Energy Association of Pennsylvania

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May 28, 2019

Rosemary Chiavetta, Esq., Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building
400 North Street, 2nd Floor
Harrisburg, Pennsylvania 17120

Re: Implementation of Alternative Energy Portfolio Standards Act of 2004: Standards for the Participation of Demand Side Management Resources – Technical Reference Manual 2021 Update, Docket M-2019-3006867

Dear Secretary Chiavetta:

Enclosed for filing please find the comments of the Energy Association of Pennsylvania filed in the above-referenced Docket.

Sincerely,

Donna M.J. Clark
Vice President & General Counsel

Enclosure

BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

Implementation of Alternative Energy Portfolio Standards Act of 2004: Standards for the Participation of Demand Side Management Resources – Technical Reference Manual 2021 Update	: : : : :	Docket No. M-2019-3006867

COMMENTS OF THE
ENERGY ASSOCIATION OF PENNSYLVANIA
TO THE 2021 TRM UPDATE
TENTATIVE ORDER

On April 11, 2019 in the context of planning for a potential Phase IV Act 129 Energy Efficiency and Conservation ("EE&C") Program[1], the Pennsylvania Public Utility Commission ("PUC" or "Commission") entered a Tentative Order[2] in anticipation of adopting an updated Technical Reference Manual ("TRM") as a component of the EE&C Program evaluation, measurement and verification process in this next phase.[3] The Tentative Order proposes a

[1] The Act 129 EE& C Program is currently in a five-year Phase III that will conclude on May 31, 2021.

[2] Implementation of the Alternative Energy Portfolio Standards Act of 2004: Standards for the Participation of Demand Side Management Resources - Technical Reference Manual 2021 Update, Docket No. M-2019-3006867, entered on April 11, 2019 (Tentative Order).

[3] In its 2009 Phase I *Energy Efficiency and Conservation Program* Implementation Order, Docket No. M-2008-2069887 (January 16, 2009), the Commission determined to utilize a TRM originally adopted in connection with the implementation of the Alternative Energy Portfolio Standards Act ("AEPS Act"), 73 P.S. §§ 1648.1 – 1648.8 to evaluate savings achieved in the ACT 129 EE&C Program. That initial TRM has been subsequently updated and expanded on a periodic basis to support both the AEPS Act and the Act 129 EE&C Program. Annual updating occurred during both Phase I and Phase II of Act 129. For the current phase of Act 129, the Commission concluded that the update finalized for that first year of Phase III which began on June 1, 2016 would be applicable for the entire phase which ends on May 31, 2021. The Phase III *Energy Efficiency and Conservation Program*

number of changes to the existing TRM and a new process for optional annual updates to incorporate codes, standards and ENERGY STAR specifications that change during the phase without undertaking a full TRM update. It is anticipated that the 2021 TRM update, once finalized, will become effective on June 1, 2021.

On behalf of its electric distribution company ("EDC") members subject to the provisions of the Act 129 EE&C Program[4], the Energy Association of Pennsylvania ("EAP") submits the following comments to the Tentative Order, including a specific proposal that provides "composite" inputs to the lighting savings algorithm contained in TRM Volume 3, measure 3.1.7 Lighting Improvements for Midstream Delivery Programs. These comments are made in concert with any comments submitted to the Tentative Order by its individual member EDCs named in footnote three (3) *supra*.

I. COMMENTS

EAP generally supports the goals detailed for the proposed 2021 TRM modifications as set forth at pages four and five in the Tentative Order. As with prior TRM updates, Commission staff together with the Statewide Evaluator ("SWE"), the EDCs and other stakeholders have engaged in a collaborative effort that will ideally result in the adoption of a TRM that will support development of the 2019 Market Potential Study as well as be an effective and efficient tool utilized to both develop the individual EDC Phase IV EE&C plans and to evaluate, measure and verify the energy savings necessary to meet Act 129 Phase IV savings goals. Finalizing

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Implementation Order, Docket No. M-201402424864 does allow for a mid-phase update if deemed necessary by the Commission. Id. at pp. 97 - 98.

[4] EAP EDC members subject to the Act 129 EE&C Program are Duquesne Light Company, Metropolitan Edison Company, PECO Energy Company, Pennsylvania Electric Company, Pennsylvania Power Company, PPL Electric Utilities Corporation and West Penn Power Company.

major modifications to the TRM well in advance of the next program phase is critical; first, as a key component of the ongoing analysis by the SWE to recommend energy saving goals for a potential Phase IV and second, as an essential building block for the EDCs to begin developing the next iteration of their individual EE&C plans. Clear and consistent guidance for evaluating, measuring and verifying the numerous measures offered in EE&C plans throughout the phase simplifies EDC implementation leading to cost efficiencies, and also provides clear direction to participants in the marketplace looking to promote and adopt energy efficiency measures.

A. Process for Code Change Updates

For the current Phase III, the Commission decided to apply the 2016 TRM for the entirety of the phase, i.e. June 1, 2016 through May 31, 2021, while reserving the right "to perform mid-phase updating if we deem it necessary, such as in instances where major market or technology transformations affect the EE&C Programs and associated savings values." *See, Energy Efficiency and Conservation Program* Implementation Order ("Phase III Implementation Order"), Docket No. M-2014-2424864, entered June 19, 2015 at p. 98.[5] EAP believes this approach has worked well. As the Association has argued in previous comments to proposed TRM updates, frequent changes in eligibility criteria, applications, rebates and the amount/type of customer data required to evaluate a measure that would necessarily follow a change to the TRM arguably discourages participation by customers and prolongs the time necessary to achieve the market transformation envisioned by the General Assembly.

[5] To date, the PUC has not elected to propose a mid-Phase III TRM update and the EDCs have worked with the SWE, as necessary, to propose interim measure protocols as a means to implement and evaluate new measures without seeking a broader review of the 2016 TRM.

For the potential Phase IV, the Commission suggests a specific annual process to modify the TRM "limited to updating values directly related to codes, standards and ENERGY STAR specifications" that may occur during the phase. *See generally,* Tentative Order at pp. 5 - 7. The process includes an analysis by the SWE of the impact of potential code or standards modifications delivered to the PUC Technical Utility Services ("TUS") staff for an initial review and the opportunity for public input prior to issuance of any final order by the Commission. The Tentative Order sets forth a timeline that states that codes and standards modifications under consideration must be in effect by July 1 of the year in which the proposed update is under consideration, *id.* at p. 7, and aims to have any Final TRM Order and Manual considered by the Commission at a Public Meeting in November of that same year. *Id.* EAP is supportive of this refinement as limited. EAP appreciates that there is an opportunity for public input and that the initial analysis by the SWE is focused on the impact of a limited TRM modification. Although not expressly stated, EAP assumes that any approved modification of the TRM would become effective on June 1 of the following calendar year which would be the beginning of a new plan year and asks the Commission to affirm its assumption.

B. Including Composite Inputs to the Lighting Savings Algorithm

On behalf of its EDC members and as detailed in the attached red-lined Exhibit A – Phase IV TRM Comments for Lighting Measures, EAP proposes the inclusion of "composite" inputs to the lighting savings algorithm pertaining to the following measures from TRM Volume 3:

- 3.1.1 Lighting Improvements
- 3.1.4 LED Exit Signs

- 3.1.7 Lighting Improvements for Midstream Delivery Programs.

II. CONCLUSION

In conclusion, EAP asks the Commission to consider the above comments as well as include the attached proposal in the final 2021 TRM. In particular, EAP supports the process for annual optional updates as limited in the Tentative Order and reiterates its belief that major modifications to the TRM should be in place for a potential Act 129 Phase IV and used to support the development of the 2019 Market Potential Study well in advance of June 1, 2021, the presumed start date for the next phase of Pennsylvania's EE&C Program. While maintaining an updated TRM is laudable, the process should be balanced and synced, to the extent possible, with the start of the next EE&C Program phase to reduce consumer confusion and the costs associated with modifying newly-approved EDC EE&C plans and budgets. EAP believes that "process for code change updates" as set forth in the Tentative Order meets industry concerns and the policy objectives of Act 129.

Respectfully Submitted:

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Dated: May 28, 2019

NAVIGANT

Memorandum

To: Pennsylvania Public Utility Commission

From: Energy Association of Pennsylvania (EAP)

Date: May 27, 2019

Re: Phase IV TRM Comments for Lighting Measures

Introduction

This memorandum is filed in response to the Pennsylvania Public Utility Commission's (PUC, or the Commission) request for comments on the Tentative 2021 Technical Reference Manual (TRM) and its associated appendices and Order. This comment pertains specifically to three measures from TRM Volume 3:

- 3.1.1 Lighting Improvements
- 3.1.4 LED Exit Signs
- 3.1.7 Lighting Improvements for Midstream Delivery Programs.

