MEMORANDUM

TO: **TECHNICAL ADVISORY COMMITTEE**

FROM: CHERYL JENKINS, PROJECT MANAGER and SAM DENT, TECHNICAL LEAD - VEIC

SUBJECT: V6.0 ERRATA MEASURES EFFECTIVE 01/01/2018

DATE: 09/13/2018

Cc: CELIA JOHNSON, SAG

This memo documents errata changes to version 6.0 of the Illinois Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 01/01/2018.

VEIC has provided a summary table showing the errata measures and a brief summary of what was changed, followed by the measure themselves.

TRM Policy Document, Section 3.2.1, states that,

> "TAC participants should notify the TAC when a TRM mistake or omission is found. If a significant mistake or omission is found in the TRM that results in an unreasonable savings estimate, the Program Administrators, Evaluators, TRM Administrator, and TAC will strive to reach consensus on a solution that will result in a reasonable savings estimate. For example, an unreasonable savings estimate may result from an error or omission in the TRM.
>
> "In these limited cases where consensus is reached, the TRM Administrator shall inform the Evaluators to use corrected TRM algorithms and inputs to calculate energy and capacity savings, in addition to using the Commission-approved TRM algorithms and inputs to calculate savings. If the corrected TRM algorithms and inputs are stipulated for acceptance by all the parties in the Program Administrator's savings docket, then the corrected TRM savings verification values may be used for the purpose of measuring savings toward compliance with the Program Administrator's energy savings goals. Errors and omissions found in the TRM will be officially corrected through the annual TRM Update proceeding and will be identified as 'Errata'."

It is our belief and understanding that the following measures have been determined to be consensus errata by the Program Administrators, Evaluators and the entire TAC. The term 'errata' is used to describe these measures, and in accordance with the TRM Policy Document, the Evaluators may use this version of the measures during evaluation of the current program year (in addition to the measures currently in Version 6.0 of the TRM).

Summary of Errata Measures

Section	Measure Name	Measure Code	Brief Summary of Change
4.4.1	Air Conditioner Tune-Up	CI-HVC-ACTU-V05-180101	Correction of error in algorithm for deemed approach.
4.4.25	Small Commercial Programmable Thermostat Adjustments	CI-HVC-PRGA-V02-180101	Correction of error in the Natural Gas Climate Zone Coefficients for Assembly building type.
4.4.35	Economizer Repair and Optimization	CI-HVC-ECRP-V03-160601	Correction of error in Integrated Economizer Operation (EL) variable and example calculation. **Note this was also fixed in an errata for version 5.0.**
4.5.4	LED Bulbs and Fixtures	CI-LTG-LEDB-V07-180101	Correction of year that the mid-life adjustment applies to account for T12 replacement, from 2018 to 2019. Addition of mid-life adjustment assumptions for omnidirectional screw based lamps.
5.1.2	ENERGY STAR and ENERGY STAR Most Efficient Clothes Washer	RS-APL-ESCL-V05-180101	Updates to the Federal Standards and ENERGY STAR specifications, which came into effect at the beginning of January 2018
5.1.3	ENERGY STAR Dehumidifier	RS-APL-ESDH-V04-180101	Updates to the efficient scenario to incorporate new ENERGY STAR specifications which became effective on 10/25/2016
5.5.1 5.5.2 5.5.3 5.5.4 5.5.5 5.5.6 5.5.8	Compact Fluorescent Lamp (CFL) ENERGY STAR Specialty Compact Fluorescent Lamp (CFL) ENERGY STAR Torchiere Exterior Hardwired Compact Fluorescent Lamp (CFL) Fixture Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture LED Specialty Lamps LED Screw Based Omnidirectional Bulbs	RS-LTG-ESCF-V07-180101 RS-LTG-ESCC-V06-180101 RS-LTG-ESTO-V05-180101 RS-LRG-EFOX-V07-180101 RS-LTG-IFIX-V07-180101 RS-LTG-LEDD-V08-180101 RS-LTG-LEDA-V06-180101	Addition of leakage factor to kW and waste heat algorithms.

4.4.1 Air Conditioner Tune-up

Description

An air conditioning system that is operating as designed saves energy and provides adequate cooling and comfort to the conditioned space

Definition of Efficient Equipment

In order for this characterization to apply, the efficient equipment is assumed to be a unitary or split system air conditioner least 3 tons and preapproved by program. The measure requires that a certified technician performs the following items:

- Check refrigerant charge
- Identify and repair leaks if refrigerant charge is low
- Measure and record refrigerant pressures
- Measure and record temperature drop at indoor coil
- Clean condensate drain line
- Clean outdoor coil and straighten fins
- Clean indoor and outdoor fan blades
- Clean indoor coil with spray-on cleaner and straighten fins
- Repair damaged insulation – suction line
- Change air filter
- Measure and record blower amp draw

A copy of contractor invoices that detail the work performed to identify tune-up items, as well as additional labor and parts to improve/repair air conditioner performance must be submitted to the program

Definition of Baseline Equipment

In order for this characterization to apply, the baseline condition is assumed to be an AC system that that does not have a standing maintenance contract or a tune up within in the past 36 months.

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 3 years.[1]

Deemed Measure Cost

The incremental capital cost for this measure is \$35[2] per ton.

Loadshape

Loadshape C03 - Commercial Cooling

Coincidence Factor

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [3]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

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[1] 3 years is given for "Clean Condenser Coils – Commercial" and "Clean Evaporator Coils". DEER2014 EUL Table. http://www.deeresources.com/files/DEER2013codeUpdate/download/DEER2014-EUL-table-update_2014-02-05.xlsx

[2] Act on Energy Commercial Technical Reference Manual No. 2010-4

[3] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

= 47.8% [4]

Algorithm

Calculation of Savings

Electric Energy Savings

ΔkWH = (kBtu/hr) * [(1/EERbefore) – (1/EERafter)] * EFLH

Where:

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

=Actual

EERbefore = Energy Efficiency Ratio[5] of the baseline equipment prior to tune-up

=Actual

EERafter = Energy Efficiency Ratio of the baseline equipment after to tune-up

=Actual

EFLH = Equivalent Full Load Hours for cooling are provided in section 4.4 HVAC End Use

Where it is not possible or appropriate to perform Test in and Test out of the equipment, the following deemed methdology can be used:

ΔkWh = (kBtu/hr) / EERbefore * EFLH * (~~1 –~~%Savings)

Where:

%Savings = Deemed percent savings per Tune-Up component. These are additive if condenser cleaning, evaporator cleaning and refrigerant charge correction are performed (totals provided below)[6]

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[4] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

[5] In the context of this measure Energy Efficiency Ratio (EER) refers to field-measured steady-state rate of heat energy removal (e.g., cooling capacity) by the equipment in Btuh divided by the steady-state rate of energy input to the equipment in watts. This ratio is expressed in Btuh per watt (Btuh/watt). The cooling capacity may be derived using either refrigerant or air-side measurements. The measurement is performed at the outdoor and indoor environmental conditions that are present at the time the tune-up is being performed, and should be normalized using a correction function to the AHRI 210/240 Standard test conditions. The correction function should be developed based on manufacturer's performance data. Care must be taken to ensure the unit is fully loaded and operating at or near steady-state. Generally, this requires that the outside air temperature is at least 60°F, and that the unit runs with all stages of cooling enabled for 10 to 15 minutes prior to making measurements. For more information, please see "IL TRM_Normalizing to AHRI Conditions Method".

[6] Savings estimates are determined by applying the findings from DNV-GL "Impact Evaluation of 2013-2014 HVAC3 Commercial Quality Maintenance Programs", April 2016, to simulate the inefficient condition within select eQuest models and across climate zones. The percent savings were consistent enough across building types and climate zones that it was determined appropriate

Tune-Up Component	% savings
Condenser Cleaning	6.10%
Evaporator Cleaning	0.22%
Refrig. Charge Off. <=20%	0.68%
Refrig. Charge Off. >20%	8.44%
Combined (Refrig. Charge Off. <=20%)	7.00%
Combined (Refrig. Charge Off. >20%)	14.76%

For example, a 12 EER 5-ton rooftop air conditioner on a department store in Rockford receives a tune-up that includes both condenser and evaporator cleaning:

ΔkWh = (5*12) / 12 * 1,392 * 6.32%

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW_{SSP} = (kBtu/hr * (1/EERbefore - 1/EERafter)) * CF_{SSP}

ΔkW_{PJM} = (kBtu/hr * (1/ EERbefore - 1/EERafter)) * CF_{PJM}

Where:

CF_{SSP} = Summer System Peak Coincidence Factor for Commercial cooling (during system peak hour)

= 91.3% [7]

CF_{PJM} = PJM Summer Peak Coincidence Factor for Commercial cooling (average during peak period)

= 47.8% [8]

Where it is not possible or appropriate to perform Test in and Test out of the equipment, the following deemed methdology can be used:

ΔkW = (kBtu/hr) / EERbefore * %Savings * CF

NATURAL GAS ENERGY SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

to apply a single set of assumptions for all. See 'eQuest C&I Tune up Analysis.xlsx' for more information.

[7] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The AC load during the utility's peak hour is divided by the maximum AC load during the year.

[8] Based on analysis of Itron eShape data for Missouri, calibrated to Illinois loads, supplied by Ameren. The average AC load over the PJM peak period (1-5pm, M-F, June through August) is divided by the maximum AC load during the year

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-ACTU-V045-180101

REVIEW DEADLINE: 1/1/2021

4.4.25 Small Commercial Programmable Thermostat Adjustments

Description

This measure involves reprogramming existing commercial programmable thermostats or building automation systems for reduced energy consumption through adjustments of unoccupied heating/cooling setpoints and/or fan control. This measure is limited to packaged HVAC units that are controlled by a commercial thermostat or building automation system. The measure is limited to select building types presented below.

Eligible Small Commercial Building Types

Building Type
Assembly
Convenience Store
Office - Low Rise
Restaurant - Fast Food
Religious Facility
Restaurant - Full Service
Retail - Strip Mall
Retail - Department Store

This measure was developed to be applicable to the following program types: RF, DI.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

The criteria for this measure is established by optimizing heating/cooling temperature setbacks and fan operation with a commercial programmable thermostat or building automation system, which reprogrammed to match actual facility occupancy.

Definition of Baseline Equipment

The baseline for this measure is a commercial programmable thermostat or building automation system that is currently operating packaged HVAC units with heating/cooling temperature setbacks and fan operation that do not align with a facilities actual occupancy.

Deemed Lifetime of Efficient Equipment

The expected measure life of a programmable thermostat is assumed to be 8 years[9] based upon equipment life only[10]. For the purposes of claiming savings for a adjustment of an existing programmable thermostat, this is reduced to a 25% persistence factor to give a final measure life of 2 years. It is recommended that this assumption be evaluated by future energy measurement and verification activities.

Deemed Measure Cost

Actual labor costs should be used if the implementation method allows. If unknown the labor cost for this measure is assumed to be $70.34[11] per thermostat, as summarized in the table below.

Measure	Units	Materials	Labor	Total Cost (including	City Cost Index (Install	Total	Source

[9] Table 1, HVAC Controls, Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, 2007

[10] Future evaluation is strongly encouraged to inform the persistence of savings to further refine measure life assumption.

[11] RSMeans, "Instrumentation and Control for HVAC", Mechanical Cost Data , Kingston, MA: Reed Construction Data, 2010, pg. 255 & 632

				O&P)	Only)*		
Adjust Temperature Set Points	4	$0.00	$5.95	$6.55	134.5%	$35.24	RS Means 2010 (pg 255, Section 23-09-8100)
Adjust Fan Schedule	2	$0.00	$11.86	$13.05	134.5%	$35.10	RS Means 2010 (pg 255, Section 23-09-8120)
Totals						**$70.34**	

* Chicago, IL - Division 23

LOADSHAPE

N/A

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS[12]

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

The following equations are used to calculate baseline and proposed electric energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Electric Energy Use Equations (kWh / ton)

Building Type	Fan Mode During Occupied Period (*Fo*)	Equation
Assembly	Continuous	***CZ***+***Fu****(0.83****Tc***+0.83****Th***+1.67****Ws***-293.018)-0.0922****Tc********Th***+1.291****Ws***
	Intermittent	***CZ***+***Fu****(1.911-0.12****Tc***)+***Tc****(0.00311****Ws***-0.229)+0.11****Ws***
Convenience Store	Continuous	***CZ***+***Fu****(-28.629****Tc***-11.69****Th***+19.118****Ws***-2935.12)+0.909****Ws***
	Intermittent	***CZ***+***Tc****(0.0863****Ws***-12.688)+***Th****(0.043****Ws***-6.38)+1.669****Ws***
Office – Low Rise	Continuous	***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)
	Intermittent	***CZ***+***Tc****(0.0806****Ws***-8.984)+***Th****(0.0864****Ws***-9.558)+1.178****Ws***
Religious	Continuous	***CZ***+***Fu****(-1.579****Tc***-18.14****Th***+15.01****Ws***-2417.74)+***Tc****(0.177****Ws***-26.412)
	Intermittent	***CZ***+***Fu****(0.266****Tc***-2.067)+***Tc****(0.0295****Ws***-4.502)+***Th****(0.0517****Ws***-8.251)+0.735****Ws***
Restaurant – Fast Food	Continuous	***CZ***+***Fu****(0.678****Tc***+0.257****Th***+2.88****Ws***-494.006)+***Tc****(0.0231****Ws***-4.074)+***Th****(0.00936****Ws***-1.655)+0.918****Ws***
	Intermittent	***CZ***+***Fu****(0.377****Tc***+0.124****Th***+0.13****Ws***-24.893)+***Tc****(-0.0143****Th***+0.0166****Ws***-2.691)+0.898****Ws***
Restaurant – Sit Down	Continuous	***CZ***+***Fu****(-8.41****Th***+11.766****Ws***-1910.81)+***Tc****(0.282****Ws***-43.851)
	Intermittent	***CZ***+0.123****Fu********Tc***+***Tc****(0.0561****Ws***-8.237)+***Th****(0.0219****Ws***-3.284)+1.038****Ws***
Retail – Large	Continuous	***CZ***+***Fu****(-1.475****Th***+0.755****Ws***-114.373)+***Th****(0.151****Ws***-24.016)+1.612****Ws***
	Intermittent	***CZ***+***Tc****(0.0173****Ws***-1.912)+***Th****(0.0249****Ws***-3.29)+0.511****Ws***

[12] Savings equations and factors determined by regression of results of a series of eQuest simulations. See Programmable T-Stat Work Paper_PECI_FinalDraft_140730_Redline.docx for details.

Building Type	Fan Mode During Occupied Period (*Fo*)	Equation
Retail – Strip Mall	Continuous	***CZ***+***Fu****(1.077****Tc***-10.697****Th***+6.91****Ws***-1117.18)+***Tc****(0.0583****Ws***-7.54)+1.231****Ws***
	Intermittent	***CZ***+0.0894****Fu**** ***Tc***+***Th****(-0.0142****Tc***+0.04****Ws***-5.278)+0.884****Ws***

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Fan Mode During Occupied Period (see table below)

Tc = Degrees of Cooling Setback °F

= Must be between 0-15°F

Th = Degrees of Heating Setback °F

=Must be between 0-15°F

Fo = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)

= Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Fu = Fan Mode during Unoccupied Period

= 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Ws = Weekly Hours thermostat is in Occupied mode,

= Minimum values depend on Building Type (see table below), maximum value of 168 (24/7) ex: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59

Electric Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

Building Type	Fan Mode During Occupied Period (*Fo*)	Climate Zone Coefficient (*CZ*)					Minimum *Ws*
		1	2	3	4	5	
Assembly	Continuous	911.366	928.924	1152.83	1208.999	1210.173	98
	Intermittent	735.752	762.831	966.562	998.927	1028.906	
Convenience Store	Continuous	4817.094	4832.784	5139.133	5182.161	5208.608	108
	Intermittent	1478.133	1514.568	1784.384	1843.463	1930.47	
Office - Low Rise	Continuous	5047.662	5039.592	5187.924	5217.672	5177.449	55
	Intermittent	825.072	808.965	946.571	979.421	945.418	
Religious Facility	Continuous	4197.117	4172.858	4380.025	4370.008	4356.054	133
	Intermittent	632.404	603.395	678.294	664.717	616.853	

Building Type	Fan Mode During Occupied Period (*Fo*)	Climate Zone Coefficient (*CZ*)					Minimum *Ws*
		1	2	3	4	5	
Restaurant – Fast Food	Continuous	1342.988	1378.661	1664.018	1714.201	1727.841	108
	Intermittent	993.764	1039.643	1307.8	1340.544	1389.791	
Restaurant – Full Service	Continuous	4070.35	4094.742	4428.966	4501.829	4522.522	117
	Intermittent	1472.014	1516.05	1856.108	1938.441	2056.45	
Retail – Department Store	Continuous	1510.201	1496.47	1706.105	1716.128	1688.464	93
	Intermittent	701.27	702.129	847.735	875.12	881.677	
Retail – Strip Mall	Continuous	1926.294	1930.137	2156.856	2174.435	2165.03	93
	Intermittent	656.479	673.257	835.906	850.322	869.921	

EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and is heated and cooled with a packaged Gas (150 kBtu output) / DX (10 Ton) RTU which is controlled by a programmable thermostat. When the technician reviews the thermostat schedule they find the unoccupied schedule is programmed incorrectly. During the unoccupied periods the fan is programmed correctly, and runs in intermittent "auto" mode, although the heating and cooling temperature setpoints are not setback.

The technician adjusts the unoccupied schedule to include a 10°F cooling and heating temperature setback during the unoccupied periods.

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

Baseline Energy Use (kWh/Ton) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)

= ***5047.662***+1*(7.082****0***-41.199****0***+18.734****55***-3288.55)+***0****(0.205****55***-34.929)

= 2,789.482 kWh/Ton

Proposed Energy Use (kWh/Ton) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(7.082****Tc***-41.199****Th***+18.734****Ws***-3288.55)+***Tc****(0.205****Ws***-34.929)

= ***5047.662***+***1****(7.082****10***-41.199***10**+18.734***55**-3288.55)+***10*(***0.205****55***-34.929)

= 2,211.722 kWh/Ton

ΔkWh = [2,789.482 (kWh/Ton) – 2,211.722 (kWh/Ton)] * 10 Tons

= 577.71 kWh/Ton * 10 Tons

SUMMER COINCIDENT PEAK DEMAND SAVINGS

N/A

NATURAL GAS ENERGY SAVINGS

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use(Therms/kBtuh)] * Output Heating Capacity (kBtuh)

The following equations are used to calculate baseline and proposed natural gas energy use. The savings is the difference between the proposed and baseline calculated usage. This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Natural Gas Energy Use Equations (therms / kbtu)

Building Type	Fan Mode During Occupied Period (*Fo*)	Equation
Assembly	Continuous	**CZ+Fu***(0.232*Th+0.0984*Ws-18.79)+Th*(0.00271*Ws-0.535)+0.0142*Ws
	Intermittent	***CZ***+***Fu****(0.00405****Th***+0.000519****Ws***-0.11)+***Th****(0.0000689****Ws***-0.0118)+0.0022****Ws***
Convenience Store	Continuous	***CZ***+***Fu****(0.00545****Th***-0.00251****Ws***+0.416)+***Th****(0.000123****Ws***-0.0204)+0.00183****Ws***
	Intermittent	***CZ***+***Fu****(0.00231****Th***-0.0349)+***Th****(0.000309****Ws***-0.0494)+0.00266****Ws***
Office – Low Rise	Continuous	***CZ***+***Fu****(0.0205****Th***+0.364)+***Th****(0.00046****Ws***-0.0554)+0.00169****Ws***
	Intermittent	***CZ***+***Fu****(0.00745****Th***-0.142)+***Th****(0.00077****Ws***-0.111)+0.00199****Ws***
Religious	Continuous	***CZ***+0.00791****Fu****Th***+***Th****(0.00096****Ws***-0.167)+0.00184****Ws***
	Intermittent	***CZ***+***Fu****(0.00143****Th***-0.0309)+***Th****(0.0008****Ws***-0.134)+0.00219****Ws***
Restaurant – Fast Food	Continuous	***CZ***+***Fu****(0.0431****Th***+0.0424****Ws***-7.517)+***Th****(0.00113****Ws***-0.213)+0.0119****Ws***
	Intermittent	***CZ***+***Fu****(0.0125****Th***+0.0036****Ws***-0.71)+***Th****(0.000329****Ws***-0.0615)+0.00738****Ws***
Restaurant –Sit Down	Continuous	***CZ***+***Fu****(0.00445****Ws***-0.535)+***Th****(0.000679****Ws***-0.1)+0.00218****Ws***
	Intermittent	***CZ***+***Fu****(0.00144****Th***+0.000262****Ws***-0.0553)+***Th****(0.00018****Ws***-0.0299)+0.00166****Ws***
Retail – Large	Continuous	***CZ***+0.00203****Fu****Th***+***Th****(0.000591****Ws***-0.0812)+0.00194****Ws***
	Intermittent	***CZ***+***Th****(0.000406****Ws***-0.0611)+0.00228****Ws***
Retail – Strip Mall	Continuous	***CZ***+***Fu****(0.00998****Th***+0.00207****Ws***-0.206)+***Th****(0.000665****Ws***-0.101)+0.00292****Ws***
	Intermittent	***CZ***+***Fu****(0.00383****Th***-0.0656)+***Th****(0.000575****Ws***-0.0912)+0.00249****Ws***

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Fan Mode During Occupied Period (see table below)

Th = Degrees of Heating Setback °F

= Must be between 0-15°F

Fo = Fan Mode During Occupied Period (Note: Commercial mechanical code requires continuous fan operation during occupied periods to meet ventilation requirements.)

