Manufacturing – Light Industrial (2 shift)	5.37	0.001103
Manufacturing – Light Industrial (3 shift)	7.53	0.001103
Medical - Hospital	5.51	0.000932
Medical - Nursing Home	5.42	0.000963
Miscellaneous	4.69	0.000854
Restaurant	5.75	0.001056
School	2.76	0.000896
Small Office	3.27	0.000933
Small Retail/Service	3.99	0.001148
Unconditioned Warehouse	3.44	0.000700
Garage (Ohio)	8.76	0.001000
Exterior (Ohio)	4.30	0.000000

Measure Savings Analysis

Annual energy savings and the peak coincident demand savings are calculated using the equations outlined in the Savings Calculation Methodology section at the beginning of the Lighting section.

Measure Life

The measure life is 11 years per DEER 2005, assuming that most are linear fluorscent. The IMC is $1.10 similar to new T5/T8 fixture retrofits.

Cooling

Cooling measures are eligible for prescriptive incentives. Most savings values stated here apply to both retrofit and new construction cases. Control measures, however, are only applicable under new construction if they not required by code. For example, variable speed drives are required under some conditions and therefore can not claim savings under those conditions.

Measures under the Self Direct program can also use this set of workpapers, however, unit replacement measures, such as package units, heat pumps, chillers, room air conditioners, or package terminal air conditioners, will require a different baseline to comply with the Ohio PUC's order. Whereas building codes dictate the baseline for non-Self Direct replacement measures, the actual existing unit efficiency is used for the savings calculation in the Self Direct program. The savings calculation methodology, equivalent full load hours, and coincidence factors may be used for Self Direct claimed savings.

DEER building types are used in the savings analysis, however the categories are condensed for HVAC. Therefore, the program building types are grouped with the building types as shown below.

These building types do not map to the program building types. The attached workbook provides the details in the calculations to map the program building types to the two data sets.This document only provides savings numbers per program specifications.

Table 71. Program Building Type Mapping

AEP Ohio Building Types	Model Building Types
Assembly	Miscellaneous
Government/Municipal	Ave of Miscellaneous and Office
School	K-12 School
College/University	College/University
Grocery	Grocery
Health/Medical – Hospital	Medical
Health/Medical – Nursing Home	
Lodging – Hotel	Hotel/Motel
Lodging – Motel	
Lodging – Guest Room	
Manufacturing/Industrial (1 Shift)	Light and Heavy Industry
Manufacturing/Industrial (2 Shift)	
Manufacturing/Industrial (3 Shift)	
Office – Large	Office
Office – Small	
Restaurant	Restaurant
Retail –Large	Retail/Service
Retail – Small	
Storage – Conditioned	Warehouse
Storage – Unconditioned	No HVAC

Unitary or Split Air Conditioning Systems and Air Source Heat Pumps

Measure Description	New unitary air conditioning units or air source heat pumps that meet or exceed the qualifying cooling efficiency shown in the table below are eligible for an incentive. They can be either split systems or single package units. Efficiencies of split systems are based on ARI reference numbers. Water-cooled systems, evaporative coolers, and water source heat pumps do not qualify under this program but may qualify under the Custom Incentive Program. All unitary and split-system cooling equipment must meet Air Conditioning, Heating and Refrigeration Institute (AHRI) standards (210/240, 320 or 340/360), be UL listed, and utilize a minimum ozone-depleting refrigerant (e.g., HCFC or HFC). A manufacturer's specification sheet indicating the system efficiency must accompany the application. Disposal of the existing unit must comply with local codes and ordinances.
Units	Ton
Base Case Description	IECC 2009 Efficiency Level

The following table are the program qualifying efficiencies.

Table 72. Program Qualifying Efficiencies

Unit Size (tons)	Unit Size (Btuh)	Minimum Efficiency (Cooling Mode)
≤ 5.4 tons	< 65,000 Btuh	14 SEER
5.4 - 20 tons	≥ 65,000 Btuh and <240,000 Btuh	12 EER/13 IEER
20-63 tons	≥240,000 Btuh and <760,000 Btuh	10.6 EER/12.1 IEER
≥ 63 tons	≥ 760,000 Btuh	10.2 EER/11.4 IEER

Measure Savings

The coincident kW and the annual kWh savings per ton of installed cooling system are provided below. Note that coincident kW savings do not vary with building type while kWh savings do.

Table 73. Measure kWh Savings for Unitary or Split Air Conditioning Systems (per ton)

Business Type	5 or less	5 to 10	10 to 20	20 to 60	≥ 60
Assembly	40.43	43.95	69.55	38.15	35.54
College/University	49.08	53.37	62.03	40.76	37.97
Conditioned Warehouse	35.97	39.11	50.46	33.16	30.89

Government/Municipal	43.84	47.67	63.84	38.17	35.04
Grocery	87.79	95.46	110.13	72.37	67.41
Hotel/Motel	87.28	94.90	106.57	70.03	65.23
Large Office	47.26	51.38	58.13	38.20	34.53
Large Retail/Service	68.64	74.63	88.64	58.25	54.26
Manufacturing – Light Industrial (1 shift)	41.49	45.11	59.95	39.39	36.69
Manufacturing – Light Industrial (2 shift)	41.49	45.11	59.95	39.39	36.69
Manufacturing – Light Industrial (3 shift)	41.49	45.11	59.95	39.39	36.69
Medical - Hospital	128.74	161.38	132.63	87.16	81.18
Medical - Nursing Home	64.71	70.36	85.60	56.25	52.40
Miscellaneous	56.23	62.33	72.11	46.97	43.69
Restaurant	54.38	59.13	72.03	47.34	44.11
School	20.68	22.49	27.18	17.86	16.64
Small Office	35.06	38.12	47.46	31.20	29.07
Small Retail/Service	57.86	62.90	77.70	51.06	47.56
Unconditioned Warehouse	0	0	0	0	0

Table 74. Measure kW Savings for Unitary or Split Air Conditioning Systems (per ton)

Business Type	5 or less	5 to 10	10 to 20	20 to 60	≥ 60
Assembly	0.0663	0.0721	0.0959	0.0630	0.0587
College/University	0.0674	0.0733	0.0974	0.0640	0.0596
Conditioned Warehouse	0.0703	0.0764	0.1015	0.0667	0.0621
Government/Municipal	0.0684	0.0744	0.0989	0.0650	0.0605
Grocery	0.0684	0.0743	0.0988	0.0649	0.0604
Hotel/Motel	0.0701	0.0762	0.1013	0.0665	0.0620
Large Office	0.0705	0.0767	0.1019	0.0670	0.0624
Large Retail/Service	0.0691	0.0751	0.0998	0.0656	0.0611
Manufacturing – Light Industrial (1 shift)	0.0683	0.0743	0.0987	0.0649	0.0603
Manufacturing – Light Industrial (2 shift)	0.0683	0.0743	0.0987	0.0649	0.0603
Manufacturing – Light Industrial (3 shift)	0.0683	0.0743	0.0987	0.0649	0.0603
Medical - Hospital	0.0679	0.0851	0.0981	0.0644	0.0600
Medical - Nursing Home	0.0676	0.0735	0.0977	0.0642	0.0598
Miscellaneous	0.0681	0.0747	0.0984	0.0647	0.0602
Restaurant	0.0675	0.0734	0.0976	0.0641	0.0596
School	0.0656	0.0713	0.0948	0.0623	0.0580
Small Office	0.0686	0.0745	0.0992	0.0654	0.0609
Small Retail/Service	0.0684	0.0744	0.0988	0.0650	0.0605
Unconditioned Warehouse	0	0	0	0	0

Savings are also provided on a per unit efficiency (SEER or EER/ IEER) increment over the Qualifying Program efficiency. Units are per unit SEER/EER/IEER efficiency improvement per ton.

Table 75. Incremental kWh Measure Savings for Unitary or Split Air Conditioning Systems (per unit efficiency over Qualifying Efficiency per ton)

Business Type	5 or less	5 to 10	10 to 20	20 to 60	≥ 60
Assembly	40.43	54.94	69.55	63.58	71.08
College/University	49.08	66.71	62.03	67.94	75.94
Conditioned Warehouse	35.97	48.89	50.46	55.27	61.78
Government/Municipal	43.84	59.58	63.84	63.62	70.07
Grocery	87.79	119.32	110.13	120.61	134.82
Hotel/Motel	87.28	118.62	106.57	116.71	130.46
Large Office	47.26	64.23	58.13	63.66	69.07
Large Retail/Service	68.64	93.29	88.64	97.08	108.52
Manufacturing – Light Industrial (1 shift)	41.49	56.39	59.95	65.66	73.38
Manufacturing – Light Industrial (2 shift)	41.49	56.39	59.95	65.66	73.38
Manufacturing – Light Industrial (3 shift)	41.49	56.39	59.95	65.66	73.38
Medical - Hospital	128.74	201.72	132.63	145.26	162.37
Medical - Nursing Home	64.71	87.95	85.60	93.75	104.80
Miscellaneous	56.23	77.91	72.11	78.28	87.38
Restaurant	54.38	73.91	72.03	78.91	88.22
School	20.68	28.11	27.18	29.77	33.28
Small Office	35.06	47.66	47.46	52.00	58.13
Small Retail/Service	57.86	78.62	77.70	85.10	95.12
Unconditioned Warehouse	0	0	0	0	0

Table 76. Incremental Coincident kW Measure Savings for Unitary or Split Air Conditioning Systems (per unit efficiency over Qualifying Efficiency per ton)

Business Type	5 or less	5 to 10	10 to 20	20 to 60	≥ 60
Assembly	0.0663	0.0901	0.0959	0.1050	0.1174
College/University	0.0674	0.0916	0.0974	0.1067	0.1192
Conditioned Warehouse	0.0703	0.0955	0.1015	0.1112	0.1243
Government/Municipal	0.0684	0.0930	0.0989	0.1083	0.1211
Grocery	0.0684	0.0929	0.0988	0.1082	0.1209
Hotel/Motel	0.0701	0.0952	0.1013	0.1109	0.1240
Large Office	0.0705	0.0959	0.1019	0.1116	0.1248
Large Retail/Service	0.0691	0.0939	0.0998	0.1093	0.1222

Manufacturing – Light Industrial (1 shift)	0.0683	0.0928	0.0987	0.1081	0.1207
Manufacturing – Light Industrial (2 shift)	0.0683	0.0928	0.0987	0.1081	0.1207
Manufacturing – Light Industrial (3 shift)	0.0683	0.0928	0.0987	0.1081	0.1207
Medical - Hospital	0.0679	0.1064	0.0981	0.1074	0.1201
Medical - Nursing Home	0.0676	0.0919	0.0977	0.1070	0.1195
Miscellaneous	0.0681	0.0933	0.0984	0.1078	0.1204
Restaurant	0.0675	0.0918	0.0976	0.1069	0.1192
School	0.0656	0.0891	0.0948	0.1038	0.1161
Small Office	0.0686	0.0931	0.0992	0.1090	0.1217
Small Retail/Service	0.0684	0.0929	0.0988	0.1083	0.1211
Unconditioned Warehouse	0	0	0	0	0

Measure Savings Analysis

Savings values are determined for units with efficiency levels listed which exceed IECC 2009 efficiency levels which is the existing state of Ohio code.

Table 77. Demand Savings and Efficiency Assumptions

Size (Tons)	IECC 2006	IECC 2009	Program Qualifying	SEER or EER
≤ 5.4	13	13	14	SEER
5.4 – 11.25	10.1	11.2	12/13 IEER	EER, IEER
11.25 – 20	9.5	11	12/13 IEER	EER, IEER
20-63	9.5	10	10.6/12.1 IEER	EER, IEER
≥ 63	9.2	9.7	10.2/11.4 IEER	EER, IEER

Savings calculations were performed by utilizing DOE-2 models generated with eQUEST software. The models are the same used to generate California's DEER with modifications pertinent to Chicago, regarding climate zone and building construction, as outlined below. Our current assumption is that Chicago weather data (and building construction) is very similar that of Ohio.

1) Representative models for all building types were obtained from the group that developed DEER.

2) The climate zone was changed to Chicago, which is a feature added to the latest version of eQUEST (version 3.63). Previous versions of eQUEST only included California and Seattle climate zones.

3) Building shell characteristics and lighting power density were changed per ComEd's 2008-2010 Energy Efficiency and Demand Response Plan, Appendix B. The primary building shell characteristics that affect weather sensitive measures include insulation levels and window SHGC and U-value.

4) For each building type, a baseline model included the baseline EER or SEER for the HVAC units.

5) Retrofit cases were determined using the CEE Tier 2 EER or SEER for the HVAC units.

6) Savings was determined by subtracting the retrofit HVAC energy usage from the baseline usage. Similarly peak demand reductions were determined in the same fashion.

7) All units with capacities greater than or equal to 10 tons were assumed to be equipped with economizers for both the baseline and retrofit cases. Units smaller than 10 tons were assumed to not have economizers.

The savings values presented here are not direct outputs from eQuest. The results from eQuest used IECC 2006 baseline efficiency values. To calculate new savings values, we applied the ratio of efficiency improvements in both cases to the old savings values as described in the following equation.

$$Savings_{NEWBaseline} = \frac{\Delta Efficiency_{NEWBaseline}}{\Delta Efficiency_{OLDBaseline}} Savings_{OLDBaseline}$$

Incremental savings values are calculated by taking the difference between the program savings determined by eQuest at two different efficiency levels, and dividing those by the difference in efficiency levels.

$$Incrementa\ lSavings = \frac{\Delta Savings}{\Delta Efficiency}$$

The results from eQuest were mapped to the AEP building types as described below:

Table 78. Building Type Mapping From eQuest to AEP Ohio Building Types

Program Building Type	eQuest Building Type

Large Office	Large Office
Small Office	Small Office
School	High School, Primary School
Small Retail/Service	Small Retail
Large Retail/Service	Large 3 Story Retail, Large Retail
Hotel/Motel	Hotel
Medical – Hospital	Hospital
Medical - Nursing Home	Nursing Home
Restaurant	Fast Food, Full Service Restaurant
Grocery	Grocery
Conditioned Warehouse	Conditioned Storage
Unconditioned Warehouse	NA
Manufacturing – Light Industrial (1 shift)	Light Industry
Manufacturing – Light Industrial (2 shift)	Light Industry
Manufacturing – Light Industrial (3 shift)	Light Industry
College/University	University, Community College
Government/Municipal	Large Office, Assembly
Assembly	Assembly
Miscellaneous	Average of All

For AEP building types for which there are multiple eQuest building types are listed, a simple average of the results from those eQuest building types was taken.

Measure Life and Incremental Measure Cost
The measure life for packaged units is 15 years according to DEER 2005.

The next table provides incremental measure cost (IMC) documented for this measure. Incremental cost is cost difference between the energy-efficient equipment and the less efficient option.

Table 79. Package Units Incremental Measure Cost[20]

20 Survey of (3) packaged unit distributors who provide service in Illinois.

Measure	Minimum Qualifying	Delta 1.0 SEER/EER Improvement
65,000 Btuh or less	$113	$113
65,000 to 120,000 Btuh	$74	$92
120,000 to 240,000 Btuh	$53	$53
240,000 to 760,000 Btuh	$95	$158
760,000 Btuh or more	$104	$208

Water-cooled Chillers and Air-cooled Chillers

Measure Description	Chillers are eligible for an incentive if they have a rated kW/ton for the Integrated Part Load Value (IPLV) that is 90 percent of the IECC 2009 value. The chiller efficiency rating must be based on ARI Standard 550/590-2003 for IPLV conditions and not based on full-load conditions. The chillers must meet ARI standards 550/590-2003, be NRTL listed, and use a minimum ozone-depleting refrigerant (e.g., HCFC or HFC). The ARI net capacity value should be used to determine the chiller tons. A manufacturer's specification sheet with the rated kW/Ton-IPLV or COP-IPLV must accompany the application.
Units	Per Ton
Base Case Description	Chillers at IECC 2009 IPLV standards

Qualifying efficiencies for chillers are summarized below.

Table 80. Efficiency Levels for Chillers

Chiller Type	Size (tons)	IECC 2009 kW/ton- IPLV	Qualifying kW/ton- IPLV
Scroll or Helical-Rotary	< 75	0.63	0.57
	75 - 149	0.615	0.55
	150 - 299	0.58	0.52
	≥ 300	0.54	0.49
Centrifugal	< 150	0.596	0.54
	150 - 299	0.596	0.54
	300 - 599	0.549	0.49
	≥ 600	0.540	0.49
Reciprocating	< 75	0.63	0.57
	75 - 149	0.615	0.55

Chiller Type	Size (tons)	IECC 2009 kW/ton- IPLV	Qualifying kW/ton- IPLV
	150 - 300	0.58	0.52
	≥ 300	0.54	0.49
Air Cooled Chiller	< 150	0.96	0.86
	≥ 150	0.94	0.85

Measure Savings
The coincident kW and the annual kWh savings per ton of installed chiller are provided below.

Table 81. Measure kWh Savings for Chillers (per ton)

	Air Cooled			Centrifugal				Reciprocating				Scroll or Helical Rotary			
Building Type	**0-150**	**150-300**	**>300**	**0-150**	**150-300**	**300-600**	**>600**	**0-75**	**75-150**	**150-300**	**>300**	**0-75**	**75-150**	**150-300**	**>300**
Assembly	64.32	62.98	62.98	61.80	59.41	59.38	58.29	41.90	40.91	38.58	35.92	44.32	43.27	37.80	38.76
College/University	77.69	76.07	76.07	64.50	61.97	61.95	60.82	51.01	49.79	46.96	43.72	51.73	50.49	44.11	45.21
Conditioned Warehouse	54.00	54.04	55.48	41.07	41.47	44.55	43.73	39.52	38.58	33.72	31.90	37.10	36.22	32.39	34.05
Government/Municipal	59.96	58.71	58.71	51.48	49.46	49.41	48.51	39.30	38.36	36.18	33.68	41.36	40.38	35.28	36.19
Grocery	95.09	93.11	93.11	102.08	98.16	98.13	96.34	67.46	65.85	62.10	57.82	77.01	75.18	65.67	67.35
Hotel/Motel	108.53	106.27	106.27	93.05	89.39	89.30	87.67	73.46	71.71	67.63	62.97	74.51	72.73	63.52	65.11
Large Office	55.60	54.44	54.44	41.15	39.50	39.44	38.72	36.69	35.82	33.78	31.45	38.40	37.49	32.76	33.62
Large Retail/Service	74.07	73.30	76.08	56.43	55.86	62.40	61.26	71.63	69.93	45.50	43.48	51.16	49.94	44.20	51.34
Manufacturing – Light Industrial (1 shift)	47.66	56.16	56.16	38.43	50.11	50.08	49.17	31.71	30.96	31.61	29.43	33.13	32.34	31.24	32.03
Manufacturing – Light Industrial (2 shift)	47.66	56.16	56.16	38.43	50.11	50.08	49.17	31.71	30.96	31.61	29.43	33.13	32.34	31.24	32.03
Manufacturing – Light Industrial (3 shift)	47.66	56.16	56.16	38.43	50.11	50.08	49.17	31.71	30.96	31.61	29.43	33.13	32.34	31.24	32.03
Medical - Hospital	115.29	112.89	112.89	87.63	84.22	84.04	82.51	76.10	74.29	70.06	65.23	78.36	76.50	66.82	68.53
Medical - Nursing Home	94.54	92.57	92.57	74.91	72.04	72.00	70.69	60.60	59.15	55.79	51.94	61.46	60.00	52.40	53.73
Miscellaneous	72.38	71.55	71.94	62.07	60.68	61.52	60.40	50.58	49.38	44.28	41.38	50.07	48.88	42.96	45.59
Restaurant	79.18	77.53	77.53	79.62	76.53	76.48	75.09	51.47	50.25	47.39	44.12	54.48	53.18	46.46	47.63
School	39.42	38.60	38.60	34.45	33.10	33.04	32.44	26.03	25.41	23.97	22.32	27.32	26.67	23.30	23.90
Small Office	54.56	53.42	53.42	40.18	38.77	38.50	37.80	35.53	34.68	32.71	30.45	37.16	36.28	31.65	32.53
Small Retail/Service	72.54	71.03	71.03	66.88	64.30	64.27	63.10	47.18	46.06	43.44	40.44	50.43	49.23	43.00	58.82
Unconditioned Warehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 82. Measure kW Savings for Chillers (per ton)

	Air Cooled	Centrifugal	Reciprocating	Scroll or Helical Rotary

Building Type	0-150	150-300	>300	0-150	150-300	300-600	>600	0-75	75-150	150-300	>300	0-75	75-150	150-300	>300
Assembly	0.0804	0.0787	0.0787	0.0598	0.0576	0.0576	0.0566	0.0569	0.0555	0.0524	0.0488	0.0578	0.0564	0.0494	0.0507
College/University	0.0806	0.0790	0.0790	0.0555	0.0534	0.0534	0.0524	0.0538	0.0526	0.0496	0.0461	0.0563	0.0549	0.0481	0.0494
Conditioned Warehouse	0.0825	0.0796	0.0815	0.0617	0.1232	0.0620	0.0609	0.0619	0.0605	0.0563	0.0529	0.0630	0.0615	0.0538	0.0592
Government/Municipal	0.0862	0.0844	0.0844	0.0609	0.0586	0.0586	0.0575	0.0583	0.0569	0.0537	0.0500	0.0608	0.0593	0.0519	0.0533
Grocery	0.0863	0.0845	0.0845	0.0638	0.0614	0.0632	0.0620	0.0629	0.0614	0.0579	0.0539	0.0667	0.0651	0.0569	0.0585
Hotel/Motel	0.0868	0.0850	0.0850	0.0722	0.0695	0.0695	0.0682	0.0571	0.0557	0.0525	0.0489	0.0664	0.0648	0.0566	0.0581
Large Office	0.0921	0.0901	0.0901	0.0620	0.0596	0.0596	0.0585	0.0598	0.0583	0.0550	0.0512	0.0638	0.0622	0.0545	0.0560
Large Retail/Service	0.0843	0.0825	0.0825	0.0580	0.0558	0.0558	0.0548	0.0860	0.0839	0.0520	0.0484	0.0600	0.0586	0.0513	0.0569
Manufacturing – Light Industrial (1 shift)	0.0878	0.0890	0.0890	0.0615	0.0592	0.0592	0.0581	0.0593	0.0579	0.0546	0.0508	0.0634	0.0619	0.0541	0.0556
Manufacturing – Light Industrial (2 shift)	0.0878	0.0890	0.0890	0.0615	0.0592	0.0592	0.0581	0.0593	0.0579	0.0546	0.0508	0.0634	0.0619	0.0541	0.0556
Manufacturing – Light Industrial (3 shift)	0.0878	0.0890	0.0890	0.0615	0.0592	0.0592	0.0581	0.0593	0.0579	0.0546	0.0508	0.0634	0.0619	0.0541	0.0556
Medical - Hospital	0.0886	0.0868	0.0868	0.0567	0.0545	0.0546	0.0536	0.0568	0.0555	0.0523	0.0487	0.0623	0.0608	0.0532	0.0546
Medical - Nursing Home	0.0865	0.0847	0.0847	0.0634	0.0610	0.0610	0.0599	0.0582	0.0568	0.0536	0.0499	0.0644	0.0628	0.0549	0.0564
Miscellaneous	0.0844	0.0828	0.0829	0.0600	0.0613	0.0580	0.0569	0.0625	0.0610	0.0544	0.0507	0.0630	0.0615	0.0563	0.0552
Restaurant	0.0852	0.0835	0.0835	0.0603	0.0581	0.0579	0.0569	0.0607	0.0593	0.0559	0.0520	0.0757	0.0739	0.0528	0.0545
School	0.0772	0.0756	0.0756	0.0567	0.0545	0.0545	0.0535	0.0555	0.0542	0.0511	0.0476	0.0567	0.0554	0.0485	0.0498
Small Office	0.0936	0.0917	0.0917	0.0624	0.0601	0.0600	0.0589	0.0767	0.0749	0.0706	0.0657	0.0637	0.0622	0.0543	0.0558
Small Retail/Service	0.0806	0.0789	0.0789	0.0559	0.0538	0.0538	0.0528	0.0626	0.0611	0.0577	0.0537	0.0655	0.0639	0.1241	0.0673
Unconditioned Warehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Savings are also provided on a per unit efficiency improvement over the Qualifying Program efficiency. Units are per 0.01 kW/ton IPLV improvements.