This comment proposes the inclusion of "composite" inputs to the lighting savings algorithm. Navigant developed the composite inputs from data submitted by all the PA electric distribution companies (EDC's)[1]. This comment suggests specific changes to the above three Phase IV TRM entries in the TRM's current format, in which the midstream delivery option is a separate entry from each measures' downstream channel option. The EAP further recommends that the PUC consider combining measures 3.1.1 and 3.1.7 so that TRM measure selection and TRM savings estimation is independent of implementation method.

This comment includes only those changes required for inclusion of the composite inputs. EDC's may submit comments about the midstream and commercial lighting TRM protocols in addition to those included in this memo. We recommend the PUC consider all comments submitted about the same protocols as a whole.

[1] PECO, PPL, Duquesne Light Company (DLC), Metropolitan Edison Company, Pennsylvania Power Company, West Penn Power Company, and Pennsylvania Electric Company

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The purpose of including composite inputs in the TRM is to allow for increased program delivery options, streamline applications, reduce customer burden, and ultimately allow more of the collected ratepayer dollars to flow back to the ratepayers in the form of incentives for saving energy.

Methodology

The EM&V contractors[2] for each of the PA EDC's sent to Navigant evaluation-verified data for sampled commercial and industrial (C&I) lighting installations in Phase III. The compiled data provides information for each input to the lighting algorithm, and it includes more than 9,000 records. The final dataset includes data from all seven PA EDC's, all program types and delivery methods, and goes back to installations starting in 2016.

The lighting algorithm and inputs are shown in Figure 1.

Figure 1. Lighting Algorithm and Inputs

$$\Delta kWh = (DeltaWatts) \times HOU \times (1 - SVG_{base}) \times \left(1 + IF_{energy}\right) \times ISR$$

$$\Delta kW_{peak} = (DeltaWatts) \times CF \times (1 - SVG_{base}) \times (1 + IF_{demand}) \times ISR$$

$$DeltaWatts = kW_{base} - kW_{ee}$$

Where,

- kW_{base}, Wattage of baseline lighting
- kW_{ee}, Wattage of incentivized lighting
- $DeltaWatts$, the difference between the baseline wattage and incentivized wattage
- SVG_{base}, Savings factor for existing lighting control (percent of time the lights are off)
- CF, Coincidence factor
- HOU, Hours of Use – the average annual operating hours of the baseline lighting equipment, which if applied to full connected load will yield annual energy use
- IF_{energy}, Interactive Energy Factor – applies to C&I interior lighting in space that has air conditioning, electric space heating, or refrigeration. This represents the secondary energy impacts which results from the decreased waste heat from efficient lighting.
- IF_{demand}, Interactive Demand Factor – applies to C&I interior lighting in space that has air conditioning or refrigeration only. This represents the secondary demand savings in cooling required which results from the decreased waste heat from efficient lighting
- *ISR,* In Service Rate, the fraction of incentivized lamps or fixtures that are installed within three years of purchase

Navigant disaggregated the records in the database by "form factor" to account for natural differences by type of installation. The form factors include:

- **Screw-based**: includes self-ballasted CFL and LED bulbs

[2] Navigant, Cadmus, and ADM

- **Other General Service**: includes fluorescent and LED technology linear bulbs, metal halides, high intensity discharge lamps, and hardwired/pin-based CFLs and LEDs
- **Exit signs**: includes exit signs of all technology types
- **Streetlighting**: accounts for all types of streetlighting installations

Navigant calculated the composite value, for each form factor, as the weighted average of each of the algorithm inputs. Weighting accounts for differences in the magnitude of savings represented by each record in the dataset originating from the range of utilities, program types, and program years. Navigant then applied a correction factor to account for interactions between the inputs. Finally, to be conservative, Navigant applied a 10% reduction to the resulting energy and demand savings per fixture calculated from the weighted average algorithm inputs.

Summary of Composite Inputs

Table 1 shows a summary of the recommended composite values for inclusion in the TRM.

Table 1. Lighting Composite Inputs and Savings by Form Factor

Input	Screw-Based	Other General Service	Exit Signs	Streetlighting	All Form Factors
kW_{base}	55	150	36	184	145
kW_{ee}	12	70	3	64	68
DeltaWatts	43	80	32	120	77
SVG_{base}	0.3%	1.6%	0.0%	0.1%	1.7%
CF	0.54	0.66	1.00	0.00	0.58
HOU	4,083	5,341	8,760	4,222	5,000
IF_{energy}	0.000	0.000	0.000	0.000	0.000
IF_{demand}	0.157	0.112	0.179	0.000	0.115
ISR*	98%	98%	98%	98%	98%
kWh Savings per fixture**	157	377	255	456	340
kW Savings per fixture**	0.024	0.052	0.034	0.000	0.044

**Navigant did not analyze the in-service rate and is using the Phase IV TRM default value in the savings calculations.*

***kWh Savings and kW Savings have a 10% reduction applied to them to be conservative.*

Source: Navigant analysis

Suggested Revisions to Phase IV TRM Entries

This section communicates the suggested changes to the existing TRM entries for 3.1.1 Lighting Improvements, 3.1.4 LED Exit Signs, and 3.1.7 Lighting Improvements for Midstream Delivery Programs.

3.1.1 Lighting Improvements

Target Sector	Commercial and Industrial Establishments
Measure Unit	Lighting Equipment
Measure Life	New Linear Fluorescent Fixture: 15 years Lamp Only: LED, Screw-in: 15 years Lamp Only: Induction Lamps: 6 years Lamp Only: Metal Halide Lamps: 6 years Lamp Only: High Pressure Sodium Lamps: 12 years Lamp Only: Mercury Vapor Lamps: 6 years Lamp Only: T8 Lamps: 10 years Lamp Only: LED, Linear, Type A: 5 years Lamp Only: LED, Linear, Type B: 15 years Lamp Only: LED, Linear, Type C: 15 years Permanent Fixture Removal: 13 years Permanent Lamp Removal: 11 years Source 1
Measure Vintage	Early Replacement or Permanent Removal

ELIGIBILITY

Lighting improvements include fixture or lamp and ballast replacement and/or permanent removal in existing commercial and industrial customers' facilities.[3] Installed and removed lamps and fixtures are broken down into two distinct types based on common load shapes: Screw-based and Other General Service. Screw-based bulbs consist of self-ballasted incandescent, halogen, CFL, and LED bulbs; Other General Service Lighting consists of all other fixture and lamp types, including but not limited to linear fluorescents, metal halides, high intensity discharge lamps, and hardwired/pin-based CFLs and LEDs.

To be eligible for savings from permanent fixture and lamp removal, customer must have permanently removed unneeded, functional light fixtures, lamps, lamp holders, and/or ballasts in accordance with local regulations. The removal of non-operational equipment is not eligible for the defined savings.

Permanent lamp removal includes the permanent removal of existing 8', 4', 3' and 2' T8 fluorescent lamps. The savings are defined on a per-removed-lamp basis and don't include savings from lamp replacements.

Note that the Energy Policy Act of 2005 ("EPACT 2005") and Energy Independence and Security Act ("EISA") 2007, and subsequent federal rulemakings, introduced new efficacy standards for linear fluorescent bulbs and ballasts, effectively phasing out magnetic ballasts (effective October 1, 2010) and most T-12 bulbs (effective July 14, 2012). This induced a shift in what a participant would have purchased in the absence of the program because T-12 bulbs on magnetic ballasts are no longer

[3] Permanent fixture and lamp removal savings do not include replacements. Customers are responsible for determining whether permanent fixture and/or lamp removal will maintain or exceed minimum lighting requirements. Recommended light levels are provided by the Illuminating Engineering Society of North America (IESNA).

viable options and, therefore, adjusts the baseline assumption. With this understanding, standard T-8s became the baseline for all T-12 linear fluorescent retrofits beginning June 1, 2016 (PY8). The comparable baseline for any removed standard T-12 fixture will be the T-8 fixture of the same length and lamp count. The comparable baseline for any removed high-output T-12 fixture will be the T-8 fixture of the same length and lamp count with a ballast factor equal to 0.98. The assumed T-8 baseline fixtures and wattages associated with the most common T-12 fixture configurations are presented in Table 3-1. For small business direct install programs where wattage of the existing T-12 fixture is known, and the existing fixture was in working condition, wattage of the existing fixture removed by the program may be used as the baseline wattage in lieu of the table below. In such cases, the lighting equipment must be replaced directly by an ICSP and not a lighting trade ally.

