NAVIGANT

California LED Workpaper Update Study

Final Report

Prepared for:
Southern California Edison, Pacific Gas & Electric, and San Diego Gas & Electric

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Executive Summary

Southern California Edison (SCE) contracted Navigant Consulting, Inc. (Navigant) on behalf of California's electric Investor Owned Utilities (IOUs) to update key parameters and methodologies used in the statewide light-emitting diode (LED) lighting workpapers.

Between May and August of 2014, Navigant collaborated with IOU stakeholders to identify and prioritize the research objectives and LED product categories to be included in the study. The final set of research objectives selected, focused on three key topics:

- LED **pricing**
- **Non-residential baseline** wattages (which inform the selection of appropriate wattage reduction ratios or wattage ranges)
- The ability of the currently used **savings estimation methods** to predict non-residential baselines (e.g., wattage reduction ratio and wattage ranges)

Prescriptive LED lighting measures in California use one of two savings estimation methodologies: wattage reduction ratios (WRRs) and wattage ranges. Wattage reduction ratios are the ratio of the deemed baseline wattage to the deemed LED wattage. The May 2014 lighting retrofit disposition provides guidance that a designated ratio must be applied to the lowest LED wattage within the range of wattages established for a LED product category (i.e. 6 – 10 W LED for A-19 lamps). The wattage ranges method maps LED wattages to baseline technology wattage ranges within various LED luminaire product categories, and savings are calculated as the difference between the lowest baseline technology wattage in the baseline range and the highest LED technology wattage in the LED range.

Table 1-1 shows the final list of product categories selected, divided into lamps (i.e. screw-in products) and luminaires. This division of product category is important to note, as each group uses a specific savings estimation methodology and carries a unique set of assumptions and findings.

Table ES-1. Priority LED Product Categories

LED Lamps*	LED Luminaires
A19	Downlight Fixture
MR16/PAR16	Recessed Troffer
PAR20, BR20, R20	High/Low Bay
BR30, R30	Parking Garage
R40, BR40	Parking Lot
PAR30	Wall Pack
PAR38	
Downlight Retrofit	

Source: Navigant summary of outcomes from discussions with IOU and CPUC staff during June and August

Data Collection

Between June of 2014 and May 2015, Navigant conducted the following primary data collection activities.

- Non-residential market-actor surveys
  - Phone and web surveys
    - Contractors
    - Distributors
    - Commercial End-Users
  - In-depth interviews
    - Manufacturers
    - Retailers
- Web-scraping[1] of LED (and non-LED) pricing and lighting specification data

In addition to primary data, the team used the following secondary data source:

- DOE pricing data - CALiPER, Gateway, SSL Municipal Consortium
- Qualified products list - Design Lights Consortium, LED Lighting Facts
- Pricing data from SCE's midstream pilot.

[1] Web-scraping is a technique used for extracting information from websites, thereby transforming unstructured data on the web into structured data that can be stored and analyzed.

Pricing Analysis Findings

As a key input to cost effectiveness, product price has been a critical yet difficult parameter to characterize and predict for LED products. The primary research objectives of the LED pricing analysis are to:

1. Develop current price estimates for high priority LED products
2. Determine the factors that significantly affect LED price
3. Project LED prices and determine how often assumptions need to be updated
4. Compare LED prices to applicable baseline prices
5. Predict price impacts on forecasted LED penetration

This section describes the findings and results of the LED pricing analysis by research objective. The detailed methodology of this analysis is included in Section 2 and Appendix A.3.

Current Price Estimates

Navigant leveraged its web-scraping database of lighting product pricing, in addition to web-scraped data provided by PG&E, as the key source for determining the current price of LEDs, with the following adjustments.[2]