= Continuous for occupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= Intermittent for occupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Fu = Fan Mode during Unoccupied Period

= 0 for unoccupied fan that runs continuously (e.g. Fan Mode Set to 'On')

= 1 for unoccupied fan that runs intermittently (e.g. Fan Mode Set to 'Auto')

Ws = Weekly Hours thermostat is in Occupied mode,

= Minimum values depends on Building Type (see table below), maximum value of 168 (24/7) ex: Weekly occupancy schedule of Mon-Sat 8AM-5PM, Sun 9AM-2PM, Ws = 59.

Natural Gas Energy Use Climate Zone Coefficients and Minimum Weekly Hours Occupied

Building Type	Fan Mode During Occupied Period (*Fo*)	Climate Zone Coefficient (*CZ*)					Minimum *Ws*
		1	2	3	4	5	
Assembly	Continuous	19.872	17.83	15.828	15.282	13.482	98
	Intermittent	0.237	0.0989	0.0267	-0.0131	-0.0871	
Convenience Store	Continuous	1.493	1.081	0.782	0.544	0.114	108
	Intermittent	1.128	0.854	0.619	0.437	0.0854	
Office - Low Rise	Continuous	1.718	1.317	0.971	0.739	0.319	55
	Intermittent	3.447	3.022	2.503	2.251	1.646	
Religious Facility	Continuous	6.294	5.55	4.678	4.202	3.122	133
	Intermittent	5.914	5.368	4.557	4.137	3.246	
Restaurant – Fast Food	Continuous	8.383	7.211	6.034	5.767	4.71	108
	Intermittent	1.227	0.636	0.302	0.102	-0.262	
Restaurant – Full Service	Continuous	5.247	4.484	3.753	3.465	2.627	117
	Intermittent	0.951	0.704	0.51	0.381	0.0746	
Retail – Department Store	Continuous	4.385	3.854	3.192	2.784	1.858	93
	Intermittent	3.061	2.672	2.182	1.829	1.008	
Retail – Strip Mall	Continuous	3.917	3.394	2.728	2.394	1.617	93
	Intermittent	2.659	2.292	1.811	1.543	0.909	

EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is occupied Mon-Fri 7AM-6PM and is heated and cooled with a packaged Gas (150 kBtu output) / DX (10 Ton) RTU which is controlled by a programmable thermostat. When the technician reviews the thermostat schedule they find the unoccupied schedule is programmed incorrectly. During the unoccupied periods the fan is programmed correctly, and runs in intermittent "auto" mode, although the heating and cooling temperature setpoints are not setback.

The technician adjusts the unoccupied schedule to include a 10°F cooling and heating temperature setback during the unoccupied periods.

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use(Therms/kBtuh)] * Output Heating Capacity (kBtuh)

Baseline Energy Use (Therms/kBtuh) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(0.0205****Th***+0.364)+***Th****(0.00046****Ws***-0.0554)+0.00169****Ws***

= ***1.718***+***1****(0.0205****0***+0.364)+***0****(0.00046****55***-0.0554)+0.00169****55***

= 2.17495 Therms/kBtuh output

Proposed Energy Use (Therms/kBtuh) = Equation for Office Low Rise, *Fo*=Continuous

= ***CZ***+***Fu****(0.0205****Th***+0.364)+***Th****(0.00046****Ws***-0.0554)+0.00169****Ws***

= ***1.718***+***1****(0.0205****10***+0.364)+***10****(0.00046****55***-0.0554)+0.00169****55***

= 2.07895 Therms/kBtuh output

ΔTherms = [2.17495 (Therms/kBtuh output) – 2.07895 (Therms/kBtuh output)] * 150kBtuh output

= 0.096 (Therms/kBtuh output) * 150kBtuh output

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-PRGA-V02~~1~~-1~~5~~80~~6~~101

REVIEW DEADLINE: 1/1/2022

4.4.35 Economizer Repair and Optimization

DESCRIPTION

Economizers are designed to use unconditioned outside air (OSA) instead of mechanical cooling to provide cooling when exterior conditions permit. When the OSA temperature is less than the changeover temperature (determined by a static setpoint or a reference return air sensor) up to 100% OSA is supplied to help meet the facility's cooling needs, thus reducing mechanical cooling energy and saving energy. An economizer that is not working or is not properly adjusted can waste energy and cause comfort issues. This HVAC Economizer Optimization measure involves the repair and optimization of common economizer problems such as adjusting changeover setpoint, repairing damper motors & linkages and replacing non-working sensors and/or controllers. These repairs and adjustments result in proper operation which maximizes both occupant comfort and energy savings.

This measure is only appropriate for single zone packaged rooftop units. Custom calculations are required for savings for multi-zone systems.

In general the HVAC Economizer Optimization measure may involve both repair and/or optimization;

Economizer Repair – The Economizer repair work is preformed to ensure that the existing economizer is working properly. This allows the system to take advantage of free cooling and ensure that the system is not supplying an excess amount of outside air (OSA) during non-economizing periods.

- **Replace Damper Motor** – If the existing damper motor is not operational, the unit will be replaced with a functioning motor to allow proper damper modulation.
- **Repair Damper linkage** – If the existing linkage is broken or not adjusted properly, the unit will be replaced or adjusted to allow proper damper modulation.
- **Repair Economizer Wiring** – If the existing economizer is not operational due to a wiring issue, the issue will be repaired to allow proper economizer operation.
- **Reduce Over Ventilation** – If the unit is supplying excess OSA, the OSA damper position will be adjusted to meet minimum ventilation requirements.
- **Economizer Sensor Replacement** – If the unit is equipped with a nonadjustable dry bulb (i.e. snapdisk) or malfunctioning analog sensor, the sensor is replaced with a new selectable sensor.
- **Economizer Control Replacement** – If the existing economizer controller is not operational, the unit will be replaced or upgraded to allow for proper economizer operation.

Economizer Optimization- The economizer optimization work is preformed to ensure that the existing economizer system is set up properly to maximize use of free cooling for units located in a particular climate zone.

- **Economizer Changeover Setpoint Adjustment** – If the unit is equipped with a fully operational economizer, the controller is adjusted to the appropriate changeover setpoint based on ASHRAE 90.1 (Figure 1 - *Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers)* for the corresponding climate zone.
- **Enable Integrated Operation** – If the unit is equipped with a fully operational economizer and is not set up to allow a minimum of two stages of cooling (1st stage – Economizer Only & 2nd Stage – Economizer & Mechanical cooling), the unit will be wired to allow two stage cooling

This measure was developed to be applicable to the following program types: RF, DI.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient equipment condition is defined by fully functional economizer that is programmed to meet ASHRAE 90.1 economizer changeover setpoint requirements for the facility's climate zone and changeover control type

(Figure 1 - Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers)[13].

Figure 1 – Baseline ASHRAE High-Limit Shutoff Control Settings

TABLE 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers[b]

Control Type	Allowed Only in Climate Zone at Listed Setpoint	Required High-Limit Setpoints (Economizer Off When):	
		Equation	Description
Fixed dry-bulb temperature	1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8	$T_{OA} > 75°F$	Outdoor air temperature exceeds 75°F
	5a, 6a	$T_{OA} > 70°F$	Outdoor air temperature exceeds 70°F
	1a, 2a, 3a, 4a,	$T_{OA} > 65°F$	Outdoor air temperature exceeds 65°F
Differential dry-bulb temperature	1b, 2b, 3b, 3c, 4b, 4c, 5a, 5b, 5c, 6a, 6b, 7, 8	$T_{OA} > T_{RA}$	Outdoor air temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperature	All	$h_{OA} > 28$ Btu/lb[a] or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds 28 Btu/lb[a] of dry air[a] or outdoor air temperature exceeds 75°F
Differential enthalpy with fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ or $T_{OA} > 75°F$	Outdoor air enthalpy exceeds return air enthalpy or outdoor air temperature exceeds 75°F

a. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at 75°F and 50% RH. As an example, at approximately 6000 ft elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.
b. Devices with selectable rather than adjustable setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

Figure 2 – ASHRAE Climate Zone Map

NORMATIVE APPENDIX B
CLIMATE ZONES FOR U.S. STATES AND COUNTIES

This normative appendix provides the climate zones for U.S. states and counties. Figure B-1 contains the county-level climate zone map for the United States. Table B-1 lists each state and major counties within the state and shows the climate number and letter for each county listed.

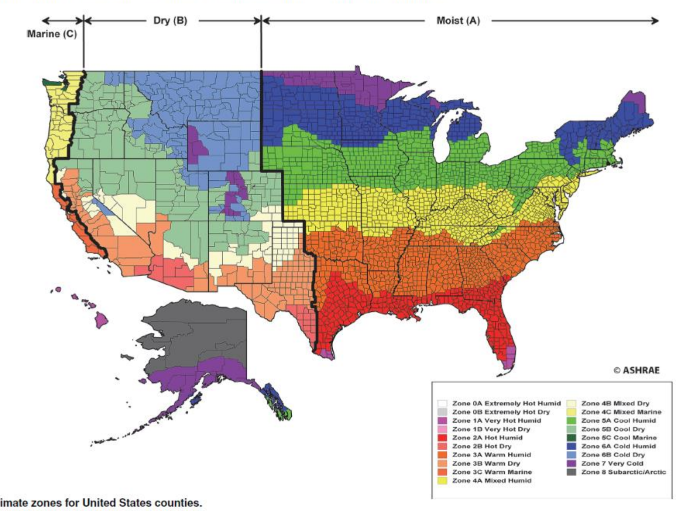

FIGURE B-1 Climate zones for United States counties.

DEFINITION OF BASELINE EQUIPMENT

The baseline for this measure is an existing economizer installed on a packaged single zone rooftop HVAC unit. The existing economizer system is currently not operating as designed due to mechanical and/or control problems, and/or is not optimally adjusted.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The measure life is assumed to be 5 years[14].

DEEMED MEASURE COST

The cost for this measure can vary considerably depending upon the existing condition of the economizer and the

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[13] ASHRAE, Standard 90.1-2013 - https://www.ashrae.org/resources--publications/bookstore/standard-90-1
[14] California Public Utilities Commission, DEER 2014 EUL Table D08 v2.05

work required to achieve the required efficiency levels. Measure cost should be determined on a site-specific basis.

LOADSHAPE

Loadshape C03 - Commercial Cooling

COINCIDENCE FACTOR

N/A

Algorithm

CALCULATION OF ENERGY SAVINGS

The savings calculation methodology uses a regression equation to calculate the energy savings for a variety of common situations[15]. The equation variables are limited to the ranges listed; if the actual conditions fall outside of these ranges custom calculations are required.

ELECTRIC ENERGY SAVINGS

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

The following equations are used to calculate baseline and proposed electric energy use[16].

Electric Energy Use Equations (kWh / ton)

Building Type	Changeover Type	Equation
Assembly	Fixed Dry-Bulb (DB)	cz+CSP*-2.021+EL*-16.362+OAn*1.665+OAx*-3.13
	Dual Temperature Dry-Bulb (DTDB)	cz+EL*-11.5+OAn*1.635+OAx*-2.817
	Dual Temperature Enthalpy (DTEnth)	cz+EL*-17.772+OAn*1.853+OAx*-3.044
	Fixed Enthalpy (Enth)	cz+CSP*-5.228+EL*-17.475+OAn*1.765+OAx*-3.003
	Analog ABCD Economizers (ABCD)	cz+CSP*-2.234+EL*-16.394+OAn*1.744+OAx*-3.01
Convenience Store	DB	cz+CSP*-3.982+EL*-27.508+OAn*2.486+OAx*-4.684
	DTDB	cz+EL*-20.798+OAn*2.365+OAx*-3.773
	DTEnth	cz+EL*-30.655+OAn*2.938+OAx*-4.461
	Enth	cz+CSP*-8.648+EL*-25.678+OAn*2.092+OAx*-3.754
	ABCD	cz+CSP*-3.64+EL*-24.927+OAn*2.09+OAx*-3.788
Office - Low Rise	DB	cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
	DTDB	cz+OAn*2.968+OAx*-0.943
	DTEnth	cz+EL*-9.799+OAn*3.106+OAx*-1.085
	Enth	cz+CSP*-2.773+EL*-7.392+OAn*2.941+OAx*-0.974
	ABCD	cz+CSP*-1.234+EL*-7.229+OAn*2.936+OAx*-0.995
Religious Facility	DB	cz+CSP*-1.131+OAn*3.542+OAx*-1.01
	DTDB	cz+EL*-10.198+OAn*4.056+OAx*-1.279
	DTEnth	cz+OAn*3.775+OAx*-1.031

[15] For more information on methodology, please refer to workpaper submitted by CLEAResult titled "CLEAResult_Economizer Repair_151020_Finalv2.doc". Note that the original ComEd eQuest models were used in the analysis, rather than the VEIC developed models used elsewhere. VEIC do not consider this a significant issue as adjustments from the ComEd models were focused on calibrating EFLH values, not to overall energy use metrics. We also believe using the ComEd models is likely more conservative. It may be appropriate to update the analysis with the updated models at a later time.

[16] This approach allows the savings estimate to account for the operational attributes of the baseline as well as the proposed case, yielding a better estimate than an approach that assumes a particular baseline or proposed energy use to determine savings.

Building Type	Changeover Type	Equation
	Enth	cz+CSP*-2.13+OAn*3.317+OAx*-0.629
	ABCD	cz+CSP*-0.95+OAn*3.313+OAx*-0.647
Restaurant	DB	cz+CSP*-2.243+EL*-21.523+OAx*-1.909
	DTDB	cz+EL*-14.427+OAn*0.295+OAx*-1.451
	DTEnth	cz+EL*-25.99+OAn*0.852+OAx*-1.951
	Enth	cz+CSP*-4.962+EL*-16.868+OAn*-0.12+OAx*-1.418
	ABCD	cz+CSP*-2.115+EL*-16.15+OAn*-0.125+OAx*-1.432
Retail - Department Store	DB	cz+CSP*-1.003+OAn*3.765+OAx*-0.938
	DTDB	cz+OAn*3.688+OAx*-0.676
	DTEnth	cz+OAn*4.081+OAx*-1.072
	Enth	cz+CSP*-2.545+OAn*3.725+OAx*-0.788
	ABCD	cz+CSP*-1.175+OAn*3.708+OAx*-0.809
Retail - Strip Mall	DB	cz+CSP*-1.192+EL*-5.62+OAn*3.353+OAx*-1.142
	DTDB	cz+OAn*3.355+OAx*-0.915
	DTEnth	cz+EL*-9.202+OAn*3.642+OAx*-1.215
	Enth	cz+CSP*-2.997+EL*-5.938+OAn*3.312+OAx*-0.964
	ABCD	cz+CSP*-1.36+EL*-5.884+OAn*3.3+OAx*-0.987

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Changover Type (see table below)

		Electric Climate Zone Coefficients				
Building Type	Changeover Type	CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
Assembly	DB	874.07	886.73	1043.38	1071.48	1072.20
	DTDB	698.45	711.89	870.13	899.51	903.10
	DTEnth	702.06	715.42	873.43	902.76	906.50
	Enth	851.95	865.43	1020.65	1047.10	1053.32
	ABCD	884.19	897.63	1053.12	1080.58	1086.35
Convenience Store	DB	1739.12	1787.09	2128.78	2206.65	2245.93
	DTDB	1389.28	1436.30	1780.99	1863.45	1904.89
	DTEnth	1398.42	1446.82	1789.71	1869.89	1912.59
	Enth	1643.51	1691.34	2032.83	2112.21	2157.63
	ABCD	1692.80	1740.62	2082.35	2162.73	2207.68
Office - Low Rise	DB	674.06	687.17	899.17	993.84	989.16
	DTDB	583.62	597.02	811.39	907.61	903.58
	DTEnth	588.94	602.11	816.02	912.49	908.26
	Enth	668.83	682.23	893.61	987.52	986.59
	ABCD	690.27	703.52	915.27	1009.94	1008.59
Religious Facility	DB	613.26	630.50	853.53	923.99	931.74
	DTDB	518.40	535.45	760.76	832.57	840.72
	DTEnth	513.59	531.20	756.26	829.13	837.26
	Enth	576.94	594.17	817.64	888.37	897.18

Building Type	Changeover Type	Electric Climate Zone Coefficients CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
	ABCD	593.78	611.04	834.69	905.83	914.27
Restaurant	DB	1397.27	1430.45	1763.21	1837.63	1872.18
	DTDB	1191.82	1225.12	1558.32	1633.95	1669.13
	DTEnth	1192.84	1226.77	1559.41	1635.13	1671.11
	Enth	1343.56	1377.52	1710.11	1783.66	1821.67
	ABCD	1373.72	1407.70	1740.43	1814.74	1852.55
Retail - Department Store	DB	717.89	730.07	968.85	1034.78	1035.06
	DTDB	628.83	641.70	883.37	951.09	951.33
	DTEnth	629.35	641.90	882.84	951.33	951.44
	Enth	705.06	717.99	956.42	1020.57	1024.45
	ABCD	728.60	741.47	980.19	1045.30	1048.57
Retail - Strip Mall	DB	800.69	818.68	1070.39	1129.87	1133.84
	DTDB	692.97	711.31	965.63	1026.68	1030.41
	DTEnth	698.12	716.34	970.06	1031.78	1035.72
	Enth	784.54	803.35	1054.37	1112.72	1120.74
	ABCD	810.10	828.86	1080.11	1139.39	1146.95

CSP = Economizer Changeover Setpoint (°F or Btu/lb) (actual in ranges below)

Economizer Control Type		Economizer Changeover Setpoint
Dry-Bulb		60°F - 80°F
Dual Temperature Dry-Bulb		0°F -5°F delta
Dual Temperature Enthalpy		0 Btu/lb -5 Btu/lb delta
Enthalpy		18 Btu/lb – 28 Btu/lb
Analog ABCD Economizers	A	73°F
	B	70°F
	C	67°F
	D	63°F
	E	55°F

EL = Integrated Economizer Operation (Economizer Lockout)

= 1~~0~~ for Economizer w/ Integrated Operation (Two Stage Cooling)

= 0~~1~~ for Economizer w/ out Integrated Operation (One Stage Cooling)

Oan = Minimum Outside Air (% OSA)[17]

= Actual. Must be between 15% -70%. If unknown assume

Functional Economizer – 30%
Non functional Economizer (Damper failed closed) – 15%
Non functional Economizer (Damper failed open) - 30% (Assume Minimum Ventilation

[17] DNV GL, "HVAC Impact Evaluation Final Report WO32 HVAC – Volume 1: Report," California Public Utilities Commission, Energy Division, HVAC Commercial Quality Maintenance (CQM) (1/28/14)

(Three Fingers)[18])

Oax = Maximum Outside Air (%)[i]

= Actual. Must be between 15% -70%. If unknown assume

Functional Economizer – 70%
Non functional Economizer (Damper failed closed) – 15%
Non functional Economizer (Damper failed open) — 30% (Assume Minimum Ventilation (Three Fingers))

EXAMPLE
A low rise office building in Rockford (Climate Zone 1) is heated and cooled with a packaged Gas (92 kBtu output) / DX (5 Ton) RTU. The RTU is equipped with a fixed dry-bulb outside air economizer and is programed for integrated operation. When the technician inspects the RTU they find that the changeover setpoint is programmed to 62°F, which does not meet ASHRAE economizer high limit shut off air economizer recommendations. After further investigation it is found that the OSA damper motor is not operational and is providing 30% outside air.