Table 3-1: Assumed T-8 Baseline Fixtures for Removed T-12 Fixtures

T-12 Lamp Length	T-12 Lamp Type	T-12 Lamp Count	Assumed T-8 Baseline Fixture Code	Assumed T-8 Baseline Wattage
24”	Standard	1	F21ILL	20
24”	Standard	2	F22ILL	33
24”	Standard	3	F23ILL	47
24”	Standard	4	F24ILL	61
36”	Standard	1	F31ILL	26
36”	Standard	2	F32ILL	46
36”	Standard	3	F33ILL	67
36”	Standard	4	F34ILL	87
48”	Standard	1	F41ILL	31
48”	Standard	2	F42ILL	59
48”	Standard	3	F43ILL	89
48”	Standard	4	F44ILL	112
48”	Standard	6	F46ILL	175
48”	Standard	8	F48ILL	224
60”	Standard	1	F51ILL	36
60”	Standard	2	F52ILL	72
72”	Standard	1	F61ILL	55
72”	Standard	2	F62ILL	111
96”	Standard	1	F81ILL	58
96”	Standard	2	F82ILL	109
96”	Standard	3	F83ILL	167
96”	Standard	4	F84ILL	219
96”	Standard	6	F86ILL	328

T-12 Lamp Length	T-12 Lamp Type	T-12 Lamp Count	Assumed T-8 Baseline Fixture Code	Assumed T-8 Baseline Wattage
96”	High-Output	1	F81LHL	85
96”	High-Output	2	F82LHL	160
96”	High-Output	3	F83LHL	253
96”	High-Output	4	F84LHL	320
96”	High-Output	6	F86LHL	506

Similarly, the EISA “backstop” provision introduced new efficacy standards for general service lamps (effective January 1, 2020) effectively requiring a minimum efficacy of 45 lm/W for most general service lamps. This induced a shift in what a participant would have purchased in the absence of the program because standard and halogen incandescent lamps are no longer viable options and, therefore, adjusts the baseline assumption. With this understanding, a generic general service lamp with an efficacy of 45 lm/W will become the assumed baseline for the majority of incandescent lamp retrofits beginning January 1, 2020.[4] The comparable baseline for any removed incandescent lamps will be a generic general service lamp with similar lumen output. The assumed generic general service lamp baseline lamps/fixtures and wattages associated with the most common incandescent lamp/fixture configurations are presented in Table 3-2.

Table 3-2: Assumed Generic GSL Baseline Lamps/Fixtures for Removed Incandescent Lamps/Fixtures

Removed Lamp/Fixture Description	Lamp Count	Baseline Fixture Code	Assumed Baseline Fixture Wattage
Incandescent, (1) 34W lamp	1	GSL8/1	8
Incandescent, (1) 40W ES lamp	1	GSL8/1	8
Incandescent, (1) 40W ES/LL lamp	1	GSL8/1	8
Incandescent, (1) 36W lamp	1	GSL8/1	8
Incandescent, (1) 40W lamp	1	GSL10/1	10
Incandescent, (1) 42W lamp	1	GSL11/1	11
Incandescent, (1) 45W lamp	1	GSL11/1	11
Incandescent, (1) 50W lamp	1	GSL13/1	13
Incandescent, (1) 52W lamp	1	GSL13/1	13
Incandescent, (1) 60W ES lamp	1	GSL13/1	13
Incandescent, (1) 60W ES/LL lamp	1	GSL13/1	13
Incandescent, (1) 54W lamp	1	GSL14/1	14
Incandescent, (1) 55W lamp	1	GSL14/1	14
Incandescent, (1) 60W lamp	1	GSL17/1	17
Incandescent, (1) 65W lamp	1	GSL18/1	18
Incandescent, (1) 67W lamp	1	GSL19/1	19

[4] By definition, general service lamps are limited to lamps with initial lumen output of greater than or equal to 310 lumens and less than or equal to 3,300 lumens, so very low and high output lamps are unaffected by this baseline shift.

Removed Lamp/Fixture Description	Lamp Count	Baseline Fixture Code	Assumed Baseline Fixture Wattage
Incandescent, (1) 75W ES lamp	1	GSL19/1	19
Incandescent, (1) 75W ES/LL lamp	1	GSL19/1	19
Incandescent, (1) 69W lamp	1	GSL19/1	19
Incandescent, (1) 72W lamp	1	GSL20/1	20
Incandescent, (1) 75W lamp	1	GSL23/1	23
Incandescent, (1) 80W lamp	1	GSL25/1	25
Incandescent, (1) 85W lamp	1	GSL26/1	26
Incandescent, (1) 100W ES lamp	1	GSL28/1	28
Incandescent, (1) 100W ES/LL lamp	1	GSL28/1	28
Incandescent, (1) 90W lamp	1	GSL28/1	28
Incandescent, (1) 93W lamp	1	GSL29/1	29
Incandescent, (1) 95W lamp	1	GSL30/1	30
Incandescent, (1) 100W lamp	1	GSL33/1	33
Incandescent, (1) 120W lamp	1	GSL40/1	40
Incandescent, (1) 125W lamp	1	GSL44/1	44
Incandescent, (1) 135W lamp	1	GSL48/1	48
Incandescent, (1) 150W ES lamp	1	GSL48/1	48
Incandescent, (1) 150W ES/LL lamp	1	GSL48/1	48
Incandescent, (1) 150W lamp	1	GSL58/1	58
Incandescent, (1) 170W lamp	1	GSL66/1	66
Incandescent, (2) 34W lamp	2	GSL8/2	16
Incandescent, (2) 40W lamp	2	GSL10/2	20
Incandescent, (2) 50W lamp	2	GSL13/2	26
Incandescent, (2) 52W lamp	2	GSL13/2	26
Incandescent, (2) 54W lamp	2	GSL14/2	28
Incandescent, (2) 55W lamp	2	GSL14/2	28
Incandescent, (2) 60W lamp	2	GSL17/2	34
Incandescent, (2) 65W lamp	2	GSL18/2	36
Incandescent, (2) 67W lamp	2	GSL19/2	38
Incandescent, (2) 75W lamp	2	GSL23/2	46
Incandescent, (2) 90W lamp	2	GSL28/2	56
Incandescent, (2) 95W lamp	2	GSL30/2	60
Incandescent, (2) 100W lamp	2	GSL33/2	66
Incandescent, (2) 120W lamp	2	GSL40/2	80
Incandescent, (2) 135W lamp	2	GSL48/2	96
Incandescent, (2) 150W lamp	2	GSL58/2	116
Incandescent, (3) 60W lamp	3	GSL17/3	51

Removed Lamp/Fixture Description	Lamp Count	Baseline Fixture Code	Assumed Baseline Fixture Wattage
Incandescent, (3) 67W lamp	3	GSL19/3	57
Incandescent, (3) 75W lamp	3	GSL23/3	69
Incandescent, (3) 90W lamp	3	GSL28/3	84
Incandescent, (3) 100W lamp	3	GSL33/3	99
Incandescent, (4) 60W lamp	4	GSL17/4	68
Incandescent, (4) 75W lamp	4	GSL23/4	92
Incandescent, (4) 100W lamp	4	GSL33/4	132
Incandescent, (5) 60W lamp	5	GSL17/5	85
Incandescent, (5) 100W lamp	5	GSL33/5	165
Halogen Incandescent, (1) 35W lamp	1	GSL12/1	12
Halogen Incandescent, (1) 40W lamp	1	GSL14/1	14
Halogen Incandescent, (1) 42W lamp	1	GSL14/1	14
Halogen Incandescent, (1) 45W lamp	1	GSL17/1	17
Halogen Incandescent, (1) 50W lamp	1	GSL19/1	19
Halogen Incandescent, (1) 52W lamp	1	GSL20/1	20
Halogen Incandescent, (1) 55W lamp	1	GSL24/1	24
Halogen Incandescent, (1) 60W lamp	1	GSL26/1	26
Halogen Incandescent, (1) 72W lamp	1	GSL33/1	33
Halogen Incandescent, (1) 75W lamp	1	GSL34/1	34
Halogen Incandescent, (1) 90W lamp	1	GSL41/1	41
Halogen Incandescent, (1) 100W lamp	1	GSL46/1	46
Halogen Incandescent, (1) 150W lamp	1	GSL69/1	69
Halogen Incandescent, (2) 45W lamp	2	GSL17/2	34
Halogen Incandescent, (2) 50W lamp	2	GSL19/2	38
Halogen Incandescent, (2) 55W lamp	2	GSL24/2	48
Halogen Incandescent, (2) 75W lamp	2	GSL34/2	68
Halogen Incandescent, (2) 90W lamp	2	GSL41/2	82
Halogen Incandescent, (2) 150W lamp	2	GSL69/2	138

See Appendix E for general eligibility requirements for solid state lighting products in commercial and industrial applications.