- **Navigant applied a 30 percent reduction factor to all LED luminaire pricing values to account for the difference between online and typical purchase price.** Input gathered from the manufacturer and retailer in-depth interviews revealed that online and in-store price offerings for LED luminaire systems differ significantly. Unlike LED lamps, which showed a negligible difference in price online versus in-store, LED luminaires are more costly and are typically purchased by commercial end-users direct from manufacturers and distributors. This purchasing channel allows for greater volume discounts, less common to the online environment. Research found luminaire product prices to be between 20 and 40 percent higher online than the prices offered by manufacturers and distributors.
- **Navigant determined that the 25th percentile is appropriate for characterizing the typical purchase price for all LED product categories.** The web-scrape process requires the selection of a statistic that best represents the typical range in price for each LED product category. This ensures that extrapolations adequately characterize the typical purchase price for each point in time. Lawrence Berkeley National Laboratory (LBNL) conducted a consumer survey for a recent LED web-scraping analysis, and found that more than 80 percent of respondents purchased a LED lamp at or below the 25th percentile price, and more than 90 percent purchased

[2] Web-scraping is a technique used for extracting information from websites, thereby transforming unstructured data on the web into structured data that can be stored and analyzed. This database was built using web-scraping software to remotely collect in-store pricing information from Home Depot, Lowes, Walmart, Target, and Ace Hardware locations in San Francisco, Los Angeles and San Diego, as well as from retailers including Best Buy, Grainger, 1000bulbs.com, Amazon, BulbsAmerica.com and ProLighting.com which do not offer locational pricing on their websites. This pricing and specifications data has been collected for all high priority LED products categories annually since 2011 and quarterly starting in Q2 2013.

at or below the median price.[3] LBNL also concluded that the mean and median are volatile metrics that represent the tail of the purchase distribution, while the 25th percentile of their web-scraped data best represents the characteristic price for LED lamps.[4]

Navigant found the adjusted web-based pricing data aligns well with data collected across the market actor interviews and surveys, as well as with the data collected through the SCE midstream trial pilot. In contrast, the pricing estimates from the CA Statewide Cost Data Sheet are far outside the upper-bound of the web-based ranges.[5] This is largely due to the fact that the cost sheet data was collected in 2012 and represents a very small sample set of products.

Factors that Significantly Affect LED Price

Navigant analyzed a wide range of LED lamp and luminaire parameters and factors to determine how they affect mean product pricing. For LED lamps, Navigant analyzed the percentage price increase over the mean price for all parameters associated with both ENERGY STAR qualified LED products, and the California LED Quality Standard.[6] Table 2-3 and Table 2-4 in Section 2.2 provide the analysis results. The team found the price increase is particularly substantial for LED A-type and MR16 lamps, where eligible products are estimated to cost nearly 50 percent more than the mean price indicated in Table 2-1.

Navigant also conducted a multi-variable regression to reveal the accuracy with which specific individual parameters predict LED luminaire price. The team considered efficacy, watts, lumens, color temperature (CCT), CRI, and lifetime, and found weak correlations between these parameters and the pricing of the LED luminaire product categories studied. Compared to LED lamps, there is a wider range of acceptable performance specifications for luminaires, which have a more diverse set of application specification considerations. There are also many additional features that characterize luminaire performance that are not tracked in the web-scraped database, such as R9 value, power factor, color tunability, advanced controls, wireless communication, DLC qualification, photometry and beam characterization. Appendix 3.3 provides the detailed results of this multi-variable regression.

Projected LED Prices

Survey responses across all market actors indicated that prices have not stabilized for any high-priority LED product category. Navigant's web-based pricing analysis indicates that in the near term, average LED lamp prices will decrease by 21 percent per year and luminaires by 20 percent per year. Market actor survey results of a 16 percent per year annual decrease support the web-based results. Constant year-over-year price decline, however, will not continue indefinitely. Rather, the rate of decline for several of these LED product categories is expected to slow within the timeframe of this projection

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[3] Over 85% of the web-based LED pricing data collected by LBNL was from online-only vendors, therefore, the data source is largely unaffected by rebates.
[4] "The evolving price of household LED lamps: Recent trends and historical comparisons for the US market", LBNL, November 2014.
[5] IMC Analysis CA Statewide Cost Data Sheet, data for LEDs was collected in May 2012. The LED price data sheet is used by the California IOUs for program planning purposes, incentive design, and measure cost estimates.
[6] California Energy Commission, A Voluntary Minimum Specification for "California Quality" LED Lamps, DECEMBER 2012. http://www.energy.ca.gov/2012publications/CEC-400-2012-016/CEC-400-2012-016-SF.pdf

analysis. The team conservatively believes that these price projections will remain reasonable for the next 2 to 3 years only (until about 2017 or 2018).

