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# Lighting Savings Overlap Estimate for 2014 IOU Home Energy Report Programs

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## Introduction

The California electric Investor-Owned Utilities (IOUs) – Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) – have multiple resource acquisition programs that encourage residential customers to purchase and install high efficacy lighting. The primary ones are the Upstream Lighting Program (ULP) that provides rebates to retailers and buys down the wholesale cost of lamps, and behavioral program such as the Home Energy Reports (HER) program that encourages residential customers to undertake a variety of actions and purchases to save energy. Others include the online audit program (Energy Advisor) and the whole house retrofit program. The ULP and the HER are the focus of this white paper. During the home inventory research undertaken by PG&E in 2012, it was observed that customers in the treatment conditions of HER had installed more CFLs, on average, compared to customers in the control conditions.[1] Since that research was conducted, the ULP program has been significantly restructured and the households treated by the HER program have grown.

The findings of the home inventory research indicated that exposure to HERs influenced treatment households to install about one (0.95) more CFL on average than the control households. Since a portion of the "excess" CFLs observed in HER-treated households (relative to households in the control conditions) may have been lamps rebated through the ULP, the 2010-2012 and 2013 HER savings claims were reduced to avoid double-counting of these savings.

Since 2012, PG&E has expanded the HER program from treating 0.6 million households in 2012 to 1.4 million in 2014. SCE and SDG&E have also provided the HER program to households in their service territories. During the same timeframe (2012 to 2014), the IOUs have substantially restructured their ULP programs by decreasing CFL buy-downs and placing a greater emphasis on LEDs. **Given the expansion of the HER treatment conditions and the restructuring of the ULP, the electric IOUs requested that TRC revise the lighting savings overlap estimate between the ULP and HER for 2014.**

[1] Freeman, Sullivan & Co. "Evaluation of PG&E Home Energy Report Initiative for the 2010-2012 Program", April 25, 2013, p. 39. CALMAC ID: ID PGE0329.01

This white paper provides the lighting savings overlap estimates that TRC developed and is structured as follows:

- Summary of Results:
  - Summarizes our methodology
  - Presents the resulting lighting savings overlap estimates for each electric IOU
  - Compares our results with those found in past HER evaluations
  - Briefly discusses recent residential lighting purchase trends found through this analysis
- Overview of Major Data Sources: Describes the key data sources used for this analysis
- Calculation of Lighting Savings Overlap: Presents the calculation of the lighting savings overlap and the methods TRC used to estimate key parameters not obtained from previous calculations, including excess CFLs and LEDs installed because of HER treatment, rebated CFL sales fractions, and rebated LED sales fractions
- Lighting Trends: Provides more detailed discussion of the residential lighting trends found here
- Appendix: Supporting Calculations and Assumptions: Provides detailed calculations and assumptions used to calculate key parameters, and additional market channel analysis.

# Summary of Results

## Lighting Savings Overlap Summary

**TRC estimates that the lighting savings overlap between the ULP and HER for 2014 is:**

- **For PG&E: 5.1 GWh and -98 MTherms** for all PG&E HER treatment waves.
- **For SCE: 0.2 GWh for the SCE HER Opower 2 wave.** (Note that SCE discontinued treatment with its Opower 1 group in December 2013 to measure persistence.)
- **For SDG&E: 0.2 GWh and -3 MTherms for the SDG&E HER Opower 1 and Opower 2 waves**.

For all electric IOUs, the HER program electric savings claims (in GWh) should be reduced by the lighting savings overlap (in GWh) to avoid double-counting lighting savings. Similarly, for PG&E and SDG&E, the HER program natural gas savings (in MTherms) should be credited with the natural gas savings from the lighting savings overlap (i.e., subtract the negative MTherms for a positive savings credit) to reflect interactive effects that did not occur.

In general, TRC used the equation from the 2012 PG&E HER evaluation to estimate the savings overlap from excess lamps that were claimed by the ULP program and installed due to HER. However, TRC made the following changes from previous HER evaluations:

**First, TRC updated several calculation parameters using more updated information**, including the fraction of CFLs sold in each IOU territory that was rebated by the IOU (the "rebated sales fraction"). **The 2012 PG&E HER evaluator developed estimates of the proportion of lamps sold that were subject to ULP rebates based on the best available data at the time – the 2006-2008 Upstream Lighting impact evaluation[2]. The 2013 PG&E HER, 2013 SCE HER, and 2013 SDG&E HER evaluations assumed the same rebated CFL sales fraction – 74% -- based on the 2006-08 evaluation values**. Because more recent data are available, TRC updated the rebated sales fraction and other parameters in the lighting savings overlap calculation to reflect the updated information.

**Secondly, TRC assumed that participating households purchased excess lamps each year of HER treatment, with the number of excess lamps declining each year.** By "excess lamps", TRC refers to the number of CFLs and LEDs

[2] DNV-GL (KEMA), 2010: Final Evaluation Report: Upstream Lighting Program. CALMAC ID CPU0015.01

installed because of HER treatment influence. TRC assumed 0.95, 0.4, 0.15, and 0.08 excess lamps for years 1, 2, 3, and 4 of HER treatment, respectively. Past HER evaluations have only assumed 0.95 excess lamps for the 1st year of HER treatment – i.e., have assumed zero excess lamps for subsequent years, so this evaluation assumed a higher total number of excess lamps due to HER treatment. The section Estimate of Excess CFLs and LEDs provides more detail on the number of excess lamps assumed in this evaluation.

Third, for 2011 through 2013, TRC assumed that all excess lamps were CFLs, (i.e., no excess LEDs); this assumption is consistent with past HER evaluations[3]. TRC used this assumption for 2011-2013 because LEDs were still a relatively small fraction of lamp sales, and it greatly simplified analysis. By 2014 however, LEDs had become a significant fraction of lamp sales, so TRC recognized the importance of including excess LEDs in the lighting savings overlap estimate. **Therefore, for 2014, TRC assumed that the excess lamps purchases were a mix of CFLs and LEDs, and calculated a lighting savings overlap for LEDs.** TRC added the lighting savings overlap from LEDs in 2014 to the lighting savings overlap from CFLs for a total lighting savings overlap.

## *Methodology Summary*

**TRC used the following equations for estimating the lighting savings overlap for each treatment wave**:

*(Equation 1)*

*kWh attributable to both programs per hh: CFLs = CFLs installed due to HERs x years CFLs have been installed x (rebated CFLs / total CFLs) x (CFLs attributable to ULP / rebated CFLs) x Installation Rate x Savings per CFL per year*

*(Equation 2)*

*kWh attributable to both programs per hh, LEDs = LEDs installed due to HERs x years LEDs have been installed x (rebated LEDs / total LEDs) x (LEDs attributable to ULP / rebated LEDs) x Installation Rate x Savings per LED per yr*

*(Equation 3)*

*Lighting Savings Overlap for Treatment Wave (GWh/yr) = Number of households in Treatment Wave x (kWh attributable to both programs per hh, CFLs + kWh attributable to both programs per hh, LEDs) x 1 GWh/$10^6$ kWh*

TRC obtained many of the values in the equations above from the 2010-12 ULP impact evaluation[4]. However, TRC developed estimates for excess lamps (excess CFLs and LEDs) and rebated sales fractions (for CFLs and LEDs), as summarized below.

Excess CFL and LED Methodology:

TRC used the results of the 2012 PG&E HER in-home survey, as well as results from a phone survey conducted for a Puget Sound Energy (PSE) evaluation to estimate 0.95, 0.4, 0.15, and 0.08 excess lamps for the 1st, 2nd, 3rd, and 4th year of HER treatment, respectively.

For 2011-2013, TRC assumed that all excess lamps were CFLs. For 2014, TRC assumed that excess lamps were a mix of CFLs and LEDs, reflecting the overall residential market purchases of CFLs and LEDs in 2014. TRC estimated the total number of LEDs sold in each IOU territory in 2014, using a similar approach to the one used for estimating CFL sales in 2014. TRC then apportioned the number of excess lamps between CFLs and LEDs for each IOU territory based on our sales estimates for 2014. The resulting CFL / LED split was 66% CFLs / 34% LEDs for PG&E, 72% CFLs / 28% LEDs for SCE, and 60% CFLs / 40% LEDs for SDG&E, which reflected each IOU's mix of CFL and LED rebates. TRC provides more detail in the section, Excess Lamp Split between CFLs and LEDs.

[3] The 2012 and 2013 PG&E, SCE, and SDG&E HER evaluations did not account for a lighting savings overlap for LEDs due to the relatively low sales volume of LEDs in previous years.

[4] California Upstream and Residential Lighting Impact Evaluation, 2010-2012 program (DNV-GL 2014). TRC developed this analysis prior to the release of the 2013-14 ULP evaluation.

Rebated Sales Fraction Methodology: Much of the work presented in this white paper concerns TRC's estimate of the rebated sales fractions – i.e., (rebated CFLs / total CFLs) and (rebated LEDs / total LEDs) in the equations above. Here, TRC presents an overview of our method for estimating the rebated CFL and LED sales fractions. TRC provides more detail on the methodology in the body of this white paper.

TRC took the number of CFLs rebated by each IOU (based on IOU program tracking data) and divided it by our estimate of total CFLs sold in that IOU territory.

*(Equation 4):*

*IOU rebated CFL sales fraction, Yr = IOU-rebated CFLs in Yr / Total CFLs sold in IOU territory that Yr*

For example:

*PG&E rebated CFL sales fraction, 2014 =PG&E-rebated CFLs in 2014 / Total CFLs sold in PG&E territory in 2014*

TRC used the same approach for LEDs.

*(Equation 5)*

*IOU rebated LED sales fraction, Yr = IOU-rebated LEDs in Yr / Total LEDs sold in IOU territory that Yr*

For example:

*PG&E-rebated LED sales fraction, 2014 = PG&E-rebated LEDs in 2014/ Total LEDs sold in PG&E territory in 2014*

To estimate the total CFLs and LEDs sold each year in each IOU territory, TRC first estimated total CFLs and LEDs sold in California. For each lamp technology (i.e., CFLs and LEDs), TRC averaged results from multiple methods:

1. A Lamp Purchasing Model (for CFLs and LEDs): Took total lamps installed per household from the 2012 California Lighting and Appliance Saturation Survey (CLASS, DNV-GL, 2014); estimated total lamp purchased in 2013 and 2014 based on effective useful life (EUL) and early retirement assumptions; and estimated the fraction of lamps purchased by technology based on California shelf survey trends.
2. Extrapolations of U.S. Purchases to California (for CFLs and LEDs): Estimated total U.S. CFL and LED sales from National Electrical Manufacturers Association (NEMA), import data, and ENERGY STAR data; and then estimated the fraction of CFLs and LEDs that were sold in California.
3. Trajectories from Historical CFL Purchases (for CFLs only): Estimated total CFL purchases for the years between 2005 and 2012 based on installation and storage data in the 2005 and 2012 CLASS surveys, IOU rebate levels, and LightTracker[5] trends; and compared sales indicators for 2013 and 2014 relative to 2012 in order to estimate 2013 and 2014 CFL purchases.
4. DNV-GL Estimates (for CFLs only): DNV-GL estimated total CFLs sold in California IOU territories in the 2010-12 ULP impact evaluation. TRC extrapolated this value up to the statewide level (i.e., included sales in Publicly Owned Utility [POU] territories) by dividing the DNV-GL value by the fraction of CFL purchases that we estimated occurred in the IOU territories.

TRC then apportioned statewide CFLs and LEDs to each IOU territory based on both the number of rebates provided by that IOU, and the fraction of housing units in that IOU territory.

## *Summary of Results for each Electric IOU*

**The following section shows key input parameters and resulting ULP/HER lighting savings overlap estimates for 2014 for each electric IOU.**

[5] Consortium for Retail Energy Efficiency Data (CREED) / LightTracker Initiative, available from Apex Analytics. For more information on this source, see the section, "Overview of Major Data Sources".

**PG&E Lighting Savings Overlap Estimate:**

Figure 1 shows the final savings overlap for PG&E for each HER treatment wave and the total for all treatment waves, along with some of the key inputs that TRC used to calculate the lighting savings overlap.

PG&E began HER treatment for several waves beginning in 2011; because several input values varied for each year from 2011 to 2014, input values varied by wave and (for each wave) by year. The input values and an example calculation are provided in the Resulting Calculation of Lighting Savings Overlap Estimates section.

| PG&E Treatment Wave | Month Treatment Began | Number of Households (hh) in 2014 | 2011 Excess CFLs | 2012 Excess CFLs | 2013 Excess CFLs | 2014 Excess CFLs | 2014 Excess LEDs | # of Yrs when 2014 Excess Lamps Installed | CFL Savings Overlap (kWh/yr) per hh | LED Savings Overlap (kWh/yr) per hh | Total Lighting Savings Overlap (kWh/yr) per hh | Total Lighting Savings Overlap (GWh/yr) | Natural Gas Savings (Therms, 000)/yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beta | Aug-11 | 46,907 | 0.4 | 0.7 | 0.3 | 0.1 | 0.04 | 0.5 | 9.2 | 0.1 | 9.2 | 0.4 | -8.2 |
| Gamma Dual Std | Nov-11 | 54,859 | 0.2 | 0.9 | 0.4 | 0.1 | 0.05 | 0.5 | 8.4 | 0.1 | 8.4 | 0.5 | -8.8 |
| Gamma Dual Reduced | Nov-11 | 54,921 | 0.2 | 0.9 | 0.4 | 0.1 | 0.05 | 0.5 | 8.4 | 0.1 | 8.4 | 0.5 | -8.8 |
| Gamma Elec-only | Nov-11 | 29,433 | 0.2 | 0.9 | 0.4 | 0.1 | 0.05 | 0.5 | 8.4 | 0.1 | 8.4 | 0.2 | -4.7 |
| Wave One Dual | Feb-12 | 284,556 | | 0.9 | 0.4 | 0.1 | 0.1 | 0.5 | 7.4 | 0.1 | 7.5 | 2.1 | -40.3 |
| Wave One Elec-only | Feb-12 | 27,947 | | 0.9 | 0.4 | 0.1 | 0.1 | 0.5 | 7.4 | 0.1 | 7.5 | 0.2 | -4.0 |
| Wave Two Non-Area 7 | Feb-13 | 259,055 | | | 0.9 | 0.3 | 0.2 | 0.5 | 2.2 | 0.2 | 2.4 | 0.6 | -12.0 |
| Wave Two Area 7 | Feb-13 | 68,123 | | | 0.9 | 0.3 | 0.2 | 0.5 | 2.2 | 0.2 | 2.4 | 0.2 | -3.2 |
| Wave Three | Jul-13 | 191,891 | | | 0.5 | 0.4 | 0.2 | 0.5 | 1.4 | 0.4 | 1.7 | 0.3 | -6.3 |
| Wave Four | May-14 | 183,629 | | | | 0.4 | 0.2 | 0.3 | 0.1 | 0.2 | 0.4 | 0.1 | -1.3 |
| Wave Five | Oct-14 | 195,443 | | | | 0.2 | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | -0.2 |
| **Total in 2014** | | **1,396,764** | | | | | | | | | | **5.1** | **-98** |

*Figure 1. PG&E Lighting Savings Overlap – Summary of Results*

**SCE Lighting Savings Overlap Estimate:**

SCE's one HER treatment wave began in 2014, so the analysis was simpler than for PG&E. This summary section presents the savings overlap estimates, and the calculation and input values for SCE.

For SCE Opower 2, TRC used the values in Figure 2, along with the following inputs, to calculate the lighting savings overlap:

- "CFLs attributable to ULP / rebated CFLs" and "LEDs attributable to ULP / rebated LEDs" equaled 0.69, the SCE net-to-gross from the 2010-2012 ULP impact evaluation (DNV-GL, 2014)
- "Installation Rate" equaled 97% for both CFLs and LEDs, from the 2010-2012 ULP Impact evaluation
- "Savings / CFL/ yr" equaled 45 kWh/CFL/ yr; and "Savings / LED / yr" equaled 20 kWh/LED/yr, from the 2010-2012 ULP Impact evaluation

Using these values in Equations 1, 2, and 3 (see the section, Main Equation and Values Used to Calculate Lighting Savings Overlap, for a description of these equations):

*Eq. 1: kWh attributable to both programs per hh, CFLs = CFLs installed due to HERs x years CFLs have been installed x (rebated CFLs / total CFLs) x (CFLs attributable to ULP / rebated CFLs) x Installation Rate x Savings/CFL/yr = 0.51 CFL x 0.38 yr x 40% x 0.69 x 97% x 45 kWh/CFL/yr = 2.3 kWh/hh*

*Eq. 2: kWh attributable to both programs per hh, LEDs = LEDs installed due to HERs x years LEDs have been installed x (rebated LEDs / total LEDs) x (LEDs attributable to ULP / rebated LEDs) x Installation Rate x Savings/LED/yr = 0.20 LED x 0.38 yr x 20% x 0.69 x 97% x 20 kWh/LED/yr = 0.2 kWh/hh*

*Eq. 3: Lighting Savings Overlap for Treatment Wave (GWh/yr) = Number of households in Treatment Wave x (kWh attributable to both programs per hh, CFLs + kWh attributable to both programs per hh, LEDs) x 1 GWh/$10^6$ kWh = 68,396 hh x (2.3+0.2) kWh/hh x 1 GWh/$10^6$ kWh = 0.17 GWh*

| SCE Treatment Wave | Month Treatment Began | Number of Households (hh) in 2014 | 2014 Excess CFLs | 2014 Excess LEDs | # of Yrs when 2014 Excess Lamps Installed | CFL Rebated Sales Fraction, 2014 | LED Rebated Sales Fraction, 2014 | CFL Savings Overlap (kWh/yr) per hh | LED Savings Overlap (kWh/yr) per hh | Total Lighting Savings Overlap (kWh/yr) per hh | Total Lighting Savings Overlap (GWh/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Opower 2 | Apr-14 | 68,396 | 0.51 | 0.20 | 0.38 | 40% | 20% | 2.3 | 0.2 | 2.5 | 0.17 |

*Figure 2. SCE Lighting Savings Overlap – Summary of Results*

**SDG&E: Lighting Savings Overlap Estimate**

Figure 3 shows the final savings overlap for each SDG&E treatment wave and the total for all SDG&E treatment waves, along with some of the key inputs that TRC used to calculate the lighting savings overlap.

Similar to PG&E, SDG&E began HER treatment for several waves beginning in 2011; because several input values varied for each year from 2011 to 2014, input values varied by wave and (for each wave) by year. The input values and an example calculation are provided in the Resulting Calculation of Lighting Savings Overlap Estimates section.

| SDG&E Treatment Wave | Month Treatment Began | Number of Households (hh) in 2014 | 2011 Excess CFLs | 2012 Excess CFLs | 2013 Excess CFLs | 2014 Excess CFLs | 2014 Excess LEDs | # of Yrs when 2014 Excess Lamps Installed | CFL Savings Overlap (kWh/yr) per hh | LED Savings Overlap (kWh/yr) per hh | Total Lighting Savings Overlap (kWh/yr) per hh | Total Lighting Savings Overlap (GWh/yr) | Natural Gas Savings (Therms, 000)/yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Opower 1 | Jul-11 | 19,977 | 0.48 | 0.68 | 0.28 | 0.07 | 0.05 | 0.50 | 11.1 | 0.09 | 11.2 | **0.22** | -3.1 |
| Opower 2 | Dec-14 | 95,002 | | | | 0.05 | 0.03 | 0.04 | 0.004 | 0.01 | 0.01 | **0.001** | -0.02 |
| **Opower total** | | | | | | | | | | | | **0.23** | -3.2 |

*Figure 3. SDG&E Lighting Savings Overlap – Summary of Results*

## Comparison of Results with Past HER Evaluations

This section compares TRC's estimate of the 2014 HER / ULP lighting savings overlap for 2014 with past HER evaluations and discusses differences in assumptions and overall results.

### *PG&E 2014 HER Lighting Savings Overlap Compared to Past HER Evaluations*

Overall, TRC's lighting savings overlap estimate for PG&E (5.1 GWh) is slightly lower than the savings overlap estimated for the 2012 PG&E HER program evaluation (6.7 GWh) and for the 2013 PG&E HER program evaluation (7.2 GWh), even though there are more PG&E households that received HER treatment in 2014 (1.4 million) compared with 2012 (0.6 million) and 2013 (1.0 million). The primary reason for the decline in potentially double-counted lighting savings is that TRC estimated lower rebated CFL sales fractions than those used by the 2012 and 2013 PG&E HER evaluators. The 2012 PG&E HER evaluator (Freeman, Sullivan and Company) developed its estimate of the rebated CFL sales fraction for 2012, 74%, based on parameter estimates contained in the 2006-2008 ULP impact evaluation. The estimates in this white paper benefit from updated information. Most notably, TRC used the actual number of ULP rebates paid in 2011-2014, based on the 2010-2012 ULP impact evaluation[6] and 2013-2014 IOU program tracking data, to estimate the rebated sales fractions for 2011-2014. The assumptions used for these estimates differ as follows:

- The 2012 PG&E HER evaluation assumed that the 2012 CFL rebates would be similar to the annual 2006-2008 CFL rebates – approximately 16 million from PG&E and 29 million from all IOUs per year. But compared to the 2006-2008 program cycle, PG&E and the IOUs reduced CFL rebates in the 2010-2012 program cycle. In actuality for 2012, PG&E and the IOUs rebated 5 million and 20 million CFLs, respectively.
- The 2013 PG&E HER evaluation used the same rebated sales fraction from the 2012 PG&E HER evaluation: 74%, which includes the assumption of 16 million PG&E rebates and 29 million total IOU rebates. However, in 2013, PG&E and the IOUs rebated 2 million and 8 million CFLs, respectively.
- In 2014, PG&E rebated less than 1 million CFLs and the IOUs rebated 6 million CFLs.

Figure 4 shows the number of CFL rebates assumed by the 2012 and 2013 PG&E HER evaluators; the resulting rebated sales fraction for the 2012 and 2013 PG&E HER evaluations; the CFL rebates provided by PG&E and the IOUs; and the resulting rebated sales fraction estimated by TRC.

<table>
<tr><th></th><th colspan="2">2012 and 2013 PG&E HER Evaluations</th><th colspan="2">2014 Lighting Savings Overlap Estimate (TRC)</th></tr>
<tr><th>Year Excess Lamp Purchased</th><th>CFL Rebates Assumed in 2012 and 2013 PG&E HER Evaluations</th><th>PG&E-Rebated CFL Sales Fraction in 2012 and 2013 PG&E HER Evaluations</th><th>Actual Number of CFL Rebates[7]</th><th>Revised PG&E-Rebated CFL Sales Fraction</th></tr>
<tr><td rowspan="3">2011</td><td rowspan="3"></td><td rowspan="3">Not Estimated</td><td>IOUs: 20 million</td><td rowspan="3">50%</td></tr>
<tr><td>PG&E: 6 million</td></tr>
<tr><td>Source: 2010-12 ULP eval</td></tr>
<tr><td rowspan="2">2012</td><td>IOUs: 29 million</td><td rowspan="2">74%</td><td>IOUs: 21 million</td><td rowspan="2">45%</td></tr>
<tr><td>PG&E: 16 million</td><td>PG&E: 5 million</td></tr>
</table>

[6] DNV GL (2014): California Upstream and Residential Lighting Impact Evaluation Work Order 28 (WO28) Final Report. CALMAC ID CPU0099.01.

[7] Refers to CFLs assumed to be installed in residential buildings only. TRC followed the residential / nonresidential split in the 2010-2012 ULP impact evaluation and assumed 93% for PG&E, 94% for SCE, and 94% for SDG&E for residential.

| | 2012 and 2013 PG&E HER Evaluations | | 2014 Lighting Savings Overlap Estimate (TRC) | |
|---|---|---|---|---|
| | Source: Assumed 2006-08 ULP rebates | | Source: 2010-12 ULP eval | |
| 2013 | IOUs: 29 million | 74% | IOUs: 8 million | 16% |
| | PG&E: 16 million | | PG&E: 2 million | |
| | Source: Assumed same as 2012 HER eval (based on 06-08 rebates) | | Source: Program tracking data | |
| 2014 | | Not Estimated | IOUs: 6 million | 7% |
| | | | PG&E: 0.6 million | |
| | | | Source: Program tracking data | |

*Figure 4. PG&E Rebated CFL Sales Fractions – Sources, Assumptions, and Values in 2012 and 2013 HER Evaluations Compared with TRC 2014 HER Evaluation*

For calculating the lighting savings overlap for the PG&E HER program in 2014, TRC made the following major adjustments – in order of significance – compared to the 2012 and 2013 PG&E HER evaluations:

1. TRC adjusted the rebated sales fraction for CFLs, as described above. This decreased the estimated lighting savings overlap compared to the 2012 and 2013 evaluations.
2. TRC added households that began treatment in 2014 – wave four and wave five. This increased the lighting savings overlap estimate.
3. In addition to the excess lamps purchased the 1st year of HER treatment, TRC assumed that HER treatment households would purchase excess lamps in the 2nd, 3rd, and 4th year of HER treatment. This increased the lighting savings overlap estimate.
4. TRC updated other parameters in the lighting savings overlap calculation, such as using assumptions for the net-to-gross ratio (NTGR) and savings (kWh) per lamp purchased in 2011 and 2012 from the 2010-2012 ULP impact evaluation (DNV-GL, 2014), and savings per lamp purchased in 2013 and 2014 from the 2013-2014 program tracking database (based on the Database of Energy Efficiency Resources - DEER for 2013-14). These adjustments had a mixed effect on the lighting savings overlap estimate.

Taken as a whole, these adjustments led to a slight decrease in the estimated lighting savings overlap for PG&E for 2014 compared to the 2012 and 2013 evaluations.

## *SCE 2014 HER Lighting Savings Overlap Compared to 2013 SCE HER Evaluation*

Thus far, SCE has provided HER treatment with two waves. The SCE Opower 1 wave launched in December 2012 and was discontinued in December 2013 in order to measure persistence. The SCE Opower 2 wave launched in February 2014 and is on-going.

TRC's lighting savings overlap estimate for the 2014 SCE HER Opower 2 program (0.2 GWh) is lower than the 2013 SCE HER evaluation for Opower 1 (0.4 GWh). Overall, TRC made the following major adjustments to the calculation:

1. TRC calculated a lower rebated CFL sales fraction for SCE in 2014 – 40%, compared to 74% in the SCE 2013 HER evaluation. The 2013 SCE HER evaluation assumed the same CFL rebated sales fraction as the 2012 PG&E HER evaluation – 74%, based on the 2006-2008 program cycle when SCE rebated 11 million CFLs on average. In 2014, SCE provided 5 million CFL rebates. This adjustment significantly decreased the lighting savings overlap relative to the 2013 SCE evaluation.
2. TRC used assumptions for savings (kWh) per lamp purchased in 2014 from the 2013-2014 program tracking database (based on DEER for 2013-14). Because SCE has shifted to primarily rebating advanced CFLs, the average savings per CFL (45 kWh/CFL) in 2014 was much higher than in 2010-2012, when the

bulk of SCE rebates were for basic CFLs (for which DEER estimates 19 kWh/CFL). The 2013 SCE evaluation used the 2010-2012 ULP evaluation values for savings per CFL, which were dominated by basic CFLs. These adjustments increased the 2014 lighting savings overlap compared to the 2013 evaluation.

3. TRC assumed that some of the excess lamps installed in 2014 were LEDs. Because the rebated sales fraction and the savings per lamp (kWh/yr) were higher for CFLs than for LEDs for SCE[8], this decreased the lighting savings overlap relative to the 2013 SCE evaluation.

The number of treatment households in SCE Opower 1 (65,910)[9] and SCE Opower 2 (68,396) were very similar, so the number of treatment households did not change significantly between the evaluations.

Taken as a whole, these adjustments led to a decrease in the lighting savings overlap for SCE for 2014 compared to the 2013 SCE HER evaluation.

### *SDG&E 2014 HER Lighting Savings Overlap Compared to 2013 SDG&E HER Evaluation*

Thus far, SDG&E has provided HER treatment in two waves: the Opower 1 SDG&E wave that launched in 2011, and the Opower 2 SDG&E wave that launched in December 2014.

