Measurement & Verification Load Impact Study for NCPA SB5X Residential Compact Fluorescent Lamp Programs

Study ID: NCP0001.08

FINAL REPORT

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June 25, 2005

Funded with California Senate Bill 5X Funds

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Acknowledgements

This measurement and verification load impact study was funded by Senate Bill 5X and administered by Northern California Power Agency under the auspices of the California Energy Commission. Field research and customer participant surveys were conducted with cooperation from the following individuals, utilities, and companies: Brad Wilke, City of Gridley; City of Biggs; Bryan Cope and Patrick Keener, Redding Electric Utility; Steve Maggi and Steve Longoria (Aanko Technologies) for City of Healdsburg; and Nell Thomas and Donna Mills, Plumas-Sierra Rural Electric Utility. Robert Mowris, P.E., and Kathleen Carlson, Esq., managed the study. Robert Mowris developed the EM&V plans, database, and survey instruments. Anne Blankenship, B.S., performed the participant surveys. Robert Mowris performed the engineering and statistical analyses and wrote the report with assistance from Ean Jones, B.S., Rachel Noack, B.S., and Anne Blankenship. Peter Pressley, Ph.D., developed the NCPA M&V tracking database and Rachel Noack managed and revised the database. John Berlin was the project manager for Northern California Power Agency. Rick Ridge, Ph.D., Ridge Associates, provided review comments and suggestions regarding the statistical analysis and sample design.

1. Executive Summary

This study was conducted at the request of Northern California Power Agency (NCPA) and the California Energy Commission (CEC). The study was managed by NCPA. It was funded by Senate Bill 5X (SB5X) and is available online at www.calmac.org. This report provides Measurement and Verification (M&V) load impact study results for the NCPA SB5X Residential Compact Fluorescent Lamp (CFL) Programs implemented by Biggs, Gridley, Healdsburg, Redding, and Plumas-Sierra Rural Electric Cooperative (PSREC). The programs realized peak kW and kWh savings by providing free CFLs to consumers.[1] The five utility CFL programs gave away 72,627 CFLs during 2001 through 2003 that were purchased with $250,096 of SB5X funds administered by NCPA.

The ex-ante and M&V ex post program savings and for the programs are summarized in **Table 1.1**. The ex ante program savings are 1,883,234 kWh/yr and 1,951 kW. The M&V gross ex post program savings are 4,822,634 ± 498,651 kWh/yr and 1,463 ± 83 kW at the 90 percent confidence level. The M&V net program savings are 3,485,846 ± 360,430 kWh/yr 1,057 ± 60 kW at the 90 percent confidence level. The net ex post lifecycle savings are 23,424,885 ± 2,422,090 kWh based on the EUL for screw-in CFLs of 6.72 years. The net realization rates are 1.85 for annual kWh savings and 0.54 for kW savings. The M&V savings are based on analyses of telephone surveys for a random sample of 62 participants. The net-to-gross ratios are also calculated based on decision maker surveys completed for 62 participants. The average net-to-gross ratio is 72 percent meaning that roughly 28 percent of customers would have purchased and used CFLs without the program.[2]

Table 1.1 Summary of M&V Results for NCPA SB5X Residential CFL Programs

NCPA Utility	Qty.	Ex Ante Program Savings kWh/yr	Ex Ante Program Savings kW	M&V Gross Program Savings kWh/yr	M&V Gross Program Savings kW	Net-to-Gross Ratio	M&V Net Program Savings kWh/yr	M&V Net Program Savings kW	Net Realization Rate Relative to Planning kWh/yr	Net Realization Rate Relative to Planning kW
Biggs	1,407	94,329	38.7	94,371	32.3	0.60	56,315	19.3	0.60	0.50
Gridley	1,117	126,126	52.0	66,993	28.2	0.71	47,433	20.0	0.38	0.38
Healdsburg	3,024	190,512	136.1	154,968	36.3	0.72	111,133	26.0	0.58	0.19
PSREC	1,469	104,299	83.7	128,363	33.5	0.80	102,469	26.7	0.98	0.32
Redding	65,610	1,367,968	1640.2	4,377,930	1,332.7	0.72	3,168,498	964.5	2.32	0.59
Average	72,627	1,883,234	1950.8	4,822,624	1,463	0.72	3,485,846	1,057	1.85	0.54

Section 2 presents the M&V approach and results. **Section 3** presents participant survey results and the methodology used to develop net-to-gross ratios. **Section 4** presents the M&V methodology used for the sample design, database, baseline, impact analysis, and program evaluation savings estimates. **Appendix A** provides the CFL Decision-Maker Survey.

[1] Biggs provided incentives to consumers who purchased CFLs at local hardware stores.

[2] The net-to-gross ratio (NTGR) analysis is discussed in Section 3. The total NTGR is the weighted average value based on savings for each program relative to total savings for all programs.

