Impact Evaluation of 2015 Upstream and Residential Downstream Lighting Programs

California Public Utilities Commission

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1 EXECUTIVE SUMMARY

This report presents an impact evaluation of the California investor-owned utilities' (IOU) 2015 upstream and residential downstream lighting programs. Upstream programs typically provide incentives to manufacturers (and in some cases, retailers) to encourage stocking of energy-efficient technologies, while downstream programs typically provide incentives directly to utility customers. DNV GL conducted this evaluation as part of the California Public Utilities Commission (CPUC) Energy Division (ED) Evaluation Measurement & Verification Work Order ED_I_LTG_4: 2013-2015 Lighting Impact Evaluation and Market Research Studies.

Our evaluation addresses all upstream lighting measure groups[1] aimed at the residential and nonresidential sectors and all downstream lighting measures targeted at the residential sector. For all upstream residential measures, we present the energy savings and peak demand reductions that these measures achieved relative to technologies that they replaced (gross savings), as well as the energy savings and peak demand reduction these measures achieved relative to products that would have been purchased in the absence of the programs (net savings). The energy savings and peak demand reductions from upstream residential measures account for the majority of savings from the upstream lighting program. Nonresidential measures and downstream residential measures account for a small percentage of overall program savings, so we use program planning assumptions for these measures (also known as "ex ante" assumptions) versus results from our evaluation (known as "ex post" results).

1.1 Program background

Together, upstream and residential downstream lighting measures account for between 4% and 18% of each IOU's reported ex ante net annual electric savings, and between 2% and 11% of each IOU's net peak demand reductions (Table 1). For comparison, during the 2013-14 program period, upstream and residential downstream lighting measures accounted for 9% to 18% of each IOU's reported net energy savings and 7% to 16% of each IOU's reported net peak demand impacts.

Table 1. Summary of IOU-reported ex ante net annual savings from upstream and residential downstream lighting measures, 2015*

IOU	IOU Reported Net Annual Savings					
	Total Portfolio		Upstream / Residential Downstream Lighting		Upstream / Residential Downstream Lighting as Percent of Total Portfolio	
	Energy (GWh)	Peak Demand Reduction (MW)	Energy (GWh)	Peak Demand Reduction (MW)	Energy (GWh)	Peak Demand Reduction (MW)
PG&E	1,146.25	244.64	43.66	5.90	4%	2%
SCE	1,183.52	245.45	211.52	28.15	18%	11%
SDG&E	243.00	53.47	33.07	4.43	14%	8%
Statewide	**2,586.53**	**549.64**	**288.25**	**38.48**	**11%**	**7%**

* Ex ante data used in this table and throughout the report were final as of October 6, 2016.

[1] The term "measure" refers to a specific lamp type (such as a 9-Watt light-emitting diode [LED] A-lamp). We collapse these into measure groups—such as "LED A-lamp (all wattages)," which consists of similar measures (for example, 3-Watt LED A-lamps, 9-Watt LED A-lamps, and so on).

Upstream lighting measures fall into 15 measure groups. For example, the light-emitting diode (LED) reflector measure group includes all LED reflector lamp wattages and styles. While savings claims included in the IOU tracking data are based on assumptions tied to specific measure characteristics, the evaluation estimates savings at the measure group level.

This evaluation researched six upstream lighting measure groups in detail. Taken together, these measures account for 87% of ex ante net savings from upstream and residential downstream lighting measures in 2015. These include:

- Medium screw-base (MSB) compact fluorescent lamp (CFL) basic spiral[2] ≤ 30 watts (W)
- MSB CFL A-lamp ≤ 30 W
- MSB CFL reflector ≤ 30 W
- MSB CFL high-wattage (> 30 W)
- LED A-lamps of all wattages[3]
- LED reflector lamps of all wattages

Most of these measure groups accounted for more than 5% of total portfolio net savings, across IOUs. The one exception is the MSB CFL basic spiral ≤ 30 W measure group, which accounted for 3%. We evaluated this measure group because we largely performed our study methodologies in parallel for all measure groups considered a-lamp replacements (MSB CFL basic ≤ 30 W, MSB CFL A-lamp ≤ 30 W, and LED A-lamp ≤ 30 W).[4] Table 2 shows the quantity of evaluated measures for which each IOU provided incentives through its 2015 upstream lighting program by measure group and IOU.

Table 2. Quantity of lamps in evaluated upstream lighting measure groups by IOU, 2015

Evaluated Upstream Lighting Measure Group	Quantity (Number of Lamps)			Overall Quantity (Across IOUs)	
	PG&E	SCE	SDG&E	Total	% of Total
MSB CFL basic spiral ≤ 30 W	499,902	0	20,795	520,697	4%
MSB CFL A-lamp ≤ 30 W	21,610	1,126,146	265,251	1,413,007	10%
MSB CFL reflector ≤ 30 W	0	2,639,047	88,564	2,727,611	20%
MSB CFL high-wattage (> 30 W)	69,696	2,315,789	203,480	2,588,965	19%
LED A-lamp, all wattages	1,381,811	1,548,699	640,392	3,570,902	26%
LED reflector, all wattages	694,575	1,626,451	423,502	2,744,528	20%
Overall	**2,667,594**	**9,256,132**	**1,641,984**	**13,565,710**	**100%**

1.2 Evaluation objectives

The overarching goal of the impact evaluation for the 2015 upstream and residential downstream lighting measures is to verify and validate the IOU-reported energy savings and peak demand reduction estimates. The impact evaluation approach has three objectives:

[2] The CPUC defines “basic spiral CFLs” as single-wattage, non-dimmable, bare spiral CFLs of up to (and including) 30 W. For the sake of clarity, we refer to these lamps as “basic spiral CFLs” throughout the report.

[3] Note that while the CFL measure groups include MSB lamps only, the LED lamp measure groups include all base types.

[4] We provide more detail on this in Section 5.1 and Section 6 of the report.

1. Develop measure quantity adjustments, which include program invoice and application verification, an assessment of the percentage of IOU-discounted products purchased by non-IOU customers (i.e., leakage), and an assessment of the percentage of IOU-discounted products purchased by residential versus nonresidential customers.
2. Develop gross savings estimates, which include an assessment of the percentage of IOU-discounted measures installed as well as estimates of the average daily operating hours (hours-of-use, or HOU), the average percent of time that measures operate during high-use periods (peak coincidence factor, or CF), the wattage displaced by IOU-discounted measures (delta watts), unit energy savings (UES) in kWh/year and therms/year, peak demand reduction in kW/year, and lamp installation rate.
3. Develop net savings estimates, which include the percent of efficient lamps that people purchased because of program discounts, market-based UES in kWh/year and therms/year, peak demand reduction in kW/year, and a net-to-gross ratio (NTGR).

1.3 Evaluation approach

Below, we present data sources that we leveraged in this evaluation and an overview of our approach.

1.3.1 Data sources

DNV GL conducted six data collection efforts in support of this evaluation (Table 3f). We leveraged the 2016 consumer telephone surveys, in-store shopper intercept surveys, and retail lamp stock inventories as inputs to a model. This model simulates shopper decision-making regarding their lamp purchases and provides estimates of the percent of the total lamp sales for which a particular lamp type accounts. As we discuss in more detail below, these market share estimates supported our assessment of the program's savings. In addition to these primary data sources, we also leveraged secondary sources such as 2015 program tracking data and past evaluation studies and reports.

Table 3. Primary data sources: upstream and residential lighting programs impact evaluation, 2015

Data Source	Timing	Sample Size
2015 consumer telephone surveys	Summer, 2015	1,016
2016 consumer telephone surveys	Fall, 2016	578
2016 consumer online surveys	Fall, 2016	313
In-depth telephone interviews with lamp suppliers	Fall, 2016	27
Retail lamp stock inventories	Winter 2015-16	207
In-store shopper intercept surveys	Winter 2015-16	431

1.3.2 Method

We used the following approach to achieve the study's objectives:

1. Develop measure quantity adjustments
    a. **Residential versus nonresidential upstream lighting purchases.** We adjusted the percentage of upstream lamps that customers installed in residential and nonresidential applications.
    b. **Invoice verification**. Using data from prior evaluations, we confirmed that lamp quantities and types in the IOUs' program records matched the quantities and types on the lamp suppliers' shipping invoices.
    c. **Leakage**. We estimated the percentage of IOU-discounted lamps that were installed outside of California IOU territory using findings from prior evaluations.
2. Develop gross savings inputs

a. **Hours of use and use at peak (high-use) periods.** We leveraged data from in-home lamp metering efforts in prior studies to estimate daily hours of use for California IOU customers' lights, and the overlap of this usage with periods of highest energy demand.

b. **Delta watts.** We used results from a residential on-site survey to estimate the average wattage of lamps installed in IOU customers' homes. This is the average wattage of lamps that program-discounted lamps replaced. The difference between the average program-discounted lamp's wattage and the average replaced lamps' wattages is called "delta watts."

c. **Lighting interactions with heating, ventilation, and cooling (HVAC) system usage**. Because CFLs and LED lamps are more efficient than traditional incandescent lamps and their newer, slightly more efficient counterparts[5], they generate less heat. When lighting generates less heat, it creates small reductions in electricity usage during the summer (because of a slightly reduced need to cool the space). Less heat from lighting also increases gas consumption slightly in the winter (because of a slightly increased need to heat the space). The industry refers to these impacts as "HVAC interactive effects". We applied ex ante assumptions to calculate HVAC interactive effects.

d. **Unit energy savings**. We used the three parameters to calculate the energy saved by each program lamp—hours of use, delta watts, and HVAC interactive effects. We refer to the savings per program-discounted lamp as "unit energy savings" (UES).

3. Develop net savings inputs

a. **Calculate program-attributable sales of each program lamp type as a percent of program volume (NTGRq)**. Customers still would have purchased some efficient lamps in the absence of program discounts. We simulate consumer decision making to estimate the degree to which customers would have purchased each lamp type with program lamps available and without program lamps available. We adjusted our model simulations using details regarding stocking practices that influenced lamp availability from in-depth telephone surveys with lamp manufacturers and retail representatives. The ratio of program lamp purchases that would have been a different lamp technology without the program to the quantity of all program lamps is called the "quantity net to gross ratio" (NTGRq).

b. **Calculate the wattage of the lamp purchases that program lamps displaced (NTGRu)**. The gross savings calculations assume that purchases made in the absence of the program would have the same technologies and wattages of lamps that were previously installed. However, the wattage of a lamp that was installed may not necessarily be the wattage of the lamp that the customer would have purchased in the absence of the program. We used the same modelling process that estimates the NTGRq to estimate the degree to which program lamps displaced competing lamp technologies. We then used retail lamp stock inventory data to estimate the wattages of those displaced lamps. We were thus able to calculate the amount of energy that the program lamps saved relative to the displaced purchases. We call this factor the "net unit energy savings." The ratio of the net unit energy savings to the gross unit energy savings is called the UES net-to-gross ratio (NTGRu).

c. **Calculate the overall net to gross ratio (NTGR)**. We multiplied the NTGRq by the NTGRu to estimate the overall NTGR. We then applid the overall NTGR to the gross savings estimate to produce the final net energy savings that the program achieved.

1.4 Evaluation results

In this section, we summarize the evaluation results, including gross savings, net savings, and net-to-gross ratios (the ratio of net savings to gross savings).

5 This refers to lamps that comply with the standards set forth in the 2007 Energy Independence and Security Act (EISA), a federal standard that regulates lamp efficiency.

1.4.1 Gross Savings

Table 4 provides an overview of ex ante and ex post gross annual energy savings, demand reductions, and realization rates[6] for 2015 evaluated upstream lighting measures across IOUs. As the table shows, the IOUs achieved ex post gross annual energy savings of more than 433 GWh for 2015 measures. Key drivers for the gross savings results include:

- **Difference in ex ante and ex post approaches to estimating gross delta watts.** Gross delta watts is the difference between program-discounted lamp wattages and the wattage of lamps they replace when installed. Ex ante estimates use a wattage reduction ratio while ex post uses a difference between the average program wattage and the average installed wattage. Where program lamps had lower average rebated watts in a specific measure group (such as LED A-lamps), ex post estimates were higher than ex ante estimates, and vice versa (such as High-wattage CFLs > 30). The low wattages of program LED A-lamps and LED reflector lamps led to high gross savings results.
- **Residential/nonresidential split for SDG&E.** SDG&E's ex ante assumptions allocated all upstream lighting program lamps to the residential sector. Ex post assumptions allocated 94% to the residential sector and 6% to the nonresidential sector. Savings are generally higher in the nonresidential sector because hours of use are greater. (PG&E's and SCE's ex ante assumptions largely matched the ex post assumptions.)
- **Higher ex post CFL installation rates than ex ante for PG&E and SCE.** PG&E's ex ante installation rates for all CFL measure groups was 67% and SCE's was 77%. The ex post installation rate estimate was 95% for all IOUs. (SDG&E's ex ante CFL installation rate was 97%.)

Table 4. Ex ante and ex post gross savings and realization rates by evaluated upstream lighting measure group across all IOUs, 2015

Gross Savings Element	Evaluated Upstream Lighting Measure Group						Overall
	MSB CFL basic spiral ≤ 30 W	MSB CFL A-lamp ≤ 30 W	MSB CFL reflector ≤ 30 W	MSB CFL high-wattage (> 30 W)	LED A-lamp, all wattages	LED reflector, all wattages	
Ex Ante							
kWh	13,621,389	38,947,183	108,611,618	162,860,055	35,674,313	74,038,848	433,753,405
kW	1,864	5,402	14,624	22,502	4,853	10,313	59,558
Therms	(247,872)	(521,845)	(1,542,560)	(2,231,110)	(581,839)	(1,129,691)	(6,254,916)
Ex Post							
kWh	11,314,334	39,913,035	91,145,975	101,521,443	109,741,192	101,120,464	454,756,443
kW	1,762	5,754	13,469	16,607	12,987	13,124	63,703
Therms	(183,691)	(516,867)	(1,141,932)	(983,407)	(2,008,537)	(1,644,388)	(6,478,823)
Gross Realization Rate							
kWh	83%	102%	84%	62%	308%	137%	105%
kW	95%	107%	92%	74%	268%	127%	107%
Therms	74%	99%	74%	44%	345%	146%	104%

1.4.2 Net Savings

We developed two factors to calculate net savings (as we explained above in Section 1.3): the NTGRq and NTGRu. Both of these factors are essential when interpreting the net savings results. The NTGRq is the share of program-discounted lamps that customers would not have purchased in the absence of the program.

[6] The realization rate is the ratio of ex post savings to ex ante savings

The NTRGu is the ratio of energy savings that the program achieved in the market, compared to the energy savings that the program achieved by efficient lamps that IOU customers replaced in homes. We multiply these two factors together to estimate an overall NTGR. For example, LED A-lamps received an overall NTGR of 30% to 33%. This finding does not suggest 67% free-ridership.[7] The NTGRq (roughly 60%) suggests that the program was responsible for selling around 60% of the program LED A-lamps, meaning 40% would have sold at higher, non-program prices. The NTGRu (roughly 50%) decreases the overall NTGR further, meaning that the lamps that were displaced on the market were in general more efficient than the lamps IOU customers replaced with LED A-lamps on average. Key drivers for net savings include:

- **NTGRq: Low program influence for CFL basic spiral and high-wattage CFLs, moderate influence for LED lamps, and high influence for CFL A-lamps and CFL reflector lamps**. The NTGRq for basic spiral CFLs and high-wattage CFLs > 30 W was between 21% and 56% across all IOUs (i.e., free-ridership was high)[8]. The NTGRq for LED A-lamps was approximately 60% across all IOUs (moderate free-ridership), and between 69% and 90% for CFL A-lamps and CFL reflectors for all IOUs (low free-ridership).
- **NTGRu: The blended efficiency of program-displaced sales, and the customers who shopped in stores where program lamps were available were major drivers in the net savings results.** For measure groups where the NTGRu was low (for example LED A-lamps, 51% to 55%), the displaced sales within a replacement group (the basis for the net UES) were of lower wattages than the existing lamps installed in IOU customer residences (the basis for gross UES). This is reasonable given the market trends suggesting an upward trend in efficient lamp purchases.[9] For other measure groups where NTGRu results were fairly high (for example CFL A-lamps, 81% for SCE to 157% for PG&E), the channels that sold program lamps largely stocked non-program lamps that were less efficient than the average lamps that IOU electric customers replaced with CFLs in their households. Furthermore, the customers who shopped in stores where the program lamps were available are the true program population, and these populations may be slightly-to-very different from overall IOU populations. The NTGRu accounts for these differences.
- **Overall NTGR (NTGRq multiplied by NTGRu): When considered in terms of NTGRq and NTGRu, the overall NTGR provides insight into the relationship between gross savings estimates and net savings estimates.** Basic spiral CFLs have low NTGRq and NTGRu, which produce overall NTGR for all IOUs around 30%. Gross savings estimates for these measures were already low, so net savings dropped further. Even when available in hard-to-reach markets, this measure group had less-than-expected program impacts in 2015. The NTGRqs for LED A-lamps and LED reflector lamps are moderate, while the NTGRus for these two measure groups are fairly low for all IOUs. This finding means that the average lamp displaced by program LED lamps was of lower wattage than the average of all installed lamps across all electric IOU customers. The NTGRu adjustment should not be considered an indicator of poor program performance as the overall ex post net savings closely matches the ex ante next savings for these two measure groups. Instead, this finding suggests that future evaluations and ex ante assumptions consider evaluating gross savings in a way that more closely aligns with this net savings approach.

Below, Table 5 provides the NTGRq, NTGRu, and overall NTGR for all evaluated upstream lighting measure groups for each IOU. Note that in some instances, the overall NTGR is over 100%. An overall NTGR over 100% does not suggest spillover, but instead is a combination of low free ridership and high market-level savings.

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7 Free-ridership is the percent of customers who purchased a program-discounted efficient lamp, but would have purchased the same lamp at the full retail price.

8 Note that SCE distributed many MSB high-wattage CFL > 30 W to grocery stores, where data suggest higher program attribution for this measure group than discount stores, where PG&E and SDG&E shipped the majority of this measure group.

9 Note that the gross savings realization rates are very high, so the low NTGRu and overall NTGR ultimately produce net realization rates close to 100%.

Table 5. Results for NTGRq, NTGRu, and overall NTGR for all evaluated upstream lighting measure groups by IOU (2015)

IOU / NTGR	Evaluated Upstream Lighting Measure Group					
	MSB CFL basic spiral ≤ 30 W	MSB CFL A-lamp ≤ 30 W	MSB CFL reflector ≤ 30 W	MSB CFL high-wattage (> 30 W)	LED A-lamp, all wattages	LED Reflector, all wattages
PG&E						
NTGRq	22%	70%	N/A	30%	59%	53%
NTGRu	203%	157%	N/A	105%	51%	73%
Overall	46%	110%	N/A	31%	30%	39%
SCE						
NTGRq	N/A	85%	89%	56%	60%	52%
NTGRu	N/A	81%	120%	145%	55%	74%
Overall	N/A	69%	107%	81%	33%	38%
SDG&E						
NTGRq	21%	69%	70%	35%	60%	56%
NTGRu	98%	146%	116%	161%	55%	94%
Overall	21%	101%	81%	57%	33%	52%

We used ex ante savings estimates rather than develop separate ex post estimates for residential downstream measures. We also adjusted the estimates of upstream measures purchased for residential versus nonresidential applications. Our ex post gross savings for the adjusted nonresidential upstream quantities rely upon the ex ante gross UES estimates. Table 6 shows that IOUs achieved ex post net annual energy savings of more than 260 GWh for 2015 measures.

Table 6. Ex ante and ex post net savings and realization rates by evaluated upstream lighting measure group across all IOUs, 2015

Net Savings Element	Evaluated Upstream Lighting Measure Group						Overall
	MSB CFL basic spiral ≤ 30 W	MSB CFL A-lamp ≤ 30 W	MSB CFL reflector ≤ 30 W	MSB CFL high-wattage (> 30 W)	LED A-lamp, all wattages	LED reflector, all wattages	
Ex Ante							
kWh	7,355,550	21,967,514	61,176,097	91,399,614	22,778,031	45,848,261	250,525,068
kW	1,007	3,046	8,234	12,627	3,117	6,433	34,464
Therms	(133,851)	(293,689)	(867,009)	(1,248,949)	(373,481)	(697,471)	(3,614,449)
Ex Post							
kWh	5,481,959	27,300,704	80,636,143	66,595,202	38,655,412	45,316,229	263,985,649
kW	877	3,792	11,038	10,419	4,908	6,304	37,338
Therms	(85,035)	(376,498)	(1,168,077)	(721,240)	(657,839)	(677,375)	(3,686,065)
Net Realization Rate							
kWh	75%	124%	132%	73%	170%	99%	105%
kW	87%	124%	134%	83%	157%	98%	108%
Therms	64%	128%	135%	58%	176%	97%	102%

1.5 Conclusions and recommendations

Based on the research we conducted in support of this evaluation, we developed conclusions and recommendations. These pertain to program tracking data, the program implementation strategy, and directions for future research.

We provide further detail below.

1.5.1 Tracking data

DNV GL relied upon program tracking data as the basis for measure quantities in our ex post savings analyses. Our review and analyses of the tracking data yielded the following conclusions:

- In a few cases, there were inconsistencies between the program year reported in the tracking data and the shipment year included in lamp suppliers' records.
- SDG&E and PG&E assigned incorrect measure groups to approximately 250,000 lamps based on the lamp wattage recorded in the program tracking.

Based on these conclusions, we recommend:

- **Recommendation 1.** Tracking data should consistently present measures that were truly discounted and shipped within the program year. We also recommend that Commission staff consider a careful review of claim year as a future research priority.
- **Recommendation 2.** Program administrators should consider performing additional review and accuracy checks on the measure group classifications and wattage estimates for program lamps.

1.5.2 Implementation strategy

Our analyses yielded three conclusions regarding related to three elements of the IOUs' upstream lighting program implementation strategy, including the retail channels in which the IOUs offer program-discounted lamps and the lamp types offered (CFLs and LED lamps). With regard to the retail channels, we conclude:

- Without program support, significantly fewer customers would have purchased energy efficient lamps in discount, drug, grocery, and hardware channels. The inefficient lamps that program lamps displaced in these channels were less efficient than the lamps that IOU customers replaced with efficient lamps on average. In big-box channels, freeridership was relatively high.

With regard to upstream lighting program strategy regarding CFLs, we conclude:

- The 2015 upstream lighting program appeared to drive very few basic spiral CFLs ≤ 30 W purchases. Freeridership was relatively high and net UES was relatively low.
- The program strategy to discount CFL A-lamps ≤ 30 W in discount, drug, grocery, and small hardware stores yielded favorable savings results. Freeridership was relatively low and net UES was relatively high.
- The program appears to have convinced some customers to purchase high-wattage CFLs (> 30 W) in grocery stores, but the energy savings achieved by high-wattage CFLs was lower than anticipated. Many consumers are using high-wattage CFLs to replace lamps that are less bright and lower wattage than expected. As such, while freeridership was reasonable, net UES for these measures was lower than anticipated.

With regard to upstream lighting program strategy regarding LED lamps, we conclude:

- The program appears to have moderately motivated customers to purchase LED A-lamps and LED reflector lamps by heavily discounting these products in membership club stores. Our analysis suggests that many of these purchases would have occurred at other retail channels in the absence of the program. LED A-lamps and LED reflector lamps achieved around 60% NTGRq, suggesting 40% of them were purchased by freeriders. However, many of the non-LED lamps that customers would have purchased in the absence of the program would have been more efficient than the ones that IOU

customers replaced on average, which produced low NTGRu results. The net UES estimates were highest in the hardware and discount channels and the lowest in the membership club channel.
- Consumer satisfaction with LED lamps in general was high during 2015 and 2016.

Based on the above conclusions regarding upstream lighting program implementation strategy, we recommend:

- **Recommendation 3.** The IOUs should consider shifting more of their upstream lighting program incentives toward the non-big box channels to minimize freeridership and maximize net UES. However, we acknowledge that these channels are not capable of moving a large volume of program-discounted lamps as quickly as the big box channels, so some effort may be required to strike the appropriate balance between program effectiveness and volume.
- **Recommendation 4.** The IOUs should continue shifting upstream lighting program incentives away from basic spiral CFLs ≤ 30 W.
- **Recommendation 5.** With regard to high-wattage CFLs (> 30 W) in particular, moderate freeridership suggests the IOUs could continue to influence customer purchases by providing incentives for these measures in grocery, discount and drug stores—however:
    a. Given the potentially limited applicability of these measures in PG&E, SCE, and SDG&E residential electric customer households, the IOUs should also consider the overall installation potential for these measures when establishing program quantities.
    b. Consumer survey results suggest that consumers are, in many cases, using high-wattage CFLs to replace lamps of lower brightness. For some applications, the program may be shifting consumers toward higher-wattage replacement lamps than they would choose absent the program, which may warrant further consideration from the IOUs.
- **Recommendation 6.** Despite low overall NTGRs, LED A-lamp and LED reflector lamp NTGRq results are moderate, and realization rates are high, suggesting IOUs should continue shifting upstream lighting program incentives to LED A-lamps and LED reflector lamps. The IOU's should begin to discount more mid-to-high brightness LED lamps, and future studies should explore the degree to which customers are replacing mid-to-high watt CFLs and incandescent lamps with low-watt LED lamps.

1.5.3 Future research

The research we conducted in support of this study suggested two topics that may be worthy of consideration for future research.

1.5.3.1 Channel shift

Channel shift is a form of program influence that "shifts" sales out of some retail channels and into others as a result of where program incentives are available. We investigated this phenomenon during our supplier interviews. Supplier representatives mentioned the channels most affected by the program are likely the discount, grocery, drug, and membership club channels. Channel shift effects were important in the membership club channel given that these stores sold the largest share of program lamps of any retail channel in 2015 (39% of lamps in evaluated measure groups). Based on these findings, we conclude:

- The upstream lighting program influences the retail channels through which manufacturers sell replacement lamps to PG&E, SCE, and SDG&E residential electric customers in California.

Based on this conclusion, we recommend:

- **Recommendation 7.** Future EM&V efforts should further explore channel shift effects—including the quantity of lamps shifted, the channels to and from which the shifts occur, and the measure groups most affected.

1.5.3.2 California Quality LED Lamp Specification

Starting in January 2014, the CPUC ED required that the IOUs demonstrate that the LED lamps for which they offer program incentives meet the performance requirements outlined in the California Quality LED Lamp Specification.[10] The specification's intent was to ensure that LED lamps would meet or exceed customer expectations regarding lamp performance and light quality.

The spec has no effect on energy savings, so this is ultimately not an impact evaluation issue. However, the IOUs have suggested that higher quality will yield higher LED lamp satisfaction, and repeat purchase. We asked about LED lamp satisfaction in our 2016 consumer telephone survey, and the specification's influence on LED lamp sales in our 2016 supplier interviews. Based on the results of these efforts, we conclude:

- Among the IOUs' residential electric customers who purchased LED lamps during 2015 and 2016, satisfaction was high. However, because LED lamps that meet the California Quality spec comprised such a small share of LED lamp stock among California retailers (13% as of winter 2015-16), it is unlikely that the spec is the primary driver of customer satisfaction.
- Manufacturers' representatives suggest that the upstream lighting program was the primary reason they produced LED lamps that met the spec in 2015.

Based on these findings, DNV GL recommends:

- **Recommendation 8.** Commission staff should consider pursuing a more definitive assessment of consumer satisfaction with LED lamps that do and do not meet the California Quality spec. The upcoming in-home lighting inventory and metering study is a good opportunity to perform this assessment. At this time, Commission staff plan to launch this study in 2018.

1.5.3.3 Impact Evaluation and Program Potential Research

This evaluation's research plan included an investigation to better understand the extent to which LED lamps replaced lamps before they reached their effective useful life.

- Consumer survey results suggest that 68% of LED lamps purchased by customers replaced functioning lamps. This finding suggests that there is a potential savings impact related to early replacement.
- While the above recommendations reflect a business-as-usual environment, market conditions are expected to change in 2018 due to California's Title 20 legislation. These changes are likely to dramatically limit or eliminate the potential for residential and upstream lighting program savings.
- The modelling in this report uses respondent demographics by applying coefficients, which are shown in Table 89. The underlying data, along with the 2016 consumer survey, have the potential to offer additional insights into the customer side of the lighting market, beyond the scope of this evaluation.

Based on these findings, DNV GL recommends:

- **Recommendation 9.** Future evaluations should further investigate which lamps are being replaced early. With this more complete picture, future evaluations should estimate savings impacts associated with early replacements.
- **Recommendation 10.** A potential study should be considered to estimate the remaining available energy savings potential that incorporates the impacts of Title 20 changes in 2018.
- **Recommendation 11.** The data collected to answer the research questions for this evaluation have the potential to offer additional insights into the customer and supplier sides of the lighting market. Such a study could look at customer segmentation among various retail channels, perceptions of lighting technologies, and could explore price sensitivities.

[10] CEC, 2012 and CEC, 2014.

2 INTRODUCTION

2.1 Program overview

During the 2015 program period, each California IOU that provides electric service—including PG&E, SCE, and SDG&E—implemented a Statewide Lighting Program designed to promote energy-efficient lighting across all market sectors. The program included three subprograms: Lighting Market Transformation; Lighting Innovation; and Primary Lighting. The IOUs intended the Primary Lighting subprogram to support lighting measures that had already proven their market viability (versus emerging technologies) and to facilitate rapid adoption of these measures through upstream, downstream, and midstream incentives. The 2015 Primary Lighting subprogram was a resource-acquisition program that included non-resource and market transformation activities. A key component of the Primary Lighting subprogram during this period was the upstream mechanism, which provided incentives to lamp manufacturers in exchange for providing discounted lamps to consumers in retail stores.

The upstream delivery mechanism has been a core part of the California IOUs' CFL program activities for many years, but during the 2013-14 program period, the IOUs began a shift away from CFLs and toward LED lamps. Starting in January 2014, the CPUC ED required that the IOUs demonstrate that the LED lamps for which they offered incentives met the performance requirements outlined in the California Quality LED Specification developed by the California Energy Commission (CEC).[11, 12] The requirements in the specification go beyond ENERGY STAR for lamp attributes such as color, dimmability, light distribution, and warranty, with the intent of meeting or exceeding customer expectations regarding lamp performance and light quality. The IOUs began introducing LED lamps into the upstream program in relatively small quantities during 2013 and in somewhat greater quantities in 2014 and 2015. The IOUs also varied in the extent to which they concurrently decreased incentives for CFLs.

2.2 Evaluation overview

We designed this impact evaluation to address all lighting measures associated with the upstream delivery mechanism as well as all downstream lighting measures targeted at the residential sector by PG&E, SCE, and SDG&E. Together, upstream and residential downstream lighting measures account for between 4% and 18% of each IOU's reported ex ante net annual electric savings, and between 2% and 11% of each IOU's net peak demand reductions (Table 7). For comparison, during the 2013-14 program period, upstream and residential downstream lighting measures accounted for 9% to 18% of each IOU's reported net energy savings and 7% to 16% of each IOU's reported net peak demand impacts.

[11] CEC, 2012.
[12] CEC, 2014.

Table 7. Summary of IOU-reported ex ante net annual savings from upstream and residential downstream lighting measures, 2015*

IOU	IOU Reported Net Annual Savings					
	Total Portfolio		Upstream / Residential Downstream Lighting		Upstream / Residential Downstream Lighting as Percent of Total Portfolio	
	Energy (GWh)	Peak Demand Reduction (MW)	Energy (GWh)	Peak Demand Reduction (MW)	Energy (GWh)	Peak Demand Reduction (MW)
PG&E	1,146.25	244.64	43.66	5.90	4%	2%
SCE	1,183.52	245.45	211.52	28.15	18%	11%
SDG&E	243.00	53.47	33.07	4.43	14%	8%
Statewide	**2,586.53**	**549.64**	**288.25**	**38.48**	**11%**	**7%**

* Ex ante data used in this table and throughout the report were final as of October 6, 2016.

Upstream lighting measures comprised the vast majority of the combined total upstream and residential downstream lighting measures during the 2015 program period (Table 8). As such, the remainder of this report focuses on upstream lighting measures and in particular, the measures identified as part of the Energy Savings Performance Incentive (ESPI) uncertain measure list[13] and that account for the majority of ex ante savings within the upstream program. For residential downstream measures, we are passing through the ex ante estimates for energy savings (kWh), demand reductions (kW), and gas impacts (therms) and for all upstream measures not included in the six evaluated upstream lighting measure groups described below.[14]

[13] CPUC, 2013.

[14] "Pass-through" measures are those for which we rely on ex ante assumptions in the evaluation.

Table 8. Summary of IOU-reported ex ante upstream and residential downstream lighting measure savings for evaluated and passed-through measure groups, 2015

IOU / Lighting Measure Category	Ex Ante Upstream and Residential Downstream Lighting Savings					
	Energy		Demand		Gas Impacts	
	GWh	% of GWh	MW	% of MW	Million Terms	% of Therms
PG&E						
Upstream - evaluated	52.9	76%	7.2	76%	-0.99	76%
Upstream - passed through	15.2	22%	2.1	22%	-0.28	21%
Downstream - passed through	1.9	3%	0.2	2%	-0.04	3%
Subtotal – PG&E	**70.0**	**100%**	**9.4**	**100%**	**-1.31**	**100%**
SCE						
Upstream - evaluated	334.0	92%	46.1	94%	-4.65	94%
Upstream - passed through	13.3	4%	2.1	4%	-0.18	4%
Downstream - passed through	17.2	5%	0.8	2%	-0.11	2%
Subtotal – SCE	**364.5**	**100%**	**49.1**	**100%**	**-4.94**	**100%**
SDG&E						
Upstream - evaluated	46.8	81%	6.3	82%	-0.62	81%
Upstream - passed through	8.9	15%	1.2	16%	-0.12	16%
Downstream - passed through	1.9	3%	0.1	2%	-0.02	2%
Subtotal – SDG&E	**57.7**	**100%**	**7.7**	**100%**	**-0.76**	**100%**
All IOUs						
Upstream – evaluated	433.8	88%	59.6	90%	-6.25	89%
Upstream - passed through	37.4	8%	5.5	8%	-0.59	8%
Downstream - passed through	21.0	4%	1.2	2%	-0.17	2%
Grand Total – All IOUs	**492.2**	**100%**	**66.2**	**100%**	**-7.01**	**100%**

Upstream lighting measures fall into 15 groups that consist of similar measures. For example, the LED reflector measure group includes all LED reflector lamp wattages and styles, such as parabolic aluminized reflector (PAR) and multifaceted reflector (MR) lamps. While savings claims included within the IOU tracking data are based on assumptions tied to specific measure characteristics, the evaluation applies updates to savings at the measure group level.

This evaluation focuses on six upstream lighting measure groups. Taken together, these measures account for nearly 90% of each IOU's ex ante net savings from upstream and residential downstream lighting measures. The 2013-14 upstream and residential downstream lighting impact evaluation addressed these measure groups as well as CFL globe lamps ≤ 30 W, but we do not focus on CFL globes in this evaluation because they accounted for less than 1% of the IOUs' reported net energy savings.[15] As such, the four upstream CFL measure groups that we address in this evaluation include the following:

- MSB CFL basic spiral ≤ 30 W
- MSB CFL A-lamp ≤ 30 W

[15] DNV GL, 2016b.

- MSB CFL reflector ≤ 30 W
- MSB CFL high-wattage (> 30 W)

As in the 2013-14 evaluation, the 2015 evaluation also addresses two upstream measure groups for LED lamps:

- LED A-lamps of all wattages
- LED reflector lamps of all wattages[16]

All of these measure groups accounted for more than 5% of total portfolio net savings, across IOUs, with the exception of the MSB CFL basic spiral measure group, which accounted for 3%. We evaluated this measure group because (as we discuss in Sections 5.1 and 6) we conducted these efforts in parallel for all measure groups considered a-lamp replacements (MSB CFL basic ≤ 30 W, MSB CFL A-lamp ≤ 30 W, and LED A-lamp ≤ 30 W).

Table 9 lists the percent of IOU-reported portfolio-level net annual energy savings and peak demand reductions by evaluated upstream lighting measure for residential and nonresidential programs. For savings estimates from all other measure groups, including residential downstream lighting measures and upstream lighting measures not included above, we rely on deemed assumptions and since these measure groups comprise insignificant savings, are not evaluable, and/or represent measures unlikely to persist in future cycles. As shown, CFL high-wattage (> 30 W) lamps provided the majority of energy savings and peak demand reductions portfolio-wide, while the measure groups CFL A-lamp ≤ 30 W, CFL Reflector lamp ≤ 30 W, LED A-lamp, all wattages, and LED reflector lamp, all wattages, account for moderate savings portfolio-wide. CFL basic spiral ≤ 30 W account for the smallest portion of savings portfolio-wide. SCE's programs provided greater annual savings and demand reductions compared with the other two IOUs. Specifically, the savings from SCE's high-wattage CFL measure group accounted for 29% of the overall IOU portfolio savings.

[16] Note that while the CFL measure groups include MSB lamps only, the LED lamp measure groups include all base types.

Table 9. Reported portfolio-level ex ante net annual energy savings and peak demand reductions by upstream lighting measure group for residential and nonresidential measures, 2015

Evaluated Upstream Lighting Measure Group	Ex Ante Net Annual Energy Savings				Ex Ante Net Peak Demand Reductions			
	Overall	PG&E	SCE	SDG&E	Overall	PG&E	SCE	SDG&E
MSB CFL basic spiral ≤ 30 W	7,355,550	7,049,716	N/A	305,834	1,007	966	N/A	41
MSB CFL A-lamp ≤ 30 W	21,967,514	260,389	18,199,714	3,507,412	3,046	36	2,534	477
MSB CFL reflector ≤ 30 W	61,176,097	N/A	59,233,369	1,942,728	8,234	N/A	7,987	247
MSB CFL high-wattage (> 30 W)	91,399,614	1,832,303	83,242,204	6,325,106	12,627	251	11,607	769
LED A-lamp, all wattages	22,778,031	11,332,268	6,544,979	4,900,785	3,117	1,527	921	669
LED reflector, all wattages	45,848,261	13,427,067	23,060,744	9,360,451	6,433	1,807	3,237	1,389
Pass-through lighting measures	37,729,743	9,758,530	21,242,000	6,729,214	4,017	1,311	1,869	837
Overall	**288,254,811**	**43,660,273**	**211,523,010**	**33,071,529**	**38,481**	**5,897**	**28,155**	**4,430**

Table 10 shows the quantity of evaluated measures for which each IOU provided incentives through its 2015 upstream programs by measure group and IOU. As shown, all IOUs discounted large quantities of LED A-lamps. This measure group accounted for the largest share of upstream program-discounted measures across IOUs (accounting for 26% of the evaluated measures). All three IOUs also heavily discounted LED reflectors, accounting for 20% of all evaluated measures. The remaining measures were heavily discounted by one or two IOUs, but not all three. SCE's discounted high-wattage CFLs > 30 W account for 25% of their evaluated measures, but only 12% of SDG&E's upstream measures, and 3% of PG&E's upstream measures. Similarly, SCE discounted over 2.5 million CFL reflector lamps (27% of their evaluated measures), while SDG&E only discounted just over 88,000 of these lamps (5% of their evaluated measures), and PG&E did not discount any. It is also worth noting that CFL basic spiral ≤ 30 W accounted for 19% of PG&E's evaluated measures but only 1% of SCE's and SDG&E's evaluated measures.

Table 10. Quantity of lamps by evaluated upstream lighting measure group and IOU, 2015

Evaluated Upstream Lighting Measure Group	Quantity			Overall Quantity (Across IOUs)	
	PG&E	SCE	SDG&E	Total	% of Total
MSB CFL basic spiral ≤ 30 W	499,902	0	20,795	520,697	4%
MSB CFL A-lamp ≤ 30 W	21,610	1,126,146	265,251	1,413,007	10%
MSB CFL reflector ≤ 30 W	0	2,639,047	88,564	2,727,611	20%
MSB CFL high-wattage (> 30 W)	69,696	2,315,789	203,480	2,588,965	19%
LED A-lamp, all wattages	1,381,811	1,548,699	640,392	3,570,902	26%
LED reflector, all wattages	694,575	1,626,451	423,502	2,744,528	20%
Overall	**2,667,594**	**9,256,132**	**1,641,984**	**13,565,710**	**100%**

2.3 Evaluation goals

The overarching goal of the impact evaluation for the 2015 upstream and residential downstream lighting measures is to verify and validate the IOU reported energy savings and peak demand reduction estimates. The impact evaluation approach has three goals:

1. Develop measure quantity adjustments, which include program invoice and application verification, an assessment of the percentage of IOU-discounted products purchased by non-IOU customers (i.e., leakage), and an assessment of the percentage of IOU-discounted products purchased by residential versus nonresidential customers.

2. Develop gross savings inputs, which include an assessment of the percentage of IOU-discounted measures installed as well as estimates of the average daily hours-of-use (HOU), the average percent of measures operating at peak coincidence factor (CF), the wattage displaced by IOU-discounted measures (delta watts), unit UES in kWh/year and peak kW, and installation rate.

3. Develop net savings inputs, which include estimates of the net-to-gross ratio (NTGR).

Given the dramatic shifts in California's residential lighting market over the past several years, the 2015 impact evaluation includes improvements to approaches applied in the 2013-14 evaluation. The most notable improvement that we made regards the net savings methodology. In this evaluation, we define net savings relative to a baseline of what would have been purchased in the absence of the program. In the

2010-12 and 2013-14 evaluations, net savings was defined relative to a baseline of what program-discounted lamps replaced.

2.4 Research questions

In addition to addressing the three over-arching goals above, this evaluation addresses six key research questions. Below, we present the research questions and our rationale for including each one.

1. **What are the ex post savings results?** As we discussed in our research plan for this effort, this question addresses the key research question in the January 2016 EM&V Plan as well as the 2015 uncertain measure list's requirement to "update … net savings" for screw-in LED lamps for PG&E, SCE, and SDG&E (as well as updating net savings for other measures). We address ex post savings in in Section 5 and Section 6 of this report (Gross Savings and Net Savings).

2. **What is the appropriate baseline for residential upstream LED lamps?** This question addresses the 2015 uncertain measure list's requirement to "update baseline assumptions … including replaced lamp for early retirement versus standard practice for normal replacement and replace-on-burnout" for PG&E, SCE, and SDG&E. To clarify, however, the evaluation team's interpretation of the phrase "replaced lamp for early retirement versus standard practice for normal replacement and replace-on-burnout" is that the uncertainty lies in the extent to which "normal replacement" activities (or "standard practice") involve "early retirement" or "replace-on-burnout." As such, we focused our evaluation efforts (in part) on understanding the share of installed LED lamps that replace functioning lamps (early retirement) versus lamps that have stopped working (replace-on-burnout). The evaluation also addressed the baseline technology mix for LED lamps. We address installation rates as well as the baseline for LED lamps in Section 5 of this report (Gross Savings).

3. **What is the appropriate baseline for residential upstream CFLs?** Question three addresses the 2015 uncertain measure list's requirement to "update … the gross baseline assumptions to account for the type and wattage of the lamp being replaced" for "screw-in CFLs of all types with wattage values greater than 30 Watts" for PG&E, SCE, and SDG&E. We address the CFL baseline in Section 5 (Gross Savings).

4. **What is the freeridership level for residential upstream LED lamps?**

5. **What is the freeridership level for upstream CFLs?**

   Questions four and five address concerns raised by program administrators and other stakeholders during discussions regarding results from the Impact Evaluation of 2013-14 Upstream and Residential Downstream Lighting Program and discussions of study priorities for the 2015 impact evaluation. We address freeridership in Section 6 of this report (Net Savings).

6. **Is there any evidence that consumer satisfaction differs with LED lamps that meet the California Quality LED Specification [the "CEC spec"] versus LED lamps that do not meet the spec?** This question arose from the same discussions and IOU comments on the 2013-14 upstream and residential downstream lighting program impact evaluation report. The current impact evaluation report provides high-level insights regarding IOU customer satisfaction with LED lamps in general in Section 7.2.2 below. We expect a more definitive answer to this question from the forthcoming in-home California lighting inventory and metering study. Additionally, this evaluation explores suppliers' perspectives regarding the influence of the CEC spec on lamp quality and sales in and outside of California (which we discuss in Section 7.2 below).

2.5 Report overview

We have organized the remainder of the report as follows:

- Section 3 reviews the data sources that support this evaluation.

- Section 4 describes the adjustments to measure quantities based on evaluation activities.
- Section 5 summarizes the gross savings approach and results by parameter and measure group.
- Section 6 summarizes the net savings approach and results by parameter and measure group.
- Section 7 presents the results of research to address qualitative topics of interest to the impact evaluation, including channel shift, influence of the California Quality Specification for LED Lamps, and consumer perceptions of LED lamp quality.
- Section 8 provides the evaluation team's conclusions and recommendations based on this research.
- Section 9 provides complete references for all sources cited in this report.
- Appendix AA provides the ex ante and ex post first year and lifecycle savings tables per the CPUC ED Impact Evaluation Standard Reporting (IESR) Guidelines.[17]
- APPENDIX AB provides the ex post first year, annual, and lifecycle savings and effective useful life (EUL) per the CPUC ED IESR Guidelines.
- APPENDIX AC provides standardized recommendations per the CPUC ED IESR Guidelines.
- APPENDIX B summarizes the methods and sampling approach for the retail lighting shelf surveys and in-store shopper intercept surveys.
- APPENDIX C summarizes the methods and sampling approach for the 2016 consumer telephone and online surveys.
- APPENDIX D summarizes the methods associated with the 2016 supplier telephone interviews.
- APPENDIX E summarizes sample sizes in the 2006-08 residential lighting metering study.
- APPENDIX F reviews the sampling approach for the 2012 California Lighting and Appliance Saturation Survey (CLASS).[18]
- APPENDIX G provides details regarding the lamp choice model methodology.
- APPENDIX H provides additional data tables to illustrate our approach to developing NTGR.
- APPENDIX I provides the data collection instruments used in support of this evaluation.
- APPENDIX J provides waterfall graphics of this evaluation's results.
- APPENDIX K provides the evaluators' response to public comments on the draft Impact Evaluation of 2015 Upstream and Residential Downstream Lighting Programs.

[17] CPUC ED, 2015a.

[18] DNV GL, 2014a.

3 DATA SOURCES

The 2015 impact evaluation relied upon several data sources. Table 6 below shows the data sources aligned with the research questions described above. We provide more details on these sources in the remainder of Section 3.

Table 11. Research questions and associated data sources, 2015

Research Question	Data Sources						
	Consumer Surveys	Supplier Interviews	Retail Lamp Stock Inventories	Shopper Intercept Surveys	Lamp Choice Model	Program Tracking Data	Secondary Data Sources
1. What are the ex post savings results?	X	X	X	X	X	X	X
2. What is the appropriate baseline for residential upstream LED lamps?	X					X	X
3. What is the appropriate baseline for residential upstream CFLs?	X					X	X
4. What is the freeridership level for residential upstream LED lamps?	X	X		X	X		X
5. What is the freeridership level for residential upstream CFLs?	X	X		X	X		X
6. Is there any evidence that consumer satisfaction differs with LED lamps that meet the California Quality LED Specification versus LED lamps that do not meet the spec?	X	X*					

* Supplier interviews will not focus on consumer satisfaction with LED lamps explicitly but instead focus on suppliers' perspectives regarding the influence of the CEC specification on their LED lamp sales—e.g., whether they would sell lamps that meet the CEC spec in absence of the program.

3.1 Consumer Surveys

This evaluation relies upon three separate surveys of PG&E, SCE, and SDG&E residential electric customers:

- 2015 telephone surveys
- 2016 telephone surveys
- 2016 online surveys

We describe each of these in more detail below.

3.1.1 2015 telephone surveys

Over the past several years, DNV GL has conducted telephone surveys with residential electric customers of PG&E, SCE, and SDG&E to support continued monitoring of purchase, installation, and storage rates for CFLs and LED lamps. During the third quarter of 2015, we conducted these surveys in support of the impact evaluation of the IOUs' 2013-14 upstream and residential downstream lighting programs.[19] Because we conducted these surveys during the 2015 program period, survey results also serve the 2015 impact evaluation by addressing **baseline measure mix for program-discounted CFLs ≤ 30 W and LED lamps of all wattages**. In the 2016 EM&V plan, the CPUC identified uncertainty regarding the "type and wattage of the lamp[s] being replaced" and identified this as a research priority for program-discounted LED lamps in particular.[20,21]

The sample frame for this effort was the IOUs' 2014 residential electric customer billing data. We stratified the sample into 42 unique strata that we defined by the following:

- IOU
- climate zone group
- customer participation in the California Alternate Rates for Energy and/or Family Electric Rate Assistance programs
- 2014 average daily kWh consumption

We completed 1,016 telephone surveys with consumers in 2015; Table 12 below summarizes the disposition of completed surveys by IOU service territory. We weighted the survey results to reflect the population of residential electric customers in PG&E, SCE, and SDG&E electric service territories. Only electric customers of PG&E, SCE, or SDG&E were eligible to complete the survey. APPENDIX C provides more details regarding survey methods, and APPENDIX I provides the data collection instrument.

Table 12. Consumer telephone survey disposition by IOU service territory, 2015

IOU	Number of Respondents (n)	Percent of Respondents
PG&E	409	40%
SCE	413	41%
SDG&E	194	19%
Overall	**1,016**	**100%**

3.1.2 2016 telephone surveys

During October, 2016, DNV GL conducted telephone surveys with PG&E, SCE, and SDG&E residential electric customers in support of the 2015 impact evaluation. These surveys asked consumers how many lamps they purchased within the A-lamp replacement and reflector lamp replacement categories since January 1, 2015, and where they made those purchases. The 2016 consumer telephone survey addressed several key inputs to the 2015 upstream and residential downstream lighting program impact evaluation, including:

1. **Installation rates.** The consumer obtained details regarding the installation rates for CFLs and LED lamps at the technology level (i.e., one installation rate for CFLs and another for LED lamps). As part of this discussion, the 2016 telephone survey addressed a priority that the CPUC identified in the 2016 EM&V plan related to uncertainty regarding share of LED lamps that replace functioning lamps

19 DNV GL, 2016a.

20 CPUC ED, 2016. Table 44 (2015 Uncertain Measures to be Prioritized). Pages 181—182. Note that the CPUC also identified the same priority (regarding baseline measure mix and wattage) for program-discounted high-wattage CFLs (> 30 W); we address high-wattage CFLs in Section 3.1.3 below.

21 We rely on results from the 2012 CLASS for details regarding baseline wattage; please see the discussion of delta watts in Section 5.4 for further detail.

(early retirement) versus LED lamps that replace lamps that have stopped working (replace-on-burnout).[22] We asked consumers two questions regarding the LED lamps they purchased and installed since January 1, 2015: whether any had burned out or stopped working, how many replaced lamps that were still working versus lamps that had burned out. We address CFL and LED lamp installation rates in Section 5.7 of the report, and provide a qualitative discussion of early retirement versus replace-on-burnout in Section 7.4.

2. **Satisfaction with LED lamps.** While the energy savings associated with LED lamps that meet the California Quality LED Lamp Specification do not differ from the savings for LED lamps that do not meet the spec, the IOUs have suggested that the superior quality of the lamps that meet the spec will have transformational consequences in California's residential lighting market. The theory is that the higher quality lamps will result in high consumer satisfaction with LED lamps, ultimately leading to repeat purchases. Conversely, the IOUs assert that LED lamps that do not meet the spec are of lower quality, which could result in consumer dissatisfaction that could reduce or eliminate their future purchases of LED lamps.

   As described in our research plan for this study, the CPUC's forthcoming in-home inventory and metering study will provide a more concrete opportunity to investigate satisfaction with LED lamps in use in IOU customer households, and thus provide a better vehicle to address the IOUs' concerns than the 2015 impact evaluation.[23] However, the 2016 consumer telephone survey briefly addressed satisfaction with LED lamps in general. While the telephone survey is unable to distinguish whether the LED lamps purchased by consumers do or do not meet the CEC spec, consistent and widespread satisfaction with LED lamps may suggest that the specification does little to affect consumer satisfaction. Conversely, if survey results suggest that consumer satisfaction with LED lamps is inconsistent, this may indicate that there are differences in satisfaction with LED lamps that could be attributable (at least in part) to the CEC spec. Such a result could demonstrate the need for more focused consumer research on this topic. We review results pertinent to this topic in Section 7.2.2 of the report.

3. **Inputs into the lamp choice model (LCM).** Section 3.4 below describes the LCM in detail as well as the inputs to and outputs from the model for this study. To support the LCM, the 2016 consumer telephone surveys obtained details regarding:

   a. **Distribution of lamp purchases by retail channel.** One challenge in using the LCM in previous impact evaluations is that the model relies, in part, on results from the in-store shopper intercept surveys (which we describe in more detail in Section 3.3 below). The intercept surveys are, by necessity, based on a convenience sampling approach. To improve the LCM's ability to represent the distribution of lamp purchases by retail channel within the purchaser population, we included questions in the 2016 consumer telephone surveys to address recent purchase locations (retail channels).

   b. **Customer demographics together with recent lamp purchase information.** As we describe below in the more detailed LCM discussion (Section 3.4), we used the 2016 consumer telephone survey respondents to represent the universe of lamp purchase decisions (rather than intercept survey respondents).

4. **Insights into channel shift.** The 2016 consumer survey included questions to address whether shoppers typically choose from among the lamps available to them in a preferred retail channel or if they will move to a different retail channel to purchase a preferred type of lamp. As we describe in Section 3.2, our in-depth interviews with lamp suppliers also obtained their perspectives regarding which retail channels and which lamp technologies are most likely to be experiencing channel shift.

We implemented the surveys using the same sample frame and stratification approach as the 2015 consumer telephone surveys. Table 13 below summarizes the disposition of completed 2016 consumer telephone surveys by IOU service territory. We weighted the survey results to reflect the population of residential electric customers in PG&E, SCE, and SDG&E electric service territories. As with the 2015 surveys,

[22] CPUC ED, 2016. Table 44 (2015 Uncertain Measures to be Prioritized). Pages 181—182.

[23] DNV GL, 2016a.

only electric customers of PG&E, SCE, or SDG&E were eligible to complete the 2016 telephone survey. APPENDIX C provides more details regarding survey methods, and APPENDIX I provides the data collection instrument.

Table 13. Consumer telephone survey disposition by IOU service territory, 2016

IOU	Number of Respondents (n)	Percent of Respondents
PG&E	262	45%
SCE	212	37%
SDG&E	104	18%
Overall	**578**	**100%**

3.1.3 2016 online surveys

Based on 2012 CLASS results suggesting that high-wattage CFLs exist in much lower quantities in IOU customer households than lower-wattage lamps, we also administered an online survey targeting high-wattage CFL purchasers. The lower implementation costs associated with online surveys versus telephone surveys enabled us to reach a much larger number of potential respondents. The primary purpose of the 2016 online surveys was to identify the **baseline technology mix and wattage for high-wattage CFLs.**

We addressed this because in the 2016 EM&V plan, the CPUC identified uncertainty regarding the "type and wattage of the lamp[s] being replaced" for program-discounted high-wattage CFLs (> 30 W).[24] During the surveys, DNV GL identified purchasers of these lamp types and asked them to identify the technology and wattage of the lamp replaced with high-wattage CFLs for up to three high-wattage CFLs per respondent.[25] We also addressed the retail channels in which they purchased these lamps.

We implemented the online surveys using the same sample frame as the 2015 and 2016 consumer telephone surveys for PG&E and SCE. Because SDG&E's 2014 billing data did not include customer email addresses, we obtained a list of premise identification numbers and associated email addresses from SDG&E and merged these with SDG&E's 2014 billing data by premise number. We then followed the same stratification approach as in the 2015 and 2016 consumer telephone surveys to yield 42 strata.

We implemented the online surveys during the fourth quarter of 2016 and completed 316 online surveys with high-wattage CFL purchasers. Table 14 summarizes survey disposition by IOU service territory. We weighted the survey results to reflect the population of residential electric customers in PG&E, SCE, and SDG&E electric service territories. As with the consumer telephone surveys, only electric customers of PG&E, SCE, or SDG&E were eligible to complete the online survey. APPENDIX C provides more details regarding

24 CPUC ED, 2016. Table 44 (2015 Uncertain Measures to be Prioritized). Pages 181—182.

25 DNV GL acknowledges the challenge associated with obtaining meaningful point estimates of lamp wattage from consumers in a survey effort of this nature. While we would likely obtain more reliable information from face-to-face interactions with consumers, the study budget and priorities allowed for no such interactions in support of the 2015 impact evaluation. As such, the online survey represented the best-available opportunity to attempt to address this issue. We structured the survey to minimize consumer confusion among the baseline lamp technologies, including provision of details regarding typical lamp wattages (e.g., 40, 60, 75 and 100 Watts for traditional incandescent lamps). Please refer to APPENDIX I for the data collection instrument. DNV GL also notes that the CPUC's forthcoming in-home lighting inventory and metering study provides an ideal opportunity to address baseline technology and wattage with consumers for installed high-wattage CFLs and have incorporated this objective into preliminary plans for that study. The inventory and metering effort will provide more concrete estimates of baseline wattage for high-wattage CFLs.

survey methods, and APPENDIX I provides the data collection instrument.

Table 14: Consumer online survey disposition by IOU service territory, 2016

IOU	Number of Respondents (n)	Percent of Respondents
PG&E	125	40%
SCE	120	38%
SDG&E	68	22%
Overall	**313**	**100%**

3.2 In-depth telephone interviews with lamp supplier representatives

Experienced DNV GL interviewers conducted in-depth telephone interviews with lamp supplier representatives during the fourth quarter of 2016.[26] Individual respondents included representatives of lamp manufacturing organizations and buyers from national brick-and-mortar retail chains. The sample frame included 17 manufacturing organizations that shipped discounted lamps in evaluated upstream lighting measure groups through the 2015 program. The frame also included the 3 retail chains that sold the most lamps discounted by these manufacturers, as well as 3 smaller retail chains that sold program-discounted lamps. These 6 retail chains represented approximately 48% of all program-discounted lamp shipments. In addition to suppliers who participated in the 2015 upstream lighting program, we also attempted to interview non-participants to obtain a more complete picture of California's retail market for replacement lamps. In many cases, individual manufacturers represent larger shares of the overall replacement lamp market than individual retailers (because manufacturers often serve multiple retain chains), so we focused our interviewing efforts on manufacturers' representatives.

Our supplier interviews addressed the following topics:

- **Inputs to the lamp choice model.** For all lamps in evaluated upstream lighting measure groups, we asked supplier representatives whether his or her company would still have sold each lamp through the same retail channel in the absence of the program. If not, we considered those lamps to be program-reliant. (For example, if a supplier representative told us he or she would not have sold LED A-lamps to discount stores without upstream lighting program incentives, we considered the presence of these lamps in discount stores to be program-reliant.) This enables us to estimate the market shares of various replacement lamp types if program-reliant lamps were not in stores and if the IOUs did not discount these lamps. We provide more detail on these scenarios in Section 3.4 below and on program-reliant lamps in Section 6 below.
- **Insights into channel shift.** We asked the supplier representatives whether they would expect sales to shift among channels for any lamp types in absence of the program. For example, they may have reported that the absence of the program might have led to a significant shift in sales in LED A-lamps away from the discount channel to the home improvement channel because discount stores tend not to stock these lamps at full price. In such cases, we asked the supplier representative to try to estimate the direction and magnitude of the channel shift effects. We describe these results in Section 7.1 below.
- **LED lamps that do not meet the CEC spec.** DNV GL recognizes the importance of addressing LED lamps that do and do not meet the California Quality LED Lamp Specification with lamp suppliers

26 Throughout the report we use "lamp suppliers" to refer collectively to manufacturers and retailers. When results are applicable only to one group or the other, we refer to the relevant respondent group (lamp manufacturers' representatives or retail lighting buyers).

given that during previous interviews, some suppliers suggest that they would not have sold any LED lamps that met the spec in absence of the upstream lighting program. We asked supplier representatives whether they sold any LED lamps that met the CEC spec without program incentives. We also asked them whether they would have sold any LED lamps that met the spec in 2015 if the program did not exist. Finally, asked them to describe any other influences of the CEC specification on their LED lamp sales in California. We present the results of these inquiries in Section 7.2.1.4 below.

In addition to these three topics, we also developed and tested a methodology to address freeridership in the 2015 upstream lighting program via the supplier interviews. We asked suppliers to estimate the percent of their sales that each lamp technology accounted for with the program compared to the percent of sales that each technology would have accounted for absent the program. In an effort to reduce the length and complexity of these interviews, we sought to produce market-level estimates of freeridership and thus did not ask these questions at the channel or measure group level. Instead, we asked suppliers to answer these questions regarding lamps in three replacement lamp categories: A-lamp replacements, reflector replacements, and high-wattage lamp replacements. The goal of this approach was to calculate the market share of each technology with the program and without the program. This result would be a comparable estimate to LCM results.

Our initial tests of each approach suggested that respondents understood the questions, and preliminary results seemed logical. However, two challenges became apparent:

1. **Disentangling the influence of program-discounted lamps within the same lamp replacement category**. In this evaluation, we used the model to estimate changes in market shares of each technology within a replacement category with and without the program. To obtain a comparable estimate from suppliers, we would have had to ask each supplier to estimate their market shares of all competing technologies (up to five) within each of three replacement lamp categories for each of seven channels. After completing these questions, we would have to repeat them for counterfactual estimates (i.e., how the percentages would differ in absence of the program for each competing technology in each lamp replacement category). Earlier, less detailed evaluation interviews with suppliers often exceeded 2 hours in length. For this reason, we simplified the approach to ask suppliers for estimates across channels (rather than at the channel level), as well as actual and counterfactual estimates for each replacement category (rather than at the measure group level). While this effort reduced interview length and was a more market-based interpretation of program influence (similar to the LCM), it obscured the influence of incentives for multiple measure groups within a lamp replacement category. The LCM ultimately produced more reasonable estimates program influence at this level.

2. **Inconsistent market volume results**. We used interview responses and measure group quantities to calculate the total market volume for each supplier and lamp replacement category. We cross-checked these estimates if the program provided incentives to the same supplier for multiple measure groups within one lamp replacement category. The tracking data quantity for each of a supplier's measure groups served as a separate starting point that should have led to the same overall volume. However, in the majority of cases, this check revealed wide divergence in a suppliers' total market estimates (see APPENDIX H for details). The underlying cause for these inconsistencies likely relates to the challenge respondents face in attempting to keep their hypothetical counterfactual estimates consistent from measure group to measure group.

As such, we relied upon the improved LCM to estimate freeridership for the 2015 upstream lighting program (as we describe in more detail in Section 3.4 below) and relied on the supplier interview results to provide context for the model-based results and to address channel shift and the CEC spec's influence on California's residential replacement lamp market.

We ultimately completed interviews with 27 supplier representatives. Table 15 shows the completed interviews by supplier type (manufacturer versus retail buyer). It also shows the percentage of total 2015 upstream lighting program shipments that interview participants represent within evaluated upstream lighting measure groups. As shown, the manufacturing organizations that participated in the in-depth interviews represented over 90% of upstream lighting program shipments in 2015. While the interviews we completed with retail lighting buyers included the largest three in the program, they ultimately represent a smaller percentage of total 2015 upstream lighting program shipments in evaluated measure groups. Appendix AA provides more details regarding the supplier interview methods, and APPENDIX I provides the data collection instruments.

Table 15: Disposition of in-depth telephone interviews with participating lamp supplier representatives by supplier type, 2016

Supplier Type	Sold Lamps in Evaluated Upstream Lighting Measure Groups in 2015?			% of 2015 Upstream Lamp Shipments Represented by Interviewees Who Sold Lamps in Evaluated Upstream Lighting Measure Groups in 2015
	No	Yes	Total	
Lamp manufacturer	5*	16	21	91%
Retail lighting buyer	0	6	6	48%
Total	**5**	**22**	**27**	

* Of these, three sold lighting products through the 2015 upstream lighting program that were not in evaluated measure groups and 2 did not sell any products through the 2015 upstream program.

3.3 Retail lamp stock inventories and shopper intercept surveys

DNV GL conducted detailed inventories of lamps for sale in California retail stores throughout PG&E, SCE and SDG&E service territories in support of the 2015 impact evaluation and prior evaluation periods. During the shelf inventories, we conducted intercept surveys with consumers who were shopping for lamps. The stock inventories gathered information regarding all residential replacement lamps stocked in the stores other than linear fluorescent lamps. The shopper intercept surveys focused on shopper purchasing decisions and installation intentions for the newly-purchased lamps.[27]

DNV GL conducted the most recent phase of stock inventories and shopper intercept surveys during the winter of 2015-16. Field staff spent a minimum of four hours in each store completing the shelf surveys and attempting to intercept shoppers. Field staff completed surveys opportunistically—that is, with individuals who were shopping during the time periods in which we conducted intercept surveys in specific stores. As such, results from the intercept surveys may not represent the broader population of shoppers purchasing replacement lamps at various stores throughout the year. Nonetheless, given the range in timeframes and

27 Field researchers also conducted shopper intercept surveys with respondents who were not purchasing lamps (non-purchaser shopper intercept surveys), but the results in this report focus on surveys with lamp purchasers only because these surveys included detailed questions regarding lamp replacement intentions.

store types in which we conducted these surveys, results provide general indications of shopper preferences, price sensitivity, lamp installation intentions, and so on.

The lamp stock inventory sample targeted approximately 200 stores. We stratified the sample by retail channel and IOU service territory (for PG&E, SCE, and SDG&E territories) and designed the sample to represent the retail market for residential replacement lamps in these areas. The sample design targeted roughly equal numbers of stores in each retail channel to ensure enough sample points per channel to enable channel-to-channel comparisons.

To support the 2015 impact evaluation, DNV GL leveraged the retail lamp stock inventory results primarily **to support the LCM.** The LCM reflects the lamp prices and availability that DNV GL staff observed in retail stores during the retail stock inventories. We updated the LCM to ensure that it represents the mix of lamp stock found on retail shelves during the winter of 2015-16. Because we only visit each store on a single day, in-store surveys do not fully capture the year-long availability of program-discounted lamps. We therefore expanded the shelf data to include all 2015 program-discounted lamps. We matched store names in the IOU tracking data to store names in the shelf data, and used a hedonic model to estimate the program lamp price.[28]

Table 16 below provides details regarding the number of stores we visited during the winter 2015-16 lamp stock inventories. Altogether, field staff conducted lamp stock inventories 207 retail stores. The DNV GL team applied sample expansion weights to the retail lamp stock inventory results such that each sample represents the population of retail stores that sell replacement lamps by retail channel in California. We based these results on a telephone sample of 800 retail stores in California stratified by retail channel.[29] APPENDIX B describes the development and application of the shelf survey weights and provides more details regarding survey methods. APPENDIX A provides the data collection instrument.

Table 16: Number of stores for retail lamp stock inventories by retail channel, winter 2015-16

Retail Channel	Number of Retail Stores
Discount	29
Drug	30
Grocery	28
Hardware	29
Home improvement	31
Mass merchandise	29
Wholesale club	31
Total	**207**

We also used the shopper intercept survey results primarily **to support the LCM.** The intercept surveys asked lamp purchasers to rank a set of hypothetical lamp technologies as most likely to purchase to least likely to purchase given a set of specific price points. The LCM uses these data to estimate model coefficients,

[28] See DNV GL, DNV GL, 2016a for further detail.

[29] See DNV GL, 2014c for further detail.

as we describe below in Section 3.4. In this evaluation, we evaluation updated model coefficients using winter 2015-16 purchaser intercept survey data.

Table 17 displays the number of lamp purchasers we intercepted during the winter 2015-16 data collection period.[30] APPENDIX B provides more details regarding survey methods, and APPENDIX I provides the data collection instrument.

Table 17: Number of intercept surveys conducted with lamp purchasers by retail channel, winter 2015-16

Retail Channel	Number of Intercept Surveys
Discount	40
Drug	17
Grocery	6
Hardware	58
Home improvement	64
Mass merchandise	104
Wholesale club	142
Total	**431**

3.4 Lamp choice model

The DNV GL team developed a residential consumer LCM as part of the impact evaluation of the IOUs' 2010-12 upstream and residential downstream lighting programs to quantify consumer responses to upstream lighting incentives.[31] The model relies upon data from the retail lamp stock inventories and in-store shopper intercept surveys to predict the probability that a consumer will choose a particular lamp. The intercept surveys collected information on consumer choices required for the model, while the shelf surveys captured information regarding the context for those choices, including details related to the selected lamp, its intended application, the retail channel in which the lamp was selected, and characteristics of the lamp purchaser. The LCM uses a nested logit model structure to predict consumer choices over a set of discrete alternatives.

Key model features include:

- **Market share predictions.** The model predicts changes in market shares as a response to price changes such as those that incentive programs introduce.
- **Heterogeneous price sensitivities.** Not all consumers have the same price sensitivity. The model design reflects that price sensitivities vary by consumer household income and whether the consumer is making an impulse or planned purchase.
- **Retail channel differences.** The model design recognizes that consumers have price sensitivities and choice sets that vary by retail channel. Specifically, the channels examined in the current study are:

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30 For the sake of simplicity, we refer to intercepted shoppers with lamps in their shopping carts or baskets as "purchasers." While each shopper has not yet purchased his or her lamp(s) at the time of the surveys, the expectation was that he or she would do so shortly after we completed the intercept survey.

31 DNV GL, 2014c.

discount stores, drug stores, grocery chain stores, grocery independent stores, hardware stores, home improvement stores, mass merchandise stores and wholesale clubs.

For the 2015 impact evaluation, our approach to using the LCM was as follows:

1. **Re-estimate the LCM.** We re-estimate the LCM with shopper intercept survey data from winter 2015-16. This process ensures that the model reflects consumer price sensitivities regarding the different lamp technologies available in brick-and-mortar retail stores during the 2015 program period.
2. **Estimate market shares under two scenarios by channel.** We estimated market shares using a simulation-based approach. The simulation involves two inputs. The first input is a representation of consumers based on results from the 2016 consumer telephone survey representing the retail channels in which shoppers typically purchase lamps of various types and the demographics of those shoppers. (Unlike the shopper intercept survey data, the consumer telephone survey data are a representative sample of consumers in the lamp market.) The second input is a representation of available lamp choices based on retail lamp stock inventory data. We ran the simulation against two scenarios:

   - **With program scenario**. This scenario reflects the lamp prices and availability that DNV GL observed in retail stores during the retail lamp stock inventories conducted in winter 2015-16. This scenario results in an estimate of the share of program lamp sales for each modelled technology in 2015.

   - **Without program scenario.** This scenario reflects the lamp prices as well as stocking changes that consumers would have seen in California retail stores in 2015, if the program had not occurred. DNV GL estimated price differences based on matching lamps to program tracking data. This scenario results in a counterfactual estimate of market shares that would have occurred if only prices on program-discounted lamps changed due no program activity. As we described in Section 3.2 above, we asked supplier representatives to indicate whether their companies would or would not have sold specific lamp types through specific retail channels in the absence of the program, we considered those lamps to be program-reliant. (For example, if a supplier representative told us he or she would not have sold basic spiral CFLs to drug stores without upstream lighting program incentives, we considered the presence of these lamps in drug stores to be program-reliant.) In a select number of cases, we use supplier responses to account for additional program influences (which we will discuss Section 6). This scenario resulted in a counterfactual estimate of market shares if program-reliant lamps were not in stores and if the IOUs did not discount lamps.

In prior evaluations, we considered the gross and net savings baseline relative to lamps that were replaced by program-discounted lamps. We then used LCM results to directly estimate a NTG ratio that represents the relative percent changes in a given technology's market shift. However, in this evaluation, we consider the net savings baseline relative to lamps that would have been purchased in the absence of the program. The team thus used the LCM to estimate the overall difference in market shares with and without the upstream lighting program, and calculated a net UES to yield market-level net energy savings (see Section 6 for further detail). We were able to generate simulations based on 2016 consumer telephone survey results. (We conducted the telephone surveys with a representative sample of 578 PG&E, SCE, and SDG&E residential electric customers.) This enhancement allowed us to increase the rigor of our model results in the absence of supplier results.

Table 18 lists the strengths and weaknesses of the model-based net savings approach. APPENDIX G provides the coefficients for the LCM and provides more detail regarding LCM methodology.

Table 18. Strengths and weaknesses of the model-based net savings approach

Strengths	Weaknesses
• *Intercept surveys inform the model estimation:* We used information from consumers making purchasing decisions in California retail stores to estimate the model. This information is as close to real-time consumer purchasing decisions as possible. • *Responses from representative sample of California consumers used to simulate choices:* We simulated lamp purchases using demographics and store locations as reported by California lamp shoppers during our 2016 phone and online consumer surveys. • *Directly models consumer choices:* Upstream programs attempt to influence consumer choices. Logit models are the preferred analytical method for quantifying how a program signal moves consumers from one lamp technology to another. • *Captures differences in shopper populations by retail channel:* The model specification captures differences in choice-making among consumers by income group, homeowner versus renter status, and planned versus impulse purchasing decisions. The model specification is sensitive to differences in the population that shops in retail stores from channel to channel (capturing, for example, differences among shoppers the discount channel versus the home improvement channel). • *Simulation based on up-to-date retail stocking information:* We built the simulation using shelf survey data from a representative sample of California retail stores that sold replacement lamps during the 2015 program period. These data record the distribution of lamp models and prices at each store, and these ground our analyses in the choices facing consumers during the program period.	• *Preference data may reflect biases that would not be present in sales data:* The evaluation team is unaware of a comprehensive data source representing retail lamp sales from all of California's major lighting retailers. As such, we cannot confirm the extent to which survey respondents' stated choices under different conditions (e.g., whether they still would have purchased the same lamp when we altered their available options in our choice sets) reflect actual retail sales volumes. • *The model does not explicitly represent sales volume:* The model predicts market shares. As such, the model does not endogenously account for the different volumes program shipments. • *The model does not comprehensively address substitution between program and non-program lamps:* Some stores (such as those in the home improvement channel) have more non-program lamps than program-discounted lamps. The model does not handle this market situation as well as situations in which the volume differences are less skewed.

3.5 Program tracking data and other secondary sources

In addition to the sources we reviewed above, this report also relies upon program tracking data and other secondary sources including prior market research and evaluation reports related to the California IOUs' residential and upstream lighting programs and other industry publications. Below, we provide more details regarding these sources and their application in this evaluation.

3.5.1 Program tracking data

Each of the IOUs uploads program tracking data onto a centralized server. We downloaded these data and then analyzed, cleaned, re-categorized, reformatted, and merged these separate datasets into one program tracking database. The tracking data provide details regarding the quantity of lighting measures shipped as well as details regarding the manufacturers and retailers involved in the 2015 upstream lighting program, the latter of which supported our development of the sample frame for the in-depth lighting supplier interviews. The tracking data also enables us to produce estimates of the average discounted lamp wattage for each evaluated upstream lighting measure group and IOU, and provides the ex-ante values for us to pass through for specific parameters that we did not address in this evaluation. We provide more detail regarding the program tracking data when we discuss measure quantity adjustments (Section 4) and our gross savings analyses (Section 5).

3.5.2 Other EM&V reports

We relied upon data from other EM&V studies to support the overall evaluation efforts that we describe herein. These data sources included:

- **Impact Evaluation of 2013-14 California Upstream and Residential Downstream Lighting Programs** (DNV GL, 2016b). This study included all lighting measures associated with upstream delivery mechanisms and all downstream lighting measures targeted at the residential sector. The impact evaluation focused on seven measures that collectively accounted for over 90% percent of each IOUs' ex ante net savings from upstream and residential downstream measures. These measures included basic spiral CFLs, CFL A-lamps, CFL globes, CFL reflectors, LED A-lamps and LED reflectors. Several of the impact evaluation parameters and methodologies used in the 2013-14 program cycle have been "passed through" and utilized in the current evaluation. We also conducted the 2015 consumer telephone surveys in support of this evaluation; we described our use of these results in Section 3.1.1 above.
- **CLASS** (DNV GL, 2014a). The CLASS study updates and augments saturation and efficiency characteristics from previous CLASS studies conducted in 2005 and 2000 for use in understanding future energy savings potential and past accomplishments in the residential sector. The 2012 CLASS study included onsite observations on a sample of 1,987 single-family, multi-family and mobile home residences with individually-metered electric accounts across the service territories of PG&E, SCE and SDG&E. The 2015 impact evaluation relied upon CLASS data to update the delta Watts, HOU, and peak coincidence factors for CFLs and LED lamps. We provide more detail in Section 5 (Gross Savings).
- **Residential Lamp Inventory and Metering Study** (DNV GL, 2014c). We conducted detailed lamp inventories and hours-of-use metering of lamps in more than 2,000 California households as part of the California Upstream and Residential Lighting Impact Evaluation Work Order 28 (WO28) Final Report. In this evaluation, we apply these saturation data to metering data collected in support of the 2006-2008 evaluation to support estimates of average daily hours of use and peak coincidence factor. Please refer to our gross savings analyses in Section 5 for further detail.
- **2016 Hedonic Pricing Model (**DNV GL, 2016c). As part of 2010-12 Evaluation, EM&V Work Order 17 (Measure Cost study[32]), the DNV GL team created a hedonic pricing model for four LED lamp styles including A-lamp, reflector, globe, and torpedo. Hedonic pricing models are regression models that predict price as a function of several variables. We used this model to estimate full-retail program lamp price in our LCM simulations if the program lamp was not observed during our retail lamp stock inventory data collection.

[32] Itron and DNV GL, 2014.

We provide further detail regarding our application of secondary sources when we discuss measure quantity adjustments (Section 4) and our gross savings analyses (Section 5). Section 9 provides complete citations for all sources cited in this report.

4 MEASURE QUANTITY ADJUSTMENTS

The 2013-14 Upstream and Downstream Residential Lighting Impact Evaluation[33] applied three adjustments to the quantity of rebated measures claimed by the IOUs as having been sold to their residential and nonresidential customers during the program period. This evaluation maintains the values associated with each of these three adjustments, which we developed as part of the 2010-12 impact evaluation.[34] These include:

1. Quantity of IOU-discounted products shipped by participating manufacturers to retailers as determined through the verification of a sample of program invoices/applications
2. Percent of IOU-discounted products purchased by residential versus nonresidential customers
3. Percent of IOU-discounted products purchased by non-IOU customers (i.e., leakage)

We provide more detail regarding measure quantity adjustments below.

4.1 Invoice verification

The 2010-12 residential and upstream lighting impact evaluation report describes the results of the evaluation team's invoice verification. Evaluators verified the quantity of IOU-discounted products shipped by participating manufacturers to retailers based on their review of a sample of program invoices and applications. The evaluation estimated an ultimate verification rate of 100% for all IOUs and retail channels. As such, we have applied the 100% verification rate in this report (as we did in the 2013-14 impact evaluation).