Baseline Price Comparisons

In addition to collecting web-based data for LED lighting products, Navigant also collected product price and specification data for baseline technologies.[7] Findings were similar to those for LEDs. Based on the analysis of the LBNL study, Navigant determined that the 25th percentile is also appropriate for characterizing the typical purchase price for incandescent, CFL, halogen, linear fluorescent and HID lighting products. The pricing estimates of baseline products included in the CA Statewide Cost Data Sheet are significantly higher than the upper-bound of the web-based ranges. This is largely due to the timing of data collection, completed in 2012, and the very small set of products represented in the sample.

Price Impacts on Forecasted LED Penetration

Navigant updated the existing U.S. DOE lighting market model based on the price projection curves developed for this study to show how national LED adoption would be impacted by these California price projections.[8] The U.S DOE lighting market model predicts LED market share as an aggregate of many individual purchase decisions, based upon two analytic components 1.) an econometric logit model that considers cost factors influencing each decision, and 2.) a technology diffusion curve that considers time dependent market factors influencing each decision.[9] The results indicate that LED price has a significant impact on adoption. If prices continue to fall according to their current trajectory, the team expects LED lamps and luminaires to represent nearly 30 percent of all installations by 2020.

Navigant predicts LEDs to have the greatest adoption in outdoor applications, such as parking and building exterior, largely due to maintenance cost benefits. Improvements to the LED technologies make them the first viable option for these applications. In contrast, saturation is slower for general service and directional lamps since first cost is the major factor driving purchasing decisions and non-energy benefits are not as compelling. LEDs have the lowest adoption in troffer applications due to low cost high efficiency linear fluorescent technology. Additional information and graphics detailing Navigant's analysis methodology and the adoption of LEDs relative to baseline technologies are provided in Section 2.5 and Appendix A.3.5.

[7] Data was collected from Home Depot, Lowes, Ace Hardware, Target, Walmart, and Grainger.
[8] U.S. DOE, Energy Savings Forecast of Solid-State Lighting in General Illumination Applications, Prepared by Navigant, August 2014. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/energysavingsforecast14.pdf
[9] The conditional logit model is a widely recognized method of forecasting a product's market penetration based on several quantitative or categorical explanatory variables. The result of the conditional logit is a probability of purchase, which represents an aggregation of a large number of individual consumer purchasing decisions.

Non-Residential Baseline Analysis Findings

The primary research objectives of the LED baseline analysis are to:

1. Define the comparison factors most considered when selecting LED products
2. Outline the type and mix of baseline technologies for early retirement (ER) and replace on burnout (ROB) LED installations
3. Determine whether the decision making for LEDs is unique such that it warrants more rigorous baseline research
4. Understand how assumptions about non-residential baseline technologies should change during the next few years

This section describes the findings and results of the LED baseline analysis by research objective. The detailed methodology of this analysis is included in Section 3.

Comparison Factors

Equivalent light output was the single most important factor for all market actors when choosing an LED product to install. End users also placed importance on light color and wattage equivalency. It is important to note that equivalent light output does not always imply equal lumen output across the baseline and LED cases: some customers wish to increase or decrease light levels for safety or aesthetic reasons and consider light distribution as well as total lumens.

Technology Mix by Baseline Type

Survey responses collectively showed a higher share of CFLs in the market baseline for LED lamps than the 50 percent assumed in the May 2014 lighting retrofit disposition. Of the three groups of surveyed market actors, distributors reported the lowest percent of CFLs in their A-line market mix, at 59 percent. This is important, as the team believes distributors are the least biased primary data source for this question due to their broader market perspective not limited to program activity. Due to program influence, participating contractors and end-users targeted by the surveys, on the other hand may be more likely to choose another incented product when LEDs are unavailable, biasing reported CFL share estimates on the high side. To minimize this bias in the baseline analysis, the team recommends using only the responses from distributors when estimating WRRs.

