DEEMED SAVINGS TECHNICAL ASSUMPTIONS

Product: Lighting Efficiency

Prescriptive rebates will be offered for replacement lighting equipment. New Construction rebates will be offered for new facilities or spaces overhauled for a new purpose.
Custom rebates are available for lighting-related improvements that are not prescriptive.

Algorithms:

Electrical Demand Savings (Customer kW)	= (kW_Base - kW_EE) x HVAC_cooling_kWsavings_factor
Electrical Energy Savings (Customer kWh/yr)	= (kW_Base - kW_EE) x Hrs x HVAC_cooling_kWhsavings_factor
Natural Gas Savings (Dth)	= (kW_Base - kW_EE) x Hrs x HVAC_heating_penalty_factor
Lighting Controls -Electrical Energy Savings (Customer kWh/yr)	=(kW connected) x (1-PAF) x Hrs x HVAC_cooling_kWhsavings_factor
Lighting Controls -Electrical Demand Savings (Customer kW)	=(kW connected) x (1-PAF) x HVAC_cooling_kWsavings_factor
Lighting Controls -Natural Gas Savings (Dth)	=(kW connected) x (1-PAF) x Hrs x HVAC_heating_penalty_factor
Electrical Energy Savings (Gross Generator kWh)	= Customer kWh / (1-TDLF)
Electrical Demand Savings (Gross Generator kW)	= Customer kW x CF / (1-TDLF)
Electrical Energy Savings (Net Generator kWh)	= Gross Generator kWh x NTG
Electrical Demand Savings (Net Generator kW)	= Gross Generator kW x NTG

Variables:

Hrs	= Annual Operating Hours. Hours to be obtained from Table 2. The type of facility is to be supplied by the customer.
kW_Base	= Baseline fixture wattage (kW per fixture) determined from stipulated fixture wattages from Standard Fixture information. Fixture type provided by customer. Table 4-5
kW_EE	= High Efficiency fixture wattage (kW per fixture) determined from stipulated fixture wattages from Standard Fixture information. Fixture type provided by customer. Table 4-5
HVAC_cooling_kWhsavings_factor	= Cooling system energy savings factor resulting from efficient lighting from Table 1. Reduction in lighting energy results in a reduction in cooling energy, if the customer has air conditioning. Existence of air conditioning to be provided by customer.
HVAC_cooling_kWsavings_factor	= Cooling system demand savings factor resulting from efficient lighting from Table 1. Reduction in lighting demand results in a reduction in cooling demand, if the customer has air conditioning. Existence of air conditioning to be provided by customer.
HVAC_heating_kWsavings_factor	= Heating system penalty factor resulting from efficient lighting. Reduction in lighting demand results in an increase in heating usage, if the customer has gas heating. A value of -0.000540 Dth/kWh given by (Reference 4).
CF	= Coincidence Factor, the probability that peak demand of the lights will coincide with peak utility system demand. CF will be determined based on customer provided building type in table 2.
Measure Life	= Length of time the lighting equipment will be operational, see Table 3 for Measure Lifetimes
Baseline Cost	= Cost of the baseline technology. For Retrofit, the cost is $0.00 since the baseline is to continue to operate the existing system. For New Construction, the cost is that of the lower efficiency option. Costs by (Reference **4**) and vendors.

High Efficiency Cost	= Cost of the High Efficiency technology. Costs given in tables 4-6 (Reference 4**,** 8) and vendors**.**
kW connected	Total connected fixture load, determined as the sum of stipulated fixture wattages from Deemed Fixture Table 6.
PAF	Stipulated power adjustment factor based on control type from Table ~~6~~ **7**.
TDLF	Transmission Distribution Loss Factor = **6.50**%, the percentage loss of electricity as it flows from the power plant to the customer, calculated using factors from Enhanced DSM Filing SRD-2
NTG	~~Net-to-gross = 84% for prescriptive measures (Reference 5) and 96% for Custom Efficiency Lighting and Lighting Redesign based on the additional influence.~~ Net-to-gross = 99.2% (Reference 5)
Incremental operation and maintenance cost	= Other annual savings or costs associated with the electrical savings. For Lighting, this consists of additional natural gas for heating. Methodology given by Reference 2.

