MEMORANDUM

TO: IOWA TRM TECHNICAL ADVISORY COMMITTEE, OVERSIGHT COMMITTEE

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

SUBJECT: TRM VERSION 2 – FINAL DELIVERABLE

DATE: 06/23/2017

VEIC has submitted the Final Version 2.0 of the Iowa TRM, with all proposed redline edits and new measures for submittal by the Technical Advisory Committee to the Oversight Committee.

Presented below is a summary table documenting all the measures that have been changed or are new, with a brief description of what has changed and whether it is being considered an errata. Highlighted in red below are changes made since the last deliverable.

Measure # and Name		Errata?	Brief description of what changed
Vol 1	Section 6.4: Electrical Loadshapes (kWh)	Y	Addition of 6 new loadshapes: • RE17 Residential Pool Pumps • NRE13 Indust. 1-shift (8/5) • NRE14 Indust. 2-shift (16/5) • NRE15 Indust. 3-shift (24/5) • NRE16 Indust. 4-shift (24/7) • NREC17 – Non-Residential Cooling – Small Programmable Thermostat Correction of RE14 Residential Clothes Washer, RE15 Freezer and RE16 Residential Refrigerator; Summer and Winter periods were reversed.
Vol 1	Section 1.2 Sunset Date Table	N	Updates to sunset dates for updated measures
2.1.1	Clothes Washer	N	Updates to Federal Standard and ENERGY STAR specifications. Update of DHW mix based on baseline study. Tier 3 label changed to Tier 2 due to pending specification changes.
2.1.2	Clothes Dryer	N	Addition of ENERGY STAR Most Efficient and full heat pump clothes dryers. Inclusion of paired ESTAR washer adjustment and waste heat impacts. Update to costs. Updates based on baseline study results.
2.1.3	Refrigerator	N	Update of default electric COP assumptions to include duct loss. Update to baseline and efficient kWh consumption based on average of available product (CEC database). Updates based on baseline study results.
2.1.4	Freezers	N	Update of default electric COP assumptions to include duct loss. Update to baseline and efficient kWh consumption based on average of available product (CEC database).

Measure # and Name		Errata?	Brief description of what changed
			Updates based on baseline study results.
2.1.5	Refrigerator and Freezer Recycling	N	Update of default electric COP assumptions to include duct loss. Adjustment to sunset date to 1/1/2019 to review if undated study available. Updates based on baseline study results.
2.1.6	Room Air Conditioning	N	Update baseline and default efficient specifications based on available product (CEC database).
2.2.1	Tier 1 Advanced Power Strip	N	Update to lifetime and costs and clarification of baseline
2.2.2	Tier 2 Advanced Power Strip	N	Update to baseline controlled usage assumption based on AESP report. Application of ISR by product classification.
N/A	Tier 2 Advanced Power Strip Product Classification Memo	N	Addition of TrickleStar product and ISR assumptions.
2.3.1	Gas Water Heater	N	Measure cost clarification. Addition of language relating to Uniform Energy Factor and conservative application for v2.0 as Energy Factor.
2.3.2	Heat Pump Water Heater	N	Addition of >55 gallon tanks. Update to measure cost. Update of default electric COP assumptions to include duct loss. Simplification of example to match algorithm. Updates based on baseline study results. Addition of language relating to Uniform Energy Factor and conservative application for v2.0 as Energy Factor.
2.3.4	Low Flor Faucet Aerators	N	Updates based on baseline study results.
2.3.5	Low Flow Showerheads	Y	Fix error in natural gas algorithm – (GPMbase – GPMlow) instead of (GPMbase * GPMlow) Measure cost clarification. Updates based on baseline study results.
2.4.1	Central Air Source Heat Pump	N	Added definition of QI programs. Clarification added in this draft. Clarification that baseline assumes no QI. Update to baseline based on available product on AHRI database. Updates to costs. Updates to coincidence factors. Updated the early replacement maximum repair cost based on updated measure costs.
2.4.2	Central Air Conditioner	N	Added definition of QI programs. Clarification added in this draft. Clarification that baseline assumes no QI. Update to baseline based on available product on AHRI database. Updates to costs. Updates to coincidence factors. Updated the early replacement maximum repair cost based on updated measure costs.
2.4.3	Boiler	N	Measure cost clarification. Addition of derating factor based on Massachusetts study.

