Memorandum

To: Technical Advisory Committee

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

subject: v8.0 Errata Measures effective 01/01/2020

date: 06/26/2020

**Cc:** CELIA JOHNSON, SAG

This memo documents errata changes to Version 8.0 of the Illinois Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 01/01/2020.

VEIC has provided a summary table below showing the errata measures and a brief summary of what was changed, followed by the v8.0 measures 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 8.0 of the TRM).

**Summary of Errata Measures**

|  |  |  |  |
| --- | --- | --- | --- |
| **Section** | **Measure Name** | **Measure Code** | **Brief Summary of Change** |
| 4.4.38 | Covers and Gap Sealers for Room Air Conditioners | CI-HVC-CRAC-V02-200101 | Fixing typos in algorithm that would result in incorrect savings. |
| 4.5.4 | LED Bulbs and Fixtures | CI-LTG-LEDB-V11-200101 | Updates to Mid-life adjustment and O&M to account for TAC Working Group developed baseline forecast. |
| 5.1.6 | ENERGY STAR and CEE Tier 2 Refrigerator | RS-APL-ESRE-V08-200101 | Fixing error in specification of CEE Tier 2 – 15% rather than 25%. |
| 5.5.6 | LED Specialty Lamps | RS-LTG-LEDD-V11-200101 | Accounting for IECC 2015 in New Construction baseline.  Updates to Mid-life adjustment and O&M to account for TAC Working Group developed baseline forecast. |
| 5.5.8 | LED Screw Based Omnidirectional Bulbs | RS-LTG-LEDA-V09-200101 |
| 5.5.9 | LED Fixtures | RS-LTG-LDFX-V03-200101 |

### Covers and Gap Sealers for Room Air Conditioners

###### Description

Room air conditioners (window ACs, through-the-wall or sleeve ACs, PTACs or PTHPs) constitute a permanent or semi-permanent penetration through the building’s envelope. These units are often poorly installed, resulting in gaps that act like air leakage pathways through the building’s envelope. The uncontrolled movement of air across the gaps in the envelope (infiltration) increases the building’s winter heating requirements and reduces its overall energy performance.

The heat loss and infiltration can be reduced by installing a rigid or flexible insulated cover on the inside of a room AC. These covers should be maintained by building staff and should remain installed through the heating season. Simple uninsulated cloth covers with no sealing at edges do not qualify for this measure.

There are several types of AC covers available that may be eligible for this measure:

1. If the room AC is left in the window or sleeve, a rigid cover that covers the indoor side of the AC unit with foam gaskets to seal the edges may be installed.
2. If the room AC is absent or is removed during the heating months, a rigid cover that fits inside the sleeve with foam gaskets along the edges for proper air sealing may be installed.
3. Flexible covers that are well insulated and perfectly cover the indoor side of the AC unit may also be eligible for this measure.

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 installed equipment is a rigid cover that fits inside the empty sleeve or completely covers the indoor side of a window AC unit, with foam gaskets sealing the edges. A flexible insulated cover that perfectly covers the indoor side of the unit and seals gaps may also be installed. Covers should remain installed throughout the winter heating season.

###### Definition of Baseline Equipment

The baseline equipment is a room AC (window AC, through-the-wall or sleeve AC, PTAC or PTHP) that is poorly installed with gaps around the edges and does not use AC covers or gap sealers during the winter heating months.

###### Deemed Lifetime of Efficient Equipment

The estimated useful life of typical AC covers is 5 years[[1]](#footnote-1).

###### Deemed Measure Cost

The measure cost is the full cost of installing AC covers. Actual installation costs (material and labor) should be used if available. In actual costs are unknown, assume material cost[[2]](#footnote-2) of $24 (flexible covers) up to $119, depending on size of the AC unit. The install time per unit is 15 to 30 minutes at assumed labor rate of $20/hour.

###### Loadshape

Loadshape C04 – Commercial Electric Heating

###### Coincidence Factor

N/A

Algorithm

###### Calculation of Energy Savings

###### Electric Energy Savings

If the building is electrically heated, electric energy savings are calculated as follows:

ΔkWh = (Qinfiltration \* 1.08 \* (TSA – TOA) \* EFLHheat) / (3,412 \* COP)

Where:

Qinfiltration = Air infiltration (CFM) due to poor installation of window or through-the-wall AC[[3]](#footnote-3)

= ELA \* 0.000645\* (fs2 \* (TSA – TOA) + fw2 \* U2)1/2 \*2118.88

Where:

ELA = Effective Leakage Area (sq. in.)

= Can be collected on site; if unknown, assume 6 sq. in.[[4]](#footnote-4)

0.000645= Converts square inches to square meters

fs = Stack Coefficient

= 1/3 \* (9.81 \* Height \* 0.3048 / TOA)0.5

fw = Wind Coefficient

= A \* B\* (Height \* 0.3048 / 10)C

Where:

9.81= Acceleration due to gravity (m/s2)

Height = Height of the location of the leakage area in feet

= Assume 8 ft per floor

TOA = Average Outside Air Temperature during heating period[[5]](#footnote-5). Use values from table below, based on facility location[[6]](#footnote-6). This figure must be in Kelvin to determine Stack Coefficient (fs) and infiltration (Qinfiltration), but in Fahrenheit to determine energy savings (ΔkWh, ΔTherms).

|  |  |  |
| --- | --- | --- |
| **Zone** | **TOA (°F)** | **TOA (K)** |
| Zone 1 (Rockford) | 31.63 | 272.94 |
| Zone 2 (Chicago) | 33.99 | 274.26 |
| Zone 3 (Springfield) | 34.58 | 274.58 |
| Zone 4 (Belleville) | 36.24 | 275.51 |
| Zone 5 (Marion) | 39.07 | 277.08 |

A, Band C = Constants based on the facility site’s shielding and terrain parameters. Use values from the tables below[[7]](#footnote-7).

| **Shielding Class** | **Shielding Type** | **Shielding Description** | **A** |
| --- | --- | --- | --- |
| 1 | None | No obstructions or local shielding whatsoever (i.e. isolated building) | 0.324 |
| 2 | Light | Light local shielding with few obstructions (e.g. A few trees or a shed in the vicinity) | 0.285 |
| 3 | Moderate | Moderate local shielding; some obstructions within two house heights (e.g. Thick hedge fence on fence and nearby building) | 0.24 |
| 4 | Heavy | Heavy shielding; obstructions around most of perimeter buildings or trees within five building heights in most directions (e.g. Well developed/dense tract house) | 0.185 |
| 5 | Very Heavy | Very heavy shielding, large obstruction surrounding perimeter within two house heights (e.g. Typical downtown area) | 0.102 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Terrain Class** | **Terrain Type** | **Terrain Description** | **B** | **C** |
| 1 | None | Ocean or other body of eater with at least 5 km of unrestricted space | 1.3 | 0.1 |
| 2 | Light | Flat terrain with some isolated obstacles (e.g. Buildings or trees well separated from each other) | 1 | 0.15 |
| 3 | Moderate | Rural areas with low buildings, trees etc. | 0.85 | 0.2 |
| 4 | Heavy | Urban, industrial or forest areas | 0.67 | 0.25 |
| 5 | Very Heavy | Center of large city (e.g. Manhattan) | 0.47 | 0.35 |

0.3048 = Converts feet to meters

TSA = Average Indoor Air Temperature during heating period. This figure will need to be in Kelvin to calculate infiltration (Qinfiltration) and Fahrenheit to calculate energy savings (ΔkWh, ΔTherms).

= Collected on site. If unknown, assume 72°F (295 K). If known, convert °F to K by using the following equation: K = (°F + 459.67) \* (5/9).

U = Average Wind Velocity (m/s) during heating period. Use table below, based on facility location[[8]](#footnote-8).

|  |  |
| --- | --- |
| **Zone** | **U (m/s)** |
| Zone 1 (Rockford) | 4.50 |
| Zone 2 (Chicago) | 4.67 |
| Zone 3 (Springfield) | 4.60 |
| Zone 4 (Belleville) | 3.92 |
| Zone 5 (Marion) | 3.07 |

2118.88 = Converts m3/s to CFM

1.08 = Sensible heat transfer constant (Btu/hr.CFM.°F)

EFLHheat = Equivalent Full Load Hours for heating in Existing Buildings from section 4.4 HVAC End Use[[9]](#footnote-9)

3,412 = Converts Btus to kWh

COP = Coefficient of Performance of the heating unit

= Collected on site. If unknown assume 2.6 for PTHP[[10]](#footnote-10)

Deemed per-unit savings for the Multi-Family Building type for Shielding Class 3 and Terrain Class 3 are as follows:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Multi-Family - Electric Savings per Unit (kWh/unit)** | | | | | | |
| **Floor** | **Height** | **Rockford** | **Chicago** | **Springfield** | **Belleville** | **Marion** |
| 1 | 8 | 55.18 | 53.16 | 45.70 | 31.09 | 25.67 |
| 2 | 16 | 68.19 | 65.31 | 56.17 | 38.72 | 32.66 |
| 3 | 24 | 77.92 | 74.34 | 63.96 | 44.45 | 37.97 |
| 4 | 32 | 86.04 | 81.85 | 70.44 | 49.25 | 42.44 |
| 5 | 40 | 93.15 | 88.42 | 76.11 | 53.46 | 46.37 |
| 6 | 48 | 99.56 | 94.34 | 81.22 | 57.26 | 49.93 |
| 7 | 56 | 105.44 | 99.76 | 85.90 | 60.75 | 53.20 |
| 8 | 64 | 110.91 | 104.80 | 90.25 | 63.99 | 56.24 |
| 9 | 72 | 116.04 | 109.53 | 94.33 | 67.04 | 59.11 |
| 10 | 80 | 120.89 | 114.00 | 98.19 | 69.92 | 61.81 |
| 12 | 96 | 129.92 | 122.31 | 105.36 | 75.29 | 66.85 |
| 14 | 112 | 138.21 | 129.94 | 111.95 | 80.22 | 71.49 |
| 16 | 128 | 145.93 | 137.04 | 118.08 | 84.81 | 75.82 |
| 18 | 144 | 153.19 | 143.72 | 123.84 | 89.13 | 79.88 |
| 20 | 160 | 160.05 | 150.03 | 129.29 | 93.21 | 83.72 |
| 22 | 176 | 166.59 | 156.03 | 134.47 | 97.10 | 87.38 |
| 24 | 192 | 172.83 | 161.77 | 139.42 | 100.82 | 90.88 |
| 26 | 208 | 178.82 | 167.28 | 144.18 | 104.38 | 94.23 |
| 28 | 224 | 184.58 | 172.57 | 148.75 | 107.81 | 97.46 |
| 30 | 240 | 190.15 | 177.69 | 153.17 | 111.12 | 100.58 |

**For example**, a mid-rise multi-family building located in the moderate terrain class and shielding class of Chicago, has 16 rooms on the 10th floor (80 feet high) with PTHPs that get covered with a cover and foam gasket during the heating months. The indoor temperature during the heating months is maintained at 74°F. The air infiltration and the related energy savings from the AC covers and seals are calculated as follows -

For Shielding Class 3 and Terrain Class 3,

A = 0.24, B = 0.85 and C = 0.2

Therefore,

fs = 1/3 \* (9.81 m/s2 \* 80 ft \* 0.3048 m/ft / 274.26 K)0.5 = 0.3 m/K½.s

fw = 0.24 \* 0.85\* (80 ft \* 0.3048 m/ft / 10 m)0.2 = 0.24

Total effective leakage area (ELA) = 16 units \* 6 sq. in. = 96 sq. in.

Qinfiltration = ELA \* 0.000645\* (fs2 \* (TSA – TOA) + fw2 \* U2)1/2\* 2118.88

= 96 \* 0.000645 \* (0.32 \* (296.48 K – 274.26 K) + 0.242 \* 4.672)1/2\* 2118.88

= 237 CFM

∆kWh = (237 \* 1.08 Btu/hr.CFM.°F \* (74°F – 33.99°F) \* 1,685) / (3,412 Btu/kWh\* 2.6)

= 1,945 kWh

###### Summer Coincident Peak Demand Savings

As the savings occur during the winter season (non-peak), there are no demand savings associated with this measure.

###### Natural Gas Savings

If the building is heated with gas, the natural gas savings are calculated as follows:

ΔTherms = (Qinfiltration \* 1.08 Btu/hr.CFM.°F \* (TSA – TOA) \* EFLHheat) / (100,000 Btu/therm \* η)

Where,

η = Efficiency of heating equipment.

= Collected on site. If unknown, assume 80%[[11]](#footnote-11).