TRC's lighting savings overlap estimate for Opower 1 (0.2 GWh) is the same (after rounding) as the savings overlap in the 2013 SDG&E HER evaluation for Opower 1 (0.2 GWh). Similar to PG&E and SCE, TRC made the following major adjustments to the 2013 SDG&E HER evaluation of the Opower 1 treatment wave:

1. TRC recalculated the SDG&E CFL rebated sales fraction for 2011 as 57%, compared with 74% from the 2013 SDG&E HER evaluation. This decreased the 2014 lighting savings overlap compared to the 2013 evaluation.
2. TRC updated other parameters in the lighting savings overlap calculation, such as using assumptions for the NTGR and savings (kWh) per lamp purchased in 2011 and 2012 from the 2010-2012 ULP impact evaluation, and savings per lamp purchased in 2013 and 2014 from the 2013-2014 program tracking database (based on DEER for 2013-14). In contrast, the 2013 SDG&E evaluation used the 2006-2008 evaluation values. These changes had a mixed effect on the lighting savings overlap.
3. TRC added a lighting savings overlap for excess lamps installed in the 2nd, 3rd, and 4th year of HER treatment, which the 2013 SCE HER evaluation did not include. This increased the 2014 lighting savings overlap relative to the 2013 evaluation.

Taken as a whole, the adjustments for SDG&E Opower 1 generally balanced out, and TRC estimated the same lighting savings overlap for 2014 for the Opower 1 wave as the 2013 SDG&E HER evaluation.

Because Opower 2 had only been launched for one month in 2014, TRC assumed that 1/12 of excess lamps for the 1st year of HER treatment (i.e., 1/12 of 0.95, or 0.08 excess lamp) had been installed in 2014. Consequently, TRC's estimate of the lighting savings overlap for Opower 2 is very small: 0.001 GWh/yr.

## Lighting Market Trend Summary

While TRC's analysis indicates that total CFLs purchased in IOU service territory have dropped significantly over the past two years, TRC found that the decline in CFLs sold is less than the reduction in IOU rebates. This decline in CFL sales may indicate that the lighting market is *partially* transformed – since many consumers are continuing to

[8] One reason is because SCE primarily rebated high wattage CFLs, for which the baseline lamps were high wattage incandescent lamps. Consequently, the "delta watts" (i.e., the energy efficiency measure wattage minus the baseline measure wattage) was higher for SCE's rebated CFLs than for SCE's rebated LEDs.

[9] Number of sites without mismatched addresses, from p. 5 of the SCE HER Evaluation: "2013 SCE Home Energy Report Program Review and Validation of Impact Evaluation" DNV-GL, 2014.

purchase CFLs without rebates – but not *wholly* transformed – since CFL purchases have declined as rebates declined.

This evaluation also identified the following trends in the lighting market:

- Various data indicate that from 2012 to 2014:
  - **CFL sales have declined** in California, and have declined or stayed relative flat in the U.S.
  - **Halogen sales have increased** in California and in the U.S.
  - **Incandescent sales have remained at approximately 30%-40%** of the California market and the U.S. market. This was somewhat surprising, given recent lighting requirements which banned the manufacturing and import of the traditional 60W incandescent in January 2013 in California under Assembly Bill (AB) 1109, and in the U.S. in January 2014 under the Energy Independence and Security Act (EISA). Based on the DNV-GL California winter 2014/2015 lighting shelf survey[10], the incandescent lamps found on shelves were a combination of lamps that were:
    - Outside the purview of EISA and AB 1109 (e.g., not medium screw based, or outside the range of 310-2600 lumens), and
    - Within EISA's and AB 1109's purview. These incandescent lamps may persist on the shelves because they have not sold through, or may represent a lack of adherence to / enforcement of EISA and AB 1109.
  - **LED sales have increased significantly both in California and the U.S., and LED growth appears to be faster in California.**
- **The decline in CFL sales appears to be appears to be faster than the increase in LED sales, when analyzed for California**. Several data sources indicate that the fraction of high efficacy lamps (i.e., CFLs and LEDs) sold relative to total lamps (i.e., incandescent lamps, halogens, CFLs, and LEDs) has dropped in California from 2012 to 2014. In addition, this drop in CFL sales has been more severe in some market channels that previously received higher levels of IOU rebates in 2010-2012, such as grocery and discount stores. The section, Market Channel Analysis in the Appendix provides more details.
- **The presumed causal relationship between the drop in IOU CFL rebates and the drop in California CFL sales is supported by information from Apex Analytics**, who compile the LightTracker reports. Apex Analytics reported that shares of CFLs in California have dropped compared to CFL sales in other states that have continued and/or ramped up CFL rebates.
- **Overall, results indicate an opportunity to increase IOU rebates for high efficacy lamps at least for the next few years until LED prices drop further**. The CPUC, IOUs, and other collaborators should continue to strategically design rebates, by identifying specific lamp classes and market channels where incandescent and halogen penetration is high, and identifying classes of high efficacy lamps for rebate that are best suited to replace those incandescent and halogen lamps.

## Overview of Major Data Sources

Figure 5 presents the major data sources used in this analysis, including a summary of the major limitations (in the context of this analysis) of each data source:

[10] https://webtools.dnvgl.com/projects62/crlss/Home.aspx

| Name (Author, Publication) | Description, and Primary Use in this Analysis | Limitations for this Analysis |
|---|---|---|
| 2012 PG&E Home Energy Report (HER) Evaluation (Freeman, Sullivan & Co., 2013, CALMAC ID: PGE0329.01) | Used this evaluation's general equation for calculating the lighting savings overlap, and used the estimate of excess lamps installed during the 1st year of HER treatment. | The parameters in the lighting savings overlap calculation were based on the 2006-2008 ULP program cycle and the 2006-2008 lighting market. Consequently, TRC updated these calculation parameters. |
| California Upstream and Residential Lighting Impact Evaluation, 2010-2012 program (DNV-GL 2014)[11] | Used for three parameters in the lighting savings overlap calculation: NTGR, installation rate, and energy savings per lamp for lamps rebated in 2011 and 2012. Also used for estimating the CFL rebated sales fraction to inform the IOU CFL rebate history and Method 4 (DNV-GL lamp installation trajectory model) for estimating total CFLs sold in California. | NTGR and savings values reflect 2010-2012 programs and the 2010-2012 lighting market, not the 2013-2014 ULP or 2013-2014 lighting market. Also, the DNV-GL lamp installation trajectory model for 2013 and 2014 assumed a higher number of IOU CFL rebates than what the IOUs ultimately provided. |
| California Upstream and Residential Lighting Impact Evaluation, 2006-2008 program (DNV-GL 2010) | Used for estimating the CFL rebated sales fraction, for informing the IOU CFL rebate history. Customer interview results also helped inform CFL early retirement assumptions. | The survey results on early retirement are based on a short timeframe of respondents' experience with CFLs and are fairly old – based on early stages of CFL adoption, when CFL dissatisfaction may have been higher. |
| California Lighting and Appliance Saturation Survey (CLASS), 2012 (DNV-GL 2014) | Used results from the 2005 and 2012 CLASS surveys for estimating the CFL and LED rebated sales fractions – specifically to develop the TRC lamp purchase model. Also used results to estimate historical CFL sales estimates. | Most recent survey was done in 2012. Consequently, TRC had to project 2012 CLASS results forward to 2014 for the TRC lamp purchase model under Method 1 for estimating CFLs and LEDs sold in California. |
| California Residential Lighting Market Status Report (DNV-GL 2014) | Used for estimating the CFL and LED rebated sales fractions – specifically for values of the average California household's lamps in storage, and the average California household's fraction of A-line, reflector, and globe lamps for adjusting NEMA data. | While this report documents the number and type of lamps in storage in 2012, and provides results of consumer interviews of when they will install recently purchased lamps, it is unknown how many lamps (and how many lamps of each technology) the average California household took from storage versus purchased in 2013 and 2014. |
| California Retail Lighting Shelf Surveys (DNV-GL, available: https://websafe.kemainc.com/projects62/crlss/Home.aspx) | Conducted periodically from 2009 through winter 2014/2015, which show the number and percent of lamps by technology, type (e.g., A-line, reflector, globe), IOU territory, and other characteristics. TRC used results for estimating the CFL and LED rebated sales fractions – specifically to estimate California purchasing trends for the TRC lamp purchase model (in Method 1); for estimating sales of reflector and globe lamps when adjusting NEMA data (which only provides A-lamp shipments - in Method 2); and as one parameter in the estimate of CFL sales based on historical CFL trends (in Method 3). | Market fractions of lamps on shelves may not coincide with fractions of actual sales, and actual sales volumes are not provided from this data source. Also, to estimate shelf survey results for 2014, TRC averaged the values from the summer 2013 shelf survey with the winter 2014/2015 survey (conducted Nov. 2014-Jan. 2015). |
| LightTracker[12], provided in 2015 | LightTracker represents sales reports of lamps sold in California and the U.S. TRC used LightTracker for estimating the CFL and LED rebated sales fractions – specifically to estimate CA total lamp sales relative to U.S. total lamp sales, and as a qualitative indicator for interpreting trends. Used to estimate the CFL and LED sales fractions in Method 2. | While LightTracker is based on actual sales, it does not include some of the major retail channels for lamp sales, including home improvement stores and one of the major mass merchant clubs. Consequently, TRC used relative trends – rather than absolute values from LightTracker. Because home improvement and mass merchant clubs are the two market channels with the highest fraction of LEDs (based on CA shelf surveys), |

[11] TRC and the IOUs came to agreement with the CPUC on lighting savings overlap values using the 2010-12 ULP evaluation values, before the 2013-14 ULP evaluation was published. However, future evaluations should use parameters from the 2013-14 ULP evaluation for calculating the lighting savings overlap from excess lamps installed in 2013 and 2014.

[12] The information contained herein is based in part on data reported by LightTracker through its Advantage service for, and as interpreted solely by LightTracker Inc. Any opinions expressed herein reflect the judgment of LightTracker Inc. and are subject to change. LightTracker disclaims liability of any kind arising from the use of this information.

| Name (Author, Publication) | Description, and Primary Use in this Analysis | Limitations for this Analysis |
|---|---|---|
| | | this data source is likely missing a large fraction of LED sales. |
| National Association of Electrical Manufacturers Association (NEMA) residential lamp data (www.nema.org/news/Pages/Compact-Fluorescent-Lamp-Shipments-Continue-to-Lag.aspx) | NEMA provides fractions of manufacturer lamp shipments by technology – i.e., incandescent, halogen, CFL, and LED – for each quarter from 2011 through Q3 2014. In addition, NEMA provides market shipment indices for each quarter 2011 through Q3 2014, benchmarked to 2011. Used for estimating the CFL and LED rebated sales fractions in Method 2. | Data are at the U.S. level, and only reflects A-lamps (e.g., excludes reflectors and globes). Shipments may not coincide with actual sales, and actual sales volumes are not provided. Q4 2014 data was not available, so TRC extrapolated results for Q4 2014. |
| D&R Residential Lighting Market Profile (2012) | Provides an estimate of residential lamp shipments in the U.S. from 2006-2011. Used for estimating the CFL and LED rebated sales fractions in Method 2. | D&R does not describe how its estimate of residential lamp shipments was developed, so TRC cannot identify its limitations. |
| U.S. Department of Commerce and International Trades Commission Import Data, http://dataweb.usitc.gov/ | This website tracks import data for goods imported into the U.S., including several categories of lamps. Used for estimating the CFL rebated sales fractions in Method 2. | Import shipment data may not coincide with retail sales. Data are provided for the U.S., not California. Data include lamps used in nonresidential buildings, so TRC estimated the residential fraction. |
| U.S. Environmental Protection Agency (EPA) CFL and LED lamp shipment estimates | The EPA asks its partners to report their number of ENERGY STAR labeled CFLs and LEDs shipments, tracks the percent of partners that reported data, and estimates the percent of market penetration for ENERGY STAR lamps. The U.S. EPA also provided TRC with an estimate of total U.S. LED sales developed by a contractor (Lighting Strategies). Used to estimate the LED rebated sales fractions in Method 2. | Most program partners report shipments, but not all partners do. Also, the EPA must estimate the fraction of the market not participating in the ENERGY STAR program. For the U.S. LED estimate, TRC does not know how the contractor developed its estimate, so TRC cannot identify the limitations of this estimate. |

*Figure 5. Description of Main Data Sources*

## Calculation of Lighting Savings Overlap

In the following section, TRC presents our estimate of the lighting savings overlap. It is structured as follows:

- Main Equation and Values Used to Calculate Lighting Savings Overlap: Presents the main equation used to estimate the savings overlap and describes each of the equation's parameters.

The next three subsections provide our estimates for the key equation parameters that TRC developed (i.e., did not assume based on values from another evaluation):

- Estimate of Excess CFLs and LEDs: Presents our method for estimating the number of excess CFLs and LEDs purchased for each year of HER treatment;
- Equation and Values for CFLs: Presents our estimate of total CFLs sold in California for 2011 through 2014, our apportionment of these CFLs to the electric IOUs, and our calculation of the resulting CFL rebated sales fraction for each IOU;
- Estimate of Total LEDs and Rebated LED Sales Fraction: Presents our estimate of total LEDs sold in California for 2014, our apportionment of these CFLs to the electric IOU territories, and our calculation of the resulting LED rebated sales fraction for each IOU;

The final subsection then provides the:

- Resulting Calculation of Lighting Savings Overlap Estimates: Synthesizes the information above – i.e. combines the main equation with the parameters estimated for that equation – to show an example calculation of the lighting savings overlap for a HER treatment wave.

The primary equations used in this analysis are numbered. For simplicity, supporting calculations, including many of the calculations used for estimating excess CFLs and LEDs, are not numbered.

## Main Equation and Values Used to Calculate Lighting Savings Overlap

### *Equation and Values for CFLs*

The 2010-2012 PG&E HER evaluation used the following equation to determine the lighting savings overlap – described by the evaluators as the "kWh attributable to both programs" – per HER treatment household (hh):

Equation Developed in the 2012 PG&E HER Evaluation:

*kWh attributable to both programs (HER and ULP) per hh, CFLs = CFLs installed due to HERs x years CFLs have been installed x (rebated CFLs / total CFLs) x (CFLs attributable to ULP / rebated CFLs) x Savings per CFL per year*

TRC made the following one modification to the equation: The 2010-2012 ULP impact evaluation found a rebated CFL installation rate of 97% - i.e., found that 3% of rebated CFLs were never installed because of permanent storage, breakage, or consumer dissatisfaction. Consequently, **TRC added a parameter for Installation Rate to the equation**, to remove the CFLs that were rebated but never installed, and thus did not contribute to HER households' savings.

Equation Used for this 2014 IOU HER Evaluation

*(Equation 1):*

*kWh attributable to both programs per hh, CFLs = CFLs installed due to HERs x years CFLs have been installed x (rebated CFLs / total CFLs) x (CFLs attributable to ULP / rebated CFLs) x Installation Rate x Savings per CFL per yr*

**Because TRC assumed an installation rate of 97%, this additional term had only a small impact on the result.**

**TRC updated several of the parameters in this calculation from the values assumed by the 2012 PG&E HER evaluation, which had a much larger impact on the result**.

TRC assumed the following values for the parameters in this equation:

- CFLs installed due to HERs – TRC assumed a value of excess lamps that depended on the year of HER treatment. For Year 1 of HER treatment, TRC assumed 0.95 excess lamps, the same as the 2012 PG&E HER Evaluation. For Year 2, 3, and 4, TRC assumed 0.4, 0.15, and 0.08 excess lamps, respectively. In addition, TRC assumed that all excess lamps were CFLs for 2011 through 2013, but that excess lamps were a mix of CFLs and LEDs for 2014. TRC provides more detail in the section, Estimate of Excess CFLs and LEDs.
- Years CFLs have been installed – This parameter refers to the number of years that the CFLs were assumed to be installed during the evaluation timeframe – i.e., number of years during 2014 for this evaluation. Following the precedent of past HER evaluations, TRC assumed that HER treatment households installed excess CFLs evenly throughout the year. Because most households had been in treatment at least one year by the end of 2014, TRC assumed one year for most treatment waves. However, for waves that began treatment mid or late 2014 (i.e., PG&E waves 4 and 5; SCE Opower 2; SDG&E Opower 2), TRC assumed a fraction of one year, based on the number of months of treatment in 2014. For example, for PG&E wave 4 launched in May 2014, TRC assumed 8/12 of one year, since the wave had been in effect for eight months.
- Rebated CFLs / Total CFLs – TRC used program tracking data for Rebated CFLs. TRC used various methods to estimate Total CFLs, as described in the section Estimate of Total CFLs and Rebated CFL Sales Fraction. Based on results, TRC assumed PG&E-rebated sales fractions of 50% for 2011, 45% for 2012, 16% for 2013, and 7% for 2014; SCE-rebated sales fraction of 40% for 2014; and SDG&E rebated sales fraction of 57% for 2011 and 18% for 2014.

- CFLs attributable to ULP / rebated CFLs – Used the average 2010-12 ULP (DNV-GL 2014[13]) NTGR values for each IOU – PG&E: 0.63, SCE: 0.69, and SDG&E: 0.61.
- Installation Rate – Used the value provided in the 2010-12 ULP (DNV-GL 2014): 97%.
- Savings per CFL – Used the IOU-average value provided in the 2010-12 ULP (DNV-GL 2014) for CFLs purchased in 2010-2012, and the IOU-average value provided in 2013-2014 program tracking data for CFLs purchased in 2013 and 2014. These values are generally between 18 and 32 kWh/CFL. The savings per CFL is higher for SCE for 2014, as described in the section SCE 2014 HER Lighting Savings Overlap Compared to 2013 SCE HER Evaluation.

### *Equation and Values for LEDs*

TRC used the same general approach (i.e., an analogous equation) for LEDs as we used for CFLs:

*(Equation 2)*

*kWh attributable to both programs per hh, LEDs = LEDs installed due to HERs x years LEDs have been installed x (rebated LEDs / total LEDs) x (LEDs attributable to ULP / rebated LEDs) x Installation Rate x Savings/LED/yr*

TRC assumed the following values for the parameters in the LED equation:

- LEDs installed due to HERs – Because the previous HER evaluations had not estimated the LED lighting savings overlap, TRC estimated the parameter, "LEDs installed due to HERs", also referred to as "excess LEDs". As explained in the section, Estimate of Excess CFLs and LEDs, TRC estimated that a portion of excess lamps for 2014 were LEDs, depending on the estimated sales of CFLs vs. LEDs in each IOU territory. For PG&E, the number of excess LEDs for 2014 ranged from a minimum of 0.04 for Beta wave (because they were in Year 4 of HER treatment and had therefore installed very few excess lamps) to a maximum of 0.2 for Wave 3 (because they were in the beginning of HER treatment). TRC estimated 0.2 excess LEDs for SCE Opower 2, and 0.05 and 0.03 excess LEDs for SDG&E Opower 1 and Opower 2, respectively.
- Years LEDs have been installed – This refers to the number of years (during the evaluation period – 2014) that the excess LEDs were installed. TRC used the same assumptions as described above for CFLs – i.e., assumed an even distribution of excess LEDs throughout the year.
- Rebated LEDs / Total LEDs – Used program tracking data for Rebated LEDs. Used various methods to estimate Total LEDs, and to develop the rebated LED sales fraction of 21%, 20%, and 32% for PG&E, SCE, and SDG&E respectively, as described in the section Estimate of Total LEDs and Rebated LED Sales Fraction.
- LEDs attributable to ULP / rebated LEDs – Used the same assumption as for CFLs. Used the average 2010-12 ULP (DNV-GL 2014) NTGR values: 0.63 for PG&E, 0.69 for SCE, and 0.61 for SDG&E.
- Installation Rate – Used the same assumption as for CFLs. Used the value provided in the 2010-12 ULP (DNV-GL 2014): 97%.
- Savings per LED –Used the IOU-average value provided in the 2013-2014 IOU program tracking database, which are based on DEER for 2013-2014: 25, 20, and 22 kWh/LED for PG&E, SCE, and SDG&E, respectively.

[13] DNV-GL 2014: "California Upstream and Residential Lighting Impact Evaluation." For each IOU, TRC divided ex-post net savings in Table 4 by ex-post gross savings in Table 3.

### *Interactive Effects*

TRC used a multiplier to estimate natural gas interactive effects from the lighting savings overlap. This value represents interactive effects that did not occur, i.e., removes the negative therm penalty that would have been double-counted through both the ULP and behavioral-based programs.

To estimate the natural-gas-interactive-effects credit, TRC first estimated the lighting savings overlap in GWh, and then multiplied the GWh savings by the average MTherms / GWh savings for ULP measures for each IOU. TRC used the IOU-average MTherms/GWh savings for ULP measures from the 2013-2014 program tracking database, which are based on DEER for 2013-14. For PG&E, this ratio (-19 MTherm/ GWh savings) was the same value as what the 2010-2012 ULP impact evaluators assumed for CFLs rebated in the 2010-2012 program cycle. The IOU-specific multipliers and example natural gas savings credits are shown below, in one example for a treatment wave for each dual-fuel IOU.

*(Equation 6)*

*Therm savings = GWh savings overlap x Therms / kWh x 1 MTherm / 1000 Therm x 1e6 kWh/GWh*

*For PG&E HER Total: 5.1 GWh x -0.019 Therm / kWh x 1 MTherm / 1000 Therm x 1e6 kWh/GWh = -98 MTherm*

*For SDG&E Opower 1: 0.22 GWh x -0.014 Therm / kWh x 1 MTherm / 1000 Therm x 1e6 kWh/GWh = -3.1 MTherm*

## Estimate of Excess CFLs and LEDs

### *Available Data and Previous Estimates*

As part of the 2012 HER program evaluation, the evaluators conducted a home inventory of 702 homes (approximately half HER households and half control households) to understand how HER treatment households were achieving the energy savings that were estimated through billing analysis. **This 2012 on-site survey found that HER treatment households had installed an average of 0.95 more CFLs than the control group** (i.e., households not treated through HER that were similar demographically). This value of 0.95 CFLs had large confidence intervals that included zero – i.e., there may have been no statistical difference in CFL installations between HER and non-HER households. In addition, a phone survey of HER treatment households (n = 1,649) and control households (n = 857) found there was no statistical difference in customer self-reported responses to the question of whether they had replaced incandescent lamps with CFLs; control and treatment households responded almost identically.[14]

However, the average value of 0.95 CFLs represented the best available estimate of the change in CFL installations due to HER treatment. Thus, the 2012 HER program evaluation assumed that HER households installed 0.95 "excess CFLs" because of the influence of the HER program. The 2013 PG&E HER, 2013 SCE HER, and 2013 SDG&E HER evaluations also assumed 0.95 excess CFLs for the first year of HER treatment, following the precedent set by the 2012 PG&E HER evaluation. Those evaluations did not assume any excess lamps for subsequent years of HER treatment.

TRC did not collect any new information regarding the number of excess CFLs installed because of the HER program treatment. However, since the time of the 2012 PG&E HER evaluation, several developments have occurred that may have affected the number and type of excess lamps installed due to HER treatment:

1. **Many HER treatment waves have been in treatment for over one year and treatment customers may have installed excess lamps after the 1st year.** For example, the original PG&E treatment waves (the Beta and Gamma waves) have been in treatment since the end of 2011 – so for over three years by the end of

[14] B. Smith and L. Arnot, "Neighbor Comparison Reports Produce Savings, but HOW?" ACEEE Summer Session 2014.

2014. It is possible that these customers installed excess lamps in the 2nd, 3rd, and 4th years of treatment due to HER influence. While the 2012 PG&E HER evaluation provides data on the number of excess lamps installed during the 1st year of treatment, there is little data available indicating whether California IOU HER treatment households continue to install excess lamps (i.e., high efficacy lamps in greater numbers than a control group) in subsequent years of treatment, and if so, at what level.

2. **The lighting market has changed so that excess lamps installed in 2014 likely included some LEDs.** As described in later sections of this document, from 2012 to 2014, various data indicate that the availability and sales of LEDs have increased while the availability and sales of CFLs have decreased. Consequently, the excess lamps installed in 2014 were likely a mix of CFLs and LEDs. However, there is a lack of available data indicating the number or proportion of excess lamps installed due to HER that are LEDs.

This evaluation makes a good-faith effort to avoid double-counting savings claimed by the ULP by including estimates of excess lamps installed after Year 1 and the CFL / LED split of excess lamps. **TRC worked in collaboration with the IOUs, the CPUC, and its evaluator to develop both estimates.** This group used the best data available to develop assumptions and estimates for these values, which are presented in the next sections. TRC recognizes that there are various limitations of these data and recommends that future studies collect data to provide updated, and presumably more precise, values for these assumptions.

### *Estimate of Excess Lamps for each Year of HER Treatment*

**This evaluation assumed that the number of excess lamps declines with each year of HER treatment, which is supported by overall HER treatment savings trends, and results of HER treatment customer surveys.** TRC based this assumption on results of the longest running PG&E HER treatment wave (Figure 6), which show a fairly sharp increase in initial savings, which grow gradually thereafter. Other HER treatment waves have shown similar trends – i.e., a sharp initial increase in savings for the 1st year of treatment, and then small incremental increases in subsequent years.

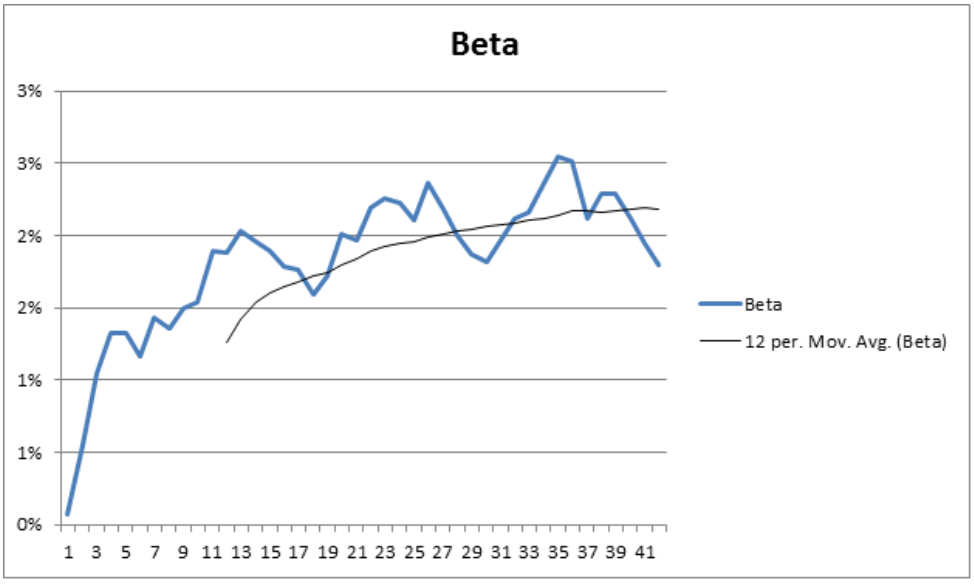



*Figure 6. Energy Savings (y-axis) Relative to Month in Treatment (x-axis) (Source: Nexant)*

The electricity savings from the 0.95 excess CFLs found in the 2012 PG&E HER evaluation represented approximately one-third of total HER electricity savings. Since the excess lighting savings represent a sizeable fraction of total HER electricity savings, TRC reasoned that the shape of the excess lamp purchases would mirror the shape of total HER savings.

The assumption that excess lamps declines each year is also supported by comparing results from the PG&E 2012 HER in-home study with results of a study of Puget Sound Energy (PSE) HER treatment customers[15]. Although the PSE study was a phone survey (not in-home survey) conducted with customers in a different state, the HER program (a.k.a., the Opower program) is administered in a similar manner in PSE as in the California IOU territories. The PSE study found an average of 0.15 and 0.08 excess lamps installed in the 3rd and 4th year of HER treatment, respectively. These values are lower than the 0.95 excess lamps found after the 1st year of HER treatment in the 2012 PG&E HER evaluation.

**Based on these data, TRC assumed the number of excess lamps for each year of HER treatment shown in Figure 7.**

| Year of HER Treatment | Number of Excess Lamps Assumed | Source for Assumption |
|---|---|---|
| Year 1 | 0.95 | PG&E 2012 HER evaluation in-home survey |
| Year 2 | 0.4 | Interpolating the values from PG&E (for year 1) and PSE values (for years 3 and 4) |
| Year 3 | 0.15 | Phone surveys with PSE HER treatment customers |
| Year 4 | 0.08 | Phone surveys with PSE HER treatment customers |

*Figure 7. Number of Excess Lamps Assumed for each Year of HER Treatment*

TRC assumed an even purchase of excess lamps throughout each year of treatment, consistent with past HER evaluations (e.g., 2012 PG&E HER, 2013 PG&E HER, and 2013 SCE HER).

