Memo to: Massachusetts Program Administrators
Research Team and Energy Efficiency Advisory Council
EM&V Consultants

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SUBJECT: LIGHTING OUTYEAR FACTOR AND EQUIVALENT MEASURE LIFE

This memo is an update of an August 2018 memo presenting the program-level equivalent measure lives (EMLs) for commercial and industrial (C&I) energy efficient (EE) lighting measures. This memo also details the development of the following factors required to calculate the lifetime savings of lighting measures:

- The outyear factor used to calculate the second-period savings of an early replacement (ER) dual baseline lighting measure.
- The estimated fraction of upstream and retrofit lighting measures that should be treated as replace on failure (ROF). This fraction is called the ROF Fraction.
- The final EML for lighting, by application type, which accounts for a mix of both ER and ROF. Gross lifetime savings is the product of first-year annualized savings and the EML.

The information and results discussed in this memo have been updated using the latest MA C&I LED Lighting Market Model (Market Model) (version V2.3b, updated April 9, 2019). This version of the Market Model was updated with end-user data from the 2018 computer-assisted telephone interviewing (CATI) surveys and on-site lighting inventory saturation data. The Market Model provides forecasted market average wattages used in the calculation of EMLs.

1 LIGHTING LIFETIME SAVINGS BACKGROUND

This section provides a review of the measure savings terms and equations adapted for lighting. Upstream and downstream prescriptive and custom measure savings, exclusive of new construction, is the sum of ER and ROF measure savings.

1.1 ER and ROF Savings Terms and Equations

The effective useful life (EUL) is equivalent to 'measure life' in the TRM and is "the number of years that a measure is installed and will operate until failure." The EUL is required for calculating ROF and ER lifetime energy savings. The remaining useful life (RUL) is the existing equipment's expected years of remaining service and is used to calculate ER lifetime energy savings measures only.

ER measures are subject to dual baseline savings methods, and the lifetime savings are equal to the sum of the first- and second-period lifetime savings, calculated as follows:

$$ER\ lifetime\ gross\ savings\ (energy) = First\ period\ lifetime\ savings + Second\ period\ lifetime\ savings$$

$$First\ period\ lifetime\ savings = First\ year\ annual\ savings \times RUL$$

$$Second\ period\ lifetime\ savings = \text{Outyear factor} \times First\ year\ annual\ savings \times (EUL - RUL)$$

$$First\ year\ annual\ savings = \left(Lamp\ watts_{average\ existing} - Lamp\ watts_{EE}\right) \times \text{hours of operation}$$

$$Outyear\ factor = \frac{\left(Lamp\ watts_{EE} - Lamp\ watts_{Future\ market\ average, no\ program\ scenario}\right)}{\left(Lamp\ watts_{average\ existing} - Lamp\ watts_{EE}\right)}$$

$$EML = \frac{(ER\ lifetime\ gross\ savings)}{(First\ year\ annual\ savings)}$$

ROF measures that replace equipment that has failed and require replacement. For lighting, the ROF applies to lighting *systems* that have failed, not to the routine replacement of burned out lamps and ballasts. ROF lifetime measure savings are calculated as follows:

$$ROF\ lifetime\ gross\ savings\ (energy) = First\ year\ annual\ savings \times EUL$$

$$First\ year\ annual\ savings = \left(Lamp\ watts_{Current\ market\ average\ without\ Program\ lamps} - Lamp\ watts_{EE}\right) \times \text{hours of use}$$

$$Equivalent\ measure\ life\ (EML) = \text{EUL}, \qquad \text{for ROF, EML and EUL are equivalent}$$

Program lifetime gross savings is the sum of the ER and ROF program lifetime gross savings:

$$Program\ lifetime\ gross\ savings\ (energy) = ROF\ Fraction\ \text{ROF}\ lifetime\ savings + (1 - ROF\ Fraction) \times \text{ER}\ lifetime\ savings$$

$$Program\ equivalent\ measure\ life\ (EML) = \frac{(ER + ROF\ lifetime\ gross\ savings)}{(ER + ROF\ first\ year\ annual\ savings)}$$

