2018 OUTDOOR LIGHTING PHASE 1 DISPOSITION
California Public Utilities Commission, Energy Division
March 1, 2018

1. Covered Workpapers

This disposition applies to the most recently submitted versions of the workpapers listed in Table 1. CPUC staff notes that this list may not be exhaustive. This disposition is based on a detailed review of workpaper ID PGECOLTG151 version 8. Direction in this disposition applies to all measures similar to those described in the workpaper list below. Furthermore, direction covering the development of ex ante savings shall also apply to custom projects for similar measures.

Table 1 - Submitted Workpapers Covered by This Disposition

ID	PA	Title
PGECOLTG151	PGE	LED Outdoor Lighting
SCE17LG097	SCE	LED Street Lighting
SCE17LG105	SCE	LED Exterior Landscape Lighting Fixture
SCE17LG114	SCE	LED Exterior Light Fixture with Motion Sensor
SCE17LG120	SCE	LED Exterior Fixture below 24 ft.
WPSDGENRLG0181	SDGE	WPSDGENRLG0181_Rev4_SF_LED_Outdoor Area and Street Lighting_FINAL_20180102.zip
WPSDGENRLG0198	SDGE	Exterior LED Sports & Athletic Field Lighting Fixtures
WPSDGERELG1057	SDGE	WPSDGERELG1057_Rev1_Residential Outdoor LED fixtures (Pathways & Floodlights)_FINAL_20171228.zip

2. Ex Ante Value Review

2.1. Measure Baseline

The submitted workpaper updates proposes baselines for all measure classes (streetlight, roadway/area, wall-mount and canopy) to include at least 60% LED technologies. The performance of the baseline technology, as proposed in the updated workpaper, is assumed to have specific efficacy equal to the 25th percentile, in terms of efficacy, of all fixtures in the Lighting Facts database. Table 2 lists the updated workpaper proposed baseline characteristics.

Table 2 - PGECOLTG151 Update Proposed Baseline Characteristics

Fixture Class	Measure Baseline Characteristics			
	Metal Halide	**Linear Fluorescent**	**LED**	**LED Efficacy**
Streetlight	20%	0%	80%	97.0 lm/w
Road & Area	40%	0%	60%	97.0 lm/w
Garage	20%	20%	60%	95.6 lm/w
Wall-Mounted	40%	0%	60%	87.3 lm/w
Canopy	40%	0%	60%	101.3 lm/w

CPUC staff examination of the Lighting Facts database shows that the typical efficacy of fixtures varies widely by output with efficacy increasing with output. In the higher wattage ranges, savings will be overestimated compared to the 25th percentile while savings will be underestimated in the lower

wattage ranges. Table 3, developed by the EAR team, shows the efficacy of the four technology classes covered by the workpaper by varying percentile and output. The largest discrepancies occur for wall-mounted fixtures where there is the largest number of DLC premium fixtures in the Lighting Facts database. For other fixture classes, there are few or no DLC premium fixtures in higher output ranges listed in the lighting facts database, however, the higher output ranges in general have much higher overall efficacies.

Table 3 - Lighting Facts Database - Fixture Efficacy

Workpaper Fixture Class	Available (note 1)	Percentile (note 2)	Lighting Facts Database Output Bins (note 3)										Work-paper Baseline Lm/W
			0-500lm	501-1000lm	1001-2500lm	2501-5000lm	5001-10000lm	10001-20000lm	20001-30000lm	30001-45000lm	45001-60000lm	> 60001lm	
DLC v4.2 Premium Efficacy Min (note 4)			none	110	110	110	115	120	120	120	120	120	
Wall	TRUE	25	32	49	78	83	89	101	104	102	100	104	87.3
Wall	TRUE	50	41	61	89	95	104	113	115	114	105	109	87.3
Wall	TRUE	75	54	75	102	110	117	123	126	123	112	112	87.3
Wall	TRUE	90	63	90	115	120	126	130	135	132	121	120	87.3
Wall	TRUE	Min DLC	none	70	54	63	68	69	82	86	110	102	87.3
Wall	TRUE	Max DLC	none	106	125	137	144	149	144	142	110	112	87.3
Wall	Avg	25	25	42	69	74	79	90	97	90	98	100	87.3
Wall	Avg	50	31	48	76	81	88	99	103	100	100	103	87.3
Wall	Avg	75	37	54	82	89	96	105	109	106	103	105	87.3
Wall	Avg	90	40	59	87	93	100	109	113	109	105	107	87.3
Wall	Avg	Avg DLC	none	79	90	97	103	109	115	100	110	107	87.3
Wall	Avg	Avg DLC Prem	none	none	118	120	126	129	132	137	none	none	87.3
Wall	QtyUnder	25	46	74	281	467	530	357	104	60	10	10	87.3
Wall	QtyUnder	50	92	150	563	918	1059	712	207	121	16	19	87.3
Wall	QtyUnder	75	142	222	834	1377	1587	1068	310	179	24	28	87.3
Wall	QtyUnder	90	164	266	1000	1649	1904	1280	371	215	28	33	87.3
Wall	QtyOver	25	137	222	836	1389	1588	1069	310	179	28	29	87.3
Wall	QtyOver	50	92	150	560	922	1059	712	208	120	16	19	87.3
Wall	QtyOver	75	49	74	278	459	529	357	104	60	8	10	87.3
Wall	QtyOver	90	19	30	112	184	212	143	42	24	4	4	87.3
Wall	QtyOver	DLC	0	9	86	177	245	170	97	29	1	2	87.3
Wall	QtyOver	DLCPrem	0	0	20	44	72	46	37	5	0	0	87.3