Measure # and Name		Errata?	Brief description of what changed
			Updated the early replacement maximum repair cost based on updated measure costs.
2.4.4	Furnace	N	Added definition of QI programs. Clarification added in this draft. Clarification that baseline assumes no QI. Measure cost clarification. Added additional extrapolated high efficiency furnace costs. Updated measure costs based on updated DOE Technical Support Document. Updated the early replacement maximum repair cost based on updated measure costs.
2.4.5	Furnace Blower Motor	N	Updates to coincidence factors.
2.4.6	Geothermal Source Heat Pump	N	Added definition of QI programs. Clarification added in this draft. Clarification that baseline assumes no QI. Fixing example parentheses. Addition of pumping energy adjustments. Updates to coincidence factors. Addition of language relating to Uniform Energy Factor and conservative application for v2.0 as Energy Factor.
2.4.7	Ductless Heat Pump	N	Addition of 'new conditioning' scenario. Update to space heating algorithm, now based on Capacity * EFLH. EFLHs made dependent on application. Load Factor applied. Updates to coincidence factors.
2.4.8	Energy Recovery Ventilator	N	Addition of gas EFLH assumptions. Addition of examples. Measure cost clarification. Updates to coincidence factors.
2.4.9	Gas Fireplace	N	Measure cost clarification.
2.4.11	Central Air Source Heat Pump Tune-Up	N	Addition of examples. Updates to coincidence factors.
2.4.12	Central Air Conditioner Tune-Up	N	Addition of examples. Updates to coincidence factors.
2.4.15	Geothermal Source Heat Pump Tune-Up	N	Addition of examples. Updates to coincidence factors.
2.4.16	Duct Sealing	N	Clarified that deemed savings are per ft of total duct length and addition of defaults. Update of default electric COP assumptions to not include duct loss. Updates to coincidence factors.
2.4.17	Programmable Thermostats	N	Update of %ElectricHeat assumption to remove resistance and default electric heat assumption. Addition of %Controlled assumption. Added Peak Gas Savings algorithm.
2.4.18	Advanced Thermostats	N	Update of %ElectricHeat assumption to remove resistance and default electric heat assumption. Addition of %Controlled assumption. Add %AC assumption to peak demand algorithm

Measure # and Name		Errata?	Brief description of what changed
			Added Peak Gas Savings algorithm. Measure cost clarification. Updates based on baseline study results. Updates to coincidence factors.
New	Duct Insulation	N	New measure. Addition of definition of unconditioned areas. Updates to coincidence factors.
2.5.1	Compact Fluorescent Lamp - Standard	N	Added language that measure only effective until end of 2017. Update of default electric COP assumptions to include duct loss.
2.5.2	Compact Fluorescent Lamp - Specialty	N	Added language that measure only effective until end of 2017. Update of default electric COP assumptions to include duct loss.
2.5.3	LED Lamp Standard	N	Update to ENERGY STAR specification. Adding CEE T2 efficacy level. Update to baseline blend and 2020 efficacy assumption. Costs and O&M calculation updated Update of default electric COP assumptions to include duct loss. Updates based on baseline study results.
2.5.3	LED Lamp Specialty	N	Update to ENERGY STAR specification. Adding CEE T2 efficacy level. Adding baseline adjustment as now not exempt from backstop provision. Update to 2020 efficacy assumption. Costs and O&M calculation updated Update of default electric COP assumptions to include duct loss. Updates based on baseline study results.
2.5.5	LED Exit Signs	N	Removal of TOS assumptions – now retrofit only. Measure cost clarification. Update of default electric COP assumptions to include duct loss. Updates based on baseline study results.
2.6.1	Infiltration Control	N	Fix typo in deemed natural gas section. Updates to coincidence factors.
2.6.2	Attic and Ceiling Insulation	N	Updates to coincidence factors.
2.6.3	Rim and Band Joist Insulation	N	Updates to coincidence factors.
2.6.4	Wall Insulation	N	Updates to coincidence factors.
2.6.5	Insulated Doors	N	Updates to coincidence factors.
2.6.6	Floor Insulation Above Crawlspace	N	Updates to coincidence factors.
2.6.7	Basement Sidewall Insulation	N	Updates to coincidence factors.
2.6.8	Efficient Windows	N	Updates to coincidence factors.
New	Low E Windows	N	New measure.
New	Residential Pool Pumps	N	New measure
3.1.1	Circulation Fans	N	Measure cost clarification.