The technician replaces the damper motor and allow for proper OSA damper modulation (30% Min OSA & 70% Max OSA). They also adjust the fixed dry-bulb changeover setpoint to meet the ASHRAE economizer high limit shut off air economizer recommendation of 70°F.

ΔkWh = [Baseline Energy Use (kWh/Ton) – Proposed Energy Use (kWh/Ton)] * Cooling Capacity (Tons)

Baseline Energy Use (kWh/Ton) = Equation for Office Low Rise
= cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
= 674.06+62*-0.967+~~0~~1*-6.327+30*2.87+30*-1.047
= 66~~8~~2.5~~.8~~ kWh/Ton

Proposed Energy Use (kWh/Ton) = Equation for Office Low Rise
= cz+CSP*-0.967+EL*-6.327+OAn*2.87+OAx*-1.047
= 674.06+70*-0.967+1~~0~~*-6.327+ 30*2.87+70*-1.047
= 61~~9~~2.~~2~~9 kWh/Ton

ΔkWh = [66~~8~~2.5~~.8~~ (kWh/Ton) – 61~~9~~2.~~2~~9 (kWh/Ton)] * 5 Tons
= 49.6 kWh/Ton * 5 Tons
= 248.08 kWh

Summer Coincident Peak Demand Savings
N/A - It is assumed that repair or optimization of the economizer will not typically have a significant impact summer peak demand.

[18] Technician rule of thumb taken from CPUC 'HVAC Impact Evaluation Final Report', WO32, 28Jan 2015, p18.

NATURAL GAS SAVINGS

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use (Therms/kBtuh)] * Output Heating Capacity (kBtuh)

The following equations are used to calculate baseline and proposed electric energy use.

Natural Gas Energy Use Equations (therms / kbtu output)

Building Type	Changeover Type	Equation
Assembly	Fixed Dry-Bulb (DB)	cz+OAn*0.0853
	Dual Temperature Dry-Bulb (DTDB)	cz+OAn*0.0866
	Dual Temperature Enthalpy (DTEnth)	cz+OAn*0.0866
	Fixed Enthalpy (Enth)	cz+OAn*0.0855
	Analog ABCD Economizers (ABCD)	cz+OAn*0.0855
Convenience Store	DB	cz+OAn*0.26
	DTDB	cz+OAn*0.263
	DTEnth	cz+OAn*0.263
	Enth	cz+OAn*0.261
	ABCD	cz+OAn*0.261
Office - Low Rise	DB	cz+OAn*0.3
	DTDB	cz+OAn*0.301
	DTEnth	cz+OAn*0.301
	Enth	cz+OAn*0.3
	ABCD	cz+OAn*0.3
Religious Facility	DB	cz+OAn*0.35
	DTDB	cz+OAn*0.348
	DTEnth	cz+OAn*0.348
	Enth	cz+OAn*0.349
	ABCD	cz+OAn*0.349
Restaurant	DB	cz+OAn*0.0867
	DTDB	cz+OAx*-0.038+OAn*OAx*0.00149
	DTEnth	cz+OAx*-0.038+OAn*OAx*0.00149
	Enth	cz+OAn*0.0878
	ABCD	cz+OAn*0.0878
Retail - Department Store	DB	cz+OAn*0.319
	DTDB	cz+OAn*0.318
	DTEnth	cz+OAn*0.318
	Enth	cz+OAn*0.318
	ABCD	cz+OAn*0.318
Retail - Strip Mall	DB	cz+OAn*0.215
	DTDB	cz+OAn*0.216
	DTEnth	cz+OAn*0.216
	Enth	cz+OAn*0.215
	ABCD	cz+OAn*0.215

Where:

CZ = Climate Zone Coefficient

= Depends on Building Type and Changeover Type (see table below)

		Natural Gas Climate Zone Coefficients				
Building Type	Changeover Type	CZ1 (Rockford)	CZ2 (Chicago)	CZ3 (Springfield)	CZ4 (Belleville)	CZ5 (Marion)
Assembly	DB	-0.03	-0.55	-1.06	-1.28	-1.71
	DTDB	-0.02	-0.57	-1.11	-1.34	-1.79
	DTEnth	-0.02	-0.57	-1.11	-1.34	-1.79
	Enth	-0.03	-0.55	-1.06	-1.29	-1.72
	ABCD	-0.03	-0.55	-1.06	-1.29	-1.72
Convenience Store	DB	2.95	0.50	-1.48	-2.96	-5.56
	DTDB	3.06	0.52	-1.56	-3.11	-5.81
	DTEnth	3.06	0.52	-1.56	-3.11	-5.81
	Enth	2.96	0.50	-1.49	-2.98	-5.59
	ABCD	2.96	0.50	-1.49	-2.98	-5.59
Office - Low Rise	DB	5.83	3.02	0.46	-0.92	-4.13
	DTDB	5.98	3.08	0.41	-1.03	-4.36
	DTEnth	5.98	3.08	0.41	-1.03	-4.36
	Enth	5.85	3.03	0.46	-0.93	-4.16
	ABCD	5.85	3.03	0.46	-0.93	-4.16
Religious Facility	DB	9.23	6.71	3.75	2.40	-0.80
	DTDB	9.41	6.83	3.77	2.39	-0.86
	DTEnth	9.41	6.83	3.77	2.39	-0.86
	Enth	9.25	6.73	3.75	2.40	-0.80
	ABCD	9.25	6.73	3.75	2.40	-0.80
Restaurant	DB	8.30	6.54	4.94	4.00	1.95
	DTDB	10.51	8.71	7.07	6.10	4.00
	DTEnth	10.51	8.71	7.07	6.10	4.00
	Enth	8.28	6.51	4.91	3.96	1.90
	ABCD	8.28	6.51	4.91	3.96	1.90
Retail - Department Store	DB	8.20	5.86	3.19	1.25	-2.59
	DTDB	8.35	5.94	3.18	1.18	-2.75
	DTEnth	8.35	5.94	3.18	1.18	-2.75
	Enth	8.21	5.87	3.18	1.24	-2.61
	ABCD	8.21	5.87	3.18	1.24	-2.61
Retail - Strip Mall	DB	6.40	4.35	2.07	0.49	-2.18
	DTDB	6.51	4.38	2.03	0.39	-2.34
	DTEnth	6.51	4.38	2.03	0.39	-2.34
	Enth	6.41	4.35	2.06	0.48	-2.20
	ABCD	6.41	4.35	2.06	0.48	-2.20

EXAMPLE

A low rise office building in Rockford (Climate Zone 1) is heated and cooled with a packaged Gas (92 kBtu output) / DX (5 Ton) RTU. The RTU is equipped with a fixed dry-bulb outside air economizer and is programed for integrated operation. When the technician inspects the RTU they find that the changeover setpoint is programmed to 62°F, which does not meet ASHRAE economizer high limit shut off air economizer recommendations. After further investigation it is found the OSA damper motor is not operational and is providing 30% outside air.

The technician replaces the damper motor and allow for proper OSA damper modulation (30% Min OSA & 70% Max OSA). They also adjust the fixed dry-bulb changeover setpoint to meet the ASHRAE economizer high limit shut off air economizer recommendation of 70°F.

ΔTherms = [Baseline Energy Use (Therms/kBtuh) – Proposed Energy Use(Therms/kBtuh)] * Output Heating Capacity (kBtuh)

Baseline Energy Use (Therms/kBtuh) = Equation for Office Low Rise
= cz+OAn*0.3
= 5.83+30*.3
=14.8 Therms/kBtuh output

Proposed Energy Use (Therms/kBtuh) = Equation for Office Low Rise
= cz+OAn*0.3
= 5.83+30*.3
=14.8 Therms/kBtuh output

ΔTherms = [14.8(Therms/kBtuh output) – 14.8 (Therms/kBtuh output)] * 92kBtuh output
= 0.0 (Therms/kBtuh output) * 92kBtuh output
= 0 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: CI-HVC-ECRP-V0~~2~~3-160601

4.5.4 LED Bulbs and Fixtures

Description

This characterization provides savings assumptions for a variety of LED lamps including Omnidirectional (e.g. A-Type lamps), Decorative (e.g. Globes and Torpedoes) and Directional (PAR Lamps, Reflectors, MR16), and fixtures including refrigerated case, recessed and outdoor/garage fixtures.

If the implementation strategy does not allow for the installation location to be known, for Residential targeted programs (e.g. an upstream retail program), a deemed split of 95% Residential and 5% Commercial assumptions should be used[19], and for Commercial targeted programs a deemed split of 96% Commercial and 4% Residential should be used[20].

This measure was developed to be applicable to the following program types: TOS, NC, RF.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

In order for this characterization to apply, new lamps must be ENERGY STAR labeled. Note a new ENERGY STAR specification v2.0 becomes effective on 1/2/2017 (https://www.energystar.gov/products/spec/lamps_specification_version_2_0_pd).

Lamps and fixtures should be found in the reference tables below. Fixtures must be ENERGY STAR labeled or on the Design Lights Consortium qualifying fixture list.

Definition of Baseline Equipment

Refer to the baseline tables. In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EIAS) required all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014.

Deemed Lifetime of Efficient Equipment

Lifetime is the life of the product, at the reported operating hours (lamp life in hours divided by operating hours per year – see reference table "LED component Costs and Lifetime." The analysis period is the same as the lifetime, capped at 15 years. (15 years from GDS Measure Life Report, June 2007).

Deemed Measure Cost

Wherever possible, actual incremental costs should be used. Refer to reference table “LED component Cost & Lifetime” for defaults.

Loadshape

Loadshape C06 - Commercial Indoor Lighting

Loadshape C07 - Grocery/Conv. Store Indoor Lighting

Loadshape C08 - Hospital Indoor Lighting

Loadshape C09 - Office Indoor Lighting

Loadshape C10 - Restaurant Indoor Lighting

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[19] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY6, PY7 and PY8 and Ameren PY5, PY6 and PY8 in store intercept survey results. See ‘RESvCI Split_112016.xls’.

[20] Based on final ComEd’s BILD program data from PY4,PY5 and PY6. For Residential installations, hours of use assumptions from ‘5.5.6 LED Downlights’ should be used for LED fixtures and ‘5.5.8 LED Screw Based Omnidirectional Bulbs’ should be used for LED bulbs.

Loadshape C11 - Retail Indoor Lighting
Loadshape C12 - Warehouse Indoor Lighting
Loadshape C13 - K-12 School Indoor Lighting
Loadshape C14 - Indust. 1-shift (8/5) (e.g., comp. air, lights)
Loadshape C15 - Indust. 2-shift (16/5) (e.g., comp. air, lights)
Loadshape C16 - Indust. 3-shift (24/5) (e.g., comp. air, lights)
Loadshape C17 - Indust. 4-shift (24/7) (e.g., comp. air, lights)
Loadshape C18 - Industrial Indoor Lighting
Loadshape C19 - Industrial Outdoor Lighting
Loadshape C20 - Commercial Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is dependent on the location type. Values are provided for each building type in the reference section below.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * Hours * WHF_e * ISR$$

Where:

$Watts_{base}$ = Input wattage of the existing or baseline system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = Actual wattage of LED purchased / installed. If unknown, use default provided below:

For ENERGY STAR rated lamps the following lumen equivalence tables should be used:

Omnidirectional Lamps - ENERGY STAR Minimum Luminous Efficacy = 80Lm/W for <90 CRI lamps and 70Lm/W for >=90 CRI lamps.

Minimum Lumens	Maximum Lumens	Lumens used to calculate LED Wattage (midpoint)	LED Wattage[21] (WattsEE)	Baseline 2014-2019 (WattsBase)	Delta Watts 2014-2019 (WattsEE)	Baseline Post EISA 2020 requirement[22] (WattsBase)	Delta Watts Post 2020 (WattsEE)
5280	6209	5745	72.9	300.0	227.1	300.0	227.1
3000	5279	4140	52.5	200.0	147.5	200.0	147.5
2601	2999	2800	35.5	150.0	114.5	150.0	114.5
1490	2600	2045	26.0	72.0	46.0	45.4	19.5
1050	1489	1270	16.1	53.0	36.9	28.2	12.1
750	1049	900	11.4	43.0	31.6	20.0	8.6
310	749	530	6.7	29.0	22.3	11.8	5.0
250	309	280	3.5	25.0	21.5	25.0	21.5

Decorative Lamps - ENERGY STAR Minimum Luminous Efficacy = 65Lm/W for all lamps

Nominal wattage of lamp to be replaced ($Watts_{base}$)	Minimum initial light output of LED lamp (lumens)	LED Wattage ($Watts_{EE}$)	Delta Watts
10	70	1.08	8.92
15	90	1.38	13.6
25	150	2.31	22.7
40	300	4.62	35.4
60	500	7.69	52.3

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 70Lm/W for <90 CRI lamps and 61 Lm/W for >=90CRI lamps.

For Directional R, BR, and ER lamp types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$	Lumens used to calculate LED Wattage (midpoint)	LED Wattage ($Watts_{EE}$)	Delta Watts
R, ER, BR with medium screw bases w/ diameter >2.25" (*see exceptions	420	472	40	446	6.6	33.4
	473	524	45	499	7.3	37.7
	525	714	50	620	9.1	40.9
	715	937	65	826	12.1	52.9
	938	1259	75	1099	16.2	58.8

[21] Based on ENERGY STAR V2.0 specs – for omnidirectional <90CRI: 80 lm/W and for omnidirectional >=90 CRI: 70 lm/W. To weight these two criteria, the ENERGY STAR qualified list was reviewed and found to contain 87.8% lamps <90CRI and 12.2% >=90CRI.
[22] Calculated as 45lm/W for all EISA non-exempt bulbs.

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$	Lumens used to calculate LED Wattage (midpoint)	LED Wattage ($Watts_{EE}$)	Delta Watts
below)	1260	1399	90	1330	19.6	70.4
	1400	1739	100	1570	23.1	76.9
	1740	2174	120	1957	28.8	91.2
	2175	2624	150	2400	35.3	114.7
	2625	2999	175	2812	41.3	133.7
	3000	4500	200	3750	55.1	144.9
***R, BR, and ER with medium screw bases w/ diameter <=2.25"**	400	449	40	425	6.2	33.8
	450	499	45	475	7.0	38.0
	500	649	50	575	8.5	41.5
	650	1199	65	925	13.6	51.4
***ER30, BR30, BR40, or ER40**	400	449	40	425	6.2	33.8
	450	499	45	475	7.0	38.0
	500	649	50	575	8.5	41.5
***BR30, BR40, or ER40**	650	1419	65	1035	15.2	49.8
***R20**	400	449	40	425	6.2	33.8
	450	719	45	585	8.6	36.4
***All reflector lamps below lumen ranges specified above**	200	299	20	250	3.7	16.3
	300	399	30	350	5.1	24.9

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[23] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[24]

$$\text{Wattsbase} =$$

$$375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)

[23] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/

[24] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

BA = Beam angle

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

Hours = Average hours of use per year are provided in the Reference Table in Section 4.5, Screw based bulb annual operating hours, for each building type. If unknown, use the Miscellaneous value.

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting are provided below for each building type in the Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

ISR = In Service Rate -the percentage of units rebated that actually get installed.

=100%[25] if application form completed with sign off that equipment is not placed into storage. If sign off form not completed assume the following 3 year ISR assumptions:

Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
95.7%[26]	1.2%	1.1%	98.0%[27]

Mid Life Baseline Adjustment

During the lifetime of a standard Omnidirectional LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Since the baseline bulb changes over time (except for <300 and 2600+ lumen lamps) the

[25] Illinois evaluation of PY1 through PY3 has not found that fixtures or lamps placed into storage to be a significant enough issue to warrant including an "In-Service Rate" when commercial customers complete an application form.
[26] Based on ComEd's BILD program data from PY5 and PY6, see "IL Commercial Lighting ISR_2014.xls".
[27] In the absence of any data for LEDs specifically it is assumed that the same proportion of bulbs eventually get installed as for CFLS. The 98% CFL assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings. Note that this Final Install Rate does NOT account for leakage of purchased bulbs being installed outside of the utility territory. EM&V should assess how and if data from evaluation should adjust this final installation rate to account for this impact

annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2018, the full savings (as calculated above in the Algorithm) should be claimed for the first three years, but a reduced annual savings (calculated energy savings above multiplied by the adjustment factor in the table below) claimed for the remainder of the measure life.

Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Delta Watts 2014-2019 (WattsEE)	Delta Watts Post 2020 (WattsEE)	Mid Life adjustment (made from 01/2021) to first year savings
1490	2600	26.0	46.0	19.5	42.3%
1050	1489	16.1	36.9	12.1	32.8%
750	1049	11.4	31.6	8.6	27.1%
310	749	6.7	22.3	5.0	22.6%

HEATING PENALTY

If electrically heated building:

$$\Delta kWh_{heatpenalty}{}^{28} = (((WattsBase-WattsEE)/1000) * ISR * Hours * -IFkWh$$

Where:

IFkWh = Lighting-HVAC Interation Factor for electric heating impacts; this factor represents the increased electric space heating requirements due to the reduction of waste heat rejected by the efficent lighting. Values are provided in the Reference Table in Section 4.5. If unknown, use the Miscellaneous value.

> For example, For example, a 9W LED lamp, 450 lumens, is installed in a heat pump heated office in 2014 and sign off form provided:
>
> $$\Delta kWh_{heatpenalty} = ((29-6.7)/1000)*1.0*3088* -0.151$$
>
> $$= - 10.4 \text{ kWh}$$

DEFERRED INSTALLS

As presented above, if a sign off form is not completed the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

[28] Negative value because this is an increase in heating consumption due to the efficient lighting.

The NTG factor for the Purchase Year should be applied.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = ((Watts_{base}-Watts_{EE})/1000) * ISR * WHF_d * CF$$

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting in cooled buildings is provided in Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

CF = Summer Peak Coincidence Factor for measure is provided in the Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, a 9W LED lamp, 450 lumens, is installed in an office in 2014 and sign off form provided:

$$\Delta kW = ((29-6.7)/1000)* 1.0*1.3*0.66$$

$$= 0.019 \text{ kW}$$

NATURAL GAS ENERGY SAVINGS

Heating Penalty if fossil fuel heated building (or if heating fuel is unknown):

$$\Delta Therms = (((WattsBase-WattsEE)/1000) * ISR * Hours * - IFTherms$$

Where:

IFTherms = Lighting-HVAC Integration Factor for gas heating impacts; this factor represents the increased gas space heating requirements due to the reduction of waste heat rejected by the efficient lighting. Values are provided in the Referecne Table in Section 4.5. If unknown, use the Miscellaneous value.

For example, For example, a 9W LED lamp, 450 lumens, is installed in an office in 2014 and sign off form provided:

$$\Delta Therms = ((29-6.7)/1000)*1.0*3088* -0.016$$

$$= - 1.10 \text{ therms}$$

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For all measures except Standard Omnidirectional lamps (which have an EISA baseline shift) the individual component lifetimes and costs are provided in the reference table section below[29].