100,000 = Converts Btus to therms

Other factors as defined above

Deemed per-unit savings per unit for the Multi-Family Building type for Shielding Class 3 and Terrain Class 3 are as follows:

| **Multi-Family - Gas Savings per Unit (Therms/Unit)** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Floor** | **Height** | **Rockford** | **Chicago** | **Springfield** | **Belleville** | **Marion** |
| 1 | 8 | 6.12 | 5.90 | 5.07 | 3.45 | 2.85 |
| 2 | 16 | 7.56 | 7.24 | 6.23 | 4.29 | 3.62 |
| 3 | 24 | 8.64 | 8.24 | 7.09 | 4.93 | 4.21 |
| 4 | 32 | 9.54 | 9.08 | 7.81 | 5.46 | 4.71 |
| 5 | 40 | 10.33 | 9.81 | 8.44 | 5.93 | 5.14 |
| 6 | 48 | 11.04 | 10.46 | 9.01 | 6.35 | 5.54 |
| 7 | 56 | 11.69 | 11.06 | 9.53 | 6.74 | 5.90 |
| 8 | 64 | 12.30 | 11.62 | 10.01 | 7.10 | 6.24 |
| 9 | 72 | 12.87 | 12.15 | 10.46 | 7.43 | 6.55 |
| 10 | 80 | 13.41 | 12.64 | 10.89 | 7.75 | 6.85 |
| 12 | 96 | 14.41 | 13.56 | 11.68 | 8.35 | 7.41 |
| 14 | 112 | 15.33 | 14.41 | 12.41 | 8.90 | 7.93 |
| 16 | 128 | 16.18 | 15.20 | 13.09 | 9.40 | 8.41 |
| 18 | 144 | 16.99 | 15.94 | 13.73 | 9.88 | 8.86 |
| 20 | 160 | 17.75 | 16.64 | 14.34 | 10.34 | 9.28 |
| 22 | 176 | 18.47 | 17.30 | 14.91 | 10.77 | 9.69 |
| 24 | 192 | 19.16 | 17.94 | 15.46 | 11.18 | 10.08 |
| 26 | 208 | 19.83 | 18.55 | 15.99 | 11.57 | 10.45 |
| 28 | 224 | 20.47 | 19.14 | 16.50 | 11.96 | 10.81 |
| 30 | 240 | 21.09 | 19.70 | 16.98 | 12.32 | 11.15 |

**For example**, a gas-heated mid-rise multi-family building located in the moderate terrain class and shielding class of Chicago, has 16 rooms on the 10th floor (80 feet high) with room air conditioners that get covered with an AC cover and foam gasket during the heating months. The indoor temperature during the heating months is maintained at 74°F. The air infiltration and the related therm savings from the AC covers and seals are calculated as follows:

For Shielding Class 3 and Terrain Class 3,

A = 0.24, B = 0.85 and C = 0.2

Therefore,

fs = 1/3 \* (9.81 m/s2 \* 80 ft \* 0.3048 m/ft / 274.26 K)0.5 = 0.3 m/K½.s

fw = 0.24 \* 0.85\* (80 ft \* 0.3048 m/ft / 10 m )0.2 = 0.24

Total effective leakage area (ELA) = 16 units \* 6 sq.in = 96 sq. in

Qinfiltration = ELA \* 0.000645\* (fs2 \* (TSA – TOA) + fw2 \* U2)1/2 \*2118.88

= 96 \* 0.000645 \* (0.32 \* (296.48 K – 274.26 K) + 0.242 \* 4.672)1/2 \* 2118.88

= 237 CFM

∆Therms = (237 \* 1.08 Btu/hr.CFM.°F \* (74°F – 33.99°F) \* 1,685) / (100,000 Btu/therm \* 80%)

= 216 therms

###### Water and Other Non-Energy Impact Descriptions and Calculation

N/A

###### Deemed O&M Cost Adjustment Calculation

N/A

###### Measure Code: CI-HVC-CRAC-V02-200101

###### Review Deadline: 1/1/2023

### 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 97% Residential and 3% Commercial assumptions should be used[[12]](#footnote-12), and for Commercial targeted programs a deemed split of 98% Commercial and 2% Residential should be used[[13]](#footnote-13).

This measure was developed to be applicable to the following program types:  TOS, NC, EREP, 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, new lamps must be ENERGY STAR labeled. Note a new ENERGY STAR specification v2.1 becomes effective on 1/2/2017.[[14]](#footnote-14)

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

The Standard Rx Program will assume a Time of Sale baseline for all one to one replacements, and early replacement for lighting redesign and early retirement for delamping.

For early replacement, the baseline is the existing fixture being replaced.

If the existing fixture is a T12: In July 14, 2012, Federal Standards were enacted that were expected to eliminate T-12s as an option for linear fluorescent fixtures. Through v3.0 of the TRM, it was assumed that the T-12 would no longer be baseline for retrofits from 1/1/2016. However, due to significant loopholes in the legislation, T-12 compliant product is still freely available and in Illinois T-12s continue to hold a significant share of the existing and replacement lamp market. From v8.0 on, a midlife adjustment is applied after the remaining useful life of the T12 fixture (calculated as 1/3 of the 40,000 hour ballast life/ hours). This assumes that T12 replacement lamps will continue to be available until then. See ‘Early Replacement Measures with T12 baseline’ section.

For Time of Sale, refer to the baseline tables at the end of this measure.

In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EIAS) required all general-purpose light bulbs (defined as omni-directional or standard A-lamps) between 40 watts and 100 watts to have ~30% increased efficiency, essentially phasing out standard incandescent technology. In 2012, the 100 w lamp standards went in to effect followed by the 75 w lamp standards in 2013 and 60 w and 40 w lamps in 2014.

Additionally, an EISA backstop provision was included that would require replacement baseline lamps to meet an efficacy requirement of 45 lumens/watt or higher beginning on 1/1/2020.

However, in December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs), finding that this more stringent standard was not economically justified.

The natural growth of LED market share however, has and will continue to grow over the lifetime of the LED measures installed. The TAC convened a Lamp Forecast Working Group to develop a forecast of the baseline growth of LED, based upon historical growth rates provided via CREED LightTracker data, comparisons of with and no-program states and review of projections provided by the Department of Energy[[15]](#footnote-15). The TAC determined that using the Residential-derived forecast is appropriate for the small commercial participants likely to be purchasing lamps through the efficiency programs.

This baseline forecast was then used to estimate how replacement lamps would change over the lifetime of an LED. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings.

Specialty and Directional lamps were not included in the original definition of General Service Lamps in the Energy Independence and Security Act of 2007 (EISA). Therefore, the initial baseline is an incandescent / halogen lamp described in the tables below.

A DOE Final Rule released on 1/19/2017 updated the EISA regulations to remove the exemption for these lamp types such that they become subject to the backstop provision defined within the original legislation. However, in September 2019 this decision was revoked in a new DOE Final Rule. The natural growth of LED market share of specialty and directional lamps was also estimated by the Working Group and applied to those lamp types.

###### Deemed Lifetime of Efficient Equipment

For fixtures, the 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).

For lamps lifetime is calculated as the rated lifetime of the product (assumed 20,000 hours for Omnidirectional, 17,000 hours for decorative and 25,000 for directional lamps based on average rated life of lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020)) divided by the reported operating hours, capped at 10 years.[[16]](#footnote-17)

###### 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 |
| 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

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

Where:

Wattsbase = Input wattage of the existing (for early replacement) 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:

For ENERGY STAR rated lamps the following lumen equivalence tables should be used:[[17]](#footnote-18)

**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[[18]](#footnote-19) (WattsEE)** | **Baseline  (WattsBase)** | **Delta Watts  (WattsEE)** |
| --- | --- | --- | --- | --- | --- |
|
|
| 5280 | 6209 | 5745 | 72.9 | 300.0 | 227.1 |
| 3301 | 5279 | 4290 | 54.5 | 200.0 | 145.5 |
| 2601 | 3300 | 2951 | 37.5 | 150.0 | 112.5 |
| 1490 | 2600 | 2045 | 26.0 | 72.0 | 46.0 |
| 1050 | 1489 | 1270 | 16.1 | 53.0 | 36.9 |
| 750 | 1049 | 900 | 11.4 | 43.0 | 31.6 |
| 310 | 749 | 530 | 6.7 | 29.0 | 22.3 |
| 250 | 309 | 280 | 3.5 | 25.0 | 21.5 |

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

| **Bulb Type** | **Minimum Lumens** | **Maximum Lumens** | **Lumens used to calculate LED Wattage (midpoint)** | **LED Wattage (WattsEE)** | **Baseline (WattsBase)** | **Delta Watts  (WattsEE)** |
| --- | --- | --- | --- | --- | --- | --- |
| **3-Way[[19]](#footnote-20)** | 250 | 449 | 350 | 4.4 | 25 | 20.6 |
| 450 | 799 | 625 | 7.9 | 40 | 32.1 |
| 800 | 1,099 | 950 | 12.1 | 60 | 47.9 |
| 1,100 | 1,599 | 1350 | 17.1 | 75 | 57.9 |
| 1,600 | 1,999 | 1800 | 22.8 | 100 | 77.2 |
| 2,000 | 2,549 | 2275 | 28.9 | 125 | 96.1 |
| 2,550 | 2,999 | 2775 | 35.2 | 150 | 114.8 |
| **Globe (medium and intermediate bases less than 750 lumens)** | 90 | 179 | 135 | 2.1 | 10 | 7.9 |
| 180 | 249 | 215 | 3.3 | 15 | 11.7 |
| 250 | 349 | 300 | 4.6 | 25 | 20.4 |
| 350 | 749 | 550 | 8.5 | 40 | 31.5 |
| **Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)** | 70 | 89 | 80 | 1.2 | 10 | 8.8 |
| 90 | 149 | 120 | 1.8 | 15 | 13.2 |
| 150 | 299 | 225 | 3.5 | 25 | 21.5 |
| 300 | 749 | 525 | 8.1 | 40 | 31.9 |
| **Globe (candelabra bases less than 1050 lumens)** | 90 | 179 | 135 | 2.1 | 10 | 7.9 |
| 180 | 249 | 215 | 3.3 | 15 | 11.7 |
| 250 | 349 | 300 | 4.6 | 25 | 20.4 |
| 350 | 499 | 425 | 6.5 | 40 | 33.5 |
| 500 | 1,049 | 775 | 11.9 | 60 | 48.1 |
| **Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)** | 70 | 89 | 80 | 1.2 | 10 | 8.8 |
| 90 | 149 | 120 | 1.8 | 15 | 13.2 |
| 150 | 299 | 225 | 3.5 | 25 | 21.5 |
| 300 | 499 | 400 | 6.1 | 40 | 33.9 |
| 500 | 1,049 | 775 | 11.9 | 60 | 48.1 |

**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** | **Minimum Lumens** | **Maximum Lumens** | **Lumens used to calculate LED Wattage (midpoint)** | **LED Wattage (WattsEE)** | **Baseline (WattsBase)** | **Delta Watts  (WattsEE)** |
| --- | --- | --- | --- | --- | --- | --- |
| **R, ER, BR with medium screw bases w/ diameter >2.25" (\*see exceptions below)** | 420 | 472 | 446 | 6.6 | 40 | 33.4 |
| 473 | 524 | 499 | 7.3 | 45 | 37.7 |
| 525 | 714 | 620 | 9.1 | 50 | 40.9 |
| 715 | 937 | 826 | 12.1 | 65 | 52.9 |
| 938 | 1259 | 1099 | 16.2 | 75 | 58.8 |
| 1260 | 1399 | 1330 | 19.6 | 90 | 70.4 |
| 1400 | 1739 | 1570 | 23.1 | 100 | 76.9 |
| 1740 | 2174 | 1957 | 28.8 | 120 | 91.2 |
| 2175 | 2624 | 2400 | 35.3 | 150 | 114.7 |
| 2625 | 2999 | 2812 | 41.3 | 175 | 133.7 |
| 3000 | 4500 | 3750 | 55.1 | 200 | 144.9 |
| **\*R, BR, and ER with medium screw bases w/ diameter <=2.25"** | 400 | 449 | 425 | 6.2 | 40 | 33.8 |
| 450 | 499 | 475 | 7.0 | 45 | 38.0 |
| 500 | 649 | 575 | 8.5 | 50 | 41.5 |
| 650 | 1199 | 925 | 13.6 | 65 | 51.4 |
| **\*ER30, BR30, BR40, or ER40** | 400 | 449 | 425 | 6.2 | 40 | 33.8 |
| 450 | 499 | 475 | 7.0 | 45 | 38.0 |
| 500 | 649 | 575 | 8.5 | 50 | 41.5 |
| **\*BR30, BR40, or ER40** | 650 | 1419 | 1035 | 15.2 | 65 | 49.8 |
| **\*R20** | 400 | 449 | 425 | 6.2 | 40 | 33.8 |
| 450 | 719 | 585 | 8.6 | 45 | 36.4 |
| **\*All reflector lamps below lumen ranges specified above** | 200 | 299 | 250 | 3.7 | 20 | 16.3 |
| 300 | [[20]](#footnote-21)399 | 350 | 5.1 | 30 | 24.9 |

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.[[21]](#footnote-22) 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.[[22]](#footnote-23)

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:

| **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 |

Additional EISA non-exempt bulb types:

| **Bulb Type** | **Minimum Lumens** | **Maximum Lumens** | **Lumens used to calculate LED Wattage (midpoint)** | **LED Wattage (WattsEE)** | **Baseline (WattsBase)** | **Delta Watts  (WattsEE)** |
| --- | --- | --- | --- | --- | --- | --- |
| **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 | 530 | 6.7 | 29 | 22.3 |
| 750 | 1049 | 900 | 11.4 | 43 | 31.6 |
| 1050 | 1489 | 1270 | 16.1 | 53 | 36.9 |
| 1490 | 2600 | 2045 | 26.0 | 72 | 46.0 |

Hours = Average hours of use per year are provided in the Reference Table in Section 4.5 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%[[23]](#footnote-24) 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** |
| --- | --- | --- | --- |
| 82.5%[[24]](#footnote-25) | 8.4% | 7.1% | 98.0%[[25]](#footnote-26) |

For Kits, use survey response data to determine appropriate ISR.

**Mid Life Baseline Adjustment**

Omnidirectional, Decorative and Directional Lamps

During the lifetime of an LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Natural growth of LED market share has, and will continue to grow over the lifetime of the measure, and so a single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. See ‘Lamp Forecast Workbook\_2020.xls’ for details.

The calculated mid-life adjustments for 2021 are provided below for each population:

| **Lamp Type** | **Year from which adjustment is applied** | **Adjustment** |
| --- | --- | --- |
| Omnidirectional | 2028 | 57% |
| Decorative | 2028 | 62% |
| Directional | 2028 | 70% |

Early Replacement Measures with T12 Baseline

For early replacement measures replacing existing T12 fixtures the full savings (as calculated above in the Algorithm section) will be claimed for the remaining useful life of the T12 fixture. This should be calculated as follows:

RUL of existing T12 fixture = (1/3 \* 40,000)/Hours.