Measure # and Name		Errata?	Brief description of what changed
3.1.2	Ventilation Fans	N	Measure cost clarification.
3.1.3	High Volume Low Speed Fans	N	Measure cost clarification.
3.1.6	Dairy Scroll Compressor	N	Addition of examples.
3.1.8	Heat Reclaimer	N	Addition of algorithm to clarify savings calculation.
3.1.11	Live Stock Waterer	N	Measure cost clarification.
3.1.14	Dairy Plate Cooler	N	Measure cost clarification.
3.2.2	Low Flow Showerheads	N	Removal of scalding language. Clarification of annual minutes of use section.
3.2.3	Gas Hot Water Heater	N	Updates to estimates of hot water consumption by building type. Clarification of baseline. Measure cost clarification.
3.2.4	Controls for Central Domestic Hot Water	N	Measure cost clarification.
3.2.5	Pool Covers	N	Measure cost clarification.
3.2.6	Drainwater Heat Recovery	N	Updates to estimates of hot water consumption by building type.
3.3	HVAC Modeling Variables	N	Addition of language for cases where building type is not well represented by existing list.
3.3.1	Boiler	N	Measure cost clarification.
3.3.2	Furnace	N	Measure cost clarification. Added additional extrapolated high efficiency furnace costs. Updated measure costs based on updated DOE Technical Support Document.
3.3.3	Furnace Blower Motor	N	Fixed typo of HP to kW conversion
3.3.5	Geothermal Source Heat Pump	N	Addition of pumping energy adjustments.
3.3.12	Small Commercial Programmable Thermostat	N	Adding programmable thermostat cooling loadshape. Fix typo in algorithm. Additional cooling/heating combinations characterized.
3.3.13	Variable Frequency Drives for HVAC Pumps	N	Clarification of limit to centrifugal pumps only. Measure cost clarification. Addition of examples.
3.3.15	Duct Insulation	N	Addition of examples.
3.3.17	Chiller Pipe Insulation	N	Addition of examples.
3.3.18	Hydronic Heating Pipe Insulation	N	Addition of examples.
3.3.21	Room Air Conditioner Recycling	N	Addition of examples.
3.4	Lighting Interactive Effects table	Y	Fixes to a number of modeling output assumptions (Health, Lodging, and Multifamily). Addition of language for cases where building type is not well represented by existing list.
3.4.1	Compact Fluorescent Lamp - Standard	N	Added language that measure only effective until end of 2017.

Measure # and Name		Errata?	Brief description of what changed
3.4.2	Compact Fluorescent Lamp - Specialty	N	Added language that measure only effective until end of 2017.
3.4.3	LED Lamp Standard	N	Update to ENERGY STAR specification. Adding CEE T2 efficacy level. Update to baseline blend and 2020 efficacy assumption. Costs and O&M calculation updated.
3.4.4	LED Lamp Specialty	N	Update to ENERGY STAR specification. Adding CEE T2 efficacy level. Adding baseline adjustment as now not exempt from backstop provision. Update to 2020 efficacy assumption. Costs and O&M calculation updated.
3.4.5	LED Fixtures	N	Addition of upper lumen ranges and note that fixtures outside that range savings should be custom calculated. Replacement of 2' / 4' linear replacement lamps with 3 lumen range measures. Update to LED wattage assumptions. Update to T8:T12 blend based on baseline study results, and associated midlife savings adjustment. Update to costs and estimate of baseline cost provided to allow actual costs to be used. Clarification in High & Low Bay Fixture section that ≤ 10,000 lumens range can be Low or High Bay.
3.4.7	High Performance and Reduced Wattage T8 Fixtures and Lamps	N	Added language to retire measure.
3.4.8	Metal Halide	N	Added language to retire measure.
3.4.9	Commercial LED Exit Sign	N	Removal of TOS assumptions – now retrofit only. Measure cost clarification. Addition of examples.
3.4.12	Occupancy Sensor	N	Fix error in peak gas savings algorithm – dividing by Heatdays rather than 365. Addition of examples.
3.4.13	Daylighting Control	N	Addition of examples.
3.4.14	Multi-level Lighting Switch	N	Addition of examples.
3.5.1	Variable Frequency Drives for Process	N	Clarification of limit to centrifugal pumps only. Addition of example. Measure cost clarification.
3.5.3	Motors	N	Update to Federal minimum efficiency requirements. Addition of example. Measure cost clarification.
3.7.4	Wall Insulation	N	Addition of examples.
3.7.5	Efficient Windows	N	Addition of examples.
3.7.6	Insulated Doors	N	Addition of examples.