In order to account for the falling EISA Qualified bulb replacement cost provided above, an equivalent annual levelized baseline replacement cost over the lifetime of the LED bulb (assumed to be 15,000/3612 =4.2 years) is

[29] See "LED Lighting Systems TRM Reference Tables" for breakdown of component cost assumptions.

calculated[30]. The key assumptions used in this calculation are documented below[31]:

	Std Inc.	EISA Compliant Halogen	CFL
2017	$0.43	$1.25	N/A
2018	$0.43	$1.25	N/A
2019	$0.43	$1.25	N/A
2020 & after	$0.43	N/A	$2.45

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.46% are presented below. It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		2018	2019	2020	2018	2019	2020
Commercial	Lumens <310 or >2600 (EISA exempt)	$6.02	$6.02	$6.02	$1.47	$1.47	$1.47
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$13.22	$9.64	$6.04	$3.22	$2.35	$1.47
Multi Family Common Areas	Lumens <310 or >2600 (non-EISA compliant)	$5.92	$5.92	$5.92	$2.37	$2.37	$2.37
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$17.20	$14.25	$8.32	$6.88	$5.70	$3.33

For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[32] The replacement cycle is based on the miscellaneous hours of use. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement and CFLs after 10,000 hours.

REFERENCE TABLES

LED Bulb Assumptions

Wherever possible, actual incremental costs should be used. If unavailable assume the following incremental costs[33]:

Bulb Type	Year	LED	Incandescent	Incremental

[30] See C&I OmniDirectional LED O&M Calc_012017.xls" for more information. The values assume the non-residential average hours assumption of 3612.

[31] Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren.

[32] The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.

[33] Baseline and LED lamp costs are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.Given LED prices are expected to continue declining assumed costs should be reassessed on an annual basis and replaced with IL specific LED program information when available.

				Cost
Omnidirectional	2017	$3.21	$1.25	$1.96
	2018	$3.21		$1.96
	2019	$3.11		$1.86
Directional	2017	$6.24	$3.53	$2.71
	2018-2019	$5.18		$1.65
Decorative and Globe	2017	$3.50	$1.60	$1.90
	2018-2019	$3.40	$1.74	$1.66

Directional and Decorative O&M; apply incandescent cost assumption provided above with a frequency calculated by dividing the assumed rated life of the baseline bulb (1000 hours) by the building specific hours of use assumption

LED Fixture Wattage and Incremental Cost Assumptions[34]

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost	Mid Life Savings Adjustment (201~~8~~9)
LED Downlight Fixtures	LED Recessed, Surface, Pendant Downlights	17.6	Baseline LED Recessed, Surface, Pendant Downlights	54.3	$27	N/A
LED Interior Directional	LED Track Lighting	12.2	Baseline LED Track Lighting	60.4	$59	N/A
	LED Wall-Wash Fixtures	8.3	Baseline LED Wall-Wash Fixtures	17.7	$59	N/A
LED Display Case	LED Display Case Light Fixture	7.1 per ft	Baseline LED Display Case Light Fixture	36.2 per ft	$11/ft	N/A
	LED Undercabinet Shelf-Mounted Task Light Fixtures	7.1 per ft	Baseline LED Undercabinet Shelf-Mounted Task Light Fixtures	36.2 per ft	$11/ft	N/A
	LED Refrigerated Case Light, Horizontal or Vertical	7.6 per ft	Baseline LED Refrigerated Case Light, Horizontal or Vertical (per foot)	15.2 per ft	$11/ft	N/A
	LED Freezer Case Light, Horizontal or Vertical	7.7 per ft	Baseline LED Freezer Case Light, Horizontal or Vertical (per foot)	18.7 per ft	$11/ft	N/A
LED Linear Replacement Lamps	LED 4' Linear Replacement Lamp	18.7	80:20 T12:T8; Lamp Only 32w T8:34w T12	33.6	$24	89%
	LED 2' Linear Replacement Lamp	9.7	80:20 T12:T8; Lamp Only 17w T8:20w T12	19.4	$13	75%
LED Troffers	LED 2x2 Recessed Light Fixture, 2000-3500 lumens	34.1	80:20 T12:Standard T8 2-Lamp 32w T8, 2-Lamp 34w T12	61.0	$48	85%
	LED 2x2 Recessed Light Fixture, 3501-5000 lumens	42.8	80:20 T12:Standard T8 3-Lamp 32w T8, 3-Lamp 34w T12	103.3	$91	69%
	LED 2x4 Recessed Light	37.9	80:20 T12:Standard T8 2-Lamp	61.0	$62	83%

[34] Watt, lumen, lamp life, and ballast factor assumptions for efficient measures are based upon Consortium for Energy Efficiency (CEE) Commercial Lighting Qualifying Product Lists alongside past Efficiency Vermont projects and PGE refrigerated case study. Watt, lumen, lamp life, and ballast factor assumptions for baseline fixtures are based upon manufacturer specification sheets. Baseline cost data comes from lighting suppliers, past Efficiency Vermont projects, and professional judgment. Efficient cost data comes from 2012 DOE "Energy Savings Potential of Solid-State Lighting in General Illumination Applications", Table A.1. See "LED Lighting Systems TRM Reference Tables.xlsx" for more information and specific product links.

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost	Mid Life Savings Adjustment (20189)
	Fixture, 3000-4500 lumens		32w T8, 2-Lamp 34w T12			
	LED 2x4 Recessed Light Fixture, 4501-6000 lumens	54.3	80:20 T12:Standard T8 3-Lamp 32w T8, 3-Lamp 34w T12	103.3	$99	62%
	LED 2x4 Recessed Light Fixture, 6001-7500 lumens	72.7	80:20 T12:Standard T8 4-Lamp 32w T8, 4-Lamp 34w T12	137.7	$150	61%
	LED 1x4 Recessed Light Fixture, 1500-3000 lumens	18.1	80:20 T12:Standard T8 1-Lamp 32w T8 , 1-Lamp 34w T12	30.6	$36	88%
	LED 1x4 Recessed Light Fixture, 3001-4500 lumens	39.6	80:20 T12:Standard T8 2-Lamp 32w T8, 2-Lamp 34w T12	61.0	$76	81%
	LED 1x4 Recessed Light Fixture, 4501-6000 lumens	53.1	80:20 T12:Standard T8 3-Lamp 32w T8, 3-Lamp 34w T12	103.3	$130	62%
LED Linear Ambient Fixtures	LED Surface & Suspended Linear Fixture, <= 3000 lumens	19.7	80:20 T12:Standard T8 1-Lamp 32w T8, 1-Lamp 34w T12	30.6	$54	86%
	LED Surface & Suspended Linear Fixture, 3001-4500 lumens	37.8	80:20 T12:Standard T8 2-Lamp 32w T8, 2-Lamp 34w T12	61.0	$104	83%
	LED Surface & Suspended Linear Fixture, 4501-6000 lumens	55.9	80:20 T12:Standard T8 3-Lamp 32w T8, 3-Lamp 34w T12	103.3	$158	60%
	LED Surface & Suspended Linear Fixture, 6001-7500 lumens	62.6	T5HO 2L-F54T5HO - 4'	120.0	$215	N/A
	LED Surface & Suspended Linear Fixture, > 7500 lumens	95.4	T5HO 3L-F54T5HO - 4'	180.0	$374	N/A
LED High & Low Bay Fixtures	LED Low-Bay Fixtures, <= 10,000 lumens	90.3	3-Lamp T8HO Low-Bay	157.0	$191	N/A
	LED High-Bay Fixtures, 10,001-15,000 lumens	127.5	4-Lamp T8HO High-Bay	196.0	$331	N/A
	LED High-Bay Fixtures, 15,001-20,000 lumens	191.0	6-Lamp T8HO High-Bay	294.0	$482	N/A
	LED High-Bay Fixtures, > 20,000 lumens	249.7	8-Lamp T8HO High-Bay	392.0	$818	N/A
LED Agricultural Interior Fixtures	LED Ag Interior Fixtures, <= 2,000 lumens	17.0	25% 73 Watt EISA Inc, 75% 1L T8	42.0	$33	N/A
	LED Ag Interior Fixtures, 2,001-4,000 lumens	27.8	25% 146 Watt EISA Inc, 75% 2L T8	81.0	$54	N/A
	LED Ag Interior Fixtures, 4,001-6,000 lumens	51.2	25% 217 Watt EISA Inc, 75% 3L T8	121.0	$125	N/A
	LED Ag Interior Fixtures, 6,001-8,000 lumens	71.7	25% 292 Watt EISA Inc, 75% 4L T8	159.0	$190	N/A
	LED Ag Interior Fixtures, 8,001-12,000 lumens	103.5	200W Pulse Start Metal Halide	227.3	$298	N/A
	LED Ag Interior Fixtures, 12,001-16,000 lumens	143.8	320W Pulse Start Metal Halide	363.6	$450	N/A
	LED Ag Interior Fixtures, 16,001-20,000 lumens	183.3	350W Pulse Start Metal Halide	397.7	$595	N/A

LED Category	EE Measure Description	$Watts_{EE}$	Baseline Description	$Watts_{BASE}$	Incremental Cost	Mid Life Savings Adjustment (201~~8~~9)
	LED Ag Interior Fixtures, > 20,000 lumens	305.0	(2) 320W Pulse Start Metal Halide	727.3	$998	N/A
LED Exterior Fixtures	LED Exterior Fixtures, <= 5,000 lumens	42.6	100W Metal Halide	113.6	$190	N/A
	LED Exterior Fixtures, 5,001-10,000 lumens	68.2	175W Pulse Start Metal Halide	198.9	$287	N/A
	LED Exterior Fixtures, 10,001-15,000 lumens	122.5	250W Pulse Start Metal Halide	284.1	$391	N/A
	LED Exterior Fixtures, > 15,000 lumens	215.0	400W Pulse Start Metal Halide	454.5	$793	N/A

LED Fixture Component Costs & Lifetime[35]

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
LED Downlight Fixtures	LED Recessed, Surface, Pendant Downlights	50,000	$30.75	70,000	$47.50	2,500	$8.86	40,000	$14.40
LED Interior Directional	LED Track Lighting	50,000	$39.00	70,000	$47.50	2,500	$12.71	40,000	$11.00
	LED Wall-Wash Fixtures	50,000	$39.00	70,000	$47.50	2,500	$9.17	40,000	$27.00
LED Display Case	LED Display Case Light Fixture	50,000	$9.75/ft	70,000	$11.88/ft	2,500	$6.70	40,000	$5.63
	LED Undercabinet Shelf-Mounted Task Light Fixtures	50,000	$9.75/ft	70,000	$11.88/ft	2,500	$6.70	40,000	$5.63
	LED Refrigerated Case Light, Horizontal or Vertical	50,000	$8.63/ft	70,000	$9.50/ft	15,000	$1.13	40,000	$8.00
	LED Freezer Case Light, Horizontal or Vertical	50,000	$7.88/ft	70,000	$7.92/ft	12,000	$0.94	40,000	$6.67
LED Linear Replacement Lamps	LED 4' Linear Replacement Lamp	50,000	$8.57	70,000	$13.67	24,000	$6.17	40,000	$11.96
	LED 2' Linear Replacement Lamp	50,000	$5.76	70,000	$13.67	24,000	$6.17	40,000	$11.96
LED Troffers	LED 2x2 Recessed Light Fixture, 2000-3500 lumens	50,000	$46.68	70,000	$40.00	24,000	$26.33	40,000	$35.00

[35] Note some measures have blended baselines (T12:T8 80:20). All values are provided to enable calculation of appropriate O&M impacts. Total costs include lamp, labor and disposal cost assumptions where applicable, see "IL LED Lighting Systems TRM Tables" for more information.

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
	LED 2x2 Recessed Light Fixture, 3501-5000 lumens	50,000	$56.31	70,000	$40.00	24,000	$39.50	40,000	$35.00
	LED 2x4 Recessed Light Fixture, 3000-4500 lumens	50,000	$49.58	70,000	$40.00	24,000	$12.33	40,000	$35.00
	LED 2x4 Recessed Light Fixture, 4501-6000 lumens	50,000	$57.76	70,000	$40.00	24,000	$18.50	40,000	$35.00
	LED 2x4 Recessed Light Fixture, 6001-7500 lumens	50,000	$68.89	70,000	$40.00	24,000	$24.67	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 1500-3000 lumens	50,000	$43.43	70,000	$40.00	24,000	$6.17	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 3001-4500 lumens	50,000	$52.31	70,000	$40.00	24,000	$12.33	40,000	$35.00
	LED 1x4 Recessed Light Fixture, 4501-6000 lumens	50,000	$63.86	70,000	$40.00	24,000	$18.50	40,000	$35.00
LED Linear Ambient Fixtures	LED Surface & Suspended Linear Fixture, <= 3000 lumens	50,000	$45.01	70,000	$40.00	24,000	$6.17	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 3001-4500 lumens	50,000	$58.73	70,000	$40.00	24,000	$12.33	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 4501-6000 lumens	50,000	$73.50	70,000	$40.00	24,000	$18.50	40,000	$35.00
	LED Surface & Suspended Linear Fixture, 6001-7500 lumens	50,000	$88.69	70,000	$40.00	30,000	$26.33	40,000	$60.00
	LED Surface & Suspended Linear Fixture, > 7500 lumens	50,000	$123.91	70,000	$40.00	30,000	$39.50	40,000	$60.00
LED High & Low Bay Fixtures	LED Low-Bay Fixtures, <= 10,000 lumens	50,000	$90.03	70,000	$62.50	18,000	$64.50	40,000	$92.50
	LED High-Bay Fixtures, 10,001-15,000 lumens	50,000	$122.59	70,000	$62.50	18,000	$86.00	40,000	$92.50

		EE Measure				Baseline			
LED Category	EE Measure Description	Lamp Life (hrs)	Total Lamp Replacement Cost	LED Driver Life (hrs)	Total LED Driver Replacement Cost	Lamp Life (hrs)	Total Lamp Replacement Cost	Ballast Life (hrs)	Total Ballast Replacement Cost
	LED High-Bay Fixtures, 15,001-20,000 lumens	50,000	$157.22	70,000	$62.50	18,000	$129.00	40,000	$117.50
	LED High-Bay Fixtures, > 20,000 lumens	50,000	$228.52	70,000	$62.50	18,000	$172.00	40,000	$142.50
LED Agricultural Interior Fixtures	LED Ag Interior Fixtures, <= 2,000 lumens	50,000	$37.00	70,000	$40.00	18,250	$1.23	40,000	$26.25
	LED Ag Interior Fixtures, 2,001-4,000 lumens	50,000	$44.96	70,000	$40.00	18,250	$1.43	40,000	$26.25
	LED Ag Interior Fixtures, 4,001-6,000 lumens	50,000	$63.02	70,000	$40.00	18,250	$1.62	40,000	$26.25
	LED Ag Interior Fixtures, 6,001-8,000 lumens	50,000	$79.78	70,000	$40.00	18,250	$1.81	40,000	$26.25
	LED Ag Interior Fixtures, 8,001-12,000 lumens	50,000	$119.91	70,000	$62.50	15,000	$63.00	40,000	$112.50
	LED Ag Interior Fixtures, 12,001-16,000 lumens	50,000	$151.89	70,000	$62.50	15,000	$68.00	40,000	$122.50
	LED Ag Interior Fixtures, 16,001-20,000 lumens	50,000	$184.62	70,000	$62.50	15,000	$73.00	40,000	$132.50
	LED Ag Interior Fixtures, > 20,000 lumens	50,000	$285.75	70,000	$62.50	15,000	$136.00	40,000	$202.50
LED Exterior Fixtures	LED Exterior Fixtures, <= 5,000 lumens	50,000	$86.92	70,000	$62.50	15,000	$58.00	40,000	$102.50
	LED Exterior Fixtures, 5,001-10,000 lumens	50,000	$111.81	70,000	$62.50	15,000	$63.00	40,000	$112.50
	LED Exterior Fixtures, 10,001-15,000 lumens	50,000	$138.32	70,000	$62.50	15,000	$68.00	40,000	$122.50
	LED Exterior Fixtures, > 15,000 lumens	50,000	$223.67	70,000	$62.50	15,000	$73.00	40,000	$132.50

MEASURE CODE: CI-LTG-LEDB-V0~~6~~7-180101

REVIEW DEADLINE: 1/1/2019

5.1.2 ENERGY STAR and ENERGY STAR Most Efficient Clothes Washers

Description

This measure relates to the installation of a clothes washer meeting the ENERGY STAR, or ENERGY STAR Most Efficient minimum qualifications. Note if the DHW and dryer fuels of the installations are unknown (for example through a retail program) savings should be based on a weighted blend using RECS data (the resultant values (kWh, therms and gallons of water) are provided). The algorithms can also be used to calculate site specific savings where DHW and dryer fuels are known.

This measure was developed to be applicable to the following program types: TOS, NC.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

Clothes washer must meet the ENERGY STAR or ENERGY STAR Most Efficient minimum qualifications, as required by the program.

Definition of Baseline Equipment

The baseline condition is a standard sized clothes washer meeting the minimum federal baseline as of ~~March~~ January 2018~~2015~~[36].

Efficiency Level	Top Loading >2.5 Cu ft	Front Loading >2.5 Cu ft
Federal Standard	~~1.29~~≥1.57 IMEF, ≤6.5~~8.4~~ IWF	≥1.84 IMEF, ≤4.7 IWF
ENERGY STAR	≥2.06 IMEF, ≤4.3 IWF	≥2.76~~2.38~~ IMEF, ≤3.2~~3.7~~ IWF
ENERGY STAR Most Efficient	2.76 IMEF, 3.5 IWF	2.74 IMEF, 3.2IWF

Deemed Lifetime of Efficient Equipment

The expected measure life is assumed to be 14 years[37].

Deemed Measure Cost

The incremental cost for an ENERGY STAR unit is assumed to be $65 and for an ENERGY STAR Most Efficient unit it is $210[38].

Deemed O&M Cost Adjustments

N/A

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[36] See http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/39.

[37] Based on DOE Life-Cycle Cost and Payback Period Excel-based analytical tool, available online at: http://www1.eere.energy.gov/buildings/appliance_standards/residential/clothes_washers_support_stakeholder_negotiations.html

[38] Cost estimates are based on Navigant analysis for the Department of Energy (see CW Analysis_09092014.xls). This analysis looked at incremental cost and shipment data from manufacturers and the Association of Home Appliance Manufacturers and attempts to find the costs associated only with the efficiency improvements. The ENERGY STAR level in this analysis was made the baseline (as it is now equivalent), the CEE Tier 3 level was made ENERGY STAR and ENERGY STAR Most efficient was extrapolated based on equal rates. Note these assumptions should be reviewed as qualifying product becomes available.

Loadshape

Loadshape R01 - Residential Clothes Washer

Coincidence Factor

The coincidence factor for this measure is 3.8%[39].

Algorithm

Calculation of Savings

Electric Energy Savings

1. Calculate clothes washer savings based on the Integrated Modified Energy Factor (IMEF).

   The Integrated Modified Energy Factor (IMEF) includes unit operation, standby, water heating, and drying energy use: "*IMEF is the quotient of the capacity of the clothes container, C, divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, M, the hot water energy consumption, E, ~~and~~ the energy required for removal of the remaining moisture in the wash load, D, and the combined low-power mode energy consumption*" [40].

   The hot water and dryer savings calculated here assumes electric DHW and Dryer (this will be separated in Step 2).

IMEFsavings[41] = Capacity * (1/IMEFbase - 1/IMEFeff) * Ncycles

Where

Capacity = Clothes Washer capacity (cubic feet)

= Actual. If capacity is unknown assume 3.45 cubic feet [42]

IMEFbase = Integrated Modified Energy Factor of baseline unit

= ~~1.66~~1.75[43]

IMEFeff = Integrated Modified Energy Factor of efficient unit

= Actual. If unknown assume average values provided below.

Ncycles = Number of Cycles per year

[39] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.
[40] Definition provided on the Energy star website.
[41] IMEFsavings represents total kWh only when water heating and drying are 100% electric.
42 Based on the average clothes washer volume of all units that pass the new Federal Standard on the California Energy Commission (CEC) database of Clothes Washer products accessed on 08/28/2014. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.
[43] Weighted average IMEF of Federal Standard rating for Front Loading and Top Loading units. Weighting is based upon the relative top v front loading percentage of available non-ENERGY STAR product in the CEC database.