### *Excess Lamp Split between CFLs and LEDs*

**In general, TRC assumed that the relative fraction of excess lamps that were CFLs versus LEDs would reflect lamp sales.** Because of the lack of survey data indicating how excess lamps might be apportioned between CFLs and LEDs, TRC assumed that this split would reflect overall lamp sales trends. In other words, TRC assumed that HER treatment households would purchase excess CFLs and excess LEDs in proportion to the purchase of total CFLs and LEDs by all households in their IOU territory. In addition, because developing a rebated sales fraction for LEDs added considerable complexity to the analysis, TRC only assumed that a portion of excess lamps would be LEDs for years when the LED lighting savings overlap was expected to significantly affect results (compared with assuming that all excess lamps were CFLs).

**For 2011 and 2012, TRC assumed that all excess lamps were CFLs, because LEDs represented a small fraction of the market, and rebated sales fractions were likely to have been higher for CFLs than LEDs.** Based on DNV-GL shelf survey data for spring 2011 and summer 2012, LEDs represented 4% and 6% of lamps on shelves in 2011 and 2012, respectively, compared with 45% and 47% of lamps that were CFLs. Thus, LEDs represented approximately 8% (based on 4%/49) and 12% (based on 6%/53% - rounded to nearest whole number) of efficient lamps in 2011 and 2012 respectively, a fairly small fraction. In addition, the IOUs were still rebating CFLs at a high level in 2011 and 2012. TRC calculated the PG&E rebated CFL sales fractions were 50% in 2011 and 45% in 2012, and that the SDG&E rebated LED sales fractions were 57% in 2011 and 68% in 2012. (SCE did not have HER treatment waves in 2011 and 2012, so this assumption does not affect SCE.) The IOUs had not yet shifted their focus to LED rebates by 2012. As shown in Figure 8, the DNV-GL shelf surveys found that the rebated sales fractions for CFLs were higher than for LEDs in 2011 and 2012 for both PG&E and SDG&E.

[15] The number of excess lamps from the PSE study was provided in personal communications with Ken Agnew, DNV-GL. The citation for the DNV-GL evaluation for PSE is as follows, although the number of excess lamps is not explicitly published in this report: DNV-GL on behalf of PSE, 2014 “Home Energy Report Program 2013 Impact Evaluation”.

| IOU | Year of DNV-GL shelf survey | % of CFLs rebated | % of LEDs rebated |
|---|---|---|---|
| PG&E | 2011 Fall | 35% | 3% |
| | 2012 Summer | 23% | 10% |
| | 2013 Summer | 16% | 16% |
| SDG&E | 2011 Fall | 16% | 0% |
| | 2012 Summer | 46% | 3% |
| | 2013 Summer | 19% | 5% |

*Figure 8. Percent of Efficient Lamps Rebated by IOUs based on DNV-GL Shelf Surveys*

While TRC cannot estimate the LED rebated sales fractions for 2011 and 2012 without calculating total LED sales, we believe that the rebated fraction for LEDs would be lower than those found for CFLs. For simplicity, TRC assumed that all excess lamps were CFLs in 2011 and 2012.

**For 2013, TRC continued to assume that all excess lamps were CFLs, because LEDs were still a smaller share of the market than CFLs, and the rebated sales fractions were likely similar for CFLs and LEDs.** Note that the only treatment waves significantly affected by the 2013 values are PG&E treatment waves[16]. The DNV-GL summer 2013 shelf survey found that LEDs and CFLs were 7% and 36% of lamps available respectively. Thus, approximately 20% (7% / 36%) of efficient lamps were LEDs. This is a more significant fraction than for 2011 and 2012. However, as shown in Figure 8, the DNV-GL summer 2013 shelf survey found that for PG&E territory, CFLs and LEDs both had a rebated sales fraction of 16%. TRC's calculations also found that rebated CFL sales fraction for PG&E 2013 was 16%. In addition, the savings per lamp for CFLs and LEDs was very similar for PG&E for 2013 (24 kWh/yr/CFL and 25 kWh/yr/LED). Since the rebated sales fractions and savings per lamp are similar for CFLs and LEDs, and to simplify the analysis, TRC assumed all excess lamps were CFLs in 2013.

**For 2014, TRC assumed that excess lamps were a mix of CFLs and LED, based on the relative sales fraction for each IOU territory.** TRC developed estimates for the number of CFLs and LEDs sold in each IOU territory, as described in the sections, Estimate of Total CFLs and Rebated CFL Sales Fraction and Estimate of Total LEDs and Rebated LED Sales Fraction. As shown in those sections, TRC estimated that the number of CFLs and LEDs sold in each IOU territory for 2014 were as follows:

- PG&E: 8.4 million CFLs, 4.4 million LEDs, corresponding to a split of 66% CFLs / 34% LEDs
- SCE: 10.2 million CFLs, 4.0 million LEDs, corresponding to a split of 72% CFLs / 28% LEDs
- SDG&E: 2.0 million CFLs, 1.3 million LEDs, corresponding to a split of 60% CFLs / 40% LEDs

The different CFL / LED splits for the IOUs reflect their 2014 ULP rebates. Because SCE provided the highest fraction of CFL rebates (compared to total rebates) of the IOUs, it is likely that their customers purchased a higher fraction of excess CFLs. Conversely, SDG&E had the highest fraction of LED rebates (compared to total rebates), so it is likely that their customers purchased a higher fraction of excess LEDs. Figure 9 summarizes the assumed excess lamp split between CFLs and LEDs for each year.

| Year | Type of Excess Lamps Assumed | Rationale for Assumption |
|---|---|---|
| 2011 | 100% CFLs | Data (e.g., CA shelf surveys, NEMA data, and LightTracker) indicate that LEDs represented a small fraction of lamps available for sale and sold |
| 2012 | 100% CFLs | Same rationale as for 2011 |
| 2013 | 100% CFLs | Data shows that LEDs were growing, but were still a smaller fraction of market than CFLs. Also, shelf surveys indicated that the rebated sales fractions were similar for CFLs and LEDs |
| 2014 | PG&E: 66% CFLs / 34% LEDs<br>SCE: 72% CFLs / 28% LEDs<br>SDG&E: 60% CFLs / 40% LEDs | Based on lamp sales estimates for each IOU territory, as presented in subsequent sections of this document |

*Figure 9. Assumptions of Excess Lamp Split between CFLs and LEDs*

[16] The SDG&E Opower 1 wave was in its third year, so the number of excess lamps is small.

### *Example Calculations of Excess Lamps for each Treatment Wave*

Based on the above estimates of excess lamps installed each year of treatment, TRC estimated a number of excess CFLs and excess LEDs for each treatment wave for each year of HER treatment. We provide an example calculation for one treatment wave of each IOU below. Figure 1, Figure 2, and Figure 3 show the resulting number of excess CFLs and excess LEDs calculated for each PG&E, SCE, and SDG&E treatment wave, respectively.

**For the PG&E Beta wave**: Because treatment began in August 2011, TRC made the following assumptions:

For 2011, assumed 5/12 of excess lamps for 1st year of treatment: *5/12 x 0.95 excess CFLs = 0.4 excess CFLs*

For 2012, assumed 7/12 of excess lamps for 1st year of treatment plus 5/12 of excess lamps for 2nd year of treatment: *7/12 x 0.95 excess CFLs + 5/12 x 0.4 excess CFLs = 0.7 excess CFLs*

For 2013, assumed 7/12 of excess lamps for 2nd year of treatment plus 5/12 of excess lamps for 3rd year of treatment: *7/12 x 0.4 excess CFLs + 5/12 x 0.15 excess CFLs = 0.3 excess CFLs*

For 2014, TRC estimated that CFLs comprised 66% and LEDs comprised 44% of excess lamps for PG&E territory. Thus, for CFLs, TRC assumed 66% of 7/12 of excess lamps for 3rd year of treatment plus 66% of 5/12 of excess lamps for 4th year of treatment*: 66% x 7/12 x 0.15 excess CFLs + 66% x 5/12 x 0.08 excess CFLs = 0.1 excess CFLs*

Similarly for LEDs for 2014: *44% x 7/12 x 0.15 excess LEDs + 44% x 5/12 x 0.08 excess LEDs = 0.04 excess LEDs*

**For SCE OPower 2:** Because treatment began in April 2014, TRC assumed 9/12 of excess lamps for the 1st year of treatment in 2014. TRC estimated that CFLs comprised 72% and LEDs comprised 28% of excess lamps for SCE territory in 2014.

Thus, for CFLs, TRC assumed 72% of 9/12 of excess lamps for 1st year of treatment*: 72% x 9/12 x 0.95 excess CFLs = 0.51 excess CFLs*

Similarly for LEDs for 2014: *28% x 9/12 x 0.95 excess LEDs = 0.2 excess LEDs*

**For SDG&E OPower 1:** Because treatment began in July 2011, TRC made the following assumptions:

For 2011, assumed 6/12 of excess lamps for 1st year of treatment: *6/12 x 0.95 excess CFLs = 0.5 excess CFLs*

For 2012, assumed 6/12 of excess lamps for 1st year of treatment plus 6/12 of excess lamps for 2nd year of treatment: *6/12 x 0.95 excess CFLs + 6/12 x 0.4 excess CFLs = 0.7 excess CFLs*

For 2013, assumed 6/12 of excess lamps for 2nd year of treatment plus 6/12 of excess lamps for 3rd year of treatment: *6/12 x 0.4 excess CFLs + 6/12 x 0.15 excess CFLs = 0.3 excess CFLs*

For 2014, TRC estimated that CFLs comprised 60% and LEDs comprised 40% of excess lamps for SDG&E territory. Thus, for CFLs, TRC assumed 60% of 6/12 of excess lamps for 3rd year of treatment plus 60% of 6/12 of excess lamps for 4th year of treatment*: 60% x 6/12 x 0.15 excess CFLs + 60% x 6/12 x 0.08 excess CFLs = 0.07 excess CFLs*

Similarly for LEDs for 2014: *40% x 6/12 x 0.15 excess LEDs + 40% x 6/12 x 0.08 excess LEDs = 0.05 excess LEDs*

## Estimate of Total CFLs and Rebated CFL Sales Fraction

IOU HER treatment began in 2011, 2012, 2013, or 2014, depending on the IOU and the treatment wave, and TRC assumed that HER treatment households purchased excess CFLs for each of those years. Consequently, TRC needed to calculate the Total CFL sales for each of these four years.

Overall, TRC used four different methods to estimate total CFL sales in California. However, the data sources for some methods were more reliable for some years than others, so TRC did not use all methods for all four years. For the methods that did provide results that TRC believed were reliable, TRC averaged the results for each year.

This section provides a summary of each method. TRC provides supporting calculations and assumptions for Methods 1-3 in the Appendix, in the Section Methods to Estimate Rebated CFL and LED Sales Fractions. Method 4 is simpler, so there are no additional calculations in the Appendix for Method 4.

Note that, when developing estimates for both CFLs and LEDs, **TRC estimated its lighting savings overlap estimate based on lamps purchased, rather than lamps installed**. For example, TRC did not calculate the lighting savings overlap from lamps in storage from previous years, but installed in 2014. These lamps were included in the previous HER evaluations, for the years in which they were rebated. TRC took this approach because: 1. This was the precedent set by the 2012 PG&E HER evaluators and followed by the 2013 IOU HER evaluators, 2. It aligns with other CPUC evaluations (e.g., the 2012-2012 ULP credited the IOUs for the years in which lamps were rebated, rather than installed), and 3. It is simpler.

### *Method 1: TRC California Lamp Purchasing model, for 2013 and 2014 Total CFLs*

For total CFLs sold in 2013 and 2014, TRC developed a lamp purchasing model. For existing homes in California, TRC started with the total lamps installed by technology (i.e., numbers of incandescent lamps, halogens, CFLs, and LEDs installed) in the average California home in the 2012 CLASS survey. TRC then projected this inventory of lamps forward to 2013, based on assumptions regarding lamp Effective Useful Life (EUL), early retirement, and lamps taken from storage, to estimate the total number of lamps that the average California home needed to replace in 2013 (an estimated 9.9 total lamps). Next, TRC multiplied this total number of lamps by the market share fractions by technology (i.e., 40% incandescent lamps, 17% halogens, 36% CFLs, 7% LEDs for 2013) found in the summer 2013 California shelf survey. The result was an estimate of the number of lamp purchases by technology per existing California home (i.e., number of incandescent lamps, halogens, CFLs, and LEDs purchased in 2013). TRC multiplied these purchases per home by the number of occupied, existing homes in California (12.5 million). TRC also developed an estimate of lamps installed in new construction homes, and added those values to the purchases for existing homes, to estimate total lamps purchased in 2013, and total lamps installed per home at the end of 2013.

TRC used the same approach to project the lamp purchasing model forward another year - to 2014. Based on the 2013 lamp inventory, and using the assumptions described above for EUL and early retirement, TRC estimated that 9.6 lamps would be removed on average per household in 2014. TRC used the California shelf surveys[17] to estimate the number of lamp purchases by technology per existing California home (i.e., 37% incandescent lamps, 18% halogens, 31% CFLs, 13% LEDs for 2014 based on California shelf survey results).

The 2012 CLASS survey found that California households had an average of 10 lamps in storage in 2012. Thus, TRC estimated results under two assumptions for the lamps in storage:

a. Assuming no net changes in lamps storage – i.e., assuming that Californians purchased the same total number of lamps that they removed because of burnout or early retirement. Specifically, TRC assumed that in 2013, the average California household removed 9.9 lamps and purchased 9.9 replacement lamps; and in 2014, removed 9.5 lamps and purchased 9.5 replacement lamps. **Based on this method, TRC estimated that residential California customers purchased 46 million CFLs in 2013 and 38 million CFLs in 2014.**
b. Assuming that the average California household's storage declined by one total lamp (0.5 CFL and 0.5 incandescent) in 2013 and 2014. Specifically, TRC assumed that Californians removed 9.9 lamps in 2013, but purchased 8.9 replacement lamps; and in 2014, removed 9.6 lamps in 2014, but purchased 8.6

[17] TRC used the 2013 summer shelf survey to estimate 2013 purchases. For 2014, TRC averaged results from the 2013 summer and 2014/15 winter shelf surveys.

replacement lamps. **Based on this method, TRC estimated that residential California customers purchased 41 million CFLs in 2013 and 34 million CFLs in 2014.**

In the Section, Final Estimate of CFL Sales for 2011-2014, TRC describes which of these estimates (Method 1a or Method 1b) we ultimately assumed for our calculation and why.

The 2012 CLASS survey indicates what California residential customers had installed by 2012, and TRC projected this inventory forward to 2013 and 2014 using other data (e.g., California shelf survey results and LightTracker reports). To estimate a lamp purchase model for 2011 and 2012, TRC would have needed to project the 2012 CLASS survey "backward" to the 2005 CLASS survey results. However, shelf survey data and LightTracker is not available prior to 2009. Consequently, TRC did not develop a lamp purchase model for 2011 or 2012.

### *Method 2: Extrapolated U.S. CFLs to California, for 2014 Total CFLs*

For CFLs sold in 2014, TRC estimated U.S. CFL sales, and then estimated how many of these were sold in California. To estimate U.S. CFL sales:

- TRC took an estimate of total residential lamp shipments in the U.S. from D&R (2012), of 1,563 million total lamp shipments in 2011. For 2014, TRC multiplied the 2011 total lamps by the NEMA shipment index for 2014 (0.75). (NEMA provides lamp shipments for each year relative to 2011.) 1,563 million x 0.75 = 1,175 total U.S. lamps in 2014. NEMA also provides market shares by technology, which indicated that 31% of these 1,175 total U.S. lamps were CFLs. 1,175 million total lamps x 31% CFLs = 363 million U.S. CFLs.
- TRC used CFL import data which indicated that 326 million CFLs were imported into the U.S. To estimate residential CFL sales: The 2010-2012 ULP impact evaluation assumed that 7% of CFLs were installed in nonresidential buildings for PG&E and at the statewide level for ULP CFLs. TRC assumed that 10% of all imported CFLs were installed in nonresidential buildings, because some nonresidential customers may purchase some CFLs in bulk, outside of the ULP-rebated retail channels. Thus, TRC multiplied the 326 million total CFLs by 90%, to estimate 293 million residential CFLs sold in the U.S. 2014.
- TRC averaged the two estimates (363 million and 293 million) to estimate that 328 million CFLs were sold in the U.S. in 2014.

TRC then estimated how many of these U.S. CFLs were sold in California under two scenarios:

a. TRC first assumed that California CFL purchases followed housing trends, and multiplied the estimate of U.S. CFLs (328 million) by the percent of housing units in California (10.8%). **Based on this method, TRC estimated that California residential customers bought 36 million CFLs in 2014.**

b. Various data indicate that California consumers do not follow average U.S. purchasing trends. Consequently, TRC developed an estimate for the percent of U.S. CFL sales that were sold in California as follows. TRC first estimated the percent of total U.S. lamps sold in California in 2014, by averaging results from three approaches:
   - **i.** LightTracker sales data for California divided by LightTracker sales data for the U.S.: 29 million total CA lamps / 654 million total U.S. lamp = 4%. (Recall that LightTracker does not include all market channels, so the values for CA total lamps and U.S. total lamps are lower than in other estimates.)
   - **ii.** Total lamps purchased in California from the lamp purchasing model (110 million) divided by total U.S. lamps based on NEMA data (1175 million): 110 million / 1175 million = 9%
   - **iii.** First taking the number of CFLs sold in California in 2014 based on historical analysis (i.e., 32 million CFLs, based on Method 3) and dividing it by the market share fractions of CFLs in California

in 2014 (31% based on the shelf surveys) to estimate total California lamps: 32 million / 31% = 103 million. Then dividing total California lamps by total U.S. lamps based on NEMA data: 103 million / 1175 million = 9%.

TRC recognizes there is a large difference in the estimate of U.S. lamps sold in California from methods i-iii. We discuss possible reasons in the Section, Method 2b. Adjusting U.S. Purchasing Trends for CA in the Appendix. TRC took the average of these three approaches, to estimate that 8% of total U.S. lamps were sold in California in 2014. The lower number of total lamps purchased by Californians (8%) compared to the fraction of households in California (11%) is reasonable because studies have found: 1. Californians have historically had higher levels of CFLs relative to the U.S. average, and 2. Californians have lower hours of use than other states. Both factors reduce lamp burnout (and thus replacement).

TRC then estimated the percent of U.S. CFLs sold in California, by taking the percent of total California lamps that were CFLs in 2014 (31%, based on California shelf surveys), dividing it by total U.S. lamps that were CFLs in 2014 (31%, based on NEMA data), and multiplying it by the percent of U.S. lamps sold in California (8%, found above). (The fact that both of the first values are 31% indicates that California consumers purchased CFLs relative to other lamps in similar proportions as the average U.S. consumer in 2014.) This estimate is shown in the equation below. TRC presents this equation with strikethroughs to show the units that cancel out, so that resulting units are CA CFLs / U.S. CFLs.

(Equation 7)

CA CFLs / U.S. CFLs = *(CA CFLs / ~~Total CA lamps~~) / (U.S. CFLs / ~~Total U.S. Lamps~~) x (~~Total CA Lamps~~ / ~~Total U.S. Lamps~~)*

Based on the values above, CA CFLs / U.S. CFLs = (31% / 31%) x 8% = 8%

TRC then multiplied U.S. CFLs, 328 million, by (CA CFLs / U.S. CFLs), 8%, to **estimate that California residential customers purchased 25 million CFLs in 2014**.

For years prior to 2014, for which historical CFL data was available, TRC believed that Method 2 presented more uncertainty than results developed under Methods 1, 3, and 4. Consequently, TRC did not use Method 2 to estimate CFL sales for 2011, 2012, or 2013.

### *Method 3: Historical CFL Data for 2011-2014 Total CFLs*

For total CFLs sold in 2011-2014, TRC developed estimates based on historical CFL data.

The 2012 CLASS survey shows the following values for the average California household: the number of CFLs installed in 2005 (based on the 2005 CLASS survey), the number of CFLs installed in 2012 (based on the 2012 CLASS survey), and the number of CFLs in storage in 2012 (based on the 2012 CLASS). Using these values, assuming an Effective Useful Life (EUL) for CFLs of 6.5 years[18] and early retirement rates for CFLs (described in the section Early Retirement Assumptions in the Appendix), TRC estimated the total number of CFLs purchased by the average California household from 2005 to 2012 – approximately 25 CFLs. TRC then multiplied total CFLs purchased per household by the number of housing units in California (12.2 million[19]) to estimate total residential CFLs purchased in California from 2005 to 2012. Based on this step, TRC estimated that a total of 300 million CFLs were purchased by California residential customers from 2005 to 2012.

[18] Based on results from a SCE/CPUC CFL lab study of 4,047 hours, and an HOU for CFLs of 1.7 based on the all IOU-average from the 2010-12 ULP impact evaluation. See the section Lamps Removed in 2013 in the Appendix for the full calculation.
[19] Based on U.S. Census data for occupied California housing units in 2009. TRC used 2009 data, because it was approximately midway between 2005 and 2012.

TRC then developed assumptions on when these total CFL were purchased – i.e., assumed a percent of the 300 million CFLs purchased for each year between 2005 and 2012. TRC developed these yearly allocation assumptions based on statewide rebate levels (i.e., assumed a higher fraction of CFLs were sold in years when IOU and POU - rebate levels were higher), LightTracker sales (i.e., assumed a higher fraction of CFLs were sold in years when LightTracker indicated higher California CFL sales), and U.S. CFL shipments from NEMA data.

| Year | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Portion of 2005-2012 CFLs assumed were sold (%) | 6.0% | 7.6% | 16.8% | 16.8% | 14.5% | 13.0% | 12.8% | 12.5% | 100% |
| Estimated CFLs sold (Millions) | 18.0 | 22.8 | 50.4 | 50.4 | 43.5 | 39.0 | 38.3 | 37.5 | 300 |

*Figure 10. Assumed Fraction of Total 2005-2012 CFLs Purchased Each Year*

**Based on this method, TRC estimated that California residential customers purchased 38 million CFLs in 2011 and 38 million CFLs in 2012.**

TRC then developed assumptions on changes in CFL purchases from 2012 to 2013, and from 2013 to 2014, based on California shelf surveys and on changes in total lamp sales in California from LightTracker. All of these data sources indicated that CFL sales have dropped from 2012 to 2014. Thus, as detailed in the section Method 2: Extrapolation of U.S. CFL and LED Sales to CA – Supporting Assumptions and Calculations in the Appendix, TRC estimated that California CFL sales dropped 9% from 2012 to 2013, and 5% from 2013 to 2014. **Based on this method, TRC estimated that California residential customers purchased 34 million CFLs in 2013 and 32 million CFLs in 2014.**

Figure 11 shows the results of the historical CFL analysis developed under Method 3, with California indicators graphed in shades of blue against the left y-axis, and U.S. indicators graphed in shades of red and orange against the right y-axis. The light blue line represents TRC's estimate of CFL sales in California. Note that LightTracker data (shown as the dark blue line) does not include all market channels, so it should be compared in relative – not absolute – terms with other estimates.

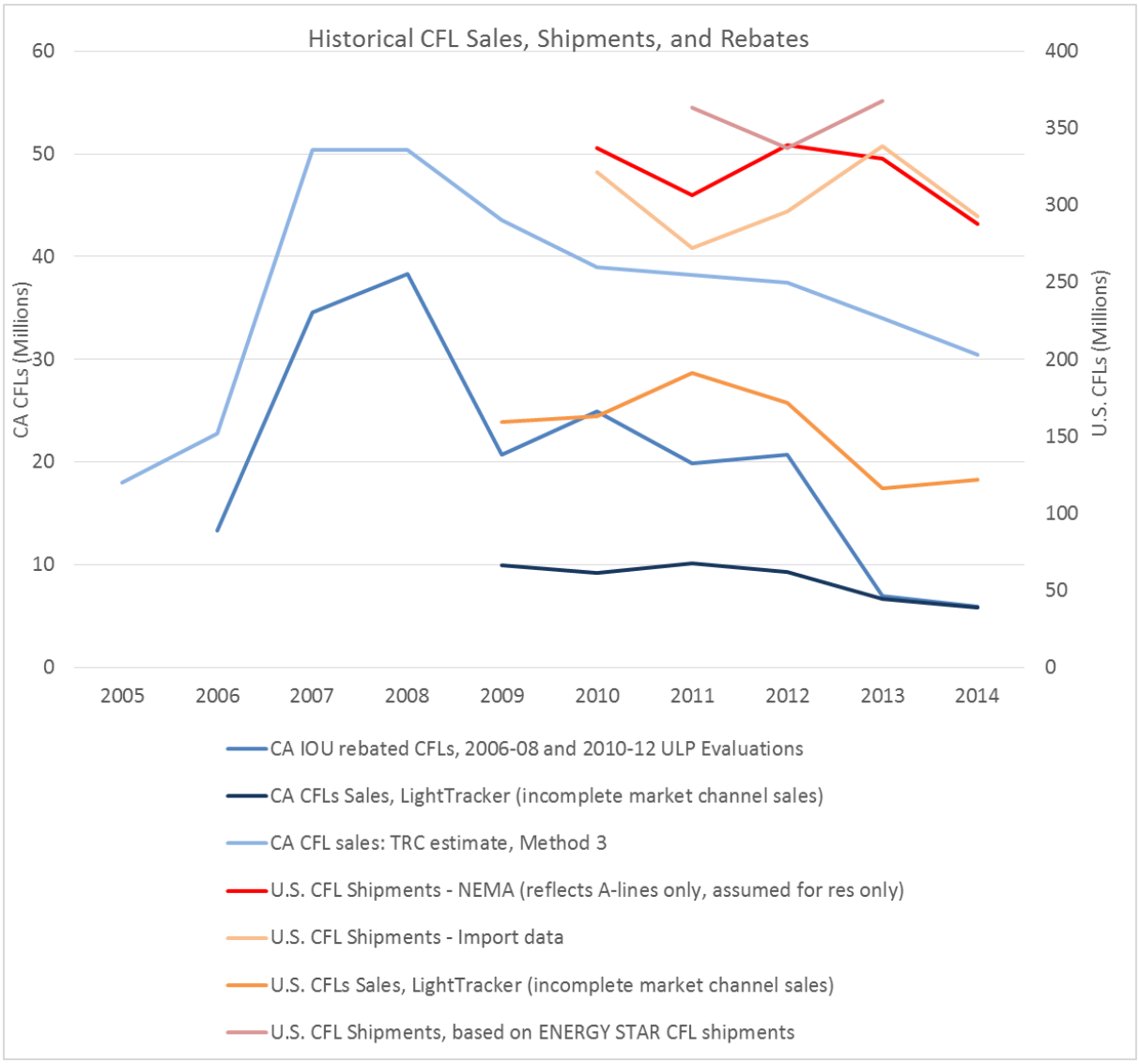



*Figure 11. Historical Data and Assumptions of CFL Sales, Shipments, and Rebates in CA and the U.S.*

Note that, under Method 3, TRC estimated the rebated sales fraction for 2006-2008, which was the timeframe for which the 2012 PG&E HER evaluators estimated their rebated sales fraction. **TRC's estimate of the rebated CFL sales fraction for the IOUs for 2006-2008 was 70%, which is close to the 2012 PG&E HER evaluation, 74%**, indicating that TRC's methodology is reasonable. In addition, the 2012 PG&E HER evaluator included all IOU rebates in the rebated sales fraction, whereas TRC only included IOU rebates assumed to be installed in residential buildings (93% of all IOU rebates). **If TRC includes all rebates (for CFLs assumed to be installed in residential and nonresidential buildings), our estimate is 78%.**

### *Method 4: DNV-GL Lamp Installation Trajectory, for 2011-2014 Total CFL sales*

For total CFLs sold in 2011, 2012, 2013, and 2014, TRC used the estimate of CFLs sold in California's IOU territories from the lamp installation trajectory in the 2010-2012 ULP Impact Evaluation (DNV-GL 2014). DNV-GL (2014) provided estimates for Total CFL sales in the IOU territories as shown in Figure 12. **Because DNV-GL's estimate was for the IOU territories only, TRC extrapolated this value up to the statewide level (i.e., divided it by the percent of CFLs TRC assumed were sold in IOU territories)**. As documented in the section Estimate of CA CFL Sales in IOU Territories in the Appendix, TRC estimated the 76% of CFLs were sold in IOU service territories in

2011-2014. In brief, TRC developed this estimate of 76% by assuming that rebated CFL sales followed rebate levels (i.e., assuming that all IOU-rebated CFLs were sold in IOU territories) and assuming that non-rebated CFLs following housing unit patterns (i.e., assuming non-rebated CFLs sold in proportion to the number of housing units in IOU territories). TRC then divided the DNV-GL estimate of IOU CFL sales by 76% to estimate statewide CFL sales.

| Year | DNV-GL Estimate of CFL Sales in IOU Territories (Millions) | TRC Estimate of CA CFL Sales in IOU Territories (%) | Estimate of CA CFL Sales (Millions) |
|---|---|---|---|
| 2011 | 31.4 | 76% | 41 |
| 2012 | 31.8 | 76% | 42 |
| 2013 | 32.3 | 76% | 43 |
| 2014 | 31.5 | 76% | 41 |

*Figure 12. Estimate of California CFL Sales under Method 4*

Note that DNV-GL developed its estimate in early 2014. While DNV-GL had accurate numbers of IOU CFL rebates for 2010-2012, DNV-GL did not have the actual number of IOU CFL rebates for 2013 and 2014. Consequently, DNV-GL had to project the number of IOU CFL rebates for 2013 and 2014, and then develop its estimate of total CFL sales in IOU territories based on these assumed CFL rebates. DNV-GL projected that the IOUs would rebate 15 million CFLs in 2013 and 15 million CFLs in 2014. In actuality, the IOUs rebated 8 million CFLs in 2013 and 6 million CFLs in 2014. Consequently, TRC believes that the DNV-GL estimate for 2011 and 2012 is more accurate than for 2013 and 2014. TRC provides more detail in the next section.