Measure # and Name		Errata?	Brief description of what changed
3.8.2	Door Heater Controls for Cooler or Freezer	N	Measure cost clarification. Adjustment of %Off assumptions.
3.8.3	Efficiency Motors for Walk-in and Display Case Coolers / Freezers	N	Addition of Q-sync assumptions. Measure cost clarification.
3.8.4	Night Covers for Open Refrigerated Display Cases	N	Measure cost clarification.
3.8.8	Strip Curtain for Walk-In Coolers and Freezers	N	Measure cost clarification.
New	Forklift Battery Chargers	N	New measure Addition of waste heat factors.

MEMORANDUM

TO: **TECHNICAL ADVISORY COMMITTEE**

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

SUBJECT: V2.0 ERRATA MEASURES EFFECTIVE 01/01/2018

DATE: 08/16/2017

Cc:

This memo documents an errata change to version 2.0 of the Iowa Technical Reference Manual (TRM) that the Technical Advisory Committee (TAC) recommends be made effective 01/01/2018.

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

It is our belief and understanding that the following measures have consensus errata by the Program Administrators and the entire TAC. The term 'errata' is used to describe these measures, and in accordance with Volume 1.0, Section 2.2; "Additions/Corrections Outside of Scheduled TRM Update Process", the Implementers and Evaluators should use this version of the measures during the current program year.

Summary of Errata Measures

Section	Measure Name	Measure Code	Brief Summary of Change
2.5.3	LED Lamp - Standard	RS-LTG-LEDA-V03-180101	Fixed error in calculation of O&M impacts. The updated calculation file is name "2017 LED Measure Cost and OandM Calc_07312017.xls" and is found in the TRM Reference Documents on the Sharepoint site.

2.5.3 LED Lamp - Standard

DESCRIPTION

This characterization provides savings assumptions for LED Screw Based Omnidirectional (e.g., A-Type) lamps. This characterization provides assumptions for LEDs installed in a known location (i.e., residential and in-unit interior or exterior) or, if the implementation strategy does not allow for the installation location to be known (e.g., an upstream retail program or efficiency kit), an unknown residential location assumption is provided. For upstream programs, utilities should develop an assumption of the Residential v Nonresidential split and apply the relevant assumptions to each portion.

Federal legislation stemming from the Energy Independence and Security Act of 2007 (EISA) requires all general-purpose light bulbs between 40W and 100W to be approximately 30% more energy efficient than standard incandescent bulbs. Production of 100W, standard efficacy incandescent lamps ended in 2012, followed by restrictions on 75W lamps in 2013 and 60W and 40W lamps in 2014. The baseline for this measure has therefore become bulbs (improved incandescent or halogen) that meet the new standard. Furthermore, the Technical Advisory Committee approved assuming a blended baseline condition of EISA qualified incandescent/halogen, CFL and LED lamps. This assumption should be reviewed during each update cycle and when the net to gross impacts for this measure are determined.

A provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt.

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

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

DEFINITION OF EFFICIENT EQUIPMENT

In order for this characterization to apply, new lamps must be ENERGY STAR labeled based upon the v2.0 ENERGY STAR specification for lamps (https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2%20Revised%20Spec.pdf) or CEE Tier 2 qualified. Specifications are as follows:

Efficiency Level	Lumens / watt	
	CRI<90	CRI≥90
ENERGY STAR v2.0	80	70
CEE Tier 2[1]	95	80

Qualification could also be based on the Design Light Consortium's qualified product list[2].

DEFINITION OF BASELINE EQUIPMENT

The baseline condition for this measure is assumed to be a blend of 55% EISA qualified halogen or incandescent and 13% CFL and 32% LED[3]. From 2020 the baseline is assumed to rise to 70 lumens / watt[4] and therefore a midlife

[1] Also required to have rated life of 25,000 hours and dimming capability.

[2] https://www.designlights.org/QPL

[3] Based on 2016 Q3 lamp shipment data from NEMA; http://www.nema.org/Intelligence/Pages/Lamp-Indices.aspx. Note this is consistent with the findings from the Dunsky baseline study, but adjusted to account for significant growth in LED market and reduction in CFL.

[4] A provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. However with the rapid decline in CFL sales and increase in LEDs, 70 lumens per watt represents an estimated mix of CFL and non-ENERGY STAR LED.

adjustment is provided.