Workpaper Fixture Class	Available (note 1)	Percentile (note 2)	Lighting Facts Database Output Bins (note 3)										Work-paper Baseline Lm/W
			0-500lm	501-1000lm	1001-2500lm	2501-5000lm	5001-10000lm	10001-20000lm	20001-30000lm	30001-45000lm	45001-60000lm	>60001lm	
DLC v4.2 Premium Efficacy Min (note 4)			none	110	110	110	115	120	120	120	120	120	
Area/Roadway	TRUE	25	37	43	78	82	87	98	101	106	102	107	97.0
Area/Roadway	TRUE	50	54	66	89	97	100	111	114	118	113	118	97.0
Area/Roadway	TRUE	75	60	81	104	110	114	123	124	127	126	125	97.0
Area/Roadway	TRUE	90	63	93	115	121	125	130	134	134	130	128	97.0
Area/Roadway	TRUE	Min DLC	none	70	54	49	68	69	65	72	110	105	97.0
Area/Roadway	TRUE	Max DLC	none	106	125	132	146	138	144	142	130	108	97.0
Area/Roadway	Avg	25	28	38	68	73	78	86	90	96	95	95	97.0
Area/Roadway	Avg	50	40	46	76	81	86	96	99	105	101	104	97.0
Area/Roadway	Avg	75	45	55	83	89	93	103	106	110	108	109	97.0
Area/Roadway	Avg	90	48	60	87	93	97	107	109	114	111	112	97.0
Area/Roadway	Avg	Avg DLC	none	81	89	95	99	107	109	107	120	107	97.0
Area/Roadway	Avg	Avg DLC Prem	none	none	119	120	127	127	131	135	130	none	97.0
Area/Roadway	QtyUnder	25	15	29	208	684	1005	904	349	216	38	24	97.0
Area/Roadway	QtyUnder	50	37	57	416	1368	2009	1803	698	433	76	47	97.0
Area/Roadway	QtyUnder	75	48	85	623	2051	3013	2704	1046	647	114	70	97.0
Area/Roadway	QtyUnder	90	60	101	748	2462	3616	3245	1255	776	136	83	97.0
Area/Roadway	QtyOver	25	45	85	623	2051	3013	2709	1046	647	114	70	97.0
Area/Roadway	QtyOver	50	34	57	416	1372	2009	1803	698	432	76	47	97.0
Area/Roadway	QtyOver	75	23	29	208	684	1005	902	349	216	38	24	97.0
Area/Roadway	QtyOver	90	11	12	84	275	402	364	140	87	16	10	97.0
Area/Roadway	QtyOver	DLC	0	8	69	198	430	331	144	35	2	2	97.0
Area/Roadway	QtyOver	DLCPrem	0	0	17	43	79	79	39	7	1	0	97.0

Workpaper Fixture Class	Available (note 1)	Percentile (note 2)	Lighting Facts Database Output Bins (note 3)										Work-paper Baseline Lm/W
			0-500lm	501-1000lm	1001-2500lm	2501-5000lm	5001-10000lm	10001-20000lm	20001-30000lm	30001-45000lm	45001-60000lm	> 60001lm	
DLC v4.2 Premium Efficacy Min (note 4)			none	110	110	110	115	120	120	120	120	120	
Canopy	TRUE	25	34	60	85	89	97	103	123	132	none	none	101.3
Canopy	TRUE	50	38	74	102	103	110	112	132	140	none	none	101.3
Canopy	TRUE	75	43	78	113	117	121	125	141	149	none	none	101.3
Canopy	TRUE	90	45	125	119	125	131	134	150	151	none	none	101.3
Canopy	TRUE	Min DLC	none	none	86	74	82	80	83	none	none	none	101.3
Canopy	TRUE	Max DLC	none	none	129	133	131	114	109	none	none	none	101.3
Canopy	Avg	25	29	53	74	81	88	94	106	129	none	none	101.3
Canopy	Avg	50	29	60	83	89	96	101	116	131	none	none	101.3
Canopy	Avg	75	29	65	91	96	103	107	123	136	none	none	101.3
Canopy	Avg	90	29	70	95	100	106	110	127	136	none	none	101.3
Canopy	Avg	Avg DLC	none	none	113	106	102	100	96	None	none	none	101.3
Canopy	Avg	Avg DLC Prem	none	none	118	124	122	none	none	None	none	none	101.3
Canopy	QtyUnder	25	1	4	27	91	135	110	18	1	0	0	101.3
Canopy	QtyUnder	50	1	7	51	182	268	221	35	2	0	0	101.3
Canopy	QtyUnder	75	1	10	76	274	403	329	53	3	0	0	101.3
Canopy	QtyUnder	90	1	11	91	327	482	395	62	3	0	0	101.3
Canopy	QtyOver	25	1	10	77	273	403	329	52	3	0	0	101.3
Canopy	QtyOver	50	1	7	51	182	268	220	35	2	0	0	101.3
Canopy	QtyOver	75	1	4	26	93	135	110	18	1	0	0	101.3
Canopy	QtyOver	90	1	2	11	37	54	44	7	1	0	0	101.3
Canopy	QtyOver	DLC	0	0	19	31	27	14	2	0	0	0	101.3
Canopy	QtyOver	DLCPrem	0	0	15	14	7	0	0	0	0	0	101.3