4.1.1 Residential versus nonresidential

To estimate the portion of upstream CFLs that are installed in nonresidential applications, the 2010-12 evaluation relied on the results of two onsite survey studies conducted during the 2010-12 period—the CLASS[35] and the Commercial Market Share Tracking Study.[36] These efforts yielded the residential versus nonresidential shares of total upstream lighting program measures shown in Table 19. As in the 2013-14 impact evaluation, we applied these estimates in this report.

[33] DNV GL, 2016b.

[34] DNV GL, 2014c.

[35] DNV GL, 2014a. Please refer to APPENDIX H for details regarding the CLASS sampling approach.

[36] Itron, Inc., 2014.

Table 19. Ex post share of residential vs. nonresidential upstream lighting measures by IOU, 2015

IOU	Ex Post	
	Nonresidential	Residential
PG&E	7%	93%
SCE	6%	94%
SDG&E	6%	94%
Overall	**7%**	**93%**

Table 20 compares ex ante and ex post estimates for the split between upstream measures installed in residential versus nonresidential applications by measure group and IOU. As shown, ex post assumptions indicate that the share of lamps installed in nonresidential applications is equal to ex ante assumptions for all PG&E and SCE measures. SDG&E submitted 100% residential claims, so we reclassified 6% of those claims as nonresidential.

Table 20. Ex ante and ex post residential and nonresidential split by upstream lighting measure group and IOU, 2015

Upstream Lighting Measure Group / IOU	Ex Ante		Ex Post	
	Residential	Nonresidential	Residential	Nonresidential
MSB CFL basic spiral ≤ 30 W				
PG&E	94%	6%	93%	7%
SCE	N/A	N/A	N/A	N/A
SDG&E	100%	0%	94%	6%
MSB CFL A-lamp ≤ 30 W				
PG&E	94%	6%	93%	7%
SCE	94%	6%	94%	6%
SDG&E	100%	0%	94%	6%
MSB CFL reflector ≤ 30 W				
PG&E	N/A	N/A	N/A	N/A
SCE	94%	6%	94%	6%
SDG&E	100%	0%	94%	6%
MSB CFL high-wattage (> 30 W)				
PG&E	94%	6%	93%	7%
SCE	94%	6%	94%	6%
SDG&E	100%	0%	94%	6%
LED A-lamp, all wattages				
PG&E	94%	6%	93%	7%
SCE	94%	6%	94%	6%
SDG&E	100%	0%	94%	6%
LED reflector, all wattages				
PG&E	94%	6%	93%	7%
SCE	94%	6%	94%	6%
SDG&E	100%	0%	94%	6%

Table 21 shows how the ex ante and ex post shares of residential versus nonresidential lamps from Table 20 affect ex ante and ex post residential and nonresidential lamp quantities in each of the IOUs' 2015 upstream lighting programs by measure group.

Table 21. Ex post and ex ante quantities of residential and nonresidential lamps by upstream lighting measure group, 2015

Evaluated Upstream Lighting Measure Group / IOU	Residential		Nonresidential	
	Ex Ante	Ex Post	Ex Ante	Ex Post
MSB CFL basic spiral ≤ 30 W				
PG&E	469,908	464,909	29,994	34,993
SCE	N/A	N/A	N/A	N/A
SDG&E	20,795	19,547	0	1,248
Overall	**490,703**	**484,456**	**29,994**	**36,241**
MSB CFL A-lamp ≤ 30 W				
PG&E	20,313	20,097	1,297	1,513
SCE	1,058,807	1,058,577	67,339	67,569
SDG&E	265,251	249,336	0	15,915
Overall	**1,344,372**	**1,328,010**	**68,635**	**84,997**
MSB CFL reflector ≤ 30 W				
PG&E	N/A	N/A	N/A	N/A
SCE	2,482,209	2,480,704	156,838	158,343
SDG&E	88,564	83,250	0	5,314
Overall	**2,570,773**	**2,563,954**	**156,838**	**163,657**
MSB CFL high-wattage (> 30 W)				
PG&E	65,514	64,817	4,182	4,879
SCE	2,177,285	2,176,842	138,504	138,947
SDG&E	203,480	191,271	0	12,209
Overall	**2,446,280**	**2,432,930**	**142,685**	**156,035**
LED A-lamp, all wattages				
PG&E	1,298,902	1,285,084	82,909	96,727
SCE	1,457,537	1,455,777	91,162	92,922
SDG&E	640,392	601,968	0	38,424
Overall	**3,396,831**	**3,342,830**	**174,071**	**228,072**
LED reflector, all wattages				
PG&E	653,235	645,955	41,340	48,620
SCE	1,532,020	1,528,864	94,431	97,587
SDG&E	423,502	398,092	0	25,410
Overall	**2,608,757**	**2,572,911**	**135,771**	**171,617**

4.2 Leakage

Leakage is defined as the quantity of program-discounted upstream lamps that “leak” out of the collective IOU service territories. Due to the lack of strong data supporting leakage, no adjustment to quantity was applied in the 2010-12 or 2013-14 impact evaluation reports. Therefore, we have applied the same 0% leakage rate in this report.

4.3 Additional measure quantity considerations

In conducting the analyses in support of this evaluation, we encountered two concerns regarding the quantity of measures that the IOUs included in the 2015 upstream lighting program. These include:

1. **Discrepancy in program year**. During the 2016 in-depth telephone interviews with lamp supplier representatives, a few suppliers noted that according to their records, they did not receive discounts for or ship some of the measures included in the 2015 program tracking data. Below, Table 22 presents the count of measures that supplier representatives identified as not discounted during the 2015 program period. This may reflect a discrepancy in the program tracking data[37]--however, because suppliers reported these discrepancies across the program, we were not able to attribute them to specific IOUs. Due to this, the limited nature of affected quantities, and the fact that addressing this was not a research priority for 2015, we did not exclude these lamps from our savings calculations. We do recommend that tracking data consistently present measures that were truly discounted and shipped within the program year. We also recommend that a careful review that claims occurred within the listed cycle be considered a future research priority. With these improvements, the evaluation will continue to more accurately estimate program impacts.

Table 22. Quantity of lamps with possible program year discrepancy (2015 tracking data)

Evaluated Upstream Lighting Measure Group	Measure Quantity
MSB CFL Reflectors ≤ 30 W	273,688
MSB LED A-lamp, all wattages	23,914
Total	**297,602**

2. **Mislabeled measure group or measure wattage in tracking data.** In reviewing the 2015 program tracking data, we found approximately 250,000 lamps assigned to incorrect measure groups based on lamp wattage (Table 23). 69,696 of these lamps were in PG&E's tracking data and the remaining 177,676 were in SDG&E's tracking data. In some cases, the tracking data assigned wattages that contradicted the measure name and measure group. In these cases, we updated the measure groups per the "Revised Measure Group" column in the table and moved forward using the proper categorization. We again recommend that program administrators perform additional review and accuracy checks on their claim measure group classifications and wattage estimates.

[37] We say that this "may" reflect a discrepancy (rather than "does" reflect a discrepancy) to acknowledge possible errors in the suppliers' records—however, because we identified this issue with more than one supplier, it seems likely that there is an underlying tracking data issue.

Table 23. Quantity of lamps listed with incorrect measure groups (2015 program tracking data)

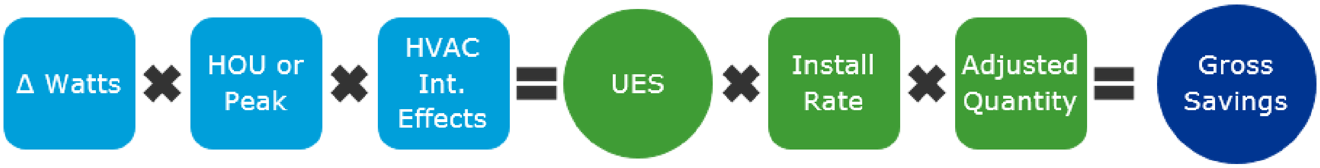
IOU (Tracking Data)	Measure Group (Tracking Data)	Revised Measure Group (DNV GL Assignment)	Measure Name (Tracking Data)	Measure Quantity (Tracking Data)
PG&E	Lighting Indoor CFL A Lamp	Lighting Indoor CFL > 30 Watts	CFL 40 Watt Int Bare Spiral Multi-Pk	69,696
SDG&E	Lighting Indoor CFL Basic	Lighting Indoor CFL > 30 Watts	Commercial-Screw-In CFL (32 Watt) >=2,001 Lumens	4,345
		Lighting Indoor CFL Other	CFL - Candalebra (7 Watt)	4,130
			CFL - Candalebra (9 Watt)	503
	Lighting Indoor LED Lamp	Lighting Indoor LED Fixture	Commercial LED Recessed Downlight 21 Watt	7,653
			Commercial-LED Recessed Downlight 14 Watt	0
			Commercial-LED Recessed Downlight 15 Watt	691
			Commercial-LED Recessed Downlight 20 Watt	1,999
			Commercial-LED Recessed Downlight 23 Watt	290
			LED Recessed Downlight 20 Watt	31,312
			LED Recessed Downlight 23 Watt	4,539
		Lighting Indoor LED Globe	Commercial-LED Screw-In Globe 12 Watt	19
			Commercial-LED Screw-In Globe 9 Watt	12
			LED Screw-In Globe 12 Watt	292
			LED Screw-In Globe 9 Watt	186
		Lighting Indoor LED Reflector Lamp	Commercial LED Screw-In R30 10 Watt	894
			Commercial-LED Screw-In Par20 10 Watt	4
			Commercial-LED Screw-In Par20 13 Watt	303
			Commercial-LED Screw-In R30 14 Watt	6,916
			LED Screw-In Par20 10 Watt	67
			LED Screw-In Par20 13 Watt	4,747
			LED Screw-In R30 14 Watt	108,356
			LED Screw-In R40 14 Watt	418
Overall				**247,372**

5 GROSS SAVINGS

5.1 Overview

This section of the report focuses on the gross savings methods and results for the IOUs' 2015 upstream and residential downstream lighting programs. Below, Figure 1 displays the components of the gross savings assessment.

Figure 1. Gross savings overview



We calculate gross savings using an estimate for UES, an evaluated installation rate, and an adjusted quantity factor. We define the UES for each measure group as the product of three parameters including: delta watts (Δ watts), hours of use (HOU) or peak coincidence factor (CF), and HVAC interactive effects (IE). The equations for these calculations are presented below in Equation 1 through Equation 4.

Equation 1. Gross unit energy savings

$$UES_L\left[\frac{kWh}{year}\right] = \Delta Watts_L[W] * HOU_L[h] * \frac{1\ kWh}{1000\ Wh} * \frac{365\ days}{1\ year} * IE_L[kWh]$$

Where:

$\Delta Watts_L$ = average displaced (delta) wattage for IOU-discounted lamp measure group, L, in watts (W)

HOU_L = annual average HOU for IOU-discounted lamp measure group, L, in hours (h)

IE_L = HVAC interactive effects in kilowatt-hours (kWh)

Equation 2. Gross savings

$$Gross\ savings_L[kWh] = UES_L[kWh] * IR_L * Q_L$$

Where:

UES = unit energy savings for lamp measure group, L (see Section 5.6)

IR_L = installation rate for lamp measure group, L

Q_L = rebated measure quantity for lamp measure group, L

Equation 3. Gross peak unit energy savings

$$UES_L\left[\frac{kW}{year}\right] = \Delta Watts_L[W] * CF_L * \frac{1\ kW}{1000\ W} * IE_L[kW]$$

Where:

ΔW_L = average displaced (delta) wattage for IOU-discounted lamp measure group, L, in watts (W)

CF_L = average percent on at peak for IOU-discounted lamp measure group, L

IE_L = HVAC interactive effects in kilowatts (kW)

Equation 4. Gross peak demand reduction

$$Gross\ savings_L[kW] = UES_L[kW] * IR_L * Q_L$$

Where:

UES = unit peak demand reduction for lamp measure group, L (see Section 5.6)

IR_L = installation rate for lamp measure group, L

Q_L = rebated measure quantity for lamp measure group, L

5.2 HOU

We use the average daily HOU to calculate UES based on the operating hours for each relevant measure group. For this evaluation—as in the 2013-14 impact evaluation—we estimated population-level average daily HOU by measure group using an ANCOVA model for residential savings estimates. We applied the ex ante UES for nonresidential savings estimates, so this section of the report applies only to residential savings estimates. This report reflects the changes we made to developing HOU estimates for the 2013-14 impact evaluation, which include:

- We developed HOU estimates for high-wattage CFLs (> 30 W) as well as a measure group for all types of LED lamps.
- To account for changes in the lower-wattage CFL measure groups with the removal of the high-wattage lamps, we developed HOU estimates for basic spiral CFLs ≤ 30 W, A-lamp CFLs ≤ 30 W, and reflector CFLs ≤ 30 W.

The ANCOVA model used logger data HOU profiles from the 2010 Residential Lighting Metering Study[38, 39] and lamp installation locations from the 2012 CLASS residential lamp inventory.[40] HOU estimates by measure group take into account lamp types as well as room location and usage within the population: for example, for a reflector CFL ≤ 30 W located in a dining room, we applied the usage profile that we generated for CFL reflectors ≤ 30 W in dining rooms.

Sample sizes in the 2010 metering study were insufficient to model LED A-lamp and LED reflector lamp usage profiles, and DNV GL is aware of no other available sources that estimate LED lamp hours of use in California. Lamp usage varies by installation location, so (as in the 2013-14 impact evaluation report), we

[38] KEMA, Inc. and Cadmus Group, 2010. The study included 1,200 households recruited randomly throughout California over three overlapping waves of data collection from July 2008 through December 2009. Please refer to APPENDIX G for more details regarding metering study sample sizes.

[39] While more current metering data would certainly be preferable, these data are not available. In the absence of more current data, DNV GL believes that adjustments to the 2010 study's metering results based on updated lamp disposition (by installation location) from the CLASS study provide the most accurate representation available for residential lamp usage in California. Commission staff and consultants are currently engaged in scoping efforts for an updated residential lighting inventory and metering study.

[40] DNV GL, 2014a.

applied the CFL usage profiles from the 2010 metering study to the LED lamps in the 2012 CLASS inventory based on installation locations to yield LED lamp usage profiles.

The model produced estimates at the statewide level and for each IOU. For all MSB CFL measure groups ≤ 30 W, we applied HOU estimates at the IOU level. Because LED lamps and high-wattage CFLs >30 W were present in lesser quantities in the 2012 CLASS data than lower-wattage CFLs, confidence intervals were too broad to support IOU-specific estimates for these measure groups. Also as a result of small sample sizes, the data do not support reporting on LED lamps by lamp shape. Table 24 provides an overview of the HOU results, including confidence intervals (CI).

Table 24. Residential lighting HOU estimates by evaluated upstream lighting measure group and IOU, 2015

Evaluated Upstream Lighting Measure Group	PG&E		SCE		SDG&E		Overall	
	HOU	90% CI	HOU	90% CI	HOU	90% CI	HOU	90% CI
MSB CFL basic spiral ≤ 30 W	1.6	±0.1	1.9	±0.2	1.4	±0.2	1.7	±0.1
MSB CFL A-lamp ≤ 30 W	1.5	±0.2	1.9	±0.2	1.3	±0.3	1.6	±0.2
MSB CFL reflector ≤ 30 W	N/A	N/A	1.9	±0.2	1.2	±0.4	1.7	±0.2
MSB CFL high-wattage (> 30 W)*	*	*	*	*	*	*	1.9	±0.2
LED A-lamp, all wattages*	*	*	*	*	*	*	2.1	±0.2
LED reflector, all wattages*	*	*	*	*	*	*	2.1	±0.2

* The table presents high-wattage CFL, LED A-lamp, and LED reflector lamp measure groups across all IOUs as a result of small sample sizes in the 2010 metering study for measures in these groups. In these cases, we applied the overall estimates in calculating impacts. Please refer to APPENDIX E for more details regarding metering study sample sizes.

5.3 Peak coincidence factor

Peak CF represents the average percent of time that a lamp is switched on during the peak period, which varies by climate zone. Similar to our approach for HOU estimates, we derived CF estimates for LED lamps and high-wattage CFLs from the logger data collected for the 2010 metering study and applied these estimates to the lighting inventory data collected during CLASS 2012. Again, high-wattage CFL, LED A-lamp, and LED reflector lamp inventories were too small to create valid estimates by lamp shape or by IOU, so we applied the overall estimates (across IOUs) in calculating impacts as we did in the 2013-14 impact evaluation report. Table 25 shows the final peak CF values for 2015.

Table 25. Residential lighting peak CF by evaluated upstream lighting measure group and IOU, 2015

Evaluated Upstream Lighting Measure Group	PG&E		SCE		SDG&E		Overall	
	Peak CF	90% CI	Peak CF	90% CI	Peak CF	90% CI	Peak CF	90% CI
MSB CFL basic spiral ≤ 30 W	0.05	±0.01	0.07	±0.01	0.04	±0.02	0.06	±0.01
MSB CFL A-lamp ≤ 30 W	0.05	±0.02	0.06	±0.02	0.04	±0.02	0.05	±0.01
MSB CFL reflector ≤ 30 W	N/A	N/A	0.06	±0.02	0.04	±0.03	0.06	±0.02
MSB CFL high-wattage (> 30 W)*	*	*	*	*	*	*	0.06	±0.01
LED A-lamp, all wattages*	*	*	*	*	*	*	0.06	±0.02
LED reflector, all wattages*	*	*	*	*	*	*	0.06	±0.02

* The table presents high-wattage CFL, LED A-lamp, and LED reflector lamp measure groups across all IOUs as a result of small sample sizes in the 2010 metering study. In these cases, we applied the overall estimates in calculating impacts. Please refer to APPENDIX E for more details regarding metering study sample sizes.

5.4 Delta watts

The estimate for delta watts is the difference between the program-discounted lamp wattage and the baseline lamp wattage (Equation 5).

Equation 5. Delta watts

$$\Delta \text{Watts}_{L,IOU} = W(Discounted)_{L,IOU} - W(Base)_{L,IOU}$$

Where:

$\Delta \text{Watts}_{L,IOU}$ = Delta watts for a measure group and IOU

$W(Discounted)_{L,IOU}$ = Average wattage of discounted lamps within a measure group and IOU

$W(Base)_{L,IOU}$ = Average wattage of lamps replaced by program lamp, by measure group and IOU (baseline wattage)

We calculated delta watts as the difference between a measure group's mixed-technology baseline wattage and its average program lamp wattage:

- **Program lamp wattage.** We calculated the average program lamp wattage for each measure group based on the 2015 program tracking data.
- **Baseline technology mix.** Results from the 2015 consumer telephone surveys provide details regarding estimates of baseline technology mix by measure group for all measure groups except high-wattage CFLs (> 30 W). We use results from the 2016 online surveys to identify the baseline technology mix and wattage of lamps that high-wattage CFLs (>30 W) replaced. Given the relative scarcity of high-wattage CFLs installed per the 2012 CLASS, it would have been cost-prohibitive to reach a reasonable number of high-wattage CFL purchasers in a telephone survey.
- **Baseline wattage.** We used the baseline technology mix from the 2015 consumer telephone surveys and the average baseline lamp wattage from the CLASS in-home lamp inventory to estimate baseline wattage of all measure groups except high-wattage CFLs (> 30 W). As noted above, for high-wattage CFLs, we used results from the 2016 consumer online survey to estimate baseline wattage. For all measure groups, we estimated baseline wattage based on the average lamp wattage for each baseline technology weighted by the proportion of all baseline measures that each technology represented in the population of PG&E, SCE, and SDG&E residential electric customers.

5.4.1 Program lamp wattage

As we described above, delta watts is the difference between the average program lamp wattage and the baseline lamp wattage. We calculated the average program lamp wattage using 2015 program tracking data. Table 26 presents these wattages below.

Table 26. Average program lamp wattage, 2015

Measure Group / IOU	Average Program Lamp Wattage*		
	PG&E	SCE	SDG&E
MSB CFL basic spiral ≤ 30 W	21	N/A	16
MSB CFL A-lamp ≤ 30 W	18	18	14
MSB CFL reflector ≤ 30 W	N/A	22	20
MSB CFL high-wattage (> 30 W)	40	41	37
LED A-lamp, all wattage	8	5	9
LED reflector, all wattages	11	11	14

* Source: 2015 program tracking data

5.4.2 Baseline technology mix

In the 2010-12 and 2013-14 impact evaluations, ex ante and ex post methodologies defined the baseline relative to incandescent lamp wattages. However, in 2015, the CPUC ED issued a decision that redefined the savings baseline as a mixture of CFL and LED lamps.[41] We therefore defined the delta watts baseline in this study as the average wattage of all baseline lamp technologies. This requires estimation of the baseline technology mix—that is, the percentage of lamps of each technology that CFLs or LED lamps replaced—as well as the average wattage of each of those technologies. We address the latter in Section 5.4.3. Table 27 shows percentage of program-discounted CFLs that replaced each baseline lamp technology and the percentage of program-discounted LED lamps that replaced each baseline technology according to the 2015 consumer telephone survey. For example, 56% of program-discounted CFLs replaced incandescent lamps, while 51% of program-discounted LED lamps replaced incandescent lamps.

Table 27. Percent of program-discounted CFLs and LED lamps that replaced each baseline technology, 2015 (2015 consumer telephone survey)

Baseline Technology	Percent of Lamps	
	CFLs (n=4,182)	LED Lamps (n=2,364)
Incandescent	56%	51%
Halogen	15%	14%
CFL	22%	30%
LED	7%	5%
Overall	**100%**	**100%**

5.4.3 Baseline wattage

We used 2012 CLASS data to calculate the baseline wattage for all technologies except incandescent lamps. Because we collected the CLASS data prior to extensive adoption of EISA-compliant general purpose halogen/incandescent lamps, we performed a fairly simple calculation to account for an increased adoption in EISA-compliant lamps in our baseline wattage estimate for incandescent lamps (an “updated” average baseline wattage). We considered the midpoint between the average CLASS incandescent lamp wattage and

[41] CPUC ED, 2015b.

the average EISA-compliant lamp wattage from the winter 2015-16 retail lamp stock inventory as the baseline wattage for incandescent lamps.[42] Table 28 shows the average installed incandescent lamp wattage per 2012 CLASS data, the average EISA-compliant halogen/incandescent lamp wattage per winter 2015-16 lamp stock inventory data, and the average of the two.

Table 28. Updated baseline incandescent lamp wattage by IOU, 2015

IOU	Average Wattage		
	Installed Incandescent Lamp[1] (A)	On-Shelf EISA-Compliant Incandescent / Halogen Lamp[2] (B)	Updated Baseline Incandescent Lamp (A+B) / 2
PG&E	61	53	57
SCE	61	54	58
SDG&E	62	56	59

[1] Source: CLASS 2012; PG&E n = 6,367; SCE n = 6,288; SDG&E n= 2,635
[2] Source: DNV GL winter 2015-16 retail lamp stock inventory; PG&E n = 406; SCE n = 325; SDG&E n = 276

We then created an overall baseline wattage for each measure group. This overall baseline wattage is a weighted average across all installed lamps[43] proportional to the frequency with which program-discounted lamps replaced each respective baseline technology. We show these results below grouped by CFL measure groups ⩽ 30 W (including basic spiral CFLs, CFL A-lamps, and CFL reflectors), LED lamp measure groups (including A-lamps of all wattages and reflector lamps of all wattages), and high-wattage CFLs (> 30 W). Table 29 shows the overall baseline wattage results for CFLs ⩽ 30 W, while Table 30 presents the same results for MSB LED A-lamps and MSB LED reflectors of all wattages.

[42] DNV GL is currently engaged in the scoping phase (Phase 1) of an in-home lamp inventory and metering study will obtain more accurate and detailed information regarding EISA-compliant lamp adoption among the California IOUs' electric customers. The January 2016 EM&V Plan provides more detail on the Phase 1 study (CPUC ED, 2016).

[43] The overall baseline wattage is a weighted average of all installed lamps regardless of installed lamp wattage.

Table 29. Baseline lamp wattage for MSB CFLs ⩽ 30 W (basic spiral and A-lamps) and MSB CFL reflector lamps ⩽ 30 W, 2015

IOU / Baseline Lamp Technology	Percent of Program-Discounted CFLs[1]	Average Baseline Lamp Wattage[2]	
		MSB Basic Spiral and A-lamps	MSB Reflector Lamps
PG&E			
Updated incandescent*	56%	57	N/A
Halogen	15%	63	N/A
CFL	22%	17	N/A
LED	7%	7	N/A
Overall	**100%**	**45**	**N/A**
SCE			
Updated incandescent*	56%	58	68
Halogen	15%	84	80
CFL	22%	17	17
LED	7%	7	12
Overall	**100%**	**49**	**55**
SDG&E			
Updated incandescent*	56%	59	66
Halogen	15%	57	69
CFL	22%	17	16
LED	7%	7	12
Overall	**100%**	**46**	**52**

* "Updated incandescent" includes a mix of traditional incandescent lamps and EISA-compliant halogen/incandescent lamps per Table 28 above.
1 Source: Consumer phone survey, 2015 (n=4,182)
2 Source: CLASS, 2012 (n=38,287) and DNV GL retail store shelf surveys, winter 2015-16 (n=1,007)

Table 30. Baseline lamp wattage for MSB LED A-lamps of all wattages and LED reflector lamps of all wattages, 2015

IOU / Baseline Lamp Technology	Percent of Program-Discounted LED Lamps[1] (n=2,364)	Average Baseline Lamp Wattage[2]	
		MSB Basic Spiral and A-lamps	MSB Reflector Lamps
PG&E			
Updated incandescent*	51%	57	71
Halogen	14%	63	68
CFL	30%	17	16
LED	5%	7	12
Overall	**100%**	**43**	**51**
SCE			
Updated incandescent*	51%	58	68
Halogen	14%	84	80
CFL	30%	17	17
LED	5%	7	12
Overall	**100%**	**47**	**52**
SDG&E			
Updated incandescent*	51%	59	66
Halogen	14%	57	69
CFL	30%	17	16
LED	5%	7	12
Overall	**100%**	**44**	**49**

* "Updated incandescent" includes a mix of traditional incandescent lamps and EISA-compliant halogen/incandescent lamps per Table 28 above.
[1] Source: Consumer phone survey, 2015 (n=2,364)
[2] Source: CLASS, 2012 (n=38,287) and DNV GL retail store shelf surveys, winter 2015-16 (n=1,007)

We used responses from the 2016 online consumer survey to calculate a baseline for high-wattage CFLs (> 30 W). During the survey, we asked consumers who had purchased high-wattage CFLs to consider up to three of these lamps and identify the wattage of the lamp that each replaced. Table 31 shows this average baseline wattage for each IOU.

Table 31. Baseline lamp wattage for high-wattage CFLs (> 30 W), 2015 (2016 consumer online survey)

Baseline Lamp Technology	Count of Installed Lamps (n)	Baseline Wattage
PG&E	270	76
SCE	247	67
SDG&E	144	63

5.4.4 Delta watts

Table 32 below uses the baseline wattages we presented in Section 5.4.3 along with average program-discounted lamp wattages to calculate delta watts for each measure group and IOU. Delta watts are lower in this evaluation than in the 2010-12 and 2013-14 evaluations because this evaluation relies upon a mixed CFL and LED lamp baseline versus the prior evaluations' incandescent lamp baselines. This change results in lower delta watts (and thus lower UES values as we will describe in Section 5.6).

Table 32. Average baseline lamp wattages, average program lamp wattages, and ex post delta watts by upstream lighting measure group and IOU, 2015

Measure Group / IOU	Average Baseline Lamp Wattage[1]	Average Program Lamp Wattage[2]	Delta Watts
MSB CFL Basic Spiral ≤ 30 W			
PG&E	45	21	24
SCE	N/A	N/A	N/A
SDG&E	46	16	30
MSB CFL A-Lamp ≤ 30 W			
PG&E	45	18	27
SCE	49	18	31
SDG&E	46	14	32
MSB CFL Reflector ≤ 30 W			
PG&E	N/A	N/A	N/A
SCE	55	22	32
SDG&E	52	20	32
MSB CFL High-Wattage (> 30 W)			
PG&E	76	40	33
SCE	67	41	26
SDG&E	63	37	26
LED A-Lamp (all wattages)			
PG&E	43	8	35
SCE	47	5	42
SDG&E	44	9	34
LED Reflector (all wattages)			
PG&E	51	11	40
SCE	52	11	41
SDG&E	49	14	36

Note: Differences between delta watts and the value generated by subtracting the rebated wattage from the baseline wattage may exist because of rounding.
[1] Source: CLASS 2012
[2] Source: 2015 program tracking data

Readers should note that the California Database for Energy Efficient Resources[44] (DEER) uses a wattage reduction ratio[45] to estimate energy savings related to efficient lamp replacements. The IOUs apply these

[44] DEER is a California Energy Commission (CEC) and CPUC-sponsored database designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) all with one data source: http://www.energy.ca.gov/deer/.

estimates in their ex ante savings calculations. Using the wattage reduction ratio yields energy savings results that differ from those described above, particularly when discounted lamp wattages are relatively high or low. The delta watts methodology we use in this report relies upon a baseline of all technologies in use by PG&E, SCE, and SDG&E residential electric customers per methodology described in Sections 5.4.2 and 5.4.3 above. For CFLs ≤ 30 watts, the ex post approach ultimately yields higher energy savings than the ex ante approach. Our methodology uses survey results that are representative of IOU customers to estimate proportions of lamp technologies that program lamps replaced. Further, it allows for the flexibility that customers are not only replacing lamps of identical brightness. Survey results of high-wattage purchasers show that customers installed these lamps to replace lamps of all brightness levels.

To show how these methodologies differ at the upper and lower lamp wattages, Table 33 shows two examples. Using the ex ante methodology, a 13 watt MSB basic spiral CFL generates a delta of 32 watts, while the ex post approach generates a delta of 49 watts. For a high-wattage CFL of 35 watts, ex ante methodology yields a delta of 86 watts and the ex post approach yields a delta of 38 watts. As shown, the divergence in results is most notable among lower and higher wattage lamps.

Table 33. Example of ex ante and ex post delta watts methodologies

Delta Watts Inputs and Outputs	MSB Basic Spiral CFL 13 W		MSB High-Wattage CFL 35 W	
	Ex Ante	Ex Post	Ex Ante	Ex Post
Program lamp wattage	13	13	35	35
Wattage reduction ratio	3.47	N/A	3.47	N/A
Baseline wattage	45	62	121	73
Delta watts	32	49	86	38

5.5 HVAC interactive effects

HVAC interactive effects account for the changes in heating and cooling energy requirements due to changes in lamp wattages and efficiency. Generally, lower-wattage efficient lamps release less heat than higher-wattage, less-efficient lamps, which results in air conditioning energy savings and increased space heating requirements. DEER reports the estimated kWh, kW, and therm savings factors for indoor CFL and LED measures. In this evaluation, we applied the IOU-weighted residential and commercial multipliers reported in DEER 2014 (Table 34). The same ratios apply to both CFL and LED lamps as the interactive effects very by the wattage reduction estimate and not by lamp technology. Our evaluation team applied these savings factors to the direct impacts as a multiplier for both kWh and kW and a decrement factor of therms per kWh for therm impacts.

[45] CPUC ED, 2015b.

Table 34. CFL and LED HVAC interactive effects factors by IOU (2014 DEER)

Building Type	Units	IOU		
		PG&E	SCE	SDG&E
Residential	kWh	1.02	1.07	1.03
	kW	1.33	1.40	1.23
	Therms	-0.025	-0.019	-0.018
Commercial	kWh	1.06	1.12	1.12
	kW	1.21	1.24	1.23
	Therms	-0.0061	-0.0032	-0.0028

5.6 Unit energy savings

UES estimates are the average gross energy and peak demand impacts per measure in kWh per year and kW, respectively. Except for the changes to the delta watts calculations described previously, DNV GL calculated UES values for each of the evaluated measure groups using the same approach described in the 2010-12 and 2013-14 impact evaluations. As in the prior evaluations, this report focuses on the parameters necessary for calculating the residential UES. For measures installed in nonresidential settings, we applied the approved weighted commercial UES value from DEER to the average wattage of IOU-discounted measures for each program year. Because DEER does not distinguish among the different lamp shapes, all CFL measure groups of interest thus have the same per-watt values. The same is true for both LED measure groups. We show the equations for estimating the residential UES below (Equation 6 and Equation 7). We apply the respective nonresidential interactive effect factor to the UES that DEER defines for each measure.

Equation 6. Unit energy savings

$$UES_L\left[\frac{kWh}{year}\right] = \Delta Watts_L[W] * HOU_L[h] * \frac{1\ kWh}{1000\ Wh} * \frac{365\ days}{1\ year} * IE_L[kWh]$$

Where:

$\Delta Watts_L$ = average displaced (delta) wattage for IOU-discounted lamp measure group, L, in watts (W)

HOU_L = annual average HOU for IOU-discounted lamp measure group, L, in hours (h)

IE_L = HVAC interactive effects in kilowatt-hours (kWh)

Equation 7. Peak demand reduction

$$PDR_L\left[\frac{kW}{year}\right] = \Delta Watts_L[W] * CF_L * \frac{1\ kW}{1000\ W} * IE_L[kW]$$

Where:

ΔW_L = average displaced (delta) wattage for IOU-discounted lamp measure group, L, in watts (W)

CF_L = average percent on at peak for IOU-discounted lamp measure group, L

IE_L = HVAC interactive effects in kilowatts (kW)

Below we present the 2015 residential and nonresidential UES results by IOU and measure group for the six upstream lighting measure groups of interest for this report.

5.6.1 MSB CFL basic spiral ≤ 30 W

Table 35 shows the UES values for MSB basic spiral CFLs ≤ 30 W. As shown, all three IOUs offered upstream incentives for CFLs in this measure group in 2015. In 2015, UES-kWh values ranged from 14.6 for PG&E to 25.7 for SCE, while nonresidential UES-kWh values ranged from 116.9 for SCE to 165.7 for PG&E. For residential downstream MSB basic spiral CFLs ≤ 30 W, we passed through the ex ante estimates for energy savings (kWh), demand reductions (kW), and gas impacts (therms).

The differences in baseline wattages and the resulting differences in the delta watts calculations caused changes to the UES values relative to 2013 and 2014 results. All three IOUs provided upstream incentives for MSB basic spiral CFLs ≤ 30 W in 2013, but only SDG&E provided upstream incentives for these measures in 2014. Residential UES-kWh values dropped by a range of 27% to 47% between 2013 and 2015, while residential UES-kW values decreased by a range of 25% to 33%.

Table 35. Residential and nonresidential UES values – upstream MSB CFL basic spiral ≤ 30 W, 2015

MSB CFL Basic Spiral ≤ 30 W	IOU		
	PG&E	SCE	SDG&E
Residential			
UES-kWh	14.6	N/A	15.5
UES-kW	0.002	N/A	0.002
UES-Therms	-0.3	N/A	-0.3
Nonresidential			
kWh/W	8.3	N/A	8.7
kW/W	1.8	N/A	1.9
Therms/W	-0.05	N/A	-0.03
Average rebated wattage	21.5	N/A	15.8
UES-kWh	178.4	N/A	138.1
UES-kW	0.04	N/A	0.03
UES-Therms	-1.2	N/A	-0.5

5.6.2 MSB CFL A-lamp ≤ 30 W

All three IOUs offered upstream incentives for MSB CFL A-lamps ≤ 30 W in 2015. Table 36 shows the UES values. In 2015, UES-kWh values ranged from 14.8 for PG&E to 22.9 for SCE, while nonresidential UES-kWh values ranged from 108.3 for SDG&E to 141.5 for PG&E and SCE. For residential downstream measures in this measure group, we passed through the ex ante estimates for energy savings, demand reductions, and gas impacts.

Relative to 2013-14 results, the differences in baseline wattages and the resulting differences in the delta watts calculations caused changes to the UES values. All three IOUs offered upstream incentives for MSB CFL A-lamps ≤ 30 W in 2013 and 2014. Residential UES-kWh values decreased by a range of 26% to 40% between 2014 and 2015, and residential UES-kW values decreased by a range of 25% to 33% in the same period. These are similar to the changes for residential upstream basic spiral CFLs.

Table 36. Residential and nonresidential UES values – upstream MSB CFL A-lamp ≤ 30 W, 2015

MSB CFL A-Lamp ≤ 30 W	IOU		
	PG&E	SCE	SDG&E
Residential			
UES-kWh	14.8	22.9	15.7
UES-kW	0.002	0.003	0.002
UES-Therms	-0.3	-0.4	-0.3
Nonresidential			
kWh/W	8.3	11.1	8.7
kW/W	1.8	2.2	1.9
Therms/W	-0.05	-0.03	-0.03
Average program lamp wattage	18.3	18.2	14.0
UES-kWh	152.4	201.3	122.1
UES-kW	0.03	0.04	0.03
UES-Therms	-1.0	-0.5	-0.4

5.6.3 MSB CFL reflector ≤ 30 W

SCE and SDG&E offered upstream incentives for MSB CFL reflector lamps ≤ 30 W in 2015. UES-kWh values ranged were 14.4 for SDG&E and 24.6 for SCE, while nonresidential UES-kWh valUES was 156.9 for SDG&E and 173.2 for SCE. We passed through the ex ante estimates for energy savings, demand reductions, and gas impacts for residential downstream measures in this measure group.

The differences in baseline wattages and the resulting differences in the delta watts calculations resulted in lower UES values in 2015 relative to 2013 and 2014 results. PG&E did not offer incentives for MSB CFL reflector lamps ≤ 30 W in 2013 or 2014, but residential UES-kWh values decreased by 32% for SCE and 37% for SDG&E between 2014 and 2015. Residential UES-kW values decreased by approximately 25% for SCE but remained approximately the same for SDG&E within the same period.

Table 37. Residential and nonresidential UES values – upstream MSB CFL reflector ≤ 30 W, 2015

MSB CFL Reflector ≤ 30 W	IOU		
	PG&E	SCE	SDG&E
Residential			
UES-kWh	N/A	24.6	14.4
UES-kW	N/A	0.003	0.002
UES-Therms	N/A	-5.1	-5.1
Nonresidential			
kWh/W	N/A	11.1	10.5
kW/W	N/A	2.2	2.3
Therms/W	N/A	-0.03	-0.03
Average program lamp wattage	N/A	22.0	20.3
UES-kWh	N/A	243.3	212.7
UES-kW	N/A	0.05	0.05
UES-Therms	N/A	-0.7	-0.7

5.6.4 MSB CFL high-wattage (> 30 W)

Table 38 shows the 2015 UES values for upstream MSB high-wattage CFLs (> 30 W). All three IOUs offered incentives for CFLs in this measure group in the 2015 program. UES-kWh values ranged from 18.5 for SDG&E to 23.4 for PG&E, while nonresidential UES-kWh values ranged from 294.3 for SDG&E to 317.8 for SCE. For residential downstream MSB high-wattage CFLs (> 30 W), we passed through the ex ante estimates for energy savings, demand reductions, and gas impacts.

The differences in baseline wattages and the resulting differences in the delta watts calculations caused reductions in the 2015 UES values relative to 2013 and 2014 results. All three IOUs offered upstream incentives for MSB CFL high-wattage (> 30 W) in 2013 and 2014. Between 2014 and 2015, residential UES-kWh values dropped by roughly 46% to 62% and UES-kW values dropped by a range of 50% to 67%.

Upstream high-wattage CFLs exhibited the largest decline in savings between the 2013-14 and 2015 program periods, and the largest driver for this decline was an approximately 40-watt drop in delta watts. In the 2013-14 impact evaluations, ex ante and ex post methodologies defined the baseline relative to incandescent lamp wattages, but a 2015 CPUC decision redefined the savings baseline as a mixture of CFL and LED lamps.[46] This change drove the baseline wattage down from over 100 watts in 2013-14 to a range of 63 to 76 watts in 2015.

Table 38. Residential and nonresidential UES values – upstream MSB CFL high-wattage (> 30 W), 2015

MSB CFL High-Wattage > 30 W	IOU		
	PG&E	SCE	SDG&E
Residential			
UES-kWh	26.0	19.8	18.4
UES-kW	0.003	0.002	0.002
UES-Therms	-0.6	-0.4	-0.3
Nonresidential			
kWh/W	8.3	11.1	8.7
kW/W	1.8	2.2	1.9
Therms/W	-0.1	-0.03	0.0
Average program lamp wattage	40.0	40.8	38.0
UES-kWh	325.0	451.7	331.9
UES-kW	0.07	0.09	0.07
UES-Therms	-2.0	-1.2	-1.1

46 CPUC ED, 2015b.

5.6.5 LED A-lamps, all wattages

Table 39 shows the UES values for LED A-lamps of all wattages in 2015. All three IOUs offered upstream incentives for LED A-lamps. Residential UES-kWh values ranged from 27.0 for SDG&E to 34.3 for SCE, and nonresidential UES-kWh values ranged from 44.4 for SCE to 85.2 for SDG&E. For residential downstream LED A-lamps, we passed through the ex ante estimates for energy savings, demand reductions, and gas impacts.

The differences in baseline wattages and the resulting differences in the delta watts calculations caused UES values to increase for MSB LED A-lamps relative to 2013 and 2014 results. All three IOUs offered incentives for these measures in 2013-14, and between 2014 and 2015, UES-kWh values increased by a range of 21% to 88% while UES-kW values increased by a range of 50% to 100% in the same period. These results are in contrast with the drop in UES values for upstream MSB CFL A-lamps ≤ 30 W between the 2013-14 and 2015 program periods.

Table 39. Residential and nonresidential UES values – upstream LED A-lamps of all wattages, 2015

LED A-Lamp, All Wattages	IOU		
	PG&E	SCE	SDG&E
Residential			
UES-kWh	27.2	34.3	27.0
UES-kW	0.003	0.004	0.003
UES-Therms	-0.6	-0.6	-0.5
Nonresidential			
kWh/W	6.3	6.7	6.7
kW/W	1.3	1.5	1.5
Therms/W	-0.04	-0.02	-0.02
Average program lamp wattage	8.4	4.9	9.4
UES-kWh	52.2	32.8	62.6
UES-kW	0.01	0.01	0.01
UES-Therms	-0.3	-0.1	-0.2

5.6.6 LED reflector lamps, all wattages

Table 40 shows the UES values for LED reflectors of all wattages in 2015. All three IOUs offered upstream incentives for LED reflectors. Residential UES-kWh values for LED reflectors ranged from 28 for SDG&E to 33.7 for SCE, and nonresidential UES-kWh values ranged from 97.3 for SCE to 123.4 for SDG&E. For residential downstream LED reflectors, we passed through the ex ante estimates for energy savings, demand reductions, and gas impacts.

The differences in baseline wattages and the resulting differences in the delta watts calculations changed the UES values relative to 2013 and 2014 results. All IOUs offered upstream incentives for LED reflector lamps in 2013 and 2014. For SCE, residential UES-kWh values increased by approximately 25% between 2013-14 and 2015 and by approximately 33% for residential UES-kW. For PG&E and SCE, UES-kWh values decreased between periods (by 12% for PG&E and by 14% for SDG&E between 2014 and 2015). PG&E's UES-kW values dropped by 25% between 2013-14 and 2015, while SDG&E's UES-kW values stayed the same.

Table 40. Residential and nonresidential UES values – upstream LED reflector lamps of all wattages, 2015

LED Reflector, All Wattages	IOU		
	PG&E	SCE	SDG&E
Residential			
UES-kWh	31.2	33.7	28.0
UES-kW	0.003	0.004	0.003
UES-Therms	-0.7	-0.6	-0.5
Nonresidential			
kWh/W	10.7	10.3	8.6
kW/W	2.3	2.3	1.9
Therms/W	-0.07	-0.04	-0.03
Average program lamp wattage	11.1	10.7	13.6
UES-kWh	127.3	109.6	117.0
UES-kW	0.03	0.02	0.03
UES-Therms	-0.8	-0.4	-0.4

5.7 Installation rate

For this evaluation, we applied installation rates that generate savings for all lamps purchased within the 2015 program period regardless of whether consumers installed the lamps in 2015. This methodology eliminates the need for an installation-based carry-over analysis, and we first adopted it in the 2010-12 impact evaluation.

Because of the uncertainty associated with CFL and LED lamp installation rates identified in the 2013 CPUC Decision Adopting ESPI Mechanism,[47] DNV GL addressed CFL and LED lamp installation rates in its 2016 telephone and online surveys (the latter for high-wattage CFLs and the former for other CFLs and LED lamps).[48] Specifically, we attempted to quantify the percentage of lamps that will never be installed. We subtract this value from 100% to yield the installation rate. The surveys asked respondents about the quantity of CFLs, LED lamps, and high-wattage CFLs that they have installed, the quantity in storage, and how many will or will not be installed in the future.

Survey results suggest that 95% of CFLs in homes within PG&E, SCE, and SDG&E's residential electric service territories are or will eventually be installed (Table 41). For LED lamps, survey results indicate that 99% of lamps were installed at the time of the survey or will be installed in the future. We applied these installation rates to calculate gross savings.[49] We also applied these installation rates to nonresidential upstream CFLs and LED lamps. For residential downstream lighting measures, we passed through the ex ante installation rates.

Table 41. Residential upstream CFL and LED lamp installation rates (2016 consumer telephone survey)

Classification	CFLs in Household		LED Lamps in Household	
	Weighted Lamp Count*	Percent (n=317)	Weighted Lamp Count*	Percent (n=267)
Installed	43,981,008	77%	53,964,920	90%
In storage, will be installed	10,177,644	18%	5,100,893	8%
Will never be installed‡*	3,136,273	5%	1,083,386	2%
Total CFLs in Household	57,294,925	100%	60,149,199	100%

* Weighted estimate of lamps installed and in storage based on survey respondents.

** "Will never be installed" includes those in storage consumers will never install plus those that they expect to throw away or give away.

Table 42 shows ex ante and ex post installation rates for 2015 upstream lighting measures by IOU and sector for each measure group. For CFL measure groups, ex ante installation rates varied by IOU, and ranged from 67% to 97% for CFL measures. The ex post estimate installation rate for CFLs of 95% is higher than the ex ante value of 67% and 77% for PG&E and SCE, respectively, and slightly lower than SDG&E's ex ante value of 97%. For all LED lamp measure groups, installation rate estimates were 2 percentage points lower for ex post versus ex ante (98% versus 100%, respectively).

[47] CPUC ED, 2014.

[48] Please refer to APPENDIX E for details regarding the consumer telephone and survey approaches and APPENDIX I for the data collection instruments.

[49] Note that we applied the CFL installation rate across all five CFL measure groups and the LED lamp installation rate across both LED measure groups.

Table 42. Ex ante and ex post residential and nonresidential installation rates by IOU and upstream lighting measure group, 2015

IOU	Evaluated Upstream Lighting Measure Group	Residential		Nonresidential	
		Ex Ante	Ex Post	Ex Ante	Ex Post
PG&E	MSB CFL basic spiral ≤ 30 W	67%	95%	73%	73%
	MSB CFL A-lamp ≤ 30 W	67%	95%	73%	73%
	MSB CFL reflector ≤ 30 W	N/A	N/A	N/A	N/A
	MSB CFL high-wattage (> 30 W)	67%	95%	73%	73%
	LED A-lamp, all wattages	100%	98%	100%	100%
	LED reflector, all wattages	100%	98%	100%	100%
SCE	MSB CFL basic spiral ≤ 30 W	77%	95%	N/A	N/A
	MSB CFL A-lamp ≤ 30 W	77%	95%	81%	81%
	MSB CFL reflector ≤ 30 W	77%	95%	81%	81%
	MSB CFL high-wattage (> 30 W)	77%	95%	81%	81%
	LED A-lamp, all wattages	100%	98%	100%	100%
	LED reflector, all wattages	100%	98%	100%	100%
SDG&E	MSB CFL basic spiral ≤ 30 W	97%	95%	N/A	97%
	MSB CFL A-lamp ≤ 30 W	97%	95%	N/A	97%
	MSB CFL reflector ≤ 30 W	97%	95%	N/A	97%
	MSB CFL high-wattage (> 30 W)	97%	95%	N/A	97%
	LED A-lamp, all wattages	100%	98%	N/A	100%
	LED reflector, all wattages	100%	98%	N/A	100%

5.8 Gross savings results

Table 43 provides an overview of the ex ante and ex post gross annual energy savings, demand reductions, and realization rates for 2015 evaluated upstream lighting measures and measure group across IOUs. As shown, realization rates exceeded 80% for nearly all combinations of IOU and measure group. This has two drivers:

- **Difference in approach to estimating delta watts between ex ante and ex post for both CFLs and LED lamps.** The average program wattage for upstream groups other than high-wattage CFLs ranged from 8 to 21 Watts per measure group for PG&E, from 5 to 22 Watts per upstream measure group for SCE, and from 9 to 20 Watts per upstream measure group for SDG&E. Where these average program-discounted upstream measure group wattages are fairly low, the ex post approach to estimating delta watts ultimately yields higher energy savings than the ex ante approach. Conversely, where average program-discounted upstream measure group wattages are relatively high, the ex post are generally lower than the ex ante estimates. The ex ante approach to calculating delta watts yields lower deltas for lower-wattage lamps than for higher-wattage lamps based on a wattage reduction ratio, while the ex post approach yields higher deltas for lower-wattage lamps because we subtract the average program-discounted lamp wattages for each evaluated measure group from the average wattage of the installed baseline lamp wattages (with incandescent lamps as the baseline for CFL measure groups and incandescent and CFLs as the baseline for LED lamp measure groups).

- **Residential / nonresidential split for SDG&E.** SDG&E's ex ante assumptions allocated all upstream lighting program lamps to the residential sector. Ex post assumptions allocated 94% to the residential sector and 6% to the nonresidential sector. (PG&E's and SCE's ex ante assumptions largely matched the ex post assumptions.)
- **Higher ex post CFL installation rates than ex ante for PG&E and SCE.** PG&E's ex ante installation rates for all CFL measure groups was 67% and for SCE's was 77%. The ex post installation rate estimate was 95% for all IOUs. (SDG&E's ex ante CFL installation rate was 97%).

Table 43. Ex ante and ex post gross savings and gross realization rates by upstream measure group across all IOUs, 2015

All IOUs Evaluated Upstream Lighting Measure Group	Ex Ante			Ex Post			Gross Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
MSB CFL basic spiral ≤ 30 W	13,621,389	1,864	-247,872	11,314,334	1,762	-183,691	83%	95%	74%
MSB CFL A-lamp ≤ 30 W	38,947,183	5,402	-521,845	39,913,035	5,754	-516,867	102%	107%	99%
MSB CFL reflector ≤ 30 W	108,611,618	14,624	-1,542,560	91,145,975	13,469	-1,141,932	84%	92%	74%
MSB CFL high-wattage (> 30 W)	162,860,055	22,502	-2,231,110	101,521,443	16,607	-983,407	62%	74%	44%
LED A-lamp, all wattages	35,674,313	4,853	-581,839	109,741,192	12,987	-2,008,537	308%	268%	345%
LED reflector, all wattages	74,038,848	10,313	-1,129,691	101,120,464	13,124	-1,644,388	137%	127%	146%
Overall	**433,753,405**	**59,558**	**-6,254,916**	**454,756,443**	**63,703**	**-6,478,823**	**105%**	**107%**	**104%**

5.8.1 PG&E

Table 44 shows the ex ante and ex post gross annual energy savings, demand reductions, gas impacts, and realization rates for PG&E by upstream lighting measure group. The table includes savings from evaluated upstream CFL and LED measure groups for 2015. Table 45 provides PG&E's ex post gross savings results for the residential and nonresidential sectors.

Table 44. PG&E ex ante and ex post gross savings and gross realization rates by evaluated upstream lighting measure group, 2015

PG&E Evaluated Upstream Lighting Measure Group	Ex Ante			Ex Post			Gross Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
MSB CFL basic spiral ≤ 30 W	13,055,030	1,788	-240,326	10,861,133	1,693	-178,257	83%	95%	74%
MSB CFL A-lamp ≤ 30 W	482,202	66	-8,876	445,443	66	-7,620	92%	100%	86%
MSB CFL reflector ≤ 30 W	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MSB CFL high-wattage (> 30 W)	3,393,154	465	-62,351	2,749,211	429	-44,647	81%	92%	72%
LED A-lamp, all wattages	16,188,955	2,181	-305,289	39,349,480	4,842	-838,421	243%	222%	275%
LED reflector, all wattages	19,801,249	2,659	-374,170	25,998,283	3,479	-504,639	131%	131%	135%
Overall	**52,920,589**	**7,159**	**-991,013**	**79,403,550**	**10,509**	**-1,573,584**	**150%**	**147%**	**159%**

Table 45. PG&E ex post gross savings by evaluated upstream lighting measure group and sector, 2015

PG&E Evaluated Upstream Lighting Measure Group	Annual Energy Savings (kWh)		Peak Demand Reductions (kW)		Gas Impact (Therms)	
	Residential	Nonresidential	Residential	Nonresidential	Residential	Nonresidential
MSB CFL basic spiral ≤ 30 W	6,400,043	4,461,090	763	930	-150,589	-27,668
MSB CFL A-lamp ≤ 30 W	280,397	165,046	31	34	-6,598	-1,023
MSB CFL reflector ≤ 30 W	N/A	N/A	N/A	N/A	N/A	N/A
MSB CFL high-wattage (> 30 W)	1,591,734	1,157,476	187	242	-37,453	-7,194
LED A-lamp, all wattages	34,298,856	5,050,625	3,785	1,057	-807,032	-31,389
LED reflector, all wattages	19,811,256	6,187,027	2,186	1,293	-466,147	-38,492
Overall	**62,382,285**	**17,021,265**	**6,952**	**3,557**	**-1,467,818**	**-105,766**

5.8.2 SCE

Table 46 shows the ex ante and ex post gross annual energy savings, demand reductions, gas impacts, and realization rates by upstream lighting measure group for SCE. The table includes savings from evaluated upstream CFL and LED measure groups for 2015. Table 47 shows the ex post gross savings results for the residential and nonresidential sectors.

Table 46. SCE ex ante and ex post gross savings and gross realization rates by evaluated upstream lighting measure group, 2015

SCE Evaluated Upstream Lighting Measure Group	Ex Ante			Ex Post			Gross Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
MSB CFL basic spiral ≤ 30 W	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MSB CFL A-lamp ≤ 30 W	31,969,775	4,453	-428,021	33,894,099	4,851	-440,047	106%	109%	103%
MSB CFL reflector ≤ 30 W	105,013,975	14,166	-1,491,791	88,913,500	13,105	-1,118,930	85%	93%	75%
MSB CFL high-wattage (> 30 W)	147,753,742	20,612	-1,995,398	91,511,442	14,935	-868,996	62%	72%	44%
LED A-lamp, all wattages	10,964,360	1,525	-163,725	52,045,476	5,958	-889,870	475%	391%	544%
LED reflector, all wattages	38,285,362	5,314	-568,195	61,220,209	7,851	-943,268	160%	148%	166%
Overall	**333,987,213**	**46,070**	**-4,647,131**	**327,584,726**	**46,700**	**-4,261,111**	**98%**	**101%**	**92%**

Table 47. SCE ex post gross energy savings by evaluated upstream lighting measure group and sector, 2015

SCE Evaluated Upstream Lighting Measure Group	Annual Energy Savings (kWh)		Peak Demand Reductions (kW)		Gas Impact (Therms)	
	Residential	Nonresidential	Residential	Nonresidential	Residential	Nonresidential
MSB CFL basic spiral ≤ 30 W	N/A	N/A	N/A	N/A	N/A	N/A
MSB CFL A-lamp ≤ 30 W	22,877,366	11,016,733	2,627	2,223	-410,510	-29,537
MSB CFL reflector ≤ 30 W	57,703,266	31,210,234	6,806	6,299	-1,035,423	-83,507
MSB CFL high-wattage (> 30 W)	40,676,119	50,835,323	4,662	10,273	-729,889	-139,107
LED A-lamp, all wattages	48,994,685	3,050,791	5,268	690	-879,157	-10,713
LED reflector, all wattages	50,529,041	10,691,168	5,433	2,418	-906,689	-36,579
Overall	**220,780,477**	**106,804,249**	**24,797**	**21,903**	**-3,961,668**	**-299,443**

5.8.3 SDG&E

Table 48 shows SDG&E's ex ante and ex post gross annual energy savings, demand reductions, gas impacts, and realization rates by upstream lighting measure group for 2015. The table includes savings from evaluated 2015 upstream CFL and LED measure groups. Table 49 shows SDG&E's ex post gross savings results for the residential and nonresidential sectors.

Table 48. SDG&E ex ante and ex post gross savings and gross realization rates by evaluated upstream lighting measure group, 2015

SCE Evaluated Upstream Lighting Measure Group	Ex Ante			Ex Post			Gross Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
MSB CFL basic spiral ≤ 30 W	566,359	76	-7,546	453,201	69	-5,434	80%	90%	72%
MSB CFL A-lamp ≤ 30 W	6,495,206	884	-84,948	5,573,492	837	-69,200	86%	95%	81%
MSB CFL reflector ≤ 30 W	3,597,644	458	-50,769	2,232,475	364	-23,001	62%	79%	45%
MSB CFL high-wattage (> 30 W)	11,713,159	1,424	-173,360	7,260,790	1,243	-69,765	62%	87%	40%
LED A-lamp, all wattages	8,520,999	1,147	-112,825	18,346,236	2,187	-280,246	215%	191%	248%
LED reflector, all wattages	15,952,236	2,340	-187,325	13,901,972	1,794	-196,481	87%	77%	105%
Overall	**46,845,603**	**6,329**	**-616,772**	**47,768,167**	**6,494**	**-644,127**	**102%**	**103%**	**104%**

Table 49. SDG&E ex post gross energy savings by evaluated upstream lighting measure group and sector, 2015

SDG&E Evaluated Upstream Lighting Measure Group	Annual Energy Savings (kWh)		Peak Demand Reductions (kW)		Gas Impact (Therms)	
	Residential	Nonresidential	Residential	Nonresidential	Residential	Nonresidential
MSB CFL basic spiral ≤ 30 W	286,043	167,158	31	37	-4,888	-547
MSB CFL A-lamp ≤ 30 W	3,689,160	1,884,332	418	420	-63,038	-6,162
MSB CFL reflector ≤ 30 W	1,136,341	1,096,134	119	244	-19,417	-3,584
MSB CFL high-wattage (> 30 W)	3,330,713	3,930,077	368	875	-56,913	-12,851
LED A-lamp, all wattages	15,940,337	2,405,899	1,652	536	-272,379	-7,867
LED reflector, all wattages	10,929,832	2,972,140	1,132	662	-186,762	-9,719
Overall	**35,312,426**	**12,455,741**	**3,720**	**2,774**	**-603,397**	**-40,730**

6 NET SAVINGS

6.1 Overview

In this section, we outline how we calculated net savings, and present results for each IOU. This evaluation uses a method that is similar to the 2010-12 and 2013-14 evaluations, but with some important improvements. Consistent with these earlier evaluations, we continue to define the gross savings baseline as the estimated wattage of the lamp that a 2015 program lamp replaced. Also consistent with earlier evaluations, we use market sales analysis to determine the proportion of program lamp purchases that represent incremental purchases of efficient technologies attributable to the program. In the current work, we refer to this proportion as the Quantity NTGR.

In an improvement on the prior work, for the full net savings analysis, we take a more integrated view of how the program affects lamp sales. Specifically, net savings is the difference in energy consumption with the program in place versus without the program in place. This conceptual definition is fully consistent with the California Energy Efficiency Evaluation Protocols.[50] For an incremental efficient lamp purchase, the savings—that is, the difference between energy consumption with versus without the program—is the difference between the energy consumption of the efficient lamp and that of ***the alternative lamp that would otherwise have been purchased***. Thus, the baseline UEC is the average UEC of the lamp purchases that would otherwise have taken place but which program-discounted lamps displaced. For the net savings analysis, we therefore calculate a UES in terms of the mix of displaced lamp sales across a mix of technologies. Net savings per program lamp is therefore the Quantity NTGR multiplied by the sales displacement mix UES.

To determine the mix of purchases displaced by the program-discounted lamps, we use the same market shares calculations used to determine the proportion of program lamps that are program-attributable incremental purchases of each measure group. Thus, using the sales displacement-mix UES as the basis of the net savings analysis provides a coherent and comprehensive representation of California's market for residential replacement lamps and the effect of the upstream lighting program on that market.

We considered this approach for the prior evaluation but did not ultimately pursue it because uncertainties in the sales share estimates for certain market segments made it difficult to produce a consistent set of reliable estimates by this method. In this evaluation, however, we increased the rigor of our modelled simulations, so that we can now interpret lighting markets at the granularity necessary to move forward with this approach. We elaborate on these improvements in Section 6.1.5.

6.1.1 Further explanation of the net savings approach

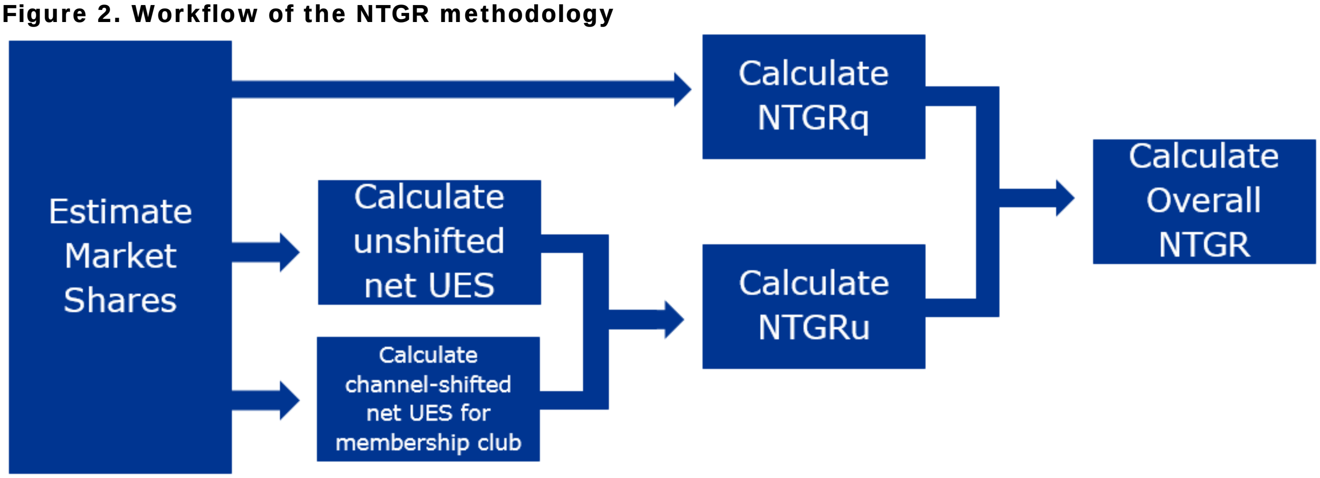
The energy consumption that would have occurred in absence of the program is not represented by the mix of existing installed technologies in 2015 but by the technologies that would otherwise have been purchased to fill those sockets without the program. The gross UES calculated in Chapter 5 represents the savings relative to existing technology in place. The displacement-mix UES represents the savings relative to what

[50] "All participant net impact analysis must be designed to estimate the proportion of savings that is program-induced and net of free-ridership estimates (not including spillover savings estimates). This means that it is net of what would have occurred in the absence of the program." (TecMarket Works et al., 2006. Page 36.)

would occur absent the program—that is, the net savings per incremental efficient lamp purchase due to the program.

It is possible—and even likely—that the program has induced more lamp purchases during the program period than would have occurred without the program. Thus, the program is displacing purchases not just from the program period but also from future years. This time shifting of purchases does not affect the net savings analysis. We consider the displacement mix to represent the mix of technologies that would have been purchased without the program, including lamps that would otherwise have been purchased at a later time. At whatever time consumers eventually install the program-discounted lamps, the savings they produce are relative to the average consumption of the lamps that would otherwise be installed at that time if the program didn't exist. Consistent with the 2010-12 and 2013-14 evaluations the programs will receive credit in a particular program year for all lamps distributed in that program year that will eventually be installed. In ignoring the timing effect, we effectively assume that the mix of technologies in the absence of the program is the same for lamps displaced from future years as for those displaced from the current year. To the extent that average lamp efficiency would be increasing in the absence of the program, this is a slightly generous assumption but the effect is likely to be minor. Figure 2, below, presents the workflow of the 2015 NTGR methodology, which we will describe in more detail below.

Figure 2. Workflow of the NTGR methodology



6.1.2 Lighting markets and lamp replacement categories

Through the remainder of this section, we will consider three separate groups of replacement lamps which we call "lamp replacement categories:" A-lamp replacement category (≤ 30 W), reflector lamp replacement category (≤ 30 W), and high-wattage lamp replacement category (> 30 W CFL equivalent). We will discuss many metrics in terms of a lamp's market share. Market shares represent the percent of purchases of a given lamp type within a replacement category. For example, if among 100 lamp purchases, 30 purchases were CFLs, then CFLs would have a market share of 30%. We will review these market shares individually within seven retail channels (discount, drug, grocery, hardware, home improvement, mass merchandise, and membership club). We consider all of these market shares when 2015 discounts were available, and compare them to market shares when we remove the effects of the program. In the 2013-14 impact evaluation, we had to account for the fact that the program shipped multiple measure groups to the same stores within the same timeframe (an annual quarter). A program simulation could have included just LED A-lamp discounts, or it could have included just CFL A-lamp discounts, or it could have included both. We thus modelled market shares for each combination of measure group discounts that were available at the same time. In the current evaluation, we found only one measure group was shipped to a given store within a quarter for all but a handful of measures. We therefore model market shares just one measure group was discounted within a store.

6.1.3 Data on lighting market purchases

We gathered information from two perspectives to understand program influences on the lighting market. We relied upon sources similar to those from the 2010-12 and 2013-14 evaluations but with updated methodologies. The two perspectives are:

- **Supply-side estimate.** We interviewed lamp manufacturer representatives and retail lighting buyers to gain their insights into program impacts. We asked these suppliers to provide market-level estimates of percentage of sales (market share) of each technology that occurred within a given lamp replacement category when program discounts were available, and market shares of each technology that would have occurred without program discounts. We also asked suppliers to identify lamps that were completely dependent on the program, and would not have been shipped to certain retail channels in the absence of the program. In the 2010-12 and 2013-14 evaluations, we asked suppliers to quantify channel-level percent change in total sales of each lamp type that the program subsidized.[51] In the updated 2015 net savings methodology, we needed to quantify more than changes in sales of the program lamp type; we needed to quantify the degree to which program lamp purchases displaced purchases of each alternative lamp type. We therefore asked about the market shares of each of the four to five ***program and non-program*** lamp technologies with program discounts and without program discounts. We asked for these estimates for each of the 3 replacement categories. Because these questions significantly increased the number of data points we had to gather, we were not able to ask them at the retail channel level. Furthermore, we needed data at a level of granularity that would allow us to isolate the individual impacts of each measure group's discounts.[52] In the 2010-12 and 2013-14 evaluations, we were able to use a weighting mechanism that accounted for the degree to which each respondent discounted each measure group. However, in the updated methodology, suppliers estimated market shares for all lamp types at the market-level. The market level provides a valuable interpretation of the broader implications of the program, but, for instance, it does not allow us to understand the discrete energy impacts of the individual measure groups. We only know the impacts of all three operating at once. The interactions that are inherent among the three measure groups leave us unable to calculate NTGRs for each individual measure group. Instead, we use supplier estimates to inform and shape the simulations that we use in the demand-side estimate. We present the overall market share estimates in APPENDIX H.
- **Demand-side estimate.** In this evaluation, we enhanced our discrete-choice model that we used in the 2010-12 and 2013-14 evaluations (the LCM). As in the past, we estimate the LCM using in-store intercept surveys, and use the estimated model to calculate the probability that each competing lamp type would be purchased by a consumer. We represent the universe of affected lamp purchases by simulating purchases by a pool of consumers in a pool of stores, facing particular available technologies at particular prices. The technology mixes and prices for the simulated with program condition are those observed during our in-store lamp stock inventories. The technologies and prices for the simulated no-program conditions remove the program discounts, and remove technologies that were available in particular channels only with the program in place.

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51 For instance, if a manufacturer discounted LED A-lamps in home improvement stores, we asked the supplier by what percent their total LED A-lamp sales in home improvement sales would have been lower without program discounts.

52 Because multiple measure groups fall within the same lamp replacement category (e.g. CFL A-lamp, basic spiral CFL, and LED A-lamp), measure groups inherently compete against one another. Therefore, as the program discounts one measure group, it will decrease the market share of another program measure group, and vice versa. In order to calculate the impacts that were due to each the discounts applied to measure group, we needed to consider the combinations of discounts that were shipped to the same store at the same time.

The demand-side estimate allows us to disaggregate a complicated market of efficient program and non-program lamps. We use tracking data and retail stock inventory data to develop simulations that reflect the prices with and without program discounts applied, and supplier interviews to adjust lamp availability for the without program simulations. Our final demand-side estimates are modelled market shares that we use for the remaining calculations.

A limitation of the prior simulations, and a source of some unrealistic or unavailable estimates, is that the simulations replicated the demographics of in-store shopper intercept survey respondents with the technologies available in those stores. The limitations of this approach were that the intercept respondents may not be representative of the universe of purchasers, and that market segments with few intercept respondents could not be estimated well or at all. This evaluation avoids both of the limitations of the prior method by using representative 2016 consumer survey data, including demographics and channels where consumers purchased lamps in 2015, as the basis for constructing the universe of lamp purchases.

For further background and methodology regarding the LCM, please see APPENDIX G.

6.1.4 Calculating NTGR from the market shares

We use these demand-side estimates (inclusive of supplier effects) to calculate upstream market net impacts using the following ratios:

- **Quantity NTGR (NTGRq).** This factor represents the fraction of program lamp purchases that are incremental purchases of that technology attributable to program discounts and availability. In the absence of the program, this proportion of the program lamp purchases within a given lamp replacement category would have been a different lamp type. We calculated NTGRq for to each combination of measure group and retail channels (described in Section 6.1.2). Combining these results across channels based on each IOU’s lamp distributions, we calculate an overall NTGRq for each IOU and evaluated upstream lighting measure group.
- **UES NTGR (NTGRu).** The NTGRu is the ratio of the sales displacement UES (described in Section 6.1.1) to the gross UES calculated in Chapter 5. Multiplying the gross UES by this ratio provides unit energy savings relative to the distribution of lamp technologies and wattages that would have been purchased in place of the program technology in the absence of the program. A NTGRu that is less than 100% means that gross savings underestimated the efficiency of a measure group’s non-program lamp purchases. Conversely, a NTGRu that is greater than 100% means that gross savings overestimated the efficiency of non-program lamp purchases. We calculate the NTGRu for each combination of measure group, retail channel, and IOU. We combine the NTGRu’s from each retail channel into a final NTGRu for each measure group and IOU.
- **Overall NTGR.** We multiply the NTGRq by the NTGRu to yield the overall NTGR. This ratio is a percentage of gross savings that is attributable to the program. We apply this ratio to gross savings to yield net savings

6.1.5 Key differences from prior work

As indicated above, the net savings analysis for the 2015 upstream lighting program uses methods similar to those of past studies with the improvements noted above. For readers who were familiar with the net savings methodology from prior evaluations, we detail highlight the differences from the past work below. These include:

1. The simulated universe of program-affected purchases uses 2016 customer phone survey results to define the pool of demographics and the distribution of lamp purchases by retail channel. This

approach gives a more robust and comprehensive representation of the purchase distributions compared to relying on the characteristics of respondents to the in-store shopper intercept surveys as in other recent evaluations.

2. In prior work, we estimated sales share changes due to the program for several combinations of program technologies in the same stores at the same time. We based the overall sales share changes on the estimated prevalence of the different combinations. This market segment estimation splintered the purchase simulations into multiple segments for each channel, and many of these segments had limited or no observations, contributing to some uncertainties in the results. In the present work, we observed that (for the most part) only one discounted technology was available at a time in a particular store during 2015. We assume that this meant that there was little-to-no competition between program lamps within the 2015 program. As a result, we conducted the analysis as if only one discounted technology was available at a time. This approach simplified the analysis and avoided unstable results.

3. The UES for net savings is based on the mix of technologies that program-discounted lamps displaced. This approach is consistent with the overall approach of basing net savings estimates on the difference in market shares with versus without the program, and is made possible by the more robust market shares estimation from the first improvement noted above.

4. As we discuss further below, an additional adjustment is made for the membership club channel, to account for the shift of purchases from other channels to the membership club channel because of program discounts. We needed to address channel shift for this channel in particular because unlike other channels, membership clubs had almost no lamps other than LED lamps and CFLs available during 2015 (based on in-store lamp stock inventory data). As a result, the assumption that all lamp displacement by the program was within the same channel would have implied that all program LED lamps displaced CFLs, whereas 2016 supplier interview results indicated that a substantial portion of the LED lamp sales were displacing sales from other channels, and these would have included a mix of technologies.

5. In the past work, we based the incremental sales of each technology attributable to the program on a weighted average of lighting choice model estimates and supplier self-reports. In the present work, we use the 2016 supplier interview results to determine which manufacturers would have had no sales in a given channel absent the program and to provide an estimate of channel shift. Supplier interview results are not used directly to estimate the NTGRq for at least two reasons: (1) the data were not available in the same form as in the past, because the questionnaire was modified to provide data on channel shift and other market factors; (2) because of the improvements in the model simulations, the demand-side estimate was more consistent than in prior studies.

Below, we provide details regarding the methodology we employed to produce the NTGRs.

6.2 Overview of net savings methodology (with example)

We estimate of 2015 net savings for each evaluated upstream lighting measure group using these steps:

- Calculate NTGRq
- Calculate net UES

- Account for channel shift for the membership club channel
- Calculate NTGRq and NTGRu
- Calculate overall NTGR

The next several subsections review how we developed each of these estimates. We demonstrate each using the LED A-lamp measure group as an example.[53] This particular measure group provides a useful demonstration of our approach because the program had discounted LED A-lamps available in all channels during 2015, and the impacts of channel shift are very clear. This example provides the details necessary to calculate net savings for this particular measure group, while Sections 6.3 and 6.4 present the results (as well as their drivers) for all measure groups including LED A-lamps.

6.2.1 Calculate NTGRq

The NTGRq quantifies the lamp purchases that were attributable to the program. This is the proportion of program lamp purchases of a given technology for which a different technology would have been purchased in the absence of the program. To calculate the NTGRq, we estimated lamp technology market shares with and without program discounts. The NTGRq is equal to the degree to which the program-discounted lamps displaced market shares of other technologies, as we describe in more detail below.

6.2.1.1 Market shares with and without program discounts

The NTGRq estimate relies upon the relationship between two estimates of market share for each retail channel:

- **With program.** The with program market shares represent the share of lamp purchases that were LED A-lamps in the presence of program discounts for LED A-lamps.
- **Without program.** The without program market shares represent those same lamp purchase transactions in absence of program discounts for LED A-lamps. In this scenario, we increased lamp prices based on the discount amounts reported in IOU tracking data. We also removed program-discounted lamps from simulated choice sets when lamp manufacturers reported they would not have sold the lamp in a specific channel in absence of the program.

We generated these market share estimates using a discrete choice model. The model simulates the with program and without program market shares for all lamps within the relevant category of replacement lamps. These categories include lamps of different technologies that may be considered as interchangeable in a typical application. LED A-lamps are part of the **A-lamp replacement category (≤ 30 W)**, which also includes MSB basic spiral CFLs; CFL A-lamps; EISA-compliant incandescent/halogen A-lamps; and traditional incandescent/halogen A-lamps—because consumers can typically use an LED A-lamp in many of the same applications as the other lamps in the A-lamp replacement category.[54]

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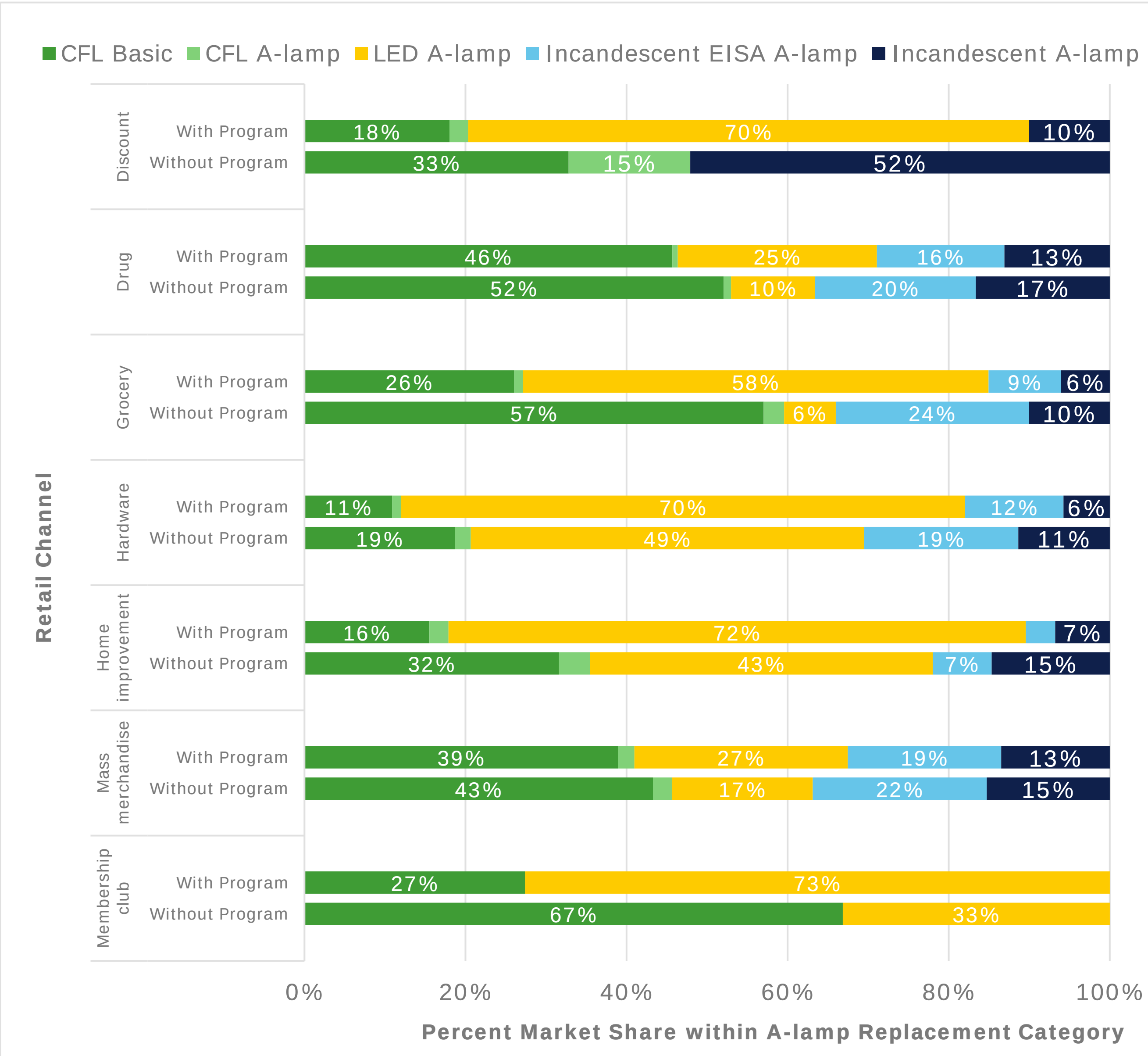
[53] Note that the evaluated upstream lighting measure group is “LED A-lamps (all wattages).” In our replacement categories, we include high-brightness lamps in the “High wattage” replacement category. Less than 1% of LED A-lamps and around 3% of LED reflectors in 2015 program data were greater than 17 W, (i.e., LED lamps greater than or equal to 1,050 lumens), there relatively few program-discounted LED lamps (A-lamps and reflectors) in the high-wattage category. Nonetheless, we leave the “all wattages” designation out of the measure group name in this section to avoid the possible misperception that we included high-wattage lamps in the modelled lamp replacement category.