ALGORITHMS

For all lighting fixture improvements (without control improvements), the following algorithms apply:

$$\Delta kWh = (\sout{kW_{base} - kW_{ee}} DeltaWatts) \times [HOU \times (1 - SVG_{base}) \times (1 + IF_{energy})] \; x \; ISR$$

$$\Delta kW_{peak} = (\sout{kW_{base} - kW_{ee}} DeltaWatts) \times [CF \times (1 - SVG_{base}) \times (1 + IF_{demand})] \; x \; ISR$$

$$DeltaWatts = kW_{base} - kW_{ee}$$

Definition of Terms

Table 3-3: Terms, Values, and References for Lighting Improvements

Term	Unit	Values	Source
kW_{base}, Connected load of the baseline lighting as defined by project classification	*kW*	See Fixture Identities in Appendix C For Permanent Lamp Removal: Table 3-10	Appendix C 14
kW_{ee}, Connected load of the post-retrofit or energy–efficient lighting system	*kW*	See Fixture Identities in Appendix C For Permanent Fixture and/or Lamp Removal, $kW_{ee} = 0$	Appendix C
DeltaWatts, the difference between the baseline wattage and incentivized wattage	*kW*	Default Screw-based Bulbs: 0.043 Default Other General Service: 0.080 Default Street Lighting: 0.120 Default Unknown Type: 0.077	16
SVG_{base}, Savings factor for existing lighting control (percent of time the lights are off)	*None*	EDC Data Gathering	EDC Data Gathering
		Default: Table 3-4 If unknown, then 1.7%	Table 3-4 16
CF, Coincidence factor	*Decimal*	EDC Data Gathering	EDC Data Gathering
		Default Screw-based Bulbs: Table 3-5 Default Other General Service: Table 3-6 Default Street Lighting: 0.00 If building and equipment type is unknown: 0.58	Table 3-5 and Table 3-6

Term	Unit	Values	Source
HOU, Hours of Use – the average annual operating hours of the baseline lighting equipment, which if applied to full connected load will yield annual energy use.	$\frac{Hours}{Year}$	EDC Data Gathering	EDC Data Gathering
		Default Screw-based Bulbs: Table 3-5 Default Other General Service: Table 3-6 Default Street Lighting: Table 3-7 If building and equipment type are unknown: 5,000 hours	Table 3-5, Table 3-6, ~~and~~ Table 3-7, 16
IF_{energy}, Interactive Energy Factor – applies to C&I interior lighting in space that has air conditioning, electric space hating, or refrigeration. This represents the secondary energy impacts which results from the decreased waste heat from efficient lighting.	*None*	Default: Table 3-8 and Table 3-9	Table 3-8 and Table 3-9
IF_{demand}, Interactive Demand Factor – applies to C&I interior lighting in space that has air conditioning or refrigeration only. This represents the secondary demand savings in cooling required which results from the decreased waste heat from efficient lighting.	*None*	Default: Table 3-8 and Table 3-9	Table 3-8 and Table 3-9
ISR, In Service Rate, the fraction of incentivized lamps or fixtures that are installed within three years of purchase	*%*	EDC Data Gathering Default = 98%	17

Other factors required to calculate savings are shown in Table 3-4, Table 3-5, Table 3-6, Table 3-7, Table 3-8, and Table 3-9. Note that if HOU is stated and verified by logging lighting hours of use groupings, actual hours should be applied. In addition, the site-specific CF must be used to calculate peak demand savings if actual hours are used. The IF factors shown in Table 3-8 and Table 3-9 are to be used only when the facilities are air conditioned and only for fixtures in conditioned or refrigerated space. The HOU for refrigerated spaces are to be estimated or logged separately.

Table 3-4: Savings Control Factors Assumptions[5]

Strategy	Definition	Technology	Savings	Source
Switch	Manual On/Off Switch	Light Switch	0%	2
Occupancy	Adjusting light levels according to the presence of occupants	Occupancy Sensors	24%	
		Time Clocks	24%	
		Energy Management System	24%	
Daylighting	Adjusting light levels automatically in response to the presence of natural light	Photosensors	28%	
		Time Clocks	28%	
Personal Tuning	Adjusting individual light levels by occupants according to their personal preferences; applies, for example, to private offices, workstation-specific lighting in open-plan offices, and classrooms	Dimmers	31%	
		Wireless on-off switches	31%	
		Bi-level switches	31%	
		Computer based controls	31%	
		Pre-set scene selection	31%	
Institutional Tuning	Adjustment of light levels through commissioning and technology to meet location specific needs or building policies; or provision of switches or controls for areas or groups of occupants; examples of the former include high-end trim dimming (also known as ballast tuning or reduction of ballast factor), task tuning and lumen maintenance	Dimmable ballasts	36%	
		On-off or dimmer switches for non-personal tuning	36%	
Multiple Types	Includes combination of any of the types described above. Occupancy and personal tuning, daylighting and occupancy are most common.	Occupancy and personal tuning/ daylighting and occupancy	38%	

[5] Subject to verification by EDC Evaluation or SWE.

Strategy	Definition	Technology	Savings	Source
Unknown	The baseline control type is unknown.	Variable	1.7%	16

Table 3-5: Lighting HOU and CF by Building Type for Screw-Based Bulbs

Building Type	HOU	CF	Source
Education	2,944	0.39	6
Exterior (All Building Types)	3,604	0.11	3
Grocery	7,798	0.99	6
Health	2,476	0.47	6
Industrial Manufacturing – 1 Shift	2,857	0.96	3, 5
Industrial Manufacturing – 2 Shift	4,730	0.96	3, 5
Industrial Manufacturing – 3 Shift	6,631	0.96	3, 5
Institutional/Public Service	1,456	0.23	6
Lodging	2,925	0.38	6
Miscellaneous/Other	2,001	0.33	6
Multi-Family Common Areas	5,950	0.73	14
Office	1,420	0.26	6
Parking Garages	8,678	0.98	3
Restaurant	3,054	0.55	6
Retail	2,383	0.56	6
Street Lighting[6]	See Table 3-7	0.00	See Table 3-7
Warehouse	2,815	0.50	6
Unknown Building Type	4,083	0.54	16

[6] Street Lighting" is generally municipally owned, operates from dusk to dawn, and is not connected to a specific facility. "Exterior Lighting" is connected to a specific facility and does not always operate from dusk to dawn. If an exterior lighting project cannot demonstrate that the lighting operates from dusk to dawn, the "Exterior Lighting" HOU should be used. However, if the exterior lighting operates from dusk to dawn, the "Street Lighting" HOU are the appropriate HOU.

Table 3-6: Lighting HOU and CF by Building Type for Other General Service Lighting

Building Type	HOU	CF	Source
Education	2,371	0.45	6
Exterior (All Building Types)	3,604	0.11	3
Grocery	6,471	0.93	6
Health	2,943	0.52	6
Industrial/Manufacturing - 1 Shift	2,857	0.96	3, 5
Industrial/Manufacturing - 2 Shift	4,730	0.96	3, 5
Industrial/Manufacturing - 3 Shift	6,631	0.96	3, 5
Institutional/Public Service	1,419	0.23	6
Lodging	3,579	0.45	6
Miscellaneous/Other	2,830	0.58	6
Multi-Family Common Areas	5,950	0.73	14
Office	2,294	0.48	6
Parking Garage	8,678	0.98	3
Restaurant	4,747	0.77	6
Retail	2,915	0.66	6
Street Lighting[7]	See Table 3-7	0.00	See Table 3-7
Warehouse	2,545	0.48	6
Unknown Building Type	5,341	0.66	16

[7] Ibid.