Provided by Customer:	**Verified during M&V:**
Number of Fixtures	Yes
Lighting equipment type	Yes
Building type	Yes
Existence of air conditioning	Yes

Assumptions:

- Each replacement lighting fixture is going in on a one-for-one basis for existing fixtures. New construction fixtures are put in on a one-for-one basis instead of lower efficiency options.

- In the Technical Assumptions, one will note that the Operating Hours does not appear, but rather a modified version. The methodology defines kW Savings on the basis of difference in kW with the HVAC Cooling demand factor. The Annual Energy Savings takes into account any heating that has to be added.

Table 1: HVAC Interactive Factors (Reference 2)

HVAC system	HVAC_cooling_kWhsavings_factor	HVAC_cooling_kWsavings_factor	Heating Penalty	kW/Ton	COP
Heating only	1.00	1.00	-0.000540	-	-
Heating and cooling	1.13	1.33	-0.000540	-	-
Cooler Door Retrofit to LED Secondary Benefits Factor	1.40	1.40	0.000000	1.41	2.49
Freezer Door Retrofit to LED Secondary Benefits Factor	1.60	1.60	0.000000	2.09	1.68

Table 2: Coincident Peak Demand Factors and Annual Operating Hours by Building Type (Reference 1 and 3)

Building Type	CF	Annual Operating Hours
24-Hour Facility	94%	8234
College	76%	2348
Cooler Door Retrofit to LED	87%	8760
Elemen./Second. School	31%	1632
Freezer Door Retrofit to LED	87%	8760
Grocery (All) / Big Box Retail (larger than 50,000 SF)	87%	4660

Health	73%	3213
Hospital	80%	5182
Hotel/Motel	9%	914
Manufacturing	57%	4739
Night Time Exterior	0%	4380
Office	61%	2567
Other/Misc.	63%	3521
Restaurant	65%	3613
Retail	73%	2829
Safety or Code Required (Including Exit Signs)	100%	8760
Traffic Signals	50%	4380
Warehouse	54%	2316

Table 3: Measure Lifetimes in Years (Reference 4,6,7)

Measure	**Lifetime in Years**
LED Interior Lamps	12
LED Interior Fixtures	20
LED Exterior Fixtures	20
Low Wattage T8 Lamps	8
Ballasted CFLs	20
Integrated 25W Ceramic Metal Halide	7
T8 Lighting Systems	20
T5 Lighting Systems	20
Lighting Controls	8
Stairwell Fixtures with Occupancy Sensors	14.4
LED Tubes (Insta-fit type only)	11

Tables 4-7: Lighting Efficiency Technical Assumption Updates

The Company has historically filed an exhaustive list with specific lighting retrofit pairings for eligible equipment in the Lighting Efficiency rebate program (for example: CMH-GEN-20-1-Fixt-EB-XX-XX-XX, which is a xxx type of bulb with an xxx type of wattage). Given that LED pairing options are rapidly entering the marketplace and evolving at a fast pace, the Company is transitioning to providing the technical assumptions—bulb qualification criteria, rebate factors, preconditions, and others—rather than listing out each pairing in the Plan. This solution will provide continued transparency while allowing the program to evolve as new LED specifications enter the market. However, the Company will continue to maintain a full list of the pairings, updated on a quarterly basis, on our website: http://www.xcelenergy.com/Save_Money_&_Energy/Rebates/Lighting_Efficiency_-_CO

Lighting Pairing Technical Assumptions for Lamps, Fixtures and Controls:

Fluorescent:

A. Low-wattage T8 Fluorescent Lamps

Rebates are based on replacing 32W T8 lamps with 28W or 25W lamps.