1.2 Effective Useful Life and the Remaining Useful Life of the Measure

The starting point for dual baseline lifetime savings is the EUL of the technology without discounting for future market events (such as Energy Independence and Security Act (EISA) or early replacement discounting). The EUL was not a topic of research for this analysis, and therefore we relied on the 2016-2018 Massachusetts technical reference manual (TRM)[1] lost opportunity EULs and assumptions used in developing the upstream measure lives (Upstream Measure Life Development or UMLD)[2] for this information. The EULs of existing (baseline) equipment and proposed high efficiency equipment, and their sources, by application are summarized in Table 1.

[1] http://ma-eeac.org/wordpress/wp-content/uploads/2016-2018-Plan-1.pdf

[2] Spreadsheet: NMR_CI Upstream Lighting Proposed MLs 2016-2018 v2.xlsx

Table 1. Measure EULs

Application	Existing Technology EUL	Energy Efficient Technology EUL
Data sources:	2016-2018 TRM lost opportunities measure lives	2016-2018 TRM lost opportunities measure lives and the Upstream Measure Life Development spreadsheet
Linear – all technologies	Fluorescent technology, 15 years	LED technology, 15 years
Area lighting	HID technology, 15 years	LED technology, 15 years
Decoratives	Screw-in mixed technology, 5 years	Decorative LED technology, 5 years
General – (A-lines)	Screw-in mixed technology, 5 years	A-lines LED technology, 6 years
Other – (PARs, MR16, G4)	Screw-in mixed technology, 5 years	PARs, MR6 LED technology, 11 years

We note that the EUL is clearly not based on a lamp life, since lamps are replaced multiple times over a 5-15-year lighting fixture/system life. The inference is that, in a commercial setting, once fixtures/lamps/ballasts are installed, the lamps/ballasts will be replaced like-with-like when individual components fail for multiple cycles until the systems have 'failed', which is distinct from the replacement of burned-out lamps or ballasts.

The remaining useful life (RUL) is estimated as one-third of the EUL by convention. This convention is accepted, since it is also not a topic of research for this study.

1.3 Baseline Definitions

The Massachusetts Baseline Framework states the measure baseline "is the condition that would have existed absent the installed measure."[3] This study reflects this definition as follows:

- The ER first period baseline is existing conditions. We use the 2016 No Program scenario market-average baseline as a proxy for the existing conditions baseline. We use the Market Model's program-sponsored technology watts for the wattage of the high-efficiency measure. We assume both are constant through the analysis timespan impacting 2019-2021.
- For the ER second period baseline, we used the "No Program" model scenario, which captures naturally occurring high-efficiency technology, assuming no program activity after 2015 for all baseline analyses for the ER second period baseline.

  The future no program baseline includes all technologies, including the program-sponsored LED technologies (although only the naturally occurring). Since, the purpose of the outyear factor is to capture the state of the future market LED technologies <u>are</u> included in the forecasts of market-average watts per lamp from the No Program scenario.
- For ROF baseline is the market average watts per lamp absent the installed measure, which in this case is LEDs, so LEDs are excluded in calculating the market average watts per lamp.

[3] Massachusetts Commercial/Industrial Baseline Framework

1.4 Summary Table

Table 2 summarizes the key differences between how ROF and ER are calculated modelled in this study.