[54] Note that when the tracking data indicated that a retail channel offered more than one IOU-discounted technology within a lamp replacement category (e.g., for both MSB LED A-lamps and MSB CFL A-lamps) within a specific quarter during 2015, we modeled the with program and without program market shares for only one measure group at a time. For example, we generated with program market share estimates in which the only program-discounted lamps in the A-lamp replacement category were LED A-lamps, and compared these to market shares when no program-discounted. We then performed separate with- and without program market share estimates in which the only program-discounted A-lamp replacements were CFL A-lamps. We took this approach because it was the most accurate representation of how the IOUs administered the program.

Figure 2 presents the market share results when program discounts for LED A-lamps were available and when they were not. For example, in home improvement stores with program discounts available, LED A-lamps had 72% market share in the A-lamp replacement category. When we removed the program effects from those simulations, LED A-lamps had 43% market share in that channel.

Figure 3. Modeled market shares with and without upstream lighting program discounts available for residential LED A-lamps by retail channel, 2015



6.2.1.2 NTGRq

We used these market share estimates to calculate the percent of program-discounted lamps that were attributable to the program. Equation 8 presents the equation for calculating NTGRq.[55]

Equation 8. NTGRq for lamp L and channel C

$$NTGRq_{L,C} = 1 - \frac{MS_{L,C,0}}{MS_{L,C,p}}$$

Where:

$MS_{L,C,0}$ = Market share of the lamp measure group L, in channel C, without program discounts

$MS_{L,C,p}$ = Market share of the lamp measure group L, in channel C, with program discounts

The incremental sales of the efficient technology attributable to the program, as a proportion of the program volume, is the difference in market share for the technology with the program versus without the program divided by the with program sales share. Alternatively, the proportion of program lamp purchases that would have been the same technology without the program is the ratio of without program to with program shares. One minus this ratio is the program-attributable proportion of program volume.

Table 50 shows the with- and without program market share estimates from Section 6, along with the resultant NTGRq for residential LED A-lamps by retail channel. Within the home improvement channel, for example, 43% (without program estimate) divided by 72% (with program estimate) yields 59% as the NTGRq. This suggests that 59% of the purchases of program-discounted LED A-lamps in home improvement stores would have been LED purchases even without program incentives. Subtracting 59% from 1 yields 41%. Thus, 41% of the purchases of program-discounted LED A-lamps in home improvement stores would *not* have been LED lamps in absence of the program.[56] This is the proportion of program-attributable LED purchases, NTGRq.

Table 50. NTGRq for residential LED A-lamps by retail channel, 2015 (upstream lighting program)

Channel	Share of A-lamp Replacement Purchases		NTGRq
	With Program	Without Program	
Discount	70%	0%	100%
Drug	25%	10%	58%
Grocery	58%	6%	89%
Hardware	70%	49%	30%
Home improvement	72%	43%	41%
Mass merchandise	27%	17%	34%
Membership club	73%	33%	54%

55 This formula is the same as the formula used for the NTGR in prior work.

56 Note that the NTGRq accounts for program-reliant lamps. For cases in which no program-discounted lamps within a specific evaluated upstream lighting measure group would not been available in absence of the program, the NTGRq is 100% (as is the case for LED A-lamps in the discount channel).

6.2.2 Calculate Net UES

As described in Section 6.1, we calculated net savings using the UES based on the mix of sales displaced by the program-discounted lamps along with the NTGRq. In Section 5, we calculated gross savings UES relative to lamps currently in sockets that program-discounted lamps replaced or will eventually replace. Said another way, the wattage of a lamp that would have been purchased in the absence of the program would have equaled the wattage of the lamps it replaced. This definition inherently assumes that in the absence of the program, a customer purchasing a program-attributable lamp would have purchased the same lamp technology that they replaced. Our net UES methodology instead uses recent in-store lamp stock inventory data and modelled market share estimates that represent California shoppers' choices to estimate the wattages of lamp purchases that program lamp purchases displaced. In other words, the NTGRu adjusts the gross UES such that we eliminate the need to assume that the displaced lamp wattage would have equaled the installed lamp wattage. Equation 9 below provides the formula for calculating a given program lamp type's NTGRu within a given channel. Note that delta watts is the only UES parameter that we update in this methodology. In theory, the methodology could have considered gross and net delta watts, we present the UES as it is a more holistic interpretation of gross and net energy impacts than just delta watts.

Equation 9. NTGRu for program lamp type "L", channel "C" and IOU "I"

$$NTGRu_{L,C,I} = \frac{UESn_{L,C,I}}{UESg_{L,I}}$$

Where:

$UESn_{L,C,I}$ = Net UES for program lamp type "L", channel "C", and IOU "I" based on lamp purchases in the absence of the program(additional detail in following sections)

$UESg_{L,I}$ = Gross UES for program lamp type "L", and IOU "I" based on installed lamps (Equation 6)

6.2.2.1 Estimate displaced market wattage

For each measure group within a lamp replacement category and channel, we generated two sets of estimates:

- **Lamp displacement rates.** We calculated the proportion of each non-measure group lamp type in the replacement category that was displaced per incremental attributable unit of the program technology. This is the program-induced change of each non-program lamp's market share, as a percentage of the program-induced change of the measure group's market share. We assume that every incremental program-attributable lamp sold displaces the sale of an alternative technology that a consumer would have purchased in the absence of the program. As we described in Section 6.1.1, the alternative technology sale might have been displaced from the program period or from a later year. Because of the 1-1 displacement, the sum of shares displaced by the program technology is equal to the incremental market shares of the program technology. That is, the displacement rates summed over the alternative technologies is equal to 100%. We show this calculation in Equation 10 below.
- **Average on-shelf wattage.** For each technology, we calculated the average wattage of non-program lamps that California retail stores stocked during winter 2015-16 by retail channel, from the in-store shelf survey data. We show this calculation in Equation 11 below.

Equation 10. Lamp displacement rate for non-program lamp l by program lamp type PL in channel C

$$D_{l,C} = -\frac{MS_{l,C,0} - MS_{l,C,p}}{MS_{PL,C,0} - MS_{PL,C,p}}$$

Where:

$MS_{L,C,0}$ = Market share of the non-program lamp l, in channel C, without program discounts

$MS_{L,C,p}$ = Market share of the non-program lamp l, in channel C, with program discounts

$MS_{PL,C,0}$ = Market share of the program lamp PL, in channel C, without program discounts

$MS_{PL,C,p}$ = Market share of the program lamp PL, in channel C, with program discounts

Equation 11. Average on-shelf wattage displaced by program lamp L in channel C

$$WD_{L,C} = \sum_{l}^{i} D_{l,C} * WD_{l,C}$$

Where:

$D_{l,C}$ = Program displacement rate of non-program lamp l through *i* in channel C

$WD_{l,C}$ = Average on-shelf wattage of non-program lamp l through i, displaced by program lamp L, in Channel C

We weighted the average wattage from the retail lamp stock inventories by the program lamp displacement rate to yield an overall average displaced market wattage by retail channel.

To illustrate this, we continue to use the example of the residential LED A-lamp measure group below. We look specifically at the home improvement channel so that we can illustrate the methodology, yet not overwhelm the discussion with a full-page table. Table 51 displays the market shares, lamp displacement rates (from Equation 10), and average on-shelf wattage (from Equation 11) for all non-program A-lamp replacement types.

In this example, consider the following example. PG&E discounted 62,553 LED A-lamps in home improvement stores. The corresponding NTGRq (from Table 50 above) suggests that 41% of these lamps were attributable to the program (~25,000 lamps). This means that without LED A-lamp discounts from the upstream lighting program, customers would have purchased about 25,000 fewer LED A-lamps in PG&E home improvement stores. Table 51 allows us to calculate the distribution of these 25,000 program-discounted LED A-lamps by alternative lamp type.

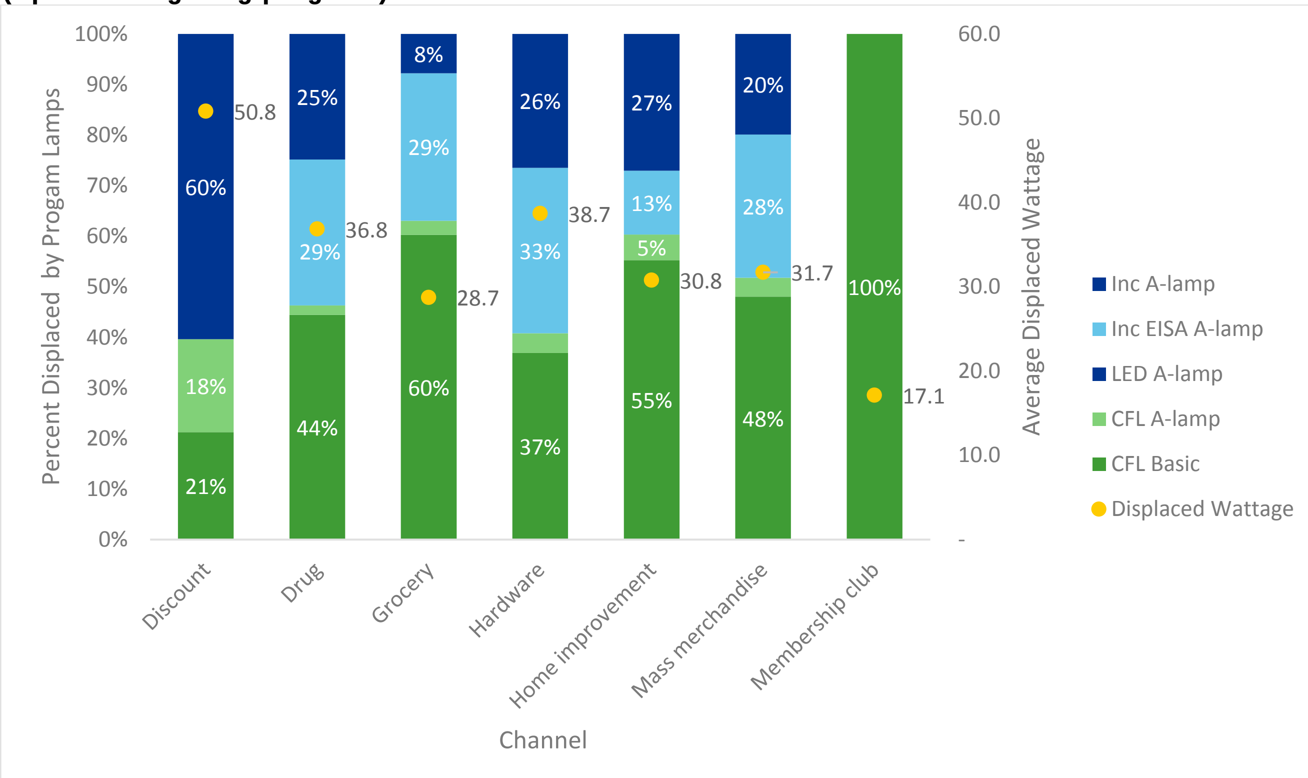
For example, we estimate the share of program LED A-lamps that would have been basic spiral CFLs. The market share for basic spiral CFLs dropped by 16 percentage points because program LED A-lamps were available, while the market share for LED A-lamps grew by 29 percentage points. Using Equation 10, we see that –(16%/-29%) = 55%. In other words, 55% of the 25,000 program-attributable LED A-lamps displaced basic spiral CFL purchases (about 14,000 lamps). Using these program-lamp displacement rates for each alternative lamp type, we calculate an overall weighted average of the on-shelf wattage that program-discounted lamps displaced. Table 51 shows that the average non-program wattage that 2015 program LED A-lamps displaced in home improvement stores was 30.8 W.

Table 51. Average displaced wattage for residential LED A-lamps in the home improvement channel, 2015 (upstream lighting program)

Channel / A-lamp Replacement Type	Market Share			Share of Lamps Displaced	Average On-Shelf Wattage Displaced by Program-Discounted LED Lamps
	With Program	Without Program	Difference		
Home improvement					
MSB CFL basic spiral ≤ 30W	16%	32%	16%	55%	16.4
MSB CFL A-lamp ≤ 30W	2%	4%	1%	5%	14.1
LED A-lamp	72%	43%	-29%	N/A	N/A
MSB incandescent, EISA compliant	4%	7%	4%	13%	49.1
MSB incandescent A-lamp	7%	15%	8%	27%	54.7
Overall	**100%**	**100%**	**0%**	**100%**	**30.8**

Figure 3 shows the average on-shelf wattages that program LED A-lamps displaced within each channel. These are the average wattages that we showed in Table 52 and used to calculate the overall on-shelf displaced wattage.

Figure 4. Average displaced wattage for residential LED A-lamps by retail channel, 2015 (upstream lighting program)



6.2.2.2 Estimate market delta watts

As part of our gross savings assessment in Chapter 5, we calculated baseline wattage using the installed lamp stock from CLASS 2012 adjusted for EISA-compliant incandescent/halogen lamps (see Section 5.4 above). Our net savings assessment requires a different estimate of delta watts. In this version of delta watts, we use a market baseline and thus refer to “market delta watts.” Market delta watts is the difference between the average displaced market wattage in each channel and the average wattage of program-discounted lamps for each IOU. We calculate a market delta watts estimate for each combination of IOU and channel. Equation 12 shows this calculation.

Equation 12. Market delta watts for program lamp L, channel C, and IOU I

$$\text{Market } \Delta\text{Watts}_{L,C,I} = W_L - WD_{L,C}$$

Where:

W_L = Average discounted wattage of program lamp (measure group) L

$WD_{L,C}$ = Average wattage displaced by program lamp (measure group) L

Table 52 shows the average displaced wattage (as demonstrated in Table 51), average program-discounted lamp wattage (as calculated using tracking data), and market delta watts by channel and IOU. As an example, the average wattage that program LED A-lamps displaced in home improvement was 30.8 W. PG&E’s average program-discounted LED A-lamp wattage was 8.4 W, yielding a market delta watts of 22.4.

Table 52. Market delta watts for residential LED A-lamps, 2015 (upstream lighting program)

IOU / Channel	Average Displaced Wattage (Watts)	Average Program Discounted Wattage (Watts)	Market Delta Watts (Watts)
PG&E			
Discount	50.8	8.4	42.4
Drug	36.8		28.4
Grocery	28.7		20.3
Hardware	38.7		30.3
Home improvement	30.8		22.4
Mass merchandise	31.7		23.3
Membership club	17.1		8.7
SCE			
Discount	50.8	4.9	46.0
Drug	36.8		32.0
Grocery	28.7		23.9
Hardware	38.7		33.8
Home improvement	30.8		25.9
Mass merchandise	31.7		26.8
Membership club	17.1		12.3
SDG&E			
Discount	50.8	9.4	41.4
Drug	36.8		27.4
Grocery	28.7		19.3
Hardware	38.7		29.3
Home improvement	30.8		21.4
Mass merchandise	31.7		22.3
Membership club	17.1		7.7

6.2.2.3 Calculate net UES

Our next step in estimating net savings was to calculate a net UES for each combination of evaluated upstream lighting measure group, channel, and IOU. We used the same formula to calculate net UES as we did to calculate gross UES and the same inputs with the exception of delta watts. As we described in the previous section, the net UES calculation uses market delta watts values while the gross UES used delta watts values based on installed lamp stock. We calculated the net UES by multiplying the market delta watts by hours of use, and applying an interactive effects factor. Equation 13 and Equation 14 show the formulas for calculating net UES for energy and peak demand, respectively.

Equation 13. Net unit energy savings for lamp L, channel C, and IOU I

$$UESn_{L,C,I}\left[\frac{kWh}{year}\right] = \text{Market }\Delta\text{Watts}_{L,I}[W] * HOU_{L,I}[h] * \frac{1\ kWh}{1000\ Wh} * \frac{365\ days}{1\ year} * IE_I[kWh]$$

Where:

$\text{Market }\Delta\text{Watts}_{L,IOU}$ = Market delta watts, relative to a market baseline, in watts (W)

$HOU_{L,I}$ = annual average HOU of measure group, L, for IOU I, in hours (h)

$IE_{,I}$ = HVAC interactive effects in kilowatt-hours for IOU I (kWh)

Equation 14. Net unit peak demand reduction for lamp L, channel C, and IOU I

$$UPDR(Net)_{L,C,I}\left[\frac{kW}{year}\right] = \text{Market }\Delta\text{Watts}_{L,I}[W] * CF_{L,I} * \frac{1\ kW}{1000\ W} * IE_I[kW]$$

Where:

$\text{Market }\Delta\text{Watts}_{L,IOU}$ = Market delta watts, relative to a market baseline, in watts (W)

CF_L = average percent on at peak for IOU-discounted lamp measure group, L

IE_L = HVAC interactive effects in kilowatts (kW)

Table 53 provides the net UES results for 2015 residential upstream LED A-lamps by IOU and retail channel. In this example, for energy, one can see that LED A-lamps in discount stores had the largest UES estimates for LED A-lamps (32.5 kWh/year for SDG&E, 33.0 kWh/year for PG&E, and 37.5 kWh/year for SCE)—likely because of the greater presence in this channel of traditional incandescent lamps (which typically have the highest wattage of all replacement lamp types). The lowest net UES is in the membership club channel because the only non-LED technology in this channel is CFL, as we showed in Figure 3 above. As a result, the average displaced wattage is low, at 17 W, as we showed in Table 58 above.

The assumption that the membership sales of discounted LED lamps displace other technologies only within the same channel drives the low UES for LED A-Lamps in this channel. Thus, for instance, absent discounted LED lamps, we implicitly assume that membership clubs would only have had non-discounted CFLs available for purchase. However, it seems likely that if discounted LED lamps were not available in membership clubs, consumers would have purchased some LED lamps in other channels instead (rather than switching completely to CFLs). Our supplier interview results support this perspective, as they suggested that many of shoppers' purchases in membership clubs would have occurred in other channels without the program's discount. In Section 6.2.3 we describe our adjustment to account for this shift in purchases away from membership clubs and toward other channels. While the program may be shifting sales across other channels besides into membership clubs, we address the potential for channel shift for membership clubs in particular because this is the one channel where alternative inefficient technologies cannot otherwise be considered as part of the baseline.

Table 53. Net UES for residential LED A-lamps by IOU and retail channel, 2015 (upstream lighting program)

IOU / Channel	Market Delta Watts	HOU (h)	Peak CF	Interactive Effects			Net UES		
				kWh	kW	Therms	kWh / Year	kW / year	Therms / year
PG&E									
Discount	42.4	2.09	0.06	1.02	1.35	(0.02)	33.0	0.004	(0.7759)
Drug	28.4						22.1	0.002	(0.5203)
Grocery	20.3						15.8	0.002	(0.3716)
Hardware	30.3						23.5	0.003	(0.5539)
Home improvement	22.4						17.4	0.002	(0.4092)
Mass merchandise	23.3						18.1	0.002	(0.4262)
Membership club	8.7						6.8	0.001	(0.1594)
SCE									
Discount	46.0	2.09	0.06	1.07	1.38	(0.02)	37.5	0.004	(0.6728)
Drug	32.0						26.1	0.003	(0.4683)
Grocery	23.9						19.5	0.002	(0.3493)
Hardware	33.8						27.6	0.003	(0.4952)
Home improvement	25.9						21.1	0.002	(0.3794)
Mass merchandise	26.8						21.9	0.002	(0.3930)
Membership club	12.3						10.0	0.001	(0.1796)
SDG&E									
Discount	41.4	2.09	0.06	1.03	1.28	(0.02)	32.5	0.003	(0.5558)
Drug	27.4						21.6	0.002	(0.3683)
Grocery	19.3						15.2	0.002	(0.2593)
Hardware	29.3						23.0	0.002	(0.3930)
Home improvement	21.4						16.8	0.002	(0.2868)
Mass merchandise	22.3						17.5	0.002	(0.2994)
Membership club	7.7						6.1	0.001	(0.1037)

6.2.3 Account for channel shift in membership club stores

The next step in our net savings assessment was to adjust the net UES for channel shift. As we described in the previous section, we made this adjustment for the membership club channel only. We only consider channel shift in membership club for two reasons:

1) The sales displacement UES in membership club is drastically lower than the other channels, due to a CFL-only baseline for LED lamps and an LED-only baseline for CFLs. If we overlooked channel shift in membership, it would have the effect of assuming a very low market UES.

2) For all IOUs, the majority of program LED lamps were shipped to membership club, so again, if we overlooked channel shift, it would have a sizeable impact on ultimate savings.

As we summarized at the opening of Section 6.2, the channel shift adjustment consists of the following steps:

- Determine the proportion of program-discounted lamps in this channel that displaced lamps that would otherwise have been sold within the same channel, versus the proportion that displaced sales from other channels.
- Calculate the NTGRq and the sales displacement mix UES separately for lamps displaced within the membership club channel versus those displaced from other channels.
- Determine the overall membership club NTGR and UES as the weighted average of the same-channel and channel shift values.

6.2.3.1 Proportion of program-discounted lamps in membership club channel that displace sales from other channels

This proportion relies upon results from the 2016 telephone interviews with lighting manufacturers and retail buyers. Respondents estimated the percentage that their sales of a given product in each channel would have changed in the absence of the program. We received one response from a membership club retail buyer, and one response from a manufacturer who was the sole program participant in the membership club channel. These two responses indicated that overall sales in membership club would have decreased in the absence of the program, and would have shifted to other channels. In order to maintain confidentiality of the respondents' answers, we calculated a simple average of the two responses. This average equaled 50%, suggesting that 50% of membership club lamp sales would have occurred in other channels in absence of the 2015 upstream lighting program.

6.2.3.2 NTGRq and market UES for in-channel and other-channel displacements

For the sales displaced within the membership club channel, we calculated the NTGRq and the market UES by the same means as for other channels. We changed only the applicable program volume to reflect the proportion of program-discounted lamps that would stay within the membership channel.

For sales displaced from other channels, the without program market shares for each channel dictate the mix of lamp types in each channel that would have been available in the absence of the program. We determined these shares as part of the market share analysis (Section 6.2.1.1 above).

The proportion of without program sales that would have been LED lamps in a given channel correspond to sales of LED lamps that are displaced from each channel to program LED lamp sales in the membership club channel. Because this is shifting a sale from a non-program LED lamp in one channel to a program-discounted LED lamp in the membership club channel, these are the non-attributable LED sales shifted from each channel. Equation 14 shows the NTGRq calculation for these lamps.

Equation 14. NTGRq for program-discounted lamps that shifted into the membership club channel from non-membership club channel c

$$NTGRq(CS)_{L,c(non-mem)} = 1 - MS_{L,c,0}$$

Where:

$NTGRq(CS)_{L,c(non-mem)}$ = NTGRq of measure group "L" purchases that shifted out of non-membership club channel "c", and into the membership club channel

$MS_{L,C}$ = Market share of measure group "L" in non-membership club channel "c", when program discounts were not available

For example, imagine the program displaced 100 lamp sales from channel c because these sales occurred at the membership club channel instead. Now imagine that in channel c without the program, 20% of sales would have been LED lamps. The NTGRq for the 100 shifted sales is 100-20% = 80%. That is, 20% of the lamps that shifted out of channel c would still have been LED lamps, so 20% of the channel-shifted membership club program lamps did not produce incremental LED sales. For the 80% that would have been non-LED lamps in channel c, the shift to program-discounted LED lamp sales in the membership club channel constitute program-attributable LED lamp sales. The average baseline W for these sales is the wattage of the individual technologies, weighted by the relative channel-shifted lamp displacement rate of each technology. Equation 15 shows the formula for calculating the channel-shifted displacement rate. This calculation estimates a given lamp's market share as a percentage of the overall market share that was displaced by the channel-shifted program lamp in the given channel.

Equation 15. Lamp displacement rate for non-program lamp type l displaced by membership club program-discounted LED lamps from non-membership club channel c

$$D_{l,c(non-mem)} = \frac{MS_{l,c(non-mem),0}}{\sum_{l}^{i} MS_{l,c(non-mem),0}}$$

Where:

$D_{l,C(non-mem)}$ = Program displacement rate for non-program lamp type "l" displaced by membership club program-discounted lamps from non-membership club channel "c", without program discounts

$MS_{L,C(non-mem),0}$ = Market share of non-program lamp type "l" through "i" in non-membership club channel "c" , without program discounts

We use the lamp displacement rate for each non-program lamp type as the weight to calculate the average wattage of lamps within a non-membership club channel that were displaced by program-discounted lamps in the membership club channel. Equation 16 illustrates this calculation.

Equation 16. Average on-shelf wattage for non-program lamps displaced by program-discounted membership club LED lamps from non-membership club channel c

$$WD_{L,c(non-mem)} = \sum\nolimits_{l}^{i} D_{l,c(non-mem)} * WD_{l,c(non-mem)}$$

Where:

$WD_{L,c(non-mem),0}$ = Average wattage that was displaced from non-membership club channel "c" membership club program-discounted lamps "L", without program discounts

$D_{l,c(non-mem),0}$ = Lamp displacement rate for non-program lamp type "l" through "i" in non-membership club channel "c", without program discounts

$WD_{l,c(non-mem)}$ = Average displaced wattage of non-program lamp type "l" through "i" in non-membership club channel "c"

In an equation that is analogous to Equation 12 (Market delta watts for program lamp L, channel C, and IOU I), Equation 17 below shows the formula for calculating the market delta watts as the difference between the average program lamp wattage, and the average wattage of lamps that were displaced by channel-shifted program-discounted lamps in the membership club channel.

Equation 17. Market delta watts for non-program lamps displaced by program-discounted membership club LED lamps from channel c in IOU I

$$\text{Market }\Delta\text{Watts(CS)}_{L,c(non-mem),I} = W_{L,I} - WD_{L,c(non-mem)}$$

Where:

Market ΔWatts(CS)$_{L,c(non\text{-}mem),I}$ = Market delta watts for program lamp "L" relative to non-membership club channel "c" that shifted to the membership club channel, for IOU "I"

$W_{L,I}$ = The average wattage of program lamp "L" for IOU "I"

$WD_{L,c(non\text{-}mem)}$ = The average wattage of lamps in non-membership club channel, "c" that were displaced by channel-shifted program-discounted lamps in the membership club channel.

Consider Table 54, which again focuses on just on the home improvement channel in an effort to limit the complexity of the methodology. Note that the with program market share is equal to 100% LED A-lamps. That is, when program discounts were available in membership club stores, 100% of these home improvement sales shifted away from home improvement, and became program LED A-lamp sales in the membership club channel.

We calculated the average on-shelf wattage displaced by channel-shifted program-discounted lamps using Equation 15, Equation 16, and Equation 17. In this example, the channel-shifted displaced on-shelf wattage is 30.2 W (per Table 54) compared to the un-shifted displaced on-shelf wattage of 30.8 W (see Table 51 above).

Table 54. Average displaced on-shelf wattage of channel-shifted, residential LED A-lamps in the home improvement channel, 2015 (upstream lighting program)

Channel / A-lamp Replacement Type	Channel-Shifted Market Share			Program Lamp Displacement Rate	Average On-shelf Wattage Displaced by Channel-Shifted Program Lamps
	With Program Shifted Lamps	Without Program	Difference Between With Program and Without program		
Home improvement					
MSB CFL basic spiral ≤ 30W	0%	32%	32%	55%	16.4
MSB CFL A-lamp ≤ 30W	0%	4%	4%	7%	14.1
LED A-lamp, all wattages	100%	43%	-57%	N/A	N/A
MSB incandescent, EISA compliant	0%	7%	7%	13%	49.1
MSB incandescent A-lamp	0%	15%	15%	25%	54.7
Overall Channel	**100%**	**100%**	**0%**	**100%**	**30.2**

We must then estimate the proportions of shifted lamp purchases that came from each non-membership club channel. We used responses from 2016 consumer surveys to define this distribution. That is, we assume that in the absence of the program, the lamp purchases would have been distributed across the other channels according to the overall channel purchase rates indicated in the survey results. We calculated the proportion of each channel's share of typical purchases relative to the total channel's share of purchases, excluding the membership club channel. We then used this distribution of purchases across non-membership club channels to weight the channel-specific NTGRq (Equation 18), displaced on-shelf wattage (Equation 18), and market UES (shown earlier in Equation 13). The results are the overall channel-shifted NTGRq and displaced on-shelf wattage are shown in Table 55. As this table shows, the weighted on-shelf wattage of lamps displaced by channel-shifted LED A-lamps is 31.7 W.

Equation 18. NTGRq for non-program lamps displaced by program-discounted membership club LED lamps from channel C in IOU I

$$\mathrm{NTGRq(CS)}_{L,I} = \sum_{c}^{i} (NTGRq(CS)_{L,c(non-mem),I} \times PS_{c(non-mem)})$$

Where:

$\mathrm{NTGRq(CS)}_{L,I}$ = Overall channel-shifted NTGRq for program-discounted lamps "L" for IOU "I"

$\mathrm{NTGRq(CS)}_{L,c(non\text{-}mem)}$ = Channel-shifted NTGRq for program-discounted lamps "L" that displaced lamps out of non-membership club channels "c" through "i", and into the membership club channel

$PS_{c(non\text{-}mem)}$ = Share of lamp purchases made in non-membership club channels "c" through "i", as percent of lamp purchases made in all non-membership club stores.

Equation 19. Market delta watts for non-program lamps displaced by program-discounted membership club LED lamps from channel C in IOU I

$$WD_{L,I} = \sum_{c}^{i} (WD_{L,c(non-mem),I} \times PS_{c(non-mem)})$$

Where:

$WD_{L,I}$ = Overall wattage displaced by channel-shifted program-discounted lamps "L" that shifted to the membership club channel, for IOU "I"

$WD_{L,c(non\text{-}mem),I}$ = Wattage displaced by channel-shifted program-discounted lamps "L" that shifted our of non-membership club channel "c" through "i" and into the membership club channel for IOU "I"

$PS_{c(non\text{-}mem)}$ = Share of lamp purchases made in non-membership club channels "c" through "i", as percent of lamp purchases made in all non-membership club stores.

Table 55. Membership club channel-shifted NTGRq and displaced on-shelf wattage for residential LED A-lamps, 2015 (upstream lighting program)

Channel	Typical Lamp Purchase Location[1]	Typical Lamp Purchase Location without Displaced Channel	Market Share without Program	Channel-shifted	
				NTGRq	Displaced On-shelf Wattage[2]
Discount	3%	3%	0%	100%	46.9
Drug	3%	3%	10%	90%	32.6
Grocery	3%	3%	6%	94%	28.6
Hardware	9%	10%	49%	51%	38.4
Home improvement	51%	58%	43%	57%	30.2
Mass merchandise	20%	22%	17%	83%	30.4
Membership club	11%				
Overall membership club, channel-shifted	**100%**	**100%**	**34%**	**66%**	**31.7**

[1] Source: 2016 consumer telephone survey
[2] Note that these displaced wattages may vary slightly compared to the wattages in Figure 3. See discussion above Table 54 for an explanation

Table 56 shows the overall channel-shifted market UES for this measure.

Table 56. Membership club channel-shifted net UES for residential LED A-lamps, 2015 (upstream lighting program)

IOU	Displaced On-shelf Wattage[1]	Average Program Discounted Wattage (Watts)	Channel-Shifted Delta Watts	Channel-Shifted Net UES kWh	Channel-Shifted Net UES kW	Channel-Shifted Net UES Therms
PG&E	31.7	8.4	23.2	18.1	0.002	(0.4)
SCE		4.9	26.8	21.9	0.002	(0.4)
SDG&E		9.4	22.3	17.5	0.002	(0.2)

Note: Differences between channel-shifted delta watts and the value generated by subtracting the rebated wattage from the displaced on-shelf wattage may exist because of rounding.
[1] Note that these displaced wattages may vary slightly compared to the wattages in Figure 3. See discussion above Table 54 for an explanation

6.2.4 Calculate NTGRq and NTGRu

The final step in calculating the NTGRq and NTGRu is rolling the channel-specific estimates into an overall estimate.

We calculate the overall NTGRq by weighting each channel's NTGRq by the volume of a given measure group's shipments that an IOU shipped to that respective channel. Below, Equation 20 provides the formula for this calculation.

Equation 20. NTGRq for program lamp type L, and IOU I

$$NTGRq_{L,I} = \sum_{C}^{i}\left(NTGRq_{L,C,I} \times \frac{V_{L,C,I}}{V_{L,I}}\right)$$

Where:

$NTGRq_{L,C,I}$ = Quantity net to gross ratio for program lamp type "L", and channel "C" (discount) through "i" (Membership club, channel shifted)

$V_{L,C,I}$ = Volume of program lamp type "L", shipped to channels "C1" (discount) through "C7" (membership club) by IOU "I"

$V_{L,I}$ = Total volume of program lamp type "L", shipped by IOU "I"

In order to calculate the overall NTGRu, we must take into account the relative NTGRq for each channel in addition to the volume of lamps within the measure group that the IOU shipped to each channel. Equation 21 shows this calculation.

Equation 21. Overall NTGRu for program lamp type L, and IOU I, weighted by product of the NTGRq and the Volume

$$NTGRu_{L,I} = \frac{\sum_{C}^{i}\left(NTGRu_{L,C} \times NTGRq_{L,C} \times V_{L,C,I}\right)}{\sum_{C}^{i}\left(NTGRq_{L,C} \times V_{L,C,I}\right)}$$

Where:

$NTGRu_{L,I}$ = Overall NTGRu for measure group "L" and IOU "I"

$NTGRu_{L,C}$ = NTGRu for measure group "L" in channels "C" through "i"

$NTGRq_{L,C}$ = NTGRq for measure group "L" in channels "C" through "i"

$V_{L,C,I}$ = Volume Measure Group "L" lamps shipped to channels "C" through "i" by IOU "I"

To calculate an overall NTGRu, we calculated a weighted average that reflects the relative impact of each channel's net UES. Two factors drive these impacts: the quantity of lamps that manufacturers shipped to a given channel, and the magnitude of program-attribution within that channel. Thus, we cannot simply weight the NTGRq by the quantity of program-discounted lamps that manufacturers shipped to each channel. Because the overall NTGR is the product of the overall NTGRq and the overall NTGRu, we thus weighted each channel's NTGRu by the product of the quantity of program-discounted lamps shipped to that channel and the NTGRq of that channel.

Table 57. NTGRu for residential LED A-lamps by IOU and retail channel, 2015 (upstream lighting program)

IOU / Channel	Quantity of LED A-lamps	NTGRq	Gross UES	Net UES	NTGRu
PG&E					
Discount	16,919	100%	27.2	33.0	121%
Drug	0	0%		N/A	0%
Grocery	27,930	89%		15.8	58%
Hardware	53,423	30%		23.5	87%
Home improvement	62,553	41%		17.4	64%
Mass merchandise	6,607	34%		18.1	67%
Membership club, not channel-shifted	557,755	54%		6.8	25%
Membership club, channel-shifted	557,755	66%		18.1	67%
Overall	**1,285,084**	**59%**		**13.9**	**51%**
SCE					
Discount	54,207	100%	34.3	37.5	109%
Drug	281	58%		26.1	76%
Grocery	125,844	89%		19.5	57%
Hardware	67,230	30%		27.6	81%
Home improvement	192,613	41%		21.1	62%
Mass merchandise	0	0%		N/A	0%
Membership club, not channel-shifted	507,801	54%		10.0	29%
Membership club, channel-shifted	507,801	66%		21.9	64%
Overall	**1,455,777**	**60%**		**18.9**	**55%**
SDG&E					
Discount	22,560	100%	27.0	32.5	121%
Drug	0	0%		N/A	0%
Grocery	54,579	89%		15.2	56%
Hardware	38,017	30%		23.0	85%
Home improvement	76,859	41%		16.8	62%
Mass merchandise	180	34%		17.5	65%
Membership club, not channel-shifted	180,850	54%		6.1	23%
Membership club, channel-shifted	180,850	66%		17.5	65%
Overall	**601,968**	**60%**		**14.9**	**55%**

6.2.5 Calculate overall NTGR

To calculate an overall NTGR, we multiply the NTGRq by the NTGRu. Below, Table 58 presents the NTGRs that we calculated for 2015 upstream lighting program LED A-lamps for each IOU and channel. Remember that that NTGRq adjusts savings to account for the quantity of program-attributable lamps. This factor is comparable to prior impact evaluations. The NTGRu adjusts the gross-savings estimate to produce savings that are relative to program-attributable displaced purchases. In this case, LED A-lamps have a particularly low NTGR (30% for PG&E, 33% for SCE, and 33% for SDG&E). It would be incorrect to interpret this result to mean that two-thirds of program LED A-lamps would have been LED purchases in the absence of the program. Rather, these results suggest that around 40% of program LED lamps would have been LED lamps purchases in the absence of the program. Additionally, the net NTGRu suggests that among the roughly 60% of program-discounted lamps that were program attributable, about 50% of program-LED efficiency gains would still have occurred in the absence of the program through organic purchases of non-program, efficient technologies.

Table 58. Overall NTGR for residential LED A-lamps by IOU and channel, 2015 (upstream lighting program)

IOU / Channel	Quantity of Program-Discounted Lamps	NTGRq	NTGRu	Overall NTGR
PG&E				
Discount	16,919	100%	121%	121%
Drug	0	N/A	N/A	N/A
Grocery	27,930	89%	58%	52%
Hardware	53,423	30%	87%	26%
Home improvement	62,553	41%	64%	26%
Mass merchandise	6,607	34%	67%	23%
Membership club, not channel-shifted	557,755	54%	25%	14%
Membership club, channel-shifted	557,755	66%	67%	44%
Overall	**1,282,942**	**59%**	**51%**	**30%**
SCE				
Discount	54,207	100%	109%	109%
Drug	281	58%	76%	44%
Grocery	125,844	89%	57%	51%
Hardware	67,230	30%	81%	24%
Home improvement	192,613	41%	62%	25%
Mass merchandise	0	N/A	N/A	N/A
Membership club, not channel-shifted	507,801	54%	29%	16%
Membership club, channel-shifted	507,801	66%	64%	42%
Overall	**1,455,777**	**60%**	**55%**	**33%**
SDG&E				
Discount	22,560	100%	121%	121%
Drug	0	N/A	N/A	N/A
Grocery	54,579	89%	56%	50%
Hardware	38,017	30%	85%	26%
Home improvement	76,859	41%	62%	25%
Mass merchandise	180	34%	65%	22%
Membership club, not channel-shifted	180,850	54%	23%	12%
Membership club, channel-shifted	180,850	66%	65%	43%
Overall	**601,968**	**60%**	**55%**	**33%**

6.2.6 Net Savings

Table 59 displays the ex post gross savings, ex post net savings, and NTGRs for residential LED A-lamps.

Table 59. Residential ex post gross savings, ex post net savings, and NTGR for LED A-lamps by IOU, 2015 (upstream lighting program)

IOU	Ex Post Gross			Ex Post Net			Ex Post Overall NTGR		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
PG&E	34,298,856	3,785	(807,032)	10,348,702	1,142	(243,499)	30%	30%	30%
SCE	48,994,685	5,268	(879,157)	16,222,241	1,744	(291,091)	33%	33%	33%
SDG&E	15,940,337	1,652	(272,379)	5,275,440	547	(90,143)	33%	33%	33%

Table 60 presents the ex ante net savings, ex post net savings, and realization rates. The table shows that while NTGR were around 30%, the realization rates remain very high.

Table 60. Residential ex ante net savings, ex post net savings and net realization rates for LED A-lamps by IOU, 2015 (upstream lighting program)

IOU	Ex Ante Net Savings			Ex Post Net Savings			Net Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
PG&E	8,301,893	892	(194,869)	10,348,702	1,142	(243,499)	125%	128%	125%
SCE	4,668,907	497	(89,470)	16,222,241	1,744	(291,091)	347%	351%	325%
SDG&E	4,900,785	669	(63,756)	5,275,440	547	(90,143)	108%	82%	141%

6.3 NTGR

This section presents the results of the NTGR analysis as described in Section 6.2. The tables that follow present the quantity of lamps that were discounted by the program by retail channel, the NTGRq, as estimated using the LCM, the gross UES that was reported in Section 5.6, the net UES, the NTGRu, and the overall NTGR. Note that in some cases, the overall NTGR is lower than in previous years (for example, the MSB CFL basic spiral ≤ 30 W is 17% for SCE, while in 2013-14 it was 26%), while others are larger (for example, MSB CFL CFL A-lamp ≤ 30 W is 81% for SDG&E, while it was 28% for SDG&E in 2013-14). The changes are differences compared to last year are largely due to the channels within which lamps were discounted, and the additional UES adjustments that were made in this evaluation.

We reiterate that these NTGRs take into account two elements: the quantity that would have sold in the absence of the program, and the average non-program technology wattage that would have sold in the absence of the program. These corrections are applied to the gross savings estimate. Readers should interpret the NTGRq as the percent of program-discounted lamps that sold due to the program, and interpret NTGRu as an adjustment to the gross savings UES.

Recall that the gross savings methodology is relative to lamps that program-discounted lamps replaced. The NTGRu adjusts that estimate so that the savings are relative to the lamp that the customer would have purchased absent program discounts and availability.

A NTGRu that is less than 100% means that the net savings UES is less than gross savings UES. This suggests that absent the program, on average, program-attributable shoppers would have purchased non-program lamps rated at lower wattages than the wattages of lamps that California customers replaced. Vice versa, when the NTGRu is greater than 100%, it suggests that in the absence of the program, program-attributable shoppers would have purchased lamps of higher wattage than the lamps that the average California customer replaced.

A NTGRu that is negative suggests that absent the program, program-attributable shoppers would have on average purchased a lamp that was lower rated at a lower wattage than the program lamp. Note that this only occurs in a handful of instances in which the IOUs provided incentives for CFLs in the membership club channel. Because the only alternative technology available would have been LED lamps, all without program purchases would have been LED lamps, and thus more efficient than the program-discounted CFLs. We will now present NTGR results for each measure group and highlight key drivers.

6.3.1 MSB CFL basic spiral ≤ 30 W

Table 61 presents the overall NTGR associated with the MSB CFL basic spiral ≤ 30 W for all IOUs. The difference in IOU results is driven by the distribution of lamps across the various channels. Note that in the case of not channel-shifted membership club purchases, the net UES is negative. As noted above, a negative NTGRu means that if a customer had not purchased a program CFL basic spiral lamp, and still would have purchased a lamp at the membership club store, their only other lamp choice was an LED, which would have been lower wattage. The negative net UES leads to a negative overall NTGR in the not channel-shifted membership club.

Overall, these findings suggest that the NTGRq in all channels is low (for example, 24% for PG&E), meaning that many people would have purchased the program lamp in the absence of discounted prices. However, the NTGRu (203% for PG&E for example) suggests that those who would have purchased another lamp would have purchased a higher-wattage lamp than estimated using the gross savings methodology. An important take-away from these findings is that discount stores stocked much higher wattage alternative lamps than other channels. The high net UES in discount stores is driven by high the average wattage of non-program lamps stocked on shelves. This means that due to discount store stocking practices, the average non-program wattages that program lamps displaced would have been less efficient than the lamps that customers replaced in sockets on average.

Table 61. Overall NTGR, residential MSB CFL basic spiral ≤ 30 W by IOU and retail channel, 2015 (upstream lighting program)

IOU / Channel	Quantity of Program-Discounted Lamps	NTGRq	Gross UES kWh	Net UES kWh	NTGRu	Overall NTGR
PG&E						
Discount	432,026	24%		29.8	204%	49%
Drug	0	N/A		N/A	N/A	N/A
Grocery	30,690	2%		9.4	65%	1%
Hardware	0	N/A		N/A	N/A	N/A
Home improvement	0	N/A	14.6	N/A	N/A	N/A
Mass merchandise	2,193	18%		13.6	93%	17%
Membership club, not channel-shifted	0	N/A		N/A	N/A	N/A
Membership club, channel-shifted	0	N/A		N/A	N/A	N/A
Total	**464,909**	**22%**		**29.6**	**203%**	**46%**
SCE						
Discount	0	N/A		N/A	N/A	N/A
Drug	0	N/A		N/A	N/A	N/A
Grocery	0	N/A		N/A	N/A	N/A
Hardware	0	N/A		N/A	N/A	N/A
Home improvement	0	N/A	N/A	N/A	N/A	N/A
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	0	N/A		N/A	N/A	N/A
Membership club, channel-shifted	0	N/A		N/A	N/A	N/A
Total	**0**	**N/A**		**N/A**	**N/A**	**N/A**
SDG&E						
Discount	0	N/A		N/A	N/A	N/A
Drug	0	N/A		N/A	N/A	N/A
Grocery	0	N/A		N/A	N/A	N/A
Hardware	0	N/A		N/A	N/A	N/A
Home improvement	2,377	43%	15.5	17.2	111%	48%
Mass merchandise	17,170	18%		14.4	93%	17%
Membership club, not channel-shifted	0	N/A		N/A	N/A	N/A
Membership club, channel-shifted	0	N/A		N/A	N/A	N/A
Total	**19,547**	**21%**		**15.1**	**98%**	**21%**

6.3.2 MSB CFL A-lamp ≤ 30 W

Table 62 presents the NTGR results for MSB CFL A-lamps ≤ 30 W for all IOUs. NTGRq results show that just over two-thirds of program-discounted lamps in this measure group were program-attributable in discount stores (70%). NTGRu results suggest that in the absence of program discounts, non-CFL A-lamp PG&E purchases would have consumed 57% more energy than the lamps they replaced, SCE purchases would have consumed 39% more energy than the lamps they replaced, and SDG&E purchases would have consumed 47% more energy than the lamps they replaced. Overall, SCE's distribution of these lamps to grocery stores, which showed high NTGRq (98%) but low NTGRu (46%), yields a relatively lower overall NTGR when compared to PG&E and SDG&E (69% versus 110% and 101%, respectively), both of which provided incentives for most of these lamps in discount stores.

Note that the results for CFL A-lamps are much higher than for CFL basic spiral. The two drivers of this result relate to stocking practices, and consumer preference. According to supplier responses, basic spiral CFLs were rarely program-reliant, even in discount stores. In other words, suppliers suggested that these lamps would have been available in the absence of the program. This is a change from prior evaluations, in which these lamps were frequently program reliant in discount stores. Furthermore, at non-program prices, many customers would still have purchased basic spiral CFLs, given the lamp stock available in these stores (CFL basic spiral and incandescent A-lamp). See Table 94 in Appendix H for more details on this modelled result. In contrast, suppliers suggested that many of the program CFL A-lamps would not have been stocked in the absence of the program, and that while some of these customers would have purchased basic spiral CFLs instead (effectively yielding no savings), many would have purchased incandescent A-lamps. See Table 101 for details on CFL A-lamp modelled results.

Table 62. Overall NTGR, residential MSB CFL A-lamps ≤ 30 W by IOU and retail channel, 2015 (upstream lighting program)

IOU / Channel	Quantity of Program-Discounted Lamps	NTGRq	Gross UES kWh	Net UES kWh	NTGRu	Overall NTGR
PG&E						
Discount	20,097	70%	14.8	23.2	157%	110%
Drug	0	N/A		N/A	N/A	N/A
Grocery	0	N/A		N/A	N/A	N/A
Hardware	0	N/A		N/A	N/A	N/A
Home improvement	0	N/A		N/A	N/A	N/A
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	0	N/A		N/A	N/A	N/A
Membership club, channel-shifted	0	N/A		N/A	N/A	N/A
Total	**20,097**	**70%**		**23.2**	**157%**	**110%**
SCE						
Discount	468,268	70%	22.9	31.7	139%	97%
Drug	809	95%		7.4	32%	31%
Grocery	511,140	98%		10.4	46%	45%
Hardware	67,232	99%		17.4	76%	76%
Home improvement	10,075	52%		2.3	10%	5%
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	0	N/A		N/A	N/A	N/A
Membership club, channel-shifted	0	N/A		N/A	N/A	N/A
Total	**1,057,524**	**85%**		**18.6**	**81%**	**69%**
SDG&E						
Discount	244,400	70%	15.7	23.1	147%	103%
Drug	0	N/A		N/A	N/A	N/A
Grocery	0	N/A		N/A	N/A	N/A
Hardware	0	N/A		N/A	N/A	N/A
Home improvement	3,717	52%		3.6	23%	12%
Mass merchandise	1,219	23%		5.3	34%	8%
Membership club, not channel-shifted	0	N/A		N/A	N/A	N/A
Membership club, channel-shifted	0	N/A		N/A	N/A	N/A
Total	**249,336**	**69%**		**22.8**	**146%**	**101%**

6.3.3 MSB CFL reflector ≤ 30 W

Table 63 presents the results for MSB CFL reflector ≤ 30 W. The discount, drug, and grocery channels all show 100% NTGRq, largely driven by responses from suppliers who said they would stock CFL reflector lamps in these stores without program discounts. The results also show that in these channels, the non-CFL reflector lamps that would have sold without program discounts would have had higher wattages than the average wattage of the lamps that CFL reflector lamps replaced (from 115% NTGRu in SCE drug stores to 142% in SDG&E drug stores). While hardware stores also have high NTGRu in both SCE (147%) and SDG&E (157%), the NTGRq is only 20%, suggesting that 80% of shoppers in hardware stores were not influenced by the program to purchase these lamps. In two of the larger, big-box stores, such as home improvement and mass merchandise, NTGRq ranged from 19% (home improvement) to 35% (mass merchandise), again suggesting many of these shoppers were not influenced by the program to purchase these lamps. Those who were influence in these channels, would have purchased lamps that were just slightly more efficient than the lamps they replaced, which can be seen with the NTGRu values which ranged from 68% (SDG&E in mass merchandise), to 92% (SDG&E home improvement). As we see with other not channel-shifted program CFLs that were shipped to membership club stores, these lamps observed a negative NTGRu, meaning purchases made in the absence of the program would have been more efficient than the program lamp.

Table 63. Overall NTGR, residential MSB CFL reflector ≤ 30 W by IOU and retail channel, 2015 (upstream lighting program)

IOU / Channel	Quantity of Program-Discounted Lamps	NTGRq	Gross UES kWh	Net UES kWh	NTGRu	Overall NTGR
PG&E						
Discount	0					
Drug	0					
Grocery	0					
Hardware	0					
Home improvement	0					N/A
Mass merchandise	0					
Membership club, not channel-shifted	0					
Membership club, channel-shifted	0					
Total	**0**					
SCE						
Discount	692,780	100%		32.5	132%	132%
Drug	11,901	100%		28.2	115%	115%
Grocery	1,379,481	100%		28.5	116%	116%
Hardware	251,783	20%		36.1	147%	29%
Home improvement	48,202	19%	24.6	20.6	84%	16%
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	46,479	74%		(7.4)	-30%	-22%
Membership club, channel-shifted	46,479	66%		20.9	85%	56%
Total	**2,477,105**	**89%**		**29.4**	**120%**	**107%**
SDG&E						
Discount	23,915	100%		20.5	142%	142%
Drug	0	N/A		N/A	N/A	N/A
Grocery	19,796	100%		18.1	125%	125%
Hardware	9,644	20%		22.7	157%	31%
Home improvement	15,353	19%	14.4	13.3	92%	17%
Mass merchandise	1,862	35%		9.9	68%	24%
Membership club, not channel-shifted	6,339	74%		(3.7)	-26%	-19%
Membership club, channel-shifted	6,339	66%		13.4	93%	61%
Total	**83,248**	**70%**		**16.8**	**116%**	**81%**

6.3.4 MSB CFL high-wattage > 30 W

Table 64 presents the NTGRs for MSB CFL high-wattage > 30 W lamps for all IOUs. The NTGRq suggests that the program was responsible for selling 78% of program CFL high-wattage > 30 W in grocery stores and 66% in hardware stores. The NTGRu results suggest that in home improvement and hardware stores, the displaced wattage of displaced lamps were generally higher than the gross savings estimate. We also note that consumer survey responses suggested that customers were replacing lamps from medium and high lumen categories. We thus believed it was most appropriate to consider the baseline market UES an average of medium to high brightness category (roughly 50 W to 150 W incandescent equivalent). We recognize that there is a challenge in how and when to define baseline cutoffs for interchangeable products, and while we agree that any cutoff can be debated, our approach was to assign a standard methodology that remained consistent with responses from consumer surveys. Note that the NTGR for high-wattage CFLs for PG&E is significantly lower than SCE and SDG&E. This difference is driven by the channel distribution of these lamps. Freeridership was found to be high at discount stores for high-wattage lamps, and was found to be lower at grocery stores, where SCE and SDG&E focused the majority of those lamps.

Table 64. Overall NTGR, residential MSB CFL high-wattage > 30 W by IOU and retail channel, 2015 (upstream lighting program)

IOU / Channel	Quantity of Program-Discounted Lamps	NTGRq	Gross UES kWh	Net UES kWh	NTGRu	Overall NTGR
PG&E						
Discount	51,425	17%	26.0	22.3	101%	17%
Drug	0	N/A		N/A	N/A	N/A
Grocery	13,392	78%		23.9	108%	84%
Hardware	0	N/A		N/A	N/A	N/A
Home improvement	0	N/A		N/A	N/A	N/A
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	0	N/A		N/A	N/A	N/A
Membership club, channel-shifted	0	N/A		N/A	N/A	N/A
Total	**64,817**	**30%**		**23.2**	**105%**	**31%**
SCE						
Discount	615,820	17%	19.8	27.0	136%	23%
Drug	6,234	0%		N/A	N/A	N/A
Grocery	1,242,351	78%		29.0	146%	114%
Hardware	140,648	66%		31.3	157%	103%
Home improvement	8,528	27%		29.2	147%	40%
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	81,057	0%		N/A	N/A	N/A
Membership club, channel-shifted	81,057	52%		23.2	117%	61%
Total	**2,175,695**	**56%**		**28.8**	**145%**	**81%**
SDG&E						
Discount	124,819	17%	18.4	20.1	153%	26%
Drug	0	N/A		N/A	N/A	N/A
Grocery	46,163	78%		21.5	164%	127%
Hardware	10,058	66%		23.1	175%	115%
Home improvement	986	27%		21.7	165%	44%
Mass merchandise	296	38%		8.8	66%	25%
Membership club, not channel-shifted	0	N/A		N/A	N/A	N/A
Membership club, channel-shifted	0	N/A		N/A	N/A	N/A
Total	**182,322**	**35%**		**21.2**	**161%**	**57%**

6.3.5 MSB LED A-lamp, all wattages

Table 65 presents the NTGR for MSB LED A-lamps, all wattages, for all IOUs. The NTGRq is around 60% for each IOU. All IOUs shipped the majority of these lamps to the membership club channel, which drives the NTGRq. As disussed in Section 6.2.3, the net UES for not-channel shifted lamps in membership club stores is 6.8, 10.0, and 6.1 for PG&E, SCE, and SDG&E respectively, due to a CFL-only baseline. After assigning 50% of these lamps to purchases made in other channels, the net UES is 18.1, 21.9, and 17.5 for PG&E, SCE, and SDG&E respectively. Here, we see the NTGRu just over 50% for each IOU. This finding suggests that the estimated replaced wattages that were estimated in gross savings were too high, given the on-shelf lamps that shoppers would have purchased absent program discounts.

Table 65. Overall NTGR, residential LED A-lamps by IOU and retail channel, 2015 (upstream lighting program)

IOU / Channel	Quantity of Program-Discounted Lamps	NTGRq	Gross UES kWh	Net UES kWh	NTGRu	Overall NTGR
PG&E						
Discount	16,919	100%	27.2	33.0	121%	121%
Drug	0	N/A		N/A	N/A	N/A
Grocery	27,930	89%		15.8	58%	52%
Hardware	53,423	30%		23.5	87%	26%
Home improvement	62,553	41%		17.4	64%	26%
Mass merchandise	6,607	34%		18.1	67%	23%
Membership club, not channel-shifted	557,755	54%		6.8	25%	14%
Membership club, channel-shifted	557,755	66%		18.1	67%	44%
Overall	**1,282,942**	**59%**		**13.9**	**51%**	**30%**
SCE						
Discount	54,207	100%	34.3	37.5	109%	109%
Drug	281	58%		26.1	76%	44%
Grocery	125,844	89%		19.5	57%	51%
Hardware	67,230	30%		27.6	81%	24%
Home improvement	192,613	41%		21.1	62%	25%
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	507,801	54%		10.0	29%	16%
Membership club, channel-shifted	507,801	66%		21.9	64%	42%
Overall	**1,455,777**	**60%**		**18.9**	**55%**	**33%**
SDG&E						
Discount	22,560	100%	27.0	32.5	121%	121%
Drug	0	N/A		N/A	N/A	N/A
Grocery	54,579	89%		15.2	56%	50%
Hardware	38,017	30%		23.0	85%	26%
Home improvement	76,859	41%		16.8	62%	25%
Mass merchandise	180	34%		17.5	65%	22%
Membership club, not channel-shifted	180,850	54%		6.1	23%	12%
Membership club, channel-shifted	180,850	66%		17.5	65%	43%
Overall	**553,895**	**60%**		**14.9**	**55%**	**33%**

6.3.6 MSB LED reflector, all wattages

Table 66 presents the overall NTGR for the MSB LED reflector, all wattages measure group. NTGRq are 100% in discount, drug, and grocery stores, driven mainly by supplier responses that these lamps would have been unavailable in these stores without the program. The NTGRq's for hardware, home improvement, mass merchandise, and not channel-shifted membership club stores, are between 29% and 37%. In other words, roughly 2/3 of shoppers in those channels would have purchased LED reflectors in the absence of the program. The NTGRq for channel-shifted membership club shoppers is 76%, suggesting that these shoppers were fairly heavily dependent on the program.

NTGRu results over 100% suggest that in the absence of the program, shoppers in the discount, drug, grocery, and hardware, and mass merchandise stores would have purchased higher wattage lamps than the average lamp replaced by an LED lamp in California. NTGRu results slightly less than 100% suggest that shoppers in the home improvement, mass merchandise, and channel-shifted membership club would have purchased lamps that were somewhat more efficient than the average lamps replaced by an LED lamp in California. As with earlier findings, the not channel-shifted purchases in membership club could only have been CFL, so the resulting NTGRu is 12%, 13%, and 7% for PG&E, SCE, and SDG&E respectively.

Table 66. Overall NTGR, residential MSB LED reflector lamps by IOU and retail channel, 2015 (upstream lighting program)

IOU / Channel	Quantity of Program-Discounted Lamps	NTGRq	Gross UES kWh	Net UES kWh	NTGRu	Overall NTGR
PG&E						
Discount	5,145	100%	31.2	42.0	134%	134%
Drug	0	N/A		N/A	N/A	N/A
Grocery	16,517	100%		37.8	121%	121%
Hardware	34,643	31%		44.4	142%	44%
Home improvement	15,881	37%		23.9	76%	28%
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	283,064	29%		3.8	12%	4%
Membership club, channel-shifted	283,064	76%		27.5	88%	67%
Total	**638,314**	**53%**		**22.9**	**73%**	**39%**
SCE						
Discount	26,536	100%	33.7	44.3	132%	132%
Drug	234	100%		39.7	118%	118%
Grocery	37,808	100%		40.0	119%	119%
Hardware	67,662	31%		46.9	139%	43%
Home improvement	185,201	37%		25.4	75%	28%
Mass merchandise	0	N/A		N/A	N/A	N/A
Membership club, not channel-shifted	605,711	29%		4.4	13%	4%
Membership club, channel-shifted	605,711	76%		29.2	87%	66%
Total	**1,528,863**	**52%**		**24.8**	**74%**	**38%**
SDG&E						
Discount	20,304	100%	28.0	40.4	144%	144%
Drug	0	N/A		N/A	N/A	N/A
Grocery	41,962	100%		36.2	129%	129%
Hardware	35,791	31%		42.9	153%	48%
Home improvement	64,560	37%		22.1	79%	29%
Mass merchandise	30	33%		30.1	107%	36%
Membership club, not channel-shifted	105,838	29%		1.9	7%	2%
Membership club, channel-shifted	105,838	76%		25.8	92%	70%
Total	**374,323**	**56%**		**26.2**	**94%**	**52%**

6.4 Net savings results

This section describes the results of the net impacts assessment for the California IOUs' 2015 upstream lighting programs. We determined net impacts by applying the NTGR discussed in Sections 6.1-6.3 (which reflect the portion of IOU-discounted lamps that would not have been purchased and the wattage that would have sold instead, if the program had not existed) to estimates of gross savings from Section 5. Table 67 shows the ante and ex post net savings and net realization rates by evaluated upstream lighting measure group across all IOUs for the 2015 period.

Net savings realization rates differ by measure group and IOU for many of the same reasons that gross savings realization rates differ. These include differences in ex ante and ex post methodologies in calculating delta watts, installation rate, and residential/nonresidential split (Sections 4 and 5). Additionally, the IOU-specific blend of channel and measure group NTGR will vary depending on each IOU's respective channel distribution of lamp shipments.

Table 67. Ex ante and ex post net savings and realization rates by evaluated upstream lighting measure group across all IOUs, 2015

All IOUs Evaluated Upstream Lighting Measure Group	Ex Ante			Ex Post			Net Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
MSB CFL basic spiral ≤ 30 W	7,355,550	1,007	(133,851)	5,481,959	877	(85,035)	75%	87%	64%
MSB CFL A-lamp ≤ 30 W	21,967,514	3,046	(293,689)	27,300,704	3,792	(376,498)	124%	124%	128%
MSB CFL reflector ≤ 30 W	61,176,097	8,234	(867,009)	80,636,143	11,038	(1,168,077)	132%	134%	135%
MSB CFL high-wattage (> 30 W)	91,399,614	12,627	(1,248,949)	66,595,202	10,419	(721,240)	73%	83%	58%
LED A-lamp, all wattages	22,778,031	3,117	(373,481)	38,655,412	4,908	(657,839)	170%	157%	176%
LED Reflector, all wattages	45,848,261	6,433	(697,471)	45,316,229	6,304	(677,375)	99%	98%	97%
Overall	**250,525,068**	**34,464**	**(3,614,449)**	**263,985,649**	**37,338**	**(3,686,065)**	**105%**	**108%**	**102%**

6.4.1 PG&E

Table 69 shows PG&E’s ante and ex post net savings and net realization rates by evaluated upstream lighting measure group across all IOUs for the 2015 period. Table 70 shows PG&E’s 2015 ex post net savings and realization rates by measure group and sector (residential and nonresidential).

Table 68. PG&E ex ante and ex post net savings and realization rates by evaluated upstream lighting group, 2015

PG&E Evaluated Upstream Lighting Measure Group	Ex Ante			Ex Post			Net Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
MSB CFL basic spiral ≤ 30 W	7,049,716	966	(129,776)	5,332,400	851	(83,727)	76%	88%	65%
MSB CFL A-lamp ≤ 30 W	260,389	36	(4,793)	397,377	53	(7,805)	153%	149%	163%
MSB CFL reflector ≤ 30 W	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MSB CFL high-wattage (> 30 W)	1,832,303	251	(33,670)	1,119,586	189	(15,521)	61%	75%	46%
LED A-lamp, all wattages	11,332,268	1,527	(213,702)	13,884,139	1,882	(265,471)	123%	123%	124%
LED Reflector, all wattages	13,427,067	1,807	(253,142)	11,860,120	1,726	(205,830)	88%	96%	81%
Overall	**33,901,743**	**4,586**	**(635,083)**	**32,593,623**	**4,701**	**(578,354)**	**96%**	**103%**	**91%**

Table 69. PG&E ex post net savings by evaluated upstream lighting measure group and sector, 2015

PG&E Evaluated Upstream Lighting Measure Group	Annual Energy Savings (kWh)		Peak Demand Reductions (kW)		Gas Impact (Therms)	
	Residential	Nonresidential	Residential	Nonresidential	Residential	Nonresidential
MSB CFL basic spiral ≤ 30 W	2,923,411	2,408,989	348	502	(68,786)	(14,941)
MSB CFL A-lamp ≤ 30 W	308,252	89,125	35	19	(7,253)	(552)
MSB CFL reflector ≤ 30 W	N/A	N/A	N/A	N/A	N/A	N/A)
MSB CFL high-wattage (> 30 W)	494,548	625,037	58	131	(11,636)	(3,885)
LED A-lamp, all wattages	10,348,702	3,535,437	1,142	740	(243,499)	(21,973)
LED Reflector, all wattages	7,628,991	4,231,129	842	884	(179,506)	(26,324)
Overall	**21,630,913**	**10,889,718**	**2,416**	**2,276**	**(508,963)**	**(67,674)**

6.4.2 SCE

Table 70 shows SCE's ante and ex post net savings and net realization rates by evaluated upstream lighting measure group across all IOUs for the 2015 period. Table 71 shows SCE's 2015 ex post net savings and realization rates by measure group and sector (residential and nonresidential).

Table 70. SCE ex ante and ex post net savings and realization rates by evaluated upstream lighting group, 2015

SCE Evaluated Upstream Lighting Measure Group	Ex Ante			Ex Post			Net Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
MSB CFL basic spiral ≤ 30 W	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MSB CFL A-lamp ≤ 30 W	18,199,714	2,534	(243,025)	22,157,566	3,090	(301,660)	122%	122%	124%
MSB CFL reflector ≤ 30 W	59,233,369	7,987	(839,594)	79,123,393	10,809	(1,150,407)	134%	135%	137%
MSB CFL high-wattage (> 30 W)	83,242,204	11,607	(1,121,664)	61,461,161	9,549	(666,446)	74%	82%	59%
LED A-lamp, all wattages	6,544,979	921	(96,022)	18,143,587	2,179	(297,802)	277%	237%	310%
LED Reflector, all wattages	23,060,744	3,237	(336,333)	26,023,006	3,603	(368,325)	113%	111%	110%
Overall	**190,281,010**	**26,286**	**(2,636,638)**	**207,098,313**	**29,251**	**(2,788,042)**	**109%**	**111%**	**106%**

Table 71. SCE ex post net savings by evaluated upstream lighting measure group and sector, 2015

SCE Evaluated Upstream Lighting Measure Group	Annual Energy Savings (kWh)		Peak Demand Reductions (kW)		Gas Impact (Therms)	
	Residential	Nonresidential	Residential	Nonresidential	Residential	Nonresidential
MSB CFL basic spiral ≤ 30 W	N/A	N/A	N/A	N/A	N/A	N/A
MSB CFL A-lamp ≤ 30 W	15,880,751	6,276,816	1,824	1,266	(284,963)	(16,697)
MSB CFL reflector ≤ 30 W	61,500,563	17,622,829	7,254	3,555	(1,103,562)	(46,846)
MSB CFL high-wattage (> 30 W)	32,800,382	28,660,779	3,759	5,790	(588,568)	(77,879)
LED A-lamp, all wattages	16,222,241	1,921,346	1,744	434	(291,091)	(6,711)
LED Reflector, all wattages	19,239,401	6,783,605	2,069	1,534	(345,230)	(23,094)
Overall	**145,643,338**	**61,265,375**	**16,650**	**12,579**	**(2,613,413)**	**(171,227)**

6.4.3 SDG&E

Table 72 shows SDG&E's ante and ex post net savings and net realization rates by evaluated upstream lighting measure group across all IOUs for the 2015. Table 73 shows SDG&E's 2015 ex post net savings and realization rates by measure group and sector (residential and nonresidential).

Table 72. SDG&E ex ante and ex post net savings and realization rates by evaluated upstream lighting group, 2015

SDG&E Evaluated Upstream Lighting Measure Group	Ex Ante			Ex Post			Net Realization Rates		
	kWh	kW	Therms	kWh	kW	Therms	kWh	kW	Therms
MSB CFL basic spiral ≤ 30 W	305,834	41	(4,075)	149,559	27	(1,308)	49%	65%	32%
MSB CFL A-lamp ≤ 30 W	3,507,412	477	(45,872)	4,745,760	649	(67,033)	135%	136%	146%
MSB CFL reflector ≤ 30 W	1,942,728	247	(27,415)	1,512,750	229	(17,670)	78%	92%	64%
MSB CFL high-wattage (> 30 W)	6,325,106	769	(93,615)	4,014,456	682	(39,273)	63%	89%	42%
LED A-lamp, all wattages	4,900,785	669	(63,756)	6,627,685	848	(94,565)	135%	127%	148%
LED Reflector, all wattages	9,360,451	1,389	(107,996)	7,433,102	975	(103,221)	79%	70%	96%
Overall	**26,342,315**	**3,592**	**(342,728)**	**24,483,313**	**3,408**	**(323,070)**	**93%**	**95%**	**94%**

Table 73. SDG&E ex post net savings by evaluated upstream lighting measure group and sector, 2015

SDG&E Evaluated Upstream Lighting Measure Group	Annual Energy Savings (kWh)		Peak Demand Reductions (kW)		Gas Impact (Therms)	
	Residential	Nonresidential	Residential	Nonresidential	Residential	Nonresidential
MSB CFL basic spiral ≤ 30 W	59,294	90,266	6	20	(1,013)	-295
MSB CFL A-lamp ≤ 30 W	3,728,221	1,017,539	422	227	(63,706)	(3,327)
MSB CFL reflector ≤ 30 W	920,838	591,912	97	132	(15,735)	(1,936)
MSB CFL high-wattage (> 30 W)	1,892,214	2,122,242	209	473	(32,333)	(6,940)
LED A-lamp, all wattages	5,275,440	1,352,245	547	301	(90,143)	(4,422)
LED Reflector, all wattages	5,711,257	1,721,846	592	383	(97,590)	(5,630)
Overall	**17,587,264**	**6,896,050**	**1,872**	**1,536**	**(300,520)**	**(22,550)**

7 QUALITATIVE RESEARCH TOPICS

DNV GL addressed four key qualitative research topics as part of our primary research in support of this study. The topics include:

- Supplier and consumer perspectives regarding the upstream lighting program's influence on the retail channels in which manufacturers sell replacement lamps in California (including the effect of shifting sales among the channels)
- Supplier perspectives regarding the CEC's California Quality LED Lamp Specification
- Consumer perceptions of LED lamp quality
- Consumer behaviors with regard to LED lamp replacement of baseline technologies (specifically, whether they typically replace lamps that are still functioning or if they typically replace lamps that have stopped working ("burned out")

We provide further detail regarding each of these topics below.

7.1 Channel shift

As we reviewed when discussing methods in Section 3.2, we used the 2016 supplier telephone interviews as an opportunity to obtain insights into channel shift—specifically, whether interviewees would expect lamp sales to shift among channels for any lamp types in absence of the upstream lighting program (including the direction and magnitude of these effects).

7.1.1 Results

Of the 27 supplier representatives who participated in our 2016 telephone interviews, 16 sold lamps in evaluated upstream lighting measure groups through the program in 2015. Of these, 15 representatives answered our questions regarding channel shift. With these representatives, we addressed whether their lamp sales would have changed in absence of the 2015 upstream lighting program, and if so, which channels and/or lamp technologies would have been most impacted as well as how and to what extent. We present the results from these inquiries below.

7.1.1.1 Program influence on lamp sales

During the supplier interviews, we asked manufacturer representatives whether their companies' 2015 lamp sales would have changed among retail channels if upstream lighting program incentives were not available in 2015. Among the 15 respondents, all but one agreed that their companies' lamp sales would have changed in some way in the absence of the program. Table 74 presents the number of manufacturers who responded to the channel shift questions in our interviews who sold program-discounted lamps in evaluated upstream lighting measure groups in 2016 by retail channel, as well as the breakdown of whether each respondent suggested the program affected their sales. As shown, the one respondent who suggested that the program had no influence on his company's 2015 lamp sales sold program-discounted lamps in the mass merchandise channel only.

Table 74. Manufacturer representatives' perspectives on whether the absence of 2015 upstream lighting program would have affected their 2015 lamp sales among participating manufacturers (2016 supplier telephone interviews)

Retail Channel	Absence of Program Would Affect Lamp Sales	Absence of Program Would Not Affect Lamp Sales	Number of Manufacturers
Discount	9	0	9
Drug	2	0	2
Grocery	7	0	7
Hardware	5	0	5
Home improvement	9	0	9
Mass merchandise	3	1	4
Membership club	1	0	1

Of the fourteen supplier representatives who suggested that their 2015 lamp sales would have been affected if 2015 upstream lighting program incentives had not been available:

- Four representatives reported that their lamp sales were entirely dependent on the program in 2015—in other words, without upstream lighting program incentives, these manufacturers would not have sold any CFLs or LED lamps in California in 2015. (Per our discussion in Section 6, we consider these lamp sales to be "program-reliant.")
- Three additional representatives reported that their lamp sales would have declined by 90 percent or more in absence of the 2015 program in each of the channels in which they sold replacement lamps.
- Twelve representatives stated that their companies lamp sales would have been lower in every channel in which they sold replacement lamps in absence of the upstream lighting program (including the 7 manufacturers that were entirely or very dependent on the program in 2015).
- Two representatives stated that their company's lamp sales would have been lower in some channels and higher in others in the absence of the upstream lighting program in 2015.

The latter results in particular suggest that at least from the perspectives of two lamp manufacturer's representatives, the program influences the retail channels through which manufacturers sell lamps in California.

7.1.1.2 Channels affected

Lamp manufacturers' representatives suggested the absence of the 2015 upstream lighting program would have affected sales in all channels (including discount, grocery, drug, mass merchandise, home improvement, and membership club). All together, the effects seem greatest in the discount channel. We provide details regarding each of these channels below.

Discount channel

Nine of the 15 representatives who responded to the channel shift questions sold lamps in the discount channel. Of these, all nine representatives said that lamp sales would have been different in 2015 without upstream lighting program incentives, and all said that their sales would have been lower. Of these nine respondents, six said that they would not have sold any lamps in discount stores (neither efficient nor inefficient), two said that their discount store sales would have dropped by 90%, and the last said that his sales in this channel would have dropped by 80%.

Drug channel

Similar to the discount and grocery channel, the absence of upstream lighting program incentives would also have affected lamp sales in the drug channel in 2015. Two of the representatives who responded to the channel shift questions sold lamps through the drug channel. Both manufacturer representatives said that the program's absence would have impacted their company's lamp sales in the drug channel, and both said that their sales would have been lower in this channel. One representative said that his firm would not have sold any lamps in the drug channel, and the other suggested that his firm's sales would have been 12% lower.

Grocery channel

Without upstream lighting program incentives, lamp sales in the grocery channel would also have declined, according to manufacturers' representatives. Seven of the 15 representatives who responded to the channel shift questions sold program-lamps through this channel in 2015, and all seven said that the absence of a 2015 upstream lighting program would have affected their company's lamp sales in grocery stores. All seven also said that their sales would have been lower in this channel without the program. Among the seven representatives who suggested lower sales in absence of the program in grocery stores, five said they would not have sold any lamps through this channel in absence of the program, one mentioned a 95% decline, and the last mentioned a 90% decline.

Hardware channel

According to manufacturer representatives, the absence of the upstream lighting program would also have affected sales in the hardware channel. Five of the representatives who answered our channel shift questions sold lamps through this channel in 2015, and all five representatives said that their company's lamp sales in hardware stores would have changed if upstream lighting program incentives hadn't been available in 2015. All five also said that their lamp sales would have declined in absence of the program. Of the five manufacturer representatives who cited declines in lamp sales, one would not have sold any lamps in the hardware channel, two would have sold 90% fewer lamps, one would have sold 50% fewer lamps, and one would have sold 13% fewer.

Mass merchandise channel

Four of the representatives who answered our channel shift questions sold lamps through the mass merchandise channel in 2015, and three said their company's lamp sales would have changed in this channel in the absence of the program:

- Two of these representatives said that their mass merchandise lamp sales would have declined in absence of the program. Of these, one said that his company would not have sold any lamps in the mass merchandise channel without the program and the other stated that his company's sales would have been lower, but was unable to quantify the percentage decrease in lamp sales.
- One representative reported that her company's lamp sales would have been higher in the mass merchandise channel without the program. This representative estimated a 15% increase in lamp sales and suggested that this would have been at the expense of his company's sales in the grocery and membership club channels. This supplier representative suggested that when program discounts are available in the grocery and membership club channels, some consumers purchase these lamps on

impulse when they would typically purchase them in mass merchandise stores in absence of the discount. Again, these comments suggest that the program may have some influence on the channels through which manufacturers sell replacement lamps in California.

Home improvement channel

Nine of the representatives who answered our channel shift questions sold program-discounted lamps through the home improvement channel in 2015. Nine of these representatives said that their company's lamp sales would have changed in the home improvement channel in the absence of the program. Of these:

- Seven representatives said that their company's lamp sales would have been lower without the program in 2015. Two stated that they would not have sold any lamps in the home improvement channel in absence of the program, two cited a 30% decline, and the other responses were scattered (90%, 68%, and 12%).
- Two representatives said that their company's lamp sales would have increased in the home improvement channel in the absence of upstream lighting program incentives in 2015. They reported that sales would have increased by 30% (1 mention) and 15% (1 mention).
    - The representative who cited a 30% increase in lamp sales in the home improvement channel without the upstream lighting program said that those sales would have been at the expense of lamp sales in the mass merchandise and hardware channels.
    - The representative who cited a 15% increase in lamp sales in the improvement channel without the program said that those sales would have been at the expense of lamp sales in the membership club and grocery channels. The supplier representative who reported that her company's lamp sales would have been higher in the mass merchandise channel without the program cited a shift away from the membership club and grocery channels as well.

Membership club channel

There was only one representative who reported lamp sales in the membership club channel and said that his company's lamp sales would have been impacted without the 2015 program incentives in that channel. This representative estimated that his company's lamp sales would have declined by 10 percent in the channel in absence of the program.

7.1.2 Conclusions

Fourteen of the 15 supplier representatives who responded to our questions regarding channel shift agreed that their companies' lamp sales would have changed in some way in the absence of the program. In other words—not surprisingly—they agreed that the program has some influence on lamp sales in California. Interview results suggest that the program may influence the channels through which manufacturers sell lamps in the state. Supplier representatives mentioned channel shift effects in every retail channel, but the channels most affected by the program are likely the discount, grocery, drug, and membership club channels. Channel shift effects may be most important in the membership club channel given that membership club stores received the largest share of program-discounted lamps of any retail channel in 2015 (39% of lamps in evaluated upstream lighting measure groups per program tracking data). These results suggest that the phenomenon of channel shift may warrant further exploration in future EM&V efforts.