Beyond the CFL-portion of the baseline, incandescent sales now include halogen incandescent bulbs with higher efficacy, due to EISA legislation. It is unclear to Navigant whether any portion of the current LED lamp baseline was assumed to be halogen.

Linear fluorescent products dominate the market baseline technology mix for both high and low-bay lighting. When asked for market shares by technology for bay lighting, responses for linear fluorescent products ranged from 49 percent for end users to 75 percent for contractors. While the May 2014 lighting retrofit disposition suggests the industry standard practice baseline for bay lighting is pulse-start metal halide (PSMH), market actors generally reported few sales of HID products. End users reported a higher share of HID technology than did distributors and contractors and also estimated that CFLs account for about 16 percent of the market.

Exterior lighting sales also include a significant number of linear fluorescents, though they are not as dominant as in the bay lighting analysis. Other exterior lighting shares vary by sales channel; distributors reported that HID would be the most common alternative to LEDs, contractors reported higher shares of induction lighting, and end-users reported a higher share of CFLs. These results suggest that as other products take market share from HID luminaires in new installations, PSMH technology may no longer be an accurate representation of standard practice in bay and exterior lighting.

Incidence of Early Replacement

The majority of contractors and end users indicated that they are more likely to replace equipment before the end of useful life when installing LEDs than when installing new non-LED equipment (Figure 3-7). This suggests that LED decision making is unique and warrants additional research on early retirement and replace-on-burnout baselines, especially given the variation in technology mixes this study found to exist across these two baselines. This finding is corroborated by the SCE LED Midstream Pilot Evaluation, which found that 92 percent of pre-existing equipment replaced in the pilot was in working order.[10] PG&E's Midstream Trial found similar results, where eighty-two percent of Trial LED replacement lamps were installed in sockets with functioning existing lamps, and 18 percent were installed in places where lamps had failed.[11]

Savings Estimation Methods Analysis Findings

Non-residential prescriptive LED lighting measures in California use one of two savings estimation methodologies: wattage reduction ratios (WRRs) and wattage ranges. These methodologies were selected, in part, due to the fact that many IOU programs offer measures in wattage ranges, rather than requesting individual lamp wattages or other technical specifications, in an attempt to reduce administrative burden on participants.

- **Wattage reduction ratios** are the ratio of the deemed baseline wattage to the deemed LED wattage. The CPUC's original integral LED disposition[12] sought to establish WRRs that drew upon the available data provided in IOU workpapers where possible. At the time, the CPUC was concerned about the use of LED wattage ranges for a single baseline wattage, as they believed there was no assurance that lower wattage LED lamps provided the same level of service as higher wattage products. CPUC also noted lack of evidence for customer preference for equivalent light output products, which this study has since researched. These concerns weighed in to the guidance delivered in May 2014 lighting retrofit disposition, which states that a designated ratio must be applied to the lowest LED wattage within the range of wattages established for a LED product category (i.e. 6 – 10 W LED for A-19 lamps), creating a disincentive for programs to focus on more efficient products. May 2014 lighting retrofit disposition.

[10] "Evaluation of the Southern California Edison Commercial Midstream LED Lighting Distributor Pilot Program." Evergreen Economics, May 2015. CALMAC ID: SCE0376.01
[11] "PG&E Lighting Innovation Midstream Trial Evaluation." Evergreen Economics, 2015. Final report not yet posted.
[12] Integral LED Lamp Disposition, 2012

- The **wattage ranges method** maps LED wattages to baseline technology wattage ranges within various LED luminaire product categories. Savings are calculated as the difference between the lowest baseline technology wattage in the baseline range and the highest LED technology wattage in the LED range, again creating a disincentive for programs to focus on more efficient products.

While CPUC and IOU staff have recognized the weaknesses of both approaches, the timing between disposition releases and revised filing deadlines have historically limited IOUs' ability to propose substantial changes to the current methodologies to date.

This study sought to provide direction for future improvements to LED workpapers, and Navigant's research aimed to address three main questions for both of these methods. Figure ES-1 summarizes these questions.

Figure ES- 1 Core Savings Estimation Research Questions

Source: Navigant

This section describes the findings and results of the LED savings estimation method analysis by method. The detailed methodology of this analysis is included in Section 4 and Appendix A.4 and A.5. Baseline findings apply to non-residential applications only; the team did not collect data on residential baseline.