DEEMED LIFETIME OF EFFICIENT EQUIPMENT

The rated life of omnidirectional LED lamps is assumed to be 20,000[5]. This would imply a lifetime of 22 years for Residential interior and 8 years for Residential exterior; however, all installations are capped at 10 years[6] so interior bulbs should assume a 10 year measure life.

DEEMED MEASURE COST

Wherever possible, actual incremental costs should be used. If unavailable, assume the following incremental costs[7]:

Lamp Type	CRI	Product Type	Cost	Incremental Cost
Standard A-lamp	<90	Baseline	$1.97	n/a
		ESTAR LED	$3.16	$1.19
		CEE T2 LED	$3.29	$1.32
	>=90	Baseline	$2.16	n/a
		ESTAR LED	$3.67	$1.51
		CEE T2 LED	$3.75	$1.58

LOADSHAPE

Loadshape RE03 - Residential Indoor Lighting

Loadshape RE08 - Residential Outdoor Lighting

Algorithm

CALCULATION OF SAVINGS

ELECTRIC ENERGY SAVINGS

$$\Delta kWh = \frac{Watts_{Base} - Watts_{EE}}{1{,}000} * ISR * Hours * (WHFeHeat + (WHFeCool - 1))$$

Where:

$Watts_{Base}$ = Based on lumens of LED bulb installed and includes blend of incandescent/halogen[8], CFL and LED by weightings provided in table below[9]. Note that when an IA net-to-gross (NTG) factor is determined for this measure, this blended baseline should be replaced with the Incandescent/Halogen baseline only.

[5] Version 1.1 of the ENERGY STAR specification required omnidirectional bulbs to have a rated life of 25,000 hours or more. Version 2.0 of the specification now only requires 15,000 hours. In the absence of data suggesting an average – an assumed average rated life of 20,000 hours is used.

[6] Based on recommendation in the Dunsky Energy Consulting, Livingston Energy Innovations and Opinion Dynamics Corporation; NEEP Emerging Technology Research Report, p 6-18. Particularly in residential applications, lamps are susceptible to persistence issues such as removal, new occupants etc.

[7] Lamp costs are based upon WECC review of bulbs purchased through the Alliant program January – April 2017. See "2017 LED Measure Cost and O&M Calc.xls" for more information.

[8] Incandescent/Halogen wattage is based upon the post first phase of EISA wattage.

[9] Weightings were determined through discussions with the Technical Advisory Committee. These are based on 2016 Q3 lamp shipment data from NEMA; http://www.nema.org/Intelligence/Pages/Lamp-Indices.aspx. Note this is consistent with the findings from the Dunsky baseline study, but adjusted to account for significant growth in LED market and reduction in CFL.

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

Lower Lumen Range	Upper Lumen Range	Inc/ Halogen	CFL[10]	LED[11]	$Watts_{Base}$	WattsEff ESTAR		WattsEff CEE T2		DeltaWatts ESTAR		DeltaWatts CEE T2	
		55%	15%	30%		CRI <90	CRI >=90	CRI <90	CRI >=90	CRI <90	CRI >=90	CRI <90	CRI >=90
250	309	25	4.7	3.7	15.6	3.5	4.0	2.9	3.5	12.1	11.6	12.6	12.1
310	749	29	8.8	7.1	19.4	6.6	7.6	5.6	6.6	12.8	11.8	13.8	12.8
750	1049	43	15.0	12.0	29.5	11.2	12.9	9.5	11.2	18.3	16.6	20.0	18.3
1050	1489	53	21.2	16.9	37.4	15.9	18.1	13.4	15.9	21.5	19.3	24.0	21.5
1490	2600	72	34.1	27.3	52.9	25.6	29.2	21.5	25.6	27.3	23.7	31.4	27.3
2601	3300	150	49.2	39.3	101.7	36.9	42.2	31.1	36.9	64.8	59.5	70.6	64.8
3301	3999	200	60.8	48.7	133.7	45.6	52.1	38.4	45.6	88.1	81.6	95.3	88.1
4000	6000	300	83.3	66.7	197.5	62.5	71.4	52.6	62.5	135.0	126.1	144.9	135.0

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

Program		Discounted In Service Rate (ISR)[12]
Retail (Time of Sale)[13]		98%
Direct Install[14]		97%
Efficiency Kits	School Kits[15]	83%
	EnergyWise (Low Income)[16]	75%

Hours = Average hours of use per year

Installation Location	Hours
Residential Interior and in-unit Multifamily	894[17]
Exterior	2,475[18]