A savings adjustment should then be applied to the annual savings for the remainder of the measure life.  The adjustment to be applied for each measure should be calculated as:

% Adjustment = (TOS Base Watts – Efficient Watts)/(Existing T12 Watts – Efficient Watts)

For example, an existing 68W T12 fixture in a college is replaced by a 3000 lumen LED 2x2 Recessed Light Fixture (25.4W).

Mid life adjustment of (57 - 25.4)/(68 – 25.4) = 74%

Applied after (1/3 \* 40000)/3395 = 3.9years.

###### Heating Penalty

If electrically heated building:

ΔkWhheatpenalty[[26]](#footnote-27) = (((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**, a 9W LED lamp, 450 lumens, is installed in a heat pump heated office in 2014 and sign off form provided:

ΔkWhheatpenalty = ((29-6.7)/1000)\*1.0\*3088\* -0.151

= - 10.4 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.

The NTG factor for the Purchase Year should be applied.

###### Summer Coincident Peak Demand Savings

ΔkW =( (Wattsbase-WattsEE)/1000) \* ISR \* WHFd \* 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 Reference 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:

ΔkW = ((29-6.7)/1000)\* 1.0\*1.3\*0.66

= 0.019 kW

###### Natural Gas Energy Savings

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

ΔTherms = (((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,** a 9W LED lamp, 450 lumens, is installed in an office in 2014 and sign off form provided:

ΔTherms = ((29-6.7)/1000)\*1.0\*3088\* -0.016

= - 1.10 therms

###### Water Impact Descriptions and Calculation

N/A

###### Deemed O&M Cost Adjustment Calculation

For fixture measures, the individual component lifetimes and costs are provided in the reference table section below[[27]](#footnote-28).

For lamps in order to account for the natural growth of LED over the lifetime of the measure, an equivalent annual levelized baseline replacement cost is calculated and applied over the life of the measure as described above.

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:

| **Lamp Type** | **Location** | **NPV of replacement costs for period** | **Levelized annual replacement cost savings** | |
| --- | --- | --- | --- | --- |
| **2020** | **2020** |
| Omnidirectional | Commercial | $11.91 | $2.18 |
| Multi family common areas | $19.31 | $5.80 |
| Decorative | Commercial | $15.26 | $3.28 |
| Multi family common areas | $22.31 | $7.88 |
| Directional | Commercial | $40.13 | $5.90 |
| Multi family common areas | $71.41 | $17.20 |







For halogen bulbs, we assume the same replacement cycle as incandescent bulbs.[[28]](#footnote-29) 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[[29]](#footnote-30):

| **Bulb Type** | **Year** | **LED** | **Incandescent** | **Incremental Cost** |
| --- | --- | --- | --- | --- |
| **Omnidirectional** | 2017 | $3.21 | $1.25 | $1.96 |
| 2018 | $3.21 | $1.96 |
| 2019 | $3.11 | $1.86 |
| 2020 | $2.70 | $1.45 |
| **Directional** | 2017 | $6.24 | $3.53 | $2.71 |
| 2018+ | $5.18 | $1.65 |
| **Decorative and Globe** | 2017 | $3.50 | $1.60 | $1.90 |
| 2018+ | $3.40 | $1.74 | $1.66 |

**LED Fixture Wattage, TOS Baseline and Incremental Cost Assumptions**[[30]](#footnote-31)

| **LED Category** | **EE Measure Description** | **WattsEE** | **Baseline Description** | **WattsBAE** | **Incremental Cost** |
| --- | --- | --- | --- | --- | --- |
| LED Downlight Fixtures | LED Recessed, Surface, Pendant Downlights | 17.6 | Baseline LED Recessed, Surface, Pendant Downlights | 54.3 | $27 |
| LED Interior Directional | LED Track Lighting | 12.2 | Baseline LED Track Lighting | 60.4 | $59 |
| LED Wall-Wash Fixtures | 8.3 | Baseline LED Wall-Wash Fixtures | 17.7 | $59 |
| LED Display Case | LED Display Case Light Fixture | 7.1 per ft | Baseline LED Display Case Light Fixture | 36.2 per ft | $11/ft |
| 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 |
| 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 |
| 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 |
| LED Linear Replacement Lamps | T8 LED Replacement Lamp (TLED), < 1200 lumens | 8.9 | F17T8 Standard Lamp - 2 foot | 15.0 | $13 |
| T8 LED Replacement Lamp (TLED), 1200-2400 lumens | 15.8 | F32T8 Standard Lamp - 4 foot | 28.2 | $15 |
| T8 LED Replacement Lamp (TLED), > 2400 lumens | 22.9 | F32T8/HO Standard Lamp - 4 foot | 41.8 | $13 |
| LED Troffers | LED 2x2 Recessed Light Fixture, 2000-3500 lumens | 25.4 | 2-Lamp 32w T8 (BF < 0.89) | 57.0 | $53 |
| LED 2x2 Recessed Light Fixture, 3501-5000 lumens | 36.7 | 3-Lamp 32w T8 (BF < 0.88) | 84.5 | $69 |
| LED 2x4 Recessed Light Fixture, 3000-4500 lumens | 33.3 | 2-Lamp 32w T8 (BF < 0.89) | 57.0 | $55 |
| LED 2x4 Recessed Light Fixture, 4501-6000 lumens | 44.8 | 3-Lamp 32w T8 (BF < 0.88) | 84.5 | $76 |
| LED 2x4 Recessed Light Fixture, 6001-7500 lumens | 57.2 | 4-Lamp 32w T8 (BF < 0.88) | 112.6 | $104 |
| LED 1x4 Recessed Light Fixture, 1500-3000 lumens | 21.8 | 1-Lamp 32w T8 (BF <0.91) | 29.1 | $22 |
| LED 1x4 Recessed Light Fixture, 3001-4500 lumens | 33.7 | 2-Lamp 32w T8 (BF < 0.89) | 57.0 | $75 |
| LED 1x4 Recessed Light Fixture, 4501-6000 lumens | 43.3 | 3-Lamp 32w T8 (BF < 0.88) | 84.5 | $83 |
| LED Linear Ambient Fixtures | LED Surface & Suspended Linear Fixture, <= 3000 lumens | 19.5 | 1-Lamp 32w T8 (BF <0.91) | 29.1 | $10 |
| LED Surface & Suspended Linear Fixture, 3001-4500 lumens | 32.1 | 2-Lamp 32w T8 (BF < 0.89) | 57.0 | $52 |
| LED Surface & Suspended Linear Fixture, 4501-6000 lumens | 43.5 | 3-Lamp 32w T8 (BF < 0.88) | 84.5 | $78 |
| LED Surface & Suspended Linear Fixture, 6001-7500 lumens | 56.3 | T5HO 2L-F54T5HO - 4' | 120.0 | $131 |
| LED Surface & Suspended Linear Fixture, > 7500 lumens | 82.8 | T5HO 3L-F54T5HO - 4' | 180.0 | $173 |
| LED High & Low Bay Fixtures | LED Low-Bay Fixtures, <= 10,000 lumens | 61.6 | 3-Lamp T8HO Low-Bay | 157.0 | $44 |
| LED High-Bay Fixtures, 10,001-15,000 lumens | 99.5 | 4-Lamp T8HO High-Bay | 196.0 | $137 |
| LED High-Bay Fixtures, 15,001-20,000 lumens | 140.2 | 6-Lamp T8HO High-Bay | 294.0 | $202 |
| LED High-Bay Fixtures, > 20,000 lumens | 193.8 | 8-Lamp T8HO High-Bay | 392.0 | $264 |
| LED Agricultural Interior Fixtures | LED Ag Interior Fixtures, <= 2,000 lumens | 12.9 | 25% 73 Watt EISA Inc, 75% 1L T8 | 42.0 | $18 |
| LED Ag Interior Fixtures, 2,001-4,000 lumens | 29.7 | 25% 146 Watt EISA Inc, 75% 2L T8 | 81.0 | $48 |
| LED Ag Interior Fixtures, 4,001-6,000 lumens | 45.1 | 25% 217 Watt EISA Inc, 75% 3L T8 | 121.0 | $57 |
| LED Ag Interior Fixtures, 6,001-8,000 lumens | 59.7 | 25% 292 Watt EISA Inc, 75% 4L T8 | 159.0 | $88 |
| LED Ag Interior Fixtures, 8,001-12,000 lumens | 84.9 | 200W Pulse Start Metal Halide | 227.3 | $168 |
| LED Ag Interior Fixtures, 12,001-16,000 lumens | 113.9 | 320W Pulse Start Metal Halide | 363.6 | $151 |
| LED Ag Interior Fixtures, 16,001-20,000 lumens | 143.7 | 350W Pulse Start Metal Halide | 397.7 | $205 |
|  | LED Ag Interior Fixtures, > 20,000 lumens | 193.8 | (2) 320W Pulse Start Metal Halide | 727.3 | $356 |
| LED Exterior Fixtures | LED Exterior Fixtures, <= 5,000 lumens | 34.1 | 100W Metal Halide | 113.6 | $80 |
| LED Exterior Fixtures, 5,001-10,000 lumens | 67.2 | 175W Pulse Start Metal Halide | 198.9 | $248 |
| LED Exterior Fixtures, 10,001-15,000 lumens | 108.8 | 250W Pulse Start Metal Halide | 284.1 | $566 |
| LED Exterior Fixtures, > 15,000 lumens | 183.9 | 400W Pulse Start Metal Halide | 454.5 | $946 |

**LED Fixture Component Costs & Lifetime[[31]](#footnote-32)**

|  |  | | **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 | T8 LED Replacement Lamp (TLED), < 1200 lumens | | 50,000 | | $5.76 | | 70,000 | | $13.67 | | 30,000 | | $6.17 | | 40,000 | | $11.96 | |
| T8 LED Replacement Lamp (TLED), 1200-2400 lumens | | 50,000 | | $8.57 | | 70,000 | | $13.67 | | 24,000 | | $6.17 | | 40,000 | | $11.96 | |
| T8 LED Replacement Lamp (TLED), > 2400 lumens | | 50,000 | | $8.57 | | 70,000 | | $13.67 | | 18,000 | | $6.17 | | 40,000 | | $11.96 | |
| LED Troffers | LED 2x2 Recessed Light Fixture, 2000-3500 lumens | | 50,000 | | $78.07 | | 70,000 | | $40.00 | | 24,000 | | $26.33 | | 40,000 | | $35.00 | |
| LED 2x2 Recessed Light Fixture, 3501-5000 lumens | | 50,000 | | $89.23 | | 70,000 | | $40.00 | | 24,000 | | $39.50 | | 40,000 | | $35.00 | |
| LED 2x4 Recessed Light Fixture, 3000-4500 lumens | | 50,000 | | $96.10 | | 70,000 | | $40.00 | | 24,000 | | $12.33 | | 40,000 | | $35.00 | |
| LED 2x4 Recessed Light Fixture, 4501-6000 lumens | | 50,000 | | $114.37 | | 70,000 | | $40.00 | | 24,000 | | $18.50 | | 40,000 | | $35.00 | |
| LED 2x4 Recessed Light Fixture, 6001-7500 lumens | | 50,000 | | $137.43 | | 70,000 | | $40.00 | | 24,000 | | $24.67 | | 40,000 | | $35.00 | |
| LED 1x4 Recessed Light Fixture, 1500-3000 lumens | | 50,000 | | $65.43 | | 70,000 | | $40.00 | | 24,000 | | $6.17 | | 40,000 | | $35.00 | |
| LED 1x4 Recessed Light Fixture, 3001-4500 lumens | | 50,000 | | $100.44 | | 70,000 | | $40.00 | | 24,000 | | $12.33 | | 40,000 | | $35.00 | |
| LED 1x4 Recessed Light Fixture, 4501-6000 lumens | | 50,000 | | $108.28 | | 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 | | $62.21 | | 70,000 | | $40.00 | | 24,000 | | $6.17 | | 40,000 | | $35.00 | |
| LED Surface & Suspended Linear Fixture, 3001-4500 lumens | | 50,000 | | $93.22 | | 70,000 | | $40.00 | | 24,000 | | $12.33 | | 40,000 | | $35.00 | |
| LED Surface & Suspended Linear Fixture, 4501-6000 lumens | | 50,000 | | $114.06 | | 70,000 | | $40.00 | | 24,000 | | $18.50 | | 40,000 | | $35.00 | |
| LED Surface & Suspended Linear Fixture, 6001-7500 lumens | | 50,000 | | $152.32 | | 70,000 | | $40.00 | | 30,000 | | $26.33 | | 40,000 | | $60.00 | |
| LED Surface & Suspended Linear Fixture, > 7500 lumens | | 50,000 | | $183.78 | | 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 | |
| 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 | | $41.20 | | 70,000 | | $40.00 | | 1,000 | | $1.23 | | 40,000 | | $26.25 | |
| LED Ag Interior Fixtures, 2,001-4,000 lumens | | 50,000 | | $65.97 | | 70,000 | | $40.00 | | 1,000 | | $1.43 | | 40,000 | | $26.25 | |
| LED Ag Interior Fixtures, 4,001-6,000 lumens | | 50,000 | | $80.08 | | 70,000 | | $40.00 | | 1,000 | | $1.62 | | 40,000 | | $26.25 | |
| LED Ag Interior Fixtures, 6,001-8,000 lumens | | 50,000 | | $105.54 | | 70,000 | | $40.00 | | 1,000 | | $1.81 | | 40,000 | | $26.25 | |
| LED Ag Interior Fixtures, 8,001-12,000 lumens | | 50,000 | | $179.81 | | 70,000 | | $62.50 | | 15,000 | | $63.00 | | 40,000 | | $112.50 | |
| LED Ag Interior Fixtures, 12,001-16,000 lumens | | 50,000 | | $190.86 | | 70,000 | | $62.50 | | 15,000 | | $68.00 | | 40,000 | | $122.50 | |
| LED Ag Interior Fixtures, 16,001-20,000 lumens | | 50,000 | | $237.71 | | 70,000 | | $62.50 | | 15,000 | | $73.00 | | 40,000 | | $132.50 | |
| LED Ag Interior Fixtures, > 20,000 lumens | 50,000 | | $331.73 | | 70,000 | | $62.50 | | 15,000 | | $136.00 | | 40,000 | | $202.50 | |
| LED Exterior Fixtures | LED Exterior Fixtures, <= 5,000 lumens | | 50,000 | | $73.80 | | 70,000 | | $62.50 | | 15,000 | | $58.00 | | 40,000 | | $102.50 | |
| LED Exterior Fixtures, 5,001-10,000 lumens | | 50,000 | | $124.89 | | 70,000 | | $62.50 | | 15,000 | | $63.00 | | 40,000 | | $112.50 | |
| LED Exterior Fixtures, 10,001-15,000 lumens | | 50,000 | | $214.95 | | 70,000 | | $62.50 | | 15,000 | | $68.00 | | 40,000 | | $122.50 | |
| LED Exterior Fixtures, > 15,000 lumens | | 50,000 | | $321.06 | | 70,000 | | $62.50 | | 15,000 | | $73.00 | | 40,000 | | $132.50 | |