Table 83. Incremental Measure kWhSavings for Chillers (per unit efficiency over Qualifying Efficiency per ton)

	Air Cooled			Centrifugal				Reciprocating				Scroll or Helical Rotary			
AEP Building Type	**0-150**	**150-300**	**>300**	**0-150**	**150-300**	**300-600**	**>600**	**0-75**	**75-150**	**150-300**	**>300**	**0-75**	**75-150**	**150-300**	**>300**
Assembly	7.31	7.31	7.31	8.88	9.96	9.01	9.01	6.67	6.67	6.67	6.67	7.06	7.06	7.63	6.00
College/University	8.83	8.83	8.83	9.26	10.39	9.39	9.39	8.12	8.12	8.12	8.12	8.24	8.24	8.90	7.00
Conditioned Warehouse	6.14	6.27	6.44	5.90	6.95	6.74	6.74	6.30	6.30	5.83	5.92	5.90	5.90	6.54	5.27
Government/Municipal	6.81	6.81	6.81	7.39	8.29	7.52	7.52	6.26	6.26	6.26	6.26	6.59	6.59	7.12	5.60
Grocery	10.81	10.81	10.81	14.67	16.47	14.89	14.89	10.74	10.74	10.74	10.74	12.27	12.27	13.25	10.42
Hotel/Motel	12.30	12.30	12.30	13.36	14.98	13.54	13.54	11.69	11.69	11.69	11.69	11.86	11.86	12.81	10.07
Large Office	6.32	6.32	6.32	5.91	6.62	6.03	6.03	5.84	5.84	5.84	5.84	6.12	6.12	6.62	5.21
Large Retail/Service	8.42	8.51	8.83	8.10	9.35	9.46	9.46	7.81	7.81	7.87	8.08	8.15	8.15	8.93	6.46
Manufacturing – Light	5.42	6.51	6.51	5.52	8.40	7.60	7.60	5.05	5.05	5.46	5.46	5.28	5.28	6.30	4.95

	Air Cooled			Centrifugal				Reciprocating				Scroll or Helical Rotary			
AEP Building Type	**0-150**	**150-300**	**>300**	**0-150**	**150-300**	**300-600**	**>600**	**0-75**	**75-150**	**150-300**	**>300**	**0-75**	**75-150**	**150-300**	**>300**
Industrial (1 shift)															
Manufacturing – Light Industrial (2 shift)	5.42	6.51	6.51	5.52	8.40	7.60	7.60	5.05	5.05	5.46	5.46	5.28	5.28	6.30	4.95
Manufacturing – Light Industrial (3 shift)	5.42	6.51	6.51	5.52	8.40	7.60	7.60	5.05	5.05	5.46	5.46	5.28	5.28	6.30	4.95
Medical - Hospital	13.10	13.10	13.10	12.59	14.10	12.74	12.74	12.11	12.11	12.11	12.11	12.48	12.48	13.49	10.61
Medical - Nursing Home	10.74	10.74	10.74	10.77	12.08	10.91	10.91	9.64	9.64	9.64	9.64	9.79	9.79	10.57	8.31
Miscellaneous	8.22	8.30	8.35	8.92	10.17	9.33	9.33	7.65	7.65	7.66	7.68	7.97	7.97	8.67	6.76
Restaurant	9.00	9.00	9.00	11.44	12.83	11.60	11.60	8.19	8.19	8.19	8.19	8.68	8.68	9.37	7.37
School	4.48	4.48	4.48	4.95	5.54	5.01	5.01	4.14	4.14	4.14	4.14	4.35	4.35	4.70	3.70
Small Office	6.20	6.20	6.20	5.79	6.46	5.86	5.86	5.66	5.66	5.66	5.66	5.92	5.92	6.40	5.04
Small Retail/Service	8.24	8.24	8.24	9.61	10.78	9.75	9.75	7.51	7.51	7.51	7.51	8.03	8.03	8.68	6.83
Unconditioned Warehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 84. Incremental Measure Coin-kWSavings for Chillers (per unit efficiency over Qualifying Efficiency per ton)

	Air Cooled			Centrifugal				Reciprocating				Scroll or Helical Rotary			
AEP Building Type	**0-150**	**150-300**	**>300**	**0-150**	**150-300**	**300-600**	**>600**	**0-75**	**75-150**	**150-300**	**>300**	**0-75**	**75-150**	**150-300**	**>300**
Assembly	0.0091	0.0091	0.0091	0.0086	0.0097	0.0087	0.0087	0.0091	0.0091	0.0091	0.0091	0.0092	0.0092	0.0100	0.0079
College/University	0.0092	0.0092	0.0092	0.0080	0.0090	0.0081	0.0081	0.0086	0.0086	0.0086	0.0086	0.0090	0.0090	0.0097	0.0077
Conditioned Warehouse	0.0094	0.0092	0.0095	0.0089	0.0088	0.0094	0.0094	0.0181	0.0181	0.0098	0.0098	0.0101	0.0101	0.0210	0.0208
Government/Municipal	0.0098	0.0098	0.0098	0.0088	0.0098	0.0089	0.0089	0.0093	0.0093	0.0093	0.0093	0.0097	0.0097	0.0105	0.0083
Grocery	0.0098	0.0098	0.0098	0.0092	0.0106	0.0093	0.0093	0.0100	0.0100	0.0100	0.0100	0.0106	0.0106	0.0115	0.0091
Hotel/Motel	0.0099	0.0099	0.0099	0.0104	0.0117	0.0105	0.0105	0.0091	0.0091	0.0091	0.0091	0.0106	0.0106	0.0114	0.0090
Large Office	0.0105	0.0105	0.0105	0.0089	0.0100	0.0090	0.0090	0.0095	0.0095	0.0095	0.0095	0.0102	0.0102	0.0110	0.0087
Large Retail/Service	0.0096	0.0096	0.0096	0.0083	0.0094	0.0119	0.0119	0.0090	0.0090	0.0090	0.0090	0.0096	0.0096	0.0104	0.0074
Manufacturing – Light Industrial (1 shift)	0.0100	0.0102	0.0102	0.0088	0.0099	0.0090	0.0090	0.0095	0.0095	0.0095	0.0095	0.0101	0.0101	0.0109	0.0086
Manufacturing – Light Industrial (2 shift)	0.0100	0.0102	0.0102	0.0088	0.0099	0.0090	0.0090	0.0095	0.0095	0.0095	0.0095	0.0101	0.0101	0.0109	0.0086
Manufacturing – Light Industrial (3 shift)	0.0100	0.0102	0.0102	0.0088	0.0099	0.0090	0.0090	0.0095	0.0095	0.0095	0.0095	0.0101	0.0101	0.0109	0.0086
Medical - Hospital	0.0101	0.0101	0.0101	0.0082	0.0092	0.0083	0.0083	0.0091	0.0091	0.0091	0.0091	0.0099	0.0099	0.0108	0.0085
Medical - Nursing Home	0.0098	0.0098	0.0098	0.0091	0.0102	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0103	0.0103	0.0111	0.0087
Miscellaneous	0.0096	0.0096	0.0096	0.0086	0.0096	0.0092	0.0092	0.0105	0.0105	0.0101	0.0101	0.0104	0.0104	0.0111	0.0089
Restaurant	0.0097	0.0097	0.0097	0.0087	0.0097	0.0088	0.0088	0.0116	0.0116	0.0116	0.0116	0.0099	0.0099	0.0108	0.0084
School	0.0088	0.0088	0.0088	0.0082	0.0092	0.0083	0.0083	0.0089	0.0089	0.0089	0.0089	0.0091	0.0091	0.0098	0.0077
Small Office	0.0106	0.0106	0.0106	0.0090	0.0101	0.0091	0.0091	0.0092	0.0092	0.0092	0.0092	0.0102	0.0102	0.0110	0.0086
Small Retail/Service	0.0092	0.0092	0.0092	0.0080	0.0090	0.0082	0.0082	0.0209	0.0209	0.0209	0.0209	0.0208	0.0208	0.0099	0.0078

Unconditioned Warehouse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Measure Savings Analysis

Savings values are determined for units with efficiency levels listed which exceed IECC 2009 efficiency levels which is the existing state of Ohio code.

Savings calculations were performed by utilizing DOE-2 models generated with eQUEST software. The models are the same used to generate California's DEER with modifications pertinent to Chicago, regarding climate zone and building construction, as outlined below. Our current assumption is that Chicago weather data (and building construction) is very similar that of Ohio.

The same calculation methodology used for "Unitary or Split Air Conditioning Systems and Air Source Heat Pumps" was used with the following additional assumptions:

1) Air handler units were assumed to be Variable Air Volume (VAV) systems with hot water reheat.
2) VAV units include economizers and supply temperature reset controls based on outside air.
3) Condenser water temperature was set to 75° F.
4) All chillers for pre and post cases were assumed to be constant speed.
5) All measure cases assumed the same type of chiller (screw, centrifugal, etc.) pre and post.

The savings values presented here are not direct outputs from eQuest. The results from eQuest used IECC 2006 baseline efficiency values. To calculate new savings values, we applied the ratio of efficiency improvements in both cases to the old savings values as described in the following equation.

$$Savings_{NEWBaseline} = \frac{\Delta Efficiency_{NEWBaseline}}{\Delta Efficiency_{OLDBaseline}} Savings_{OLDBaseline}$$

Incremental savings values are calculated by taking the difference between the program savings determined by eQuest at two different efficiency levels, and dividing those by the difference in efficiency levels.

$$Incrementa\ lSavings = \frac{\Delta Savings}{\Delta Efficiency}$$

The results from eQuest were mapped to the AEP OH building types as described below:

Table 85. Building Type Mapping From eQuest to AEP Ohio Building Types

Program Building Type	eQuest Building Type
Large Office	Large Office
Small Office	Small Office
School	High School, Primary School
Small Retail/Service	Small Retail
Large Retail/Service	Large 3 Story Retail, Large Retail
Hotel/Motel	Hotel
Medical - Hospital	Hospital
Medical - Nursing Home	Nursing Home
Restaurant	Fast Food, Full Service Restaurant
Grocery	Grocery
Conditioned Warehouse	Conditioned Storage
Unconditioned Warehouse	NA
Manufacturing – Light Industrial (1 shift)	Light Industry
Manufacturing – Light Industrial (2 shift)	Light Industry
Manufacturing – Light Industrial (3 shift)	Light Industry
College/University	University, Community College
Government/Municipal	Large Office, Assembly
Assembly	Assembly
Miscellaneous	Average of All

For AEP OH building types for which there are multiple eQuest building types are listed, a simple average of the results from those eQuest building types was taken.

Measure Life and Incremental Measure Cost

The measure life for packaged units is 20 years according to DEER[21].

The following table provides IMC documented for this measure. Incremental cost is the cost difference between the energy efficient equipment and the less efficient option. The costs are based on a regression analysis of the MEMD (Michigan database) data.

[21] 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report

Table 86. Chiller Incremental Measure Cost

Chiller Type	Chiller Size	Base IMC	Incremental IMC (per 0.01 kW/ton)
Air Cooled	0-150	$110.57	$11.52
	150-300	$107.05	$11.65
	>300	$107.05	$11.65
Centrifugal	0-150	$86.09	$18.27
	150-300	$147.19	$11.69
	300-600	$23.61	$4.85
	>600	$19.92	$5.46
Reciprocating	0-75	$76.75	$9.24
	75-150	$74.92	$9.24
	150-300	$70.65	$9.24
	>300	$65.78	$9.24
Scroll or Helical Rotary	0-75	$132.23	$10.05
	75-150	$129.08	$10.05
	150-300	$20.73	$24.17
	>300	$19.30	$4.28

Room Air Conditioners

Measure Description	Room air conditioning units are through-the-wall (or built-in), self-contained units that are 2 tons or less. This measure consists of the installation of a Room Air Conditioner that falls under Super Efficient Home Appliance (SEHA) Tier 1 standards. The minimum requirements and eligible equipment are listed CEE high-efficiency room air conditioning specifications (www.cee1.org)[22]. These units are with and without louvered sides, without reverse cycle (i.e., heating), and casements. Disposal of existing unit must comply with local codes and ordinances.
Units	Per Ton
Base Case Description	Federal standard baseline

The qualifying efficiencies for both levels are provided below.

[22] This website also has a list of eligible units.

Table 87. Qualifying Efficiencies[23]

Size (Btuh)	October 2000 Federal Standard (EER) Baseline	SEHA Tier 1 Retrofit (EER)
< 8,000	9.7	11.2
8000 to 13,999	9.8	11.3
14,000 to 19,999	9.7	11.2
>= 20,000	8.5	9.8

Measure Savings

Below are the coincident kW and the annual kWh savings per ton of installed cooling system.

Table 88. Room A/C kWh Savings (per ton)

Size (Btuh)	Demand Difference, kW	Annual Electric Savings, kWh	Peak Demand Reduction, kW
< 8,000	0.166	150.8	0.123
8000 to 13,999	0.163	147.9	0.120
14,000 to 19,999	0.166	150.8	0.123
>= 20,000	0.187	170.4	0.139
Average (11,400 Btuh)	**0.163**	**147.9**	**0.120**

Measure Savings Analysis

Savings values are calculated with the baseline efficiencies shown above, since efficiency levels depend on the size of the unit. The equivalent full load hours for Columbus is 910 and the coincident factor is 0.74 from the draft Ohio TRM page 192. The sizes, in BTUh used in the calculations are 4,000, 11,000, 17,000, and 20,500. The default savings for this measure were calculated at 11,400 BTUh, since that is the average sized unit according to the ENERGY STAR list of qualified products[24].

[23] These efficiency levels are for units with louvered sides, whereas units without louvered sides or casement-only or casement-slider tend to have lower efficiency thresholds.
[24] Average of 11,400 Btuh is calculated from the ENERGY STAR list of eligible products from December 2010.

The energy and demand savings are calculated using the following formulas, where size is in BTUh, EER is in BTUh/Watt, and EFLH are in hours:

Energy savings = Size x ($1/EER_{base}$ – $1/EER_{EE}$) x EFLH / 1000

Demand Savings = Size x ($1/EER_{base}$ – $1/EER_{EE}$) x CF

Measure Life and Incremental Measure Cost
The measure life is 12 years from the Ohio TRM.

The incremental measure cost for this measure is from the OH TRM at $80 for a CEE TIER 1 (or SEHA Tier 1) unit.

Package Terminal Air Conditioners/Heat Pumps

Measure Description	Package terminal air conditioners and heat pumps are through-the-wall self contained units that are 2 tons (24,000 Btuh) or less. Only units that have an EER greater than or equal to 13.08 – (0.2556 * Capacity in Btuh/ 1000), where capacity is in Btuh, qualify for the incentive. All EER values must be rated at 95 °F outdoor dry-bulb temperature.
Units	Per Ton
Base Case Description	IECC 2009 EER Efficiencies

Measure Savings
Below are the coincident kW and the annual kWh savings per ton of installed cooling system. The savings are based on efficiencies 20 percent higher than the IECC 2009 minimum efficiency. The peak demand savings is 0.177 kW/ton.

Table 89. Measure Savings for PTAC/HP (per ton)

Business Type	kWh
Assembly	147
College/University	179
Conditioned Warehouse	131
Grocery	320
Hospital	469
Hotel/Motel	318
Industrial/Manufacturing	151
Large Office	172
Large Retail	250
Nursing Home	236

Business Type	kWh
Restaurant	198
School	75
Small Office	128
Small Retail	211
Government/Municipal	160
Miscellaneous	209
Unconditioned Warehouse	0

Measure Savings Analysis
Savings values are calculated for qualifying PTAC/HPs with IECC 2009 efficiency standards as the baseline. Both qualifying efficiency levels and baseline efficiencies are based on the capacity of the unit, but, for purposes of calculating savings, we have assumed a baseline of 8.3 EER and a replacement efficiency of 10 EER on average, the efficiencies for a 12,000 Btuh (one ton) unit. The following table provides the efficiencies for a range of PTAC/HP sizes.

Table 90. PTAC/HP Efficiencies

PTAC size	IECC 2009	Qualifying EER
6000	9.6	11.5
7000	9.4	11.3
8000	9.2	11.0
9000	9.0	10.8
10000	8.8	10.5
11000	8.6	10.3
12000	8.3	10.0
13000	8.1	9.8
14000	7.9	9.5
15000	7.7	9.2
16000	7.5	9.0
17000	7.3	8.7
18000	7.1	8.5

The coincident factor assumed for this measure is 0.74 per the Ohio TRM. The EFLH values were derived from the eQuest models run for the Chicago weather, and are provided in the table below.

Table 91. PTAC EFLH by AEP OH Business Type

Business Type	5.4 or less
Assembly	613
College/University	744
Conditioned Warehouse	546
Grocery	1331

Hospital	1953
Hotel/Motel	1324
Industrial/Manufacturing	629
Large Office	717
Large Retail	1041
Nursing Home	981
Restaurant	825
School	314
Small Office	532
Small Retail	877
Government/Municipal	665
Miscellaneous	873
Unconditioned Warehouse	0

The coincident kW savings is calculated using the following equation:

kW Savings per ton = (12/Baseline EER – 12/Replacement EER) / 1,000

Coincident kW Savings = kW Savings x Coincidence Factor

kWh Savings per ton = kW Savings per ton x EFLH

Measure Life and Incremental Measure Cost
The measure life for packaged units is 15 years according to DEER[25]. The IMC documented for this measure is $84 per ton[26], which is the cost difference between the energy-efficient equipment and the less efficient option.

Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioners and Heat Pumps

Measure Description	New variable refrigerant flow (VRF) multi-split air conditioning or heat pump units that meet or exceed the qualifying cooling efficiencies are

[25] 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report
[26] 2008 DEER, www.deeresources.com

	eligible for an incentive. Water-cooled systems and water source heat pumps do not qualify under this program but may qualify under the Custom Incentive Program. A manufacturer's specification sheet indicating the system efficiency must accompany the application. Disposal of the existing unit must comply with local codes and ordinances.
Units	Ton
Base Case Description	ASHRAE 90.1-2010 Minimum Standard for VRF Multi-Split System Air Conditioners

New variable refrigerant flow (VRF) multi-split air conditioning or heat pump units for new construction, replace-on-burnout, or replacement that meet or exceed the qualifying cooling efficiencies are eligible for an incentive. Only annual cooling savings and cooling demand savings are presented in this section; heating savings from efficient heat pumps are not documented. These multi-split systems are defined as having a single refrigerant circuit, with one or more outdoor condensing units, at least one variable speed compressor or an alternative compressor combination for varying the capacity of the system by three or more stages, multiple indoor fan coil units, each of which is individually (refrigerant) metered and individually controlled by an integral control device and common communications network. All VRF multi-split air conditioning or heat pump units must meet Air Conditioning, Heating and Refrigeration Institute (AHRI) standards (1230), be UL listed, and utilize a minimum ozone-depleting refrigerant (e.g., HCFC or HFC).

Table 92. Program Qualifying Efficiencies (Cooling Mode)

Unit Size (tons)	Unit Size (Btuh)	Minimum EER
≤ 5.4 tons	< 65,000 Btuh	14 SEER
5.4 – 11.25 tons	≥ 65,000 Btuh and <135,000 Btuh	12 EER
11.25 - 20 tons	≥ 135,000 Btuh and <240,000 Btuh	12 EER
≥ 20 tons	≥240,000 Btuh	10.8 EER

Measure Savings

The coincident kW and the annual kWh savings per ton of installed cooling system are provided below. Note that coincident kW savings do not vary with building type while kWh savings do.

Table 93. Measure kWh Savings for VRF Multi-Split Air Conditioners (per ton)

Business Type	5.4 or less	5.4 to 11.25	11.25 to 20	More than 20
Assembly	134.0	89.4	78.3	80.4
College/University	107.7	71.8	74.1	76.1
Conditioned Warehouse	91.1	60.7	58.2	59.7
Grocery	222.2	148.2	56.3	103.1
Hospital	566.8	378.0	137.0	140.7
Hotel/Motel	334.9	223.3	114.2	117.2
Industrial/Manufacturing	89.7	59.8	46.8	48.0
Large Office	137.7	91.9	53.9	55.4
Large Retail	184.5	123.0	87.0	89.3
Nursing Home	277.1	184.8	127.1	130.6
Restaurant	249.5	166.4	88.2	90.5
School	116.2	77.5	39.2	40.2
Small Office	90.6	60.4	48.6	49.9
Small Retail	135.8	90.5	71.2	73.1
Government/Municipal	135.9	90.6	66.1	67.9
Miscellaneous	191.6	127.8	76.4	81.5
Unconditioned Warehouse	0.0	0.0	0.0	0.0

Table 94. Measure kW Savings for VRF Multi-Split Air Conditioners (per ton)

Size (Tons)	Coincident Demand kW
≤ 5.4	0.049
5.4 – 11.25	0.053
11.25 – 20	0.067
≥ 20	0.066

Savings are also provided on a per unit efficiency (SEER or EER) increment over the Qualifying Program efficiency. Units are per unit SEER/EER efficiency improvement per ton.

Table 95. Incremental kWh Measure Savings for VRF Multi-Split Air Conditioners (per unit efficiency over Qualifying Efficiency per ton)

Business Type	5.4 or less	5.4 to 11.25	11.25 to 20	More than 20
Assembly	116.2	132.1	115.5	141.7
College/University	93.4	106.2	109.4	134.2
Conditioned Warehouse	78.9	89.7	85.8	105.3

Grocery	192.6	218.9	83.0	181.7
Hospital	491.2	558.5	202.0	247.9
Hotel/Motel	290.2	330.0	168.4	206.6
Industrial/Manufacturing	77.8	88.4	69.0	84.6
Large Office	119.4	135.7	79.5	97.5
Large Retail	159.9	181.8	128.3	157.4
Nursing Home	240.1	273.0	187.5	230.0
Restaurant	216.2	245.8	130.0	159.5
School	100.7	114.5	57.8	70.9
Small Office	78.5	89.3	71.6	87.8
Small Retail	117.7	133.8	104.9	128.7
Government/Municipal	117.8	133.9	97.5	119.6
Miscellaneous	166.0	188.8	112.7	143.6
Unconditioned Warehouse	0.0	0.0	0.0	0.0

Table 96. Incremental Coincident kW Measure Savings for VRF Multi-Split Air Conditioners (per unit efficiency over Qualifying Efficiency per ton)

Size (Tons)	Coincident kW savings
≤ 5.4	0.042
5.4 – 11.25	0.057
11.25 – 20	0.057
≥ 20	0.070

Measure Savings Analysis

HVAC (S)EER and IEER values used in the analysis are provided in the table below. Units that are sized 5.4 tons or less only have SEER value requirements. The base efficiencies for all unit size ranges are those that are currently in effect under ASHRAE 90.1-2010 standards.

Table 97. Demand Savings and Efficiency Assumptions

Size (Tons)	Base (S)EER	Base IEER	Efficient (S)EER	Efficient IEER	SEER or EER
≤ 5.4	13	-	14	-	SEER
5.4 – 11.25	11.2	12.5	12.0	13.1	EER
11.25 – 20	11.0	12.3	12.0	12.9	EER
≥ 20	10.0	11.1	10.8	11.6	EER

Savings calculations were performed by utilizing DOE-2 models generated with eQUEST software. The models are the same used to generate California's DEER with modifications pertinent to Chicago, regarding climate zone and building construction, as outlined below. Our current assumption is that Chicago weather data (and building construction) is very similar to that of Ohio.

1) Representative models for all building types were obtained from the group that developed DEER.
2) The climate zone was changed to Chicago, which is a feature added to the latest version of eQUEST (version 3.63). Previous versions of eQUEST only included California and Seattle climate zones.
3) Building shell characteristics and lighting power density were changed per ComEd's 2008-2010 Energy Efficiency and Demand Response Plan, Appendix B. The primary building shell characteristics that affect weather sensitive measures include insulation levels and window SHGC and U-value.
4) For each building type, a baseline model included the baseline EER or SEER for the HVAC units. Note that unitary AC systems of equivalent efficiencies were used in the models.
5) Retrofit cases were determined using the Tier 2 EER or SEER for the HVAC units.
6) Savings were determined by looking up the total annual building load cooling hours (The SS-E report in the model's accompanying SIM report file) and using both the annual cooling hours and the difference between base and efficient case IEER values (SEER for units 5.4 tons or less) to compute annual energy saved in kWh. Non-coincident demand savings were calculated by using the difference in base and efficient case EER/SEER values.

The peak demand savings is based on the Ohio TRM coincident factor value of 0.74. Since the coincident factor is constant for all building types, coincident kW savings do not vary with building type. The savings calculations are:

Non-coincident demand reduction = 12 x [1/baseline efficiency (EER/SEER) – 1/retrofit efficiency (EER/SEER)] / 1000

kWh savings = 12 x [1/baseline efficiency (IEER) – 1/retrofit efficiency (IEER)] x Annual Cooling Hours (SS-E report from e-Quest SIM report)

Peak kW savings = non-coincident demand reduction x coincident factor (0.74)

The following table summarizes the annual cooling hours by building type.

Table 98. Package Air Conditioner EFLCH

Business Type	5.4 or less	5.4 to 11.25	11.25 to 20	More than 20
Assembly	2033	2033	1726	1726
College/University	1634	1634	1634	1634
Conditioned Warehouse	1381	1381	1282	1282
Grocery	3370	3370	1240	2213
Hospital	8596	8596	3019	3019
Hotel/Motel	5079	5079	2516	2516
Industrial/Manufacturing	1361	1361	1031	1031
Large Office	2089	2089	1188	1188
Large Retail	2798	2798	1917	1917
Nursing Home	4202	4202	2802	2802
Restaurant	3784	3784	1943	1943
School	1762	1762	863	863
Small Office	1374	1374	1070	1070
Small Retail	2059	2059	1568	1568
Government/Municipal	2061	2061	1457	1457
Miscellaneous	2906	2906	1684	1749
Unconditioned Warehouse	0	0	0	0

Measure kWh savings are calculated by using EFLH values for each building. Incremental savings values are calculated by taking the difference between the qualifying program efficiencies and the incremental case where the unit efficiency has been increased by 1.0 SEER/EER. The non-coincident demand reduction for the incremental savings are calculated as follows:

Non-coincident demand reduction = 12 x (1/baseline efficiency – 1/(retrofit efficiency+1))

Measure Life and Incremental Measure Cost
The measure life for packaged units is 15 years according to DEER 2005.

The next table provides incremental measure cost (IMC) documented for this measure. Incremental cost is cost difference between the energy-efficient equipment and the less efficient option.

Table 99. VRF Incremental Measure Cost[27]

Size	IMC
5.4 or less	$132
5.4 to 11.25	$74
11.25 to 20	$53
More than 20	$100

[27] Survey of (3) packaged unit distributors who provide service in Illinois

Lodging – Hotel Guest Room Energy Management System (GREM)

Measure Description	GREM is a multi-purpose Direct Digital Control (DDC) device designed to control HVAC unit in hotel guestrooms. Incentives are available for sensors that control HVAC units for individual hotel rooms. Key cards that indicate occupancy also qualify. Sensors controlled by a front desk system are not eligible. Guest room temperature set point or the on/off cycle of the HVAC unit must be controlled by an automatic occupancy sensor or key-card system that indicates the occupancy status of the room. During unoccupied periods the default setting for controlled units must differ from the operating set point by at least 5 degrees (or shut the unit fan and heating or cooling off completely). The control system may also be tied into other electric loads, such as lighting and plug loads to shut them off when occupancy is not sensed. The incentive is per guestroom controlled, rather than per sensor, for multi-room suites. Replacement or upgrades of existing occupancy-based controls are not eligible for an incentive.
Units	Per room HVAC controller
Base Case Description	Manual Heating/Cooling Temperature Setpoint and Fan On/Off/Auto Thermostat

The savings are achieved based on GREM's ability to automatically adjust the guest room's set temperatures or reduce the cycle time of the HVAC unit for various occupancy modes.

Measure Savings
The annual kWh savings per HVAC unit controlled are summarized in the following table for different sizes and types of HVAC units. The savings are achieved based on GREM's ability to automatically adjust the guest room's set temperatures and control the HVAC unit to maintain set temperatures under occupied or unoccupied modes of operation.

Key operating assumptions are summarized in the discussion below. These values are from the Michigan savings database using Michigan's 574 annual CDD and 6,676 annual HDD, which are comparable to 925 CDD and 5,546 HDD in Columbus[28].