**Based on this method, TRC estimated that California residential customers bought 41 million CFLs in 2011, 42 million CFLs in 2012, 43 million CFLs in 2013, and 41 million CFLs in 2014.**

### *Final Estimate of CFL Sales for 2011–2014*

TRC then chose the best estimate for each method for each year, and averaged the estimates across the methods, as described below.

**For 2011,** TRC averaged the values provided by methods 3 and 4, to estimate that California residential customers purchased a total of 40 million CFLs.

| Method | Estimate |
|---|---|
| Method 1: TRC Lamp Purchase Model | No estimate developed |
| Method 2: CA as % of U.S. CFL Sales | No estimate developed |
| Method 3. Based on Historical CFL Purchases | 38 million CFLs |
| Method 4. DNV-GL (2014) Lamp installation trajectory | 41 million CFLs |
| **Final Estimate (Average of Methods) for 2011** | **40 million CFLs** |

*Figure 13. Estimate of California CFL Sales for 2011*

**For 2012,** TRC averaged the values provided by methods 3 and 4, to estimate that California residential customers purchased a total of 40 million CFLs.

| Method | Estimate |
|---|---|
| Method 1: TRC Lamp Purchase Model | No estimate developed |
| Method 2: CA as % of U.S. CFL Sales | No estimate developed |
| Method 3. Based on Historical CFL Purchases | 38 million CFLs |
| Method 4. DNV-GL (2014) Lamp installation trajectory | 42 million CFLs |
| **Final Estimate (Average of Methods) for 2012** | **40 million CFLs** |

*Figure 14. Estimate of California CFL Sales for 2012*

**For 2013,** TRC first picked the best estimate from Method 1, for which TRC estimated two values for CFL purchases in 2013:

a. 46 million CFLs under Method 1a – assuming no net changes in lamp storage in 2013,
b. 41 million CFLs under Method 1b – assuming total lamps in storage decreased by 1 in 2013.

To identify whether Method 1a or 1b provided the best estimate, TRC leveraged the historical trends developed under Methods 3 and 4. As shown in Figure 14, TRC estimated that CFL sales were approximately 40 million for 2012. California shelf survey data, LightTracker sales data, and IOU CFL rebates all indicate that CFL sales have dropped from 2012 to 2013. In addition, Method 1b assumes that Californians took one net lamp from storage in 2013; LightTracker data indicate a significant decline in California total lamp purchases from 2012 to 2013, which would support the assumption that California consumers took lamps from storage in 2013. Consequently, TRC chose the estimate under Method 1b, 41 million CFLs, and rejected the higher CFL sales estimate in Method 1a.

TRC also rejected the results for 2013 under Method 4. DNV-GL estimated Total CFL Sales in 2013 under the assumption that the IOUs would rebate 15 million CFLs in 2013. In actuality, the IOUs rebated 8 million CFLs in 2013. In a discussion with TRC, DNV-GL staff stated that they would have assumed a lower Total CFL sales value if they had known that IOU CFL rebates would be lower.

By rejecting the higher CFL sales values, TRC estimated lower total CFL sales, which resulted in a higher rebated sales fraction, and a higher lighting savings overlap.

**As shown in Figure 15, TRC estimated that California residential customers bought 38 million CFLs in 2013.**

| Method | Estimate |
|---|---|
| Method 1: TRC Lamp Purchase Model | |
| 1a. Assume no net changes in lamp storage | ~~46 million CFLs~~ |
| 1b. Assume total lamps in storage decreased by 1 in 2013 | 41 million CFLs |
| Method 2: CA as % of U.S. CFL Sales | No estimate developed |
| Method 3. Based on Historical CFL Purchases | 34 million CFLs |
| Method 4. DNV-GL (2014) Lamp installation trajectory | ~~43 million CFLs~~ |
| **Final Estimate (Average of Methods) for 2013** | **38 million CFLs** |

*Figure 15. Estimate of California CFL Sales for 2013*

**For 2014,** TRC used a similar approach as we did for 2013. TRC first picked the best estimate from Method 1, under which we estimated two values for CFL purchases in 2014:

a. 38 million CFLs under Method 1a – assuming no net changes in lamp storage in 2014,
b. 34 million CFLs under Method 1b – assuming 1 total lamp taken from storage in 2014.

To identify whether Method 1a or 1b provided the best estimate, TRC again used the historical trends developed under Methods 3 and 4. As shown in Figure 14, TRC estimated that CFL sales were approximately 40 million for 2012. California shelf survey data, LightTracker sales data, and IOU CFL rebates all indicate that CFL sales have dropped from 2012 to 2014. In addition, LightTracker sales data indicate a significant drop in CFL sales from 2013 to 2014, again supporting the assumption (under Method 1b) that California consumers' took lamps from storage. Consequently, rejected the higher CFL sales estimate under Method 1a, 38 million CFLs, and chose the lower CFL sales estimate under Method 1b, 34 million CFLs.

TRC also used its historical CFL analysis to identify the best estimate under Method 2, under which we estimated two values for CFL purchases in 2014:

a. 36 million CFLs under Method 2a – assuming that California followed national trends and purchased CFLs at the same percentage as the number of U.S. housing units in California – for an estimate of 11% of U.S. CFL sales in CA,
b. 25 million CFLs under Method 2b -- adjusting U.S. CFL purchases to California from comparing U.S. NEMA shipments to California shelf surveys and based on LightTracker sales – for an estimate of 8% of U.S. CFL sales in CA.

Similar to our decision to choose Method 1b for 2014, TRC selected the lower estimate for Method 2 (i.e., 25 million under Method 2b), because it agreed better with historical CFL trends. In addition, Method 2b assumes that California households purchased 8% of total U.S. lamps – a lower value than what is assumed based strictly on population trends (11% under Method 2a). TRC believes that California households purchased fewer total lamps than the average U.S. household in 2014, because California homes have had a higher penetration of CFLs (D&R 2012), and because California homes have lower hours of use than other states where metering has been conducted. (See Section Method 2b. Adjusting U.S. Purchasing Trends for CA in the Appendix for more detail.) Both factors would decrease the burn out rate, thereby lowering the total number of lamps purchased in California.

TRC also rejected the results for 2014 under Method 4. DNV-GL developed its estimate for Total CFL Sales in 2014 under the assumption that the IOUs would rebate 15 million CFLs. In actuality, the IOUs rebated 6 million CFLs in 2014. In a discussion with TRC, DNV-GL staff stated that they would have assumed a lower Total CFL sales value if they had known that CFL rebates would be lower.

Again, by rejecting the higher values of total CFL sales, TRC estimated a higher rebated sales fraction, and a higher lighting savings overlap.

**As shown in Figure 16, TRC estimated that California residential customers purchased 30 million CFLs in 2014.** By dividing 30 million CFLs by the number of occupied housing units in California (12.5 million), the implication of this estimate is that the average California household purchased 2.4 CFLs in 2014.

| Method | Estimate |
|---|---|
| Method 1: TRC Lamp Purchase Model | |
| 1a. Assume no net changes in lamp storage | ~~38 million CFLs~~ |
| 1b. Assume total lamps in storage decreased by 1 in 2014 | 34 million CFLs |
| Method 2: CA as % of U.S. CFL Sales | |
| 2a. Assume CA follows U.S. trends based on number of housing units | ~~36 million CFLs~~ |
| 2a. Adjust U.S. CFL sales to CA based on LightTracker trends, and by comparing CA shelf surveys to U.S. NEMA lamp shipments | 25 million CFLs |
| Method 3. Based on Historical CFL Purchases | 32 million CFLs |
| Method 4. DNV-GL (2014) Lamp installation trajectory | ~~42 million CFLs~~ |
| **Final Estimate (Average of Methods) for 2014** | **30 million CFLs** |

*Figure 16. Estimate of California CFL Sales for 2014*

### *Apportionment of Total CFL Sales to IOU service territory*

As the next step, **TRC apportioned this value of statewide CFLs to CFLs sold in each IOU service territory**. Below, we present our calculation for apportioning 2014 CFLs for PG&E. TRC used a similar approach to apportion CFLs to PG&E service territory for other years; and to apportion CFLs to SCE and SDG&E service territories.

Of the 30 million CFLs estimated to have been sold to residential customers in California in 2014, a total of 7 million CFLs were rebated by the IOUs and POUs[20] and assumed to be purchased by residential customers. This means that the remaining 23 million were unrebated. TRC apportioned these statewide CFLs to PG&E service territory as follows:

- Apportioned the rebated CFLs according to rebate levels. Because PG&E rebated 0.6 million CFLs in 2014 (assumed to be purchased by residential customers), TRC assumed that 0.6 million of the state's rebated CFLs were sold to residential customers in PG&E service territory.
- Apportioned the unrebated CFLs according to housing unit trends. TRC multiplied the 23 million statewide unrebated CFLs by 34% - the percent of housing units found in PG&E service territory[21], to estimate that 7.8 million unrebated CFLs were sold to residential customers in PG&E service territory.
- Combined the rebated (0.6 million) and unrebated (7.8 million) CFLs sold in PG&E service territory to estimate that 8 million CFLs were sold to residential customers in PG&E service territory. These 8 million CFLs represent 28% of the statewide 30 million CFLs.

TRC then divided the number of PG&E-rebated residential CFLs (0.6 million) by the estimate of residential CFLs sold in PG&E service territory (8 million), to estimate that the PG&E rebated CFL sales fraction was 7% in 2014.

TRC used the same approach for PG&E for apportioning 2011, 2012, and 2013 statewide CFLs. Figure 17 shows the main values used to apportion statewide CFL sales to PG&E service territory for each year from 2011 to 2014, and the resulting rebated sales fraction. TRC provides further details of these calculation and assumptions used in the Appendix in Section, Apportionment of CA Sales to IOU service territories – Detailed Calculation.

| **Lamps in Millions, and represent only lamps assumed to be sold to residential customers.** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **CFLs Rebated by PG&E** | **Total CFLs Rebated by IOUs and POUs** | **Total CFLs Sold in CA** | **Unrebated CFLs Sold in CA** | **Unrebated CFLs Sold in PG&E service territory** | **Total CFLs sold in PG&E service territory** | **CA CFLs sold in PG&E service territory (%)** | **PG&E Rebated CFL Sales Fraction (%)** |
| 2011 | 6 | 22 | 40 | 18 | 6 | 12 | 30% | 50% |
| 2012 | 5 | 23 | 40 | 17 | 6 | 10 | 26% | 45% |
| 2013 | 2 | 9 | 38 | 29 | 10 | 12 | 31% | 16% |
| 2014 | 0.6 | 7 | 30 | 23 | 8 | 8 | 28% | 7% |

*Figure 17. Apportionment of CA CFLs to PG&E service territory and Calculation of PG&E CFL Rebated Sales Fractions*

[20] Based on Energy Efficiency in California's Public Power Sector, Annual Report 2015, Sacramento Municipal Utility District (SMUD) rebated 1.2 million CFLs in 2014, Los Angeles Department of Water and Power (LADWP) did not have a residential lighting program, and the remaining POUs rebated (based on TRC's estimates) an additional 0.1 million CFLs. TRC assumed 93% of the POU-rebated CFLS would be installed in residential buildings.

[21] Thirty-four percent represents the number of residential customers in PG&E service territory in 2013 divided by total housing units in California in 2013s based on U.S. Census data.

TRC used the same approach to apportion statewide CFLs to SCE service territory and SDG&E service territory, as shown in the Appendix in Figure 43 for SCE and Figure 44 for SDG&E.

### *Comparison of Rebated CFLs from TRC Analysis and Shelf Survey Data*

As part of the California lamp shelf surveys, DNV-GL notes whether lamps are rebated by the IOUs, as denoted by a sticker on the lamp package or as part of the signage. TRC compared the shelf survey values for rebated CFL sales fractions with our estimates, as shown in Figure 18. Because the shelf surveys are not conducted at exactly the same points in time each year, the shelf survey data points are sometimes staggered compared to the IOU rebate levels and TRC's estimates of rebated CFL sales fractions.

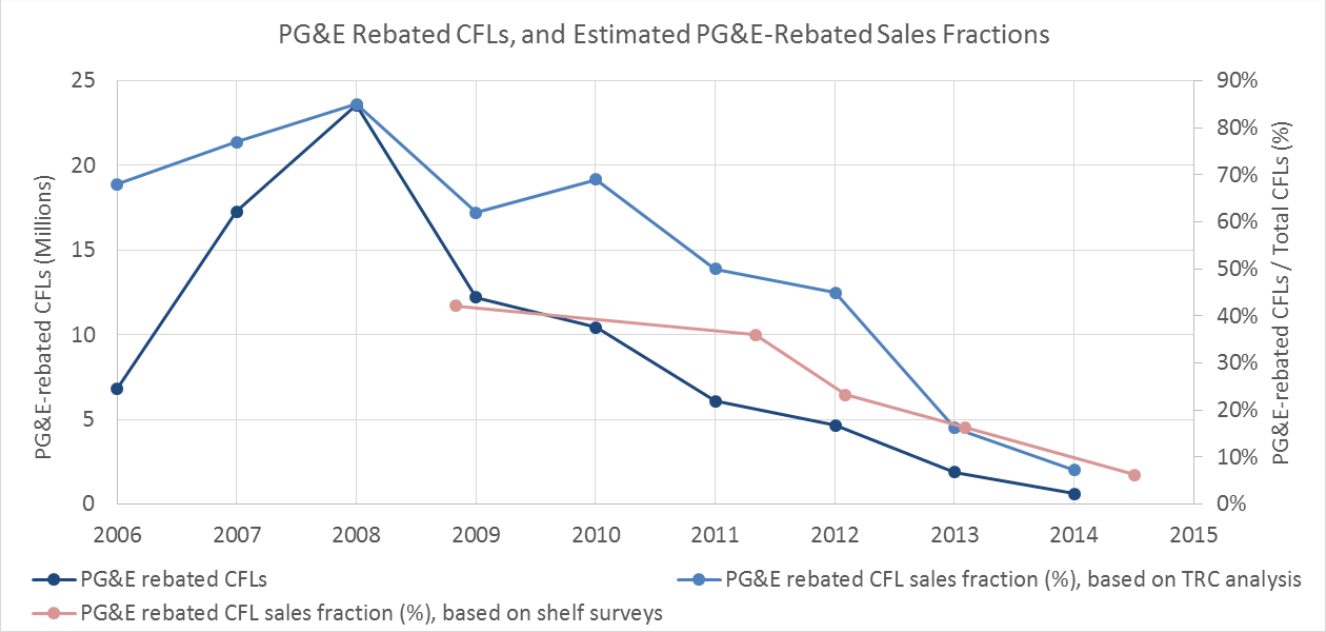



*Figure 18. PG&E-rebated CFL Sales Fraction: Comparison of TRC Estimate with Shelf Survey Results*

As shown in Figure 18, TRC's estimate of the PG&E rebated CFL sales fraction generally follows the same trends as the shelf surveys. In addition, TRC's estimate of the PG&E rebated CFL sales fraction is higher than what was found in the California shelf surveys for 2011 and 2012, and approximately the same for 2013 and 2014.

Figure 19 provides the same comparison for CFL rebates and CFL-rebated fractions aggregated across all IOUs.

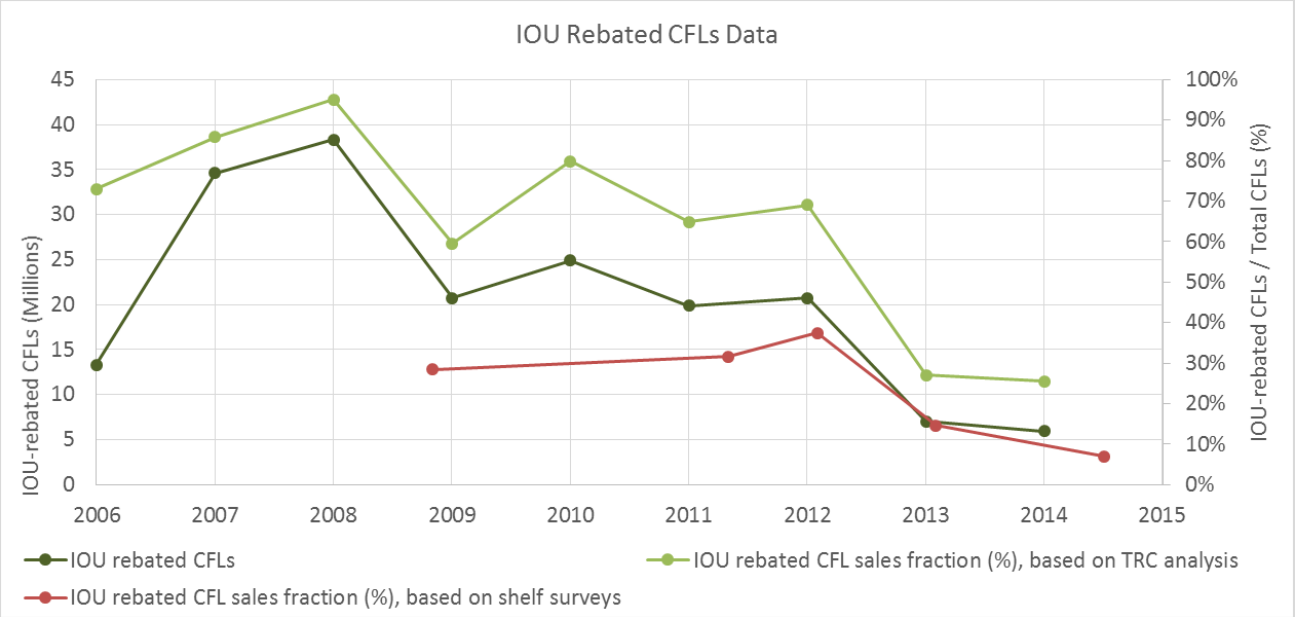



*Figure 19. IOU-rebated CFL Sales Fraction: Comparison of TRC Estimate with Shelf Survey Results*

In general, TRC's estimate of the IOU rebated CFL sales fractions follows trends found in the shelf surveys. **TRC estimated a rebated CFL sales fraction that was generally similar to, or higher than, what was found in the shelf surveys. This indicates that TRC did not underestimate that rebated CFL sales fraction.**

## Estimate of Total LEDs and Rebated LED Sales Fraction

TRC used two different methods to estimate LED sales in California. This section provides a summary of each method. TRC provides more detail on each method in the Appendix, in the section Methods to Estimate Rebated CFL and LED Sales Fractions.

Overall, TRC used the same general approach for LEDs as we did for CFLs, described in the section above, Estimate of Total CFLs and Rebated CFL Sales Fraction. However, because there is much less historical LED sales, shipment, and rebate data compared to CFLs, and because DNV-GL did not provide an LED lamp installation trajectory, TRC did not develop LED estimates analogous to Methods 3 and 4 for CFLs.

In addition, because TRC assumed that all excess lamps were CFLs for 2011 through 2013 (as described in the section, Estimate of Excess CFLs and LEDs), TRC only estimated total LEDs sold and the rebated LED sales fraction for 2014.

### *Method 1: TRC California Lamp Purchase Model*

TRC used the same lamp purchasing model for California described in the Section, Estimate of Total CFLs and Rebated CFL Sales Fraction. In brief, TRC developed a lamp purchasing model for existing homes in California, starting with the total lamps installed by technology in the average California home in the 2012 CLASS survey. TRC then projected this inventory of lamps forward to 2014, based on assumptions regarding lamp EUL, early retirement, and lamps taken from storage, to estimate the total number of lamps that the average Californian home purchased in 2014. Finally, TRC multiplied this total number of lamps by the lamp share fractions by technology found in the California shelf surveys to estimate the number of lamp purchases by type. TRC also developed an estimate of lamps installed in new construction homes, and added those values to the purchases for existing homes. TRC used the same two scenarios described for CFLs, to develop estimates of LED purchases in 2014:

**a.** Assuming no net changes in lamps storage – i.e., assuming that Californians purchased the same total number of lamps that they removed because of burnout or early retirement. **Based on this method, TRC estimated 16 million LEDs sold in California in 2014.**

**b.** Assuming that the average California household's storage decreased by 1 total lamp (0.5 CFL and 0.5 incandescent) in 2013 and again in 2014. Stated differently, TRC assumed that Californians purchased one fewer total lamp than they removed because of burnout or early retirement in 2013, and one fewer lamp in 2014. **Based on this method, TRC estimated 15 million LEDs sold in California in 2014.**

### *Method 2: Extrapolated U.S. LEDs to California*

In general, TRC used a similar methodology to estimate the percent of U.S. LEDs sold in California as described for CFLs in the section, Method 2: Extrapolated U.S. CFLs to California, for 2014 Total CFLs. TRC began by estimating U.S. LED sales in 2014:

- TRC used the estimate of total residential lamp shipments in the U.S. from D&R (2012), of 1,563 million total lamp shipments in 2011. As we did for CFLs, TRC multiplied the 2011 total lamps by the NEMA shipment index for 2014: 0.75. 1,563 million x 0.7 = 1,175 total U.S. lamps in 2014. TRC then multiplied total U.S. lamps in 2014 by the NEMA market shares of LEDs for 2014, which indicated that 9% were LEDs. 1,175 million total lamps x 9% LEDs = 102 million U.S. LEDs.
- TRC used an estimate provided by the U.S. EPA (which was developed by a consultant – Lighting Strategies), that 109 million LEDs were sold in the U.S. in 2014. TRC multiplied this value by 90% to estimate residential LED shipments. 109 million x 90% = 98 million LEDs
- TRC averaged the two estimates (102 million and 98 million) to estimate that 100 million LEDs were sold in the U.S. in 2014.

As we did with LEDs, TRC assumed a percent of these U.S. LEDs that were sold in California using two methods:

a. TRC first assumed that LED purchases followed housing trends, and multiplied U.S. LEDs by the percent of housing units in California (10.8%). 100 million LEDs x 10.8% = 11 million LEDs. This method estimates 11 million CFLs sold in California.

b. As we did for CFLs, TRC developed an alternative method for allocating U.S. sales to California. *(Equation 8):*

CA LEDs / U.S. LEDs = *(CA LEDs / ~~Total CA lamps~~) / (U.S. LEDs / ~~Total U.S. Lamps~~) x (~~Total CA Lamps~~ / ~~Total U.S. Lamps~~)*

TRC first estimated the percent of total U.S. lamps sold in California. TRC used the same values for U.S. lamps sold in California described above for CFLs (see Method 2: Extrapolated U.S. CFLs to California, for 2014 Total CFLs), to estimate that 8% of U.S. lamps were sold in California in 2014. TRC took the percent of California lamp shares that were LEDs in 2014 (13%, based on California shelf survey), divided it by U.S. lamps shares that were LEDs in 2014 (9%, based on NEMA), and multiplied this by U.S. lamps sold in California (13% / 9%) x 8% = 12% of U.S. LEDs were sold in California.

Based on the values found above for Equation 8, CA LEDs / U.S. LEDs = 13% / 9% x 8% = 12%

TRC then multiplied U.S. LEDs (100 million) by Percent of U.S. LEDs sold in California (12%) to estimate that 12 million LEDs were sold in California.

### *Final Estimate of LED Sales for 2014*

In choosing the "best estimate" for each method for LEDs, TRC followed the same assumptions used for the CFL analysis. In other words, TRC used the CFL analysis (which is supported by a longer history and more data) to identify appropriate assumptions, and applied the same assumptions to LEDs. Consequently, TRC:

1. **TRC California Lamp Purchasing model:** Selected 1b, the estimate of 15 million LEDs, based on the assumption that the average California household's lamp storage decreased by one total lamp in 2013, and by one total lamp in 2014.
2. **Extrapolated U.S. CFLs to California:** Selected 2b, the estimate of 12 million LEDs, which reflects adjustments to California purchases relative to the U.S. average.

TRC summarized results of the LED analysis in Figure 20. As shown, TRC estimated that California residential customers purchased 12 to 15 million LEDs in 2014. Based on an average of these estimates, **TRC's best point estimate is that Californian residential customers purchased 13 million LEDs in 2014.** By dividing 13 million LEDs by the number of occupied housing units in California (12.5 million), the implication of this estimate is that the average California household purchased 1.1 LEDs in 2014. By dividing total LEDs (13 million) by total lamps purchased in California (99 million, based on the average from the lamp purchase model in Method 1 and the fraction of U.S. lamps sold in California in Method 2), TRC also estimated that 23% of total lamps purchased in California in 2014 were LEDs.

| Method | Estimate |
|---|---|
| Method 1: TRC Lamp Purchase Model | |
| 1a. Assume no net changes in lamp storage | ~~16 Million LEDs~~ |
| 1b. Assume total lamps in storage decreased by 1 in 2014 | 15 million LEDs |
| Method 2: CA as % of U.S. LED Sales | |
| 2a. Assume CA follows U.S. trends based on number of housing units | ~~11 million LEDs~~ |
| 2a. Adjust U.S. LED sales to CA based on LightTracker trends, and by comparing CA shelf surveys to U.S. NEMA lamp shipments | 12 million LEDs |
| **Final Estimate (Average of Methods) for 2014** | **13 million LEDs** |

*Figure 20. Estimate of Total LEDs Sold in 2014*

### *Apportionment of Total LED Sales to IOU service territories and Rebated LED Sales Fraction*

Similar to the process for CFLs, **TRC apportioned the statewide LEDs to those sold in each electric IOU service territory**. Of the 13 million statewide LEDs sold in 2014, a total of 3 million were rebated by the IOUs and POUs[22] and assumed to be installed in residential buildings. The remaining 10 million were unrebated. Here, we provide the example calculation for allocating LEDs to PG&E service territory. TRC:

1. Apportioned the rebated LEDs according to rebate levels. Because PG&E-rebated 0.9 million LEDs in 2014 (excluding those assumed to be installed in nonresidential buildings), TRC assumed that 0.9 million of the rebated LEDs were sold in PG&E service territory.

[22] Based on Energy Efficiency in California's Public Power Sector, Annual Report 2015, SMUD rebated 0.7 million LEDs in 2014, LADWP did not have a residential lighting program, and the remaining POUs rebated (based on TRC's estimates) approximately 0.2 million LEDs.

2. Apportioned the unrebated LEDs according to housing unit trends. TRC multiplied the 10 million statewide unrebated LEDs by 34% - the percent of California housing units found in PG&E service territory[23], to estimate that 3 million unrebated LEDs were sold in PG&E service territory.
3. Combined the rebated (0.9 million) and unrebated (3 million) LEDs sold in PG&E service territory to estimate that 4 million LEDs were sold in PG&E service territory. These 4 million LEDs represent 33% of the statewide 13 million LEDs.

Note that the percent of LEDs sold in PG&E service territory (33%) is higher than the percent of CFLs sold in PG&E service territory (28%), because PG&E provided 32% of the total IOU and POU LED rebates, but only 9% of total IOU and POU CFL rebates.