Table 3-7: Street lighting HOU by EDC

EDC	HOU	Source
Duquesne	4,200	7
PECO	4,100	8
PPL	4,300	9
Met-Ed	4,200	10
Penelec	4,200	11
Penn Power	4,070	12
West Penn Power	4,200	13

Table 3-8: Interactive Factors for All Bulb Types

Term	Unit	Values	Source
IF_{demand}	*None*	Comfort Cooled = See Table 3-9	6
		Freezer spaces (-35 °F – 20 °F) = 0.50	4
		Medium-temperature refrigerated spaces (20 °F – 40 °F) = 0.29	
		High-temperature refrigerated spaces (40 °F – 60 °F) = 0.18	
		Un-cooled space = 0	
IF_{energy}	*None*	Comfort Cooled = See Table 3-9	6
		Freezer spaces (-35 °F – 20 °F) = 0.50	4
		Medium-temperature refrigerated spaces (20 °F – 40 °F) = 0.29	
		High-temperature refrigerated spaces (40 °F – 60 °F) = 0.18	
		Un-cooled space = 0	

Table 3-9: Interactive Factors for Comfort Cooled Spaces for All Building Types

Heating Fuel	IF_{energy}	IF_{demand}
Non-Electric Heat	0.031	0.192
Electric Heat	-0.142	0.192
Unknown	0.000	0.~~192~~115

Table 3-10: Connected Load of the Baseline Lighting

Lamp Length	Wattage Removed (kW_{base}) per Lamp
	T8
8-foot	0.0386
4-foot	0.0194
3-foot	0.0146
2-foot	0.0098

DEFAULT SAVINGS

~~There are no default savings associated with this measure.~~ Default savings associated with this measure are found in Table 3-11.

Table 3-11: Default Savings for Lighting Improvements

	Screw-Based	Other General Service	Streetlighting	Unknown Form Factor
kWh Savings per Fixture	157	377	456	340
kW Savings per Fixture	0.024	0.052	0.000	0.044

EVALUATION PROTOCOLS

Methods for Determining Baseline Conditions

The following are acceptable methods for determining baseline conditions when verification by direct inspection is not possible as may occur in a rebate program where customers submit an application and equipment receipts only after installing efficient lighting equipment, or for a retroactive project as allowed by Act 129. In order of preference:

- Examination of replaced lighting equipment that is still on site waiting to be recycled or otherwise disposed of
- Examination of replacement lamp and ballast inventories where the customer has replacement equipment for the retrofitted fixtures in stock. The inventory must be under the control of the customer or customer's agent
- Interviews with and written statements from customers, facility managers, building engineers or others with firsthand knowledge about purchasing and operating practices at the affected site(s) identifying the lamp and ballast configuration(s) of the baseline condition
- Interviews with and written statements from the project's lighting contractor or the customer's project coordinator identifying the lamp and ballast configuration(s) of the baseline equipment
- Use of DeltaWatts as shown in Table 3-3

Detailed Inventory Form

A detailed lighting inventory is ~~required~~ encouraged for all lighting improvement projects. The lighting inventory form will use the algorithms presented above to derive the total ΔkW and ΔkWh savings for each installed measure. Within a single project, to the extent there are multiple combinations of control strategies (SVG), hours of use (HOU), coincidence factors (CF) or interactive factors (IF), the ΔkW will be broken out to account for these different factors. This will be accomplished using Appendix C, a Microsoft Excel inventory form that specifies the lamp and ballast configuration using the "Fixture Identities" sheet and SVG, HOU, CF and IF values for each line entry. The inventory form will also specify the location and number of fixtures for reference and validation.

Appendix C was developed to automate the calculation of energy and demand impacts for retrofit lighting projects, based on a series of entries by the user defining key characteristics of the retrofit project. The "General Information" sheet is provided for the user to identify facility-specific details of the project that have an effect on the calculation of gross savings. Facility-specific details include contact information, electric utility, building area information, and operating schedule. The "Lighting Inventory" sheet is the main worksheet that calculates energy savings and peak demand reduction for the user-specified lighting fixture and controls improvements. This form follows the algorithms presented above and facilitates the calculation of gross savings for implementation and evaluation purposes. Each line item on this tab represents a specific area with common baseline fixtures, retrofit fixtures, controls strategy, space cooling, and space usage.

Baseline and retrofit fixture wattages are determined by selecting the appropriate fixture code from the "Fixture Identities" sheet. The sheet can also be used to find the appropriate code for a particular lamp-ballast combination by using the enabled auto-filter options. Actual wattages of fixtures determined by manufacturer's equipment specification sheets or other independent sources may not be used unless (1) the manufacturer's cut sheet indicates that the difference in delta-watts of fixture wattages (i.e. difference in delta watts of baseline and "actual" installed efficient fixture wattage and delta watts of baseline and nearest matching efficient fixture in the "Fixture Identities" of Appendix C is more than 10% or (2) the corresponding fixture code is not listed in the "Fixture Identities" list. In these cases, alternate wattages for lamp-ballast combinations can be inputted using the appropriate cells within the "Fixture Identities" tab. Rows 9 through 28 provide a guided custom LED fixture generator to be used with non-self-ballasted LEDs. All other custom cut sheets should be inputted into rows 932 through 981. Documentation supporting the alternate wattages must be provided in the form of manufacturer-provided specification sheets or other industry accepted sources (e.g. ENERGY STAR listing, Design Lights Consortium listing, etc.). Submitted specification sheets must cite test data performed under standard ANSI procedures. These exceptions will be used as the basis for periodically updating the "Fixture Identities" to better reflect market conditions and more accurately represent savings.

Some EDC Implementation CSPs may have developed in-house lighting inventory forms that are used to determine reported savings estimates for projects and calculate rebate amounts. The Appendix C form is the preferred tool for reported and verified savings calculations. However, a ICSP lighting inventory form may be used for program delivery purposes provided it (1) includes all the same functionality, formulas, and calculation steps as the Appendix C form and (2) is approved by the SWE prior to being utilized to calculate reported savings. In the case where an ICSP tool produces a different savings estimate from the Appendix C calculator, the Appendix C result is considered to be the TRM-supported savings value. Appendix C will be updated periodically to include new fixtures and technologies available as may be appropriate. Additional guidance can be found in the "Manual" sheet of Appendix C. ICSPs and evaluators may use the default savings values as shown in Table 3-11 in lieu of Appendix C.

Custom Hours of Use and Coincidence Factors

If the project cannot be described by the building type categories listed in Table 3-5 and Table 3-6, or if the facility's actual lighting hours deviate by more than 10% from the tables, or if the project retrofitted only a portion of a facility's lighting system for which whole building hours of use would not be appropriate, the deemed HOU and CF assumptions can be overridden by inputting custom operating schedules into the Lighting Operation Schedule portion of the "General Information" tab of Appendix C. The custom schedule inputs must be corroborated by an acceptable source such as posted hours, customer interviews, building monitoring system (BMS), or metered data. If the building type or lighting schedule is unknown, the ICSPs and evaluators may use the "Unknown Building Type" in Tables 3-5 and 3-6.

For all projects, annual hours are subject to adjustment by EDC evaluators or SWE.

Metering – Projects with savings below 750,000 kWh

Metering is encouraged for projects with expected savings below 750,000 kWh but have high uncertainty, i.e. where hours are unknown, variable, or difficult to verify. Exact conditions of "high uncertainty" are to be determined by the EDC evaluation contractors to appropriately manage variance. Metering completed by the implementation contractor maybe leveraged by the evaluation contractor, subject to a reasonableness review. Sampling methodologies within a site are to be either discerned by the EDC evaluation contractor based on the characteristics of the facility in question or performed consistent with guidance the EDC EM&V contractor provides.

Metering – Projects with savings of 750,000 kWh or higher

For projects with expected savings of 750,000 kWh or higher, metering is required[8]. Installation of light loggers is the accepted method of metering, but trend data from BMS is an acceptable substitute. Metering completed by the implementation contractor may be leveraged by the evaluation contractor, subject to a reasonableness review. Sampling methodologies within a site are to be either discerned by the EDC evaluation contractor or communicated to implementation contractors based on the characteristics of the facility in question or performed consistent with guidance the EDC EM&V contractor provides.

When BMS data is used as a method of obtaining customer-specific data in lieu of metering, the following guidelines should be followed:

- Care should be taken with respect to BMS data, since the programmed schedule may not

[8] The Commission allows the EDCs to use alternative methods for obtaining customer-specific data where customer processes do not support metering. The EDCs are required to provide supporting documentation to the SWE for review if there are any such exceptions.

reflect regular hours of long unscheduled overrides of the lighting system, such as nightly cleaning in office buildings, and may not reflect how the lights were actually used, but only the times of day the common area lighting is commanded on and off by the BMS.

- The BMS trends should represent the actual status of the lights (not just the command sent to the lights), and the ICSP and EC are required to demonstrate that the BMS system is functioning as expected, prior to relying on the data for evaluation purposes.
- The BMS data utilized should be specific to the lighting systems, and should be required to be representative of the building areas included in the lighting project.