2. M&V Approach and Results

The measurement and verification approach for the study was based on the *International Performance Measurement & Verification Protocols* (IPMVP) defined in **Table 2.1**.[3] Ex post energy and peak demand savings were determined using IPMVP Option A (i.e., partially measured retrofit isolation and stipulated values). This study performed telephone surveys and M&V analyses for a random sample of 62 customers including interview questions regarding old lamp Wattages, hours of operation, on-peak time of use (i.e., on from 2-6PM), and retention (i.e., still using lamps). The following M&V methodology was used for the telephone surveys.

1. Randomly select customers from the utility program tracking databases.
2. Review utility program information for selected customers to ask questions.
3. Perform telephone surveys:
   - Verify CFLs are still being used (i.e., retention).
   - Verify pre-retrofit incandescent lamp Wattages.
   - Verify hours of operation and on-peak time-of-use (i.e., peak period from 2-6PM) to develop the M&V baseline of energy and peak demand (i.e., kWh/yr and kW). Customer reported Wattages and hours of operation were compared to standard values to ensure accurate engineering analysis of energy and peak demand savings.
   - Collect decision-maker questionnaire responses.
4. Analyze survey responses to evaluate retention, pre-retrofit incandescent lamp Wattages, hours of operation, on-peak time-of-use, and net-to-gross ratios.

M&V telephone surveys were performed from May 2002 through October 2003 for the following utility service areas: Biggs, Gridley, Healdsburg, Redding, and Plumas-Sierra. Retention was checked 6 months after installation and double-checked 2 years after installation.

[3] See *International Performance Measurement & Verification Protocols*, DOE/GO-102000-1132, October 2000.

Table 2.1 IPMVP M&V Options

M&V Option	How Savings are Calculated	Typical Applications
Option A. Partially Measured Retrofit Isolation Savings are determined by partial field measurement of energy use of system(s) to which a measure was applied, separate from facility energy use. Measurements may be either short-term or continuous. Partial measurement means that some but not all parameters may be stipulated, if total impact of possible stipulation errors is not significant to resultant savings. Careful review of measure design and installation will ensure that stipulated values fairly represent the probable actual value.	Engineering calculations using short term or continuous post-retrofit measurements or stipulations.	Pre- and post-retrofit values are measured with a kW meter and operating hours are based on interviews with occupants or stipulated values.
Option B. Retrofit Isolation Savings are determined by field measurement of the energy use of the systems to which the measure was applied; separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Engineering calculations using short term or continuous measurements	Refrigerator/freezer electricity use is measured with kW meters for several days, weeks, or months and extrapolated to annual usage using standard methodologies.
Option C. Whole Facility Savings are determined by measuring energy use (and production) at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period. Continuous measurements are based on whole-facility billing data.	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis or conditional demand analysis.	Energy management program affecting many systems in a building. Utility meters measure energy use for 12-month base year and throughout post-retrofit period.
Option D. Calibrated Simulation Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.	Project affecting systems in a building but where pre or post year data are unavailable. Utility billing meters measure pre- or post-retrofit energy use. Savings are determined by simulation using a model calibrated with utility billing data.

2.1 M&V Algorithms for Estimating kW and kWh Savings

M&V algorithms for estimating kW and kWh savings for each site in the random sample are based on the verified quantity of installed measures, pre- and post-installation CFL wattages, hours of operation, and time-of-use. Savings for each M&V site are summed and compared to the ex ante savings to develop Average Gross Realization Rates (AGRR) for kW and kWh savings. The AGRR is combined with the Net-to-Gross Ratio (NTGR) to develop the Net Realization Rate (NRR) relative to planning (shown in **Table 1.1**). The methodology and equations used to calculate Net-To-Gross Ratios (NTGR) are discussed in **Section 3**. Equations used to calculate sample sizes and confidence intervals are discussed in **Section 4**.

The M&V kW and kWh savings for each site were calculated using **Equations 1** and **2**.

Eq. 1 $$\text{kW Savings}_k = \sum_{k=1}^{n} \text{Quantity}_k \times \left[\text{kW}_{pre} - \text{kW}_{post}\right]_k$$

Where,

kW Savings_k = kW savings for site "k" in the random sample.

Quantity = Quantity of fixtures.

kW_{pre} = Pre-installation kW use per fixture.

kW_{post} = Post-installation kW use per fixture.

Eq. 2 $$\text{kWh Savings}_k = \sum_{j=1}^{m} \text{Quantity} \times \left[kW_{pre} - kW_{post}\right] \times \text{hours/year}$$

Where,

kWh Savings_k = kWh savings for site "k" in the random sample.

hours/year = Hours of operation per year per fixture.

Savings for the M&V sites were summed and compared to ex ante savings to develop Average Gross Realization Rates (AGRR) for kW and kWh savings. The AGRR for kW and kWh savings were calculated using **Equation 3**.

