### 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) evaluation data could be used to determine an appropriate residential v commercial split. If this is not available, it is recommended to use this residential characterization for all installs in unknown locations to be appropriately conservative in savings assumptions.

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.

**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.

**Deemed Lifetime of Efficient Equipment**

13.7 years (exterior) to 26 years (residential home), however all installations are capped at 10 years[[1]](#footnote-1).

**Deemed Measure Cost**

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

**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[[2]](#footnote-2).

**Algorithm**

**Calculation of Savings**

**Electric Energy Savings**

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

Where:

Wattsbase = Input wattage of the existing or baseline system. Reference the “LED New and Baseline Assumptions” table for default values.

WattsEE = 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 [[3]](#footnote-3) (WattsEE)** | **Baseline 2014-2019 (WattsBase)** | **Delta Watts 2014-2019 (WattsEE)** | **Baseline Post EISA 2020 requirement[[4]](#footnote-4)  (WattsBase)** | **Delta Watts Post 2020 (WattsEE)** |
|
|
| 5280 | 6209 | 5745 | 104.4 | 300.0 | 195.6 | 300.0 | 195.6 |
| 3000 | 5279 | 4140 | 75.3 | 200.0 | 124.7 | 200.0 | 124.7 |
| 2601 | 2999 | 2800 | 50.9 | 150.0 | 99.1 | 150.0 | 99.1 |
| 1490 | 2600 | 2045 | 37.2 | 72.0 | 34.8 | 45.4 | 8.3 |
| 1050 | 1489 | 1270 | 23.1 | 53.0 | 29.9 | 28.2 | 5.1 |
| 750 | 1049 | 900 | 16.4 | 43.0 | 26.6 | 20.0 | 3.6 |
| 310 | 749 | 530 | 9.6 | 29.0 | 19.4 | 11.8 | 2.1 |
| 250 | 309 | 280 | 5.6 | 25.0 | 19.4 | 25.0 | 19.4 |

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) | | 95%[[5]](#footnote-5) | 1.6% | 1.4% | 98.0%[[6]](#footnote-6) |
| Direct Install | | 96.9%[[7]](#footnote-7) |  |  |  |
| Efficiency Kits[[8]](#footnote-8) | CFL Distribution[[9]](#footnote-9) | 59% | 13% | 11% | 83% |
| School Kits[[10]](#footnote-10) | 61% | 13% | 11% | 86% |
| Direct Mail Kits[[11]](#footnote-11) | 66% | 14% | 12% | 93% |

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

Upstream (TOS) Lighting programs = Determined through evaluation[[12]](#footnote-12).

All other programs = 0

Hours = Average hours of use per year

|  |  |
| --- | --- |
| **Installation Location** | **Hours[[13]](#footnote-13)** |
| 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 [[14]](#footnote-14) |
| Multi family in unit | 1.04 [[15]](#footnote-15) |
| 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 2014, the full savings (as calculated above in the Algorithm) should be claimed for the first six 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 June 2020) to first year savings** |
| --- | --- | --- | --- | --- | --- |
| 1490 | 2600 | 37.2 | 34.8 | 8.3 | 23.8% |
| 1050 | 1489 | 23.1 | 29.9 | 5.1 | 17.1% |
| 750 | 1049 | 16.4 | 26.6 | 3.6 | 13.5% |
| 310 | 749 | 9.6 | 19.4 | 2.1 | 10.8% |

For example, an 8W LED lamp, 450 lumens, is installed in the interior of a home in 2014. The customer purchased the lamp through an upstream program:

ΔkWH = ((29-8 /1000) \* 847 \* 1.06 \* 0.92

= 17.3 kWh

This value should be claimed for six years, i.e. June 2014 – May 2020, but from May 2020 until the end of the measure life for that same bulb, savings should be reduced to (17.3 \* 0.108 =) 1.9 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts as well.

**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 in 2014.

ΔkWH1st year installs = ((29-8/1000)\*847\*1.06\*0.92

= 17.3 kWh

ΔkWH2nd year installs = ((29-8/1000)\*847\*1.06\*0.032

= 0.6 kWh

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

ΔkWH3rd year installs = ((29-8/1000)\*847\*1.06\*0.028

= 0.5 kWh

**Heating Penalty**

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

∆kWh[[16]](#footnote-16) = - (((WattsBase - WattsEE) / 1000) \* ISR \* Hours \* HF) / ηHeat

Where:

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

= 49%[[17]](#footnote-17) for interior or unknown location

= 0% for exterior or unheated location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[[18]](#footnote-18):

|  |  |  |  |
| --- | --- | --- | --- |
| **System Type** | **Age of Equipment** | **HSPF Estimate** | **ηHeat**  **(COP Estimate)** |
| Heat Pump | Before 2006 | 6.8 | 2.00 |
| After 2006 - 2014 | 7.7 | 2.26 |
| 2015 on | 8.2 | 2.40 |
| Resistance | N/A | N/A | 1.00 |

Using the same 8 W LED that is installed in home with 2.0 COP Heat Pump (i.e., the heat pump was installed prior to 2006):

∆kWh1st year = - (((29-8) / 1000) \* 0.92 \* 759 \* 0.49) / 2.0

= - 3.6 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**

∆kW = ((WattsBase - WattsEE) / 1 000) \* ISR \* 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[[19]](#footnote-19) |
| Multi family in unit | 1.07[[20]](#footnote-20) |
| Exterior or uncooled location | 1.0 |

CF = Summer Peak Coincidence Factor for measure.

|  |  |
| --- | --- |
| **Bulb Location** | **CF[[21]](#footnote-21)** |
| 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 in 2014, the demand savings are:

ΔkW = ((29-8) / 1000) \* 0.92\* 1.11 \* 0.071

= 0.0015 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 \* Hours \* HF \* 0.03412) / ηHeat

Where:

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

= 49% [[22]](#footnote-22) for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [[23]](#footnote-23)

**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[[24]](#footnote-24).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Std Inc.** | **EISA Compliant Halogen** | **CFL** | **LED-A** |
| 2014 | $0.34 | $1.25 | $2.50 | $13.81 |
| 2015 | $0.34 | $0.90 | $2.50 | $10.86 |
| 2016 | $0.34 | $0.80 | $2.50 | $8.60 |
| 2017 | $0.34 | $0.70 | $2.50 | $7.74 |
| 2018 | $0.34 | $0.60 | $2.50 | $6.96 |
| 2019 | $0.34 | $0.60 | $2.50 | $6.27 |
| 2020 & after | $0.34 | N/A | $2.50 | $5.64 |

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 [[25]](#footnote-25)** | **Measure Life in Years**  **(capped at 10)** |
| --- | --- | --- | --- |
| Residential and in-unit Multi Family | 25,000 | 759 | 10 |
| Exterior | 25,000 | 2475 | 10 |
| Unknown | 25,000 | 847 | 10 |

The NPV for replacement lamps and annual levelized replacement costs using the statewide real discount rate of 5.23% are presented below:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Location** | **Lumen Level** | **NPV of replacement costs for period** | | | **Levelized annual replacement cost savings** | | |
| **June 2015 - May 2016** | **June 2016 - May 2017** | **June 2017 - May 2018** | **June 2015 - May 2016** | **June 2016 - May 2017** | **June 2017 - May 2018** |
| Residential and in-unit Multi Family | Lumens <310 or >2600 (non-EISA compliant) | $1.73 | $1.73 | $1.73 | $0.23 | $0.23 | $0.23 |
| Lumens ≥ 310 and ≤ 2600 (EISA compliant) | $2.52 | $2.22 | $1.97 | $0.33 | $0.29 | $0.26 |
| Exterior | Lumens <310 or >2600 (non-EISA compliant) | $6.10 | $6.10 | $6.10 | $0.80 | $0.80 | $0.80 |
| Lumens ≥ 310 and ≤ 2600 (EISA compliant) | $9.48 | $8.35 | $7.55 | $1.24 | $1.09 | $0.99 |
| Unknown | Lumens <310 or >2600 (non-EISA compliant) | $1.93 | $1.93 | $1.93 | $0.25 | $0.25 | $0.25 |
| Lumens ≥ 310 and ≤ 2600 (EISA compliant) | $2.81 | $2.47 | $2.20 | $0.37 | $0.32 | $0.29 |

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.[[26]](#footnote-26) 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.

**Measure Code: RS-LTG-LEDA-V04-160601**

1. Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report: <https://www.neep.org/Assets/uploads/files/emv/emv-products/NEEP_EMV_EmergingTechResearch_Report_Final.pdf>, p 6-18. [↑](#footnote-ref-1)
2. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. [↑](#footnote-ref-2)
3. Based on ENERGY STAR specs – minimum luminous efficacy for Omnidirectional Lamps. For LED lamp power <10W = 50lm/W and for LED lamp power >=10W = 55lm/W. [↑](#footnote-ref-3)
4. Calculated as 45lm/W for all EISA non-exempt bulbs. [↑](#footnote-ref-4)
5. 1st year in service rate is based upon analysis of ComEd PY7 intercept data. [↑](#footnote-ref-5)
6. 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. [↑](#footnote-ref-6)
7. 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. <http://www.icc.illinois.gov/downloads/public/edocket/287090.pdf>. [↑](#footnote-ref-7)
8. 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. [↑](#footnote-ref-8)
9. Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions. [↑](#footnote-ref-9)
10. Kits provided free to students through school, with education program. Consistent with Standard CFL assumptions. [↑](#footnote-ref-10)
11. Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions. [↑](#footnote-ref-11)
12. Using a leakage estimate from the current program year evaluation, from past evaluation results, or a rolling average of leakage estimates from previous years. [↑](#footnote-ref-12)
13. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. [↑](#footnote-ref-13)
14. 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; <http://www.eia.gov/consumption/residential/data/2009/xls/HC7.9%20Air%20Conditioning%20in%20Midwest%20Region.xls> ) [↑](#footnote-ref-14)
15. 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); <http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls> [↑](#footnote-ref-15)
16. Negative value because this is an increase in heating consumption due to the efficient lighting. [↑](#footnote-ref-16)
17. 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. [↑](#footnote-ref-17)
18. 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. [↑](#footnote-ref-18)
19. 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. [↑](#footnote-ref-19)
20. 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); <http://205.254.135.7/consumption/residential/data/2009/xls/HC7.1%20Air%20Conditioning%20by%20Housing%20Unit%20Type.xls>. [↑](#footnote-ref-20)
21. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations. [↑](#footnote-ref-21)
22. Average result from REMRate modeling of several different configurations and IL locations of homes [↑](#footnote-ref-22)
23. 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: http://www.eia.gov/consumption/residential/data/2009/xls/HC6.9%20Space%20Heating%20in%20Midwest%20Region.xls))

    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 [↑](#footnote-ref-23)
24. Based upon pricing forecast developed by Applied Proactive Technologies Inc (APT) based on industry input and provided to Ameren. [↑](#footnote-ref-24)
25. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluations. [↑](#footnote-ref-25)
26. 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. [↑](#footnote-ref-26)