[28] http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmcdd.html, http://www.ncdc.noaa.gov/oa/climate/online/ccd/nrmhdd.html

Table 100. Measure Savings for GREM

Cooling Type	Cooling kWh		Heating (kWh & Therms)		Total kWh	
	3/4 ton	1 ton	3/4 ton	1 ton	3/4 ton	1 ton
PTAC	208	287	1,234 kWh	1,645 kWh	1,441	1,932
PTHP	181	263	721 kWh	988 kWh	902	1,251
FCU with Gas Heat/Elec Cool	407	542	53 Therms	70 Therms	407	542

On average, the annual kWh saving for a 0.75 ton and 1 ton HVAC unit with electric cooling and electric heating is 1,117 kWh per room. For non-electric heating, it is assumed the savings are approximately one third at 334 kWh per room. The average between 0.75 and 1 tons is used for a conservative estimate. However, it is assumed that most PTAC units in hotel rooms are sized to 1 ton.

Measure Savings Analysis

The coincident kW impacts for this measure have not been sufficiently studied or modeled to provide a confident estimate. In the meantime the following kW impacts are estimated for systems that control cooling operation.

kW Savings per ton = (12/HVAC EER) x average on peak uncontrolled load factor of 50% (estimated from anecdotal observations by DNV KEMA) x estimated cycling reduction of 30% (estimated by DNV KEMA from empirical observations and logging from manufacturers for NV Energy).

$$kW = (12/8.344) \times 0.5 \times 0.3 = 0.215 \text{ kW per one-ton unit}$$

where,

HVAC EER = is based on a 1 ton unit at code baseline efficiency of PTAC, defined as EER = 10.9 – (0.213 x 12000 btu/hr/1000) = 8.344

It is estimated as 0.74 as the coincident factor to be consistent with the other HVAC measures.

Coincident kW Savings = 0.215 x 0.74 = 0.159 kW per one-ton unit.

Measure Life and Incremental Measure Cost

The measure life for GREM is 15 years according to CA DEER 2008 value for energy management systems. Cost is $260 based on review of projects in the midwest.

Variable Speed Drive on HVAC Chillers

Measure Description	Variable-speed drives (VSDs) which are installed on existing chillers are eligible for this incentive. New chillers with integrated VSDs are eligible under the chiller incentive. The installation of a VSD must accompany the permanent removal or disabling of any throttling devices. VSDs for non-HVAC applications may be eligible for a custom incentive.
Units	Per HP
Base Case Description	No VSD installed.

Measure Savings

Provided below are the coincident kW savings and the annual kWh savings per hp of installed motor. The coincident kW savings are the same across all building and application types. The annual kWh savings are dependent on building type and application type. Peak kW savings is assumed to be 0.025 kW per HP.

Table 101. Energy Savings VSD for Chillers (Per HP)

Business Type	kWh Savings
Assembly	145.4
College/University	182.9
Conditioned Warehouse	142.3
Government/Municipal	132.6
Grocery	153.5
Hotel/Motel	280.2
Large Office	119.9
Large Retail/Service	172.0
Manufacturing – Light Industrial	115.9
Medical - Hospital	385.5
Medical - Nursing Home	307.8
Miscellaneous	179.2
Restaurant	190.4
School	104.4
Small Office	121.9
Small Retail/Service	154.5
Unconditioned Warehouse	0

Measure Savings Analysis

Savings values are calculated with an estimate of a 19 percent savings[29]. The motors are assumed to have a load factor of 80 percent and an efficiency of 92.5 percent for calculating the equipment kW.

kW reduction = 0.19 x (kW of existing equipment)

Where kW of equipment is calculated using:

$$\frac{(\text{Motor HP})\times(0.746\ \text{kW/HP})\times(\text{Load Factor})}{\text{Motor Efficiency}}.$$

The coincident kW savings are calculated using the following equation. The coincidence factor is assumed to be 0.20.

Coincident kW reduction = kW reduction x coincidence factor

Annual energy savings values were calculated based on run hours for each building type as modeled in our chillers section. Here run hours were obtained from building simulation runs for 150-300 ton centrifugal chillers at baseline efficiencies.

Annual kWh Savings = kW Savings x Run Hours

Table 102. Chiller Annual Operating Hours

Business Type	Hours
Assembly	1186
College/University	1491
Conditioned Warehouse	1160
Government/Municipal	1081
Grocery	1252
Hotel/Motel	2285
Large Office	977
Large Retail/Service	1403
Manufacturing – Light Industrial (1 shift)	945
Medical - Hospital	3145
Medical - Nursing Home	2510

[29] This percentage is a conservative estimate. DEER 2005 on average calculated over 30% savings for installing a VSD for various motor application types.

Business Type	Hours
Miscellaneous	1462
Restaurant	1553
School	851
Small Office	994
Small Retail/Service	1260

Measure Life and Incremental Measure Cost
The measure life for packaged units is 15 years according to DEER[30].

The IMC documented for this measure is $90 per horsepower for chiller applications[31].

Commercial Kitchen Demand Ventilation Controls

Measure Description	The measure consists of installing a control system that varies the exhaust rate of kitchen ventilation (exhaust and/or makeup air fans) based on the energy and effluent output from the cooking appliances (i.e., the more heat and smoke/vapors generated, the more ventilation needed). This involves installing a temperature sensor in the hood exhaust collar and/or an optic sensor on the end of the hood that sense cooking conditions which allows the system to automatically vary the rate of exhaust to what is needed by adjusting the fan speed accordingly. A VSD must be installed on the exhaust fan, and if applicable, on the make-up air unit.
Units	Per exhaust fan horsepower
Base Case Description	Exhaust and makeup fans that operate at 100% speed

Measure Savings
The savings for this measure is 0.76 kW and 4,486 kWh per exhaust fan horsepower.

Measure Savings Analysis
Annual energy use was based on monitoring results from five different types of sites, as summarized in PG&E Food Service Equipment workpaper[32].

[30] 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report
[31] 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report from assessment of several measures that include a VSD retrofit.
[32] Demand Ventilation Controls PGECOFST116 R1 slb4 090517.doc

Measure Life and Incremental Measure Cost

The measure life is assumed to be the same as that of variable speed drives at 15 years. The incremental cost is cost difference between the energy-efficient equipment and the less efficient option. In the retrofit case, the IMC is equal to the full measure cost since cost of the less efficient option is $0. The cost for the new system is the incremental (difference in) cost of installing ventilation with and without controls. The cost is $1988 for a retrofit system and $1,000 for a new system per the PG&E workpapers.

Toilet Exhaust Occupancy Sensor

Measure Description	This measure is the installation of occupancy sensors on toilet exhaust fans between 0.6 and 2.0 amps.
Units	Per exhaust fan
Base Case Description	Exhaust fan with manual control tied to wall mounted light switch.

Measure Savings

The following table summarizes the measure savings.

Table 103. Measure Savings for Toilet Exhaust Fan Occupancy Sensor per Exhaust Fan

Building Type	kWh Savings	kW Savings
Large Office	127	0.0407
Small Office	138	0.0391
School	116	0.0376
Small Retail/Service	168	0.0486
Large Retail/Service	170	0.0453
Hotel/Motel and Guest Rooms	355	0.0128
Medical - Hospital	262	0.0408
Medical - Nursing Home	214	0.0447
Restaurant	219	0.0371
Grocery	225	0.0382
Conditioned Warehouse	145	0.0295
Unconditioned Warehouse	165	0.0463
Manufacturing – Light Industrial (1 shift)	137	0.0463

Manufacturing – Light Industrial (2 shift)	226	0.0463
Manufacturing – Light Industrial (3 shift)	315	0.0399
College/University	124	0.0344
Government/Municipal	129	0.0284
Assembly	120	0.0380
Miscellaneous	160	0.0421
Garage (Ohio)	369	0.0000
Exterior (Ohio)	181	0.0000

Measure Savings Analysis
Annual energy savings and the peak coincident demand savings are calculated using the Operating hours, energy, and demand factors outlined in the Savings Calculation Methodology section at the beginning of the Lighting section. Based on a survey of the Grainger website, the typical amperage draw of toilet exhaust fans ranged from 0.6 to 2.0 amps[33]. A median value of 1.3 amps was used to determine the power draw on a typical 120 volt toilet exhaust fan. Assuming a power factor of 0.90, the connected wattage per exhaust fan would be 1.3 Amps x 120 Volts x x 0.90 = 140.4 Watts controlled.

Energy savings are calculated by applying the annual operating hours and the energy interactive effect, according to the following formula:

*kWh Reduction = Connected wattage/1000 * Annual operating hours * Energy interactive effect*Energy Savings Factor*

Coincident demand savings are calculated by applying the coincidence factor and the demand interactive effect, according to the following formula:

*Coincident kW savings = Connected wattage/1000 * Energy Savings Factor * Coincidence Factor * Demand interactive effect*

The Ohio TRM defines the Energy Savings Factor for Occupancy Sensors as 30%. The Ohio TRM also defines the summer peak coincidence factor for occupancy sensors as 0.15.[34] The

[33] http://www.grainger.com/Grainger/BROAN-Bathroom-Fan-Finish-kit-2HYB1?Pid=search
[34] Ohio TRM, Page 151

baseline for this measure is fixtures that do not include any automatic controls, i.e., manual switches.

Measure Life and Incremental Measure Cost

The incremental cost is assumed to $42, which is the cost of a wall mounted occupancy sensor per the Ohio TRM. The expected measure life for the toilet exhaust control is assumed to be the same as for lighting occupancy sensors, which is 8 years.

Window Film

Measure Description	This measure applies to window film installed to reduce the solar gain through the affected window. Windows with a northern exposure (+/- 45° of true north) are not eligible. Film must meet one of the following requirements: • For clear, single-pane glass, the solar heat gain coefficient (SHGC) of the window film must be less than 0.39. • For clear, double paned glass, the SHGC of the window film must be less than 0.25. • For applications that don't meet either of the previous requirements, the film must have a SHGC ≤ 0.47 and visible transmittance/solar heat gain coefficient (VT/SHGC) ratio 1.3.
Units	Per square foot of non-north facing window
Base Case Description	Double paned clear glass windows without any window film, with a U-value of 0.72, and a SHGC of 0.73.

Measure Savings
The average default savings for this measure is 0.12 kW and 274 kWh per square foot of non-north facing window. Savings by building type as provided by the draft Ohio TRM for the Columbus area are provided in the table below.

Table 104. Energy Savings for Window Film

Building Type	TRM Building Type Mapping	ΔkWh_{100SF}	ΔkW_{100SF}
Large Office	Small Office	271	0.12
Small Office	Small Office	271	0.12
School	Primary School	352	0.17
Small Retail/Service	Small Retail	277	0.14

Building Type	TRM Building Type Mapping	ΔkWh_{100SF}	ΔkW_{100SF}
Large Retail/Service	Big Box Retail	304	0.12
Hotel/Motel and Guest Rooms	Average/Miscellaneous	274	0.12
Medical – Hospital	Average/Miscellaneous	274	0.12
Medical - Nursing Home	Average/Miscellaneous	274	0.12
Restaurant	Full Service Restaurant	255	0.17
Grocery	Average/Miscellaneous	274	0.12
Conditioned Warehouse	Light Industrial	160	0.14
Unconditioned Warehouse	NA - No Savings	0	0.00
Manufacturing – Light Industrial (1 shift)	Light Industrial	160	0.14
Manufacturing – Light Industrial (2 shift)	Light Industrial	160	0.14
Manufacturing – Light Industrial (3 shift)	Light Industrial	160	0.14
College/University	Average/Miscellaneous	274	0.12
Government/Municipal	Average/Miscellaneous	274	0.12
Assembly	Assembly	316	0.05
Miscellaneous	Average/Miscellaneous	274	0.12
Garage (Ohio)	NA - No Savings	0	0.00
Exterior (Ohio)	NA - No Savings	0	0.00

Measure Savings Analysis
The savings for this measure come from the Ohio Draft TRM.

Measure Life and Incremental Measure Cost
Per the Ohio TRM, the incremental cost for this measure is $267 per 100 square feet of window, and the expected lifetime of the measure is 10 years.

Centralized Energy Management System Controls

Measure Description	Incentives are available for existing buildings that currently have no digital automated HVAC controls or outdated pneumatic control systems with inoperable time control functions. Existing HVAC control systems cannot have time of day scheduling (including 7-day programmable thermostats). Upgrading obsolete EMS HVAC system with inoperable time clock functions will be reviewed on a case-by-case basis for incentive eligibility. Buildings upgrading existing digital EMS systems are not eligible for prescriptive incentives. If incorporated with Demand Control Ventilation, real-time carbon-dioxide monitoring at the operator interface is required. HVAC EMS systems must be new and include (a) central time control, (b) real-time outside air damper positioning, (c) graphic operator interface, (d) whole building real-time power and energy monitoring capability, (e) open-protocol architecture (shall consist of either LonTalk (ANSI/CEA 709.1) or BACNet (ASHRAE/ANSI 135) protocol being used between all controlled and controlling devices and every node on the network), (f) web-based interface with PC based controls, (g) have a minimum setback space temperature of at least 8°F in both heating and air condition mode, (h) minimum setback period must exceed 2,200-hours per year, and (i) at least three "enhanced" control strategies (see Table 2). Buildings with 2,000-ft2 - 50,000 -ft2 of conditioned, controlled space are eligible for this prescriptive incentive.
Units	Per square foot of conditioned space
Base Case Description	No control or only basic electronic or electromechanical time controls.
Measure Savings	Source: DNV KEMA experience, and CBECS data
Measure Incremental Cost	Source: DNV KEMA experience
Effective Useful Life	Source: DNV KEMA experience

List of eligible enhanced control strategies:

- Optimal Start
- Economizer Control
- DB or WB Changeover Temperature Setpoint
- Improved Outside Air Volume Control (other than economizer)
- Morning Warm Up Cycle
- Static Pressure Reset
- Supply Air Temperature Reset
- Unoccupied Temperature Setback
- OA Damper Control
- Summer/Winter Volume Change

- Load Shedding for Demand Control
- Equipment Cycling
- Cooling Lockout on OSAT
- Heating Lockout on OSAT
- Condenser Water Temperature Setpoint Reset
- Chilled Water Temperature Setpoint Reset
- Chiller or Compressor Sequencing
- Distribution Pump Selection/Sequencing
- Distribution Pump Speed Control
- Cooling Tower Fan Staging
- Cooling Tower Fan Speed Control
- Partial Light Shutoff
- Floating Head Pressure Control (Groceries)
- Evaporator Fan Speed Control (Groceries)
- Cold Case Lighting Control (Groceries)
- Variable Light Level Control
- Head Pressure Controls (Groceries)
- Anti Sweat Heater Controls (Groceries)

Note: Enhanced control strategies listed above may not count unless they can be monitored, scheduled, and controlled from a central operator interface.

Measure Savings

The average default savings for this measure is 0.0 kW and 2.31 kWh per square foot of conditioned space. Initial default savings by building type are provided in the table below.

Table 105. Energy Savings for EMS Measure, per square foot

Building Types	kWh
Large Office	2.84
Small Office	2.84
School	1.19
Small Retail/Service	2.15
Large Retail/Service	2.15
Hotel/Motel	2.21
Medical- Hospital	4.19
Medical- Nursing Home	2.88
Assembly/Meeting Place	0.65
Restaurant	5.78

Grocery	2.15
Conditioned Warehouse	1.62
Unconditioned Warehouse	1.62
Industrial/Manufacturing	1.62
College/University	1.19
Government/Municipal	1.85
Miscellaneous	2.31

For larger projects, the numbers shown above may be overwritten in the database after a billing analysis is complete, and more accurate savings for the project can be determined. The values above may be used for initial tracking, and reservation processing as necessary, but are based on general experience from past projects. However, the savings from EMS projects may vary considerably depending on the scope of the project.

Measure Savings Analysis

The Energy Information Administration's Commercial Building Energy Consumption Survey (CBECS) data was used to determine the baseline energy use for the (17) different building types within the program. Specifically, data on the energy intensity (kWh/SF) for the building types within the east north central census region of the US was used[35]. The east north central census region includes Wisconsin, Michigan, Illinois, Indiana, and Ohio[36]. The table below shows the electrical intensities for the EIA space types, along with the closest AEP building type.

Table 106. Electrical Intensities for EIA Space Types and Program Building Type Mapping

EIA Building Type	Electricity Energy Intensity (kWh/square foot) for the East North Central Census Area	Associated Program Building Type
Education	7.9	School
Food Sales	NA	Small Retail/Service and Large Retail/Service
Food Service	38.5	Restaurant

[35] http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set15/2003pdf/c17a.pdf
[36] ftp://ftp.abag.ca.gov/pub/mtc/planning/temp/HBrazil/Scoping%20Plan/supmap.pdf

EIA Building Type	Electricity Energy Intensity (kWh/square foot) for the East North Central Census Area	Associated Program Building Type
Health Care – Total	24.2	NA
Health Care – Inpatient	27.9	Medical - Hospital
Health Care – Outpatient	NA	Medical - Nursing Home
Lodging	14.7	Hotel/Motel
Mercantile -Total	15.6	Small Retail/Service and Large Retail/Service
Mercantile - Retail (Other than Mall)	12.3	NA
Mercantile - Enclosed and Strip Malls	17.9	NA
Office	18.9	Large Office and Small Office
Public Assembly	12.3	Government/Municipal
Public Order and Safety	NA	NA
Religious Worship	4.3	Assembly/Meeting Place
Service	12	Small Retail/Service and Large Retail/Service
Warehouse and Storage	10.8	Conditioned Warehouse and Unconditioned Warehouse
Other	NA	NA
Vacant	NA	NA

A mapping was done from the (18) CBECS building types to the (17) AEP building types. The energy intensities for the Small Retail, Large Retail and Grocery space types within the AEP program are the weighted average by total square footage of the Service and Mercantile space types within CBECS. The Other/Miscellaneous is the simple average of the other (16) mapped AEP building types.

Data from CBECS, which shows the electric intensities of different building types by end use, is used to determine the baseline energy consumption, as well as to estimate the anticipated energy reduction with the EMS system[37]. Estimates on anticipated energy reductions within building end uses are shown in the table below, for illustrative purposes.

Table 107. Potential Energy Savings Calculation Example

	Electricity Energy Intensity (kWh/square foot)										
	Space Heating	Cooling	Ventilation	Water Heating	Lighting	Cooking	Refrigeration	Office Equipment	Computers	Other	Total
Electricity is Main Heat Source	0.6	2.1	1.8	0.3	5.6	0.1	1.8	0.3	0.7	1.7	15
Potential Savings (Electric Heat)	*2.0%*	*4.0%*	*2.0%*	*0.0%*	*6.0%*	*0.0%*	*1.0%*	*0.0%*	*0.0%*	*0.0%*	**15.0%**

The sum of all of end use savings is 15%, which is the factor applied to the electric intensities in order to come up with the default kWh/SF savings values for each building type.

Measure Life and Incremental Measure Cost

The measure life for this measure is assumed to be 15 years (DEER 2008), and the incremental measure cost is assumed to be $1.5/SF, both values are assumptions based on past experience.

Air-side Economizer

Measure Description	This measure consists of retrofitting Roof-Top Units (RTUs), Air Handling Units (AHUs), Split Direct-Expansion (DX) systems, or Unit Ventilators (UVs), which were designed without economizers. Repairing systems which have inoperable economizer controls are not eligible for this measure. The area served must be air conditioned space. New damper actuators and controls must be installed to the existing system with the proper calibration.
Units	Per ton
Base Case Description	System which was designed without economizers.

Measure Savings

The annual energy savings for this measure is 552 kWh per ton.

[37] http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set19/2003pdf/e06.pdf

Measure Savings Analysis

The savings for this measure are based on a simulation using eQUEST version 3.64. For this analysis, a simulation was run for a 10 story, 350,000 ft^2. office building in Chicago, IL. The model simulated HVAC systems with and without economizers to determine the differences in electric energy consumption the cooling loads require to maintain the indoor building temperature at acceptable levels. The specifications of the simulated buildings are defined in the following table.

Table 108. Simulated Building Specifications

Building	Building Area	350,000-ft^2 with 10 floors
	Schedule	Monday to Saturday: 9am to 6pm, and closed on Sunday and holidays
	Lighting density (W/ft^2)	1.55 (perimeter office) and 1.45 (core offices)
	Plug load density (W/ft^2)	1.6 (perimeter office) and 0.7 (core offices)
	Wall construction	Glass curtain wall (R-8)
	Roof construction	Built-up roof (R-14)
	Glazing type	Multipane
HVAC	HVAC system type	Single zone air handler with HW heat
	HVAC system sizing	Based on ASHRAE design day conditions, 10% over sizing assumed
	Chiller type	400 Ton Electric Centrifugal Hermetic, with water cooled condenser, with constant speed compressor
	Boiler type	Hot water, 80% efficiency
	Thermostat setpoints	Occupied hours: 75F (cooling) and 70F (heating) Unoccupied hours: 80F (heating) and 65F (heating)

From the analysis, based on a 10% over-sizing of system size, this building requires a 400 ton unit to maintain comfort and air quality. The modeled cooling system without an economizer mode consumes 7,565,279-kWh/yr. The modeled cooling system with economizer mode consumes 7,344,479-kWh/yr. The model shows that there are energy savings all year. The electrical energy saved from installing an economizer in this building is 220,800-kWh/yr. For this simulation, the energy required to mechanically cool this building is reduced by 3%.

Measure Life and Incremental Measure Cost

The estimated measure life is 10 years[38]. The incremental measure cost is $155/ton based on DEER 2008.

[38] http://www.intel.com/it/pdf/reducing_data_center_cost_with_an_air_economizer.pdf

Premium Motors

Motor measures are eligible for prescriptive new construction incentives, too. Variable speed drives are only available for new construction when they are not required by code.

Self direct measures can also use these set of workpapers, by referring to the savings calculation methodology, run time hours, load factor, and coincidence factors are used. The actual existing unit and replacement unit efficiencies are used for the savings calculation instead of code baseline.

NEMA® Premium-Efficiency Motors

Measure Description	Motors eligible for an incentive are three-phase AC induction motors, 1-200 hp, of open drip-proof (open) and totally enclosed fan-cooled (closed) classifications. Rewound motors do not qualify. Incentives are based on the motor's nominal full-load efficiencies, tested in accordance with IEEE (Institute of Electrical and Electronics Engineers) Standard 112, method B, that exceed the NEMA premium-efficiency or CEE premium standards (www.cee1.org). The application must include the manufacturer's performance data sheet that at least shows equipment type, equipment size, model number, and efficiency rating. Customers should consider matching water or air flows (GPM, CFM) of the existing pump or fan when installing energy-efficient motors that inherently have higher speeds (less slip), which may increase energy savings.
Units	Per motor
Base Case Description	Federal minimum NEMA Premium Nominal efficiency

Measure Savings
The following tables provide the measure savings for exceeding NEMA premium motor efficiency levels or EISA 2007 standards. The minimum qualifying efficiency levels are provided below.

Table 109. Measure Coincident kW Savings, EISA 2007 Baseline (per motor)

	1200 RPM		1800 RPM		3600 RPM	
HORSEPOWER	**ODP**	**TEFC**	**ODP**	**TEFC**	**ODP**	**TEFC**
1	0.006	0.006	0.006	0.006	0.007	0.007
1.5	0.008	0.008	0.008	0.008	0.009	0.009
2	0.011	0.010	0.011	0.011	0.011	0.011
3	0.016	0.015	0.015	0.015	0.017	0.016
5	0.026	0.026	0.026	0.026	0.027	0.026
7.5	0.038	0.037	0.037	0.037	0.039	0.038
10	0.049	0.049	0.049	0.049	0.051	0.050
15	0.073	0.074	0.071	0.072	0.075	0.074
20	0.096	0.097	0.095	0.095	0.099	0.099
25	0.118	0.118	0.117	0.117	0.122	0.122
30	0.140	0.142	0.139	0.140	0.146	0.146
40	0.185	0.185	0.185	0.185	0.192	0.192
50	0.231	0.231	0.229	0.229	0.237	0.237
60	0.275	0.275	0.272	0.272	0.281	0.281
75	0.344	0.344	0.340	0.338	0.351	0.351

	1200 RPM		1800 RPM		3600 RPM	
HORSEPOWER	ODP	TEFC	ODP	TEFC	ODP	TEFC
100	0.454	0.454	0.450	0.450	0.468	0.463
125	0.567	0.567	0.563	0.563	0.578	0.567
150	0.675	0.670	0.670	0.670	0.694	0.681
200	0.900	0.893	0.893	0.886	0.908	0.900
250	1.126	1.116	1.116	1.107	1.135	1.116

Table 110. Measure kWh Savings, EISA 2007 Baseline (per motor)

	1200 RPM		1800 RPM		3600 RPM	
HORSEPOWER	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	22	22	21	21	26	26
1.5	30	30	30	30	32	32
2	40	39	41	41	42	42
3	58	57	57	57	62	61
5	95	95	95	95	101	97
7.5	173	170	170	167	180	176
10	223	227	223	223	234	231
15	335	340	326	330	346	340
20	440	446	434	434	453	453
25	651	651	642	642	669	669
30	771	781	763	771	803	803
40	1,017	1,017	1,017	1,017	1,055	1,055
50	1,271	1,271	1,261	1,261	1,301	1,301
60	1,982	1,982	1,962	1,962	2,020	2,020
75	2,478	2,478	2,452	2,432	2,525	2,525
100	3,269	3,269	3,242	3,242	3,367	3,332
125	3,988	3,988	3,954	3,954	4,064	3,988
150	4,745	4,706	4,706	4,706	4,877	4,785
200	6,327	6,275	6,275	6,223	6,380	6,327
250	7909	7843	7843	7779	7975	7843

Measure Savings Analysis

The two types of capacity savings estimates discussed here are connected-load reduction achieved by the measure (non-coincident) and demand reduction coincident with the utility's system peak. The non-coincident demand reduction achieved by the measure is estimated from engineering analyses using the following formula:

Non-coincident kW reduction = kW of existing equipment - kW of replacement equipment

$$kW = \frac{(\text{Motor HP}) \times (0.746 \text{ kW/HP}) \times (\text{Load Factor})}{\text{Motor Efficiency}}.$$

Generally motors are oversized and so the load factor is assumed to be 75 percent.[39]

Energy savings are based on the difference between baseline and efficient equipment connected wattage and annual operating hours, according to the following formula:

kWh Reduction = (kW of existing equipment - kW of replacement equipment) * (Annual operating hours)

To determine coincident demand reduction, engineering estimates of savings are multiplied by a coincident diversity factor. Coincident diversity factors have been estimated to be 0.74[40].