###### Measure Code: CI-LTG-LEDB-V11-200101

###### Review Deadline: 1/1/2021

### ENERGY STAR and CEE Tier 2 Refrigerator

###### Description

This measure relates to:

1. Time of Sale: the purchase and installation of a new refrigerator meeting either ENERGY STAR or CEE TIER 2 specifications.
2. Early Replacement: the early removal of an existing residential inefficient Refrigerator from service, prior to its natural end of life, and replacement with a new ENERGY STAR or CEE Tier 2 qualifying unit. Savings are calculated between existing unit and efficient unit consumption during the remaining life of the existing unit, and between new baseline unit and efficient unit consumption for the remainder of the measure life.

Energy usage specifications are defined in the table below (note, Adjusted Volume is calculated as the fresh volume + (1.63 \* Freezer Volume):

| **Product Category** | **Existing Unit** | **Assumptions after September 2014** | |
| --- | --- | --- | --- |
| **Based on Refrigerator Recycling algorithm** | **Federal Baseline  Maximum Energy Usage in kWh/year[[32]](#footnote-33)** | **ENERGY STAR Maximum Energy Usage in kWh/year[[33]](#footnote-34)** |
| 1. Refrigerators and Refrigerator-freezers with manual defrost | Use Algorithm in 5.1.8 Refrigerator and Freezer Recycling measure to estimate existing unit consumption | 6.79AV + 193.6 | 6.11 \* AV + 174.2 |
| 2. Refrigerator-Freezer--partial automatic defrost | 7.99AV + 225.0 | 7.19 \* AV + 202.5 |
| 3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost | 8.07AV + 233.7 | 7.26 \* AV + 210.3 |
| 4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service | 8.51AV + 297.8 | 7.66 \* AV + 268.0 |
| 5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service | 8.85AV + 317.0 | 7.97 \* AV + 285.3 |
| 5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service | 9.25AV + 475.4 | 8.33 \* AV + 436.3 |
| 6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service | 8.40AV + 385.4 | 7.56 \* AV + 355.3 |
| 7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service | 8.54AV + 432.8 | 7.69 \* AV + 397.9 |

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

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

###### Definition of Efficient Equipment

The efficient equipment is defined as a refrigerator meeting the efficiency specifications of ENERGY STAR or CEE Tier 2 (defined as requiring >= 10% or >= 15% less energy consumption than an equivalent unit meeting federal standard requirements respectively). The ENERGY STAR standard varies according to the size and configuration of the unit, as shown in table above.

###### Definition of Baseline Equipment

Time of Sale: baseline is a new refrigerator meeting the minimum federal efficiency standard for refrigerator efficiency. The current federal minimum standard varies according to the size and configuration of the unit, as shown in table above.. Note also that this federal standard will be increased for units manufactured after September 1, 2014.

Early Replacement: the baseline is the existing refrigerator for the assumed remaining useful life of the unit and the new baseline as defined above for the remainder of the measure life.

###### Deemed Lifetime of Efficient Equipment

The measure life is assumed to be 17 years.[[34]](#footnote-35)

Remaining life of existing equipment is assumed to be 6 years[[35]](#footnote-36)

###### Deemed Measure Cost

Time of Sale: The incremental cost for this measure is assumed to be $40[[36]](#footnote-37) for an ENERGY STAR unit and $140[[37]](#footnote-38) for a CEE Tier 2 unit.

Early Replacement: The measure cost is the full cost of removing the existing unit and installing a new one. The actual program cost should be used. If unavailable assume $451 for ENERGY STAR unit and $551 for CEE Tier 2 unit[[38]](#footnote-39).

The avoided replacement cost (after 4 years) of a baseline replacement refrigerator is $413[[39]](#footnote-40). This cost should be discounted to present value using the nominal societal discount rate.

###### Loadshape

Loadshape R05 - Residential Refrigerator

###### Coincidence Factor

A coincidence factor is not used to calculate peak demand savings for this measure, see below.

**Algorithm**

###### Calculation of Savings

###### Electric Energy Savings:

Time of Sale: ΔkWh = UECBASE – UECEE

Early Replacement:

ΔkWh for remaining life of existing unit (1st 6 years) = UECEXIST – UECEE

ΔkWh for remaining measure life (next 11 years) = UECBASE – UECEE

Where:

UECEXIST = Annual Unit Energy Consumption of existing unit as calculated in algorithm from 5.1.8 Refrigerator and Freezer Recycling measure.

UECBASE = Annual Unit Energy Consumption of baseline unit as calculated in algorithm provided in table above.

UECEE = Annual Unit Energy Consumption of ENERGY STAR unit as calculated in algorithm provided in table above.

For CEE Tier 2, unit consumption is calculated as 15% lower than baseline.

If volume is unknown, use the following defaults, based on an assumed Adjusted Volume of 25.8[[40]](#footnote-41):

Assumptions after standard changes on September 1st, 2014:

| **Product Category** | **Existing Unit UECEXIST[[41]](#footnote-42)** | **New Baseline UECBASE** | **New Efficient**  **UECEE** | | **Early Replacement**  **(1st 6 years)**  **ΔkWh** | | **Time of Sale and**  **Early Replacement (last 11 years) ΔkWh** | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ENERGY STAR** | **CEE T2** | **ENERGY STAR** | **CEE T2** | **ENERGY STAR** | **CEE T2** |
| 1. Refrigerators and Refrigerator-freezers with manual defrost | 1027.7 | 368.6 | 331.6 | 313.3 | 696.1 | 714.5 | 36.9 | 55.3 |
| 2. Refrigerator-Freezer--partial automatic defrost | 1027.7 | 430.9 | 387.8 | 366.3 | 640.0 | 661.5 | 43.1 | 64.6 |
| 3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost | 814.5 | 441.7 | 397.4 | 375.4 | 417.2 | 439.1 | 44.3 | 66.2 |
| 4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service | 1241.0 | 517.1 | 465.4 | 439.5 | 775.6 | 801.4 | 51.7 | 77.6 |
| 5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service | 814.5 | 545.1 | 490.7 | 463.3 | 323.9 | 351.2 | 54.4 | 81.8 |
| 5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service | 814.5 | 713.8 | 651.0 | 606.7 | 163.6 | 207.8 | 62.8 | 107.1 |
| 6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service | 814.5 | 601.9 | 550.1 | 511.6 | 264.4 | 303.0 | 51.7 | 90.3 |
| 7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service | 1241.0 | 652.9 | 596.1 | 554.9 | 644.9 | 686.0 | 56.8 | 97.9 |

###### Summer Coincident Peak Demand Savings

ΔkW = (ΔkWh/8766) \* TAF \* LSAF

Where:

TAF = Temperature Adjustment Factor

= 1.25[[42]](#footnote-43)

LSAF = Load Shape Adjustment Factor

= 1.057 [[43]](#footnote-44)

If volume is unknown, use the following defaults:

| **Product Category** | **Assumptions after September 2014 standard change ΔkW** | | | |
| --- | --- | --- | --- | --- |
| **Early Replacement (1st 6 years)** | | **Time of Sale and Early Replacement (last 11 years)** | |
| **ENERGY STAR** | **CEE T2** | **ENERGY STAR** | **CEE T2** |
| 1. Refrigerators and Refrigerator-freezers with manual defrost | 0.105 | 0.108 | 0.006 | 0.008 |
| 2. Refrigerator-Freezer--partial automatic defrost | 0.096 | 0.100 | 0.006 | 0.010 |
| 3. Refrigerator-Freezers--automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerators--automatic defrost | 0.063 | 0.066 | 0.007 | 0.010 |
| 4. Refrigerator-Freezers--automatic defrost with side-mounted freezer without through-the-door ice service | 0.117 | 0.121 | 0.008 | 0.012 |
| 5. Refrigerator-Freezers--automatic defrost with bottom-mounted freezer without through-the-door ice service | 0.049 | 0.053 | 0.008 | 0.012 |
| 5A Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service | 0.025 | 0.031 | 0.009 | 0.016 |
| 6. Refrigerator-Freezers--automatic defrost with top-mounted freezer with through-the-door ice service | 0.040 | 0.046 | 0.008 | 0.014 |
| 7. Refrigerator-Freezers--automatic defrost with side-mounted freezer with through-the-door ice service | 0.097 | 0.103 | 0.009 | 0.015 |

###### Natural Gas Savings

N/A

###### Water Impact Descriptions and Calculation

N/A

###### Deemed O&M Cost Adjustment Calculation

N/A

###### Measure Code: RS-APL-ESRE-V08-200101

###### Review Deadline: 1/1/2021

### 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 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[[44]](#footnote-45).

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

To qualify for this measure the installed equipment must be an ENERGY STAR LED lamp or fixture. Note a new ENERGY STAR specification v2.1 becomes effective on 1/2/2017.

###### Definition of Baseline Equipment

Specialty and Directional lamps were not included in the original definition of General Service Lamps in the Energy Independence and Security Act of 2007 (EISA). Therefore, the initial baseline is an incandescent / halogen lamp described in the table below.

A DOE Final Rule released on 1/19/2017 updated the EISA regulations to remove the exemption for these lamp types such that they become subject to the backstop provision defined within the original legislation. However, in September 2019 this decision was revoked in a new DOE Final Rule.

The natural growth of LED market share however, has and will continue to grow over the lifetime of the LED measures installed. The TAC convened a Lamp Forecast Working Group to develop a forecast of the baseline growth of LED, based upon historical growth rates provided via CREED LightTracker data, comparisons of with and no-program states and review of projections provided by the Department of Energy[[45]](#footnote-46).

This baseline forecast was then used to estimate how replacement lamps would change over the lifetime of an LED. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings.

Income Eligible Program Adjustments

The Lamp Forecast Working Group also developed forecasts for estimated Income Eligible market growth in LEDs. These forecasts are used to provide a separate mid-life adjustment for programs supporting income eligible populations. Note that upstream lighting programs in DIY, Warehouse, and Big Box stores located in income eligible neighborhoods should not assume that all customers are from income eligible populations, as data has indicated that the product selection and low prices found in these stores attract customers from beyond[[46]](#footnote-47). A weighted blend of the two measure types (Income eligible and non-income eligible) can be used for DIY, Warehouse, and Big Box stores located in income eligible neighborhoods based upon primary evaluation research at these store types, or using a default of 30% income eligible customers[[47]](#footnote-48).

New Construction Programs

IECC 2015 has the following mandatory requirements for lighting: *“Not less than 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent of the permanently installed lighting fixtures shall contain only high-efficacy lamps”*. To meet the ‘high efficacy’ requirements, lamps need to be CFL or LED, however since CFLs are no longer commonly purchased (only 1% baseline forecast) it is assumed that 75% of the New Construction baseline is an LED and therefore savings are reduced by 75% for bulbs provided in New Construction projects.

Early Replacement

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

###### Deemed Lifetime of Efficient Equipment

The average rated life for Decorative lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020) is approximately 17,000 hours, and for Directional Lamps is approximately 25,000 hours.

The deemed measure life is 6.9 years for exterior application of decorative lamps, and lifetimes are capped at 10 years for all other applications[[48]](#footnote-50).

For early replacement measures, if replacing a halogen or incandescent bulb, the remaining life is assumed to be 333 hours. For CFLs, the remaining life is 3,333 hours[[49]](#footnote-51).

###### 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[[50]](#footnote-52):

| **Bulb Type** | **Year** | **Incandescent** | **LED** | **Incremental Cost** | **Incremental Cost for New Construction** |
| --- | --- | --- | --- | --- | --- |
| Directional | 2019 and on | $3.53 | $5.18 | $1.65 | $0.41 |
| Decorative and Globe | 2019 and on | $1.74 | $3.40 | $1.66 | $0.42 |

###### Loadshape

|  |
| --- |
| Loadshape R06 - Residential Indoor Lighting |
| Loadshape R07 - Residential Outdoor Lighting |

###### Coincidence Factor

The summer peak coincidence factor is assumed to be 0.109 for residential and in-unit multifamily bulbs[[51]](#footnote-53), 0.273 for exterior bulbs[[52]](#footnote-54) and 0.117 for unknown[[53]](#footnote-55).Use Multifamily if: Building meets utility’s definition for multifamily.