As the final step, TRC divided the number of PG&E-rebated residential LEDs (0.9 million) by the estimate of LEDs sold in PG&E service territory (4 million), **to estimate that the PG&E rebated LED sales fraction was 21% in 2014.**

**TRC used the same approach for the other electric IOUs to estimate a rebated LED sales fraction of 20% for SCE and 32% for SDG&E for 2014.** Figure 46 and Figure 47 in the Appendix show the calculations for SCE and SDG&E, respectively.

There was not enough historical data to develop previous estimates of rebated LED sales fractions, similar to TRC's analysis for CFLs in Figure 19. However, for 2014, TRC estimated that the PG&E-rebated LED sales fraction was 21.2%. This is very similar to the PG&E rebated LED sales fraction identified through the shelf surveys – 21.7%. TRC's estimate of the rebated sales fraction for LEDs for SCE (20%) and SDG&E (32%) were higher than what was found in the 2014/2015 shelf survey – 6% for SCE and 8% for SDG&E. **TRC's estimate of IOU-rebated LED sales fractions for 2014 are similar to, or higher than, what was observed in the 2014/15 shelf survey, indicating that we did not underestimate LED rebated sales fractions.**

## Resulting Calculation of Lighting Savings Overlap Estimates

As described in the section, Main Equation and Values Used to Calculate Lighting Savings Overlap, TRC used the following equation (Equation 1) to calculate the lighting savings overlap from CFLs:

*kWh attributable to both programs per hh, CFLs = CFLs installed due to HERs x years CFLs have been installed x (rebated CFLs / total CFLs) x (CFLs attributable to ULP / rebated CFLs) x Installation Rate x Savings/CFL/yr*

TRC used an analogous equation to calculate the lighting savings overlap from LEDs, and combined results for the total lighting savings overlap.

As a summary of inputs, Figure 21 presents key values used to estimate the lighting savings overlap for this evaluation. Note that:

- The equation above and Figure 21 use the terms from the PG&E 2012 HER evaluation, from which this equation was originally taken. For brevity, these terms are described elsewhere in this document as follows:
  - "Lamps installed due to HER" are also known as "Excess lamps"
  - "Rebated CFLs / total CFLs" are also known as "CFL rebates sales fraction". Similarly, "Rebated LEDs / total LEDs" are also known as "LED rebates sales fraction"
  - "CFLs attributable to ULP / rebated CFLs" is also known as the CFL net-to-gross ratio (NTGR). Similarly, "LEDs attributable to ULP / rebated LEDs" is the LED NTGR.

[23] Thirty-four percent reflects the number of residential customers in PG&E service territory in 2013 divided by total housing units in California in 2013 based on U.S. Census data.

- Several parameters are not applicable (N/A) for SCE, because SCE's one treatment wave (Opower 2) has been in treatment for less than one year, beginning in 2014. In addition, SCE does not claim natural gas savings, so there are no therm penalties for SCE.
- As noted in the section, Methodology Summary, TRC and the IOUs came to agreement with the CPUC on lighting savings overlap values using the 2010-12 ULP evaluation values, before the 2013-14 ULP evaluation was published. However, future evaluations should use parameters from the 2013-14 ULP evaluation for calculating the lighting savings overlap from excess lamps installed in 2013 and 2014.

| Parameter | PG&E | SCE | SDG&E | Source |
|---|---|---|---|---|
| Lamps installed due to HER, Yr 1 | 0.95 | 0.95 | 0.95 | Based on 2012 PG&E in-home survey |
| Lamps installed due to HER, Yr 2 | 0.4 | N/A | 0.4 | Interpolated from PG&E and PSE values |
| Lamps installed due to HER, Yr 3 | 0.15 | N/A | 0.15 | Based on 2015 PSE phone survey |
| Lamps installed due to HER, Yr 4 | 0.08 | N/A | 0.08 | Based on 2015 PSE phone survey |
| rebated CFLs / total CFLs, 2011 | 50% | N/A | 57% | TRC estimate |
| kWh/yr, CFLs 2011 | 27 | N/A | 23 | from 2010-12 ULP eval (DNV-GL 2014) |
| rebated CFLs / total CFL, 2012 | 45% | N/A | 68% | TRC estimate |
| kWh/yr, CFLs 2012 | 26 | N/A | 23 | from 2010-12 ULP eval (DNV-GL 2014) |
| rebated CFLs / total CFL, 2013 | 16% | N/A | 40% | TRC estimate |
| kWh/yr, CFLs 2013 | 24 | N/A | 18 | Program tracking data, based on DEER for 2013-14 |
| rebated CFLs / total CFL, 2014 | 7% | 40% | 18% | TRC estimate |
| kWh/yr, CFLs 2014 | 24 | 45 | 18 | Program tracking data, based on DEER for 2013-14 |
| rebated LEDs / total LEDs, 2014 | 21% | 20% | 32% | TRC estimate |
| kWh/yr, LEDs 2014 | 25 | 20 | 22 | Program tracking data, based on DEER for 2013-14 |
| Fraction of excess lamps that are CFLs, 2014 | 0.66 | 0.72 | 0.60 | TRC's estimate of CFLs and LEDs sold in territory |
| Fraction of excess lamps that are LEDs, 2014 | 0.34 | 0.28 | 0.40 | TRC's estimate of CFLs and LEDs sold in territory |
| CFLs attributable to ULP / rebated CFLs (2011-14) | 0.63 | 0.69 | 0.61 | 2010-12 ULP eval (DNV-GL 2014) |
| LEDs attributable to ULP / rebated LEDs (2011-14) | 0.63 | 0.69 | 0.61 | 2010-12 ULP eval (DNV-GL 2014) |
| Installation rate (2011-2014) | 97% | 97% | 97% | 2010-12 ULP eval (DNV-GL 2014) |
| Gas Savings Assumed (Therm/kWh) | -0.019 | N/A | -0.014 | Program tracking data, based on DEER for 2013-14 |

*Figure 21. Calculation Parameters Assumed for Lighting Savings Overlap*

**Below, TRC shows an example of how we estimated the lighting savings overlap for the PG&E Beta wave**.

In addition to the values shown in Figure 21, TRC used the following values that are wave specific, and specific to each year, to calculate the PG&E Beta wave lighting savings overlap:

- Lamps installed due to HER: The PG&E Beta wave began treatment in August 2011. As described in the section, Example Calculations of Excess Lamps for each Treatment Wave, for the PG&E Beta wave, these values are 2011: 0.4 excess CFLs; 2012: 0.7 excess CFLs; 2013: 0.3 excess CFLs; 2014: 0.1 excess CFLs and 0.04 excess LEDs.
- Years CFLs (or LEDs) have been installed: Note that the term refers to the number of years during the evaluation timeframe – i.e., during 2014 – that the excess CFLs had been installed. Thus, for the PG&E Beta wave, this value is 1 year (all of 2014) for the CFLs installed in 2011, 2012, and 2013; and 0.5 year (half of 2014) for the CFLs and LEDs installed during 2014.

TRC calculated the lighting savings overlap for each treatment wave as shown in Equation 9. Note that Equation 9 is the same as Equation 3, but summed across all years of HER treatment.

*(Equation 9)*

*kWh attributable to both programs per hh =*

*$\sum_{2011\text{-}2014}$ {CFLs installed due to HERs x years CFLs have been installed x (rebated CFLs / total CFLs) x (CFLs attributable to ULP / rebated CFLs) x Installation Rate x Savings/CFL/yr*

*+ [LEDs installed due to HERs x years LEDs have been installed x (rebated LEDs / total LEDs) x (LEDs attributable to ULP / rebated LEDs) x Installation Rate x Savings/LED/yr]}*

TRC calculated the lighting savings overlap using Equation 9 for the PG&E Beta wave as follows:

For 2011:

*= 0.4 CFLs x 1 yr x 50% x 0.63 x 97% x 27 kWh/yr/CFL = 3.2 kWh/hh*

For 2012:

*= 0.7 CFLs x 1 yr x 45% x 0.63 x 97% x 26 kWh/yr/CFL = 5.2 kWh/hh*

For 2013:

*= 0.3 CFLs x 1 yr x 16% x 0.63 x 97% x 24 kWh/yr/CFL = 0.7 kWh/hh*

For 2014:

*= 0.1 CFLs x 0.5 yr x 7% x 0.63 x 97% x 24 kWh/yr/CFL + 0.04 LEDs x 0.5 yr x 21% x 0.63 x 97% x 25 kWh/yr/LED*

*= 0.1 kWh/hh*

Summing across 2011 through 2014:

*3.2+5.2+0.7+0.1 = 9.2 kWh/hh*

TRC multiplied the savings overlap per household by the total number of households in the Beta wave.

*Savings Overlap for Beta Treatment Wave = kWh attributable to both programs per hh x No. of Treatment Households = 9.2 kWh/hh x 46,907 households =0.4 GWh*

TRC used the same approach to calculate the lighting savings overlap for each treatment wave for PG&E, and for each treatment for SCE and SDG&E.

Figure 1, Figure 2, and Figure 3 present the lighting savings overlap per HER treatment wave for each IOU, and the total lighting savings overlap for each IOU.

## Lighting Trends

**While the primary purpose of this study was to support the 2014 IOU HER Program Evaluations, TRC identified the following lighting trends based on the results.**

### CFL Sales Have Declined, While Halogen and LED Sales Have Increased

New lighting requirements took effect in California (under Assembly Bill 1109 – AB 1109) and at the federal level (under the Energy Independence and Security Act- EISA), including the ban on manufacturing and importing of traditional 60W incandescent lamps in January 2013 in California and in January 2014 in the U.S. Overall, the results of this analysis indicate that **since the new lighting requirements have taken effect, California consumers have shifted to purchasing more halogens, more LEDs, and fewer CFLs**. This section provides more detail.

Figure 22 shows CFL shipments and sales estimates in California (indicators graphed against the left y-axis, in shades of blue) and in the U.S. (indicators graphed against the right y-axis, in shades of red and orange). As

shown, results indicate that CFL sales have declined in California from 2012 to 2014. Indicators are mixed for the U.S., but U.S. CFL sales appear to have been flat or declined from 2012 to 2014.

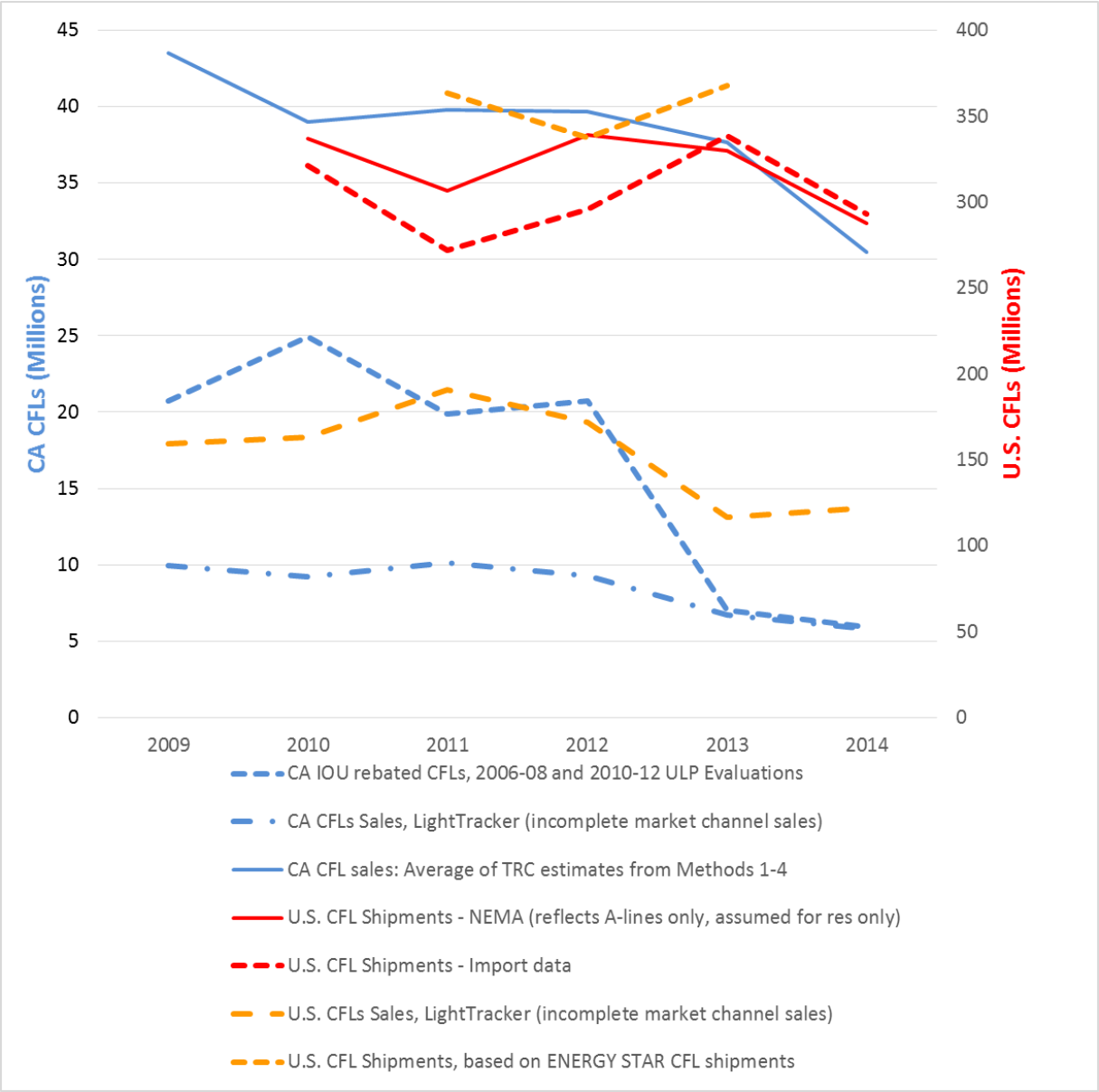



*Figure 22. CA and U.S. CFL Sales, Shipments, and Rebates*

TRC also provides trends for halogen sales and shipments. As shown in Figure 23, halogen sales appear to have increased from 2012 to 2014 in California (indicator graphed against the left y-axis, in blue) and in the U.S. (indicators graphed against the right y-axis, in shades of red and orange).

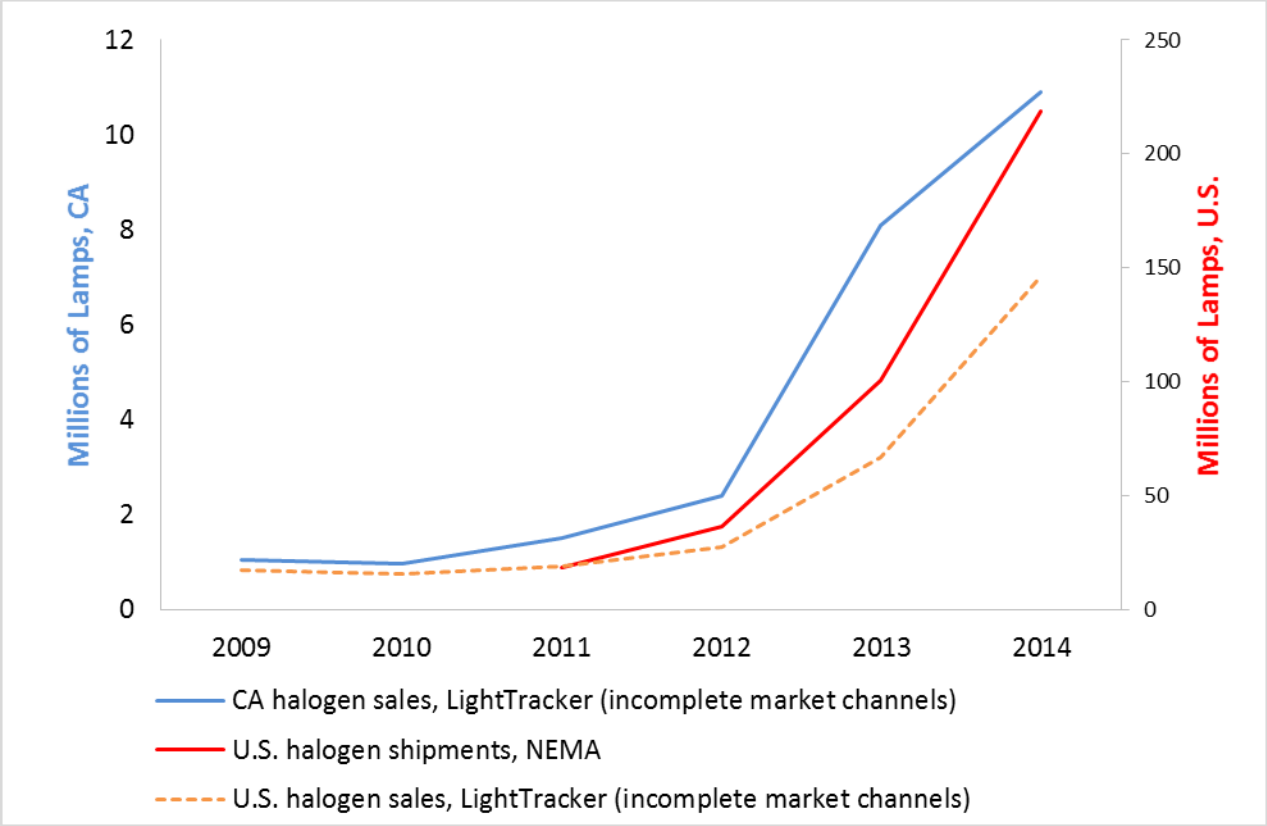



*Figure 23. Indicators of Halogen Sales in the U.S. and California, 2009-2014*

As another comparison, Figure 24 compares:

- Shares, by lamp technology, of lamp shipments in NEMA data. Because NEMA reflects A-line lamps only, TRC adjusted values using the California shelf surveys for other major lamp types (reflectors and globes).
- Shares, by lamp technology, of lamps on shelves in the California shelf surveys. Note that the 2014 California shelf survey is an average of the summer 2013 shelf survey and the winter 2014/15 shelf survey.
- Lamp sales by lamp technology from LightTracker. As described in Figure 5, while LightTracker results are calculated from actual sales data, LightTracker does not include all market channels. In particular, LightTracker does not include home improvement stores and one wholesale club chain, both of which have greater availability of LEDs (based on the California shelf surveys). Consequently, LightTracker results differ from NEMA and shelf survey results, and LightTracker shows a lower percentage of LEDs.

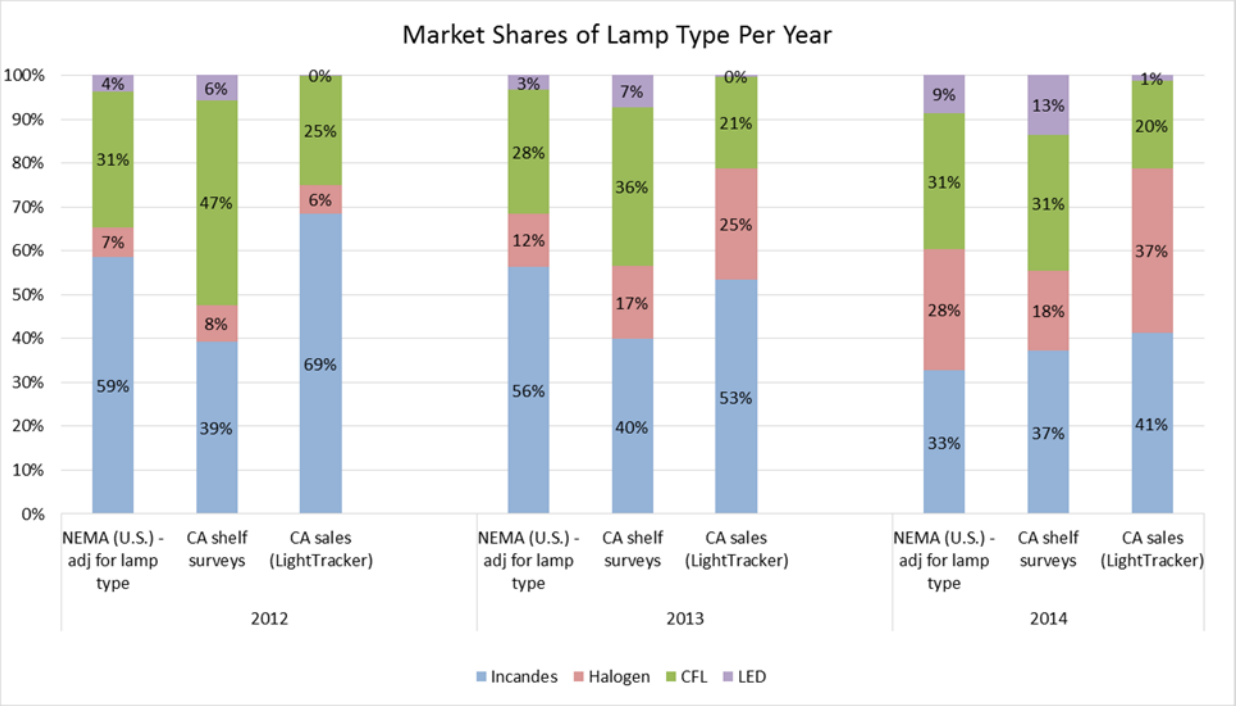



*Figure 24. Comparison of Market Shares for Different Lamp Technologies, 2012-2014, among NEMA, CA Shelf Surveys, and LightTracker*

**As shown in Figure 24, these results indicate that, for California, CFL shares have decreased, while halogen shares have increased.** In the U.S., NEMA data indicate that CFLs have remained steady or slightly declined, while halogen sales have increased.

**Consumers are also purchasing more LEDs in 2014 than 2012.** In particular, the California shelf surveys show that LEDs have increased from 7% in summer 2013 to 20% in winter 2014/2015 (results not graphed). While these results indicate a rapid increase in LED sales, our study indicates that LEDs still comprise a relatively small part of the market. TRC's estimate is that LEDs comprised 13% of residential lighting sales in California in 2014.

**In addition, Figure 24 shows that incandescent lamps continue to be available in California and in the U.S., and purchased by California customers, despite the new lighting requirements**. While it was beyond the scope of this project to fully analyze these incandescent lamp purchases, TRC noted that the incandescent lamps found in the winter 2014/2015 shelf survey included:

- Incandescent lamps not governed by EISA and AB 1109, including lamps that:
  - Fell outside the lumen lighting range of EISA (310-2600 lumens), and/or
  - Were not medium-screw based (MSB), such as candelabra-based lamps.
- Incandescent lamps governed by EISA and AB 1109. The persistence of these lamps on California shelves at the end of 2014 could indicate that these lamps have yet to be sold through; or a lack of adherence to, and enforcement of, the requirements.

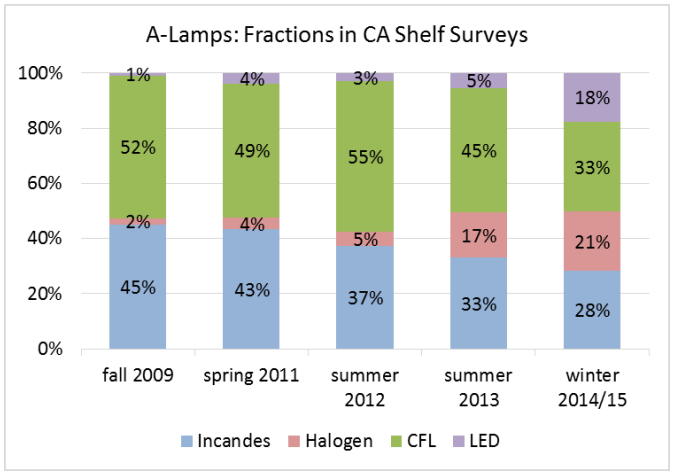
Furthermore, the fraction of high efficacy lamps (CFLs and LEDs) relative to total lamps (incandescent lamps, halogens, CFLs, and LEDs) appears to have declined from 2012 to 2014 in California. In 2012, high efficacy lamps represented 52% of California shelf surveys and 25% of California sales in LightTracker. In 2014, high efficacy lamps represented 45% of California shelf surveys and 21% of California sales in LightTracker.

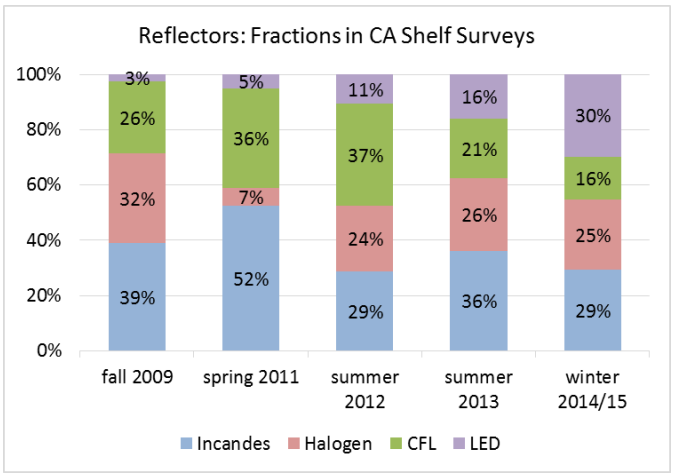
In addition, Figure 50 in the Appendix indicates that the fraction of high efficacy lamps has declined from 2012 to 2014 in market channels that had previously received higher IOU CFL rebates. For example, shelf surveys found

that high efficacy lamps comprised over 50% of lamps on shelves in Discount and Grocery stores in 2012, but only 16% in Discount and 29% in Grocery in 2014. Both of these market channels had received significantly more IOU CFL discounts in 2012 compared to 2014.

**The results indicate the potential to increase rebates for high efficacy lamps, particularly in the next few years before LED prices drop further, to encourage California consumers to purchase a greater percentage of high efficacy lamps.**

The California shelf surveys also show that LED and CFL lamp penetrations and trends differ greatly by lamp type (i.e., A-lamps vs. reflectors vs. globes), as shown in Figure 25 below. It was beyond the scope of this project to analyze technology penetrations based on other lamp characteristics (e.g., base type or lumen range), but there may be other differences in technology penetrations for these characteristics as well.



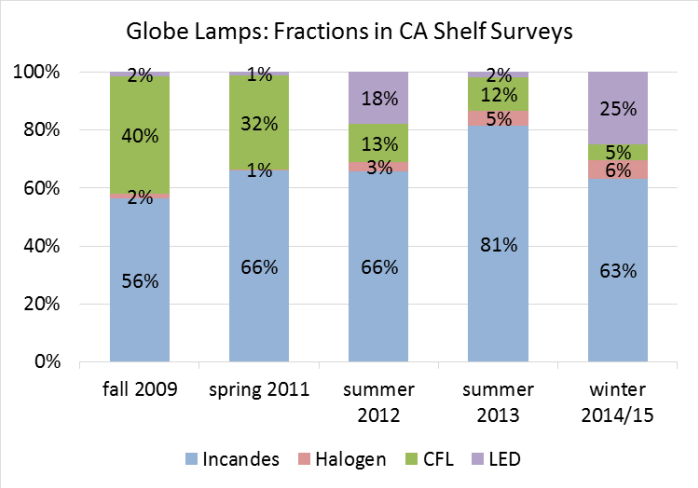



*Figure 25. Lamp Technologies found in California Shelf Surveys, by Lamp Type*

**These results indicate that the IOUs and the CPUC should continue to consider specific lamp types and applications when identifying lamp classes for rebates**.

## More Research Would Provide a More Reliable Estimate

TRC developed an estimate of the lighting savings overlap using the best available information. However, there were numerous limitations for developing our estimate, including a lack of data on the number of excess lamps installed after the 1st year of treatment, the relative fraction of excess lamps that are CFLs versus LEDs, and various data gaps for estimating total CFLs and LEDs sold in California, including a lack of complete lighting sales data (causing TRC to rely on lamp shipments and stocking availability).

**TRC recommends that further research be pursued to provide a more refined estimate of the lighting savings overlap, and of lighting sales and trends in California**. In particular, the CPUC and IOUs should gather more updated information on:

- The number of excess lamps purchased because of HER treatment, including:
  - How the number of excess lamps may vary depending on the overall savings for the HER treatment wave. This evaluation followed the precedent of assuming 0.95 excess lamps for the 1st year of HER treatment. The 0.95 value was based on treatment waves of customers with high electricity use, and high HER savings. HER treatment waves with lower electricity savings may have lower numbers of excess lamps.
  - The number of excess lamps installed after the first year of HER treatment.
  - The interplay between the number of excess CFLs and excess LEDs.
- How California sales compare to U.S. sales, both for total lamps and for lamps of each technology. Such results would enable future researchers to more reliably leverage U.S. lighting data for California.
- How shelf survey fractions and lamp shipments compare to actual sales fractions.