Eq. 3 $$AGRR_h = \frac{\sum_{k=1}^{n} \text{M \& V Sample Savings}_k}{\sum_{k=1}^{n} \text{Ex Ante Sample Savings}_k}$$

Where,

$AGRR_h$ = Average gross realization rate for program stratum "h." Defined as the sum of M&V savings for measures or sites in the random sample divided by ex ante savings for measures or sites in the random sample (kW or kWh).

The AGRR is combined with the Net-to-Gross Ratio (NTGR) to develop the Net Realization Rate (NRR) relative to planning. The net realization rates for kW and kWh savings were calculated using **Equation 4**.

Eq. 4 $$NRR_h = NTGR_h \times AGRR_h$$

Where,

NRR_h = Net Realization Rate for kW or kWh savings in program stratum "h."

$NTGR_h$ = Net to Gross Ratio defined as the number of units that would not have been installed without the program divided by the total number of units installed through the program (kW or kWh).

2.2 Findings of the Random M&V Telephone Surveys

Ex-ante savings for the residential CFL programs are shown in **Table 2.2**. Findings of the random M&V telephone surveys are provided in **Table 2.3**. The overall retention factor is 0.9 indicating that 90% of the CFLs were still installed after 2 years. The overall on-peak factor is 0.49 indicating that 49% of the CFLs are used during the 2PM to 6PM peak period. The overall

gross realization rates are 0.40 for kW savings and 1.39 for annual kWh savings.[4] The gross realization rates are further adjusted by the net-to-gross ratios (see **Table 1.1** and **Table 3.2**). The average hours of operation for all programs are 1,489 hours per year. Therefore, the effective useful lifetime (EUL) is 6.72 years, based on the expected CFL lifetime of 10,000 hours.

Table 2.2 Ex-Ante Savings for Residential CFL Programs

NCPA Utility	Ex-Ante Qty.	Ex-Ante Pre-Retrofit Watts	Ex-Ante Post-Retrofit Watts	Ex-Ante Hours of Operation	Ex-Ante kW Savings	Ex-Ante kWh/yr Savings
Biggs	1,407	68	18	2190	70.4	154,067
Gridley	1,117	68	22	2424	52.0	126,126
Healdsburg	3,024	68	18	2190	151.2	331,128
Plumas-Sierra REC	1,469	60	15	1578	66.1	104,299
Redding	65,610	75	25	840	3280.5	2,755,620
Average	72,627	68	20	1,844	3,620	3,471,239

Table 2.3 Findings of Random M&V Telephone Surveys for Residential CFL Programs

NCPA Utility	M&V Retention Factor	M&V Qty.	M&V Pre-Retrofit Watts	M&V Post-Retrofit Watts	M&V Hours of Operation	M&V On-Peak Factor	M&V Gross kW Savings	M&V Gross kWh/yr Savings	Average Gross Realization Rate kW	Average Gross Realization Rate kWh/yr
Biggs	0.90	1,266	69	18	1,460	0.50	32.3	94,371	0.46	0.61
Gridley	0.95	1,061	65	21	1,424	0.60	28.2	66,993	0.54	0.53
Healdsburg	0.80	2,419	60	15	1,424	0.33	36.3	154,968	0.24	0.47
PSREC	1.00	1,469	74	17	1,533	0.40	33.5	128,363	0.51	1.23
Redding	0.83	54,675	74	25	1,643	0.50	1332.7	4,377,930	0.41	1.59
Average	0.90	65,599	68	20	1,489	0.49	1,463	4,822,624	0.40	1.39

[4] Gross realization rates are defined as the M&V gross savings divided by the ex-ante savings. The net realization rate is defined as the net-to-gross ratio times the gross realization rate.

3. Participant Survey Results

This study uses participant surveys to estimate the net-to-gross ratios for kWh and peak kW savings. Participant surveys were completed for 62 participants in five NCPA utility service areas.

3.1 Participant Survey Methodology

Participant surveys were used to evaluate retention (i.e., bulbs still installed), pre-retrofit lamp Watts, hours of operation, and time-of-use (i.e., turned on from 2-6PM). The participant surveys were also used to evaluate net-to-gross (NTG) ratios for calculating net kW and kWh savings. The NTG ratio is used to estimate the fraction of free riders who would have otherwise implemented lighting improvements in the absence of the program. Nine participant survey questions were used to assess net-to-gross ratios as shown in **Table 3.1**. The NTG ratio score for each completed participant survey is the average score based on answers to questions 5 through 13. No score is assigned to responses of "don't know", "refused to answer," or "other."