7.2 California Quality LED Lamp Specification

In partnership with the CPUC, the CEC developed the California Quality LED Lamp Specification ("CEC spec") to ensure the availability of high-quality LED lamps in California that would meet customer expectations regarding attributes such as color quality, color consistency, light distribution, dimmability, and so on, to avoid the quality issues that plagued early CFLs. The CEC published Version 1.1 of the specification in December 2012.[57] Via Decision 12-11-015 in November, 2012, the CPUC required the California IOUs to ensure that LED lamps met the standard as a condition for program incentive eligibility effective January 1, 2014, but the CPUC also established a “transition period” of up to one year during which the IOUs could still provide incentives for non-compliant lamps.[58] The CEC published an updated version of the spec in 2014 (Version 2.0) that included several enhancements (such as adding requirements for LED retrofit kits) and was effective on November 21, 2014 (although the spec considers lamps manufactured in accordance with Version 1.1 requirements to still be qualified as meeting the specification after the Version 2.0 changes went into effect).[59]

As we discussed above in Section 2.3 (Evaluation goals), the 2015 impact evaluation research plan[60] identified the CEC spec as a key topic of interest in the evaluation. The IOUs assert that LED lamps that meet the spec are more expensive to produce than LED lamps that do not meet the spec, and thus require higher upstream lighting program incentives to reduce their costs enough to make them attractive to consumers. The IOUs assert that requiring them to adhere to the spec when offering incentives for LED lamps decreases the overall quantity of lamps for which they are able to provide incentives through the program, but because lamps that meet the specification do not use or save more than LED lamps that do not, they receive no corresponding increase in the savings credit for the lamps.

While the impact evaluation cannot account for the market transformational elements of the IOUs' adherence to the specification—that is, for the upstream lighting program's efforts to move the market toward high-quality LED lamps with which consumers will be satisfied—we nonetheless explored suppliers' perspectives on these issues to provide additional information to the CPUC ED and IOUs regarding this important issue.

7.2.1 Results

Below we present the results of our analyses on supplier responses to interview questions regarding the following topics:

- Awareness of the CEC spec
- Whether suppliers sold qualifying lamps in 2015 without IOU program incentives (within California and/or in other states)
- Whether suppliers would have sold any qualifying lamps in 2015 if the upstream lighting program incentives had not been available
- Influences of the CEC spec (including increased or reduced sales and other possible influences)

As we described in 3.2 above, 27 supplier representatives participated in our telephone interviews. One abstained from responding to our questions regarding the CEC spec, so the results below reflect the responses of the remaining 26 supplier representatives.

7.2.1.1 Awareness

The vast majority of supplier representatives reported that they were aware of the CEC spec with no prompting regarding the specification's details (23 out of 26 representatives). Of the 26 supplier representatives, 13 received program incentives for LED lamps in 2015. Eleven of the 14 representatives

57 CEC, 2012.

58 *Ibid*. and CEC, 2014.

59 CEC, 2014.

60 DNV GL, 2016a.

were aware of the CEC spec without any additional prompting. After prompting, the remaining 3 representatives reported that they were aware of the CEC spec (2 received program incentives for LED lamps and 1 did not).

7.2.1.2 Sales of qualifying lamps without IOU program incentives

Interviewers asked supplier representatives whether they sold any LED lamps in 2015 that met the CEC spec but did not receive any incentives through California's upstream lighting program, and 23 supplier representatives responded to the question. Of these, 7 said that their companies sold LED lamps that met the CEC spec but did not receive incentives from the California upstream lighting program (14 said they did not, and two were unsure). Among the 7 who reported selling CEC spec LED lamps without upstream lighting program incentives, 2 received program incentives for LED lamps in 2015 and the other 5 did not. When asked where they sold these CEC spec LED lamps that did not receive program incentives in 2015:

- Four representatives reported that their companies sold these lamps both inside and outside of California (1 received program incentives for LED lamps and 3 did not)
- Two reported that they only sold these lamps outside of California (1 received program incentives for LED lamps and 1 did not)
- One reported that they sold these lamps in California but not in other states (this respondent's company did not receive program incentives for LED lamps)

In California

Among the five suppliers who reported having sold LED lamps that met the spec in California without upstream lighting program incentives in 2015, estimates regarding the quantity of these lamps ranged widely—from only 50 lamps to between 8 and 10 million lamps.[61] Interestingly, four of these five reported that they did not sell *any* LED A-lamps or LED reflector lamps through the upstream lighting program in 2015. Their reasons for not participating in the program but still selling LED lamps that met the CEC spec in California most reflected some level of dissatisfaction with the program or its requirements, including:

- The lengthy testing and approval process for getting LED lamps certified as meeting the CEC spec
- Refusal to participate in the upstream lighting program from a retail chain to which the respondent (a manufacturer's representative) sold LED lamps; the manufacturer representative said that the retail buyer did not want to participate in the California program "to prove a point"
- The low volume of LED lamps sold in California did not justify participation in the program
- The lack of any logo or marketing materials acknowledging the higher quality of LED lamps that meet the CEC spec

One manufacturer's representative said that his company sold LED lamps that met the CEC spec through the upstream program in 2015, but the primary retail chain that the manufacturer sold lamps in decided to sell additional LED lamps that met the spec without incentives. In other words, the retailer made the decision to sell additional LED lamps that met the CEC spec above and beyond the number of lamps being incentivized through the upstream lighting program.

Outside of California

Interviewers asked the six supplier representatives who reported selling LED lamps that met the CEC spec outside of California (and without California IOU incentives) in 2015 to estimate the quantity of lamps they

[61] The five responses included: 1. between 8 and 10 million lamps; 2. 400,000 lamps; 3. 100,000 units (LED retrofit kits only); 4. 120 lamps; and 5. 50 lamps.

sold (2 received incentives for LED lamps in California in 2015 and 4 did not). Again, estimates ranged widely—from approximately 10,000 lamps up to 17 to 18 million lamps.[62] Representatives said that they sold these lamps throughout U.S. Reasons for not participating in the upstream lighting program but selling LED lamps that met the CEC spec outside of California included the following:

- Retail chain requested that the manufacturer sell the lamps in store locations both inside and outside of California (2 mentions by suppliers that received incentives for LED lamps in California)
- Retail chain requested that the manufacturer sell the lamps in store locations only outside of California (1 mention by suppliers that received no incentives for LED retrofit kits in California)
- Manufacturer decided to sell the same LED retrofit kits across all California and non-California locations within the same retail chain (2 mentions by suppliers that did not receive incentives for LED lamps, but did receive incentives for LED retrofit kits)
- Manufacturer made the decision to sell high CRI reflector LED lamps that met the spec across the country in all chains and retail stores that the manufacturer serves (1 mention)

7.2.1.3 Sales of qualifying lamps if upstream lighting program non-existent

Interviewers next asked representatives of suppliers that sold LED A-lamps and LED reflector lamps through the upstream lighting program in 2015 whether they would have sold any lamps that met the spec if upstream lighting program incentives had not been available. Twelve supplier representatives responded to the question, and 8 representatives said that their company would not have sold any LED lamps that met the CEC spec in 2015 if program incentives had not been available. Two reported that they would have sold the lamps if the program discounts had not been available, and two were unsure.

Of the two supplier representatives who said their companies would have sold LED lamps that met the CEC spec in 2015 if upstream lighting program incentives had not been available, interviewers asked whether they would have sold more or fewer of them under these circumstances. Both reported that they would have sold fewer. When interviewers asked these respondents to quantify this difference in sales, one estimated that his company would have sold at least 250,000 fewer lamps (a drop of more than 80%) and the other could not provide a quantity but said that “it would have been a lot less” than what they sold through the upstream lighting program.

When we asked the two supplier representatives whether they thought their companies would have sold some (but fewer) LED lamps that met the CEC spec without upstream lighting program incentives, one cited the higher price point of the CEC spec LED lamps without incentives which would have driven down sales volumes, but not completely eliminated sales of CEC spec LED lamps; the other representative also agreed that sales would have been lower, but mentioned that there would still have been some early adopters who bought the LED lamps that met the spec.

7.2.1.4 Influence of the CEC spec

Below we review the specification’s influence on LED lamp sales in California and other influences of the spec.

Influence on LED lamp sales

The next topic that interviewers discussed with supplier representatives was whether the CEC spec had any influence on their company’s LED lamp sales in California in 2015. Twenty-two representatives responded to the question, and 10 said the CEC spec influenced their LED lamps sales in 2015 while seven said that the

[62] The six responses were: 1. between 17 and 18 million lamps; 2. 600,000 units (LED retrofit kits); 3. 200,000 lamps; 4. 100,000 units (LED retrofit kits); 5. approximately 26,000 units (including lamps and retrofit kits); and 6. 10,000 lamps.

spec had no influence on their company's LED lamps sales (5 were unsure). Among the 10 who said that the spec influenced their sales, seven said that the spec increased their LED lamp sales and 3 said it decreased them. Estimated increases in sales ranged from 5% to 80% (n=7) and decreases, from 20% to 80% (n=2).

Other influences

Interviewers next asked the 26 supplier representatives whether they believed the CEC spec had any other influences on the California lighting market in general in 2015. Twenty-two said they did, while two did not (the other two were unsure). The 22 representatives who responded in the affirmative cited both positive and negative influences; nine representatives cited only positive influences, 9 cited only negative influences and 4 cited both positive and negative influences. Positive perspectives suggested that the CEC spec:

- Improved LED lamp quality (12 mentions)
- Increased consumer awareness and acceptance of LED lamps (2 mentions)
- Steered consumers toward more efficient lamps, such as LED lamps, and away from inefficient lamps (2 mentions)[63]

Among the 13 representatives who cited negative influences, responses suggest that the CEC spec:

- Reduced the number of suppliers that could manufacture or sell LED lamps through the upstream lighting program because of the higher manufacturing costs associated with LED lamps that meet the CEC spec (5 mentions)
- Caused consumers to pay more for higher CRI LED lamps (3 mentions)
- Required suppliers to manufacture or stock LED lamps that met the CEC spec for stores in California and functionally similar LED lamps that did not meet the spec for stores outside of California (3 mentions)
- Enabled non-Energy Star LED lamps to take market share away from Energy Star LED lamps because of the higher costs associated with lamps that met the CEC spec (which not all customers can afford; 2 mentions)
- Did not lead to higher lamp efficiency, and may have hurt lamp efficiency (2 mentions)
    - One of these representatives mentioned that the LED driver chip required to produce an LED lamp that meets the spec's high color rendering requirements requires the lamp to use more energy than would be required to achieve a lower color rendering index
- Created an unnecessarily over-engineered LED lamp (1 mention)

7.2.2 Conclusions

Awareness of the CEC spec was universal among the 26 supplier representatives who responded to our telephone interview questions regarding the spec. Discussions with these representatives suggest that the upstream lighting program's incentives were the primary driver for manufacturers producing lamps that met the CEC specification. Although a few suppliers sold LED lamps that met the specification whether or not they received upstream lighting program incentives and/or both inside and outside of California, eight of twelve representatives reported that they would not have sold LED lamps that met the specification if upstream lighting program incentives had not been available in 2015. Most supplier representatives reported that the CEC spec had an influence on their company's LED lamp sales, and more than two-thirds of these representatives suggested that their LED lamp sales increased because of the spec.

63 It is unclear whether the two representatives who mentioned that the CEC specification steered consumers toward more efficient lamps mistakenly believed that the spec made lamps more efficient, or whether they believed the spec encouraged folks who might not otherwise have purchased LED lamps to do so.

7.3 Consumer satisfaction with LED lamps

The IOUs have pointed out that by supporting lamps that meet the CEC specification, the programs are helping to ensure customers have positive experiences with LEDs. The theory is that the higher quality lamps will result in high consumer satisfaction with LED lamps, ultimately leading to repeat purchases. Conversely, the IOUs assert that LED lamps that do not meet the spec are of questionable quality, which could result in consumer dissatisfaction that could reduce or eliminate their future purchases of LED lamps.

To this end, the 2016 consumer telephone survey briefly addressed satisfaction with LED lamps in general. While the survey is unable to distinguish whether the LED lamps purchased by consumers do or do not meet the CEC spec, DNV GL suggested (in our research plan for this study[64]) that consistent and widespread satisfaction with LED lamps may suggest that the specification does little to affect consumer satisfaction. Conversely, if survey results suggest that consumer satisfaction with LED lamps is inconsistent, this may indicate that there are differences in satisfaction with LED lamps that could be attributable (at least in part) to the CEC spec. Such a result could demonstrate the need for more focused consumer research on this topic. We present the results from these survey questions below as well as the related conclusions.

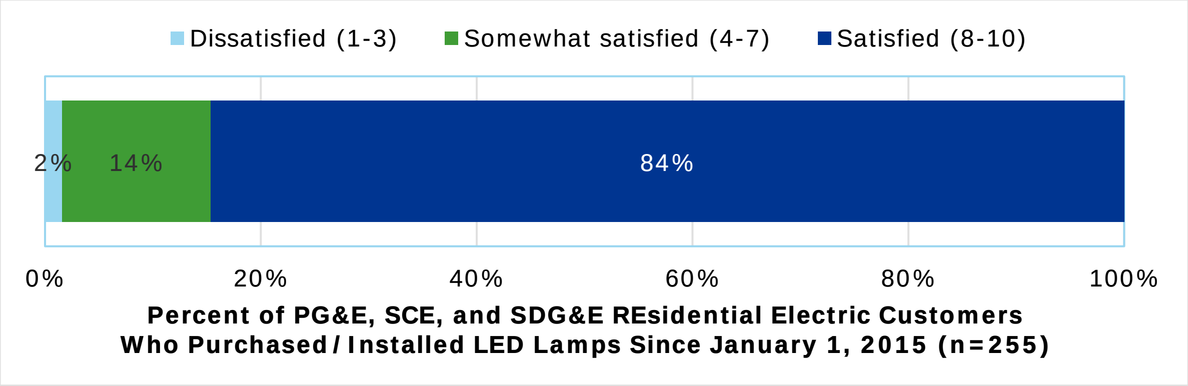
7.3.1 Results

The 2016 consumer telephone survey first identified respondents who purchased and installed LED Lamps between January 1, 2015 and when we fielded the surveys in October, 2016. Interviewers then asked these respondents, “On a scale of 1 to 10 where 1 means very dissatisfied and 10 means very satisfied, how satisfied are you with the LED bulbs you purchased and installed at your home since January 1, 2015?” Figure 4 shows their responses. As shown, approximately 84%of PG&E, SCE, and SDG&E residential electric customers who purchased and installed LED lamps in this timeframe provided ratings of 8, 9, or 10, suggesting that the majority of consumers are satisfied with the LED lamps they purchased and installed, and another 14% are at least somewhat satisfied (ratings of 4, 5, 6, or 7).

The average rating across respondents was 8.9, and 97% provided ratings of 6 through 10. The remaining respondents—who provided relatively low satisfaction ratings of 1 through 5—made up only 6% of respondent who purchased and installed LED lamps since January 1, 2015 (n=15). The surveys asked these respondents why they were less than satisfied with their LED lamps, but the sample size is too small here to provide meaningful results.

[64] DNV GL, 2016a.

Figure 5. Satisfaction with LED lamps among PG&E, SCE, and SDG&E residential electric customers who purchased and installed them between January 1, 2015 and October 2016 (2016 consumer telephone surveys)



7.3.2 Conclusions

The 2016 consumer telephone survey results suggest that satisfaction with LED lamps is relatively high among PG&E, SCE, and SDG&E residential electric customers who purchased and installed LED lamps between January 2015 and October 2016. Only 6% of respondents provided satisfaction ratings of between 1 and 5 (inclusive) a scale of 1 to 10 where 1 means very dissatisfied and 10 means very satisfied, and only 3% provided ratings of between 1 and three (inclusive). When interpreting these results, it's important to consider that the winter 2015-16 retail lamp stock inventory suggests that LED lamps that meet the specification comprised only 13% of all LED lamps stocked during that period (n=2,049,54). Because these lamps represented such a small share of the overall California market for LED lamps in 2015, it is unlikely that they are the primary driver for the high satisfaction associated with LED lamps among PG&E, SCE, and SDG&E residential electric customers.

One could conduct a more focused survey effort to identify dissatisfied LED lamp purchasers and investigate the reasons for their dissatisfaction, or to more clearly distinguish between purchasers of LED lamps that do and do not meet the CEC spec. However, given that the dissatisfied portion of the customer base is so small, this may not be a high-value research endeavor. Nonetheless, the CPUC will investigate this issue further as part of the forthcoming in-home lighting inventory and metering study: at this time, preliminary study plans suggest that field researchers will obtain lamp model numbers for some portion of LED lamps installed in participants' households, ask participants to rate their satisfaction with these lamps, and then later perform look-ups to determine whether each LED lamp met or did not meet the CEC spec. This investigation will yield more reliable information regarding the specification's influence on consumer satisfaction with LED lamps.

7.4 LED lamp installation behaviors (early retirement of installed lamps versus replacement-on-burnout)

The 2016 EM&V plan notes the 2015 uncertain measure list's requirement to "update baseline assumptions … including replaced lamp for early retirement versus standard practice for normal replacement and replace-on-burnout" for PG&E, SCE, and SDG&E.[65] We address broader issues regarding the baseline in

[65] CPUC ED, 2016. Table 44 (2015 Uncertain Measures to be Prioritized). Pages 181—182.

Section 5.4 above (as part of our discussion on delta watts), but we also attempted to understand the share of installed LED lamps that replace functioning lamps (early retirement) versus lamps that have stopped working (replace-on-burnout) as part of our 2016 consumer telephone survey efforts.

7.4.1 Results

As described previously in this report, the evaluation team's interpretation of the phrase "replaced lamp for early retirement versus standard practice for normal replacement and replace-on-burnout" is that the uncertainty lies in the extent to which "normal replacement" activities (or "standard practice") involve "early retirement" or "replace-on-burnout." We thus asked a series of questions to address the total quantity of LED lamps purchased and installed since January 1, 2015, and of these:

- How many replaced lamps that had burned out or stopped working
- How many replaced lamps that were still working

The 2016 consumer telephone surveys identified 269 PG&E, SCE, and SDG&E residential electric customers who collectively purchased and installed approximately 3,352 LED lamps between January 1, 2015 and when we fielded the surveys during October 2016. Of these 3,352 lamps, survey respondents reported that approximately 26% replaced lamps that had burned out or stopped working and 56% replaced lamps that were still working; respondents were unsure about the remaining lamps. If we eliminate the LED lamps for which the functional status of replaced lamps was unclear, approximately 32% of LED lamps that customers purchased installed between January 2015 and October 2016, approximately 68% of LED lamps replaced lamps that were still functioning and 32% replaced lamps that had burned out.

7.4.2 Conclusions

These relatively straightforward analyses suggest that of PG&E, SCE, and SDG&E residential electric customers who purchased and installed LED lamps between January 2015 and October 2016 and were able to recall whether they replaced working or burned-out lamps, roughly twice as many LED lamps replaced functioning lamps as replaced lamps that no longer worked at the time of removal (26% versus 56%, respectively). As stated above, eliminating the LED lamps for which the functional status of replaced lamps was unclear yields that 68% of LED lamps replaced lamps that were still functioning and 32% replaced lamps that had burned out. These results suggest that LED lamp installations among PG&E, SCE, and SDG&E residential electric customers in 2015 and 2016 were skewed toward early retirement of existing installed technologies—however, DNV GL cautions that these results may not be generalizable to future periods, as LED lamp adoption continues to increase over time and the installation patterns for LED lamps continues to evolve.

8 CONCLUSIONS AND RECOMMENDATIONS

Based on the research we conducted in support of this evaluation, we developed conclusions and recommendations. These pertain to program tracking data, the program implementation strategy, and directions for future research.

We provide further detail below.

8.1.1 Tracking data

DNV GL relied upon program tracking data to support the evaluation in numerous ways, including as the basis for measure quantities in our ex post savings analyses. Our review and analyses of the tracking data yielded the following conclusions:

- In a few cases, there were inconsistencies between the program year reported in the tracking data and the shipment year included in lamp suppliers' records. (Note that supplier records did not attribute these issues to specific IOUs.)
- SDG&E and PG&E assigned incorrect measure groups to approximately 250,000 lamps based on the lamp wattage recorded in the program tracking. In some cases, the tracking data included contradictory wattages in the measure name and measure group (e.g., a measure name including "9 watts" in the "high-wattage CFL [> 30 Watts]" measure group).

Based on these conclusions, we recommend:

- **Recommendation 1.** Tracking data should consistently present measures that were truly discounted and shipped within the program year. We also recommend that Commission staff consider a careful review of claim year as a future research priority.
- **Recommendation 2.** Program administrators should consider performing additional review and accuracy checks on the measure group classifications and wattage estimates for program-discounted lamps.

8.1.2 Implementation strategy

Our analyses yielded three conclusions regarding related to three elements of the IOUs' upstream lighting program implementation strategy, including the retail channels in which the IOUs offer program-discounted lamps and the lamp types offered (CFLs and LED lamps). With regard to the retail channels, we conclude:

- Without program support, significantly fewer customers would have purchased energy efficient lamps in drug, grocery, and hardware channels. Furthermore, the inefficient lamps that program lamps displaced in these channels were even less efficient than the lamps that IOU customers replaced with efficient lamps on average. In other channels—such as home improvement, mass merchandize, and membership club—many consumers would purchase program-discounted lamp technologies even without the program discounts.

With regard to upstream lighting program strategy regarding CFLs, we conclude:

- The 2015 upstream lighting program appeared to drive very few basic spiral CFLs ≤ 30 W purchases. Freeridership was relatively high and net UES was relatively low.
- The program strategy to discount CFL A-lamps ≤ 30 W in discount, drug, grocery, and small hardware stores yielded favorable savings results. Freeridership was relatively low and net UES was relatively high.
- The program appears to have convinced some customers to purchase high-wattage CFLs (> 30 W) in grocery stores, but the energy savings achieved by high-wattage CFLs was lower than anticipated. Many consumers are using high-wattage CFLs to replace lamps that are less bright and lower wattage than

expected. As such, while freeridership was reasonable, net UES for these measures was lower than anticipated.

With regard to upstream lighting program strategy regarding LED lamps, we conclude:

- The program appears to have moderately motivated customers to purchase LED A-lamps and LED reflector lamps by heavily discounting these products in membership club stores. Our analysis suggests that many of these purchases would have occurred at other retail channels in the absence of the program. LED A-lamps and LED reflector lamps achieved around 60% NTGRq, suggesting 40% of them were purchased by freeriders. However, many of the non-LED lamps that customers would have purchased in the absence of the program would have been more efficient than the ones that IOU customers replaced on average, which produced low NTGRu results. The net UES estimates were highest in the hardware and discount channels and the lowest in the membership club channel.
- Consumer satisfaction with LED lamps in general was high during 2015 and 2016.

Based on the above conclusions regarding upstream lighting program implementation strategy, we recommend:

- **Recommendation 3.** The IOUs should consider shifting more of their upstream lighting program incentives toward the non- big box channels (discount, drug, grocery, and small hardware) to minimize freeridership and maximize net UES. However, we acknowledge that these channels are not capable of moving a large volume of program-discounted lamps as quickly as the big box channels, so some effort may be required to strike the appropriate balance between program effectiveness and volume.
- **Recommendation 4.** The IOUs should continue shifting upstream lighting program incentives away from basic spiral CFLs ≤ 30 W.
- **Recommendation 5.** With regard to high-wattage CFLs (> 30 W) in particular, moderate freeridership suggests the IOUs could continue to influence customer purchases by providing incentives for these measures in grocery, discount and drug stores—however:

    c. Given the potentially limited applicability of these measures in PG&E, SCE, and SDG&E residential electric customer households, the IOUs should also consider the overall installation potential for these measures when establishing program quantities.

    d. Consumer survey results suggest that consumers are, in many cases, using high-wattage CFLs to replace lamps of lower brightness. It is possible that consumers would choose lower-wattage replacement lamps in the absence of program incentives for high-wattage CFLs. The implication here is that the for some applications, the program may be shifting consumers toward higher-wattage replacement lamps than they would choose absent the program. This point may warrant further consideration from the IOUs, particularly in light of the previous point.

- **Recommendation 6.** Despite low overall NTGRs, LED A-lamp and LED reflector lamp NTGRq results are moderate, and realization rates are high, suggesting IOUs should continue shifting upstream lighting program incentives to LED A-lamps and LED reflector lamps. The IOU's should begin to discount more mid-to-high brightness LED lamps, and future studies should explore the degree to which customers are replacing mid-to-high watt CFLs and incandescent lamps with low-watt LED lamps.

8.1.3 Future research

The research we conducted in support of this study suggested two topics that may be worthy of consideration for future research.

8.1.3.1 Channel shift

Channel shift is a form of program influence that "shifts" sales out of some retail channels and into others as a result of where program incentives are available. We investigated this phenomenon during our supplier interviews. Supplier representatives mentioned channel shift effects in every retail channel, but the channels most affected by the program are likely the discount, grocery, drug, and membership club channels. Channel shift effects may be most important in the membership club channel given that these stores sold the largest share of program-discounted lamps of any retail channel in 2015 (39% of lamps in evaluated upstream lighting measure groups). Based on these findings, we conclude:

- The upstream lighting program influences the retail channels through which manufacturers sell replacement lamps to PG&E, SCE, and SDG&E residential electric customers in California.

Based on this conclusion, we recommend:

- **Recommendation 7.** Future EM&V efforts should further explore channel shift effects—including the quantity of lamps shifted, the channels to and from which the shifts occur, and the measure groups most affected.

8.1.3.2 California Quality LED Lamp Specification

Starting in January 2014, the CPUC ED required that the IOUs demonstrate that the LED lamps for which they offer program incentives meet the performance requirements outlined in the California Quality LED Lamp Specification.[66] The specification's intent was to ensure that LED lamps would meet or exceed customer expectations regarding lamp performance and light quality.

The spec has no effect on energy savings, so this is ultimately not an impact evaluation issue. However, the IOUs have suggested that the superior quality of lamps will help support a shift toward increased LED lamp sales in California. They suggest that the higher quality will result in higher consumer satisfaction with LED lamps and repeat purchases. As such, we briefly addressed satisfaction with LED lamps during our 2016 consumer telephone survey. We also addressed the influence of the specification on LED lamp sales during our 2016 supplier interviews. Based on the results of these efforts, we conclude:

- Among the IOUs' residential electric customers who purchased LED lamps during 2015 and 2016, satisfaction was high However, because LED lamps that meet the California Quality spec comprised such a small share of LED lamp stock among California retailers—approximately 13% as of winter 2015-16—it is unlikely that the spec is the primary driver of customer satisfaction. It is worth noting that 55% of led lamps stocked on shelves did qualify for Energy Star, which may also have had an impact on consumer satisfaction.
- Manufacturers' representatives suggest that the upstream lighting program was the primary reason they produced LED lamps that met the spec in 2015.

Based on these findings, DNV GL recommends:

- **Recommendation 8.** Commission staff should consider pursuing a more definitive assessment of consumer satisfaction with LED lamps that do and do not meet the California Quality spec. The best opportunity for this assessment may be during the upcoming in-home lighting inventory and metering study. Note that at this time, Commission staff plan to launch this study in 2018, and preliminary study objectives include this topic.

[66] CEC, 2012 and CEC, 2014.

8.1.3.3 Impact Evaluation and Program Potential Research

This evaluation's research plan included an investigation to better understand the extent to which LED lamps replaced lamps before they reached their effective useful life.

- Consumer survey results suggest that 68% of LED lamps purchased by customers replaced functioning lamps. The extent to which LED lamps are replacing CFLs, other LEDs, incandescent, or halogen lamps remains unknown, but this finding suggests that there is a potential savings impact related to early replacement.
- While the above recommendations reflect a business-as-usual environment, market conditions are expected to change in 2018 due to California's Title 20 legislation. These changes are likely to dramatically limit or eliminate the potential for residential and upstream lighting program savings.
- The modelling in this report uses respondent demographics by applying coefficients, which are shown in Table 89, in Appendix G. These results serve the primary goals of this impact evaluation well, as they produce accurate savings estimates at the channel-level. However, the underlying data have the potential to offer additional insights into the customer side of the lighting market. Additionally, the consumer survey and supplier interview results that were collected in pursuit of estimating program impacts also have potential to offer additional demand and supply-side insights into the lighting market. While we do not have the space available in this report to delve into such details, we would recommend leveraging these results in a future market report.

Based on these findings, DNV GL recommends:

- **Recommendation 9.** Future evaluations should further investigate which lamps are being replaced early. With this more complete picture, future evaluations should estimate savings impacts associated with early replacements.
- **Recommendation 10.** A potential study should be considered to estimate the remaining available energy savings potential that incorporates the impacts of Title 20 changes in 2018. This study could leverage data collected from the upcoming in-home metering study, and attempt to establish the extent to which upstream lighting programs and the CEC spec are transforming the market.
- **Recommendation 11.** The data collected to answer the research questions for this evaluation have the potential to offer additional insights into the customer and supplier sides of the lighting market. Such a study could look at customer segmentation among various retail channels, perceptions of lighting technologies, and could explore price sensitivities.

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APPENDIX AA. STANDARDIZED HIGH LEVEL SAVINGS, STANDARDIZED PER UNIT SAVINGS, AND RECOMMENDATIONS

The tables in Appendix AA summarizing natural gas savings make use of the unit MTherms – 1,000 Therms – rather than MMTherms – 1,000,000 Therms – for formatting purposes.

Gross Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	NonRes Upst LTG IND CFL > 30 W	3,373	3,935	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL A LAMP	481	561	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL BASIC	13,001	15,168	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED LAMP	29,005	33,839	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED REF	35,232	41,456	1.18	0.0%	1.18
PGE	Res Upst LTG IND CFL > 30 W	22,089	14,644	0.66	0.0%	0.66
PGE	Res Upst LTG IND CFL A LAMP	3,135	2,580	0.82	0.0%	0.82
PGE	Res Upst LTG IND CFL BASIC	84,927	58,880	0.69	0.0%	0.69
PGE	Res Upst LTG IND LED LAMP	189,758	548,782	2.89	0.0%	2.89
PGE	Res Upst LTG IND LED REF	232,691	316,980	1.36	0.0%	1.36
PGE	**Total**	**613,692**	**1,036,825**	**1.69**	**0.0%**	**1.69**
SCE	NonRes Upst LTG IND CFL > 30 W	163,984	164,497	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL A LAMP	35,583	35,704	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL REF	100,210	101,044	1.01	0.0%	1.01
SCE	NonRes Upst LTG IND LED LAMP	19,384	19,849	1.02	0.0%	1.02
SCE	NonRes Upst LTG IND LED REF	67,809	69,605	1.03	0.0%	1.03
SCE	PassThrough Upstream	33,543	33,543	1.00	100.0%	
SCE	Res Upst LTG IND CFL > 30 W	941,649	394,558	0.42	0.0%	0.42
SCE	Res Upst LTG IND CFL A LAMP	203,605	221,910	1.09	0.0%	1.09
SCE	Res Upst LTG IND CFL REF	718,398	559,722	0.78	0.0%	0.78
SCE	Res Upst LTG IND LED LAMP	127,762	783,915	6.14	0.0%	6.14
SCE	Res Upst LTG IND LED REF	445,917	808,465	1.81	0.0%	1.81
SCE	**Total**	**2,857,843**	**3,192,813**	**1.12**	**1.2%**	**1.12**
SDGE	NonRes Upst LTG IND CFL > 30 W	0	12,969			
SDGE	NonRes Upst LTG IND CFL A LAMP	0	6,218			
SDGE	NonRes Upst LTG IND CFL BASIC	0	552			
SDGE	NonRes Upst LTG IND CFL REF	0	3,617			
SDGE	NonRes Upst LTG IND LED LAMP	0	16,120			
SDGE	NonRes Upst LTG IND LED REF	0	19,913			
SDGE	PassThrough Upstream	28,702	28,702	1.00	100.0%	
SDGE	Res Upst LTG IND CFL > 30 W	101,410	30,940	0.31	0.0%	0.31
SDGE	Res Upst LTG IND CFL A LAMP	51,135	34,266	0.67	0.0%	0.67
SDGE	Res Upst LTG IND CFL BASIC	4,518	2,665	0.59	0.0%	0.59
SDGE	Res Upst LTG IND CFL REF	30,009	10,645	0.35	0.0%	0.35
SDGE	Res Upst LTG IND LED LAMP	114,620	246,005	2.15	0.0%	2.15
SDGE	Res Upst LTG IND LED REF	198,401	163,508	0.82	0.0%	0.82
SDGE	**Total**	**528,795**	**576,120**	**1.09**	**5.4%**	**1.09**
	Statewide	*4,000,330*	*4,805,758*	*1.20*	*1.6%*	*1.20*

Net Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	NonRes Upst LTG IND CFL > 30 W	1,822	2,125	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL A LAMP	260	303	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL BASIC	7,020	8,191	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND LED LAMP	20,304	23,687	1.17	0.0%	0.70	0.70	0.70	0.70
PGE	NonRes Upst LTG IND LED REF	24,119	28,351	1.18	0.0%	0.68	0.68	0.68	0.68
PGE	Res Upst LTG IND CFL > 30 W	11,928	4,550	0.38	0.0%	0.54	0.31	0.54	0.31
PGE	Res Upst LTG IND CFL A LAMP	1,693	2,836	1.68	0.0%	0.54	1.10	0.54	1.10
PGE	Res Upst LTG IND CFL BASIC	45,861	26,895	0.59	0.0%	0.54	0.46	0.54	0.46
PGE	Res Upst LTG IND LED LAMP	132,830	165,579	1.25	0.0%	0.70	0.30	0.70	0.30
PGE	Res Upst LTG IND LED REF	157,239	122,064	0.78	0.0%	0.68	0.39	0.68	0.39
PGE	**Total**	**403,076**	**384,581**	**0.95**	**0.0%**	**0.66**	**0.37**	**0.66**	**0.37**
SCE	NonRes Upst LTG IND CFL > 30 W	92,517	92,807	1.00	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND CFL A LAMP	20,290	20,359	1.00	0.0%	0.57	0.57	0.57	0.57
SCE	NonRes Upst LTG IND CFL REF	56,623	57,097	1.01	0.0%	0.57	0.57	0.57	0.57
SCE	NonRes Upst LTG IND LED LAMP	12,212	12,506	1.02	0.0%	0.63	0.63	0.63	0.63
SCE	NonRes Upst LTG IND LED REF	43,041	44,188	1.03	0.0%	0.63	0.63	0.63	0.63
SCE	PassThrough Upstream	18,318	18,318	1.00	100.0%	0.55	0.55		
SCE	Res Upst LTG IND CFL > 30 W	530,309	318,164	0.60	0.0%	0.56	0.81	0.56	0.81
SCE	Res Upst LTG IND CFL A LAMP	115,859	154,043	1.33	0.0%	0.57	0.69	0.57	0.69
SCE	Res Upst LTG IND CFL REF	405,041	596,555	1.47	0.0%	0.56	1.07	0.56	1.07
SCE	Res Upst LTG IND LED LAMP	74,703	259,556	3.47	0.0%	0.58	0.33	0.58	0.33
SCE	Res Upst LTG IND LED REF	263,248	307,830	1.17	0.0%	0.59	0.38	0.59	0.38
SCE	**Total**	**1,632,162**	**1,881,425**	**1.15**	**1.1%**	**0.57**	**0.59**	**0.57**	**0.59**
SDGE	NonRes Upst LTG IND CFL > 30 W	0	7,003				0.54		0.54
SDGE	NonRes Upst LTG IND CFL A LAMP	0	3,358				0.54		0.54
SDGE	NonRes Upst LTG IND CFL BASIC	0	298				0.54		0.54
SDGE	NonRes Upst LTG IND CFL REF	0	1,953				0.54		0.54
SDGE	NonRes Upst LTG IND LED LAMP	0	9,060				0.56		0.56

Net Lifecycle Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	NonRes Upst LTG IND LED REF	0	11,536				0.58		0.58
SDGE	PassThrough Upstream	21,321	21,321	1.00	100.0%	0.74	0.74		
SDGE	Res Upst LTG IND CFL > 30 W	54,761	17,577	0.32	0.0%	0.54	0.57	0.54	0.57
SDGE	Res Upst LTG IND CFL A LAMP	27,613	34,628	1.25	0.0%	0.54	1.01	0.54	1.01
SDGE	Res Upst LTG IND CFL BASIC	2,440	553	0.23	0.0%	0.54	0.21	0.54	0.21
SDGE	Res Upst LTG IND CFL REF	16,205	8,626	0.53	0.0%	0.54	0.81	0.54	0.81
SDGE	Res Upst LTG IND LED LAMP	65,158	81,415	1.25	0.0%	0.57	0.33	0.57	0.33
SDGE	Res Upst LTG IND LED REF	115,129	85,439	0.74	0.0%	0.58	0.52	0.58	0.52
SDGE	**Total**	**302,626**	**282,769**	**0.93**	**7.0%**	**0.57**	**0.49**	**0.56**	**0.48**
	Statewide	***2,337,864***	***2,548,774***	***1.09***	***1.7%***	***0.58***	***0.53***	***0.58***	***0.53***

Gross Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	NonRes Upst LTG IND CFL > 30 W	0.7	0.8	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL A LAMP	0.1	0.1	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL BASIC	2.7	3.2	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED LAMP	6.1	7.1	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED REF	7.4	8.7	1.18	0.0%	1.18
PGE	Res Upst LTG IND CFL > 30 W	2.4	1.7	0.73	0.0%	0.73
PGE	Res Upst LTG IND CFL A LAMP	0.3	0.3	0.86	0.0%	0.86
PGE	Res Upst LTG IND CFL BASIC	9.1	7.0	0.77	0.0%	0.77
PGE	Res Upst LTG IND LED LAMP	20.4	60.6	2.97	0.0%	2.97
PGE	Res Upst LTG IND LED REF	25.0	35.0	1.40	0.0%	1.40
PGE	**Total**	**74.1**	**124.4**	**1.68**	**0.0%**	**1.68**
SCE	NonRes Upst LTG IND CFL > 30 W	33.1	33.2	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL A LAMP	7.2	7.2	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL REF	20.2	20.4	1.01	0.0%	1.01
SCE	NonRes Upst LTG IND LED LAMP	4.4	4.5	1.02	0.0%	1.02
SCE	NonRes Upst LTG IND LED REF	15.3	15.7	1.03	0.0%	1.03
SCE	PassThrough Upstream	4.1	4.1	1.00	100.0%	
SCE	Res Upst LTG IND CFL > 30 W	100.6	45.2	0.45	0.0%	0.45
SCE	Res Upst LTG IND CFL A LAMP	21.7	25.5	1.17	0.0%	1.17
SCE	Res Upst LTG IND CFL REF	76.8	66.0	0.86	0.0%	0.86
SCE	Res Upst LTG IND LED LAMP	13.6	84.3	6.19	0.0%	6.19
SCE	Res Upst LTG IND LED REF	47.3	86.9	1.84	0.0%	1.84
SCE	**Total**	**344.4**	**393.1**	**1.14**	**1.2%**	**1.14**
SDGE	NonRes Upst LTG IND CFL > 30 W	0.0	2.9			
SDGE	NonRes Upst LTG IND CFL A LAMP	0.0	1.4			
SDGE	NonRes Upst LTG IND CFL BASIC	0.0	0.1			
SDGE	NonRes Upst LTG IND CFL REF	0.0	0.8			
SDGE	NonRes Upst LTG IND LED LAMP	0.0	3.6			
SDGE	NonRes Upst LTG IND LED REF	0.0	4.4			
SDGE	PassThrough Upstream	4.4	4.4	1.00	100.0%	
SDGE	Res Upst LTG IND CFL > 30 W	11.2	3.4	0.31	0.0%	0.31
SDGE	Res Upst LTG IND CFL A LAMP	6.0	3.9	0.65	0.0%	0.65
SDGE	Res Upst LTG IND CFL BASIC	0.5	0.3	0.55	0.0%	0.55
SDGE	Res Upst LTG IND CFL REF	3.4	1.1	0.33	0.0%	0.33
SDGE	Res Upst LTG IND LED LAMP	13.6	25.5	1.88	0.0%	1.88
SDGE	Res Upst LTG IND LED REF	25.0	16.9	0.68	0.0%	0.68
SDGE	**Total**	**64.2**	**68.8**	**1.07**	**6.9%**	**1.08**
	Statewide	***482.7***	***586.3***	***1.21***	***1.8%***	***1.22***

Net Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	NonRes Upst LTG IND CFL > 30 W	0.4	0.4	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL A LAMP	0.1	0.1	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL BASIC	1.5	1.7	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND LED LAMP	4.2	5.0	1.17	0.0%	0.70	0.70	0.70	0.70
PGE	NonRes Upst LTG IND LED REF	5.0	5.9	1.18	0.0%	0.68	0.68	0.68	0.68
PGE	Res Upst LTG IND CFL > 30 W	1.3	0.5	0.42	0.0%	0.54	0.31	0.54	0.31
PGE	Res Upst LTG IND CFL A LAMP	0.2	0.3	1.75	0.0%	0.54	1.10	0.54	1.10
PGE	Res Upst LTG IND CFL BASIC	4.9	3.2	0.65	0.0%	0.54	0.46	0.54	0.46
PGE	Res Upst LTG IND LED LAMP	14.3	18.3	1.28	0.0%	0.70	0.30	0.70	0.30
PGE	Res Upst LTG IND LED REF	16.9	13.5	0.80	0.0%	0.68	0.39	0.68	0.39
PGE	**Total**	**48.7**	**48.9**	**1.00**	**0.0%**	**0.66**	**0.39**	**0.66**	**0.39**
SCE	NonRes Upst LTG IND CFL > 30 W	18.7	18.7	1.00	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND CFL A LAMP	4.1	4.1	1.00	0.0%	0.57	0.57	0.57	0.57
SCE	NonRes Upst LTG IND CFL REF	11.4	11.5	1.01	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND LED LAMP	2.8	2.8	1.02	0.0%	0.63	0.63	0.63	0.63
SCE	NonRes Upst LTG IND LED REF	9.7	10.0	1.03	0.0%	0.63	0.63	0.63	0.63
SCE	PassThrough Upstream	2.2	2.2	1.00	100.0%	0.55	0.55		
SCE	Res Upst LTG IND CFL > 30 W	56.6	36.5	0.64	0.0%	0.56	0.81	0.56	0.81
SCE	Res Upst LTG IND CFL A LAMP	12.3	17.7	1.43	0.0%	0.57	0.69	0.57	0.69
SCE	Res Upst LTG IND CFL REF	43.3	70.4	1.63	0.0%	0.56	1.07	0.56	1.07
SCE	Res Upst LTG IND LED LAMP	7.9	27.9	3.51	0.0%	0.58	0.33	0.58	0.33
SCE	Res Upst LTG IND LED REF	27.9	33.1	1.19	0.0%	0.59	0.38	0.59	0.38
SCE	**Total**	**197.0**	**235.0**	**1.19**	**1.1%**	**0.57**	**0.60**	**0.57**	**0.60**
SDGE	NonRes Upst LTG IND CFL > 30 W	0.0	1.6				0.54		0.54
SDGE	NonRes Upst LTG IND CFL A LAMP	0.0	0.7				0.54		0.54
SDGE	NonRes Upst LTG IND CFL BASIC	0.0	0.1				0.54		0.54
SDGE	NonRes Upst LTG IND CFL REF	0.0	0.4				0.54		0.54
SDGE	NonRes Upst LTG IND LED LAMP	0.0	2.0				0.56		0.56

Net Lifecycle Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	NonRes Upst LTG IND LED REF	0.0	2.6				0.58		0.58
SDGE	PassThrough Upstream	3.1	3.1	1.00	100.0%	0.70	0.70		
SDGE	Res Upst LTG IND CFL > 30 W	6.0	1.9	0.32	0.0%	0.54	0.57	0.54	0.57
SDGE	Res Upst LTG IND CFL A LAMP	3.2	3.9	1.21	0.0%	0.54	1.01	0.54	1.01
SDGE	Res Upst LTG IND CFL BASIC	0.3	0.1	0.21	0.0%	0.54	0.21	0.54	0.21
SDGE	Res Upst LTG IND CFL REF	1.8	0.9	0.50	0.0%	0.54	0.81	0.54	0.81
SDGE	Res Upst LTG IND LED LAMP	7.8	8.4	1.08	0.0%	0.57	0.33	0.57	0.33
SDGE	Res Upst LTG IND LED REF	14.7	8.9	0.60	0.0%	0.59	0.52	0.59	0.52
SDGE	**Total**	**36.9**	**34.6**	**0.94**	**8.3%**	**0.58**	**0.50**	**0.57**	**0.49**
	Statewide	***282.7***	***318.5***	***1.13***	***1.9%***	***0.59***	***0.54***	***0.58***	***0.54***

Gross Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	NonRes Upst LTG IND CFL > 30 W	-21	-24	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL A LAMP	-3	-3	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL BASIC	-81	-94	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED LAMP	-180	-210	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED REF	-219	-258	1.18	0.0%	1.18
PGE	Res Upst LTG IND CFL > 30 W	-517	-345	0.67	0.0%	0.67
PGE	Res Upst LTG IND CFL A LAMP	-74	-61	0.82	0.0%	0.82
PGE	Res Upst LTG IND CFL BASIC	-1,993	-1,385	0.70	0.0%	0.70
PGE	Res Upst LTG IND LED LAMP	-4,454	-12,913	2.90	0.0%	2.90
PGE	Res Upst LTG IND LED REF	-5,463	-7,458	1.37	0.0%	1.37
PGE	**Total**	**-13,005**	**-22,752**	**1.75**	**0.0%**	**1.75**
SCE	NonRes Upst LTG IND CFL > 30 W	-448	-450	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL A LAMP	-95	-96	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL REF	-268	-270	1.01	0.0%	1.01
SCE	NonRes Upst LTG IND LED LAMP	-68	-70	1.02	0.0%	1.02
SCE	NonRes Upst LTG IND LED REF	-232	-238	1.03	0.0%	1.03
SCE	PassThrough Upstream	-568	-568	1.00	100.0%	
SCE	Res Upst LTG IND CFL > 30 W	-18,010	-7,080	0.39	0.0%	0.39
SCE	Res Upst LTG IND CFL A LAMP	-3,866	-3,982	1.03	0.0%	1.03
SCE	Res Upst LTG IND CFL REF	-13,667	-10,044	0.73	0.0%	0.73
SCE	Res Upst LTG IND LED LAMP	-2,452	-14,067	5.74	0.0%	5.74
SCE	Res Upst LTG IND LED REF	-8,521	-14,507	1.70	0.0%	1.70
SCE	**Total**	**-48,196**	**-51,370**	**1.07**	**1.2%**	**1.07**
SDGE	NonRes Upst LTG IND CFL > 30 W	0	-42			
SDGE	NonRes Upst LTG IND CFL A LAMP	0	-20			
SDGE	NonRes Upst LTG IND CFL BASIC	0	-2			
SDGE	NonRes Upst LTG IND CFL REF	0	-12			
SDGE	NonRes Upst LTG IND LED LAMP	0	-53			
SDGE	NonRes Upst LTG IND LED REF	0	-65			
SDGE	PassThrough Upstream	-345	-345	1.00	100.0%	
SDGE	Res Upst LTG IND CFL > 30 W	-1,641	-529	0.32	0.0%	0.32
SDGE	Res Upst LTG IND CFL A LAMP	-787	-586	0.74	0.0%	0.74
SDGE	Res Upst LTG IND CFL BASIC	-70	-46	0.65	0.0%	0.65
SDGE	Res Upst LTG IND CFL REF	-477	-182	0.38	0.0%	0.38
SDGE	Res Upst LTG IND LED LAMP	-1,741	-4,204	2.41	0.0%	2.41
SDGE	Res Upst LTG IND LED REF	-2,828	-2,794	0.99	0.0%	0.99
SDGE	**Total**	**-7,888**	**-8,878**	**1.13**	**4.4%**	**1.13**
	Statewide	***-69,089***	***-83,000***	***1.20***	***1.3%***	***1.20***

Net Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	NonRes Upst LTG IND CFL > 30 W	-11	-13	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL A LAMP	-2	-2	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL BASIC	-44	-51	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND LED LAMP	-126	-147	1.17	0.0%	0.70	0.70	0.70	0.70
PGE	NonRes Upst LTG IND LED REF	-150	-176	1.18	0.0%	0.68	0.68	0.68	0.68
PGE	Res Upst LTG IND CFL > 30 W	-279	-107	0.38	0.0%	0.54	0.31	0.54	0.31
PGE	Res Upst LTG IND CFL A LAMP	-40	-67	1.68	0.0%	0.54	1.10	0.54	1.10
PGE	Res Upst LTG IND CFL BASIC	-1,076	-633	0.59	0.0%	0.54	0.46	0.54	0.46
PGE	Res Upst LTG IND LED LAMP	-3,118	-3,896	1.25	0.0%	0.70	0.30	0.70	0.30
PGE	Res Upst LTG IND LED REF	-3,692	-2,872	0.78	0.0%	0.68	0.39	0.68	0.39
PGE	**Total**	**-8,538**	**-7,964**	**0.93**	**0.0%**	**0.66**	**0.35**	**0.66**	**0.35**
SCE	NonRes Upst LTG IND CFL > 30 W	-251	-252	1.00	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND CFL A LAMP	-54	-54	1.00	0.0%	0.57	0.57	0.57	0.57
SCE	NonRes Upst LTG IND CFL REF	-150	-152	1.01	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND LED LAMP	-43	-44	1.02	0.0%	0.63	0.63	0.63	0.63
SCE	NonRes Upst LTG IND LED REF	-146	-150	1.03	0.0%	0.63	0.63	0.63	0.63
SCE	PassThrough Upstream	-310	-310	1.00	100.0%	0.55	0.55		
SCE	Res Upst LTG IND CFL > 30 W	-10,127	-5,709	0.56	0.0%	0.56	0.81	0.56	0.81
SCE	Res Upst LTG IND CFL A LAMP	-2,196	-2,764	1.26	0.0%	0.57	0.69	0.57	0.69
SCE	Res Upst LTG IND CFL REF	-7,693	-10,705	1.39	0.0%	0.56	1.07	0.56	1.07
SCE	Res Upst LTG IND LED LAMP	-1,432	-4,657	3.25	0.0%	0.58	0.33	0.58	0.33
SCE	Res Upst LTG IND LED REF	-5,021	-5,524	1.10	0.0%	0.59	0.38	0.59	0.38
SCE	**Total**	**-27,424**	**-30,320**	**1.11**	**1.1%**	**0.57**	**0.59**	**0.57**	**0.59**
SDGE	NonRes Upst LTG IND CFL > 30 W	0	-23				0.54		0.54
SDGE	NonRes Upst LTG IND CFL A LAMP	0	-11				0.54		0.54
SDGE	NonRes Upst LTG IND CFL BASIC	0	-1				0.54		0.54
SDGE	NonRes Upst LTG IND CFL REF	0	-6				0.54		0.54
SDGE	NonRes Upst LTG IND LED LAMP	0	-30				0.56		0.56

Net Lifecycle Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	NonRes Upst LTG IND LED REF	0	-38				0.58		0.58
SDGE	PassThrough Upstream	-277	-277	1.00	100.0%	0.80	0.80		
SDGE	Res Upst LTG IND CFL > 30 W	-886	-300	0.34	0.0%	0.54	0.57	0.54	0.57
SDGE	Res Upst LTG IND CFL A LAMP	-425	-592	1.39	0.0%	0.54	1.01	0.54	1.01
SDGE	Res Upst LTG IND CFL BASIC	-38	-9	0.25	0.0%	0.54	0.21	0.54	0.21
SDGE	Res Upst LTG IND CFL REF	-257	-147	0.57	0.0%	0.54	0.81	0.54	0.81
SDGE	Res Upst LTG IND LED LAMP	-981	-1,391	1.42	0.0%	0.56	0.33	0.56	0.33
SDGE	Res Upst LTG IND LED REF	-1,625	-1,460	0.90	0.0%	0.57	0.52	0.57	0.52
SDGE	**Total**	**-4,489**	**-4,286**	**0.95**	**6.2%**	**0.57**	**0.48**	**0.56**	**0.47**
	Statewide	***-40,450***	***-42,570***	***1.05***	***1.5%***	***0.59***	***0.51***	***0.58***	***0.51***

Gross First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	NonRes Upst LTG IND CFL > 30 W	992	1,157	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL A LAMP	141	165	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL BASIC	3,824	4,461	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED LAMP	4,329	5,051	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED REF	5,258	6,187	1.18	0.0%	1.18
PGE	Res Upst LTG IND CFL > 30 W	2,401	1,592	0.66	0.0%	0.66
PGE	Res Upst LTG IND CFL A LAMP	341	280	0.82	0.0%	0.82
PGE	Res Upst LTG IND CFL BASIC	9,231	6,400	0.69	0.0%	0.69
PGE	Res Upst LTG IND LED LAMP	11,860	34,299	2.89	0.0%	2.89
PGE	Res Upst LTG IND LED REF	14,543	19,811	1.36	0.0%	1.36
PGE	**Total**	**52,921**	**79,404**	**1.50**	**0.0%**	**1.50**
SCE	NonRes Upst LTG IND CFL > 30 W	50,677	50,835	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL A LAMP	10,980	11,017	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL REF	30,952	31,210	1.01	0.0%	1.01
SCE	NonRes Upst LTG IND LED LAMP	2,979	3,051	1.02	0.0%	1.02
SCE	NonRes Upst LTG IND LED REF	10,416	10,691	1.03	0.0%	1.03
SCE	PassThrough Upstream	4,477	4,477	1.00	100.0%	
SCE	Res Upst LTG IND CFL > 30 W	97,077	40,676	0.42	0.0%	0.42
SCE	Res Upst LTG IND CFL A LAMP	20,990	22,877	1.09	0.0%	1.09
SCE	Res Upst LTG IND CFL REF	74,062	57,703	0.78	0.0%	0.78
SCE	Res Upst LTG IND LED LAMP	7,985	48,995	6.14	0.0%	6.14
SCE	Res Upst LTG IND LED REF	27,870	50,529	1.81	0.0%	1.81
SCE	**Total**	**338,464**	**332,062**	**0.98**	**1.3%**	**0.98**
SDGE	NonRes Upst LTG IND CFL > 30 W	0	3,930			
SDGE	NonRes Upst LTG IND CFL A LAMP	0	1,884			
SDGE	NonRes Upst LTG IND CFL BASIC	0	167			
SDGE	NonRes Upst LTG IND CFL REF	0	1,096			
SDGE	NonRes Upst LTG IND LED LAMP	0	2,406			
SDGE	NonRes Upst LTG IND LED REF	0	2,972			
SDGE	PassThrough Upstream	2,813	2,813	1.00	100.0%	
SDGE	Res Upst LTG IND CFL > 30 W	11,713	3,331	0.28	0.0%	0.28
SDGE	Res Upst LTG IND CFL A LAMP	6,495	3,689	0.57	0.0%	0.57
SDGE	Res Upst LTG IND CFL BASIC	566	286	0.51	0.0%	0.51
SDGE	Res Upst LTG IND CFL REF	3,598	1,136	0.32	0.0%	0.32
SDGE	Res Upst LTG IND LED LAMP	8,521	15,940	1.87	0.0%	1.87
SDGE	Res Upst LTG IND LED REF	15,952	10,930	0.69	0.0%	0.69
SDGE	**Total**	**49,658**	**50,581**	**1.02**	**5.7%**	**1.02**
	Statewide	***441,043***	***462,046***	***1.05***	***1.7%***	***1.05***

Net First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	NonRes Upst LTG IND CFL > 30 W	536	625	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL A LAMP	76	89	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL BASIC	2,065	2,409	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND LED LAMP	3,030	3,535	1.17	0.0%	0.70	0.70	0.70	0.70
PGE	NonRes Upst LTG IND LED REF	3,600	4,231	1.18	0.0%	0.68	0.68	0.68	0.68
PGE	Res Upst LTG IND CFL > 30 W	1,297	495	0.38	0.0%	0.54	0.31	0.54	0.31
PGE	Res Upst LTG IND CFL A LAMP	184	308	1.68	0.0%	0.54	1.10	0.54	1.10
PGE	Res Upst LTG IND CFL BASIC	4,985	2,923	0.59	0.0%	0.54	0.46	0.54	0.46
PGE	Res Upst LTG IND LED LAMP	8,302	10,349	1.25	0.0%	0.70	0.30	0.70	0.30
PGE	Res Upst LTG IND LED REF	9,827	7,629	0.78	0.0%	0.68	0.39	0.68	0.39
PGE	**Total**	**33,902**	**32,594**	**0.96**	**0.0%**	**0.64**	**0.41**	**0.64**	**0.41**
SCE	NonRes Upst LTG IND CFL > 30 W	28,571	28,661	1.00	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND CFL A LAMP	6,255	6,277	1.00	0.0%	0.57	0.57	0.57	0.57
SCE	NonRes Upst LTG IND CFL REF	17,477	17,623	1.01	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND LED LAMP	1,876	1,921	1.02	0.0%	0.63	0.63	0.63	0.63
SCE	NonRes Upst LTG IND LED REF	6,608	6,784	1.03	0.0%	0.63	0.63	0.63	0.63
SCE	PassThrough Upstream	2,445	2,445	1.00	100.0%	0.55	0.55		
SCE	Res Upst LTG IND CFL > 30 W	54,671	32,800	0.60	0.0%	0.56	0.81	0.56	0.81
SCE	Res Upst LTG IND CFL A LAMP	11,944	15,881	1.33	0.0%	0.57	0.69	0.57	0.69
SCE	Res Upst LTG IND CFL REF	41,757	61,501	1.47	0.0%	0.56	1.07	0.56	1.07
SCE	Res Upst LTG IND LED LAMP	4,669	16,222	3.47	0.0%	0.58	0.33	0.58	0.33
SCE	Res Upst LTG IND LED REF	16,453	19,239	1.17	0.0%	0.59	0.38	0.59	0.38
SCE	**Total**	**192,726**	**209,354**	**1.09**	**1.3%**	**0.57**	**0.63**	**0.57**	**0.63**
SDGE	NonRes Upst LTG IND CFL > 30 W	0	2,122				0.54		0.54
SDGE	NonRes Upst LTG IND CFL A LAMP	0	1,018				0.54		0.54
SDGE	NonRes Upst LTG IND CFL BASIC	0	90				0.54		0.54
SDGE	NonRes Upst LTG IND CFL REF	0	592				0.54		0.54
SDGE	NonRes Upst LTG IND LED LAMP	0	1,352				0.56		0.56

Net First Year Savings (MWh)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	NonRes Upst LTG IND LED REF	0	1,722				0.58		0.58
SDGE	PassThrough Upstream	1,938	1,938	1.00	100.0%	0.69	0.69		
SDGE	Res Upst LTG IND CFL > 30 W	6,325	1,892	0.30	0.0%	0.54	0.57	0.54	0.57
SDGE	Res Upst LTG IND CFL A LAMP	3,507	3,728	1.06	0.0%	0.54	1.01	0.54	1.01
SDGE	Res Upst LTG IND CFL BASIC	306	59	0.19	0.0%	0.54	0.21	0.54	0.21
SDGE	Res Upst LTG IND CFL REF	1,943	921	0.47	0.0%	0.54	0.81	0.54	0.81
SDGE	Res Upst LTG IND LED LAMP	4,901	5,275	1.08	0.0%	0.58	0.33	0.58	0.33
SDGE	Res Upst LTG IND LED REF	9,360	5,711	0.61	0.0%	0.59	0.52	0.59	0.52
SDGE	**Total**	**28,280**	**26,421**	**0.93**	**6.9%**	**0.57**	**0.52**	**0.56**	**0.51**
	Statewide	***254,908***	***268,369***	***1.05***	***1.7%***	***0.58***	***0.58***	***0.58***	***0.58***

Gross First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	NonRes Upst LTG IND CFL > 30 W	0.2	0.2	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL A LAMP	0.0	0.0	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL BASIC	0.8	0.9	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED LAMP	0.9	1.1	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED REF	1.1	1.3	1.18	0.0%	1.18
PGE	Res Upst LTG IND CFL > 30 W	0.3	0.2	0.73	0.0%	0.73
PGE	Res Upst LTG IND CFL A LAMP	0.0	0.0	0.86	0.0%	0.86
PGE	Res Upst LTG IND CFL BASIC	1.0	0.8	0.77	0.0%	0.77
PGE	Res Upst LTG IND LED LAMP	1.3	3.8	2.97	0.0%	2.97
PGE	Res Upst LTG IND LED REF	1.6	2.2	1.40	0.0%	1.40
PGE	**Total**	**7.2**	**10.5**	**1.47**	**0.0%**	**1.47**
SCE	NonRes Upst LTG IND CFL > 30 W	10.2	10.3	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL A LAMP	2.2	2.2	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL REF	6.2	6.3	1.01	0.0%	1.01
SCE	NonRes Upst LTG IND LED LAMP	0.7	0.7	1.02	0.0%	1.02
SCE	NonRes Upst LTG IND LED REF	2.4	2.4	1.03	0.0%	1.03
SCE	PassThrough Upstream	0.6	0.6	1.00	100.0%	
SCE	Res Upst LTG IND CFL > 30 W	10.4	4.7	0.45	0.0%	0.45
SCE	Res Upst LTG IND CFL A LAMP	2.2	2.6	1.17	0.0%	1.17
SCE	Res Upst LTG IND CFL REF	7.9	6.8	0.86	0.0%	0.86
SCE	Res Upst LTG IND LED LAMP	0.9	5.3	6.19	0.0%	6.19
SCE	Res Upst LTG IND LED REF	3.0	5.4	1.84	0.0%	1.84
SCE	**Total**	**46.7**	**47.3**	**1.01**	**1.4%**	**1.01**
SDGE	NonRes Upst LTG IND CFL > 30 W	0.0	0.9			
SDGE	NonRes Upst LTG IND CFL A LAMP	0.0	0.4			
SDGE	NonRes Upst LTG IND CFL BASIC	0.0	0.0			
SDGE	NonRes Upst LTG IND CFL REF	0.0	0.2			
SDGE	NonRes Upst LTG IND LED LAMP	0.0	0.5			
SDGE	NonRes Upst LTG IND LED REF	0.0	0.7			
SDGE	PassThrough Upstream	0.5	0.5	1.00	100.0%	
SDGE	Res Upst LTG IND CFL > 30 W	1.4	0.4	0.26	0.0%	0.26
SDGE	Res Upst LTG IND CFL A LAMP	0.9	0.4	0.47	0.0%	0.47
SDGE	Res Upst LTG IND CFL BASIC	0.1	0.0	0.41	0.0%	0.41
SDGE	Res Upst LTG IND CFL REF	0.5	0.1	0.26	0.0%	0.26
SDGE	Res Upst LTG IND LED LAMP	1.1	1.7	1.44	0.0%	1.44
SDGE	Res Upst LTG IND LED REF	2.3	1.1	0.48	0.0%	0.48
SDGE	**Total**	**6.8**	**7.0**	**1.02**	**7.6%**	**1.03**
	Statewide	***60.7***	***64.9***	***1.07***	***1.9%***	***1.07***

Net First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	NonRes Upst LTG IND CFL > 30 W	0.1	0.1	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL A LAMP	0.0	0.0	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL BASIC	0.4	0.5	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND LED LAMP	0.6	0.7	1.17	0.0%	0.70	0.70	0.70	0.70
PGE	NonRes Upst LTG IND LED REF	0.8	0.9	1.18	0.0%	0.68	0.68	0.68	0.68
PGE	Res Upst LTG IND CFL > 30 W	0.1	0.1	0.42	0.0%	0.54	0.31	0.54	0.31
PGE	Res Upst LTG IND CFL A LAMP	0.0	0.0	1.75	0.0%	0.54	1.10	0.54	1.10
PGE	Res Upst LTG IND CFL BASIC	0.5	0.3	0.65	0.0%	0.54	0.46	0.54	0.46
PGE	Res Upst LTG IND LED LAMP	0.9	1.1	1.28	0.0%	0.70	0.30	0.70	0.30
PGE	Res Upst LTG IND LED REF	1.1	0.8	0.80	0.0%	0.68	0.39	0.68	0.39
PGE	**Total**	**4.6**	**4.7**	**1.03**	**0.0%**	**0.64**	**0.45**	**0.64**	**0.45**
SCE	NonRes Upst LTG IND CFL > 30 W	5.8	5.8	1.00	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND CFL A LAMP	1.3	1.3	1.00	0.0%	0.57	0.57	0.57	0.57
SCE	NonRes Upst LTG IND CFL REF	3.5	3.6	1.01	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND LED LAMP	0.4	0.4	1.02	0.0%	0.63	0.63	0.63	0.63
SCE	NonRes Upst LTG IND LED REF	1.5	1.5	1.03	0.0%	0.63	0.63	0.63	0.63
SCE	PassThrough Upstream	0.3	0.3	1.00	100.0%	0.55	0.55		
SCE	Res Upst LTG IND CFL > 30 W	5.8	3.8	0.64	0.0%	0.56	0.81	0.56	0.81
SCE	Res Upst LTG IND CFL A LAMP	1.3	1.8	1.43	0.0%	0.57	0.69	0.57	0.69
SCE	Res Upst LTG IND CFL REF	4.5	7.3	1.63	0.0%	0.56	1.07	0.56	1.07
SCE	Res Upst LTG IND LED LAMP	0.5	1.7	3.51	0.0%	0.58	0.33	0.58	0.33
SCE	Res Upst LTG IND LED REF	1.7	2.1	1.19	0.0%	0.59	0.38	0.59	0.38
SCE	**Total**	**26.6**	**29.6**	**1.11**	**1.3%**	**0.57**	**0.62**	**0.57**	**0.63**
SDGE	NonRes Upst LTG IND CFL > 30 W	0.0	0.5				0.54		0.54
SDGE	NonRes Upst LTG IND CFL A LAMP	0.0	0.2				0.54		0.54
SDGE	NonRes Upst LTG IND CFL BASIC	0.0	0.0				0.54		0.54
SDGE	NonRes Upst LTG IND CFL REF	0.0	0.1				0.54		0.54
SDGE	NonRes Upst LTG IND LED LAMP	0.0	0.3				0.56		0.56

Net First Year Savings (MW)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	NonRes Upst LTG IND LED REF	0.0	0.4				0.58		0.58
SDGE	PassThrough Upstream	0.3	0.3	1.00	100.0%	0.65	0.65		
SDGE	Res Upst LTG IND CFL > 30 W	0.8	0.2	0.27	0.0%	0.54	0.57	0.54	0.57
SDGE	Res Upst LTG IND CFL A LAMP	0.5	0.4	0.88	0.0%	0.54	1.01	0.54	1.01
SDGE	Res Upst LTG IND CFL BASIC	0.0	0.0	0.16	0.0%	0.54	0.21	0.54	0.21
SDGE	Res Upst LTG IND CFL REF	0.2	0.1	0.39	0.0%	0.54	0.81	0.54	0.81
SDGE	Res Upst LTG IND LED LAMP	0.7	0.5	0.82	0.0%	0.58	0.33	0.58	0.33
SDGE	Res Upst LTG IND LED REF	1.4	0.6	0.43	0.0%	0.59	0.52	0.59	0.52
SDGE	**Total**	**3.9**	**3.7**	**0.95**	**8.6%**	**0.57**	**0.53**	**0.57**	**0.52**
	Statewide	***35.1***	***38.0***	***1.08***	***1.9%***	***0.58***	***0.59***	***0.58***	***0.59***

Gross First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Gross	Ex-Post Gross	GRR	% Ex-Ante Gross Pass Through	Eval GRR
PGE	NonRes Upst LTG IND CFL > 30 W	-6	-7	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL A LAMP	-1	-1	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND CFL BASIC	-24	-28	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED LAMP	-27	-31	1.17	0.0%	1.17
PGE	NonRes Upst LTG IND LED REF	-33	-38	1.18	0.0%	1.18
PGE	Res Upst LTG IND CFL > 30 W	-56	-37	0.67	0.0%	0.67
PGE	Res Upst LTG IND CFL A LAMP	-8	-7	0.82	0.0%	0.82
PGE	Res Upst LTG IND CFL BASIC	-217	-151	0.70	0.0%	0.70
PGE	Res Upst LTG IND LED LAMP	-278	-807	2.90	0.0%	2.90
PGE	Res Upst LTG IND LED REF	-341	-466	1.37	0.0%	1.37
PGE	**Total**	**-991**	**-1,574**	**1.59**	**0.0%**	**1.59**
SCE	NonRes Upst LTG IND CFL > 30 W	-139	-139	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL A LAMP	-29	-30	1.00	0.0%	1.00
SCE	NonRes Upst LTG IND CFL REF	-83	-84	1.01	0.0%	1.01
SCE	NonRes Upst LTG IND LED LAMP	-10	-11	1.02	0.0%	1.02
SCE	NonRes Upst LTG IND LED REF	-36	-37	1.03	0.0%	1.03
SCE	PassThrough Upstream	-62	-62	1.00	100.0%	
SCE	Res Upst LTG IND CFL > 30 W	-1,857	-730	0.39	0.0%	0.39
SCE	Res Upst LTG IND CFL A LAMP	-399	-411	1.03	0.0%	1.03
SCE	Res Upst LTG IND CFL REF	-1,409	-1,035	0.73	0.0%	0.73
SCE	Res Upst LTG IND LED LAMP	-153	-879	5.74	0.0%	5.74
SCE	Res Upst LTG IND LED REF	-533	-907	1.70	0.0%	1.70
SCE	**Total**	**-4,709**	**-4,323**	**0.92**	**1.3%**	**0.92**
SDGE	NonRes Upst LTG IND CFL > 30 W	0	-13			
SDGE	NonRes Upst LTG IND CFL A LAMP	0	-6			
SDGE	NonRes Upst LTG IND CFL BASIC	0	-1			
SDGE	NonRes Upst LTG IND CFL REF	0	-4			
SDGE	NonRes Upst LTG IND LED LAMP	0	-8			
SDGE	NonRes Upst LTG IND LED REF	0	-10			
SDGE	PassThrough Upstream	-26	-26	1.00	100.0%	
SDGE	Res Upst LTG IND CFL > 30 W	-173	-57	0.33	0.0%	0.33
SDGE	Res Upst LTG IND CFL A LAMP	-85	-63	0.74	0.0%	0.74
SDGE	Res Upst LTG IND CFL BASIC	-8	-5	0.65	0.0%	0.65
SDGE	Res Upst LTG IND CFL REF	-51	-19	0.38	0.0%	0.38
SDGE	Res Upst LTG IND LED LAMP	-113	-272	2.41	0.0%	2.41
SDGE	Res Upst LTG IND LED REF	-187	-187	1.00	0.0%	1.00
SDGE	**Total**	**-642**	**-670**	**1.04**	**4.0%**	**1.04**
	Statewide	***-6,342***	***-6,566***	***1.04***	***1.4%***	***1.04***

Net First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
PGE	NonRes Upst LTG IND CFL > 30 W	-3	-4	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL A LAMP	0	-1	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND CFL BASIC	-13	-15	1.17	0.0%	0.54	0.54	0.54	0.54
PGE	NonRes Upst LTG IND LED LAMP	-19	-22	1.17	0.0%	0.70	0.70	0.70	0.70
PGE	NonRes Upst LTG IND LED REF	-22	-26	1.18	0.0%	0.68	0.68	0.68	0.68
PGE	Res Upst LTG IND CFL > 30 W	-30	-12	0.38	0.0%	0.54	0.31	0.54	0.31
PGE	Res Upst LTG IND CFL A LAMP	-4	-7	1.68	0.0%	0.54	1.10	0.54	1.10
PGE	Res Upst LTG IND CFL BASIC	-117	-69	0.59	0.0%	0.54	0.46	0.54	0.46
PGE	Res Upst LTG IND LED LAMP	-195	-243	1.25	0.0%	0.70	0.30	0.70	0.30
PGE	Res Upst LTG IND LED REF	-231	-180	0.78	0.0%	0.68	0.39	0.68	0.39
PGE	**Total**	**-635**	**-578**	**0.91**	**0.0%**	**0.64**	**0.37**	**0.64**	**0.37**
SCE	NonRes Upst LTG IND CFL > 30 W	-78	-78	1.00	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND CFL A LAMP	-17	-17	1.00	0.0%	0.57	0.57	0.57	0.57
SCE	NonRes Upst LTG IND CFL REF	-46	-47	1.01	0.0%	0.56	0.56	0.56	0.56
SCE	NonRes Upst LTG IND LED LAMP	-7	-7	1.02	0.0%	0.63	0.63	0.63	0.63
SCE	NonRes Upst LTG IND LED REF	-23	-23	1.03	0.0%	0.63	0.63	0.63	0.63
SCE	PassThrough Upstream	-34	-34	1.00	100.0%	0.55	0.55		
SCE	Res Upst LTG IND CFL > 30 W	-1,044	-589	0.56	0.0%	0.56	0.81	0.56	0.81
SCE	Res Upst LTG IND CFL A LAMP	-226	-285	1.26	0.0%	0.57	0.69	0.57	0.69
SCE	Res Upst LTG IND CFL REF	-793	-1,104	1.39	0.0%	0.56	1.07	0.56	1.07
SCE	Res Upst LTG IND LED LAMP	-89	-291	3.25	0.0%	0.58	0.33	0.58	0.33
SCE	Res Upst LTG IND LED REF	-314	-345	1.10	0.0%	0.59	0.38	0.59	0.38
SCE	**Total**	**-2,670**	**-2,818**	**1.06**	**1.3%**	**0.57**	**0.65**	**0.57**	**0.65**
SDGE	NonRes Upst LTG IND CFL > 30 W	0	-7				0.54		0.54
SDGE	NonRes Upst LTG IND CFL A LAMP	0	-3				0.54		0.54
SDGE	NonRes Upst LTG IND CFL BASIC	0	0				0.54		0.54
SDGE	NonRes Upst LTG IND CFL REF	0	-2				0.54		0.54
SDGE	NonRes Upst LTG IND LED LAMP	0	-4				0.56		0.56

Net First Year Savings (MTherms)

PA	Standard Report Group	Ex-Ante Net	Ex-Post Net	NRR	% Ex-Ante Net Pass Through	Ex-Ante NTG	Ex-Post NTG	Eval Ex-Ante NTG	Eval Ex-Post NTG
SDGE	NonRes Upst LTG IND LED REF	0	-6				0.58		0.58
SDGE	PassThrough Upstream	-20	-20	1.00	100.0%	0.77	0.77		
SDGE	Res Upst LTG IND CFL > 30 W	-94	-32	0.35	0.0%	0.54	0.57	0.54	0.57
SDGE	Res Upst LTG IND CFL A LAMP	-46	-64	1.39	0.0%	0.54	1.01	0.54	1.01
SDGE	Res Upst LTG IND CFL BASIC	-4	-1	0.25	0.0%	0.54	0.21	0.54	0.21
SDGE	Res Upst LTG IND CFL REF	-27	-16	0.57	0.0%	0.54	0.81	0.54	0.81
SDGE	Res Upst LTG IND LED LAMP	-64	-90	1.41	0.0%	0.57	0.33	0.57	0.33
SDGE	Res Upst LTG IND LED REF	-108	-98	0.90	0.0%	0.58	0.52	0.58	0.52
SDGE	**Total**	**-362**	**-343**	**0.95**	**5.4%**	**0.56**	**0.51**	**0.56**	**0.50**
	Statewide	*-3,668*	*-3,739*	*1.02*	*1.5%*	*0.58*	*0.57*	*0.58*	*0.57*

APPENDIX AB. STANDARDIZED PER UNIT SAVINGS

Per Unit (Quantity) Gross Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	NonRes Upst LTG IND CFL > 30 W	0	0.0%	0.0%	3.4	806.6	237.3	237.3
PGE	NonRes Upst LTG IND CFL A LAMP	0	0.0%	0.0%	3.4	371.0	109.1	109.1
PGE	NonRes Upst LTG IND CFL BASIC	0	0.0%	0.0%	3.4	433.4	127.5	127.5
PGE	NonRes Upst LTG IND LED LAMP	0	0.0%	0.0%	6.7	349.8	52.2	52.2
PGE	NonRes Upst LTG IND LED REF	0	0.0%	0.0%	6.7	852.7	127.3	127.3
PGE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.2	225.9	24.6	24.6
PGE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.2	128.4	14.0	14.0
PGE	Res Upst LTG IND CFL BASIC	0	0.0%	0.0%	9.2	126.6	13.8	13.8
PGE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	16.0	427.0	26.7	26.7
PGE	Res Upst LTG IND LED REF	0	0.0%	0.0%	16.0	490.7	30.7	30.7
SCE	NonRes Upst LTG IND CFL > 30 W	0	0.0%	0.0%	3.2	1,183.9	365.9	365.9
SCE	NonRes Upst LTG IND CFL A LAMP	0	0.0%	0.0%	3.2	528.4	163.0	163.0
SCE	NonRes Upst LTG IND CFL REF	0	0.0%	0.0%	3.2	638.1	197.1	197.1
SCE	NonRes Upst LTG IND LED LAMP	0	0.0%	0.0%	6.5	213.6	32.8	32.8
SCE	NonRes Upst LTG IND LED REF	0	0.0%	0.0%	6.5	713.3	109.6	109.6
SCE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.7	181.3	18.7	18.7
SCE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.7	209.6	21.6	21.6
SCE	Res Upst LTG IND CFL REF	0	0.0%	0.0%	9.7	225.6	23.3	23.3
SCE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	16.0	538.5	33.7	33.7
SCE	Res Upst LTG IND LED REF	0	0.0%	0.0%	16.0	528.8	33.1	33.1
SCE	PassThrough Upstream	1	0.0%		9.3	224.3	29.9	29.9
SDGE	NonRes Upst LTG IND CFL > 30 W	0		0.0%	3.3	1,062.3	321.9	321.9
SDGE	NonRes Upst LTG IND CFL A LAMP	0		0.0%	3.3	390.7	118.4	118.4
SDGE	NonRes Upst LTG IND CFL BASIC	0		0.0%	3.3	442.1	134.0	134.0
SDGE	NonRes Upst LTG IND CFL REF	0		0.0%	3.3	680.7	206.3	206.3
SDGE	NonRes Upst LTG IND LED LAMP	0		0.0%	6.7	419.5	62.6	62.6
SDGE	NonRes Upst LTG IND LED REF	0		0.0%	6.7	783.7	117.0	117.0
SDGE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.3	161.8	17.4	17.4
SDGE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.3	137.4	14.8	14.8

Per Unit (Quantity) Gross Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
SDGE	Res Upst LTG IND CFL BASIC	0	0.0%	0.0%	9.3	136.4	14.6	14.6
SDGE	Res Upst LTG IND CFL REF	0	0.0%	0.0%	9.4	127.9	13.6	13.6
SDGE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	15.4	408.7	26.5	26.5
SDGE	Res Upst LTG IND LED REF	0	0.0%	0.0%	15.0	410.7	27.5	27.5
SDGE	PassThrough Upstream	1	0.0%		13.4	497.0	48.7	48.7