[10] Baseline CFL watts are calculated using the midpoint of the lumen range and an assumed efficacy of 60 lumens/watt.
[11] Baseline LED watts are calculated using the midpoint of the lumen range and an assumed efficacy of 75 lumens/watt.
[12] All Programs except for Direct Install assume that some lamps are not installed in the first year but are later installed in years 2 and 3. To ease implementation, these future installs are discounted using the statewide real discount rate (7.71%), see "Res Lighting ISR calculation.xlsx" for more information.
[13] 1st year in service rate is based upon analysis of ComEd PY7 intercept data. The Lifetime ISR assumption is assumed to be 98% 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.'
[14] Based upon review of the Illinois PY2 and PY3 ComEd Direct Install program surveys. http://www.ilsag.info/evaluation-documents.html
[15] In Service Rates provided are for the CFL bulb within a kit only. Kits provided free to students through school, with education program. Based on 'Impact and Process Evaluation of 2013 (PY6) Ameren Illinois Company Residential Efficiency Kits Program', table 10.
[16] Based on Cadmus, "Final Report: Iowa 2015 Energy Wise Program", January 29, 2016, p16.
[17] Average of four Midwest metering studies: 2011 Ameren Missouri Lighting and Appliance Evaluation – PY 2; 2012 Consumers Energy - Technical Memo; 2012 DTE - Technical Memo; and PY5/PY6 ComEd, Illinois Residential Lighting Program evaluation.
[18] Based on secondary research conducted as part of the Illinois PY5/PY6 ComEd Residential Lighting Program evaluation.

Installation Location	Hours
Unknown (e.g., Retail, Upstream, and Efficiency Kits)	973[19]

$WHFe_{Heat}$ = Waste Heat Factor for energy to account for electric heating increase from reducing waste heat from efficient lighting (if fossil fuel heating – see calculation of heating penalty in that section).

= 1 - ((HF / ηHeat) * %ElecHeat)

If unknown assume 0.93[20]

Where:

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

= 53%[21] for interior or unknown location

= 0% for exterior or unheated location

$\eta Heat_{Electric}$ = Efficiency in COP of Heating equipment

= Actual system efficiency including duct loss - If not available, use[22]:

System Type	Age of Equipment	HSPF Estimate	ηHeat (Effective COP Estimate) (HSPF/3.412)*0.85
Heat Pump	Before 2006	6.8	1.7
	2006 - 2014	7.7	1.92
	2015 on	8.2	2.04
Resistance	N/A	N/A	1
Unknown	N/A	N/A	1.27[23]

%ElecHeat = Percentage of home with electric heat

Heating fuel	%ElecHeat
Electric	100%
Fossil Fuel	0%
Unknown	17%[24]

[19] Assumes 5% exterior lighting, based on PYPY5/PY6 ComEd Residential Lighting Program evaluation.
[20] Calculated using defaults; 1-((0.53/1.27) * 0.17) = 0.93.
[21] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Des Moines, Mason City, and Burlington, IA.
[22] 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 means that using the minimum standard is appropriate. An 85% distribution efficiency is then applied to account for duct losses for heat pumps.
[23] Calculation assumes 33% Heat Pump and 67% Resistance, which is based upon data from Energy Information Administration, 2009 Residential Energy Consumption Survey, see "HC6.9 Space Heating in Midwest Region.xls". Average efficiency of heat pump is based on the assumption that 50% are units from before 2006 and 50% 2006-2014.
[24] Based on Dunsky and Opinion Dynamics Baseline Study results.

$WHFe_{Cool}$ = Waste Heat Factor for energy to account for cooling savings from reducing waste heat from efficient lighting.

Bulb Location	$WHFe_{Cool}$
Building with cooling	1.12[25]
Building without cooling or exterior	1.0
Unknown	1.11[26]

Mid-Life Baseline Adjustment

During the lifetime of a standard Omnidirectional LED, the baseline incandescent/halogen bulb would need to be replaced multiple times. Since the baseline bulb changes to a CFL equivalent in 2020 due to the EISA backdrop provision (except for <310 and 3300+ lumen lamps), the annual savings claim must be reduced within the life of the measure to account for this baseline shift. This reduced annual savings will need to be incorporated in to cost effectiveness screening calculations. The baseline adjustment also impacts the O&M schedule.

For example, for 43W equivalent LED lamp installed in 2018, the full savings (as calculated above in the Algorithm) should be claimed for the first two years, but a reduced annual savings (calculated energy savings above multiplied by the adjustment factor in the table below) claimed for the remainder of the measure life.