B. Lighting Optimization

Rebates are based on the permanent removal of the equivalent of at least one 4-foot (T8) lamp from an 8-foot or 4-foot fixture as a result of a retrofit. Rebate amount is per fixture, based on the final quantity of lamps installed in each fixture. Reducing the quantity of fixtures does not qualify. In order to qualify, the fixture must be retrofitted such that the existing ballast(s) must be disconnected and removed, new lamp-quantity appropriate high-efficiency electronic ballast is installed, and the sockets for the eliminated lamps are removed. In addition, the customer may not remove more than 50% of the existing lamp quantity (e.g., replacing a 3-lamp system with a 1-lamp system is not allowed). High-efficiency electronic ballasts are required for all 4-foot T8 optimization rebates. A list of qualified ballasts can be found at http://library.cee1.org/content/commercial-lighting-qualifying-products-listsh. Customer must sign the line below the optimization rebate on page 4 of the rebate application to verify that optimization has occurred. Although Xcel Energy recommends customer follow IES guidelines, the final light levels are the responsibility of the customer.

C. High-Efficiency Ballast

New fixtures that include high-efficiency electronic ballasts qualify for this rebate. Approved ballasts must be listed by CEE at http://library.cee1.org/content/commercial-lighting-qualifying-products-lists to qualify. The high-efficiency ballast cannot be in addition, or added to, the optimization rebates. The high-efficiency ballast is already incorporated into the optimization rebate.

D. High-Bay Fluorescent T8, T8VHO and T5HO Lamps with High-Efficiency Electronic Ballasts

Rebates are based on a one-for-one replacement of HID fixtures (including mercury vapor, high-pressure sodium, metal halide, or pulse-start metal halide) ranging in size from 175W to 1000W. Rebates are available for T8, T8VHO systems or T5HO systems. High-efficiency electronic ballasts are required for all fixtures using 4-foot, 4-lamp or less T8 ballasts. Other fixture configurations will be considered under the Custom Efficiency program.

E. Parking Garage Fluorescent T8 & T5HO with High-Efficiency Electronic Ballasts

Eligible parking garage structures need to be either underground or semi-enclosed above ground. The lighting within the garage must operate 24 hours a day. Rebates are based on a one-for-one replacement of HID fixtures (including mercury vapor, high-pressure sodium, metal halide, or pulse-start metal halide) ranging in size from 150W to 175W. Rebates are available for T8 or T5HO systems. High-efficiency electronic ballasts are required for all fixtures using 4-foot T8 ballasts, regardless of the number of lamps. Other fixture configurations will be considered under the Custom Efficiency program.

F. Compact Fluorescent Fixtures

Rebates are based on one-for-one replacement of incandescent fixtures with new hard-wired (dedicated) or modular fixtures containing pin-based compact fluorescent lamps (CFLs). For fixtures that house more than one lamp, the rebate is based on the total fixture wattage (i.e., one fixture that houses two 18W CFLs would be rebated as one 36W CFL fixture). Screw-base (integral) CFLs do not qualify. Two-foot low-wattage CFL rebate is paid per lamp.

Ceramic Metal Halide Fixtures:

G. Ceramic Metal Halide Fixtures

Rebates are based on one-for-one replacement of incandescent, halogen, mercury vapor, high-pressure sodium, metal halide, or pulse start metal halide fixtures. Ceramic metal halide lamp wattage must be lower than the existing lamp wattage and must be a full fixture replacement.

LED:

H. LED and LEC Exit Signs

Rebates are based on one-for-one replacement of incandescent exit signs to LED or LEC exit signs. CFL and photoluminescent exit signs do not qualify for a rebate. LED Exit Signs do not need to follow the DLC requirement until a DLC category is created.

I. LED Lamps and Luminaires (ENERGY STAR-qualified)

Rebates are based on one-for-one replacement of incandescent or halogen lamps with ENERGY STAR-qualified LED lamps (screw-based or pin-based). Rebates are based on wattage per lamp, not total fixture wattage. LED lamps and commercial downlight luminaires are required for prescriptive rebates. This is a midstream incentive implemented by a third-party and the incentive is paid directly to participating distributors.

K. Commercial LED Downlight Luminaires (hardwired and screw in/retrofit) (ENERGY STAR-qualified)

Rebates are based on one-for-one full fixture replacement of incandescent fixtures with ENERGY STAR-qualified commercial LED hardwired and screw-in downlight luminaires. Rebates are based on HID lamp wattage and total fixture wattage (Fixture must be a commercial downlight; not all products listed qualify for rebates).