Table 3.1 Net-to-Gross Ratio Participant Survey Questions and Scoring

#	Question	Answer	Score
1	Are you using the CFLs that you received from the utility program (i.e., are CFLs being retained)?	Yes, No	1=Y, 2 =0
2	What size (i.e., Wattage) bulbs did you replace with the new CFLs?	60W, 75W, 100W	
3	How many hours per day do you use the CFLs?	<3, 4.5, 6, DK	
3a	Are the CFLs turned on from 2-6PM (i.e., peak period)?	Yes, No	1=Y, 2=N
5	Did you understand the value of the program BEFORE or AFTER you installed the efficiency upgrades?	Before	1
		After	0
6	Did you install the lighting efficiency upgrade BEFORE or AFTER you heard about the Rebate Program?	Before	0
		After	1
7	On a scale from 0 to 10, with 0 being no influence at all and 10 being very influential, how much influence did the Utility or Rebate have on your decision to install the efficiency upgrades?	0 to 10	0=0, 10=1
8	If the rebates had not been available, how likely is it you would have done exactly the *same* thing. Please use a scale from 0 to 10, with 0 being not at all likely and 10 being very likely.	0 to 10	0=1, 10=0
9	What role did the Utility Program play in your decision to install the upgrades?	1 = Reminded	0.25
		2 = Speeded Up (i.e., early replacement)	0.5
		3 = Showed Benefits Didn't Know Before	1
		4 = Clarified Benefits	0.75
		5 = No role	0
10	The Utility Program was nice but it was unnecessary to get the efficiency upgrades installed.	0 to 10	0=1, 10=0
11	The Utility Program was a critical factor in installing the efficiency upgrades.	0 to 10	0=0, 10=1
12	We would not have installed the efficiency upgrades without the Utility Program.	0 to 10	0=0, 10=1
13	If you had not received the [rebate or service] from the Utility, would you have installed upgrades?	Within 6 months	0
		< 1 year	0.125
		1 to 2 years	0.25
		2 to 3 years	0.5
		3 to 4 years	0.75
		4 or more years	1
		Never	1

3.2 Findings of the Participant Surveys

Findings of the participant surveys for each program are presented in **Table 3.2**. The weighted average net-to-gross ratio is 0.72 based on average participant survey results multiplied times savings for each program divided by total savings for all programs.[5]

Table 3.2 Findings of Participant Surveys

NCPA Utility	Qty.	Completed Surveys	Ex Ante Program Savings kWh/yr	Ex Ante Program Savings kW	M&V Weighting Factor	M&V Retention Factor	M&V Pre-Retrofit Watts	M&V Post-Retrofit Watts	M&V Annual Hours of Operation	M&V On-Peak Factor	Net-to-Gross Ratio
Biggs	1,407	10	94,371	32.3	0.022090	0.90	69.4	18.4	1,460	0.50	0.60
Gridley	1,117	20	66,993	28.2	0.019300	0.95	65.3	20.9	1,424	0.60	0.71
Healdsburg	3,024	10	154,968	36.3	0.024803	0.80	60.0	15.0	1,424	0.33	0.72
Redding	1,469	10	128,363	33.5	0.022893	1.00	74.0	17.0	1,533	0.40	0.80
PSREC	65,610	12	4,377,930	1332.7	0.910913	0.83	73.8	25.0	1,643	0.50	0.72
Average	72,627	62	4,822,624	1,463	1.00	0.90	68.1	19.7	1,489	0.49	0.72

4. M&V Methodology

The M&V methodology for the random M&V telephone survey tasks are discussed above in **Sections 2** and **3**. The M&V methodology for sample design, database tracking, baseline, and program evaluation savings estimates are discussed below.

4.1 Sample Design and Statistical Analysis

Statistical survey sampling methods were used to select a sample of customers or projects from each program population in order to evaluate load impacts.[6] Selecting participants for the sample was guided by the statistical sampling plan as well as input from NCPA utilities. Statistical analysis methods were used to analyze the data and extrapolate mean savings estimates from the sample sites to the population of all program participants and to evaluate the statistical precision of the results. Considering each NCPA utility program within a program category as a stratum, the sample mean within a program was calculated using **Equation 5**.

Eq. 5 $$\text{Mean Savings} = \bar{y}_h = \frac{1}{N_h}\sum_{k=1}^{n} y_k$$

Where,

$\bar{y}_h$ = M&V mean kW or kWh savings for stratum "h."

N_h = Number of measures or sites in stratum "h."

y_k = M&V kW or kWh savings estimate for measure "k."

[5] Participant survey results for programs with lower savings are weighted lower in terms of the total weighted average NTG ratio for all sites.

[6] Cochran, William G. *Sampling Techniques*. New York: John Wiley & Sons, 1977, Kish, Leslie. *Survey Sampling*. New York: John Wiley & Sons, 1965. Thompson, Steven K. *Sampling*. New York: John Wiley & Sons, 1992.