= 295[44]

IMEFsavings is provided below based on deemed values[45]:

Efficiency Level	IMEF	IMEF Savings (kWh)
Federal Standard	~~1.66~~1.75	0.0
ENERGY STAR	~~2.26~~2.49	~~163~~173
ENERGY STAR Most Efficient	~~2.74~~2.74	~~242~~210

2. Break out savings calculated in Step 1 for electric DHW and electric dryer

ΔkWh = [Capacity * 1/IMEFbase * Ncycles * (%CWbase + (%DHWbase * %Electric_DHW) + (%Dryerbase * %Electric_Dryer))] - [Capacity * 1/IMEFeff * Ncycles * (%CWeff + (%DHWeff * %Electric_DHW) + (%Dryereff * %Electric_Dryer))]

Where:

%CW = Percentage of total energy consumption for Clothes Washer operation (different for baseline and efficient unit – see table below)

%DHW = Percentage of total energy consumption used for water heating (different for baseline and efficient unit – see table below)

%Dryer = Percentage of total energy consumption for dryer operation (different for baseline and efficient unit – see table below)

	Percentage of Total Energy Consumption[46]		
	%CW	%DHW	%Dryer
Baseline	7.6%	31.2%	61.2%
ENERGY STAR	8.1%	23.4%	68.5%
ENERGY STAR Most Efficient	13.6%	10%	76.3%

%Electric_DHW = Percentage of DHW savings assumed to be electric

DHW fuel	%Electric_DHW
Electric	100%
Natural Gas	0%

[44] Weighted average of 295 clothes washer cycles per year (based on 2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section, state of IL: http://www.eia.gov/consumption/residential/data/2009/
If utilities have specific evaluation results providing a more appropriate assumption for single-family or multi-family homes, in a particular market, or geographical area then that should be used.

[45] IMEF values are the weighted average of the new ENERGY STAR specifications. Weighting is based upon the relative top v front loading percentage of available ENERGY STAR and ENERGY STAR Most Efficient product in the CEC database. See "CW Analysis_01142016.xls" for the calculation.

[46] The percentage of total energy consumption that is used for the machine, heating the hot water or by the dryer is different depending on the efficiency of the unit. Values are based on a weighted average of top loading and front loading units based on data from DOE Life-Cycle Cost and Payback Period Excel-based analytical tool. See "CW Analysis_01142016.xls" for the calculation.

DHW fuel	%Electric_DHW
Unknown	16%[47]

%Electric_Dryer = Percentage of dryer savings assumed to be electric

Dryer fuel	%Electric_Dryer
Electric	100%
Natural Gas	0%
Unknown	36%[48]

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔkWH								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	~~162.7~~172.8	~~77.0~~87.2	~~96.0~~96.8	~~10.2~~11.2	~~120.0~~117.3	~~34.3~~31.7	~~90.7~~100.9	~~24.0~~24.9	~~48.0~~45.4
ENERGY STAR Most Efficient	~~242.1~~209.8	~~88.2~~66.0	~~149.9~~137.4	~~-4.~~-06.5	~~183.1~~156.9	~~29.2~~13.1	~~112.8~~89.0	~~20.6~~16.5	~~53.8~~36.1

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ΔkWh/Hours * CF

Where:

ΔkWh = Energy Savings as calculated above

Hours = Assumed Run hours of Clothes Washer

= 295 hours[49]

CF = Summer Peak Coincidence Factor for measure.

[47] Default assumption for unknown fuel is based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

[48] Default assumption for unknown is based on percentage of homes with electric dryer from EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.

[49] Based on a weighted average of 295 clothes washer cycles per year assuming an average load runs for one hour (2009 Residential Energy Consumption Survey (RECS) national sample survey of housing appliances section: http://www.eia.gov/consumption/residential/data/2009/)

= 0.038[50]

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔkW								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	~~0.0210~~0.0223	~~0.0099~~0.0112	~~0.0124~~0.0125	~~0.0013~~0.0014	~~0.0155~~0.0151	~~0.0044~~0.0041	~~0.0117~~0.0130	~~0.0031~~0.0032	~~0.0062~~0.0059
ENERGY STAR Most Efficient	~~0.0312~~0.0270	~~0.0114~~0.0085	~~0.0193~~0.0177	~~-0.0005~~-0.0008	~~0.0236~~0.0202	~~0.0038~~0.0017	~~0.0145~~0.0115	~~0.0027~~0.0021	~~0.0069~~0.0047

NATURAL GAS SAVINGS

Break out savings calculated in Step 1 of electric energy savings (MEF savings) and extract Natural Gas DHW and Natural Gas dryer savings from total savings:

ΔTherm = [(Capacity * 1/IMEFbase * Ncycles * ((%DHWbase * %Natural Gas_DHW * R_eff) + (%Dryerbase * %Gas _Dryer))) – (Capacity * 1/IMEFeff * Ncycles * ((%DHWeff * %Natural Gas_DHW * R_eff) + (%Dryereff * %Gas_Dryer)))] * Therm_convert

Where:

Therm_convert = Convertion factor from kWh to Therm

= 0.03413

R_eff = Recovery efficiency factor

= 1.26[51]

%Natural Gas_DHW = Percentage of DHW savings assumed to be Natural Gas

DHW fuel	%Natural Gas_DHW
Electric	0%
Natural Gas	100%
Unknown	84%[52]

%Gas_Dryer = Percentage of dryer savings assumed to be Natural Gas

[50] Calculated from Itron eShapes, 8760 hourly data by end use for Missouri, as provided by Ameren.

[51] To account for the different efficiency of electric and Natural Gas hot water heaters (gas water heater: recovery efficiencies ranging from 0.74 to 0.85 (0.78 used), and electric water heater with 0.98 recovery efficiency (http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf). Therefore a factor of 0.98/0.78 (1.26) is applied.

[52] Default assumption for unknown fuel is based on percentage of homes with gas dryer from EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used

Dryer fuel	%Gas_Dryer
Electric	0%
Natural Gas	100%
Unknown	58%[53]

Other factors as defined above

Using the default assumptions provided above, the prescriptive savings for each configuration are presented below:

	ΔTherms								
	Electric DHW Electric Dryer	Gas DHW Electric Dryer	Electric DHW Gas Dryer	Gas DHW Gas Dryer	Electric DHW Unknown Dryer	Gas DHW Unknown Dryer	Unknown DHW Electric Dryer	Unknown DHW Gas Dryer	Unknown DHW Unknown Dryer
ENERGY STAR	0.0~~0~~	3.7	~~2.3~~2.6	~~6.0~~6.3	~~1.3~~1.1	~~5.0~~4.8	3.1	~~5.4~~5.7	~~4.4~~4.2
ENERGY STAR Most Efficient	0.0~~0~~	~~6.6~~6.2	~~3.1~~2.5	~~9.8~~8.7	~~1.8~~7.3	~~8.4~~7.3	~~5.6~~5.2	~~8.7~~7.7	~~7.4~~6.3

WATER IMPACT DESCRIPTIONS AND CALCULATION

ΔWater (gallons) = Capacity * (IWFbase - IWFeff) * Ncycles

Where

IWFbase = Integrated Water Factor of baseline clothes washer

= ~~5.92~~5.29[54]

IWFeff = Water Factor of efficient clothes washer

= Actual. If unknown assume average values provided below.

Using the default assumptions provided above, the prescriptive water savings for each efficiency level are presented below:

Efficiency Level	IWF[55]	ΔWater (gallons per year)
Federal Standard	~~5.92~~5.29	0.0
ENERGY STAR	~~3.93~~3.62	~~2024~~1,701
ENERGY STAR Most Efficient	3.21	~~2760~~2,123

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

[53] Ibid.

[54] Weighted average IWF of Federal Standard rating for Front Loading and Top Loading units. Weighting is based upon the relative top v front loading percentage of available non-ENERGY STAR product in the CEC database.

[55] IWF values are the weighted average of the new ENERGY STAR specifications. Weighting is based upon the relative top v front loading percentage of available ENERGY STAR and ENERGY STAR Most Efficient product in the CEC database. See "CW Analysis_01142016.xls" for the calculation.

MEASURE CODE: RS-APL-ESCL-~~V04~~V05-~~160601~~180101

REVIEW DEADLINE: 1/1/~~2021~~2019

5.1.3 ENERGY STAR Dehumidifier

Description

A dehumidifier meeting the minimum qualifying efficiency standard established by the current ENERGY STAR Version ~~3.0~~4.0 (effective 10/~~1~~25/~~2012~~2016) is purchased and installed in a residential setting in place of a unit that meets the minimum federal standard efficiency.

This measure was developed to be applicable to the following program types: TOS, NC.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify for this measure, the new dehumidifier must meet the ENERGY STAR standards as defined below:

Capacity (pints/day)	ENERGY STAR Criteria (L/kWh)
<75	≥~~1.85~~2.00
75 to ≤185	≥2.80

Qualifying units shall be equipped with an adjustable humidistat control or shall require a remote humidistat control to operate.

Definition of Baseline Equipment

The baseline for this measure is defined as a new dehumidifier that meets the f~~F~~ederal ~~Standard~~ efficiency standards. The Federal Standard for Dehumidifiers as of October 2012 is defined below:

Capacity (pints/day)	Federal Standard Criteria (L/kWh)
Up to 35	≥1.35
> 35 to ≤ 45	≥1.50
> 45 to ≤ 54	≥1.60
> 54 to ≤ 75	≥1.70
> 75 to ≤ 185	≥2.50

Deemed Lifetime of Efficient Equipment

The assumed lifetime of the measure is 12 years[56].

Deemed Measure Cost

The assumed incremental capital cost for this measure is $60[57].

Loadshape

Loadshape R12 - Residential - Dehumidifier

[56] EPA Research, 2012; ENERGY STAR Dehumidifier Calculator

[57] Based on extrapolating available data from the Department of Energy's Life Cycle Cost analysis spreadsheet and weighting based on volume of units available:
See 'DOE life cycle cost_dehumidifier.xls' for calculation.

Coincidence Factor

The coincidence factor is assumed to be 37% [58].

Algorithm

Calculation of Savings

Electric Energy Savings

$$\Delta kWh = (((\text{Avg Capacity} * 0.473) / 24) * \text{Hours}) * (1 / (L/kWh\_Base) - 1 / (L/kWh\_Eff))$$

Where:

Avg Capacity = Average capacity of the unit (pints/day)

= Actual, if unknown assume capacity in each capacity range as provided in table below, or if capacity range unknown assume average.

0.473 = Constant to convert Pints to Liters

24 = Constant to convert Liters/day to Liters/hour

Hours = Run hours per year

= 1632 [59]

L/kWh = Liters of water per kWh consumed, as provided in tables above

Annual kWh results for each capacity class are presented below:

Capacity Range (pints/day)	Capacity Used (pints/day)	Federal Standard Criteria (≥ L/kWh)	ENERGY STAR Criteria (≥ L/kWh)	Annual kWh		
				Federal Standard	ENERGY STAR	Savings
≤25	20	1.35	~~1.85~~2.00	477	~~348~~322	~~129~~155
> 25 to ≤35	30	1.35	~~1.85~~2.00	715	~~522~~482	~~193~~232
> 35 to ≤45	40	1.50	~~1.85~~2.00	858	~~695~~643	~~162~~214
> 45 to ≤ 54	50	1.60	~~1.85~~2.00	1,005	~~869~~804	~~136~~201
> 54 to ≤ 75	65	1.70	~~1.85~~2.00	1,230	~~1130~~1045	~~100~~184
> 75 to ≤ 185	130	2.50	~~2.8~~2.80	1,673	1493	179
Average[60]	57.6	1.60	2.00	1,155	926	~~140~~229

[58] Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1632 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1632/4392 = 37.2%

[59] ENERGY STAR Dehumidifier Calculator; 24 hour operation over 68 days of the year.

[60] The relative weighting of each product class is based on number of units on the ENERGY STAR certified list, accessed in July 2016. See "Dehumidifier Calcs_05082018.xls.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \Delta kWh / Hours * CF$$

Where:

Hours = Annual operating hours

= 1632 hours [61]

CF = Summer Peak Coincidence Factor for measure

= 0.37 [62]

Summer coincident peak demand results for each capacity class are presented below:

Capacity (pints/day) Range	Annual Summer peak kW Savings
≤25	~~0.029~~0.035
> 25 to ≤35	~~0.044~~0.053
> 35 to ≤45	~~0.037~~0.049
> 45 to ≤ 54	~~0.031~~0.046
> 54 to ≤ 75	~~0.023~~0.042
> 75 to ≤ 185	0.041
Average	~~0.032~~0.052

NATURAL GAS SAVINGS

N/A

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

N/A

MEASURE CODE: RS-APL-ESDH-~~V03~~V04-~~160601~~180101

REVIEW DEADLINE: 1/1/2019

[61] Based on 68 days of 24 hour operation; ENERGY STAR Dehumidifier Calculator

[62] Assume usage is evenly distributed day vs. night, weekend vs. weekday and is used between April through the end of September (4392 possible hours). 1632 operating hours from ENERGY STAR Dehumidifier Calculator. Coincidence peak during summer peak is therefore 1632/4392 = 37.2%

5.5.1 Compact Fluorescent Lamp (CFL)

DESCRIPTION

A low wattage qualified compact fluorescent screw-in bulb (CFL) is installed in place of a baseline screw-in bulb. Note a new ENERGY STAR specification v2.0 becomes effective on 1/2/2017 (https://www.energystar.gov/products/spec/lamps_specification_version_2_0_pd). The efficacy requirements cannot currently be met by Compact Fluorescent Lamps, and therefore this specification has been removed. ENERGY STAR will maintain a list on their website with the final qualifying list of products prior to this change and it is strongly recommended that programs continue to use this list as qualifying criteria for products in the programs.

This characterization assumes that the CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program), a deemed split of 95% Residential and 5% Commercial assumptions should be used[63].

Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) required all general-purpose light bulbs between 40W and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ended in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

A provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until 2021.

This measure was developed to be applicable to the following program types: TOS, NC, DI, KITS. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the high-efficiency equipment must be a standard qualified compact fluorescent lamp.

DEFINITION OF BASELINE EQUIPMENT

The baseline equipment is assumed to be an EISA qualified incandescent or halogen as provided in the table provided in the Electric Energy Savings section.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life (number of years that savings should be claimed) for bulbs installed in 2018 is assumed to be 3 years and then for every subsequent year should be reduced by one year[64].

DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost is $1.20[65].

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[63] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY6, PY7 and PY8 and Ameren PY5, PY6 and PY8 in store intercept survey results. See 'RESvCI Split_112016.xls'.

[64] Since the replacement baseline bulb from 2020 on will be equivalent to a CFL, no additional savings should be claimed from that point. Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until 2021.

[65] Based upon field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

For the Direct Install measure, the full cost of $2.45 per bulb should be used, plus $5 labor cost[66] for a total of $7.45 per bulb. However actual program delivery costs should be utilized if available.

For bulbs provided in Efficiency Kits, the actual program delivery costs should be utilized.

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 7.1% for Time of Sale Residential and in-unit Multi Family bulbs, 27.3% for exterior bulbs and 8.1% for unknown[67] and 7.4% for Residential Direct Install[68].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe

Where:

WattsBase = Based on lumens of CFL bulb and program year installed:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 (WattsBase)
5280	6209	300
3000	5279	200
2601	2999	150
1490	2600	72
1050	1489	53
750	1049	43
310	749	29
250	309	25

WattsEE = Actual wattage of CFL purchased / installed

ISR = In Service Rate, the percentage of units rebated that are actually in service.

[66] Based on 15 minutes at $20 an hour. Includes some portion of travel time to site.
[67] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[68] Based on lighting logger study conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation and excluding all logged bulbs installed in closets.

Program		Weighted Average 1st Year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)		76.5%[69]	11.6%	9.9%	98.0%[70]
Direct Install		96.9%[71]			
Efficiency Kits[72]	CFL Distribution[73]	59%	13%	11%	83%
	School Kits[74]	61%	13%	11%	86%
	Direct Mail Kits[75]	66%	14%	12%	93%

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[76]) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Determined through evaluation or use deemed assumptions below[77]:

ComEd: 2.1%

Ameren: 13.1%

69 1st year in service rate is based upon review of PY6-8 evaluations from ComEd and PY5,6 and 8 for Ameren (see 'IL RES Lighting ISR_112016.xls' for more information). The average first year ISR for each utility was calculated weighted by the number of bulbs in the each year's survey. This was then weighted by annual sales to give a statewide assumption.

70 The 98% Lifetime ISR assumption is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

71 Based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010.

72 In Service Rates provided are for the CFL bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provided may be used.

73 Free bulbs provided without request, with little or no education. Based on 'Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential CFL Distribution Program', Report Table 11 and Appendix B.

74 Kits provided free to students through school, with education program. Based on 'Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential Efficiency Kits Program', table 10. Final ISR assumptions are based upon comparing with CFL Distribution First year ISR and multiplying by the CFL Distribution Final ISR value, and second and third year estimates based on same proportion of future installs.

75 Opt-in program to receive kits via mail, with little or no education. Based on 'Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential Efficiency Kits Program', table 10, as above.

76 Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

77 Leakage rate is based upon review of PY6-8 evaluations from ComEd and PY5,6 and 8 for Ameren (see 'IL Leakage Rates_112016.xls' for more information).

All other programs = 0

Hours = Average hours of use per year

Program Delivery	Installation Location	Hours[78]
Retail (Time of Sale) and Efficiency Kits	Residential Interior and in-unit Multi Family	759
	Exterior	2,475 [79]
	Unknown	847 [80]
Direct Install	Residential Interior and in-unit Multi Family	793
	Exterior	2,475

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [81]
Multi family in unit	1.04 [82]
Exterior or uncooled location	1.0

DEFERRED INSTALLS

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

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[78] Except where noted, based on lighting logger study conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation. Direct Install value excludes all logged bulbs installed in closets.

[79] Based on secondary research conducted as part of the PY5/PY6 ComEd Residential Lighting Program evaluation.

[80] Assumes 5% exterior lighting, based on PYPY5/PY6 ComEd Residential Lighting Program evaluation.

[81] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey)

[82] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from “Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009” which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

For example, for a 14W CFL (60W standard incandescent and 43W EISA qualified incandescent/halogen):

$\Delta kWH_{1st\ year\ installs}$ = ((43 - 14) / 1000) * 0.765 * 847 * 1.06

= 19.9 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((43 - 14) / 1000) * 0.116 * 847 * 1.06

= 3.0 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((43 - 14) / 1000) * 0.099 * 847 * 1.06

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[83] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[84] for interior or unknown location

= 0% for exterior or unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[85]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[86]	N/A	N/A	1.28

[83] Negative value because this is an increase in heating consumption due to the efficient lighting.

[84] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[85] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.

[86] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls", using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

For example, a 14W standard CFL is purchased and installed in home with 2.0 COP (including duct loss) Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((43 - 14) / 1000) * 0.765 * 759 * 0.49) / 2.0

= - 4.2 kWh

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * (1-Leakage) * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[87]
Multi family in unit	1.07[88]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Program Delivery	Bulb Location	CF[89]
Retail(Time of Sale)	Interior single family or Multi Family in unit	7.1%
	Exterior	27.3%
	Unknown location	8.1%
Direct Install	Residential	7.4%

Other factors as defined above

[87] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[88] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

[89] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. Direct Install value is based on resut excluding all logged bulbs installed in closets.

For example, a 14W standard CFL is purchased and installed in a single family interior location:

ΔkW = ((43 - 14) / 1000) * 0.765 * 1.11 * 0.071

= 0.0017 kW

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and

NATURAL GAS SAVINGS

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

ΔTherms[90] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[91] for interior or unknown location

= 0% for exterior or unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[92]

For example, a 14 standard CFL is purchased and installed in a home:

ΔTherms = - (((43 - 14) / 1000) * 0.765 * 759 * 0.49 * 0.03412) / 0.7

= - 0.40 Therms

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

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[90] Negative value because this is an increase in heating consumption due to the efficient lighting.