L. Exterior LED Canopy, Soffit and Wall Pack Fixtures (DLC QPL Required)

Rebates are based on one-for-one replacement of HID canopy, soffit or wall pack fixtures with LED fixtures rated for exterior use. Rebates are based on total fixture wattage. Wall packs can be installed in parking garages, however parking garage ceiling fixtures do not qualify for this rebate, but can be analyzed through Custom Efficiency. Wall packs must include wall pack terminology on spec sheet to qualify for rebate.

M. Refrigerated LED Case Lighting (DLC QPL Required)

Rebates are based on replacement of T12 or T8 linear 5 to 6 foot fluorescent refrigerated case door lighting with 5 to 6 foot LED refrigerated case door strip lighting. Rebates are per door, not per lamp. Linear LED tube lights do not qualify for this rebate, but can be analyzed through Custom Efficiency.

N. LED Troffer Fixture & Retrofit Kits (DLC QPL Required)

New fixtures and retrofit kits must be listed on the current DLC QPL to qualify for rebates. Rebates are based on a one-for-one fixture and retrofit kit replacement of existing linear fluorescent troffer systems to qualify for rebates. Eligible LED fixture types are 2X2, 2X1, 2X4, 1X4, and retrofit kits. LED T8 tubes do not qualify for the retrofit kit, but can be analyzed through Custom Efficiency.

O. LED Parking Garage Fixture (DLC QPL Required)

Eligible parking garage structures need to be either underground or semi-enclosed above ground. The lighting within the garage must operate 24 hours a day. Rebates are based on a one-for-one replacement of HID (including mercury vapor, high-pressure sodium, metal halide, or pulse-start metal halide) ranging in size from 100W–250W. LED retrofit kits are not available for prescriptive rebates, but can be analyzed through Custom Efficiency.

P. Street and Area LED Lighting (DLC QPL Required)

Rebates are based on one-for-one replacement of HID fixture with LED fixtures rated for exterior use. Rebates are based on total fixture wattage.

Q. LED High Bay Fixtures or Retrofit Kits (DLC QPL Required)

Rebates are based on one-for-one replacement of HID fixture with an LED fixture in a high-bay interior space. Retrofit kits that work within the existing HID fixture but use LED lamps are included in this measure, but use separate cost and energy assumptions. New construction fixtures are also included, using separate assumptions.

R. LED Tubes (Linear lamps) (DLC QPL Required)

Rebates are based on one-for-one replacement of linear T8 fluorescent lamps with LED lamps in interior fixtures. Two different types of LED linear lamps are included using separate assumptions: insta-fit type lamps (require no re-wiring of fixture)and external driver lamps (require removal of ballasts and installation of separate driver). Eligible lengths are 2, 3, 4, and 8 feet.

Automatic Controls:

S Occupancy Sensors, Photocells and Stairwell Fixtures

Rebate is based on the type of sensor (wall vs. ceiling mount) as well as the connected load of each sensor. Stairwell fixtures may be 2–3 lamp T8 or 20W–30W LED and be controlled via an integrated occupancy sensor or step-dimming ballast. Fixture must operate in low-standby light level during vacancy and switch to full light output upon occupancy. The fixture cannot exceed 35% of full wattage during unoccupied periods. Low mode setting should be chosen so that the surface illumination levels are code compliant.

T. Standalone:

Occupancy sensors may be wall or ceiling mounted, and must be permanently installed; they can be passive infrared, ultrasonic or dual technology sensors. Photocells

U. Integrated:

Automatic controls must be permantently integrated into the fixture to qualify for this rebate.