The mean savings for each program category is based on the sample mean savings estimate across NCPA utility programs strata in the program category. The program category sample mean savings were calculated using **Equation 6**.

Eq. 6 Program Category Sample Mean $= \bar{y}_p = \sum_{h=1}^{L} W_h \bar{y}_h$

Where,

$\bar{y}_p$ = Program category sample mean savings estimate.

$W_h = \frac{N_h}{N_p}$ = Weighting factor across all strata.

N_p = Total number of measures across all strata in program category.

The variance, s_h^2, of the sample mean for a utility program stratum within a program category was calculated using **Equation 7**.

Eq. 7 $$s_h^2 = \frac{\sum_{k=1}^{n} (y_k - \bar{y}_h)^2}{N_h - 1}$$

The coefficient of variation (Cv) provides a relative measure of the sample size required to satisfy the 90/10 criteria (or 80/20 criteria) for estimating the mean of the population. The sample Cv for the utility program stratum was calculated using **Equation 8**.

Eq. 8 Sample Coefficient of Variation = $Cv_h = \frac{s_h}{\bar{y}_h}$

Where,

$s_h = \sqrt{s_h^2}$ = Standard deviation of the sample mean savings in stratum "h."

The sample size necessary to obtain a desired level of relative precision for the utility program stratum mean savings estimate was calculated using **Equation 9**.

Eq. 9 Utility Program Stratum Sample Size = $n_h = \frac{t_o Cv_h^2}{r_h^2}$

Where,

n_h = Sample size of the utility program stratum.

r_h = Desired relative precision for the utility program stratum.

For small populations, the sample size was corrected using the finite population correction (FPC) equation as follows.[7]

Eq. 10 FPC Sample Size = $n_{FPCh} = \frac{n_h}{1 + (n_h - 1)/N_h}$

[7] Cochran, William G. *Sampling Techniques*. New York: John Wiley & Sons, 1977, Kish, Leslie. *Survey Sampling*. New York: John Wiley & Sons, 1965. Thompson, Steven K. *Sampling*. New York: John Wiley & Sons, 1992.

Where,

$n_{FPC\,h}$ = Sample size for stratum with finite population correction.

The utility program stratum error bound of $\bar{y}_h$ as an estimator of the mean value at the 90% level of confidence was calculated using **Equation 11**.

Eq. 11 $$\text{Stratum Error Bound} = Eb(\bar{y}_h) = t_o \frac{s_h}{\sqrt{n_h}}$$

Where,

t_o = 1.645 at 90 percent level of confidence (1.28 at 80 percent confidence).

n_h = Number of units in sample in stratum "h."

An unbiased estimate of the program category variance was calculated using **Equation 12**.

Eq. 12 $$s_p^2 = \sum_{h=1}^{L} \frac{W_h^2 s_h^2}{n_h} - \sum_{h=1}^{L} \frac{W_h s_h^2}{N_p}$$

Where,

s_p^2 = Variance of the program category mean savings estimate, $\bar{y}_p$.

The Cv for the program category was calculated using **Equation 13**.

Eq. 13 $$\text{Program Category Coefficient of Variation} = Cv_p = \frac{s_p}{\bar{y}_p}$$

Where,

$s_p = \sqrt{s_p^2}$ = Standard deviation of the mean savings in the program category.

Statistical analysis was used to extrapolate M&V ex post kW and kWh savings at the sample level for a utility program stratum to the program category level and finally for the NCPA SB5X portfolio. This step included an assessment of the error bounds and relative precision of program-level kW and kWh savings as discussed above. The gross M&V ex post program category savings were calculated as the sum of the ex ante program stratum savings times the respective M&V average gross realization rate (AGRR) as shown in **Equation 14**.

Eq. 14 $$\hat{Y}_p = \text{M\&V Gross Ex Post Program Category Savings} = \sum_{h=1}^{L} \left[\hat{X}_h \times AGRR_h \right]$$

Where,

$\hat{Y}_p$ = M&V gross ex post program category savings (kW or kWh).

$\hat{X}_h$ = Ex ante program stratum "h" savings (kW or kWh).

$AGRR_h$ = M&V average gross realization rate for program stratum "h." Defined as the sum of M&V savings for measures or sites in the random sample divided by ex ante savings for measures or sites in the random sample (kW or kWh).

The error bound for the program category is the square root of the sum of the squared error bounds for each of the utility program stratums and was calculated using **Equation 15**.[8]

Eq. 15 $$\hat{E}b(\bar{y}_p) = \sqrt{\sum_{h=1}^{L}\left[Eb(\bar{y}_h)\right]^2}$$

Some statistics were calculated using other equations.[9]

The M&V sample coefficient of variation of is 0.47 for kWh and 0.26 for kW based on the gross realization rates from the M&V results. Therefore, the minimum 90/10 sample size for the M&V audits was 60 (based on **Equations 9** and **10**). The participant survey coefficient of variation was 0.29, indicating a minimum 90/10 sample size of 23. The M&V telephone participant survey sample size was 62.[10] These sample sizes meet or exceed the 90/10 confidence level.