Workpaper Fixture Class	Available (note 1)	Percentile (note 2)	Lighting Facts Database Output Bins (note 3)										Work-paper Baseline Lm/W
			0-500lm	501-1000lm	1001-2500lm	2501-5000lm	5001-10000lm	10001-20000lm	20001-30000lm	30001-45000lm	45001-60000lm	> 60001lm	
DLC v4.2 Premium Efficacy Min (note 4)			none	110	110	110	115	120	120	120	120	120	
Parking Garage	TRUE	25	none	none	88	84	88	96	87	100	none	none	95.6
Parking Garage	TRUE	50	none	none	102	96	104	107	95	105	none	none	95.6
Parking Garage	TRUE	75	none	none	115	112	116	118	100	108	none	none	95.6
Parking Garage	TRUE	90	none	none	126	120	128	129	116	110	none	none	95.6
Parking Garage	TRUE	Min DLC	none	none	88	64	60	78	none	None	none	none	95.6
Parking Garage	TRUE	Max DLC	none	none	129	144	139	130	none	None	none	none	95.6
Parking Garage	Avg	25	none	none	75	77	79	88	81	89	none	none	95.6
Parking Garage	Avg	50	none	none	86	84	88	95	86	96	none	none	95.6
Parking Garage	Avg	75	none	none	93	90	95	102	89	100	none	none	95.6
Parking Garage	Avg	90	none	none	97	94	99	105	93	100	none	none	95.6
Parking Garage	Avg	Avg DLC	none	none	110	99	107	116	none	None	none	none	95.6
Parking Garage	Avg	Avg DLC Prem	none	none	117	126	128	126	none	None	none	none	95.6
Parking Garage	QtyUnder	25	0	0	9	118	170	19	3	1	0	0	95.6
Parking Garage	QtyUnder	50	0	0	18	236	340	38	6	2	0	0	95.6
Parking Garage	QtyUnder	75	0	0	26	354	509	57	8	3	0	0	95.6
Parking Garage	QtyUnder	90	0	0	31	424	611	67	10	3	0	0	95.6
Parking Garage	QtyOver	25	0	0	26	354	509	56	8	3	0	0	95.6
Parking Garage	QtyOver	50	0	0	18	236	340	38	6	2	0	0	95.6
Parking Garage	QtyOver	75	0	0	9	118	170	20	3	1	0	0	95.6
Parking Garage	QtyOver	90	0	0	4	48	68	8	2	1	0	0	95.6
Parking Garage	QtyOver	DLC	0	0	7	44	65	10	0	0	0	0	95.6
Parking Garage	QtyOver	DLCPrem	0	0	5	15	27	5	0	0	0	0	95.6

Notes:

1. TRUE=>Only available fixtures; Avg=>Average of all available fixtures below criteria; QtyUnder=>number of available fixture below criteria; QtyOver=>number of available fixture above criteria

2. Percentile is calculated on all fixtures of a specific class in the Lighting Facts database. There is no consideration for sales volumes in this calculation.

3. "none" means there are no fixtures in the Lighting Facts database that fall into the output category.

4. Fixtures listed by the DLC must meet this minimum efficacy to be identified as "Premium"

2.2. Costs

2.2.1. <u>Comparison of Measure and Baseline Costs in the Workpaper:</u>
The PG&E submitted workpaper update materials provided a cost-analysis for measure and baseline technologies using three major sources:
- Navigant Consulting for PG&E. California LED Pricing Analysis. Draft version, October 2017.
- Online pricing and web-scraping
- Analysis of 2017 PG&E rebate and incentive invoices

The PG&E analysis applied the baseline technology mix from Table 2 to the individual costs for each technology to develop weighted baseline costs. Measure costs are developed based on data from the three sources listed above for fixtures identified as meeting the measure eligibility criteria defined in the workpaper.