SOURCES

1) Measure life values were developed using rated life values of lamps and ballasts from Osram Sylvania's 2014 – 2015 Lamp & Ballast Catalog. The rated lives were divided by the average HOU for all building types. https://assets.sylvania.com/assets/onlinemedia/ihdp/Lamp-and-Ballast-Catalog

2) Williams, A., Atkinson, B., Garbesi, K., Rubinstein, F., "A Meta-Analysis of Energy Savings from Lighting Controls in Commercial Buildings", Lawrence Berkeley National Laboratory, September 2011.https://www.acuitybrands.com/-/media/Files/Acuity/Resources/Regulations%20Codes%20and%20Standards/LBNL%20study.pdf?la=en

3) Mid-Atlantic Technical Reference Manual v8.0, https://neep.org/sites/default/files/resources/Mid_Atlantic_TRM_V7_FINAL.pdf.

   a. Development of Interior Lighting Hours of Use and Coincidence Factor Values for EmPOWER Maryland DRAFT Final Impact Evaluation Deemed Savings (June 1, 2017 – May 31, 2018) Commercial & Industrial Prescriptive, Small Business, and Direct Install Programs, Navigant, March, 2018.

4) Efficiency Vermont Technical Reference User Manual (TRM), March 16, 2015. https://puc.vermont.gov/sites/psbnew/files/doc_library/ev-technical-reference-manual.pdf

5) UI and CL&P Program Savings Documentation for 2013 Program Year, United Illuminating Company, September 2012.

6) Pennsylvania Statewide Act 129 2014 Commercial & Residential Lighting Metering Study. Prepared for Pennsylvania Public Utilities Commission. January 13, 2015. http://www.puc.pa.gov/pcdocs/1340978.pdf

7) Duquesne Light Schedule of Rates, Page 68, Released September 20, 2018. https://www.duquesnelight.com/docs/default-source/default-document-library/CurrentTariff.pdf?sfvrsn=e69ca442_44

8) PECO Energy Company Electric Service Tariff, Page 62, Released May 28, 2018. https://www.peco.com/SiteCollectionDocuments/PECOProposedTariffNo6Clean.PDF

9) PPL Electric Utilities General Tariff, Page 19Z.1A, Released September 20, 2018. https://www.pplelectric.com/~/media/pplelectric/at%20your%20service/docs/current-electric-tariff/master.pdf

10) Metropolitan Edison Company Electric Service Tariff, Page 86, Released August 22, 2018. https://www.firstenergycorp.com/content/dam/customer/Customer%20Choice/Files/PA/tariffs/Met-Ed-Tariff-52-Supp-56.pdf

11) Pennsylvania Electric Company Electric Service Tariff, Page 102, Released September 20, 2018.

https://www.firstenergycorp.com/content/dam/customer/Customer%20Choice/Files/PA/tariffs/Penelec-Tariff-81-Supp-62.pdf

12) Pennsylvania Power Company Schedule of Rates, Rules and Regulations for Electric Service, Page 88, Released September 20, 2018. https://www.firstenergycorp.com/content/dam/customer/Customer%20Choice/Files/PA/tariffs/PP-Tariff-36-Supp-49.pdf

13) West Penn Power Company Tariff, Page 96, Released September 20, 2018. https://www.firstenergycorp.com/content/dam/customer/Customer%20Choice/Files/PA/tariffs/WPP-Tariff-40-Supp-45.pdf

14) Illinois Statewide Technical Reference Manual for Energy Efficiency v7.0. Multi-family common area value based on DEER 2008. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_2_C_and_I_092818_Final.pdf. Accessed December 2018.

15) Illinois Statewide Technical Reference Manual for Energy Efficiency v7.0. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_2_C_and_I_092818_Final.pdf. Accessed December 2018.

16) Navigant analysis of Phase III evaluation-verified lighting data across all seven Pennsylvania EDC's

17) Illinois Statewide Technical Reference Manual for Energy Efficiency v7.0, 4.5.4 LED Bulbs and Fixtures. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_2_C_and_I_092818_Final.pdf.

3.1.4 LED Exit Signs

Target Sector	Commercial and Industrial Establishments
Measure Unit	LED Exit Sign
Measure Life	15 years [Source 1]
Measure Vintage	Early Replacement

ELIGIBILITY

This measure includes the early replacement of existing incandescent or fluorescent exit signs with a new LED exit sign. If the exit signs match those listed in Table 3-17, the default savings value for LED exit signs installed cooled spaces can be used without completing Appendix C.

See Appendix E for general eligibility requirements for solid state lighting products in commercial and industrial applications.

ALGORITHMS

The algorithms shown below can be used to calculate annual energy savings and peak demand savings associated with this measure.

$$\Delta kWh = (\sout{kW_{base} - kW_{ee}} DeltaWatts) \times [HOU \times (1 + IF_{energy})]$$

$$\Delta kW_{peak} = (\sout{kW_{base} - kW_{ee}} DeltaWatts) \times [CF \times (1 + IF_{demand})]$$

$$DeltaWatts = kW_{base} - kW_{ee}$$

Definition of Terms

Table 3-11: Terms, Values, and References for LED Exit Signs

Term	Unit	Values	Source
kW_{base}, Connected load of baseline lighting as defined by project classification	*kW*	Actual Wattage	EDC Data Gathering
		Single-Sided Incandescent: 0.020 Dual-Sided Incandescent: 0.040 Single-Sided Fluorescent: 0.009 Dual-Sided Fluorescent: 0.020	Appendix C
kW_{ee}, Connected load of the post-retrofit or energy-efficient lighting	*kW*	Actual Wattage	EDC Data Gathering
		Single-Sided: 0.002 Dual-Sided: 0.004	Appendix C
DeltaWatts, the difference between the baseline wattage and incentivized wattage	*kW*	Unknown Type: 0.032	3
CF, Coincidence factor	*Decimal*	1.0	2
HOU, Hours of Use – the average annual operating hours of the baseline lighting equipment.	$\frac{Hours}{Year}$	8,760	2
IF_{energy}, Interactive Energy Factor	*None*	Default: Table 3-8 and Table 3-9	Table 3-8 and Table 3-9
IF_{demand}, Interactive Demand Factor	*None*	Default: Table 3-8 and Table 3-9	Table 3-8 and Table 3-9

DEFAULT SAVINGS

Single-Sided LED Exit Signs replacing Incandescent Exit Signs in Cooled Spaces

$\Delta kWh = 158\ kWh$

$\Delta kW_{peak} = 0.021\ kW$

Dual-Sided LED Exit Signs replacing Incandescent Exit Signs in Cooled Spaces

$\Delta kWh = 315\ kWh$

$\Delta kW_{peak} = 0.043\ kW$

Single-Sided LED Exit Signs replacing Fluorescent Exit Signs in Cooled Spaces

$\Delta kWh = 61\ kWh$

$\Delta kW_{peak} = 0.008\ kW$

Dual-Sided LED Exit Signs replacing Fluorescent Exit Signs in Cooled Spaces

$\Delta kWh = 140\ kWh$

$\Delta kW_{peak} = 0.019\ kW$

LED Exit Sign replacing unknown baseline exit signs

$\Delta kWh = 255\ kWh$

$\Delta kW_{peak} = 0.034\ kW$

EVALUATION PROTOCOLS

For most projects, the appropriate evaluation protocol is to verify installation and proper selection of default values. For projects using customer specific data for open variables, the appropriate evaluation protocol is to verify installation and proper application of TRM protocol along with verification of open variables. The Pennsylvania Evaluation Framework provides specific guidelines and requirements for evaluation procedures.

SOURCES

1) California Public Utilities Commission Database for Energy Efficient Resources (DEER) EUL Support Table for 2020, http://www.deeresources.com/files/DEER2020/download/SupportTable-EUL2020.xlsx. Accessed December 2018.

2) This assumes operation 24 hours per day, 365 days per year. Additionally, the load shape is assumed to be flat, so the coincidence factor is assumed to be 1.

2)3) Navigant analysis of Phase III evaluation-verified lighting data across all seven Pennsylvania EDC's

3.1.7 Lighting Improvements for Midstream and Upstream Delivery Programs

Target Sector	Commercial and Industrial Establishments
Measure Unit	Lighting Equipment
Measure Life	Variable[9]
Measure Vintage	Replace on burnout or Early Replacement

MID-STREAM AND UPSTREAM LIGHTING OVERVIEW

Significant changes in the lighting industry in recent years, particularly related to LED lamp products, have created an opportunity for utility programs to engage directly with commercial lighting suppliers to increase the adoption of energy efficient lighting technologies.

Lighting Improvements for Midstream and Upstream Delivery Programs will offer incentives on eligible products sold to trade allies and customers through commercial sales channels such as distributors of lighting products, or direct to consumer. This complements other delivery channels (such as downstream rebates to trade allies and customers) by providing incentives to encourage distributors to stock, promote, and sell more efficient lighting. Midstream and Upstream Delivery Programs should be used for one-for-one fixture replacement; if fixtures are being removed and not replaced, the contractor should go through the downstream program and complete Appendix C.