References

1. Arkansas Deemed Savings Quick Start Program Draft Report Commercial Measures Final Report, Nexant. CF and hours
2. HVAC Interactive Factors developed based on the Rundquist Simplified HVAC Interaction Factor method for Minnesota, presented on page 28 of the 11/93 issue of the ASHRAE Journal - "Calculating lighting and HVAC interactions".
3. Technical Reference User Manual No. 2004-31, Efficiency Vermont, 12/31/04. CF and Hours
4. Deemed Savings Database, Minnesota Office of Energy Security, 2008. CF, Hours, kW, Costs, Measure life
5. Net-to-Gross factor from ~~2008 Xcel Energy Lighting Efficiency Program Evaluation~~ Evaulation of Xcel Energy's Lighting Efficiency Program, Dec 29 2015, The Cadmus Group, Inc.
6. LED Lamp measure life based on average 2009 custom project LED life of 45,000 hours / weighted hours of operation average
7. LED Fixture measure life based on Xcel Energy Minnesota Lighting Efficiency Program average replacement fixture lifetime
8. LED Fixture costs based on Xcel Energy Custom Lighting Efficiency project costs
9. LED high bay and linear LED costs come from Xcel Energy Custom Lighting Efficiency projects, ShineRetrofits.com, LightingAtlanta.org, 1000bulbs.com, grainger.com, Pro Lighting.com
10. LED high bay and linear LED wattages come from Reference 9 and the Western Area Power Administration, San Diego Gas & Electric, the Department of Veteran's Affairs, the Wisconsin Focus on Energy Technical Reference Manual, the Delware Technical Reference Manual, the Mid-Atlantic Technical Reference Manual, e3tnw.org, and Delany, John. "Cost Effectiveness of Solid State Lighting" ComEd.

DEEMED SAVINGS TECHNICAL ASSUMPTIONS

Product: Lighting Efficiency (Midstream)

Customers will receive point of sale rebates at their lighting equipment distributor for qualified ENERGY STAR ® Integrated Lamps and Retrofit Kits.

Algorithms:

Electrical Demand Savings (Customer kW)	= (kW_Base - kW_EE) x HVAC_cooling_kWsavings_factor
Electrical Energy Savings (Customer kWh/yr)	= (kW_Base - kW_EE) x Hrs x HVAC_cooling_kWhsavings_factor
kW_Base	= kW_EE x LPW_EE / LPW_Base
Hrs_Base	=Hrs *HVAC_cooling_kWhsavings_factor/HVAC_cooling_kWsavings_factor
Hrs_EE	=Hrs *HVAC_cooling_kWhsavings_factor/HVAC_cooling_kWsavings_factor
Electrical Energy Savings (Gross Generator kWh)	=Customer kWh / (1-TDLF)
Electrical Demand Savings (Gross Generator kW)	=Customer kW x CF / (1-TDLF)
Electrical Energy Savings (Net Generator kWh)	=Gross Generator kWh x NTG
Electrical Demand Savings (Net Generator kW)	=Gross Generator kW x NTG

Variables:

Hrs	= Annual Operating Hours. The Program will not have direct access to market segment information, so a deemed average based on the Commercial Buildings Energy Consumption Survey results is used in combination with an ASHRAE deemed lighting operating hours table as shown in Table 1. The assumed participation mix will be updated as necessary to accurately reflect the market. 3,063 hrs is used as a result of this analysis.
kW_EE	= High Efficiency fixture wattage (kW per fixture). This is defined by the manufacturer and maintained and reported by the distributor.
LPW_EE	=Efficacy of the efficient technology (lumens per watt). This is defined by the manufacturer and maintained and reported by the distributor.
LPW_Base	=Efficacy of the baseline technology (lumens per watt). This is defined according to lamp category in Table 2 below.
HVAC_cooling_kWhsavings_factor	= Reduction in lighting energy results in a reduction in cooling energy, if the customer has air conditioning. CBECS is used to determine a market average for the region (Reference 11 and 12). 1.1027788 is used.
HVAC_cooling_kWsavings_factor	= Reduction in lighting demand results in a reduction in cooling demand, if the customer has air conditioning. CBECS is used to determine a market average for the region (Reference 11 and 12). 1.2609000 is used.
CF	= Coincidence Factor, the probability that peak demand of the lights will coincide with peak utility system demand. CF will be determined based on industry weighted building type as shown in Table 1. 59.5 % is used
Measure Life	= Length of time the lighting equipment will be operational. Defined by Manufacturers and collected and reported by distributors to Xcel Energy. Values shown in Table 3 are used.