The EAR team created side-by-side comparisons of baseline and measure costs for each of the technology classes (see Figure 1, Figure 2, Figure 3 and Figure 4). The EAR team comparisons show that, in many cases, there is no significant incremental cost for the measure technology. This indicates that incentives would only be necessary if it can be shown there are other market barriers leading to the purchase of less efficient technologies with equal or greater price than the measure technologies.

2.2.2. <u>Specific Cost Data Review:</u>
The EAR team also performed a limited review of some of the costs reported in the workpaper cost workbook. For several types of qualifying fixtures, the EAR team identified much lower prices from web sources such as Amazon and 1000bulbs. The EAR team only examined costs for DLC Premium products, but similar differences may exist for baseline technologies.

More specific examples of concerns in 2.2.1 and 2.2.2 are described below.

2.2.3. Street, Area and Roadway Fixtures

Figure 1 - Workpaper Cost Comparison: Street, Area and Roadway Fixtures
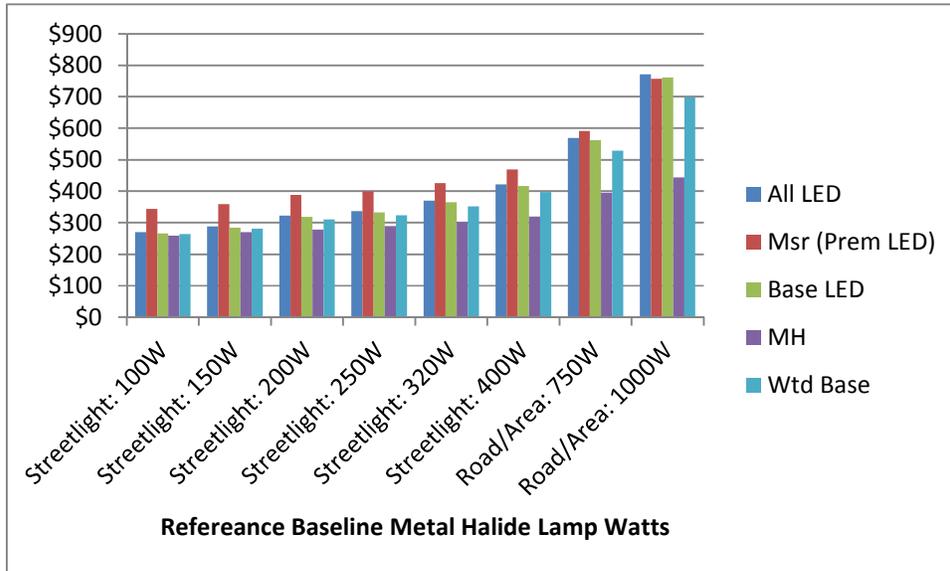
- In lower wattage ranges, the base LED and MH lamps have nearly the same price which indicates the baseline should be 100% LEDs instead of the proposed 80%.
- In higher wattage ranges, the base and measure LEDs have nearly the same price which indicates incentives would only be necessary if it can be shown that there are other market forces causing purchases of the lower efficacy products for the same price.
- Measure cost may be overestimated by a factor of two. For example, amazon sells a fixture that will fall into the 750w MH baseline category for about $300: https://www.amazon.com/LED-Flying-Direct-Parking-Outdoor/dp/B01N7DH3L1/ref=sr_1_57?s=lamps-light&ie=UTF8&qid=1489427182&sr=1-57&keywords=LED+street

2.2.4. Parking Garage Fixtures

Figure 2 - Workpaper Cost Comparison: Parking Garage Fixtures
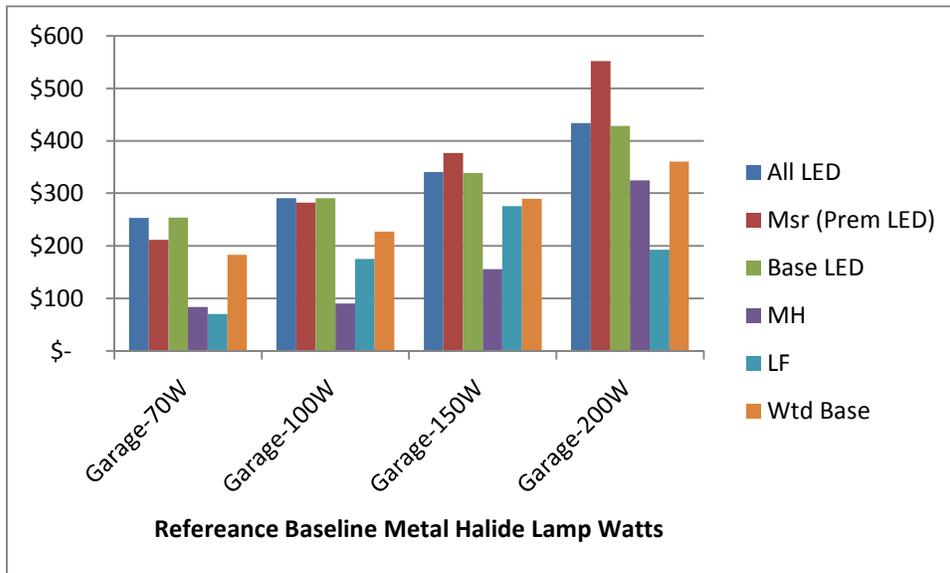
- In the lower wattage ranges, the measure LEDs are less expensive than the base LEDs which indicates there is no need for incentives for the portion of the baseline comprised of LEDs. For the 150W base measure, the cost difference of the measure LED over the base LED is very small.
- Linear fluorescent costs do not appear consistent as the 200w equivalent cost is lower than the 150w equivalent baseline.