Coincident kW Reduction = Coincident Diversity Factor * Non-coincident reduction with Demand Interactive Effects

DEER uses the data from a study for the Department of Energy completed in 1998[41]. The data for Overall Manufacturing, SIC 20 through 39, is used as for the operating hours to represent the industrial market sector. These hours are assumed reasonable for use with all market sectors.

Table 111. Annual Operating Hours[42]

Size Category	Operating Hours
1 to 5 hp	2,745
6 to 20 hp	3,391
21 to 50 hp	4,067
51 to 100 hp	5,329
101 to 200 hp	5,200

39 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report - Residential and Commercial Non-Weather Sensitive Measures and Ohio TRM.
40 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report - Residential and Commercial Non-Weather Sensitive Measures and VEIC comments filed November 15, 2010.
41 Xenergy, United States Industrial Electric Motor Systems Market Opportunities Assessment. Burlington, MA, 1998. Hours are from Page B-2 for Overall Manufacturing (SIC 20-39).
42 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report - Residential and Commercial Non-Weather Sensitive Measures referencing the Xenergy study.

Baseline and retrofit equipment assumptions are presented in the next tables. Motor replacement is considered a replace on burn-out measure. The baseline represents the nonenergy-efficient equipment that would be purchased, which is set at NEMA Premium efficiency values, which are equivalent to U.S. minimum standards for 1 – 200 HP general purpose motors, per EISA 2007. This table shows the standard efficiencies used for the savings calculations. The average efficiency improvement found on the CEE motor list is 1% higher than EISA 2007. Savings calculation is based on this improvement level for all motor sizes and speed.

Table 112. EISA 2007 or NEMA Premium Efficiencies Motors

HORSEPOWER	1200 RPM		1800 RPM		3600 RPM	
	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	82.5%	82.5%	85.5%	85.5%	77.0%	77.0%
1.5	86.5%	87.5%	86.5%	86.5%	84.0%	84.0%
2	87.5%	88.5%	86.5%	86.5%	85.5%	85.5%
3	88.5%	89.5%	89.5%	89.5%	85.5%	86.5%
5	89.5%	89.5%	89.5%	89.5%	86.5%	88.5%
7.5	90.2%	91.0%	91.0%	91.7%	88.5%	89.5%
10	91.7%	91.0%	91.7%	91.7%	89.5%	90.2%
15	91.7%	91.0%	93.0%	92.4%	90.2%	91.0%
20	92.4%	91.7%	93.0%	93.0%	91.0%	91.0%
25	93.0%	93.0%	93.6%	93.6%	91.7%	91.7%
30	93.6%	93.0%	94.1%	93.6%	91.7%	91.7%
40	94.1%	94.1%	94.1%	94.1%	92.4%	92.4%
50	94.1%	94.1%	94.5%	94.5%	93.0%	93.0%
60	94.5%	94.5%	95.0%	95.0%	93.6%	93.6%
75	94.5%	94.5%	95.0%	95.4%	93.6%	93.6%
100	95.0%	95.0%	95.4%	95.4%	93.6%	94.1%
125	95.0%	95.0%	95.4%	95.4%	94.1%	95.0%
150	95.4%	95.8%	95.8%	95.8%	94.1%	95.0%
200	95.4%	95.8%	95.8%	96.2%	95.0%	95.4%
250	95.4%	95.8%	95.8%	96.2%	95.0%	95.8%

Measure Life and Incremental Measure Cost

The measure life is assumed to be 15 years.[43]

The following table provides the incremental measure cost. Incremental cost is cost difference between the energy-efficient equipment and the less efficient or standard option. However for the cost differences between NEMA premium and the retrofit motor at the efficiency stated above are provided in the table based on analysis of Motor Master data.

Table 113. Motor Incremental Measure Cost for Exceeding NEMA (EISA 2007) Efficiency[44]

HORSEPOWER	1200 RPM		1800 RPM		3600 RPM	
	ODP	TEFC	ODP	TEFC	ODP	TEFC
1	$ 41.00	$ 112.83	$ 55.33	$ 163.05	$ 18.00	$ 78.04
1.5	$ 27.71	$ 245.90	$ 41.10	$ 205.77	$ 24.00	$ 139.89
2	$ 14.71	$ 232.77	$ 60.36	$ 226.31	$ 33.08	$ 155.70
3	$ 126.63	$ 340.33	$ 12.40	$ 259.40	$ 54.38	$ 175.93
5	$ 46.00	$ 254.27	$ 29.45	$ 237.06	$ 71.78	$ 201.27
7.5	$ 150.63	$ 360.01	$ 92.73	$ 349.00	$ 45.44	$ 371.01
10	$ 204.25	$ 308.93	$ 13.00	$ 255.33	$ 127.67	$ 253.19
15	$ 135.43	$ 201.06	$ 21.09	$ 341.20	$ 143.90	$ 270.60
20	$ 111.40	$ 426.10	$ 130.58	$ 199.77	$ 229.13	$ 185.53
25	$ 494.14	$ 281.10	$ 114.07	$ 102.34	$ 122.57	$ 111.42
30	$ 247.20	$ 585.29	$ 28.92	$ 159.73	$ 683.00	$ 106.86
40	$ 668.83	$ 859.70	$ 368.10	$ 169.76	$ 392.50	$ 254.25
50	$ 511.67	$ 583.94	$ 59.38	$ 58.20	$ 599.13	$ 66.22
60	$ 642.83	$ 1,205.69	$ 342.60	$ 764.11	$ 782.50	$ 60.31
75	$ 836.83	$ 597.12	$ 700.62	$ 670.95	$ 676.27	$ 549.15
100	$ 911.43	$ 866.51	$ 115.09	$ 633.04	$ 793.82	$ 1,320.57
125	$ 1,148.88	$ 260.72	$ 852.13	$ 568.68	$ 765.82	$ 182.77
150	$ 1,312.71	$ 103.87	$ 619.00	$ 88.96	$ 1,213.43	$ 657.38
200	$ 794.33	$ 5,088.92	$ 1,325.60	$ 200.70	$ 2,080.33	$ 1,301.07
250	$ 794.33	$ 5,088.92	$ 1,325.60	$ 200.70	$ 2,080.33	$ 1,301.07

43 2005 Database for Energy Efficiency Resources (DEER) Update Study Final Report - Residential and Commercial Non-Weather Sensitive Measures
44 MotorMaster+ v4.1, October 1, 2010. All costs based on list price

Variable Speed Drives for HVAC and Process Applications

Measure Description	This applies to variable-speed drives (VSDs) installed on existing HVAC or process fans or pumps up to 200 horsepower. The installation of a VSD must accompany the permanent removal or disabling of any flow control devices such as inlet vanes, bypass dampers, and throttling valves. This measure does not apply to chillers. VSDs for chillers are considered under a separate measure.
Units	Per rated motor HP controlled
Base Case Description	Mechanical restriction (damper or valve), bypass, on/off cycling, or no flow control.

Variable-speed drives (VSDs) installed on existing HVAC or non-HVAC fans or pumps and air compressors are eligible for this incentive. The installation of a VSD must accompany the permanent removal or disabling of any flow control devices such as inlet vanes, bypass dampers, and throttling valves to be eligible. Other requirements include:

- Rated motor horsepower ≤ 200 hp and minimum annual operating hours are as indicated below.
- Does not apply to redundant or backup/standby motors that are expected to operate less than 1,200 operating hours per year.
- Does not apply to variable pitch fans and forward curve with inlet guide vanes unless applicant supplies proof of kWh savings from logged or measured data.
- Does not apply to replacement of a multi-speed motor.
- Does not apply to VFDs on new chillers (existing chillers qualify under a lower rebate of $30 per hp).
- Applies only to VSDs installed with an automatic control technology.
- For motors greater than 100 hp, applicant must provide information regarding the equipment type and location, the equipment the drive is installed on, the daily and weekly operating schedule, a description of the existing flow control method, the proposed control strategy and, to the extent possible an estimate of hours the system will operate at 10 percent load increments[45].

Measure Savings

The measure default HVAC VSD savings by building type are summarized in Table 1 and 2. Details on analysis methodology are in the following section. The HVAC motor savings application are based on the large office building type (eQuest model prototype), since that is to

[45] Additional information may be required for all projects, upon request.

date been where the highest penetration of the measure. To calculate the savings by building type, the large office building savings value is multiplied by a ratio of operating hours of the other building type and large office for the specific fan and pump application. Table 3 provides the peak demand savings which is from the large office models only and assumed to representative for all the building types[46].

Savings are provided by fan and pump types for space conditioning for human comfort. If specific supply/return fan and pre-retrofit control types are know, Table 2 should be used.

Table 114. HVAC Motor Default VSD Savings by Building Type by Application Type (kWh/yr/hp)

Building Type	Chilled Water Pumps	Condenser Water Pumps	Hot Water Pumps	Cooling Tower Fans	Supply/Return Fans	Other HVAC Motor
Assembly	456	843	678	506	778	652
College/ University	673.5	1,246.5	1,649.5	748.5	1,386.0	1,141.0
Grocery	405	749	1567	450	1037	841
Government/Municipal	332	614	523.5	368.5	631	493.5
Hotel	682	1261	2526	758	1556	1356
Light Industry	231	428	431	257	535	376
Hospital	641	1185	2729	712	1556	1365
Nursing Home	605	1119	2619	672	1556	1314
Small Office	226	419	469	251	484	370
Large Office	208	385	369	231	484	335
Restaurant	446	826	1107.5	496.0	940	763
Small Retail	349	646	583	388	713	536
Large Retail	340	631	900	379	790	609
Primary School	266	493	741	296	467	453
School	242	448	684.5	269.0	446	418
Warehouse, Conditioned	324	599	537	360	706	505

46 It is understood that this assumption is not appropriate, but nevertheless, DNV KEMA is using it to simplify analysis and will consider revisions if the measure penetration is high in other building types.

Average = Miscellaneous	418	774	1177	465	918	751

Table 115. HVAC Supply Return Fan Motor Default VSD Savings by Building Type by Application Type (kWh/yr/hp)

Building Type	Backward Inclined – Inlet Guide Vanes	Forward Curve - Discharge Dampers	Backward Inclined - Discharge Dampers
Assembly	714	514	1107
College/ University	1271	915	1971
Government/Municipal	579	417	898
Grocery	952	685	1475
Hotel	1427	1028	2213
Light Industry	491	353	761
Hospital	1427	1028	2213
Nursing Home	1427	1028	2213
Small Office	444	320	689
Large Office	444	320	689
Restaurant	862.5	621	1337.5
Small Retail	654	471	1014
Large Retail	725	522	1124
School	409.5	295	634
Warehouse, Conditioned	648	466	1004
Average = Miscellaneous	842	607	1306

Table 116. HVAC Motor Default VSD Savings by Application Type (kW/ hp)[47]

[47] Savings are based on large office building as the representative building type.

Motor Type[48]	kW/hp
Supply/Return Fan	0.119
AF/BI with IGV	0.126
FC with discharge dampers	0.112
AF/BI with discharge dampers	0.236
Chilled Water Pump	0.121
Condenser Water Pump	0.182
Hot Water Pump	0.000
Cooling Tower Fan	0.024
Other HVAC Motor	0.097

The following table provides a summary of the default savings values for non HVAC motors.

Table 117. Non HVAC Motor Default Savings (per hp)

Custom VSD Measure Type	Calculated kWh/HP	Calculated kW/HP
Air Compressor	1435	0.299
Process	833	0.174
Other Motor	592	0.123

Measure Savings Analysis

DNV KEMA used DEER based eQuest models modified for ComEd specific elements including climate, building type and basic system type (central chilled water plant)[49]. Large offices were used as the basis for the models based on the historical predominance of this building in applications for this measure.

DNV KEMA modeled using eQuest 3.64 the following pre-retrofit cases for a prototype large office building and determined the kWh/hp savings from installation of variable speed control for each pre-retrofit case. Specifics of the fan models include:

- A 1.30 sizing ratio applied to the fan supply volume and the coil size
- Fan power – 0.0006 kW/cfm based off a standard 25,000 CFM size fan (source is Greenheck manufacturer)

48 FC = forward curve, AF/BI = airfoil/backward inclined, IGV = inlet guide vanes.
49 At this time, DNV KEMA assumes Chicago weather is sufficient for Columbus, Ohio.

- To convert the calculated kW sizing of the motors from eQuest to rated (or nameplate) horsepower, the following calculation is used where motor efficiency is the default eQuest efficiency from DEER, kW is an output field from .sim file, and LF is assumed to be 0.75.

$$Rated\ hp = kW_{eQuest} x\ motor\ eff / 0.746 / LF$$

- Used various eQUEST default fan performance curves: FC-Fan-w/Dampers, FC-Fan-w/Vanes, AF-Fan-w/Dampers, AF-Fan-w/Vanes
- eQUEST is not capable of modeling VFDs for each FC fan and AF fan, but only as applied to general fan. The fan curve used for the measure is Fan-Pwr-fPLR-w/VFD.

The chilled water and hot water pump models assume a conversion from 3-way to 2-way coil admission valves for the bypass pre-retrofit cases only. The models do not include any conversion from primary to primary/secondary distribution loops. Table 6 shows the results of this effort.

Table 118. Large Office Parametric Runs and Results (per hp)

Motor Type	Pre-Retrofit	Operating Hours	kWh	kW	Average	
					kWh	kW
Supply/Return fan	VAV with discharge dampers / forward curve	2727	444	0.126	363	0.119
Supply/Return fan	VAV with inlet guide vanes / airfoil (backward inclined)	2727	320	0.112		
Supply/Return fan	VAV with discharge dampers / airfoil (backward inclined)	2727	689	0.236		
Chilled water pump	Throttle, 2-way valves	1157	141	0.127	208	0.121
Chilled water pump	Bypass, 3-way valves	1157	275	0.114		
Hot water pump	Throttle, 2-way valves	1287	160	0.000	369	0.000
Hot water pump	Bypass, 3-way valves	1287	577	0.000		
Condenser Water Pump	Constant speed	1145	385	0.182	385	0.182
Cooling tower fan	Constant speed	1157	156	0.024	156	0.024

The demand savings for each case is captured as the average hourly savings during the Peak Hours (1 PM to 5 PM, June 1 – August 31) from eQuest 8,760 hour files.

To determine savings by building type, fan and pump run hours for each building type were determined by modeling a chilled water system for a typical large office building and then calculating the ratio of modeled hours to typical office building motor operating hours for supply/return fans, chilled water pumps, hot water pumps, and cooling tower fans (calculation is shown below). Table 8 below provides the operating hour data extracted from the models. Cooling tower fan and chilled (and condenser) water pump run hours are assumed to be the same as chiller run hours. The 300 ton centrifugal chiller baseline model (used to calculate the deemed chiller savings) was used to as the source for extracting the run hours data.

Potential savings by building type is provided in Table 1 and 2. The team recognizes that the energy intensity will vary by building type and additional modeling may be considered for building types that exhibit high penetration for this measure.

$$Annual\ \ kWh\ \ Savings_{BuildingTy\ pe} = Annual\ \ kWh\ \ Savings_{L\ arg\ e\ Office} \times \frac{RunHours_{Building\ \ Type}}{RunHours_{L\ arg\ e\ Office}}$$

Table 119. Baseline Annual Operating Hours from SS-E Report

Building Type	Chilled/Condenser Water Pumps and Cooling Tower Fans	Hot Water Pumps	Supply/Return Fans
Assembly	2518	2175	4380
College	3680	3948	7801
University	3766	6642	7801
Grocery	2237	5029	5840
Hotel	3768	8107	8760
Light Industry	1277	1385	3012
Hospital	3541	8760	8760
Nursing Home	3342	8407	8760
Small Office	1251	1506	2727
Large Office	1150	1183	2727
Restaurant Fast Food	2761	4571	6205
Restaurant Sit Down	2174	2538	4380
Small Retail	1930	1871	4015
Large Retail	1976	4232	4745
Large 3-story Retail	1791	1551	4152
Primary School	1473	2378	2630
High School	1204	2015	2392
Warehouse, Conditioned	1790	1723	3975
Average = Miscellaneous	2313	3779	5170

Savings for non HVAC motors are based on final project estimates for VSD applications from the program. The following table summarizes the data collected and analyzed. The kW was determined by dividing the kWh by 4800 hours (as an estimate).

Table 120. Custom VSD Projects Sampled

Custom VSD Measure Type	Sample Size	Total Ex-Ante kWh	Total Ex Ante kW	Total HP	kWh/HP	kW/HP
VSD on Air Compressor	14	4,717,646	364	2630	1794	0.374
VSD on Process	3	104,133	62	100	1041	0.217
Other VSD	7	613,842	79	829	740	0.154

Savings for VSD on air compressors were determined using pre and post-power measurements and applicable production data, while kWh savings for other non-HVAC applications were mostly determined using load profiles submitted by customers or trade allies, and actual power measurements when available.

The deemed values are based on the ex-ante kWh and kW savings. Since the prescriptive measure is acceptable for motors with at least 1,200 hours of operation and the projects analyzed above have unknown operating hours, DNV KEMA assumed a “correction” factor of 80% the average value to minimize evaluation risk.

Table 121. Custom VSD Savings Data

Custom VSD Measure Type	Calculated kWh/HP	Calculated kW/HP
Air Compressor	1435	0.299
Process	833	0.174
Other Motor	592	0.123

Measure Life and Incremental Measure Cost

The measure life for variable speed drives is 15 years[50]. The incremental measure cost documented for this measure is $125 per horsepower[51].

[50] 2008 Database for Energy Efficiency Resources (DEER), www.deeresources.com
[51] Average from Connecticut CL&P and UI Program Savings Documentation for 2008 Program Year.

Refrigeration

DNV KEMA has developed a refrigeration savings calculator in Refrigeration Spreadsheet AEP.xls. The spreadsheet uses a cooling load calculation to calculate the refrigeration load of a typical refrigerated case, walk-in cooler or freezer found in convenience stores, grocery stores, or restaurants. The calculator is designed to be most applicable to convenience stores. It is not applicable for stand-alone display cases without a walk-in main door. Savings calculated in the spreadsheet are attributed to decreased cooling load and compressor usage.

Cooling load calculations are based on ASHRAE methodology[52] for typical refrigeration loads. Details of the analysis are provided in a separate attachment and spreadsheets. The total cooling load of a refrigerated space requires the calculation of the following:

1. Transmission or conduction load
2. Anti-sweat heater (ASH) load
3. Internal load (load due to evaporator fan motors, lighting, and people)
4. Product load (product shelving and product pull-down load)
5. Infiltration load

Additional assumptions must be made regarding the air properties of the refrigerated and adjacent spaces, number of doors, door type, and door size. Current values are based on DNV KEMA field observations in California, SCE Workpaper assumptions[53], and ADM evaluation results of gasket and strip curtain installations[54]. All assumptions and their source are documented in the spreadsheet.

Savings estimates for different measures can be calculated by adjusting these parameters and comparing the pre-retrofit and post-retrofit annual energy consumptions. The spreadsheet calculator contains the details. The calculator is set up for cooler walk-in, freezer walk-in, cooler reach-in, and freezer reach-in. The difference between the two in this document is that the reach-in is a walk-in with glass doors. Stand-alone refrigerated cases are not applicable to the calculator. The analysis adjustments per measure are discussed below.

Calculator Shortcomings

The calculator methodology is based on assumptions that require further research to validate. However based on the available information, they are satisfactory for calculating deemed savings. DNV KEMA believes this approach uses the most up to date data available and building up from the basics. Much of the calculator is based on the methodology and

[52] ASHRAE 2002. Refrigeration Handbook. Atlanta, Georgia. pp. 12.1
[53] Southern California Edison Company. WPSCNRRN002.1 – Infiltration Barriers – Strip Curtains, October 2007.
[54] "Commercial Facilities Contract Group Direct Impact Evaluation Draft Final Report: HIM Appendices". ADM Associates, Inc., prepared for the California Public Utilities Commission, December 8, 2009.

assumptions found in the SCE refrigeration workpapers[55]. The SCE methodology assumes that the system is comprised of a single reciprocating compressor and an air cooled condenser. Refrigeration system configurations vary widely depending on capacity and use. For example, many systems found at large commercial grocery stores are comprised of multiplex systems with water cooled condensers. There was also disagreement over the calculation methodology regarding the defrost heater internal load, which resulted in this internal load being omitted from the spreadsheet calculations[56].

In addition, the methodology for determining the EER for both medium and low temperature applications uses SCE's internal review of reciprocating compressor manufacturer performance curves to calculate EER. Their data and analysis is not available for review. Questions have arose about whether this data is applicable to different areas of the country, since these performance curves are dependant on saturated condensing temperature, cooling load, and the cooling capacity of the compressor. Further research is recommended to account for different types and how they would affect overall system efficiency and energy usage. Weather normalization analysis can be improved by using TMY3 8760 hourly weather data. However, only a simplified normalization is currently used.

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[55] Southern California Edison Company. WPSCNRRN002.1 – Infiltration Barriers – Strip Curtains, October 2007.
[56] Defrost heater load should be considered in future iterations.

Anti-sweat Heater Controls

Measure Description	Installation of relative humidity sensors for the air outside of the display case and controls that reduce or turn off the glass door (if applicable) and frame anti-sweat heaters at low-humidity conditions.
Units	Per Linear Foot (width of door)
Base Case Description	No Anti-Sweat Heater controls installed.

An anti-sweat heater is a device that senses the relative humidity in the air outside of the display case and reduces or turns off the glass door (if applicable) and frame anti-sweat heaters at low-humidity conditions. Technologies that can turn off anti-sweat heaters based on sensing condensation (on the inner glass pane) also qualify.

Measure Savings [57]
The anti-sweat heat (ASH) controller determines the amount of power necessary by sensing the ambient dew point within the installation's location. Methodology is taken from the SCE workpaper, which derives ASH runtime based on ambient space conditions and controller setpoints. It's assumed that these controllers are set to turn off at 42.89°F dewpoint (35% relative humidity) as the "All OFF SetPoint" and all on at 52.87°F dewpoint (50% relative humidity) as the "All ON SetPoint." Between these values, the ASH duty cycle changes proportionally:

$$\text{ASH ON\%} = \frac{DP_{meas} - \text{All OFF Set Point}}{\text{All ON Set Point} - \text{All OFF Set Point}}$$

where
DP_{meas} = measured dewpoint temperature inside the sales area

Energy savings are dependent on climate zone. Direct power savings are calculated using TMY3 weather data for the two typical AEP OH cities, using the methodology outlined above for each representative hour. The percent ASH on-time is then multiplied by the instantaneous ASH power, which is assumed to be 0.04255 kW/linear foot per the SCE workpaper. The total ASH direct energy consumption is calculated by taking the sum of all 1-hour kW consumption values for the entire representative TMY3 year. Interactive savings are calculated for the retrofit case by multiplying the baseline ASH heat load by the percent ASH runtime for each representative city.

57 "Anti-Sweat Heat (ASH) Controls," Workpaper WPSCNRRN0009. Southern California Edison Company. 2007. PG&E uses the same method as SCE, ASH Controls PGECOREF108.

Table 122. Savings for Anti-Sweat Heater Controls (per linear ft)

City	Columbus		Canton	
Application Type	**kWh**	**kW**	**kWh**	**kW**
Cooler (MT) walk-in door	0	0	0	0
Freezer (LT) walk-in door	303	0.0346	307	0.0350
Cooler (MT) walk-in door w/reach-in glass	288	0.0329	292	0.0333
Freezer (LT) walk-in door w/reach-in glass	292	0.0334	296	0.0338
Average	294	0.034	298	0.034

Both energy and peak kW savings take into account additional savings due to interactive effects.

Measure Life and Incremental Measure Cost
The measure life is 12 years and $34 per linear foot per the SCE workpapers.

Electronically Commutated Motors (ECM)

Measure Description	This measure is applicable to the replacement of an existing standard-efficiency shaded-pole evaporator fan motor in refrigerated display cases or fan coil in walk-ins. The replacement unit must be an ECM. This measure cannot be used in conjunction with the evaporator fan controller measure.
Units	Per Motor
Base Case Description	Shaded Pole Motors

Measure Savings[58]
Energy savings are based on the methodology found in SCE's work paper and depend on display-case type, either cooler or freezer. The baseline condition assumes a motor with a connected wattage of 135.5W per the FSTC report, with a fan motor efficiency of 70%. The post retrofit condition assumes a power reduction of 67% (44W) and a new efficiency of 85%. These motors are assumed to be in continuous operation, i.e., no evaporator fan controller installed. Total savings for replacing an existing electronically commuted motor with a new, more efficient unit are presented in the following table. The savings values from the spreadsheet Refrigeration Spreadsheet AEP.xls are added to the wattage reduction from the shaded-pole unit to the electronically commutated motor for walk-in cases.

Table 123. EC Motor Savings for Walk-ins (per motor)

City	Columbus		Canton	
Application Type	**kWh**	**kW**	**kWh**	**kW**
Cooler (MT) walk-in door	859	0.0981	859	0.0980
Freezer (LT) walk-in door	877	0.1001	875	0.0999
Average	864	0.0986	863	0.0985

Average savings values in the table above are a weighted average of walk-in cooler (75 percent) and freezer (25 percent) applications. This is the weighing methodology used in the SCE workpapers.[59]

Savings values for ECMs for Reach-In coolers are obtained from the SCE workpaper for efficient evaporator fan motors, which covers all 16 California climate zones, since stand-alone refrigerated cases are not applicable to the calculator. SCE savings values were determined

[58] "Efficient Evaporator Fan Motors (Shaded Pole to ECM)," Workpaper WPSCNRRN0011. Southern California Edison Company. 2007.
[59] "Average Infiltration Barriers". Workpaper WPSCNRRN0007.1. Southern California Edison Company. 2007.

using a set of assumed conditions for restaurants and grocery stores. We have used only PG&E climate zones in calculating our averages and have taken out the drier, warmer climates of southern California.

Table 124. SCE Grocery Savings Reach-In

SCE Workpaper Values	Grocery			
	Cooler		Freezer	
Northern California Climate Zones	kWh Savings Per Motor	Peak kW Savings Per Motor	kWh Savings Per Motor	Peak kW Savings Per Motor
1	306	0.031	362	0.031
2	269	0.033	273	0.035
3	331	0.032	421	0.034
4	332	0.032	422	0.034
5	323	0.032	402	0.033
11	357	0.034	476	0.037
12	350	0.034	462	0.036
13	355	0.034	472	0.037
16	325	0.032	409	0.034
Average	328	0.033	411	0.035

Table 125. ECM Reach-In Savings Values Summary

kWh Savings/ft	Peak kW Savings/ft
345	0.033

Measure Life and Incremental Measure Cost

The measure life is 15 years per the 2008 DEER. The cost of a reach-in ECM is $185 per the SCE workpaper. The cost of a walk-in ECM is $250 per Fisher Nickel[60].