Baseline Cost	= Cost of the baseline technology. Costs will be collected from the equipment distributor to align with cost estimation methodology for proposed equipement.
High Efficiency Cost	= Cost of the high efficiency technology. Costs will be collected from the equipment distributor on the product invoice.
TDLF	Transmission Distribution Loss Factor = **6.50**%, the percentage loss of electricity as it flows from the power plant to the customer, calculated using factors from Enhanced DSM Filing SRD-2
NTG	Net-to-gross = 99.2% (Reference 14)

Inputs:
Number of Fixtures
Lighting equipment type
Efficient technology rated wattage
Efficient technology rated brightness (lumens)
Customer Address

Assumptions:
- Midstream LED Lamps are put in on a one-for-one basis instead of lower efficiency options.

Table 1: Derivation of Segment-Weighted Average Operating Hours and Coincidence Factor

Building Type	Market Share (%) [1,2]	Hrs [3]	CF [3]
24-Hour Facility	0%	8,234	94.0%
College	0%	2,348	76.0%
Elemen./Second. School	10%	1,632	31.0%
Exterior Lighting	0%	4,380	0.0%
Grocery/Supermarket	4%	4,660	87.0%
Health	0%	3,213	73.0%
Hospital	3%	5,182	80.0%
Hotel/Motel	4%	914	9.0%
Office	17%	2,567	61.0%
Other/Misc.	14%	3,521	63.0%
Refrigerated Cases	0%	8,760	87.0%
Restaurant	5%	3,613	65.0%
Retail	21%	2,829	73.0%
Warehouse	8%	2,316	54.0%
Manufacturing	12%	4,739	57.0%
Weighted Average		**3,063**	**59.5%**

Table 2: Baseline Lamp Efficacy based on Lamp Category (References 4 - 10)

Measure Category	Ave Baseline Efficacy
A Lamps rated for 310 - 749 Lumens	27.12
A Lamps rated for 750 - 1049 Lumens	36.88
A Lamps rated for 1050 - 1489 Lumens	39.45
A Lamps rated for 1490 - 2600 Lumens	37.93
General Directional (PAR, BR, R)	18.69
Multifaceted Reflector (MR16)	13.00
Decorative (B, BA, Candle, Globe)	10.45
Retrofit Kits	24.39

Table 3: Measure Lifetimes in Years (Reference 12)

Measure Category	Lifetime in Years
LED Interior Lamp - A Lamps	9.09
General Directional (PAR, BR, R)	10.14
Multifaceted Reflector (MR16)	9.20
Decorative (B, BA, Candle, Globe)	8.07
Retrofit Kits	11.43

References

[1] CBECS 2003. Table A3. Census Region and Division, Number of Buildings for All Buildings (Including Malls), 2003
[2] http://nces.ed.gov/programs/stateprofiles. National Center for Education Statistics. accessed 7/22/2014.
[3] Technical Reference User Manual No. 2004-31, Efficiency Vermont, 12/31/04.
[4] Energy Independence and Security Act. United States Congress. Jan 4, 2007.
http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/eisa_2007.pdf
[5] Stipulated factors by MN DER as part of MN 2013-2015 triennial home lighting estimate
[6] Adoption of Light-Emitting Diodes in Common Lighting Applications. Prepared for the U.S. Department Of Energy by Navigant Consulting. April 2013.
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/led-adoption-report_2013.pdf
[7] Caliper Benchmark Report - Performance of Incandescent A-Type and Decorative Lamps and LED Replacements. U.S. Department of Energy. November, 2008.
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/a-type_benchmark_11-08.pdf
[8] ENERGY STAR ® Integral LED Product Qualifications Requirements. 2010.
[9] Caliper Benchmark Report - Performance of Halogen Incandescent MR 16 Lamps and LED Replacements. U.S. Department of Energy. November, 2008.
http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/mr16_benchmark_11-08.pdf
[10 Incandescent Reflector Lamps minimum efficacy standards. http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/58
[11] CBECS 2003. Microdata File 1. General Building Information and Energy End Uses, 2003
[12] HVAC Interactive Factors developed based on the Rundquist Simplified HVAC Interaction Factor method for Minnnesota, presented on page 28 of the 11/93 issue of the ASHRAE Journal - "Calculating lighting and HVAC interactions".
[13] ENERGY STAR ® Integral LED Qualified Products List. Accessed 7/27/2014.
[14] Evaulation of Xcel Energy's Lighting Efficiency Program, Dec 29 2015, The Cadmus Group, Inc.