**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.[[54]](#footnote-56)

WattsEE = Actual wattage of LED purchased / installed. If unknown, use default provided below.

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

| **Bulb Type** | **Minimum Lumens** | **Maximum Lumens** | **Lumens used to calculate LED Wattage (midpoint)** | **LED Wattage (WattsEE)** | **Baseline (WattsBase)** | **Baseline for New Construction**  **(WattsBase)** | **Delta Watts  (WattsEE)** | **Delta Watts for New Construction  (WattsEE)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **3-Way** | 250 | 449 | 350 | 4.4 | 25 | 9.6 | 20.6 | 5.2 |
| 450 | 799 | 625 | 7.9 | 40 | 15.9 | 32.1 | 8.0 |
| 800 | 1,099 | 950 | 12.1 | 60 | 24.1 | 47.9 | 12.0 |
| 1,100 | 1,599 | 1350 | 17.1 | 75 | 31.6 | 57.9 | 14.5 |
| 1,600 | 1,999 | 1800 | 22.8 | 100 | 42.1 | 77.2 | 19.3 |
| 2,000 | 2,549 | 2275 | 28.9 | 125 | 52.9 | 96.1 | 24.0 |
| 2,550 | 2,999 | 2775 | 35.2 | 150 | 63.9 | 114.8 | 28.7 |
| **Globe (medium and intermediate bases less than 750 lumens)** | 90 | 179 | 135 | 2.1 | 10 | 4.1 | 7.9 | 2.0 |
| 180 | 249 | 215 | 3.3 | 15 | 6.2 | 11.7 | 2.9 |
| 250 | 349 | 300 | 4.6 | 25 | 9.7 | 20.4 | 5.1 |
| 350 | 749 | 550 | 8.5 | 40 | 16.4 | 31.5 | 7.9 |
| **Decorative (Shapes B, BA, C, CA, DC, F, G, medium and intermediate bases less than 750 lumens)** | 70 | 89 | 80 | 1.2 | 10 | 3.4 | 8.8 | 2.2 |
| 90 | 149 | 120 | 1.8 | 15 | 5.1 | 13.2 | 3.3 |
| 150 | 299 | 225 | 3.5 | 25 | 8.9 | 21.5 | 5.4 |
| 300 | 749 | 525 | 8.1 | 40 | 16.1 | 31.9 | 8.0 |
| **Globe (candelabra bases less than 1050 lumens)** | 90 | 179 | 135 | 2.1 | 10 | 4.1 | 7.9 | 2.0 |
| 180 | 249 | 215 | 3.3 | 15 | 6.2 | 11.7 | 2.9 |
| 250 | 349 | 300 | 4.6 | 25 | 9.7 | 20.4 | 5.1 |
| 350 | 499 | 425 | 6.5 | 40 | 14.9 | 33.5 | 8.4 |
| 500 | 1,049 | 775 | 11.9 | 60 | 23.9 | 48.1 | 12.0 |
| **Decorative (Shapes B, BA, C, CA, DC, F, G, candelabra bases less than 1050 lumens)** | 70 | 89 | 80 | 1.2 | 10 | 3.4 | 8.8 | 2.2 |
| 90 | 149 | 120 | 1.8 | 15 | 5.1 | 13.2 | 3.3 |
| 150 | 299 | 225 | 3.5 | 25 | 8.9 | 21.5 | 5.4 |
| 300 | 499 | 400 | 6.1 | 40 | 14.6 | 33.9 | 8.5 |
| 500 | 1,049 | 775 | 11.9 | 60 | 23.9 | 48.1 | 12.0 |

**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[[55]](#footnote-57):

| **Bulb Type** | **Minimum Lumens** | **Maximum Lumens** | **Lumens used to calculate LED Wattage (midpoint)** | **LED Wattage (WattsEE)** | **Baseline (WattsBase)** | **Baseline for New Construction**  **(WattsBase)** | **Delta Watts  (WattsEE)** | **Delta Watts for New Construction  (WattsEE)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **R, ER, BR with medium screw bases w/ diameter >2.25" (\*see exceptions below)** | 420 | 472 | 446 | 6.6 | 40 | 15.0 | 33.4 | 8.4 |
| 473 | 524 | 499 | 7.3 | 45 | 16.7 | 37.7 | 9.4 |
| 525 | 714 | 620 | 9.1 | 50 | 19.3 | 40.9 | 10.2 |
| 715 | 937 | 826 | 12.1 | 65 | 25.3 | 52.9 | 13.2 |
| 938 | 1259 | 1099 | 16.2 | 75 | 30.9 | 58.8 | 14.7 |
| 1260 | 1399 | 1330 | 19.6 | 90 | 37.2 | 70.4 | 17.6 |
| 1400 | 1739 | 1570 | 23.1 | 100 | 42.3 | 76.9 | 19.2 |
| 1740 | 2174 | 1957 | 28.8 | 120 | 51.6 | 91.2 | 22.8 |
| 2175 | 2624 | 2400 | 35.3 | 150 | 64.0 | 114.7 | 28.7 |
| 2625 | 2999 | 2812 | 41.3 | 175 | 74.7 | 133.7 | 33.4 |
| 3000 | 4500 | 3750 | 55.1 | 200 | 91.3 | 144.9 | 36.2 |
| **\*R, BR, and ER with medium screw bases w/ diameter <=2.25"** | 400 | 449 | 425 | 6.2 | 40 | 14.7 | 33.8 | 8.5 |
| 450 | 499 | 475 | 7.0 | 45 | 16.5 | 38.0 | 9.5 |
| 500 | 649 | 575 | 8.5 | 50 | 18.9 | 41.5 | 10.4 |
| 650 | 1199 | 925 | 13.6 | 65 | 26.5 | 51.4 | 12.9 |
| **\*ER30, BR30, BR40, or ER40** | 400 | 449 | 425 | 6.2 | 40 | 14.7 | 33.8 | 8.5 |
| 450 | 499 | 475 | 7.0 | 45 | 16.5 | 38.0 | 9.5 |
| 500 | 649 | 575 | 8.5 | 50 | 18.9 | 41.5 | 10.4 |
| **\*BR30, BR40, or ER40** | 650 | 1419 | 1035 | 15.2 | 65 | 27.7 | 49.8 | 12.5 |
| **\*R20** | 400 | 449 | 425 | 6.2 | 40 | 14.7 | 33.8 | 8.5 |
| 450 | 719 | 585 | 8.6 | 45 | 17.7 | 36.4 | 9.1 |
| **\*All reflector lamps below lumen ranges specified above** | 200 | 299 | 250 | 3.7 | 20 | 7.8 | 16.3 | 4.1 |
| 300 | [[56]](#footnote-58)399 | 350 | 5.1 | 30 | 11.3 | 24.9 | 6.2 |

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.[[57]](#footnote-59) 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.[[58]](#footnote-60)

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:

| **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 |

Additional EISA non-exempt bulb types:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Bulb Type** | **Minimum Lumens** | **Maximum Lumens** | **Lumens used to calculate LED Wattage (midpoint)** | **LED Wattage (WattsEE)** | **Baseline (WattsBase)** | **Baseline for New Construction**  **(WattsBase)** | **Delta Watts  (WattsEE)** | **Delta Watts for New Construction  (WattsEE)** |
| **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 | 530 | 6.7 | 29 | 12.3 | 22.3 | 5.6 |
| 750 | 1049 | 900 | 11.4 | 43 | 19.3 | 31.6 | 7.9 |
| 1050 | 1489 | 1270 | 16.1 | 53 | 25.3 | 36.9 | 9.2 |
| 1490 | 2600 | 2045 | 26.0 | 72 | 37.5 | 46.0 | 11.5 |

ISR = In Service Rate or the percentage of lamps 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) | | 81.5%[[59]](#footnote-61) | 8.9% | 7.6% | 98.0%[[60]](#footnote-62) |
| Direct Install | | 94.5%[[61]](#footnote-63) |  |  |  |
| Efficiency Kits[[62]](#footnote-64) | LED Distribution[[63]](#footnote-65) | 59% | 13% | 11% | 83% |
| School Kits[[64]](#footnote-66) | 60% | 13% | 11% | 84% |
| Direct Mail Kits[[65]](#footnote-67) | 66% | 14% | 12% | 93% |
| Direct Mail Kits, Income Qualified[[66]](#footnote-68) | 68% | 15% | 12% | 95% |
| Community Distributed Kits[[67]](#footnote-69) | 88% | 4% | 3% | 95% |

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[[68]](#footnote-70)) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Use deemed assumptions below[[69]](#footnote-71):

ComEd: 1.1%

Ameren: 13.1%

All other programs = 0

Hours = Average hours of use per year

| **Installation Location** | **Annual hours of use (HOU)** |
| --- | --- |
| Residential and In-Unit Multi Family | 763[[70]](#footnote-72) |
| Exterior | 2,475[[71]](#footnote-73) |
| Unknown | 1,020[[72]](#footnote-74) |

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

| **Bulb Location** | **WHFe** |
| --- | --- |
| Interior single family | 1.06 [[73]](#footnote-75) |
| Multifamily in unit | 1.04 [[74]](#footnote-76) |
| Exterior or uncooled location | 1.0 |
| Unknown location | 1.046[[75]](#footnote-77) |

Use Multifamily if: Building meets utility’s definition for multifamily

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

ΔkWh = ((45 - 13) / 1000) \* 0.840 \* (1 – 0.011) \* 763 \* 1.06

= 21.5 kWh

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

The NTG factor for the Purchase Year (Year 1) should be applied.

**Heating Penalty**

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

∆kWh[[76]](#footnote-78)  = - (((WattsBase - WattsEE) / 1000) \* ISR \* (1-Leakage) \* Hours \* HF) / ηHeat

Where:

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

= 49%[[77]](#footnote-79) for interior location

= 0% for exterior location

= 42%[[78]](#footnote-80) for unknown location

ηHeat = Efficiency in COP of Heating equipment

= Actual. If not available use: [[79]](#footnote-81):

|  |  |  |  |
| --- | --- | --- | --- |
| **System Type** | **Age of Equipment** | **HSPF Estimate** | **COPHEAT**  **(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[[80]](#footnote-82) | N/A | N/A | 1.28 |

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

ΔkWh = - (((45 - 13) / 1000) \* 0.840 \* (1 – 0.011) \* 763 \* 0.49) / 2.04

= - 4.87 kWh

**Mid-Life Baseline Adjustment**

During the lifetime of an LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Natural growth of LED market share has, and will continue to grow over the lifetime of the measure, and so a single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. See ‘Lamp Forecast Workbook\_2020.xls’ for details.

The calculated mid-life adjustments for 2020 are provided below for each population:

| **Population** | **Lamp Type** | **Year from which adjustment is applied** | **Adjustment** |
| --- | --- | --- | --- |
| Income Eligible | Decorative | 2027 | 53% |
| Directional | 2027 | 67% |
| All others | Decorative | 2024 | 56% |
| Directional | 2024 | 54% |

**Summer Coincident Peak Demand Savings**

∆kW = ((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 | 1.11[[81]](#footnote-83) |
| Multifamily in unit | 1.07[[82]](#footnote-84) |
| Exterior or uncooled location | 1.0 |
| Unknown location | 1.083[[83]](#footnote-85) |

Use Multifamily if: Building meets utility’s definition for multifamily

CF = Summer Peak Coincidence Factor for measure

= 0.109 for residential and in-unit multifamily bulbs[[84]](#footnote-86), 0.273 for exterior bulbs[[85]](#footnote-87) and 0.117 for unknown[[86]](#footnote-88).

Use Multifamily if: Building meets utility’s definition for multifamily

Other factors as defined above

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

ΔkW = (((45 - 13) / 1000) \* 0.840 \* (1 – 0.011) \* 1.11\* 0.109

= 0.0032 kW

**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% [[87]](#footnote-89) for interior

= 0% for exterior location

= 42%[[88]](#footnote-90) for unknown location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [[89]](#footnote-91)

Other factors as defined above

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

Δtherms = - (((45 - 13) / 1000) \* 0.840 \* (1 – 0.011) \* 763 \* 0.49\* 0.03412) / 0.70

= - 0.48 therms

**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[[90]](#footnote-92).

| **Lamp Type** | **Standard Incandescent** | **EISA Compliant Halogen** | **CFL** | **LED** |
| --- | --- | --- | --- | --- |
| Decorative | $1.74 | $1.74 | $2.50 | $3.40 |
| Directional | $3.53 | $3.53 | $4.50 | $5.18 |

For non-exempt EISA bulb types defined above, in order to account for natural growth of LED over the lifetime of the measure, an equivalent annual levelized baseline replacement cost is calculated and applied over the life of the measure life.

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.46% are presented below[[91]](#footnote-93).

| **Lamp Type** | **Population** | **Location** | **NPV of replacement costs for period** | **Levelized annual replacement cost savings** | |
| --- | --- | --- | --- | --- | --- |
| **2020** | **2020** |
| Decorative | Income eligible | Residential and in-unit Multi Family, and Unknown | $13.60 | $1.39 |
| Exterior | $20.16 | $2.99 |
| All others | Residential and in-unit Multi Family, and Unknown | $12.08 | $1.24 |
| Exterior | $18.21 | $2.70 |
| Directional | Income eligible | Residential and in-unit Multi Family, and Unknown | $28.47 | $2.92 |
| Exterior | $59.60 | $6.11 |
| All others | Residential and in-unit Multi Family, and Unknown | $23.75 | $2.44 |
| Exterior | $48.70 | $4.95 |







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-LEDD-V11-200101**

###### Review Deadline: 1/1/2021

### 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 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 97% Residential and 3% Commercial assumptions should be used[[92]](#footnote-94).