4.2 Database

Data for the commercial and industrial lighting programs was tracked and archived in the NCPA Tracking Database. Data for all programs of this type are summarized within the database for M&V sampling and reporting purposes. The source of the tracking system data is based on reports provided by the respective utilities. The database includes general customer information, quantity and type of lighting fixtures, make and model number, and NCPA account number (if available). Tracking data was delivered electronically by utility program staff and entered into the database after the programs were completed.

4.3 Baseline

The baseline kWh and kW values are based on customer reported incandescent lamp Wattages, hours of operation, and time-of-use from the telephone surveys. Data were collected from a random sample of customer telephone surveys (i.e., decision maker survey). Reported values were compared to standard values to ensure accurate engineering analysis of energy and peak demand savings. The baseline kWh and kW values are based on a random sample of 62

[8] This result is a consequence of (a) the fact that the standard deviation of the difference between two statistically independent random variables (e.g., the standard savings of each program) is the square root of the sum of the squares of the standard deviations of each of the random variables, and (b) the error bound at the 90 percent level of confidence is 1.645 times the standard deviation. See Hall, N., Barata, S., Chernick, P., Jacobs, P., Keating, K., Kushler, M., Migdal, L., Nadel, S., Prahl, R., Reed, J., Vine, E., Waterbury, S., Wright, R. 2004. *The California Evaluation Framework*, Chapter 12: Uncertainty, pp. 280-306. San Francisco, Calif.: California Public Utilities Commission.

[9] Hall, N., Barata, S., Chernick, P., Jacobs, P., Keating, K., Kushler, M., Migdal, L., Nadel, S., Prahl, R., Reed, J., Vine, E., Waterbury, S., Wright, R. 2004. *The California Evaluation Framework*, San Francisco, Calif.: California Public Utilities Commission. Cochran, William G. *Sampling Techniques*. New York: John Wiley & Sons, 1977, Kish, Leslie. *Survey Sampling*. New York: John Wiley & Sons, 1965. Thompson, Steven K. *Sampling*. New York: John Wiley & Sons, 1992.

[10] M&V telephone survey participants were randomly selected in each utility service area based available customer information from the utility program tracking databases and customers who were willing to participate.

customers. The sample mean baseline energy consumption for CFLs is 106 ± 9.8 kWh/yr and 0.068 ± 0.003 kW at the 90 percent confidence level.

4.4 Program Evaluation Savings Estimates

Gross M&V program evaluation savings (i.e., kWh/yr and kW) are based on the average gross realization rates from the telephone survey sites. Gross M&V savings for each site in the telephone survey sample are based on the difference between pre- and post-retrofit lamp power, hours of operation, and time-of-use. The sample mean M&V gross unit savings for CFLs are 66.4 ± 6.87 kWh/yr and 0.020 ± 0.001 kW at the 90 percent confidence level. Gross savings for the sampled sites were used to develop gross realization rates for kW and kWh/yr, and these values were multiplied by the ex ante program savings to develop gross M&V program savings. Net program evaluation savings are based on the participant decision-maker survey results that were analyzed to develop net-to-gross ratios for kWh and kW savings. Methods used to develop net-to-gross ratios are described above in **Section 3**. The gross and net savings estimates obtained at the participant level are extrapolated to the population of program participants using the methods described above in **Section 4**. Gross M&V savings and average gross realization rates for all utilities in the residential CFL program category are provided in **Table 4.1**. Ex-ante and M&V ex post program savings and for the residential CFL programs are shown in **Table 4.2**.

Table 4.1 Gross M&V Savings and Realization Rates for Residential CFL Programs

NCPA Utility	Qty.	Ex Ante Program Savings kWh/yr	Ex Ante Program Savings kW	M&V Gross Program Savings kWh/yr	M&V Gross Program Savings kW	AGRR kWh/yr	AGRR kW
Biggs	1,407	94,329	38.7	94,371	32.3	1.000	0.835
Gridley	1,117	126,126	52.0	66,993	28.2	0.531	0.543
Healdsburg	3,024	190,512	136.1	154,968	36.3	0.813	0.267
PSREC	1,469	104,299	83.7	128,363	33.5	1.231	0.400
Redding	65,610	1,367,968	1640.2	4,377,930	1,332.7	3.200	0.813
M&V Total	72,627	1,883,234	1,951	4,822,624	1,463	2.561	0.750