Wattage Reduction Ratio Findings

Navigant's analysis resulted in three key findings:

- **The WRR approach provides a disincentive for programs to focus on more efficient products**. The current WRR method assumes that the baseline always shifts linearly with LED wattage within a product group. For LEDs, a product family where the efficacy is changing at rates of 20 percent per year[13] and is highly variable at any point in time across and within manufacturers, this is not an accurate assumption. Moreover, this use of a multiplier results in lower savings for more efficient (lower wattage) LED products and higher savings for less efficient (higher wattages) LEDs products. For example, in the case where both a 13 W and 11 W A-lamp LEDs have the same lumen output, using a WRR of 2.96 would yield a savings of 26 W and 22W

[13] Year over year change in average efficacy of A-line products in the 25th price percentile from 2013 to 2014: 14% for 40W equivalents, 23% for 60W equivalents, 15% for 75W equivalents, and 24% for 100W equivalents.

respectively.[14] Despite the 11W product being more efficient by 2 W (or 15%), the savings determined using the current WRR method is reduced by 3.9 W (-15%). This disparity creates an incentive for *less efficient* technology and underestimates savings for more efficient LEDs. Additionally, the current method forces program staff to apply the WRR to the most efficient product regardless of what is installed. For a measure covering a range of LED wattages, for example 15-21W LED A-lamps, current guidance states that the WRR must be applied to the lowest LED wattage within the range, providing no incentive to promote the most efficient products in the market.[15]

- **Some existing WRRs may be too broad.** In the case of A-line lamps, the existing WRRs are too broad to accurately capture the range of efficacies within a product category: LED efficacy varies across the different lumen bins defined by EISA. In addition, the baseline varies across these bins due to bin-jumping.
- **Most existing WRRs are too high.** Increases in the shares of efficient baseline screw-in lamp technologies have lowered the baseline wattage for most screw-in technologies in the non-residential sector. For A-lamps and most reflectors, CFLs are becoming an increasingly large portion of sales. In addition, A-lamp incandescent sales are giving way to more efficient halogen lamps as the EISA legislation takes effect.

Navigant collected survey responses regarding the current market mix of baseline technologies to create revised WRRs for LED lamps. These values, as well as recommendations to further improve the methodology are provided in Section 4-2 and 4.4 respectively.

Wattage Ranges

Navigant's analysis suggests that the typical installed LED wattage for bay and exterior lighting applications falls nearer to the mean of the existing LED wattage ranges. The existing methodology of deriving delta watt savings using the upper bound of the LED wattage range is therefore underestimating savings and not reflecting typical installation. It also dis-incentivizes the promotion of more efficacious products.

Navigant collected survey responses regarding the current market mix of baseline technologies to create revised wattage ranges for LED bay lighting. These ranges, as well as recommendations to further improve the methodology are provided in Section 4.3 and Section 4.5 respectively.

Key Findings and Recommendations

Navigant has identified the following key findings and recommendations by research topic, as well as providing the stakeholder for whom each recommendation is most relevant.

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[14] The baseline for the 13W LED would be: 13W x 2.96 = 38.5W, and the delta Watts would be: 38.5W – 13W = 25.5W. For the 11W LED, the baseline would be 11W x 2.96 = 32.6W, and the Delta Watts would be: 32.6W – 11W = 21.6W.

[15] In response to this guidance, Program Staff have created individual measure codes to very finely bin wattage ranges, which has complicated both the programs and evaluation efforts.

Pricing

Program Staff

- Finding: Current prices for both LED and baseline (non-LED) products included on the CA Statewide Cost Data Sheet are no longer accurate.[16]
    - Recommendation: Update cost sheet to use web-based pricing analysis results for LED and baseline (non-LED) products provided in Table 2-1. Also consider using updated incremental cost results.
- Finding: There is no statistical difference for any high-priority LED product category between the San Francisco and San Diego mean price at the 95 percent level of confidence.
    - Recommendation: All IOUs can use the same updated cost data.
- Finding: Prices have not stabilized for any high-priority LED product category. The web-based pricing analysis indicates that in the near term, average LED lamp prices will decrease annually by 21 percent per year and luminaires by 20 percent per year.
    - Recommendation: Use updated costs data for the next 2 to 3 years only (until about 2017 or 2018).