This measure was developed to be applicable to the following program types:  TOS, NC, EREP, 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, new lamps must be ENERGY STAR labeled. Note a new ENERGY STAR specification v2.1 became effective on 1/2/2017.

###### Definition of Baseline Equipment

In 2012, Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) 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.

Additionally, an EISA backstop provision was included that would require replacement baseline lamps to meet an efficacy requirement of 45 lumens/watt or higher beginning on 1/1/2020. However, in December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs), finding that this more stringent standard was not economically justified.

The natural growth of LED market share however, has and will continue to grow over the lifetime of the LED measures installed. The TAC convened a Lamp Forecast Working Group to develop a forecast of the baseline growth of LED, based upon historical growth rates provided via CREED LightTracker data, comparisons of with and no-program states and review of projections provided by the Department of Energy[[93]](#footnote-95).

This baseline forecast was then used to estimate how replacement lamps would change over the lifetime of an LED. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings.

Income Eligible Program Adjustments

The Lamp Forecast Working Group also developed forecasts for estimated Income Eligible market growth in LEDs. These forecasts are used to provide a separate mid-life adjustment for programs supporting income eligible populations. Note that upstream lighting programs in DIY, Warehouse, and Big Box stores located in income eligible neighborhoods should not assume that all customers are from income eligible populations, as data has indicated that the product selection and low prices found in these stores attract customers from beyond[[94]](#footnote-97). A weighted blend of the two measure types (Income eligible and non-income eligible) can be used for DIY, Warehouse, and Big Box stores located in income eligible neighborhoods based upon primary evaluation research at these store types, or using a default of 30% income eligible customers[[95]](#footnote-98).

New Construction Programs

IECC 2015 has the following mandatory requirements for lighting: *“Not less than 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent of the permanently installed lighting fixtures shall contain only high-efficacy lamps”*. To meet the ‘high efficacy’ requirements, lamps need to be CFL or LED, however since CFLs are no longer commonly purchased (only 1% baseline forecast) it is assumed that 75% of the New Construction baseline is an LED and therefore savings are reduced by 75% for bulbs provided in New Construction projects.

Early Replacement

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

###### Deemed Lifetime of Efficient Equipment

The average rated life for Omnidirectional lamps on the ENERGY STAR Qualified Products list (accessed 6/16/2020) is approximately 20,000 hours.

The deemed measure life is 8 years for exterior application and lifetimes are capped at 10 years for other applications[[96]](#footnote-100).

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[[97]](#footnote-101).

###### 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[[98]](#footnote-102):

| **Year** | **EISA Compliant Halogen** | **LED A-Lamp** | **Incremental Cost** | **Incremental Cost for New Construction** |
| --- | --- | --- | --- | --- |
| 2019 | $1.25 | $3.11 | $1.86 | $0.47 |
| 2020 and on | $2.70 | $1.45 | $0.36 |

###### Loadshape

|  |
| --- |
| Loadshape R06 – Residential Indoor Lighting |
| Loadshape R07 – Residential Outdoor Lighting |

###### Coincidence Factor

The summer peak coincidence factor is assumed to be 0.128 for Residential and in-unit Multi Family bulbs[[99]](#footnote-103), 0.273 for exterior bulbs[[100]](#footnote-104) and 0.135 for unknown[[101]](#footnote-105).

Use Multifamily if: Building meets utility’s definition for multifamily

**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:[[102]](#footnote-106)

**LED New and Baseline Assumptions Table**

| **Minimum Lumens** | **Maximum Lumens** | **Lumens used to calculate LED Wattage**  **(midpoint)** | **LED Wattage [[103]](#footnote-107) (WattsEE)** | **Baseline  (WattsBase)** | **Baseline for New Construction**  **(WattsBase)** | **Delta Watts  (WattsEE)** | **Delta Watts for New Construction (WattsEE)** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 5280 | 6209 | 5745 | 72.9 | 300.0 | 129.7 | 227.1 | 56.8 |
| 3301 | 5279 | 4290 | 54.5 | 200.0 | 90.9 | 145.5 | 36.4 |
| 2601 | 3300 | 2951 | 37.5 | 150.0 | 65.6 | 112.5 | 28.1 |
| 1490 | 2600 | 2045 | 26.0 | 72.0 | 37.5 | 46.0 | 11.5 |
| 1050 | 1489 | 1270 | 16.1 | 53.0 | 25.3 | 36.9 | 9.2 |
| 750 | 1049 | 900 | 11.4 | 43.0 | 19.3 | 31.6 | 7.9 |
| 310 | 749 | 530 | 6.7 | 29.0 | 12.3 | 22.3 | 5.6 |
| 250 | 309 | 280 | 3.5 | 25.0 | 8.9 | 21.5 | 5.4 |

ISR = In Service Rate, the percentage of lamps 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[[104]](#footnote-108)** |
| --- | --- | --- | --- | --- | --- |
| Retail (Time of Sale) | | 76.0%[[105]](#footnote-109) | 11.9% | 10.1% | 98.0%[[106]](#footnote-110) |
| Direct Install | | 94.5%[[107]](#footnote-111) |  |  |  |
| Efficiency Kits[[108]](#footnote-112) | LED Distribution[[109]](#footnote-113) | 59% | 13% | 11% | 83% |
| School Kits[[110]](#footnote-114) | 60% | 13% | 11% | 84% |
| Direct Mail Kits[[111]](#footnote-115) | 66% | 14% | 12% | 93% |
| Direct Mail Kits, Income Qualified[[112]](#footnote-116) | 68% | 15% | 12% | 95% |
| Community Distributed Kits[[113]](#footnote-117) | 88% | 4% | 3% | 95% |
| Food Bank / Pantry Distribution[[114]](#footnote-118) | | 80.3%[[115]](#footnote-119) | 9.6% | 8.1% | 98%[[116]](#footnote-120) |

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[[117]](#footnote-121)) of the Utility Jurisdiction.

KITS programs = Determined through evaluation

Upstream (TOS) Lighting programs = Use deemed assumptions below[[118]](#footnote-122):

ComEd: 0.8%

Ameren: 13.1%

All other programs = 0

Hours = Average hours of use per year

| **Installation Location** | **Hours** |
| --- | --- |
| Residential and in-unit Multi Family | 1,089[[119]](#footnote-123) |
| Exterior | 2,475[[120]](#footnote-124) |
| Unknown | 1,159[[121]](#footnote-125) |

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

| **Bulb Location** | **WHFe** |
| --- | --- |
| Interior single family | 1.06 [[122]](#footnote-126) |
| Multifamily in unit | 1.04 [[123]](#footnote-127) |
| Exterior or uncooled location | 1.0 |
| Unknown location | 1.051[[124]](#footnote-128) |

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

ΔkWh = ((29.0 - 6.7) /1000) \* 0.784 \* (1 - 0.008) \* 1,089 \* 1.06

= 20.0 kWh

**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 2 and 3 installs: Characterized using delta watts assumption and hours of use from the Install Year i.e. the actual deemed 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 a ComEd upstream program.

ΔkWh2nd year installs = ((29 - 6.7)/1000) \* 0.106 \* (1 – 0.008) \* 1,089 \* 1.06

= 2.7 kWh

ΔkWh3rd year installs = ((29 - 6.7)/1000) \* 0.09 \* (1 – 0.008) \* 1,089 \* 1.06

= 2.3 kWh

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

**Heating Penalty**

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

∆kWh[[125]](#footnote-129) = - (((WattsBase - WattsEE) / 1000) \* ISR \* (1-Leakage) \* Hours \* HF) / ηHeat

Where:

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

= 49%[[126]](#footnote-130) for interior

= 0% for exterior or unheated location

= 42%[[127]](#footnote-131) for unknown location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[[128]](#footnote-132):

|  |  |  |  |
| --- | --- | --- | --- |
| **System Type** | **Age of Equipment** | **HSPF Estimate** | **COPHEAT**  **(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[[129]](#footnote-133) | 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) through a ComEd upstream program:

∆kWh1st year = - (((29 - 6.7) / 1000) \* 0.784 \* (1-0.008) \* 1,089 \* 0.42) / 2.0

= - 4.0 kWh

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

**Mid-Life Baseline Adjustment**

During the lifetime of a standard Omnidirectional LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. In December 2019, DOE issued a final determination for General Service Incandescent Lamps (GSILs), finding that the more stringent standards (45 lumen per watt) prescribed in the 2007 EISA regulation to become effective in 2020 (known as the ‘Backstop’ provision), was not economically justified. However, natural growth of LED market share has, and will continue to grow over the lifetime of the measure, and so a single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. See ‘Lamp Forecast Workbook\_2020.xls’ for details.

The calculated mid-life adjustments for 2020 are provided below for each population:

| **Population** | **Year from which adjustment is applied** | **Adjustment** |
| --- | --- | --- |
| Income Eligible | 2027 | 57% |
| All others | 2024 | 40% |

**Summer Coincident Peak Demand Savings**

∆kW = ((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 | 1.11[[130]](#footnote-135) |
| Multifamily in unit | 1.07[[131]](#footnote-136) |
| Exterior or uncooled location | 1.0 |
| Unknown location | 1.093[[132]](#footnote-137) |

CF = Summer Peak Coincidence Factor for measure.

| **Bulb Location** | **CF** |
| --- | --- |
| Interior | 0.128[[133]](#footnote-138) |
| Exterior | 0.273[[134]](#footnote-139) |
| Unknown | 0.135[[135]](#footnote-140) |

Other factors as defined above

For the same 8 W LED that is installed in a single family interior location through a ComEd upstream program:

ΔkW = ((29 - 6.7) / 1000) \* 0.784 \* (1-0.008) \* 1.11 \* 0.128

= 0.0025 kW

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

**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% [[136]](#footnote-141) for interior

= 0% for exterior location

= 42%[[137]](#footnote-142) for unknown location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [[138]](#footnote-143)

**Water Impact Descriptions and Calculation**

N/A

**Deemed O&M Cost Adjustment Calculation**

In order to account for the natural growth of LED over the lifetime of the measure, an equivalent annual levelized baseline replacement cost is calculated and applied over the life of the measure as described above.

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.46% are presented below[[139]](#footnote-144). 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:

| **Population** | **Location** | **NPV of replacement costs for period** | **Levelized annual replacement cost savings** | |
| --- | --- | --- | --- | --- |
| **2020** | **2020** |
| Income eligible | Residential and in-unit Multi Family, and Unknown | $9.70 | $1.00 |
| Exterior | $16.17 | $2.06 |
| All others | Residential and in-unit Multi Family, and Unknown | $7.91 | $0.81 |
| Exterior | $13.36 | $1.71 |

**Measure Code: RS-LTG-LEDA-V09-200101**

###### Review Deadline: 1/1/2021

### LED Fixtures

###### Description

This characterization provides savings assumptions for LED Fixtures and is broken into four ENERGY STAR fixture types: Indoor Fixtures (including track lighting, wall-wash, sconces, ceiling and fan lights), Task and Under Cabinet Fixtures, Outdoor Fixtures (including flood light, hanging lights, security/path lights, outdoor porch lights), and Downlight Fixtures.

For upstream programs, utilities should develop an assumption of the residential v commercial split and apply the relevant assumptions to each portion. A default deemed split of 97% Residential and 3% Commercial assumptions can be used based on Omnidirectional Bulbs[[140]](#footnote-146).

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

In order for this characterization to apply, new fixtures must be ENERGY STAR labeled based upon the v2.1 ENERGY STAR specification for luminaires. Specifications are as follows:

|  |  |
| --- | --- |
| **Fixture Category** | **Lumens/Watt** |
| Indoor | 65 |
| Task and Under Cabinet | 50 |
| Outdoor | 60 |
| Downlight | 55 |

###### Definition of Baseline Equipment

The baseline condition for this measure is assumed to be an average of EISA-equivalent wattages for ENERGY STAR-qualified products. Most of the lamp types in this measure are considered specialty so the baseline adjustments are consistent with the 5.5.6 LED Specialty Lamps.

Specialty and Directional lamps were not included in the original definition of General Service Lamps in the Energy Independence and Security Act of 2007 (EISA). Therefore, the initial baseline is an incandescent / halogen lamp described in the tables below.

A DOE Final Rule released on 1/19/2017 updated the EISA regulations to remove the exemption for these lamp types such that they become subject to the backstop provision defined within the original legislation. However, in September 2019 this decision was revoked in a DOE Final Rule.

The natural growth of LED market share however, has and will continue to grow over the lifetime of the LED measures installed. The TAC convened a Lamp Forecast Working Group to develop a forecast of the baseline growth of LED, based upon historical growth rates provided via CREED LightTracker data, comparisons of with and no-program states and review of projections provided by the Department of Energy[[141]](#footnote-148).

This baseline forecast was then used to estimate how replacement lamps would change over the lifetime of an LED. A single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings.

Income Eligible Program Adjustments

The Lamp Forecast Working Group also developed forecasts for estimated Income Eligible market growth in LEDs. These forecasts are used to provide a separate mid-life adjustment for programs supporting income eligible populations. Note that upstream lighting programs in DIY, Warehouse, and Big Box stores located in income eligible neighborhoods should not assume that all customers are from income eligible populations, as data has indicated that the product selection and low prices found in these stores attract customers from beyond[[142]](#footnote-149). A weighted blend of the two measure types (Income eligible and non-income eligible) can be used for DIY, Warehouse, and Big Box stores located in income eligible neighborhoods based upon primary evaluation research at these store types, or using a default of 30% income eligible customers[[143]](#footnote-150).

New Construction Programs

IECC 2015 has the following mandatory requirements for lighting: *“Not less than 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent of the permanently installed lighting fixtures shall contain only high-efficacy lamps”*. To meet the ‘high efficacy’ requirements, lamps need to be CFL or LED, however since CFLs are no longer commonly purchased (only 1% baseline forecast) it is assumed that 75% of the New Construction baseline is an LED and therefore savings are reduced by 75% for bulbs provided in New Construction projects.