This protocol applies to efficient lighting delivered through a midstream or upstream channel. Code minimum baseline (where applicable) and least efficient readily available (replace on burnout) product were used to determine baseline wattage.

ELIGIBILITY

Measures covered by the Lighting Improvements for Midstream and Upstream Delivery Programs protocol include fixture, lamp, or lamp and ballast replacement in existing commercial and industrial customers' facilities. The protocol is used for programs where EDCs pay incentives to qualified midstream participants including but not limited to distributors, for eligible LED lamps and fixtures. The protocol may also be used for upstream program delivery, such as direct to consumer programs and incentives. Retrofit measures where incentives are paid to customers or trade allies are covered by the Lighting Improvements protocol. New construction measures are covered by the New Construction Lighting protocol and excluded here. Lamps and fixtures included in this protocol are categorized as follows:

- Omnidirectional, directional, and decorative screw-based LED lamps
- LED lamps and fixtures
- LED exit signs
- LED highbay and lowbay fixtures

[9] See Lighting Improvements measure.

- LED highbay and lowbay fixtures with integrated controls
- Exterior area and wall pack LED fixtures
- Parking garage LED lighting

See Appendix E for general eligibility requirements for solid state lighting products in commercial and industrial applications.

ALGORITHMS

For all lighting fixture improvements (without control improvements), the following algorithms apply:

$$\Delta kWh = (\sout{kW_{base} - kW_{ee}} DeltaWatts) \times HOU \times (1 - SVG_{base}) \times (1 + IF_{energy}) \times ISR$$

$$\Delta kW_{peak} = (\sout{kW_{base} - kW_{ee}} DeltaWatts) \times CF \times (1 - SVG_{base}) \times (1 + IF_{demand}) \times ISR$$

$$DeltaWatts = kW_{base} - kW_{ee}$$

DEFINITION OF TERMS

Table 3-12: Terms, Values, and References for Lighting Improvements for Midstream and Upstream Delivery Programs

Term	Unit	Values	Source
kW_{base}, Wattage of baseline lighting	*kW*	Default: Table 3-21, Table 3-22, Table 3-23, and Table 3-24	Table 3-21, Table 3-22, Table 3-23, and Table 3-24
kW_{ee}, Wattage of incentivized lighting	*kW*	EDC Data Gathering	EDC Data Gathering
DeltaWatts, the difference between the baseline wattage and incentivized wattage	*kW*	Default Screw-based Bulbs: 0.043 Default Other General Service: 0.080 Default Street Lighting: 0.120 Default Exit Signs: 0.032 Default Unknown Type: 0.077	17
HOU, Hours of Use – the average annual operating hours of the lighting equipment, which if applied to full connected load will yield annual energy use.	$\frac{Hours}{Year}$	Default Screw-based Bulbs: Table 3-5 Default Other General Service: Table 3-6 Default Street Lighting: Table 3-7 Default Exit Signs: 8,760 hours	Table 3-5, Table 3-6, and Table 3-7

Term	Unit	Values	Source
		EDC Data Gathering If building and equipment type unknown: ~~2,500~~5,000 hours	EDC Data Gathering
CF, Coincidence Factor	*Decimal*	Default Screw-based Bulbs: Table 3-5 Default Other General Service: Table 3-6 Default Street Lighting: 0.00 Default Exit Signs: 1.00 If building and equipment type is unknown: ~~0.60~~0.58	Table 3-5 and Table 3-6
SVG_{base}, Savings factor for existing lighting control (percent of time the lights are off)	*None*	Default: Table 3-25 If unknown then 1.7%	1, 2
IF_{energy}, Interactive Energy Factor	*None*	Default: Table 3-8 and Table 3-9	Table 3-8 and Table 3-9
IF_{demand}, Interactive Demand Factor	*None*	Default: Table 3-8 and Table 3-9	Table 3-8 and Table 3-9
ISR, In Service Rate, the fraction of incentivized lamps or fixtures that are installed within three years of purchase	*%*	EDC Data Gathering Default = 98%	4

Table 3-21, Table 3-22, Table 3-23, and Table 3-24 are arranged by lamp type. When the lamp type is covered by codes or standards, those code/standard wattages apply. For lamps not covered by codes/standards, baseline wattage is the least-efficient, commercially-available, commonly-installed technology. The baseline wattage for LED lamps and fixtures measures is the wattage for the least efficient, standards compliant equipment commonly available in the market.

Efficient product wattages are manufacturer published values as collected by EDCs and ICSPs.

HOU and CF values in Table 3-5 and Table 3-6 use building types or EDC data gathering. Building type information ~~must~~ is encouraged to be collected by EDCs and ICSPs for all projects with a change in connected load above 20 KW.

Table 3-13: Baseline Wattage, Omnidirectional Lamps

Efficient Lamp or Fixture	Minimum Lumen	Maximum Lumen	Incandescent Equivalent (For Reference Only)	$Watts_{base}$ 2021-2026	Source
Omnidirectional, General Service Lamp, Screw-based	250	309	25	25	5, 6, 7
	310	449	25	8	
	450	749	40	13	
	750	1,049	60	20	
	1,050	1,489	75	28	
	1,490	1,999	100	39	
	2,000	2,600	125	51	
	2,601	3,000	150	62	
	3,001	3,300	200	70	
	3,301	3,999	200	200	
	4,000	6,000	300	300	

Table 3-14: Baseline Wattage, Decorative Lamps

Efficient Lamp or Fixture	Minimum Lumen	Maximum Lumen	Incandescent Equivalent (For Reference Only)	$Watts_{base}$ 2021-2026	Source
Decorative, Non-Globe, Screw-based	70	89	10	10	5, 6, 7
	90	149	15	15	
	150	299	25	25	
	300	309	40	29	
	310	499	40	9	
	500	699	60	13	
Decorative, Globe, Screw-based	250	309	25	25	5, 6, 7
	310	349	25	7	
	350	499	40	9	
	500	574	60	12	
	575	649	75	14	
	650	749	100	16	
	750	1,049	100	20	
	1,049	1,300	150	26	

Table 3-15: Baseline Wattage, Directional Lamps

Efficient Lamp or Fixture	Minimum Lumen	Maximum Lumen	Incandescent Equivalent (For Reference Only)	$Watts_{base}$ 2021-2026	Source
Reflector Lamp; R, ER, BR, with screw-based, >=2.25" diameter	400	472	40	10	5, 6, 7
	473	524	45	11	
	525	714	50	14	
	715	937	65	18	
	938	1,259	75	24	
	1,260	1,399	90	30	
	1,400	1,739	100	35	
	1,740	2,174	120	43	
	2,175	2,624	150	53	
	2,625	2,999	175	62	
	3,000	3,300	200	70	
	3,301	4,500	200	200	
Reflector Lamp; R, ER, BR, with screw-based, diameter <2.25"	400	449	40	9	5, 6, 7
	450	499	45	11	
	500	649	50	13	
	650	1,199	65	21	
ER30, BR30, BR40, or ER40	400	449	40	9	5, 6, 7
	450	499	45	11	
	500	649	50	13	
	650	1,199	65	21	
R20	400	449	40	9	5, 6, 7
	450	719	45	13	
Reflector Lamp; PAR, MR, MRX	400	472	Custom[10]	10	5, 6, 7
	473	524		11	
	525	714		14	
	715	937		18	
	938	1,259		24	
	1,260	1,399		30	
	1,400	1,739		35	
	1,740	2,174		43	

[10] Use one of the following approaches to determine the incandescent equivalent for PAR, MR and MRX bulbs: (1) If the ENERGY STAR Qualified Products List (QPL) (https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Light-Bulbs/v33x-ybr3) provides a value for "Wattage Equivalency (watts)," use that value. (2) If the product does not have the aforementioned value, enter the bulb's beam angle, center beam candle power, and diameter into the ENERGY STAR Center Beam Candle Power tool (http://energystar.supportportal.com/link/portal/23002/23018/Article/32655/).