Lower Lumen Range	Upper Lumen Range	Mid Lumen Range	WattsBase after EISA 2020[27]	%Adj in 2020 ESTAR		%Adj in 2020 CEE T2	
				CRI <90	CRI >=90	CRI <90	CRI >=90
250	309	280	15.6	100%	100%	100%	100%
310	749	530	7.6	7%	0%	14%	7%
750	1049	900	12.9	9%	0%	17%	9%
1050	1489	1270	18.1	11%	0%	20%	11%
1490	2600	2045	29.2	13%	0%	25%	13%
2,601	3,300	2,775	42.2	8%	0%	16%	8%
3,301	3,999	3,500	133.7	100%	100%	100%	100%
4,000	6,000	5,000	197.5	100%	100%	100%	100%

[25] The value is estimated at 1.12 (calculated as 1 + (0.34 / 2.8)). Based on cooling loads decreasing by 34% of the lighting savings (average result from REMRate modeling of several different building configurations in Des Moines, Mason City, and Burlington), 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 * $SEER^2$) + (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).

[26] The value is estimated at 1.11 (calculated as 1 + (0.88*(0.34 / 2.8)). Based on assumption that 88% of homes have central cooling (based on Dunsky and Opinion Dynamics Baseline Study results).

[27] Baseline post 2020 watts are calculated using the midpoint of the lumen range and an assumed efficacy of 70 lumens/watt.. A provision in the EISA regulations requires that by January 1, 2020, all lamps meet efficiency criteria of at least 45 lumens per watt, in essence making the baseline equivalent to a current day CFL. However with the rapid decline in CFL sales and increase in LEDs, 70 lumens per watt represents an estimated mix of CFL and non-ENERGY STAR LED.

For example, a 11W LED lamp, 900 lumens, CRI 85, is purchased through retail in 2018:

ΔkWh = ((29.5 – 11) /1000) * 0.98 * 973 * (0.93 + (1.11 – 1))

= 18.3 kWh

This value should be claimed for two years, but from 2020 until the end of the measure life for that same lamp, savings should be reduced to (18.3 * 0.09 =) 1.6 kWh for the remainder of the measure life. Note these adjustments should be applied to kW and fuel impacts as well.

SUMMER COINCIDENT PEAK DEMAND SAVINGS

$$\Delta kW = \frac{Watts_{Base} - Watts_{EE}}{1{,}000} * ISR * WHFdCool * CF$$

Where:

WHFdCool = Waste Heat Factor for demand to account for cooling savings from efficient lighting.

Bulb Location	WHFdCool
Building with cooling	1.22[28]
Building without cooling or exterior	1.0
Unknown (e.g. Retail, Upstream and Efficiency Kits)	1.19[29]

CF = Summer peak Coincidence Factor for measure.

Bulb Location	CF
Residential Interior and in-unit Multifamily [30]	13.1%
Exterior [31]	1.8%
Unknown (e.g., Retail, Upstream, and Efficiency Kits)[32]	12.5%

Other factors as defined above

For example, for a 11W LED lamp, 900 lumens, purchased through retail in 2015:

ΔkW = ((29.5 – 11) /1000) * 0.98 * 1.19 * 0.125

= 0.0027 kW

[28] The value is estimated at 1.22 (calculated as 1 + (0.61 / 2.8)). See footnote relating to WHFe for details. Note the 61% factor represents the Residential cooling coincidence factor calculated using the average load during the peak period (as opposed to the peak hour) consistent with the lighting peak hours.

[29] The value is estimated at 1.19 (calculated as 1 + (0.88 * 0.61 / 2.8)).

[30] Based on analysis of loadshape data provided by Cadmus.

[31] Based on Itron eShapes lighting loadprofiles.