2.2.5. Wall Mounted Fixtures

Figure 3 - Workpaper Cost Comparison: Wall Mounted Fixtures
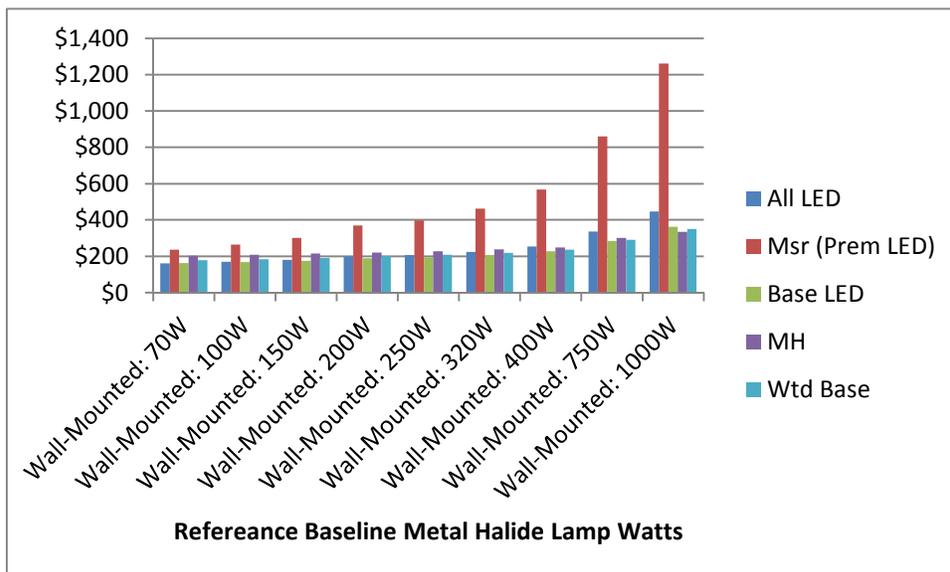
- In all cases except the two highest wattage classes, the cost of the metal halide base technology is nearly identical and often greater than the base LED cost, which indicates the baseline should be 100% LEDs.
- High wattage equivalent prices do not appear reasonable. CPUC staff found several wall mounted DLC fixtures in this output range with prices of $150-$200.

2.2.6. Canopy Fixtures

Figure 4 - Workpaper Cost Comparison: Canopy Fixtures
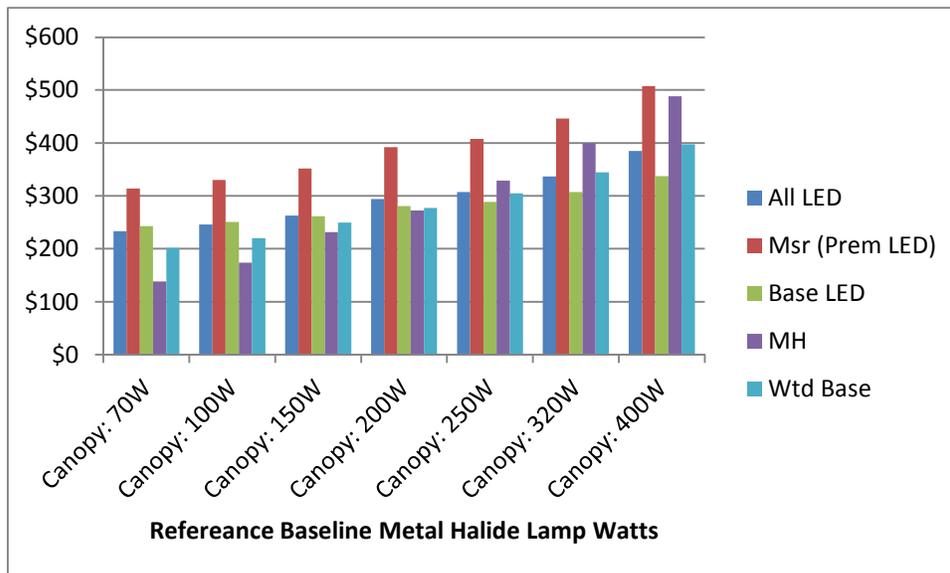
- In the highest wattage ranges, the base metal halide cost is equal to greater than the base LED cost which indicates the baseline should be 100% LEDs.