Non-Residential Baseline

CPUC – Energy Division & IOU Program Staff

- Finding: Although there was variation among market actors, survey responses collectively showed a higher share of CFL lamps in the non-residential market baseline than the 50 percent assumed in the disposition. Additionally, due to EISA legislation, incandescent sales now include halogen incandescent lamps with higher efficacy. For bay lighting applications, most market actors reported high shares of linear fluorescent lamps and relatively low shares of PSMH lighting. This indicates that a baseline of 100 percent PSMH may no longer be standard practice. Standard practice baselines are especially important where no code requirements exist or code requirements are unclear.
    - Recommendation: Consider updating the non-residential baseline for LED lamps to reflect the current market mix of baseline technologies.
    - Recommendation: Consider updating the non-residential baseline for bay lighting to reflect the current market mix of baseline technologies. This may require additional research since not all fixtures are one-to-one replacements and the survey did not collect data on number of lamps per linear fluorescent fixture.

Savings Estimation Methods

Wattage Reduction Ratios
CPUC – Energy Division & IOU Program Staff

[16] IMC Analysis CA Statewide Cost Data Sheet, data for LEDs was collected in May 2012.

- Finding: The WRR method underestimates savings for more efficient lamps and overestimates savings for less efficient lamps, which provides a disincentive for programs to focus on more efficient products. Additionally, existing WRR values also do not accurately reflect the current baseline and LED efficacies in the non-residential market.
    - Recommendation: Navigant presents the following "good, better, best" options for the DEER team to consider as they continue research focused on improving the methodology for screw-in lamps, recognizing that some changes may not be possible.
        - **Ideal "Best" Method**. The most accurate option is to determine a single baseline for each product category—i.e. EISA lumen bin—and determine which bin LEDs fall into by collecting actual lumen output for incented products. This is the recommended approach for A-line lamps in the residential lighting uniform methods protocol.[17] Average program LED wattage per bin would determine the savings. In lieu of program LED wattage averages, average LED wattage for each bin could be updated annually with web-scraping data.
            - This approach would require programs to collect detailed records of incented LED products including wattage and efficacy or lumen output.
        - **Alternative "Better" Method**. If collecting lumen output is not possible, simply assigning a single baseline wattage for each product category and assigning product categories by LED wattage could be an improvement. In this case, savings should be the category baseline watts minus the actual LED watts. Programs would need to review the LED wattage bin mapping annually to account for increases in efficacy that will change the LED bounds of each EISA category.
            - This approach would require programs to collect the rated wattage of incented LED products.
        - **Possible Improvements to WRR Method**. If the WRR method cannot be changed, the following improvements to its application will improve accuracy:
            - Update average LED efficacy and wattage annually using web-scraped data
            - Apply different WRRs to each EISA bin as determined by LED lumens (ideal) or wattage (possible)
            - Update baseline technology mix and wattage regularly, starting with mix reported in distributor surveys

Wattage Ranges
CPUC – Energy Division & IOU Program Staff

[17] Dimetrosky, Scott. "Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 6, Residential Lighting Evaluation Protocol." p. 6-7. http://energy.gov/sites/prod/files/2013/11/f5/53827-6.pdf

- Finding: Navigant's analysis suggests that the typical installed LED wattage for bay and exterior lighting applications falls nearer to the mean of the existing LED wattage ranges. The existing methodology of deriving delta watt savings using the upper bound of the LED wattage range, therefore, is underestimating savings and not reflecting typical installation. Moreover, it provides a disincentive to promote the most efficacious products.
  - Recommendation: Update guidance in next lighting disposition to specify using the mean of LED wattage ranges for delta watts calculations instead of upper end.
  - Recommendation (for bay lighting):[18] Consider adding the narrower ranges suggested in Figure 4-7 within the current lowest wattage range to improve accuracy in the delta watts savings calculation.