# APPENDIX: SUPPORTING CALCULATIONS AND ASSUMPTIONS

This section provides further descriptions, calculations, and assumptions for:

- Methods for estimating total CFLs and LEDs sold in California in 2014. TRC used these values to estimate the rebated sales fraction for CFLs and LEDs.
- In support of these methods for estimating CFL and LED sales, TRC used the following values or assumptions, and describes these in the subsection, Additional Supporting Assumptions and Calculations:
  - Apportionment of CA Sales to IOU service territories – Detailed Calculation. Once TRC developed estimates of statewide CFL and LED sales, TRC apportioned them to each electric IOU territory.
  - Estimate of California Sales in IOU Territories. TRC used these results in Method 4, to adjust the DNV-GL estimate of CFL sales in the IOU Territories to a statewide estimate.
  - Early retirement assumptions for each lamp type. TRC used these in Method 1 (Lamp Purchase Model) and Method 3 (Historical CFL analysis).
- Market channel analysis, including a discussion of the coverage of this market channel in LightTracker, percent of high efficacy lamps by market channel in California shelf surveys, and levels of IOU rebates (in 2012 and 2014) to these market channels.

Because of the various assumptions used in this analysis, TRC generally provides values rounded to the nearest whole number. Because of rounding, the resulting values are sometimes slightly different from what would be calculated using the numbers shown in the calculation.

## Methods to Estimate Rebated CFL and LED Sales Fractions

Key parameters in the lighting savings overlap calculation were the rebated sales fractions of CFLs and LEDs for each electric IOUs, for years when treatment households were assumed to purchase excess CFLs (2011-2014) and excess LEDs (2014). This section describes TRC's method for calculating these rebated sales fractions.

TRC estimated the sales fraction of rebated CFLs as the number of CFLs rebated by the IOU divided by total number of CFLs sold in the IOU service territory. As an example, for PG&E in 2014:

*Rebated CFL sales fraction = CFLs rebated by PG&E, 2014 / Total CFLs sold in PG&E service territory, 2014*

TRC used the same approach for the sales fraction of rebated LEDs in 2014. Again, as an example for PG&E:

*Rebated LED sales fraction = LEDs rebated by PG&E, 2014 / Total LEDs sold in PG&E service territory, 2014*

For the numerator, TRC obtained the number of:

- CFLs rebated in 2011 and 2012 from the 2010-2012 ULP impact evaluation,
- CFLs rebated in 2013 and 2014 from IOU program tracking data,
- LEDs rebated in 2014 from IOU program tracking data.

To estimate the denominator – total CFLs and LEDs sold in the IOU service territory:

- TRC first estimated statewide CFL and LED sales in multiple ways, and averaged the results of these methods. This section provides a detailed explanation of Methods 1-3, supporting the general description in the main body of this document. For Method 4, TRC only provides a description in the main body of this document, because it was simpler. (Additional calculations were not necessary.)
- Once TRC estimated statewide CFL and LED sales, we apportioned these lamps to each electric IOU service territory, as described in Apportionment of CA Sales to IOU service territories – Detailed Calculation.

When reviewing these calculations, note that **any assumption that leads to a lower number of total CFLs and LEDs** sold in the IOU service territory **leads to a higher rebated sales fraction, which in turn leads to a higher lighting savings overlap penalty**.

## Method 1: TRC Lamp Purchase Model – Supporting Assumptions and Calculations

**TRC developed a simple mathematical model of the number of lamps purchased by California households, based on the average California household's inventory of lamps found in 2012 CLASS**. To project the 2012 CLASS inventory forward to 2014, TRC assumed that Californians purchased lamps in relative proportions based on the percent of each technology found in the California shelf surveys. Specifically, TRC assumed that Californians purchased lamps:

- In 2013 based on percent (by technology) in the summer shelf surveys for 2013,
- In 2014 based on the average of the percent (by technology) in the summer 2013 and winter 2014/2015 shelf surveys. TRC believed that the summer 2013 shelf survey was a better indicator of early 2014 lamp purchases, and that the winter 2014/15 survey was a better indicator of late 2014 lamp purchases.

Although shelf surveys reflect relative proportions of lamp technologies available for purchase, rather than actual purchased lamps, TRC identified the shelf survey data as the best available indicator of lamp purchases in California in 2013 and 2014.

TRC also assumed that California households took an average of 1 lamp per year from storage – i.e., assumed that Californians installed approximately 10 lamps each year in 2013 and 2014, but purchased approximately 9 lamps each of those years.

TRC provides more description of this method and assumptions below.

### *Lamps Removed in 2013*

Figure 23 shows the number of lamps that the 2012 CLASS study found in the average California home, by technology. In developing this figure, TRC removed the following two groups of lamps from the 2012 CLASS inventory:

- Linear fluorescent lamps. TRC removed these lamps from our purchase model, because we assumed that California consumers would primarily replace linear fluorescent lamps with other linear fluorescent lamps given the socket constraints.
- Empty sockets. The 2012 CLASS found approximately 1 empty socket per home. TRC assumed that the number of empty sockets stayed the same in 2014 as it was in 2012, so did not include them in the model.

Figure 23 also shows the Effective Useful Life (EUL) for each technology. TRC assumed EULs as follows:

- Incandescent lamps: TRC developed the EUL for incandescent lamps based on DEER.
- Halogens: DEER did not provide the EUL for halogens, so TRC used its industry knowledge to estimate a rated hours of 3,500 hours and divide this by 1.7 hours of use (the IOU-average from the DNV-GL 2010-2012 Upstream Lighting Impact evaluation).
- CFLs: TRC took the EUL from an SCE - CPUC CFL Lab study[24], which found the average lifetime for a basic spiral CFL is 4,047 hrs. At 1.7 hours of use per day (the IOU-average from the 2010-2012 ULP impact evaluation), the CFL EUL is 4,047 hr / 1.7 hr/day / 365 d/ yr = 6.5 yrs. Note the CFL EUL in DEER is longer, 9

[24] Brett Close, "Survival Analysis of SCE / CPUC CFL Lab Study", March 8, 2015.

years. However, the SCE - CPUC CFL lab study and an ENERGY STAR study[25] support an assumption for a shorter EUL for CFLs than what is assumed in DEER.

- LEDs: For LEDs, TRC assumed the maximum EUL for lamps in DEER – 15 years.

TRC used the EUL to estimate lamps removed due to burn out. In addition, TRC assumed values for early retirement, including lamps removed because of consumer dissatisfaction and breakage. TRC describes the rationale and values for these assumptions in the section Early Retirement Assumptions.

TRC then estimated the number of lamps removed for each technology by 1. Dividing the number of lamps by its EUL, representing lamps that would have burned out, and 2. Adding this to the number of lamps retired early. For example, for CFLs:

*CFLs removed in 2013 = CFLs per home in 2012 / CFL EUL + CFLs per home in 2012 x CFL Early Retirement rate = 13.6 CFLs / 6.5 yrs + 13.6 CFLs x 4%/yr = 2.6 CFLs*

TRC made similar calculations for the other lamp technologies, with results shown in Figure 23.

| | Rated hours | EUL | Early Retirement (%/yr) | Lamps/home in 2012 (2012 CLASS) | Lamps removed in 2013 |
|---|---|---|---|---|---|
| Incandescent | 2,000 | 3.7 | 2% | 22.3 | 6.5 |
| Halogen | 3,500 | 5.6 | 1% | 3.9 | 0.7 |
| CFL | | 6.5 | 4% | 13.6 | 2.6 |
| LED | 20,000 | 15.0 | 1% | 0.5 | 0.0 |
| Total | | | | 40.3 | 9.9 |

*Figure 23 - Lamps Removed in 2013*

As shown in Figure 23, **TRC estimated that the average California household removed a total of 9.9 lamps in 2013.** TRC then projected how Californians would purchase lamps in 2013 for replacing those lamps removed. TRC then repeated the procedure to estimate the number of lamps removed in 2014 and to project how Californians would purchase lamps in 2014 to replace the lamps removed. TRC provides more detail in the subsections below.

### *Lamps Purchased vs. Used from Storage*

The Residential Lighting Market Status report for 2013 (DNV-GL 2014) found that California households had an average of ten lamps in storage, both in the 2009 and the 2012 on-site surveys. In the 2012 on-site survey, these ten lamps in storage were comprised (on average) of 5.6 incandescent lamps, 3.6 CFLs, and 1 other (primarily halogens).

There are many possibilities for the average number of lamps that California consumers took from storage versus purchased, to replace the lamps they removed in 2013 and 2014. For both 2013 and 2014, TRC assumed that California consumers installed 1 total lamp (0.5 CFL and 0.5 incandescent) from storage, and purchased the remaining number of lamps removed. TRC developed this estimate based on LightTracker data, which indicate a significant sales decline in total lamps for California from 2012 to 2013 and again from 2013 to 2014. (This may indicate that California consumers purchased fewer total lamps in response to new lighting requirements.) Thus, TRC assumed that in 2013, the average California household removed 9.9 lamps and purchased 8.9 total lamps.

[25] D&R 2013, "ENERGY STAR CFL Third Party Testing and Verification: Off-the-Shelf CFL performance".

### *Lamps Purchased in 2013*

To estimate lamps purchased in 2013 and 2014, and to project the 2012 CLASS lamp inventory forward to 2014, **TRC began by estimating the number of lamps of each technology that the average California household purchased in 2013.** TRC multiplied total lamps purchased by the fractions by technology found in the California summer 2013 shelf survey. For example, for CFLs, TRC multiplied 8.9 lamps (total lamps purchased in 2013) by 36% (the fraction of lamps that were CFLs in the 2013 shelf survey) to estimate that California households purchased 3.2 CFLs on average in 2013.

*CFLs purchased in 2013 = Total lamps purchased in 2013 x Percent of total lamp that were CFLs in 2013 shelf survey = 8.9 lamps x 36% = 3.2 CFLs*

TRC used a similar method to estimate that California households purchased 0.6 LEDs in 2013.

*LEDs purchased in 2013 = Total lamps purchased in 2013 x Percent of total lamp that were LEDs in 2013 shelf survey = 8.9 lamps x 7% = 0.6 LEDs*

**The next step was to extrapolate the number of lamps purchased per household to the statewide level**. TRC multiplied the number of lamps purchased per household for each technology, by the number of occupied housing units in California (based on U.S. Census data for 2013[26]). For example, for CFLs, TRC estimated that total number purchased by existing homes was:

*Total CFLs purchased for existing homes in CA, 2013 = CFLs purchased per household, 2013 x Number of housing units = 3.2 CFLs / housing unit x 12.5 million housing units = 40 million CFLs.*

TRC made similar calculations for the other technologies. Figure 26 shows the results for the number of purchases made for existing homes. As shown in Figure 26, TRC also calculated the "Lamps/home at end of 2013" for each technology. For example, for CFLs:

*CFLs/home at end of 2013 = CFLs per home in 2012 – CFLs removed in 2013 + CFLs purchased in 2013 + CFLs installed from storage = 13.6-2.6+3.2+0.5 = 14.7*

TRC used Lamps/home at end of 2013 in a later step to project the lamps purchased in 2014.

| | Lamps/home in 2012 (2012 CLASS) | Lamps removed in 2013 | Sales fractions 2013, based on DNV-GL 2013 shelf survey | Lamps purchased in 2013 | Lamps installed from storage | Lamps/ home at end of 2013 | Total lamps purchased for existing Homes, 2013 |
|---|---|---|---|---|---|---|---|
| Incandescent | 22.3 | 6.5 | 40% | 3.5 | 0.5 | 19.9 | 44,107,588 |
| Halogen | 3.9 | 0.7 | 17% | 1.5 | | 4.6 | 18,432,185 |
| CFL | 13.6 | 2.6 | 36% | 3.2 | 0.5 | 14.7 | 40,115,613 |
| LED | 0.5 | 0.0 | 7% | 0.6 | | 1.1 | 7,960,727 |
| Total | 40.3 | 9.9 | | 8.9 | | 40.3 | 110,616,112 |

*Figure 26. Calculation of Total Lamps Purchased in Existing Homes in 2013*

As the next step for calculating lamps purchased in 2013, TRC estimated the number of lamps that would be purchased for new construction homes in 2013. TRC began by estimating the total number of lamps purchased for new construction. As shown in Figure 27, TRC estimated that 3.4 million total lamps were purchased for new construction homes in California in 2013.

[26] http://factfinder.census.gov/faces

| Parameter | Value | Source/ Assumption/ Calculation |
|---|---|---|
| Number of new construction homes, CA | 0.08 Million | California Building Industry Association (CBIA) [27] based on 2013 data |
| Number of lamps per new construction home | 40.8 | CLASS 2012, excluding linear fluorescents |
| Total Lamps purchased in New Construction homes | 3.4 Million | Calculated: Number of lamps per home x Number of New Construction homes = 40.8 x 0.08 million = 3.4 million |

*Figure 27. Calculation of Total Lamps Purchased in New Construction Homes in 2013*

As we did for existing homes, TRC assumed that lamps installed in new construction followed the lamp technology fractions found in the California shelf survey results assumed for 2014. For example, for CFLs, TRC multiplied total lamps for new construction homes (3.4 million) by the fraction of lamps that were CFLs based on shelf surveys (36%), to estimate that 1.2 million CFLs were purchased for new construction homes in 2013. Figure 28 shows results for new construction homes for 2013 for all technologies.

| | Sales fractions 2013, based on DNV-GL 2013 shelf survey | lamps per new constr home for 2013 | Total lamps purchased for new construction, 2013 |
|---|---|---|---|
| Incandescent | 40% | 16 | 1,350,259 |
| Halogen | 17% | 7 | 564,262 |
| CFL | 36% | 15 | 1,228,054 |
| LED | 7% | 3 | 243,701 |
| Total | | 40.8 | 3,386,276 |

*Figure 28. Calculation of Total Lamps Purchased by Technology for New Construction Homes in 2013*

TRC added the lamps for existing homes to the lamps for new construction for a total estimate of lamps purchased per technology. As shown in Figure 29, **TRC estimated that a total of 41 million CFLs were purchased for residential use in California in 2013.**

| | Total lamps purchased for existing Homes, 2013 | Total lamps purchased for new construction, 2013 | Total lamps purchased, 2013 |
|---|---|---|---|
| Incandescent | 44,107,588 | 1,350,259 | 45,457,847 |
| Halogen | 18,432,185 | 564,262 | 18,996,446 |
| CFL | 40,115,613 | 1,228,054 | 41,343,666 |
| LED | 7,960,727 | 243,701 | 8,204,427 |
| Total | 110,616,112 | 3,386,276 | 114,002,387 |

*Figure 29. Total Lamps Purchased in 2013*

[27] CBIA reported 83,000 housing permits for California in 2013: http://www.mychf.org/go/cirb/.http://www.mychf.org/go/cirb/. TRC divided 83,000 by 12.5 million (the number of occupied housing units in California) to estimate that 0.7% of housing units were new construction.

### *Lamps Removed and Purchased in 2014*

Using the same approach as we did for 2013, TRC projected the lamp purchased model forward to 2014. TRC began by estimating total lamps removed by technology, using the same method described for 2013 in the section above, Lamps Removed in 2013. In summary, TRC estimated lamps removed in 2014 based on the 2013 lamp inventory, the EUL for each technology, and assuming a small level of early retirement. For example, for CFLs, TRC calculated:

*CFLs removed in 2014 = CFLs installed at end of 2013 / CFL EUL + CFLs installed at end of 2013 x CFL Early Retirement = 14.7 CFLs / 6.5 yrs + 14.7 CFLs x 4%/yr = 2.8 CFLs.*

Using this approach for all technologies, TRC estimated that the average California household removed 5.8 incandescent lamps, 0.9 halogens, 2.8 CFLs, and 0.1 LEDs in 2014. **In total, TRC estimated the average California household removed 9.6 total lamps in 2014.**

To estimate lamps purchased in 2014, TRC made the same assumption as for 2013 – that Californians took one lamp from storage, and purchased lamps to replace the remaining lamps removed. Thus, **TRC assumed that the average California household removed 9.6 lamps but purchased 8.6 lamps in 2014.**

TRC then estimated the number of lamps purchased by technology by multiplying total lamps purchased by the percent of lamps by technology (i.e., % incandescent, % halogen, % CFL, % LED) found in the California shelf surveys. TRC "assumed" 2014 shelf survey results by averaging the results of the summer 2013 shelf survey with the winter 2014/ 2015 shelf survey. (As described above, TRC believes that the summer 2013 shelf survey is more representative of early 2014, and the winter 2014/ 2015 shelf survey – conducted Nov. 2014 through Jan. 2015 - is more representative of late 2014.) For example, for CFLs, TRC multiplied 8.6 total lamps by 31% (the percent of lamps assumed for CFLs in 2014) to estimate that California households purchased 2.7 CFLs on average in 2014.

*CFLs purchased in 2014 = Total lamps purchased in 2014 x Percent of total lamp that were CFLs in "assumed" 2014 shelf survey = 8.6 lamps x 31% = 2.7 CFLs*

TRC used a similar method for the other technologies to estimate that California households purchased 3.2 incandescent lamps, 1.6 halogens, 2.7 CFLs, and 1.2 LEDs in 2014.

### *Extrapolating CFL Purchases per Household to the Statewide Level*

As we did with 2013, TRC then extrapolated the number of lamps purchased per household to the statewide level. TRC multiplied the number of lamps purchased per household for each technology, by the number of occupied housing units in California. Because 2014 census data was not available at the time of this white paper, TRC assumed the number of housing units for 2013: 12.5 million.

For example, for CFLs, TRC estimated that total number purchased by existing homes in 2014 was:

*Total CFLs purchased for existing homes in CA, 2013 = CFLs purchased per household, 2013 x Number of housing units = 2.7 CFLs / housing unit x 12.5 million housing units = 33 million CFLs.*

TRC made similar calculations for the other technologies. Figure 30 shows the total number of lamps purchased of each technology for existing homes in 2014, as well as several intermediary calculations and assumptions.

| | EUL | Early Retirement Rate | Lamps/ home at end of 2013 | Lamps removed in 2014 | Sales fractions 2014: Ave of 2013 and 2014/15 shelf surveys | Lamps purchased in 2014 | Lamps installed from storage | Total lamps purchased for existing Homes, 2014 |
|---|---|---|---|---|---|---|---|---|
| Incandescent | 3.7 | 2% | 19.9 | 5.8 | 37% | 3.2 | 0.5 | 39,710,464 |
| Halogen | 5.6 | 1% | 4.6 | 0.9 | 18% | 1.6 | | 19,392,826 |
| CFL | 6.5 | 4% | 14.7 | 2.8 | 31% | 2.7 | 0.5 | 33,260,443 |
| LED | 15.0 | 1% | 1.1 | 0.1 | 13% | 1.2 | | 14,391,377 |
| Total | | | 40.3 | 9.6 | | 8.6 | | 106,755,111 |

*Figure 30. Lamp Purchase Model: Calculation of Total Lamps Purchased in Existing Homes in 2014*

Next, TRC estimated the number of lamps that would be purchased for new construction homes. Because building permit information was not available for all of 2014 at the time of analysis, TRC assumed the same number of permits for 2014 as we did for 2013 - 0.08 million. As shown in Figure 28, this indicates a total of 3.4 million lamps purchased for new construction homes in 2014 (the same number estimated for 2013).

As was done for existing homes, TRC assumed that lamps installed in new construction followed the lamp technology fractions found in the California shelf survey results assumed for 2014. For example, for CFLs, TRC multiplied total lamps for new construction homes (3.4 million) by the fraction of lamps that were CFLs based on shelf surveys (31% - the average of summer 2013 and winter 2014/15 shelf survey results for CFLs), to estimate that 1.1 million CFLs were purchased for new construction homes. Using a similar approach, TRC estimated 0.5 million LEDs sold for new construction homes in 2014. Figure 31 shows new construction results for 2014.

| | Sales fractions 2014: Ave of 2013 and 2014/15 shelf surveys | Lamps per new constr home for 2014 | Total lamps purchased for new construction, 2014 |
|---|---|---|---|
| Incandescent | 37% | 15 | 1,259,617 |
| Halogen | 18% | 7 | 615,141 |
| CFL | 31% | 13 | 1,055,022 |
| LED | 13% | 5 | 456,495 |
| Total | | 40.8 | 3,386,276 |

*Figure 31. Lamp Purchasing Model: Lamps Purchased for New Construction Homes in 2014*

TRC added the lamps for existing homes to the lamps for new construction for a total estimate of lamps purchased per technology**. As shown in Figure 32, TRC estimated that a total of 34 million CFLs, 15 million LEDs, and 110 million total lamps were purchased in California in 2014.**

| | Total lamps purchased for existing Homes, 2014 | Total lamps purchased for new construction, 2014 | Total lamps purchased in CA, 2014 |
|---|---|---|---|
| Incandescent | 39,710,464 | 1,259,617 | 40,970,081 |
| Halogen | 19,392,826 | 615,141 | 20,007,967 |
| CFL | 33,260,443 | 1,055,022 | 34,315,466 |
| LED | 14,391,377 | 456,495 | 14,847,872 |
| Total | 106,755,111 | 3,386,276 | 110,141,427 |

*Figure 32. Lamp Purchasing Model: Total Lamps Purchased in 2014*

### *Rejected Scenarios*

TRC also used different assumptions for the lamp purchase model to project the 2012 CLASS lamp inventory to 2014. For example, TRC assumed that Californians purchased as many lamps as they installed –i.e., assumed no net changes in lamp storage. However, LightTracker data indicates that total lamps purchased in California dropped significantly from 2012 to 2013, possibly because of the introduction of AB 1109 lighting requirements. In addition, the resulting CFL purchases under the "no changes in storage" scenario were too high compared with data for previous CFL purchases in CA based on 2005 and 2012 CLASS. Consequently, TRC rejected the "0 lamps from storage" scenario. In the description in the body of this document, Method 1: TRC California Lamp Purchasing model, this scenario is shown as Method 1a.

TRC had also considered a model in which California consumers purchased lamps according to national trends – i.e., based on fractions of lamp shipments by technology, based on NEMA data. However, the result of this method was 42 million CFLs purchased in California in 2014. TRC believed this value was too high based on historical CFL data for California, and rejected this scenario.

Note that both of these rejected methods would have produced a higher estimate of total CFLs sold, resulting in a lower rebated CFL sales fraction and a lower lighting savings overlap.

## Method 2: Extrapolation of U.S. CFL and LED Sales to CA – Supporting Assumptions and Calculations

In this method, TRC first estimated total CFLs sold in the U.S. (by averaging U.S. CFLs from different sources), and then estimated the percent of those U.S. CFLs sold in California in 2014. TRC used a similar approach for estimating LEDs sold in California in 2014. This section describes this method. Note that TRC used Method 2 to estimate sales for 2014 only.

Data sources indicating total U.S. CFL and LED sales include:

1. NEMA data
2. The D&R Residential Lighting Market Profile (2012)
3. CFL import data from the U.S. Department of Commerce
4. U.S. Environmental Protection Agency EPA) estimates for its ENERGY STAR program

### *U.S. Estimate Source 1: NEMA Data*

On its website, the National Electrical Manufacturers Association (NEMA) provides the following, for Q1 2011 through Q3 2014 for A-line lamps[28]:

- Shipment indices for each technology, referenced to 2011 shipments
- Percent of total shipments for each technology (i.e., % incandescent, % halogen, % CFLs, % LEDs)

TRC used these values to estimate lamp shipments for 2014, and assumed that sales coincided with shipments. TRC provides more explanation of this method in the following subsections.

*Assumption of Q4 2014 NEMA values*

Because Q4 2014 values were not available from NEMA at the time of the original analysis, TRC estimated the percent of lamp technologies for Q4 2014 by projecting the trends from previous years and from the first three quarters of 2014. For LEDs, TRC averaged the increase in LED share (%) from Q1 to Q2, and from Q2 to Q3. To

[28] http://www.nema.org/news/Pages/Compact-Fluorescent-Lamp-Shipments-Continue-to-Lag.aspxhttp://www.nema.org/news/Pages/Compact-Fluorescent-Lamp-Shipments-Continue-to-Lag.aspx This website presents figures with these numbers. TRC obtained the numerical values shown in these figures from NEMA.

project market shares for the other technologies, TRC drew smooth projection curves based on Q1 through Q3 2014 market share trends, and ensured that the total market shares summed to 100%. TRC provides our projected market shares for Q4 2014 in Figure 33 below, along with the market shares for Q1-Q3 of 2014 from NEMA.

| Year/Quarter | A-Line LED Share % | A-Line Halogen Share % | A-line Incandescent Share % | A-line CFL Share % | Total (%) |
|---|---|---|---|---|---|
| 2014Q1 | 1.4% | 15.8% | 57.4% | 25.4% | 100.0% |
| 2014Q2 | 3.0% | 26.4% | 33.5% | 37.1% | 100.0% |
| 2014Q3 | 5.1% | 39.9% | 13.6% | 41.4% | 100.0% |
| 2014Q4 extrapolated | 9.7% | 41.8% | 5.5% | 43.0% | 100.0% |
| 2014 average | 4.8% | 31.0% | 27.5% | 36.7% | 100.0% |

*Figure 33. Percent of Shipments by Technology for Q1-Q3 2014 (NEMA) and Projected Values for Q4 2014*

*Adjustments to NEMA Data to Reflect All Lamp Type*

The NEMA shipments represent A-line lamp shipments for the U.S. Because CFLs are primarily used for A-line applications, CFLs have a higher market share of A-lines than of other lamp types (e.g., reflectors and globes). In addition, because LEDs are inherently directional, there is likely a higher market share for LEDs in reflectors than for A-line type lamps. This theory is supported by results of the California shelf surveys, which indicate higher market penetrations for CFLs for A-lines (relative to reflectors and globes), and higher penetrations of LEDs for reflectors and globes (relative to A-line), as shown in Figure 25. Consequently**, if TRC had assumed that all lamp types followed NEMA sales (i.e., that all lamp types followed A-line only trends), we would have overestimated total CFLs and underestimated total LEDs sold.**

Because NEMA does not provide similar data for other residential lamp types (e.g., reflectors and globes), **TRC adjusted the NEMA A-line values using data from the 2012 CLASS and the California shelf surveys.** Figure 34 shows an example calculation for adjusting NEMA 2014 incandescent shares to reflect all lamp types. As shown, incandescent lamps comprised 28% of A-line shipments (i.e., based on shipments tracked by NEMA) in 2014, and TRC estimated that incandescent lamps comprised 33% of total lamp types in 2014. The increase was primarily because California shelf surveys found that incandescent lamps comprised almost three-quarters (72%) of globe lamps on shelves in 2014.

| Parameter | Value | Source / Assumption / Calculation |
|---|---|---|
| U.S. Incandescent market share of A-lines, 2014 (%) | 28% | NEMA shipments |
| Fraction of California sales that are A-lines | 74% | From CLASS 2012, as reported in the 2013 Residential Lighting Market Status report, tables 29-31. Note this value is very similar to the percent of A-lines in the 2013 California shelf survey: 71%. |
| Fraction of California sales that are reflectors | 16% | From CLASS 2012, as reported in the 2013 Residential Lighting Market Status report, tables 29-31. This value is similar to the percent of reflectors in the 2013 California shelf survey: 21%. |
| Fraction of California sales that are globes | 10% | From CLASS 2012, as reported in the 2013 Residential Lighting Market Status report, tables 29-31. This value is similar to the percent of globes in the 2013 California shelf survey: 8%. |
| Incandescent market share of reflectors, 2014 (%) | 33% | Assumed the fraction of incandescent lamps found for reflectors in the shelf surveys. Since shelf surveys were conducted in summer 2013 and winter 2014/2015, TRC assumed values for a 2014 shelf survey by averaging values in the summer 2013 and winter 2014/2015 surveys. Incandescent |

| Parameter | Value | Source / Assumption / Calculation |
|---|---|---|
| | | lamps represented 36% of reflectors in the summer 2013 survey and 29% of reflectors in the winter 2014/15 survey. Average (36%, 29%) = 33%. |
| Incandescent market share of globe lamps, 2014 (%) | 72% | Similar to the calculation above for reflectors, TRC averaged the percent of globe lamps that were incandescent lamps in the summer 2013 survey (81%) with the percent of globe lamps that were incandescents in the winter 2014/2015 survey (63%). Average (81%, 63%) = 72%. |
| U.S. Incandescent market share, 2014, adjusted by lamp type (%) | 33% | Calculated: (U.S. incandescent market share of A-lines x Fraction of California sales that are A-lines) + (Incandescent market share of reflectors x Fraction of California sales that are reflectors) + (Incandescent market share of globe lamps x Fraction of California sales that are globes) = 28% x 74% + 33% x 16% + 72% x 10% = 33%. |

*Figure 34. Calculation to Adjust NEMA Shares to Represent All Lamp Types*

TRC made similar calculations to adjust NEMA market shares in 2014 for the other lamp types. TRC also made similar adjustments to NEMA market shares for 2011 through 2013. For the 2011, 2012, and 2013 calculations, TRC assumed that market shares of reflectors and globes for each technology followed the fall 2011, summer 2012, and summer 2013 shelf survey trends, respectively. In other words, TRC only assumed an average value for shelf surveys for 2014.