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

NATURAL GAS SAVINGS

Heating Penalty for Natural Gas heated homes[33]:

$$\Delta Therms = -\frac{\frac{Watts_{Base} - Watts_{EE}}{1{,}000} * ISR * Hours * HF * 0.03412}{\eta Heat} * \%GasHeat$$

Where:

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

= 53%[34] for interior or unknown location

= 0% for exterior or unheated location

0.03412 =Converts kWh to Therms

$\eta Heat_{Gas}$ = Efficiency of heating system

=74%[35]

%GasHeat = Percentage of homes with gas heat

Heating fuel	%GasHeat
Electric	0%
Gas	100%
Unknown	83%[36]

For example, for a 11W LED lamp, 900 lumens, purchased through retail in 2018:

ΔTherms = - ((((29.5 - 11) / 1000) * 0.98 * 973 * 0.53 * 0.03412) / 0.74) * 0.83

PEAK GAS SAVINGS

For ease of application, savings for this measure is assumed to be evenly spread across the year. The Peak Gas Savings is therefore assumed to be:

$$\Delta PeakTherms = \frac{\Delta Therms}{HeatDays}$$

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

[34] This means that heating loads increase by 53% of the lighting savings. This is based on the average result from REMRate modeling of several different building configurations in Des Moines, Mason City, and Burlington, IA.

[35] This has been estimated assuming that natural gas central furnace heating is typical for Iowa residences (the predominant heating is gas furnace with 49% of Iowa homes (based on Energy Information Administration, 2009 Residential Energy Consumption Survey)). In 2000, 60% of furnaces purchased in Iowa 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 15 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: ((0.60*0.92) + (0.40*0.8)) * (1-0.15) = 0.74.

[36] Based on Dunsky and Opinion Dynamics Baseline Study results

Where:

ΔTherms = Therm impact calculated above

HeatDays = Heat season days per year

= 217[37]

For example, for a 11W LED lamp, 900 lumens, purchased through retail in 2018:

ΔPeakTherms = - 0.36 /217

= -0.0017 therms

WATER IMPACT DESCRIPTIONS AND CALCULATION

N/A

DEEMED O&M COST ADJUSTMENT CALCULATION

In order to account for the shift in baseline due to the backstop provision of the Energy Independence and Security Act of 2007, requiring all standard bulbs (except for <310 and 3300+ lumen lamps) to have an efficacy equivalent to today's CFL, an annual levelized baseline replacement cost over the lifetime of the LED bulb is calculated. Bulb replacement costs assumed in the O&M calculations are provided below[38].

CRI	Product Type	Cost
<90	Inc/Hal	$1.40
	CFL	$1.68
	LED	$3.16
>=90	Inc/Hal	$1.40
	CFL	$1.95
	LED	$3.67

The present value of replacement lamps and annual levelized replacement costs using the statewide real discount rate of 7.71% are presented below[39]:

		PV of replacement costs for period			Levelized annual replacement cost savings		
CRI	Location	2018 Installs	2019 Installs	2020 Installs	2018 Installs	2019 Installs	2020 Installs
<90	Residential and in-unit Multi Family	$1.73	$0.60	$0.00	$0.25	$0.09	$0.00
	Exterior	$4.34	$2.80	$1.01	$0.64	$0.41	$0.15
	Unknown	$1.73	$0.60	$0.00	$0.25	$0.09	$0.00
>=90	Residential and in-unit Multi Family	$1.90	$~~1.01~~0.81	$0.00	$0.28	$0.~~10~~08	$0.00
	Exterior	$4.60	$~~2.05~~3.80	$3.67	$0.68	$0.~~20~~38	$0.37
	Unknown	$1.90	$~~1.01~~0.81	$0.00	$0.28	$0.~~10~~08	$0.00

[37] Number of days where HDD 60 >0.

[38] Lamp costs are based upon WECC review of bulbs purchased through the Alliant program January – April 2017 and equivalent baseline bulbs.

[39] See "2017 LED Measure Cost and O&M Calc.xls" for more information.

Note: incandescent lamps in lumen range <310 and >3300 are exempt from EISA. For these bulb types, an O&M cost should be applied as follows:

Installation Location	Replacement Period (years)[40]	Replacement Cost
Residential Interior and in-unit Multifamily	8.3	$1.97
Exterior	3.0	
Unknown (e.g., Retail, Upstream, and Efficiency Kits)	7.7	

MEASURE CODE: RS-LTG-LEDA-V0~~2~~3-180101

SUNSET DATE: 1/1/2019

[40] Calculated by dividing assumed rated life of baseline bulb by hours of use. Assumed lifetime of EISA qualified Halogen/ Incandescents is 1000 hours. The manufacturers are simply using a regular incandescent lamp with halogen fill gas rather than Halogen Infrared to meet the standard (as provided by G. Arnold, NEEP and confirmed by N. Horowitz at NRDC). Assumed lifetime of CFL is 10,000 and of LED is 20,000 hours. Values provided are an average based on 55% incandescent/halogen, 10% CFL and 30% LED (blended average of 7500 hours).