IOU Program Staff

- Finding: Due to the large variability in LED product efficacy and quality, using broad wattage ranges may lead to inaccurate savings estimates.
  - Recommendation: Collect more detailed product information on pre-and post-retrofit fixtures, namely quantity and rated input wattage and lumen output. This will allow programs to verify whether high quality, efficacious products are in fact the majority of program participation. An alternative method based on lumen output and fixture quantity is presented in the recent disposition on LED troffers, which could be used here but would also require programs to collect data on rated lumen output.[19]

Suggestions for Future Work

As the price, specifications and market share of LED products are rapidly changing, Navigant suggests the following areas for future work, aimed at keeping LED workpaper assumptions current and accurately predicting achieved savings.

Pricing

Program Staff

- Goal: Update price forecasting assumptions for LEDs annually until prices stabilize.
  - Suggested method: Use web-scraping to continually collect LED and baseline pricing. Specifically consider conducing web-scraping:
    - Quarterly for LEDs
    - Annually for baseline technologies
- Goal: Product price is a key determinant of LED cost-effectiveness, and is often cited as the most powerful influencer of adoption. The insights gained from a customized California lighting

[18] Bay lighting was the only wattage range application for which Navigant collected sufficient survey data to compare to the existing wattage ranges.
[19] Workpaper Disposition for PGECOLTG179 LED Ambient Commercial Fixtures and Retrofit Kits, California Public Utilities Commission, Energy Division, June 26, 2015

market model could be used to identify future attainable savings potential and help shape long term lighting measure goals and strategies.

  - Suggested method: Further customize DOE's lighting market model to better reflect the unique trends in the California region. (e.g. Initial installed stock and distribution of lighting technologies, building stock and space types, floor space growth, lighting product characteristics and performance, operating hours, etc.)

Non-Residential Baseline

CPUC – Energy Division & IOU Program Staff

- Goal: Better understand the distribution of early retirement versus replace on burnout LED installation. The majority of surveyed contractors and end users indicated that they are more likely to replace equipment before the end of useful life when installing LEDs than when installing new non-LED equipment.
  - Suggested method: Conduct additional research, including on-site evaluations, to establish prevalence of various baselines and customer motivations for early retirement LED projects.[20]

Savings Estimation Methods

Wattage Reduction Ratios
Program Staff

- Goal: Keep WRRs accurate.
  - Suggested method: Conduct annual web-scraping to update LED efficacies and wattages.
  - Suggested method: Continue research on baseline technology mix and consider alternative research methods such as field work or collecting non-residential sales data. Field work can support research on early replacement baselines, but understanding ROB baselines requires data on the mix of products newly installed outside of programs. While difficult to collect, sales data from distributors can be a valuable tool for assessing market baselines and has been used successfully in the Northwest.[21]
  - Suggested method: Collect lumen output data of incented lamps to improve understanding of which baseline products they are replacing by using lumens to map an incented product to its EISA lumen range

Wattage Ranges

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[20] Note that IOUs cannot claim early retirement projects unless they are program-induced early retirements. CPUC has provided guidance on establishing the "preponderance of evidence" that a program influenced early retirement.
[21] Bonneville Power Administration, "Northwest Nonresidential Lighting Market Characterization: 2010-2012." Prepared by Navigant Consulting and Cadeo Group, May 2014. http://www.bpa.gov/EE/Utility/research-archive/Documents/Northwest_NonRes_Lighting_Market_Characterization.pdf

Program Staff

- Goal: Keep Wattage ranges accurate:
    - Suggested method: Conduct additional research focused on mapping LED lumen output and wattages to baseline technology lumen output and wattages. This could include the following activities:
        - Reviewing a random sample of manufacturer literature for suggested equivalency
        - Reviewing custom program tracking data or tracking data from other jurisdictions where pre-and-post case fixture wattage, efficacy and quantity are known
        - Collecting more detailed data on program LED products and equipment they are replacing, including wattage, efficacy and quantity
        - Repeating original workpaper analysis with current Design Lights Consortium (DLC) data[22]
        - Conducting field research to confirm reported preference for equivalent light output

[22] Using the current Design Lights Consortium qualified product list available at https://www.designlights.org/QPL