### 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 96% Residential and 4% Commercial assumptions should be used[[1]](#footnote-1).

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.

**Definition of Baseline Equipment**

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

**Deemed Lifetime of Efficient Equipment**

While LED rated lives are often 25,000 – 50,000 hours, all installations are assumed to be 10 years[[2]](#footnote-2) except for recessed downlight and track lights at 15 years[[3]](#footnote-3)



**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[[4]](#footnote-5):

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Bulb Type** | **LED Wattage** | **LED** | **Incandescent** | **Incremental Cost** |
| Directional Lamps | < 20W | $22.42 | $6.31 | $16.11 |
| ≥20W | $70.78 | $64.47 |
| Recessed downlight luminaries | All | $94.00 | $4.00 | $90.00 |
| Track lights | All | $60.00 | $4.00 | $56.00 |
| Decorative and Globe | <15W | $12.76 | $3.92 | $8.84 |
| ≥15 | $25.00 | $21.08 |



**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[[5]](#footnote-7)

| **Bulb Type** | **Peak CF** |
| --- | --- |
| Three-way | 0.078[[6]](#footnote-8) |
| Dimmable | 0.078[[7]](#footnote-9) |
| 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**

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

Where:

Wattsbase = Input wattage of the existing or baseline system. Reference the table below for default values.

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 -**

For Directional R, BR, and ER lamp types[[8]](#footnote-10):

| **Bulb Type** | **Lower Lumen Range** | **Upper Lumen Range** | **WattsBase** |
| --- | --- | --- | --- |
| **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 |
| 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 | [[9]](#footnote-11)399 | 30 |

Directional lamps are exempt from EISA regulations.

or if the equation below returns a negative value (or undefined), use the manufacturer’s recommended baseline wattage equivalent.[[10]](#footnote-13)

|  |  |
| --- | --- |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

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 LED purchased / installed.



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

|  |  |  |
| --- | --- | --- |
| **Program** | **Bulb Type** | **ISR** |
| Retail (Time of Sale) | Recessed downlight luminaries and Track Lights | 100%[[11]](#footnote-19) |
| All other lamps | 95% |
| Direct Install | All lamps | 96.9%[[12]](#footnote-20) |

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[[13]](#footnote-21).

All other programs = 0



Hours = Average hours of use per year [[14]](#footnote-22)

| **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

| **Bulb Location** | **WHFe** |
| --- | --- |
| Interior single family or unknown location | 1.06 [[15]](#footnote-24) |
| Multi family in unit | 1.04 [[16]](#footnote-25) |
| 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) \* 0.95 \* 861 \* 1.06

= 27.7 kWh

**Heating Penalty**

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

∆kWh[[17]](#footnote-26)  = - (((WattsBase - WattsEE) / 1000) \* ISR \* Hours \* HF) / ηHeat

Where:

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

= 49%[[18]](#footnote-27) for interior or unknown location

= 0% for exterior location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use:[[19]](#footnote-28)

|  |  |  |  |
| --- | --- | --- | --- |
| **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 |

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) \* 0.95 \* 861 \* 0.49) / 2.26

= - 5.67 kWh

**Summer Coincident Peak Demand Savings**

∆kW = ((WattsBase - WattsEE) / 1000) \* 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[[20]](#footnote-29) |
| Multi family in unit | 1.07[[21]](#footnote-30) |
| Exterior or uncooled location | 1.0 |

CF = Summer Peak Coincidence Factor for measure, see above for values. [[22]](#footnote-31)

| **Bulb Type** | **Peak CF** |
| --- | --- |
| Three-way | 0.078[[23]](#footnote-32) |
| Dimmable | 0.078[[24]](#footnote-33) |
| 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:

ΔkW = ((45 - 13) / 1000) \* 0.95 \* 1.11\* 0.091

= 0.0031 kW

**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% [[25]](#footnote-35) for interior or unknown location

= 0% for exterior location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [[26]](#footnote-36)

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) \* 0.95 \* 861 \* 0.49\* 0.03412) / 0.70

= - 0.63 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[[27]](#footnote-37); baseline replacement cost is assumed to be $3.5[[28]](#footnote-38).

For reflectors t

| **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, the following O&M assumptions should be used: Life of the baseline bulb is assumed to be 1.32 year[[29]](#footnote-39); baseline replacement cost is assumed to be $5[[30]](#footnote-40).

**Measure Code: RS-LTG-LEDD-V05-150601**

1. RES v C&I split is based on a weighted (by sales volume) average of ComEd PY4, PY5 and PY6 and Ameren PY5 and PY6 in store intercept survey results. See ‘RESvCI Split\_122014.xls’. [↑](#footnote-ref-1)
2. 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-2)
3. Limited by persistence. NEEP EMV Emerging Technologies Research Report (December 2011) [↑](#footnote-ref-3)
4. LED lamp 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. [↑](#footnote-ref-5)
5. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. [↑](#footnote-ref-7)
6. 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. [↑](#footnote-ref-8)
7. Ibid [↑](#footnote-ref-9)
8. From pg 11 of the Energy Star Specification for lamps v1.1 [↑](#footnote-ref-10)
9. [↑](#footnote-ref-11)
10. 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. [↑](#footnote-ref-13)
11. NEEP EMV Emerging Technologies Research Report (December 2011) [↑](#footnote-ref-19)
12. 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. <http://www.icc.illinois.gov/downloads/public/edocket/287090.pdf>. [↑](#footnote-ref-20)
13. 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-21)
14. 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. [↑](#footnote-ref-22)
15. 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](http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf)) [↑](#footnote-ref-24)
16. 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](http://205.254.135.7/consumption/residential/data/2009/) [↑](#footnote-ref-25)
17. Negative value because this is an increase in heating consumption due to the efficient lighting. [↑](#footnote-ref-26)
18. 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-27)
19. 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-28)
20. 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-29)
21. 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](http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/94/940111.html). [↑](#footnote-ref-30)
22. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. [↑](#footnote-ref-31)
23. 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. [↑](#footnote-ref-32)
24. Ibid [↑](#footnote-ref-33)
25. Average result from REMRate modeling of several different configurations and IL locations of homes [↑](#footnote-ref-35)
26. 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-36)
27. Assuming 1000 hour rated life for incandescent bulb: 1000/759 = 1.32 [↑](#footnote-ref-37)
28. NEEP Residential Lighting Survey, 2011 [↑](#footnote-ref-38)
29. Assuming 1000 hour rated life for halogen bulb: 1000/759 = 1.32 [↑](#footnote-ref-39)
30. NEEP Residential Lighting Survey, 2011 [↑](#footnote-ref-40)