Table 2. Summary of ROF and ER Definitions

Factor	ER		ROF	
	Definition	As Modeled	Definition	As Modeled
First period baseline	Defined as the existing equipment baseline.	Modeled as the PY2016 market average as a proxy for existing conditions.	Defined as the "condition that would have existed absent the installed measure" or the market average watts per lamp in the absence of the EE technology.	Derived from the Market Model average watts per lamp for the year the lamp was installed, excluding LED technology.
First period measure life	Defined in the baseline framework as the RUL of the existing equipment with a default of one-third of the EUL.	Derived from the 2016-2018 MA TRM and UMLD lost opportunity measure lives for the existing conditions technology mix.	Defined as the full measure life without discounting for ER.	Derived from the 2016-2018 MA TRM and UMLD lost opportunity measure lives for LEDs by application.
Second period baseline	Defined as the market average watts per lamp for lamps installed in RUL years without the influence of the program.	Derived from the Market Model average watts per lamp for a future year using the No Program scenario.	Does not apply	Does not apply
Second period measure life	EUL of the high efficiency equipment minus the RUL of the existing equipment	Derived from the 2016-2018 MA TRM and UMLD lost opportunity measure lives for the existing conditions technology mix.	Does not apply	Does not apply
ROF Fraction	Does not apply	Does not apply	The fraction of installed upstream and retrofit measures that are considered failed.	Estimated from recent stakeholder surveys and interviews.

2 CALCULATION OF AVERAGE MARKET WATTS/LAMP

The market-average watts per lamp reflects the technology mix of new lamps sold serving an application in a year of interest. The market-average watts per lamp is used in calculating both ROF (excluding LED lamps) and ER (using the No Program scenario). This section describes how the Market Model is used to calculate market-average watts per lamp.

2.1 Calculating the Market Average Watts per Lamp

Our best source for estimates of the technology mix sold in the market today and in the future is the Market Model. The Market Model estimates the mix of technologies (i.e. LED, fluorescents) serving each of 10 applications (such as Indoor Linear Lamps) each year and includes annual energy consumption, saturation, and market share estimates by lamp, application, and building type. The Market Model is a dataset of unique records, where each record is a unique combination of:

- Year
- Building type (i.e. Office, Retail, etc. – there are 13 types where the average hours of operation and the saturations of the technology is specific to the building type.)
- Application (indoor/outdoor for area, linear, screw-in: decorative, other, and general)
- Technology (i.e. LED, halogen, etc.)
- Program vs. no program scenario

Each record identifies:

- Total number of sockets present, a breakdown between new and replacement sockets (from new construction, retrofit, or replace on burn-out), and sockets that did not change
- Total energy use of all sockets

Table 3 presents a snapshot of the market for one building type segment in the Market Model. The table shows the Market Model's estimate of the number of Indoor Linear sockets by technology present in office buildings in 2018 in the No Program scenario. In addition to socket counts, the table shows the annual energy consumption by technology, which is the product of the number of sockets, the technology wattage, and the hours of operation.

Table 3. Market Model Socket Counts for Indoor Linear Application for 2018 Office Buildings

Technology	Sum of Total Number of Lamps	Sum of Total New Lamps	Sum of No Change Lamps	Sum of Annual Energy Consumption (MWh)
Indoor Linear Lamp	**10,011,177**	**1,600,972**	**8,410,205**	**1,084,636**
Fluorescent U-Tube	750,378	110,999	639,379	81,266
Linear Fluorescent Low Wattage T8	2,039,644	301,732	1,737,912	206,167
Linear Fluorescent Standard T8	4,663,404	773,927	3,889,477	538,716
Linear Fluorescent T12	1,465,855	216,311	1,249,545	179,919
Linear Fluorescent T5	536,668	65,920	470,747	46,497
Linear LED	555,227	132,083	423,144	32,070

Average change in watts	
Number of new lamps	1,600,972
Energy consumption of new lamps (MWh)	171,815
Energy use per lamp (kWh)	107.32
Average building hours of operation	4,076
Average watts (watts of use, not savings)	26.33 (Approximate)

The market-average wattage reflects the technology mix that serves that application. Records in the Market Model can be filtered to calculate average watts per lamp by application to define:

- ROF baseline – filtered for the No Program scenario for all new lamps, absent the installed measure, that is absent LEDs.
- Second-period future market baseline – filtered for the No Program scenario for all new lamps, although naturally occurring LEDs are included.