Per Unit (Quantity) Gross Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	NonRes Upst LTG IND CFL > 30 W	0	0.0%	0.0%	3.4	-5.0	-1.5	-1.5
PGE	NonRes Upst LTG IND CFL A LAMP	0	0.0%	0.0%	3.4	-2.3	-0.7	-0.7
PGE	NonRes Upst LTG IND CFL BASIC	0	0.0%	0.0%	3.4	-2.7	-0.8	-0.8
PGE	NonRes Upst LTG IND LED LAMP	0	0.0%	0.0%	6.7	-2.2	-0.3	-0.3
PGE	NonRes Upst LTG IND LED REF	0	0.0%	0.0%	6.7	-5.3	-0.8	-0.8
PGE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.2	-5.3	-0.6	-0.6
PGE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.2	-3.0	-0.3	-0.3
PGE	Res Upst LTG IND CFL BASIC	0	0.0%	0.0%	9.2	-3.0	-0.3	-0.3
PGE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	16.0	-10.0	-0.6	-0.6
PGE	Res Upst LTG IND LED REF	0	0.0%	0.0%	16.0	-11.5	-0.7	-0.7
SCE	NonRes Upst LTG IND CFL > 30 W	0	0.0%	0.0%	3.2	-3.2	-1.0	-1.0
SCE	NonRes Upst LTG IND CFL A LAMP	0	0.0%	0.0%	3.2	-1.4	-0.4	-0.4
SCE	NonRes Upst LTG IND CFL REF	0	0.0%	0.0%	3.2	-1.7	-0.5	-0.5
SCE	NonRes Upst LTG IND LED LAMP	0	0.0%	0.0%	6.5	-0.7	-0.1	-0.1
SCE	NonRes Upst LTG IND LED REF	0	0.0%	0.0%	6.5	-2.4	-0.4	-0.4
SCE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.7	-3.3	-0.3	-0.3
SCE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.7	-3.8	-0.4	-0.4
SCE	Res Upst LTG IND CFL REF	0	0.0%	0.0%	9.7	-4.0	-0.4	-0.4
SCE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	16.0	-9.7	-0.6	-0.6
SCE	Res Upst LTG IND LED REF	0	0.0%	0.0%	16.0	-9.5	-0.6	-0.6
SCE	PassThrough Upstream	1	0.0%		9.3	-3.8	-0.4	-0.4
SDGE	NonRes Upst LTG IND CFL > 30 W	0		0.0%	3.3	-3.5	-1.1	-1.1
SDGE	NonRes Upst LTG IND CFL A LAMP	0		0.0%	3.3	-1.3	-0.4	-0.4
SDGE	NonRes Upst LTG IND CFL BASIC	0		0.0%	3.3	-1.4	-0.4	-0.4
SDGE	NonRes Upst LTG IND CFL REF	0		0.0%	3.3	-2.2	-0.7	-0.7
SDGE	NonRes Upst LTG IND LED LAMP	0		0.0%	6.7	-1.4	-0.2	-0.2
SDGE	NonRes Upst LTG IND LED REF	0		0.0%	6.7	-2.6	-0.4	-0.4
SDGE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.3	-2.8	-0.3	-0.3
SDGE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.3	-2.3	-0.3	-0.3

Per Unit (Quantity) Gross Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
SDGE	Res Upst LTG IND CFL BASIC	0	0.0%	0.0%	9.3	-2.3	-0.3	-0.3
SDGE	Res Upst LTG IND CFL REF	0	0.0%	0.0%	9.4	-2.2	-0.2	-0.2
SDGE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	15.4	-7.0	-0.5	-0.5
SDGE	Res Upst LTG IND LED REF	0	0.0%	0.0%	15.0	-7.0	-0.5	-0.5
SDGE	PassThrough Upstream	1	0.0%		13.4	-6.0	-0.4	-0.4

Per Unit (Quantity) Net Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	NonRes Upst LTG IND CFL > 30 W	0	0.0%	0.0%	3.4	435.6	128.1	128.1
PGE	NonRes Upst LTG IND CFL A LAMP	0	0.0%	0.0%	3.4	200.3	58.9	58.9
PGE	NonRes Upst LTG IND CFL BASIC	0	0.0%	0.0%	3.4	234.1	68.8	68.8
PGE	NonRes Upst LTG IND LED LAMP	0	0.0%	0.0%	6.7	244.9	36.6	36.6
PGE	NonRes Upst LTG IND LED REF	0	0.0%	0.0%	6.7	583.1	87.0	87.0
PGE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.2	70.2	7.6	7.6
PGE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.2	141.1	15.3	15.3
PGE	Res Upst LTG IND CFL BASIC	0	0.0%	0.0%	9.2	57.9	6.3	6.3
PGE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	16.0	128.8	8.1	8.1
PGE	Res Upst LTG IND LED REF	0	0.0%	0.0%	16.0	189.0	11.8	11.8
SCE	NonRes Upst LTG IND CFL > 30 W	0	0.0%	0.0%	3.2	667.9	206.3	206.3
SCE	NonRes Upst LTG IND CFL A LAMP	0	0.0%	0.0%	3.2	301.3	92.9	92.9
SCE	NonRes Upst LTG IND CFL REF	0	0.0%	0.0%	3.2	360.6	111.3	111.3
SCE	NonRes Upst LTG IND LED LAMP	0	0.0%	0.0%	6.5	134.6	20.7	20.7
SCE	NonRes Upst LTG IND LED REF	0	0.0%	0.0%	6.5	452.8	69.5	69.5
SCE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.7	146.2	15.1	15.1
SCE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.7	145.5	15.0	15.0
SCE	Res Upst LTG IND CFL REF	0	0.0%	0.0%	9.7	240.5	24.8	24.8
SCE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	16.0	178.3	11.1	11.1
SCE	Res Upst LTG IND LED REF	0	0.0%	0.0%	16.0	201.3	12.6	12.6
SCE	PassThrough Upstream	1	0.0%		9.3	122.5	16.3	16.3
SDGE	NonRes Upst LTG IND CFL > 30 W	0		0.0%	3.3	573.6	173.8	173.8
SDGE	NonRes Upst LTG IND CFL A LAMP	0		0.0%	3.3	211.0	63.9	63.9
SDGE	NonRes Upst LTG IND CFL BASIC	0		0.0%	3.3	238.7	72.3	72.3
SDGE	NonRes Upst LTG IND CFL REF	0		0.0%	3.3	367.6	111.4	111.4
SDGE	NonRes Upst LTG IND LED LAMP	0		0.0%	6.7	235.8	35.2	35.2
SDGE	NonRes Upst LTG IND LED REF	0		0.0%	6.7	454.0	67.8	67.8
SDGE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.3	91.9	9.9	9.9
SDGE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.3	138.9	15.0	15.0

Per Unit (Quantity) Net Energy Savings (kWh)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
SDGE	Res Upst LTG IND CFL BASIC	0	0.0%	0.0%	9.3	28.3	3.0	3.0
SDGE	Res Upst LTG IND CFL REF	0	0.0%	0.0%	9.4	103.6	11.1	11.1
SDGE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	15.4	135.2	8.8	8.8
SDGE	Res Upst LTG IND LED REF	0	0.0%	0.0%	15.0	214.6	14.3	14.3
SDGE	PassThrough Upstream	1	0.0%		13.4	369.2	33.6	33.6

Per Unit (Quantity) Net Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
PGE	NonRes Upst LTG IND CFL > 30 W	0	0.0%	0.0%	3.4	-2.7	-0.8	-0.8
PGE	NonRes Upst LTG IND CFL A LAMP	0	0.0%	0.0%	3.4	-1.2	-0.4	-0.4
PGE	NonRes Upst LTG IND CFL BASIC	0	0.0%	0.0%	3.4	-1.5	-0.4	-0.4
PGE	NonRes Upst LTG IND LED LAMP	0	0.0%	0.0%	6.7	-1.5	-0.2	-0.2
PGE	NonRes Upst LTG IND LED REF	0	0.0%	0.0%	6.7	-3.6	-0.5	-0.5
PGE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.2	-1.7	-0.2	-0.2
PGE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.2	-3.3	-0.4	-0.4
PGE	Res Upst LTG IND CFL BASIC	0	0.0%	0.0%	9.2	-1.4	-0.1	-0.1
PGE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	16.0	-3.0	-0.2	-0.2
PGE	Res Upst LTG IND LED REF	0	0.0%	0.0%	16.0	-4.4	-0.3	-0.3
SCE	NonRes Upst LTG IND CFL > 30 W	0	0.0%	0.0%	3.2	-1.8	-0.6	-0.6
SCE	NonRes Upst LTG IND CFL A LAMP	0	0.0%	0.0%	3.2	-0.8	-0.2	-0.2
SCE	NonRes Upst LTG IND CFL REF	0	0.0%	0.0%	3.2	-1.0	-0.3	-0.3
SCE	NonRes Upst LTG IND LED LAMP	0	0.0%	0.0%	6.5	-0.5	-0.1	-0.1
SCE	NonRes Upst LTG IND LED REF	0	0.0%	0.0%	6.5	-1.5	-0.2	-0.2
SCE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.7	-2.6	-0.3	-0.3
SCE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.7	-2.6	-0.3	-0.3
SCE	Res Upst LTG IND CFL REF	0	0.0%	0.0%	9.7	-4.3	-0.4	-0.4
SCE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	16.0	-3.2	-0.2	-0.2
SCE	Res Upst LTG IND LED REF	0	0.0%	0.0%	16.0	-3.6	-0.2	-0.2
SCE	PassThrough Upstream	1	0.0%		9.3	-2.1	-0.2	-0.2
SDGE	NonRes Upst LTG IND CFL > 30 W	0		0.0%	3.3	-1.9	-0.6	-0.6
SDGE	NonRes Upst LTG IND CFL A LAMP	0		0.0%	3.3	-0.7	-0.2	-0.2
SDGE	NonRes Upst LTG IND CFL BASIC	0		0.0%	3.3	-0.8	-0.2	-0.2
SDGE	NonRes Upst LTG IND CFL REF	0		0.0%	3.3	-1.2	-0.4	-0.4
SDGE	NonRes Upst LTG IND LED LAMP	0		0.0%	6.7	-0.8	-0.1	-0.1
SDGE	NonRes Upst LTG IND LED REF	0		0.0%	6.7	-1.5	-0.2	-0.2
SDGE	Res Upst LTG IND CFL > 30 W	0	0.0%	0.0%	9.3	-1.6	-0.2	-0.2
SDGE	Res Upst LTG IND CFL A LAMP	0	0.0%	0.0%	9.3	-2.4	-0.3	-0.3

Per Unit (Quantity) Net Energy Savings (Therms)

PA	Standard Report Group	Pass Through	% ER Ex-Ante	% ER Ex-Post	Average EUL (yr)	Ex-Post Lifecycle	Ex-Post First Year	Ex-Post Annualized
SDGE	Res Upst LTG IND CFL BASIC	0	0.0%	0.0%	9.3	-0.5	-0.1	-0.1
SDGE	Res Upst LTG IND CFL REF	0	0.0%	0.0%	9.4	-1.8	-0.2	-0.2
SDGE	Res Upst LTG IND LED LAMP	0	0.0%	0.0%	15.4	-2.3	-0.1	-0.1
SDGE	Res Upst LTG IND LED REF	0	0.0%	0.0%	15.0	-3.7	-0.2	-0.2
SDGE	PassThrough Upstream	1	0.0%		13.4	-4.8	-0.3	-0.3

APPENDIX AC. RECOMMENDATIONS

Study ID	Study Type	Study Title	Study Manager
ED_I_LTG_4	Impact Evaluation	Impact Evaluation of 2015 Upstream and Residential Downstream Lighting Programs	CPUC ED

Rec.#	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
1	Upstream lighting programs	In a few cases, there were inconsistencies between the program year reported in the tracking data and the shipment year included in lamp suppliers' records. (Note that supplier records did not attribute these issues to specific IOUs.)	SDG&E and PG&E assigned incorrect measure groups to approximately 250,000 lamps based on the lamp wattage recorded in the program tracking data (177,676 lamps in SDG&E's tracking data and 69,696 in PG&E's). In some cases, the tracking data assigned wattages that contradicted the measure name and measure group (e.g., assigned wattage of 9 Watts for a lamp in the "high-wattage CFL [> 30 Watts]" measure group).	1. Tracking data should consistently present measures that were truly discounted and shipped within the program year. We also recommend that a careful review that claims occurred within the listed cycle be considered a future research priority.	All IOUs	All upstream measures
2	Upstream lighting programs			2. Program administrators should consider performing additional review and accuracy checks on the measure group classifications and wattage estimates for program-discounted lamps.		
3	Upstream lighting programs	Without program support, significantly fewer customers would have purchased energy efficient lamps in drug, grocery, and hardware channels. Furthermore, the inefficient lamps that program lamps displaced in these channels were even less efficient than the lamps that IOU customers replaced with efficient lamps on average. In other channels—such as home improvement, mass merchandize, and membership club—many consumers would purchase program-discounted lamp technologies even without the program discounts.	hard-to-reach channels generally received high NTGRq and big-box channels generally received lower NTGRq.	The IOUs should consider shifting more of their upstream lighting program incentives toward the non- big box channels (discount, drug, grocery, and small hardware) to minimize freeridership and maximize net UES. However, we acknowledge that these channels are not capable of moving a large volume of program-discounted lamps as quickly as the big box channels, so some effort may be required to strike the appropriate balance between program effectiveness and volume.	All IOUs	All upstream measures
4	Upstream lighting programs	1. The 2015 upstream lighting program appeared to drive very few basic spiral CFLs ≤ 30 W purchases. Free-ridership was relatively high and net UES was relatively low. 2. The program strategy to discount CFL A-lamps ≤ 30 W in discount, drug, grocery, and small hardware stores yielded favorable savings results. Free-ridership	Basic spiral CFLs generally saw low NTGRq and low NTGRu while A-lamp CFLs received relatively high NTGRq and NTGRu.	The IOUs should continue shifting upstream lighting program incentives away from basic spiral CFLs ≤ 30 W.	All IOUs	CFL upstream measures

Rec.#	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
		was relatively low and net UES was relatively high.				
5	Upstream lighting programs	The program appears to have convinced some customers to purchase high-wattage CFLs (> 30 W) in grocery stores, but the energy savings achieved by high-wattage CFLs was lower than anticipated. Many consumers are using high-wattage CFLs to replace lamps that are less bright and lower wattage than expected. As such, while free-ridership was reasonable, net UES for these measures was lower than anticipated.	High-wattage CFLs received low-to-moderate NTGRq, modest NTGRu, however, gross UES estimates suggested low realization rates, so these measures ultimately saved less energy than expected.	With regard to high-wattage CFLs (> 30 W) in particular, moderate free-ridership suggests the IOUs could continue to influence customer purchases by providing incentives for these measures in grocery, discount and drug stores—however: a. Given the potentially limited applicability of these measures in PG&E, SCE, and SDG&E residential electric customer households, the IOUs should also consider the overall installation potential for these measures when establishing program quantities. b. Consumer survey results suggest that consumers are, in many cases, using high-wattage CFLs to replace lamps of lower brightness. It is possible that consumers would choose lower-wattage replacement lamps in the absence of program incentives for high-wattage CFLs. The implication here is that the for some applications, the program may be shifting consumers toward higher-wattage replacement lamps than they would choose absent the program. This point may warrant further consideration from the IOUs, particularly in light of the previous point.	All IOUs	High-wattage CFL upstream measures
6	Upstream lighting programs	1. The program appears to have moderately motivated customers to purchase LED A-lamps and LED reflector lamps by heavily discounting these products in membership club stores. Our analysis suggests that many of these purchases would have occurred at other retail channels in the absence of the program. LED A-lamps and LED reflector lamps achieved around 60% NTGRq, suggesting 40% of them were purchased by free-riders. However, many of the non-LED lamps that customers would have	LED A-lamps and LED reflector lamps received low overall NTGRs, however the NTGRq around 60% showed modest program influence, and high gross savings were responsible for creating low NTGRus. Final net savings realization rates suggest that LED lamps saved about as much energy as anticipated.	Despite low overall NTGRs, LED A-lamp and LED reflector lamp NTGRq results are moderate, and realization rates are high, suggesting IOUs should continue shifting upstream lighting program incentives to LED A-lamps and LED reflector lamps. The IOU's should begin to discount more mid-to-high brightness LED lamps, and future studies should explore the degree to which customers are replacing mid-to-high watt CFLs and incandescent lamps with low-watt LED lamps.	All IOUs	LED upstream Measures

Rec.#	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
		purchased in the absence of the program would have been more efficient than the ones that IOU customers replaced on average, which produced low NTGRu results. The net UES estimates were highest in the hardware and discount channels and the lowest in the membership club channel. 2. Consumer satisfaction with LED lamps in general was high during 2015 and 2016.				
7	Upstream lighting programs	The upstream lighting program influences the retail channels through which manufacturers sell replacement lamps to PG&E, SCE, and SDG&E residential electric customers in California.	Supplier interviews continue to show that upstream program influence retail stocking decisions and strategy.	Future EM&V efforts should further explore channel shift effects—including the quantity of lamps shifted, the channels to and from which the shifts occur, and the measure groups most affected.	All IOUs	All upstream measures
8	Upstream lighting programs	1. Among the IOUs' residential electric customers who purchased LED lamps during 2015 and 2016, satisfaction was high However, because LED lamps that meet the California Quality spec comprised such a small share of LED lamp stock among California retailers—approximately 13% as of winter 2015-16—it is unlikely that the spec is the primary driver of customer satisfaction 2 Manufacturers' representatives suggest that the upstream lighting program was the primary reason they produced LED lamps that met the spec in 2015.	Consumers claimed high satisfaction with LED lamps in 2015 and 2016, and suppliers noted that the program was the primary reason they manufacturered lamps that met the CEC spec. However, we have little data to suggest causation between these two findings.	Commission staff should consider pursuing a more definitive assessment of consumer satisfaction with LED lamps that do and do not meet the California Quality spec. The best opportunity for this assessment may be during the upcoming in-home lighting inventory and metering study. Note that at this time, Commission staff plan to launch this study in 2018, and preliminary study objectives include this topic.	Commission Staff	LED upstream Measures
9		Consumer survey results suggest that 68% of LED lamps purchased by customers replaced functioning lamps. The extent to which LED lamps are replacing CFLs, other LEDs, incandescent, or halogen lamps remains unknown, but this finding suggests that there is a potential savings impact related to early replacement.		Future evaluations should further investigate which lamps are being replaced early. With this more complete picture, future evaluations should estimate savings impacts associated with early replacements.	Commission Staff	All upstream measures
10		While the above recommendations reflect a business-as-usual environment, market conditions are expected to change in 2018		A potential study should be considered to estimate the remaining available energy savings potential that	All stakeholders	All upstream measures

Rec.#	Program or Database	Summary of Findings	Additional Supporting Information	Best Practice / Recommendations	Recipient	Affected Workpaper or DEER
		due to California's Title 20 legislation. These changes are likely to dramatically limit or eliminate the potential for residential and upstream lighting program savings.		incorporates the impacts of Title 20 changes in 2018. This study could leverage data collected from the upcoming in-home metering study, and attempt to establish the extent to which upstream lighting programs and the CEC spec are transforming the market.		
11		The modelling in this report uses respondent demographics by applying coefficients, which are shown in Table 89, in Appendix G. These results serve the primary goals of this impact evaluation well, as they produce accurate savings estimates at the channel-level. However, the underlying data have the potential to offer additional insights into the customer side of the lighting market. Additionally, the consumer survey and supplier interview results that were collected in pursuit of estimating program impacts also have potential to offer additional demand and supply-side insights into the lighting market. While we do not have the space available in this report to delve into such details, we would recommend leveraging these results in a future market report.		The data collected to answer the research questions for this evaluation have the potential to offer additional insights into the customer and supplier sides of the lighting market. Such a study could look at customer segmentation among various retail channels, perceptions of lighting technologies, and could explore price sensitivities.	All stakeholders	The upstream lighting market

APPENDIX B. SHELF SURVEY AND SHOPPER INTERCEPT SURVEY APPROACH

Overview

Field researchers conducted complete inventories (shelf surveys) of all screw-base and pin-based lamps[67] for sale in California retail stores throughout PG&E, SCE, and SDG&E service territories. At the same time, field staff conducted shopper intercept surveys with consumers who were shopping for lamps. This report draws on shelf survey and shopper intercept survey data collected during two periods: November 2014 through February 2015 (Winter 2014-2015) and November 2015 through February 2016 (Winter 2015-2016). DNV GL field researchers conducted both shelf surveys and shopper intercept surveys during all three phases of data collection.

The shelf surveys gathered detailed information regarding all residential replacement lamps stocked in the stores other than linear fluorescent lamps, while the shopper intercept surveys focused on shopper purchasing decisions and installation intentions for newly-purchased lamps.

Below we provide a brief description of the data collection process and the sampling approach for the shelf surveys and shopper intercept surveys analyzed in support of the Impact Evaluation of 2015 Upstream and Residential Downstream Lighting Programs. For additional details regarding data cleaning protocols and field work procedures, protocols, and training, please refer to Appendix C of the California Upstream and Residential Lighting Impact Evaluation Work Order 28 (WO28) Final Report.[68]

Data Collection

During the shelf surveys, field staff recorded key information for every store visited such as the retail channel, store name, IOU service territory, and store address. They also recorded information specific to each package of lamps in the store, including model number, lamp type, base type, lamp shape, manufacturer, wattage, and number of lamps in each package. Additionally, field staff recorded the number of packages, whether or not the lamps were 3-way or dimmable, full price, discounted price and discount provider (if relevant), rated life, color temperature, lamp coating, lumens, wattages, and whether each model was 3-way, dimmable, and/or Energy Star labeled for each package of lamps. Field staff recorded most of this information into a tablet computer using a handheld scanner. The barcode for each scanned lamp packages linked to a reference database that contained key lamp specifications such as lamp technology, style, wattage, lumens, and number of lamps per package. The tablet computer would then auto-populate the lamp characteristics into fields in a database, which the researcher would verify. DNV GL staff compiled all shelf survey results into a comprehensive database[69] for analysis.

During the shopper intercept surveys, field researchers conducted on-the-spot interviews with shoppers who were planning to purchase common replacement lamps across four major lamp technologies: CFLs, LED

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[67] This includes all CFLs, LED lamps, halogen lamps, incandescent lamps, high-intensity discharge (HID) lamps, and cold cathode lamps regardless of base type but does not include linear lamps (e.g., T8).

[68] DNV GL, 2014c.

[69] DNV GL staff has created a California lighting retail shelf survey searchable online database that contains California retail shelf survey data from research dating back to 2008. To access the database and learn more about the online tool's capabilities, please visit https://www.bulbstockdata.com.

lamps, incandescent lamps, and halogen lamps (including EISA-compliant lamps). For all intercepted lamp purchasers, field researchers used the same barcode scanner that they used to conduct shelf surveys to scan the lamp packages in purchasers' shopping carts or baskets. From there, the field researchers would proceed with conducting the intercept surveys, which obtained information from lamp purchasers regarding their installation plans for the lamp(s) they were purchasing as well as details regarding the influence of price on their purchasing decisions to serve LCM efforts. APPENDIX G provides additional detail regarding construction of the choice sets for the intercept survey and their application in the LCM.

Sampling Approach

The sampling approach used for the Winter 2014-2015 and Winter 2015-2016 shelf surveys mirrored the sampling approaches used for the Summer 2012, Winter 2012-2013, and Summer 2013 shelf surveys.[70] Field staff conducted surveys in chain and independent retail stores, including stores that participated in the IOUs' 2010-2012 upstream lighting program as well as non-participating stores. Field staff spent a minimum of four hours in each store completing the shelf surveys and attempting to intercept shoppers. Field staff spent approximately 1,800 hours in the stores across the two data collection periods. Field staff completed surveys opportunistically—that is, with individuals who were shopping during the time periods in which we conducted intercept surveys in specific stores. As such, results from the intercept surveys may not represent the broader population of shoppers purchasing replacement lamps at various stores throughout the year. Nonetheless, given the range in timeframes and store types in which we conducted these surveys, results provide general indications of shopper preferences, price sensitivity, lamp installation intentions, and so on.

We targeted approximately 200 store visits during each data collection period. We stratified the sample by retail channel and IOU service territory (for PG&E, SCE, and SDG&E territories), and designed the sample to represent the retail market for residential replacement lamps in these areas. We included stores that had IOU-discounted lamps in stock at the time of our store visits; stores that stocked IOU-discounted lamps but did not have any in stock at the time of our visits; stores that stocked IOU-discounted lamps in the past but not during the program cycle in which we conducted our visits; and stores that have never stocked IOU-discounted lamps. The sample design targeted roughly equal numbers of stores in each retail channel to ensure enough sample points per channel to enable channel-to-channel comparisons. For store visits conducted during the Winter 2015-2016 period, DNV GL staff attempted to revisit the stores included in the Winter 2014-2015 data collection period to enable time-series comparisons of un-weighted lamp stocking volumes across the retail stores for market characterization purposes.

[70] For further details on the sampling approaches used in earlier shelf survey efforts, please see DNV GL, 2014c, Appendix C.

Table 75 below provides details regarding the number of targeted and completed store visits during both of the shelf survey phases by retail channel and IOU. Each store visit represents one completed shelf survey. Across all two phases, field researchers conducted more than 400 shelf surveys in seven retail channels. In a small number of cases, field researchers had to substitute stores in other channels for planned visits (for example, because a store had closed, or because they were refused permission to conduct the research by store personnel); the table highlights cases in which the number of targeted and completed visits differ.

Table 75. Number of targeted and completed shelf surveys conducted by survey phase, retail channel, and IOU

Retail Channel	Winter 2014-2015				Winter 2015-2016				Overall			
	PG&E	SCE	SDG&E	Total	PG&E	SCE	SDG&E	Total	PG&E	SCE	SDG&E	Total
Targeted Shelf Surveys												
Discount	11	11	7	29	11	11	7	29	22	22	14	58
Drug	11	11	7	29	11	11	7	29	22	22	14	58
Grocery	10	11	7	28	10	11	7	28	20	22	14	56
Hardware	11	11	7	29	11	11	7	29	22	22	14	58
Home improvement	11	10	7	28	11	10	7	28	22	20	14	56
Mass merchandise	10	11	8	29	10	11	8	29	20	22	16	58
Membership club	11	10	7	28	11	10	7	28	22	20	14	56
Total Targeted	**75**	**75**	**50**	**200**	**75**	**75**	**50**	**200**	**150**	**150**	**100**	**400**
Completed Shelf Surveys												
Discount	11	11	7	29	11	11	7	29	22	22	14	58
Drug	11	11	7	29	11	12	7	30	22	23	14	59
Grocery	10	11	7	28	10	11	7	28	20	22	14	56
Hardware	11	11	7	29	11	11	7	29	22	22	14	58
Home improvement	11	10	7	28	12	9	10	31	23	19	17	59
Mass merchandise	10	11	8	29	10	11	8	29	20	22	16	58
Membership club	11	10	7	28	11	11	9	31	22	21	16	59
Total Completed	**75**	**75**	**50**	**200**	**76**	**76**	**55**	**207**	**151**	**151**	**105**	**407**

Table 76 displays the number of intercept surveys completed with lamp purchasers during the same three data collection periods by retail channel and IOU. Field staff completed shopper intercept surveys with more than 900 purchasers across the two phases of data collection.

Table 76. Number of intercept surveys completed with lamp purchasers by survey phase, retail channel, and IOU

Channel	Winter 2014-2015				Winter 2015-2016				Overall			
	PG&E	SCE	SDG&E	Total	PG&E	SCE	SDG&E	Total	PG&E	SCE	SDG&E	Total
Discount	10	8	10	28	15	10	15	40	25	18	25	68
Drug	6	10	3	19	7	7	3	17	13	17	6	36
Grocery	3	4	2	9	4	2	0	6	7	6	2	15
Hardware	17	6	15	38	29	14	16	59	46	20	31	97
Home improvement	47	38	56	141	23	19	26	68	70	57	82	209
Mass merchandise	31	42	29	102	40	31	33	104	71	73	62	206
Membership club	55	45	31	131	56	40	47	143	111	85	78	274
Total Surveys	**169**	**153**	**146**	**468**	**174**	**123**	**140**	**437**	**343**	**276**	**286**	**905**

APPENDIX C. CONSUMER SURVEY METHODS

DNV GL modelled the survey instrument on components of the consumer telephone survey fielded in support of the 2010-2012 California Upstream and Residential Lighting Impact Evaluation[71] and the 2014 California Residential Replacement Lamp Market Status Report.[72] APPENDIX I provides the data collection instrument.

During the third quarter of 2016, DNV GL conducted telephone and e-mail surveys with residential electric customers of PG&E, SCE, and SDG&E to support continued monitoring of purchase, installation, and storage rates for CFLs and LED lamps. This section provides an overview of the sampling approach associated with these surveys.

Sampling Approach

DNV GL designed the 2016 telephone and email survey sampling approach to be as consistent as possible with the approach used for the 2015 telephone surveys and 2012 and 2013 consumer telephone surveys in support of the 2010-2012 California Upstream and Residential Lighting Impact Evaluation, the other major IOU evaluation studies, and the 2012 CLASS study. Below we provide an overview of how we leveraged the sampling approach used in prior studies to the 2016 consumer telephone and email surveys.

Stratification

For the 2015-2016 surveys, we applied the same stratification approach that was used for the 2014, 2012 and 2013 consumer telephone surveys to the IOUs' 2014 billing data. There were 42 strata defined by:

- IOU
- Climate zone groups
- California Alternate Rates for Energy (CARE)[73]/Family Electric Rate Assistance (FERA)[74] participation status
- 2014 average daily kWh

We summarize these stratification variables in greater detail below.

Climate Zone Groups

DNV GLGL leveraged the cooling degree days (CDD) analyses performed for the 2009 Residential Appliance Saturation Study (RASS) to group CEC Title 24 climate zones into climate groups. We then stratified the IOUs' 2014 residential accounts by these climate zones.

Table 77 shows the climate zone groups used for sample stratification and the associated CDD and heating degree days (HDD). As shown, the Desert climate group includes only climate zone 15 (which had more than twice the CDD of the other zones). The Inland climate group includes climate zones 8 through 14, and

[71] DNV GL, 2014c.

[72] DNV GL, 2014b.

[73] CARE provides a monthly discount on energy bills for income-qualified households and housing facilities. Qualifications are based on the number of persons living in the home and the total annual household income.

[74] FERA provides a monthly discount on electric bills for income-qualified households of three or more persons.

the third group (“Mild”) includes the remaining zones (1 through 7 and 16).

Table 77. Climate zone groups for sample stratification (sorted by descending CDD)

Climate Zone Group	Title 24 Climate Zone	2009 HDD (65°F Base)	2009 CDD (65°F Base)
Desert	15	950	4,015
Inland	13	2,355	1,930
	14	3,107	1,769
	11	2,841	1,325
	10	1,799	1,268
	9	1,487	948
	12	2,812	792
	8	1,551	720
Mild	7	1,430	470
	2	3,232	426
	6	1,669	321
	4	2,512	283
	16	5,593	255
	3	2,792	38
	5	2,704	34
	1	4,149	0

CARE/FERA Participation Status

For the 2012 and 2013 surveys, Commission staff and IOU staff expressed interest in obtaining a representation of customers that participate in the CARE and FERA programs. The sample stratification approach for those surveys incorporated CARE/FERA participation status by coding utility customers that participated in CARE and/or FERA in 2010 as Yes (participants) and coding all other customers as No (nonparticipants).

We note that there was a substantial reduction in the number of CARE/FERA participants in the 2014 data in the SCE service territory (see Table 78

A	B	C	D	E	G	H	I
IOU	CARE/FERA Participant	Number of Customers	% of Customers		2014 Daily kWh	% of Daily kWh	
			Overall (Across IOUs)	By IOU		Overall (Across IOUs)	By IOU
PG&E	No	3,480,370	34%	74%	59,877,608	33%	73%
	Yes	1,198,722	12%	26%	22,205,283	12%	27%
SCE	No	4,297,234	42%	99%	80,188,221	44%	99%
	Yes	26,099	0%	1%	848,297	0%	1%
SDG&E	No	973,817	9%	78%	15,758,369	9%	79%
	Yes	279,295	3%	22%	4,185,105	2%	21%
Total		**10,257,558**	**100%**	**-**	**183,097,198**	**100%**	**-**

).

When looking at CARE/FERA status, the proportion of energy used per stratum closely follows the proportion of customers in the stratum, as shown in the pairs of Columns D/G or E/H, based on the 2014 data utilized in this sampling frame. In the PG&E service territory, 26% of customers had CARE/FERA status, and they used 27% of the energy consumed by PG&E customers in 2014. The corresponding proportions are 0% of customers and 0% of energy for SCE, and 3% of customers and 2% of energy for SDG&E.

Table 78. CARE/FERA participation status by IOU, 2014

A	B	C	D	E	G	H	I
IOU	CARE/FERA Participant	Number of Customers	% of Customers		2014 Daily kWh	% of Daily kWh	
			Overall (Across IOUs)	By IOU		Overall (Across IOUs)	By IOU
PG&E	No	3,480,370	34%	74%	59,877,608	33%	73%
	Yes	1,198,722	12%	26%	22,205,283	12%	27%
SCE	No	4,297,234	42%	99%	80,188,221	44%	99%
	Yes	26,099	0%	1%	848,297	0%	1%
SDG&E	No	973,817	9%	78%	15,758,369	9%	79%
	Yes	279,295	3%	22%	4,185,105	2%	21%
Total		**10,257,558**	**100%**	**-**	**183,097,198**	**100%**	**-**

Daily kWh

For each customer, DNV GL summed all of the 2014 billed kWh and divided by the sum of the number of billed days in 2014. This produced average daily kWh for each customer that can be compared to other customers even if a customer did not have billing data available for all months in 2014.[75]

Within each stratum, identified by the variables described above, we: (a) sorted customers by their average daily consumption, (b) calculated the total average daily consumption in the stratum, and (c) calculated the individual daily average kWh cut-off points that would place approximately one third of the energy in three usage strata within each stratum. These cut-off points define the daily average kWh strata. This approach is consistent with the approach used for the 2014 consumer telephone survey and 2012 and 2013 consumer telephone surveys in support of the 2010-2012 California Upstream and Residential Lighting Impact Evaluation.

Sampling Frame

The stratification approach described above results in 48 strata. Table 79 below present the strata, the number of customers in the 2014 billing data, and the average daily kWh associated with each stratum.

[75] As acknowledged in the 2010-2012 impact evaluation report, DNV GL recognizes that this is an imperfect way of comparing consumption across all customers. For example, if a customer has only the summer months available, he/she is likely to have a higher daily average than if the only months available are in the winter. However, in the absence of complete annual consumption for some customers, daily average kWh provides a better way to compare consumption among customers than total annual usage estimated from partial billing data.

Table 79. Sampling frame – PG&E (based on 2014 billing data)

Stratum / IOU	Climate Zone Group	CARE / FERA Participant	Daily kWh	Number of Customers	% of Customers	Average Daily kWh	% of Average Daily kWh	Standard Deviation from Avg Daily kWh
PG&E								
1	Inland	N	<=21.36	756,272	7%	12.4	1%	5.7
2	Inland	N	<=33.45	354,286	3%	26.6	2%	3.4
3	Inland	N	>33.45	202,351	2%	46.5	3%	23.2
4	Inland	Y	<=20.46	357,544	3%	13.2	1%	4.5
5	Inland	Y	<=30.64	189,186	2%	25.0	2%	2.9
6	Inland	Y	>30.64	107,716	1%	43.9	3%	99.4
7	Mild	N	<=14.12	1,327,843	13%	7.9	0%	3.7
8	Mild	N	<=24.46	576,582	6%	18.3	1%	2.9
9	Mild	N	>24.46	263,036	3%	40.1	2%	42.2
10	Mild	Y	<=13.39	328,759	3%	8.1	0%	3.0
11	Mild	Y	<=22.99	154,610	2%	17.3	1%	2.7
12	Mild	Y	>22.99	60,907	1%	43.9	3%	179.9
SCE								
13	Desert	N	<=27.54	78,839	1%	15.6	1%	6.9
14	Desert	N	<=45.29	35,341	0%	34.9	2%	4.9
15	Desert	N	>45.29	16,730	0%	73.7	4%	145.9
16	Desert	Y	<=37.12	568	0%	15.5	1%	10.3
17	Desert	Y	<=88.16	177	0%	50.3	3%	12.1
18	Desert	Y	>88.16	36	0%	246.5	15%	282.7
19	Inland	N	<=18.25	1,824,163	18%	11.3	1%	4.2
20	Inland	N	<=28.96	898,572	9%	22.8	1%	3.0
21	Inland	N	>28.96	486,837	5%	42.1	3%	74.3
22	Inland	Y	<=31.16	9,159	0%	21.8	1%	6.2
23	Inland	Y	<=44.47	5,413	0%	37.0	2%	3.7
24	Inland	Y	>44.47	3,190	0%	62.7	4%	45.5
25	Mild	N	<=14.68	574,003	6%	8.7	1%	3.5
26	Mild	N	<=25.30	261,654	3%	19.0	1%	2.9
27	Mild	N	>25.30	121,095	1%	41.1	2%	76.0
28	Mild	Y	<=26.62	4,212	0%	17.5	1%	5.6
29	Mild	Y	<=42.70	2,228	0%	33.2	2%	4.4
30	Mild	Y	>42.70	1,116	0%	66.3	4%	40.2
SDG&E								
31	Desert	N	<=18.32	1,293	0%	8.8	1%	5.0
32	Desert	N	<=31.87	474	0%	24.1	1%	3.9
33	Desert	N	>31.87	254	0%	45.1	3%	17.3
34	Desert	Y	<=27.26	242	0%	16.4	1%	6.9
35	Desert	Y	<=42.50	117	0%	33.3	2%	3.9
36	Desert	Y	>42.50	41	0%	98.5	6%	150.4
37	Inland	N	<=18.86	160,273	2%	11.4	1%	4.6
38	Inland	N	<=30.57	76,714	1%	23.8	1%	3.3
39	Inland	N	>30.57	40,962	0%	44.6	3%	26.7
40	Inland	Y	<=16.40	50,559	0%	10.4	1%	3.5
41	Inland	Y	<=29.61	24,649	0%	21.4	1%	3.6
42	Inland	Y	>29.61	8,015	0%	65.9	4%	256.6
43	Mild	N	<=14.04	412,956	4%	8.3	1%	3.4

Stratum / IOU	Climate Zone Group	CARE / FERA Participant	Daily kWh	Number of Customers	% of Customers	Average Daily kWh	% of Average Daily kWh	Standard Deviation from Avg Daily kWh
44	Mild	N	<=23.73	190,182	2%	18.0	1%	2.7
45	Mild	N	>23.73	92,730	1%	37.0	2%	27.8
46	Mild	Y	<=11.97	113,929	1%	7.6	0%	2.6
47	Mild	Y	<=20.15	56,184	1%	15.3	1%	2.3
48	Mild	Y	>20.15	25,559	0%	33.7	2%	114.3

Based on the table above, it is clear that for SCE, CARE/FERA participant portion of customers is minimal. Therefore, CARE/FERA is combined to call the CARE/FERA Status All i.e. ‘A’.

Similarly, for SDGE we see that the desert climate zone customers are minimal, so we combine them with inland customers for sampling purpose. This gives us the updated frame as shown in Table 80.

Table 80. Sampling frame – PG&E (based on 2014 billing data)

Stratum / IOU	Climate Zone Group	CARE / FERA Participant	Daily kWh	Number of Customers	% of Customers	Average Daily kWh	% of Average Daily kWh	Standard Deviation from Avg Daily kWh
PG&E								
1	Inland	N	<=21.36	756,272	7%	12.4	1%	5.7
2	Inland	N	<=33.45	354,286	3%	26.6	3%	3.4
3	Inland	N	>33.45	202,351	2%	46.5	5%	23.2
4	Inland	Y	<=20.46	357,544	3%	13.2	2%	4.5
5	Inland	Y	<=30.64	189,186	2%	25.0	3%	2.9
6	Inland	Y	>30.64	107,716	1%	43.9	5%	99.4
7	Mild	N	<=14.12	1,327,843	13%	7.9	1%	3.7
8	Mild	N	<=24.46	576,582	6%	18.3	2%	2.9
9	Mild	N	>24.46	263,036	3%	40.1	5%	42.2
10	Mild	Y	<=13.39	328,759	3%	8.1	1%	3.0
11	Mild	Y	<=22.99	154,610	2%	17.3	2%	2.7
12	Mild	Y	>22.99	60,907	1%	43.9	5%	179.9
SCE								
13	Desert	A	<=27.58	79,422	1%	15.6	2%	7.0
14	Desert	A	<=45.43	35,534	0%	35.0	4%	5.0
15	Desert	A	>45.43	16,735	0%	74.2	9%	146.6
16	Inland	A	<=18.33	1,836,317	18%	11.3	1%	4.2
17	Inland	A	<=29.11	902,019	9%	23.0	3%	3.0
18	Inland	A	>29.11	488,998	5%	42.4	5%	74.3
19	Mild	A	<=14.78	579,335	6%	8.7	1%	3.5
20	Mild	A	<=25.55	263,424	3%	19.1	2%	3.0
21	Mild	A	>25.55	121,549	1%	41.5	5%	76.0
SDG&E								
22	Inland	N	<=18.85	161,490	2%	11.4	1%	4.7
23	Inland	N	<=30.59	77,293	1%	23.8	3%	3.3
24	Inland	N	>30.59	41,187	0%	44.6	5%	26.7
25	Inland	Y	<=16.45	50,858	0%	10.5	1%	3.5
26	Inland	Y	<=29.75	24,725	0%	21.5	2%	3.6
27	Inland	Y	>29.75	8,040	0%	66.2	8%	256.5
28	Mild	N	<=14.04	412,956	4%	8.3	1%	3.4
29	Mild	N	<=23.73	190,182	2%	18.0	2%	2.7
30	Mild	N	>23.73	92,730	1%	37.0	4%	27.8
31	Mild	Y	<=11.97	113,929	1%	7.6	1%	2.6
32	Mild	Y	<=20.15	56,184	1%	15.3	2%	2.3
33	Mild	Y	>20.15	25,559	0%	33.7	4%	114.3

In Table 80, we see that even after collapsing CARE/FERA strata, strata 14 and 15 still account for less than one percent of all IOU customers. We therefore collapse strata 14 and 15 into strata 13, which then represent more than 1% of all IOU customers.

Sample Allocation

For consistency with the sample allocation approach used in the 2014 survey and 2010-2012 California Upstream and Residential Lighting Impact Evaluation, DNV GL allocated 40% of the overall sample for PG&E,

40% for SCE, and 20% to SDG&E, and then allocated the sample proportionally to the average daily kWh in each stratum.[76]

For the phone survey sample, we planned to complete 600 surveys (240 from PGE and SCE and 120 from SDGE). For the email survey, we planned to complete 300 surveys (120 from PGE and SCE and 60 from SDGE). The available number of customers in each strata is based on availability of phone numbers or email address for each of the phone survey and email survey respectively.

Table 81. Consumer phone survey targets and available numbers of customers by stratum, 2016

IOU	Stratum	Climate Zone Group	Target Number of Completes	Available Number of Customers
PG&E	1	Inland	28	685,098
	2	Inland	28	320,854
	3	Inland	28	179,740
	4	Inland	14	320,545
	5	Inland	14	164,350
	6	Inland	14	91,549
	7	Mild	32	1,221,531
	8	Mild	32	527,308
	9	Mild	31	237,342
	10	Mild	8	298,212
	11	Mild	8	136,299
	12	Mild	8	52,961
SCE	13	Desert	12	130,612
	16	Inland	62	1,815,256
	17	Inland	61	895,325
	18	Inland	61	486,497
	19	Mild	15	571,128
	20	Mild	15	260,809
	21	Mild	15	120,612
SDG&E	22	Inland	11	161,155
	23	Inland	11	77,174
	24	Inland	11	41,135
	25	Inland	3	50,638
	26	Inland	3	24,642
	27	Inland	3	8,014
	28	Mild	21	411,746
	29	Mild	21	189,819
	30	Mild	21	92,587
	31	Mild	5	113,376
	32	Mild	5	55,949
	33	Mild	5	25,470
Total			**606**	**9,767,733**

[76] For the 2012 and 2013 surveys, DNV GL estimated the statistical precision of four different allocation methods: (1) proportional to the number of customers in each stratum; (2) proportional to the average daily kWh in each stratum; (3) 40% of the sample for each of PG&E and SCE, and 20% to SDG&E, then proportional to the number of customers in each stratum; and (4) 40% of the sample for each of PG&E and SCE, and 20% to SDG&E, then proportional to the average daily kWh in each stratum. All methods produced high statistical precision at the statewide level, but the 40/40/20 methods improved precision in SDG&E's service territory with very little impact on precision for PG&E's and SCE's service territories. We thus adopted method 4 for the 2012 and 2013 consumer telephone surveys (40/40/20 with allocation proportional to kWh within each utility). We used the same method for the 2015 consumer telephone surveys.

Table 82. Consumer email survey targets and available numbers of customers by stratum, 2016

IOU	Stratum	Climate Zone Group	Target Number of Completes	Available Number of Customers
PG&E	1	Inland	14	401,204
	2	Inland	14	186,883
	3	Inland	14	109,928
	4	Inland	7	158,588
	5	Inland	7	96,328
	6	Inland	7	60,627
	7	Mild	16	733,317
	8	Mild	16	298,320
	9	Mild	15	135,554
	10	Mild	4	132,232
	11	Mild	4	71,042
	12	Mild	4	30,810
SCE	13	Desert	6	26,248
	16	Inland	32	347,460
	17	Inland	31	254,269
	18	Inland	31	154,992
	19	Mild	7	99,992
	20	Mild	7	63,175
	21	Mild	7	31,251
SDG&E	22	Inland	6	110,554
	23	Inland	6	51,977
	24	Inland	6	28,610
	25	Inland	2	32,457
	26	Inland	2	17,500
	27	Inland	2	5,826
	28	Mild	10	300,967
	29	Mild	10	128,898
	30	Mild	10	63,465
	31	Mild	3	73,789
	32	Mild	3	39,401
	33	Mild	3	18,572
Total			**306**	**4,264,236**

Survey Implementation and Weighting

DNV GL hired an experienced survey research firm to conduct telephone surveys with residential electric customers of PG&E, SCE, and SDG&E using a Computer-Aided Telephone Interviewing (CATI) and online email approach. The survey firm completed 578 phone surveys and 313 email surveys in November of 2016.

We developed strata level case weights for each completed survey based on total number of available customers in a particular strata (N) divided by number of survey completed survey in the strata(n). For the strata with less than five completes, we collapsed it with a similar strata so that each strata of analysis would have at least five observations. The weights for each strata is shown in Table 83Table 85 and Table 86, the strata highlighted in grey have been collapsed.

Table 83. Consumer telephone survey targets and completed surveys by stratum, 2016

IOU	Stratum	Climate Zone Group	Target Number of Completes	Number of Completed Surveys	Weight
PG&E	1	Inland	28	23	32,881
	2	Inland	28	34	10,420
	3	Inland	28	35	5,781
	4	Inland	14	8	44,693
	5	Inland	14	14	13,513
	6	Inland	14	17	6,336
	7	Mild	32	31	42,834
	8	Mild	32	38	15,173
	9	Mild	31	40	6,576
	10	Mild	8	4	40,281
	11	Mild	8	8	40,281
	12	Mild	8	10	6,091
SCE	13	Desert	12	9	14,632
	16	Inland	62	41	44,788
	17	Inland	61	61	14,787
	18	Inland	61	61	8,016
	19	Mild	15	9	64,371
	20	Mild	15	15	17,562
	21	Mild	15	16	7,597
SDG&E	22	Inland	11	10	16,149
	23	Inland	11	10	7,729
	24	Inland	11	8	5,148
	25	Inland	3		9,291
	26	Inland	3	3	9,291
	27	Inland	3	6	9,291
	28	Mild	21	15	27,530
	29	Mild	21	21	9,056
	30	Mild	21	19	4,881
	31	Mild	5	3	24,302
	32	Mild	5	4	24,302
	33	Mild	5	5	5,112
Total			**606**	**578**	**10,257,558**

Table 84. Consumer online survey targets and completed surveys by stratum, 2016

IOU	Stratum	Climate Zone Group	Target Number of Completes	Number of Completed Surveys (Overall)	Weights (Overall)
PG&E	1	Inland	14	14	54,019
	2	Inland	14	14	25,306
	3	Inland	14	20	10,118
	4	Inland	7	7	51,078
	5	Inland	7	7	27,027
	6	Inland	7	7	15,388
	7	Mild	16	14	94,846
	8	Mild	16	15	38,439
	9	Mild	15	15	17,536
	10	Mild	4	4	45,356
	11	Mild	4	4	45,356
	12	Mild	4	4	45,356
SCE	13	Desert	6	6	21,949
	16	Inland	32	31	59,236
	17	Inland	31	31	29,097
	18	Inland	31	31	15,774
	19	Mild	7	7	82,762
	20	Mild	7	7	37,632
	21	Mild	7	7	17,364
SDG&E	22	Inland	6	6	26,915
	23	Inland	6	7	11,042
	24	Inland	6	7	5,884
	25	Inland	2	3	9,291
	26	Inland	2	4	9,291
	27	Inland	2	2	9,291
	28	Mild	10	10	41,296
	29	Mild	10	10	19,018
	30	Mild	10	9	10,303
	31	Mild	3	3	19,567
	32	Mild	3	3	19,567
	33	Mild	3	4	19,567
Total			**306**	**313**	**10,257,558**

Table 85. Consumer telephone survey targets and completed surveys by stratum, 2015

IOU	Stratum	Climate Zone Group	Targeted Number of Completed Surveys	Number of Completed Surveys
PG&E	1	Inland	42	43
	2	Inland	43	43
	3	Inland	43	43
	4	Inland	25	25
	5	Inland	25	25
	6	Inland	25	25
	7	Mild	50	51
	8	Mild	50	50
	9	Mild	50	50
	10	Mild	18	18
	11	Mild	18	18
	12	Mild	18	18
SCE	13	Desert	5	5
	14	Desert	5	5
	15	Desert	5	5
	16	Desert	2	2
	17	Desert	2	2
	18	Desert	2	2
	19	Inland	67	67
	20	Inland	68	70
	21	Inland	68	68
	22	Inland	36	36
	23	Inland	36	37
	24	Inland	37	38
	25	Mild	20	20
	26	Mild	20	20
	27	Mild	20	20
	28	Mild	5	5
	29	Mild	5	5
	30	Mild	5	6
SDG&E	31	Desert	19	19
	32	Desert	19	19
	33	Desert	19	17
	34	Desert	6	6
	35	Desert	6	6
	36	Desert	6	6
	37	Inland	34	32
	38	Inland	34	34
	39	Inland	35	29
	40	Inland	9	9
	41	Inland	10	7
	42	Inland	10	10
Total			Mild	**1,016**

Table 86. Consumer telephone survey disposition, 2015

Disposition Category	Total
QUOTA	1,022
COMPLETES	1,016
TOTAL SAMPLE	17,503
NO ANSWER	1,121
BUSY	56
SCHEDULED CALLBACK	241
UNSPEC. CALLBACK	282
ANSWERING MACHINE	1,143
6+ ATTEMPTS NO INTERVIEW	6,058
NON-WORKING NUMBER	2,604
NONRESIDENTIAL	531
LANGUAGE BARRIER	787
OTHER PHONE PROBLEMS - FAX/MODEM	527
CLAIMS PREVIOUS INTERVIEW	67
HARD REFUSALS	1,971
BREAK-OFFS - SCREENER	43
QUALIFIED REFUSALS	43
DON'T KNOW / REFUSED IF LANDLINE OR WIRELESS	82
NOT CORRECT COMPANY	53
DON'T KNOW / REFUSED COMPANY	26

APPENDIX D. IN-DEPTH TELEPHONE INTERVIEWS WITH LAMP SUPPLIER REPRESENTATIVES METHODS

DNV GL modelled the survey instrument on components of the consumer telephone survey fielded in support of the 2010-2012 California Upstream and Residential Lighting Impact Evaluation[77] and the 2014 California Residential Replacement Lamp Market Status Report.[78] APPENDIX I provides the data collection instrument.

[77] DNV GL, 2014c.
[78] DNV GL, 2014b.

APPENDIX E. 2006-2008 RESIDENTIAL LIGHTING METERING STUDY SAMPLE SIZES

The 2006-2008 Residential Lighting Metering Study utilized a sample stratified by IOU and geographic region. Within each region, we selected a simple random sample. Essentially, every residential account in the IOU records had an equal probability of selection into the sample.

Within each home, we obtained a complete inventory of all lamps in use and of all CFLs in storage. We targeted four CFL fixture groups and three non-CFL fixture groups for metering in each home, taking a systematic sample from the full inventory.

Table 87 shows 2006-2008 residential lighting metering study sample sizes by month and year.

Table 87. 2006-2008 residential lighting metering study resident sample sizes by month and year*

Wave and Quantity Details	2008									2009								
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wave 1																		
# Sites	26	191	92				-26	-191	-92									
# Meters	174	1,280	622				-174	-1,280	-622									
Wave 2																		
# Sites				118	181	15					-118	-181	-15					
# Meters				814	1,249	104					-814	-1,249	-104					
Wave 3																		
# Sites									188	76	213	133		-24	-231		-155	-200
# Meters									1,297	524	1,470	918				-524	-1,470	-2,570
# Downloads														291	64			
Active # Sites	**26**	**217**	**309**	**427**	**608**	**623**	**597**	**406**	**502**	**578**	**673**	**625**	**610**	**586**	**355**	**355**	**200**	**0**
Cumulative # Meters	**174**	**1,454**	**2,076**	**2,890**	**4,139**	**4,243**	**4,069**	**2,789**	**3,464**	**3,988**	**4,644**	**4,313**	**4,209**	**4,500**	**4,564**	**4,040**	**2,570**	**0**

*Negative sample size indicates removed meters and associated follow-up site visits

Initially, we estimated the required metering sample size for achieving 90/10 precision for coincidence peak use at approximately 2,700 homes with summer metering. This sample size was several times the size of any previous study, and would have been impractical to achieve within the timeframe available for this evaluation. Instead, we set the metering sample size at 1,200 homes including a minimum of 600 during the summer. The projected statewide precision at 90 percent confidence for this design was +/- 7 percent for average daily HOU and +/- 19 percent for percent on at peak.

We developed estimates of average daily HOU and peak use from the metering data in two ways. The first was a direct expansion using the sampling weights. The second was a leveraged expansion, which first estimated HOU and peak use for each lamp in the inventory based on a model fit to the metered data and then applied sample expansion weights to produce averages from the full inventory data set. For the direct expansion, statistical confidence intervals are based on the estimated sampling d for the metering sample. For the leveraged estimates, statistical confidence intervals combine the modeling error with the inventory sampling error.

The leveraged expansion can provide more robust estimates for subdivisions of the data across multiple dimensions, particularly if the subdivision results in small sample sizes for direct expansion. For larger subgroups, the direct expansion generally provides better precision.

Achieved precision using direct estimation for HOU was +/- 3 percent for the state as a whole, and +/- 8 percent or better for each IOU. Achieved precision for peak was +/- 8.7 percent for the state as a whole and +/- 21 percent or better for each IOU.

APPENDIX F. CLASS SAMPLING APPROACH

This appendix is the CLASS sampling design memo that DNV GL distributed on May 25, 2012 under WO 21. This provides full background regarding how we designed the CLASS sample.

memo

To:	IOUs, CPUC Energy Division and their Consultants	Date:	May 25, 2012
From:	Claire Palmgren, Paula Ham-Su, Jarred Metoyer, - DNV KEMA		
Copy:	Dina Mackin, Carmen Best		

Subject:	Final Sample Design for WO21: California Lighting and Appliance Saturation Study (CLASS)

The approved research plan for the California Lighting and Appliance Saturation Study (CLASS) discussed the possible sampling dimensions for the study. This memo defines the final stratification that will be used in the sample design for the 2012 CLASS study.

Background

The previous (2005) CLASS study utilized a sample design with stratification by rate classes known as "long rates" that contained information such as baseline territory, low income status and electric heat. By stratifying along these older rate classes, the sample was implicitly stratified along the attributes contained in the rates.

The current IOU CIS systems have some of this information contained in separate variables, so the individual variables need to be included separately into the sample design to include this information. The approved research plan also listed several dimensions that would be considered in the development of the sampling plan beyond the characteristics embedded in the 2005 sample design: multi-family dwellings, manufactured homes, and new construction. These dimensions were not consistently available in the data received from the IOUs, so were not incorporated in the sample design.

Proposed Stratification

The stratification for the current 2012 CLASS study consists of 42 strata defined by:

1. Utility (PG&E, SCE, SDG&E)
2. Climate zone groups (Mild, Inland, Desert)
3. CARE/FERA status (Yes or No)
4. Daily kWh (Average daily kWh for 2010)

The stratification variables are explained in greater detail below.

Climate Zone Groups

KEMA analyzed the climate zone Cooling Degree Days that are associated with the 2009 RASS to group T24 climate zones into climate zone groups. These CDDs are presented in Column D of Table 1.

Table 1 shows that there is a substantial difference in Cooling Degree Days between Climate Zone 15 and the other zones.

- CZ 15 has over twice the amount of CDDs than the second highest zone, CZ 13. Because of this, CZ 15 was placed in its own group ("Desert").
- The second group, "Inland", groups CZs 8 through 14. These CZs have CDDs between 700 and 2,000 approximately.
- The third group, "Mild", groups the remainder of the climate zones: CZs 1 through 7 and CZ 16. These range between 0 and 470 CDDs.

Table 1: Climate Zone Groups for CLASS Stratification
Sorted by Descending Cooling Degree Days

A	B	C	D
Climate Zone Group	T24 Climate Zone	2009 HDD (65°F Base)	2009 CDD (65°F Base)
Desert	15	950	4,015
Inland	13	2,355	1,930
Inland	14	3,107	1,769
Inland	11	2,841	1,325
Inland	10	1,799	1,268
Inland	9	1,487	948
Inland	12	2,812	792
Inland	8	1,551	720
Mild	7	1,430	470
Mild	2	3,232	426
Mild	6	1,669	321
Mild	4	2,512	283
Mild	16	5,593	255
Mild	3	2,792	38
Mild	5	2,704	34
Mild	1	4,149	0

CARE / FERA[1] Status

The Energy Division and the IOUs have expressed interest in obtaining a representation of customers that participate in the CARE and FERA programs. The sample stratification has incorporated the CARE/FERA status by coding utility customers that participated in CARE and/or FERA in 2010 as Yes and coding all other customers as No.

When looking at CARE/FERA status, the proportion of energy used per stratum closely follows the proportion of customers in the stratum, as shown in the pairs of Columns D/G or E/H , based on the 2010 data utilized in this sampling frame. In the PG&E service territory, 28 percent of customers have CARE/FERA status, and they use 31 percent of the energy. These proportions are 32 percent and 31 percent for SCE, and 23 percent and 22 percent for SDG&E.

Table 2: CARE/FERA Status by IOU

A	B	C	D	E	F	G	H
IOU	CARE FERA Status	Number of Customers	Percent Customers Overall	Percent Customers IOU	Average Daily kWh	Percent Daily kWh Overall	Percent Daily kWh IOU
PGE	N	4,017,574	32%	72%	66,439,652	32%	69%
PGE	Y	1,573,317	13%	28%	30,507,941	15%	31%
SCE	N	3,640,787	29%	68%	60,350,520	29%	69%
SCE	Y	1,703,287	14%	32%	27,575,663	13%	31%
SDGE	N	1,253,097	10%	77%	18,046,401	9%	78%
SDGE	Y	368,341	3%	23%	4,985,869	2%	22%
TOTAL		12,556,403	100%		207,906,045	100%	

Daily Average kWh

For each customer, KEMA summed all of the 2010 kWh and divided by the sum of the number of days in 2010. This produced average daily kWh for each customer that can be compared to other customers even if a customer does not have all of the billing months available in 2010[2].

Within each stratum identified by the variables described above, we: (a) sorted customers by their average daily consumption, (b) calculated the total average daily consumption in the stratum, and (c) calculated the individual daily average kWh cutoff points that would place approximately one third of the energy in three usage strata within each stratum. These cutoff points define the daily average kWh strata.

---

[1] CARE, the California Alternate Rates for Energy program, provides a monthly discount on energy bills for income-qualified households and housing facilities. Qualifications are based on the number of persons living in the home and the total annual household income. FERA, the Family Electric Rate Assistance program, provides a monthly discount on electric bills for income-qualified households of three or more persons.

[2] KEMA recognizes that this is an imperfect way of comparing consumption across all customers. For example, if a customer has only the summer months available, it is likely to have a higher daily average than if the only months available are in the winter. However, in the absence of complete annual consumption for some customers, daily average kWh provides a better way to compare consumption among customers than total annual usage.

Sampling Frame

The stratification described above results in 42 strata. The strata, the number of customers and the average daily kWh associated with each stratum are provided in Table 3.

Table 3: Sampling Frame (Based on 2010 Billing Data)

A	B	C	D	E	F	G	H	I	J	K
Stratum	IOU	Climate Zone Group	CARE FERA	Daily kWh	Number of Customers	Percent Customers Overall	Percent Customers IOU	Average Daily kWh	Percent Daily kWh	Std Dev Daily kWh
1	PGE	I	N	<= 20.9	939,212	7.5%	16.8%	9,979,587	4.8%	6.1
2	PGE	I	N	<= 33	388,491	3.1%	6.9%	10,177,432	4.9%	3.4
3	PGE	I	N	> 33	224,254	1.8%	4.0%	10,177,563	4.9%	21.3
4	PGE	I	Y	<= 20.6	467,446	3.7%	8.4%	5,946,164	2.9%	4.8
5	PGE	I	Y	<= 32.7	232,332	1.9%	4.2%	5,991,679	2.9%	3.4
6	PGE	I	Y	> 32.7	123,785	1.0%	2.2%	6,005,512	2.9%	91.9
7	PGE	M	N	<= 14.9	1,533,933	12.2%	27.4%	11,910,622	5.7%	4.1
8	PGE	M	N	<= 25.4	627,322	5.0%	11.2%	12,075,995	5.8%	2.9
9	PGE	M	N	> 25.4	304,362	2.4%	5.4%	12,118,454	5.8%	39.2
10	PGE	M	Y	<= 15.2	465,218	3.7%	8.3%	4,127,128	2.0%	3.5
11	PGE	M	Y	<= 28	209,521	1.7%	3.7%	4,226,823	2.0%	3.5
12	PGE	M	Y	> 28	75,015	0.6%	1.3%	4,210,634	2.0%	166.9
13	SCE	D	N	<= 27.1	79,399	0.6%	1.5%	954,642	0.5%	7.7
14	SCE	D	N	<= 48.1	26,808	0.2%	0.5%	961,120	0.5%	5.9
15	SCE	D	N	> 48.1	12,976	0.1%	0.2%	962,392	0.5%	46.4
16	SCE	D	Y	<= 24.2	24,353	0.2%	0.5%	362,100	0.2%	5.8
17	SCE	D	Y	<= 36.9	12,295	0.1%	0.2%	367,191	0.2%	3.6
18	SCE	D	Y	> 36.9	7,600	0.1%	0.1%	369,300	0.2%	12.5
19	SCE	I	N	<= 18.2	1,612,167	12.8%	30.2%	14,696,925	7.1%	5.4
20	SCE	I	N	<= 29.7	640,260	5.1%	12.0%	14,791,400	7.1%	3.2
21	SCE	I	N	> 29.7	352,762	2.8%	6.6%	14,872,178	7.2%	21.4
22	SCE	I	Y	<= 15.6	800,106	6.4%	15.0%	7,763,625	3.7%	3.5
23	SCE	I	Y	<= 24.8	400,663	3.2%	7.5%	7,843,450	3.8%	2.6
24	SCE	I	Y	> 24.8	234,996	1.9%	4.4%	7,914,104	3.8%	9.9
25	SCE	M	N	<= 14.8	575,692	4.6%	10.8%	4,320,386	2.1%	4.2
26	SCE	M	N	<= 25.5	228,303	1.8%	4.3%	4,385,988	2.1%	3
27	SCE	M	N	> 25.5	112,420	0.9%	2.1%	4,405,490	2.1%	25.6
28	SCE	M	Y	<= 12.5	126,138	1.0%	2.4%	969,106	0.5%	2.8
29	SCE	M	Y	<= 20.5	62,214	0.5%	1.2%	988,140	0.5%	2.3
30	SCE	M	Y	> 20.5	34,922	0.3%	0.7%	998,648	0.5%	9.7
31	SDGE	I	N	<= 18.4	219,329	1.7%	13.5%	2,090,941	1.0%	5.2
32	SDGE	I	N	<= 31.1	88,816	0.7%	5.5%	2,104,734	1.0%	3.6
33	SDGE	I	N	> 31.1	47,423	0.4%	2.9%	2,119,819	1.0%	17.9
34	SDGE	I	Y	<= 14.8	63,893	0.5%	3.9%	603,105	0.3%	3.2
35	SDGE	I	Y	<= 25.2	32,483	0.3%	2.0%	619,430	0.3%	2.9
36	SDGE	I	Y	> 25.2	16,766	0.1%	1.0%	615,817	0.3%	13.7
37	SDGE	M	N	<= 13.5	565,791	4.5%	34.9%	3,886,287	1.9%	3.7
38	SDGE	M	N	<= 23.5	221,662	1.8%	13.7%	3,901,656	1.9%	2.8

A	B	C	D	E	F	G	H	I	J	K
Stratum	IOU	Climate Zone Group	CARE FERA	Daily kWh	Number of Customers	Percent Customers Overall	Percent Customers IOU	Average Daily kWh	Percent Daily kWh	Std Dev Daily kWh
39	SDGE	M	N	> 23.5	110,076	0.9%	6.8%	3,942,963	1.9%	20.3
40	SDGE	M	Y	<= 11.5	143,281	1.1%	8.8%	1,035,485	0.5%	2.5
41	SDGE	M	Y	<= 18.9	72,179	0.6%	4.5%	1,055,179	0.5%	2.1
42	SDGE	M	Y	> 18.9	39,739	0.3%	2.5%	1,056,853	0.5%	9.4
TOTAL					12,556,403	100.0%		207,906,045	100.0%	

Sample Allocation and Estimated Precision

Given a sample size of 2,000 on site surveys, KEMA tested the precision of four different allocation methods:

1. Proportional to the number of customers in each stratum (Column B in tables below)
2. Proportional to the average daily kWh in each stratum (Column D in tables below)
3. Forty percent of the sample for each of PG&E and SCE, and 20 percent to SDG&E, then proportional to the number of customers in each stratum (Column F in tables below)
4. Forty percent of the sample for each of PG&E and SCE, and 20 percent to SDG&E, then proportional to the average daily kWh in each stratum (Column H in tables below)

These four methods of allocation are presented in Table 4 through 6.

Overall and IOU Estimated Precisions

All four methods of sample allocation will produce the same Overall Precision, as shown in Table 3.

The 40/40/20 allocation method improves precision for SDG&E, while maintaining a similar level of precision for PG&E and SCE. This is accomplished by allocating SDG&E a larger number of sample points relative to the number that would be allocated if strict proportions by stratum were allocated. The number of sample points allocated to PG&E and SCE is large enough that the decrease of sample size results in less than a 1% change in precision.

Table 4: Sample Allocation and Precision by IOU[3]

A	B	C	D	E	F	G	H	I
IOU	Proportional Allocation (Customers)	Estimated Precision at 90% Confidence	Proportional Allocation (kWh)	Estimated Precision at 90% Confidence	40/40/20 Allocation (Customers)	Estimated Precision at 90% Confidence	40/40/20 Allocation (kWh)	Estimated Precision at 90% Confidence
TOTAL	2,000	2%	2,001	2%	2,001	2%	1,999	2%
PG&E	890	3%	935	3%	801	3%	800	3%
SCE	851	3%	845	3%	800	3%	800	3%
SDG&E	259	5%	221	6%	400	4%	399	4%

[3] Stratum Precision is based on a 50% proportion.

CARE/FERA Program Estimated Precision

Precision for CARE/FERA participants from SDG&E is improved from 11% or 12% to 9% when the 40/40/20 allocation method is applied, while keeping the precision the same for participants from SCE and PG&E. Precision for non-participants from SDG&E is also improved by 1%, while decreasing precision for PG&E and SCE non-participants by 1% or less. This is illustrated in Table 5.

Table 5: Sample Allocation and Stratum Precision[4] by IOU and CARE/FERA Status

	A	B	C	D	E	F	G	H	I
IOU	**CARE FERA Status**	**Proportional Allocation (Customers)**	**Estimated Precision at 90% Confidence**	**Proportional Allocation (kWh)**	**Estimated Precision at 90% Confidence**	**40/40/20 Allocation (Customers)**	**Estimated Precision at 90% Confidence**	**40/40/20 Allocation (kWh)**	**Estimated Precision at 90% Confidence**
PGE	N	640	3%	640	3%	575	3%	548	4%
PGE	Y	250	5%	295	5%	226	5%	252	5%
SCE	N	580	3%	579	3%	545	4%	550	4%
SCE	Y	271	5%	266	5%	255	5%	250	5%
SDGE	N	200	6%	173	6%	309	5%	313	5%
SDGE	Y	59	11%	48	12%	91	9%	86	9%
Total		2,000	2%	2,001	2%	2,001	2%	1,999	2%

Stratum Estimated Precisions

The allocation method will affect the strata precisions, as shown in Table 6.

Table 6: Sample Allocation and Stratum Precision[5]

A	B	C	D	E	F	G	H	I
Stratum	**Proportional Allocation (Customers)**	Estimated Precision at 90% Confidence	**Proportional Allocation (kWh)**	Estimated Precision at 90% Confidence	**40/40/20 Allocation (Customers)**	Estimated Precision at 90% Confidence	**40/40/20 Allocation (kWh)**	Estimated Precision at 90% Confidence
1	150	7%	96	8%	134	7%	82	9%
2	62	10%	98	8%	56	11%	84	9%
3	36	14%	98	8%	32	15%	84	9%
4	74	10%	57	11%	67	10%	49	12%
5	37	14%	58	11%	33	14%	49	12%
6	20	18%	58	11%	18	19%	50	12%
7	244	5%	115	8%	219	6%	98	8%
8	100	8%	116	8%	90	9%	100	8%
9	48	12%	117	8%	44	12%	100	8%
10	74	10%	40	13%	67	10%	34	14%
11	33	14%	41	13%	30	15%	35	14%
12	12	24%	41	13%	11	25%	35	14%

[4] Stratum Precision is based on a 50% proportion.
[5] Stratum Precision is based on a 50% proportion

A	B	C	D	E	F	G	H	I
Stratum	**Proportional Allocation (Customers)**	Estimated Precision at 90% Confidence	**Proportional Allocation (kWh)**	Estimated Precision at 90% Confidence	**40/40/20 Allocation (Customers)**	Estimated Precision at 90% Confidence	**40/40/20 Allocation (kWh)**	Estimated Precision at 90% Confidence
13	13	23%	9	27%	12	24%	9	27%
14	4	41%	9	27%	4	41%	9	27%
15	2	58%	9	27%	2	58%	9	27%
16	4	41%	3	47%	4	41%	3	47%
17	2	58%	4	41%	2	58%	3	47%
18	1	82%	4	41%	1	82%	3	47%
19	257	5%	141	7%	241	5%	134	7%
20	102	8%	142	7%	96	8%	135	7%
21	56	11%	143	7%	53	11%	135	7%
22	127	7%	75	9%	120	8%	71	10%
23	64	10%	75	9%	60	11%	71	10%
24	37	14%	76	9%	35	14%	72	10%
25	92	9%	42	13%	86	9%	39	13%
26	36	14%	42	13%	34	14%	40	13%
27	18	19%	42	13%	17	20%	40	13%
28	20	18%	9	27%	19	19%	9	27%
29	10	26%	10	26%	9	27%	9	27%
30	6	34%	10	26%	5	37%	9	27%
31	35	14%	20	18%	54	11%	36	14%
32	14	22%	20	18%	22	18%	37	14%
33	8	29%	20	18%	12	24%	37	14%
34	10	26%	6	34%	16	21%	10	26%
35	5	37%	6	34%	8	29%	11	25%
36	3	47%	6	34%	4	41%	11	25%
37	90	9%	37	14%	140	7%	67	10%
38	35	14%	38	13%	55	11%	68	10%
39	18	19%	38	13%	27	16%	68	10%
40	23	17%	10	26%	35	14%	18	19%
41	11	25%	10	26%	18	19%	18	19%
42	6	34%	10	26%	10	26%	18	19%

Gas Service

The CLASS study has a unique focus on electric end-uses by the nature of the lighting inventory, appliances, and consumer electronics included in the scope. The study also includes heating and water heating systems which typically comprise a majority of gas consumption. The stratification for the sample design is based on electric service provider and electric consumption to avoid unnecessary complexity.

Although the sample frame is defined by electric accounts, the sample is expected to include customers with gas accounts with the IOUs along the proportions occurring within the population for each stratum. Since the sample is based on electric accounts, customers who purchase gas from an IOU but not electric from an IOU are precluded from the sample. Likewise, customers who purchase electric from an IOU may have gas service from another provider. Equipment saturations will be collected for all customers with gas service regardless of service provider. Reporting for SoCalGas will be included based on the sample of customers with IOU electric accounts.

Table 7 presents the sample frame with the number of customers with gas service accounts with IOUs.

Table 7: Sampling Frame with Gas Service

A	B	C	D	E	F	G	H	I	J	K	L
Stratum	IOU	T24 Climate Zone Group	CARE FERA	Daily kWh	Number of Customers	Number of Customers with Gas Account	Proportion with Gas Accounts	Average Daily Therms	Std Dev Daily Therms	Percent Daily kWh	Percent Daily Therms
1	PGE	I	N	<= 20.9	939,212	719,074	77%	677,504	1.1	5%	6%
2	PGE	I	N	<= 33	388,491	303,553	78%	443,018	0.8	5%	4%
3	PGE	I	N	> 33	224,254	144,026	64%	284,951	2.2	5%	3%
4	PGE	I	Y	<= 20.6	467,446	389,599	83%	393,510	0.7	3%	4%
5	PGE	I	Y	<= 32.7	232,332	188,696	81%	254,629	0.7	3%	2%
6	PGE	I	Y	> 32.7	123,785	80,505	65%	153,863	8.0	3%	1%
7	PGE	M	N	<= 14.9	1,533,933	1,123,368	73%	1,109,650	2.3	6%	10%
8	PGE	M	N	<= 25.4	627,322	520,179	83%	823,176	1.8	6%	8%
9	PGE	M	N	> 25.4	304,362	225,950	74%	552,879	5.4	6%	5%
10	PGE	M	Y	<= 15.2	465,218	366,882	79%	350,730	1.1	2%	3%
11	PGE	M	Y	<= 28	209,521	168,805	81%	244,930	0.8	2%	2%
12	PGE	M	Y	> 28	75,015	47,172	63%	142,022	17.8	2%	1%
13	SCE	D	N	<= 27.1	79,399	46,949	59%	31,606	0.7	0%	0%
14	SCE	D	N	<= 48.1	26,808	21,484	80%	27,707	1.1	0%	0%
15	SCE	D	N	> 48.1	12,976	11,137	86%	32,102	3.1	0%	0%
16	SCE	D	Y	<= 24.2	24,353	14,487	59%	9,716	0.5	0%	0%
17	SCE	D	Y	<= 36.9	12,295	8,551	70%	7,895	0.6	0%	0%
18	SCE	D	Y	> 36.9	7,600	5,604	74%	7,260	1.0	0%	0%
19	SCE	I	N	<= 18.2	1,612,167	1,052,084	65%	966,509	0.7	7%	9%
20	SCE	I	N	<= 29.7	640,260	518,182	81%	701,992	0.7	7%	6%
21	SCE	I	N	> 29.7	352,762	286,409	81%	575,221	1.5	7%	5%
22	SCE	I	Y	<= 15.6	800,106	560,824	70%	479,021	0.6	4%	4%
23	SCE	I	Y	<= 24.8	400,663	295,355	74%	374,334	0.6	4%	3%
24	SCE	I	Y	> 24.8	234,996	168,752	72%	274,079	0.9	4%	3%
25	SCE	M	N	<= 14.8	575,692	284,352	49%	253,913	0.7	2%	2%
26	SCE	M	N	<= 25.5	228,303	150,842	66%	209,485	0.8	2%	2%
27	SCE	M	N	> 25.5	112,420	79,243	70%	188,935	2.2	2%	2%
28	SCE	M	Y	<= 12.5	126,138	58,196	46%	46,487	0.6	0%	0%
29	SCE	M	Y	<= 20.5	62,214	31,568	51%	39,036	0.7	0%	0%
30	SCE	M	Y	> 20.5	34,922	17,466	50%	29,021	0.9	0%	0%
31	SDGE	I	N	<= 18.4	219,329	143,777	66%	134,208	3.3	1%	1%
32	SDGE	I	N	<= 31.1	88,816	65,282	74%	81,175	2.4	1%	1%
33	SDGE	I	N	> 31.1	47,423	28,458	60%	61,868	4.2	1%	1%
34	SDGE	I	Y	<= 14.8	63,893	37,053	58%	26,356	1.3	0%	0%
35	SDGE	I	Y	<= 25.2	32,483	20,446	63%	20,928	0.6	0%	0%
36	SDGE	I	Y	> 25.2	16,766	8,996	54%	12,756	2.1	0%	0%

A	B	C	D	E	F	G	H	I	J	K	L
Stratum	IOU	T24 Climate Zone Group	CARE FERA	Daily kWh	Number of Customers	Number of Customers with Gas Account	Proportion with Gas Accounts	Average Daily Therms	Std Dev Daily Therms	Percent Daily kWh	Percent Daily Therms
37	**SDGE**	**M**	**N**	**<= 13.5**	565,791	360,336	64%	268,337	2.8	2%	2%
38	**SDGE**	**M**	**N**	**<= 23.5**	221,662	182,343	82%	196,314	2.1	2%	2%
39	**SDGE**	**M**	**N**	**> 23.5**	110,076	97,407	88%	179,464	3.1	2%	2%
40	**SDGE**	**M**	**Y**	**<= 11.5**	143,281	98,044	68%	61,381	1.6	0%	1%
41	**SDGE**	**M**	**Y**	**<= 18.9**	72,179	54,452	75%	50,267	0.7	1%	0%
42	**SDGE**	**M**	**Y**	**> 18.9**	39,739	32,839	83%	40,538	0.7	1%	0%
TOTAL					12,556,403	9,018,727		10,818,770		100%	100%

Recommended Sample Allocation

KEMA believes allocating the sample by utilizing the 40/40/20 by kWh method will produce the best overall balance of study objectives. The columns have been shaded in Tables 4 through 6 to highlight the final sample allocation.