Table 4.2 Summary of M&V Results for NCPA SB5X Residential CFL Programs

NCPA Utility	Qty.	Ex Ante Program Savings kWh/yr	Ex Ante Program Savings kW	M&V Gross Program Savings kWh/yr	M&V Gross Program Savings kW	Net-to-Gross Ratio	M&V Net Program Savings kWh/yr	M&V Net Program Savings kW	Net Realization Rate Relative to Planning kWh/yr	Net Realization Rate Relative to Planning kW
Biggs	1,407	94,329	38.7	94,371	32.3	0.60	56,315	19.3	0.60	0.50
Gridley	1,117	126,126	52.0	66,993	28.2	0.71	47,433	20.0	0.38	0.38
Healdsburg	3,024	190,512	136.1	154,968	36.3	0.72	111,133	26.0	0.58	0.19
PSREC	1,469	104,299	83.7	128,363	33.5	0.80	102,469	26.7	0.98	0.32
Redding	65,610	1,367,968	1640.2	4,377,930	1,332.7	0.72	3,168,498	964.5	2.32	0.59
Average	72,627	1,883,234	1950.8	4,822,624	1,463	0.72	3,485,846	1,057	1.85	0.54

The ex ante program savings are 1,883,234 kWh/yr and 1,951 kW. The M&V gross ex post program savings are 4,822,634 ± 498,651 kWh/yr and 1,463 ± 83 kW at the 90 percent confidence level. The M&V net program savings are 3,485,846 ± 360,430 kWh/yr 1,057 ± 60

kW at the 90 percent confidence level. The net ex post lifecycle savings are 23,424,885 ± 2,422,090 kWh based on the EUL for screw-in CFLs of 6.72 years. The net realization rates are 1.85 for annual kWh savings and 0.54 for kW savings. The M&V kWh savings and net realization rates are greater than anticipated. However, the M&V kW savings and net realization rates are lower than anticipated primarily due to lower baseline usage and lower net-to-gross ratios. The average net-to-gross ratio is 72 percent meaning that roughly 28 percent of customers would have purchased and used CFLs without the program.[12]

[12] The net-to-gross ratio (NTGR) analysis is discussed in Section 3. The total NTGR is the weighted average value based on savings for each program relative to total savings for all programs.

Appendix A: Residential CFL Decision-Maker Survey

Interview Instructions for Decision-Maker Survey

1. Purpose

The purpose of the Decision-Maker Survey is to obtain sufficient information to estimate the Net-to-Gross Ratio (NTGR).

2. Selection of Respondent

The **decision-maker** must be the person who decided to install or implement rebated measures.

3. Two Types of Sites

This survey can be used for two types of sites:

1. **On-Site M&V Only**. Sites that receive an on-site inspection for the M&V evaluation.
2. **Telephone Only**. Sites that only receive a telephone survey.

4. How to Start a Survey

Complete the following steps to start one of these surveys:

1. Review file information for the site (if available).
2. Make sure you understand what was installed prior to initiating the call or visit.
3. Contact the person and explain the purpose of the Survey. Tell them that the data provided by them will be kept strictly confidential and will not be shared with anyone.

RESIDENTIAL CFL DECISION-MAKER SURVEY

Customer Name:_____ Date: _____

Business Name: _____ Contact: _____

Phone Number:_____ City: _____

Start Call Time: _____ End Call time:_____

Surveyor Initials: _____ Survey Completed: Y NA R WB BN

Y = yes, NA = no answer, R = refused, WB = wrong business, BN = bad number

The purpose of the decision-maker survey is to obtain information necessary to calculate a net-to-gross ratio. You will need to interview the customer who was responsible for the decision to implement measures at the site. If this person is not available attempt to locate someone who is at least familiar with how that decision was made.

Introduction

Say: "Hello. My name is [**Anne**] and I'm conducting a telephone survey regarding the [**Biggs, Gridley, Healdsburg, Redding, or Plumas-Sierra**] energy efficiency programs. Would you mind spending 5 minutes to answer a few questions to help us evaluate the utility Compact Fluorescent Lamp Program."

Begin Survey

1. Are you using the Compact Fluorescent Lamps (CFLs) [**or other measures**] that you received from the utility program [**or purchased with a utility rebate**]? If they say "no," then say - Are you aware that CFLs save 75% on your lighting costs (for example a typical CFL costs $2/year compared to a 60W incandescent bulb that costs $10/year to operate)?