[60] "GE ECM Evaporator Fan Motor Energy Monitoring" Food Service Technology Center, Fisher-Nickel Inc. 2006. Prepared for PG&E.

Evaporator Fan Control

Measure Description	This measure is for the installation of controls in medium and low temperature walk-in coolers. The controller reduces airflow of the evaporator fans when there is no refrigerant flow. The measure must control a minimum of 1/20 HP where fans operate continuously at full speed. The measure also must reduce fan motor power by at least 75 percent during the off cycle. This measure is not applicable if any of the following conditions apply: 1) The compressor runs all the time with high duty cycle 2) The evaporator fan does not run at full speed all the time 3) The evaporator fan motor runs on poly-phase power 4) Evaporator does not use off-cycle or time-off defrost.
Units	Per Motor
Base Case Description	Cooler with continuously running evaporator fan.

Measure Savings

The base case for the existing equipment is walk-in cooler or freezer with either shaded-pole evaporator or electronically commutated motors that are continuously running at full speed. Shaded pole and electronically commutated motor wattages are taken from the FSTC Evaporator Fan Motor Energy Monitoring Study[61]. One shaded pole evaporator fan motor has an average connected wattage of 135.5 watts. One electronically commutated motor has an average connected wattage of 44 watts. Walk-in cases are assumed to contain two evaporator fan motors each. Walk-in cases with reach-in glass doors are assumed to contain six evaporator fan motors.

Evaporator fan controller savings are dependant on compressor duty cycle. Assumed compressor duty cycle is 40% for winter and 50% for non-winter seasons. Weather data for the representative cities is used to find the distribution of annual below freezing (winter) and above freezing (non-winter) hours. These hours are multiplied by their respective duty cycle assumptions to arrive at an estimate for compressor annual operating hours. The operation of the fan controller specifies that fans are to be turned off when the compressor is off. Fan power savings are calculated by multiplying the connected evaporator fan motor wattage by the total hours the compressor is turned off. Interactive effects are calculated by multiplying the evaporator fan heat load by the % On-Time of the compressor. Savings are provided in the table below using the cooler/ freezer distruction of 75%/25%..

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[61] GE ECM Evaporator Fan Motor Energy Monitoring, FSTC Report # 5011.04.13. Fisher-Nickel, Inc. July 2006.

Table 126. Shaded Pole Motor Evaporator Fan Controller Savings (per motor)

City	Columbus		Canton	
Application Type	**kWh**	**kW**	**kWh**	**kW**
Cooler (MT) walk-in door	1322	0.151	1329	0.152
Freezer (LT) walk-in door	1348	0.154	1353	0.154
Cooler (MT) walk-in door w/reach-in glass	3999	0.457	4018	0.459
Freezer (LT) walk-in door w/reach-in glass	4064	0.464	4078	0.466
Average	2672	0.305	2684	0.306

Table 127. ECM Evaporator Fan Controller Savings (per motor)

City	Columbus		Canton	
Application Type	**kWh**	**kW**	**kWh**	**kW**
Cooler (MT) walk-in door	445	0.0508	462	0.0527
Freezer (LT) walk-in door	458	0.0523	484	0.0552
Cooler (MT) walk-in door w/reach-in glass	1378	0.1573	1463	0.1670
Freezer (LT) walk-in door w/reach-in glass	1396	0.1594	1479	0.1688
Average	915	0.1045	967	0.1104

Measure Life and Incremental Measure Cost

The measure life is 16 years and $162 per motor per the 2008 DEER.

LED Refrigerated Case Lighting – with Doors

Measure Description	Replace fluorescent refrigerated case lighting with light emitting diode (LED) source illumination. Fluorescent lamps, ballasts, and associated hardware are typically replaced with pre-fabricated LED light bars and driver units. Replace fluorescent refrigerated case lighting with light emitting diode (LED) source illumination. Fluorescent lamps, ballasts, and associated hardware are typically replaced with pre-fabricated LED light bars and LED driver units. The two LED lamp products, 5' light bars and 6' light bars are eligible and must meet DesignLights Consortium specification.
Units	Per linear foot of case
Base Case Description	Fluorescent refrigerated case lighting

The LED lighting must meet DesignLights Consortium specification summarized in the table below.

Table 128. DLC Criteria for LED Refrigerated Case Lighting

Minimum Light Output	Zonal Lumen Density	Minimum Luminaire Efficacy	Allowable CCTs (ANSI C78.377-2008)	Minimum CRI	Minimum LED Lumen Maintenance at 6000hrs1	Minimum Luminaire Warranty
Center-mounted: >=100 lm/ft End-mounted: >= 50 lm/ft	>=95% 0º-80º	35 lm/W	2700K, 3000K, 3500K, 4000K, 4500K and 5000K	70	95.80%	5 years

Measure Savings
The coincident demand savings is 0.032 KW per linear foot of case and annual energy savings is 215.9 kWh per linear foot of case.

Measure Savings Analysis
The energy and demand savings are derived from the Ohio TRM, August 6, 2010. The TRM provides the possibility of 5-foot or 6-foot LED light bar replacement options. The average demand reduction is 0.024 kW. The savings calculation per foot of case is:

kWh Savings = demand reduction x Hours x (1+waste heat factor) x Energy savings factor / Door Width

where,Hours = 6205

Energy savings factor = 1.0 with no motion sensor
Waste heat factor = 0.41 for coolers and 0.52 for freezers
Door Width = 2.5 feet

The savings across cooler and freezers are weighted with 75.6% and 24.4% split per the SCE workpapers referenced above.

The coincidence factor for peak savings per the TRM is 0.92 and the same waste heat factors for the demand savings.

Measure Life and Incremental Measure Cost
It is well documented that LED life is extended in a low-temperature environment; therefore the expected useful life of 50,000 hours assumed for this application is probably conservative. Based on the fixture run-time of 6,205 hours annually for the facility in the study, the expected life calculates to 8 years (based on Ohio TRM).

The incremental measure cost is assumed to be $100 per linear foot, based on $250 per door, and 2.5 ft/door per the Ohio TRM.

LED Refrigerated Case Lighting in Open Display Cases

Measure Description	Replace fluorescent refrigerated case lighting with light emitting diode (LED) source illumination. Fluorescent lamps, ballasts, and associated hardware are typically replaced with pre-fabricated LED light bars and LED driver units. The two LED lamp products, 5' light bars and 6' light bars are eligible. The LED lighting must meet DesignLights Consortium specification.
Units	Per linear foot of case
Base Case Description	Fluorescent refrigerated case lighting

The LED lighting must meet DesignLights Consortium specification summarized in the table below.

Table 129. DLC Criteria for LED Refrigerated Case Lighting

Minimum Light Output	Zonal Lumen Density	Minimum Luminaire Efficacy	Allowable CCTs (ANSI C78.377-2008)	Minimum CRI	Minimum LED Lumen Maintenance at 6000hrs1	Minimum Luminaire Warranty
Center-mounted: >=100 lm/ft End-mounted: >= 50 lm/ft	>=95% 0º-80º	35 lm/W	2700K, 3000K, 3500K, 4000K, 4500K and 5000K	70	95.80%	5 years

Measure Savings
The coincident demand savings is 0.026 KW per linear foot of case and annual energy savings is 172.1 kWh per linear foot.

Measure Savings Analysis
The energy and demand savings are derived from the Ohio TRM, August 6, 2010. The TRM provides the possibility of 5-foot or 6-foot LED light bar replacement options. The average demand reduction is 0.024 kW. The savings calculation is:

kWh Savings = demand reduction x Hours x (1+waste heat factor) x Energy savings factor / Door Width

where,

Hours = 6205
Energy savings factor = 1.0 with no motion sensor
Waste heat factor = 0.061 for grocery stores (per table in lighting section)
Door Width = 2.5 feet

The savings across cooler and freezers are weighted with 75.6% and 24.4% split per the SCE workpapers referenced above. The coincidence factor for peak savings per the TRM is 0.92 and the same waste heat factors for the demand savings.

Measure Life and Incremental Measure Cost
It is well documented that LED life is extended in a low-temperature environment; therefore the expected useful life of 50,000 hours assumed for this application is probably conservative. Based on the fixture run-time of 6,205 hours annually for the facility in the study, the expected life calculates to 8 years (based on Ohio TRM).

The incremental measure cost is assumed to be $100 per linear foot, based on $250 per door, and 2.5 ft/door per the Ohio TRM.

Lighting Controls for Freezers and Coolers with Doors

Measure Description	Passive infrared, ultrasonic, and fixture-integrated sensors or sensors with a combination thereof are eligible.
Units	Per linear foot of case controlled
Base Case Description	Refrigerated case lighting with no controls

Measure Savings
The coincident demand savings is 0.0096 kW per linear foot of case controlled and annual energy savings is 170.4 kWh per linear foot of case controlled.

Measure Savings Analysis
The electricity use (kWh) savings and gross summer peak demand (kW) reduction comprises two factors: reduced lighting load and reduced refrigeration requirements due to reduced heat gain. Reductions in lighting load occur continuously over the expected annual operating period,

which includes the summer peak period. Savings due to reduced heat gain are computed assuming those reduced effects occur during the period in which the lighting systems operate, in consideration of the refrigeration compressor COP and the reduced cooling load, under normal operation (i.e., doors closed).

Connected lighting fixture assumptions are presented in the next table. LED wattages are per the Ohio TRM. The average across all fixture types is 44.2 W per linear foot of case.

Table 130. Equipment Wattages LED Refrigeration Lighting

Fixture Type	Fixture Code	Fixture Wattage	Watts per door[62]	Watts per linear foot of Case[63]	Weight
1-5' T12	F51SS	63	126	50.4	35%
1-5' T8	F51ILL	36	72	28.8	35%
1-6' T12 HO	F61SHS	120	240	96	30%
			141.3	**56.5**	
5' LED Lightbar	N/A	38	76	30.4	70%
6' LED Lightbar	N/A	46	92	36.8	30%
			80.8	**32.3**	

kWh Savings = Controlled Wattage per Door x Hours x (1+waste heat factor) x Energy savings factor / Door Width / 1000

where,

Hours = 6205
Energy savings factor = 0.3
Waste heat factor = 0.41 for coolers and 0.52 for freezers
Door Width = 2.5 feet

The savings across cooler and freezers are weighted with 75% and 25% split per the SCE workpapers referenced above.

The coincidence factor for peak savings per the TRM is 0.92 and the same waste heat factors for the demand savings.

Measure Life and Incremental Measure Cost

[62] Assume 2 fixtures per door
[63] Assume 2.5 ft per door

It's assumed that the average cost of the sensor is the same as general lighting occupancy sensors, which is $66 per the Ohio TRM. It's assumed that a sensor controls on average 3 doors, 2.5 feet wide each. This results in an IMC of $8.8 per foot controlled.

According to 2008 DEER, the EUL for an interior occupancy sensor is estimated to be 8 years. Refrigerated case lighting controls are assumed to have the same EUL, due to the similar characteristics shared between the two control types.

Lighting Controls for Open Display Cases

Measure Description	Passive infrared, ultrasonic, and fixture-integrated sensors or sensors with a combination thereof are eligible
Units	Per linear foot of case controlled
Base Case Description	Refrigerated case lighting with no controls

Measure Savings
The coincident demand savings is 0.0076 kW per linear foot of case controlled and annual energy savings is 135.8 kWh per linear foot of case controlled.

Measure Savings Analysis
The electricity use (kWh) savings and gross summer peak demand (kW) reduction comprises two factors: reduced lighting load and reduced refrigeration requirements due to reduced heat gain. Reductions in lighting load occur continuously over the expected annual operating period, which includes the summer peak period. Savings due to reduced heat gain are computed assuming those reduced effects occur during the period in which the lighting systems operate, in consideration of the refrigeration compressor COP and the reduced cooling load, under normal operation (i.e., doors closed).

Connected lighting fixture assumptions are presented in the next table. LED wattages are per the Ohio TRM. The average across all fixture types is 44.2 W per linear foot of case.

Table 131. Equipment Wattages LED Refrigeration Lighting

Fixture Type	Fixture Code	Fixture Wattage	Watts per door[64]	Watts per linear foot of Case[65]	Weight
1-5' T12	F51SS	63	126	50.4	35%
1-5' T8	F51ILL	36	72	28.8	35%

[64] Assume 2 fixtures per door
[65] Assume 2.5 ft per door

1-6' T12 HO	F61SHS	120	240	96	30%
			141.3	**56.5**	
5' LED Lightbar	N/A	38	76	30.4	70%
6' LED Lightbar	N/A	46	92	36.8	30%
			80.8	**32.3**	

kWh Savings = Controlled Wattage per Door x Hours x (1+waste heat factor) x Energy savings factor / Door Width / 1000

where,

Hours = 6205
Energy savings factor = 0.3
Waste heat factor = 0.061 for grocery stores (per table in lighting section)
Door Width = 2.5 feet

The savings across cooler and freezers are weighted with 75% and 25% split per the SCE workpapers referenced above.

The coincidence factor for peak savings per the TRM is 0.92 and the same waste heat factors for the demand savings.

Measure Life and Incremental Measure Cost
It's assumed that the average cost of the sensor is the same as general lighting occupancy sensors, which is $66 per the Ohio TRM. It's assumed that a sensor controls on average 3 doors, 2.5 feet wide each. This results in an IMC of $8.80 per foot controlled.

According to 2008 DEER, the EUL for an interior occupancy sensor is estimated to be 8 years. Refrigerated case lighting controls are assumed to have the same EUL, due to the similar characteristics shared between the two control types.

ENERGY STAR® Solid or Glass Door Reach-In Freezer

Measure Description	This measure consists of the replacement of a conventional solid or glass reach-in freezer unit with an ENERGY STAR Version 2.0 rated unit. Only units with built-in refrigeration systems are qualified. Units with remote refrigeration systems or units do not qualify. Customers must provide proof that the appliance meets the CEE Tier II efficiency specifications using ASHRAE Standard 117-1992 (38°F ± 2°F).
Units	Per freezer
Base Case Description	Conventional, non ENERGY STAR unit

Table 132.ENERGY STAR Qualified Commercial Freezers (kWh per day)[66]

Product Volume, cubic feet	Solid Door Freezer	Glass Door Freezer
0 < V < 15	≤ 0.250V + 1.250	≤ 0.607V + 0.893
15 ≤ V < 30	≤ 0.400V – 1.000	≤ 0.733V – 1.000
30 ≤ V < 50	≤ 0.163V + 6.125	≤ 0.250V + 13.500
50 ≤ V	≤ 0.158V + 6.333	≤ 0.450V + 3.500

Measure Savings

The savings for this measure is calculated using ENERGY STAR methodology. The baseline based on Energy Policy Act of 2005 is summarized in the following table.

Table 133. Baseline Commercial Freezers (kWh per day)

Type	kWh per day
Solid Door Freezer	0.40V + 1.38
Glass Door Freezer	0.75V + 4.10

Savings are calculated using an average volume for all qualified reach-in freezer units, which is 37.07 and 28.02 cubic feet for solid and glass door units, respectively[67]. The estimated annual savings is 1,475 kWh and 0.168 kW for solid door units. The estimated annual savings is 2,035 kWh and 0.232 kW for glass door units. Actual savings will vary based on equipment type and volume.

Measure Life and Incremental Measure Cost

The measure life is 12 years per DEER 2008.

Incremental cost is cost difference between the energy-efficient equipment and the less efficient option. Costs are averaged across unit volumes. The solid door units modeled in PG&E's work papers have slightly different efficiency requirements, but incremental costs are assumed to be similar[68]. For glass door units, costs are assumed to be comparable to glass door reach-in refrigerators[69].

Table 134. ENERGY STAR® Freezer Incremental Measure Cost

66 www.energystar.gov, Note: V = Internal volume in ft^3
67 Per the ENERGY STAR listing as of May 15, 2012.
68 PG&E Workpaper PGECOFST107.1
69 PG&E Workpaper PGECOFST106.1

Cost Basis	Solid Door	Glass Door
Full Measure Cost	$5624.00	$4241.00
Incremental Measure Cost	$804.75	$163.25

ENERGY STAR® Solid Door Refrigerator

Measure Description	This measure consists of the replacement of a conventional Solid Reach-In Refrigerator unit with an ENERGY STAR rated unit. Only units with built-in refrigeration systems are qualified. Units with remote refrigeration systems or units do not qualify.
Units	Per freezer
Base Case Description	Conventional, non ENERGY STAR unit

Table 135. ENERGY STAR Qualified Commercial Solid Door Refrigerators (kWh per day)[70]

Product Volume, cubic feet	Refrigerator
0 < V < 15	≤ 0.089V + 1.411
15 ≤ V < 30	≤ 0.037V + 2.200
30 ≤ V < 50	≤ 0.056V + 1.635
50 ≤ V	≤ 0.060V + 1.416

The baseline federal maximum energy usage for solid door refrigerations is 0.10V + 2.04 kWh per day. V is in cubic feet[71].

Measure Savings

The savings for this measure is calculated using ENERGY STAR methodology. Savings are calculated using an average volume for all qualified Solid Door Reach-In Freezer units, which is 30.86 cubic feet[72]. The estimated annual savings is 643.47 kWh and 0.0735 kW. Actual savings will vary based on equipment type and volume.

Measure Life and Incremental Measure Cost

The measure life is 12 years and IMC is $164 per unit per the 3/16/12 Draft IL TRM.

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70 www.energystar.gov, Note: V = Internal volume in ft^3

71 http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=6897a2d07f4267b3924df5885ccd44ae;rgn=div5;view=text;node=10%3A3.0.1.4.19;idno=10;cc=ecfr , Note: V = Internal volume in ft^3

72 Per the ENERGY STAR listing as of April 12, 2012.

Food Service

The measures in the following section are not based on the Ohio TRM or the responses from VEIC from November 2010. Updates to the measure savings may be considered that address the TRM to adjust the baseline and retrofit efficiencies actual found in the market place.

Ice makers, steam cookers, combination ovens, and hot food holding cabinet may qualify for new construction.

High-efficiency Ice Makers

Measure Description	The rebate covers ice machines that generate 60 grams (2 oz.) or lighter ice cubes, flaked, crushed, or fragmented ice. Only air-cooled machines qualify (self contained, ice making heads, or remote condensing). The machine must have a minimum capacity of 101 lb of ice per 24-hour period (per day). The minimum efficiency required is per ENERGY STAR® or CEE Tier 1.[73] A manufacturer's specification sheet must accompany the application that shows rating in accordance to ARI standard 810.
Units	Per icemaker
Base Case Description	Federal Minimum

Measure Savings[74]
Savings values are derived from values found in the PG&E workpaper. Annual operating hours are assumed to be 8,760, with a duty cycle of 56.8%.

Table 136. Ice Maker Savings, per icemaker

Size (lb / 24 hrs)	Peak kW Savings	Annual kWh Savings
101-200	0.039	252
201-300	0.064	415
301-400	0.080	515
401-500	0.094	606
501-1,000	0.150	964
1,001-1,500	0.185	1,192
> 1,500	0.259	1,669

Measure Savings Analysis
Federal minimum and ENERGY STAR® efficiency requirements can be found in the following table.

Table 137. Ice Maker Efficiency Standards

Equipment Type	Federal Standard, kWh_{base}	ENERGY STAR®, kWh_{ee}
Ice Making Head (H < 450)	10.26-0.0086*H	9.23-0.0077*H
Ice Making Head (H ≥ 450)	6.89-0.0011*H	6.20-0.0010*H
Remote Condensing Unit, without remote compressor (H < 1000)	8.85-0.0038*H	8.05-0.0035*H
Remote Condensing Unit, without remote compressor (H ≥ 1000)	5.1	4.64

[73] The websites have a list of qualifying model numbers, www.energystar.gov or www.cee1.org.
[74] Work Paper PGECOFST108.2 – Commercial Ice Machines, Pacific Gas and Electric 2009.

Equipment Type	Federal Standard, kWh_{base}	ENERGY STAR®, kWh_{ee}
Remote Condensing Unit, with remote compressor (H < 934)	8.85-0.0038*H	8.05-0.0035*H
Remote Condensing Unit, with remote compressor (H ≥ 934)	5.3	4.82
Self Contained Unit (H < 175)	18-0.0469*H	16.7-0.0436*H
Self Contained Unit (H ≥ 175)	9.8	9.11

The savings methodology for this measure is based on the method presented in PG&E's 2009 Ice Machine workpaper. The savings are based on the difference of the ice harvest rate (IHR) which is expressed as kWh per 100 lb. Icemaker sizes are expressed by the rate of their production in lb per 24-hour period. The following equations are used to calculate savings.

$$Annual\ kWh\ Savings = \frac{(kWh_{base} - kWh_{retrofit})}{100} \times Duty\ Cycle \times IHR \times 365$$

Where

- 100 = conversion factor to convert kWh_{base} and kWh_{ee} into maximum kWh consumption per pound of ice.
- DC = Duty Cycle of the ice machine = 0.568[75]
- IHR = Ice Harvest Rate (pounds of ice made per day)
- 365 = days per year
-

$$Coincident\ peak\ kW\ savings = \frac{Annual\ kWh\ Savings}{Annual\ operating\ hours \times Duty\ Cycle} \times Summer\ Peak\ Coincident\ Factor$$

Where:

- Annual operating hours= 8760
- Summer Peak Coincidence Factor for measure= 0.772[76]

The following table provides values for average IHR, baseline kWh and retrofit kWh used to calculate savings.

[75] FSTC Icemaker metering study
[76] Ohio TRM

Table 138. Savings Calculation Inputs[77]

Ice Harvest Rate (IHR) (lbs per 24 hrs.)	Average IHR Used in Energy Calculations (lbs/day)	Baseline Model Energy Usage (kWh/100 lbs)	Retrofit Model Energy Usage (kWh/100 lbs)
101-200	150	10.97	10.16
201-300	250	8.11	7.31
301-400	350	7.25	6.54
401-500	450	6.40	5.75
501-1,000	750	6.07	5.45
1,001-1,500	1,250	5.10	4.64
> 1,500	1,750	5.10	4.64

Measure Life and Incremental Measure Cost

The measure life for icemakers is 10 years based on 2008 DEER.

The following table provides the IMC documented for this measure. For some measures the IMC is equal to the full measure cost. These are replace-on-burnout measures or measures that are a new technology. Retrofit measures generally dictate IMC, which is the cost difference between the retrofit and baseline technology. Installing high-efficiency icemakers is typically a retrofit that occurs as a replace on burnout; hence, the incremental measure cost is the difference between the retrofit and baseline equipment.

Table 139. Ice Maker Incremental Measure Cost[78]

Size (lbs / 24 hrs)	$ per unit
101-200	$189
201-300	$818
301-400	$281
401-500	$63
501-1,000	$234
1,001-1,500	$550
> 1,500	$866

[77] Work Paper PGECOFST108.2 – Commercial Ice Machines, Pacific Gas and Electric 2009.
[78] Work Paper PGECOFST108.2 – Commercial Ice Machines, Pacific Gas and Electric 2009.

ENERGY STAR® Steam Cooker

Measure Description	This measure consists of the replacement of a conventional Steam Cooker unit with an ENERGY STAR rated unit. Steamer performance is determined by applying the ASTM *Standard Test Method for the Performance of Steam Cookers* (F1484),[79] considered to be the industry standard for quantifying the efficiency and performance of steamers. The following table is the ENERGY STAR standards for electric steam cookers. The standard is version 1.1, current as of August 2003.
Units	Per cooker
Base Case Description	Conventional, non ENERGY STAR unit

Table 140. ENERGY STAR Steam Cooker Standards

Pan Capacity	Cooking Energy Efficiency	Idle Rate (watts)
3-pan	50%	400
4-pan	50%	530
5-pan	50%	670
6-pan and larger	50%	800

*Cooking Energy Efficiency is based on heavy load (potato) cooking capacity

Measure Savings

The savings for this measure is calculated using ENERGY STAR methodology, with updates based upon research done at the Food Service Technology Center. Measure data for savings calculations are based on average equipment characteristics. Annual energy use is calculated based on preheat, idle, and potato cooking energy efficiency and production capacity test results from applying ASTM F1484.

The following is the calculation for daily energy consumption per the PG&E workpapers.

$$EDay = LBFood * \frac{EFood}{Efficiency} + IdleRate * (OpHrs - \frac{LBFood}{PC} - \frac{TpreHT}{60}) + EpreHT$$

$$Average\ \ Demand = \frac{EDay}{OpHrs}$$

[79] American Society for Testing and Materials. 2005. *Standard Test Method for the Performance of Steam Cookers.* ASTM Designation F1484-05, in *Annual Book of ASTM Standards,* West Conshohocken, PA.

Table 141. Steam Cooker Variable Assumptions[80]

Variable	Variable Description (Units)	Value Assumed (Baseline)	Value Assumed (ENERGY STAR)
EDay	Daily Energy Consumption (kWh/day)	23.7	11.6
LBFood	Pounds of Food Cooked per Day (lb/day)	100	100
Efood	ASTM Energy to Food (kWh/lb) = kWh/pound of energy absorbed by food product during cooking	0.0308	0.0308
Efficiency	Heavy Load Cooking Energy Efficiency %	26%	50%
IdleRate	Idle Energy Rate (kW)	1.0	0.4
OpHrs	Operating Hours/Day (hr/day)	12	12
PC	Production Capacity (lbs/hr)	70	50
TPreHt	Preheat Time (min/day)	15	15
EPreHt	Preheat Energy (kWh/day)	1.5	1.5

Savings assume a 3-pan steam cooker, operating 12 hours a day, 365 days per, with one preheat daily. The annual savings calculated for an ENERGY STAR steam cooker is 4,419 kWh. Average demand savings is total kWh savings divided by the operating hours, which results in 1 kW. Coincident peak demand savings, using a coincidence factor of 0.84 from the Ohio TRM, is 0.847 kW.

Measure Life and Incremental Measure Cost
The measure life is 12 years per ENERGY STAR and $2,490 per PG&E workpapers[81].