3. Direction

It should be noted that the submitted updated workpaper covers normal replacements (NR), new construction (NC), and replace-on-burnout (ROB) measure types. The EAR team review assumed that the primary participant case envisioned by the workpaper measures is replacement of all or most of the fixtures in an area, not a single or very small percentage of fixture replacements in an area. The workpaper does not propose an accelerated replacement (AR) measure type. The EAR team review provides a strong indication from the cost analysis that the baseline, for the measure types and expected project types (not "one off" fixture replacements) covered by the workpaper, should be 100% LEDs in many cases. However, EAR team review of the cost data indicates that some of the data for measure and baseline fixtures is either out of date or possibly obtained from low volume sellers. In a limited review of prominent on-line retailers, EAR team found many LED products, both meeting workpaper requirements and not, with lower prices than those in the prices listed in the workpaper analysis.

Based on the most recent Lighting Facts database, the baseline LED efficacy appears to be too low for higher output fixtures, particularly wall-mounted fixtures, and too low for all lower output fixtures. This will overestimate savings for higher output fixtures and underestimate savings for lower output fixtures. This analysis is based on equal weighting of all fixtures in the Lighting Facts database within a particular fixture class and output bin. Further research is needed to get a better understanding of the performance of fixtures currently being sold as well as the likely future trends in fixture performance.

3.1. Baseline Technology Mix

Revise the baseline technology mix for normal replacement and new construction (ROB/NR/NC) and the second baseline for accelerated replacement (AR) measures as follows:

a. Streetlights: 100% LED
b. Roadway/Area: 100% LED
c. Garage: Proposed workpaper baseline is acceptable
d. Wall-mounted: 100% LED
e. Canopy: 100% LED

AR measures shall use the pre-existing equipment that has been replaced as the first baseline. Staff recommends the addition of AR measures for some or all categories coved by the workpaper(s) as noted in Section 4 below.

3.2. Baseline LED Performance

For each of the measures covered by this workpaper, revise the baseline LED efficacy be representative of the typical performance of non-qualifying fixtures that provide the same level of service as the measure fixture. This will likely result in lower baseline performance in lower output ranges (which will increase savings) and higher baseline performance in higher output ranges (which will decrease savings).

3.3. Cost Data and Analysis

Perform additional cost research on measure and baseline LED fixtures and re-analyze cost data. At a minimum, costs for the products listed in the analysis workbook should be identified from additional common supply sources such as large distributors or on-line retailers. Some on-line retailers such as Amazon have the capabilities to prevent data harvesting by web-scraping utilities. (On the other hand, Amazon also publishes its own free software that allows users to perform detailed searches). The EAR team also notes that some of the cost data may be incorrectly classified in the cost analysis workbook. For example, there appear to be some costs for roadway lighting products in the wall-mounted cost worksheet. Provide an updated cost workbook and cost data with the revised workpaper.

4. Additional Program Implications

The workpaper uses a fixed baseline mixture of technologies and performance across all measures within a fixture class (streetlight, roadway/area, canopy, garage and wall-mount). This baseline may not be appropriate for all customer classes. Smaller customers may have smaller quantities of fixtures,

or perhaps less available capital, and may tend to replace fixtures one at a time. For these customers, the least expensive baseline may be the most appropriate. In these projects, the workpaper may underestimate savings and the available incentives may not be large enough to motivate the customer to install products covered by this workpaper. Furthermore, these smaller customer groups represent an opportunity for early replacement (AR) measure applications. As noted above, the workpapers currently submitted only cover NR, ROB and NC measure applications. For accelerated replacement (which may also be appropriate treatment for "one off" fixture replacements, or certain customer classes) it would be appropriate to add that measure type treatment in a future workpaper submission. Such a submission would need to include the preponderance of evidence (PoE) approach that would be used to establish program induced accelerated replacements to qualify the participant for the AR treatment.

5. Un-reviewed Ex Ante Value

The scope of this detailed review covers the specific values discussed in the previous sections. The EAR team did not review the development of the operating hours for each fixture class. Also, the workpaper notes that a large portion of the savings attributable to LED technologies is due to the more even distribution of light across and illuminated area compared to HID and linear fluorescent technologies. The savings analysis spreadsheet accompanying the workpaper includes representative fixture performance characteristics along with calculations of equivalent LED wattage needed to provide similar minimum performance characteristics as HID and linear fluorescent technologies. The EAR team did not review these calculations as part of this detailed review. CPUC staff waives further review of these ex ante values at this time, pending the resubmission of the workpaper based on the requirements noted above.

6. Savings Resulting from Different Baseline Assumptions

The EAR team investigated how changes in assumptions for annual operating hours and technology baselines would change the annual savings of each measure covered by the workpaper. Results of this analysis are shown in figures 5-9 below.