Table 4: Columns H and I
Table 5: Columns I and J
Table 6: Columns H and I

APPENDIX G. LAMP CHOICE MODEL METHODOLOGY

Overview

Upstream lighting programs use incentives to influence consumer decision-making. The underlying theory is that providing discounts for a CFL or LED lamp makes that CFL or LED lamp a more attractive choice relative to other lamp choices. The question behind this impact evaluation is: what choice would the consumer have made in the absence of the incentive? The program's effects include providing lower-priced lamps in retail stores than would be available without the program, enabling specific retail stores (such as those in the discount channel) to stock lamps that they otherwise would meet their price point requirements. Discrete choice models are the analytical framework designed to address these types of effects. Discrete choice models combine the relevant information about each possible choice— for example, the lamp price and consumer characteristics—and assign a probability to each of the choices. To answer the impact evaluation question, we use the model to estimate the mix of lamp choices with and without the program in place. The difference is the movement of lamp purchases attributable to the program.

This section presents a summary of the data available for estimation and the estimation results for each of the two lamp replacement categories (A-lamp replacements and reflector lamp replacements) as described in Section 6.1.2. For additional background on logit models details on how we developed the lamp choice model, please refer to the CPUC ED 2010-12 California Upstream and Residential Lighting Impact Evaluation Work Order 28 (WO28) Final Report.[79]

Data

Estimating a discrete choice model requires data regarding consumer preferences and their characteristics. DNV GL (formerly DNV KEMA and KEMA, Inc.) collected these data with in-store shopper intercept surveys (please refer to APPENDIX I for the data collection instrument). The goal of the data collection was to capture the relationships between the choices that consumers make, the prices of lamps available to consumers, and consumer characteristics. Consumers' ranked preferences regarding their lamp choices forms the dependent variables of the logit model. The prices, the retail channels, and customer characteristics are the independent variables.

We collected data regarding characteristics of the intercepted shoppers, the lamp(s) they purchased, and their lamp installation intentions as we expected there would be some correlation between these characteristics and lamp technology preferences. The specific elements we used to construct the lamp choice model include:

- **Replaced lamp technology.** Our expectation was that technology of the lamp the consumer is replacing can influence the purchase decisions. A consumer who is replacing a CFL, for example, may be more likely to purchase a CFL than a consumer who is replacing an incandescent lamp.
- **Annual household income.** Our expectation was that price sensitivity would vary by income level. We settled on three household income categories for constructing the lamp choice model: high income ($100,000 or greater), middle or low income (less than $100,000), and unknown/refused.
- **Rent versus own.** Our expectation was that consumer preferences regarding lamp technologies vary with homeowner status. For example, LED lamps have longer expected lifetimes compared to other technologies as well as higher retail prices. Consumers who are more transient (such as renters versus homeowners) may not realize an energy savings payback from LED lamps.
- **Planned purchased versus impulse purchase.** Our expectation was that the price of the lamp would have greater influence on the decisions of impulse purchasers than on the decisions of shoppers who entered the store planning to purchase a lamp or lamps on the day of the shopper intercept survey.

[79] DNV GL, 2014c.

Estimation approach and results

We estimated separate models for each lamp replacement category (A-lamp replacements and reflector lamp replacements) following the same general approach. We started with simple models and incrementally added complexity to increase the explanatory power of the model and/or to improve the relationships among the model parameters. The general approach is as follows:

1. **Establish the fundamental relationship.** We designed the model primarily to capture the effect of program price incentives on consumer choice. This model specification, shown in Table 88, has alternative-specific constants and generic coefficient on price. The alternative-specific constants force the model to predict market shares that are consistent with market shares in the survey data. The generic price coefficient constrains consumers to have the same price sensitivity toward each alternative technology.

   These results meet our *a priori* expectation that the price coefficient is negative. Consumers prefer lower prices, all other things being equal. Further, we see that consumers are more price-sensitive when shopping for A-lamp replacements than when shopping for reflector lamp replacements. This is consistent with our observation that A-lamps are more of a commodity good than reflector lamps. Manufacturers of reflector lamps compete through a combination of price and unique features. In comparison, A-lamp replacements have fewer distinguishing features and compete mostly on price.

   Technical note: we need to fix the value of one alternative-specific constant. (This is due to utility values being relative.) We have fixed the value of the CFL alternative (the CFL spiral in the case of the A-lamp replacements model) to zero.

Table 88. Initial estimation results of the A-Lamp replacement model and reflector lamp replacement model, 2015-16

Coefficient	A-lamp Replacements		Reflector Lamp Replacements	
	Estimate	T-Stat	Estimate	T-Stat
Incandescent A-lamp	-1.25	-13.45	0.55	4.51
Halogen A-lamp	-1.22	-12.47	N/A	N/A
CFL spiral				
CFL A-lamp	-1.15	-9.10	N/A	N/A
LED A-lamp	1.34	7.28	1.35	7.67
Price	**-0.24**	**-15.47**	**-0.10**	**-9.03**
Pseudo R2	**0.18**		**0.27**	

2. **Refine the model specification.** The refinements include:

   a. **Differentiate price-sensitivity by alternative**. We let the price coefficients vary by technology. Incandescent, CFL, and LED lamps are not perfect substitutes for each other. LED lamps, for example, have a much longer expected life. Our expectation was that consumers would be most price-sensitive toward incandescent lamps and the least price sensitive toward LED lamps because of differences in the technologies. The result was consistent with our *a priori* expectations for each model.

   b. **Constrain to channel targets.** We constrained the model to match the observed market shares for each alternative by channel. This constraint accounts for the unobserved differences between channels.

c. **Include customer characteristics.** We included customer characteristics in the model to reflect that each retail channel serves different populations. We included four customer characteristics in the models:

i. **Income.** We stratified the price variable by income level to reflect that consumers with a household income of $100,000 or greater (high income) are less price sensitive than other consumer groups.
ii. **Planned versus impulse purchases.** For the A-lamp replacements model, we stratified the price variable by planned versus impulse purchase. The result was consistent with our expectation that planned purchasers would be less price-sensitive than impulse purchasers. Consumer who visited a store to buy a particular lamp tended to be less price-sensitive than a consumer who decided to buy a lamp when at the store.
iii. **Replacement lamp technology.** The model results supported our expectation that consumers tend not to switch technologies when replacing a lamp.
iv. **Rent versus own.** LED lamps save consumers money over time. However, they have a high initial cost than other technologies. Consumers who own their homes tend to make longer-term decisions than consumers in rental units. Results in past years suggested that renters were less likely to buy LED lamps than homeowners; however, during this most recent wave rent versus own was not statistically significant.

Table 89 and Table 90 show the final model estimations results for A-Lamp replacements and reflector lamp replacements, respectively. Note that the high-wattage modelled results simulate high-wattage choices using the A-lamp replacement model. The table groups related variables:

- **Alternative-specific constants.** These constants ensure that the total market share for each technology is consistent between model predictions and survey responses.
- **Channel constants.** These constants ensure that the total market share for each technology is consistent between the model predictions and survey responses by retail channel.
- **Price by technology.** These constants reflect the impact of price on utility for each technology
- **Price/technology interactions by latest wave.** Only A-lamp purchases are in a large enough quantity to control for time, whereas reflectors are limited.
- **Price/income interactions** We were able to quantify that high-income consumers are less price sensitive than consumers in other groups for A-lamp replacements and reflector replacements. The difference being that the reflectors does not stratify income by lamp technology whereas the A-lamps lamp choice model does stratify income by each lamp technology.
- **Pseudo R^2.** For each lamp replacement category, the overall fit of the final model shows improvement over the initial results shown in Table 88. Pseudo R^2 values tend to decrease as the number of alternatives in the model increases. As there are five alternatives in the A-lamp replacements model, we expected a relatively lower pseudo R^2 value.

Table 89. Model estimation results for A-lamp replacements, 2015-16

Variable	Estimate	T-Statistic
Alternative-specific constants		
Incandescent A-lamp	-1.43	-8.17
Halogen A-lamp	-1.16	-6.39
CFL spiral		
CFL A-lamp	-1.15	-3.81
LED A-lamp	-0.49	-2.19
Channel constants for incandescent A-lamps		
Discount	1.02	4.19
Drug	-0.09	-0.23
Grocery	1.03	2.05
Hardware	0.33	1.26
Home Improvement	0.42	1.89
Channel constants for halogen A-Lamps		
Drug	0.19	0.52
Grocery	1.55	2.73
Hardware	0.32	1.27
Home Improvement	-0.23	-1.14
Channel constants for CFL A-Lamps		
Discount	0.66	1.87
Hardware	0.52	1.49
Home Improvement	0.32	0.96
Channel constants for LED A-lamps		
Hardware	1.30	3.97
Home Improvement	1.45	6.03
Price by technology		
Incandescent A-lamp	-0.47	-8.74
Halogen A-lamp	-0.38	-6.50
CFL spiral	-0.31	-14.15
CFL A-lamp	-0.39	-7.68
LED A-lamp	-0.17	-10.98
Price / technology interactions by latest wave		
Incandescent A-lamp	-0.04	-0.38
Halogen A-lamp	0.02	0.27
CFL spiral	-0.02	-0.51
CFL A-lamp	-0.07	-0.97
LED A-lamp	-0.03	-1.54
Price / high income interactions		
High Income	0.06	3.97
Low Income	0.01	0.32
Pseudo R^2	**0.25**	

Table 90. Model estimation results for reflector lamp replacements, 2015-16

Variable	Estimate	T-Statistic
Alternative-specific constants		
Incandescent reflector	1.45	4.33
LED reflector	1.18	5.28
Channel constants for incandescent reflectors		
Hardware	-0.45	-1.14
Home improvement	-0.67	-2.37
Channel constants for LED reflectors		
Hardware	-1.14	-2.35
Home improvement	-0.84	-3.08
Price by technology		
Incandescent reflector	-0.22	-7.55
CFL reflector	-0.15	-5.84
LED reflector	-0.10	-7.15
Price / income interactions		
High income	-0.01	-0.25
Unknown income	0.03	2.58
Pseudo R^2		**0.30**

After obtaining the final model coefficients indicated in Table 89 and Table 90, DNV GL applied these fitted models to three scenarios.

Simulation and Scenario Analysis Methodology

Overview

Although the lamp choice model is interesting and insightful on its own, to add value from the lamp choice model, it is essential to perform a scenario analysis, via simulations. There are two scenarios we produced from simulations a with program, and without program that adjusted supply to reflect no program.

Data

Retail lamp stock inventories. DNV GL conducted the most recent phase of stock inventories and shopper intercept surveys during the winter of 2015-16. Field staff spent a minimum of four hours in each store completing the shelf surveys and attempting to intercept shoppers to participate in in-store surveys. Field staff completed surveys opportunistically—that is, with individuals who were shopping during the time periods in which we conducted intercept surveys in specific stores. As such, results from the intercept surveys may not represent the broader population of shoppers purchasing replacement lamps at various stores throughout the year. Nonetheless, given the range in timeframes and store types in which we conducted these surveys, results provide general indications of shopper preferences, price sensitivity, lamp installation intentions, and so on.

The lamp stock inventory sample targeted approximately 200 stores. We stratified the sample by retail channel and IOU service territory (for PG&E, SCE, and SDG&E territories) and designed the sample to represent the retail market for residential replacement lamps in these areas. The sample design targeted roughly equal numbers of stores in each retail channel to ensure enough sample points per channel to enable channel-to-channel comparisons.

The LCM reflects the lamp prices and availability that DNV GL staff observed in retail stores during the retail stock inventories. We updated the LCM to ensure that it represents the mix of lamp stock found on retail shelves during the winter of 2015-16. Because we only visit each store on a single day, in-store surveys do not fully capture the year-long availability of program-discounted lamps. We therefore expanded the shelf data to include all 2015 program-discounted lamps. We matched store names in the IOU tracking data to store names in the shelf data, and used a hedonic model to estimate the program lamp price.[80]

Shopper intercept surveys. In addition to collecting shelf survey data at those stores, DNV GL administered an in-store survey to shoppers present during the store visit. Due to being a convenience sample, this survey is not representative of the whole population of lamp shoppers in California during that year. Nevertheless, with the various timeframes and store types where we conducted these surveys, the results are generally indicative of shopper preferences, price sensitivity, lamp installation intentions, and so on. For instance, the surveys were stratified by retail channel and IOU service territory so the sample can represent the retail market for residential replacement lamps in these areas. Additionally, the sample focused on having a roughly equal number of stores from each channel to ensure enough sample points in each channel to enable channel-to-channel comparisons. Researchers from DNV GL intercepted shoppers,

80 See DNV GL, DNV GL, 2016a for further detail.

who were purchasing replacement lamps, and surveyed them on their purchase decisions and installation intentions for the lamps being purchased. We conducted over 800 intercept surveys concurrent with the winter of 2014-15 and winter 2015-16 shelf surveys.[81] DNV GL also collected these data in previous evaluation periods.[82]

Program tracking data. Each of the IOUs uploads program tracking data onto a centralized server. We use the tracking data to augment the retail lamp stock inventory data, and to assign program discounts to the simulations, which we describe in greater detail below.

In-depth telephone interviews with lamp supplier representatives. During the second quarter of 2016, DNV GL researchers conducted an in-depth survey of lamp suppliers with suppliers participating lamp manufacturers. These representatives shared their perspectives on the influences of the ULP, regulations, standards on California's residential replacement lamp market, as well as numerous other topics. We asked them to predict CFL and LED lighting sales with program discounts available, and one without IOU support for CFLs and LED lamps. The 2015 sample frame included 31 manufacturing organizations and the 13 retail chains to which manufacturers shipped the largest shares of total 2013-14 ULP lamps. DNV GL also collected these data in previous evaluation periods.[83]

2016 consumer telephone survey. During October, 2016, DNV GL conducted telephone surveys with PG&E, SCE, and SDG&E residential electric customers. These surveys asked consumers how many lamps they purchased within the A-lamp replacement and reflector lamp replacement categories since January 1, 2015, and where they made those purchases. The 2016 consumer telephone survey provided key inputs to generation the simulations. These included:

a. **Distribution of lamp purchases by retail channel.** One challenge in using the LCM in previous impact evaluations is that the model relies, in part, on results from the in-store shopper intercept surveys. The intercept surveys are, by necessity, based on a convenience sampling approach. To improve the LCM's ability to represent the distribution of lamp purchases by retail channel within the purchaser population, we included questions in the 2016 consumer telephone surveys to address recent purchase locations (retail channels).

b. **Customer demographics together with recent lamp purchase information.** We used the 2016 consumer telephone survey respondents to represent the universe of lamp purchase decisions (rather than intercept survey respondents).

California Lighting Appliance Saturation Study (CLASS). This survey, produced in 2012 by DNV GL, builds upon previous ones in 2005 and 2000 and consists of stratified random sampling of 1,987 people who live in either single-family, multi-family, or mobile homes with individually metered electric accounts. Teams of people from DNV GL travelled to the homes to collect the data. It includes a complete lamp inventory of each home, characteristics of each home, demographics for each respondent, and an appliance inventory. Lamp characteristics include a count of every type of lamp installed and stored, lamp fixture location, lights per fixture, fixture type, lamp technology, lamp wattage, lamp shape, and lamp base type.

The Simulation Building Process

[81] Table 3 in "California Residential Replacement Lamp Market Status Report: Upstream Lighting Program and Market Activities in California through 2015" shows the number of intercept surveys by channel for the last two waves.

[82] Additional information on the results of the intercept surveys can be found in 5.1-5.4 in "California Residential Replacement Lamp Market Status Report: Upstream Lighting Program and Market Activities in California through 2015".

[83] Additional information on the supplier surveys can be found in 4.1 in "California Residential Replacement Lamp Market Status Report: Upstream Lighting Program and Market Activities in California through 2015"

We build LCM simulations based on a series of steps that leverage the data described above. We created three sets of simulations based on the three lamp replacement categories described in Section 6.1.2 (A-lamp replacement, reflector replacement, high-wattage replacement). These steps were:

1. **Compile and augment retail lamp stock inventory dataset**. Because we could only collect retail lamp stock data over a single day, we may not have visited participating stores when they were offering discounted lamps. We thus append program lamps from tracking data to the retail lamp stock data sets. This merge is performed when the store name and zip code match between the tracking data and retail lamp stock data. The augmented retail lamp stock inventory dataset then allows us to model a full year's worth of program lamp data. (Retail lamp stock inventory data and 2015 program tracking data)
2. **Estimate prices for program lamps that were not observed in stores.** While the 2015 program tracking data provides discount amounts, it does not list the full-retail price of those lamps. We thus used a hedonic model to estimate the retail prices of these augmented lamps.
3. **Identify the quantity and retail locations of lamps purchased in California**. We used 2016 consumer phone surveys to identify the quantity of lamps purchased across different locations. These purchases became the basis for each simulation that we ran through the model. We created 10 simulations for every lamp purchase.
4. **Assign customer demographics to each lamp purchase.** Using the same 2016 survey responses that provided the quantity and location of lamp purchases, we assigned demographic data to these simulations as reported by the survey respondents. These demographic variables included: income, education, number of bedrooms, number of bathrooms, and whether the respondent rented or owned their home.
5. **Estimate the lumen category for each purchased lamp.** While we asked survey respondents to identify the quantity and location of their lamp purchases, we used CLASS data to identify the percentage of installed lamps that fell within 4 lumen bins (where 1 is the lowest lumen and 4 is the highest lumen). We considered the demographics of each respondent, and used the frequency that lamps of each lumen bin were installed in homes matching their demographic to select a lumen bin in a probabilistic random fashion. We assigned this lumen bin to the lamp and store purchase simulation.
6. **Select comparable on-shelf lamps to model customer purchase utility and probability.** We referred back to the augmented retail lamp stock inventory data (described in step 1) to build a simulation that represented the survey respondent's lamp purchase. For every simulation, we selected one program lamp from the retail lamp stock inventory data, and any non-program lamps of competing technologies that were available and within the same lumen bin.
7. **Assign with program prices to create simulations that represent a with program universe.** Using the augmented retail lamp stock inventory data, we assigned observed (and hedonically modelled when observed were not available) with program prices. We aggregated all simulations to product a model universe of lamp purchases that were made in California when program discounts were available.
8. **Remove discounts and adjust lamp availability to create simulations that represent a without program universe.** We used the with program simulations, but increased the prices of program lamps by the discounts observed in the tracking data. Additionally, we removed program lamps from the simulations when suppliers informed us that they would not have sold those lamps in those respective channels without the program (known in prior evaluations as "reliant" or "constrained")
9. **Adjust membership club availability.** In membership club store, in the absence of the program, suppliers suggested sales would have been mostly CFLs, claimed that LED lamps would still have been available. If we did not adjust lamp availability, our model would have no choice but to suggest customers would have purchased LED lamps with and without the program. We thus added CFL availability to membership club shelves in the without program simulations. We retained availability of the LED lamps in these simulations as well. The resulting simulations

represent our best estimate of the conditions that would have been observed in the absence of the program.

Two Scenarios for the California Lighting Marketplace

We created two scenarios to estimate the lighting marketplace in California with the program and without the program:

- **With program scenario**. This scenario reflects the lamp prices and availability that DNV GL observed in retail stores during the retail lamp stock inventories conducted in winter 2015-16. This scenario results in an estimate of the share of program lamp sales for each modelled technology in 2015.
- **Without program scenario.** This scenario reflects the lamp prices as well as stocking changes that consumers would have seen in California retail stores in 2015, if the program had not occurred. DNV GL estimated price differences based on matching lamps to program tracking data. This scenario results in a counterfactual estimate of market shares that would have occurred if only prices on program-discounted lamps changed due no program activity. As we described in Section 3.2 above, we asked supplier representatives to indicate whether their companies would or would not have sold specific lamp types through specific retail channels in the absence of the program, we considered those lamps to be program-reliant. (For example, if a supplier representative told us he or she would not have sold basic spiral CFLs to drug stores without upstream lighting program incentives, we considered the presence of these lamps in drug stores to be program-reliant.) In a select number of cases, we use supplier responses to account for additional program influences (which we will discuss Section 6). This scenario resulted in a counterfactual estimate of market shares if program-reliant lamps were not in stores and if the IOUs did not discount lamps.

Net to Gross from Simulation Estimates

The lamp choice model estimates with program and without program lamp market shares that feed directly into the NTGRq calculation (Equation 22).

Equation 22. Model-based NTGRq

$$NTGRq = \frac{Program\ Share - No - Program\ Share}{Program\ Share}$$

The NTGRq is the percentage change in market share due to the influence of program activity—that is, the difference between the observed and counterfactual market shares divided by the program market share. For each combination of channel and lamp technology, we evaluated the differences between the with program observed scenarios and the without program counterfactual scenario.

APPENDIX H. ADDITIONAL TABLES – NET SAVINGS

Supplier Market Share Estimates

A-lamp lamp replacement category

Table 91 presents the average supplier market share estimate for each a-lamp replacement technology with program discounts available and without program lamp discounts available. Because MSB CFL A-lamp ≤ 30 W lamps, MSB CFL basic spiral ≤ 30 W lamps, and MSB LED A-lamps are all options within this lamp replacement category, these measure groups displace purchases from one another. This oversimplifies the way the program works in the market in that it does not allow us to disaggregate the influence of the program's incentives for *one measure group at a time* within the lamp replacement category. The supplier estimates present an "all or nothing" perspective—in other words, these estimates suggest the market shares when incentives for all three measure groups are available (the "with program" estimates) versus when incentives for none of the three measure groups are available (the "without program" estimates). Because the impact evaluation must assign savings at the measure group level, we must be able to disaggregate these estimates.

This is the reason that we are unable to combine supplier estimates of market impacts with LCM estimates. However, while the supplier estimates do not feed into the impact calculations, the suppler perspective provides important insights into the overall market influence of the program as a whole (without disaggregating by measure group as required for the impact assessment).

Table 91. Supplier-based technology market share estimates for the A-lamp replacement category market (2016 supplier interviews)

Lamp Technology and Shape	Market Share	
	With Program	Without Program
MSB CFL basic spiral ≤ 30 W	22%	35%
MSB CFL A-lamp ≤ 30 W	10%	7%
MSB LED A-lamp, all wattages	51%	29%
MSB incandescent, EISA compliant	12%	17%
MSB incandescent A-lamp	5%	11%
Total affected market	**100%**	**100%**

Reflector lamp replacement category

Table 92 displays the average supplier market share estimate for each reflector technology with program discounts available and without program lamp discounts available. Similar to the a-lamp replacement category, we see that CFL reflector lamps ≤ 30 W would have slightly increased in the absence of the program. This finding is a result of the relative impacts that the two reflector measure groups have against one another.

Table 92. Supplier-based technology market share estimates for the reflector replacement category market

Lamp Technology and Shape	Market Share	
	With Program	Without Program
MSB CFL Reflector Lamps ≤ 30 W	36%	38%
MSB LED Reflector Lamps, All Wattages	57%	41%
MSB Halogen Reflector Lamps	5%	8%
MSB Incandescent Reflector Lamps	2%	13%
Total affected market	**100%**	**100%**

High-wattage lamp replacement category

Table 93 shows the average supplier market share estimate for each high-wattage replacement technology with program discounts available and without program lamp discounts available.

Table 93. Supplier-based technology market share estimates for the high-wattage replacement category market

Lamp Technology and Shape	Market Share	
	With Program	Without Program
MSB High-Wattage CFL > 30 W	70%	59%
MSB LED A-lamps, High Wattage	13%	19%
MSB Halogen A-lamps, High Wattage	9%	11%
MSB Incandescent A-lamps, High Wattage	8%	11%
Total affected market	100%	100%

Derivation of NTGRu weighting mechanism

For a given program lamp type L, the total savings in a channel "c" is the product of program volume V_{LC}, NTGRq, and market UES (temporarily ignoring the interactive effects and installation rate that are the same across channels). The market UES is the product of the NTGRu and the gross UES. Equation 23 presents this calculation below.

Equation 23. Net savings for program lamp type L, channel C, and IOU I

$$Net\ Savings_{L,C,I} = NTGRq_{L,C} \times NTGRu_{L,C} \times UESg_{L,I} \times V_{L,C,I}$$

Where:

$NTGRq_{L,C}$ = Quantity net to gross ratio for program lamp type "L" and channel "C"

$NTGRu_{L,C}$ = UES net to gross ratio for program lamp type "L" and channel "C"

$UESq_{L,I}$ = Gross savings UES for program lamp type "L", and IOU "I"

$V_{L,C,I}$ = Volume of program lamp type "L", channel "C", and IOU "I"

For each IOU, we sum the net savings of each channel to calculate total net savings for each program lamp type. Equation 24, below, provides the details for this calculation.

Equation 24. Total net savings for program lamp type L, and IOU I

$$Total\ Net\ Savings_{L,I} = \sum_{C}^{i} Net\ Savings_{L,C,I}$$

Where:

Net $Savings_{L,CiI}$= Net savings for program lamp type "L", Cannels "C" through "I" (discount through Membership Club, channel-shifted), and IOU "I"

For each IOU, we define the overall NTGRq as the volume-weighted channel-specific values. Equation 25, shown below, details this calculation:

Equation 25. NTGRq for program lamp type L, and IOU I

$$NTGRq_{L,I} = \frac{\sum_{C1}^{C7}(NTGRq_{L,Ci,} \times V_{L,Ci,I})}{\sum_{C1}^{C7} V_{L,Ci,I}} = \sum_{C1}^{C7}\left(NTGRq_{L,C,I} \times \frac{V_{L,Ci,I}}{V_{L,I}}\right)$$

Where:

$NTGRq_{L,Ci,I}$ = Quantity net to gross ratio for program lamp type "L", and channel "C1" (discount) through "C7" (Membership club)

$V_{L,Ci,I}$ = Volume of program lamp type "L", shipped to channels "C1" (discount) through "C7" (membership club) by IOU "I"

$V_{L,I}$ = Total volume of program lamp type "L", shipped by IOU "I"

Lastly, we can define the overall UES adjustment as the sum of the channel adjustment factors, weighted by the product of NTGRq and program volume. Equation 26 provides the calculation for this step.

Equation 26. Overall NTGRu for program lamp type L, and IOU I, weighted by product of the NTGRq and the Volume

$$NTGRu_{L,I} = \frac{\sum_{C}^{i}(NTGRu_{L,C} \times NTGRq_{L,C} \times V_{L,C,I})}{\sum_{C}^{i}(NTGRq_{L,C} \times V_{L,C,I})}$$

With these definitions,

$$Total\ Savings = NTGRq_{L,Ci} \times NTGRu_{L,I} \times UESg_{L,I} \times V_{L,Ci,I}$$

$$= \sum_{C1}^{C7}\left(\frac{NTGRq_{L,Ci} \times V_{L,Ci,I}}{V_{L,I}}\right) \times \frac{\sum_{C1}^{C7}(NTGRu_{L,Ci} \times NTGRq_{L,Ci} \times V_{L,Ci,I})}{\sum_{C1}^{C7}(NTGRq_{L,Ci}\ V_{L,Ci,I})} \times UESg_{L,I} \times V_{L,I}$$

$$= \sum_{C1}^{C7}(NTGRu_{L,Ci} \times NTGRq_{L,Ci,} \times UESg_{L,I} \times V_{L,Ci,I})$$

Final Net Savings Tables

The following series of tables provide the results that lead to the NTGRq, NTGRu, and overall NTGRs for each measure group.

MSB CFL basic spiral ≤ 30 W

Table 94. Market shares with and without the program for CFL basic spiral lamps

Lamp Technology and Shape	Market Share	
	With Program	Without Program
Discount		
MSB CFL Basic Spiral	95%	73%
MSB CFL A-Lamp	0%	0%
MSB LED A-Lamp	0%	0%
MSB Incandescent, EISA Compliant	0%	0%
MSB Incandescent A-lamp	5%	27%
Drug[1]		
MSB CFL Basic Spiral	N/A	N/A
MSB CFL A-Lamp	N/A	N/A
MSB LED A-Lamp	N/A	N/A
MSB Incandescent, EISA Compliant	N/A	N/A
MSB Incandescent A-lamp	N/A	N/A
Grocery		
MSB CFL Basic Spiral	89%	88%
MSB CFL A-Lamp	3%	2%
MSB LED A-Lamp	3%	4%
MSB Incandescent, EISA Compliant	3%	5%
MSB Incandescent A-lamp	1%	2%
Hardware[1]		
MSB CFL Basic Spiral	N/A	N/A
MSB CFL A-Lamp	N/A	N/A
MSB LED A-Lamp	N/A	N/A
MSB Incandescent, EISA Compliant	N/A	N/A
MSB Incandescent A-lamp	N/A	N/A
Home improvement		
MSB CFL Basic Spiral	37%	21%
MSB CFL A-Lamp	8%	8%
MSB LED A-Lamp	36%	38%
MSB Incandescent, EISA Compliant	5%	6%
MSB Incandescent A-lamp	14%	28%
Mass merchandise		
MSB CFL Basic Spiral	53%	44%
MSB CFL A-Lamp	0%	0%
MSB LED A-Lamp	6%	8%
MSB Incandescent, EISA Compliant	27%	33%
MSB Incandescent A-lamp	13%	15%
Membership club		
MSB CFL Basic Spiral	78%	58%
MSB CFL A-Lamp	0%	0%
MSB LED A-Lamp	22%	42%
MSB Incandescent, EISA Compliant	0%	0%
MSB Incandescent A-lamp	0%	0%

[1]We did not model these channels because the program did not ship lamps to them.

Table 95. Average wattage displaced by program CFL basic spiral purchases

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Basic Spiral	N/A	N/A	70.1
MSB CFL A-Lamp	0%	N/A	
MSB LED A-Lamp	0%	N/A	
MSB Incandescent, EISA Compliant	0%	N/A	
MSB Incandescent A-lamp	100%	70.1	
Drug[3]			
MSB CFL Basic Spiral	N/A	N/A	N/A
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	N/A	N/A	
MSB Incandescent A-lamp	N/A	N/A	
Grocery			
MSB CFL Basic Spiral	N/A	N/A	36.9
MSB CFL A-Lamp	0%	N/A	
MSB LED A-Lamp	31%	9.9	
MSB Incandescent, EISA Compliant	51%	48.0	
MSB Incandescent A-lamp	18%	51.5	
Hardware[3]			
MSB CFL Basic Spiral	N/A	N/A	N/A
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	N/A	N/A	
MSB Incandescent A-lamp	N/A	N/A	
Home improvement			
MSB CFL Basic Spiral	N/A	N/A	49.1
MSB CFL A-Lamp	1%	14.1	
MSB LED A-Lamp	11%	9.2	
MSB Incandescent, EISA Compliant	3%	49.1	
MSB Incandescent A-lamp	85%	54.7	
Mass merchandise			
MSB CFL Basic Spiral	N/A	N/A	43.7
MSB CFL A-Lamp	0%	N/A	
MSB LED A-Lamp	16%	10.4	
MSB Incandescent, EISA Compliant	59%	49.1	
MSB Incandescent A-lamp	26%	51.5	
Membership club			
MSB CFL Basic Spiral	N/A	N	9.4
MSB CFL A-Lamp	0%	N/A	
MSB LED A-Lamp	100%	9.4	
MSB Incandescent, EISA Compliant	0%	N/A	
MSB Incandescent A-lamp	0%	N/A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data
[3]We did not model these channels because the program did not ship lamps to them.

Table 96. Market delta watts for CFL basic spiral

Channel	Average Displaced Wattage (Watts)	Average Program Discounted Wattage (Watts)[1]	Market Delta Watts
PG&E			
Discount	70.1	21.5	48.6
Drug[2]	N/A		N/A
Grocery	36.9		15.4
Hardware[2]	N/A		N/A
Home improvement	49.1		27.6
Mass merchandise	43.7		22.2
Membership club	9.4		(12.1)
SCE			
Discount	N/A	N/A	N/A
Drug[2]	N/A		N/A
Grocery	N/A		N/A
Hardware[2]	N/A		N/A
Home improvement	N/A		N/A
Mass merchandise	N/A		N/A
Membership club	N/A		N/A
SDG&E			
Discount	70.1	15.8	54.2
Drug[2]	N/A		N/A
Grocery	36.9		21.0
Hardware[2]	N/A		N/A
Home improvement	49.1		33.3
Mass merchandise	43.7		27.9
Membership club	9.4		(6.4)

[1]Source: 2015 program tracking data
[2]We did not model these channels because the program did not ship lamps to them.

Table 97. Calculation of CFL basic spiral lamps that shifted into membership club due to the program

IOU	Program lamps purchased at Membership club[1]	Program lamps that would have shifted channels without the program		
		Percent of Membership club program purchases that would have occurred elsewhere[2]	Quantity of lamp purchases that would have occurred elsewhere	Quantity of lamp purchases that would have still occurred at Membership club
PG&E	0	N/A	N/A	N/A
SCE	0		N/A	N/A
SDG&E	0		N/A	N/A

[1]Source: 2015 program tracking data
[2]Source: 2016 in-depth telephone interviews with lamp suppliers

Table 98. NTGRq, NTGRu, and overall NTGR for MSB CFL basic spiral ≤ 30 W

Channel	Count of Program lamps[1]	Gross UES	Net UES	NTGRu	NTGRq	Overall NTGR	SE	CI
PG&E								
Discount	432,026	14.6	29.8	204%	24%	49%	1%	1%
Drug[2]	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	30,690		9.4	65%	2%	1%	0%	0%
Hardware[2]	0		N/A	N/A	N/A	N/A	N/A	N/A
Home improvement	0		N/A	N/A	N/A	N/A	N/A	N/A
Mass merchandise	2,193		13.6	93%	18%	17%	1%	1%
Membership club, Unshifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Total	**464,909**		**29.6**	**203%**	**22%**	**46%**	**1%**	**2%**
SCE								
Discount	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Drug[2]	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	0		N/A	N/A	N/A	N/A	N/A	N/A
Hardware[2]	0		N/A	N/A	N/A	N/A	N/A	N/A
Home improvement	0		N/A	N/A	N/A	N/A	N/A	N/A
Mass merchandise	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Unshifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Total	**0**		N/A	N/A	N/A	N/A	N/A	N/A
SDG&E								
Discount	0	15.5	N/A	N/A	N/A	N/A	N/A	N/A
Drug[2]	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	0		N/A	N/A	N/A	N/A	N/A	N/A
Hardware[2]	0		N/A	N/A	N/A	N/A	N/A	N/A
Home improvement	2,377		17.2	111%	43%	48%	1%	1%
Mass merchandise	17,170		14.4	93%	18%	17%	1%	1%
Membership club, Unshifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Total	**19,547**		**15.1**	**98%**	**21%**	**21%**	**1%**	**2%**

[1]Source: 2015 program tracking data
[2]We did not model these channels because the program did not ship lamps to them.

MSB CFL A-lamp ≤ 30 W

Table 99. Market shares with and without the program for CFL A- lamps

Lamp Technology and Shape	Market Share	
	With Program	Without Program
Discount		
MSB CFL Basic Spiral	2%	12%
MSB CFL A-Lamp	76%	23%
MSB LED A-Lamp	0%	0%
MSB Incandescent, EISA Compliant	0%	0%
MSB Incandescent A-lamp	22%	65%
Drug		
MSB CFL Basic Spiral	34%	74%
MSB CFL A-Lamp	66%	3%
MSB LED A-Lamp	0%	4%
MSB Incandescent, EISA Compliant	0%	10%
MSB Incandescent A-lamp	0%	9%
Grocery		
MSB CFL Basic Spiral	0%	44%
MSB CFL A-Lamp	95%	1%
MSB LED A-Lamp	0%	4%
MSB Incandescent, EISA Compliant	5%	47%
MSB Incandescent A-lamp	0%	4%
Hardware		
MSB CFL Basic Spiral	16%	28%
MSB CFL A-Lamp	44%	0%
MSB LED A-Lamp	6%	8%
MSB Incandescent, EISA Compliant	21%	42%
MSB Incandescent A-lamp	12%	23%
Home improvement		
MSB CFL Basic Spiral	22%	23%
MSB CFL A-Lamp	4%	2%
MSB LED A-Lamp	57%	58%
MSB Incandescent, EISA Compliant	8%	9%
MSB Incandescent A-lamp	9%	9%
Mass merchandise		
MSB CFL Basic Spiral	39%	51%
MSB CFL A-Lamp	20%	15%
MSB LED A-Lamp	26%	14%
MSB Incandescent, EISA Compliant	10%	13%
MSB Incandescent A-lamp	5%	6%
Membership club[1]		
MSB CFL Basic Spiral	N/A	N/A
MSB CFL A-Lamp	N/A	N/A
MSB LED A-Lamp	N/A	N/A
MSB Incandescent, EISA Compliant	N/A	N/A
MSB Incandescent A-lamp	N/A	N/A

[1]We did not model these channels because the program did not ship lamps to them.

Table 100. Average wattage displaced by program CFL A-lamp purchases

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Basic Spiral	20%	22.2	60.7
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	0%	5.0	
MSB Incandescent, EISA Compliant	0%	54.3	
MSB Incandescent A-lamp	80%	70.1	
Drug			
MSB CFL Basic Spiral	64%	18.8	28.1
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	6%	10.0	
MSB Incandescent, EISA Compliant	15%	53.4	
MSB Incandescent A-lamp	14%	51.2	
Grocery			
MSB CFL Basic Spiral	47%	17.0	32.1
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	4%	9.9	
MSB Incandescent, EISA Compliant	45%	48.0	
MSB Incandescent A-lamp	5%	51.5	
Hardware			
MSB CFL Basic Spiral	26%	18.4	41.5
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	3%	9.8	
MSB Incandescent, EISA Compliant	47%	48.6	
MSB Incandescent A-lamp	23%	57.6	
Home improvement			
MSB CFL Basic Spiral	23%	16.4	21.2
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	52%	9.2	
MSB Incandescent, EISA Compliant	13%	49.1	
MSB Incandescent A-lamp	12%	54.7	
Mass merchandise			
MSB CFL Basic Spiral	71%	14.5	24.7
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	0%	0%	
MSB Incandescent, EISA Compliant	20%	49.1	
MSB Incandescent A-lamp	8%	51.5	
Membership club[3]			
MSB CFL Basic Spiral	N/A	N/A	N/A
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	N/A	N/A	
MSB Incandescent A-lamp	N/A	N/A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

[3]We did not model these channels because the program did not ship lamps to them.

Table 101. Market delta watts for CFL A-lamps

Channel	Average Displaced Wattage (Watts)	Average Program Discounted Wattage (Watts)[1]	Market Delta Watts
PG&E			
Discount	60.7	18.3	42.4
Drug	28.1		9.8
Grocery	32.1		13.8
Hardware	41.5		23.2
Home improvement	21.2		2.9
Mass merchandise	24.7		6.3
Membership club[2]	N/A		N/A
SCE			
Discount	60.7	18.2	42.5
Drug	28.1		10.0
Grocery	32.1		14.0
Hardware	41.5		23.4
Home improvement	21.2		3.1
Mass merchandise	24.7		6.5
Membership club[2]	N/A		N/A
SDG&E			
Discount	60.7	14.0	46.7
Drug	28.1		14.1
Grocery	32.1		18.1
Hardware	41.5		27.5
Home improvement	21.2		7.2
Mass merchandise	24.7		10.7
Membership club[2]	N/A		N/A

[1]Source: 2015 program tracking data
[2]We did not model these channels because the program did not ship lamps to them.

Table 102. NTGRq, NTGRu, and overall NTGR for MSB CFL A-lamp ≤ 30 W

Channel	Count of Program lamps[1]	Gross UES	Net UES	NTGRu	NTGRq	Overall NTGR	SE	CI
PG&E								
Discount	20,097	14.8	23.2	157%	70%	110%	0%	1%
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	0		N/A	N/A	N/A	N/A	N/A	N/A
Hardware	0		N/A	N/A	N/A	N/A	N/A	N/A
Home improvement	0		N/A	N/A	N/A	N/A	N/A	N/A
Mass merchandise	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Unshifted Counterfactual[2]	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual	N/A		N/A	N/A	N/A	N/A	N/A	N/A
Total	**20,097**		**23.2**	**157%**	**70%**	**110%**	**0%**	**1%**
SCE								
Discount	468,268	22.9	N/A	N/A	N/A	N/A	N/A	N/A
Drug	809		7.4	32%	95%	31%	1%	1%
Grocery	511,140		10.4	46%	98%	45%	0%	0%
Hardware	67,232		17.4	76%	99%	76%	1%	1%
Home improvement	10,075		2.3	10%	52%	5%	2%	5%
Mass merchandise	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Unshifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual	N/A		N/A	N/A	N/A	N/A	N/A	N/A
Total	**1,057,524**		**18.6**	**81%**	**85%**	**69%**	**2%**	**5%**
SDG&E								
Discount	244,400	15.5	23.1	147%	70%	103%	0%	1%
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	0		N/A	N/A	N/A	N/A	N/A	N/A
Hardware	0		N/A	N/A	N/A	N/A	N/A	N/A
Home improvement	3,717		3.6	23%	52%	12%	2%	5%
Mass merchandise	1,219		5.3	34%	23%	8%	2%	4%
Membership club, Unshifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual[2]	N/A		N/A	N/A	N/A	N/A	N/A	N/A
Total	**249,336**		**22.8**	**146%**	**69%**	**101%**	**2%**	**5%**

[1]Source: 2015 program tracking data
[2]We did not model these channels because the program did not ship lamps to them.

MSB CFL reflector ≤ 30 W

Table 103. Market shares with and without the program for CFL reflector lamps

Lamp Technology and Shape	Market Share	
	With Program	Without Program
Discount		
MSB CFL Reflector	100%	0%
MSB LED Reflector	0%	0%
MSB Halogen Reflector	0%	100%
Total affected market	100%	100%
Drug		
MSB CFL Reflector	100%	0%
MSB LED Reflector	0%	0%
MSB Halogen Reflector	0%	100%
Total affected market	100%	100%
Grocery		
MSB CFL Reflector	100%	0%
MSB LED Reflector	0%	0%
MSB Halogen Reflector	0%	100%
Total affected market	100%	100%
Hardware		
MSB CFL Reflector	47%	38%
MSB LED Reflector	24%	22%
MSB Halogen Reflector	29%	40%
Total affected market	100%	100%
Home improvement		
MSB CFL Reflector	45%	36%
MSB LED Reflector	14%	17%
MSB Halogen Reflector	41%	47%
Total affected market	100%	100%
Mass merchandise		
MSB CFL Reflector	34%	23%
MSB LED Reflector	29%	34%
MSB Halogen Reflector	36%	43%
Total affected market	100%	100%
Membership club		
MSB CFL Reflector	85%	22%
MSB LED Reflector	15%	78%
MSB Halogen Reflector	0%	0%
Total affected market	100%	100%

Table 104. Average wattage displaced by program CFL reflector purchases

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Reflector	N/A	N/A	65.0
MSB LED Reflector	0%	N/A	
MSB Halogen Reflector	100%	65.0	
Drug			
MSB CFL Reflector	N/A	N/A	59.3
MSB LED Reflector	0%	N/A	
MSB Halogen Reflector	100%	59.3	
Grocery			
MSB CFL Reflector	N/A	N/A	59.7
MSB LED Reflector	0%	N/A	
MSB Halogen Reflector	100%	59.7	
Hardware			
MSB CFL Reflector	N/A	N/A	69.7
MSB LED Reflector	0%	N/A	
MSB Halogen Reflector	100%	69.7	
Home improvement			
MSB CFL Reflector	N/A	N/A	49.3
MSB LED Reflector	28%	11.0	
MSB Halogen Reflector	72%	64.4	
Mass merchandise			
MSB CFL Reflector	N/A	N/A	41.8
MSB LED Reflector	42%	10.6	
MSB Halogen Reflector	58%	64.3	
Membership club			
MSB CFL Reflector	N/A	N/A	12.2
MSB LED Reflector	100%	12.2	
MSB Halogen Reflector	0%	N.A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

Table 105. Market delta watts for CFL reflector lamps

Channel	Average Displaced Wattage (Watts)	Average Program Discounted Wattage (Watts)[1]	Market Delta Watts
PG&E			
Discount	N/A	N/A	N/A
Drug	N/A		N/A
Grocery	N/A		N/A
Hardware	N/A		N/A
Home improvement	N/A		N/A
Mass merchandise	N/A		N/A
Membership club	N/A		N/A
SCE			
Discount	65.0	22.0	43.0
Drug	59.3		37.4
Grocery	59.7		37.7
Hardware	69.7		47.8
Home improvement	49.3		27.3
Mass merchandise	41.8		19.8
Membership club	12.2		(9.8)
SDG&E			
Discount	65.0	20.3	44.7
Drug	59.3		39.1
Grocery	59.7		39.4
Hardware	69.7		49.4
Home improvement	49.3		29.0
Mass merchandise	41.8		21.5
Membership club	12.2		(8.1)

[1]Source: 2015 program tracking data

Table 106. Calculation of CFL reflector lamps that shifted into membership club due to the program

IOU	Program lamps purchased at Membership club[1]	Program lamps that would have shifted channels without the program		
		Percent of Membership club program purchases that would have occurred elsewhere[2]	Quantity of lamp purchases that would have occurred elsewhere	Quantity of lamp purchases that would have still occurred at Membership club
PG&E	0	50%	0	0
SCE	0		0	0
SDG&E	12,679		6,339	6,339

[1]Source: 2015 program tracking data

[2]Source: 2016 in-depth telephone interviews with lamp suppliers

Table 107. Average wattage of lamps that were displaced by channel-shifted program CFL reflector lamps

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Reflector	N/A	N/A	65.0
MSB LED Reflector	0%	14.0	
MSB Halogen Reflector	100%	65.0	
Drug			
MSB CFL Reflector	N/A	N/A	59.3
MSB LED Reflector	0%	N/A	
MSB Halogen Reflector	100%	59.3	
Grocery			
MSB CFL Reflector	N/A	N/A	59.7
MSB LED Reflector	0%	N/A	
MSB Halogen Reflector	100%	59.7	
Hardware			
MSB CFL Reflector	N/A	N/A	49.4
MSB LED Reflector	35%	12.3	
MSB Halogen Reflector	65%	69.7	
Home improvement			
MSB CFL Reflector	N/A	N/A	50.5
MSB LED Reflector	26%	11.0	
MSB Halogen Reflector	74%	64.4	
Mass merchandise			
MSB CFL Reflector	N/A	N/A	40.4
MSB LED Reflector	44%	10.6	
MSB Halogen Reflector	56%	64.3	
Membership club			
MSB CFL Reflector	N/A	N/A	N/A
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	N/A	N/A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

Table 108. Calculation of the overall wattage of lamps that were displaced by channel-shifted program CFL reflector lamps

Channel	Purchases made with program lamps available[1]	Typical Lamp Purchase Location	Typical Lamp Purchase Location without displaced channel	Channel-Shifted Quantity NTGR[2]	Channel-Shifted Displaced Wattage[3]
Discount	432,246	1%	1%	100%	65.0
Drug	37,943	0%	0%	100%	59.3
Grocery	1,053,709	1%	1%	100%	59.7
Hardware	9,863,232	12%	14%	62%	49.4
Home improvement	51,648,507	62%	73%	64%	50.5
Mass merchandise	7,527,370	9%	11%	77%	40.4
Membership club	13,191,709	16%			
Total	**83,754,717**	**100%**	**100%**	**66%**	**49.5**

[1]Source: 2016 consumer telephone survey
[2]Source: LCM
[3]Source: 2015-16 retail lamp stock inventory data

Table 109. NTGRq, NTGRu, and overall NTGR for MSB CFL reflector ≤ 30 W

Channel	Count of Program lamps[1]	Gross UES	Net UES	NTGRu	NTGRq	Overall NTGR	SE	CI
PG&E								
Discount	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	0		N/A	N/A	N/A	N/A	N/A	N/A
Hardware	0		N/A	N/A	N/A	N/A	N/A	N/A
Home improvement	0		N/A	N/A	N/A	N/A	N/A	N/A
Mass merchandise	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Unshifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual	N/A		N/A	N/A	N/A	N/A	N/A	N/A
Total	**0**		**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
SCE								
Discount	692,780	24.6	32.5	132%	100%	132%	0%	0%
Drug	11,901		28.2	115%	100%	115%	0%	0%
Grocery	1,379,481		28.5	116%	100%	116%	0%	0%
Hardware	251,783		36.1	147%	20%	29%	1%	2%
Home improvement	48,202		20.6	84%	19%	16%	1%	2%
Mass merchandise	0		N/A	N/A	N/A	N/A	1%	2%
Membership club, Unshifted Counterfactual	46,479		N/A	N/A	N/A	N/A	1%	2%
Membership club, Shifted Counterfactual	46,479		N/A	N/A	N/A	N/A	1%	2%
Total	**2,477,105**		**29.9**	**122%**	**90%**	**109%**	**1%**	**2%**
SDG&E								
Discount	23,915	14.4	20.5	142%	100%	142%	0%	0%
Drug	0		N/A	N/A	N/A	N/A	0%	0%
Grocery	19,796		18.1	125%	100%	125%	0%	0%
Hardware	9,644		22.7	157%	20%	31%	1%	2%
Home improvement	15,353		13.3	92%	19%	17%	1%	2%
Mass merchandise	1,862		9.9	68%	35%	24%	1%	2%
Membership club, Unshifted Counterfactual	6,339		(3.7)	-26%	74%	-19%	0%	2%
Membership club, Shifted Counterfactual	6,339		13.4	93%	66%	61%	1%	2%
Total	**83,248**		**16.8**	**116%**	**70%**	**81%**	**1%**	**2%**

[1]Source: 2015 program tracking data

MSB CFL high-wattage > 30 W

Table 110. Market shares with and without the program for high-wattage CFLs > 30 W

Lamp Technology and Shape	Market Share	
	With Program	Without Program
Discount		
MSB CFL Basic Spiral	93%	77%
MSB LED lamps	0%	0%
MSB Halogen lamps	0%	0%
MSB Incandescent lamps	7%	23%
Drug		
MSB CFL Basic Spiral	100%	100%
MSB LED lamps	0%	0%
MSB Halogen lamps	0%	0%
MSB Incandescent lamps	0%	0%
Grocery		
MSB CFL Basic Spiral	89%	20%
MSB LED lamps	2%	4%
MSB Halogen lamps	7%	14%
MSB Incandescent lamps	2%	62%
Hardware		
MSB CFL Basic Spiral	11%	4%
MSB LED lamps	0%	0%
MSB Halogen lamps	0%	0%
MSB Incandescent lamps	89%	96%
Home improvement		
MSB CFL Basic Spiral	75%	55%
MSB LED lamps	1%	1%
MSB Halogen lamps	2%	3%
MSB Incandescent lamps	22%	41%
Mass merchandise		
MSB CFL Basic Spiral	70%	44%
MSB LED lamps	4%	8%
MSB Halogen lamps	18%	34%
MSB Incandescent lamps	8%	15%
Membership club		
MSB CFL Basic Spiral	100%	100%
MSB LED lamps	0%	0%
MSB Halogen lamps	0%	0%
MSB Incandescent lamps	0%	0%

Table 111. Average wattage displaced by program high-wattage CFLs > 30 W purchases

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Basic Spiral	NA	NA	76.4
MSB LED lamps	0%	NA	
MSB Halogen lamps	0%	NA	
MSB Incandescent lamps	100%	76.4	
Drug			
MSB CFL Basic Spiral	0%	NA	15.5
MSB LED lamps	100%	15.5	
MSB Halogen lamps	0%	NA	
MSB Incandescent lamps	0%	NA	
Grocery			
MSB CFL Basic Spiral	NA	NA	79.1
MSB LED lamps	3%	13.4	
MSB Halogen lamps	10%	55.4	
MSB Incandescent lamps	87%	83.8	
Hardware			
MSB CFL Basic Spiral	NA	NA	82.1
MSB LED lamps	0%	NA	
MSB Halogen lamps	0%	NA	
MSB Incandescent lamps	100%	82.1	
Home improvement			
MSB CFL Basic Spiral	NA	NA	79.4
MSB LED lamps	2%	14.8	
MSB Halogen lamps	6%	53.0	
MSB Incandescent lamps	92%	82.3	
Mass merchandise			
MSB CFL Basic Spiral	NA	NA	54.5
MSB LED lamps	14%	14.9	
MSB Halogen lamps	60%	54.5	
MSB Incandescent lamps	26%	75.0	
Membership club			
MSB CFL Basic Spiral	NA	NA	14.6
MSB LED lamps	100%	14.6	
MSB Halogen lamps	0%	NA	
MSB Incandescent lamps	0%	NA	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

Table 112. Market delta watts for high-wattage CFLs > 30 W

Channel	Average Displaced Wattage (Watts)	Average Program Discounted Wattage (Watts)[1]	Market Delta Watts
PG&E			
Discount	76.4	40.0	36.4
Drug	N/A		N/A
Grocery	79.1		39.1
Hardware	82.1		42.1
Home improvement	79.4		39.4
Mass merchandise	54.5		14.5
Membership club	N/A		N/A
SCE			
Discount	76.4	40.8	35.6
Drug	N/A		N/A
Grocery	79.1		38.3
Hardware	82.1		41.3
Home improvement	79.4		38.6
Mass merchandise	54.5		13.7
Membership club	N/A		N/A
SDG&E			
Discount	76.4	37.6	38.8
Drug	N/A		N/A
Grocery	79.1		41.5
Hardware	82.1		44.5
Home improvement	79.4		41.8
Mass merchandise	54.5		16.9
Membership club	N/A		N/A

[1]Source: 2015 program tracking data

Table 113. Calculation of high-wattage CFLs > 30 W that shifted into membership club due to the program

IOU	Program lamps purchased at Membership club[1]	Program lamps that would have shifted channels without the program		
		Percent of Membership club program purchases that would have occurred elsewhere[2]	Quantity of lamp purchases that would have occurred elsewhere	Quantity of lamp purchases that would have still occurred at Membership club
PG&E	0	50%	0	0
SCE	162,114		81,057	81,057
SDG&E	0		0	0

[1]Source: 2015 program tracking data
[2]Source: 2016 in-depth telephone interviews with lamp suppliers

Table 114. Average wattage of lamps that were displaced by channel-shifted program high-wattage CFLs > 30 W

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Basic Spiral	NA	NA	76.4
MSB LED lamps	0%	NA	
MSB Halogen lamps	0%	NA	
MSB Incandescent lamps	100%	76.4	
Drug			
MSB CFL Basic Spiral	NA	NA	15.5
MSB LED lamps	100%	15.5	
MSB Halogen lamps	0%	NA	
MSB Incandescent lamps	0%	NA	
Grocery			
MSB CFL Basic Spiral	NA	NA	75.6
MSB LED lamps	4%	13.4	
MSB Halogen lamps	18%	55.4	
MSB Incandescent lamps	78%	83.8	
Hardware			
MSB CFL Basic Spiral	NA	NA	82.1
MSB LED lamps	0%	NA	
MSB Halogen lamps	0%	NA	
MSB Incandescent lamps	100%	82.1	
Home improvement			
MSB CFL Basic Spiral	NA	NA	79.0
MSB LED lamps	2%	14.8	
MSB Halogen lamps	7%	53.0	
MSB Incandescent lamps	91%	82.3	
Mass merchandise			
MSB CFL Basic Spiral	NA	NA	54.3
MSB LED lamps	14%	14.9	
MSB Halogen lamps	60%	54.5	
MSB Incandescent lamps	26%	75.0	
Membership club			
MSB CFL Basic Spiral	N/A	N/A	N/A
MSB LED lamps	N/A	N/A	
MSB Halogen lamps	N/A	N/A	
MSB Incandescent lamps	N/A	N/A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

Table 115. Calculation of the overall wattage of lamps that were displaced by channel-shifted program high-wattage CFLs > 30 W

Channel	Purchases made with program lamps available[1]	Typical Lamp Purchase Location	Typical Lamp Purchase Location without displaced channel	Channel-Shifted Quantity NTGR[2]	Channel-Shifted Displaced Wattage[3]
Discount	1,511,600	3%	3%	23%	76.4
Drug	1,652,593	3%	3%	0%	15.5
Grocery	1,555,836	3%	3%	80%	75.6
Hardware	5,036,369	9%	10%	96%	82.1
Home improvement	27,670,674	51%	58%	45%	79.0
Mass merchandise	10,656,753	20%	22%	56%	54.3
Membership club	6,010,840	11%			
Total	**54,094,664**	**100%**	**100%**	**52%**	**71.5**

[1]Source: 2016 consumer telephone survey
[2]Source: LCM
[3]Source: 2015-16 retail lamp stock inventory data

Table 116. NTGRq, NTGRu, and overall NTGR for MSB CFL High-Wattage > 30 W

Channel	Count of Program lamps[1]	Gross UES	Net UES	NTGRu	NTGRq	Overall NTGR	SE	CI
PG&E								
Discount	51,425	26.0	26.1	101%	17%	17%	1%	1%
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	13,392		28.1	108%	78%	84%	1%	1%
Hardware	0		N/A	N/A	N/A	N/A	N/A	N/A
Home improvement	0		N/A	N/A	N/A	N/A	N/A	N/A
Mass merchandise	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Unshifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Total	**64,817**		**27.2**	**105%**	**105%**	**31%**	**2%**	**3%**
SCE								
Discount	615,820	19.8	26.8	136%	17%	23%	1%	1%
Drug	6,234		N/A	N/A	N/A%	81%	2%	3%
Grocery	1,242,351		28.9	146%	78%	114%	1%	1%
Hardware	140,648		31.1	157%	66%	103%	2%	3%
Home improvement	8,528		29.1	147%	27%	40%	1%	2%
Mass merchandise	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Unshifted Counterfactual	81,057		(19.7)	-100%	0%	0%	0%	0%
Membership club, Shifted Counterfactual	81,057		23.1	117%	52%	61%	0%	0%
Total	**2,175,695**		**28.7**	**145%**	**56%**	**81%**	**2%**	**3%**
SDG&E								
Discount	124,819	18.4	28.2	153%	17%	26%	1%	1%
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	46,163		30.1	164%	78%	127%	1%	1%
Hardware	10,058		32.3	175%	66%	115%	2%	3%
Home improvement	986		30.3	165%	27%	44%	1%	2%
Mass merchandise	296		12.2	66%	38%	25%	1%	2%
Membership club, Unshifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Shifted Counterfactual	0		N/A	N/A	N/A	N/A	N/A	N/A
Total	**182,322**		**29.7**	**161%**	**35%**	**57%**	**2%**	**3%**

[1]Source: 2015 program tracking data

MSB LED A-lamp, all wattages

Table 117. Market shares with and without the program for LED A-lamps

Lamp Technology and Shape	Market Share	
	With Program	Without Program
Discount		
MSB CFL Basic Spiral	18%	33%
MSB CFL A-Lamp	2%	15%
MSB LED A-Lamp	70%	0%
MSB Incandescent, EISA Compliant	0%	0%
MSB Incandescent A-lamp	10%	52%
Drug		
MSB CFL Basic Spiral	46%	52%
MSB CFL A-Lamp	1%	1%
MSB LED A-Lamp	25%	10%
MSB Incandescent, EISA Compliant	16%	20%
MSB Incandescent A-lamp	13%	17%
Grocery		
MSB CFL Basic Spiral	26%	57%
MSB CFL A-Lamp	1%	3%
MSB LED A-Lamp	58%	6%
MSB Incandescent, EISA Compliant	9%	24%
MSB Incandescent A-lamp	6%	10%
Hardware		
MSB CFL Basic Spiral	11%	19%
MSB CFL A-Lamp	1%	2%
MSB LED A-Lamp	70%	49%
MSB Incandescent, EISA Compliant	12%	19%
MSB Incandescent A-lamp	6%	11%
Home improvement		
MSB CFL Basic Spiral	16%	32%
MSB CFL A-Lamp	2%	4%
MSB LED A-Lamp	72%	43%
MSB Incandescent, EISA Compliant	4%	7%
MSB Incandescent A-lamp	7%	15%
Mass merchandise		
MSB CFL Basic Spiral	39%	43%
MSB CFL A-Lamp	2%	2%
MSB LED A-Lamp	27%	17%
MSB Incandescent, EISA Compliant	19%	22%
MSB Incandescent A-lamp	13%	15%
Membership club		
MSB CFL Basic Spiral	27%	67%
MSB CFL A-Lamp	0%	0%
MSB LED A-Lamp	73%	33%
MSB Incandescent, EISA Compliant	0%	0%
MSB Incandescent A-lamp	0%	0%

Table 118. Average wattage displaced by program LED A-lamp purchases

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Basic Spiral	21%	22.2	50.8
MSB CFL A-Lamp	18%	20.6	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	0%	N/A	
MSB Incandescent A-lamp	60%	70.1	
Drug			
MSB CFL Basic Spiral	44%	18.8	36.8
MSB CFL A-Lamp	2%	18.5	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	29%	53.4	
MSB Incandescent A-lamp	25%	51.2	
Grocery			
MSB CFL Basic Spiral	60%	17.0	28.7
MSB CFL A-Lamp	3%	17.2	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	29%	48.0	
MSB Incandescent A-lamp	8%	51.5	
Hardware			
MSB CFL Basic Spiral	37%	18.4	38.7
MSB CFL A-Lamp	4%	18.8	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	33%	48.6	
MSB Incandescent A-lamp	26%	57.6	
Home improvement			
MSB CFL Basic Spiral	55%	16.4	30.8
MSB CFL A-Lamp	5%	14.1	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	13%	49.1	
MSB Incandescent A-lamp	27%	54.7	
Mass merchandise			
MSB CFL Basic Spiral	48%	14.5	31.7
MSB CFL A-Lamp	4%	15.7	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	28%	49.1	
MSB Incandescent A-lamp	20%	51.5	
Membership club			
MSB CFL Basic Spiral	100%	17.1	17.1
MSB CFL A-Lamp	0%	N/A	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	0%	N/A	
MSB Incandescent A-lamp	0%	N/A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

Table 119. Market delta watts for LED A-lamps

Channel	Average Displaced Wattage (Watts)	Average Program Discounted Wattage (Watts)[1]	Market Delta Watts
PG&E			
Discount	50.8	8.4	42.4
Drug	36.8		28.4
Grocery	28.7		20.3
Hardware	38.7		30.3
Home improvement	30.8		22.4
Mass merchandise	31.7		23.3
Membership club	17.1		8.7
SCE			
Discount	50.8	4.9	46.0
Drug	36.8		32.0
Grocery	28.7		23.9
Hardware	38.7		33.8
Home improvement	30.8		25.9
Mass merchandise	31.7		26.8
Membership club	17.1		12.3
SDG&E			
Discount	50.8	9.4	41.4
Drug	36.8		27.4
Grocery	28.7		19.3
Hardware	38.7		29.3
Home improvement	30.8		21.4
Mass merchandise	31.7		22.3
Membership club	17.1		7.7

[1]Source: 2015 program tracking data

Table 120. Calculation of LED A-lamps that shifted into membership club due to the program

IOU	Program lamps purchased at Membership club[1]	Program lamps that would have shifted channels without the program		
		Percent of Membership club program purchases that would have occurred elsewhere[2]	Quantity of lamp purchases that would have occurred elsewhere	Quantity of lamp purchases that would have still occurred at Membership club
PG&E	1,115,511	50%	557,755	557,755
SCE	1,015,602		507,801	507,801
SDG&E	361,700		180,850	180,850

[1]Source: 2015 program tracking data
[2]Source: 2016 in-depth telephone interviews with lamp suppliers

Table 121. Average wattage of lamps that were displaced by channel-shifted program LED A-lamps

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Basic Spiral	33%	22.2	46.9
MSB CFL A-Lamp	15%	20.6	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	0%	N/A	
MSB Incandescent A-lamp	52%	70.1	
Drug			
MSB CFL Basic Spiral	58%	18.8	32.6
MSB CFL A-Lamp	1%	18.5	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	22%	53.4	
MSB Incandescent A-lamp	19%	51.2	
Grocery			
MSB CFL Basic Spiral	61%	17.0	28.6
MSB CFL A-Lamp	3%	17.2	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	26%	48.0	
MSB Incandescent A-lamp	11%	51.5	
Hardware			
MSB CFL Basic Spiral	37%	18.4	38.4
MSB CFL A-Lamp	4%	18.8	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	37%	48.6	
MSB Incandescent A-lamp	22%	57.6	
Home improvement			
MSB CFL Basic Spiral	55%	16.4	30.2
MSB CFL A-Lamp	7%	14.1	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	13%	49.1	
MSB Incandescent A-lamp	26%	54.7	
Mass merchandise			
MSB CFL Basic Spiral	52%	14.5	30.4
MSB CFL A-Lamp	3%	15.7	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	26%	49.1	
MSB Incandescent A-lamp	18%	51.5	
Membership club			
MSB CFL Basic Spiral	N/A	N/A	N/A
MSB CFL A-Lamp	N/A	N/A	
MSB LED A-Lamp	N/A	N/A	
MSB Incandescent, EISA Compliant	N/A	N/A	
MSB Incandescent A-lamp	N/A	N/A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

Table 122. Calculation of the overall wattage of lamps that were displaced by channel-shifted program LED A-lamps

Channel	Purchases made with program lamps available[1]	Typical Lamp Purchase Location	Typical Lamp Purchase Location without displaced channel	Channel-Shifted Quantity NTGR[2]	Channel-Shifted Displaced Wattage[3]
Discount	1,511,600	3%	3%	100%	46.9
Drug	1,652,593	3%	3%	90%	32.6
Grocery	1,555,836	3%	3%	94%	28.6
Hardware	5,036,369	9%	10%	51%	38.4
Home improvement	27,670,674	51%	58%	57%	30.2
Mass merchandise	10,656,753	20%	22%	83%	30.4
Membership club	6,010,840	11%			
Total	**54,094,664**	**100%**	**100%**	**66%**	**31.7**

[1]Source: 2016 consumer telephone survey
[2]Source: LCM
[3]Source: 2015-16 retail lamp stock inventory data

Table 123. NTGRq, NTGRu, and overall NTGR for MSB LED A-lamp, all wattages

Channel	Count of Program lamps[1]	Gross UES	Net UES	NTGRu	NTGRq	Overall NTGR	SE	CI
PG&E								
Discount	16,919	27.2	33.0	121%	100%	121%	0%	0%
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	27,930		15.8	58%	89%	52%	1%	1%
Hardware	53,423		23.5	87%	30%	26%	1%	3%
Home improvement	62,553		17.4	64%	41%	26%	1%	2%
Mass merchandise	6,607		18.1	67%	34%	23%	2%	3%
Membership club, Unshifted Counterfactual	557,755		6.8	25%	54%	14%	1%	3%
Membership club, Shifted Counterfactual	557,755		18.1	67%	66%	44%	1%	3%
Total	**1,282,942**		**13.9**	**51%**	**59%**	**30%**	**2%**	**5%**
SCE								
Discount	54,207	34.3	37.5	109%	100%	109%	0%	0%
Drug	281		26.1	76%	58%	44%	2%	5%
Grocery	125,844		19.5	57%	89%	51%	1%	1%
Hardware	67,230		27.6	81%	30%	24%	1%	3%
Home improvement	192,613		21.1	62%	41%	25%	1%	2%
Mass merchandise	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Unshifted Counterfactual	507,801		10.0	29%	54%	16%	1%	3%
Membership club, Shifted Counterfactual	507,801		21.9	64%	66%	42%	1%	3%
Total	**1,455,777**		**18.9**	**55%**	**60%**	**33%**	**2%**	**5%**
SDG&E								
Discount	22,560	27.0	32.5	121%	100%	121%	0%	0%
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	54,579		15.2	56%	89%	50%	1%	1%
Hardware	38,017		23.0	85%	30%	26%	1%	3%
Home improvement	76,859		16.8	62%	41%	25%	1%	2%
Mass merchandise	180		17.5	65%	34%	22%	2%	3%
Membership club, Unshifted Counterfactual	180,850		6.1	23%	54%	12%	1%	3%
Membership club, Shifted Counterfactual	180,850		17.5	65%	66%	43%	1%	3%
Total	**553,895**		**14.9**	**55%**	**60%**	**33%**	**2%**	**5%**

[1]Source: 2015 program tracking data

MSB LED reflector, all wattages

Table 124. Market shares with and without the program for LED reflector lamps

Lamp Technology and Shape	Market Share	
	With Program	Without Program
Discount		
MSB CFL Reflector	0%	0%
MSB LED Reflector	100%	0%
MSB Halogen Reflector	0%	100%
Drug		
MSB CFL Reflector	0%	0%
MSB LED Reflector	100%	0%
MSB Halogen Reflector	0%	100%
Grocery		
MSB CFL Reflector	0%	0%
MSB LED Reflector	100%	0%
MSB Halogen Reflector	0%	100%
Hardware		
MSB CFL Reflector	6%	6%
MSB LED Reflector	48%	33%
MSB Halogen Reflector	47%	61%
Home improvement		
MSB CFL Reflector	32%	38%
MSB LED Reflector	35%	22%
MSB Halogen Reflector	33%	40%
Mass merchandise		
MSB CFL Reflector	12%	17%
MSB LED Reflector	50%	33%
MSB Halogen Reflector	38%	50%
Membership club		
MSB CFL Reflector	0%	29%
MSB LED Reflector	100%	71%
MSB Halogen Reflector	0%	0%

Table 125. Average wattage displaced by program LED reflector purchases

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Reflector	0%	N/A	65.0
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	100%	65.0	
Drug			
MSB CFL Reflector	0%	N/A	59.3
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	100%	59.3	
Grocery			
MSB CFL Reflector	0%	N/A	59.7
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	100%	59.7	
Hardware			
MSB CFL Reflector	3%	21.3	68.2
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	97%	69.7	
Home improvement			
MSB CFL Reflector	48%	17.0	41.8
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	52%	64.4	
Mass merchandise			
MSB CFL Reflector	31%	23.7	51.9
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	69%	64.3	
Membership club			
MSB CFL Reflector	100%	16.0	16.0
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	0%	N/A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

Table 126. Market delta watts for LED reflector lamps

Channel	Average Displaced Wattage (Watts)	Average Program Discounted Wattage (Watts)[1]	Market Delta Watts
PG&E			
Discount	65.0	11.1	53.9
Drug	59.3		48.3
Grocery	59.7		48.6
Hardware	68.2		57.1
Home improvement	41.8		30.7
Mass merchandise	51.9		40.8
Membership club	16.0		4.9
SCE			
Discount	65.0	10.7	54.3
Drug	59.3		48.7
Grocery	59.7		49.0
Hardware	68.2		57.5
Home improvement	41.8		31.1
Mass merchandise	51.9		41.2
Membership club	16.0		5.3
SDG&E			
Discount	65.0	13.6	51.4
Drug	59.3		45.7
Grocery	59.7		46.0
Hardware	68.2		54.6
Home improvement	41.8		28.1
Mass merchandise	51.9		38.3
Membership club	16.0		2.4

[1]Source: 2015 program tracking data

Table 127. Calculation of LED reflector lamps that shifted into membership club due to the program

IOU	Program lamps purchased at Membership club[1]	Program lamps that would have shifted channels without the program		
		Percent of Membership club program purchases that would have occurred elsewhere[2]	Quantity of lamp purchases that would have occurred elsewhere	Quantity of lamp purchases that would have still occurred at Membership club
PG&E	566,128	50%	283,064	283,064
SCE	1,211,422		605,711	605,711
SDG&E	211,677		105,838	105,838

[1]Source: 2015 program tracking data

[2]Source: 2016 in-depth telephone interviews with lamp suppliers

Table 128. Average wattage of lamps that were displaced by channel-shifted program LED reflector lamps

Lamp Technology and Shape	Percent of Displaced Market Share[1]	Average Wattage on Shelf[2]	Average Displaced Wattage
Discount			
MSB CFL Reflector	0%	20.7	65.0
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	100%	65.0	
Drug			
MSB CFL Reflector	0%	18.6	59.3
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	100%	59.3	
Grocery			
MSB CFL Reflector	0%	21.5	59.7
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	100%	59.7	
Hardware			
MSB CFL Reflector	9%	21.3	65.4
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	91%	69.7	
Home improvement			
MSB CFL Reflector	49%	17.0	41.3
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	51%	64.4	
Mass merchandise			
MSB CFL Reflector	25%	23.7	54.0
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	75%	64.3	
Membership club			
MSB CFL Reflector	N/A	N/A	N/A
MSB LED Reflector	N/A	N/A	
MSB Halogen Reflector	N/A	N/A	

[1]Source: LCM
[2]Source: 2015-2016 retail lamp stock inventory data

Table 129. Calculation of the overall wattage of lamps that were displaced by channel-shifted program LED reflector lamps

Channel	Purchases made with program lamps available[1]	Typical Lamp Purchase Location	Typical Lamp Purchase Location without displaced channel	Channel-Shifted Quantity NTGR[2]	Channel-Shifted Displaced Wattage[3]
Discount	432,246	1%	1%	100%	65.0
Drug	37,943	0%	0%	100%	59.3
Grocery	1,053,709	1%	1%	100%	59.7
Hardware	9,863,232	12%	14%	67%	65.4
Home improvement	51,648,507	62%	73%	78%	41.3
Mass merchandise	7,527,370	9%	11%	67%	54.0
Membership club	13,191,709	16%			
Total	**83,754,717**	**100%**	**100%**	**76%**	**46.5**

[1]Source: 2016 consumer telephone survey
[2]Source: LCM
[3]Source: 2015-16 retail lamp stock inventory data

Table 130. NTGRq, NTGRu, and overall NTGR for MSB LED reflectors, all wattages

Channel	Count of Program lamps[1]	Gross UES	Net UES	NTGRu	NTGRq	Overall NTGR	SE	CI
PG&E								
Discount	5,145	31.2	42.0	134%	100%	134%	0%	0%
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	16,517		37.8	121%	100%	121%	0%	0%
Hardware	34,643		44.4	142%	31%	44%	1%	2%
Home improvement	15,881		23.9	76%	37%	28%	1%	2%
Mass merchandise	0		N/A	N/A	N/A	N/A	2%	3%
Membership club, Unshifted Counterfactual	283,064		3.8	12%	29%	4%	1%	1%
Membership club, Shifted Counterfactual	283,064		27.5	88%	76%	67%	1%	1%
Total	**638,314**		**22.9**	**73%**	**53%**	**39%**	**2%**	**3%**
SCE								
Discount	26,536	33.7	44.3	132%	100%	132%	0%	0%
Drug	234		39.7	118%	100%	118%	0%	0%
Grocery	37,808		40.0	119%	100%	119%	0%	0%
Hardware	67,662		46.9	139%	31%	43%	1%	2%
Home improvement	185,201		25.4	75%	37%	28%	1%	2%
Mass merchandise	0		N/A	N/A	N/A	N/A	N/A	N/A
Membership club, Unshifted Counterfactual	605,711		4.4	13%	29%	4%	1%	1%
Membership club, Shifted Counterfactual	605,711		29.2	87%	76%	66%	1%	1%
Total	**1,528,863**		**24.8**	**74%**	**52%**	**38%**	**2%**	**3%**
SDG&E								
Discount	20,304	28.0	40.4	144%	100%	144%	0%	0%
Drug	0		N/A	N/A	N/A	N/A	N/A	N/A
Grocery	41,962		36.2	129%	100%	129%	0%	0%
Hardware	35,791		42.9	153%	31%	48%	1%	2%
Home improvement	64,560		22.1	79%	37%	29%	1%	2%
Mass merchandise	30		30.1	107%	33%	36%	2%	3%
Membership club, Unshifted Counterfactual	105,838		1.9	7%	29%	2%	0%	0%
Membership club, Shifted Counterfactual	105,838		25.8	92%	76%	70%	1%	1%
Total	**374,323**		**26.2**	**94%**	**56%**	**52%**	**2%**	**3%**

[1]Source: 2015 program tracking data

APPENDIX I. DATA COLLECTION INSTRUMENTS

This appendix includes:

- 2016 consumer telephone survey instrument
- 2016 consumer online survey instrument
- 2016 supplier in-depth interview guide
- Winter 2015-16 shelf survey instrument
- Winter 2015-16 shopper intercept survey instrument

APPENDX J. WATERFALL GRAPHICS

This appendix includes three waterfall graphics for each measure group and IOU: a gross, net, and hybrid version of the graphic. These charts provide insight into the impacts that each parameter have in the adjustment of ex ante to ex post savings estimates.