Since every record of the dataset has unique hours of operation, wattage, and annual use, record values are weighted by annual energy use, rather than socket counts, so that the results are proportional to portfolio energy savings. To calculate market-average lamp watts, records are filtered by year, and applications are filtered to a set of *n* records. The average watts per lamps is calculated as follows:

$$Market\ averare\ watts\ per\ lamp\ (by\ year, by\ application) = \frac{\sum_{i=1}^{n} Lamp\ watts_i\ \times\ Energy\ use_i}{\sum_{i=1}^{n} Energy\ use_i}$$

Table 4 presents the market average watts per lamp by application and year used in the Market Model. The average wattage by application type decreases over time as a result of the increased use of LEDs in each application type. Table 4 shows the Program scenario and therefore represents the best forecast of the market today.

Table 4. Market Model Average Watts/Lamp Results – With Program Scenario

Average Installed Watts of New Lamps	PY2016	PY2017	PY2018	PY2019	PY2020	PY2021	PY2022	PY2023	PY2024	PY2025	PY2026
Indoor HID Lamp	235.02	210.74	206.52	202.84	198.52	194.60	190.61	186.69	183.01	179.68	176.76
Indoor Linear Lamp	28.47	27.71	25.82	23.29	21.88	21.20	20.73	20.38	20.11	19.89	19.70
Indoor Screw-Based Decorative	27.60	25.04	24.12	23.30	22.47	21.64	20.84	20.05	19.30	18.59	17.92
Indoor Screw-Based General	29.91	28.03	26.73	25.85	25.19	24.66	24.17	23.77	23.45	23.17	22.96
Indoor Screw-Based Other	26.20	23.29	21.16	19.33	18.18	17.34	16.71	16.23	15.87	15.60	15.40
Outdoor HID Lamp	231.19	221.31	213.97	206.89	200.36	195.76	192.06	188.59	185.38	182.51	180.14
Outdoor Linear Lamp	29.63	29.69	29.40	27.01	24.11	23.30	22.70	22.31	22.03	21.81	21.60
Outdoor Screw-Based Decorative	21.89	20.77	19.93	18.65	17.26	15.97	14.84	13.88	13.10	12.47	11.96
Outdoor Screw-Based General	29.96	26.67	27.22	26.33	25.41	24.51	23.62	22.85	22.19	21.64	21.18
Outdoor Screw-Based Other	35.38	28.65	24.86	21.06	19.65	18.99	18.76	18.75	18.75	18.75	18.75

3 EARLY REPLACEMENT OUTYEAR FACTOR

ER calculations require an outyear factor. The factor accounts for market changes between the year the measure was installed and a future market when the original equipment would have been replaced, if used for its entire EUL. The Market Model No Program scenario is the source of the future market-average watts per lamp.

Referring to Table 5, the second baseline for an indoor high-intensity discharge (HID) lamp installed in 2016 with a 15-year EUL and thus a 5-year RUL is established by the market-average wattage in 2021 (highlighted blue). A screw-based decorative measure installed in 2016 with an EUL of six and an RUL of two years will use the 2018 market-average wattage (highlighted green) for the second-period baseline.