**Figure 5 - Savings for Baseline Alternatives: Streetlights**
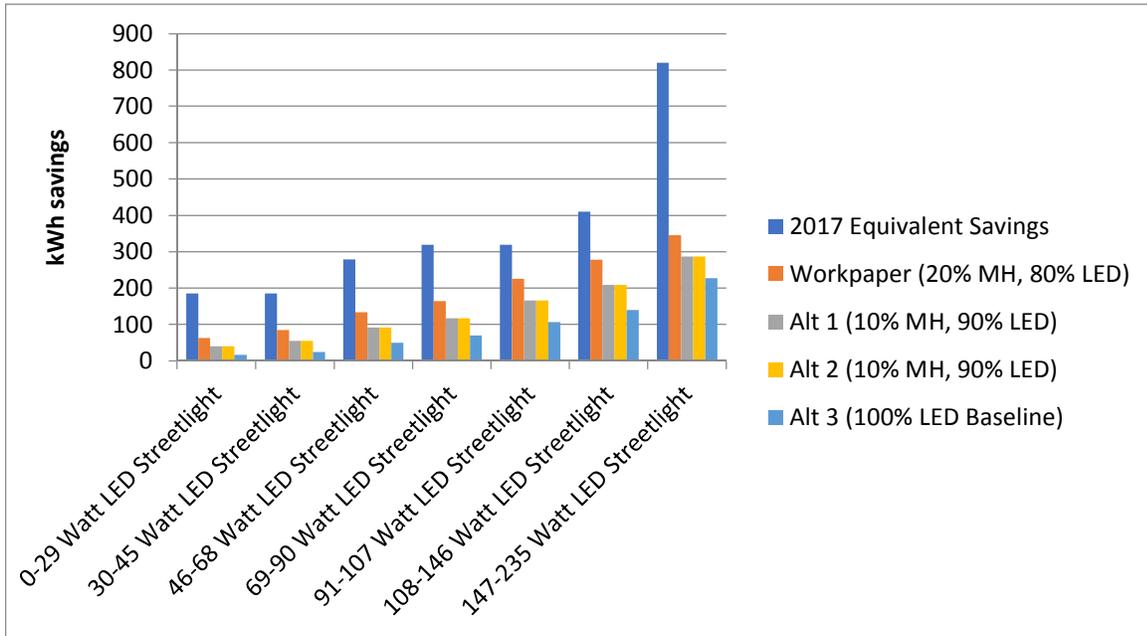
**Figure 6 - Savings for Baseline Alternatives: Road & Area**
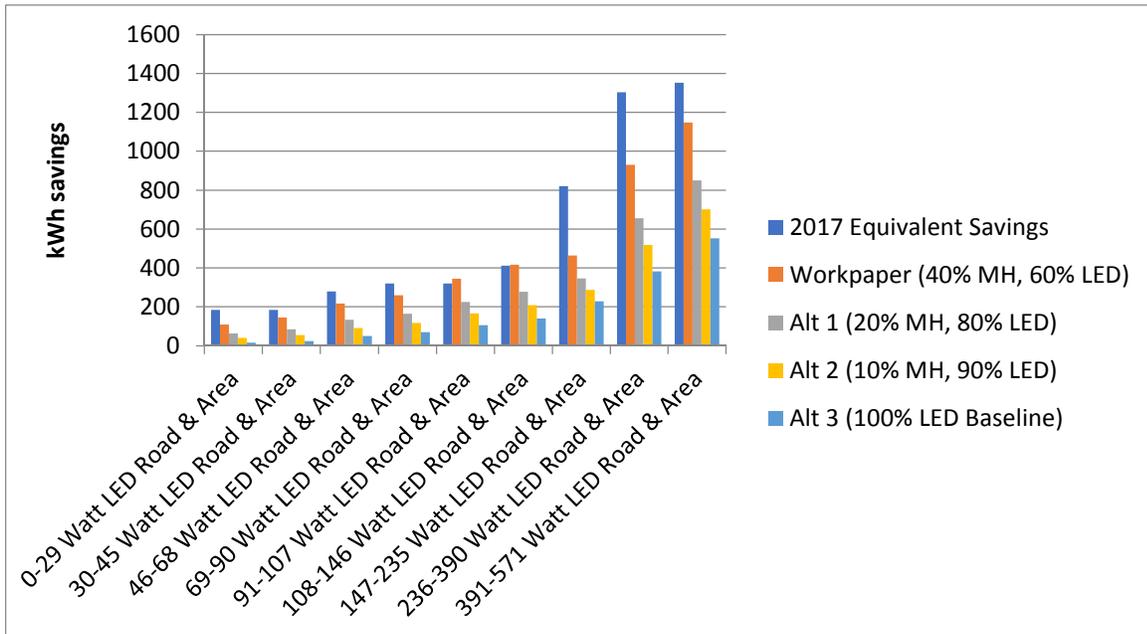