MSB CFL basic spiral ≤ 30 W

Gross waterfalls

Figure 6. Gross waterfall graphic for MSB CFL basic spiral ≤ 30 W, PG&E

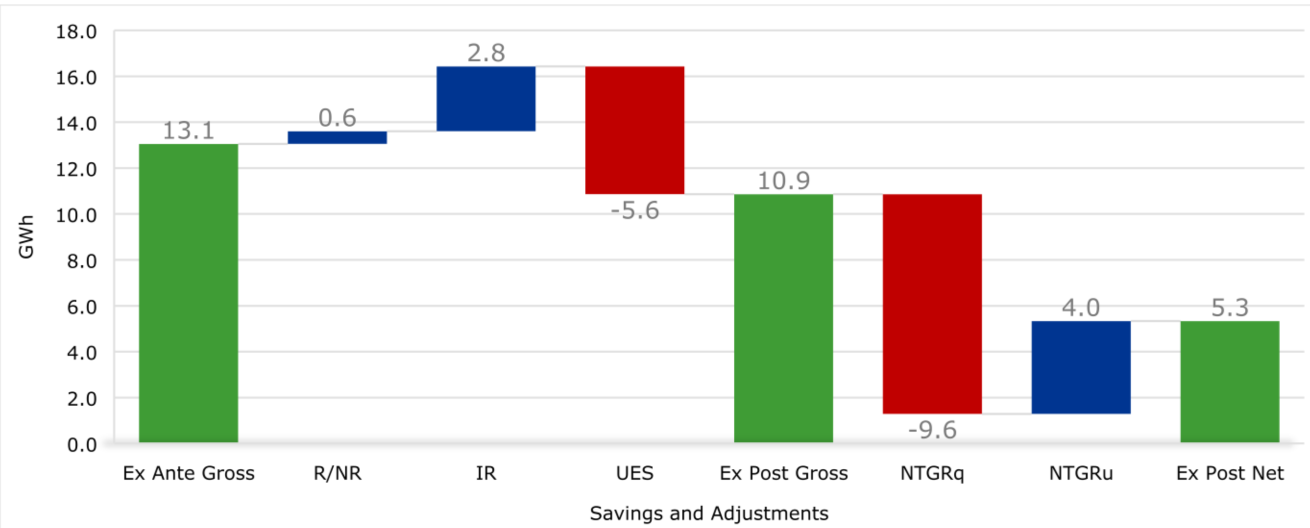
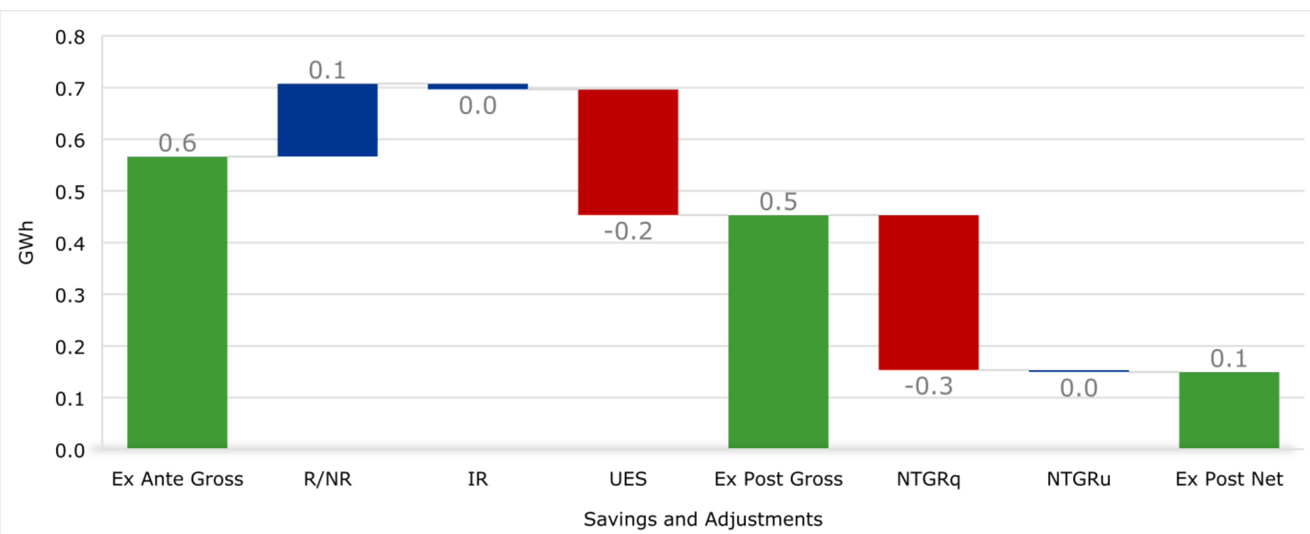


Figure 7. Gross waterfall graphic for MSB CFL basic spiral ≤ 30 W, SDG&E



Net waterfalls

Figure 8. Net waterfall graphic for MSB CFL basic spiral ≤ 30 W, PG&E

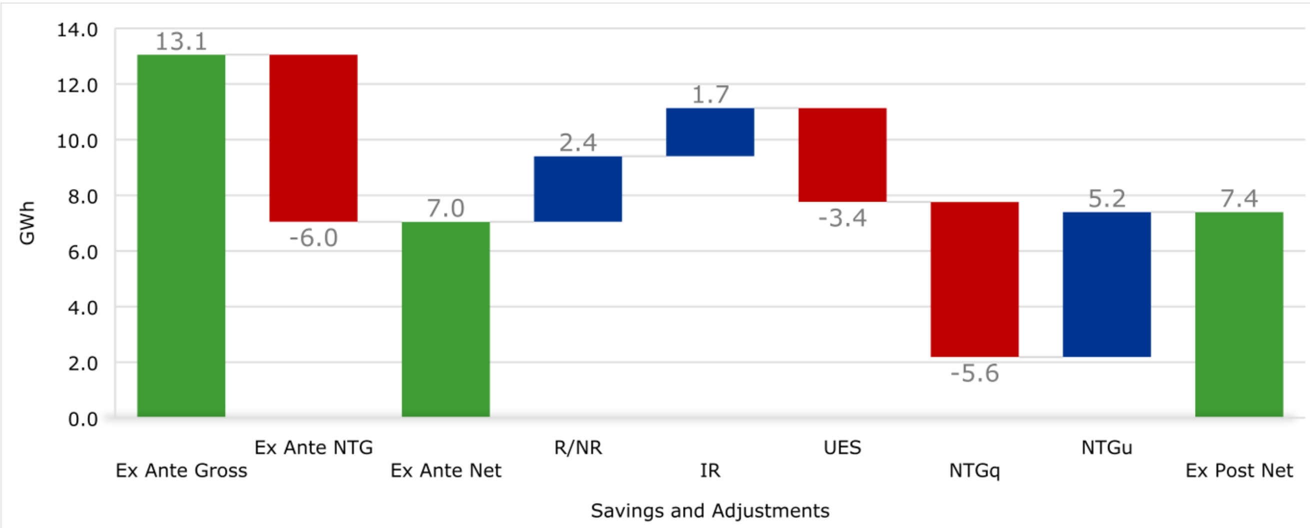
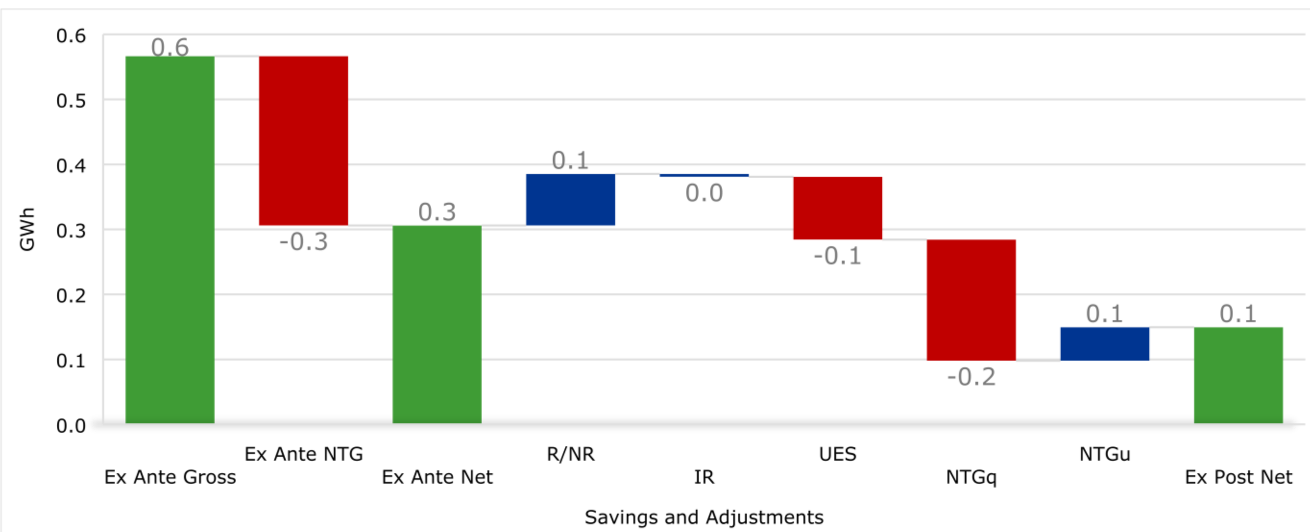


Figure 9. Net waterfall graphic for MSB CFL basic spiral ≤ 30 W, SDG&E



Hybrid waterfalls

Figure 10. Hybrid waterfall graphic for MSB CFL basic spiral ≤ 30 W, PG&E

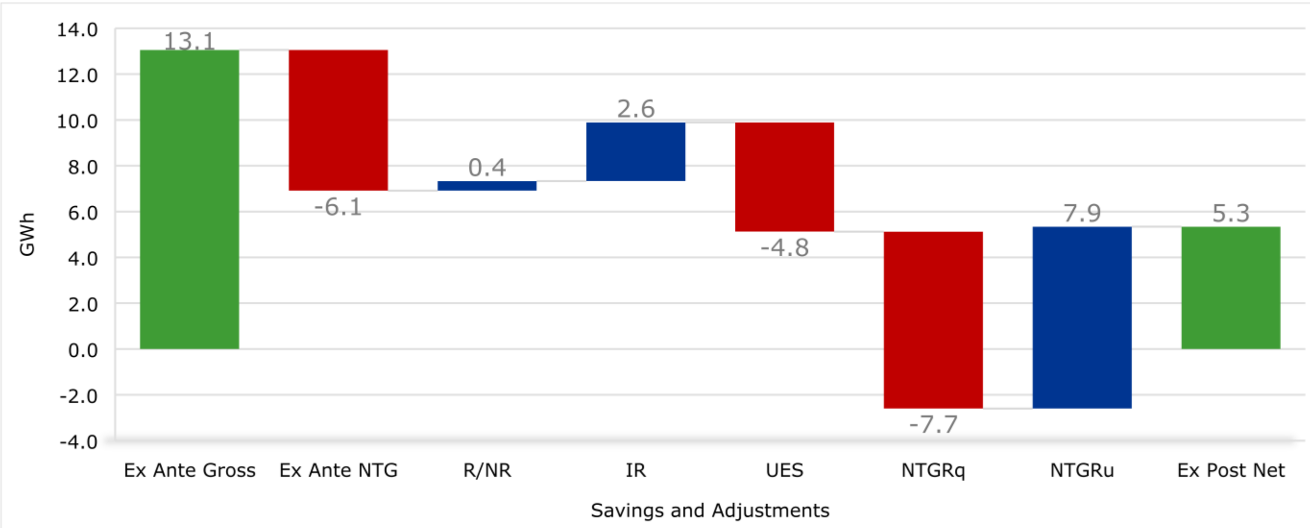
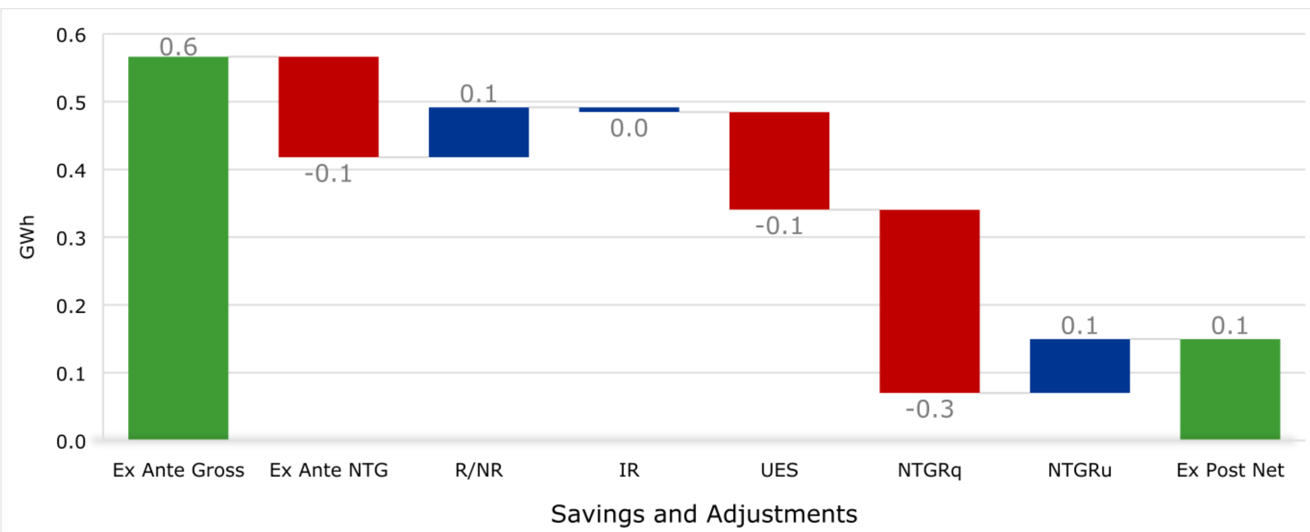


Figure 11. Hybrid waterfall graphic for MSB CFL basic spiral ≤ 30 W, SDG&E



MSB CFL A-lamp, ≤ 30 W

Gross waterfalls

Figure 12. Gross waterfall graphic for MSB CFL A-lamp ≤ 30 W, PG&E

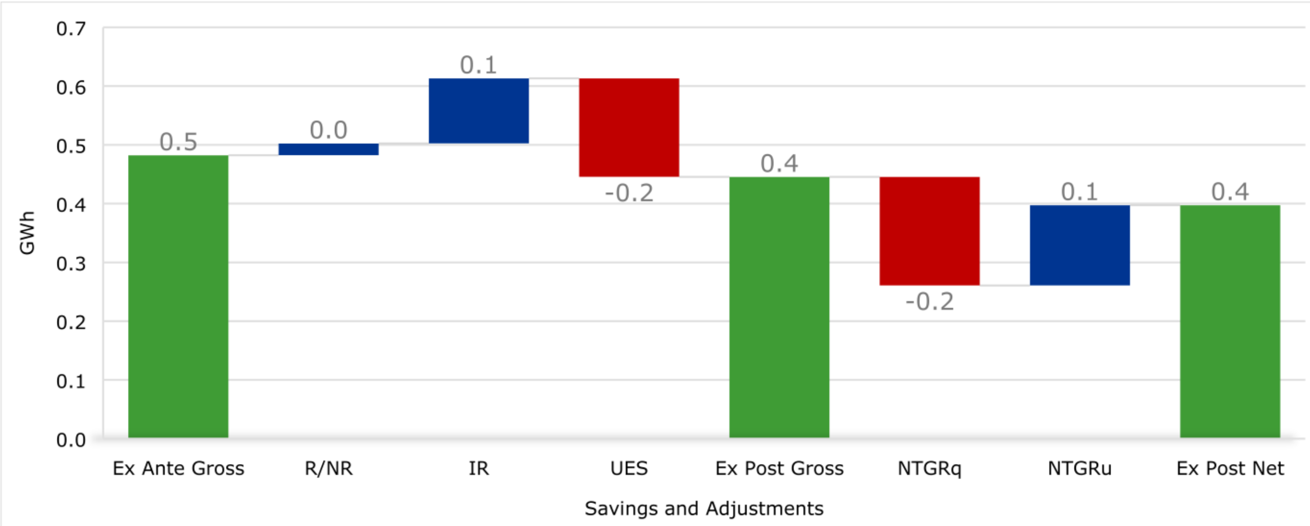


Figure 13. Gross waterfall graphic for MSB CFL A-lamp ≤ 30 W, SCE

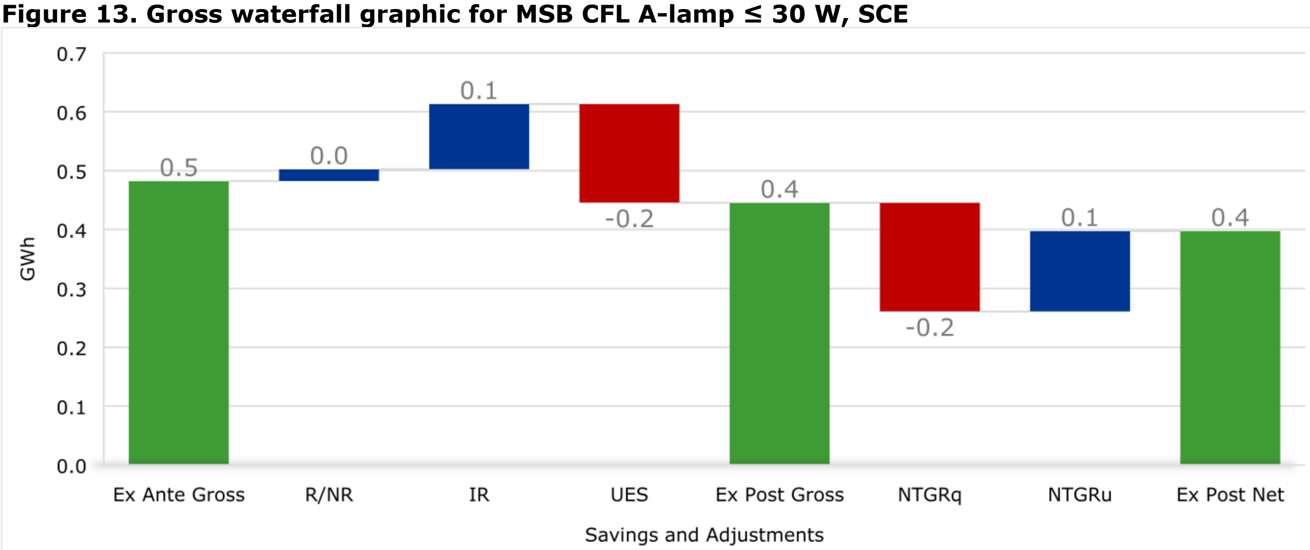
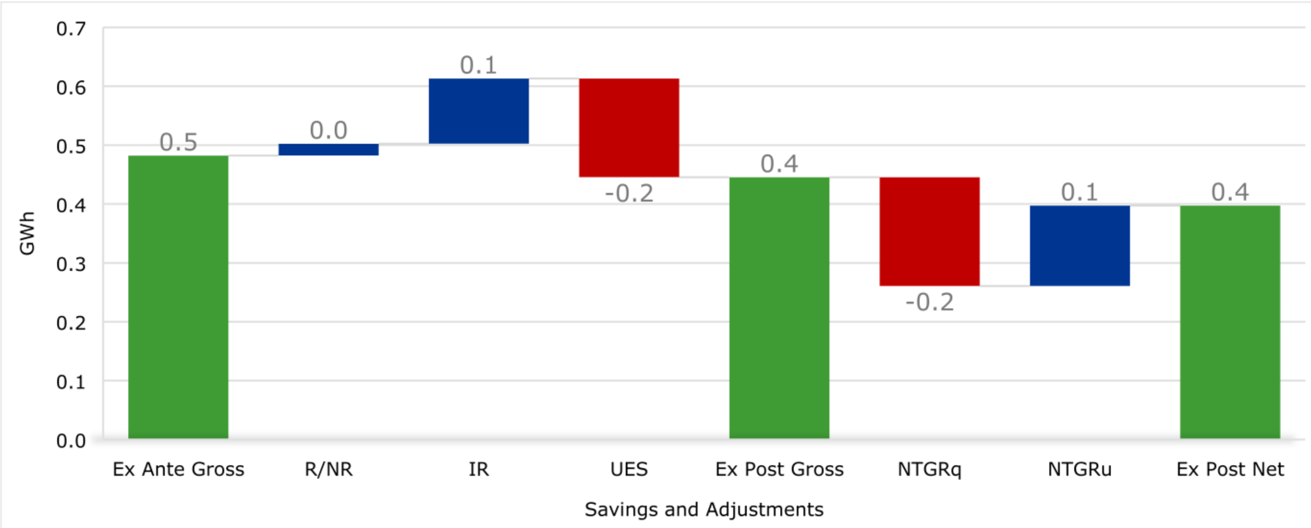


Figure 14. Gross waterfall graphic for MSB CFL A-lamp ≤ 30 W, SDG&E



Net waterfalls

Figure 15. Net waterfall graphic for MSB CFL A-lamp ≤ 30 W, PG&E

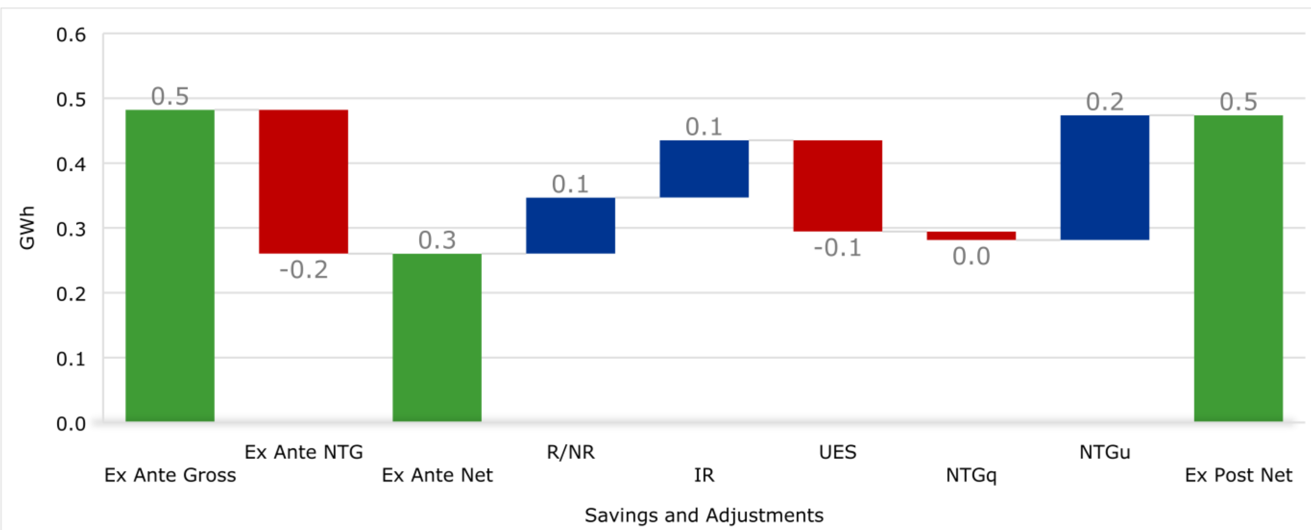


Figure 16. Net waterfall graphic for MSB CFL A-lamp ≤ 30 W, SCE

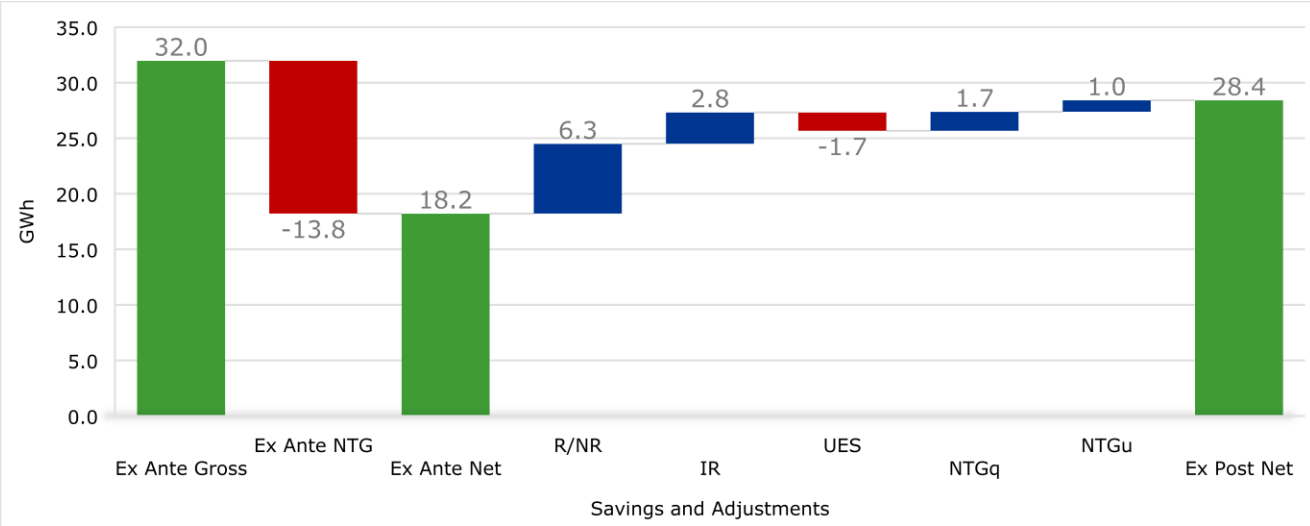
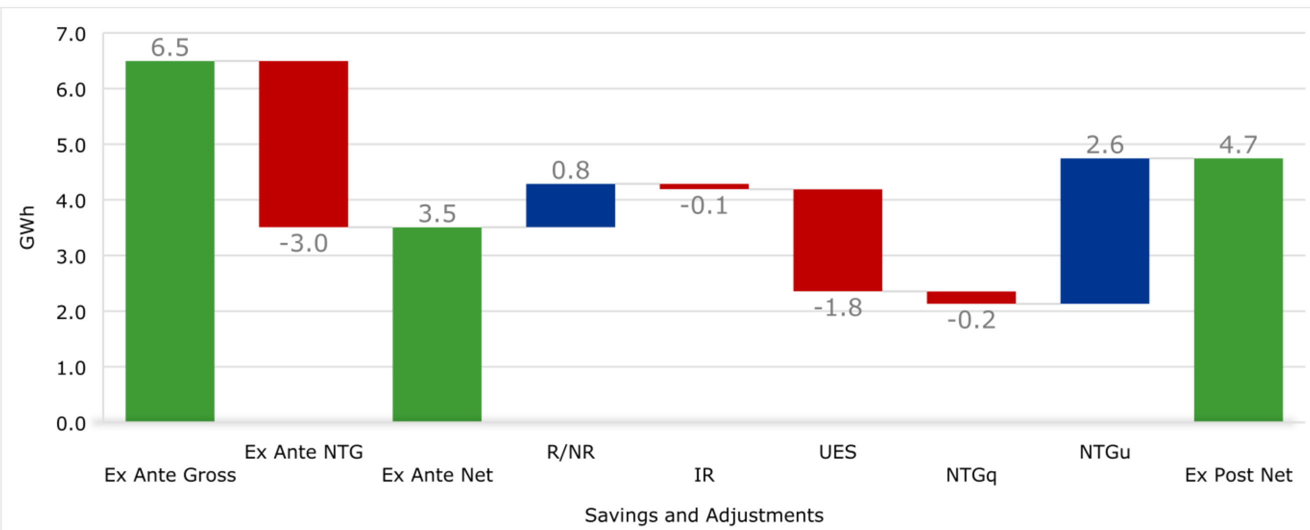


Figure 17. Net waterfall graphic for MSB CFL A-lamp ≤ 30 W, SDG&E



Hybrid waterfalls

Figure 18. Hybrid waterfall graphic for MSB CFL A-lamp ≤ 30 W, PG&E

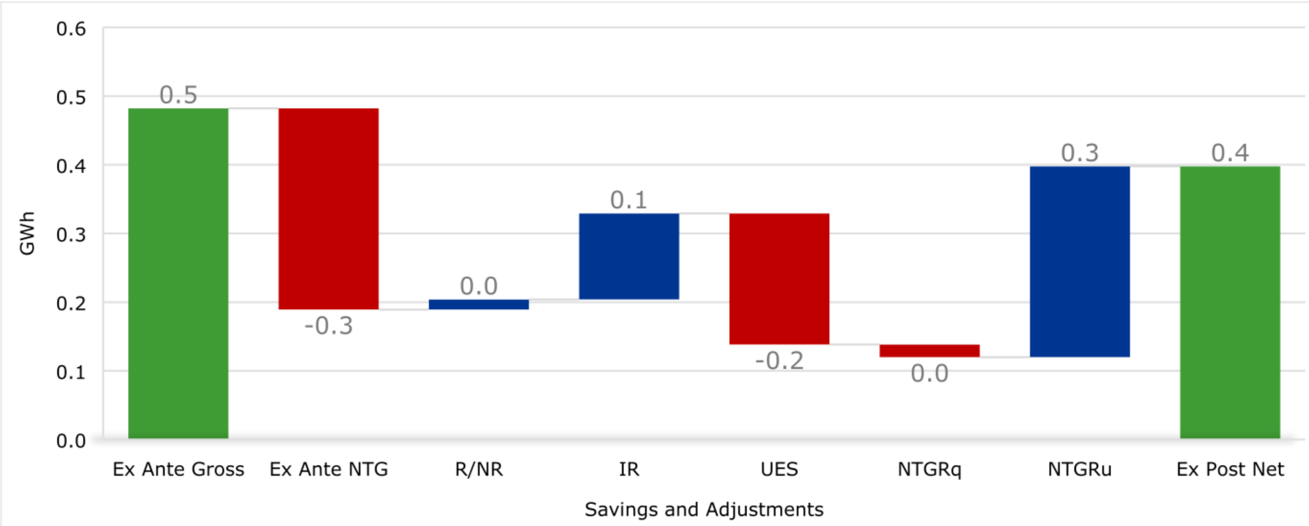


Figure 19. Hybrid waterfall graphic for MSB CFL A-lamp ≤ 30 W, SCE

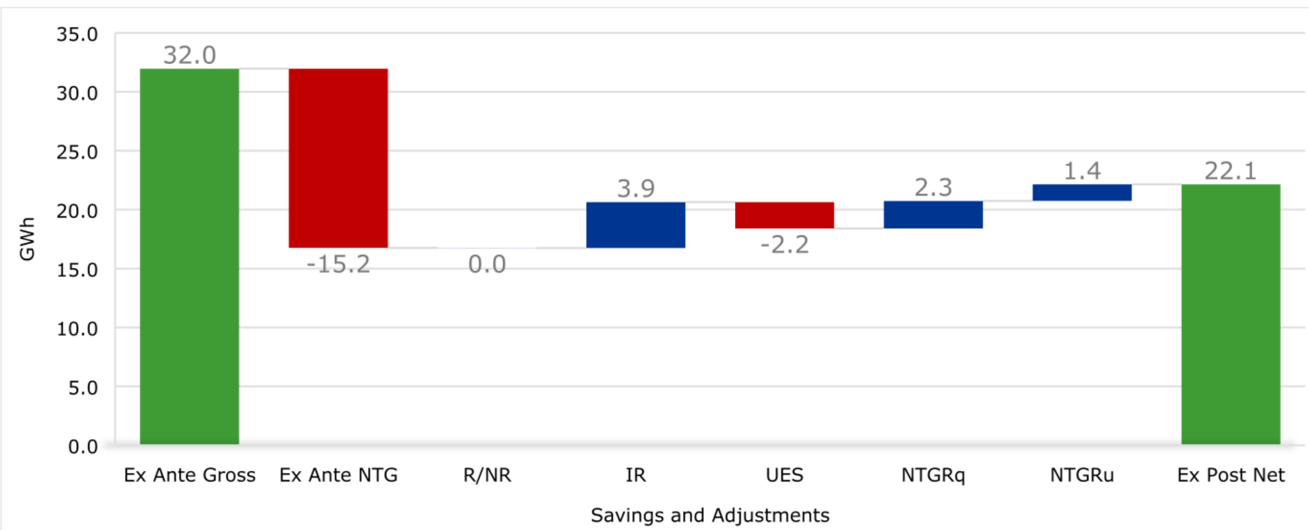
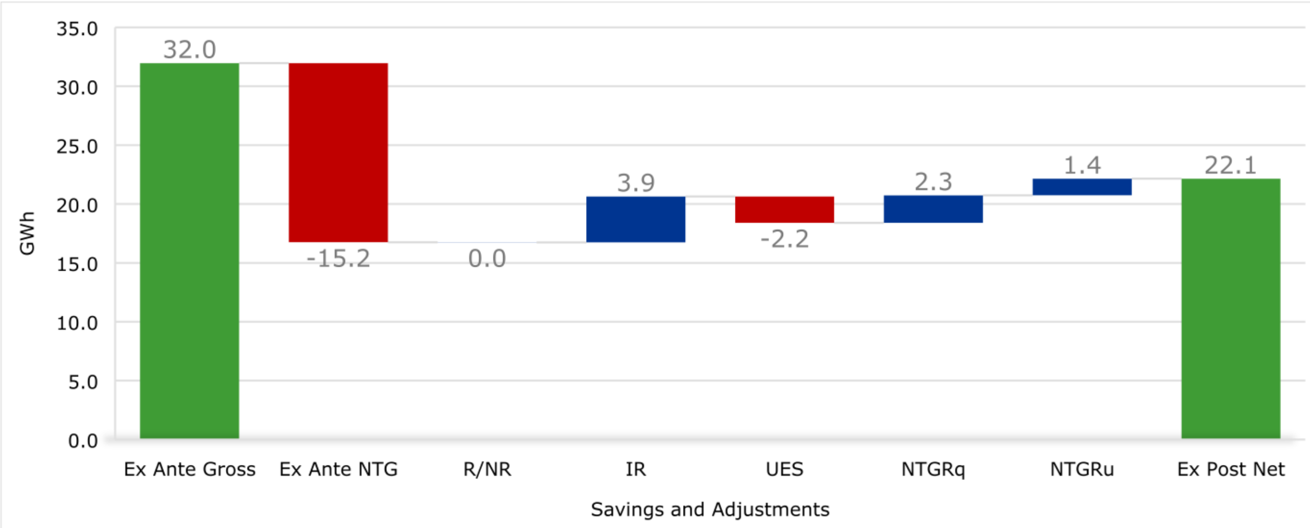


Figure 20. Hybrid waterfall graphic for MSB CFL A-lamp ≤ 30 W, SDG&E



MSB CFL reflector, ≤ 30 W

Gross waterfalls

Figure 21. Gross waterfall graphic for MSB CFL reflector ≤ 30 W, SCE

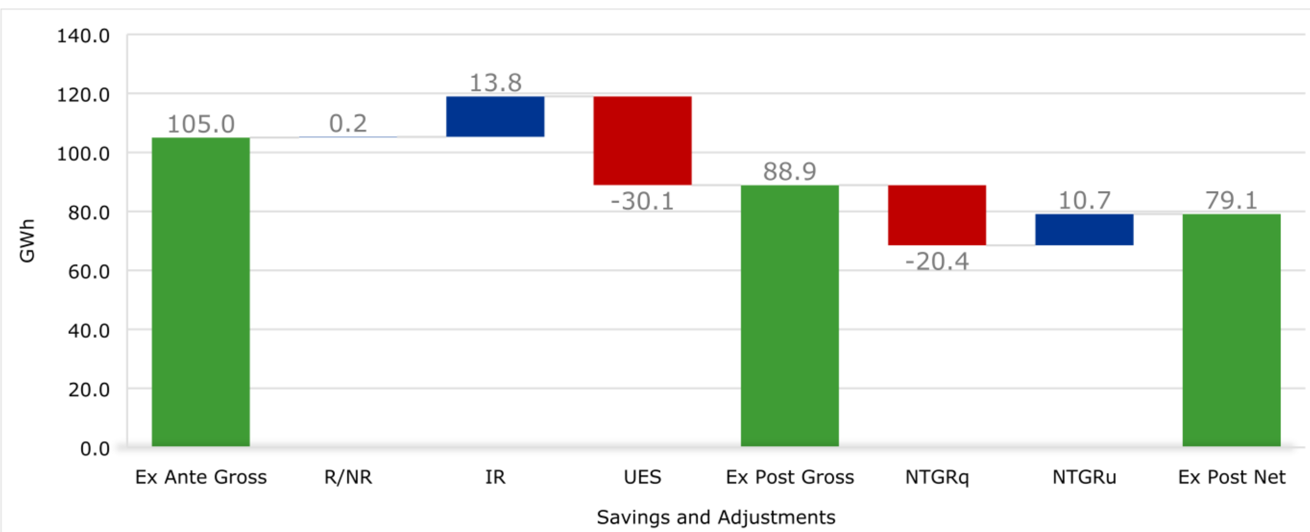
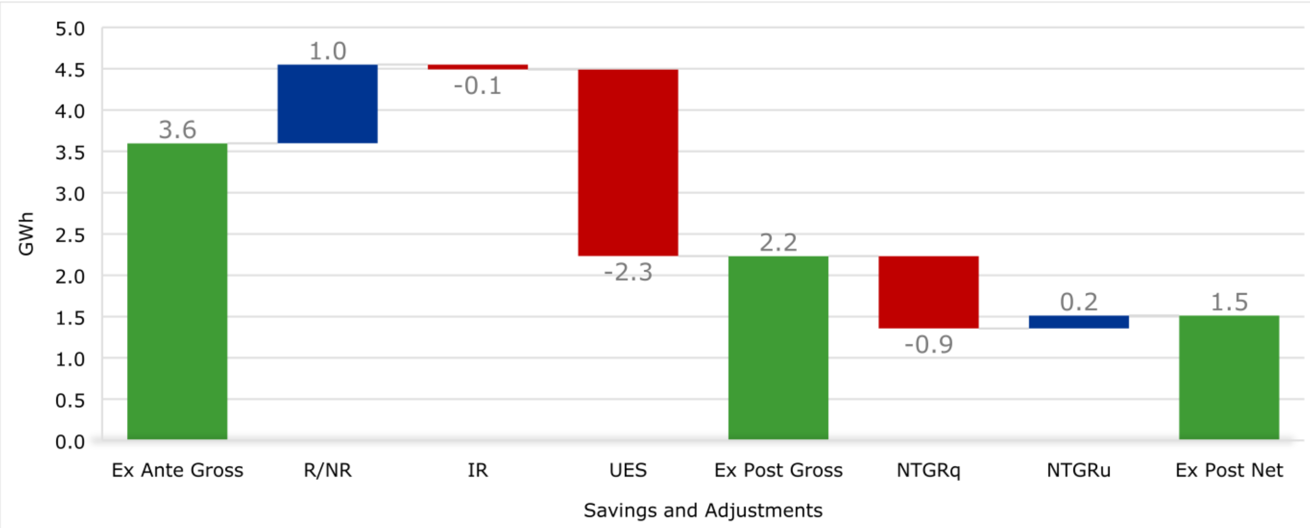


Figure 22. Gross waterfall graphic for MSB CFL reflector ≤ 30 W, SDG&E



Net waterfalls

Figure 23. Net waterfall graphic for MSB CFL reflector ≤ 30 W, SCE

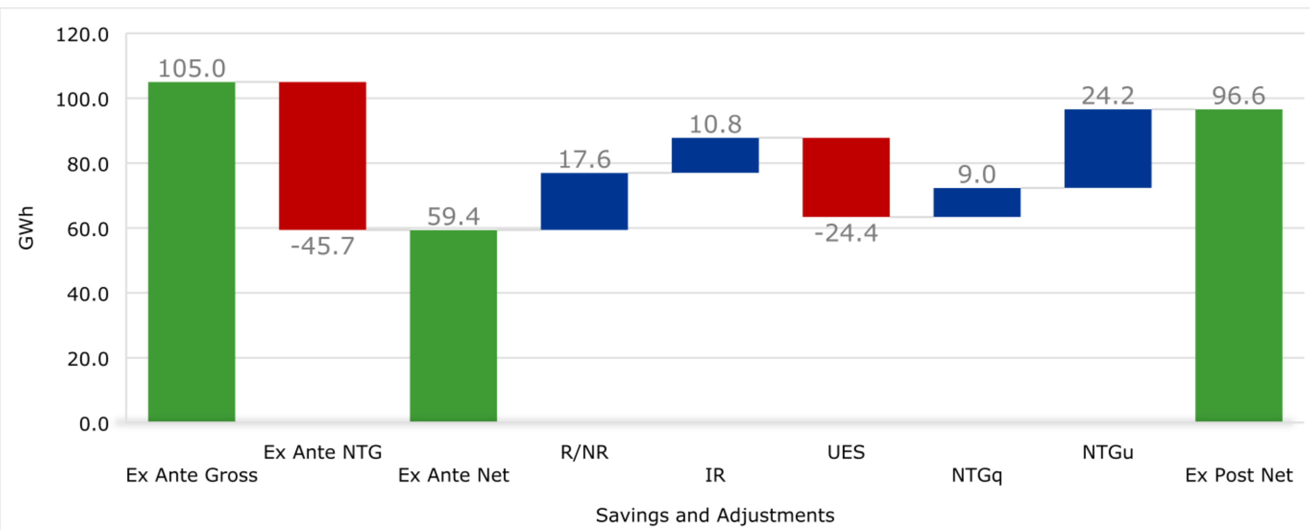
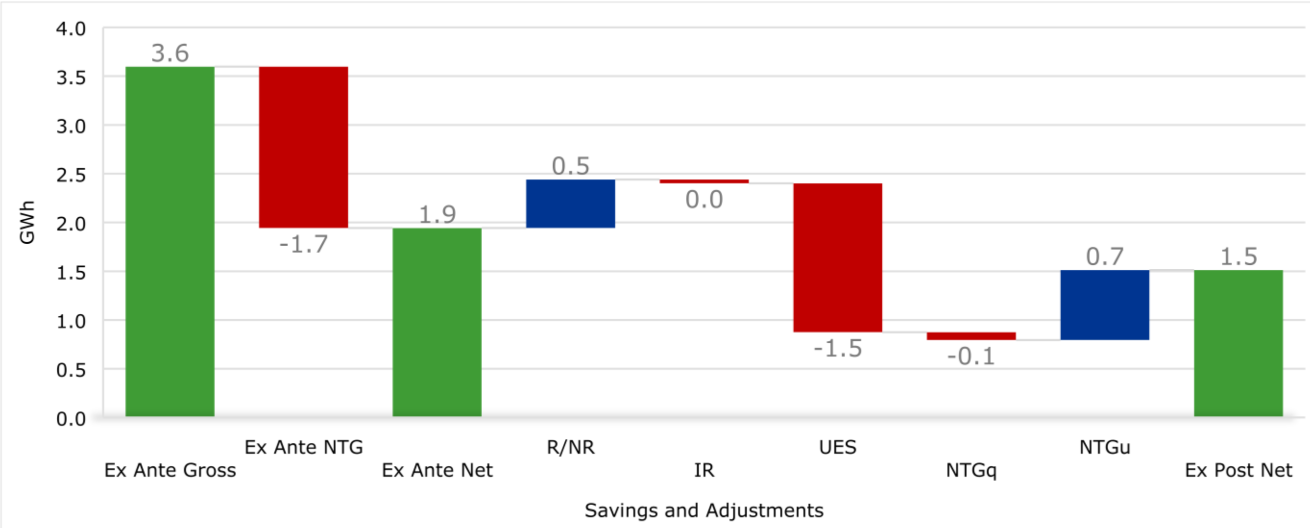


Figure 24. Net waterfall graphic for MSB CFL reflector ≤ 30 W, SDG&E



Hybrid waterfalls

Figure 25. Hybrid waterfall graphic for MSB CFL reflector ≤ 30 W, SCE

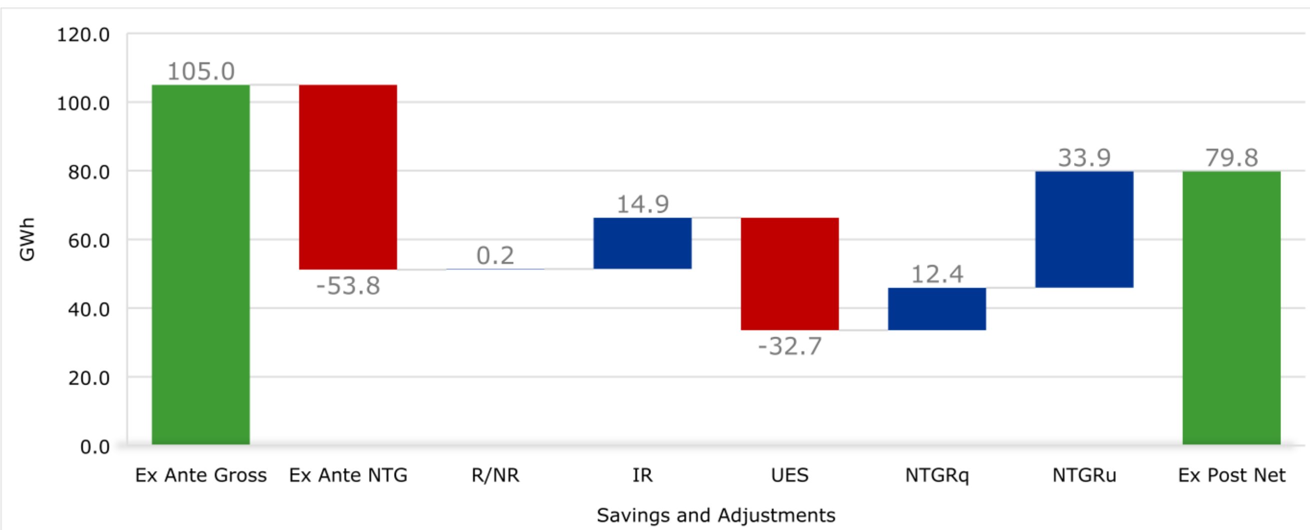
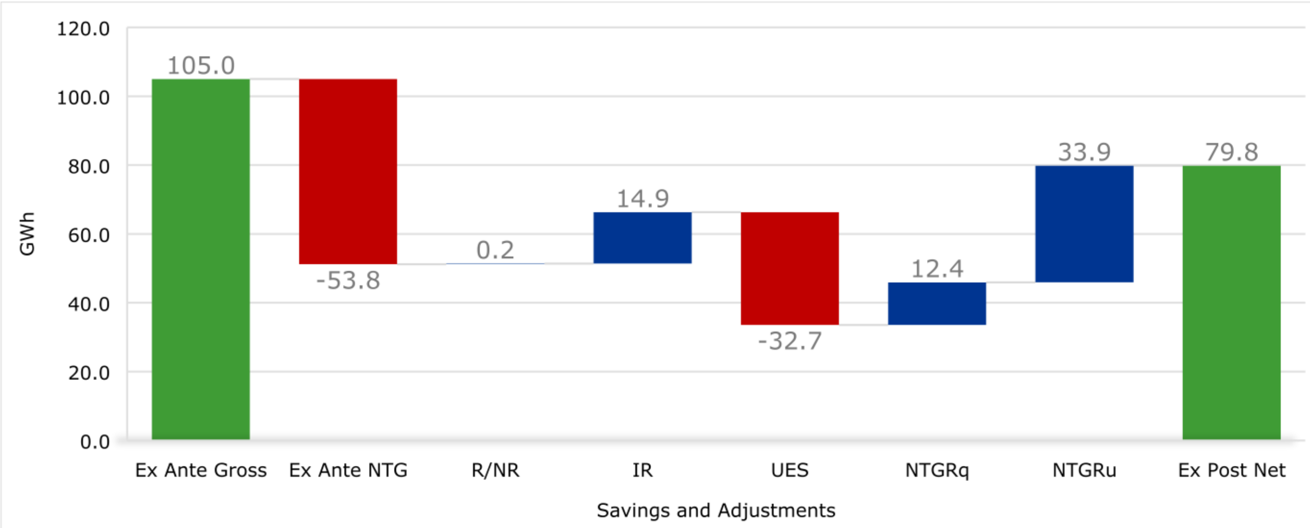


Figure 26. Hybrid waterfall graphic for MSB CFL reflector ≤ 30 W, SDG&E



MSB CFL high-wattage, > 30 W

Gross waterfalls

Figure 27. Gross waterfall graphic for MSB CFL high-wattage > 30 W, PG&E

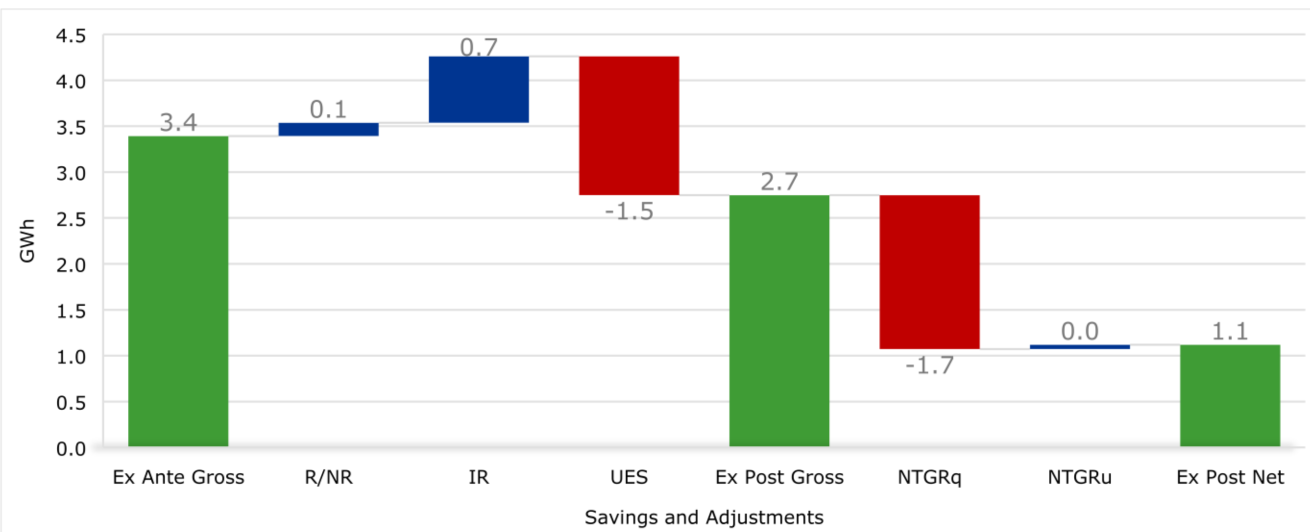


Figure 28. Gross waterfall graphic for MSB CFL high-wattage > 30 W, SCE

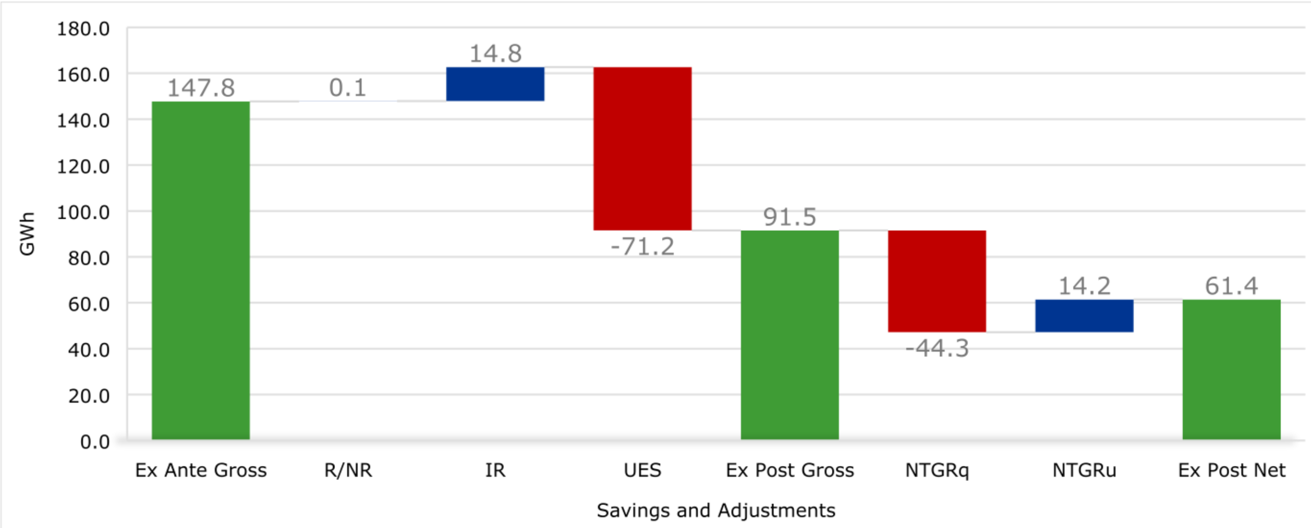
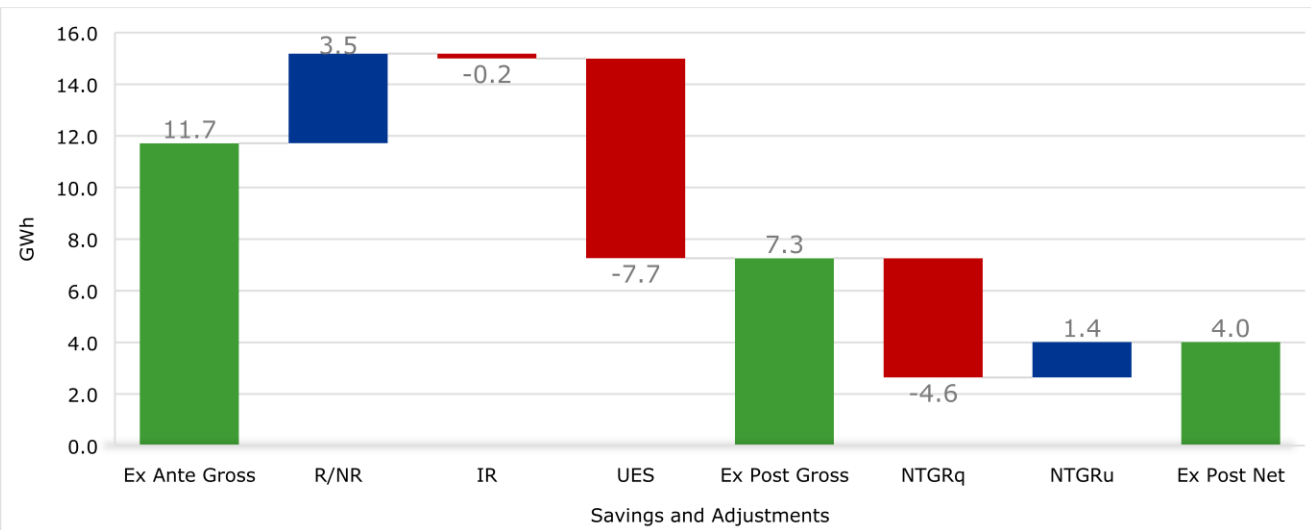


Figure 29. Gross waterfall graphic for MSB CFL high-wattage > 30 W, SDG&E



Net waterfalls

Figure 30. Net waterfall graphic for MSB CFL high-wattage > 30 W, PG&E

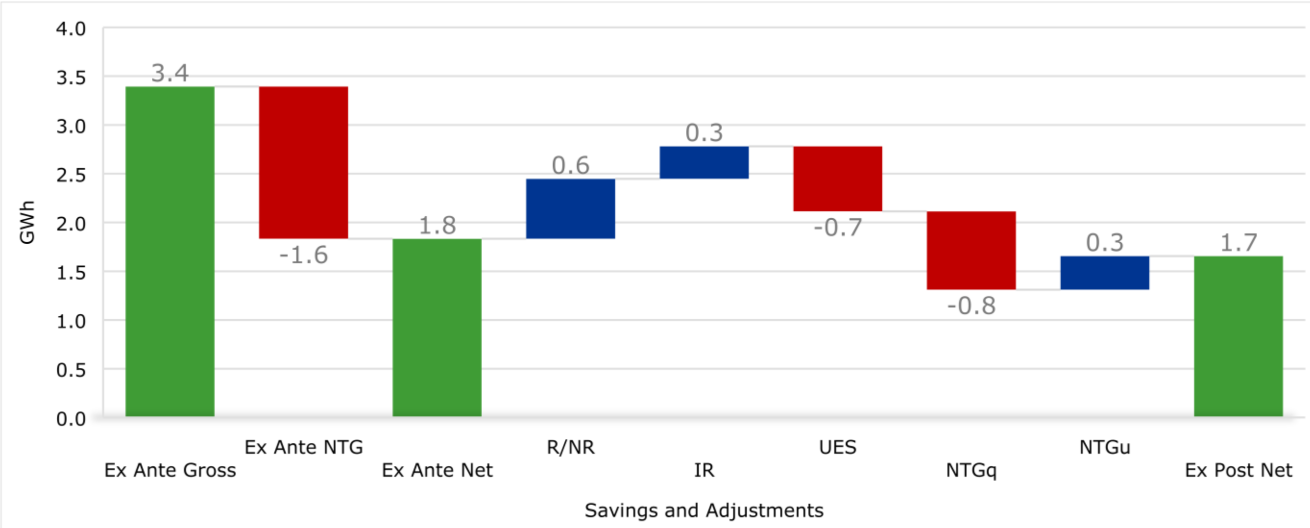


Figure 31. Net waterfall graphic for MSB CFL high-wattage > 30 W, SCE

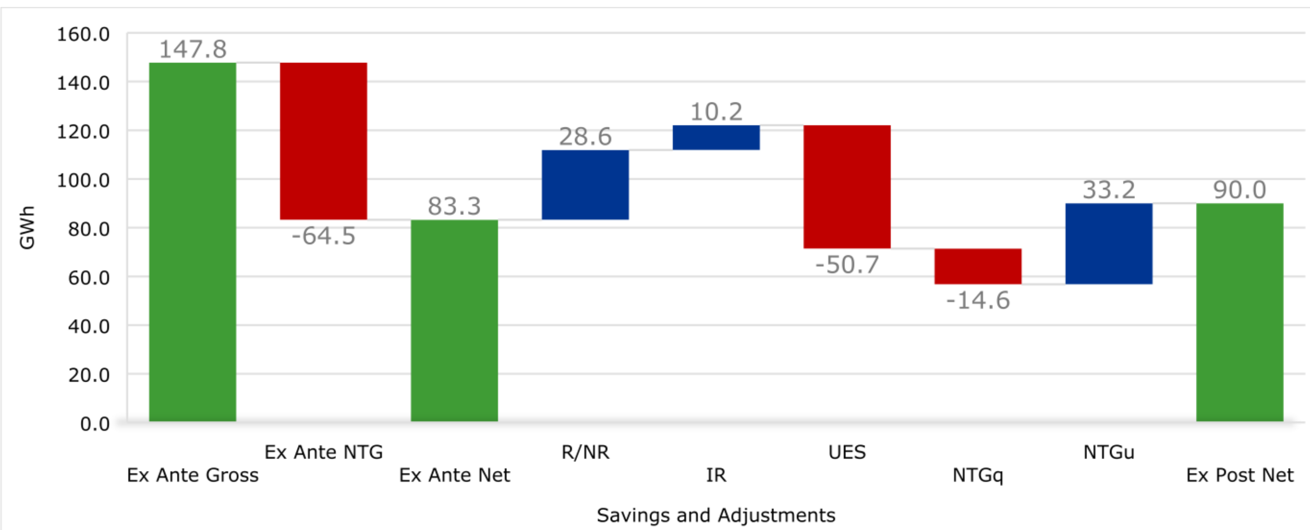
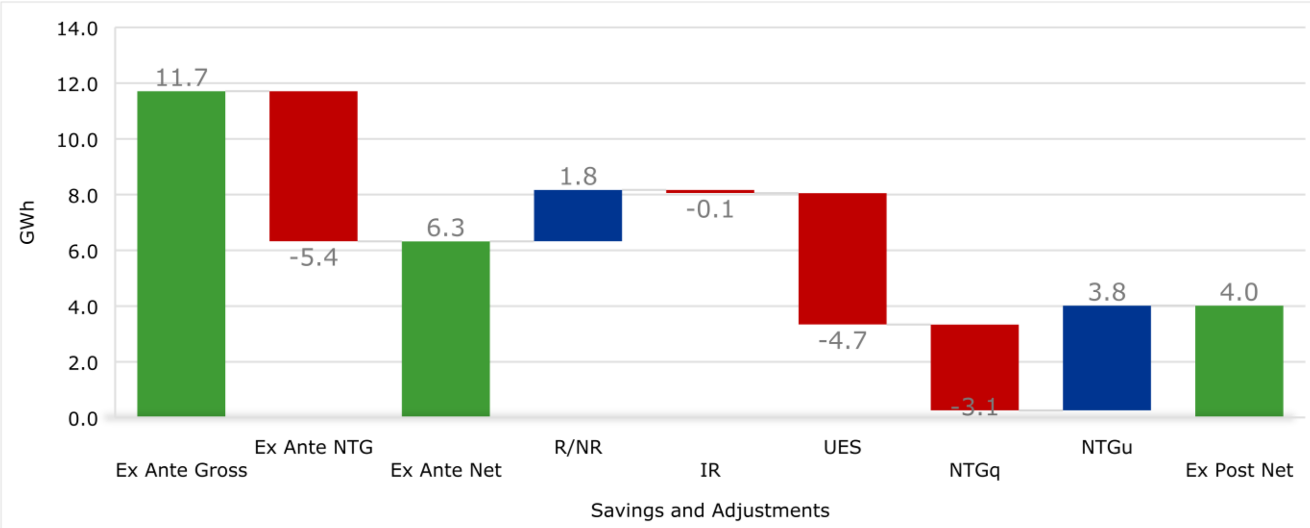


Figure 32. Net waterfall graphic for MSB CFL high-wattage > 30 W, SDG&E



Hybrid waterfalls

Figure 33. Hybrid waterfall graphic for MSB CFL high-wattage > 30 W, PG&E

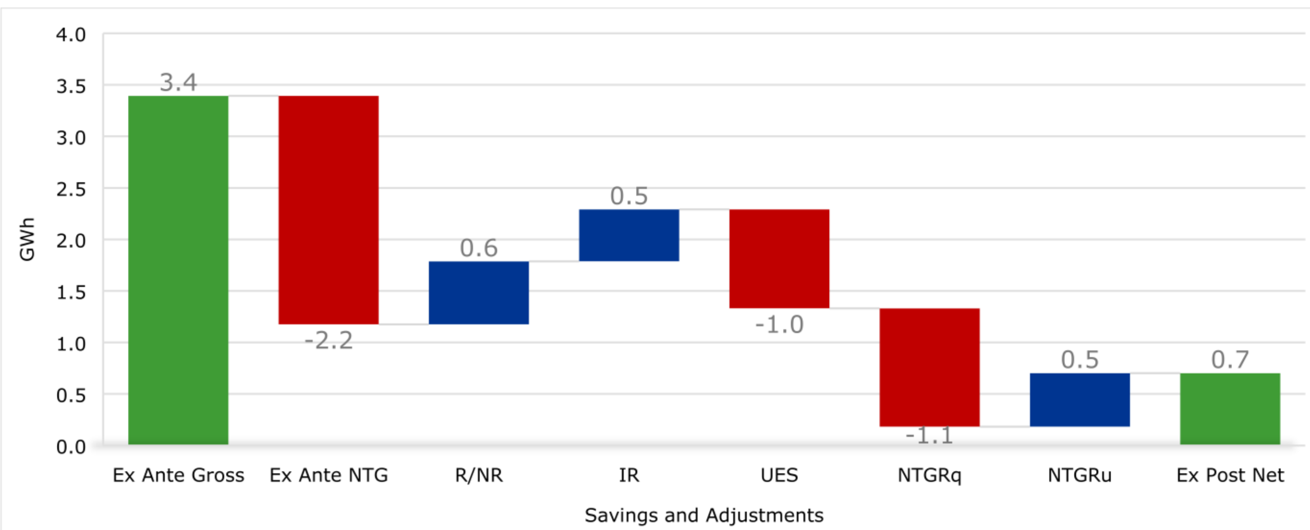


Figure 34. Hybrid waterfall graphic for MSB CFL high-wattage > 30 W, SCE

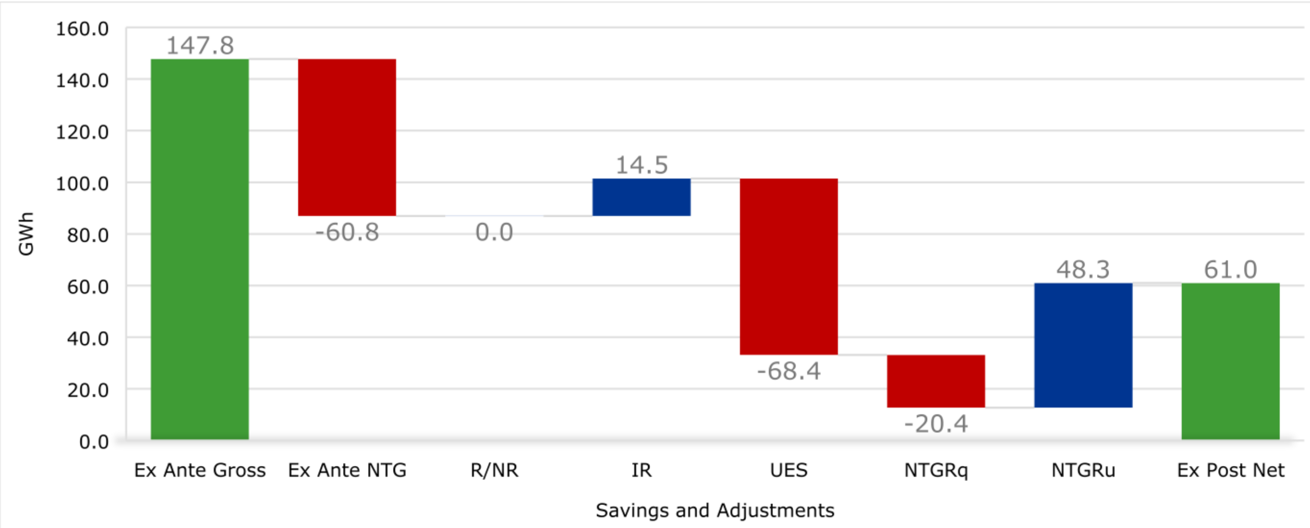
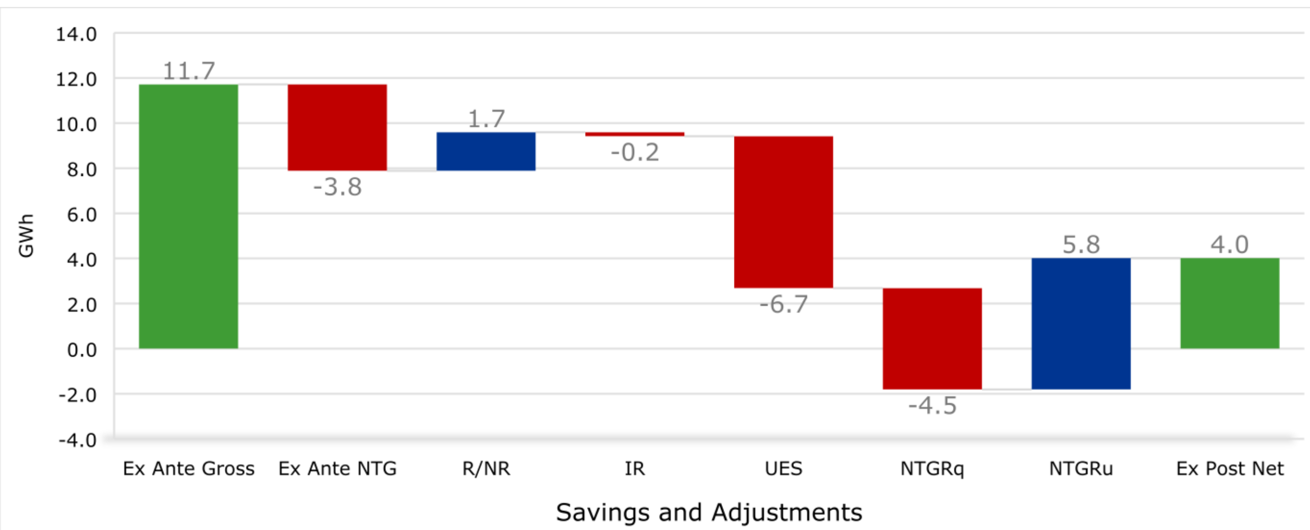


Figure 35. Hybrid waterfall graphic for MSB CFL high-wattage > 30 W, SDG&E



MSB LED A-lamp, all wattages

Gross waterfalls

Figure 36. Gross waterfall graphic for MSB LED A-lamp, all wattages, PG&E

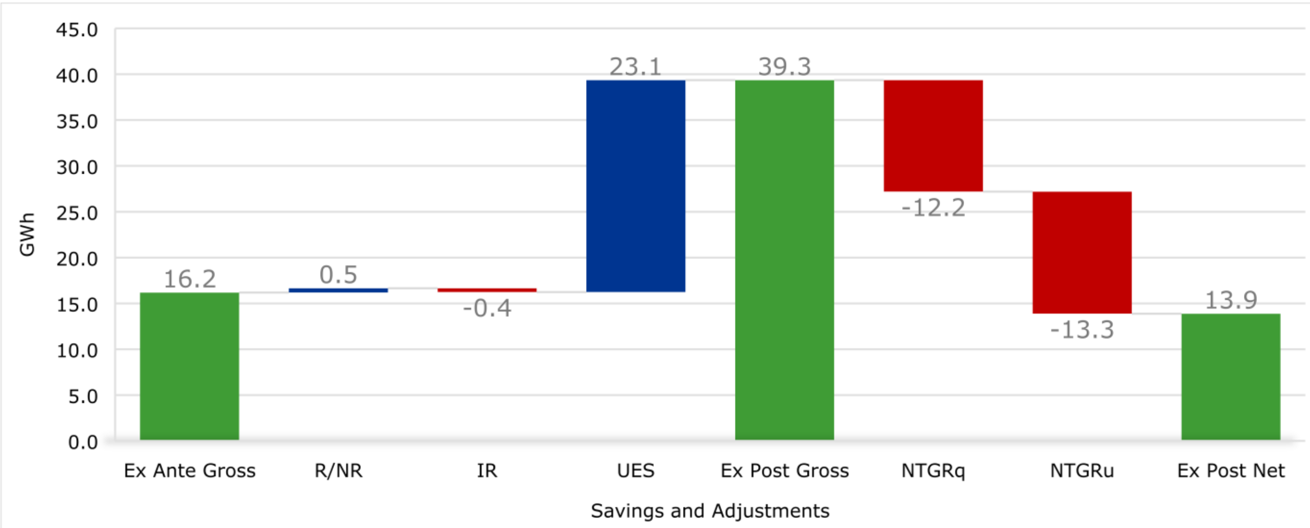


Figure 37. Gross waterfall graphic for MSB LED A-lamp, all wattages, SCE

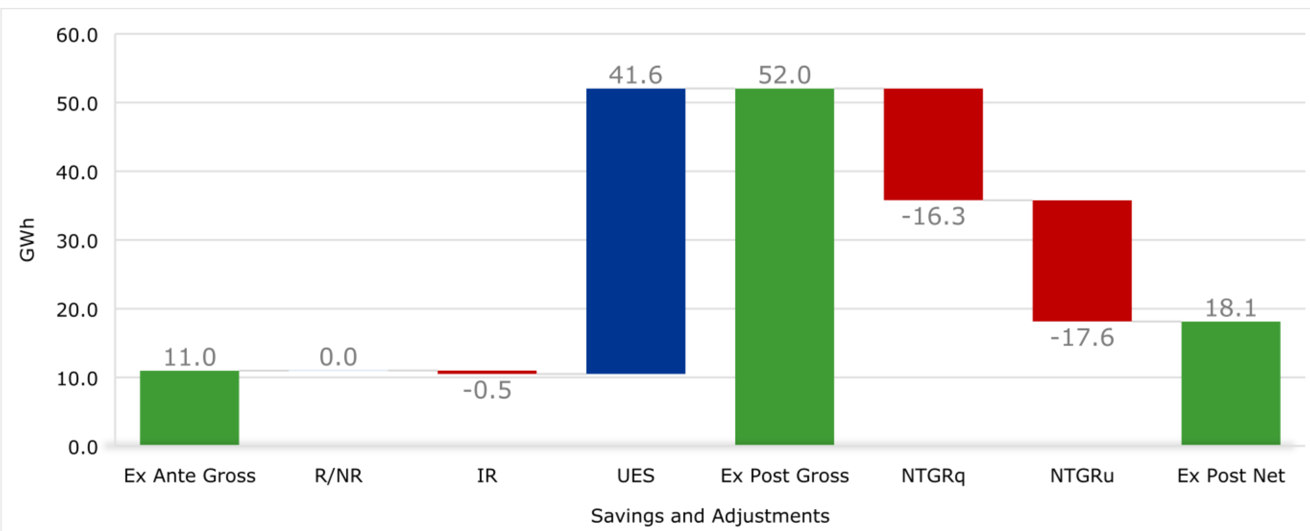
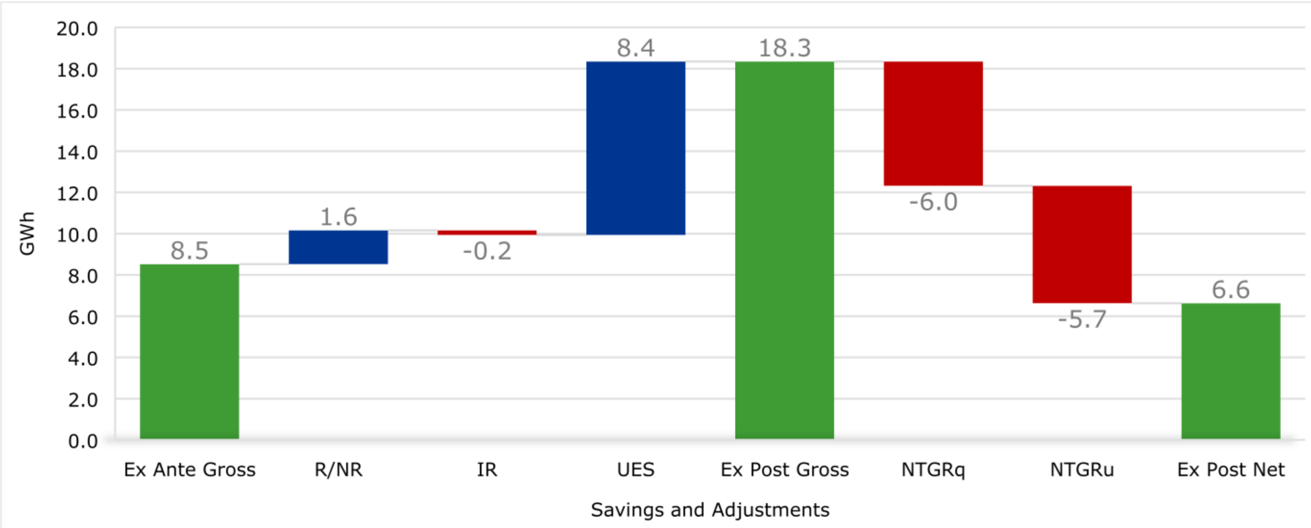


Figure 38. Gross waterfall graphic for MSB LED A-lamp, all wattages, SDG&E



Net waterfalls

Figure 39. Net waterfall graphic for MSB LED A-lamp, all wattages, PG&E

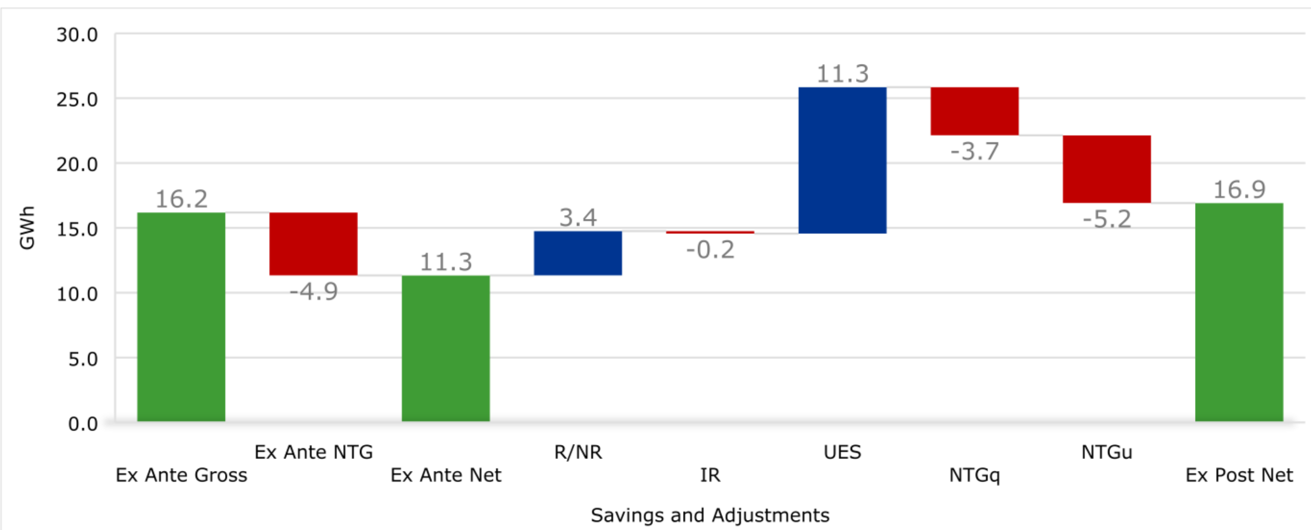


Figure 40. Net waterfall graphic for MSB LED A-lamp, all wattages, SCE

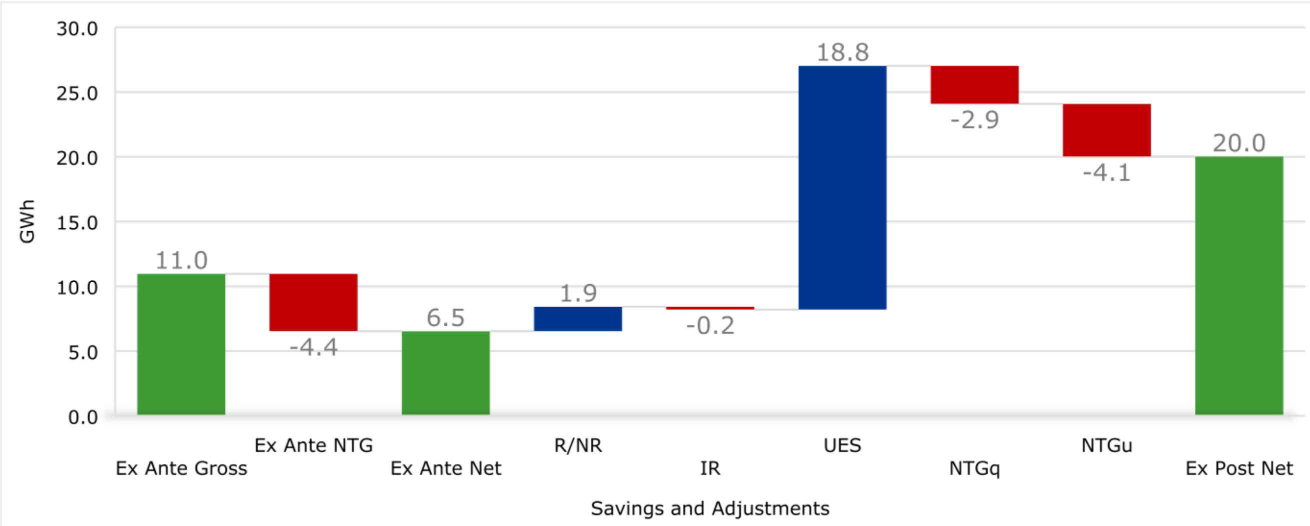
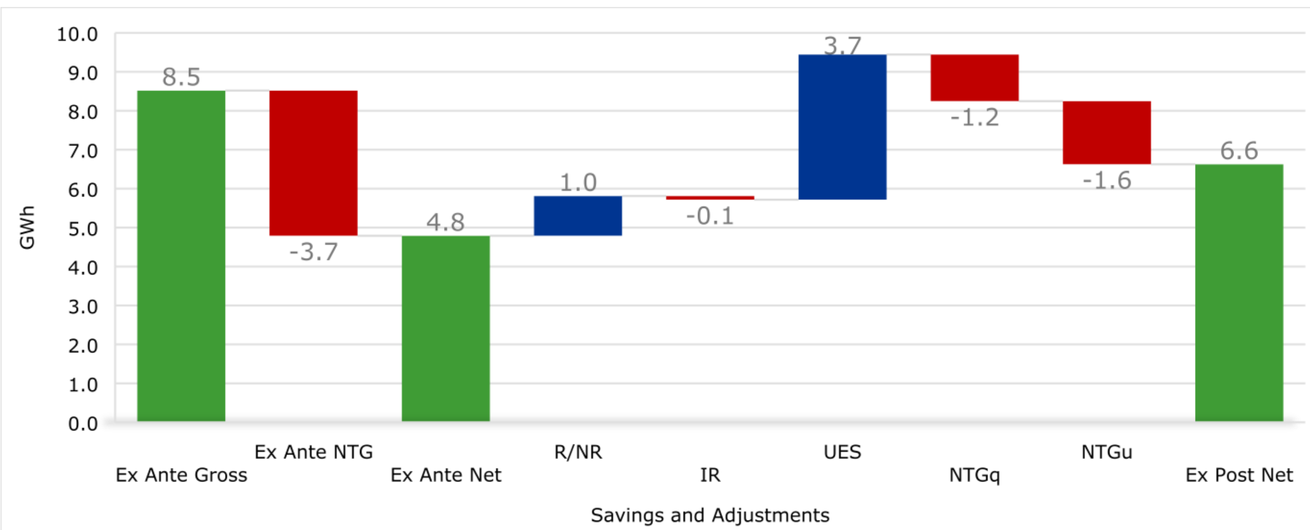