Table 5. Selection of Future Baseline with the No Program Scenario

Average watts per lamp of new lamps [A]	PY2016	PY2017	PY2018	PY2019	PY2020	PY2021	PY2022	PY2023	PY2024	PY2025	PY2026
Indoor HID Lamp	249.52	249.53	249.45	249.30	249.08	248.86	248.71	248.64	248.63	248.63	248.64
Indoor Linear Lamp	30.80	30.74	30.43	29.97	29.42	28.84	28.40	28.16	28.03	27.94	27.84
Indoor Screw-Based Decorative	37.12	36.29	34.95	33.55	32.26	31.12	29.83	28.46	27.01	25.51	23.97
Indoor Screw-Based General	32.74	30.23	27.99	25.90	24.00	22.62	21.27	20.09	19.01	17.96	16.96
Indoor Screw-Based Other	35.56	34.54	33.53	32.46	31.39	30.49	29.52	28.62	27.78	27.01	26.31
Outdoor HID Lamp	247.51	247.55	247.46	247.25	246.95	246.66	246.47	246.40	246.39	246.43	246.46
Outdoor Linear Lamp	29.91	29.94	29.91	29.79	29.50	29.07	28.74	28.58	28.51	28.48	28.45
Outdoor Screw-Based Decorative	33.80	32.59	31.14	29.62	28.19	26.92	25.58	24.23	22.86	21.48	20.12
Outdoor Screw-Based General	40.08	37.69	35.26	32.95	30.68	29.02	27.28	25.72	24.23	22.78	21.35
Outdoor Screw-Based Other	48.04	46.84	45.49	44.06	42.59	41.16	39.75	38.41	37.15	35.98	34.90

The second period savings is then calculated as a function of the difference between the new baseline wattage and the high-efficiency wattage. The ratio of the second-period savings to the first-period savings is the outyear factor. Table 6 presents the outyear factor by Program year.

Table 6. ER Outyear Factor

Outyear factor				
Early replacement Only	**PY2019**	**PY2020**	**PY2021**	**Applies to …**
Indoor HID Lamp	0.99	0.99	0.99	Area LED
Indoor Linear Lamp	0.82	0.82	0.81	TLEDs, T5
Indoor Screw-Based Decorative	0.81	0.77	0.72	Decoratives
Indoor Screw-Based General	0.59	0.54	0.49	A-lines
Indoor Screw-Based Other	0.76	0.72	0.68	PARs, MR16, G4
Outdoor HID Lamp	0.99	0.99	0.99	Area LED
Outdoor Linear Lamp	0.91	0.90	0.90	TLEDs, T5
Outdoor Screw-Based Decorative	0.75	0.70	0.66	Decoratives
Outdoor Screw-Based General	0.66	0.60	0.55	A-lines
Outdoor Screw-Based Other	0.77	0.72	0.68	PARs, MR16, G4

4 REPLACE ON FAILURE FRACTION

A lighting system that has failed[4] and is replaced is classified as ROF. The lifetime savings of a ROF measure is the product of the delta watts per lamp, the hours of operation, and the EUL of the measure. The delta-watts is the difference between the market-average watts per lamp excluding

[4] Note, this excludes regular maintenance practices of replacing burned-out lamp and ballast.

LEDS and the high efficiency watts per lamp. ROF savings applies to the percentage of the program upstream and downstream prescriptive and custom measures that are considered failed (the ROF fraction).

We found that the ROF lifetime energy savings was, on average, about 17% greater than ER lifetime savings.

4.1 Replace on Failure Program Fraction

To date, there has not been a need for a formal definition of ROF for lighting. Savings from Upstream Lighting are typically included as part of the 'Lost Opportunities' category of measures, which is largely equivalent to ROF, even though in practice, the delta watts assumes an existing conditions baseline. The evaluated existing delta watts are determined using an existing equipment baseline verified in the field. While the ex-post evaluations have rigorously assessed whether a site is new construction or retrofit, we have not attempted to discern whether the retrofit scenario should be further split into ER or ROF scenarios.