Combination Oven

Measure Description	This measure consists of the replacement of a conventional Combination Oven unit with a unit that has a Heavy-Load Cooking Energy Efficiency of at least 60%.
Units	Per oven
Base Case Description	Conventional combination oven unit

A combination oven is a convection oven that includes the added capability to inject steam into the oven cavity and typically offers at least three distinct cooking modes. In the combination mode, it provides a way to roast or bake with moist heat (hot air and steam); in the convection

[80] ENERGY STAR Commercial Steam Cooker Calculator
[81] 2009 PG&E Workpaper – PGECOFST104.1 – Commercial Steam Cooker – Electric and Gas

mode, it operates purely as a convection oven providing dry heat; or it can serve as a straight pressureless steamer.[82]

Oven performance is determined by the ASTM Standard Test Method for the Performance of Combination Ovens,[83] considered to be the industry standard for quantifying combination oven efficiency and performance.[84] Savings calculations for combination ovens assume they meet or exceed heavy-load cooking energy efficiencies of > 60%, utilizing the ASTM standard F1639.

Measure Savings

The savings for this measure is calculated using ENERGY STAR methodology, with updates based upon research done at the Food Service Technology Center. Measure data for savings calculations are based on average equipment characteristics, as established by ENERGY STAR. Annual energy use was calculated based on preheat, idle, and cooking energy efficiency and production capacity test results from applying ASTM testing.

The following is the calculation for daily energy consumption per the PG&E workpapers.

$$EDay = LBFood * \frac{EFood}{Efficiency} + IdleRate * (OpHrs - \frac{LBFood}{PC} - \frac{TpreHT}{60}) + EpreHT$$

$$Average\ \ Demand = \frac{EDay}{OpHrs}$$

Table 142. Combination Oven Variable Assumptions[85]

Variable	Variable Description (Units)	Value Assumed (Baseline)	Value Assumed (Energy Efficient)
EDay	Daily Energy Consumption (kWh/day)	106	55
LBFood	Pounds of Food Cooked per Day (lb/day)	200	200
Efood	ASTM Energy to Food (kWh/lb) = kWh/pound of energy absorbed by food product during cooking	0.0732	0.0732
Efficiency	Heavy Load Cooking Energy Efficiency %	44%	60%
IdleRate	Idle Energy Rate (kW)	7.5	3.0
OpHrs	Operating Hours/Day (hr/day)	12	12
PC	Production Capacity (lbs/hr)	80	100
TPreHt	Preheat Time (min/day)	15	15

[82] PG&E. “Commercial Kitchen Appliance Technology Assessment.” PG&E Food Service Technology Center. Section 7 Ovens.
[83] American Society for Testing and Materials. “Standard Test Method for the Performance of Convection Ovens.”. in *Annual Book of ASTM Standards*, West Conshohocken, PA.
[84] PG&E Food Service
[85] PG&E Food Service Equipment Workpapers (October 2005)

EPreHt	Preheat Energy (kWh/day)	3.0	1.5

Savings assume a 10-pan oven, operating 12 hours a day, 365 days per, with one preheat daily. The annual savings calculated for an energy efficienty combination oven is 18,432 kWh. Average demand savings is 4.208 kW. Coincident peak demand savings, using a coincidence factor of 0.84 provided in the Ohio TRM, is 3.535 kW.

Measure Life and Incremental Measure Cost
The measure life is 12 years per DEER 2008 and $3,824 per PG&E workpapers[86].

ENERGY STAR® Hot Food Holding Cabinet

Measure Description	This measure consists of the replacement of a conventional Hot Food Holding Cabinet unit with an ENERGY STAR rated unit. Hot-food holding cabinets that meet current ENERGY STAR specifications are 60% more energy-efficient than standard models and must meet a maximum idle energy rate of 40 watts/ft^3. All operating energy rates' savings assumptions are used in accordance with American Society for Testing and Materials' (ASTM) Standard F2140.
Units	Per cabinet
Base Case Description	Conventional, non ENERGY STAR unit

Measure Savings
The savings based on ENERGY STAR savings methodology are summarized in the table below. Coincident peak demand savings uses a coincidence factor of 0.84,which is provided in the Ohio TRM. The program assumes savings from the half-size units.

Table 143. Hot Holding Cabinet Savings by Size

	Full-size	Three-quarter size	Half size
Energy (kWh/year)	9,308	3,942	2,628
Demand (kW)	2.125	0.900	0.600
Coincident Peak Demand (kW)	1.785	0.756	0.504

Measure Savings Analysis
Energy-usage calculations are based on 15 hours-a-day, 365 days-per-year operation (5,475 hours) at a typical temperature setting of 150°F (based on ENERGY STAR assumptions).

[86] 2009 PG&E Workpaper – PGECOFST100.1 – Commercial Combination Oven – Electric and Gas

To estimate energy savings, hot food holding cabinets are categorized into three size categories, as in the following table.

Table 144. Cabinet Size Assumptions[87]

Size	Internal volume	Average volume for calculations
Full-size	> 15 ft^3	20 ft^3
Three-quarter size	10 – 15 ft^3	12 ft^3
Half size	< 10 ft^3	8 ft^3

Measure Life and Incremental Measure Cost

The estimate useful life of this measure is 12 years (DEER 2008). The following table provides the IMC documented for this measure. Cost data is taken from PG&E workpapers. Incremental cost is cost difference between the energy-efficient equipment and the less efficient option.

Table 145. Hot Holding Cabinet Measure Cost

	Full-size	Three-quarter size	Half size
Full Measure Cost	$4160	$3743	$2295
Incremental Measure Cost	$1891	$1497	$707

Beverage Machine Controls

Measure Description	The beverage machine is assumed to be a refrigerated vending machine that contains only nonperishable bottled and canned beverages. The controller must include a passive infrared occupancy sensor to turn off fluorescent lights and other vending machine systems when the surrounding area is unoccupied for 15 minutes or longer. For the beverage machine, the control logic should power up the machine at 2-hour intervals to maintain product temperature and provide compressor protection.
Units	Per machine
Base Case Description	No controls

Measure Savings

Beverage machine controls savings are taken from the DEER 2005 database. It is assumed that controls are only effective during off-peak hours and so have no peak-kW savings. The annual energy savings are 1,612 kWh per year. The Ohio TRM results in the same savings when assuming that the baseline wattage is 400 W and energy savings factor is 46% at 8,760 hours of operation.

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[87] ENERGY STAR Commercial Hot Food Holding Cabinet Calculator based on PG&E FSTC research.

Measure Life and Incremental Measure Cost
The measure life is 5 years.[88] The IMC documented for this measure is $180 per unit.[89]

Snack Machine Controls

Measure Description	The controller must include a passive infrared occupancy sensor to turn off fluorescent lights and other vending machine systems when the surrounding area is unoccupied for 15 minutes or longer.
Units	Per machine
Base Case Description	No controls

Measure Savings
Snack machine controls savings are taken from the DEER database. It is assumed that controls are only effective during off-peak hours and so have no peak-kW savings. The annual energy savings are 387 kWh per year.[90]

A baseline is used to calculate savings and incremental cost. In this case, the baseline for this measure assumes that there are controls installed for the machine.

Measure Life and Incremental Measure Cost
The measure life is 5 years[91]. The IMC documented for this measure is $80 per unit per DEER 2005.

[88] Ohio TRM and DEER 2008
[89] 2005 DEER
[90] DEER 2005. The Ohio TRM assumes 345 kWh per year using a 46% energy savings factor and connected watts of the machine at 85 Watts.
[91] DEER 2008 and Ohio TRM

ENERGY STAR® Refrigerated Beverage Vending Machine Refurbishment Kit

Measure Description	ENERGY STAR beverage vending machines qualify for an incentive. Qualifying machines can be found at http://www.energystar.gov/ia/products/prod_lists/vending_machines_prod_list.pdf.
Units	Per Machine
Base Case Description	Standard Unit

Measure Savings[92]
Beverage machine savings are taken from the ENERGY STAR savings calculator and summarized in the following table. ENERGY STAR provides savings numbers for machines with and without control software. The average savings are calculated here. It is assumed that controls are only effective during off-peak hours and so have no peak-kW savings.

Table 146. ENERGY STAR Vending Machine Savings

Vending Machine Capacity (cans)	kWh Conventional Machine	kWh ENERGY STAR Machine w/o software	kWh ENERGY STAR Machine w/ software	kWh Savings Per Machine w/o software	kWh Savings Per Machine w/ software
<500	3,113	2,014	1,454	1,099	1,659
500	3,916	2,162	1,685	1,754	2,231
699	3,551	2,309	1,800	1,242	1,751
799	4,198	2,457	1,915	1,741	2,283
800+	3,318	2,605	2,030	713	1,288
Average	3,619	2,309	1,777	1,310	1,842
Total Average			1,576		

Measure Life and Incremental Measure Cost
The measure life is 14 years according to ENERGY STAR. The measure cost is $200 according to ENERGY STAR.

92 ENERGY STAR Savings Calculator. http://www.energystar.gov/index.cfm?c=vending_machines.pr_vending_machines

High Efficiency Electric Water Heater and ENERGY STAR® Heat Pump Hot Water Heater

Measure Description	**High Efficiency Hot Water Heater:** New hot water heater must be ≥ 40 gallons have an Energy Factor ≥0.93. **ENERGY STAR Heat Pump Hot Water Heater:** Must meet ENERGY STAR criteria with an Energy Factor ≥2.0 and first hour rating (FHR) ≥ 50 gallons per hour.
Units	Per unit
Base Case Description	Baseline is based on January 2004 standard energy factor, 0.97-(0.00132 x rated storage volume in gallons)
Measure Savings	DEER and Ohio TRM
Measure Incremental Cost	Source: PG&E
Effective Useful Life	Source: DEER and Ohio TRM, and DNV KEMA

Measure Savings

The coincident electrical demand (kW), annual electrical energy savings (kWh/yr are provided in the following table.

Table 147. Electric Hot Water Heater Savings, per unit

Building Type	Electric Hot Water Heaters		Heat Pump Hot Water Heaters	
	Energy Savings (kWh)	Peak Savings (kW)	Energy Savings (kWh)	Peak Savings (kW)
Assembly	138	0.030	1316	0.290
College/University	1644	0.362	15728	3.460
Conditioned Warehouse	809	0.178	7743	1.703
Government/Municipal	929	0.204	8893	1.956
Grocery	1176	0.259	11252	2.475
Hotel/Motel	1042	0.229	9965	2.192
Guest Rooms	912	0.201	8727	1.920
Large Office	929	0.204	8893	1.956
Large Retail/Service	1159	0.255	11090	2.440
Manufacturing – Light Industrial (1 shift)	809	0.178	7743	1.703
Manufacturing – Light Industrial (2 shift)	809	0.178	7743	1.703
Manufacturing – Light Industrial (3 shift)	809	0.178	7743	1.703

Building Type	Electric Hot Water Heaters		Heat Pump Hot Water Heaters	
	Energy Savings (kWh)	Peak Savings (kW)	Energy Savings (kWh)	Peak Savings (kW)
Medical - Hospital	266	0.058	2541	0.559
Medical - Nursing Home	159	0.035	1524	0.335
Miscellaneous	956	0.210	9143	2.012
Restaurant	271	0.060	2589	0.570
School	131	0.029	1249	0.275
Small Office	261	0.057	2500	0.550
Small Retail/Service	445	0.098	4259	0.937
Unconditioned Warehouse	809	0.178	7743	1.703

Measure Savings Analysis

The following tables summarize the savings analysis and calculations for hot water heater savings.

Table 148. Electric Hot and Heat Pump Water Heater Savings Analysis

Bldg Type	Typical Storage (gallons)	EUI - kWh/year/sf	UEC, kWh/year (Fed min)	UEC, kWh/year (assuming 100% efficient)	UEC, kWh/Year (Assuming 93% efficient)	UEC, kWh/year (assuming 200% efficient	Area (Sq Ft)	# of smaller water heaters
Assembly	200	0.32	10,880	9,692	10,421	4,846	34,000	3.333
College/University	500	0.5	325,000	289,510	311,301	144,755	650,000	8.333
Conditioned Warehouse	150	0.32	48,000	42,758	45,977	21,379	150,000	2.500
Government/Municipal	100	0.21	36,750	32,737	35,201	16,368	175,000	1.667
Grocery	100	0.93	46,500	41,422	44,540	20,711	50,000	1.667
Hotel/Motel	85	1.01	35,006	31,183	33,530	15,591	34,659	1.417
Guest Rooms	450	1.01	162,289	144,567	155,448	72,283	160,682	7.500
Large Office	100	0.21	36,750	32,737	35,201	16,368	175,000	1.667
Large Retail/Service	60	0.22	27,500	24,497	26,341	12,249	125,000	1.000
Manufacturing – Light Industrial (1 shift)	150	0.32	48,000	42,758	45,977	21,379	150,000	2.500
Manufacturing – Light Industrial (2 shift)	150	0.32	48,000	42,758	45,977	21,379	150,000	2.500
Manufacturing – Light Industrial (3 shift)	150	0.32	48,000	42,758	45,977	21,379	150,000	2.500
Medical - Hospital	500	0.21	52,500	46,767	50,287	23,384	250,000	8.333
Medical - Nursing Home	200	0.21	12,600	11,224	12,069	5,612	60,000	3.333
Miscellaneous	193.82	0.51	73,240	65,242	70,153	32,621	142,785	3.230
Restaurant	60	2.14	6,420	5,719	6,149	2,859	3,000	1.000

Bldg Type	Typical Storage (gallons)	EUI - kWh/year/sf	UEC, kWh/year (Fed min)	UEC, kWh/year (assuming 100% efficient)	UEC, kWh/Year (Assuming 93% efficient)	UEC, kWh/year (assuming 200% efficient	Area (Sq Ft)	# of smaller water heaters
School	310	0.16	16,000	14,253	15,326	7,126	100,000	5.167
Small Office	30	0.31	3,100	2,761	2,969	1,381	10,000	0.500
Small Retail/Service	10	0.22	1,760	1,568	1,686	784	8,000	0.167
Unconditioned Warehouse	150	0.32	48,000	42,758	45,977	21,379	150,000	2.500

The savings presented here are based on the approach in the PG&E workpapers, PGECODHW107 R1 Elec Storage Water Heater Nonres.doc. Building types are mapped to the PG&E workpaper building types (averages are used when more than one building type maps). Savings are determined using electric water heating Energy-Use Indices (EUI) values provided by the California Commercial End Use Study (CEUS). An EUI value is defined as the annual energy usage for a specific fuel and end-use per square foot of area served. These EUI values are then multiplied by square footage for the non-residential DEER building prototypes to result in total water heater usage for each building type. Energy savings at the building level are calculated by assuming an Energy Factor improvement from federal minimum for a 60 gallon tank, 0.8908 to 0.93. To determine the energy savings per unit, the energy savings per building is divided by the average number of water heaters there are per building. The number of hot water heaters per building is determined by dividing the typical water storage capacity found in the different buildings as determined by the CEUS, by the average electric water heater size of 60 gallons. Peak demand impact is based on the load shapes contained in the California Energy Commission's (CEC) peak demand forecasting model. In all cases, the energy/peak factor for water heating measures is 0.22.[93] The energy/peak factor is the ratio of the connected load reduction to peak energy demand.

For heat pump water heaters, a climate factor is added to the equation (for electric storage water heater, the climate factor is 1.0). This climate factor takes into consideration the low winter temperatures affect on heat pump operation. This factor was calculated using data from the ACEEE report on emerging hot water technologies[94]. The factor is the ratio between the

93 2004-2005 Database for Energy Efficiency Resources (DEER), Version 2.01, Measure ID D03-939, Section 6 and 7
94 http://www.aceee.org/consumer/water-heating

savings of residential heat pump water heater savings for moderate and northern climates, which is 72.7%.

Hot Water Energy Savings/unit =

$$\frac{\left[(EUI \times Building\_Area) \times EF_{fed\,min} \times \left(1 - \frac{1}{EF_{new}}\right)\right]}{\#Hot\_Water\_Heaters\_per\_Building} \times ClimateFactor$$

Table 149. Mapping Building Types

DEER 2005 Prototype	Program Bldg Types
Assembly	Assembly
Primary School	School
Secondary School	
Community College	College/University
University – Instruction	
Grocery	Grocery
Hospital	Medical - Hospital
Nursing Home	Medical - Nursing Home
Hotel – Public Area	Hotel/Motel
Hotel – Guest Rooms	Guest Rooms
Motel	Hotel/Motel
Manufacturing – BioTech	Manufacturing, Warehouses
Manufacturing – Light	
Large Office	Large Office, Government/Municipal
Small Office	Small Office
Sit Down Restaurant	Restaurant
Fast Food Restaurant	
3-Story Retail	Large Retail/Service
1-Story Retail	
Small Retail	Small Retail/Service

Table 150. DEER Water Heater Data

DEER 2005 Prototype	Typical Storage (gallons)	Building square feet	EUI - kWh/year/sf
Assembly	200	34,000	0.32
Primary School	120	50,000	0.16
Secondary School	500	150,000	0.16
Community College	500	300,000	0.5
University – Instruction	500	1,000,000	0.5
Grocery	100	50,000	0.93
Hospital	500	250,000	0.21
Nursing Home	200	60,000	0.21
Hotel – Public Area	120	39,318	1.01
Hotel – Guest Rooms	450	160,682	1.01
Motel	50	30,000	1.01
Manufacturing – BioTech	200	200,000	0.32
Manufacturing – Light	100	100,000	0.32
Large Office	100	175,000	0.21
Small Office	30	10,000	0.31
Sit Down Restaurant	60	4,000	2.14
Fast Food Restaurant	60	2,000	2.14
3-Story Retail	60	120,000	0.22
1-Story Retail	60	130,000	0.22
Small Retail	10	8,000	0.22

Table 151. Mapped Data to Program Building Types

Building Type	Gallons	Typical Bldg SF (from DEER)	EUI
Assembly	200	34000	0.32
College/University	500	650000	0.50
Conditioned Warehouse	150	150000	0.32
Government/Municipal	100	175000	0.21
Grocery	100	50000	0.93
Hotel/Motel	85	34659	1.01
Guest Rooms	450	160682	1.01
Large Office	100	175000	0.21
Large Retail/Service	60	125000	0.22
Manufacturing – Light Industrial (1 shift)	150	150000	0.32

Building Type	Gallons	Typical Bldg SF (from DEER)	EUI
Manufacturing – Light Industrial (2 shift)	150	150000	0.32
Manufacturing – Light Industrial (3 shift)	150	150000	0.32
Medical - Hospital	500	250000	0.21
Medical - Nursing Home	200	60000	0.21
Miscellaneous	194	142785	0.51
Restaurant	60	3000	2.14
School	310	100000	0.16
Small Office	30	10000	0.31
Small Retail/Service	10	8000	0.22
Unconditioned Warehouse	150	150000	0.32

Measure Life and Incremental Measure Cost

Table 152. Hot Water Heat Measures EUL and IMC

	High Efficiency Hot Water Heater	Heat Pump Water Heater
EUL	15	10
EUL Source	DEER 2008	Ohio Draft TRM
IMC	$72	Default: $1000
IMC Source	PG&E Workpapers	ACEEE Report[95]

[95] Emerging Hot Water Technologies and Practices for Energy Efficiency as of 2011, Report Number A112, October 2011.

Miscellaneous

Network PC Management Software

Measure Description	Network PC management software allows network administrators to control the power settings on all network computers. Most computers come with power settings that include "on", "standby", "sleep" and "off" modes, each of which can be set to activate during periods of inactivity. These modes however may not be set properly. This measure can achieve savings by allowing network administrators to put all network computers on low power settings during appropriate hours. The software installed must automatically control the power settings of networked personal computers at the server level. Software must be capable of managing power consumption for each individual PC and must be capable of reporting energy saving results. A report directly from the network energy management software that verifies the number of PC's that are being controlled by the system must be supplied.
Units	Per Workstation
Base Case Description	Computers without network power management software.

Measure Savings
The savings result due to an increase in the rate of idle to standby mode and the time spent in the "Off". Savings for network PC power management is 115 kWh per year per workstation. Coincident peak demand reduction is 0 kW.

Measure Savings Analysis
Various studies have been conducted on the savings achieved by central computer power management systems. Savings depend on both the baseline conditions as well as the usage type of the computers. The analysis in this paper is based on the savings documentation for the Regional Technical Forum (RTF). The documentation can be found at http://www.nwcouncil.org/energy/rtf/measures/com/NetworkComputerPwrMgmnt_Provisional_FY10v2_0.xls. The RTF documentation includes recent studies conducted by ECOS, Quantec, Lawrence Berkeley National Laboratories using data from U.S. Consumer Electronics Sales and Forecasts 2002 – 2007 and Energy Star[96]. The savings analysis includes weighing laptop and

96 Ecos Analysis of ENERGY STAR v5.0 Desktop Computer Dataset, 2008. Ecos/NRDC ENERGY STAR v4.0 Desktop Energy Use and Savings Estimates, 2004, LBNL-48581, "Surveyor Network Energy Manager, Market Progress Evaluation Report, No 2," Prepared by Quantec for Northwest Energy Efficiency Alliance. Section V. Verification of Surveyor Functionality and Energy Savings. January 19, 2005., "Energy Use and Power Levels in New Monitors and Personal Computers" by Roberson et al, July 2002, and CEA, U.S. Consumer Electronics Sales and Forecasts 2002 - 2007, January 2007, and forecasts from website articles.

desktop distributions by type, assumes some built-in power management of computers and monitors before applying the effects of a centralized power management control.

There is no peak demand saving for this measure, since at peak times it is assumed that the computers are on.

Measure Life and Incremental Measure Cost
Measure life indicates the license life and so goes beyond the useful life of the computer itself (usually 3-5 years). The measure life is assumed to be ten years and cost of $23 per computer[97].

Plug Load Occupancy Sensors

Measure Description	Plug-load sensors in combination with smart strip or other technology must control electricity using equipment in offices or cubicles, including lighting, shared copiers, and/or printers.
Units	Per sensor
Base Case Description	50W of task lighting and a computer monitor with no controls

Measure Savings
The coincident demand savings is 0 kW and annual energy savings is 169 kWh per application.

Measure Savings Analysis
The savings analysis method can be found in the Ohio TRM, draft August 6, 2010. The savings is for devices that are at least 100 connected watts during the 'on' mode.

Measure Life and Incremental Measure Cost
The measure life is assumed to be 8 years and cost of $70 per sensor per the Ohio TRM.

[97] "Surveyor Network Energy Manager, Market Progress Evaluation Report, No 2," Prepared by Quantec for Northwest Energy Efficiency Alliance. Section V. Verification of Surveyor Functionality and Energy Savings. January 19, 2005.

Intelligent Surge Protector

Measure Description	This incentive applies to surge protectors with built-in plug-load detection and control capabilities. The surge protector (power strip) must include at least one uncontrolled socket, which would be a primary device. Turning the primary device (usually a computer) on or off subsequently will turn the associated controlled devices in the power strip on or off (for example, printers, monitors, etc.). The intelligent power strip also may contain sockets for devices that require a constant supply of power. These will not be affected by the "control" device.
Units	Per unit
Base Case Description	No detection or control capabilities.

Measure Savings

The savings are based on the Ohio Draft TRM. They are calculated to be 23.6 kWh per year and 0 kW.

Measure Savings Analysis

The savings analysis can be found in the Ohio Draft TRM, p. 280.

Measure Life and Incremental Measure Cost

The measure life is assumed to be 8 years and the incremental measure cost is $15 per unit, as documented in the Ohio Draft TRM.

ENERGY STAR® Commercial Electric Clothes Washer

Measure Description	Incentives are available for high efficiency commercial clothes washers, which wash more clothes per load than standard clothes washers and use less water and energy. Qualified clothes washers must meet a minimum efficiency of CEE© Tier 2, with a Modified Energy Factor (MEF) $\geq$ 2.00 and a Water Factor (WF) $\leq$ 6.00.
Units	Per unit
Base Case Description	Baseline clothes washer that meets federal minimum requirements of MEF $\geq$ 1.26.

Measure Savings

The savings are based on PG&E's workpaper, PGECOAPP115 R1 Clothes Washers Nonres.doc dated October 23, 2009. The savings are 0.245 kW and 587 kWh/year.

Measure Savings Analysis

The savings analysis is based on the PG&E workpapers.

Measure Life and Incremental Measure Cost

The measure life is assumed to be 11 years and the incremental measure cost is $258 per unit, as documented in the ENERGY STAR Calculator Tool.

Compressed Air

Added Compressor Storage on Load/No Load Systems

Measure Description	Addition of air receiver tanks for 5 gallons per cfm capacity or more for air compressor systems that have load/no load controls. This prescriptive measure is eligible for air compressor systems whose rated horse-power (hp) is less than or equal to 300 hp. Both new and retrofit receivers are eligible for incentives. The additional air receiver tanks must meet or exceed the minimum receiver size of 5 gallons of storage per rated volume flow rate (scfm) of the compressor, while the existing air receiver capacity must be less than or equal to 2 gallons per scfm compressor capacity to qualify. Compressed air systems with variable-speed or variable displacement controlled compressors are not eligible.
Units	Per gallon[98]
Base Case Description	Air compressor system with 1 gallon per cfm capacity

This measure describes the addition of compressed air receiver tanks for systems whose compressors have load/no load (LNL) controls. Adding receiver tank capacity to compressors that have LNL controls can potentially offset power consumption of the compressor by reducing the frequency of cycling periods between loading and unloading the compressor. It is not intended for the consequential purpose of increasing storage capacity due to lowering the system's operating pressure or other system changes.

Air receivers buffer the air demand that the supply side (compressor) experiences. With LNL controlled compressors, there is a period of time that elapses during an unloading event that uses considerably more energy than the final unloaded (and possibly turned off if compressor has dual-control, depending on air demand and controls in place) state. Reducing the frequency of these transitions increases the overall efficiency of compressor usage. An increased receiver capacity will decrease the frequency of these inefficient unloading transition periods, hence saving energy.

It is expected that the applicant must provide the following operating conditions in order to qualify for prescriptive incentives:

[98] Savings is dependent not only on compressor size, but also on a nonlinear compressor power load factor. Thus, savings is kept on a arbitrary per "unit" basis, where the unit in the default case is a 25 hp compressor with air receiver capacity increasing from 1 gal/cfm to 5 gal/cfm.