[91] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[92] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey) In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

DEEMED O&M COST ADJUSTMENT CALCULATION

The O&M assumptions that should be used in cost effectiveness calculations are provided below:

Program Delivery	Installation Location	Replacement Period (years)[93]	Replacement Cost[94]
Retail (Time of Sale) and Efficiency Kits	Residential Interior and in-unit Multi Family	1.3	$1.25
	Exterior	0.4	
	Unknown	1.2	
Direct Install	Residential Interior and in-unit Multi Family	1.3	
	Exterior	0.4	

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs are actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: RS-LTG-ESCF-V0~~6~~7-180101

REVIEW DEADLINE: 1/1/2020

[93] Calculated by dividing assumed rated life of baseline bulb by hours of use. Assumed lifetime of EISA qualified Halogen/ Incandescents is 1000 hours. The manufacturers are simply using a regular incandescent lamp with halogen fill gas rather than Halogen Infrared to meet the standard (as provided by G. Arnold, NEEP and confirmed by N. Horowitz at NRDC).

[94] Based upon field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

5.5.2 ENERGY STAR Specialty Compact Fluorescent Lamp (CFL)

DESCRIPTION

A qualified specialty compact fluorescent bulb is installed in place of an incandescent specialty bulb.

Note a new ENERGY STAR specification v2.0 becomes effective on 1/2/2017 (https://www.energystar.gov/products/spec/lamps_specification_version_2_0_pd). The efficacy requirements cannot currently be met by Compact Fluorescent Lamps, and therefore this specification has been removed. ENERGY STAR will maintain a list on their website with the final qualifying list of products prior to this change and it is strongly recommended that programs continue to use this list as qualifying criteria for products in the programs.

This characterization assumes that the specialty CFL is installed in a residential location. If the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) a deemed split of 95% Residential and 5% Commercial assumptions should be used[95].

This measure was developed to be applicable to the following program types: TOS, NC, DI, KITS.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, the high-efficiency equipment must be a qualified specialty compact fluorescent lamp.

DEFINITION OF BASELINE EQUIPMENT

The baseline is a specialty incandescent light bulb including those exempt of the EISA 2007 standard: three-way, plant light, daylight bulb, bug light, post light, globes G40 (<40W), candelabra base (<60W), vibration service bulb, decorative candle with medium or intermediate base (<40W), shatter resistant and reflector bulbs and standard bulbs greater than 2601 lumens, and those non-exempt from EISA 2007: dimmable, globes (less than 5” diameter and >40W), candle (shapes B, BA, CA >40W, candelabra base lamps (>60W) and intermediate base lamps (>40W).

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected measure life is assumed to be 6.8 year[96] for bulbs exempt from EISA, or 3 years for bulbs non-exempt installed in 2018 and then for every subsequent year should be reduced by one year[97].

DEEMED MEASURE COST

For the Retail (Time of Sale) measure, the incremental capital cost for this measure is $5[98].

For the Direct Install measure, the full cost of $8.50 should be used plus $5 labor[99] for a total of $13.50. However

[95] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY6, PY7 and PY8 and Ameren PY5, PY6 and PY8 in store intercept survey results. See ‘RESvCI Split_112015.xls’.

[96] The assumed measure life for the specialty bulb measure characterization was reported in "Residential Lighting Measure Life Study", Nexus Market Research, June 4, 2008 (measure life for markdown bulbs). Measure life estimate does not distinguish between equipment life and measure persistence. Measure life includes products that were installed and operated until failure (i.e., equipment life) as well as those that were retired early and permanently removed from service for any reason, be it early failure, breakage, or the respondent not liking the product (i.e., measure persistence).

[97] Since the replacement baseline bulb from 2020 on will be equivalent to a CFL, no additional savings should be claimed from that point. Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until 2021.

[98] NEEP Residential Lighting Survey, 2011

[99] Based on 15 minutes at $20 per hour.

actual program delivery costs should be utilized if available.

For bulbs provided in Efficiency Kits, the actual program delivery costs should be utilized.

Loadshape

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

Coincidence Factor

Unlike standard CFLs that could be installed in any room, certain types of specialty CFLs are more likely to be found in specific rooms, which affects the coincident peak factor. Coincidence factors by bulb types are presented below[100]

Bulb Type	Peak CF
Three-way	0.078[101]
Dimmable	0.078[102]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081
Standard spirals >= 2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

Algorithm

Calculation of Savings

Electric Energy Savings

$$\Delta kWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe$$

Where:

WattsBase = Actual wattage equivalent of incandescent specialty bulb, use the tables below to obtain the incandescent bulb equivalent wattage[103]; use 60W if unknown[104]

[100] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[101] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[102] Ibid

[103] Based upon the draft ENERGY STAR specification for lamps (http://energystar.gov/products/specs/sites/products/files/ENERGY_STAR_Lamps_V1_0_Draft%203.pdf) and the Energy Policy and Conservation Act of 2012.

[104] A 2006-2008 California Upstream Lighting Evaluation found an average incandescent wattage of 61.7 Watts (KEMA, Inc, The Cadmus Group, Itron, Inc, PA Consulting Group, Jai J. Mitchell Analytics, Draft Evaluation Report: Upstream Lighting Program.

EISA exempt bulb types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
Standard Spirals >=2601	2601	2999	150
	3000	5279	200
	5280	6209	300
3-Way	250	449	25
	450	799	40
	800	1099	60
	1100	1599	75
	1600	1999	100
	2000	2549	125
	2550	2999	150
Globe (medium and intermediate bases less than 750 lumens)	90	179	10
	180	249	15
	250	349	25
	350	749	40
Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	70	89	10
	90	149	15
	150	299	25
	300	749	40
Globe (candelabra bases less than 1050 lumens)	90	179	10
	180	249	15
	250	349	25
	350	499	40
	500	1049	60
Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	70	89	10
	90	149	15
	150	299	25
	300	499	40
	500	1049	60

Directional Lamps - ENERGY STAR Minimum Luminous Efficacy = 40Lm/W for lamps with rated wattages less than 20Wand 50 Lm/W for lamps with rated wattages >= 20 watts[105].

For Directional R, BR, and ER lamp types[106]:

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
R, ER, BR with medium screw bases w/ diameter >2.25" (*see exceptions below)	420	472	40
	473	524	45
	525	714	50
	715	937	65
	938	1259	75

Prepared for the California Public Utilities Commission, Energy Division. December 10, 2009)

[105] From pg 10 of the Energy Star Specification for lamps v1.1

[106] From pg 11 of the Energy Star Specification for lamps v1.1

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
	1260	1399	90
	1400	1739	100
	1740	2174	120
	2175	2624	150
	2625	2999	175
	3000	4500	200
***R, BR, and ER with medium screw bases w/ diameter <=2.25"**	400	449	40
	450	499	45
	500	649	50
	650	1199	65
***ER30, BR30, BR40, or ER40**	400	449	40
	450	499	45
	500	649	50
***BR30, BR40, or ER40**	650	1419	65
***R20**	400	449	40
	450	719	45
***All reflector lamps below lumen ranges specified above**	200	299	20
	300	399	30

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[107] If CBCP and beam angle information are not available, or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[108]

$$\text{Wattsbase} =$$

$$375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)

BA = Beam angle

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

[107] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/

[108] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

EISA non-exempt bulb types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	Incandescent Equivalent Post-EISA 2007 (WattsBase)
Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	310	749	29
	750	1049	43
	1050	1489	53
	1490	2600	72

WattsEE = Actual wattage of energy efficient specialty bulb purchased, use 15W if unknown[109]

ISR = In Service Rate, the percentage of units rebated that are actually in service.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	88.0%[110]	5.4%	4.6%	98.0%[111]
Direct Install	96.9%[112]			
Efficiency CFL	59%	13%	11%	83%

[109] An evaluation (Energy Efficiency / Demand Response Plan: Plan Year 2 (6/1/2009-5/31/2010) Evaluation Report: Residential Energy Star ® Lighting) reported 13-17W as the most common specialty CFL wattage (69% of program bulbs). 2009 California data also reported an average CFL wattage of 15.5 Watts (KEMA, Inc, The Cadmus Group, Itron, Inc, PA Consulting Group, Jai J. Mitchell Analytics, Draft Evaluation Report: Upstream Lighting Program, Prepared for the California Public Utilities Commission, Energy Division. December 10, 2009).

[110] 1st year in service rate is based upon review of PY4-6 evaluations from ComEd and PY5-6 from Ameren (see 'IL RES Lighting ISR_122014.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

[111] The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[112] Consistent with assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type). Based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010.

Program		Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Kits[113]	Distribution[114]				
	School Kits[115]	61%	13%	11%	86%
	Direct Mail Kits[116]	66%	14%	12%	93%

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[117]) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Determined through evaluation

or use deemed assumptions below[118]:

ComEd: 2.1%

Ameren: 13.1%

All other programs = 0

Hours = Average hours of use per year, varies by bulb type as presented below:[119]

Bulb Type	Annual hours of use (HOU)
Three-way	850
Dimmable	850
Interior reflector (incl. dimmable)	861
Exterior reflector	2475
Candelabra base and candle medium and intermediate base	1190
Bug light	2475
Post light (>100W)	2475

[113] In Service Rates provided are for the bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provide may be used.

[114] Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.

[115] Kits provided free to students through school, with education program. Consistent with Standard CFL assumptions.

[116] Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.

[117] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

[118] Leakage rate is based upon review of PY6-8 evaluations from ComEd and PY5,6 and 8 for Ameren (see 'IL Leakage Rates_112016.xls' for more information).

[119] Hours of use by specialty bulb type calculated using the average hours of use in locations or rooms where each type of specialty bulb is most commonly found. Values for Reflector, Decorative and Globe are taken directly from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. All other hours have been updated based on the room specific hours of use from the PY5/PY6 logger study.

Bulb Type	Annual hours of use (HOU)
Daylight	847
Plant light	847
Globe	639
Vibration or shatterproof	847
Standard Spiral >2601 lumens, Residential, Multi Family in-unit	759
Standard Spiral >2601 lumens, unknown	847
Standard Spiral >2601 lumens, Exterior	2475
Specialty - Generic	847

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [120]
Multi family in unit	1.04 [121]
Exterior or uncooled location	1.0

DEFERRED INSTALLS

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

[120] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey)

[121] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average).

For example, for a 13W dimmable CFL impacted by EISA 2007 (60W standard incandescent and 43W EISA qualified incandescent/halogen).

$$\Delta kWH_{1st\ year\ installs} = ((60 - 13) / 1000) * 0.823 * 850 * 1.06$$

$$= 34.9 \text{ kWh}$$

$$\Delta kWH_{2nd\ year\ installs} = ((43 - 13) / 1000) * 0.085 * 850 * 1.06$$

$$= 2.3 \text{ kWh}$$

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$$\Delta kWH_{3rd\ year\ installs} = ((43 - 13) / 1000) * 0.072 * 850 * 1.06$$

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta kWh^{122} = - (((WattsBase - WattsEE) / 1000) * ISR * (1\text{-}Leakage) * Hours * HF) / \eta Heat$$

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[123] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[124]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[125]	N/A	N/A	1.28

[122] Negative value because this is an increase in heating consumption due to the efficient lighting.

[123] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[124] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.

[125] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see “HC6.9 Space Heating in Midwest Region.xls”, using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

For example, a 15W globe CFL replacing a 60W incandescent specialty bulb installed in home with 2.0 COP Heat Pump (including duct loss):

$\Delta kWh_{1st\ year}$ = - (((60 - 15) / 1000) * 0.823 * 639 * 0.49) / 2.0

= - 5.8 kWh

Summer Coincident Peak Demand Savings

ΔkW =((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[126]
Multi family in unit	1.07[127]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure. Coincidence factors by bulb types are presented below[128]

Bulb Type	Peak CF
Three-way	0.078[129]
Dimmable	0.078[130]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081

[126] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[127] As above but using estimate of 45% of multifamily buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average); http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls.

[128] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[129] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[130] Ibid

Bulb Type	Peak CF
Standard Spiral >=2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

Other factors as defined above

For example, a 15W specialty CFL replacing a 60W incandescent specialty bulb:

$\Delta kW_{1st\ year}$ = ((60 - 15) / 1000) * 0.823 * 1.11 * 0.081

= 0.003 kW

NATURAL GAS SAVINGS

Heating Penalty if Natural Gas heated home (or if heating fuel is unknown):

ΔTherms[131] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[132] for interior or unknown location

= 0% for exterior location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[133]

[131] Negative value because this is an increase in heating consumption due to the efficient lighting.

[132] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[133] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on EIA Residential Energy Consumption Survey (RECS) 2009 for Midwest Region, data for the state of IL. If utilities have specific evaluation results providing a more appropriate assumption for homes in a particular market or geographical area then that should be used.)
In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

For example, a 15W Globe specialty CFL replacing a 60W incandescent specialty bulb:

ΔTherms = - (((60 - 15) / 1000) * 0. 823 * 639 * 0.49 * 0.03412) / 0.7

= - 0.57 Therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

The following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[134]; baseline replacement cost is assumed to be $3.5[135].

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: RS-LTG-ESCC-V06~~5~~-180101

REVIEW DEADLINE: 1/1/2020

[134] Assuming 1000 hour rated life for incandescent bulb: 1000/759 = 1.32

[135] NEEP Residential Lighting Survey, 2011

5.5.3 ENERGY STAR Torchiere

DESCRIPTION

A high efficiency ENERGY STAR fluorescent torchiere is purchased in place of a baseline mix of halogen and incandescent torchieres and installed in a residential setting.

This measure was developed to be applicable to the following program types: TOS, NC.

If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

To qualify for this measure the fluorescent torchiere must meet ENERGY STAR efficiency standards.

DEFINITION OF BASELINE EQUIPMENT

The baseline is based on a mix of halogen and incandescent torchieres.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The lifetime of the measure is assumed to be 8 years[136].

DEEMED MEASURE COST

The incremental cost for this measure is assumed to be $5[137].

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor for this measure is 7.1% for Residential and in-unit Multi Family bulbs and 8.1% for bulbs installed in unknown locations[138].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((\Delta Watts) / 1000) * ISR * (1 - Leakage) * HOURS * WHFe$$

Where:

ΔWatts = Average delta watts per purchased ENERGY STAR torchiere

= 115.8 [139]

[136] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007.
[137] DEER 2008 Database Technology and Measure Cost Data (www.deeresources.com) and consistent with Efficiency Vermont TRM.
[138] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[139] Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 43 (Table 4-9)

ISR = In Service Rate or percentage of units rebated that get installed.

= 0.86 [140]

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[141]) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Determined through evaluation

or use deemed assumptions below[142]:

ComEd: 2.1%

Ameren: 13.1%

All other programs = 0

HOURS = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	1095 (3.0 hrs per day)[143]

WHFe = Waste Heat Factor for Energy to account for cooling savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [144]
Multi family in unit	1.04 [145]
Exterior or uncooled location	1.0

[140] Nexus Market Research, RLW Analytics "Impact Evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs" table 6-3 on p63 indicates that 86% torchieres were installed in year one. http://publicservice.vermont.gov/energy/ee_files/efficiency/eval/marivtreportfinal100104.pdf

[141] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

[142] Leakage rate is based upon review of PY6-8 evaluations from ComEd and PY5,6 and 8 for Ameren (see 'IL Leakage Rates_112016.xls' for more information).

[143] Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 104 (Table 9-7)

[144] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey)

[145] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

For single family buildings:

ΔkWh = (115.8 /1000) * 0.86 * 1095 * 1.06

= 116 kWh

For multi family in unit:

ΔkWh = (115.8 /1000) * 0.86 * 1095 * 1.04

= 113 kWh

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[146] = - ((ΔWatts) /1000) * ISR * (1-Leakage) * HOURS * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[147] for interior or unknown location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use defaults provided below[148]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[149]	N/A	N/A	1.28

[146] Negative value because this is an increase in heating consumption due to the efficient lighting.
[147] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.
[148] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.
[149] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see “HC6.9 Space Heating in Midwest Region.xls”, using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

For example, an ES torchiere installed in a house with a 2016 heat pump:

ΔkWh = - ((115.8) / 1000) * 0.86 * 1095 * 0.49) / 2.04

= - 26.2 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((ΔWatts) /1000) * ISR * (1-Leakage) * WHFd * CF

Where:

WHFd = Waste Heat Factor for Demand to account for cooling savings from efficient lighting

Bulb Location	WHFd
Interior single family or unknown location	1.11[150]
Multi family in unit	1.07[151]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure

Bulb Location	CF[152]
Interior single family or Multi family in unit	7.1%
Unknown location	8.1%

For single family and multi-family in unit buildings:

ΔkW = (115.8 / 1000) * 0.86 * 1.11 * 0.071

= 0.008kW

For unknown location:

ΔkW = (115.8 / 1000) * 0.86 * 1.07 * 0.081

= 0.009 kW

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$\Delta Therms_{WH}$ = - (((ΔWatts) /1000) * ISR * (1-Leakage) * HOURS * 0.03412 * HF) / ηHeat

Where:

[150] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[151] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

[152] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

$\Delta Therms_{WH}$ = gross customer annual heating fuel increased usage for the measure from the reduction in lighting heat in therms.

0.03412 = conversion from kWh to therms

HF = Heating Factor or percentage of light savings that must be heated

= 49% [153]

ηHeat = average heating system efficiency

= 70% [154]

$\Delta Therms_{WH}$ = - ((115.8 / 1000) * 0.86 * 1095 * 0.03412 * 0.49) / 0.70

= - 2.60 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Life of the baseline bulb is assumed to be 1.83 years[155] for residential and multifamily in unit. Baseline bulb cost replacement is assumed to be $6.[156]

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: RS-LTG-ESTO-~~V04~~V05-180101

REVIEW DEADLINE: 1/1/2020

[153] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[154] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey) In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

[155] Based on VEIC assumption of baseline bulb (mix of incandescent and halogen) average rated life of 2000 hours, 2000/1095 = 1.83 years.

[156] Derived from Efficiency Vermont TRM.

5.5.4 Exterior Hardwired Compact Fluorescent Lamp (CFL) Fixture

DESCRIPTION

An ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps is installed in an exterior residential setting. This measure could relate to either a fixture replacement or new installation (i.e. time of sale).

Federal legislation stemming from the Energy Independence and Security Act of 2007 required all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

A provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until 2021.

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

DEFINITION OF EFFICIENT EQUIPMENT

The efficient condition is an ENERGY STAR lighting exterior fixture for pin-based compact fluorescent lamps.

DEFINITION OF BASELINE EQUIPMENT

The baseline condition is a standard EISA qualified incandescent or halogen exterior fixture as provided in the table provided in the Electric Energy Savings section.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The expected life of an exterior fixture is 20 years[157]. However due to the backstop provision in the Energy Independence and Security Act of 2007 that requires by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, the baseline replacement would become a CFL in that year. The expected measure life for CFL fixtures installed in 2018 is therefore assumed to be 3 years. For bulbs installed in 2019, this would be reduced to 2 years[158].

DEEMED MEASURE COST

The incremental cost for an exterior fixture is assumed to be $32[159].

LOADSHAPE

Loadshape R07 - Residential Outdoor Lighting

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[157] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007 (http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf) gives 20 years for an interior fluorescent fixture.

[158] Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until 2021.

159 ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for exterior fixture (http://www.energystar.gov/buildings/sites/default/uploads/files/light_fixture_ceiling_fan_calculator.xlsx?4349-303e=&b6b3-3efd&b6b3-3efd)

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 27.3%[160].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh =((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 (WattsBase)
5280	6209	300
3000	5279	200
2601	2999	150
1490	2600	72
1050	1489	53
750	1049	43
310	749	29
250	309	25

WattsEE = Actual wattage of CFL purchased

ISR = In Service Rate or the percentage of units rebated that get installed.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	87.5%[161]	5.7%	4.8%	98.0%[162]
Direct Install	96.9[163]			

[160] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[161] 1st year in service rate is based upon review of PY2-3 evaluations from ComEd (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

[162] The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[163] In the absence of evaluation results for Direct Install Fixtures specifically, this is made consistent with the Direct Install CFL measure which is based upon review of the PY2 and PY3 ComEd Direct Install program surveys.

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[164]) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Determined through evaluation

or use deemed assumptions below[165]:

ComEd: 1.05%

Ameren: 6.55%

All other programs = 0

Hours = Average hours of use per year

=2475 (6.78 hrs per day)[166]

DEFERRED INSTALLS

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated assumptions if available.