**Figure 7 - Savings for Baseline Alternatives: Parking Garage**
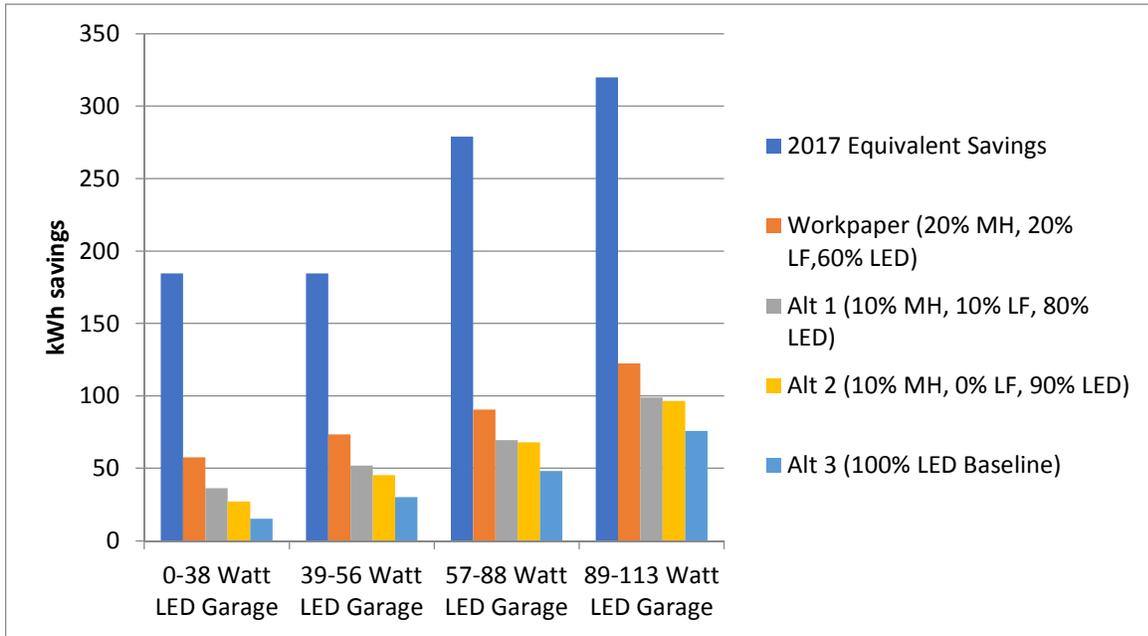
**Figure 8 - Savings for Baseline Alternatives: Canopy**
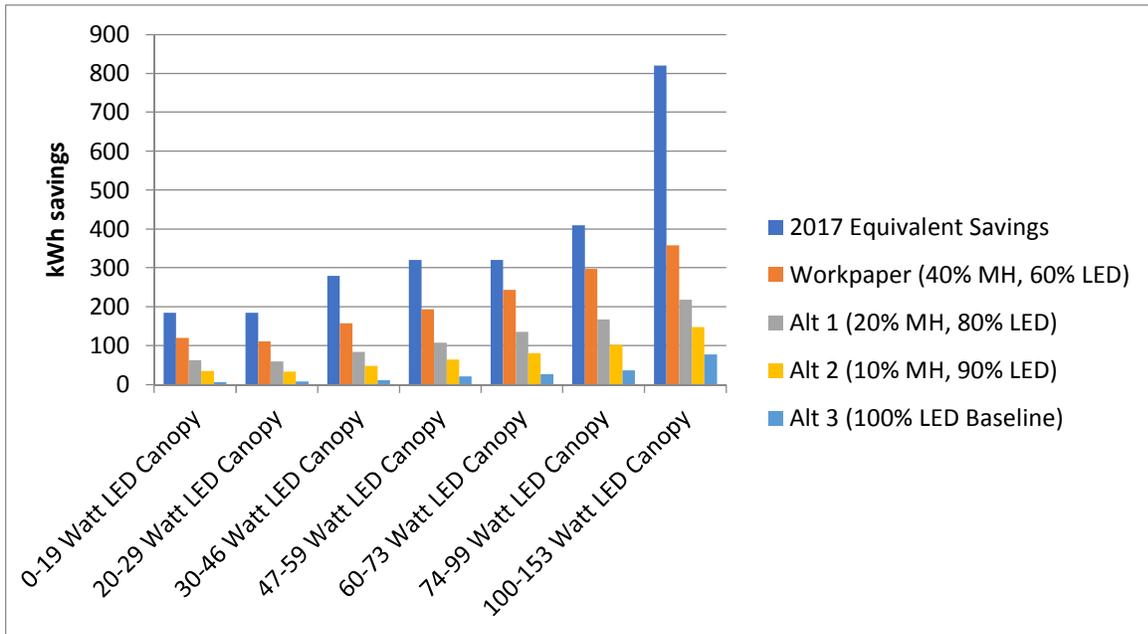
Figure 9 - Savings for Baseline Alternatives: Wall-Mounted