###### Deemed Lifetime of Efficient Equipment

The lifetime of a fixture is a function of its rated life and average hours of use. The rated life is 47,000 hours for indoor and downlight, 45,000 for task and cabinet, and 49,000 for outdoor fixtures[[144]](#footnote-151). This would imply a lifetime of 51 years for indoor and downlight, 62 years for task and under cabinet, and 20 years for outdoor fixtures. However, all fixture lifetimes are capped at 15 years[[145]](#footnote-152) so a 15 year measure life should be assumed.

###### Deemed Measure Cost

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

| **Fixture Category** | **Incremental Cost** | **Incremental Cost for New Construction** |
| --- | --- | --- |
| Indoor | $26[[146]](#footnote-153) | $6.50 |
| Task /Under Cabinet | $18[[147]](#footnote-154) | $4.50 |
| Outdoor | $26 | $6.50 |
| Downlight | $13 | $3.25 |

###### Loadshape

Loadshape R06 - Residential Indoor Lighting

Loadshape R07 - Residential Outdoor Lighting

###### Coincidence Factor

The summer peak coincidence factor is assumed to be 0.119 for residential and in-unit multifamily fixtures[[148]](#footnote-155), 0.273 for exterior fixtures[[149]](#footnote-156) and 0.127 for unknown[[150]](#footnote-157).

**Algorithm**

###### Calculation of Savings

###### Electric Energy Savings

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

Where:

WattsBase = Baseline is an average of lumen-equivalent EISA wattages for ENERGY STAR products within the fixture category;[[151]](#footnote-158) see table below

WattsEE = Actual wattage of LED fixture purchased / installed - If unknown, use default provided below[[152]](#footnote-159)

| **Fixture Category** | **WattsBase** | **WattsBase For New Construction** | **WattsEE** |
| --- | --- | --- | --- |
| Indoor | 88.5 | 38.9 | 22.4 |
| Task /Under Cabinet | 45.2 | 20.0 | 11.6 |
| Outdoor | 79.6 | 33.6 | 18.3 |
| Downlight | 72.8 | 33.4 | 20.3 |

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

= 1.0[[153]](#footnote-160)

Leakage = Adjustment to account for the percentage of program bulbs that move out (and in if deemed appropriate[[154]](#footnote-161)) of the Utility Jurisdiction.

Upstream (TOS) Lighting programs = Use deemed assumptions below[[155]](#footnote-162):

ComEd: 0.7%

Ameren: 6.6%

All other programs = 0

Hours = Average hours of use per year

| **Fixture Category** | **Hours** |
| --- | --- |
| Indoor and Downlight | 926[[156]](#footnote-163) |
| Task/Under Cabinet | 730[[157]](#footnote-164) |
| Outdoor | 2,475[[158]](#footnote-165) |

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

| **Bulb Location** | **WHFe** |
| --- | --- |
| Interior single family | 1.06 [[159]](#footnote-166) |
| Multifamily in unit | 1.04 [[160]](#footnote-167) |
| Exterior or uncooled location | 1.0 |
| Unknown location | 1.051[[161]](#footnote-168) |

For example, an indoor LED fixture is purchased through a ComEd retail program in 2019:

ΔkWh = ((88.5 – 22.4) /1000) \* 1.0 \* (1 – 0.007) \* 926 \* 1.06

= 64.4 kWh

**Heating Penalty**

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

∆kWh[[162]](#footnote-169) = - (((WattsBase - WattsEE) / 1000) \* ISR \* (1-Leakage) \* Hours \* HF) / ηHeat

Where:

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

= 49%[[163]](#footnote-170) for interior location

= 0% for exterior or unheated location

= 42%[[164]](#footnote-171) for unknown location

ηHeat = Efficiency in COP of Heating equipment

= actual. If not available use[[165]](#footnote-172):

| **System Type** | **Age of Equipment** | **HSPF Estimate** | **COPHEAT**  **(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[[166]](#footnote-173) | N/A | N/A | 1.28 |

Using the same indoor LED fixture that is installed in home with 2.0 COP Heat Pump (including duct loss) through a ComEd retail program in 2019:

∆kWh1st year = - (((88.5 – 22.4) / 1000) \* 1.0 \* (1 – 0.007) \* 926 \* 0.49) / 2.0

= - 14.9 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.

**Mid-Life Baseline Adjustment**

During the lifetime of an LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Natural growth of LED market share has, and will continue to grow over the lifetime of the measure, and so a single mid-life adjustment is calculated that results in an equivalent net present value of lifetime savings as the forecast decline in annual savings. For fixtures the directional lamp adjustments from the ‘Lamp Forecast Workbook\_2020.xls’ are applied.

The calculated mid-life adjustments for 2020 are provided below for each population:

| **Population** | **Year from which adjustment is applied** | **Adjustment** |
| --- | --- | --- |
| Income Eligible | 2027 | 67% |
| All others | 2024 | 54% |

###### Summer Coincident Peak Demand Savings

∆kW = ((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 | 1.11[[167]](#footnote-174) |
| Multifamily in unit | 1.07[[168]](#footnote-175) |
| Exterior or uncooled location | 1.0 |
| Unknown location | 1.093[[169]](#footnote-176) |

CF = Summer Peak Coincidence Factor for measure.

| **Bulb Location** | **CF** |
| --- | --- |
| Interior | 0.119[[170]](#footnote-177) |
| Exterior | 0.273[[171]](#footnote-178) |
| Unknown | 0.127[[172]](#footnote-179) |

Other factors as defined above

For the same indoor LED fixture that is installed in a single family interior location through a ComEd retail program in 2019, the demand savings are:

ΔkW = ((88.5 – 22.4) / 1000) \* 1.0 \* (1-0.007) \* 1.11 \* 0.119

= 0.0087 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% [[173]](#footnote-180) for interior or unknown location

= 0% for exterior location

= 42%[[174]](#footnote-181) for unknown location

0.03412 = Converts kWh to Therms

ηHeat = Average heating system efficiency.

= 0.70 [[175]](#footnote-182)

###### 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[[176]](#footnote-183).

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Standard Incandescent** | **CFL** | **LED** |
| 2019 | $1.90 | N/A |  |
| 2020 | $1.90 | N/A |  |
| 2021 & after | $1.90 | $3.15 | $4.35 |

In order to account for the natural growth of LED over the lifetime of the measure, an equivalent annual levelized baseline replacement cost is calculated and applied over the life of the measure life.

The NPV for replacement lamps and annual levelized replacement costs using the societal real discount rate of 0.46% are presented below[[177]](#footnote-184). 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:

| **Population** | **Location** | **NPV of replacement costs for period** | **Levelized annual replacement cost savings** | |
| --- | --- | --- | --- | --- |
| **2020** | **2020** |
| Income eligible | Indoor and Downlight, Task/Under Cabinet | $6.11 | $0.42 |
| Exterior | $13.56 | $0.94 |
| All others | Indoor and Downlight, Task/Under Cabinet | $2.77 | $0.19 |
| Exterior | $5.87 | $0.41 |