Distinguishing whether a replacement event is ER or ROF triggered by equipment failure is challenging. ROF in a commercial setting occurs when a lighting system has "failed" in the eyes of the customer. Individual lamps and ballasts can be replaced indefinitely, and that condition, as discussed above, is reflected in the TRM measure life, which far exceeds the lamp life and somewhat exceeds the ballast life. Lamp burn-out is not equivalent to a lighting system failure. In addition, systems are "locked down", requiring consistent housing/lamp/ballast across a space for a uniform lighting appearance, which prevents lamp upgrades on burn-out without affecting the appearance of the lighting. Recent Responses to questions in the 2018 end-user CATI survey also confirm that many facilities conduct a like-for-like replacement upon lamp failure. Customers and contractors are also reporting that they are allowing their lighting systems to reach the end of life but understanding what is meant by this requires additional future research.

4.2 Estimate of the ROF Fraction

Since the difference in savings between the ROF and ER scenarios can be large, it is important to discern the portion of the portfolio that may be attributable to ROF, or the fraction of the market where the existing equipment has failed prior to replacement, which we call the ROF Fraction. As noted, existing research on the lighting market has not attempted to distinguish and define an ROF and ER event. However, other surveys of end-users and lighting contractors conducted in 2018 explored some of these issues and the results of those efforts were used to determine the ROF fraction. Various participants, non-participants, contractors, and distributors were asked variants of these questions:

- What was the state of the existing lighting equipment replaced by the measure?
- Why was the existing equipment replaced? (Where one reason could be that it had failed)

The summary in Table 5, below, reflects the results of these surveys and interviews. Each survey was designed for multiple purposes, therefore, the questions differed, as did their nuances. The recommended estimate of a 12.2% ROF Fraction is an average of the highlighted responses from six studies characterizing the state of existing lighting equipment conditions. We note that we used a more conservative definition of failure (“Failure or broken”), excluding states that were close to failure.

Table 5. Summary of ROF Findings

		Motivation	State of Existing Lighting			
Study Group	Size	Replaced due to poor or failed lighting	Failed or broken	Still functioning, but with significant problems	Still functioning, but old, wanted to replace before problems	Reference Study
P78 Market	595	9%	**7%**	7%	11%	MA C&I Comprehensive Lighting Inventory: CATI and Onsite Survey Results Memorandum, March 4, 2019
P81 End-user, P	201		**9%**	19%	21%	C&I Upstream Lighting Evaluation Draft Final Report Nov26, 2018 (process evaluation). Results are unweighted.
P81 Contractor, P	20	13%	13%			C&I Upstream Lighting Evaluation Draft Final Report Nov26, 2018 (process evaluation). Results are unweighted.
P81 Contractor, NP	14	21%	34%			
P81 Distributor	20	17%				
		20%	**24%**			
NTG Study End-user, P	216		**3%**			Massachusetts C&I Upstream Lighting Net-to-Gross Study – Revised DRAFT August 3, 2018
P69 SBDI	67		**12%**	**1%**	7%	Impact Evaluation of PY2016 Massachusetts Commercial & Industrial Small Business Initiative: Phase I.
P80 Custom Lighting	53		**15%**			MA Commercial and Industral Impact Evaluation of 2016 Custom Electric Installations Draft, March 6, 2019
Proposed final ROF Fraction			**12.2%**			

5 PROGRAM-LEVEL LIFETIME SAVINGS AND EQUIVALENT MEASURE LIVES

With all the factors defined, the equations outlined in Section 1 can be employed to calculate program-level lifetime savings and a program-level EML which accounts for both ER and ROF calculations. The final EML by application type and year are summarized in Table 6.

Table 6. July 2019 Update: Program-Level EML by Application and by Year

Application	PY2019	PY2020	PY2021	Applies to …
Indoor HID Lamp	14.9	15.0	15.0	Area LED
Indoor Linear Lamp	13.5	13.5	13.4	TLEDs, T5
Indoor Screw-Based Decorative	4.5	4.4	4.2	Decoratives
Indoor Screw-Based General	4.4	4.2	4.0	A-lines
Indoor Screw-Based Other	10.1	9.7	9.3	PARs, MR16, G4
Outdoor HID Lamp	14.9	14.9	14.9	Area LED
Outdoor Linear Lamp	14.2	14.2	14.2	TLEDs, T5
Outdoor Screw-Based Decorative	4.3	4.1	4.0	Decoratives
Outdoor Screw-Based General	4.7	4.5	4.3	A-lines
Outdoor Screw-Based Other	10.1	9.7	9.3	PARs, MR16, G4

Table 7 presents the August 2018 results which are currently being used by the PAs for 2019 tracking.