Year 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied.

The NTG factor for the Purchase Year should be applied.

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[164] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

[165] Leakage rate is based upon TAC agreed 50% of the lamp leakage assumptions (based upon review of PY6-8 evaluations from ComEd and PY5,6 and 8 for Ameren (see 'IL Leakage Rates_112016.xls' for more information)).

[166] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

For example, for a 2 x 14W pin based CFL fixture (43W EISA qualified incandescent/halogen).

$\Delta kWH_{1st\ year\ installs}$ = ((86 - 28) / 1000) * 0.875 * 2475

= 125.6 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 2475

= 8.2 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((86 - 28) / 1000) * 0.048 * 2475

Summer Coincident Peak Demand Savings

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * (1-Leakage) * CF

Where:

CF = Summer Peak Coincidence Factor for measure.

= 27.3%[167]

Other factors as defined above

For example, a 2 x 14W pin-based CFL fixture:

$\Delta kW_{1st\ year}$ = ((86 - 28) / 1000) * 0.875 * 0.273

= 0.0142 kW

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and

Natural Gas Savings

N/A

Water Impact Descriptions and Calculation

N/A

Deemed O&M Cost Adjustment Calculation

Life of the baseline bulb is assumed to be 0.4 years[168] for exterior applications. Baseline bulb cost replacement is assumed to be $1.25.[169]

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be

[167] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[168] Calculated by dividing assumed rated life of baseline bulb by hours of use. Assumed lifetime of EISA qualified Halogen/ Incandescents is 1000 hours. The manufacturers are simply using a regular incandescent lamp with halogen fill gas rather than Halogen Infrared to meet the standard (as provided by G. Arnold, NEEP and confirmed by N. Horowitz at NRDC).

[169] Based upon field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: RS-LRG-EFOX-V0~~6~~7-180101

REVIEW DEADLINE: 1/1/2020

5.5.5 Interior Hardwired Compact Fluorescent Lamp (CFL) Fixture

Description

An ENERGY STAR lighting fixture wired for exclusive use with pin-based compact fluorescent lamps is installed in an interior residential setting. This measure could relate to either a fixture replacement or new installation (i.e. time of sale).

Federal legislation stemming from the Energy Independence and Security Act of 2007 required all general-purpose light bulbs between 40 and 100W to be approximately 30% more energy efficient than current incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ends in 2012, followed by restrictions on 75W in 2013 and 60W and 40W in 2014. The baseline for this measure has therefore become bulbs (improved incandescent or halogen) that meet the new standard.

A provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. Therefore the measure life (number of years that savings should be claimed) should be reduced once the assumed lifetime of the bulb exceeds 2020. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until 2021.

This measure was developed to be applicable to the following program types: TOS, NC. If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

The efficient condition is an ENERGY STAR lighting interior fixture for pin-based compact fluorescent lamps.

Definition of Baseline Equipment

The baseline condition is a standard EISA qualified incandescent or halogen interior fixture as provided in the table provided in the Electric Energy Savings section.

Deemed Lifetime of Efficient Equipment

The expected life of an interior fixture is 20 years[170]. However due to the backstop provision in the Energy Independence and Security Act of 2007 that requires by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, the baseline replacement would become equivalent to a CFL in that year. The expected measure life for CFL fixtures installed in 2018 is therefore assumed to be 3 years. For bulbs installed in 2019, this would be reduced to 2 years and should be reduced each year[171].

Deemed Measure Cost

The incremental cost for an interior fixture is assumed to be $32[172].

Loadshape

Loadshape R06 - Residential Indoor Lighting

[170] Measure Life Report, Residential and Commercial/Industrial Lighting and HVAC Measures, GDS Associates, June 2007 (http://www.ctsavesenergy.org/files/Measure%20Life%20Report%202007.pdf) gives 20 years for an interior fluorescent fixture.

171 Due to expected delay in clearing stock from retail outlets and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until 2021.

172 ENERGY STAR Qualified Lighting Savings Calculator default incremental cost input for interior fixture (http://www.energystar.gov/buildings/sites/default/uploads/files/light_fixture_ceiling_fan_calculator.xlsx?4349-303e=&b6b3-3efd&b6b3-3efd)

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 7.1%[173] for Residential and in-unit Multi Family bulbs.

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe

Where:

WattsBase = Based on lumens of CFL bulb and program year purchased:

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Post-EISA 2007 ($Watts_{Base}$)
5280	6209	300
3000	5279	200
2601	2999	150
1490	2600	72
1050	1489	53
750	1049	43
310	749	29
250	309	25

WattsEE = Actual wattage of CFL purchased

ISR = In Service Rate or the percentage of units rebated that get installed.

Program	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	87.5%[174]	5.7%	4.8%	98.0%[175]
Direct Install	96.9[176]			

[173] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[174] 1st year in service rate is based upon review of PY2-3 evaluations from ComEd (see 'IL RES Lighting ISR.xls' for more information. The average first year ISR was calculated weighted by the number of bulbs in the each year's survey.

[175] The 98% Lifetime ISR assumption is consistent with the assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type) based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[176] In the absence of evaluation results for Direct Install Fixtures specifically, this is made consistent with the Direct Install CFL

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[177]) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Determined through evaluation

or use deemed assumptions below[178]:

ComEd: 1.05%

Ameren: 6.55%

All other programs = 0

Hours = Average hours of use per year

Installation Location	Hours
Residential and in-unit Multi Family	759 [179]

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [180]
Multi family in unit	1.04 [181]

DEFERRED INSTALLS

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs: Characterized using assumptions provided above or evaluated

measure which is based upon review of the PY2 and PY3 ComEd Direct Install program surveys.

[177] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.

[178] Leakage rate is based upon TAC agreed 50% of the lamp leakage assumptions (based upon review of PY6-8 evaluations from ComEd and PY5,6 and 8 for Ameren (see 'IL Leakage Rates_112016.xls' for more information)).

[179] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[180] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey)

[181] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

	assumptions if available.
Year 2 and 3 installs:	Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied. The NTG factor for the Purchase Year should be applied.

For example, for a 2 x 14W pin based CFL fixture (43W EISA qualified incandescent/halogen):

$\Delta kWH_{1st\ year\ installs}$ = ((86 - 28) / 1000) * 0.875 * 759 * 1.06

= 40.8 kWh

$\Delta kWH_{2nd\ year\ installs}$ = ((86 - 28) / 1000) * 0.057 * 759 * 1.06

= 2.7 kWh

Note: Here we assume no change in hours assumption. NTG value from Purchase year applied.

$\Delta kWH_{3rd\ year\ installs}$ = ((86 - 28) / 1000) * 0.048 * 759 * 1.06

HEATING PENALTY

If electric heated building:

ΔkWh[182] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[183] for interior or unknown location

= 0% for unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[184]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006 - 2014	7.7	1.92

182 Negative value because this is an increase in heating consumption due to the efficient lighting.

183 This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

184 These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[185]	N/A	N/A	1.28

For example, a 2 x 14W pin-based CFL fixture is purchased and installed in home with 2.0 COP (including duct loss) Heat Pump:

$\Delta kWh_{1st\ year}$ = - (((86 – 28) / 1000) * 0.875 * 759 * 0.49) / 2.0

= - 9.4 kWh

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * (1-Leakage) * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[186]
Multi family in unit	1.07[187]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF[188]
Interior single family or unknown location	7.1%
Multi family in unit	7.1%

Other factors as defined above

185 Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls", using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

186 The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

187 As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

188 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

For example, a 14W pin-based CFL fixture:

$\Delta kW_{1st\ year}$ = ((86- 28) / 1000) * 0.875 * 1.11 * 0.071

= 0.004 kW

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and

NATURAL GAS SAVINGS

ΔTherms[189] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[190] for interior or unknown location

= 0% for unheated location

0.03412 =Converts kWh to Therms

ηHeat = Efficiency of heating system

=70%[191]

For example, a 2 x 14W pin-based CFL fixture is purchased and installed in home with gas heat at 70% efficiency:

$\Delta Therms_{1st\ year}$ = -((86 - 28) / 1000) * 0.875 * 759 * 0.49 * 0.03412) / 0.7

= - 0.9 Therms

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year.

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Life of the baseline bulb is assumed to be 1.3 years[192] for interior applications. Baseline bulb cost replacement is

189 Negative value because this is an increase in heating consumption due to the efficient lighting.

190 This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

191 This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey) In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

192 Calculated by dividing assumed rated life of baseline bulb by hours of use. Assumed lifetime of EISA qualified Halogen/ Incandescents is 1000 hours. The manufacturers are simply using a regular incandescent lamp with halogen fill gas rather than Halogen Infrared to meet the standard (as provided by G. Arnold, NEEP and confirmed by N. Horowitz at NRDC).

assumed to be $1.25.[193]

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

MEASURE CODE: RS-LTG-IFIX-V07~~6~~-180101

REVIEW DEADLINE: 1/1/2020

[193] Based upon field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

5.5.6 LED Specialty Lamps

Description

This measure describes savings from a variety of specialty LED lamp types (including globe, decorative and downlights). This characterization assumes that the LED lamp or fixture is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) a deemed split of 95% Residential and 5% Commercial assumptions should be used[194].

This measure was developed to be applicable to the following program types: TOS, NC.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

To qualify for this measure the installed equipment must be an ENERGY STAR LED lamp or fixture. Note a new ENERGY STAR specification v2.0 becomes effective on 1/2/2017 (https://www.energystar.gov/products/spec/lamps_specification_version_2_0_pd).

Definition of Baseline Equipment

The baseline condition is assumed to be an incandescent/halogen lamp for all lamp types.

The baseline for the early replacement measure is the existing bulb being replaced.

Deemed Lifetime of Efficient Equipment

While LED rated lives are often 15,000 – 50,000 hours, all installations are assumed to be 10 years[195] except for recessed downlight and track lights at 15 years[196]

For early replacement measures, if replacing a halogen or incandescent bulb, the remaining life is assumed to be 333 hours. For CFL's, the remaining life is 3,333 hours[197].

Deemed Measure Cost

The price of LED lamps is falling quickly. Where possible, the actual cost should be used and compared to the baseline cost provided below. If the incremental cost is unknown, assume the following[198]:

Bulb Type	Year	Incandescent	LED	Incremental Cost
Recessed Downlight Luminaires	All	$4.00	$94.00	$90.00
Track Lights	All	$4.00	$60.00	$56.00
Directional	2017	$3.53	$6.24	$2.71
	2018-2019		$5.18	$1.65
Decorative and Globe	2017	$1.60	$3.50	$1.90
	2018-2019	$1.74	$3.40	$1.66

194 RES v C&I split is based on a weighted (by sales volume) average of ComEd PY6, PY7 and PY8 and Ameren PY5, PY6 and PY8 in store intercept survey results. See 'RESvCI Split_112016.xls'.
195 Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18.
196 Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011)
197 Representing a third of the expected lamp lifetime.
198 Baseline and LED lamp costs for both directional and decorative and globe are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis. Recessed downlight and track light costs are based on VEIC review of a year's worth of LED sales data through VEIC implemented programs and the retail cost averaged (see 2015 LED Sales Review.xls) and of price reports provided to Efficiency Vermont by a number of manufacturers and retailers. Baseline cost based on "2010-2012 WA017 Ex Ante Measure Cost Study Draft Report", Itron, February 28, 2014.

LOADSHAPE

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

COINCIDENCE FACTOR

Unlike standard lamps that could be installed in any room, certain types of specialty lamps are more likely to be found in specific rooms, which affects the coincident peak factor. Coincidence factors by bulb types are presented below[199]

Bulb Type	Peak CF
Three-way	0.078[200]
Dimmable	0.078[201]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Unknown reflector	0.094
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081
Standard Spiral >=2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

ΔkWh = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * WHFe

Where:

$Watts_{base}$ = Input wattage of the existing or baseline system. Reference the table below for default values.

EISA exempt bulb types:

[199] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[200] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[201] Ibid

Bulb Type	Lower Lumen Range	Upper Lumen Range	WattsBase
Standard Spirals >=2601	2601	2999	150
	3000	5279	200
	5280	6209	300
3-Way	250	449	25
	450	799	40
	800	1099	60
	1100	1599	75
	1600	1999	100
	2000	2549	125
	2550	2999	150
Globe (medium and intermediate bases less than 750 lumens)	90	179	10
	180	249	15
	250	349	25
	350	749	40
Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)	70	89	10
	90	149	15
	150	299	25
	300	749	40
Globe (candelabra bases less than 1050 lumens)	90	179	10
	180	249	15
	250	349	25
	350	499	40
	500	1049	60
Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)	70	89	10
	90	149	15
	150	299	25
	300	499	40
	500	1049	60

Directional Lamps -

For Directional R, BR, and ER lamp types[202]:

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
R, ER, BR with medium screw bases w/ diameter >2.25" (*see exceptions below)	420	472	40
	473	524	45
	525	714	50
	715	937	65
	938	1259	75
	1260	1399	90
	1400	1739	100
	1740	2174	120
	2175	2624	150
	2625	2999	175

[202] From pg 11 of the Energy Star Specification for lamps v1.1

Bulb Type	Lower Lumen Range	Upper Lumen Range	$Watts_{Base}$
	3000	4500	200
***R, BR, and ER with medium screw bases w/ diameter <=2.25"**	400	449	40
	450	499	45
	500	649	50
	650	1199	65
***ER30, BR30, BR40, or ER40**	400	449	40
	450	499	45
	500	649	50
***BR30, BR40, or ER40**	650	1419	65
***R20**	400	449	40
	450	719	45
***All reflector lamps below lumen ranges specified above**	200	299	20
	300	399	30

Directional lamps are exempt from EISA regulations.

For PAR, MR, and MRX Lamps Types:

For these highly focused directional lamp types, it is necessary to have Center Beam Candle Power (CBCP) and beam angle measurements to accurately estimate the equivalent baseline wattage. The formula below is based on the Energy Star Center Beam Candle Power tool.[203] If CBCP and beam angle information are not available or if the equation below returns a negative value (or undefined), use the manufacturer's recommended baseline wattage equivalent.[204]

$$\text{Wattsbase} =$$

$$375.1 - 4.355(D) - \sqrt{227{,}800 - 937.9(D) - 0.9903(D^2) - 1479(BA) - 12.02(D * BA) + 14.69(BA^2) - 16{,}720 * \ln(CBCP)}$$

Where:

D = Bulb diameter (e.g. for PAR20 D = 20)

BA = Beam angle

CBCP = Center beam candle power

The result of the equation above should be rounded DOWN to the nearest wattage established by Energy Star:

[203] http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/

[204] The Energy Star Center Beam Candle Power tool does not accurately model baseline wattages for lamps with certain bulb characteristic combinations – specifically for lamps with very high CBCP.

Diameter	Permitted Wattages
16	20, 35, 40, 45, 50, 60, 75
20	50
30S	40, 45, 50, 60, 75
30L	50, 75
38	40, 45, 50, 55, 60, 65, 75, 85, 90, 100, 120, 150, 250

EISA non-exempt bulb types:

Bulb Type	Lower Lumen Range	Upper Lumen Range	Incandescent Equivalent Post-EISA 2007 (WattsBase)
Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	310	749	29
	750	1049	43
	1050	1489	53
	1490	2600	72

$Watts_{EE}$ = Actual wattage of LED purchased / installed.

ISR = In Service Rate or the percentage of units rebated that get installed

Program	Bulb Type	Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)	Recessed downlight luminaries and Track Lights	100%[205]			
	All other lamps	93.5%[206]	2.4%	2.1%	98.0%[207]
Direct Install	All lamps	96.9%[208]			

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed

[205] NEEP EMV Emerging Technologies Research Report (December 2011)

[206] 1st year in service rate is based upon analysis of ComEd PY7 and PY8 intercept data (see 'IL RES Lighting ISR_112016.xls' for more information).

[207] The 98% Lifetime ISR assumption is based upon the standard CFL measure in the absence of any better reference. This value is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.

[208] Consistent with assumption for standard CFLs (in the absence of evidence that it should be different for this bulb type). Based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010.

appropriate[209]) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Determined through evaluation

or use deemed assumptions below[210]:

ComEd: 2.1%

Ameren: 13.1%

All other programs = 0

Hours = Average hours of use per year [211]

Bulb Type	Annual hours of use (HOU)
Three-way	850
Dimmable	850
Interior reflector (incl. dimmable)	861
Exterior reflector	2475
Unknown reflector	891
Candelabra base and candle medium and intermediate base	1190
Bug light	2475
Post light (>100W)	2475
Daylight	847
Plant light	847
Globe	639
Vibration or shatterproof	847
Standard Spiral >2601 lumens, Residential, Multi Family in-unit	759
Standard Spiral >2601 lumens, unknown	847
Standard Spiral >2601 lumens, Exterior	2475
Specialty – Generic Interior	847
Specialty – Generic Exterior	2475

WHFe = Waste heat factor for energy to account for cooling savings from efficient lighting

[209] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.
[210] Leakage rate is based upon review of PY6-8 evaluations from ComEd and PY5,6 and 8 for Ameren (see 'IL Leakage Rates_112016.xls' for more information).
[211] Hours of use by specialty bulb type calculated using the average hours of use in locations or rooms where each type of specialty bulb is most commonly found. Values for Reflector, Decorative and Globe are taken directly from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. All other hours have been updated based on the room specific hours of use from the PY5/PY6 logger study.

Bulb Location	WHFe
Interior single family or unknown location	1.06 [212]
Multi family in unit	1.04 [213]
Exterior or uncooled location	1.0

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location:

ΔkWh = ((45 - 13) / 1000) * 0.935 * 861 * 1.06

= 27.3 kWh

Mid Life Baseline Adjustment

For non-exempt lamps, an appropriate baseline adjustment should be included to account for the 2020 EISA backstop provision making replacement baseline lamps meet 45 lumens/watt. Due to expected delay in clearing retail inventory and to account for the operating life of a halogen incandescent potentially spanning over 2020, this shift is assumed not to occur until 2021.

Note for early replacement measures an additional baseline shift accounting for the replacement of the existing unit with a new baseline lamp should be accounted for.

HEATING PENALTY

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

ΔkWh[214] = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / ηHeat

Where:

HF = Heating Factor or percentage of light savings that must be heated

= 49%[215] for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

[212] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey)

[213] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from “Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009” which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

[214] Negative value because this is an increase in heating consumption due to the efficient lighting.

[215] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

= Actual. If not available use: [216]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[217]	N/A	N/A	1.28

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5",installed in single family interior location with a 2016 heat pump:

ΔkWh = - ((45 - 13) / 1000) * 0.935 * 861 * 0.49) / 2.04

6.18 kWh

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[218]
Multi family in unit	1.07[219]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure, see above for values. [220]

[216] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.

[217] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see “HC6.9 Space Heating in Midwest Region.xls”, using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

[218] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak hours divided by the maximum cooling load.

[219] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from “Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009” which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

[220] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

Bulb Type	Peak CF
Three-way	0.078[221]
Dimmable	0.078[222]
Interior reflector (incl. dimmable)	0.091
Exterior reflector	0.273
Unknown reflector	0.094
Candelabra base and candle medium and intermediate base	0.121
Bug light	0.273
Post light (>100W)	0.273
Daylight	0.081
Plant light	0.081
Globe	0.075
Vibration or shatterproof	0.081
Standard Spiral >=2601 lumens, Residential, Multi-family in unit	0.071
Standard spirals >= 2601 lumens, unknown	0.081
Standard spirals >= 2601 lumens, exterior	0.273
Specialty - Generic	0.081

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location:

$$\Delta kW = ((45 - 13) / 1000) * 0.935 * 1.11 * 0.091$$

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

$$\Delta therms = - (((WattsBase - WattsEE) / 1000) * ISR * (1\text{-}Leakage) * Hours * HF * 0.03412) / \eta Heat$$

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [223] for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

[221] Based on average of bedroom, dining room, office and living room results from the lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.