   ___ **1** (Yes) ___ **2** (No) **98** Don't Know **99** Refused to Answer

2. What size light bulbs did you replace with the new CFLs?

   ___ **1** (60 W) ___ **2** (75 W) ___ **3** (100W) **98** Don't Know **99** Refused to Answer

3. How many hours per day do you use the CFLs?

   ___ **1** (<3 hrs) ___ **2** (4-5 hrs) ___ **3** (>6 hrs) **98** Don't Know **99** Refused to Answer

3a. Are the CFLs on from 2-6PM Weekdays? ____ **1** (Yes) ___ **2** (No) **98** DK **99** Refused

4. When and how did you first learn about the Utility CFL Program?

   _____

   1 Didn't know there was a program (**Go to Q.6**)

5. Keeping that in mind, did you understand the value of the program BEFORE or AFTER you installed the CFLs? (**Circle One**)

   1 Before **2** After (**Go to Q.7**) **98** Don't Know **99** Refused to Answer

6. Did you install CFL(s) BEFORE or AFTER you received information, rebates or CFL(s) from the utility? (**Circle One**)

   1 Before **2** After **98** Don't Know **99** Refused to Answer

RESIDENTIAL CFL DECISION-MAKER SURVEY (Continued)

7. On a scale from 0 to 10, with 0 being no influence at all and 10 being very influential, how much influence did the Utility or Rebate have on your decision to install the CFL(s)?

   ___ Response (**0-10**) **98** Don't Know **99** Refused to Answer

8. If the CFL(s) had not been available, how likely is it you would have done exactly the *same* thing. Please use a scale from 0 to 10, with 0 being not at all likely and 10 being very likely.

   ___ Response (**0-10**) **98** Don't Know **99** Refused to Answer

   Notes: _____

Special Instruction for Contradictory Responses: If [**Q.7 is 0,1,2** *and* **Q.8 is 0,1,2**] *or* [**Q.7 is 8,9,10** *and* **Q.8 is 8,9,10**]. Probe for the reason. However, it is important not to communicate a challenging attitude when posing the question. For example, say,

> When you answered "8" for the question about the influence of the rebate or service, I interpreted that to mean that the Utility Program was important to your decision. Then, when you answered "8" for how likely you would be to take the same action *without* the rebate or service, it sounds like the Utility was *not* very important. I want to check to see if I understand your answers or if the questions may have been unclear.
>
> If they volunteer a helpful answer at this point, respond by changing the appropriate answer. If not, follow up with something like: "Would you explain in your own words, the role the Utility Program played in your decision to take this action?

If possible translate their answer into responses for **Questions 7** and **8** and check these responses with the respondent for accuracy. If the answer doesn't allow you to decide what answer should be changed, write the answer down and continue the interview.

Answer: _____

9. What role did the Utility Program play in your decision to install the CFLs? [Prompt by reading list if the respondent has trouble answering.]

   1 Reminded us of something we already knew
   2 Speeded up process of what we would have done anyway (i.e., early replacement)
   3 Showed us the benefits of this action that we didn't know before
   4 Clarified benefits that we were *somewhat* aware of before
   5 Recommendation had no role
   6 Other _____
   98 Don't Know
   99 Refused to Answer

RESIDENTIAL CFL DECISION-MAKER SURVEY (Continued)

Say: Here are some statements that may be more or less applicable for your home or business about the Utility CFL Program [**or recommendation**]. Please assign a number between 0 and 10 to register how applicable it is. A 10 indicates that you fully agree, and 0 indicates that you completely disagree.

10. The Utility Program was nice but it was unnecessary to get the CFL(s) installed.

    ___ Response (**0-10**) **98** Don't Know **99** Refused to Answer

11. The Utility Program was a critical factor in installing the CFL(s).

    ___ Response (**0-10**) **98** Don't Know **99** Refused to Answer

12. We would not have installed the CFL(s) without the Utility Program.

    ___ Response (**0-10**) **98** Don't Know **99** Refused to Answer

Special Instruction for Contradictory Responses: If [**Q.10 is 0**,**1**,**2,** *and* **Q.11/12 is 8**,**9**,**10**] *or* [**Q.10 is 8,9,10** *and* **Q.11/12 is 0,1,2**].

When you answered "0" for the question about "the Utility Program being 'nice' but unnecessary," I interpreted that to mean that the Utility Program was unimportant to your decision. Then, you answered "8, 9 or 10" for "the Utility Program being a critical factor." I want to check to see if I understand your

If they volunteer a helpful answer, respond by changing the appropriate answer. If not, follow up with something like: "Would you explain in your own words, why the Utility Program was a critical factor in your decision?"

If possible translate their answer into responses for **Questions 10/11/12**. If the answer doesn't allow you to decide what answer should be changed, write the answer down and continue the interview. answers or if the questions are clear.

Answer: _____

13. If you had not received the CFL [rebate or service] from the Utility, would you have installed CFLs [**or other measures**]...

    1 ..within 6 months?
    2 ..6 months to 1 year?
    3 ..one to two years later?
    4 ..two to three years later?
    5 ..three to four years later?
    6 ..four or more years later?
    7 ..Never
    98 ..Don't Know - **Try less precise response, if still "don't know" use 98**
        8 ...less than one year?
        9 ...one year or more?
    99 ...Refused to Answer

Time relative to the installation date. For customers with more than one measure ask if their response is the same. If not, obtain a response for each measure. Write answers in margins and enter answers on a new line in the Excel spreadsheet.