Table 7. August 2018 Update: Program-Level EML by Application and by Year

Application	PY2019	PY2020	PY2021	Applies to …
Indoor HID Lamp	12	12	11	Area LED
Indoor Linear Lamp	10	10	9.2	TLEDs, T5
Indoor Screw-Based Decorative	4.6	4.5	4.4	Decoratives
Indoor Screw-Based General	5.6	5.5	5.4	A-lines
Indoor Screw-Based Other	5.5	4.9	4.4	PARs, MR16, G4
Outdoor HID Lamp	12	12	12	Area LED
Outdoor Linear Lamp	13	13	12	TLEDs, T5
Outdoor Screw-Based Decorative	3.8	3.6	3.5	Decoratives
Outdoor Screw-Based General	4.9	4.7	4.6	A-lines
Outdoor Screw-Based Other	5.4	4.9	4.5	PARs, MR16, G4

6 RECOMMENDATIONS AND CONSIDERATIONS

The DNV GL Team marshalled a variety of resources to derive a reasonable initial estimate of market baselines and the ROF Fraction. However, there are improvements stakeholders should consider in future revisions of Market Model and the EML estimates.

- We recommend that the PAs use the EMLs in Table 6 as placeholder values for PY2019 until updated EMLs are available after the next Market Model update, expected in Q1 2020. These values in Table 6 should not be applied retrospectively to PY2018.
- We recommend that additional annual saturation data be collected through the end of the 2019-2021 term to closely monitor changes in the C&I lighting market, particularly within linear lighting applications. These results should be used as calibration points in the Market Model to verify or improve the market share forecasts that are used to establish future market baselines for EML calculations.
- We recommend that the PAs consider additional improvements to the Market Model that will reduce the uncertainty of the future market share forecasts. These include:
    - Conduct secondary lighting research to verify and improve the reliability of the NO Program Scenario in the Market Model. This could include research into national market share forecasts or saturation estimates that can be used to compare against the no program scenario results with subsequent revisions to adoption curves.
    - Consider modelling improving LED efficacy over time. The current Market Model and this analysis assumes a constant lamp wattage across the analysis timespan. However, LED efficacy is improving at about 5% per year, which could provide a second order improvement in the accuracy of the model. The impact on the results are expected to be minor because both baseline and energy-efficient efficacies will evolve in parallel.
    - Consider alternate modelling of the existing equipment baseline in the EML calculations. This analysis uses the market average watts per lamp for new lamps in PY2016 as the

baseline across the timespan. Alternatively, the baseline could be defined by the Market Model existing lamp average watts per lamp or from ex post evaluation existing conditions findings. This would likely increase first-period savings and decrease second-period savings, thereby decreasing the EML.

- Consider weighting each record by the product of operating hours and number of new sockets. The current EML analysis weights each record by energy use, which over-emphasizes wattage.
- Incorporate the program-level EML analysis directly into future versions of the Market Model. Building the calculations directly into the Market Model will be more efficient and reduce the possibility of translation errors.
- Conduct further research to accurately and consistently define ROF. Since characterizing existing lighting systems as failed is subject to judgement (because it is extremely rare that a business is operating in darkness), care must be taken to develop a panel of questions that produces consistent and credible results across all the programs where lighting is deployed.
- Develop an additional NO Program type scenario that ceases program influence at a later point in time rather than in 2015. 2015 was used as the starting point because of data availability, but it may be more appropriate to use a baseline that includes program influence through 2018.