[222] Ibid

[223] Average result from REMRate modeling of several different configurations and IL locations of homes

= 0.70 [224]

Other factors as defined above

For example, a 13W PAR20 LED is installed in place of a 750 lumen PAR20 incandescent screw-in lamp with medium screw base, diameter >2.5", installed in single family interior location with gas heating at 70% total efficiency:

Δtherms = - (((45 - 13) / 1000) * 0.935 * 861 * 0.49* 0.03412) / 0.70

= - 0.62 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

For those bulbs types exempt from EISA (except for reflectors) the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[225]; baseline replacement cost is assumed to be $4.0.

For reflectors the life of the baseline bulb and the cost of its replacement is presented in the following table:

Lamp Type	Baseline Lamp Life (hours)	Baseline Life (Single Family and in unit Multifamily - 1010 hours)	Baseline Replacement Cost
PAR20, PAR30, PAR38 screw-in lamps	2000	2.0	$4.00
MR16/PAR16 pin-based lamps	2000	2.0	$3.00
Recessed downlight luminaries	2000	2.0	$4.00
Track lights	2000	2.0	$4.00

For non-exempt EISA bulb types defined above, in order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the LED bulb is calculated. The key assumptions used in this calculation are documented below:

Bulb replacement costs assumed in the O&M calculations are provided below[226].

	EISA Compliant Incandescent	Specialty CFL

[224] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey) In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:
(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

[225] Assuming 1000 hour rated life for incandescent bulb: 1000/759 = 1.32

[226] Baseline costs are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

	/Halogen (Decorative/Globe)	
2017	$1.74	N/A
2018	$1.74	N/A
2019	$1.74	N/A
2020 & after	N/A	$3.40[227]

Installation Location	Omnidirectional LED Measure Hours	Hours of Use per year [228]	Measure Life in Years (capped at 10)
Interior and Unknown	15,000	847	10
Exterior	15,000	2475	6.1

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.46% are presented below[229].

Location	EISA Compliant Bulb Type	NPV of replacement costs for period			Levelized annual replacement cost savings		
		2018	2019	2020	2018	2019	2020
Interior and Unknown	Dimmable Twist, Globe (less than 5" in diameter and > 749 lumens), candle (shapes B, BA, CA > 749 lumens), Candelabra Base Lamps (>1049 lumens), Intermediate Base Lamps (>749 lumens)	$2.86	$2.86	$2.86	$0.29	$0.29	$0.29
Exterior		$5.96	$5.96	$5.96	$0.61	$0.61	$0.61

It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR.

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227 Assumed consistent with LED cost.
228 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations.
229 See “Specialty LED EISA compliant O&M Calc.xlsx” for calculation.

5.5.8 LED Screw Based Omnidirectional Bulbs

Description

This characterization provides savings assumptions for LED Screw Based Omnidirectional (e.g. A-Type lamps) lamps within the residential and multifamily sectors. This characterization assumes that the LED lamp or fixture is installed in a residential location. Where the implementation strategy does not allow for the installation location to be known (e.g. an upstream retail program) a deemed split of 95% Residential and 5% Commercial assumptions should be used[230].

This measure was developed to be applicable to the following program types: TOS, NC, EREP, KITS.

If applied to other program types, the measure savings should be verified.

Definition of Efficient Equipment

In order for this characterization to apply, new lamps must be ENERGY STAR labeled. Note a new ENERGY STAR specification v2.0 becomes effective on 1/2/2017 (https://www.energystar.gov/products/spec/lamps_specification_version_2_0_pd).

Definition of Baseline Equipment

In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EIAS) will require all general-purpose light bulbs between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards apply; in 2013 the 75 w lamp standards will apply, followed by restrictions on the 60 w and 40 w lamps in 2014. Since measures installed under this TRM all occur after 2014, baseline equipment are the values after EISA. These are shown in the baseline table below.

The baseline for the early replacement measure is the existing bulb being replaced.

Deemed Lifetime of Efficient Equipment

The deemed measure life is 6.1 years[231] for exterior application. For all other applications, lifetimes are capped at 10 years[232].

For early replacement measures, if replacing a halogen or incandescent bulb, the remaining life is assumed to be 333 hours. For CFL's, the remaining life is 3,333 hours[233].

Deemed Measure Cost

The price of LED lamps is falling quickly. Where possible, the actual LED lamp cost should be used and compared to the baseline cost provided below. If the incremental cost is unknown, assume the following[234]:

Year	EISA Compliant Halogen	LED-A	Incremental Cost
2017	$1.25	$3.21	$1.96
2018		$3.21	$1.96
2019		$3.11	$1.86

[230] RES v C&I split is based on a weighted (by sales volume) average of ComEd PY6, PY7 and PY8 and Ameren PY5, PY6 and PY8 in store intercept survey results. See 'RESvCI Split_112016.xls'.

[231] ENERGY STAR v2.0 requires omnidirectional LED bulbs to be rated for at least 15,000 hours. 15000/2475 (exterior hours of use) = 6.1 years.

[232] Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18.

[233] Representing a third of the expected lamp lifetime.

[234] Baseline and LED lamp costs are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

LOADSHAPE

Loadshape R06 – Residential Indoor Lighting

Loadshape R07 – Residential Outdoor Lighting

COINCIDENCE FACTOR

The summer peak coincidence factor is assumed to be 7.1% for Residential and in-unit Multi Family bulbs, 27.3% for exterior bulbs and 8.1% for unknown[235].

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = ((Watts_{base} - Watts_{EE})/1000) * ISR * (1-Leakage) * Hours * WHF_e$$

Where:

$Watts_{base}$ = Input wattage of the existing or baseline system. Reference the "LED New and Baseline Assumptions" table for default values.

$Watts_{EE}$ = Actual wattage of LED purchased / installed. If unknown, use default provided below:

LED New and Baseline Assumptions Table

Minimum Lumens	Maximum Lumens	Lumens used to calculate LED Wattage (midpoint)	LED Wattage [236] (WattsEE)	Baseline 2014-2019 (WattsBase)	Delta Watts 2014-2019 (WattsEE)	Baseline Post EISA 2020 requirement[237] (WattsBase)	Delta Watts Post 2020 (WattsEE)
5280	6209	5745	72.9	300.0	227.1	300.0	227.1
3000	5279	4140	52.5	200.0	147.5	200.0	147.5
2601	2999	2800	35.5	150.0	114.5	150.0	114.5
1490	2600	2045	26.0	72.0	46.0	45.4	19.5
1050	1489	1270	16.1	53.0	36.9	28.2	12.1
750	1049	900	11.4	43.0	31.6	20.0	8.6
310	749	530	6.7	29.0	22.3	11.8	5.0
250	309	280	3.5	25.0	21.5	25.0	21.5

ISR = In Service Rate, the percentage of units rebated that are actually in service.

[235] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[236] Based on ENERGY STAR V2.0 specs – for omnidirectional <90CRI: 80 lm/W and for omnidirectional >=90 CRI: 70 lm/W. To weight these two criteria, the ENERGY STAR qualified list was reviewed and found to contain 87.8% lamps <90CRI and 12.2% >=90CRI.
[237] Calculated as 45lm/W for all EISA non-exempt bulbs.

Program		Weighted Average 1st year In Service Rate (ISR)	2nd year Installations	3rd year Installations	Final Lifetime In Service Rate
Retail (Time of Sale)		89.9%[238]	4.3%	3.7%	98.0%[239]
Direct Install		96.9%[240]			
Efficiency Kits[241]	CFL Distribution[242]	59%	13%	11%	83%
	School Kits[243]	61%	13%	11%	86%
	Direct Mail Kits[244]	66%	14%	12%	93%

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[245]) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Determined through evaluation

or use deemed assumptions below[246]:

ComEd: 2.1%

Ameren: 13.1%

All other programs = 0

[238] 1st year in service rate is based upon analysis of ComEd PY7 and PY8 and Ameren PY8 intercept data (see 'IL RES Lighting ISR_112016.xls' for more information).
[239] The 98% Lifetime ISR assumption is based upon the standard CFL measure in the absence of any better reference. This value is based upon review of two evaluations:
'Nexus Market Research, RLW Analytics and GDS Associates study; "New England Residential Lighting Markdown Impact Evaluation, January 20, 2009' and 'KEMA Inc, Feb 2010, Final Evaluation Report:, Upstream Lighting Program, Volume 1.' This implies that only 2% of bulbs purchased are never installed. The second and third year installations are based upon Ameren analysis of the Californian KEMA study showing that 54% of future installs occur in year 2 and 46% in year 3. The 2nd and 3rd year installations should be counted as part of those future program year savings.
[240] Based upon Standard CFL assumption in the absence of better data, and is based upon review of the PY2 and PY3 ComEd Direct Install program surveys. This value includes bulb failures in the 1st year to be consistent with the Commission approval of annualization of savings for first year savings claims. ComEd PY2 All Electric Single Family Home Energy Performance Tune-Up Program Evaluation, Navigant Consulting, December 21, 2010.
[241] In Service Rates provided are for the bulb within a kit only. Given the significant differences in program design and the level of education provided through Efficiency Kits programs, the evaluators should apply the ISR estimated through evaluations (either past evaluations or the current program year evaluation) of the specific Efficiency Kits program. In cases where program-specific evaluation results for an ISR are unavailable, the default ISR values for Efficiency Kits provide may be used.
[242] Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions.
[243] Kits provided free to students through school, with education program. Consistent with Standard CFL assumptions.
[244] Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions.
[245] Leakage in is only appropriate to credit to IL utility program savings if it is reasonably expected that the IL utility program marketing efforts played an important role in influencing customer to purchase the light bulbs. Furthermore, consideration that such customers might be free riders should be addressed. If leakage in is assessed, efforts should be made to ensure no double counting of savings occurs if the evaluation is estimating both leakage in and spillover savings of light bulbs.
[246] Leakage rate is based upon review of PY6-8 evaluations from ComEd and PY5,6 and 8 for Ameren (see 'IL Leakage Rates_112016.xls' for more information).

Hours = Average hours of use per year

Installation Location	Hours[247]
Residential and in-unit Multi Family	759
Exterior	2475
Unknown	847

WHFe = Waste heat factor for energy to account for cooling energy savings from efficient lighting

Bulb Location	WHFe
Interior single family or unknown location	1.06 [248]
Multi family in unit	1.04 [249]
Exterior or uncooled location	1.0

Mid Life Baseline Adjustment

During the lifetime of a standard Omnidirectional LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Since the baseline bulb changes over time (except for <300 and 2600+ lumen lamps) the annual savings claim must be reduced within the life of the measure to account for this baseline shift.

For example, for 60W equivalent bulbs installed in 2018, the full savings (as calculated above in the Algorithm) should be claimed for the first three years, but a reduced annual savings (calculated energy savings above multiplied by the adjustment factor in the table below) claimed for the remainder of the measure life.

Minimum Lumens	Maximum Lumens	LED Wattage (WattsEE)	Delta Watts 2014-2019 (WattsEE)	Delta Watts Post 2020 (WattsEE)	Mid Life adjustment (made from 01/2021) to first year savings
1490	2600	26.0	46.0	19.5	42.3%
1050	1489	16.1	36.9	12.1	32.8%
750	1049	11.4	31.6	8.6	27.1%
310	749	6.7	22.3	5.0	22.6%

[247] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation.
[248] The value is estimated at 1.06 (calculated as 1 + (0.66*(0.27 / 2.8)). Based on cooling loads decreasing by 27% of the lighting savings (average result from REMRate modeling of several different configurations and IL locations of homes), assuming typical cooling system operating efficiency of 2.8 COP (starting from standard assumption of SEER 10.5 central AC unit, converted to 9.5 EER using algorithm (-0.02 * SEER2) + (1.12 * SEER) (from Wassmer, M. (2003). A Component-Based Model for Residential Air Conditioner and Heat Pump Energy Calculations. Masters Thesis, University of Colorado at Boulder), converted to COP = EER/3.412 = 2.8COP) and 66% of homes in Illinois having central cooling ("Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey)
[249] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

For example, an 8W LED lamp, 450 lumens, is installed in the interior of a home. The customer purchased the lamp through an upstream program:

$$\Delta kWH = ((29-6.7 /1000) * 847 * 1.06 * 0.899$$

$$= 18.0 \text{ kWh}$$

This value should be claimed for three years, i.e. 2018-2020, but from 2021 until the end of the measure life for that same bulb, savings should be reduced to (18.0 * 0.226 =) 4.1 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts as well.

Note for early replacement measures an additional baseline shift accounting for the replacement of the existing unit with a new baseline lamp should be accounted for.

Deferred Installs

As presented above, the characterization assumes that a percentage of bulbs purchased are not installed until Year 2 and Year 3 (see ISR assumption above). The Illinois Technical Advisory Committee has determined the following methodology for calculating the savings of these future installs.

Year 1 (Purchase Year) installs:	Characterized using assumptions provided above or evaluated assumptions if available.
Year 2 and 3 installs:	Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed (or evaluated if available) assumptions active in Year 2 and 3 should be applied. The NTG factor for the Purchase Year should be applied.

Using the example from above, for an 8W LED, 450 Lumens purchased for the interior of a residential homes through an upstream program.

$$\Delta kWH_{\text{1st year installs}} = ((29-6.7)/1000)*847*1.06*0.899$$

$$= 18.0 \text{ kWh}$$

$$\Delta kWH_{\text{2nd year installs}} = ((29-6.7)/1000)*847*1.06*0.043$$

$$= 0.9 \text{ kWh}$$

Heating Penalty

If electric heated home (if heating fuel is unknown assume gas, see Natural Gas section):

$$\Delta kWh^{250} = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF) / \eta Heat$$

Where:

[250] Negative value because this is an increase in heating consumption due to the efficient lighting.

HF = Heating Factor or percentage of light savings that must be heated

= 49%[251] for interior or unknown location

= 0% for exterior or unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[252]:

System Type	Age of Equipment	HSPF Estimate	COP_{HEAT} (COP Estimate) = (HSPF/3.413)*0.85
Heat Pump	Before 2006	6.8	1.7
	After 2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1.00
Unknown[253]	N/A	N/A	1.28

Using the same 8 W LED that is installed in home with 2.0 COP Heat Pump (including duct loss):

$\Delta kWh_{1st\ year}$ = - (((29-6.7) / 1000) * 0.899 * 759 * 0.49) / 2.0

= - 3.7 kWh

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year. The appropriate baseline shift adjustment should then be applied to all installs

SUMMER COINCIDENT PEAK DEMAND SAVINGS

ΔkW = ((WattsBase - WattsEE) / 1 000) * ISR * (1-Leakage) * WHFd * CF

Where:

WHFd = Waste heat factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFd
Interior single family or unknown location	1.11[254]

[251] This means that heating loads increase by 49% of the lighting savings. This is based on the average result from REMRate modeling of several different configurations and IL locations of homes.

[252] These default system efficiencies are based on the applicable minimum Federal Standards. In 2006 the Federal Standard for Heat Pumps was adjusted. While one would expect the average system efficiency to be higher than this minimum, the likely degradation of efficiencies over time mean that using the minimum standard is appropriate. Note efficiency should include duct losses. Defaults provided assume 15% duct loss for heat pumps.

[253] Calculation assumes 35% Heat Pump and 65% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see “HC6.9 Space Heating in Midwest Region.xls”, using average for East North Central Region. Average efficiency of heat pump is based on assumption that 50% are units from before 2006 and 50% from 2006-2014. Program or evaluation data should be used to improve this assumption if available.

[254] The value is estimated at 1.11 (calculated as 1 + (0.66 * 0.466 / 2.8)). See footnote relating to WHFe for details. Note the 46.6% factor represents the average Residential cooling coincidence factor calculated by dividing average load during the peak

Bulb Location	WHFd
Multi family in unit	1.07[255]
Exterior or uncooled location	1.0

CF = Summer Peak Coincidence Factor for measure.

Bulb Location	CF[256]
Interior single family or unknown location or Multi family in unit	7.1%
Exterior	27.3%
Unknown	8.1%

Other factors as defined above

For the same 8 W LED that is installed in a single family interior location, the demand savings are:

ΔkW = ((29-6.7) / 1000) * 0.899* 1.11 * 0.071

= 0.0016 kW

Second and third year install savings should be calculated using the appropriate ISR and the delta watts and hours from the install year. The appropriate baseline shift adjustment should then be applied to all installs

NATURAL GAS SAVINGS

Heating penalty if Natural Gas heated home, or if heating fuel is unknown.

ΔTherms = - (((WattsBase - WattsEE) / 1000) * ISR * (1-Leakage) * Hours * HF * 0.03412) / ηHeat

Where:

HF = Heating factor, or percentage of lighting savings that must be replaced by heating system.

= 49% [257] for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [258]

hours divided by the maximum cooling load.

[255] As above but using estimate of 45% of multi family buildings in Illinois having central cooling (based on data from "Table HC7.1 Air Conditioning in U.S. Homes, By Housing Unit Type, 2009" which is for the whole of the US, scaled to IL air conditioning prevalence compared to US average)

[256] Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations.

[257] Average result from REMRate modeling of several different configurations and IL locations of homes

[258] This has been estimated assuming that natural gas central furnace heating is typical for Illinois residences (66% of Illinois

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

Bulb replacement costs assumed in the O&M calculations are provided below[259].

	Std Inc.	EISA Compliant Halogen	CFL	LED-A
2017	$0.43	$1.25	N/A	$3.21
2018	$0.43	$1.25	N/A	$3.21
2019	$0.43	$1.25	N/A	$3.11
2020 & after	$0.43	N/A	$2.45	$2.70

In order to account for the shift in baseline due to the Energy Independence and Security Act of 2007, an equivalent annual levelized baseline replacement cost over the lifetime of the LED bulb is calculated. The key assumptions used in this calculation are documented below:

Installation Location	Omnidirectional LED Measure Hours	Hours of Use per year [260]	Measure Life in Years (capped at 10)
Residential and in-unit Multi Family	15,000	759	10
Exterior	15,000	2475	6.1
Unknown	15,000	847	10

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.46% are presented below[261]. It is important to note that for cost-effectiveness screening purposes, the O&M cost adjustments should only be applied in cases where the light bulbs area actually in service and so should be multiplied by the appropriate ISR:

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		2018	2019	2020	2018	2019	2020
Residential and in-unit Multi Family	Lumens <310 or >2600 (non-EISA compliant)	$2.86	$2.86	$2.86	$0.29	$0.29	$0.29
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$3.14	$2.38	$1.63	$0.32	$0.24	$0.17

homes have a Natural Gas Furnace (based on Energy Information Administration, 2009 Residential Energy Consumption Survey) In 2000, 24% of furnaces purchased in Illinois were condensing (based on data from GAMA, provided to Department of Energy during the federal standard setting process for residential heating equipment - see Furnace Penetration.xls). Furnaces tend to last up to 20 years and so units purchased 10 years ago provide a reasonable proxy for the current mix of furnaces in the State. Assuming typical efficiencies for condensing and non-condensing furnaces and duct losses, the average heating system efficiency is estimated as follows:

(0.24*0.92) + (0.76*0.8) * (1-0.15) = 0.70

259 Baseline and LED lamp costs are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis.

260 Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations.

261 See "LED TRM Examples_012017.xls" for calculation.

Location	Lumen Level	NPV of replacement costs for period			Levelized annual replacement cost savings		
		2018	2019	2020	2018	2019	2020
Exterior	Lumens <310 or >2600 (non-EISA compliant)	$5.96	$5.96	$5.96	$0.61	$0.61	$0.61
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$9.79	$7.34	$4.87	$1.00	$0.75	$0.50
Unknown	Lumens <310 or >2600 (non-EISA compliant)	$3.19	$3.19	$3.19	$0.33	$0.33	$0.33
	Lumens ≥ 310 and ≤ 2600 (EISA compliant)	$3.50	$2.66	$1.82	$0.36	$0.27	$0.19

Note incandescent lamps in lumen range <310 and >2600 are exempt from EISA. For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[262] The replacement cycle is based on the location of the lamp and varies based on the hours of use for that location. Both incandescent and halogen lamps are assumed to last for 1,000 hours before needing replacement.

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[262] The manufacturers of the new minimally compliant EISA Halogens are using regular incandescent lamps with halogen fill gas rather than halogen infrared to meet the standard and so the component rated life is equal to the standard incandescent.