1. Rated power (hp) of the air compressors that the receiver tanks serve
2. Rated volume flow rate (scfm) of the air compressors
3. Existing (if any) storage capacity per rated volume flow rate (gallons per scfm) of the air compressors
4. Proposed storage capacity in gallons per scfm

Measure Savings
The annual kWh and peak kW savings per gallon increased air capacity is 62.4 kWh per year and 0.009 peak kW.

Measure Savings Analysis
Savings will be estimated by establishing average annual air compressor power capacity factors for both base case and measure case air receiver capacities. The increase in air receiver capacity to the system effectively reduces the average compressor power load over the year; applying this difference in compressor power load between base and measure case to the estimated full load compressor energy usage over the year will result in energy savings due to the increase in air receiver capacity.

Annual energy (kWh) and maximum non-coincident demand (kW) saved are calculated using the following formulas. The base and measure cases both assume the same single compressor with LNL controls; the base case conditions assume the compressor has a total of 2 gallon per cfm storage capacity, while the measure case assumes the compressor has a total of 5 gallons per cfm storage capacity.

$$kWh_{saved} = \frac{\eta_{air\ comp} \times Hours \times \eta_{Savings}}{DC_{existing}}$$

$$kW_{saved} = \frac{(kWh_{saved} \times CF_{comp\ air})}{(Hours)}$$

<u>**Definition of Variables**</u>

kWh_{saved} = *Annual kWh saved*

kW_{saved} = *Demand (kW) reduced*

$Hours$ = *typical compressed air process annual hours of operation, 3,9686,240-hrs/yr*

ηair comp = *compressed air generation efficiency, 0.20-kW/scfm* *ηsavings* =*total percent of energy savings by increasing the capacity of the receiver tank, 10%*

DC existing = *air demand unit capacity of the existing compressed air system, 2-scfm/gallon*

CF comp air = *compressed air coincidence factor, 86.5 %*

Table 153. Variables for Increased Air Receiver Capacity

Component	Type	Value	Source
Hours	Variable	Ranges through 8,760 hours. Default: 6,240 hours	Application, DNV KEMA
ηair comp	Fixed	0.18 kW/scfm	US DOE
UF	Fixed	0.81, see the following table	Review of 12 air compressor projects, average
ηsavings	Fixed	10%, See figure below	US DOE
DC existing	Fixed	2 gal/scfm	Existing condition assumption
$CF_{comp\ air}$	Fixed	0.865	New Jersey's Clean Energy Program[99]

[99] DNV Kema, New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review, July 10, 2009.

The following table summarizes 12 projects air compressor load factors recorded and calculated from metered data.

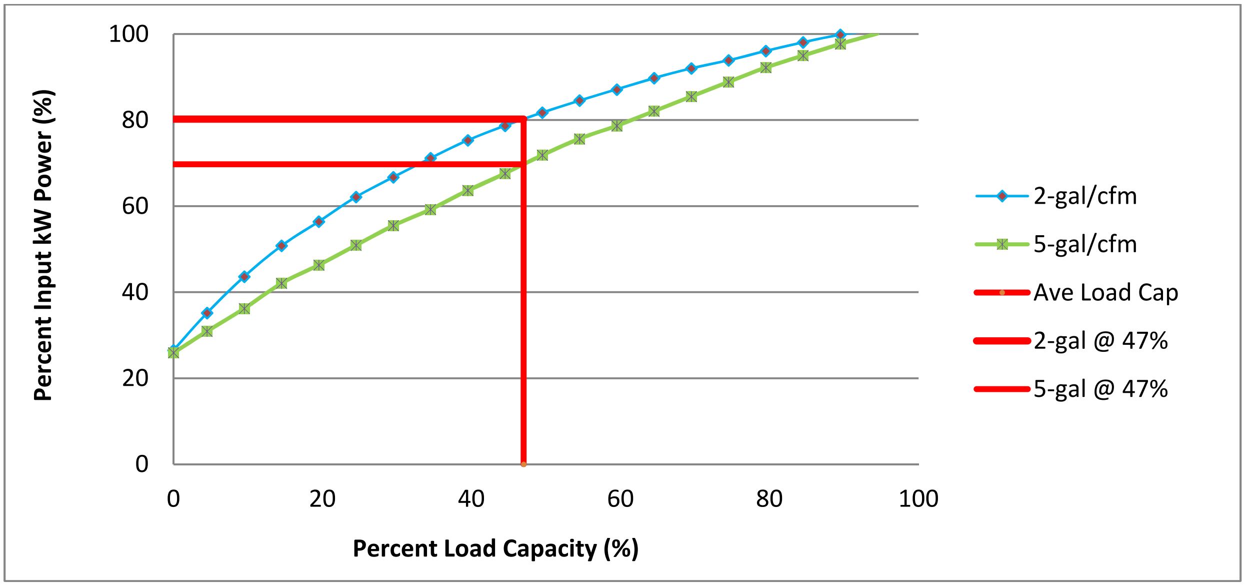
Table 154. Average Compressor Loading Summary

	File #	Controls	% Loading	Weekly Operating Hours	Use Factor
Michigan Program	CE 8420	VSD	16%	168	100%
	CE 7198	VSD	50%	168	100%
	CE 9239	VSD	53%	114	68%
	CE 8148	VSD	48%	168	100%
	CE 7345	VSD	45%	136	81%
	CE 7926	VSD	54%	146	87%
Ohio Program	KEMA - 1936	VSD	65%	30	18%
	KEMA - 2865	VSD	41%	113	67%
	KEMA - 3158	VSD	68%	167	99%
	KEMA - 0511	VSD	28%	114	68%
	KEMA - 1506	VSD	44%	144	86%
	KEMA - 2388	VSD	55%	168	100%
TOTALS			**47%**		**81%**

Assuming that the facilities' ability to generate compressed air equals the facilities' ability to properly dry the generated compressed air, the dryers' load factor would equal the air compressors' load factor of forty-seven percent (47%). Based on the compressed air system being continuously operated (8,760-hrs/yr), the usage factor (UF) is shown as eighty-one percent (81%). On average, the compressed air systems in these industrial projects operate approximately 7,100-hours per year. We believe that this compressed air measure will be installed in similar industrial facilities operating in similar circumstances. For this analysis, we have determined that a typical industrial facility using compressed air operates three (3) shifts per week or approximately 6,240-hrs/yr (24 hours per day, 5 days a week).

Some load/unload capacity control air compressors are claiming to be the most energy efficient, which is only true if the compressed air system has adequate compressed air receiver volume.[100] The following chart depicts the effect of receiver capacity on the compressed air systems energy consumption:

Figure 1. Effect of Receiver Capacity on Air Compressor Control[101]



Please note that the data on the preceding figure was originally developed for 1-gal/cfm, 3-gal/cfm, 5-gal/cfm, and 10-gal/cfm. The 2-gal/cfm curve was calculated through a linear relationship between the 1-gal/cfm and 3-gal/cfm curves on the original data set.

As depicted in the chart, assuming a forty-seven percent (47%) compressor load factor, the power draw of a 5-gal/cfm system draws approximately ten percent (10%) less power than a compressed air system with only 2-gal/cfm storage capacity.

$\eta_{Savings}$ = total percent of energy savings by increase the capacity of the receiver tank, %

$\eta_{2\text{-gal/cfm}}$ = percent input kW electrical power consumption of a 2-gal/cfm receiver system, %

$\eta_{5\text{-gal/cfm}}$ = percent input kW electrical power consumption of a 5-gal/cfm receiver system, %

[100] US DOE Energy Efficiency and Renewable Energy – Improving Compressed Air System Performance, a sourcebook for industry; Lawrence Berkeley National Lab, p 42-43.

[101] ibid.

$$\boldsymbol{\eta_{Savings}} = \eta_{5.gal/cfm} - \eta_{2.gal/cfm} = \mathbf{80\%} - \mathbf{70\%} = \mathbf{10\%}$$

The actual system efficiency will vary significantly depending on the air compressor type and application. Referencing a recent internal review of CAGI data sheets for rotary screw air compressor systems, compressor efficiencies of 0.19-kW/scfm to 0.23-kW/scfm were typically witnessed, with efficiencies approaching 0.29-kW/scfm for poorly performing, under-loaded systems. The results of this review is in line with other sources which show typical specific power at 100-psig at approximately 18-kW/100 scfm to 22-kW/100 scfm[102] and a common "rule of thumb" of 4 cfm per kW or 0.25-kW/scfm[103]. It is expected that industrial compressed air systems being retrofitted with this measure will not be the most efficient systems. The engineering calculations for this analysis assume a system efficiency of 0.20-kW/scfm.

Measure Life and Incremental Measure Cost

Measure life is assumed to be 10 years.[104] The incremental measure cost (IMC) is estimated to be $4.58 per gallon incremental receiver capacity over existing capacity (i.e. IMC($) = $4.58 x (Efficient tank size – existing tank size)). [105,106]

102 http://www.plantservices.com/articles/2008/013.html?page=2
103 http://www.airbestpractices.com/industries/plastics/bottler-best-practices-california
104 Efficiency Vermont (EVT) Technical Resource Manual (TRM)
105 See supplemental spreadsheet AEPAirReceiver.xlsx for regression cost curve. In line with the EVT TRM IMC of $5 per gallon incremental receiver capacity over existing capacity.
106 Regression analysis of tank prices sold by air receiver vendor: http://www.pneumaticdepot.com/

Cycling Compressed Air Dryer

Measure Description	This measure replaces a non-cycling refrigerated air dryer with a cycling refrigerated air dryer of equivalent capacity. Prescriptive incentives are limited to dryers whose capacities are equal to or less than 600 scfm; dryers with larger capacities are handled on a custom basis. The cycling dryer must run exclusively in cycling mode – the dryer cannot be equipped with a feature that allows it to run in a non-cycling mode and have dewpoint control.
Units	Per sCFM
Base Case Description	Compressed air system with a non-cycling refrigerated air dryer with a capacity of 600 scfm or less

Potential power savings over non-cycling refrigerated dryers arise when the compressor inlet air's heat and moisture content vary below the full load rating of the dryer. This can happen frequently under multiple conditions: 1) Seasonal changes where compressor inlet air has lower humidity (i.e. cold winters), or average air inlet temperatures are lower than the full load rating of the dryer, 2) less than full load flow through the dryer, 3) or air pressure at the inlet of the dryer is higher than the full load rating. These conditions affect the drying (cooling load) required by the discharge air of the compressor to reach an adequate temperature and relative humidity for the compressed air system. A cycling dryer allows the unit's compressor to cycle on and off relative to the 'drying demand' of the compressed air.

It is expected that the applicant must provide the following operating conditions of the compressed air system upon request in order to qualify for prescriptive incentives:

1. Daily, weekly, and annual operating schedule of the compressed air system
2. HP rating of the air compressor system that the existing and proposed dryers would be servicing
3. Rated flow rate (scfm) of existing and proposed dryers (Flow rates should be equivalent)
4. Rated and maximum operating flow rate of the compressor
5. Detailed load demand profile, or estimation of percentage of time the compressor will operate at full and 10% increments of partial load/flow

Measure Savings
The annual kWh and non-coincident kW savings per air dryer depends on the retrofit type.

Table 155. Measures Savings for Cycling Compressed Air Dryer (per scfm)

Dryer Type	kWh	kW
Thermal-Mass	10.48	0.00145
VSD	34.07	0.00472
Digital Scroll	32.32	0.00448
Average	25.62	0.00355

Measure Savings Analysis

Several sources were reviewed in order to gain a consensus of savings methodologies currently being used for cycling dryers. Although the best source would be large samples of cycling dryer projects that leverage power trend metering in order to develop an empirically derived savings unit (i.e. kW per full flow rated cfm of the dryer; kW/cfm), the sources reviewed did offer a consistent method for determining savings relative to the prescriptive criteria for this measure. The table below presents the sources reviewed, and the savings unit values used for the prescriptive cycling dryer measure.

Table 156. Cycling Dryer kW/cfm Savings by Source

Source	Savings Value (kW/cfm)		Notes
Massachusetts TRM	Dryer Capacity (cfm)	kW Reduction per cfm	Includes cycling dryers or dryers equipped with a VSD controller.
	< 100	0.00474	
	≥ 100 and < 200	0.00359	
	≥ 200 and < 300	0.00316	
	≥ 300 and < 400	0.00290	
	≥ 400	0.00272	
Efficiency Vermont TRM	0.00305[107]		Base/measure case dryer capacities are less than or equal to 600 cfm. Compressor load profiles were developed from motors ≤ 40 hp

[107] EVT TRM uses 1) a compressor cfm to baseline (non-cycling) dryer kW conversion factor of 0.0087 (kW/cfm), 2) an average compressor operating capacity of 65% to calculate, and 3) a derating factor of 0.925 to account for the chilled coil response time for cycling dryers, to develop a ‘kW/cfm’ savings unit. The derating factor was not included because this measure is a thermal mass dryer and is assumed to have a negligible coil response time (0.0087 x (1-65%) = 0.00305)

Source	Savings Value (kW/cfm)	Notes
AEP Ohio Compressed Air Project #1	0.00068	125 hp compressor; 800 rated cfm dryer (base/measure cfm are equivalent)
AEP Ohio Compressed Air Project #2	0.00805	40 hp compressor; 200 rated cfm dryer (base/measure cfm are equivalent)
Ingersoll Rand Nirvana Dryer specifications & TEP TRM	0.00211	Uses compressor operating hours distribution referenced from a Tucson Electric Power (TEP) TRM[108] spreadsheet to calculate an average compressor capacity(%). See AEPCyclicDryer.xlsx for derivation of savings value.
Average	0.00344	Average of above values

Savings assume that a non-cyclic refrigerated dryer is replaced with an equivalently sized cyclic thermal mass refrigerated dryer and the dryers are properly sized for the compressor they are serving. For the purposes of this prescriptive measure, the savings values were referenced but the following was the methodology used.

Referencing the Compressed Air Challenge Best Practices Cycling Refrigerate Air Dryers article dated November, 2011, fully loaded refrigerated air dryer specific power levels range between 0.6-kW and 0.8-kW per 100-scfm[109]. For this analysis, we shall use a specific power of 0.7-kW per 100-scfm or 0.007-kW per scfm.

The full load percentage energy consumption of ing dryers is based on the inlet volume flow rate percentage[110]. A typical Inlet Volume Flow Rate Percentage is fifty percent (50%). At this level, per the following 4 graphs, the full load percentage energy consumption is summarize in the following table.

[108] Tucson Electric Power Technical Resource Manual (TRM) No. 2008-1. VariableScrewComp_MAS_CI_TEP_2011_01_14.xlsx

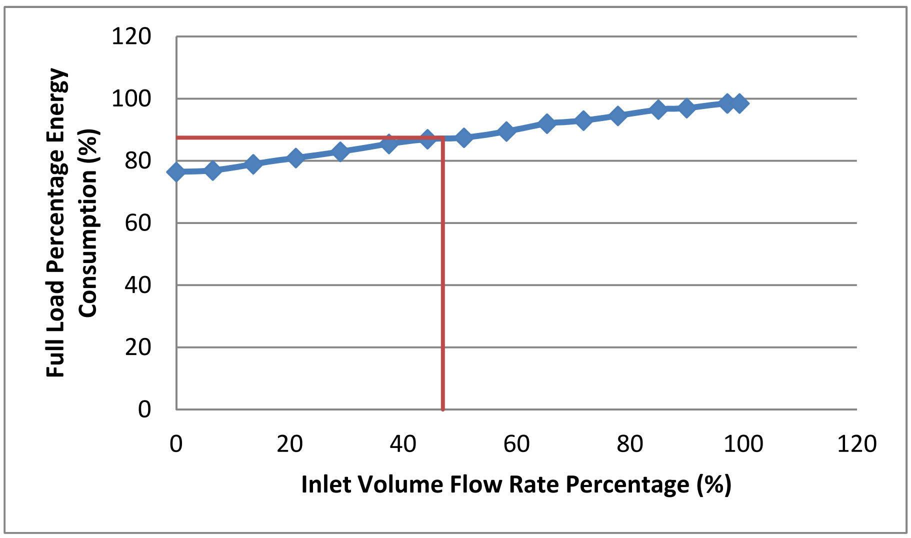
[109] Compressed Air Challenge: Compressed Air Best Practice, written by Timothy J. Fox and Ron Marshall – Cycling Refrigerated Air Dryers – Are Savings Significant?

[110] Compressed Air Challenge: Compressed Air Best Practice, written by Timothy J. Fox and Ron Marshall – Cycling Refrigerated Air Dryers – Are Savings Significant?

Table 157. Full Load Percentage Energy Consumption per Air Dryer Type

Dryer Type	%
Non-cycling	88%
Thermal-Mass	76%
VSD	49%
Digital Scroll	51%

Figure 2. NON-CYCLING COMPRESSED AIR DRYER[111]



[111] Compressed Air Challenge: Compressed Air Best Practice, written by Timothy J. Fox and Ron Marshall – Cycling Refrigerated Air Dryers – Are Savings Significant?

Figure 3. THERMAL-MASS CYCLING COMPRESSED AIR DRYER[112]

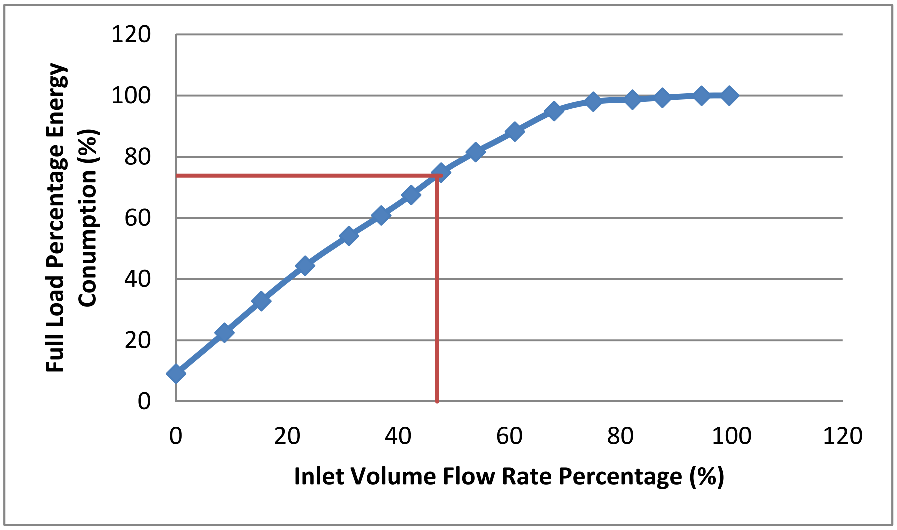
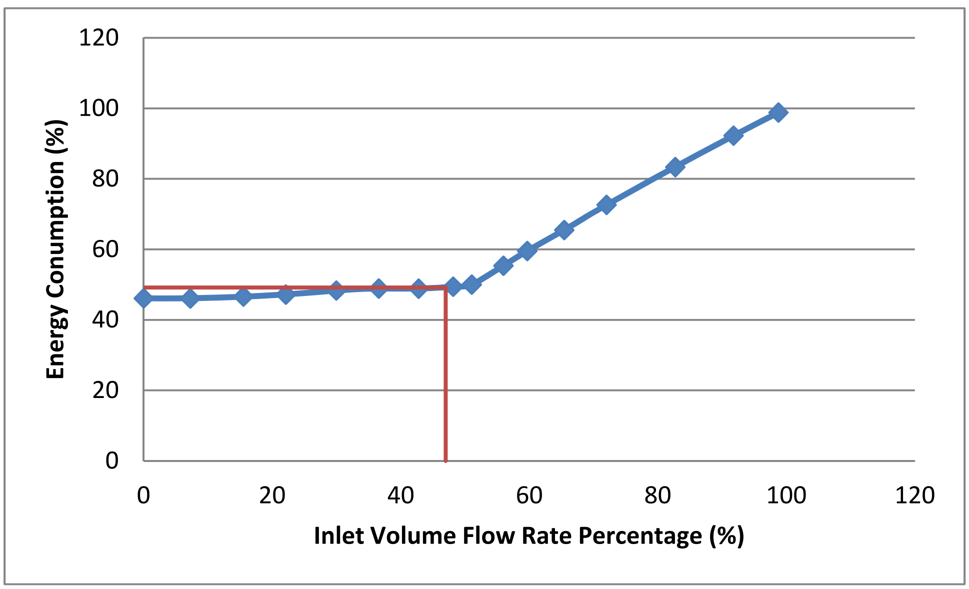


Figure 4. VSD CYCLING COMPRESSED AIR DRYER[113]



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[112] Compressed Air Challenge: Compressed Air Best Practice, written by Timothy J. Fox and Ron Marshall – Cycling Refrigerated Air Dryers – Are Savings Significant?
[113] Compressed Air Challenge: Compressed Air Best Practice, written by Timothy J. Fox and Ron Marshall – Cycling Refrigerated Air Dryers – Are Savings Significant?

Annual energy (kWh) and non-coincident average demand (kW) saved are calculated using the simple equations below:

$$kWh_{saved} = \left(\frac{kW}{cfm} dryer\right) \times (cfm_{dryer}) \times \left(PL\%_{non-cycling} - PL\%_{new\ dryer}\right) \times (Hours)$$

$$kW_{saved} = \left(\frac{kW}{cfm} dryer\right) \times (cfm_{dryer}) \times \left(PL\%_{non-cycling} - PL\%_{new\ dryer}\right) \times CF_{comp\ air}$$

Definition of Variables

$Hours$ = *Projected operating hours of the dryer*

$\frac{kW}{cfm} dryer$ = *Power (kW) per rated dryer capacity (cfm) reduced by measure*

cfm_{dryer} = *Full flow rated capacity of the refrigerated air dryer in cubic feet per minute (cfm)*

$PL\%_{non-cycling}$ =*Typical non-cycling compressed air dryer's part-load percent of energy consumption at 50% inlet volume flow rate operation*

$PL\%_{new\ dryer}$ = *New cycling compressed air dryer's part-load percent of energy consumption at 50% inlet volume flow rate operation*

$CF_{comp\ air}$ = *compressed air coincidence factor, 86.5 %*

Table 158. Variables for Cycling Dryer Savings

Component	Type	Value	Source
$\frac{kW}{cfm} Savings$	Fixed	0.007	See above
cfm_{dryer}	Variable	cfm ranges through 600 cfm Default: 300 cfm	Application, DNV KEMA
PL %			See Table 157. Full Load Percentage Energy Consumption

Component	Type	Value	Source
			per Air Dryer Type
Hours	Variable	Hours range through 8,760 hours. Default: 6,240 hours[114]	Application, DNV KEMA
$CF_{comp\ air}$	Fixed	0.865	New Jersey's Clean Energy Program[115]

Measure Life and Incremental Measure Cost
Measure life is assumed to be 15 years.[116] The incremental measure cost (IMC) is estimated to be $2.47 per scfm.[117]

No Loss Condensate Drain for Compressed Air Systems

Measure Description	A no loss condensate drain is controlled by a sensor that monitors the level of condensate in the trap, and opens only for enough time for the condensate to be purged without the unintentional purging and wasting of compressed air. This measure describes the savings associated with the installation of a no loss condensate drain in both new and retrofit compressed air system projects. The condensate drain being replaced (or being proposed in new construction projects) must be a timed drain or manually opened drain. Manual drains, timed drains, and electronic solenoid valve drains are not considered no loss drains, and are not eligible. This prescriptive measure is eligible for compressed air systems whose rated horse-power (HP) is less than or equal to 300 HP. The compressed air system HP shall not include redundant, backup, or out-of-service compressors.
Units	Per drain
Base Case Description	Timed or manually opened condensate drain

[114] 16 hours per day, 5 days per week, minus 9 holidays and 3 scheduled down time days
[115] DNV Kema, New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review, July 10 2009.

[116] After reviewing Efficiency Vermont (EVT) Technical Resource Manual (TRM), February 2010; and Massachusetts TRM, 2011 Program Year, October 2010
[117] EVT TRM 2010

It is expected that the applicant must provide the following operating conditions upon request in order to qualify for prescriptive incentives:

1. Daily, weekly, and annual operating schedule of the compressed air system
2. Existing flow control method (Load/No Load (LNL), variable-speed, variable displacement (VD), etc.)
3. Compressed air system operating pressure
4. Type of drain being replaced (e.g. timed drain, manual drain, solenoid valve drain, etc.)
5. Purging orifice size of drain being replaced and new drain.
6. If a timed drain is being replaced, the time interval between openings and the amount of time that the drain remains open. If a manual drain or other type of drain, an estimate of time that the drain is opened and frequency of opening intervals.

Measure Savings
The annual kWh and peak demand kW savings per drain is 931 kWh per year and 0.2033 peak kW.

Measure Savings Analysis
Energy savings is realized from this measure by estimating the amount of compressed air saved from unintentional purging through a conventional timed drain. Unintentionally purged air must eventually be remade for the system to maintain its operating pressure so the compressor works longer to reclaim that lost air. Below is a frequently referenced table that estimates air loss based on system operating pressure and drain orifice diameter.

Table 159. Air Loss Rates (cfm) by Operating Pressure and Orifice Diameter[118]

Pressure (psig)	Orifice Diameter (inches)					
	1/64	1/32	1/16	1/8	1/4	3/8
70	0.29	1.16	4.66	18.62	74.4	167.8
80	0.32	1.26	5.24	20.76	83.1	187.2
90	0.36	1.46	5.72	23.1	92	206.6
100	0.4	1.55	6.31	25.22	100.9	227
125	0.48	1.94	7.66	30.65	122.2	275.5

The table will provide the assumed air loss rate through the timed drain for the portion of time when the drain is open and purging compressed air instead of condensate. The following

[118] For well rounded orifices, values should be multiplied by 0.97 and by 0.61 for sharp ones. Source: Compressed Air Challenge (CAC), "Compressed Air Tip Sheet #3", August, 2004

equations are used to estimate the energy (kWh) and demand (kW) savings from replacing a timed drain with a no loss drain. The timed drain is assumed to open according to a preset schedule regardless of condensate level, while the no loss drain operates only when there is a need to drain condensate and closes before compressed air can be purged. For this analysis, we have determined that a typical industrial facility using compressed air operates three (3) shifts per week or approximately 6,240-hrs/yr.