###### Measure Code: RS-LTG-LDFX-V03-200101

###### Review Deadline: 1/1/2022

1. New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs V4, April 2016 (New York TRM). [↑](#footnote-ref-1)
2. Cost estimates from customer invoices and vendors. Material costs can be lower for bulk orders. [↑](#footnote-ref-2)
3. Infiltration equation and values for stack and wind coefficient equations from “The Use of Blower Door Data.” Max Sherman, 1998. The equation is adjusted for wall leakage area (i.e. no ceiling or floor leakage). [↑](#footnote-ref-3)
4. Average effective leakage area for multi-family building AC units from “There are Holes in Our Walls.” Prepared for Urban Green Council by Steven Winter Associates, April 2011. [↑](#footnote-ref-4)
5. “Heating Period” is defined as hours when the TMY3 dry bulb temperature is less than 55°F (balance point) [↑](#footnote-ref-5)
6. Based on NREL’s Typical Meteorological Year 3 (TMY3) data for different weather stations. [↑](#footnote-ref-6)
7. Shielding and terrain class descriptions and constants from “The Use of Blower Door Data.” Max Sherman, 1998” and “Wind and Infiltration Interaction for Small Buildings.” MH Sherman and DT Grimsrud, Lawrence Berkley Laboratory, 1982. [↑](#footnote-ref-7)
8. Based on TMY3 data, see “Covers for Room AC\_11092016.xls” for more information. [↑](#footnote-ref-8)
9. Although in theory the hours should be all hours that infiltration is expected (i.e. all hours <55F), the IL TAC has agreed to use the Equivalent Full Load Hours to keep the savings at a more conservative level. [↑](#footnote-ref-9)
10. From IECC 2012 Minimum Efficiency Requirements. For a 1 ton PTHP, COP = 2.9 – (0.026 \* 12,000/1,000). [↑](#footnote-ref-10)
11. Energy Independence and Security Act of 2007 – averaged for hot water and steam boilers. [↑](#footnote-ref-11)
12. RES v C&I split is based on a weighted (by sales volume) average of ComEd PY8, PY9 and CY2018 and Ameren PY8 in store intercept survey results. See ‘RESvCI Split\_2019.xlsx. [↑](#footnote-ref-12)
13. Based on final ComEd’s Instant Incentives program data from PY7 and PY9. 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. [↑](#footnote-ref-13)
14. ENERGY STAR Program Requirements Product Specifications for Lamps (Light Bulbs), version 2.1, effective January 2, 2017 [↑](#footnote-ref-14)
15. US Department of Energy, “Energy Savings Forecast of Solid State Lighting in General Illumination Applications”, December 2019. The resultant forecast is provided on the SharePoint site “Lamp Forecast Workbook.xls”. [↑](#footnote-ref-15)
16. Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18. [↑](#footnote-ref-17)
17. See file “LED baseline and EE wattage table\_2018.xlsx” for details on lamp wattage calculations. [↑](#footnote-ref-18)
18. 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. [↑](#footnote-ref-19)
19. For 3-way bulbs or fixtures, the product’s median lumens value will be used to determine both LED and baseline wattages. [↑](#footnote-ref-20)
20. [↑](#footnote-ref-21)
21. ENERGY STAR Lamps Center Beam Intensity Benchmark Tool and Calculator [↑](#footnote-ref-22)
22. 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-23)
23. 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. [↑](#footnote-ref-24)
24. Based on ComEd’s Instant Incentives program data from PY7 and PY9 and Ameren’s Instant Incentives program for PY9, see “IL Commercial Lighting ISR\_2018.xlsx”. [↑](#footnote-ref-25)
25. 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 [↑](#footnote-ref-26)
26. Negative value because this is an increase in heating consumption due to the efficient lighting. [↑](#footnote-ref-27)
27. See IL LED Lighting Systems TRM Reference Tables\_2018.xlsx for breakdown of component cost assumptions. [↑](#footnote-ref-28)
28. 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-29)
29. 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. [↑](#footnote-ref-30)
30. 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\_2018.xlsx" for more information and specific product links. [↑](#footnote-ref-31)
31. Note that some measures have blended baselines (T12:T8 18:82). 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 Reference Tables\_2018.xlsx for more information. [↑](#footnote-ref-32)
32. See Department of Energy Federal Standards. [↑](#footnote-ref-33)
33. See Version 5.0 ENERGY STAR specification. [↑](#footnote-ref-34)
34. Based on 2011 DOE Rulemaking Technical Support Document, as recommended in Navigant ‘ComEd Effective Useful Life Research Report’, May 2018. [↑](#footnote-ref-35)
35. Standard assumption of one third of effective useful life. [↑](#footnote-ref-36)
36. From ENERGY STAR calculator linked above. [↑](#footnote-ref-37)
37. Based on weighted average of units participating in Efficiency Vermont program and retail cost data provided in Department of Energy, “TECHNICAL REPORT: Analysis of Amended Energy Conservation Standards for Residential Refrigerator-Freezers”, October 2005. [↑](#footnote-ref-38)
38. ENERGY STAR full cost is based upon IL PHA Efficient Living Program data on sample size of 910 replaced units finding average cost of $430 plus an average recycling/removal cost of $21. The CEE Tier 2 estimate uses the delta from the Time of Sale estimate. [↑](#footnote-ref-39)
39. Calculated using incremental cost from Time of Sale measure and applying inflation rate of 1.91%. [↑](#footnote-ref-40)
40. Volume is based on the ENERGY STAR calculator average assumption of 14.75 ft3 fresh volume and 6.76 ft3 freezer volume. [↑](#footnote-ref-41)
41. Estimates of existing unit consumption are based on using the 5.1.8 Refrigerator and Freezer Recycling algorithm and the inputs described here: Age = 10 years, Pre-1990 = 0, Size = 21.5 ft3 (from ENERGY STAR calc and consistent with AV of 25.8), Single Door = 0, Side by side = 1 for classifications stating side by side, 0 for classifications stating top/bottom, and 0.5 for classifications that do not distinguish, Primary appliances = 1, unconditioned = 0, Part use factor = 0. [↑](#footnote-ref-42)
42. Average temperature adjustment factor (to account for temperature conditions during peak period as compared to year as a whole) based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 47). It assumes 90 °F average outside temperature during peak period, 71°F average temperature in kitchens and 65°F average temperature in basement, and uses assumption that 66% of homes in Illinois have central cooling (CAC saturation: "Table HC7.9 Air Conditioning in Homes in Midwest Region, Divisions, and States, 2009 from Energy Information Administration", 2009 Residential Energy Consumption Survey). [↑](#footnote-ref-43)
43. Daily load shape adjustment factor (average load in peak period /average daily load) also based on Blasnik, Michael, "Measurement and Verification of Residential Refrigerator Energy Use, Final Report, 2003-2004 Metering Study", July 29, 2004 (p. 48, using the average Existing Units Summer Profile for hours 13 through 17) [↑](#footnote-ref-44)
44. RES v C&I split is based on a weighted (by sales volume) average of ComEd PY8, PY9 and CY2018 in store intercept survey results. See ‘RESvCI Split\_2019.xlsx’. [↑](#footnote-ref-45)
45. US Department of Energy, “Energy Savings Forecast of Solid State Lighting in General Illumination Applications”, December 2019. The resultant forecast is provided on the SharePoint site “Lamp Forecast Workbook.xls”. [↑](#footnote-ref-46)
46. Navigant and Itron, “CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations”. [↑](#footnote-ref-47)
47. 30% of the respondents at the three Income Eligible Program stores where in-store intercepts were conducted met ComEd’s income eligible definition; Navigant and Itron, “CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations”. [↑](#footnote-ref-48)
48. Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18. [↑](#footnote-ref-50)
49. Representing a third of the expected lamp lifetime. [↑](#footnote-ref-51)
50. 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. . [↑](#footnote-ref-52)
51. Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs. [↑](#footnote-ref-53)
52. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for specialty LEDs in exterior applications. [↑](#footnote-ref-54)
53. Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-55)
54. See file “LED baseline and EE wattage table\_2018.xlsx” for details on lamp wattage calculations. [↑](#footnote-ref-56)
55. From pg 13 of the ENERGY STAR Specification for lamps v2.1 [↑](#footnote-ref-57)
56. [↑](#footnote-ref-58)
57. See ‘ESLampCenterBeamTool.xls’. [↑](#footnote-ref-59)
58. 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-60)
59. 1st year in service rate is based upon analysis of ComEd PY8, PY9 and CY2018 intercept data (see ‘Res Lighting ISR\_2019.xlsx’ for more information). [↑](#footnote-ref-61)
60. 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-62)
61. Consistent with assumption for standard LEDs (in the absence of evidence that it should be different for this bulb type). Based upon average of Navigant low income single family direct install field work LED ISR and 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. [↑](#footnote-ref-63)
62. 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-64)
63. Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions. [↑](#footnote-ref-65)
64. 1st year ISR for school kits based on ComEd PY9 data for the Elementary Energy Education program. 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. [↑](#footnote-ref-66)
65. Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions. [↑](#footnote-ref-67)
66. Research from 2018 Ameren Illinois Income Qualified participant survey. [↑](#footnote-ref-68)
67. Kits distributed in a community setting, targeted to income qualified communities. Research from 2018 Ameren Illinois Income Qualified participant survey. [↑](#footnote-ref-69)
68. 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. [↑](#footnote-ref-70)
69. Leakage rate is based upon review of PY8-CY2018 evaluations from ComEd and PY5,6 and 8 for Ameren. [↑](#footnote-ref-71)
70. Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs. [↑](#footnote-ref-72)
71. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. The IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide hours of use for specialty LEDs in exterior applications. [↑](#footnote-ref-73)
72. Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-74)
73. 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) [↑](#footnote-ref-75)
74. 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) [↑](#footnote-ref-76)
75. Unknown is weighted average of interior v exterior (assuming 15% exterior specialty lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009. [↑](#footnote-ref-77)
76. Negative value because this is an increase in heating consumption due to the efficient lighting. [↑](#footnote-ref-78)
77. 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-79)
78. Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-80)
79. 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. [↑](#footnote-ref-81)
80. 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. [↑](#footnote-ref-82)
81. 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-83)
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) [↑](#footnote-ref-84)
83. Unknown is weighted average of interior v exterior (assuming 15% exterior specialty lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009. [↑](#footnote-ref-85)
84. Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs. [↑](#footnote-ref-86)
85. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for specialty LEDs in exterior applications. [↑](#footnote-ref-87)
86. Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-88)
87. Average result from REMRate modeling of several different configurations and IL locations of homes [↑](#footnote-ref-89)
88. Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-90)
89. 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 [↑](#footnote-ref-91)
90. Baseline costs are based on field data collected by CLEAResult and provided by ComEd. See ComEd Pricing Projections 06302016.xlsx for analysis. [↑](#footnote-ref-92)
91. See “Lamp Forecast Workbook\_2020.xlsx” for calculation. [↑](#footnote-ref-93)
92. RES v C&I split is based on a weighted (by sales volume) average of ComEd PY8, PY9 and CY2018 and Ameren PY8 in store intercept survey results. See ‘RESvCI Split\_2019.xlsx’. [↑](#footnote-ref-94)
93. US Department of Energy, “Energy Savings Forecast of Solid State Lighting in General Illumination Applications”, December 2019. The resultant forecast is provided on the SharePoint site “Lamp Forecast Workbook.xls”. [↑](#footnote-ref-95)
94. Navigant and Itron, “CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations”. [↑](#footnote-ref-97)
95. 30% of the respondents at the three Income Eligible Program stores where in-store intercepts were conducted met ComEd’s income eligible definition; Navigant and Itron, “CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations”. [↑](#footnote-ref-98)
96. Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18. [↑](#footnote-ref-100)
97. Representing a third of the expected lamp lifetime. [↑](#footnote-ref-101)
98. 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. [↑](#footnote-ref-102)
99. Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs. [↑](#footnote-ref-103)
100. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for screw-based omnidirectional LEDs in exterior applications. [↑](#footnote-ref-104)
101. Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-105)
102. See file “LED baseline and EE wattage table\_2018.xlsx” for details on lamp wattage calculations. [↑](#footnote-ref-106)
103. Based on ENERGY STAR V2.1 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. [↑](#footnote-ref-107)
104. Final ISR assumptions for efficiency kits are based upon comparing with CFL Distribution First year ISR and multiplying by the CFL Distribution Final ISR value, capped at 95%, and second and third year estimates based on same proportion of future installs. 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-108)
105. 1st year in service rate is based upon analysis of ComEd PY8, PY9 and CY2018 and Ameren PY8 intercept data (see ‘RES Lighting ISR\_2019.xlsx’ for more information). [↑](#footnote-ref-109)
106. 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. [↑](#footnote-ref-110)
107. Based upon average of Navigant low income single family direct install field work LED ISR and 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. [↑](#footnote-ref-111)
108. 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-112)
109. Free bulbs provided without request, with little or no education. Consistent with Standard CFL assumptions. [↑](#footnote-ref-113)
110. 1st year ISR for school kits based on ComEd PY9 data for the Elementary Energy Education program. 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. [↑](#footnote-ref-114)
111. Opt-in program to receive kits via mail, with little or no education. Consistent with Standard CFL assumptions. [↑](#footnote-ref-115)
112. Research from 2018 Ameren Illinois Income Qualified participant survey. [↑](#footnote-ref-116)
113. Kits distributed in a community setting, targeted to income qualified communities. Research from 2018 Ameren Illinois Income Qualified participant survey. [↑](#footnote-ref-117)
114. Free bulbs provided through local food banks and food pantries. [↑](#footnote-ref-118)
115. 1st year ISR is determined based on online surveys conduted for ComEd CY2018 Food Bank LED Distribution program. See ‘CY2018 ComEd Foodbank LED Dist Survey Results\_Navigant’. [↑](#footnote-ref-119)
116. In the absence of any program specific data, 98% lifetime ISR assumption is made based on similarity between 1st year ISR values with the Retail (Time of Sale) program and the 2nd and 3rd year installations are scaled accordingly. [↑](#footnote-ref-120)
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. [↑](#footnote-ref-121)
118. Leakage rate is based upon review of PY8-CY2018 evaluations from ComEd and PY8 for Ameren. [↑](#footnote-ref-122)
119. Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs. [↑](#footnote-ref-123)
120. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. The IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide hours of use for screw-based omnidirectional LEDs in exterior applications. [↑](#footnote-ref-124)
121. Based on a weighted average of hours of use in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-125)
122. 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) [↑](#footnote-ref-126)
123. 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) [↑](#footnote-ref-127)
124. Unknown is weighted average of interior v exterior (assuming 5% exterior lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009. [↑](#footnote-ref-128)
125. Negative value because this is an increase in heating consumption due to the efficient lighting. [↑](#footnote-ref-129)
126. 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-130)
127. Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-131)
128. 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. [↑](#footnote-ref-132)
129. 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. [↑](#footnote-ref-133)
130. 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-135)
131. 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) [↑](#footnote-ref-136)
132. Unknown is weighted average of interior v exterior (assuming 5% exterior lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009. [↑](#footnote-ref-137)
133. Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs. [↑](#footnote-ref-138)
134. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for screw-based omnidirectional LEDs in exterior applications. [↑](#footnote-ref-139)
135. Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-140)
136. Average result from REMRate modeling of several different configurations and IL locations of homes [↑](#footnote-ref-141)
137. Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-142)
138. 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 [↑](#footnote-ref-143)
139. See “Lamp Forecast Workbook\_2020.xlsx” for calculation. [↑](#footnote-ref-144)
140. RES v C&I split is based on a weighted (by sales volume) average of ComEd PY7, PY8 and PY9 and Ameren PY8 in store intercept survey results. See ‘RESvCI Split\_2018.xlsx’. [↑](#footnote-ref-146)
141. US Department of Energy, “Energy Savings Forecast of Solid State Lighting in General Illumination Applications”, December 2019. The resultant forecast is provided on the SharePoint site “Lamp Forecast Workbook.xls”. [↑](#footnote-ref-148)
142. Navigant and Itron, “CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations”. [↑](#footnote-ref-149)
143. 30% of the respondents at the three Income Eligible Program stores where in-store intercepts were conducted met ComEd’s income eligible definition; Navigant and Itron, “CY2018 ComEd Income Eligible Product Discounts – Lighting NTG Recommendations”. [↑](#footnote-ref-150)
144. Average rated lives are based on the average rated lives of fixtures available on the ENERGY STAR qualifying list as of 2/26/2018. [↑](#footnote-ref-151)
145. Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18. [↑](#footnote-ref-152)
146. Incremental costs for indoor and outdoor fixtures based on ENERGY STAR Light Fixtures and Ceiling Fans Calculator, which cites “EPA research on available products, 2012.” ENERGY STAR cost assumptions were reduced by 20% to account for falling LED prices. [↑](#footnote-ref-153)
147. Incremental costs for task/under cabinet and downlight fixtures are from the 2018 Michigan Energy Measures Database. [↑](#footnote-ref-154)
148. Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs. Average of values for standard and specialty bulbs. [↑](#footnote-ref-155)
149. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for screw-based omnidirectional LEDs in exterior applications. [↑](#footnote-ref-156)
150. Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-157)
151. See “Analysis” tab within file Residential LED Fixtures\_Analysis\_June 2018.xlsx for baseline calculations. [↑](#footnote-ref-158)
152. Average of ENERGY STAR product category watts for products at or above the version 2.1 efficacy specification [↑](#footnote-ref-159)
153. ISR recommendation for fixtures in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-22. [↑](#footnote-ref-160)
154. 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. [↑](#footnote-ref-161)
155. Leakage rate is based upon review of PY7-9 evaluations from ComEd and PY8 for Ameren (see for more information) for LED omnidirectional and specialty lamps. Leakage rates for fixtures are an average of rates for standard and specialty lamps, reduced by half according to TAC agreement. [↑](#footnote-ref-162)
156. Assuming 365.25 days/year and average of recommended values for standard LED lamps (2.98) and specialty LED lamps (2.09) in interior locations from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs [↑](#footnote-ref-163)
157. Task/under cabinet hours of use are estimated at 2 hours per day. [↑](#footnote-ref-164)
158. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. The IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide hours of use for screw-based omnidirectional LEDs in exterior applications. [↑](#footnote-ref-165)
159. 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) [↑](#footnote-ref-166)
160. 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) [↑](#footnote-ref-167)
161. Unknown is weighted average of interior v exterior (assuming 5% exterior lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009. [↑](#footnote-ref-168)
162. Negative value because this is an increase in heating consumption due to the efficient lighting. [↑](#footnote-ref-169)
163. 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-170)
164. Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-171)
165. 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. [↑](#footnote-ref-172)
166. 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. [↑](#footnote-ref-173)
167. 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-174)
168. 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) [↑](#footnote-ref-175)
169. Unknown is weighted average of interior v exterior (assuming 5% exterior lighting based on distribution of LEDs from on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study) and SF v MF interior based on statewide weighted average of 69% single family and 31% multifamily, based on IL data from 2009 RECS Table HC2.9 Structural and Geographic Characteristics of Homes in Midwest Region, Divisions and States, 2009. [↑](#footnote-ref-176)
170. Based on the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs. Average of values for standard and specialty bulbs. [↑](#footnote-ref-177)
171. Based on lighting logger study conducted as part of the PY5/6 ComEd Residential Lighting Program evaluation. the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs was unable to provide coincidence factors for screw-based omnidirectional LEDs in exterior applications. [↑](#footnote-ref-178)
172. Based on a weighted average of coincidence factors in interior and exterior applications, assuming 5% exterior lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-179)
173. Average result from REMRate modeling of several different configurations and IL locations of homes [↑](#footnote-ref-180)
174. Based on a weighted average of interior and exterior hours of use from the IL Statewide LED Lighting Logger study conducted as part of the PY8/PY9 evaluations of the Ameren Illinois and ComEd Residential Lighting programs, assuming 15% exterior specialty lighting. The distribution of LEDs is based on the on-site lighting inventory conducted as part of the IL Statewide LED Lighting Logger study. [↑](#footnote-ref-181)
175. 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 [↑](#footnote-ref-182)
176. 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. Costs for standard, decorative, and directional bulbs were averaged. [↑](#footnote-ref-183)
177. See “Residential LED Fixtures\_Analysis\_2019b.xlsx” for calculation. [↑](#footnote-ref-184)