Based on this method, TRC developed the following values for NEMA market shares, adjusted by lamp types**. As shown in Figure 35, LED shares generally increased and CFL shares generally decreased because of the lamp type adjustments.**

| Year | A-line only Shares (Source: NEMA) | | | | Shares Adjusted for all Lamp Types | | | |
|---|---|---|---|---|---|---|---|---|
| | A-line LED Share (%) | A-line Halogen Share (%) | A-line Incandescent Share (%) | A-line CFL Share (%) | LED Share (%), Adj. by Type | Halogen Share (%), Adj. by Type | Incandescent Share (%), Adj. by Type | CFL Share (%), Adj. by Type |
| 2011 | 0.1% | 2% | 72% | 27% | 1% | 2% | 68% | 29% |
| 2012 | 0.3% | 3% | 64% | 32% | 4% | 7% | 59% | 31% |
| 2013 | 0.7% | 10% | 58% | 32% | 3% | 12% | 56% | 28% |
| 2014 | 4.8% | 31% | 28% | 37% | 9% | 28% | 33% | 31% |

*Figure 35. NEMA Shares, Adjusted for All Lamp Types*

*Assumption of Total Lamp Shipments*

NEMA does not provide value of actual lamp shipments. TRC estimated these values by assuming a total number of lamp shipments for 2011 from D&R (2012), and combining the shipment indices and market shares. TRC provides more detail on this approach below.

The D&R Residential Lighting Market Profile (2012) provides a figure with an estimate of total lamp shipments in the U.S. from 2006-2011 that were ultimately used by residential customers.[29] Based on that figure, TRC estimated that 1,563 million lamps were shipped in the U.S. in 2011.

TRC then multiplied this total number of lamps (1,563 million) by the NEMA market shares for each technology for 2011 adjusted by lamp type, to estimate shipments for each technology in 2011. For example, for LEDs:

[29] See Figure 3 in D&R (2012). While this figure is quantitative, it does not label the number associated with each column. TRC read the values off of this figure as follows: This figure shows a slow, steady decline of lamp shipments from 2006 to 2011, and shows approximately 1,750 million lamps in 2006 and 1,600 million lamps in 2010 – a drop of (1750-1600)/4 yrs = 37.5 million lamps each year. Thus, TRC assumed that lamp shipments for 2011 were 1,600 - 37.5 =1,563 million lamps.

*2011 LED market share adj. by lamp type x 2011 total lamp shipments = 1% x 1,563 million = 16 million LEDs shipped in 2011*

TRC made similar calculations for the other lamp technologies, as shown in Figure 36.

| Technology | 2011 Shipment Share (NEMA), adj. for lamp type | Total Lamp Shipments in 2011 (Millions) |
|---|---|---|
| Total Lamps (D&R, 2011) | | 1,563 |
| LED | 1% | 16 |
| Halogen | 2% | 36 |
| Incandescent | 68% | 1,061 |
| CFL | 29% | 449 |

*Figure 36. Shipments by Technology for 2011, based on NEMA Shipment Shares (Adjusted for Lamp Type) and D&R (2012) Total Lamp Shipments*

TRC then used the NEMA shipment indices for subsequent years (2012-2014), which are benchmarked to 2011 shipments, to estimate lamp shipments for 2012-2014. For example, for LEDs for 2014, TRC multiplied the number of LEDs shipped in 2011 (16 million LEDs, see Figure 36 above) by the index value for LEDs for 2014 from NEMA (2,015) to estimate that 102 million LEDs were shipped in 2014:

*LED shipments in 2014 = LEDs shipments 2011 x 2014 LED index value relative to 2011 (NEMA) = 16 million LEDs x 2,015 = 102 million LEDs shipments in 2014*

TRC made similar calculations for the other lamp technologies and other years. Figure 37 shows results. Note that the index value for 2011 is 100, because all shipments are relative to 2011 (i.e., 2011 is benchmarked against itself).

| Year | Parameter - Lamps in Millions (Source) | LED | Halogen | Incandes-cent | CFL | Total (source of total) |
|---|---|---|---|---|---|---|
| 2011 | Index value (NEMA) | 100 | 100 | 100 | 100 | |
| 2012 | Index value (NEMA) | 273 | 199 | 83 | 111 | |
| 2013 | Index value (NEMA) | 582 | 543 | 72 | 108 | |
| 2014 | Index value (NEMA) | 2,015 | 1,178 | 40 | 94 | |
| 2011 | Lamps (From Figure 36) | 16 | 36 | 1,061 | 449 | 1,563 (from D&R 2012) |
| 2012 | Lamps (2012 Index Value x 2011 Lamps) | 54 | 98 | 846 | 445 | 1,444 (sum of columns to the left) |
| 2013 | Lamps (2013 Index Value x 2011 Lamps) | 47 | 168 | 791 | 396 | 1,401 (sum of columns to the left) |
| 2014 | Lamps (2014 Index Value x 2011 Lamps) | 102 | 325 | 284 | 363 | 1,175 (sum of columns to the left) |

*Figure 37. Shipments by Technology for 2012-2014, Based on NEMA Shipment Indices*

As shown in Figure 37, **using this method, TRC estimated that 363 million CFLs and 102 million LEDs were shipped to the U.S. in 2014.**

### *U.S. Estimate Source 2: CFL Import Data*

The U.S. Department of Commerce and International Trades Commission Import Data maintains a website that tracks goods shipped into the U.S.[30] This website includes a category for "DISCHARGE LAMPS, OTHER THAN ULTRAVIOLET, FLUORESCENT, HOT CATHODE, WITH A SINGLE SCREW-IN BASE", under the Harmonized Tariff Schedule (HTS) number 8539310060.

TRC multiplied the total number of CFLs imported into the U.S. by 90% to estimate the number of lamps purchased by residential customers. The 2010-2012 ULP impact evaluation[31] assumed that 7% of CFLs were installed in nonresidential buildings for PG&E and at the statewide level for ULP CFLs. However, TRC assumed that 10% of all imported CFLs were installed in nonresidential buildings, because some nonresidential customers may purchase some CFLs in bulk, outside of the ULP-rebated retail channels.

Figure 38 shows the total number of CFLs shipped to the U.S. for 2010 through 2014, and the number that TRC assumed were installed in residential buildings.

| Parameter | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|
| Total CFLs shipped to U.S. (Millions) | 357 | 302 | 329 | 376 | 326 |
| Assumed sold for Res buildings (%) | 90% | 90% | 90% | 90% | 90% |
| CFLs sold for Residential buildings (Millions) | 321 | 272 | 296 | 338 | 293 |

*Figure 38. CFLs Shipped to U.S. from Import Data*

**Based on this approach, residential U.S. CFL shipments were 293 million in 2014.**

The import data does not include a category for LED lamps. The import data has a category for "Light-emitting diodes (LED's)", but this category is within the semiconductor category and shows sales of over 7 billion LEDs in 2014. Because this value is greater than the total number of lamps purchased annually by U.S. residential customers, TRC assumed that this category does not refer to LED lamps, or that it includes other LED products besides lamps. Thus, TRC did not estimate U.S. LED sales from U.S. Department of Commerce import data.

### *U.S. Estimated Source 3: EPA Estimates for the ENERGY STAR program*

The U.S. EPA has published estimates of ENERGY STAR labeled lamp shipments and ENERGY STAR lamp market penetration (i.e., fractions of CFLs and LEDs that are ENERGY STAR) for 2011-2013[32]. TRC spoke with EPA staff to gather information on how the EPA develops these estimates, and how these values would change for 2014. Through this discussion, the EPA provided an estimate of 109 million total LEDs (75 million A-lines and 34 million reflectors) sold in the market in 2014, based on values provided by a contractor, Lighting Strategies. As described above for the CFL import data method, TRC assumed that 90% of these LEDs were shipped for residential buildings. Based on this method, TRC estimated 98 million residential LED shipments in the U.S. in 2014.

Note that the U.S. EPA had not developed an estimate of total CFL sales for 2014. However, TRC developed estimates of total CFL sales in 2011-2013 based on the ENERGY STAR shipment and market penetration data for 2011-2013 CFLs. TRC's estimates of total U.S. CFL shipments for 2011-2013 based on ENERGY STAR data agreed well with TRC's estimates of total U.S. CFL shipments for 2011-2013 based on NEMA data and CFL import data, as shown in Figure 11 in the main body of this document.

[30] http://dataweb.usitc.gov/

[31] DNV-GL 2014. California Upstream and Residential Impact Evaluation. Table 11 shows the nonresidential purchases as 7% for PG&E, 6% for SCE, 6% for SDG&E, and 7% overall.

[32] The U.S. EPA provides ENERGY STAR lamp shipment estimates at www.energystar.gov/USDwww.energystar.gov/USD.

### *Average U.S. CFL and LED Shipments*

TRC averaged the number of CFLs and LEDs from the different methods to develop an estimate of U.S. CFL and LED shipments in 2014:

*U.S. CFL shipments = Average (NEMA estimate, CFL import estimate) = Average (363, 293) = 331 million CFLs*

*U.S. LED shipments = Average (NEMA estimate, U.S. EPA estimate) = Average (102, 98) = 100 million LEDs*

### *Apportionment of U.S. CFL and LED Shipments to California*

To apportion the number of U.S. CFLs sold in California in 2014, TRC first assumed that number of U.S. shipments corresponded to the number of sales. In actuality, there is likely a lag time between when lamps shipped and when residential customers purchased them. However, developing an assumption for this lag time would add greater complexity to the analysis, and TRC did not have a reliable method for estimating a value for this lag time.

TRC then multiplied total U.S. CFL shipments by the percent of U.S. CFLs that were purchased in California. TRC used two different assumptions, as described below.

*Method 2a. Assuming National Trends*

TRC assumed that California residential customers purchased CFLs and LEDs at levels proportional to their number of occupied housing units. Based on U.S. Census data for 2013, there were 12.5 million occupied California housing units and 115.6 million occupied U.S. housing units. Thus, California had 10.8% of total U.S. housing units.

Under this assumption, TRC estimated:

*Total CFLs shipped in U.S. x Occupied U.S. housing units in CA (%) = 328 million x 10.8% = 36 million CFLs in CA*

*Total LEDs shipped in U.S. x Occupied U.S. housing units in CA (%) = 100 million x 10.8% = 11 million LEDs in CA*

*Method 2b. Adjusting U.S. Purchasing Trends for CA*

Various data indicate that California consumers purchase lamp technologies in different proportions, and in different quantities, than the U.S. average. Consequently, TRC developed a second method to estimate the percent of U.S. CFLs and LEDs sold in California.

**Total Lamps Sold in CA / Total Lamps Sold in U.S.:**

TRC first estimated the percent of total U.S. lamps sold in California. To develop this estimate, TRC averaged the result from three methods, as described below.

Method i. LightTracker Sales Data: LightTracker provides total lamps purchased in California and the U.S. First, TRC removed the "Other" lamp category from the California and U.S. data, because that primarily represents linear fluorescents. The remaining "total" lamps consisted of incandescents, halogens, CFLs, and LEDs. TRC took the total number of lamps sold in California in 2014 and divided it by the total lamps sold in the U.S. in 2014:

*Total lamps sold in CA / Total lamps sold in U.S. (%), Method i = Total lamps sold in CA from LightTracker / Total lamps sold in U.S. from LightTracker = 29 million / 654 million = 4.5%*

Method ii. Total lamps purchased in California from the lamp purchasing model divided by total U.S. lamps based on NEMA and D&R (2011): TRC took the total lamps purchased in California that we estimated using the lamp purchasing model. As shown in Figure 32 (in the calculations for Method 1), TRC estimated that California purchased 110 million lamps in 2014. TRC divided total CA lamps (110 million) by the number of total U.S. lamps based on the D&R (2012) estimate of total lamps purchased in 2011 (1,563 million) adjusted to 2014 using the NEMA shipment indices (which indicated that 2014 U.S. shipments were 75% of 2011 values):

*Total lamps sold in CA / Total lamps sold in U.S. (%), Method ii = Total lamps sold in CA from Lamp Purchase Model / (Total lamps shipped in U.S. in 2011 x 2014 U.S. shipments relative to 2011 U.S. Shipments [%]) =*

*110 million / (1563 million x 75%) = 9.4%*

Method iii. Total lamps purchased in California based on historical CFL purchases, divided by market share fractions of CFLs in the shelf surveys, divided by total U.S. lamps based on NEMA and D&R (2011): TRC developed an estimate of total lamp purchases in California, by taking its estimate of CFL purchases for 2014 under the Historical CFL analysis under Method 2 (32.2 million) and dividing it by the fraction of total lamps that were CFLs based on the California shelf surveys (31% - found by averaging the percentages of CFLs in the summer 2013 and winter 2014/ 2015 surveys). Based on this method, TRC estimated a total of 103 million lamps sold in California in 2014. Similar to method ii, TRC then divided this value by the total U.S. lamps based on the D&R estimate for 2011 and the NEMA shipment indices for 2014 compared to 2011:

*Total lamps sold in CA / Total lamps sold in U.S. (%), Method iii = (CFLs sold in CA / CFL market share fraction) / (Total lamps shipped in U.S. in 2011 x 2014 U.S. shipments relative to 2011 U.S. Shipments [%]) = (32.2 million / 31%)/ (1563 million x 75%) = 103 million / 1,175 million = 8.8%*

As shown in the calculations above, all three methods indicate that Californians purchase lamps at a lower level (relative to the number of occupied housing units) than U.S. consumers. This agrees with logic, because:

- California has had a higher penetration of CFLs relative to the U.S. In its 2010 CFL Market Profile, D&R (2010) found that California had the highest penetration of CFLs of all states considered – California's median socket saturation was approximately 28%, while U.S. average was 22.5%.[33] Because CFLs have a higher EUL than incandescent lamps, Californians would have purchased fewer replacement lamps than the U.S. average.
- California appears to have lower Hours of Use (HOU) than at least some other states. Metering conducted for the 2006-2008 ULP Impact Evaluation found that HOU for California was approximately 1.9.[34] In contrast, a recent northeast residential study found an average HOU of 3.0 for efficient lamps.[35] While these studies were conducted in different years, and the Northeast study included both CFLs and LEDs, results indicate that Californians may operate lamps less than other U.S. residents. This would also lead to a lower burnout rate, causing Californians to purchase fewer replacement lamps than other U.S. consumers.

However, the three methods predict different percentages. TRC believes this is because each of these methods has limitations, which may include, but is not limited to:

- LightTracker data may underestimate California sales relative to U.S. sales, because Californians may purchase more lamps through the market channels not captured in LightTracker compared to other U.S. consumers.
- Californians may purchase a different number of lamps than what TRC predicted in its lamp purchasing model, because of inaccurate assumptions for burn out rates, early retirement, or changes in net storage.
- The total U.S. shipment estimate for 2011 from D&R (2012) may be inaccurate.
- The NEMA market shipment indices are based only on A-line lamps, and the changes in total lamp shipments from 2011 to 2014 may be different than for A-lines only.
- Predicting CFL purchases based on the fraction of lamps that are CFLs from shelf surveys may overestimate CFL purchases.

[33] D&R (2010): ENERGY STAR CFL Market Profile, Figure 8, Regional CFL Saturation. https://www.energystar.gov/ia/products/downloads/CFL_Market_Profile_2010.pdf
[34] DNV-GL (2010): 2006-2008 Final Upstream Lighting Program Evaluation, Table 38.
[35] NMR Group (2014): Northeast Residential Lighting Hours-of-Use Study. www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2014ContractorReports/2014-EMEP-Northeast-Residential-Lighting.pdf

It was beyond the scope of this project to try to identify which of these possible limitations were actual inaccuracies, and to quantitatively adjust for these (and other) potential inaccuracies. Consequently, TRC averaged the results of total lamp purchases in California compared to the U.S., since each method has different limitations.

*Total lamps sold in CA / Total lamps sold in U.S. (%) = Avg of Methods i, ii, iii = Avg (4.5%, 9.4%, 8.8%) = 8%*

**Fraction of U.S. CFLs and U.S. LEDs Sold in CA:**

In the final step for calculating CFL sales in California, TRC took the percent of total lamps in California that were CFLs (31%, based on California shelf surveys) and divided it by the percent of total lamps in the U.S. that were CFLs (31%, based on NEMA market shares adjusted by lamp type). (The similarity in these values – both 31% – indicates that CFLs comprised about the same market share of total lamps for California as CFLs did nationally for 2014.) TRC then multiplied it by Total lamps sold in CA / Total lamps sold in U.S. (8%, estimated as described above).

Note that the units of "Total lamps sold in CA" and "Total lamps Sold in U.S." cancel out in the equation below, and the resulting units are CFLs sold in CA / CFLs sold in U.S. (%). Using Equation 7:

*U.S. CFLs purchased in California (%) = (CFLs sold in CA/ ~~Total lamps sold in CA~~) / (CFLs sold in U.S. / ~~Total lamps sold in U.S.~~) x (~~Total lamps sold in CA~~ / ~~Total lamps sold in U.S.~~) = 31% / 31% x 8% = 8%.*

This indicates that 8% of U.S. CFLs were sold in California.

To estimate the number of U.S. CFLs sold in California, TRC multiplied total U.S. CFL shipments by the percent of U.S. CFLs that were purchased in California.

*CFLs sold in CA = U.S. CFL shipments x U.S. CFLs purchased in California (%) = 328 million x 8% = 25 million*

Similarly, to estimate the number of U.S. LEDs sold in California, TRC first took the percent of total lamps in California that were LEDs (13%, based on California shelf surveys) and divided it by the fraction of total lamps in the U.S. that were LEDs (9%, based on NEMA market shares adjusted by lamp type). TRC then multiplied this by Total lamps sold in CA / Total lamps sold in U.S. (8%, estimated as described above). Similar to the CFL calculation, the terms "Total lamps sold in CA" and "Total lamps Sold in U.S." cancel out. Using Equation 8:

*U.S. LEDs purchased in California = (LEDs sold in CA/ ~~Total lamps sold in CA~~) / (LEDs sold in U.S. / ~~Total lamps sold in U.S.~~) x (~~Total lamps sold in CA~~ / ~~Total lamps sold in U.S.~~) = 13% / 9% x 8% = 12%*

This indicates that 12% of U.S. LEDs were sold in California. To estimate the number of U.S. LEDs sold in California, TRC multiplied total U.S. LED shipments by the percent of U.S. LEDs that were purchased in California.

*LEDs sold in CA = U.S. LED shipments x U.S. LEDs purchased in California (%) = 100 million x 12% = 12 million*

**Thus, Method 2b estimates that residential California customers bought 25 million CFLs and 12 million LEDs in 2014**. The estimate of LEDs purchased in California under the two assumptions (2a - assuming that Californians follow national trends, and 2b - adjusting U.S. purchases for California). TRC believes the reason is that Californians purchase fewer total lamps, but more LEDs relative to U.S. consumers; this effect generally balanced out in 2014.

## Method 3: Estimates based on Historical CFL trends – Supporting Assumptions and Calculations

TRC estimated total CFLs purchased in California from 2005 to 2012, based on the number of CFLs installed in California households from the 2005 and 2012 California Lighting and Appliance Saturation Surveys (CLASS), the

number of CFLs found in storage in the 2012 CLASS, the number of CFLs removed due to burn-out (based on CFL Effective Useful Life – EUL) and early retirement (based on TRC assumptions). Figure 39 presents this calculation.

| Parameter | Value | Source / Assumption / Calculation |
|---|---|---|
| CFLs per housing unit in 2005 | 3.5 | 2005 CLASS, as cited in the 2012 CLASS report |
| CFLs per housing unit in 2012 | 13.1 | 2012 CLASS. Note this is a different value than the number of CFLs assumed per household in the TRC lamp purchase model in Method 1 (13.6 CFLs). CLASS 2012 provided 13.1 CFLs as the average number for census-weighted spaces, so TRC used 13.6 in M. CLASS 2012 provided 13.1 CFLs as the average number for 2005 CLASS weighted spaces – i.e., for comparison with 2005 CLASS values, so TRC used 13.1 CFLs in Method 3. |
| Years between CLASS studies | 7 | Calculated: 2012-2005 |
| CFL installation for net increase per housing unit | 9.6 | Calculated: (CFLs per housing unit in 2012 – CFLs per housing unit in 2005) / Years between CLASS studies = (13.1 – 3.5) / 7 = 9.6 CFL |
| CFL installations / year per housing unit for net increase | 1.4 | Calculated: CFL installations for net increase / Years between CLASS studies = 9.6 CFLs / 7 yr = 1.4 CFL / yr |
| CFLs removed through early retirement / year per housing unit | 0.5 | Calculated: Average number of CFLs from 2005 to 2012 x Average Early Retirement rate for 2005 to 2012 (described in the Section, Early Retirement Assumptions. Ave (3.5 CFL, 13.1 CFL) x Ave (8%/yr, 4%/yr) = 0.5 CFL / yr |
| Total CFL installations / year per housing unit for net increase and early retirement | 1.9 | Calculated: CFL installations / year per housing unit for net increase + CFLs removed through early retirement / year per housing unit = 1.4 CFL + 0.5 CFL = 1.9 CFL / yr |
| Total CFL installations per housing unit for net increase and early retirement | 13.0 | Calculated: (Total CFL installations / year per housing unit for net increase and early retirement) x Years between CLASS studies = 1.9 CFL / yr x 7 yr = 13.0 CFL |
| CFL Effective Useful Life (EUL) (yr) | 6.5 | Total hours from CPUC / SCE CFL Lab Study and assuming 1.7 HOU |
| CFL installations per housing unit to replace burned out CFLs | 8.7 | Calculated: CFLs per housing unit in 2005 + (CFL installation for net increase per housing unit x Average length CFLs installed / CFL EUL) = 3.5 CFL + [9.6 CFL x (7 yr/2) / 6.5 yr] = 8.7 CFL |
| Total CFL installations per housing unit, 2005 to 2012 | 21.7 | Calculated: Total CFL installations per housing unit for net increase and early retirement + CFL installations per housing unit to replace burned out CFLs = 13.0 CFL + 8.7 CFL = 21.7 CFL |
| Total CFL installations, 2005 to 2012 | 264 million | Calculated: Total CFL installations per housing unit, 2005 to 2012 x Number of occupied housing units in CA in 2009 (from U.S. Census: http://factfinder.census.govhttp://factfinder.census.gov) = 21.7 CFL per housing unit x 12.2 million housing units = 264 million |
| CFLs found in storage in 2012 | 36 million | Based on 2012 CLASS data, as presented in Table 41 of the 2013 Residential Lighting Market Status report. This source does not provide the total number of CFLs in storage in 2005, so TRC assumed 0 CFLs in storage in 2005. |
| Total CFLs sold in CA, 2005 to 2012 | 300 million | Calculated: Total CFL installations, 2005 to 2012 + CFLs found in storage in 2012 = 264 million + 36 million = 300 million CFLs |

*Figure 39. Calculation of Total CFLs purchased in California, 2005-2012*

**Based on this analysis, TRC estimated that approximately 300 million CFLs were purchased by California consumers between 2005 and 2012.**

TRC then apportioned this total number of CFLs (300 million) to each year between 2005 and 2012. TRC based the portion of 2005-2012 CFLs purchased each year based on IOU CFL rebates, CFL market shares in the California shelf surveys, California CFL sales data from LightTracker, and NEMA data for U.S. CFL shipments. Figure 40 below shows the results.

| Year | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | Total |
|---|---|---|---|---|---|---|---|---|---|
| Portion of 2005-2012 CFLs assumed were sold (%) | 6.0% | 7.6% | 16.8% | 16.8% | 14.5% | 13.0% | 12.8% | 12.5% | 100% |
| Estimated CFLs sold (Millions) | 18.0 | 22.8 | 50.4 | 50.4 | 43.5 | 39.0 | 38.3 | 37.5 | 300 |

*Figure 40. Number of CFLs that TRC Assumed Were Sold each Year in California, 2005 to 2012*

**Based on this analysis, TRC estimated that California residential customers bought 38.3 million CFLs in 2011 and 37.5 million CFLs in 2012.**

As a check, TRC estimated the rebated sales fraction for 2006-2008, for comparison with the 2012 HER program evaluation estimate for this timeframe. TRC estimated this value as follows, using the Residential CFLs rebated by IOUs from the 2006-2008 ULP Impact Evaluation:

*IOU rebated fraction, 2006-2008 = Res CFLs rebated by IOUs (2006 - 2008) / Res CFLs sold (2006 - 2008) = 87 million rebated Res CFLs / (22.8+50.4+50.4) million Total CFLs = 87 / 123.6 = 70%*

**TRC's estimate for the rebated sales fraction for 2006-2008, 70%, agrees closely with the 2012 PG&E HER evaluator's estimate for this timeframe, 74%.** The 2012 PG&E HER evaluators identified 96 million rebated CFLs; TRC identified the same number of total rebates, but used the 2006-2008 evaluators' assumption that 90% (i.e., 87 million rebated CFLs) were purchased for residential use. The 2012 PG&E HER evaluator estimated 132 million total CFLs sold in California, and TRC estimated 124 million total CFLs sold in California. **If TRC had included all CFL rebates (those assumed used in residential and nonresidential buildings) as the 2012 PG&E HER evaluator did, TRC estimates a rebated sales fraction of 78%.** Our similar estimate to the 2012 PG&E HER evaluator indicates that TRC's methodology is reasonable.

Next, TRC projected the 2012 estimate (38 million CFLs) forward to 2013 and 2014. TRC estimated that CFL purchases decreased 9% from 2012 to 2013, and decreased 5% from 2013 to 2014. TRC developed these percentages based on changes to the CFL fraction of total lamps found in California shelf surveys, and changes in total lamps sold in CA from LightTracker. While TRC acknowledges that changes in CFL market share fractions in shelf surveys may not reflect changes in actual CFL purchases, TRC believes the shelf survey data are the best available indication of changes in purchases. In addition, the CFL shelf survey trends from 2012 to 2014 followed trends in IOU rebates from 2012 to 2014 and trends in CFL sales in California in LightTracker.

Finally, TRC estimated total CFLs sold in California in 2014 by multiplying the 2012 CFL estimate by the percent changes for 2013 and 2014:

*CFLs sold in 2014 = CFLs sold in 2012 x (100%+ CFL sales change from 2012 to 2013) x (100%+ CFL sales change from 2013 to 2014) = 37.5 million CFLs x (100% - 9%) x (100% - 5%) = 32.2 million CFLs*

**Based on this method, TRC estimated a total of 32 million CFLs purchased in 2014.**

There was not enough historical data regarding LEDs for TRC to develop a similar estimate for LEDs.

## Additional Supporting Assumptions and Calculations

### *Apportionment of CA Sales to IOU service territories – Detailed Calculation*

To estimate the number of CFLs and LEDs sold in California that were sold in the each electric IOU service territory, TRC began by calculating the percent of California housing units in each electric IOU service territory.

For PG&E, TRC took the number of residential customers in PG&E service territory (4.6 million residential customers for PG&E, excluding gas only customers) and divided it by the total number of housing units in California based on U.S. Census data: 13.7 million.[36] The resulting value is an estimate that 34% of California's housing units are in PG&E service territory.