Efficient Lamp or Fixture	Minimum Lumen	Maximum Lumen	Incandescent Equivalent (For Reference Only)	$Watts_{base}$ 2021-2026	Source
	2,175	2,624		53	
	2,625	2,999		62	
	3,000	3,300		70	
	3,301	4,500		200	
All reflector lamps < 400 lumen	200	309	20	20	5, 6, 7
	310	399	30	8	

Table 3-16: Baseline Wattage, Linear Lamps & Fixtures, HID Interior and Exterior Fixtures

Efficient Lamp or Fixture	Minimum Lumen	Maximum Lumen	$Watts_{base}$	Note	Source
Linear Lamp, 2 ft			16.5	Baseline is standard T8 lamp adjusted for fixture and ballast	Appendix C; 17 4 ft 2 lamp T8 fixture 59 watt/2 = 29.5 watt / lamp
Linear Lamp, < 3,200 lumen, 4 ft			29.5	Baseline is standard T8 lamp adjusted for fixture and ballast	
Linear Lamp, ≥ 3,200 lumen, 4 ft			54	Baseline is T5 HO	
Linear Lamp, 5 ft			40	Baseline is standard T8	
Linear Lamp, 6 ft			65	Baseline is standard T8	
Linear Lamp, 8 ft		4,000	59	Baseline is standard T8	
Linear Lamp, 8 ft HO	4,001		86	Baseline is HO T8	
Linear LED Fixture, 2 ft	1,500	3,500	33	Baseline is standard 2L T8	Linear LED Fixture Max Lumen = Number lamps x Lumen Output x Fixture Efficiency x Ballast Factor; where 4' T8 mean lumen = 3,199, fixture efficiency =
Linear LED Fixture, 2 ft	3,501	5,500	61	Baseline is standard 4L T8	
Linear LED Fixture, 4 ft		< 2,132	31	Baseline is standard 1L T8	
Linear LED Fixture, 4 ft	2,132	4,261	59	Baseline is standard 2L T8	

Efficient Lamp or Fixture	Minimum Lumen	Maximum Lumen	$Watts_{base}$	Note	Source
Linear LED Fixture, 4 ft	4,262	6,392	89	Baseline is standard 3L T8	74%, ballast factor = 0.90
Linear LED Fixture, 4 ft	6,393	9,400	112	Baseline is standard 4L T8	5, 9, 10
Linear LED Fixture, 8 ft		< 3,290	58	Baseline is standard 1L T8	
Linear LED Fixture, 8 ft	3,291	6,580	109	Baseline is standard 2L T8	
Linear LED Fixture, 8 ft	6,581	9,870	167	Baseline is standard 3L T8	
Linear LED Fixture, 8 ft	9,871		219	Baseline is standard 4L T8	
Highbay & Lowbay LED Fixture	3,850	6,550	135	Average 150 watt HID lamp/ T8 HLO	LED Lumen Equivalent = HID Initial Lamp Lumen x HID LLD at 40% rated life x HID Fixture Efficiency HID LLD = 75.8%, HID Fixture Efficiency = 80.4%; survey of manufacturer data, MH, PSMH 9, 11, 12, 13, 14, 15
	6,551	9,300	168	Average 175 watt HID lamp/ T8 HLO	
	9,301	11,150	198	Average 200 watt HID lamp/ T8 HLO	
	11,151	12,200	236	Average 250 watt HID lamp/ T8 HLO	
	12,201	15,550	289	Average 320 watt HID lamp/ T8 HLO	
	15,551	20,100	367	Average 400 watt HID lamp/ T8 HLO	
	20,101	34,700	634	Average 750 watt HID lamp/ T8 HLO	
	34,701	57,250	901	Average 1,000 watt HID lamp/ T8 HLO	

Efficient Lamp or Fixture	Minimum Lumen	Maximum Lumen	$Watts_{base}$	Note	Source
Exterior Fixture (Pole, Wall Pack or Parking Garage)	250	4,650	133	100 watt HID lamp	LED Lumen Equivalent = HID Initial Lamp Lumen x HID LLD at 40% rated life x HID Fixture Efficiency x DLC adjustment DLC Adjust = 80/70 lumen/watt where 80 is DLC minimum for indoor highbay, 70 for outdoor, HID LLD = 75.8%, HID Fixture Efficiency = 81.5%; survey of manufacturer data, MH, PSMH, HPS 9, 11, 12, 13, 14, 15, 16
	4,651	7,900	215	175 watt HID lamp	
	7,901	11,050	295	250 watt HID lamp	
	11,051	24,700	462	400 watt HID lamp	
	24,701	40,750	843	750 watt HID lamp	
	40,751	54,650	1,090	1,000 watt HID lamp	

Table 3-17: Savings Control (SVG_{base}) Factors Assumptions[11,12,13]

Efficient Lamp or Fixture Type	Strategy	Definition	Technology	Savings	Sources
Fixture without integrated sensor/ control	Switch	Manual On/Off Switch	Light Switch	1.44%[14]	1, 2
Fixture with integrated sensor/control	Occupancy	Adjusting light levels according to the presence of occupants	Occupancy Sensors	24%	
Fixture with integrated sensor/control	Multiple Types	Includes combination of 2 or more of the types: *occupancy, daylighting, personal tuning, institutional tuning.*	Occupancy and personal tuning /daylighting, dimming and occupancy	38%	

DEFAULT SAVINGS

[11] Subject to verification by EDC Evaluation or SWE.
[12] Subject to verification by EDC Evaluation or SWE.
[13] Integrated control requires fixture to have built-in sensor or be prewired for sensor and sold with sensor.
[14] The Pennsylvania Statewide Act 129 2014 SWE Commercial & and Residential Light Metering Study (Figure 4-16). On average 6 percent of commerical lighting load controlled by sensors including wall-mounted sensors. 6% x 24% = 1.44%.

~~There are no default savings associated with this measure.~~Default savings associated with this measure are found in Table 3-26.

Table 3-26: Default Savings for Lighting Improvement for Midstream and Upstream Delivery Programs

	Screw-Based	Other General Service	Exit Signs	Streetlighting	Unknown Form Factor
kWh Savings per Fixture	157	377	255	456	340
kW Savings per Fixture	0.024	0.052	0.034	0.000	0.044

EVALUATION PROTOCOLS

For all projects selected for evaluation:

- EDCs have the option to collect building type data or use a default HOU for all building types, as shown in Table 3-20, above. This decision should be documented in the EM&V plan and handled consistently for all projects in program year.
- ~~Using the SVG_{base} values appearing in~~
- Using the SVG_{base} values appearing in Table 3-25 is acceptable for both implementation and evaluation (i.e., treat as deemed). However, EDCs are encouraged to collect customer-specific controls information where feasible.
- The default baseline wattage can be used to estimate savings provided that the distributor certifies the lamp type, lamp wattage, ballast type and fixture configuration (2 lamp, 4 lamp, etc.). DeltaWatts should be used where fixture wattages are unknown.

The Pennsylvania Evaluation Framework provides specific guidelines and requirements for evaluation procedures.

SOURCES

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2) Pennsylvania Statewide Act 129 2014 Commercial & Residential Lighting Metering Study. Prepared for Pennsylvania Public Utilities Commission. January 13, 2015. http://www.puc.pa.gov/pcdocs/1340978.pdf

3) Efficiency Vermont Technical Reference User Manual (TRM), March 16, 2015. https://puc.vermont.gov/sites/psbnew/files/doc_library/ev-technical-reference-manual.pdf

4) Illinois Statewide Technical Reference Manual for Energy Efficiency v7.0, 4.5.4 LED Bulbs and Fixtures. http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_7/Final_9-28-18/IL-TRM_Effective_010119_v7.0_Vol_2_C_and_I_092818_Final.pdf.

5) Energy Independence and Security Act ("EISA") of 2007. https://www.congress.gov/bill/110th-congress/house-bill/6. EISA requires all general service lamps sold on or after 1/1/2020 to meet efficacy requirements of 45 lm/W.

6) Energy Conservation Program: Energy Conservation Standards for General Service Lamps. 82 Fed. Reg. 12 (January 19, 2017). Federal Register: The Daily Journal of the United States. Amends the definition of general service lamps to cover the vast majority of screw-base lamps (including incandescent reflectors).

7) ENERGY STAR® Program Requirements for Lamps (Light Bulbs) V2.1. https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Lamps%20V2.1%20Final%20Specification.pdf

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11) Lamp and Ballast Catalogue, 2014-2015, Osram, www.osram-americas.com.

12) US Department of Energy, Lumen Maintenance and Light Loss Factors, September 2013, www.pnnl.gov/main/publications/external/technical_reports/PNNL-22727.pdf

13) GE Lamps and Ballasts Catalogue, 2015-2016, http://www.gelighting.com/LightingWeb/na/smart-catalog.jsp.

14) Lithonia, 2016, http://www.lithonia.com/psg/.

15) Eaton Cooper, http://www.cooperindustries.com/content/public/en/lighting.html.

16) DOE LED Lighting Facts, http://www.lightingfacts.com/.

~~16)~~17) Navigant analysis of Phase III evaluation-verified lighting data across all seven Pennsylvania EDC's