Figure 41. Net waterfall graphic for MSB LED A-lamp, all wattages, SDG&E



Hybrid waterfalls

Figure 42. Hybrid waterfall graphic for MSB LED A-lamp, all wattages, PG&E

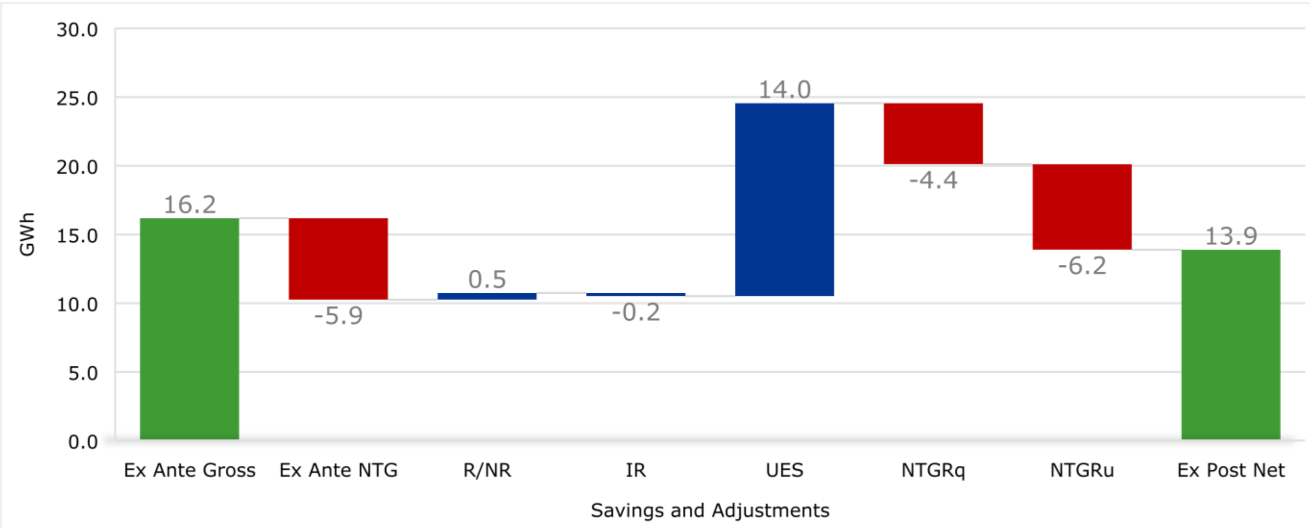


Figure 43. Hybrid waterfall graphic for MSB LED A-lamp, all wattages, SCE

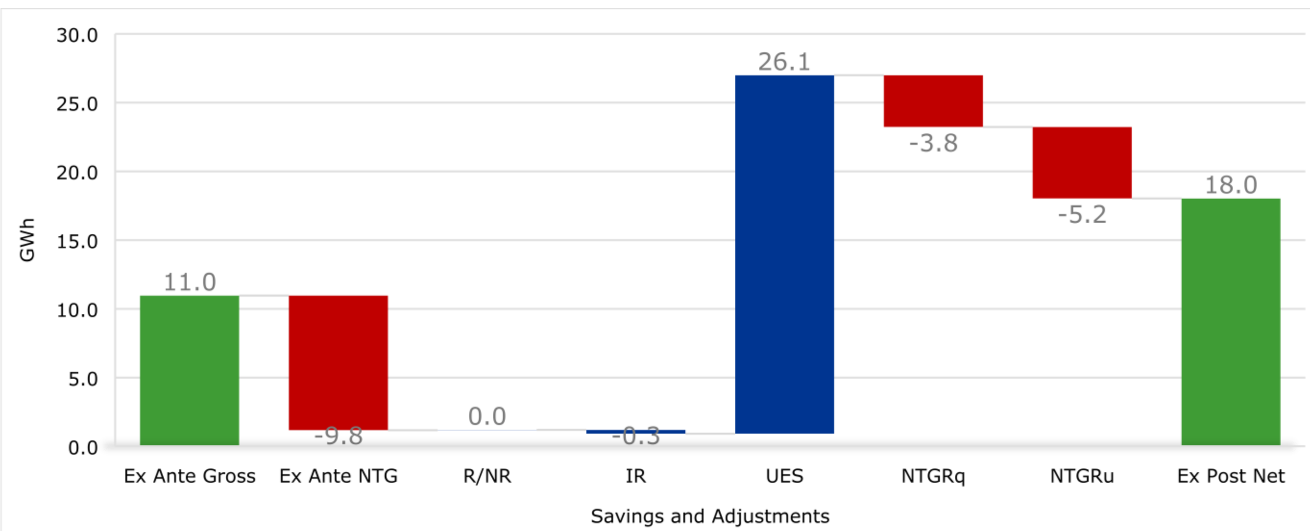
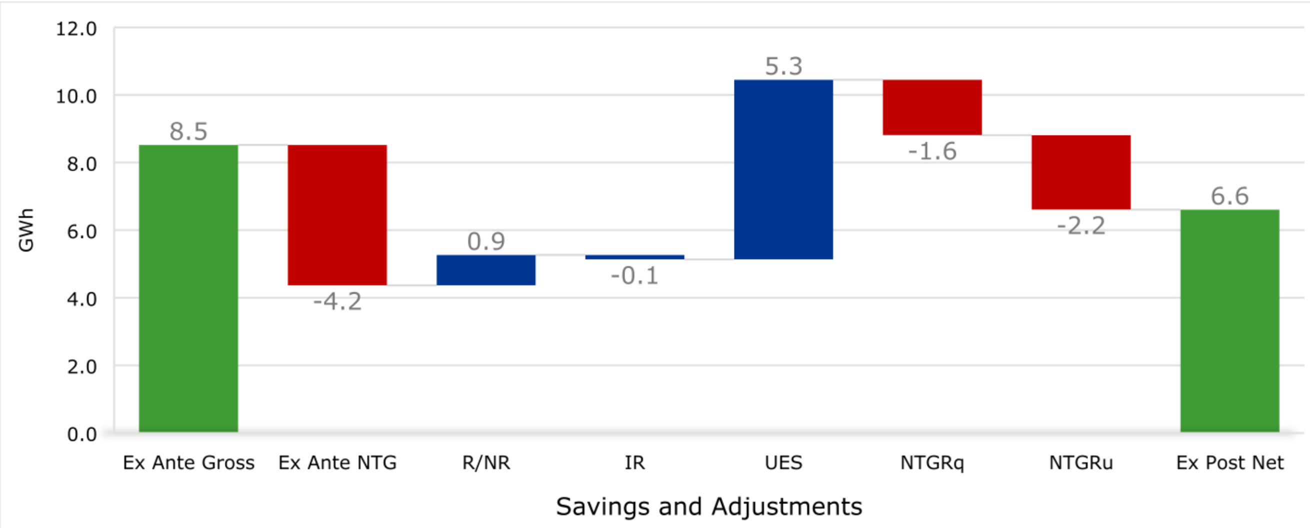


Figure 44. Hybrid waterfall graphic for MSB LED A-lamp, all wattages, SDG&E



MSB LED reflector, all wattages

Gross waterfalls

Figure 45. Gross waterfall graphic for MSB LED reflector, all wattages, PG&E

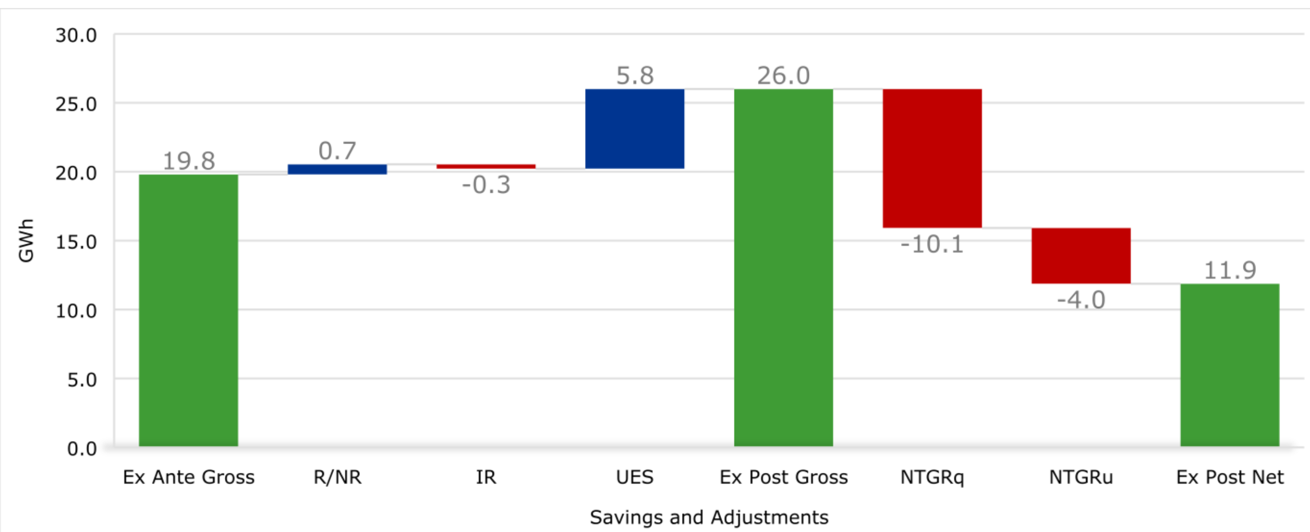


Figure 46. Gross waterfall graphic for MSB LED reflector, all wattages, SCE

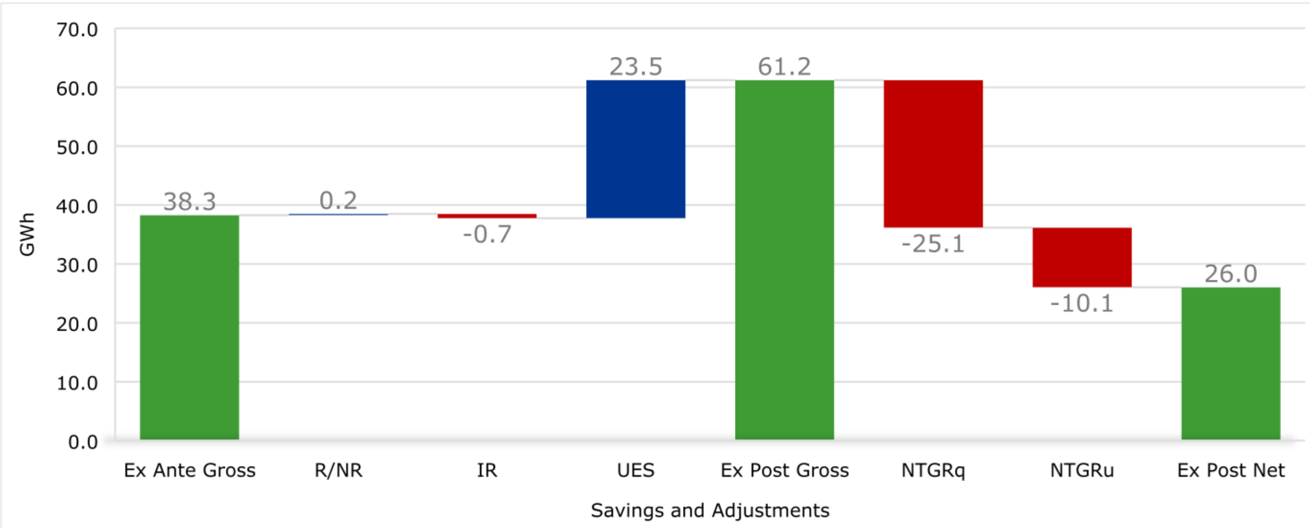
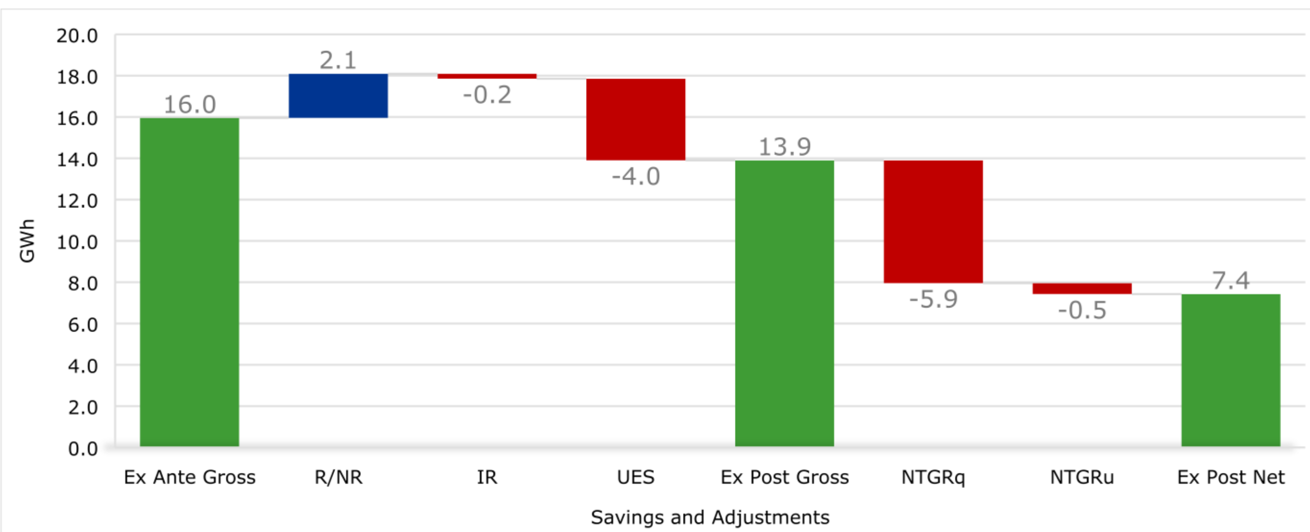


Figure 47. Gross waterfall graphic for MSB LED reflector, all wattages, SDG&E



Net waterfalls

Figure 48. Net waterfall graphic for MSB LED reflector, all wattages, PG&E

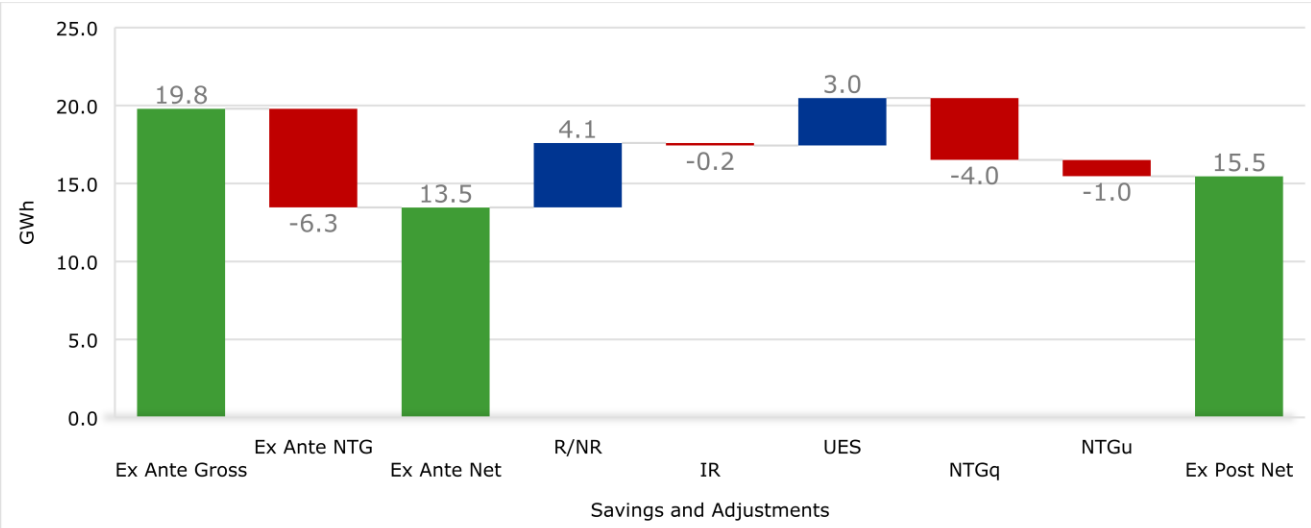


Figure 49. Net waterfall graphic for MSB LED reflector, all wattages, SCE

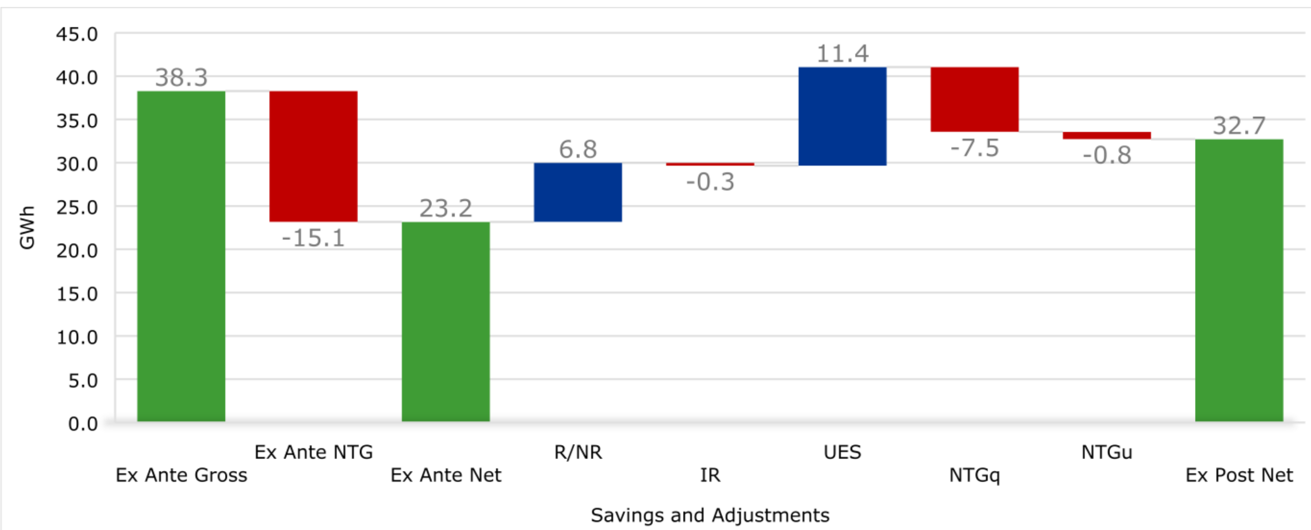
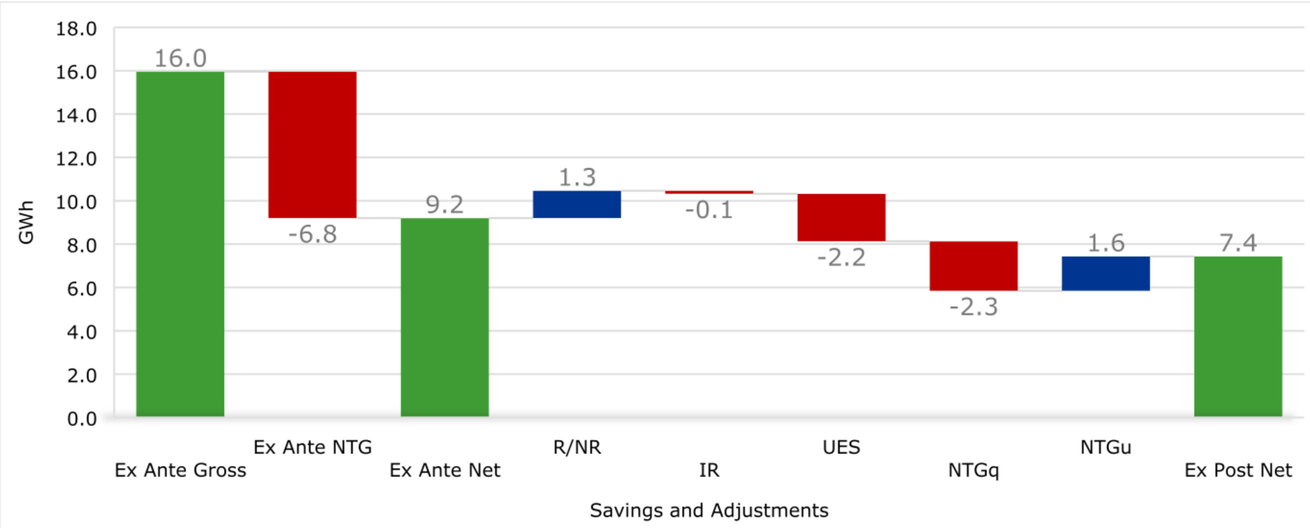


Figure 50. Net waterfall graphic for MSB LED reflector, all wattages, SDG&E



Hybrid waterfalls

Figure 51. Hybrid waterfall graphic for MSB LED reflector, all wattages, PG&E

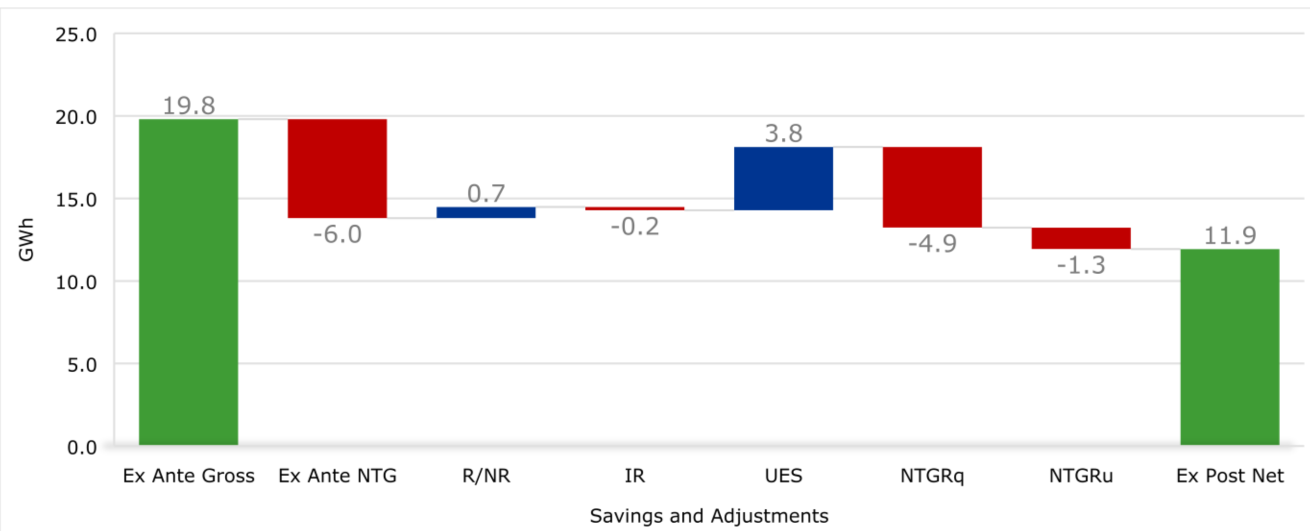


Figure 52. Hybrid waterfall graphic for MSB LED reflector, all wattages, SCE

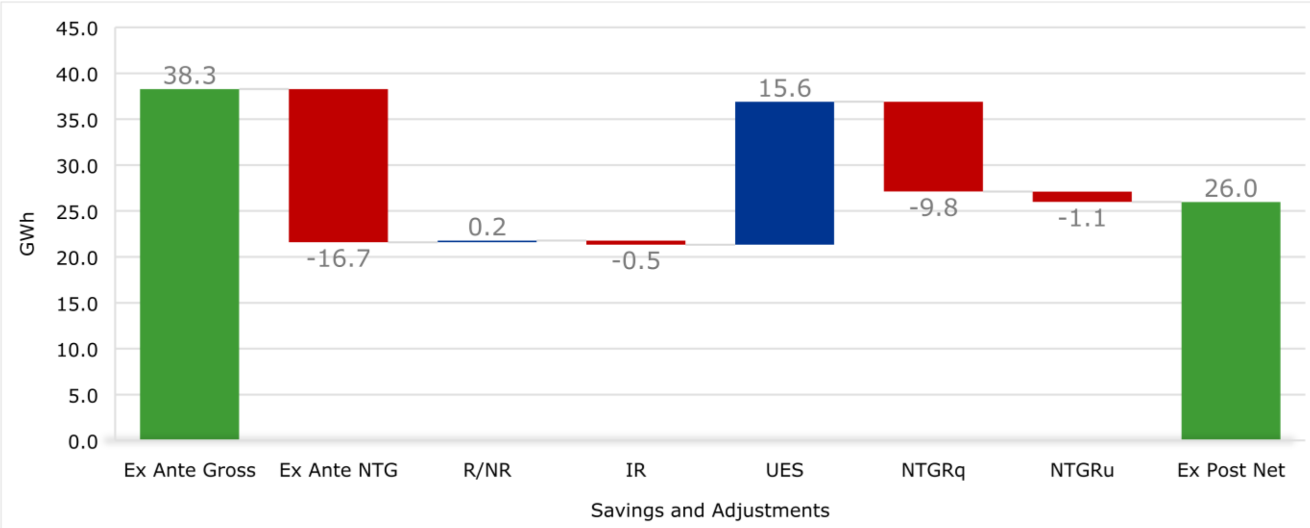
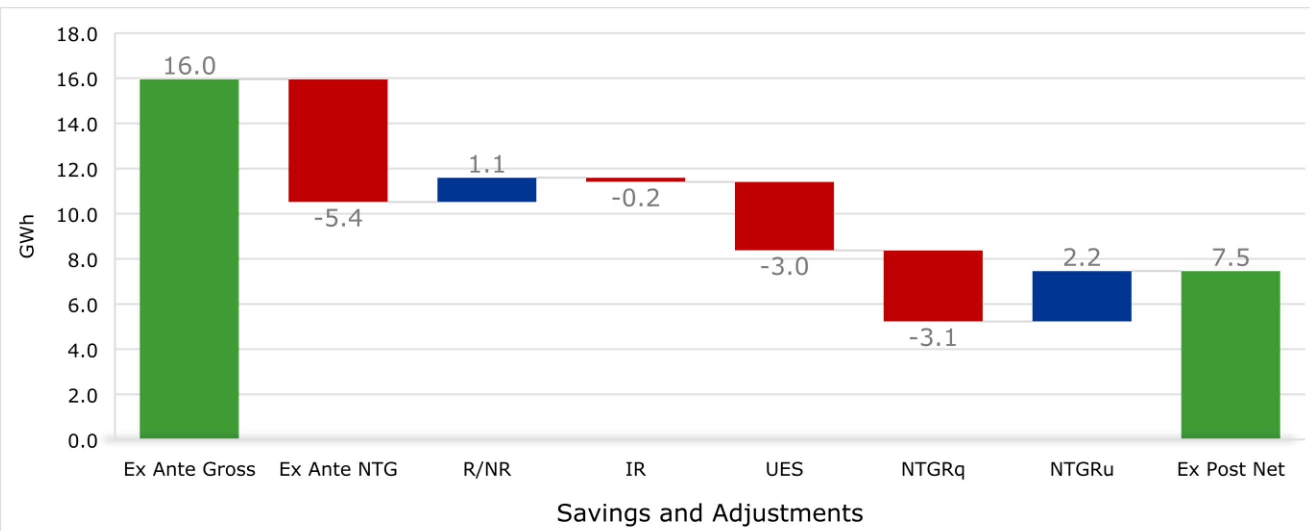


Figure 53. Hybrid waterfall graphic for MSB LED reflector, all wattages, SDG&E



APPENDIX A. RESPONSES TO PUBLIC COMMENTS

This appendix includes public comments and DNV GL's responses to those comments:

Table 1. Public comments and DNV GL Responses to the 2015 Upstream Lighting Impact Evaluation

#	Section	Topic	Page	Comment	DNV Gl
PG&E-1	Overarching	Improvements from 2013-14	NA	We commend DNV GL for making several improvements to approaches from the 2013-14 impact evaluation in the 2015 impact evaluation, including: a) implementing a market-based UES that accounts for increased lamp stock diversity and LED market presence that could contribute to the baseline; b) accounting for the program influence of channel shift in membership club stores by applying an adjustment to net UES for the membership club channel; and c) implementing a more robust and comprehensive consumer survey used in the Lamp Choice Model, versus the less rigorous in-store shopper intercept survey used in past evaluations. d) breaking down the NTG into a free ridership component (NTGq) and a component that assesses the difference between in-home lamp replacement and in-store purchasing counterfactual (NTGu). The combined NTG gives a good picture of 'what would have happened in the absence of the program.' Viewing net savings through this lens, instead of free ridership exclusively, gives the reader a better understanding of the drivers behind both gross and net savings. We believe these enhancements have yielded an evaluation that is more appropriately reflective of the diverse California residential lighting market, and the effect of the upstream lighting program on that market.	DNV GL and the the repo
PG&E-2	Overarching	Early Retirement	p. 117	The report indicates that 68% of LED lamps purchased by customers replaced functioning lamps. In other words, LEDs were more often used for early retirement (ER) than replacement-on-burn out (ROB). As stated in the report, "These results suggest that LED lamp installations among PG&E, SCE, and SDG&E residential electric customers in 2015 and 2016 were skewed toward early retirement of existing installed technologies…" PG&E requests that DNV GL update the report to explain how this high early retirement rate was taken into account in this evaluation, and how it affected the baseline assumptions. PG&E's "back-of-the envelope" calculations show that including ER has a significant impact on net savings, and so we believe it warrants	That the early re importa evaluat investig suggest evaluat quantify to quan sufficien research team w (in part share o replace retirem have st

#	Section	Topic	Page	Comment	DNV GL
				incorporation into the analysis and greater discussion in the report. *[PG&E back-of-the-envelope calculations: ER could be incorporated by only applying NTGRq (not Overall NTGR: NTGRq x NTGRu) to lamps that were replaced through ER. NTGRu would not be applied to ER lamps, because NTGRu adjusts for the difference between installed wattage and wattage available in the market, which does not apply if the existing condition is the baseline. Even if the evaluation assumed that CFLs and LEDs were replaced first through ER (so all 35% of replacements of either CFLs or LEDs from Table 27), this leaves 68%-35% = 33% of lamps that were incandescent or halogens that were replaced through ER. Because NTGRu was high for LEDs (particularly for LED A-lamps: 51% for PG&E LED A-lamps), removing the NTGRu adjustment for ER would have a significant impact on LED lamp savings.]*	on-burn evaluat this is s evaluat impacts explicit
PG&E-3	Overarching	Reliability/ Uncertainty	NA	The report would benefit from an explanation of the reliability/uncertainty of the results, particularly as it relates to the new approaches used to estimate net savings. Can DNV GL please include this level of detail in the report? Can DNV GL note in the report, using a "Yes", "No", or "Maybe" designation, which results are and are not reliable enough for ex ante updates? Including this level of detail would enable a full vetting of the accuracy and reliability of the results and their applicability to ex ante updates.	The NTC potentia consum survey of the L concent analysis market standar Tables 1 and 132 these st conserv be samp consum the exce which h of +/- 5 confider evaluate or less t are suff updates discussi
PG&E-4	Overarching	Recommendations	p. 8-9 and p. 118-119	The Recommendations in the report do not appear to take into account upcoming California Code of Regulations Title 20 , and thus they fail to be meaningful or actionable in the imminent reality of lighting programs. This upcoming Code will effectively reduce or eliminate all lamp incentives from the California IOUs upstream lighting programs. PG&E requests that DNV GL review and revise the recommendations in the report with consideration of the upcoming Title 20 Code and its implications to our programs.	We reco changes eliminat upstrea their cu added F which s potentia potentia remain program and to i transfor spec.

#	Section	Topic	Page	Comment	DNV GI
PG&E-5	5	Include More Ex Ante and Ex Post Comparisons	p. 37 and 39	Can DNV GL include more ex ante parameters to compare to ex post parameters? For example, DNV GL provided these comparisons for res/nonres split and ISR, but didn't for HOU and Delta Watts. Can DNV GL include these comparisons for ISR and Delta Watts? This additional detail is very useful to see for updating workpapers.	While th provide and do delta wa included Append which p post cor possible
PG&E-6	1.4.2	NTGRq	p. 7, table 5	It's interesting that the NTGRq for basic spiral CFLs (22%, 47%, 21% for PG&E, SCE, SDG&E) is much lower than for MSB A-lamps <30W (70%, 85%, 69% for PG&E, SCE, SDG&E). Can DNV GL provide any insights into why? For example, does this indicate that customers prefer CFL A-lamps compared with basic spirals?	The two relate to consum to supp CFLs we even in words, these la availabl program prior ev lamps w reliant i Further prices, still hav CFLs, gi availabl basic sp lamp). H for m modelle supplier the prog not hav absence while so would h CFLs ins no savin purchas See Tab A-lamp have ac Section
PG&E-7	1.5	Program Tracking Data	p. 8	In the report, DNV GL stated they identified a small number of program tracking data issues in the evaluation (i.e., inconsistencies between the program year reported in the tracking data and the shipment year included in lamp suppliers' records, and incorrect measure groups assignments). PG&E thanks DNV GL for bringing these issues to our attention so that we can improve program tracking data. For future impact evaluations, we recommend a meeting between DNV GL, the PG&E ULP program manager, and the PG&E EM&V	Thank y will brin the atte

#	Section	Topic	Page	Comment	DNV GL
				representative to review and discuss program tracking data, to ensure understanding of the data and discuss and resolve possible issues early on. The other CA electrics IOUS may find such a meeting valuable also. We understand and appreciate that due to the limited nature of the program tracking data issues, DNV GL did not exclude these lamps from the savings calculations.	
PG&E-8	2.2	Typo	p. 13	The report states, "This evaluation focuses on six upstream lighting measure groups. Taken together, these measures account for over 90% of each IOUs ex ante net savings…" Should this actually say "nearly 90"? I ask because on page 2 of the report, it states, "...these measures account for 87% of ex ante net savings..."	We hav
PG&E-9	3.4	LCM	p. 28	The report states, "Estimate market shares under three scenarios by channel". But then the bullets only describe 2 scenarios: with and without the program. There is an adjustment mentioned before the bullet (to represent phone surveys, not intercept surveys). Was that adjustment used for both scenarios? What is the 3rd scenario?	We hav
PG&E-10	3.4	LCM	p. 29	In Table 18: "The model specification captures differences in choice-making among consumers by income group, homeowner versus renter status, and planned versus impulse purchasing decisions". This could be very useful information. Can DNV-GL please provide a description of any differences found, in this report or a subsequent report?	The LCM demogr through coefficie Table 8 because alone pr higher-l the com underly a marke better u segmen populat folding updated report, Recomm
PG&E-11	3.5.2	HOU Source	p. 30	The bullet point describing the metering study could be interpreted as the metering work was done in CLASS (in 2012). Instead, the older metering results (from the 06-08 study) were applied to the socket saturations found in CLASS. Can DNV GL please clarify this in the report?	We hav to the r
PG&E-12	5.4.4	Delta Watts	p. 44-45	The description comparing the wattage reduction ratio (WRR) and delta watts method is helpful. Can DNV GL please add a sentence explaining why this evaluation used the delta watts method instead of the WRR?	We hav regardin the esta

#	Section	Topic	Page	Comment	DNV Gl
PG&E-13	5.5	Interactive Effects	p. 45-46	This impact evaluation used the usual DEER HVAC interactive effects values. The CPUC commissioned a 2013 – 2014 Interactive Effects Study with Itron, and a final report was released on September 15, 2016. Did this interactive effects study find anything that could be used in this impact evaluation, or to at least comment on the accuracy of the DEER IE factors?	DNV GL report, DEER ir per dire staff.
PG&E-14	5.5	Interactive Effects	p. 45-46	Paragraph in 5.5 cites "DEER 2011", but table shows DEER 2014: On p. 45 (section 5.5) of the report, it reads, "In this evaluation, we applied the IOU-weighted residential and commercial multipliers reported in DEER 2011 (Table 34)." But then on p. 46, Table 34, it shows "CFL and LED HVAC interactive effects factors by IOU (2014 DEER)". Can DNV GL clarify in the report which was used - DEER 2011 or DEER 2014?	We hav
PG&E-15	5.8.1	Gross Savings Results	p. 58, table 45	Half of peak demand (kW) and one-quarter of energy savings (kWh) come from nonresidential customers, but evaluation data collection focused on residential customers. While the evaluation provided a rigorous assessment of residential customers' behavior (such as through the LCM), can DNV GL explain in the report the level of rigor used for nonresidential purchases and net savings adjustments? Can DNV GL please add a description of possible limitations and biases regarding the nonresidential savings results?	Non-res 2014 DI the unc residen rigor of Stakeho investig parame watts, a making 2016 im such res
PG&E-16	6.1.5	Net Savings Findings	p. 66	The report states, "only one discounted technology was available at a time in a particular store during 2015." Does that imply there was little (no) competition between rebated lamps within the same store? Can this be clarified in the report?	Yes, thi assump added a in this b
PG&E-17	6.2	NTGR Method	p. 67	Is there a typo in the second to last bullet, "Calculate overall NTGRq and NTGRu"? If not, how is this different from the last bullet, "Calculate overall NTGR"?	We hav
PG&E-18	6.2.2	NTGRu	p. 71	To help the reader understand the NTGRu calculation, can DNV GL add to (or describe above or below the UESn definition), "based on lamp purchases in the absence of program"? Similarly, for UESg definition, add "based on installed lamps"?	We hav definitio
PG&E-19	6.2.2	NTGRu	p. 71	Besides delta watts, what parameters in the UES calculation are different for UESn and UESg? Is it just delta watts that changes? For example, HOU and interactive effects are the same, correct?	Delta w parame method clarifica the repo
PG&E-20	6.2.3.2	Channel Shifting	p. 81	Table 54, line 3, can you please describe why the difference for LEDs is -100%, rather than 43% - 100% = -57%	This wa did not followin

#	Section	Topic	Page	Comment	DNV Gl
					fixed th
PG&E-21	6.2.3.2	Consumer Survey Results	p. 82	Can the report provide results, or a summary of results, from the 2016 consumer surveys? If this is beyond the scope of this report, can they please be provided in subsequent reports, such as a residential lighting market status report? Information on the channels where customers buy lamps, rooms of installation, installation vs storage practices, and other data collected through these surveys would be very helpful for IOU program planning and market research.	We hav into Rec recomm report. the 201 results, supplier
PG&E-22	6.2.3.2	Channel Shifting	p. 82	Equations 18 and 19 have the same caption. Should equation 18 have a caption for NTGR, not delta watts?	Yes, we for Equa
PG&E-23	6.2.5	Net Savings	p. 98	Table 58 shows a total of 1,285,084 LED A-lamps for PG&E, but the column totals 1,282,942. Similarly, Table 66 shows a total of 645,955 LED reflectors for PG&E, but the column totals 638,314. What are the sources of these differences?	These w did not results. A-lamps overall included classifie but thos from th received We hav to matc
PG&E-24	6.3.4	NTGR results	p. 94	Can the evaluators please describe why the NTGRu for high wattage CFLs is significantly lower for PG&E than for SCE for the discount and grocery stores?	This diff channel lamps. be high high-wa found to stores, focused lamps. explana
PG&E-25	7.1	Supplier Interviews	p. 107-108	Section 7.1.1 describes "supplier representatives" but table 74 shows "manufacturer representatives". What about the retailer representatives? Also, the number of manufacturers is described as 27 on p. 107, but the total in table 74 is 37. Did some manufacturer representatives represent multiple channels? Perhaps add "n=XX" to the caption of Table 74.	These q manufa have up to this t
PG&E-26	7.1.1.2	Channels Affected	p. 109	These results state that without the program, the representatives wouldn't have sold "any lamps" in these channels. Does this mean the representatives wouldn't have sold any lamps at all to these channels, or just CFLs or LEDs?	This sta supplier lamps a have up this dist

#	Section	Topic	Page	Comment	DNV Gl
PG&E-27	7.3	IOUs Position - CEC Spec	p. 115	On page 115 of the report, it states, "The IOUs have suggested that the superior quality of LED laps that meet the California Quality LED Specification may have transformational consequences in California's residential lighting market. The theory is that the higher quality lamps will result in high consumer satisfaction with LED lamps, ultimately leading to repeat purchases. Conversely, the IOUs assert that LED lamps that do not meet the spec are of lower quality, which could result in consumer dissatisfaction that could reduce or eliminate their future purchases of LED lamps." The CEC Spec is a requirement of the CPUC Decision 12-11-015. It would be accurate to state that the IOUs have pointed out that by supporting lamps that meet the CEC Spec we are helping to ensure customers have positive experiences with LEDs. PG&E believes that high customer satisfaction with LEDs will be essential to ensure market transformation. Can DNV GL please revise this paragraph of the report to reflect this?	We hav Section
PG&E-28	7.3	IOUs Position - CEC Spec	p. 115	The sentence on page 115 of the report is inaccurate: "Conversely, the IOUs assert that LED lamps that do not meet the spec are of lower quality…" We ask that this sentence be revised as follows: "Conversely, the IOUs assert that LED lamps that do not meet the spec are of questionable quality…"	We hav Section
PG&E-29	8.1.2	Implementation strategy	p. 118	The report states that, without program support, there would be fewer energy efficient purchases in drug, grocery, and hardware. Should discount stores be included in this statement?	Discour included have up 8.1.2 ac
PG&E-30	8.1.3.2	CEC Spec Influence	p. 120, p. 116	The results regarding CEC spec influence and availability are very interesting. It would also be helpful to include information on ENERGY STAR lamps. For the current report, please add the percent of LED lamp stock that is ENERGY STAR, not just CEC spec (p. 120). While the majority of LEDs installed by customers were not CEC spec, it would be interesting to understand what percent were ENERGY STAR, particularly given the high rate of satisfaction. For the upcoming in-home survey (p. 116), please also compare lamp model numbers to see if they are ENERGY STAR labeled and ask participants about their satisfaction with these lamps.	55% of shelves Star, wl impact We hav referenc
PG&E-31	Appendix AA-AB	IESR Tables	Appendix AA-AB	The residential downstream lighting measures should be included in the IESR tables as a single line item – passed through. Can DNV GL please include this in the report?	Pass-th delivere databas use the these cl append

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					recogni stakeho project whether should l append
PG&E-32	Appendix C	Tables 81 and 82	p. C-7 through C-12	For ease of reading the report (i.e., to avoid needing to flip to page C-6) can DNV GL please add the Climate Zone Group Column to Tables 81, 82, 83, 84 and 85?	We hav group i
SCE/SDG&E-1	Overarching	Overarching	Overarching	The study has used many of the standard data collection and analysis in use for the ULP savings estimation since past program cycles. In some cases, the study has used previously evaluated study parameters. One new analysis is introduced in this evaluation using LCM technique for estimating the NTG for the program technologies with the introduction of two new parameters NTG g and NTG u. There are several concerns about this new complicated approach to an already complicated measurement issue: (1) The new NTG approach seems to be inadvertently including market effects of the program into the current definition of NTG which is Net of free-ridership.	This me program not the program effects i particip spillove does no a factor lamps s lamp sa Futhern savings to-CFL savings cases is compon approac generat those sa does no savings
SCE/SDG&E-2	Overarching	Overarching	Overarching	(2) In this NTGR q and u method, the study used the results to re-estimate UES at the market level. This seems like a double adjustment. As indicated in the report (see page-4), factors such as installation, HOUs, Interactive effect, UES, delta watts are already accounted for as gross savings adjustments.	The NT UES to the com estimat (installa interact watts), account twice.
SCE/SDG&E-3	Overarching	Overarching	Overarching	(3) This study is using a bottom-up approach starting with program shipment data to identify the various channel of distribution. We agree that this is important program information. It would seem that the causal-links for the ULP program are -- (1) authorized MFG/program ship to various stores defined as channel of distribution, (2) end-users purchase program qualified products at distribution channel of choice, (3) once lights/bulbs are home they are installed into the sockets. The retail channel cross-effect (i.e., cannibalization) is market effect which is not counted in the current definition of NTG.	The cha our eva channel a marke exclusiv sold thr program custome destinat a progra does no program program an asse

#	Section	Topic	Page	Comment	DNV Gl
					The 201 account NTGR a
SCE/SDG&E-4	Overarching	Overarching	Overarching	(4) Given the dramatic change in program scale and depth for 2010-2012, 2013-2014 and 2015 program periods, how can we be certain that the pooled data (i.e., including intercept survey, shelf survey, etc.) are still representative of reality for 2015?	While th was dev impact shelf an that we 2015 th Table 1 sample lamp st Table 1 for 201
SCE/SDG&E-5	Overarching	Overarching	Overarching	Possible improvements: Consider using more direct and standard NTGR approach for comparability and as a part of tri-angulation effort. The current study method seems exploratory. While it can be considered innovative, it may be a good idea to also use a more direct approach to verify the workpaper parameters and free-ridership assumptions, to produce a second set of results for comparison.	The prin to gene savings method specific capture We reco specific reflecte but sav upstrea lamps is distribu recogni traditio for a m reflects Our eva upstrea to consi distribu measur appropr example adminis lamps i the eva adminis NTGRq A and B than ap reflects channel the mea approac accurac

#	Section	Topic	Page	Comment	DNV GI
SCE/SDG&E-6	Overarching	Overarching	Overarching	The study result did not specify confidence and precision clearly. This is especially the case for the complicated NTGR q and u modeled/simulated estimates. The modeling/simulation efforts also leveraged and pooled data from prior studies that may have separate study confidence/precision considerations. Can you discussion possible concern for propagation of errors?	The mo data fro NTGR c potentia consum survey of the L concent analysis market standar Tables and 132 these st conserv be samp consum the exce which h of +/- 5 confide evaluat or less are suff updates discussi uncerta
SCE/SDG&E-7	Overarching	Overarching	Overarching	Given the study complexity, sample disposition and data sets used for modeling/simulation are not clearly explained. It would be helpful to develop additional report content to carefully explain the sources/size of data and the limitations, including a data map to identify the flow of the data and sample size of these data sets used. It is also important to properly communicate how the various data sources contributed to the overall analyses. For example, how did the completed manufacturer/retailer survey inform this study? Did the modeling/simulation use the Manufacturer/retailer survey results?	DNV GL this rep level, a detailed of data We add 6.6.1 to of the n direct th which p descript that we shares. Tables and 132 errors.
SCE/SDG&E-8	Overarching	Overarching	Overarching	The below construct is a gross simplification of study method and it is NOT sufficient to guide the readers to better understand the nuanced study methods. As indicated above, a more detailed data flow map may provide clarity for readers.	As note SCE/SD Figure 2 overarc savings
SCE/SDG&E-9	Overarching	Overarching	Overarching	The IE factor should be technology based and not wattage based as we see more and more base technologies do not have the same IE issues due to the program i.e a CFL base technology replaced by a program LED should	DNV GL did not interact the stud Stakeho

#	Section	Topic	Page	Comment	DNV Gl
				not adjust for IE effect due to the program.	conside effects s evaluati evaluati
SCE/SDG&E-10	Overarching	Overarching	Overarching	Some of the appendixes contain important sample size and disposition information. These appendixes should be moved forward to help the reader discern the quality and quantity of available data.	DNV GL estimat 1.3.1 in We app recomm of the a of the r believe to clutte than cla
SCE/SDG&E-11	Overarching	Overarching	Overarching	Improve end-user and on-site data collection to validate workpaper parameters. While store shelf inventory study will continue to be important, acting as indicators of purchase behaviors, but the workpaper energy savings is really about energy usage behavior. Store intercept data can also be important but stated preference may not be the same as revealed preference.	In the c program is deper behavio upcomi will prov regardi but such budget timeline this eva researc drivers (installa
SCE/SDG&E-12	Overarching	Overarching	Overarching	Since the ULP program is a legitimate market transformation program, some of the NTGR q and u concepts may be more relevant for a market transformation study. The other idea is to not lump NTGR q and u under the NTGR, which should aim at free-ridership estimate. Perhaps, the NTGR g and u can be expressed as market transformation effects.	See cor

#	Section	Topic	Page	Comment	DNV Gl
SCE/SDG&E-13	Overarching	Overarching	Overarching	In contrast, the 2015 Non-Residential Deemed Lighting Impact Study by Itron, takes a more direct approach of developing a series of six adjustments to the reported ex-ante gross energy/demand savings to address key differences in work-paper parameters. These adjustments included: 1. Delta Ex-Ante adjustment, 2. Delta HOUs, 3. Delta quantity (i.e., missing, removal, etc.), 4. Delta interactive effect, 5. Delta Watts, 6. Delta EUL. This Itron study, then used a standard free-ridership survey results (i.e., PA1, 2, 3) to derive at the net ex-post savings: • PA-1: reflect the influence of most important of the various program related elements in customer's decision to select a given program measure • PA-2: captures the perceive importance of the program design factors (i.e., rebate, delivery, etc.) relative to non-program factors in the decisions to implement the specific program measure that is eventually adopted and installed • PA-3: captures the likelihood of various actions the customer might have taken at a given time and in the future if the program had not been available (i.e., counter factual). This straight-forward study approach yielded understandable results that are easy to follow, including estimated relative precision for consideration. Currently, the study methods between ULP and Non-Res Deemed programs stand in sharp contrast. Again, the workpaper parameters for energy savings claim is energy usage level rather than at the market level.	This eva parame commen points. that the stand in non-res program Howeve two are Particip deemed decision by desig particip cases, c recogni particip yields s evaluat program speciali method
SCE1	Overarching	Table 10, Table 35, Table 37, Tables 46, Tables 47	Overarching	There is an error in the product categories assigned to SCE on Table 10 and Table 35- SCE did not incentivize any products in the "MSB CFL basic spiral <30 W category. Instead, the number stated in the report of 98,892 was for a CFL reflector 15 W model. The KWh was 2,305,344. This will need to be corrected in Tables 35 and 37. Tables 46, 47 as well any other tables that are affected by this number should be corrected so that the savings claims are accurate.	DNV GL groups claims

APPENDIX K. RESPONSES TO PUBLIC COMMENTS

This appendix includes public comments and DNV GL's responses to those comments:

Table 131. Public comments and DNV GL Responses to the 2015 Upstream Lighting Impact Evaluation

#	Section	Topic	Page	Comment	DNV GL Response
PG&E-1	Overarching	Improvements from 2013-14	NA	We commend DNV GL for making several improvements to approaches from the 2013-14 impact evaluation in the 2015 impact evaluation, including: a) implementing a market-based UES that accounts for increased lamp stock diversity and LED market presence that could contribute to the baseline; b) accounting for the program influence of channel shift in membership club stores by applying an adjustment to net UES for the membership club channel; and c) implementing a more robust and comprehensive consumer survey used in the Lamp Choice Model, versus the less rigorous in-store shopper intercept survey used in past evaluations. d) breaking down the NTG into a free ridership component (NTGq) and a component that assesses the difference between in-home lamp replacement and in-store purchasing counterfactual (NTGu). The combined NTG gives a good picture of 'what would have happened in the absence of the program.' Viewing net savings through this lens, instead of free ridership exclusively, gives the reader a better understanding of the drivers behind both gross and net savings. We believe these enhancements have yielded an evaluation that is more appropriately reflective of the diverse California residential lighting market, and the effect of the upstream lighting program on that market.	DNV GL appreciates the comment and the ensuing careful review of the report.

#	Section	Topic	Page	Comment	DNV GL Response
PG&E-2	Overarching	Early Retirement	p. 117	The report indicates that 68% of LED lamps purchased by customers replaced functioning lamps. In other words, LEDs were more often used for early retirement (ER) than replacement-on-burn out (ROB). As stated in the report, "These results suggest that LED lamp installations among PG&E, SCE, and SDG&E residential electric customers in 2015 and 2016 were skewed toward early retirement of existing installed technologies…" PG&E requests that DNV GL update the report to explain how this high early retirement rate was taken into account in this evaluation, and how it affected the baseline assumptions. PG&E's "back-of-the envelope" calculations show that including ER has a significant impact on net savings, and so we believe it warrants incorporation into the analysis and greater discussion in the report. *[PG&E back-of-the-envelope calculations: ER could be incorporated by only applying NTGRq (not Overall NTGR: NTGRq x NTGRu) to lamps that were replaced through ER. NTGRu would not be applied to ER lamps, because NTGRu adjusts for the difference between installed wattage and wattage available in the market, which does not apply if the existing condition is the baseline. Even if the evaluation assumed that CFLs and LEDs were replaced first through ER (so all 35% of replacements of either CFLs or LEDs from Table 27), this leaves 68%-35% = 33% of lamps that were incandescent or halogens that were replaced through ER. Because NTGRu was high for LEDs (particularly for LED A-lamps: 51% for PG&E LED A-lamps), removing the NTGRu adjustment for ER would have a significant impact on LED lamp savings.]*	That the majority of LEDs are early replacements is indeed an important finding. This evaluation's goal was to investigate early retirement to suggest whether future evaluations should attempt to quantify this, rather than attempt to quantify such impacts with sufficient rigor. As state in the research plan, "...the evaluation team will focus evaluation efforts (in part) on understanding the share of installed LED lamps that replace functioning lamps (early retirement) versus lamps that have stopped working (replace-on-burnout). " The current evaluation results do suggest that this is something future evaluations should quantify these impacts, so we have added an explicit recommendation to do so.
PG&E-3	Overarching	Reliability/ Uncertainty	NA	The report would benefit from an explanation of the reliability/uncertainty of the results, particularly as it relates to the new approaches used to estimate net savings. Can DNV GL please include this level of detail in the report? Can DNV GL note in the report, using a "Yes", "No", or "Maybe" designation, which results	The NTGR contains at least three potential sources of uncertainty: consumer surveys data, shelf survey data, and the estimation of the Lamp Choice Model. We concentrate our uncertainty analysis associated with modelled

#	Section	Topic	Page	Comment	DNV GL Response
				are and are not reliable enough for ex ante updates? Including this level of detail would enable a full vetting of the accuracy and reliability of the results and their applicability to ex ante updates.	market shares, and include these standard error estimates in Tables 100, 104, 111, 118, 125, and 132. We acknowledge that these standard errors are conservative as there is likely to be sampling error due to the consumer and shelf surveys. With the exception of CFL A-lamps, which have a confidence interval of +/- 5%, the resulting confidence intervals for all other evaluated measures are equal to or less than 3%, which we believe are sufficient to include in ex ante updates. We have added this discussion to Section 6.3.
PG&E-4	Overarching	Recommendations	p. 8-9 and p. 118-119	The Recommendations in the report do not appear to take into account upcoming California Code of Regulations Title 20 , and thus they fail to be meaningful or actionable in the imminent reality of lighting programs. This upcoming Code will effectively reduce or eliminate all lamp incentives from the California IOUs upstream lighting programs. PG&E requests that DNV GL review and revise the recommendations in the report with consideration of the upcoming Title 20 Code and its implications to our programs.	We recognize that upcoming code changes will dramatically limit or eliminate residential and upstream lighting programs in their current form. We have added Recommendation 10, which suggests considering a potential study to evaluate the potential energy savings that will remain for upstream lighting programs in 2018 and beyond, and to investigate the market transformation effects of the CEC spec.
PG&E-5	5	Include More Ex Ante and Ex Post Comparisons	p. 37 and 39	Can DNV GL include more ex ante parameters to compare to ex post parameters? For example, DNV GL provided these comparisons for res/nonres split and ISR, but didn't for HOU and Delta Watts. Can DNV GL include these comparisons for ISR and Delta Watts? This additional detail is very useful to see for updating workpapers.	While the tracking data only provide ex ante UES estimates, and do not have DEER HOU or delta watt assumptions, we have included waterfall graphics in Appendix J in the final report, which provide ex ante and ex post comparisons to the extent possible in the tracking data.

#	Section	Topic	Page	Comment	DNV GL Response
PG&E-6	1.4.2	NTGRq	p. 7, table 5	It's interesting that the NTGRq for basic spiral CFLs (22%, 47%, 21% for PG&E, SCE, SDG&E) is much lower than for MSB A-lamps <30W (70%, 85%, 69% for PG&E, SCE, SDG&E). Can DNV GL provide any insights into why? For example, does this indicate that customers prefer CFL A-lamps compared with basic spirals?	The two drivers of this result relate to stocking practices, and consumer preference. According to supplier responses, basic spiral CFLs were rarely program-reliant, even in discount stores. In other words, suppliers suggested that these lamps would have been available in the absence of the program. This is a change from prior evaluations, in which these lamps were frequently program reliant in discount stores. Furthermore, at non-program prices, many customers would still have purchased basic spiral CFLs, given the lamp stock available in these stores (CFL basic spiral and incandescent A-lamp). See Table 94 in Appendix H for more details on this modelled result. In contrast, suppliers suggested that many of the program CFL A-lamps would not have been stocked in the absence of the program, and that while some of these customers would have purchased basic spiral CFLs instead (effectively yielding no savings), many would have purchased incandescent A-lamps. See Table 101 for details on CFL A-lamp modelled results. We have added this discussion into Section 6.3.2.
PG&E-7	1.5	Program Tracking Data	p. 8	In the report, DNV GL stated they identified a small number of program tracking data issues in the evaluation (i.e., inconsistencies between the program year reported in the tracking data and the shipment year included in lamp suppliers' records, and incorrect measure	Thank you for this feedback. We will bring this recommendation to the attention of commission staff.

#	Section	Topic	Page	Comment	DNV GL Response
				groups assignments). PG&E thanks DNV GL for bringing these issues to our attention so that we can improve program tracking data. For future impact evaluations, we recommend a meeting between DNV GL, the PG&E ULP program manager, and the PG&E EM&V representative to review and discuss program tracking data, to ensure understanding of the data and discuss and resolve possible issues early on. The other CA electrics IOUS may find such a meeting valuable also. We understand and appreciate that due to the limited nature of the program tracking data issues, DNV GL did not exclude these lamps from the savings calculations.	
PG&E-8	2.2	Typo	p. 13	The report states, "This evaluation focuses on six upstream lighting measure groups. Taken together, these measures account for over 90% of each IOUs ex ante net savings..." Should this actually say "nearly 90"? I ask because on page 2 of the report, it states, "...these measures account for 87% of ex ante net savings..."	We have corrected this typo.
PG&E-9	3.4	LCM	p. 28	The report states, "Estimate market shares under three scenarios by channel". But then the bullets only describe 2 scenarios: with and without the program. There is an adjustment mentioned before the bullet (to represent phone surveys, not intercept surveys). Was that adjustment used for both scenarios? What is the 3rd scenario?	We have corrected this typo.
PG&E-10	3.4	LCM	p. 29	In Table 18: "The model specification captures differences in choice-making among consumers by income group, homeowner versus renter status, and planned versus impulse purchasing decisions". This could be very useful information. Can DNV-GL please provide a description of any differences found, in this report or a subsequent report?	The LCM takes a respondent's demographics into account through its application of coefficients, which are provided in Table 89, in Appendix G. But because such coefficients do not alone provide the levels of higher-level insight suggested in the comment, we believe the underlying data could be used in

#	Section	Topic	Page	Comment	DNV GL Response
					a market report with the intent of better understanding various segmentations of lamp purchaser populations. We thus recommend folding this investigation into an updated market assessment report, and have included this as Recommendation 11.
PG&E-11	3.5.2	HOU Source	p. 30	The bullet point describing the metering study could be interpreted as the metering work was done in CLASS (in 2012). Instead, the older metering results (from the 06-08 study) were applied to the socket saturations found in CLASS. Can DNV GL please clarify this in the report?	We have added this clarification to the referenced bullet point.
PG&E-12	5.4.4	Delta Watts	p. 44-45	The description comparing the wattage reduction ratio (WRR) and delta watts method is helpful. Can DNV GL please add a sentence explaining why this evaluation used the delta watts method instead of the WRR?	We have added a description regarding our rationale for using the established methodology.
PG&E-13	5.5	Interactive Effects	p. 45-46	This impact evaluation used the usual DEER HVAC interactive effects values. The CPUC commissioned a 2013 – 2014 Interactive Effects Study with Itron, and a final report was released on September 15, 2016. Did this interactive effects study find anything that could be used in this impact evaluation, or to at least comment on the accuracy of the DEER IE factors?	DNV GL did review the referenced report, but ultimately used the DEER interactive effects values per direction from commission staff.
PG&E-14	5.5	Interactive Effects	p. 45-46	Paragraph in 5.5 cites "DEER 2011", but table shows DEER 2014: On p. 45 (section 5.5) of the report, it reads, "In this evaluation, we applied the IOU-weighted residential and commercial multipliers reported in DEER 2011 (Table 34)." But then on p. 46, Table 34, it shows "CFL and LED HVAC interactive effects factors by IOU (2014 DEER)". Can DNV GL clarify in the report which was used - DEER 2011 or DEER 2014?	We have fixed this typo.

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PG&E-15	5.8.1	Gross Savings Results	p. 58, table 45	Half of peak demand (kW) and one-quarter of energy savings (kWh) come from nonresidential customers, but evaluation data collection focused on residential customers. While the evaluation provided a rigorous assessment of residential customers' behavior (such as through the LCM), can DNV GL explain in the report the level of rigor used for nonresidential purchases and net savings adjustments? Can DNV GL please add a description of possible limitations and biases regarding the nonresidential savings results?	Non-residential measures used 2014 DEER assumptions. Thus, the uncertainty surrounding non-residential results is driven by the rigor of the DEER assumptions. Stakeholders should consider an investigation of non-residential parameters (such as HOU, delta watts, and purchaser decision-making) in the scoping of the 2016 impact evaluation, although such research could be extensive.
PG&E-16	6.1.5	Net Savings Findings	p. 66	The report states, "only one discounted technology was available at a time in a particular store during 2015." Does that imply there was little (no) competition between rebated lamps within the same store? Can this be clarified in the report?	Yes, this comment interprets our assumption correctly. We have added a sentence for clarification in this bullet in the report.
PG&E-17	6.2	NTGR Method	p. 67	Is there a typo in the second to last bullet, "Calculate overall NTGRq and NTGRu"? If not, how is this different from the last bullet, "Calculate overall NTGR"?	We have fixed this typo.
PG&E-18	6.2.2	NTGRu	p. 71	To help the reader understand the NTGRu calculation, can DNV GL add to (or describe above or below the UESn definition), "based on lamp purchases in the absence of program"? Similarly, for UESg definition, add "based on installed lamps"?	We have clarified these definitions in Equation 9.
PG&E-19	6.2.2	NTGRu	p. 71	Besides delta watts, what parameters in the UES calculation are different for UESn and UESg? Is it just delta watts that changes? For example, HOU and interactive effects are the same, correct?	Delta watts is the only UES parameter that we update in this methodology. We have added this clarification in Section 6.2.2 in the report.
PG&E-20	6.2.3.2	Channel Shifting	p. 81	Table 54, line 3, can you please describe why the difference for LEDs is -100%, rather than 43% - 100% = -57%	This was a typo in Table 54 that did not have any impacts on the following calculations. We have fixed this typo.
PG&E-21	6.2.3.2	Consumer Survey Results	p. 82	Can the report provide results, or a summary of results, from the 2016 consumer surveys? If this is beyond the scope of this report, can they please be provided in subsequent reports,	We have added this suggestion into Recommendation 11, which recommends an additional market report. This report would leverage

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				such as a residential lighting market status report? Information on the channels where customers buy lamps, rooms of installation, installation vs storage practices, and other data collected through these surveys would be very helpful for IOU program planning and market research.	the 2016 consumer survey results, the LCM, and 2016 supplier interviews.
PG&E-22	6.2.3.2	Channel Shifting	p. 82	Equations 18 and 19 have the same caption. Should equation 18 have a caption for NTGR, not delta watts?	Yes, we have fixed this in the title for Equation 18.
PG&E-23	6.2.5	Net Savings	p. 98	Table 58 shows a total of 1,285,084 LED A-lamps for PG&E, but the column totals 1,282,942. Similarly, Table 66 shows a total of 645,955 LED reflectors for PG&E, but the column totals 638,314. What are the sources of these differences?	These were reporting errors that did not impact calculations or results. The 1,285,084 PG&E LED A-lamps that were reported in the overall row in the draft report included extra lamps that were classified as "OTHER" channels, but those lamps were excluded from the table, and simply received the overall NTGR results. We have revised the table totals to match the sum of channels.
PG&E-24	6.3.4	NTGR results	p. 94	Can the evaluators please describe why the NTGRu for high wattage CFLs is significantly lower for PG&E than for SCE for the discount and grocery stores?	This difference is driven by the channel distribution of these lamps. Freeridership was found to be high at discount stores for high-wattage lamps, and was found to be lower at grocery stores, where SCE and SDG&E focused the majority of those lamps. We have added this explanation in Section 6.3.4.
PG&E-25	7.1	Supplier Interviews	p. 107-108	Section 7.1.1 describes "supplier representatives" but table 74 shows "manufacturer representatives". What about the retailer representatives? Also, the number of manufacturers is described as 27 on p. 107, but the total in table 74 is 37. Did some manufacturer representatives represent multiple channels? Perhaps add "n=XX" to the caption of Table 74.	These questions were asked of manufacturer representatives. We have updated the text leading up to this table to reflect this.

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PG&E-26	7.1.1.2	Channels Affected	p. 109	These results state that without the program, the representatives wouldn't have sold "any lamps" in these channels. Does this mean the representatives wouldn't have sold any lamps at all to these channels, or just CFLs or LEDs?	This statement means that the supplier would not have sold any lamps at all in these channels. We have updated the text to make this distinction clearer.
PG&E-27	7.3	IOUs Position - CEC Spec	p. 115	On page 115 of the report, it states, "The IOUs have suggested that the superior quality of LED laps that meet the California Quality LED Specification may have transformational consequences in California's residential lighting market. The theory is that the higher quality lamps will result in high consumer satisfaction with LED lamps, ultimately leading to repeat purchases. Conversely, the IOUs assert that LED lamps that do not meet the spec are of lower quality, which could result in consumer dissatisfaction that could reduce or eliminate their future purchases of LED lamps." The CEC Spec is a requirement of the CPUC Decision 12-11-015. It would be accurate to state that the IOUs have pointed out that by supporting lamps that meet the CEC Spec we are helping to ensure customers have positive experiences with LEDs. PG&E believes that high customer satisfaction with LEDs will be essential to ensure market transformation. Can DNV GL please revise this paragraph of the report to reflect this?	We have revised this sentence in Section 7.3
PG&E-28	7.3	IOUs Position - CEC Spec	p. 115	The sentence on page 115 of the report is inaccurate: "Conversely, the IOUs assert that LED lamps that do not meet the spec are of lower quality…" We ask that this sentence be revised as follows: "Conversely, the IOUs assert that LED lamps that do not meet the spec are of questionable quality…"	We have revised this sentence in Section 7.3
PG&E-29	8.1.2	Implementation strategy	p. 118	The report states that, without program support, there would be fewer energy efficient purchases in drug, grocery, and hardware. Should discount stores be included in this statement?	Discount stores should be included in this sentence. We have updated the text in Section 8.1.2 accordingly.

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PG&E-30	8.1.3.2	CEC Spec Influence	p. 120, p. 116	The results regarding CEC spec influence and availability are very interesting. It would also be helpful to include information on ENERGY STAR lamps. For the current report, please add the percent of LED lamp stock that is ENERGY STAR, not just CEC spec (p. 120). While the majority of LEDs installed by customers were not CEC spec, it would be interesting to understand what percent were ENERGY STAR, particularly given the high rate of satisfaction. For the upcoming in-home survey (p. 116), please also compare lamp model numbers to see if they are ENERGY STAR labeled and ask participants about their satisfaction with these lamps.	55% of led lamps stocked on shelves did qualify for Energy Star, which may also have had an impact on consumer satisfaction. We have added this to the referenced conclusion.
PG&E-31	Appendix AA-AB	IESR Tables	Appendix AA-AB	The residential downstream lighting measures should be included in the IESR tables as a single line item – passed through. Can DNV GL please include this in the report?	Pass-through claims were not delivered to DNV GL in the ATR database, so we were unable to use the database tool to include these claims in the IESR appendix. However, DNV GL recognizes that in the future, stakeholders should decide in the project and research scoping whether pass-through claims should be included in the appendices.
PG&E-32	Appendix C	Tables 81 and 82	p. C-7 through C-12	For ease of reading the report (i.e., to avoid needing to flip to page C-6) can DNV GL please add the Climate Zone Group Column to Tables 81, 82, 83, 84 and 85?	We have added the climate zone group in tables 81-85.
SCE/SDG&E-1	Overarching	Overarching	Overarching	The study has used many of the standard data collection and analysis in use for the ULP savings estimation since past program cycles. In some cases, the study has used previously evaluated study parameters. One new analysis is introduced in this evaluation using LCM technique for estimating the NTG for the program technologies with the introduction of two new parameters NTG g and NTG u. There are several concerns about this new	This methodology looks at the program's effects on the market, not the market effects of the program. Traditionally, market effects includes things like participant and non-participant spillover, which this evaluation does not consider. The NTGRu is a factor that accounts for the lamps sales displaced by program

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				complicated approach to an already complicated measurement issue: (1) The new NTG approach seems to be inadvertently including market effects of the program into the current definition of NTG which is Net of free-ridership.	lamp sales. Futhermore, because the gross savings already accounts for CFL-to-CFL replacements (and the savings associated with these cases is zero), the NTGRu component of our net savings approach was necessary to avoid generating negative savings for those same lamps because it does not add the double-hit to savings from free ridership.
SCE/SDG&E-2	Overarching	Overarching	Overarching	(2) In this NTGR q and u method, the study used the results to re-estimate UES at the market level. This seems like a double adjustment. As indicated in the report (see page-4), factors such as installation, HOUs, Interactive effect, UES, delta watts are already accounted for as gross savings adjustments.	The NTGRu is a ratio of the net UES to the gross UES. Therefore, the components of these two estimates must be the same (installation rate, HOU, interactive effects, UES, and delta watts), and there is no issue with accounting for these parameters twice.
SCE/SDG&E-3	Overarching	Overarching	Overarching	(3) This study is using a bottom-up approach starting with program shipment data to identify the various channel of distribution. We agree that this is important program information. It would seem that the causal-links for the ULP program are -- (1) authorized MFG/program ship to various stores defined as channel of distribution, (2) end-users purchase program qualified products at distribution channel of choice, (3) once lights/bulbs are home they are installed into the sockets. The retail channel cross-effect (i.e., cannibalization) is market effect which is not counted in the current definition of NTG.	The channel-cross effect is what our evaluation refers to as channel shift. Channel shift is not a market effect because it is exclusive to the lamps that are sold through the program. If program lamps changed a customer's lamp purchase destination, it remains the sale of a program lamp. This evaluation does not quantify the effect of program lamp sales on non-program lamps, which would be an assessment of market effects. The 2015 impact evaluation accounts for channel shift in the NTGR assessment.

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SCE/SDG&E-4	Overarching	Overarching	Overarching	(4) Given the dramatic change in program scale and depth for 2010-2012, 2013-2014 and 2015 program periods, how can we be certain that the pooled data (i.e., including intercept survey, shelf survey, etc.) are still representative of reality for 2015?	While the modelling approach was developed in the 2010-12 impact evaluation, we applied shelf and intercept survey data that we collected in December 2015 through January 2016. Table 16 presents the store sample sizes for 2015-16 retail lamp stock inventory data, and Table 17 shows the sample sizes for 2015-16 intercept surveys.
SCE/SDG&E-5	Overarching	Overarching	Overarching	Possible improvements: Consider using more direct and standard NTGR approach for comparability and as a part of tri-angulation effort. The current study method seems exploratory. While it can be considered innovative, it may be a good idea to also use a more direct approach to verify the workpaper parameters and free-ridership assumptions, to produce a second set of results for comparison.	The primary goal of evaluation is to generate accurate estimates of savings. This evaluation's methodology captures a level of specificity that has not been captured by previous methods. We recognize that this level of specificity is not typically reflected in work paper estimates, but savings associated with upstream program discounted lamps is closely tied to the distribution channel. We recognize that workpapers traditionally report a single NTGR for a measure. That single NTGR reflects all distribution channels. Our evaluation approach enables upstream program administrators to consider the intended distribution channels for a measure and build up the most appropriate NTGR from there. For example, if program administrators only discount lamps in two channels (A and B), the evaluation enables administrators to blend the NTGRq associated with channels A and B for that measure, rather

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					than applying a NTGR that reflects distribution through channels that are not relevant to the measure. This evaluation approach enables that level of accuracy and flexibility.
SCE/SDG&E-6	Overarching	Overarching	Overarching	The study result did not specify confidence and precision clearly. This is especially the case for the complicated NTGR q and u modeled/simulated estimates. The modeling/simulation efforts also leveraged and pooled data from prior studies that may have separate study confidence/precision considerations. Can you discussion possible concern for propagation of errors?	The modeling efforts used recent data from 2015 and 2016. The NTGR contains at least three potential sources of uncertainty: consumer surveys data, shelf survey data, and the estimation of the Lamp Choice Model. We concentrate our uncertainty analysis associated with modelled market shares, and include these standard error estimates in Tables 100, 104, 111, 118, 125, and 132. We acknowledge that these standard errors are conservative as there is likely to be sampling error due to the consumer and shelf surveys. With the exception of CFL A-lamps, which have a confidence interval of +/- 5%, the resulting confidence intervals for all other evaluated measures are equal to or less than 3%, which we believe are sufficient to include in ex ante updates. We included this discussion on the methodology's uncertainty in Section 6.3.1.
SCE/SDG&E-7	Overarching	Overarching	Overarching	Given the study complexity, sample disposition and data sets used for modeling/simulation are not clearly explained. It would be helpful to develop additional report content to carefully explain the sources/size of data and	DNV GL structured the body of this report to remain at a higher-level, and include the more detailed results, such as the array of data sources, to the appendix.

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				the limitations, including a data map to identify the flow of the data and sample size of these data sets used. It is also important to properly communicate how the various data sources contributed to the overall analyses. For example, how did the completed manufacturer/retailer survey inform this study? Did the modeling/simulation use the Manufacturer/retailer survey results?	We added Figure 2 in Section 6.6.1 to assist in the explanation of the methodology. We also direct the reader to Appendix G, which provides a step-by-step description of the data sources that we used to estimate market shares. In addition, we have Tables 100, 104, 111, 118, 125, and 132, which present standard errors.
SCE/SDG&E-8	Overarching	Overarching	Overarching	The below construct is a gross simplification of study method and it is NOT sufficient to guide the readers to better understand the nuanced study methods. As indicated above, a more detailed data flow map may provide clarity for readers.	As noted in comment SCE/SDG&E-7, we have added Figure 2 to provide an overarching schematic of the net savings methodology.
SCE/SDG&E-9	Overarching	Overarching	Overarching	The IE factor should be technology based and not wattage based as we see more and more base technologies do not have the same IE issues due to the program i.e a CFL base technology replaced by a program LED should not adjust for IE effect due to the program.	DNV GL and study stakeholders did not identify exploration of interactive effects as a priority in the study's research plan. Stakeholders may wish to consider whether interactive effects should be an impact evaluation priority for the 2016 evaluation.
SCE/SDG&E-10	Overarching	Overarching	Overarching	Some of the appendixes contain important sample size and disposition information. These appendixes should be moved forward to help the reader discern the quality and quantity of available data.	DNV GL provides sample size estimates in Table 3 in Section 1.3.1 in the body of the report We appreciate the recommendation to include some of the appendix detail in the body of the report, but we ultimately believe that they would do more to clutter the earlier discussion than clarify it.

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SCE/SDG&E-11	Overarching	Overarching	Overarching	Improve end-user and on-site data collection to validate workpaper parameters. While store shelf inventory study will continue to be important, acting as indicators of purchase behaviors, but the workpaper energy savings is really about energy usage behavior. Store intercept data can also be important but stated preference may not be the same as revealed preference.	In the context of upstream programs, energy usage behavior is dependent on purchase behavior. We expect that the upcoming lighting metering study will provide updated data regarding energy usage behavior, but such studies are time and budget intensive. Given the timeline, budget, and scope of this evaluation, DNV GL researched the most impactful drivers of energy savings (installation rate and delta watts).
SCE/SDG&E-12	Overarching	Overarching	Overarching	Since the ULP program is a legitimate market transformation program, some of the NTGR q and u concepts may be more relevant for a market transformation study. The other idea is to not lump NTGR q and u under the NTGR, which should aim at free-ridership estimate. Perhaps, the NTGR g and u can be expressed as market transformation effects.	See comment SCE/SDG&E-1

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SCE/SDG&E-13	Overarching	Overarching	Overarching	In contrast, the 2015 Non-Residential Deemed Lighting Impact Study by Itron, takes a more direct approach of developing a series of six adjustments to the reported ex-ante gross energy/demand savings to address key differences in work-paper parameters. These adjustments included: 1. Delta Ex-Ante adjustment, 2. Delta HOUs, 3. Delta quantity (i.e., missing, removal, etc.), 4. Delta interactive effect, 5. Delta Watts, 6. Delta EUL. This Itron study, then used a standard free-ridership survey results (i.e., PA1, 2, 3) to derive at the net ex-post savings: • PA-1: reflect the influence of most important of the various program related elements in customer's decision to select a given program measure • PA-2: captures the perceive importance of the program design factors (i.e., rebate, delivery, etc.) relative to non-program factors in the decisions to implement the specific program measure that is eventually adopted and installed • PA-3: captures the likelihood of various actions the customer might have taken at a given time and in the future if the program had not been available (i.e., counter factual). This straight-forward study approach yielded understandable results that are easy to follow, including estimated relative precision for consideration. Currently, the study methods between ULP and Non-Res Deemed programs stand in sharp contrast. Again, the workpaper parameters for energy savings claim is energy usage level	This evaluation addressed the parameters outlined in the comment's initial set of bullet points. The reviewer rightly notes that the net savings methods stand in sharp contrast to the non-residential deemed lighting program and the ULP evaluations. However, this is logical because two are very different programs. Participants in the non-residential deemed lighting program make a decision to participate. The ULP, by design, is largely invisible to participants. In the majority of cases, customers do not recognize that they are participating in a program. This yields several challenges of an evaluation of an upstream program, and thus a different and specialized set of evaluation methods is appropriate.

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				rather than at the market level.	
SCE1	Overarching	Table 10, Table 35, Table 37, Tables 46, Tables 47	Overarching	There is an error in the product categories assigned to SCE on Table 10 and Table 35- SCE did not incentivize any products in the “MSB CFL basic spiral <30 W category. Instead, the number stated in the report of 98,892 was for a CFL reflector 15 W model. The KWh was 2,305,344. This will need to be corrected in Tables 35 and 37. Tables 46, 47 as well any other tables that are affected by this number should be corrected so that the savings claims are accurate.	DNV GL has updated the measure groups associated with these claims