Ex Ante Update for ESPI Uncertain Measures
T-5 Replacing Metal Halide Uncertain Measure Analysis
19 May 2015

During the ex ante review of IOU portfolio applications for the 2013-2014 program cycle, the ex ante review team examined all high-bay linear fluorescent measures proposed in IOU workpapers[1] (lighting disposition). As a result of the concerns developing out of this review, these measures were added to the ESPI uncertain measures list, subject to ex post evaluation for determination of final savings values. The ESPI uncertain measure list includes the following measure description and comments[2]:

> Descriptions: T5 fluorescent lamps and fixtures replacing metal halide
> Comments on Need: **Update baseline** of replaced lamp assumptions; **net savings and installation rate**; market move to T5 technology requires verification of assumptions.

The Nonresidential Downstream Lighting Impact Evaluation (WO29)[3] and the and 2013 Nonresidential Downstream Deemed ESPI Lighting Impact Evaluation Report (ESPI)[4] investigated ex post savings accomplishments for T5 linear fluorescent lighting fixtures installed in high-bay applications. The evaluation efforts included significant field data and subsequent analysis that, combined with the lighting disposition, can be used to update all ex ante values for these measures, including the following:

- Replace-on-burnout and new construction baselines should be revised in DEER to reflect standard industry practice baselines of pulse start metal halide technologies providing approximately equal levels of service in terms of overall lighting output and serviceability.
- Logger data analysis of high bay applications indicates a need for revisions to current DEER assumptions, which are based on more conventional linear fluorescent general lighting applications.
- Net-to-gross results from ex post evaluations, both WO29 and ESPI, indicate that unique NTG values for high bay linear fluorescent applications are necessary.

Gross Unit Energy Savings

Unit energy savings (UES) values are calculated using a reference method based on several pre-determined values[5]:

$$UES_{kWh} = (kW_{base} - kW_{msr}) * HOU * IEF_{kWh} \quad \textit{Equation 1}$$

$$UES_{kW} = (kW_{base} - kW_{msr}) * CDF * IEF_{kW} \quad \textit{Equation 2}$$

$$UES_{therm} = UES_{kWh} * IEF_{therm} \quad \textit{Equation 3}$$

[1] Lighting Retrofit Disposition Summary of Changes High Bay and HID Technologies and Hard-wired Exterior Lighting, file name: Summary of Changes -Lighting Disposition - November2014 (HighBay HID)-final (Emailed 2014-12-23).docx, November 25, 2014
[2] D.13.09.023, Decision Adopting Efficiency Savings and Performance Incentive Mechanism, Attachment 3
[3] Final Report, WO29: Nonresidential Downstream Lighting Impact Evaluation (WO29), Prepared for: California Public Utilities Commission, Energy Division, 2010-2012 EM&V Work Order 29 – Nonresidential Downstream Lighting, Prepared by: Itron, Inc., August 5, 2014
[4] 2013 Nonresidential Downstream Deemed ESPI Lighting Impact Evaluation Report (ESPI), Prepared for: California Public Utilities Commission, Energy Division, Prepared by: Itron, Inc., April 28, 2015
[5] Refer to "DEER2014-Lighting-IE_and_Adjustment-Factor-Tables-17Feb2014.xlsx", sheet "Example Calcs" available at www.deeresources.com.

Where:

UES_{kWh}: The unit energy consumption savings
UES_{kW}: The unit energy demand savings
UES_{therm}: The unit energy natural gas savings (always negative for lighting measures)
kW_{base}: The input power of the base fixture, above which the savings are calculated.
kW_{msr}: The input power of the measure fixture.
HOU: The annual hours of use
IEF_{kWh}: The annual HVAC interactive effects factor for energy consumption, expressed as kWh/kWh. This factor represents the additional savings benefits due reduced installed lighting power which results in reduced operation of air conditioning systems.
CDF: The coincident demand factor, which represents the total fraction of lights turned on during the DEER peak demand period
IEF_{kW}: The HVAC peak demand interactive effects factor, expressed as kW/kW. This factor represents the additional demand reduction due to reduced installed lighting power which results in lower overall cooling demand during the DEER peak demand period.
IEF_{therm}: The HVAC natural gas heating interactive effects factor, expressed as therm/kWh. This factor represents the additional natural gas consumptions needed due to reduced installed lighting power, which results in increased operation of natural gas heating equipment.

Hours of Use and Coincident Demand Factors

The current DEER hours of use for high-bay T5s were last revised for DEER2008. At that time, the only available logger data were for more conventional, ceiling installed, linear fluorescent lighting equipment. Therefore, DEER used the same overall HOU and CDF values for high-bay and conventional applications. The overall HOU and CDFs were based on the legacy DEER prototype assumptions and updated to reflect the most recent logger data from the 2004-2005 program evaluations for the building types that were reasonably represented in the available logger data.