*Housing Units in PG&E service territory (%) = PG&E Residential Customers / CA Housing Units = 4.6 Million / 13.7 million = 34%*

TRC made similar calculations to estimate the number of households in SCE and SDG&E territories, as shown below:

*Housing Units in SCE service territory (%) = SCE Residential Customers / CA Housing Units = 4.3 Million / 13.7 million = 31%*

*Housing Units in SCE service territory (%) = SDG&E Residential Customers / CA Housing Units = 1.3 Million / 13.7 million = 9%*

Figure 41 shows the calculation for percent of statewide CFLs sold in PG&E service territory in 2014. As shown, TRC estimated that 28% of statewide CFLs were sold in the PG&E service territory in 2014.

[36] Based on U.S. Census data for California in 2013, http://quickfacts.census.gov/qfd/states/06000.html.http://quickfacts.census.gov/qfd/states/06000.html. Values for 2014 were not available. For better comparison with the 2013 census values, PG&E provided its number of residential customers for December 2013.

| Parameter (Lamps in Millions) | Value (CFLs in Millions) | Source/ Assumption / Calculation |
|---|---|---|
| PG&E CFL rebates for res | 0.6 | PG&E staff, from program tracking data (0.7 million) multiplied by 93% to assume portion sold to Res customers. 0.7 x 93% = 0.6 |
| SCE CFL rebates for res | 4.8 | SCE staff, from program tracking data (5.1 million) multiplied by 94% to assume portion sold to Res customers. 5.1 x 94% = 4.8 |
| SDG&E CFL rebates for res | 0.5 | SDG&E staff, from program tracking data (0.5 million) multiplied by 94% to assume portion sold to Res customers. 0.5 x 94% = 0.5 |
| Total IOU rebates for res | 5.9 | Calculated: PG&E CFLs rebates + SCE CFL rebates + SDG&E rebates = 0.6 + 4.8 + 0.5 = 5.9 million CFLs |
| SMUD CFL rebates | 1.2 | Energy Efficiency in California's Public Power Sector, Annual Report 2015, p. A-135 |
| Total POU CFL rebates | 1.3 | Calculated by assuming that POU Residential lighting rebates had the same proportions of CFLs to LEDs as SMUD, since SMUD provided the vast majority of POU Residential Lighting savings: Divided total Residential Lighting savings for all POUs (from Energy Efficiency in California's Public Power Sector, Annual Report 2015, Figure 7) by SMUD Residential Lighting Savings, multiplied by SMUD CFL rebates = 63 GWh for all POU Res Ltg / 55 GWh for SMUD Res Ltg x 1.2 million Rebated CFLs from SMUD = 1.3 million rebated CFLs from POUs |
| Total POU CFL rebates in res | 1.2 | Calculated: Total POU CFL rebates x 93% assumed in res = 1.3 x 93% = 1.2 |
| Total res rebated CFLs sold in CA | 7.1 | Calculated: Total IOU CFL rebates in res + Total POU CFL rebates in res = 5.9 million + 1.2 million = 7.1 million |
| CFLs sold in CA in res | 30.5 | Calculated: Based on TRC analysis, as described in the Section Methods to Estimate Rebated CFL and LED Sales Fractions. |
| Total Unrebated CFLs in CA | 23.4 | Calculated: CFLs sold in CA – Total res rebated CFLs in CA = 30.5 million – 7.1 million = 23.4 million |
| CFLs sold in PG&E service territory for res, rebated | 0.6 | Assumed to be the same number of res CFLs rebated by PG&E |
| CFLs sold in PG&E service territory for res, unrebated | 7.8 | Calculated: Total Unrebated CFLs in CA x (PG&E residential customers / Housing Units in California) = 23.4 million x 34% = 7.8 million |
| Total CFLs sold in PG&E service territory | 8.4 | Calculated: CFLs sold in PG&E service territory for res, rebated + CFLs sold in PG&E service territory for res, unrebated = 0.6 + 7.8 = 8.4 million |
| Statewide CFLs sold in PG&E service territory (%) | 28% | Calculated: Total CFLs sold in PG&E territories / CFLs sold in CA = 8.4 million / 30.5 million = 28% |
| **PG&E rebated CFL sales fraction** | **7%** | Calculated: PG&E CFL rebates for res / Total CFLs sold in PG&E service territory = 0.6 million / 8.4 million = 7% |

*Figure 41. Calculation of CA CFLs Sold in PG&E service territory and PG&E-Rebated CFL Sales Fraction, 2014*

TRC used a similar approach to apportion CA CFL sales to PG&E service territory for 2011, 2012, and 2013 and to estimate the resulting rebated CFL sales fraction for 2011, 2012, and 2013. As shown in Figure 42, TRC estimated a PG&E-rebated CFL sales fraction of 50%, 45%, and 16% for 2011, 2012, and 2013, respectively.

| Parameter (Lamps in Millions) | 2011 | 2012 | 2013 | Source/ Assumption / Calculation |
|---|---|---|---|---|
| Total res CFLs sold in CA | 39.8 | 39.7 | 37.7 | Based on TRC calculations, as shown Figure 13, Figure 14, Figure 15 |
| PG&E rebated CFLs, res | 6.1 | 4.7 | 1.9 | 2011 and 2012 from 2010-2012 ULP Impact Evaluation Appendix A; 2013 from Program tracking data multiplied by 94% for res |
| IOU rebated CFLs, res | 19.9 | 20.7 | 7.7 | 2011 and 2012 from 2010-2012 ULP Impact Evaluation Appendix A; 2013 from Program tracking data multiplied by 94% for PG&E and 93% for SCE and SDG&E res |
| POU rebated CFLs, res | 2.0 | 2.0 | 1.3 | Energy Efficiency in California's Public Power Sector 2012, 2013, and 2014 Annual Reports. Multiplied CFLs by 93% for res. |
| Total Rebated Res CFLs in CA | 21.9 | 22.7 | 9.0 | Calculated: IOU rebated CFLs, res + POU rebated CFLs, res |
| Non-rebated CFLs sold in CA | 17.9 | 17.0 | 28.7 | Calculated: Total res CFLs sold in CA - Total Rebated Res CFLs in CA |
| Non-rebated CFLs sold in PG&E service territory | 6.0 | 5.7 | 9.6 | Calculated: Non-rebated CFLs sold in CA x 34% |
| Total CFLs sold in PG&E service territory | 12.1 | 10.3 | 11.5 | Calculated: PG&E rebated CFLs, res + Non-rebated CFLs sold in PG&E service territory |
| **CFLs sold in PG&E service territory / CA CFLs (%)** | **30%** | **26%** | **31%** | Calculated: Total CFLs sold in PG&E service territory / Total res CFLs sold in CA |
| **PG&E rebated CFL sales fraction** | **50%** | **45%** | **16%** | Calculated: PG&E rebated CFLs, res / Total CFLs sold in PG&E service territory |

*Figure 42. Fraction of CFLs sold in PG&E Service Territory, and PG&E-Rebated CFL Sales Fractions for 2011-2013*

TRC used the same approach for SCE for 2014. Figure 43 shows the values and the resulting rebated sales fraction.

| **Lamps in Millions, and represent only lamps assumed to be sold to residential customers.** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **CFLs Rebated by SCE** | **Total CFLs Rebated by IOUs and POUs** | **Total CFLs Sold in CA** | **Unrebated CFLs Sold in CA** | **Unrebated CFLs Sold in SCE service territory** | **Total CFLs sold in SCE service territory** | **CA CFLs sold in SCE service territory (%)** | **SCE Rebated CFL Sales Fraction (%)** |
| 2014 | 4.8 | 7.1 | 30.5 | 23.4 | 7.3 | 12.1 | 40% | 40% |

*Figure 43. Apportionment of CA CFLs to SCE service territory and Calculation of SCE CFL Rebated Sales Fractions*

TRC used the same approach for SDG&E for 2011-2014. Figure 44 shows the values and resulting rebated sales fraction. Note that TRC only used the values for 2011 and 2014 in this evaluation, because SDG&E did not begin HER treatment waves in 2012 or 2013.

| Lamps in Millions, and represent only lamps assumed to be sold to residential customers. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **CFLs Rebated by SDG&E** | **Total CFLs Rebated by IOUs and POUs** | **Total CFLs Sold in CA** | **Unrebated CFLs Sold in CA** | **Unrebated CFLs Sold in SDG&E service territory** | **Total CFLs sold in SDG&E service territory** | **CA CFLs sold in SDG&E service territory (%)** | **SDG&E Rebated CFL Sales Fraction (%)** |
| 2011 | 2.1 | 21.9 | 39.8 | 17.9 | 1.6 | 3.8 | 9% | 57% |
| 2012 | 3.3 | 22.7 | 39.7 | 17.0 | 1.6 | 4.8 | 12% | 68% |
| 2013 | 1.7 | 9.0 | 37.7 | 28.7 | 2.6 | 4.3 | 12% | 40% |
| 2014 | 0.5 | 7.1 | 30.5 | 23.4 | 2.1 | 2.6 | 9% | 18% |

*Figure 44. Apportionment of CA CFLs to SDG&E service territory and Calculation of SDG&E CFL Rebated Sales Fractions*

TRC used the same methodology to estimate statewide LEDs sold in PG&E service territory, as shown in Figure 45.

| Parameter (Lamps in Millions) | Value | Source/ Assumption / Calculation |
|---|---|---|
| PG&E LED rebates for res | 0.9 | PG&E staff, from program tracking data multiplied by 93% to assume portion sold to Res customers. 1.0 x 93% = 0.9 |
| SCE LED rebates for res | 0.8 | SCE staff, from program tracking data multiplied by 94% to assume portion sold to Res customers. 0.8 x 94% = 0.8 |
| SDG&E LED rebates for res | 0.4 | SDG&E staff, from program tracking data multiplied by 94% to assume portion sold to Res customers. 0.4 x 94% = 0.4 |
| Total IOU LED rebates for res | 2.1 | Calculated: PG&E LED rebates + SCE LED rebates + SDG&E LED rebates = 0.9+0.8+0.4 = 2.1 million LEDs |
| SMUD LED rebates | 0.7 | Energy Efficiency in California's Public Power Sector, Annual Report 2015, p. A-135 |
| Total POU LED rebates | 0.9 | Calculated by assuming that POU Residential lighting rebates had the same proportions of CFLs to LEDs as SMUD, since SMUD provided the vast majority of POU Residential Lighting savings: Divided total Residential Lighting savings for all POUs (from Energy Efficiency in California's Public Power Sector, Annual Report 2015, Figure 7) by SMUD Residential Lighting Savings, multiplied by SMUD LED rebates = 63 GWh for all POU Res Ltg / 55 GWh for SMUD Res Ltg x 0.7 million Rebated LEDs from SMUD = 0.8 million rebated LEDs from POUs |
| Total POU LED rebates in res | 0.8 | Calculated: Total POU LED rebates x 93% = 0.9 x 93% = |
| Total res rebated LEDs sold in CA | 2.9 | Calculated: Total res IOU LED rebates + Total res POU LED rebates = 2.1 million + 0.8 million = 2.9 million |
| LEDs sold in CA in res | 13.2 | Calculated: Based on TRC analysis, as described in the Section Methods to Estimate Rebated CFL and LED Sales Fractions. |
| Total Unrebated LEDs in CA | 10.4 | Calculated: LEDs sold in CA – Total res rebated LEDs in CA = 13.2 million – 2.9 million = 10.4 million |
| LEDs sold in PG&E service territory, rebated | 0.9 | Assumed to be the same number of res LEDs rebated by PG&E |
| LEDs sold in PG&E service territory, unrebated | 3.4 | Calculated: Total Unrebated LEDs in CA x (PG&E residential customers / Housing Units in California) = 10.4 million x 34% = 3.5 million |
| Total LEDs sold in PG&E service territory | 4.4 | Calculated: LEDs sold in PG&E service territory, rebated + LEDs sold in PG&E service territory, unrebated = 0.9 million + 3.5 million = 4.4 million |
| **Statewide LEDs sold in PG&E service territory (%)** | **33%** | Calculated: Total LEDs sold in PG&E territories / LEDs sold in CA = 4.4 million / 13.2 million = 33% |
| **PG&E rebated LED sales fraction** | **21%** | Calculated: PG&E LED rebates for res / Total LEDs sold in PG&E service territory = 0.9 million / 4.4 million = 21% |

*Figure 45. Calculation of CA LEDs Sold in PG&E service territory and PG&E-Rebated LED Sales Fraction, 2014*

As shown in Figure 41 and Figure 45, **TRC estimated that 8.4 million CFLs, or 28% of statewide CFLs, and 4.4 million LEDs, or 33% of statewide LEDs, were sold in PG&E service territory in 2014.** Note that most (approximately three-fourths) of the CFLs and LEDs purchased in California in 2014 were non-rebated. Consequently, the percent of statewide CFLs and LEDs sold in PG&E service territory are very similar to the percent of housing units in PG&E service territory – 34%. The fraction of LEDs sold in PG&E service territory is higher than the fraction of CFLs sold in PG&E service territory, because PG&E provided 32% of the total IOU and POU LED rebates, but only 9% of total IOU and POU CFL rebates.

**TRC used the same approach to calculate the rebated LED sales fraction for SCE, with a resulting SCE-rebated LED sales fraction of 20%.**

| Parameter (Lamps in Millions) | Value | Source/ Assumption / Calculation |
|---|---|---|
| SCE LED rebates for res | 0.8 | SCE staff, from program tracking data multiplied by 94% to assume portion sold to Res customers. 0.8 x 94% = 0.8 |
| Total res rebated LEDs sold in CA | 2.9 | See Figure 45. |
| LEDs sold in CA in res | 13.2 | Calculated: Based on TRC analysis, as described in the Section Methods to Estimate Rebated CFL and LED Sales Fractions. |
| Total Unrebated Res LEDs sold in CA | 10.4 | See Figure 45. |
| LEDs sold in SCE service territory, rebated | 0.8 | Assumed to be the same number of res LEDs rebated by SCE |
| LEDs sold in SCE service territory, unrebated | 3.2 | Calculated: Total Unrebated LEDs in CA x (SCE residential customers / Housing Units in California) = 10.4 million x 31% = 3.2 million |
| Total LEDs sold in SCE service territory | 4.0 | Calculated: LEDs sold in SCE service territory, rebated + LEDs sold in SCE service territory, unrebated = 0.8 million + 3.2 million = 4.0 million |
| **Statewide LEDs sold in SCE service territory (%)** | **30%** | Calculated: Total LEDs sold in SCE territories / LEDs sold in CA = 4.0 million / 13.2 million = 30% |
| **SCE rebated LED sales fraction** | **20%** | Calculated: SCE LED rebates for res / Total LEDs sold in SCE service territory = 0.8 million / 4.0 million = 20% |

*Figure 46. Calculation of CA LEDs Sold in SCE Service Territory and SCE-Rebated LED Sales Fraction, 2014*

**TRC used the same approach to estimate the rebated LED sales fraction for SDG&E, with a resulting SDG&E-rebated LED sales fraction of 32%.**

| Parameter (Lamps in Millions) | Value | Source/ Assumption / Calculation |
|---|---|---|
| SDG&E LED rebates for res | 0.4 | SDG&E staff, from program tracking data multiplied by 94% to assume portion sold to Res customers. 0.4 x 94% = 0.4 |
| Total res rebated LEDs sold in CA | 2.9 | See Figure 45. |
| LEDs sold in CA in res | 13.2 | Calculated: Based on TRC analysis, as described in the Section Methods to Estimate Rebated CFL and LED Sales Fractions. |
| Total Unrebated Res LEDs sold in CA | 10.4 | See Figure 45. |
| LEDs sold in SDG&E service territory, rebated | 0.4 | Assumed to be the same number of res LEDs rebated by SDG&E |
| LEDs sold in SDG&E service territory, unrebated | 1.0 | Calculated: Total Unrebated LEDs in CA x (SDG&E residential customers / Housing Units in California) = 10.4 million x 9% = 1.0 million |
| Total LEDs sold in SDG&E service territory | 1.3 | Calculated: LEDs sold in SDG&E service territory, rebated + LEDs sold in SDG&E service territory, unrebated = 0.4 million + 1.0 million = 1.3 million |
| **Statewide LEDs sold in SDG&E service territory (%)** | **10%** | Calculated: Total LEDs sold in SDG&E territories / LEDs sold in CA = 1.3 million / 13.2 million = 10% |
| **SDG&E rebated LED sales fraction** | **32%** | Calculated: SDG&E LED rebates for res / Total LEDs sold in SDG&E service territory = 0.4 million / 1.3 million = 32% |

*Figure 47. Calculation of CA LEDs Sold in SDG&E service territory and SDG&E-Rebated LED Sales Fraction, 2014*

### *Estimate of CA CFL Sales in IOU Territories*

In Method 4, because DNV-GL estimated total CFL sales in electric IOU service territories only, TRC needed to extrapolate the DNV-GL estimate up to the statewide level – i.e., include POU service territories. This section shows that extrapolation.

TRC began by calculating the percent of California housing units in electric IOU territories. TRC took the number of residential customers in electric IOU territories (10.2 million residential customers for PG&E, SCE, and SDG&E combined, excluding gas only customers for PG&E and SDG&E) and divided it by the total number of housing units in California based on U.S. Census data: 13.7 million.[37] The resulting value is an estimate that 74% of California's housing units are in electric IOU service territories.

*Housing Units in Elec IOU Territories = Residential Customers in Elec IOU Territories / CA Housing Units = 10.2 million / 13.7 million = 74%*

TRC then adjusted this value of 74% based on the level of rebates provided by the IOUs relative to the POUs. Figure 41 shows the calculation for percent of statewide CFLs sold in IOU territories. As shown, **TRC estimated that 76% of statewide CFLs were sold in electric IOU service territories.**

| Parameter (Lamps in Millions) | Value | Source/ Assumption / Calculation |
|---|---|---|
| Total IOU rebates for res | 5.9 | See calculation in Figure 41. |
| Total POU rebates for res | 1.2 | See calculation in Figure 41. |
| Total rebated CFLs in CA for res | 7.1 | Calculated: Total IOU rebates for res + Total POU rebates for res = 5.9 + 1.2 = 7.1 |
| IOU rebates / total CA rebates | 83% | Calculated: IOU res rebates / Total rebated res CFLs in CA =5.9 million / 7.1 million = 83%. |
| CFLs sold in CA in 2014 | 30.5 | Calculated: Based on TRC analysis, as described in the Section Methods to Estimate Rebated CFL and LED Sales Fractions. |
| Total Unrebated CFLs in CA | 23.4 | Calculated: CFLs sold in CA – Total rebated CFLs in CA = 30.5 million – 7.1 million = 23.4 million |
| CFLs sold in IOU territories, rebated | 5.9 | Assumed to be as Total IOU rebates for res |
| CFLs sold in IOU territories, unrebated | 17.2 | Calculated: Total Unrebated CFLs in CA x Fraction of CA Households in IOU territories = 23.4 million x 74% = 17.2 million |
| Total CFLs sold in IOU territories | 23.2 | Calculated: CFLs sold in IOU territories, rebated + CFLs sold in IOU territories, unrebated = 5.9 million + 17.4 million = 23.2 million |
| CFLs sold in IOU territories (%) | 76% | Calculated: Total CFLs sold in IOU territories / CFLs sold in CA = 23.2 million / 30.5 million = 76% |

*Figure 48. Calculation of Statewide CFLs Sold in IOU Territories for 2014*

TRC assumed that the same fraction of CFLs were sold in IOU territories in 2011, 2012, and 2013 as we estimated for 2014 – i.e., 76%.

### *Early Retirement Assumptions*

TRC used early retirement values in its lamp purchase model (Method 1) and historical CFL analysis (Method 3).

TRC estimated that the early retirement rate for CFLs (including rejected and broken CFLs) was 8% for 2005-2008 and 4% from 2009-2012. TRC developed the estimate of early retirement for 2005-2008 based on dispositions of CFL purchasers from quarterly CFL user surveys, as shown in the 2006-2008 ULP Impact Evaluation. Those

[37] Based on U.S. Census data for California in 2013, http://quickfacts.census.gov/qfd/states/06000.html. For comparison, PG&E provided its number of residential customers for 2013; SCE and SDG&E provided total numbers of residential customers for early 2015.

dispositions found CFL purchasers reported that 3.9% of CFLs had burned out, 0.6% had broken, and 1.3% had been "rejected" by the purchasers. Thus, the combined rate for breakage and rejected CFLs was approximately half of the CFLs burned out:

*Early Retirement / Burned out CFLs = (Breakage + Rejected CFLs) / Burned out CFLs = (0.6% + 1.3%) / 3.9% = 49%*

In other words, these results indicate that, for every 1 CFL removed because of burn-out, 0.49 CFLs are removed because of early retirement.

TRC multiplied this fraction to the burn-out rate of CFLs – i.e., the inverse of the Effective Useful Life (EUL), to estimate an early retirement rate per year:

*Early Retirement Rate = (Early Retirement / Burned out CFLs) x 1/ CFL EUL = 49% x 1 / 6.5 yrs = 8%/yr*

Thus, TRC estimated that the early retirement rate was 8% per year for 2005 through 2008.

TRC then assumed that the early retirement rate dropped in half for 2009-2012 – i.e., to 4%. This is because CFLs have generally improved in quality (including many models with improved dimming), which should have reduced customer dissatisfaction. In addition, TRC believes that as consumers gained more experience with CFLs, they became savvier regarding where (i.e., in which rooms and in which applications) to install them to improve their satisfaction with CFLs.

DNV-GL assumed an early retirement value for CFLs of 10% for 2009-2014 in their lamp installation trajectory. However, TRC believes this value is too high for the current CFL market. In addition, using an early retirement value of 10% in TRC's analysis resulted in a high number of total lamps purchased in California in 2014: approximately 120 million total lamps in California. This value represented approximately 10.2% of U.S. lamps. TRC believes that Californians purchased significantly fewer lamps relative to U.S. households (per housing unit), because of their penetration of lamps with higher EUL and lower HOU. Consequently, TRC rejected the 10% early retirement assumption. Note this is a conservative decision, because a higher early retirement assumption results in higher total lamp sales, which reduces the CFL rebated sales fractions and reduces the lighting savings overlap.

Thus, TRC assumed the following early retirement values shown in Figure 49:

| Lamp Technology | Early Retirement Assumption | Rationale |
|---|---|---|
| Incandescent | 2% | Consumers are generally pleased with lighting quality, but understand that other lamp types use less energy. Incandescents are also cheap, so "sunk costs" are low. |
| Halogen | 1% | Higher prices of halogens would likely discourage consumers from removing them. |
| CFLs (2009-2014) | 4% | See description above for CFL early retirement. Relative to other lamp types, TRC assumed the highest early retirement value for CFLs, because these are the lamps for which consumers have expressed the most dissatisfaction. |
| CFLs (2005-2008) | 8% | See description above for CFL early retirement. |
| LED | 1% | Consumers are generally pleased with LEDs, and the higher prices of LEDs would likely discourage consumers from removing them. |

*Figure 49. Early Retirement Assumptions*

## Market Channel Analysis

Figure 50 presents various market channel data, including:

- Whether this channel is included in LightTracker sales reports
- Indicators of CFLs and LEDs sold through the channel, including the:

- Frequency with which consumers self-reported that they purchased CFLs through this channel, based on data collected in 2010 from D&R (2010)[38],
- Percent of total lamps that CFLs and LEDs comprised in shelf surveys conducted in summer 2012 and winter 2014/15 (DNV-GL shelf survey tool[39])

◆ Indicators of 2010-2012 CFL and LED rebates to each market channel, including the:

- Percent of total CFL rebates, and percent of total LED rebates, that the IOUs provided to each channel in the 2010-2012 ULP program (DNV-GL Residential Market Status Report for 2013[40]).

| | Retail Channel | Discount | Drug | Grocery | Hardware | Home Improvement | Lighting & Electronics | Mass Merchant | Wholesale Club | All Market Channels |
|---|---|---|---|---|---|---|---|---|---|---|
| | Example stores (DNV-GL Res Ltg Mkt Status 2013) | 99 Cents only, Big Lots, Dollar Tree | CVS, Rite Aid, Walgreens | Albertsons, Food 4 Less, Stater Brothers | Ace, True Value | Home Depot, Lowes, Orchard Supply | Lamps Plus, Best Buy | K-Mart, Target, Walmart | Costco, Sam's Club | |
| **LightTracker coverage** | Included in LightTracker | Full / Near Full | Full | Full | None | None | None | Full | Partial (1 of 2) | |
| **Indicators of CFLs and LEDs sold through channel** | CFL Purchasing Location, in order of frequency (D&R 2011) | 7 | 6 | 3 | 4 | 1 | Not surveyed | 2 | 5 | |
| | CFLs as % of total lamp on shelves, summer 2012 (DNV-GL shelf survey tool) | 58% | 28% | 54% | 27% | 34% | | 40% | 81% | 47% |
| | LEDs as % of total lamp on shelves, summer 2012 | 0% | 1% | 0% | 1% | 3% | | 3% | 18% | 6% |
| | **% High Efficacy Lamps, 2012: (CFLs + LEDs) / total lamps** | **58%** | **28%** | **54%** | **27%** | **37%** | | **43%** | **98%** | **52%** |
| | CFLs as % of total lamp on shelves, Winter 2014/15 (DNV-GL shelf survey tool) | 16% | 32% | 25% | 19% | 22% | | 21% | 45% | 26% |
| | LEDs as % of total lamp on shelves, Winter 2014/15 (DNV-GL shelf survey tool) | 0% | 3% | 3% | 6% | 16% | | 8% | 55% | 20% |
| | **% High Efficacy Lamps, 2014/15: (CFLs + LEDs) / total lamps** | **16%** | **35%** | **29%** | **25%** | **37%** | | **29%** | **100%** | **46%** |
| **2010-12 IOU Rebates** | % of IOU 2010-12 rebated CFLs to market channel | 20% | 4% | 39% | 5% | 8% | 1% | 3% | 19% | |
| | % of IOU 2010-12 rebated LEDs | 4% | 0 | 48% | 3% | 36% | 0% | 1% | 3% | |

*Figure 50. Indicators of CFLs and LEDs sold through, and Rebated to, each Market Channel*

As shown in Figure 50, home improvement stores were the primary location for consumers to purchase CFLs based on the D&R (2010) study, and this channel was not included in LightTracker. Consumers listed wholesale clubs as 5th in terms of CFL purchasing locations; however, the shelf survey data shows that these clubs almost exclusively sell CFLs and LEDs. **Data in Figure 50 help explain why the percent of CFL and LED sales, relative to total lamp sales, are much lower in LightTracker than in the NEMA market shares.**

Based on the rows within "Indicators of CFLs and LEDs sold through channel", Figure 50 also shows that **different market channels have very different levels of high efficacy lamp availability**. For example, in the 2014/15 shelf

[38] D&R 2010, "2010 CFL Market Profile", figure 3. www.energystar.gov/ia/products/downloads/CFL_Market_Profile_2010.pdf

[39] summer 2013 results from https://websafe.kemainc.com/projects62/crlss/Home.aspx

[40] DNV-GL 2014, "California Residential Replacement Lamp Market Status Report: ULP and Market Activities in California through 2013."

survey, 16% of lamps in Discount stores were high efficacy, as calculated as (CFLs + LEDs) / Total lamps, compared to 100% in wholesale clubs.

In addition, **the fraction of lamps that are high efficacy has dropped in several market channels from 2012 compared to 2014**. As shown in Figure 50, high efficacy lamps comprised over half of lamps on shelves in the summer 2012 survey (52% across all market channels), but less than half of lamps on shelves in the 2014/15 survey (46% across all market channels). **The decline has been more dramatic for some market channels, including those that had previously received higher levels of IOU rebates.** For example, high efficacy lamps comprised 58% of lamps in Discount stores in the summer 2012 shelf survey, but only 16% of lamps in the 2014/15 shelf survey. Similarly, high efficacy lamps comprised 54% of total lamps in grocery stores in the 2012 shelf survey, but only 29% in the 2014/15 shelf survey. As shown in the last rows of Figure 50, the IOUs had provided a significant fraction of their CFL rebates to Discount and Grocery stores through the 2010-12 ULP. The IOUs continued to provide a significant portion of CFL rebates to Discount and Grocery stores through the 2013-14 2014; but because the total number of IOU CFL rebates has declined from 2012 to 2014, these market channels received fewer rebated CFLs in 2014 than 2012.

**These results indicate that some market channels may offer fewer high efficacy lamps (relative to total lamps) in 2014 compared to 2012, perhaps because of the decline in IOU rebates.**

According to Apex Analytics staff members who compile the LightTracker reports, shares of CFLs in California have dropped compared to CFL sales in areas that have continued and/or ramped up support for CFLs.