The annual hours the timed drain operates (t) is based on one (1) cycle every ten (10) minutes, each cycle lasts 10 seconds, throughout the year[119].

$$t = \frac{6\ cycles}{hr} \times \frac{10\ sec}{cycle} \times \frac{1\ min}{60\ sec} \times \frac{1\ hr}{60\ min} \times \frac{6{,}240\ hrs}{yr} = \mathbf{104\ hrs/yr}$$

The actual system efficiency will vary significantly depending on the air compressor type and application. Referencing a recent internal review of CAGI data sheets for rotary screw air compressor systems, compressor efficiencies of 0.19-kW/scfm to 0.23-kW/scfm were typically witnessed, with efficiencies approaching 0.29-kW/scfm for poorly performing, under-loaded systems. The results of this review is in line with other sources which show typical specific power at 100-psig at approximately 18-kW/100 scfm to 22-kW/100 scfm[120] and a common "rule of thumb" of 4 cfm per kW or 0.25-kW/scfm[121].

It is expected that industrial compressed air systems being retrofitted with this measure will not be the most efficient systems. The engineering calculations for this analysis assume a system efficiency of 0.20-kW/scfm.

The Efficiency Vermont Technical Resource Manual[122] (EVT TRM 2010) has been heavily referenced due to the comprehensive approach that its no loss condensate drain methodology follows.

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119 Efficiency Vermont Technical Reference User Manual – Measure Savings Algorithms and Cost Assumptions. February 19, 2010

120 http://www.plantservices.com/articles/2008/013.html?page=2

121 http://www.airbestpractices.com/industries/plastics/bottler-best-practices-california

122 Efficiency Vermont Technical Resource Manual – Measure Savings Algorithms and Cost Assumptions. February 19, 2010

$$kWh_{saved} = ALR \times ODT \times \frac{kW}{cfm}_{compressor}$$

$$kW_{saved} = \frac{kWh_{saved}}{Hours} \times CF_{air\ compress}$$

Definition of Variables

kWh_{saved} = *Annual energy (kWh) saved per no loss drain*

kW_{saved} = *Power demand (kW) saved per no loss drain*

ALR = *Air loss rate (cfm) of base case drain when valve/orifice is open*

ODT = *Open drain time (hours) – the cumulative amount of time that the base case (timed) drain is open during the annual operating schedule*

$\frac{kW}{cfm}_{compressor}$ = *Compressor average power demand per cfm compressed air produced.*

$CF_{comp\ air}$ = *Compressed air coincidence factor, 86.5 %*

Table 160. Variables for No Loss Condensate Drain Savings

Component	Type	Value	Source
ALR	Multiple	Orifice size and operating pressure required on application. ALR default = 92 cfm. (See Table 159)	Compressed Air Challenge (CAC), "Compressed Air Tip Sheet #3", August, 2004
ODT	Variable	Open time interval required on application, if timed drain retrofit. Default = 104 hours	DNV KEMA
$\frac{kW}{cfm}_{compressor}$	Multiple	Default = 0.2 kW/cfm	Compressed Air Challenge (CAC), "Compressed Air Tip Sheet #3", August, 2004
$CF_{comp\ air}$	Fixed	0.865	New Jersey's Clean Energy Program[123]

Measure Life and Incremental Measure Cost

[123] DNV Kema, New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review, July 10 2009.

Measure life is assumed to be 5 years.[124] The incremental measure cost (IMC) is estimated to be $200 per drain[125].

Low Pressure Drop Filter for Compressed Air Systems

Measure Description	Filters must be installed on compressor systems whose rated horse-power (HP) is greater than 25-HP, but less than or equal to 300-HP and have a rated capacity ≤ 500 SCFM. Filter must be of the deep-bed "mist eliminator" style, have a pressure loss at rated flow ≤ 1 psi when new and ≤ 3 psi at element change, have particulate filtration that is 100% at ≥ 3.0 microns and at least 99.98% at 0.1 to 3.0 microns, be rated for ≤ 5 PPM liquid carryover, and have a filter element life greater than or equal to five (5) years.
Units	Per scfm
Base Case Description	Standard performance air filter

The replacement of standard filters with high performance, low pressure drop filters can prevent the over filtering of compressed air systems and save energy by reducing the cumulative pressure drops throughout the compressed air system. The energy savings result from allowing a lower pressure set point at the compressors, thereby reducing system pressure and maximizing air flow. Suitable air filters should have high dust separation capacity, low-pressure drops, and robust design to avoid frequent cleaning and replacement.

Measure Savings

The annual kWh and peak kW savings per scfm is 14.98 kWh and 0.00315 kW.

Measure Savings Analysis

Pressure drops in the compressed air distribution system should always be minimized. For every 2-psig reduction at the compressor, 1% reduction in power draw can be achieved, as a result of the compressor not having to work as hard to overcome the pressure drops throughout

124 EVT TRM 2010
125 EVT TRM 2010

the system[126]. The table below shows the relationship between the pressure drop across an air filter and the power consumption at the compressor.

Table 161. Effect of pressure drop across the filter on increase in power consumption

Pressure Drop Across Air Filter (mmWC)	Increase in Power Consumption (%)
0	0
200	1.6
400	3.2
600	4.7
800	7

As a general rule, "For every 250 mm WC pressure drop increase across at the suction path due to choked filters etc, the compressor power consumption increases by about 2 percent for the same output"[127]. A rule of thumb is that a pressure drop of 2 psi will reduce the capacity by 1% (USDOE, 2010). The table below presents findings from various sources on average pressure drops across filters before and after filter replacement.

Table 162. Estimated Pressure Drops Across Filter by Source

Pressure Drop Across	Baseline Pressure Drop (psig)	Retrofit Pressure Drop (psig)	Energy Savings	Source	
Filter	6	2	2%	*Best Practices & Preventive Maintenance Strategies for Compressed Air Systems* (US DOE, 2010)	
Dryer + Filter			4 - 6%	*Industrial Motor Systems Market Opportunities Assessment* (US DOE, 1998)	
Filter	4	0.5		National Resources Canada[128]	
Dryer + Filter	10	3	5%	National Resources Canada	
Filter	6-10	1.5		*Compressed Air Energy* Efficiency (A. Bhatia. Continuing Education and Development, Inc.)	

[126] US DOE Energy Efficiency and Renewable Energy – Improving Compressed Air System Performance, a sourcebook for industry; Lawrence Berkeley National Lab, p 35.
[127] Ministry of Power, Government of India, Bureau of Energy Efficiency. (2005). *National certificate examination for energy managers and energy auditors - chapter 3.3 compressed air system*. New Delhi
[128] Cunha, I. National Resources Canada . *Compressed Air Energy Efficiency Reference Guide.* CEA Technology (2007)

Using these values, the following averages have been derived for use in calculation.

Table 163. Average Pressure Drops Across Single Filter

Baseline Pressure Drop (psi)	Retrofit Pressure Drop (psi)	Approximate Capacity Reduction
5	1	2.00%

The actual system efficiency will vary significantly depending on the air compressor type and application. Referencing a recent internal review of CAGI data sheets for rotary screw air compressor systems, compressor efficiencies of 0.19-kW/scfm to 0.23-kW/scfm were typically witnessed, with efficiencies approaching 0.29-kW/scfm for poorly performing, under-loaded systems. The results of this review is in line with other sources which show typical specific power at 100-psig at approximately 18-kW/100 scfm to 22-kW/100 scfm[129] and a common "rule of thumb" of 4 cfm per kW or 0.25-kW/scfm[130].

[129] http://www.plantservices.com/articles/2008/013.html?page=2
[130] http://www.airbestpractices.com/industries/plastics/bottler-best-practices-california

The following table summarizes 12 projects air compressor load factors recorded and calculated from metered data.

Table 164. Average Compressor Loading Summary

	File #	Controls	% Loading	Weekly Operating Hours	Use Factor
Michigan Program	CE 8420	VSD	16%	168	100%
	CE 7198	VSD	50%	168	100%
	CE 9239	VSD	53%	114	68%
	CE 8148	VSD	48%	168	100%
	CE 7345	VSD	45%	136	81%
	CE 7926	VSD	54%	146	87%
Ohio Program	KEMA - 1936	VSD	65%	30	18%
	KEMA - 2865	VSD	41%	113	67%
	KEMA - 3158	VSD	68%	167	99%
	KEMA - 0511	VSD	28%	114	68%
	KEMA - 1506	VSD	44%	144	86%
	KEMA - 2388	VSD	55%	168	100%
TOTALS			**47%**		**81%**

Assuming that the facilities' ability to generate compressed air equals the facilities' ability to properly dry the generated compressed air, the dryers' load factor would equal the air compressors' load factor of forty-seven percent (47%). Based on the compressed air system being continuously operated (8,760-hrs/yr), the usage factor (UF) is shown as eighty-one percent (81%). On average, the compressed air systems in these industrial projects operate approximately 7,100-hours per year. We believe that this compressed air measure will be installed in similar industrial facilities operating in similar circumstances. For this analysis, we have determined that a typical industrial facility using compressed air operates three (3) shifts per week or approximately 6,240-hrs/yr (24 hours per day, 5 days a week).

The annual kWh and non-coincident kW savings are calculated per the sum total HP of the existing compressor system at the facility using the following equation:

$$kWh_{saved} = V_{system} \times PRC \times \eta_{air\ comp} \times t$$

$$kW_{saved} = (kWh_{saved}) \times CF_{comp\ air} \div t$$

Where:

V_{system}	=	Total volume flow rate of the system, provided by the Customer, scfm
PRC	=	Percent Reduction in Capacity, 2.0%
$\eta_{air\ comp}$	=	Compressed air generation efficiency, 0.20-kW/scfm[131]
t	=	Typical production annual hours of operation, 6,240-hrs/yr[132]
$CF_{comp\ air}$	=	compressed air coincidence factor, 86.5 %[133]

Measure Life and Incremental Measure Cost

Measure life is assumed to be 5 years. The incremental measure cost (IMC) is estimated to be $75 per filter.

131 US DOE Energy Efficiency and Renewable Energy – Energy Tips: Compressed Air Tip Sheet #3, August 2004.

132 Focus on Energy Evaluation "Business Programs: Deemed Savings Manual V1.0" March 22, 2010, using a 50/50 weighting of industrial and commercial values.

133 DNV Kema, New Jersey's Clean Energy Program Energy Impact Evaluation and Protocol Review, July 10, 2009.

Agriculture

VSD on Dairy Milking Pumps (Agricultural)

Measure Description	Vacuum Pump: • Existing milking pump must operate at constant speed. • Applicants are required to submit the following information: o Nominal HP of pump o Number of milking units controlled by pump/VSD o Estimated hours per day milking pump operates o Estimated days per year that milking pump runs Transfer Pump: • Transfer pump must be used in conjunction with a once-through well water-to-milk pre-cooler • Existing transfer pump must operate at a constant speed. • Applicants are required to submit the following information: o Nominal HP of pump o Estimated days per year that pump runs
Units	Vacuum Pump VSD: Per Horsepower (HP)
	Transfer Pump VSD: Per 100 gallons of milk production per day
Base Case Description	Milk Vacuum Pumping Station without a VSD control, or Milk Transfer Pumping Station with a pre-cooler plate, but without a VSD control

Two VSD measures with similar applications are covered in this work paper – VSD for milking transfer pumps and VSD for milk vacuum pumps. VSD controls on milk transfer pumps allows the motor to match its speed with the amount (load) of milk in the receiver tank and allows a more uniform flow over the pre-cooler plate, which increases the plate's effectiveness and reduces the amount of energy needed to mechanically cool the milk. Note that a pre-cooler plate is a prerequisite for this measure to be incentivized. VSD controls on milk vacuum pumps modulate the speed of the pump when the milking units are taken on and off the cows' udders. Less vacuum is needed when the units are attached to udders, thus appreciable savings are realized (due to lower motor speeds) during the actual milking process, and also help by reducing possible udder irritation/inflammation due to high pressure suction.

Measure Savings

The coincident kW and the annual kWh savings per pump HP controlled by VSD are documented below. The savings are heavily informed by the measures and assumptions covered in the California PG&E work papers developed by EnSave, Inc[134][135].

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[134] PG&E Measure Codes WPenNRPR0006 Rev7 (Milk Vacuum Pump VSD. EnSave, Inc. March 10, 2010) and WPenNRPR0004 Rev11 (Milk Transfer Pump VSD. EnSave, Inc. March 5, 2010)

Table 165. Measure Savings for Milking Pump VSDs (per unit)

Measure	Unit Definition	kWh	Peak kW
Milking Vacuum Pump VSD	HP	2,409	0.440
Milking Transfer Pump VSD	100 gallons of milk production per day	142.4	0.013

Measure Savings Analysis

Milk Vacuum Pump:

The following equation is used to estimate the milking vacuum pump VSD savings:

$$Annual\ kWh\ Savings\ per\ HP = \frac{[(HP - (0.25 \times MilkUnits)) \times 0.88 \times MilkHours \times MilkDays]}{HP}$$

$$Peak\ kW\ Savings\ per\ HP = \frac{Annual\ kWh\ Savings\ per\ HP}{MilkHours \times MilkDays} \times CF$$

Where,

$HP = Pump\ power\ in\ horsepower$

$0.25 = HP\ required\ per\ milking\ unit\ that\ VSD\ uses$

$MilkUnits = Numbers\ of\ milking\ units\ with\ VSD$

$0.88 = {}^{kW}/_{HP}\ conversion\ and\ efficiency\ (Assumed\ 85\%)\ constant. \frac{0.746\ {}^{kW}/_{HP}}{0.85} = 0.88$

$MilkHours = Hours\ per\ day\ milking\ pump\ runs$

$MilkDays = Days\ per\ year\ that\ milking\ pump\ runs$

$CF = On\ peak\ coincidence\ factor$

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[135] The PG&E VSD Vacuum pump work paper value was derived using an equation for the California 2006-2008 Dairy Energy Efficiency Program and averaged results across all installations

Table 166. Variables for Milking Vacuum Pump VSD Savings[136]

Component	Type	Value	Source
MilkUnits	Variable	Default: 10 units	DNV KEMA
MilkHours	Variable	Default: 15 hours (3x per day, 5 hours each milking, assumed conservative)	DNV KEMA
MilkDays	Variable	Default: 365 days	DNV KEMA
HP	Variable	Default: 5 HP	DNV KEMA
CF	Constant	1.0	DNV KEMA
0.25 HP	Constant	0.25 HP per milking unit that VSD consumes	PG&E Milk Transfer Pump VSD work paper (WPenNRPR0004.11)
0.88 kW/HP	Constant	Conversion from HP to kW (0.746 kW/HP) and assumed 85% motor efficiency	PG&E Milk Transfer Pump VSD work paper (WPenNRPR0004.11)

To form variable estimates based on the Ohio state milking production, an Ohio source[137] was used to approximate average farm size (i.e. milking units) and milking rates per day.

Milk Transfer Pump:

The following equation is used to estimate the milking transfer pump VSD savings:

$$\frac{Annual\ kWh\ Savings}{100\ gallons\ per\ day\ of\ milk\ production\ per\ dairy\ site} = 0.39\ \times MilkDays = AnnualkWh$$

$$\frac{Peak\ kW\ Savings}{100\ gallons\ per\ day\ of\ milk\ production\ per\ dairy\ site} = \frac{AnnualkWh}{AnnualOperatingHours} \times CF$$

Where,

$0.39 = Daily\ savings\ in\ kWh\ per\ 100\ gallons\ milk\ production$

[136] Reference to: "Variable Frequency Drives in Dairy Vacuum Milking Systems". Prepared by Southern California Edison (SCE), Design and Engineering Services. March 25, 1998. This source was used to find a proxy for pump size and number of milking units for a farm size typical to Ohio (See footnote below)

[137] www.ohiodairyfarms.com estimates that, in Ohio, there are 272,000 dairy cows that live on more than 3,200 dairy farms. In 2010, Ohio's dairy cows produced more than 600 million gallons of milk. This equates to approximately 85 cows per dairy farm, and about 6 gallons of milk per cow per day.

$365 = Number\ of\ days\ per\ year\ dairy\ farm\ produces\ milk$

$CF = On\ peak\ coincidence\ factor$

$AnnualOperatingHours = Number\ of\ hours\ milking\ transfer\ pump\ is\ in\ operation\ per\ year$

Table 167. Variables for Milking Transfer Pump VSD Savings

Component	Type	Value	Source
0.39	Constant	0.39 kWh/day/100gal	kW Engineering. March 15, 2007. EM&V for the 2004-2005 California Multi-Measure Farm Program
MilkDays	Variable	Default: 365	PG&E Milk Transfer Pump VSD work paper (WPenNRPR0004.11)
CF	Constant	0.5	PG&E Milk Transfer Pump VSD work paper (WPenNRPR0004.11)
AnnualOperatingHours	Variable	Default: 5,475 hours (15 hours per day, 365 days per year)	2006-2008 California Dairy Energy Efficiency Program, as discussed in the PG&E Milk Transfer Pump VSD work paper (WPenNRPR0004.11)

Measure Life and Incremental Measure Cost

The measure life for both measures, the VSD on milk transfer pumps and VSD on milk vacuum pumps, is 15 years, according to DEER 2008.

The next table provides incremental measure cost (IMC) documented for this measure. Incremental cost is cost difference between the VSD-controlled pump and the non-VSD-controlled (constant speed or on/off) pump. Note that the measure units are different for each measure – the vacuum pump VSD unit is per motor HP and the transfer pump VSD unit is per 100 gallons of milk production per day.

Table 168. VSD for Milk Pump Applications Incremental Measure Cost ($/HP)[138]

Measure	IMC ($/unit)
VSD for Milking Vacuum Pump	$468/HP
VSD for Milk Transfer Pump	$32.86/100 gal milk/day

[138] The VSD for milk vacuum pumps was derived in the PG&E work paper as the average per-drive cost from all milk vacuum pump VSD installations during the 2006-2008 California Dairy Energy Efficiency Program ($6,631) divided by the corresponding average of 14.2 HP per drive. The VSD for milk transfer pumps was derived as the average of all VSD transfer pump installations during the 2006-2008 California Dairy Energy Efficiency Program ($2,257) divided by the corresponding average of 68.68 hundreds of gallons of daily milk production.

Low Pressure Nozzles (Agricultural)

Measure Description	Low pressure sprinkler nozzles that replace (by retrofit) high pressure sprinkler nozzles with an operating pressure of greater than 50 psi at the sprinkler head are eligible for an incentive. Permanent or solid set (nozzle placement fixed in the area being irrigated) and portable, hand-move nozzles are allowed for incentive. The pumping plant for the farmland must rely on electric pumping, and must have an overall pumping efficiency of 45% or above.
Units	Per nozzle
Base Case Description	High pressure sprinkler nozzle of respective application (50 psi or higher)

This low pressure sprinkler nozzle is for irrigation field applications only. High pressure nozzles generally break water droplets in to various sizes over its coverage; low pressure nozzles have different orifice shapes to accomplish the same water coverage while operating under a lower pressure, thus requiring less pumping energy and less water.

Measure Savings

The coincident kW and the annual kWh savings per low pressure nozzle are documented below. The savings are based on the measures and assumptions covered in the 2005 DEER which heavily references the California Express Efficiency nozzle measure[139,140].

Table 169. Measure Savings for Low Pressure Sprinkler Nozzles (per nozzle)

Measure	kWh	kW
Portable	31.25	0.029
Solid Set	9.25	0.00375

Measure Savings Analysis

The low pressure nozzle measure documented in the 2005 DEER has savings estimates for central valley and coastal/coastal valley California regions. It is assumed that these regions' energy savings differences are based primarily on net water applied per acre of irrigated land, which is assumed to be highly correlated to average annual temperatures and relative humidity. The measure savings applied for Ohio will be a weighted mix of central valley and coastal/coastal valley California regional DEER savings – 75% central valley and 25%

[139] DEER Measure IDs D03-970 and D03-971
[140] Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.

coastal/coastal valley, based on judgment after review of differences between annual average relative humidity and temperatures of Ohio and California.

Measure Life and Incremental Measure Cost

The measure life for low pressure sprinkler nozzles is 3 years for portable-set nozzles and 5 years for solid-set nozzles, according to DEER 2008.

The next table provides incremental measure cost (IMC) documented for this measure. Incremental cost is cost difference between the energy-efficient equipment and the less efficient option.

Table 170. Low Pressure Sprinkler Nozzle Incremental Measure Cost[141]

Measure	Solid-Set	Portable-Set
Low Pressure Sprinkler Nozzle	$1.74	$1.24

Sprinkler to Drip Irrigation (Agricultural)

Measure Description	To qualify for incentives, the existing irrigation system must consist of high pressure sprinkler nozzles operating at 50 psi or more, and retrofitted with a micro-irrigation system. Incentives are not applicable to new planting of vineyards or orchards unless the previous crop was one of the aforementioned (For means of comparing energy needs). Drip tape systems do not qualify as micro-irrigation systems due to their shorter life time.
Units	Per acre
Base Case Description	High pressure sprinkler nozzle irrigation of respective application (50 psi or higher)

Micro-irrigation systems consist of systems of above and below ground pipelines and hoses that deliver water under pressure, to specialized drip devices located at, or very near, individual plants. The basic intent is to accurately supply small amounts of water on a frequent basis so as to maintain constant, comparatively high, root-zone soil moisture. There are possible energy and water savings by converting from a high pressure sprinkler irrigation system to a micro-irrigation system because the irrigation system's water pressure is reduced, and because these

[141] DEER 2005

systems have a potentially higher irrigation efficiency (lower wind sensitivity and lower evaporation losses) thus reducing the amount of water pumping energy required.

Measure Savings

The coincident kW and the annual kWh savings per acre of crop land irrigated are documented below. The savings are based on the measures[142] and assumptions covered in the 2005 DEER and a PG&E workpaper[143], which heavily reference the California Express Efficiency agriculture measure[144,145,146].

Table 171. Measure kWh Savings for Micro-Irrigation (per acre)

Measure	Field/Vegs kWh		Deciduous Trees kWh		Citrus Trees kWh		Grapes kWh	
Micro-Irrigation	Non well	Well	Non well	Well	Non well	Well	Non well	Well
	385.75	444	590.75	688.25	566.25	660.25	466.5	543.5
Average	543.2							

Table 172. Measure kW Savings for Micro-Irrigation (per acre)

Measure	Field/Vegs kWh	Deciduous Trees kWh	Citrus Trees kWh	Grapes kWh
Micro-Irrigation	0.354	0.309	0.169	0.213
Average	0.261			

Measure Savings Analysis

The micro-irrigation measure documented in the 2005 DEER has savings estimates for central valley and coastal/coastal valley California regions. It is assumed that these regions' energy savings differences are based primarily on net water applied and absorbed per acre of irrigated land, which is assumed to be highly correlated to average annual temperatures and relative

[142] DEER Measure IDs D03-972, D03-974, D03-975, D03-978, D03-979
[143] "Sprinkler to Drip Irrigation". Work paper PGECOAGR111 Revision #2.
[144] Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
[145] Canessa, 1995. Micro-Irrigation for Energy-Use Reduction, San Luis Obispo, CA.
[146] Canessa, Peter. 2002. Review of Sprinkler to Micro Irrigation Conversion – An Express Efficiency Measure, Fresno, CA

humidity. The measure savings applied for Ohio will be a weighted mix of central valley and coastal/coastal valley California regional DEER savings – 75% central valley and 25% coastal/coastal valley, based on judgment after review of differences between annual average relative humidity and temperatures of Ohio and California.

Measure Life and Incremental Measure Cost
The measure life for micro-irrigation is 20 years, according to DEER 2008. The incremental measure cost (IMC) is $1,000 per acre, according to DEER 2005.

Engine Block Heater Timer (Agricultural)

Measure Description	Engine block heater timers save energy by reducing the amount of time that the heaters operate. Typical heater operation involves the heater being plugged in during the night, and staying on until the engine is used in the morning. With a timer-controlled heater, the heater can turn on at a pre-set time during the night, therefore only supplying power to the engine block heater when it's needed. In addition to the timer function, the timers included under this measure require a thermostat function that restricts power from being delivered to the engine block heater if ambient temperature is above a certain threshold, typically 39°F.
Units	Per timer, controlling a single engine block heater
Base Case Description	An engine block heater that is turned on/off manually

Measure Savings
The annual kWh savings per engine block timer is 576 kWh per year per timer. There is no peak demand or non-coincident demand savings because it is assumed that the timer (and heater) is operating only during off-peak hours and there is no reduction in heater load because of the timer.

Measure Savings Analysis
The annual kWh savings are calculated using the following equation:

$$Annual\ kWh\ Savings\ per\ timer = Power\ \times Hours\ x\ Days\ \times (1 - ManualUse)$$

Where,

$$Power = Load\ of\ engine\ block\ heater\ in\ kW$$

$$Hours = Number\ of\ Hours\ per\ night\ that\ engine\ block\ heater\ timer\ offsets\ compared\ to\ manual\ operation$$

$* \, Includes \; time \; that \; thermostat \; overrides \; timer.$

$Days = \; Number \; of \; days \; per \; year \; that \; engine \; block \; heater \; is \; used$

$ManualUse = Fraction \;\; of \; time \; that \; engine \; block \; heater \; is \; used \; manually$

It is assumed that a typical engine block heater without a timer would be turned on during the night before the operator retires for the day, and is turned off when the operator resumes work in the morning. This amount of time can vary significantly depending on the operator; however, it is assumed that a typical time range would be around 10-12 hours. The timer would turn the heater on only long enough to sufficiently heat the engine, which typically can range from 2-4 hours.

Table 173. Variables for Engine Block Timer Savings[147]

Component	Type	Value
Power	Variable	Default: 1 kW. Depending on engine size, heaters typically range from 0.4 kW to 2 kW[148]
Hours	Variable	Default: 8 hours.
Days	Variable	Default: 90 days (Heater used during coldest months only)
ManualUse	Variable	Default: 0.20 (Assumes timer is not used/used incorrectly 20% of the time)

Measure Life and Incremental Measure Cost

The measure life for engine block heater timers is assumed to be 11 years, with reference to DEER 2008 that reports the EUL of “Time Clocks (heating/cooling)”. While the actual application for these time clocks may not apply to engine block heater timers, other DEER time clock applications ranged between 8 and 11 years. The relatively low usage of the engine block heater timer gives reasonable conclusion to use the upper bound of 11 years.

The incremental measure cost (IMC) documented for this measure is $40 per timer[149].

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[147] DNV KEMA assumptions

[148] http://www.focusonenergy.com/files/Document_Management_System/Business_Programs/engineblockheaters_factsheet.pdf

[149] Ibid. The fact sheet referenced above states that 120-volt block heaters drawing 1.8 kW or less can accept plug-in timers that cost $20, and for 240-volt, 1.8 kW or more block heaters, timers can range from $40-60. The mid-range was taken to be the average IMC ($40)