The 2006-2008 Small Commercial (SmallCom)[6], Government Partnership (LGP)[7] and WO29 evaluations included lighting logger studies across a wide range of building types, activity areas, technologies and applications. As part of the DEER2011 update, the DEER team initiated a review and analysis of the SmallCom data with the intent of revising the simulation profiles, CDF values and HOU values to be used in the modeling and calculation of savings for lighting retrofits. This effort was not completed in time to be included in the DEER2011 update, however, the results of that

[6] Small Commercial Contract Group Direct Impact Evaluation Report (SmallCom), Prepared for: California Public Utilities Commission, Energy Division, December 11, 2009
[7] Government Partnerships Programs Direct Impact Evaluation Report, prepared by Summit Blue Consulting, for the California Public Utilities Commission, February 8, 2010.

work may be applicable to an update to UES values for T5 high-bay technologies. WO29 lighting logger studies also included high-bay installations.

The DEER team updated the HOU and CDF values were developed using the combined on-site lighting logger data available from 2004-2005 studies, SmallCom and WO29. Since T-5 high-bay measures were removed from the uncertain measure list, the HOU and CDF update was first performed for the DEER2015 update for the uncertain measures. Table 1 provides the revised HOU and CDF values for high-bay lighting applications. The results of this analysis were then combined with the full update for DEER2016. The Excel workbook with the full development of HOU and CDF values for all lighting types is available on the DEER website.

Table 1 - Hours-of-Use and Coincident Demand Factors for High-Bay Lighting

	Annual hours of use		Coincident demand factor		Percent Change	
DEER Building Type	DEER2014	DEER2016	DEER2014	DEER2016	HOU	CDF
Assembly	2713	1668	0.55	0.49	-38.5%	-10.5%
Primary School	2326	2291	0.63	0.75	-1.5%	18.4%
Secondary School	2426	2368	0.70	0.80	-2.4%	14.2%
Community College	2504	2478	0.80	0.79	-1.0%	-2.0%
University	2310	2646	0.69	0.85	14.5%	23.6%
Relocatable Classroom	2623	1086	0.70	0.43	-58.6%	-38.0%
Grocery	4865	5453	0.68	0.90	12.1%	31.8%
Manuf. Light Industrial	3271	2921	0.92	0.59	-10.7%	-36.2%
Manufacturing Bio/Tech	4002	2803	0.85	0.57	-29.9%	-32.3%
Hospital	5362	5866	0.83	0.77	9.4%	-7.3%
Nursing Home	4326	3814	0.67	0.68	-11.8%	0.0%
Hotel	1457	5351	0.17	0.68	267.2%	299.9%
Motel	1372	4197	0.15	0.37	205.9%	148.0%
Office - Large	2788	2863	0.71	0.72	2.7%	1.1%
Office - Small	2776	2102	0.69	0.70	-24.3%	1.3%
Restaurant - Fast Food	4830	3398	0.81	0.63	-29.6%	-22.8%
Restaurant - Sit Down	4817	3823	0.80	0.63	-20.6%	-21.5%
Retail - 3-Story (Dept Store)	3409	5596	0.75	0.97	64.2%	28.4%
Retail - Large (Bigbox)	4168	4059	0.83	0.93	-2.6%	11.8%
Retail - Small	3467	2288	0.88	0.64	-34.0%	-26.4%
Storage Conditioned	3450	2305	0.70	0.51	-33.2%	-26.6%
Storage Unconditioned	3450	2175	0.70	0.45	-37.0%	-35.3%
Refrigerated Warehouse	4791	4818	0.55	0.55	0.6%	-0.6%

Code or Standard Practice Baseline

The DEER code baseline for T5 technologies in high-bay applications are pulse start metal halide fixtures with similar light output as the measure fixtures. The WO29 evaluation recommends keeping this industry standard practice (ISP) baseline. DEER, as well as dispositions on deemed lighting workpapers, establish specific code baseline technologies for specific measure technologies. Table 2 lists the current pairings of T-5 high-bay technologies with corresponding code/ISP metal

halide baselines. For example, below is a description of a DEER measure with the characteristics of the measure and code baseline fixtures:

Measure Fixture: (4) T5-HO 46" 54 watt lamps; (2) high light output (HLO) electronic ballasts; 20,900 mean lumens; 234 total fixture watts

Code Baseline Fixture: (1) 320 PSMH lamp; (1) constant wattage autotransformer (CWA) ballast; 21,000 mean lumens; 365 total fixture watts

Table 2 - Current Code/ISP Baselines for T5 High-Bay Technologies

Measure Fixture			Code/ISP Baseline Fixture		
Description	Mean Lumens	Watts	Description	Mean Lumens	Watts
1 lamp, 1 ballast	5,225	62	100w MH	5,525	128
2 lamps, 1 ballast	10,450	117	175w PSMH	11,200	208
3 lamps, 1 or 2 ballasts (including tandem wired)	15,675	179	250w PSMH	16,625	288
4 lamps, 2 or 4 ballasts	20,900	234	320w PSMH	21,000	365
6 lamps, 3 ballasts	31,350	351	400w PSMH	30,000	456
8 lamps, 2 or 4 ballasts	41,800	468	450w PSMH	38,000	506
10 lamps, 3 ballasts	52,250	585	750w PSMH	60,000	818

Net-to-Gross Ratio

Currently, DEER includes NTG values for the category of "T5 and T8 lamps" with a value of 0.70 for all downstream implementations. Based on evaluation results for deemed measures in both WO29 and ESPI, the DEER team recommends revising the NTG for T5 high-bay applications to 0.65. For detailed references to ex post NTG results, refer to the complete NTG table update workbook posted on the DEER website.